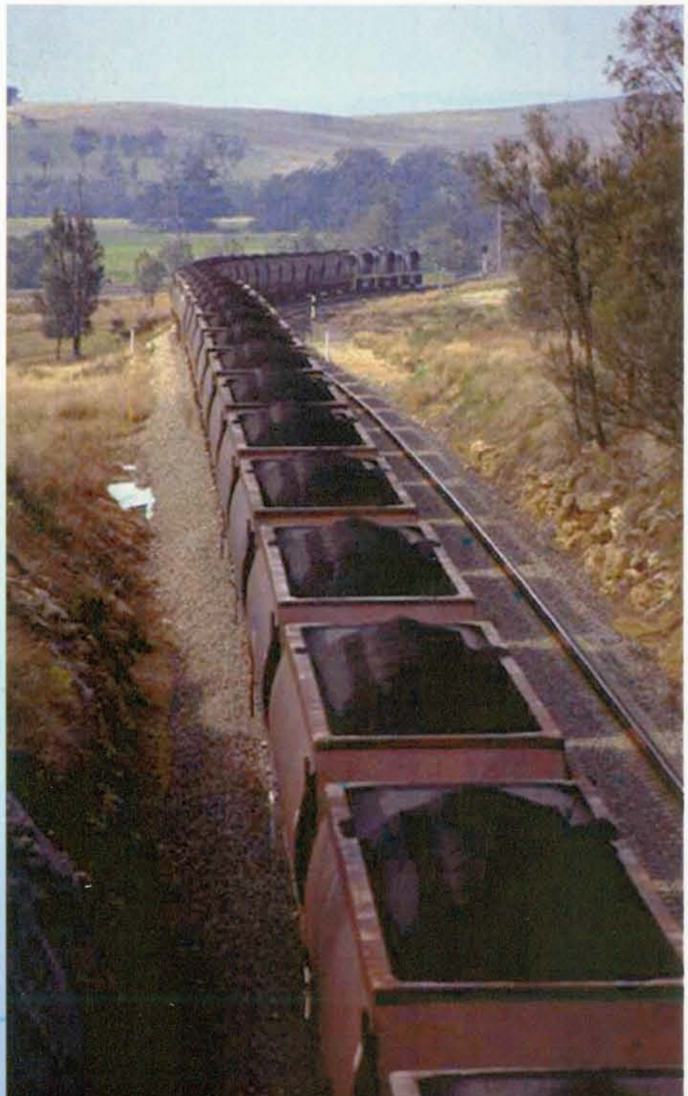
Drayton Coal Pty Ltd &
Coal Operations Australia Limited

Antiene Joint User Rail Facility Environmental Impact Statement



Volume 2
Appendices

March 2000

DRAYTON
COAL PTY. LTD.
A.C.N. 002 028 257

COAL
COAL OPERATIONS
AUSTRALIA LIMITED

Report No. 1323/R01

Prepared for:

COAL OPERATIONS AUSTRALIA LIMITED & DRAYTON COAL PTY LTD

ANTIENE JOINT USER RAIL FACILITY ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2

Umwelt (Australia) Pty Limited

Environmental and Catchment Management Consultants

PO Box 838
Toronto NSW 2283

Ph. (02) 4950 5322

Fax (02) 4950 5737

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APPENDIX 1A

Correspondence in relation to Coal Operations Australia Limited Development Application

FAXED 29/11/1999

Department of
Urban Affairs and Planning

Development and Infrastructure
Assessment
Level 22, 1 Farrer Place
Sydney NSW 2000
GPO Box 3927
Sydney NSW 2001

Telephone: 02 9391 2344
Facsimile: 02 9391 2151
Email:david.fitzgibbon@duap.nsw.gov.au

Ms Barbra Crossley
Director
Umwelt (Australia) Pty Limited
PO Box 833
TORONTO NSW 2283

Dear Ms Crossley

Proposed Bayswater Rail Loading Facility – Lots 1, 2, 3, 5 and 6, DP 701496 AND Lot 11, DP 632691, Parish of Brougham, Bayswater Coal Mine, Muswellbrook
Our reference: N99/00203

Thank you for your letter of 15 October 1999 seeking consultation with the Director-General for the preparation of an Environmental Impact Statement (EIS) for the above development.

Under clause 55 of the *Environmental Planning and Assessment Regulation 1994* (the Regulation), the EIS should specifically address the issues outlined below.

Specific Issues

- a comprehensive project justification that should undertake consideration and assessment of all possible alternatives, including the potential use of the existing Drayton rail loop;
- interrelationship of the proposal with any proposed changes to the capacities of the Drayton Rail Loop and the Antiene Spur, and resultant cumulative impacts;
- ensure as far as possible a co-operative and cumulative assessment of key environmental issues is undertaken with Drayton Coal Pty Ltd in relation to any proposals to change the capacities of the Drayton Rail Loop and Antiene Spur, to enable DUAP to assess each EIS having full regard to potential cumulative impacts. Specific issues to be addressed during this cooperative assessment should include in particular rail movements, noise and air quality;
- the relationship between the proposal and the existing consent and operations at the Bayswater Mine;
- protection of Ramrod Creek and its tributaries during construction and operation of the proposal;
- sediment and erosion control management plan;
- surface water and groundwater issues, including an outline of proposed water management measures;
- timing of proposal in terms of meeting deadline of cessation of road haulage required under the existing consent;
- outline any height restrictions placed on vehicles using Thomas Mitchell Drive as a result of the 2 proposed railway bridge crossings;
- consideration of potential mine/coal resource impacted upon as a result of the proposal and provide a discussion of the resource economic viability and provide a justification for the "sterilisation" of any economically viable coal resources by the proposed development;
- discussion on the proposed relocation and modification of the Energy Australia owned 33kV transmission line;

- provide an outline of proposed rehabilitation, in particular in regard to the areas where sections of native forest have been disturbed and also existing drainage areas and collection dams;
- consideration of impacts on Aboriginal Archaeological and Cultural Heritage, which shall include an Aboriginal Cultural assessment and management report to help identify any significant Aboriginal Heritage sites within the development area for salvage, excavation or conservation, and provide details of how any salvage, excavation or conservation of any identified Aboriginal Heritage sites will be undertaken;
- details of management of identified European Heritage items;
- provide a description of the pollution control and environmental management measures to be adopted, including monitoring programs to assess the predicted impacts and the ongoing environmental performance of the facility;
- A report on threatened species, populations or ecological communities, or their habitats, with particular consideration of the Squirrel glider, Yellow-bellied Sheathtail Bat and Common Bent-wing Bat, including the following:
  - (a) a description of the study area, including details of the types and condition of the habitat(s) in, and adjacent to, the land to be affected by the proposal;
  - (b) a list of those threatened species, populations or ecological communities known to occur in the same or similar habitats in the region; and
  - (c) an assessment of the likelihood of those species, populations or ecological communities identified in (b) occurring within the study area, given their habitat requirements and the habitats present within the study area.
- consideration of the objectives and relevant provisions of State Environmental Planning Policies and Regional Environmental Plans;
- consideration of the objectives and relevant provisions of the Upper Hunter Cumulative Impact Strategy and Study, and the Upper Hunter Sub Regional Strategy;

The EIS should address the detailed requirements of the Environment Protection Authority (EPA) (see attached Environment Protection Authority letter). The EPA requires 3 copies of the EIS when a Development Application is submitted. These documents should be lodged at the EPA's Newcastle Office.

The EIS should also address the requirements of Muswellbrook Shire Council, Mine Subsidence Board, National Parks and Wildlife Service and the Department of Land and Water Conservation (letters also attached).

Attachment No. 1 outlines the statutory matters that must be included in any EIS under clauses 54 and 54A of the Regulation.

Attachment No. 2 contains a guide to the issues that may be relevant to the preparation of the EIS for your proposal.

As a result of amendments to the *Environmental Planning and Assessment Act 1979*, Development Applications (DAs) lodged after 1 July 1998 are "integrated development" where certain licences or approvals are required from bodies other than the consent authority. You have identified a number of licences or approvals that you may need if you are granted development consent. The NSW Heritage Council was identified as an integrated approval body at the Planning Focus Meeting held on 3 November 1999. You need to conduct your own consultation with the Heritage Council to identify its requirements for the EIS. If further integrated approvals are identified before the Development Application is lodged, you must conduct your own consultation with the relevant agencies to identify their requirements for the EIS.

When lodging your Development Application, you must lodge at least one copy of the Development Application and supporting documentation (including a fee of $250) with <u>each</u> of the agencies from whom you need an integrated approval.

You should consult with Muswellbrook Shire Council and take into account any comments Council may have in the preparation of the EIS. The EIS should also address other issues that emerge from consultations with relevant local, State and Commonwealth government authorities, service providers and community groups, in particular Freight Corp, Rail Access Corporation, Department of Mineral Resources; Rural Land Protection Board, EPA, National Parks and Wildlife Service, Heritage Council, Department of Land and Water Conservation, Wanaruah Local Aboriginal Land Council, Wonnarua Tribal Council, Mine Subsidence Board, and Energy Australia.

The Development Application should be lodged with the Department rather than the Council because this proposal is State Significant Development. When submitting your Development Application, please include at least 6 copies of the EIS and any other supporting documentation.

Please contact David Fitzgibbon on (02) 9391 2344 if you require any further information regarding the Director-General's requirements for the EIS or lodgement of the DA.

Yours sincerely

29/11/1999

Derek Mullins
Assistant Director
Development and Infrastructure Assessment
As Delegate for the Director-General

Department of Urban Affairs and Planning

Attachment No. 2

Director - General's Requirements
Proposal to Construct and Operate a Rail Loading Facility at Bayswater Coal Mine
Muswellbrook LGA

The matters listed below should be clearly and succinctly outlined in the text of the EIS and where appropriate supported by adequate maps, plans, diagrams or other descriptive details to enable all concerned to gain a clear understanding of the full scope of the development and its likely impact on the environment.

Issues outlined below are not necessarily a comprehensive identification of all issues which may arise in respect of this proposal relevant to the preparation and consideration of an EIS. There may be other issues, not included, that are appropriate for consideration in the EIS. It is the applicant's responsibility to identify and address as fully as possible the matters relevant to the specific development proposal in complying with the requirements for EIS preparation.

1. Planning and Environmental Context

i. Planning Information and Permissibility

❒ The following information should be provided:

- zonings, permissibility and any land use constraints;
- compatibility of the proposal with any provisions in:
  - Hunter Regional Environmental Plan 1989
  - Hunter Regional Environmental Plan 1989 – Heritage
  - State Environmental Planning Policy No.33 – Hazardous and Offensive Development
  - State Environmental Planning Policy No.44 – Koala Habitat Protection
  - State Environmental Planning Policy No.45 – Permissibility of Mining
  - Muswellbrook Local Environmental Plan 1985
  - any relevant Development Control Plans
- existing land uses; and
- any heritage items or environmental protection areas.

ii. Site description and locality information

❒ The following information should be provided:

- title details, land tenure, lease details;
- site description and maps, plans, aerial photographs clearly identifying the location of the proposal relative to surrounding roads, and other communities, dwellings and residences and any land use likely to be affected by the development, utilities including transmission lines, pipelines, cables or easements, sight lines from dwellings or public spaces such as roads. A clear illustration of the development application area should also be included.

iii. Overview of the affected environment

❒ This should provide details of the environment in the vicinity of the development site and also those aspects of the environment likely to be affected by any facet of the proposal. Baseline information should be provided on the following:

- meteorological characteristics which may influence erosion, dust or noise impacts. These may include prevailing wind and intensity, average yearly rainfall, evaporation, seasonal distribution, storm intensity, storm return period (that is average interval between storms of specific magnitude);
- surface contours and general topography. These may include slope gradient, slope length, catchment size, drainage;

- presence and condition of watercourses, flood liability, any water storage or drinking water catchments including groundwater bores within 1 kilometre, watertable and the relationship with the maximum excavation depth;
- existing flora and fauna communities and the presence of any threatened species populations or ecological communities, or their habitats, including the Squirrel glider, Yellow-bellied Sheathtail Bat and Common Bent-wing Bat;
- features of heritage, conservation or archaeological value, including potential European heritage item (glass ceramic fragment found) within the site of the proposed rail loop;
- visual amenity;
- suitability of the land for agricultural purposes, including the area of land adjacent to Thomas Mitchell Drive owned by the Rural Lands Protection Board used for travelling stock reserve;
- social and economic aspects of the environment.

2. Description of the proposal

The description of the proposal should provide general background information on:

i. Proposal objectives

❐ Clearly identify objectives and characteristics of the proposal. There should be a clear statement of the proposal having regard to the:

- the proposed coal loading bin and rail loop;
- quantity and types of coal to be loaded and transported;
- potential conflicts with other users of the rail lines involved (in particular Drayton Coal Mine); and
- interrelationship of the proposal with existing development and existing development consent.

ii. Existing coal loading and transportation

❐ Outline the existing coal road transportation methods in the Muswellbrook area, including

- existing coal loading methods;
- existing throughput volumes at Ravensworth Coal Terminal;
- transportation routes which are used in the transportation of coal;
- existing coal truck movements; and
- requirements in current planning consents regarding transportation by road, including the date cessation of road haulage is required under existing consent;

iii. Proposed works

❐ Describe the proposed coal loader and rail spur in full detail, including:

- the balloon rail loop;
- 1000 tonne train loading bin;
- double track rail bridge;
- connection to existing Antiene rail spur;
- 40000 tonne stockpile and truck dump station
- proposed location of rail loop, train loading bin, double track rail bridge, stockpile and truck dump;
- details of the management of the total development proposal;
- staging and construction schedule;
- works to be undertaken prior to construction and operation commencing;
- proposals for progressive rehabilitation of any areas disturbed by construction activities;
- type of machinery and equipment to be used;
- plans of operation and facilities;
- estimated daily, weekly and annual volumes of material to be transported and loaded, including estimated capacity of the proposed coal loader;

- employment (during construction and operation);
- hours of operation for construction and operation, including loading, and coal transportation;
- energy requirements;
- quantities and method of storage of any fuels and chemicals on the site;
- sanitary and waste disposal arrangements;
- water management and erosion control; and
- details of the proposed land swap with the Rural Lands Protection Board in relation to the travelling stock reserve, located within the site of the proposed rail loop, adjacent to Thomas Mitchell Drive.

iv. Infrastructure considerations

❒ Nature, extent and proposed location of any additional infrastructure on and off site necessary to meet the projects construction and operational needs.

The following factors should be considered:

- electricity supply; measures to protect or the need to relocate easements, cables, pipelines which may be impacted by the proposal, in particular the need to relocate the EnergyAustralia owned 33kv transmission line located along the proposed rail route;
- energy conservation measures;
- water requirements, source of water supply, demands on water resources, proposed supply or storage, identify water recycling and reuse options;
- waste disposal requirements, proposed methods and locations for disposal; and
- transport requirements.

v. Alternatives and justification

❒ Consideration of alternatives and justification for the preferred proposal. This should include an assessment of the environmental impacts or consequences of adopting alternatives including:

- coal transportation technology (eg transporting coal by conveyor rather than by the proposed rail loop, use of the existing Drayton rail loop);
- location of the proposed rail loop, including investigating utilisation of existing service corridors and avoidance of the woodland area in the vicinity of the proposed rail loop;
- coal transport, handling and storage techniques or technology, in particular in relation to the proposed train loading bin;
- electricity generation technology;
- facility design, site layout or access roads;
- proposed infrastructure location;
- disposal methods;
- alternative rehabilitation; and
- staging

The selection of the preferred options should be justified in terms of:

- type, quality and quantities of coal to be loaded in relation to market demand; and
- environmental factors including the bio-physical, economic and social factors.

1. Analysis of environmental impacts and mitigating measures

Environmental impacts usually associated with coal loading and associated rail spur facilities are listed below. The EIS should provide an overview of the methodology used to identify and prioritise issues and provide a summary of the outcomes of the process. The potential impacts of the proposal on the environment should be addressed in the EIS in satisfactory detail and suitability quantified. In addition, the proposed mitigation and management strategies to mitigate the impacts should be identified and take account of the effectiveness of the measures proposed.

i. Existing environmental performance

A review of the environmental performance and identification of critical problems for existing coal transportation in the Muswellbrook area. This should include ways in which the proposed development will enable existing problems, if any, to be remedied, including problems with existing road haulage.

ii. Transport and traffic issues

Assessment of transport and traffic issues associated with the proposal during construction and operation of the development taking into account the current and projected traffic on existing coal transportation routes in the Muswellbrook area, including volumes and vehicle types.

<u>During Construction</u>

- estimated average and maximum hourly, daily and weekly transport movements, including movements on Thomas Mitchell Drive, the proposed rail loop and the and the Antiene spur;
- proposed transport routes and possible alternative routes or transport modes;
- adequacy of the local and regional road network to accommodate construction traffic demands;
- cumulative impacts in terms of other current and potential users, in particular Drayton Mine;
- the need for any associated road upgrades and potential impacts on maintenance programs;
- the need to provide access for affected land owners;
- associated noise, vibration and dust emission impacts on residential and industrial receptors
- potential impact on the rail maintenance program;
- rail safety issues;
- proposed measures to improve safety; and
- associated management and/or mitigating measures including possible alternative routes.

<u>During Operation</u>

- estimated average maximum hourly, daily and weekly rail movements to and from the proposed loader;
- the need for rail bridge crossings over Thomas Mitchel Drive;
- impacts of locomotive headlights on opposing road traffic and proposed ameliorative measures;
- the need to provide access for affected landowners;
- implications of arrangements for road haulage of coal when emergencies arise.

iii. Air quality

❒ Issues to consider include:

- identification of fixed and mobile sources of air pollution such as mining, processing, handling, storage, loading or transport operations;
- provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring;
- likely impact of the proposal on the local and regional air quality, (this should include baseline data on ambient quality of the air, projected dust emissions and deposition rates and frequency and times of significant emissions);
- cumulative effects on sensitive residential or industrial receptors;
- meteorological conditions under which nearby dwellings and sensitive land are likely to be affected;
- mitigation and management measures to minimise the generation of dust and to ensure compliance with air quality objectives especially in the transportation, handling and storage of coal on-site; and
- dust monitoring programme (deposition and concentration).

iv. Noise and vibration impacts

❒ Issues to consider include:

- existing acoustic environment including a statistical breakdown of the meteorological conditions (predominant wind, temperature, humidity and inversion conditions) and any topographical features which will influence the noise or vibration impacts;
- provide details of the land use zoning of the proposed site and surrounding properties;
- proposed hours of transport and loading;
- noise levels from fixed and mobile noise sources, including rail;
- predictive noise levels at potentially affected dwellings, industrial receptors and any other noise sensitive locations likely to be affected by the proposal;
- cumulative effects on sensitive residential and industrial receptors, both in the vicinity of the proposed coal loader and adjacent to the proposed rail loop;
- mitigation and management measures to control the generation of noise to ensure compliance with relevant noise standards including details of noise control measures;
- proposed monitoring program;
- see attached EPA letter for methodology details.

v. Water quality and drainage

❐ Issues to consider include:

- description of potential sources of water pollution;
- condition of waterbodies or environmentally sensitive areas which could be impacted by:
  - demand on water resources, particularly flow levels and water quality;
  - any change in the surface or groundwater hydrology as a result of the proposal; and/or
  - any change in the water quality as a result of any activity on the site;
- drainage and sediment management system;
- water balance;
- potential impacts on groundwater;
- any effects on the local or regional watertable and implications for other users;
- details of control measures to be implemented to prevent adverse impacts by waste water, leachate and contaminated stormwater on the water quality of local streams and groundwater, in particular Ramrod Creek;
- adequacy of measures to ensure no contamination of the groundwater;
- plan for ongoing maintenance and monitoring of water quality controls to ensure their correct installation, operation and effectiveness; and
- a water management plan and site water balance shall be prepared for the construction and operational phases of the development proposal. The following principles shall be incorporated into the water management plan:
  - maximum on-site reuse of waste water, i.e. dust suppression water;
  - minimisation of wet whether overflows of contaminated stormwater;
  - segregation of contaminated water from non-contaminated water to minimise the volume of polluted water to be dealt with;
  - examination of options to reuse wastewater from washdown and dust control measures;
  - details of stormwater diversion works particularly in regard to their capacity and stabilisation;
  - sewage effluent treatment requirements are outlined in the EPA letter attached.

vi. Flood liability

❐ The following issues should be included:

- determine the potential impact of floods on the proposal (especially rail and road access); and
- any likely effects of the operation on flood liability of surrounding lands.

vii. Infrastructure constraints

Identify any constraints presented by demand for utility services and other infrastructure and assess the implications on the proposal's construction and operational needs should augmentation not occur at the required time.

viii. Cumulative impact

❐ Identify any key cumulative impacts:

- on the surrounding area having regard to dust, noise, vibration, visual impacts, water quality issues, traffic impacts, and any loss of heritage items, vegetation or fauna habitat;
- associated with coal transportation by rail in terms of size and frequency of trains using the rail network compared with the existing situation; and
- address cumulative impacts with the existing operations at the Bayswater Mine, Drayton Mine, Drayton rail loop and rail movements on the Antiene spur, the approved Mount Arthur North Coal Mine, and any other mining operations proposed, approved or in operation in the Muswellbrook area, including the proposed coal tonnage modification being sought for the Drayton Loop and the Antiene spur.

ix. Visual impact

❒ Issues to consider include:

- consideration of the site in relation to any landscapes of local or regional significance as considered from the fore, middle and background;
- visibility from nearby properties, and general surrounds;
- lighting impacts from lights for security and night time operations including lighting impacts from train operations;
- impacts of rail loop on the visual environment;
- form and bulk of coal loading facility, stockpile, location of access roads and fences; and
- proposed landscaping to reduce visual impacts, and location, layout and species composition of intended screening.

x. Spontaneous combustion

Consider the likelihood of spontaneous combustion of coal to be stockpiled or stored. Provide details of proposed management practices.

xi. Risk and Hazard Analysis

A risk analysis should be prepared taking into consideration the provisions of State Environmental Planning Policy No.33 – Hazardous and Offensive Development, referring to DUAPs Guideline "Applying SEPP33".

xii. Flora and Fauna impacts

❒ Issues to consider include:

- plant species and communities within the proposal site area and its habitat significance;
- extent of disturbance of flora;
- details of proposed mitigation methods to protect indigenous plant species;
- fauna known likely to occur within the proposal area and note occurrence of any endangered fauna;
- assessment of the effects on fauna and its habitat, in particular in regard to the Squirrel glider, Yellow-bellied Sheathtail Bat, and Common Bent-wing Bat;
- measures to ameliorate impact and to prevent weed invasion, vermin or feral animal problems;
- the 8 part test contained in Section 5A of the Environmental Planning and Assessment Act 1979 and the need to prepare a Species Impact Statement to be prepared in accordance with the Threatened Species Conservation Act, 1995.

xiii. Heritage aspects

❒ Issues to consider include:

- any likely affectation of sites of Aboriginal, archaeological or European heritage value (including industrial heritage) if located in the vicinity of operations;
- assessment of significance, including assessment of the significance of glass ceramic fragments found within the site of the proposed rail loop; and
- proposed measures to mitigate impacts or conserve the heritage significance of the sites or items.

xiv. Social environment

❒ Issues should include:

- affect on population growth (urban and rural areas) and changes to population location;
- the consequent housing and social service needs and measures to monitor and, if necessary, satisfy demand;
- changes in the amenity of the area; and
- impacts on the health of the community from any potential changes in air quality, water quality, noise and vibration and rail safety.

xv. Economic environment

❐ Issues should include:

- changes to local employment patterns;
- cost of living for employees and non-employees;
- community growth and commercial development;
- the agricultural viability and the severance of land holdings; and
- impact on property values (also taking account of the aesthetic impact of the facility and infrastructure); and
- affect on municipal finances.

xvi. Erosion and soil stability issues

❐ Issues to consider include:

- meteorological data, soil properties and characteristics and attributes of soil units;
- landform characteristics which influence the erosion hazard, ratio of the rate of runoff to rate of rainfall, site history in regard to possible soil contamination issues (see attached EPA letter for specific soil contamination requirements), any stream crossings;
- integrated erosion and sediment control measures;
- maintenance program of all erosion control works;
- brief description of the geology of the area to be traversed by the proposed development; and
- provision of a detailed sediment erosion control plan.

xvii. Agricultural viability

❐ Issues to consider include:

- sensitive agricultural uses in the vicinity of the facility, in particular travelling stock reserve located adjacent to Thomas Mitchell Drive; and
- any effects on the agricultural viability of the adjoining land holdings; particularly in relation to dust and water.

xviii. Ecologically Sustainable Development Principles

❐ Basic concepts of ESD are to be applied to the development as a whole and should be addressed in the EIS, including:

- ***the precautionary principle:*** Show that decisions made for the proposal are predictable and transparent. Including:
  - making information available at an early stage and establishing appropriate conflict resolution mechanisms from project planning stage, assessment and determination process;
  - discussion of Best Practice Environmental Management techniques including the potential use of environmental management plans and environmental audits;
  - ensuring that best practice monitoring and enforcement procedure are proposed; and
  - identifying the responsibilities of the proponent and government agencies for environmental management and enforcement.
- ***inter- and intra-generational equity:*** Overall project management and investment in plant and equipment that minimises pollution and waste and is energy efficient.
- ***conservation of biodiversity and ecological integrity:*** Including:
  - identification and assessment of all environmental characteristics and habitat values that could be affected by the proposal;

- likely environmental impacts on these characteristics and values;
- implementation of measures designed to minimise likely environmental impacts; and
- consideration given to adopting a whole-of-life cycle through use of environmentally benign materials, products and processes (e.g. fuel efficient motors, use of recyclable and recycled materials) and integrated waste minimisation, reuse and recycling.

- ***valuation and pricing of resources:*** The costs and benefits of all aspects of the proposal should be considered. This should include non-economic environmental resources within a defined area around the subject site using methodologies such as contingency valuation.

  Consideration could be given to measuring positive environmental initiatives (e.g. energy savings) for possible use as a trade off for other environmental concessions.

xix. Rehabilitation

❒ The EIS should address the progressive rehabilitation of the site. Including:

- plans for the staged rehabilitation of the stockpile area, screening areas for surface facilities and final landform for the site of the proposed rail loop post operation.

xx. On-going environmental management

❒ Outline proposed on-going management for the proposal. This should provide a comprehensive framework for managing or mitigating environmental impacts for the life of the operation. The plan should:

- demonstrate strategies for sound environmental practice during construction, and operation;
- identify all government licensing and approval requirements and demonstrate how the plan will facilitate compliance with these requirements; and
- set out the framework of a monitoring program of all key impacts on the environment (this framework should indicate what specific information will be monitored, the monitoring intervals, procedures to be undertaken should the monitoring indicate an environmental problem, and the reporting procedures).

4. Consultation

xxi. Government agency consultation

❒ Results of consultation with Environment Protection Authority; Department of Mineral Resources; Department of Land and Water Conservation; NSW Agriculture; National Parks and Wildlife Service; Freight Rail / Rail Access Corporation; Mine Subsidence Board; Local Aboriginal Lands Council, Wonnarua Tribal Council, Hunter Catchment Management Trust, Rural Lands Protection Board, Roads and Traffic Authority, Energy Australia, and Muswellbrook Shire Council.

❒ It is the responsibility of the person preparing the EIS to determine other Departments relevant to the proposed development and to follow up any outstanding issues raised by attendees of the PFM.

xxii. Potentially affected landowners

❒ Consideration and review of key issues which emerged from discussion with potentially affected landowners.

xxiii. Community consultation

❒ Details of consultation undertaken to date, including any local Aboriginal groups or Aboriginal Land Councils, including the Wonnarua Tribal Council. Consideration and review of key environmental issues discerned by the community.

xxiv. Mines in the area

Details of consultation with owners of Mines in the area, including Drayton Mine.

LAND & WATER
CONSERVATION

Director
Development and Infrastructure Assessment
Department of Urban Affairs and Planning
Box 3927 GPO
Sydney 2001

Your ref: N99/00203
Our ref: ER1574

4 November, 1999

Attention: Mr David Fitzgibbon

Dear David,

EIS Requirements for Proposed Bayswater Rail Loading Facility

I refer to your correspondence dated 19th October 1999 about the above project and your request for information following the Planning Focus Meeting on 3rd November 1999. The Department of Land and Water Conservation (DLWC) provides the following information for your consideration in the Environmental Impact Statement.

DLWC REQUIREMENTS FOR RELEVANT STATUTORY APPROVALS

DLWC requires detailed information in the EIS for assessment of approval conditions for any authorisations to be issued under:

- the Water Act 1912 for any industrial use of water collected in constructed dam structures and any monitoring bores for groundwater assessment
- the River and Foreshores Act 1948 for any crossings of Ramrod Creek and its tributaries
- the Roads Act 1993 to carry out work through a Crown Road and
- the Crown Lands Act 1989 for any works on Crown Land

Licensing under the Water Act 1912

The outline of the proposal involves works which require licensing under Part 2 of the Water Act. These include:

- provision of water supply for industrial purposes harvested from constructed dam structures
- diversion of watercourses which are covered by the Water Act.

The EIS will be required to clarify these details to allow a suitable assessment of statutory requirements.

The proposed sedimentation basins will not require a licence under Part 2 of the Water Act, providing:

- all storages and basins are designed and operated solely to retain runoff waters for pollution control or sedimentation.
- all storages detain water for treatment to acceptable levels of water quality prior to release to the downstream environment.

The EIS must demonstrate that the development complies with the Section 20BA and Section 20Y embargoes on water extraction within the Hunter Valley. This will require an assessment of exemption provisions and modifications of extraction regimes from unregulated streams for the development.

Groundwater

The EIS must consider the short-term and long-term effects of seepage from stockpile areas on the groundwater regime. The EIS should identify a monitoring program which will assess any adverse impact of leachates from the stockpile area. Any monitoring bores will require a license under Part 5 of the Water Act.

Any groundwater works, including bores for excavation, testing, extraction and monitoring, must be licensed with the Department of Land and Water Conservation. This licensing requirement applies prior to construction of any new bores.

Rivers and Foreshores Improvement Act, 1948

A Part 3A Permit is required from DLWC under the *Rivers and Foreshores Improvement Act, 1948* for the excavation, filling or removal of material from the bank of a river as defined in the legislation. A Part 3A permit only applies to freehold land and does not apply to Crown Land

Information required regarding an assessment Part 3A application includes:

- a map indicating the location of the works and the name of the river or creek
- the description of the nature of the works including appropriate design details, stages of work, preventative measures to minimise soil erosion and site rehabilitation details;
- estimated volumes of material to be moved in the vicinity of the river banks and channel, including the maximum depth of excavation below the natural surface of the channel bed;
- a report giving details of hydraulic conditions before and after the proposed works for water levels and average velocities at natural bankful discharge, along with sketch plans and survey plans;
- a report on the environmental effects of the works including details of any planned impact on vegetation otherwise covered by the *Native Vegetation Conservation Act, 1997.*

Roads Act 1993

The EIS should provide comprehensive details on any impacts of the development on any Crown roads and to address requirements in terms of the Roads Act, 1993. There is a need to preserve and maintain continuity of access to the Crown road network for use by the public and affected property owners. An applicant may however, consider making application to close and purchase non-essential Crown roads.

Crown Lands Act 1989

The interests of the Department of Land and Water Conservation and the Hunter Rural Lands Protection Board or any other Trust Manager on Crown land affected by the development must be addressed in the EIS.

The EIS needs to consider any potential impacts the development proposal may have on the current/future use, management and amenity of any Crown land, as defined by the Crown Lands Act 1989 that is included or directly affected by the proposal. The EIS should identify the location and status of the Crown Land, and any potential impact on its use, management or amenity.

Land Assessment

The Crown Lands Act, 1989 requires that before any parcel of Crown land can either be sold, leased, licensed or reserved for any purpose the land must first be subject to land assessment in terms of Part 3 of the Act. The objective of the Crown land assessment process is to ensure the ecologically sustainable use, development and management of Crown land in NSW in accordance with Sections 10 and 11 of the Crown Lands Act, 1989 and to provide the opportunity for public input and consideration of the views of other government authorities.

The Minister may consider the waiver of the requirement for land assessment when it is in the public interest to do so and due regard has been given to the principles of Crown land management. An EIS may contain sufficient information to enable the preparation of a waiver submission.

Native Vegetation Conservation Act 1997

The clearing of native vegetation requires approval from DLWC in its provisions in the above legislation. However there are exemptions in the legislation including any clearing that is part of designated development within the meaning of the Environmental Planning and Assessment Act 1979 or any clearing authorised under the Mining Act 1992.

Details of the nature and extent of the proposed clearing should be detailed in the EIS including any compensatory tree plantings proposed for the development.

GENERAL DLWC ISSUES

Water Management

The area of the development is drained by Ramrod Creek and its tributaries. Any of these watercourses could initiate headward or bed erosion and scour if stormwater concentrations are directed through them. In addition, direct disturbances may initiate bed scour or slaking of sodic soil material associated with bank materials.

The proponent must develop an erosion and sedimentation control plan to prevent erosion of watercourses or associated riparian land. The plan must include:

* stormwater collection and distribution methods
* sedimentation and energy dissipation controls along stormwater channels
* stabilisation methods and revegetation programs for stream banks
* complete revegetation methodologies and final vegetation
* water quality treatment and water quality triggers prior to release into the Ramrod Creek catchment.

The EIS should discuss the water drainage issues including:

- comparing the pre-development and post-development drainage network specifically referring to catchment areas, drainage density, discharge characteristics and affects on downstream watercourses
- erosion and sediment control details

Rehabilitation

DLWC requires details of the major soil types and a land capability study in the development area prior to it assessing the adequacy of the rehabilitation proposals. It is a standard condition of DLWC that the land used for non-permanent developments be rehabilitated to the equivalent of its pre-development land capability prior to decommissioning.

The major soil types in the development area must be identified including details of typical morphologic features, any limitations which will affect plant growth and increase the risk of soil erosion. Detailed soil tests will be required to identify the need for any soil amelioration to stabilise the soil.

It is important that all suitable topsoil be recovered during the construction of the development and properly managed to maintain its quality prior to its subsequent respreading over areas of rehabilitation. Any deficit of suitable topsoil material will require specific rehabilitation measures to ensure its revegetation and subsequent stability of the ground surface, particularly on any batters of 2:1 or steeper.

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The impact of any sodic soils on the land rehabilitation programme will require special consideration, particularly where surface sealing and/or tunnel erosion is a potential problem due to high soil sodicity levels.

The EIS should provide details of the proposed revegetation works indicating the conceptual placement of areas of trees to complement existing woodland areas.

Erosion and Sediment Control

The EIS should provide details of the proposed soil conservation strategies to reduce the risk of soil erosion, including details of any specific erosion and sediment control practices proposed for the development.

The development will require the implementation of an erosion and sediment control plan which satisfies the requirements of DLWC. All runoff from disturbed areas is to report to adequate sedimentation structures in order to contain the movement of sediment from the operational area of the development.

The EIS should include details of strategies to ensure stability of any waterways and drainage lines, particularly where there construction is required and the site limitations include slope and/or erodible soil type.

The location of structures in the erosion and sediment control plan should maximise opportunities for similarities between pre-development and post-development drainage networks specifically referring to catchment areas, drainage densities and discharge characteristics.

In addition, the EIS should identify the impact of any unstable soils on the land rehabilitation program specifically where soil sodicity levels increase the risk of potential instability problems.

Where diversion banks are used to redirect water, design details are required to ensure that the re-entry areas to the natural drainage system will remain stable.

Groundwater

The EIS must provide adequate information, to the satisfaction of the DLWC, on groundwater quality and quantity of the lease area to:

- ensure that the groundwater resource is not adversely affected by subsequent mining operations and associated activities and
- establish the baseline conditions for future monitoring purposes.

The proponent is required to minimise any adverse impacts on the groundwater regime, particularly on quality acquifers where the most sensitive identified beneficial use is to be maintained. Therefore, the groundwater monitoring program is to be developed in consultation with DLWC to meet its requirements regarding the duration of the monitoring program, the frequency of sampling, the parameters to be measured, the need for any contingency plans, the reporting procedure and determination of appropriate cut-off criteria for monitoring purposes.

DLWC standardised its approach to monitoring and reporting on changes in the groundwater environment. The groundwater monitoring program should be outlined in the EIS and comply with DLWC requirements.

Crown Land Issues

Land Status

The EIS should identify the location and status of any Crown land included or directly affected by the proposal. A detailed status search is recommended to confirm whether Crown land, as defined by the Crown Lands Act, 1989 is involved and to identify any other interests in the land.

Mining Lease Issues

The applicant needs to clarify if any Crown land involved in the proposal is subject to mining lease(s) inclusive of "surface rights" under Mining Act legislation. Should this be the case, it is recommended that the applicant liaise directly with the Department of Mineral Resources to seek approval requirements from that department in respect of occupation matters.

In the event that the Crown land involved is not subject to mining lease "surface rights', authorisation for the use and occupation of the Crown land will require consideration under the provisions of the Crown Lands Act, 1989, and have regard to any other interests in the land as well as policies and guidelines of the Department of Land and Water Conservation. The EIS needs to address this issue.

Authority to Occupy Crown Land

The Crown Lands Act, 1989 requires that any use or occupation of Crown land be authorised by the department in terms of the Act. Generally such use or occupation can be considered for authorisation by way of a term lease or licence provided that the use or occupation:-

- is supported by land assessment;
- complies with departmental policies and guidelines; and
- meets the statutory requirements of other relevant statutory authorities.

The EIS needs to address this issue should any Crown land be involved that is not subject to mining lease "surface rights".

Potential Impacts

The EIS needs to consider any potential impacts the development may have on the current/future use, management or amenity of any Crown land (if any) that is included or directly affected by the proposal.

Native Title

Should Crown land be involved in the proposal, the EIS needs to consider the implications of the Commonwealth Native Title Act, 1993 & address the issues of any native title rights & interests that may exist in the Crown land.

Development Application (Landowner's Consent)

Owner's consent is required for the lodgement of development applications with Councils and other consent authorities under Section 78A of the Environmental Planning and Assessment Act, 1979.

If the proposal involves Crown land (which is not subject to mining lease "surface rights"), the original development application form together with all supporting documentation (EIS etc) must be submitted to the department for consideration. Consent to lodgement will only be considered to development proposals which are "permissible with consent" under the relevant planning instrument and satisfy departmental policy guidelines.

It should be noted that the granting of owner's consent for the lodgement of a development application does not imply or presume the Minister (administering the Crown Lands Act) approval or support of the proposal. Any approval by the department may be subject to additional conditions to those imposed by other authorities.

Irrespective of approval by any other authority or development consent, no works shall commence on Crown land without the prior written agreement of the department.

Crown Public Roads

Crown Public Roads - Construction

With any proposal reliant upon Crown public roads for access which involves 'road work' under Section 71 of the Roads Act, 1993, the applicant is required to obtain Council's concurrence to the ownership of the road being transferred to Council, in terms of Section 151 of the Roads Act. Provided the department concurs, action will be taken to transfer ownership of the subject road to Council which will then be responsible for setting the standards for road construction and any other requirements as the roads authority under the Roads Act.

Ancillary works and structures other than 'road works' (eg. drainage pipe under the road) can be considered by the department on application under Section 138 of the Roads Act.

To ensure that the work is carried out within the road reserve a boundary survey by a registered surveyor may be required.

In the event works are proposed on Crown roads the EIS needs to address this issue & also provide details on land capability, soil erosion/sediment control and stormwater management.

Buffer Zones

It is preferable that the EIS makes provision for a vegetative buffer of native species endemic to the area wholly within the freehold development site along the common boundary with any Crown land. The buffer is considered necessary to minimise the impacts on the current/future use and general amenity of adjoining Crown land.

Should you require further information, please contact Tony Voller at the Muswellbrook office of the Department on (02) 6542 1203.

Yours faithfully

Tony Voller

T Voller
for Manager
Resource Assessment Planning
HUNTER REGION.

DEVELOPMENT &
INFRASTRUCTURE ASSESSMENT
RECEIVED

NSW EPA

Northern Regions

Mr G Noonan
Development and Infrastructure Assessment
Department of Urban Affairs and Planning
GPO Box 3927
SYDNEY NSW 2001

Our Reference : 271979A3

11 NOV 1999

Your Reference : N99/00203

Contact : Colin Charters

Dear Sir

PROPOSED COAL WORKS – BAYSWATER RAIL LOADING FACILITY

I refer to your request for the Environment Protection Authority's (EPA) requirements for the preparation of an Environmental Impact Statement (EIS) relating to the proposed Bayswater rail loading facility (rail loop, conveyor and rail loader). The EPA received your letter on 22 October 1999.

The information specified in the Attachment must be provided in any Environmental Impact Statement (EIS) submitted in support of the development proposal to enable the EPA to adequately assess those impacts of the development on the environment that relate to the EPA's statutory responsibilities. In summary, the EPA requires the following information:

i) details of existing ambient air, noise, water conditions at the site and at locations likely to be impacted by the proposal;
ii) detailed assessment of the potential impacts on air, noise and water quality and of waste management issues during the construction and operational phases of the proposed facility; and
iii) a description of the pollution control and environmental management measures to be adopted, including monitoring programs to assess the predicted impacts and the ongoing environmental performance of the facility.

Coal works, that include loading operations, are classified as 'Scheduled premises' as defined by the Protection of the Environment Operations Act 1997. Consequently, if development consent is granted the activity will require an environment protection licence from the EPA for (a) scheduled development work and (b) to operate a premises-based scheduled activity. Environment protection licences are subject to conditions covering environmental objectives as well as a variety of operational, monitoring and reporting requirements which can be amended as necessary to cater for changing circumstances.

The EPA will require 3 copies of the EIS when the application is submitted. These documents should be lodged at the EPA's Newcastle office located in the Government Office Building at 117 Bull Street Newcastle and marked to the attention of the Regional Manager, Hunter.

If you have any inquiries regarding this matter, please contact Mr Colin Charters on (02) 49269701.

Yours sincerely

MITCHELL BENNETT
A/Head, Regional Operations Unit, Hunter
for **Director General**

Encl: Attachment

File No. N 99 00203
ACT. OFFICER G Norman
MARKING
LOCATION

ATTACHMENT

ENVIRONMENT PROTECTION AUTHORITY REQUIREMENTS FOR ENVIRONMENTAL IMPACT STATEMENT – PROPOSED COAL WORKS – BAYSWATER RAIL LOADING FACILITY

A. Executive summary

- The executive summary should include a brief discussion of the extent to which the proposal achieves identified environmental outcomes.

B. The proposal

1. Objectives of the proposal

- The objectives of the proposal should be clearly stated and refer to:
  - the size and type of the operation
  - the anticipated level of performance in meeting required environmental standards and cleaner production principles
  - the staging and timing of the proposal
  - the proposal's relationship to any other industry or facility.

2. Description of the proposal

General

- A description of the proposed development including the rail and conveyor systems and coal loading facilities including detailed site layout and locality maps.
- Details of how the proposed conveyor and loader, which are the subject of this application, will link with the coal stockpile and handling systems that were the subject of a previous consent.
- If the proponent intends to utilise existing infrastructure at any adjoining mine, eg, water management system, the details and formal agreements must be provided.
- As the loading and stockpile facilities are to be established on Crown land adjoining the Bayswater No 2 lease area it will be necessary to clearly delineate the premises, describe the management structure and nominate the accountable party who will be responsible for an environment protection licence
- Outline construction works including:
  - actions to address any existing soil contamination
  - any earthworks or site clearing; re-use and disposal of cleared material (including use of spoil on-site)
  - construction timetable and staging; hours of construction; proposed construction methods
  - environment protection measures, including noise mitigation, dust controls and erosion and sediment control measures.

Air

- Identify all sources of air emissions from the development.
- Provide details of the project that are essential for predicting and assessing impacts on air quality including:
  - the quantity and physico-chemical characteristics of materials to be handled, stored or transported
  - an outline of procedures for coal handling, storage and transport
  - the management of activities and areas with potential for impacts on air quality.

  Note: emissions can be classed as either:
  - *point (eg emissions from stack or vent) or*
  - *fugitive (from wind erosion, leakages or spillages, associated with loading or unloading, conveyors, storage facilities, plant and yard operation, vehicle movements (dust from road, exhausts, loss from load), land clearing and construction works).*

Noise and vibration

- Identify all noise and vibration sources from the development (including both construction and operation phases). Detail all potential noise generating activities and equipment including off-site rail movements and conveyor use.
- Specify the times of operation for the construction and operational phases of the development and for all noise producing activities.
- Provide details of the rail and conveyor corridors and land use (particularly residential) along the proposed routes. Diagrams should be to a scale sufficient to delineate individual residential blocks.
- Specify noise monitoring locations.

Water

- Provide details of the project relevant to any water impacts of the development such as drainage works and associated infrastructure; general earthworks; working capacity of structures; and water resource requirements of the proposal.
- Outline site layout, demonstrating efforts to avoid proximity to water resources (especially for activities with significant potential impacts eg effluent ponds) and showing potential areas of modification of contours, drainage etc.
- Outline how total water cycle considerations are to be addressed showing total water balances for the development (with the objective of minimising demands and impacts on water resources). Include water requirements (quantity, quality and source(s)) and proposed storm and waste water disposal, including type, volumes, proposed treatment and management methods and re-use options.

Waste and chemicals

Provide details of:

- the quantity and type of any liquid waste and non-liquid waste generated at the premises;
- the method for storing and disposing of any wastes or recovered materials at the facility.

ESD

Demonstrate that the planning process and any subsequent development incorporates objectives and mechanisms for complying with ESD principles.

3. Consideration of alternatives and justification for the proposal

- Consider the environmental consequences of adopting alternatives, including alternative:
  - sites and site layouts
  - access modes and routes
  - materials handling and loading processes
  - waste and water management
  - impact mitigation measures, particularly air quality and noise measures
  - energy sources
- Selection of the preferred option should be justified in terms of:
  - ability to satisfy the objectives of the proposal
  - relative environmental and other costs of each alternative
  - acceptability of environmental impacts
  - acceptability of any environmental risks or uncertainties
  - reliability of proposed environmental impact mitigation measures
  - efficient use (including minimising re-use) of land, raw materials, energy and other resources.

C. The location

General

- Provide an overview of the affected environment to place the proposal in its local and regional environmental context including:
  - meteorological data (eg rainfall, temperature and evaporation, wind speed and direction)
  - topography (landform element, slope type, gradient and length)
  - surrounding land uses (potential synergies and conflicts)
  - geomorphology (rates of landform change and current erosion and deposition processes)
  - soil types and properties (including erodibility; engineering and structural properties; dispersibility; permeability; presence of acid sulfate soils and potential acid sulfate soils)
  - ecological information (water system habitat, vegetation, fauna)
  - availability of services and the accessibility of the site.

Air

- Describe the topography and surrounding land uses.
- Provide details of the exact locations of dwellings, schools and hospitals. Where appropriate provide a perspective view of the study area such as the terrain file used in dispersion models.
- Provide and analyse site representative data on the following meteorological parameters:
  - temperature and humidity
  - rainfall and evaporation
  - wind speed and direction.

Noise and vibration

- Identify any noise sensitive locations likely to be affected by activities at the site, such as residential properties, schools, churches, and hospitals.
- Identify the land use zoning of the site and the immediate vicinity and the potentially affected areas.

Water

- Describe the catchment including proximity of the development to any waterways and provide an assessment of their sensitivity/significance from a public health, ecological and/or economic perspective.

Soil Contamination Issues

- Provide details of site history – if earthworks are proposed, this needs to be considered with regard to possible soil contamination
- Identify any stream crossings.

D. Identification and prioritisation of issues (scoping of impact assessment)

- Provide an overview of the methodology used to identify and prioritise issues. The methodology should take into account:
  - relevant NSW government guidelines
  - industry guidelines
  - EISs for similar projects
  - relevant research and reference material
  - relevant preliminary studies or reports for the proposal
  - consultation with stakeholders.

- Provide a summary of the outcomes of the process including:
  - all issues identified including local, regional and global impacts (eg increased/ decreased greenhouse emissions)
  - key issues which will require a full analysis (including comprehensive baseline assessment)
  - issues not needing full analysis though they may be addressed in the mitigation strategy
  - justification for the level of analysis proposed (the capacity of the proposal to give rise to high concentrations of pollution compared with the ambient environment or environmental outcomes is an important factor in setting the level of assessment).

E. The environmental issues

The potential impacts identified in the scoping study need to be assessed to determine their significance, particularly in terms of achieving environmental outcomes, and minimising environmental pollution.

1. Describe baseline conditions

General

Provide a description of existing environmental conditions for any potential impacts.

Air

- Provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring data. This description should include the following parameters:
  - dust deposition
  - total suspended particulates
  - PM_{10} particulate matter

Noise and vibration

- Determine existing background noise levels at noise sensitive locations in the area in accordance with EPA guidelines. (Usually requires continuous monitoring to obtain a minimum of seven (7) days valid data, ie, exclude periods of unfavourable weather conditions (ie: wind speeds >5m/s and rain) or with extraneous noise which affect measured noise levels).

  Note:- *Monitoring to determine the lowest repeatable background noise level should be completed in the absence of the proposed activity (eg where an extension to an existing operation is proposed then monitoring to determine background noise level must be designed to exclude the noise produced by the existing operation).*

  - *All noise descriptors that will be used in the assessment should be monitored. For stationary sources this may include one or more of L_{Amax}, L_{A1}, L_{A10}, L_{Aeq}, L_{A90} while for traffic noise this may include $L_{eq(1hr)}$, $L_{eq(15hr)}$, $L_{eq(9hr)}$ and maximum noise levels depending on the area classification and the types of land use involved.*

Water

- Describe existing surface water quality – an assessment needs to be undertaken for any water resource likely to be affected by the proposal and for all conditions (eg a wet weather sampling program is needed if runoff events may cause impacts).
- Provide historic stream flow data for the catchment where available.
- Provide site drainage details and surface runoff yield.
- Describe the condition of the local catchment eg erosion levels, soils, vegetation cover, etc.
- Outline baseline groundwater information, including, but not restricted to, depth to watertable, flow direction and gradient, groundwater quality, reliance on groundwater by surrounding users and by the environment.

2. Assess environmental impacts

General

- For any potential impacts relevant for the assessment of the proposal provide a detailed analysis of the impacts of the proposal on the environment including the cumulative impact of the proposal on the receiving environment especially where there are sensitive receivers.
- Describe the methodology used and assumptions made in undertaking this analysis (including any modelling or monitoring undertaken) and indicate the level of confidence in the predicted outcomes and the resilience of the environment to cope with the predicted impacts.
- The analysis should also make linkages between different areas of assessment where necessary to enable a full assessment of environmental impacts eg assessment of impacts on air quality will often need to draw on the analysis of traffic, health, social, soil and/or ecological systems impacts; etc.
- The assessment needs to consider impacts during construction and routine activities (including delivery of coal to the facility and outwards rail transport.
- Information provided at a Planning Focus meeting at Warkworth on 14 October 1999 indicated that a number of options were under consideration for delivering coal from participating mines to the loader. The EIS will need to identify and address the impacts involved with the selected option. If no decision has been made by the time the development application is lodged, then the environmental implications of all options under consideration will need to be covered.

Air

- Identify all pollutants of concern and estimate emissions by quantity (and size for particles), source(s) and discharge point(s).
- Estimate the resulting ground level concentrations of all pollutants. Use an appropriate dispersion model to predict ambient TSP and PM_{10} dust concentrations and dust deposition levels.
- Describe the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals.
- Describe the contribution (if any) that the development will make to regional and global pollution, particularly in sensitive locations.

Noise and vibration

- Determine the expected noise levels and noise characteristics (eg: tonality, impulsiveness, vibration, etc) likely to be generated from noise sources during
  - site establishment
  - construction
  - operational phases
  - transport including rail and conveyor noise generated by the proposal
  - other services.
- Determine the appropriate operational noise criteria for the surrounding area using the relevant guideline.
- Determine the noise levels likely to be received at the most sensitive locations under both prevailing and adverse meteorological conditions. (These may also vary during construction and operational phases of the development).

  Note:- *Computer modelling of noise impacts should be undertaken using a recognised computer model.*
  - *Maximum noise levels during night-time period (10pm-7am) should be assessed to analyse possible affects on sleep. This should include the maximum noise levels due to rail traffic, the extent these maximum noise levels exceed ambient noise levels and the number of noise events from rail traffic during the night on an hourly basis for a 'typical' night.*
  - *Noise emission/immision predictions for individual receptors should be provided with one or more of the L_{Amax}, L_{A1}, L_{A10}, L_{Aeq}, L_{A90} descriptors reported for noise from stationary sources. For rail traffic noise, descriptors may include $L_{eq(1hr)}$, $L_{eq(15hr)}$, $L_{eq(9hr)}$ and maximum noise levels depending on the area classification and the types of land use involved.*
  - *For the assessment of existing and future rail noise, details should be included of assumed rail movements by time of day; and details of the calculation process.*
- Noise contours for both daytime (7am-10pm) and night time (10pm-7am) periods should be provided. Contours should include predicted noise levels under prevailing as well as "worst-case" scenarios during adverse meteorological conditions of wind and temperature inversions.
- Consider the influence of existing meteorological conditions such as winds and temperature inversions in the prediction model so as to provide a true representation of actual noise levels.
- Assess the effect of noise mitigation measures incorporated into the predictive modelling.
- Compare the predicted noise levels with the appropriate noise criteria for the phase of development or activity being considered.
- Discuss the findings from the predictive modelling and, where relevant noise criteria have not been met, recommend additional mitigation measures.

- Where relevant noise/vibration criteria cannot be met after application of all feasible and cost effective mitigation measures the residual level of noise impact needs to be quantified by identifying:
  - locations where the noise level exceeds the criteria and extent of exceedence
  - numbers of people (or areas) affected
  - times when criteria will be exceeded;
  - likely impact on activities (speech, sleep, relaxation, listening, etc)
  - change on ambient conditions.

Water

- Determine any changes to hydrology (including drainage patterns, surface runoff yield, flow regimes, wetland hydrologic regimes and groundwater).
- Identify any potential impacts on quality or quantity of groundwater describing their source and significance.
- Identify potential impacts associated with geomorphological activities with potential to increase surface water and sediment runoff or to reduce surface runoff and sediment transport. Also consider possible impacts such as bed lowering, bank lowering, instream siltation, floodplain erosion and floodplain siltation.
- Detail sewage effluent treatment and disposal arrangements. Effluent should be treated and used on the site. On-site effluent disposal should conform to the EPA's draft "*Environmental Guideline for the Utilisation of Treated Effluent by Irrigation*", 1995.
- Identify impacts associated with the disturbance of acid sulfate soils and potential acid sulfate soils.

  Note:- The assessment of water quality impacts needs to be undertaken in a total catchment management context to provide a wide perspective on development impacts, in particular cumulative impacts.

Soil contamination issues

- Identify any likely impacts resulting from the construction or operation of the proposal – this should include the likelihood of:
  - disturbing any existing contaminated soil
  - contamination of soil by operation of the activity
  - soil erosion or instability
  - disturbing acid sulfate or potential acid sulfate soils.

Waste and chemicals

- Identify potential impacts from the handling and storage of any wastes and/or chemicals.

ESD

The basic principles of ESD should be addressed in the EIS.

- **The Precautionary Principle**
  - The proposal should include decision-making processes that are predictable and transparent. This should include;
    * making information available at an early stage so that major issues can emerge and be addressed during the project planning stage;
    * adopting consultative mechanisms between the proponent and the community as a means of minimising disputation at the formal environmental assessment stage;

*   establishing appropriate conflict resolution mechanisms for use during the project approval process.
- Discussion of Best Practice Environmental Management techniques including the potential use of environmental management plans and environmental audits.
- Ensuring that best practice monitoring and enforcement procedures are proposed.
- Identifying the responsibilities of the proponent and government agencies for environmental management and enforcement.

- **Inter and Intra Generational Equity**
    - Overall project management and investment in plant and equipment that minimises pollution and waste and is energy efficient.
    - Ensure rehabilitation of land disturbed during construction.

- **Conservation of Biodiversity and Ecological Integrity**
    - The identification and assessment of all environmental characteristics and habitat values that could be affected by the proposal.
    - The identification and assessment of the likely environmental impacts on these characteristics and values.
    - The implementation of measures designed to minimise likely environmental impacts.
    - Consideration given to adopting a whole of life cycle approach through:
        * use of environmentally benign materials, products and processes. Eg. Fuel-efficient motors, use of recyclable and recycled materials.
        * integrated waste minimisation, reuse and recycling.

- **Valuation and Pricing of Resources**
    - The costs and benefits of all aspects of the proposal should be considered. This should include non-economic environmental resources within a defined area around the subject site using methodologies such as contingency valuation.
    - Consideration could be given to measuring positive environmental initiatives (e.g. energy savings) for possible use as a trade off for other environmental concessions.

Cumulative impacts

- Identify the extent that the receiving environment is already stressed by existing development and background levels of emissions to which this proposal will contribute.
- Assess the impact of the proposal against the long-term air, noise and water quality objectives for the area or region.
- Identify infrastructure requirements flowing from the proposal (eg water and sewerage services, transport infrastructure upgrades).
- Assess likely impacts from such additional infrastructure and measures reasonably available to the proponent to contain such requirements or mitigate their impacts (eg travel demand management strategies).

3. Management and mitigation of environmental impacts

General

- Use environmental impacts as key criteria in selecting between alternative sites, designs and technologies, and to avoid options having the highest environmental impacts.
- Describe any mitigation measures and management options proposed to minimise identified environmental impacts associated with the proposal including an assessment of their effectiveness and reliability and any residual impacts after these measures are implemented.

- Outline any proposed approach (such as an Environmental Management Plan) that will demonstrate how commitments made in the EIS will be implemented. Areas that should be described include:
  - operational procedures to manage environmental impacts
  - monitoring procedures
  - training programs
  - community consultation
  - complaint mechanisms including site contacts
  - strategies to use monitoring information to improve performance
  - strategies to achieve acceptable environmental impacts and to respond in event of exceedences.

Air

- Outline specifications of pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.
- Describe consideration of stockpile alignment and optimum stockpile height to minimise wind erosion.
- Air quality monitoring program.

Noise and vibration

- Determine the most appropriate noise mitigation measures including both noise controls and management of impacts for both construction and operational noise. This will include selecting quiet equipment and construction methods, noise barriers or acoustic screens, location of stockpiles, temporary offices, compounds and vehicle routes, scheduling of activities, etc.
- For rail noise impacts, provide a description of the ameliorative measures considered (if required), reasons for inclusion or exclusion, and procedures for calculation of noise levels including ameliorative measures. Also include, where necessary, a discussion of any potential problems associated with the proposed ameliorative measures, such as overshadowing effects. Appropriate ameliorative measures may include:
  - use of alternative transportation modes and alternative routes
  - control of rail traffic (eg: limiting times of access or speed limitations);
  - use of noise barriers or bunds.
- Noise and vibtation monitoring program.

Water

- Outline stormwater management to control pollutants at the source and contain them within the site. Also describe measures for maintaining and monitoring any stormwater controls.
- Outline erosion and sediment control measures directed at minimising disturbance of land, minimising water flow through the site and filtering, trapping or detaining sediment. Also include measures to maintain and monitor controls.
- Describe waste water treatment measures that are appropriate to the type and volume of waste water and are based on a hierarchy of avoiding generation of waste water; capturing all contaminated water (including stormwater) on the site; reusing/recycling waste water; and treating any unavoidable discharge from the site to meet specified water quality requirements
- Outline pollution control measures relating to storage of materials, possibility of accidental spills (eg preparation of contingency plans), appropriate disposal methods, and generation of leachates.
- Describe hydrological impact mitigation measures including:
  - site selection (avoiding sites prone to flooding and waterlogging, actively eroding or affected by deposition)

- minimising runoff
- minimising reductions or modifications to flow regimes
- avoiding modifications to groundwater
- preventing coal spillage entering waters at stream crossings.

- Describe groundwater impact mitigation measures including:
  - site selection
  - retention of native vegetation and revegetation
  - artificial recharge
  - providing surface storages with impervious linings
  - monitoring program.
- Describe geomorphological impact mitigation measures including:
  - site selection
  - erosion and sediment controls
  - minimising instream works
  - treating existing accelerated erosion and deposition
  - monitoring program.

Waste and chemicals

- Outline measures to avoid the generation of waste and promote the re-use and recycling and reprocessing of any waste.
- Outline measures to support any approved regional or industry waste plans.

Soil issues

- Describe and assess the effectiveness or adequacy of any soil management and mitigation measures during construction and operation of the proposal including:
  - erosion and sediment control measures
  - proposals for the management of any acid sulfate soils .

F. EPA Licensing

- Identify licensing required by the EPA under environment protection legislation including details of all scheduled activities, types of ancillary activities and types of discharges (to air, land, water).

G. Compilation of mitigation measures

- Outline how the proposal and its environmental protection measures would be implemented and managed in an integrated manner so as to demonstrate that the proposal is capable of complying with statutory obligations under an EPA licence (eg outline of an environmental management plan).
- The mitigation strategy should include the environmental management and cleaner production principles which would be followed when planning, designing, establishing and operating the proposal. It should include two sections, one setting out the program for managing the proposal and the other outlining the monitoring program with a feedback loop to the management program.

H. Justification for the Proposal

- Reasons should be included which justify undertaking the proposal in the manner proposed, having regard to the potential environmental impacts.

FAXED 12/9/11/99

NSW NATIONAL PARKS AND WILDLIFE SERVICE

Director
Development and Infrastructure Assessment
Department of Urban Affairs and Planning
GPO Box 3927
SYDNEY NSW 2001

Attention: David Fitzgibbon

Dear Sir

RE: Proposed Designated Integrated Development (IDA) Bayswater Rail Loading Facility –Bayswater Coal Mine, Muswellbrook

Thank you for your letter dated 18 October 1999 in which you consult with the National Parks and Wildlife Service (NPWS) regarding the above proposal.

The NPWS understands that the proposal has been identified as integrated development as defined in the *Environmental Planning and Assessment* (EP&A) *Act 1997.* The NPWS approval role under the IDA process is triggered in this case as the proposed development is likely to impact on known Aboriginal relics, thereby requiring a consent to destroy pursuant to Section 90 of the *National Parks & Wildlife Act 1974.*

The Development Proposal

The NPWS understands that the proposal is for the establishment of a rail loading facility adjacent to the existing Bayswater No2 mine. The proposed rail loading facility will comprise the following:

- 4km rail corridor from the existing Antiene Rail Spur Line off the main northern railway;
- balloon loop located on land between the northern boundary of the existing Bayswater No 2 mine and Thomas Mitchell Drive;
- a train loading bin; and
- conveyor system to transport coal from stockpiles located on the Bayswater No2 mine site.

Sydney Zone
6th Floor
43 Bridge Street
Hurstville NSW
Australia
PO Box 1967
Hurstville 2220
Fax: (02) 9585 6442
Tel: (02) 9585 6678

Integrated Development Assessment-Aboriginal Heritage

For the purposes of the IDA process the NPWS considers that a site may be considered 'known' if:

- It is registered on the NPWS Aboriginal Sites Register; and/or
- It is an Aboriginal site known to the Aboriginal community; and/or
- It is located during surveys or test excavation prior to the lodgement of the DA.

The Department of Urban Affairs & Planning (DUAP) has requested the NPWS' requirements for the preparation of the Environmental Impact Statement for the above development. The DUAP has advised that the NPWS' requirements should focus on the information the NPWS considers necessary to consider the provision of our general terms of approval.

The NPWS information requirements for Aboriginal heritage assessment in the IDA process are clearly set out in the '*NPWS Aboriginal Cultural Heritage and the Integrated Development Assessment Process Information for Applicants*' guidelines. A copy of these guidelines is attached.

The guidelines provide that applicants need to include two principal types of information in their IDA application:

- Aboriginal cultural heritage assessment
- Archaeological assessment

The guidelines provide detailed advice on the NPWS' requirements for each of these types of assessment and this should form the basis for the Aboriginal heritage assessment for the above proposal.

Native Fauna and Flora

The following information is provided as general advice to assist DUAP in assessing the impacts of the proposal in accordance with *EP&A Act 1997* and *Threatened Species Conservation Act 1995* requirements.

The NPWS is pleased to note the level of supporting information that has been provided by the applicant in the Planning Focus document. The inclusion of aerial photos of the subject area and surrounding environs with the location of the proposed rail loop clearly shown, mapping of vegetation distribution and of fauna survey sites assists in identifying the flora and fauna issues raised by the proposal which should be addressed by the EIS.

The NPWS notes that this information indicates that the proposed rail link route passes through two remnants of native vegetation. Results of the preliminary assessment indicate that this vegetation may be regarded as having high to moderate habitat for native fauna and flora. The following threatened fauna species have been recorded within the subject lands:

Squirrel Glider
Yellow-bellied Sheathtail Bat
Large Bent-wing Bat

The significance of remnant native vegetation in this area is increased by the high levels of disturbance and clearing that have occurred within the Hunter Valley and the lack of conservation reserves in areas with similar attributes.

Remnant vegetation in the study area has already been subject to considerable disturbance and fragmentation from previous infrastructure corridors including Thomas Mitchell Drive and the Drayton Rail Loop. It is likely that native fauna (including the population of Squirrel Gliders) is already under stress from habitat fragmentation and would therefore be particularly vulnerable to any further disturbance.

Given this context it is the NPWS preference that:

- alternative routes for the proposed rail link be investigated that utilise existing service corridors and avoid any further disturbance to areas of native vegetation..

Minimising disturbance would also minimise the need for further targeted survey work that may be required to understand how existing populations of threatened fauna are utilising remnant vegetation that is proposed to be disturbed and to address the requirements of the *Threatened Species Conservation Act 1995.*

Where residual impacts on habitat exist after the principles of avoidance and minimisation have been adopted then the NPWS recommends that the assessment should incorporate detailed mitigation measures. Mitigation measures should be based on specific impacts created by the proposal (eg general habitat removal, barrier effects, fragmentation) and may include:

- landscaping and rehabilitation
- site rehabilitation
- compensatory habitat

The NPWS trusts that this information will be of assistance.

Please do not hesitate to contact Jacqualine Breakspear, Environmental Planning Officer on (02) 9585 6675 if you wish to discuss this further.

Yours sincerely

19/11/99.

Lou Ewins
Manager Environmental Planning Unit
Sydney Zone

Muswellbrook Shire Council

ENQUIRIES
PLEASE ASK FOR C. Gidney
DIRECT 02 65493770
OUR REFERENCE 520/00
YOUR REFERENCE

DEVELOPMENT & INFRASTRUCTURE ASSESSMENT
ADMINISTRATION CENTRE MUSWELLBROOK NSW 2333
RECEIVED
1 NOV 1999

9 November, 1999

The Senior Environmental Planning Officer
Development & Infrastructure Assessment
Department of Urban Affairs and Planning
GPO Box 3927
SYDNEY NSW 2001

RECEIVED 12 NOV 1999

Dear Sir,

<u>Proposed Bayswater Rail Loading Facility</u>
<u>Bayswater Coal Mine, Muswellbrook</u>

Thank you for the opportunity for Council to submit comments regarding the Director General's requirements for Environmental Impact Statement preparation for the subject development.

As you are aware, a planning focus meeting was conducted at Bayswater Mine office on Wednesday 3 November, 1999 to consider the proposed development and identify requirements to be addressed in the Environmental Impact Statement for this development.

On behalf of Council I would submit the following matters which should be considered for inclusion in the Environmental Impact Statement for the subject proposal:

1. Assessment of the cumulative impacts of the project with specific emphasis on the existing rail loading facility operated by Drayton Coal. This assessment should have specific reference to neighbouring property owners especially those residing in the Pamger Drive and Balmoral Road areas adjacent to the site.

2. Protection of Ramrod Creek and its tributaries. The proposed location of the rail loading facility is adjacent to the head of the Ramrod Creek and its tributaries. This creek meanders through rural lands and proposed rural residential land adjacent to the township of Muswellbrook. The protection of Ramrod Creek from pre- development operations as well as the ongoing operations of the rail coal handling facility should be addressed. It is understood that Ramrod Creek currently has a high salinity level and collection of existing levels should be undertaken to assess future cumulative impact on this area.

C:\My Documents\ENVIRO\CHRIS\el091199m3.doc

3. Transport including coal movement and road and rail infrastructure.

4. Rehabilitation especially in those areas where sections of native forest have been disturbed to allow access for the rail loop and general rail access. Attention to existing drainage areas and collection dams should also be undertaken.

5. Flora and Fauna, Aboriginal and Heritage Assessment should be addressed particularly in the areas adjacent to Ramrod Creek and its tributaries.

6. Environmental issues in general involving air, noise, water quality and general current issues affecting the local area.

Thank you for the opportunity to comment on this matter.

Yours faithfully

C.A. Gidney
MANAGER, ENVIRONMENTAL SERVICES

(cag:msh)

G. Norman

Roads and Traffic Authority
New South Wales

RTA

www.rta.nsw.gov.au

Hunter Region
59 Darby Street
(Locked Bag 30)
Newcastle NSW 2300
Telephone (02) 4924 0240
DX 7813 Newcastle

David

92/M.4190;1
Greg Gola
Tel: (02) 4924 0332
Fax: (02) 4924 0342
greg_gola@rta.nsw.gov.au

Mr Richard Lloyd
Department of Urban Affairs and Planning
Development & Infrastructure Assessment
GPO Box 3927
SYDNEY NSW 2001

Attention: David Fitzgibbon

PROPOSED BAYSWATER RAIL LOADING FACILITY – BAYSWATER COAL MINE, MUSWELLBROOK

Dear Sir

I refer to your letter dated 19 October 1999 and subsequent planning focus meeting on 3 November 1999 regarding the identification of issues to be addressed in an Environmental Impact Statement (EIS) for the proposed Bayswater coal loading facility at Bayswater Coal Mine.

The RTA raises no issues that need to be directly addressed in the EIS. There is, however, concern regarding the timing of this project in terms of its ability to comply with the proposed date of the cessation of road haulage of coal by Bayswater coal mine currently being considered by your Department.

Should you have any enquiries regarding the above advice, please contact Greg Gola, Land Use Planner on 4924 0332.

Yours faithfully

4/11/99

Colin Nunn
Development Manager
Hunter Client Services

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24/12 '99 09:07 FAX 61 2 93912151 DUAP-ASSESSMENTS

CONTACT: Mr Steven Andrews
PHONE: (02)65719703
FAX:(02)65719706

EnergyAustralia

145 Newcastle Road
Wallsend NSW 2287
Telephone 13 1525
+ 61 2 4951 9555

Address all mail to
PO Box 487
Newcastle NSW
2300 Australia
DX 7853 Newcastle

9 November 1999

DUAP
GPO Box 3927
Sydney NSW 2001

Att Mr David Fitzgibbon

Dear Sir

Proposed Bayswater Rail Loading Facility – Bayswater Coal Mine Muswellbrook

I refer to the planning focus meeting of the 3 November 1999 and the planning focus document regarding the proposed Bayswater Rail Loading Facility that is being considered by your department.

EnergyAustralia has conducted a preliminary investigation of the proposal and the following comments are forwarded for your consideration.

1. Electricity Supply

A facility of this type will cause an increase in the overall electricity demand for the area.

The electricity supply will be via the existing Bayswater No2 / Drayton - 33kV subtransmission feeder that emanates from the Liddell 33kV substation.

From initial planning investigations it is envisaged that no major augmentation of electricity infrastructure owned by EnergyAustralia will be needed for this project.

A full planning study will be undertaken at the detailed design stage of the project and Bayswater Mine should consult EnergyAustralia again at this stage.

2. Assets Affected

The rail route and the alteration of the mine road entrance of Mitchell Line Road will affect EnergyAustralia's assets.

The construction of the rail will require all overhead electricity mains assets to be modified to meet vertical clearances to statuary regulations for any rail crossings. With the proposed alignment the amount of work will be minimal.

The proposed new mine entrance road will require the relocation of a small section of the existing 33kV subtransmission feeder.

The relocation works and the modification of overhead mains on the rail crossings will have negligible cumulative environmental impact on the overall project, but should be specifically mentioned in the EIS.

Please don't hesitate to contact Steven Andrews on (02) 65719703 if further advice is required.

Yours Sincerely

S. Andrews.

Steven Andrews
Hunter Planning

In reply please send to: Singleton

Our reference: 89/05071L RH:AD

Your reference:

Contact: Ray Howison

Mr Richard Lloyd
Department of Urban Affairs & Planning
GPO Box 3927
SYDNEY 2001

4 November 1999

Dear Sir,

PROPOSED BAYSWATER RAIL LOADING FACILITY

Thank you for your invitation to comment in the E.I.S.

The Mine Subsidence Board would only require submission of plans for the proposal and the subsequent approval may have design criteria relative to predicted subsidence parameters.

The applicant should be advised to seek the Board's approval for erection of the improvements at the appropriate time.

Yours faithfully,

Ray Howison
Acting District Supervisor - Singleton

HEAD OFFICE:
PO Box 488G
Newcastle 2300
Telephone: (02) 4926 9995
Facsimile: (02) 4929 1032

NEWCASTLE:
NSW Government Offices
117 Bull Street
Newcastle West 2302
PO Box 488G
Newcastle 2300
Telephone: (02) 4926 9750
Facsimile: (02) 4929 1032
DX 4322 Newcastle West

SPEERS POINT:
143 Main Road
Speers Point 2284
PO Box 9 Boolaroo 2284
Telephone: (02) 4950 8088
Facsimile: (02) 4950 8101
DX 7820 Newcastle

WYONG:
Suite 3 Feldwin Court
30 Hely Street
Wyong 2259
PO Box 157 Wyong 2259
Telephone: (02) 4352 1646
Facsimile: (02) 4352 1757
DX 7317 Wyong

SINGLETON:
Joint Coal Board Building
1 Civic Avenue
Singleton 2330
PO Box 524 Singleton 2330
Telephone: (02) 6572 4344
Facsimile: (02) 6572 4504

PICTON:
100 Argyle Street
Picton 2571
PO Box 40 Picton 2571
Telephone: (02) 4677 1967
Facsimile: (02) 4677 2040

EMAIL:
MINESUB@n130.aone.net.au

WEBSITE:
http://www.minesub.nsw.gov.au

Hunter Rural Lands Protection Board

Reply To: SCONE

SINGLETON
98 John Street
SINGLETON NSW 2330
Telephone:
(02) 6572 2944
Facsimile:
(02) 6572 2533
Email:
hunterrlpb@hunterlink.net.au

SCONE
PO Box 200
196 Kelly Street
SCONE NSW 2337
Telephone:
(02) 6546 1311
Facsimile:
(02) 6545 1644

15 November 1999

David Fitzgibbon
Dept of Urban Affairs and Planning
GPO Box 3927
SYDNEY NSW 2001

Dear Sir,

Further to the attendance of our Board's representatives at the planning focus meeting regarding the proposed rail loading facility which is being planned by Bayswater Coal, please address the following issues of concern which were raised at the Meeting, when preparing the Environmental Impact Statement for the project.

A significant part of the proposal is planned to be constructed on land that is Crown Land which is Gazetted as Travelling Stock Reserve and placed under this Board's control. The Board has obligation to improve and maintain the reserves and to protect them from trespassing. Although some discussion has taken place with regard to relocating those reserves, we have not yet received a written proposal. When this happens the Board may or may not agree with it although it is likely that the agreement will eventually be reached, the fact remains that at this point in time, the Company needs to obtain permission from the Board and the Department of Land and Water Conservation to firstly enter onto the reserves to do whatever is needed and to satisfy the requirements of both parties.

Thank you for the opportunity to comment on the issue.

Yours faithfully,

M. Steepe
Mary Steepe
Administrative Officer

TOTAL P.01

Hunter Rural Lands Protection Board

30 December 1999

Reply To: SCONE

COPY

Mr Mike Heath
Project Manager
Mount Arthur North Project
6 Maitland Street
Muswellbrook NSW 2333

SINGLETON

98 John Street
SINGLETON NSW 2330

Telephone:
(02) 6572 2944

Facsimile:
(02) 6572 2533

Email:
hunterrlpb@hunterlink.net.au

SCONE

PO Box 250
196 Kelly Street
SCONE NSW 2337

Telephone:
(02) 6545 1311

Facsimile:
(02) 6545 1644

Dear Mr Heath,

With reference to your letter dated 15 November 1999, I wish to advise that Senior Ranger Ken Hassett has carried out an inspection of the land sites being offered in exchange for Edinglassie Reserve and I enclose for your information a copy of his inspection reports.

The land exchange was discussed at the Board Meeting on 16 December 1999. It must again be pointed out that before for any land exchange can take effect approval must be obtained from Department of Land and Water Conservation at Maitland, however the Board agrees in principle to the proposed exchange subject to the following condition and requirements.

1. All legal, survey and improvements costs to be carried out at the expense of Coal Operations Australia Limited (COAL).
2. All unsatisfactory fences on the proposed exchange area be replaced with new fencing and gates to a reasonable standard suitable to the Board.
3. The proposed exchange area be sprayed for saffron thistles on an annual basis for three years, being 2000 to 2002. Tree landscaping (planting) and an ongoing weed control program to be implemented on both land sites.
4. Dozer hire be provided for the construction of three additional dams in locations suited to the Board on the proposed exchange areas.
5. A set of stockyards and loading ramp be erected in a suitable situation near the old wool shed.
6. Creek crossings be constructed in each paddock.
7. Fertiliser and seed to be applied the exchanged area as advised by an agronomist.
8. All unnecessary fences and buildings be demolished and buried after consultation with the Board.
9. COAL will make the proposed exchange available for occupation by the Board from a time mutually agreed.
10. The Board will occupy the proposed exchange land and vacate the current TSR land at a time mutually agreed.

Unfortunately Senior Ranger Hassett will be retiring in early January, so if you have any queries or comments regarding this matter please contact the undersigned.

Yours faithfully,

M. Steepe

Mary Steepe
Administrative Officer

Copy: Brett Jenkins - Environmental Manager

WONNARUA TRIBAL COUNCIL INC
PO Box 184
Unit 17 / 174 JOHN st
SINGLETON NSW 2330
Phone 02 6571 4888 Fax 02 6571 4889 Mobile 0408 174946
TRADITIONAL LAND OWNERS

Geoff Noonan
Environmental Assessment Manager
Department of Urban Affairs and Planning
GPO Box 3927
SYDNEY NSW 2001

24th November 1999

RE; PROPOSED BAYSWATER RAIL LOADING FACILITY by BAYSWATER COAL MINE.

Dear Geoff
The wonnarua Tribal Council would like to advise you that this development should be included in the standard consent conditions as agreed to for large coal operation facilities.

The Wonnarua TC would support the project by Coal Operations for the Bayswater Rail loading facility on the following conditions;

1. That this type of development be included in the standard conditions concerning the contribution to the Wonnarua TC Regional Study etc.

2. That an Aboriginal Cultural heritage assessment and management report be done that will help identify the significant Aboriginal Heritage sites within this development for salvage and excavation.

3. Once this report has been completed a salvage of all affected Aboriginal Heritage Sites must be completed to the satisfaction of the Wonnarua TC and the NPWS. This salvage should be completed before the development of this project occurs.

4. That the Wonnarua TC will control and manage the salvage with the assistance of a suitably qualified team of consulting archaeologists employed by the Wonnarua TC to assist in this project.
This is to be negotiated with the developer before the project proceeds.

5. The Wonnarua TC would request that there be no analysis of the Aboriginal Artifacts which is normal procedures once archaeological investigation has ceased in this case the funds usually spent on artifact analysis should be spent on a visual record of the area before development. The Wonnarua TC would suggest a cultural Video filmed by our people.

WONNARUA TRIBAL COUNCIL INC
PO Box 184
Unit 17 / 174 JOHN st
SINGLETON NSW 2330
Phone 02 6571 4888 Fax 02 6571 4889 Mobile 0408 174946
TRADITIONAL LAND OWNERS

6. That the Wonnarua TC be given an opportunity to tender for small works contracts with the rail line and facility works within this development such as tree planting and fencing etc.

Victor Perry
Cultural Heritage Manager
Wonnarua Tribal Council Inc

WONNARUA TRIBAL COUNCIL INC
PO Box 184
Unit 17 / 174 JOHN st
SINGLETON NSW 2330
Phone 02 6571 4888 Mobile 0408 225521
Fax 02 6571 4889 Mobile 0428 174946
TRADITIONAL LAND OWNERS

Mr M J Heath
Project Manager
Coal Australia Operations Ltd
6 Maitland Street
MUSWELLBROOK NSW 2333

30th March 2000

RE; BAYSWATER COAL LOADING FACILITY

Dear Mike
As per our meeting in relation to the above Coal Loading Facility, the local Wonnarua people have decided to give in principal support to the development.

This is based upon the 4 point agreement that has been reached between Coal Australia Ltd and the Wonnarua Tribal Council.

Having stated this, the agreement will only stand as long as both sides keep to their word and work towards the agreement as soon as possible.

Yours Thankfully

Rhoda Perry
Wonnarua Elder
Wonnarua Tribal Council Inc

APPENDIX 1B

Correspondence in relation to Drayton Coal Development Application

Department of
Urban Affairs and Planning

Development and Infrastructure
Assessment
Level 22, 1 Farrer Place
Sydney NSW 2000
GPO Box 3927
Sydney NSW 2001

Facsimile: 02 9391 2151

Ms Barbara Crossley
Director
Umwelt (Australia) Pty Limited
PO Box 838
TORONTO NSW 2283

Dear Ms Crossley,

Proposed Drayton Rail Loop and Antiene Spur Joint User Proposal – Drayton Coal Mine, Muswellbrook
Our reference: S99/01070 Pt 1

For your information, I have attached a copy of the Director-General's requirements for the preparation of an Environmental Impact Statement (EIS) provided to Mr David White of Fitzgerald White Talbot, on behalf of Drayton Coal Pty Limited for the above integrated development project.

If you have any further enquiries please contact David Fitzgibbon on telephone (02) 9391 2344.

Yours sincerely

19/01/2000.

David Fitzgibbon
Environmental Planning Officer
Development and Infrastructure Assessment

Department of
Urban Affairs and Planning

Development and Infrastructure
Assessment
Level 22, 1 Farrer Place
Sydney NSW 2000
GPO Box 3927
Sydney NSW 2001

Telephone: 02 9391 2344
Facsimile: 02 9391 2151
Email:david.fitzgibbon@duap.nsw.gov.au

Mr David White
Partner
Fitzgerald White Talbot
PO Box 266
MUSWELLBROOK NSW 2333

Dear Mr White,

Proposed Drayton Rail Loop and Antiene Spur Joint User Proposal – Drayton Coal Mine, Muswellbrook
Our reference: S99/01070 Pt 1

Thank you for your letter of 20 December 1999 seeking consultation with the Director-General for the preparation of an Environmental Impact Statement (EIS) for the above development.

Under clause 55 of the *Environmental Planning and Assessment Regulation 1994* (the Regulation), the EIS should specifically address the issues outlined below.

Specific Issues

- interrelationship of the proposal with the capacities of the proposed Bayswater Rail Loading Facility, and resultant cumulative impacts;
- ensure as far as possible a co-operative and cumulative assessment of key environmental issues is undertaken with Coal Operations Australia Limited (COAL) in relation to the proposed Bayswater Rail Loading Facility (as outlined in the Project Briefing Paper Antiene Joint User Rail Facility), to enable DUAP to assess each proposal having full regard to potential cumulative impacts. Specific issues to be addressed during this cooperative assessment should include in particular rail movements, noise and air quality;
- the relationship between the proposal and the existing consent and operations at the Drayton Mine;
- details of any track upgrading works that may be required, and associated environmental impacts;
- a description of the pollution control and environmental management measures to be adopted, including monitoring programs to assess the predicted impacts and the ongoing environmental performance of the facility;
- consideration of the objectives and relevant provisions of State Environmental Planning Policies and Regional Environmental Plans;
- consideration of the objectives and relevant provisions of the Upper Hunter Cumulative Impact Strategy and Study, and the Upper Hunter Sub Regional Strategy; and
- a report on threatened species, populations or ecological communities, or their habitats, including the following:
  (a) a description of the study area, including details of the types and condition of the habitat(s) in, and adjacent to, the land to be affected by the proposal;
  (b) a list of those threatened species, populations or ecological communities known to occur in the same or similar habitats in the region; and

(c) an assessment of the likelihood of those species, populations or ecological communities identified in (b) occurring within the study area, given their habitat requirements and the habitats present within the study area.

The EIS should address the detailed requirements of the Environment Protection Authority (EPA) (see attached Environment Protection Authority letter). The EPA requires 3 copies of the EIS when a Development Application is submitted. These documents should be lodged at the EPA's Newcastle Office.

Attachment No. 1 outlines the statutory matters that must be included in any EIS under clauses 54 and 54A of the Regulation.

Attachment No. 2 contains a guide to the issues that may be relevant to the preparation of the EIS for your proposal.

Where certain licences or approvals are required from bodies other than the consent authority for the proposal, the development is "integrated development" under the *Environmental Planning and Assessment Act 1979*. You identified a number of licences or approvals that you may need if you are granted development consent. If further integrated approvals are identified before the Development Application is lodged, you must conduct your own consultation with the relevant agencies to identify their requirements for the EIS.

When lodging your Development Application, you must lodge at least one copy of the Development Application and supporting documentation (including a fee of $250) with <u>each</u> of the agencies from whom you need an integrated approval.

You should consult with Muswellbrook Shire Council and take into account any comments Council may have in the preparation of the EIS. The EIS should also address other issues that emerge from consultations with relevant local, State and Commonwealth government authorities, service providers and community groups, in particular Environment Protection Authority, Freight Corp, Rail Access Corporation, and Department of Mineral Resources.

The Development Application should be lodged with the Department rather than the Council because this proposal is State Significant Development. When submitting your Development Application, please include at least 6 copies of the EIS and any other supporting documentation.

Please contact David Fitzgibbon on (02) 9391 2344 if you require any further information regarding the Director-General's requirements for the EIS or lodgement of the DA.

Yours sincerely

19/1/2000

Derek Mullins
Assistant Director
Development and Infrastructure Assessment
As Delegate for the Director-General

Department of Urban Affairs and Planning

Attachment No. 2

Director General Requirements
Proposal for Use of the Drayton Rail Loop as a Joint User Coal Loading Facility and Increase in Capacity of the Antiene Spur Line
Muswellbrook LGA

The matters listed below should be clearly and succinctly outlined in the text of the EIS where appropriate, and supported by adequate maps, plans, diagrams or other descriptive details to enable all concerned to gain a clear understanding of the full scope of the development and its likely impact on the environment.

Issues outlined below are not necessarily a comprehensive identification of all issues which may arise in respect of this proposal relevant to the preparation and consideration of an EIS. There may be other issues, not included, that are appropriate for consideration in the EIS. It is the applicant's responsibility to identify and address as fully as possible the matters relevant to the specific development proposal in complying with the requirements for EIS preparation.

1. Planning and Environmental Context

i. Planning Information and Permissibility

❒ The following information should be provided:

- zonings, permissibility and any land use constraints;
- compatibility of the proposal with any provisions:
  - in Hunter Regional Environmental Plan 1989
  - in Hunter Regional Environmental Plan 1989 – Heritage
  - in State Environmental Planning Policy No.34 – Major Employment Generating Industrial Development
  - in State Environmental Planning Policy No.33 – Hazardous and Offensive Development
  - in State Environmental Planning Policy No.44 – Koala Habitat Protection
  - in Muswellbrook Local Environmental Plan 1985
  - in any relevant Development Control Plans
  - of the Hunter Valley Railway Programs Task force 1998
- existing land uses; and
- any heritage items or environmental protection areas.

ii. Site description and locality information

❒ The following information should be provided:

- title details, land tenure, lease details;
- site description and maps, plans, aerial photographs clearly identifying the location of the proposal relative to surrounding roads, and other communities, dwellings and residences and any land use likely to be affected by the development, utilities including transmission lines, pipelines, cables or easements, sight lines from dwellings or public spaces such as roads.

iii. Overview of the affected environment

❒ This should provide details of the environment in the vicinity of the development site and also those aspects of the environment likely to be affected by any facet of the proposal. Baseline information should be provided on the following:

- meteorological characteristics which may influence erosion, dust or noise impacts. These may include prevailing wind and intensity, average yearly rainfall, evaporation, seasonal distribution, storm intensity, storm return period (that is average interval between storms of specific magnitude);
- surface contours and general topography. These may include slope gradient, slope length, catchment size, drainage;

- presence and condition of watercourses, flood liability, any water storage or drinking water catchments including groundwater bores within 1 kilometre, watertable and the relationship with the maximum excavation depth;
- existing flora and fauna communities and the presence of any threatened species populations or ecological communities, or their habitats;
- features of heritage, conservation or archaeological value, including potential European heritage items;
- visual amenity;
- suitability of the land for agricultural purposes;
- social and economic aspects of the environment.

2. Description of the proposal

The description of the proposal should provide general background information on:

i. Proposal objectives

❐ Clearly identify objectives and characteristics of the proposal. There should be a clear statement of the proposal having regard to the:

- quantity and types of coal to be loaded and transported;
- details of any track upgrading works that may be required;
- agreement with Coal Operations Australia (COAL) in relation to the joint use of the Antiene Spur;
- potential conflicts with other users of the rail lines involved; and
- interrelationship of the proposal with existing development and existing development consent.

ii. Existing coal loading and transportation

❐ Outline the existing coal loading and transportation methods in the Muswellbrook area, including

- existing coal loading methods;
- existing throughput volumes at the Drayton Rail Loading Facility;
- transportation routes which are used in the transportation of coal;
- existing coal train movements at the Drayton Rail Loading Facility and on the Antiene Spur; and
- requirements in current planning consents regarding coal transportation.

iii. Proposed works

❐ Describe the proposed joint user facility and increase capacity of the Antiene rail spur line in full detail, including:

- details of any track upgrading works that may be required,
- details of the management of the total development proposal;
- staging and construction schedule if track upgrading works are required;
- type of machinery and equipment to be used for track upgrading;
- plans of operation and facilities;
- estimated daily, weekly and annual volumes of material to be transported and loaded, including estimated capacity of the existing coal loading facility;
- employment (during construction and operation);
- hours of operation for construction and operation, including loading, and coal transportation;
- energy requirements;
- quantities and method of storage of any fuels and chemicals on the site;
- sanitary and waste disposal arrangements;

iv. Infrastructure considerations

❐ Nature, extent and proposed location of any additional infrastructure on and off site necessary to meet the projects construction and operational needs.

The following factors should be considered:

- electricity supply; measures to protect or the need to relocate easements, cables, pipelines which may be impacted by the proposal;
- energy conservation measures;
- water requirements, source of water supply, demands on water resources, proposed supply or storage, identify water recycling and reuse options;
- waste disposal requirements, proposed methods and locations for disposal; and
- transport requirements.

v. Alternatives and justification

❒ Consideration of alternatives and justification for the preferred proposal. This should include an assessment of the environmental impacts or consequences of adopting alternatives including:

- coal transportation technology (eg transporting coal by conveyor rather than by the existing coal loading facility);
- coal transport, handling and storage techniques or technology;
- electricity generation technology;
- disposal methods;
- staging of track upgrading works if required

The selection of the preferred options should be justified in terms of:

- type, quality and quantities of coal to be loaded in relation to market demand; and
- environmental factors including the bio-physical, economic and social factors.

1. **Analysis of environmental impacts and mitigating measures**

Environmental impacts usually associated with coal loading and associated rail spur facilities are listed below. The EIS should provide an overview of the methodology used to identify and prioritise issues and provide a summary of the outcomes of the process. The potential impacts of the proposal on the environment should be addressed in the EIS in satisfactory detail and suitability quantified. In addition, the proposed mitigation and management strategies to mitigate the impacts should be identified and take account of the effectiveness of the measures proposed.

i. Existing environmental performance

A review of the environmental performance and identification of critical problems for existing coal transportation in the Muswellbrook area. This should include ways in which the proposal will enable existing problems, if any, to be remedied, including problems with existing road haulage.

ii. Transport and traffic issues

Assessment of transport and traffic issues associated with the proposal during construction (if required) and operation of the development taking into account the current and projected traffic on existing coal transportation routes in the Muswellbrook area, including volumes and vehicle types.

<u>During Construction</u>

- estimated average and maximum hourly, daily and weekly transport movements, including movements on Thomas Mitchell Drive, the Drayton rail loop and the Antiene spur;
- proposed transport routes and possible alternative routes or transport modes;
- adequacy of the local and regional road network to accommodate construction traffic demands (if any);
- cumulative impacts in terms of other current and potential users, in particular Bayswater Mine;
- the need for any associated road upgrades and potential impacts on maintenance programs;
- associated noise, vibration and dust emission impacts on residential and industrial receptors;
- potential impact on the rail maintenance program;
- rail safety issues;
- proposed measures to improve safety; and
- associated management and/or mitigating measures including possible alternative routes.

During Operation

- estimated average maximum hourly, daily and weekly rail movements to and from the Drayton rail loading facility and Antiene spur;
- impacts of locomotive headlights on opposing road traffic and proposed ameliorative measures;
- implications of arrangements for road haulage of coal when emergencies arise.

iii. Air quality

❒ Issues to consider include:

- identification of fixed and mobile sources of air pollution such as mining, processing, handling, storage, loading or transport operations;
- provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring;
- likely impact of the proposal on the local and regional air quality, (this should include baseline data on ambient quality of the air, projected dust emissions and deposition rates and frequency and times of significant emissions);
- cumulative effects on sensitive residential or industrial receptors;
- meteorological conditions under which nearby dwellings and sensitive land are likely to be affected;
- mitigation and management measures to minimise the generation of dust and to ensure compliance with air quality objectives especially in the transportation, handling and storage of coal on-site; and
- dust monitoring programme (deposition and concentration).

iv. Noise and vibration impacts

❒ Issues to consider include:

- existing acoustic environment including a statistical breakdown of the meteorological conditions (predominant wind, temperature, humidity and inversion conditions) and any topographical features which will influence the noise or vibration impacts;
- provide details of the land use zoning of the proposed site and surrounding properties;
- proposed hours of transport and loading;
- noise levels from fixed and mobile noise sources, including rail;
- predictive noise levels at potentially affected dwellings, industrial receptors and any other noise sensitive locations likely to be affected by the proposal;
- cumulative effects on sensitive residential and industrial receptors, both in the vicinity of the Drayton Rail Loop and the Antiene Spur;
- mitigation and management measures to control the generation of noise to ensure compliance with relevant noise standards including details of noise control measures;
- proposed monitoring program;
- see attached EPA letter for methodology details.

v. Water quality and drainage

❒ Issues to consider include:

- description of potential sources of water pollution;
- condition of waterbodies or environmentally sensitive areas which could be impacted by:
  - demand on water resources, particularly flow levels and water quality;
  - any change in the surface or groundwater hydrology as a result of the proposal; and/or
  - any change in the water quality as a result of any activity on the site;
- drainage and sediment management system;
- water balance;
- potential impacts on groundwater;
- any effects on the local or regional watertable and implications for other users;
- details of control measures to be implemented to prevent adverse impacts by waste water, leachate and contaminated stormwater on the water quality of local streams and groundwater;
- adequacy of measures to ensure no contamination of the groundwater;

- plan for ongoing maintenance and monitoring of water quality controls to ensure their correct installation, operation and effectiveness; and
- a water management plan and site water balance shall be prepared for the construction and operational phases of the development proposal. The following principles shall be incorporated into the water management plan:
  - maximum on-site reuse of waste water, i.e. dust suppression water;
  - minimisation of wet whether overflows of contaminated stormwater;
  - segregation of contaminated water from non-contaminated water to minimise the volume of polluted water to be dealt with;
  - examination of options to reuse wastewater from washdown and dust control measures;
  - details of stormwater diversion works particularly in regard to their capacity and stabilisation;
  - sewage effluent treatment requirements are outlined in the EPA letter attached.

vi. Flood liability

❒ The following issues should be included:

- determine the potential impact of floods on the proposal (especially rail access); and
- any likely effects of the operation on flood liability of surrounding lands.

vii. Infrastructure constraints

Identify any constraints presented by demand for utility services and other infrastructure and assess the implications on the proposal's construction and operational needs should augmentation not occur at the required time.

viii. Cumulative impact

❒ Identify any key cumulative impacts:

- on the surrounding area having regard to dust, noise, vibration, visual impacts, water quality issues, traffic impacts, and any loss of heritage items, vegetation or fauna habitat;
- associated with coal transportation by rail in terms of size and frequency of trains using the rail network compared with the existing situation; and
- address cumulative impacts with the existing operations at the Drayton Mine, Bayswater Mine, rail movements on the Antiene spur, the proposed Bayswater Rail Loop, and any other mining operations proposed, approved or in operation in the Muswellbrook area.

ix. Visual impact

❒ Issues to consider include:

- consideration of the site in relation to any landscapes of local or regional significance as considered from the fore, middle and background;
- visibility from nearby properties, and general surrounds;
- lighting impacts from lights for security and night time operations including lighting impacts from train operations;
- impacts of increased rail movements on the visual environment; and
- proposed landscaping to reduce visual impacts, and location, layout and species composition of intended screening.

x. Spontaneous combustion

Consider the likelihood of spontaneous combustion of coal to be stockpiled or stored. Provide details of proposed management practices.

xi. Risk and Hazard Analysis

A risk analysis should be prepared taking into consideration the provisions of State Environmental Planning Policy No.33 – Hazardous and Offensive Development, referring to DUAPs Guideline "Applying SEPP33".

xii. Flora and Fauna impacts

❒ Issues to consider include:

- plant species and communities within the proposal site area and its habitat significance;
- extent of disturbance of flora;
- details of proposed mitigation methods to protect indigenous plant species;
- fauna known likely to occur within the proposal area and note occurrence of any endangered fauna;
- assessment of the effects on fauna and its habitat;
- measures to ameliorate impact and to prevent weed invasion, vermin or feral animal problems;
- the 8 part test contained in Section 5A of the Environmental Planning and Assessment Act 1979 and the need to prepare a Species Impact Statement to be prepared in accordance with the Threatened Species Conservation Act, 1995.

xiii. Heritage **aspects**

❐ Issues to consider include:

- any likely affectation of sites of Aboriginal, archaeological or European heritage value (including industrial heritage) if located in the vicinity of operations;
- assessment of significance of any items affected;
- proposed measures to mitigate impacts or conserve the heritage significance of the sites or items.

xiv. Social environment

❐ Issues should include:

- affect on population growth (urban and rural areas) and changes to population location;
- the consequent housing and social service needs and measures to monitor and, if necessary, satisfy demand;
- changes in the amenity of the area; and
- impacts on the health of the community from any potential changes in air quality, water quality, noise and vibration and rail safety.

xv. Economic environment

❐ Issues should include:

- changes to local employment patterns;
- cost of living for employees and non-employees;
- community growth and commercial development;
- the agricultural viability and the severance of land holdings; and
- impact on property values; and
- affect on municipal finances.

xvi. Erosion and soil stability issues

❐ Issues to consider include:

- meteorological data, soil properties and characteristics and attributes of soil units;
- landform characteristics which influence the erosion hazard, ratio of the rate of runoff to rate of rainfall, site history in regard to possible soil contamination issues (see attached EPA letter for specific soil contamination requirements), any stream crossings;
- integrated erosion and sediment control measures;
- maintenance program of all erosion control works;
- brief description of the geology of the area to be traversed by the proposed development; and
- provision of a detailed sediment erosion control plan.

xvii. Agricultural viability

❐ Issues to consider include:

- sensitive agricultural uses in the vicinity of the facility; and
- any effects on the agricultural viability of the adjoining land holdings; particularly in relation to dust and water.

xviii. Ecologically Sustainable Development Principles

- ☐ Basic concepts of ESD are to be applied to the development as a whole and should be addressed in the EIS, including:
  - ***the precautionary principle:*** Show that decisions made for the proposal are predictable and transparent. Including:
    - making information available at an early stage and establishing appropriate conflict resolution mechanisms from project planning stage, assessment and determination process;
    - discussion of Best Practice Environmental Management techniques including the potential use of environmental management plans and environmental audits;
    - ensuring that best practice monitoring and enforcement procedure are proposed; and
    - identifying the responsibilities of the proponent and government agencies for environmental management and enforcement.
  - ***inter- and intra-generational equity:*** Overall project management and investment in plant and equipment that minimises pollution and waste and is energy efficient.
  - ***conservation of biodiversity and ecological integrity:*** Including:
    - identification and assessment of all environmental characteristics and habitat values that could be affected by the proposal;
    - likely environmental impacts on these characteristics and values;
    - implementation of measures designed to minimise likely environmental impacts; and
    - consideration given to adopting a whole-of-life cycle through use of environmentally benign materials, products and processes (e.g. fuel efficient motors, use of recyclable and recycled materials) and integrated waste minimisation, reuse and recycling.
  - ***valuation and pricing of resources:*** The costs and benefits of all aspects of the proposal should be considered. This should include non-economic environmental resources within a defined area around the subject site using methodologies such as contingency valuation.

    Consideration could be given to measuring positive environmental initiatives (e.g. energy savings) for possible use as a trade off for other environmental concessions.

xix. Rehabilitation

- ☐ The EIS should address the progressive rehabilitation of the site.

xx. On-going environmental management

- ☐ Outline proposed on-going management for the proposal. This should provide a comprehensive framework for managing or mitigating environmental impacts for the life of the operation. The plan should:
  - demonstrate strategies for sound environmental practice during construction, and operation;
  - identify all government licensing and approval requirements and demonstrate how the plan will facilitate compliance with these requirements; and
  - set out the framework of a monitoring program of all key impacts on the environment (this framework should indicate what specific information will be monitored, the monitoring intervals, procedures to be undertaken should the monitoring indicate an environmental problem, and the reporting procedures).

Your Reference : S99/01070 Pt1
Our Reference : 270038A
Contact : Colin Charters, (02) 49269701

NSW **EPA**

Northern Regions

The Director
Development and Infrastructure Assessment
Department of Urban Affairs and Planning
GPO Box 3927
SYDNEY NSW 2001

10 JAN 2000

Attention: Mr D Fitzgibbon

Dear Sir

PROPOSED DEVELOPMENT – USE OF THE DRAYTON RAIL LOOP AS A JOINT USER COAL LOADING FACILITY AND INCREASE IN CAPACITY OF ANTIENE RAIL SPUR LINE

I refer to your request for the Environment Protection Authority's (EPA) requirements for the preparation of an Environmental Impact Statement (EIS) relating to the proposed use of the Drayton rail loop as a joint rail loading facility and an increase in the capacity of the Antiene rail spur line. The EPA received your request by email on 24 December 1999.

The information specified in the Attachment must be provided in any Environmental Impact Statement (EIS) submitted in support of the development proposal to enable the EPA to adequately assess those impacts of the development on the environment that relate to the EPA's statutory responsibilities. In summary, the EPA requires the following information:

i) details of existing ambient air, noise, water conditions at the site and at locations likely to be impacted by the proposal;
ii) detailed assessment of the potential impacts on air, noise and water quality and of waste management issues during any construction work and the operational phases of the proposed facility; and
iii) a description of the pollution control and environmental management measures to be adopted, including monitoring programs to assess the predicted impacts and the ongoing environmental performance of the facility and spur line.

Coal works, that include loading operations, are classified as 'Scheduled premises' as defined by the Protection of the Environment Operations Act 1997. Consequently, if development consent is granted the activity will require an environment protection licence from the EPA for (a) any scheduled development work and (b) to operate a premises-based scheduled activity. Environment protection licences are subject to conditions covering environmental objectives as well as a variety of operational, monitoring and reporting requirements which can be amended as necessary to cater for changing circumstances.

The EPA will require 3 copies of the EIS when the application is submitted. These documents should be lodged at the EPA's Newcastle office located in the Government Office Building at 117 Bull Street Newcastle and marked to the attention of the Regional Manager, Hunter.

If you have any inquiries regarding this matter, please contact Mr Colin Charters on (02) 49269701.

Yours sincerely

MITCHELL BENNETT
A/Head, Regional Operations Unit, Hunter
for **Director General**

Encl: Attachment

ATTACHMENT

ENVIRONMENT PROTECTION AUTHORITY REQUIREMENTS FOR ENVIRONMENTAL IMPACT STATEMENT – PROPOSED DEVELOPMENT– USE OF THE DRAYTON RAIL LOOP AS A JOINT USER COAL LOADING FACILITY AND INCREASE IN CAPACITY OF ANTIENE RAIL SPUR LINE

A. Executive summary

- The executive summary should include a brief discussion of the extent to which the proposal achieves identified environmental outcomes.

B. The proposal

1. Objectives of the proposal

- The objectives of the proposal should be clearly stated and refer to:
  - the size and type of the activities
  - the anticipated level of performance in meeting required environmental standards and cleaner production principles
  - the staging and timing of the proposal
  - the proposal's relationship to any other industry or facility.

2. Description of the proposal

General

- A description of the proposed development including the coal loading facilities and the Antiene rail spur line with detailed site layout and locality maps.
- Details of how the proposed loading facility and use of the rail spur line which are the subject of this application, will link with other coal mining and handling operations.
- If the proponent intends to utilise existing infrastructure at any adjoining mine, eg, water management system, the details and formal agreements must be provided.
- Clear delineation of the ownership, management structure and accountable parties for the joint loading facility and the rail spur line.
- Outline any construction works including:
  - actions to address any existing soil contamination
  - any earthworks or site clearing; re-use and disposal of cleared material (including use of spoil on-site)
  - construction timetable and staging; hours of construction; proposed construction methods
  - environment protection measures, including noise mitigation, dust controls and erosion and sediment control measures.

Air

- Identify all sources of air emissions from the activities to be carried out.
- Provide details of the project that are essential for predicting and assessing impacts on air quality including:
  - the quantity and physico-chemical characteristics of materials to be handled, stored or transported
  - an outline of procedures for coal handling, storage and transport
  - the management of activities and areas with potential for impacts on air quality.

Note: emissions can be classed as either:
- point (eg emissions from stack or vent) or
- fugitive (from wind erosion, leakages or spillages, associated with loading or unloading, conveyors, storage facilities, plant and yard operation, vehicle and rail movements (dust from road, exhausts, loss from load), land clearing and construction works).

Noise and vibration
- Identify all noise and vibration sources from the activities to be carried out (including both construction (if any) and operation phases). Detail all potential noise generating activities and equipment particularly rail movements and coal handling.
- Specify the times of operation for the construction (if any) and operational phases of the development and for all noise producing activities.
- Provide details of the rail corridor(s) and land use (particularly residential) along the proposed route(s). Diagrams should be to a scale sufficient to delineate individual residential blocks.
- Specify noise monitoring locations.

Water
- Provide details of the project relevant to any water impacts of the development such as drainage works and associated infrastructure; general earthworks; working capacity of structures; and water resource requirements of the proposal.
- Outline site layout, demonstrating efforts to avoid proximity to water resources (especially for activities with significant potential impacts, eg effluent ponds) and showing potential areas of modification of contours, drainage etc.
- Outline how total water cycle considerations are to be addressed showing total water balances for the development (with the objective of minimising demands and impacts on water resources). Include water requirements (quantity, quality and source(s)) and proposed storm and waste water disposal, including type, volumes, proposed treatment and management methods and re-use options.

Waste and chemicals
Provide details of:
- the quantity and type of any liquid waste and non-liquid waste generated at the joint user rail loading facility and on the spur line corridor;
- the method for storing and disposing of any wastes or recovered materials.

ESD
Demonstrate that the planning process and any subsequent development incorporates objectives and mechanisms for complying with ESD principles.

3. Consideration of alternatives and justification for the proposal

- Consider the environmental consequences of adopting alternatives, including alternative:
  - sites and site layouts
  - access modes and routes
  - materials handling and loading processes
  - waste and water management
  - impact mitigation measures, particularly air quality and noise measures
  - energy sources
- Selection of the preferred option should be justified in terms of:
  - ability to satisfy the objectives of the proposal

- relative environmental and other costs of each alternative
- acceptability of environmental impacts
- acceptability of any environmental risks or uncertainties
- reliability of proposed environmental impact mitigation measures
- efficient use (including minimising re-use) of land, raw materials, energy and other resources.

C. The location

General

- Provide an overview of the affected environment to place the proposal in its local and regional environmental context including:
  - meteorological data (eg rainfall, temperature and evaporation, wind speed and direction)
  - topography (landform element, slope type, gradient and length)
  - surrounding land uses (potential synergies and conflicts)
  - geomorphology (rates of landform change and current erosion and deposition processes)
  - soil types and properties (including erodibility; engineering and structural properties; dispersibility; permeability; presence of acid sulfate soils and potential acid sulfate soils)
  - ecological information (water system habitat, vegetation, fauna)
  - availability of services and the accessibility of the site.

Air

- Describe the topography and surrounding land uses.
- Provide details of the exact locations of dwellings, schools and hospitals. Where appropriate provide a perspective view of the study area such as the terrain file used in dispersion models.
- Provide and analyse site representative data on the following meteorological parameters:
  - temperature and humidity
  - rainfall and evaporation
  - wind speed and direction.

Noise and vibration

- Identify any noise sensitive locations likely to be affected by activities at the various sites, such as residential properties, schools, churches, and hospitals.
- Identify the land use zoning of the various sites and the immediate vicinity and the potentially affected areas.

Water

- Describe the catchment(s) including proximity of the development works to any waterways and provide an assessment of their sensitivity/significance from a public health, ecological and/or economic perspective.

Soil Contamination Issues

- Provide details of site history – if earthworks are proposed, this needs to be considered with regard to possible soil contamination
- Identify any stream crossings.

D. Identification and prioritisation of issues (scoping of impact assessment)

- Provide an overview of the methodology used to identify and prioritise issues. The methodology should take into account:
  - relevant NSW government guidelines
  - industry guidelines
  - EISs for similar projects
  - relevant research and reference material
  - relevant preliminary studies or reports for the proposal
  - consultation with stakeholders.

- Provide a summary of the outcomes of the process including:
  - all issues identified including local, regional and global impacts (eg increased/ decreased greenhouse emissions)
  - key issues which will require a full analysis (including comprehensive baseline assessment)
  - issues not needing full analysis though they may be addressed in the mitigation strategy
  - justification for the level of analysis proposed (the capacity of the proposal to give rise to high concentrations of pollution compared with the ambient environment or environmental outcomes is an important factor in setting the level of assessment).

E. The environmental issues

The key environmental issues identified in the project briefing paper need to be assessed to determine their significance, particularly in terms of achieving environmental outcomes, and minimising environmental pollution.

1. Describe baseline conditions

General
Provide a description of existing environmental conditions for any potential impacts.

Air

- Provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring data. This description should include the following parameters:
  - dust deposition
  - total suspended particulates
  - PM_{10} particulate matter

Noise and vibration

- Determine existing background noise levels at noise sensitive locations in the area in accordance with EPA guidelines. (Usually requires continuous monitoring to obtain a minimum of seven (7) days valid data, ie, exclude periods of unfavourable weather conditions (ie: wind speeds >5m/s and rain) or with extraneous noise which affect measured noise levels).

  Note:- *Monitoring to determine the lowest repeatable background noise level should be completed in the absence of the proposed activity (eg where an extension to an existing operation is proposed then monitoring to determine background noise level must be designed to exclude the noise produced by the existing operation).*

- *All noise descriptors that will be used in the assessment should be monitored. For stationary sources this may include one or more of L_{Amax}, L_{A1}, L_{A10}, L_{Aeq}, L_{A90} while for traffic noise this may include $L_{eq(1hr)}$, $L_{eq(15hr)}$, $L_{eq(9hr)}$ and maximum noise levels depending on the area classification and the types of land use involved.*

Water

- Describe existing surface water quality – an assessment needs to be undertaken for any water resource likely to be affected by the proposal and for all conditions (eg a wet weather sampling program is needed if runoff events may cause impacts).
- Provide historic stream flow data for the catchment(s) where available.
- Provide site drainage details and surface runoff yield.
- Describe the condition of the local catchment(s), eg erosion levels, soils, vegetation cover, etc.
- Outline baseline groundwater information, including, but not restricted to, depth to watertable, flow direction and gradient, groundwater quality, reliance on groundwater by surrounding users and by the environment.

2. Assess environmental impacts

General

- For any potential impacts relevant for the assessment of the proposal provide a detailed analysis of the impacts of the proposal on the environment including the cumulative impact of the proposal on the receiving environment especially where there are sensitive receivers.
- Describe the methodology used and assumptions made in undertaking this analysis (including any modelling or monitoring undertaken) and indicate the level of confidence in the predicted outcomes and the resilience of the environment to cope with the predicted impacts.
- The analysis should also make linkages between different areas of assessment where necessary to enable a full assessment of environmental impacts eg assessment of impacts on air quality will often need to draw on the analysis of traffic, health, social, soil and/or ecological systems impacts; etc.
- The assessment needs to consider impacts during construction (if any) and routine activities (including coal handling at the facility and outwards rail transport.

Air

- Identify all pollutants of concern and estimate emissions by quantity (and size for particles), source(s) and discharge point(s).
- Estimate the resulting ground level concentrations of all pollutants. Use an appropriate dispersion model to predict ambient TSP and PM_{10} dust concentrations and dust deposition levels.
- Describe the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals.
- Describe the contribution (if any) that the development will make to regional and global pollution, particularly in sensitive locations.

Noise and vibration

- Determine the expected noise levels and noise characteristics (eg: tonality, impulsiveness, vibration, etc) likely to be generated from noise sources during
  - site establishment (if any)
  - construction (if any)
  - operation of the joint rail coal loading facility
  - rail transport
  - other services.

- Determine the appropriate operational noise criteria for the areas surrounding the joint rail coal loading facility and adjoining the Antiene rail spur line using the relevant guideline.
- Determine the noise levels likely to be received at potentially affected receivers under both prevailing and adverse meteorological conditions. (These may also vary during construction and operational phases of the development).

  Note:- *Computer modelling of noise impacts should be undertaken using a recognised computer model.*
  - *Maximum noise levels during night-time period (10pm-7am) should be assessed to analyse possible affects on sleep. This should include the maximum noise levels due to rail traffic, the extent these maximum noise levels exceed ambient noise levels and the number of noise events from rail traffic during the night on an hourly basis for a 'typical' night.*
  - *Noise emission/immision predictions for individual receptors should be provided with one or more of the L_{Amax}, L_{A1}, L_{A10}, L_{Aeq}, L_{A90} descriptors reported for noise from stationary sources. For rail traffic noise, descriptors may include $L_{eq(1hr)}$, $L_{eq(15hr)}$, $L_{eq(9hr)}$ and maximum noise levels depending on the area classification and the types of land use involved.*
  - *For the assessment of existing and future rail noise, details should be included of assumed rail movements by time of day; and details of the calculation process.*
- Noise contours for both daytime (7am-10pm) and night time (10pm-7am) periods should be provided. Contours should include predicted noise levels under prevailing as well as "worst-case" scenarios during adverse meteorological conditions of wind and temperature inversions.
- Consider the influence of existing meteorological conditions such as winds and temperature inversions in the prediction model so as to provide a true representation of actual noise levels.
- Assess the effect of noise mitigation measures incorporated into the predictive modelling.
- Compare the predicted noise levels with the appropriate noise criteria for the phase of development or activity being considered.
- Discuss the findings from the predictive modelling and, where relevant noise criteria have not been met, recommend additional mitigation measures.
- Where relevant noise/vibration criteria cannot be met after application of all feasible and cost effective mitigation measures the residual level of noise impact needs to be quantified by identifying:
  - locations where the noise level exceeds the criteria and extent of exceedence
  - numbers of people (or areas) affected
  - times when criteria will be exceeded;
  - likely impact on activities (speech, sleep, relaxation, listening, etc)
  - change on ambient conditions.

Water

- Determine any changes to hydrology (including drainage patterns, surface runoff yield, flow regimes, wetland hydrologic regimes and groundwater).
- Identify any potential impacts on quality or quantity of groundwater describing their source and significance.
- Identify potential impacts associated with geomorphological activities with potential to increase surface water and sediment runoff or to reduce surface runoff and sediment transport. Also consider possible impacts such as bed lowering, bank lowering, instream siltation, floodplain erosion and floodplain siltation.
- Detail any new sewage effluent treatment and disposal arrangements. Effluent should be treated and used on the site. On-site effluent disposal should conform to the EPA's draft "*Environmental Guideline for the Utilisation of Treated Effluent by Irrigation*", 1995.
- Identify impacts associated with the disturbance of acid sulfate soils and potential acid sulfate soils.

Note:- *The assessment of water quality impacts needs to be undertaken in a total catchment management context to provide a wide perspective on development impacts, in particular cumulative impacts.*

Soil contamination issues

- Identify any likely impacts resulting from the construction or operation of the proposal – this should include the likelihood of:
  - disturbing any existing contaminated soil
  - contamination of soil by operation of the activity
  - soil erosion or instability
  - disturbing acid sulfate or potential acid sulfate soils.

Waste and chemicals

- Identify potential impacts from the handling and storage of any wastes and/or chemicals.

ESD

The basic principles of ESD should be addressed in the EIS.

- **The Precautionary Principle**
  - The proposal should include decision-making processes that are predictable and transparent. This should include;
    * making information available at an early stage so that major issues can emerge and be addressed during the project planning stage;
    * adopting consultative mechanisms between the proponent and the community as a means of minimising disputation at the formal environmental assessment stage;
    * establishing appropriate conflict resolution mechanisms for use during the project approval process.
  - Discussion of Best Practice Environmental Management techniques including the potential use of environmental management plans and environmental audits.
  - Ensuring that best practice monitoring and enforcement procedures are proposed.
  - Identifying the responsibilities of the proponent and government agencies for environmental management and enforcement.

- **Inter and Intra Generational Equity**
  - Overall project management and investment in plant and equipment that minimises pollution and waste and is energy efficient.
  - Ensure rehabilitation of land disturbed during construction or upgrading works.

- **Conservation of Biodiversity and Ecological Integrity**
  - The identification and assessment of all environmental characteristics and habitat values that could be affected by the proposal.
  - The identification and assessment of the likely environmental impacts on these characteristics and values.
  - The implementation of measures designed to minimise likely environmental impacts.
  - Consideration given to adopting a whole of life cycle approach through:
    - use of environmentally benign materials, products and processes. Eg. Fuel-efficient motors, use of recyclable and recycled materials.
    - integrated waste minimisation, reuse and recycling.

- **Valuation and Pricing of Resources**
  - The costs and benefits of all aspects of the proposal should be considered. This should include non-economic environmental resources within a defined area around the subject site using methodologies such as contingency valuation.
  - Consideration could be given to measuring positive environmental initiatives (e.g. energy savings) for possible use as a trade off for other environmental concessions.

Cumulative impacts

- Identify the extent that the receiving environment is already stressed by existing development and background levels of emissions to which this proposal will contribute.
- Assess the impact of the proposal against the long-term air, noise and water quality objectives for the area or region.
- Identify infrastructure requirements flowing from the proposal (eg water and sewerage services, transport infrastructure upgrades).
- Assess likely impacts from such additional infrastructure and measures reasonably available to the proponent to contain such requirements or mitigate their impacts (eg travel demand management strategies).

3. Management and mitigation of environmental impacts

General

- Use environmental impacts as key criteria in selecting between alternative sites, designs and technologies, and to avoid options having the highest environmental impacts.
- Describe any mitigation measures and management options proposed to minimise identified environmental impacts associated with the proposal including an assessment of their effectiveness and reliability and any residual impacts after these measures are implemented.
- Outline any proposed approach (such as an Environmental Management Plan) that will demonstrate how commitments made in the EIS will be implemented. Areas that should be described include:
  - operational procedures to manage environmental impacts
  - monitoring procedures
  - training programs
  - community consultation
  - complaint mechanisms including site contacts
  - strategies to use monitoring information to improve performance
  - strategies to achieve acceptable environmental impacts and to respond in event of exceedences.

Air

- Outline specifications of pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.
- Describe measures to be implemented or equipment installed to minimise the generation or emission of air pollutants.
- Air quality monitoring program.

Noise and vibration

- Determine the most appropriate noise mitigation measures including both noise controls and management of impacts for both construction (if any) and operational noise. This will include selecting quiet equipment and construction methods, noise barriers or acoustic screens, location of stockpiles, temporary offices, compounds and vehicle routes, scheduling of activities, etc.

- For rail noise impacts, provide a description of the ameliorative measures considered (if required), reasons for inclusion or exclusion, and procedures for calculation of noise levels including ameliorative measures. Also include, where necessary, a discussion of any potential problems associated with the proposed ameliorative measures, such as overshadowing effects. Appropriate ameliorative measures may include:
  - use of alternative transportation modes and alternative routes
  - control of rail traffic (eg: limiting times of access or speed limitations);
  - use of noise barriers or bunds.
- Noise and vibration monitoring program.

Water

- Outline stormwater management to control pollutants at the source and contain them within the site. Also describe measures for maintaining and monitoring any stormwater controls.
- Outline erosion and sediment control measures directed at minimising disturbance of land, minimising water flow through the site and filtering, trapping or detaining sediment. Also include measures to maintain and monitor controls.
- Describe waste water treatment measures that are appropriate to the type and volume of waste water and are based on a hierarchy of avoiding generation of waste water; capturing all contaminated water (including stormwater) on the site; reusing/recycling waste water; and treating any unavoidable discharge from the site to meet specified water quality requirements
- Outline pollution control measures relating to storage of materials, possibility of accidental spills (eg preparation of contingency plans), appropriate disposal methods, and generation of leachates.
- Describe hydrological impact mitigation measures including:
  - site selection (avoiding sites prone to flooding and waterlogging, actively eroding or affected by deposition)
  - minimising runoff
  - minimising reductions or modifications to flow regimes
  - avoiding modifications to groundwater
  - preventing coal spillage entering waters at stream crossings.
- Describe groundwater impact mitigation measures including:
  - site selection
  - retention of native vegetation and revegetation
  - artificial recharge
  - providing surface storages with impervious linings
  - monitoring program.
- Describe geomorphological impact mitigation measures including:
  - site selection
  - erosion and sediment controls
  - minimising instream works
  - treating existing accelerated erosion and deposition
  - monitoring program.

Waste and chemicals

- Outline measures to avoid the generation of waste and promote the re-use and recycling and reprocessing of any waste.
- Outline measures to support any approved regional or industry waste plans.

Soil issues

- Describe and assess the effectiveness or adequacy of any soil management and mitigation measures during construction and operation of the proposal including:
  - erosion and sediment control measures
  - proposals for the management of any acid sulfate soils .

F. EPA Licensing

- Identify licensing required by the EPA under environment protection legislation including details of all scheduled activities, types of ancillary activities and types of discharges (to air, land, water).

G. Compilation of mitigation measures

- Outline how the proposal and its environmental protection measures would be implemented and managed in an integrated manner so as to demonstrate that the proposal is capable of complying with statutory obligations under an EPA licence (eg outline of an environmental management plan).
- The mitigation strategy should include the environmental management and cleaner production principles which would be followed when planning, designing, establishing and operating the proposal. It should include two sections, one setting out the program for managing the proposal and the other outlining the monitoring program with a feedback loop to the management program.

H. Justification for the Proposal

- Reasons should be included which justify undertaking the proposal in the manner proposed, having regard to the potential environmental impacts.

APPENDIX 2

Form 2 and Project Team

Form 2

Submission of
environmental impact statement (EIS)
prepared under the Environmental Planning and Assessment Act 1979
Section 78A (8)

EIS prepared by

Name:	**Barbara Crossley**
Qualifications:	**B. Nat. Res. (Hons)**
Address:	Umwelt (Australia) Pty Limited PO Box 838 Toronto 2283

in respect of

development application

Applicant Name	Coal Operations Australia Limited
Applicant Address	Mount Arthur North Project Office 6 Maitland Street MUSWELLBROOK 2333
Land to be developed: lot no, DP/MPS, vol/fol etc	Refer to attached Schedule 1
Proposed Development	Construction and operation of a rail loading facility.

or

☐ map(s) attached.

environmental impact statement

☑ an environmental impact statement (EIS) is attached

certificate

I certify that I have prepared the contents of this Statement and to the best of my knowledge

- it is in accordance with clauses 54A and 55 of the *Environmental Planning and Assessment Regulation 1994*, and
- it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.

Signature:	B Crossley
Name:	Barbara Crossley
Date:	31 March 2000

Form 2

Submission of environmental impact statement (EIS)
prepared under the Environmental Planning and Assessment Act 1979
Section 78A (8)

EIS prepared by	
Name:	**Barbara Crossley**
Qualifications:	**B. Nat. Res. (Hons)**
Address:	Umwelt (Australia) Pty Limited PO Box 838 Toronto 2283
in respect of	
development application	
Applicant Name	Drayton Coal Pty Ltd
Applicant Address	PMB 9 MUSWELLBROOK 2333
Land to be developed: lot no, DP/MPS, vol/fol etc	Refer to attached Schedule 1
Proposed Development	Increase the tonnage of coal transported via the existing Drayton Rail Loop and use of the Antiene Rail Spur up to a limit of 20 million tonnes per annum
	or
environmental impact statement	☐ map(s) attached. ☑ an environmental impact statement (EIS) is attached
certificate	I certify that I have prepared the contents of this Statement and to the best of my knowledge • it is in accordance with clauses 54A and 55 of the *Environmental Planning and Assessment Regulation 1994*, and • it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.
Signature: Name: Date:	[signature] Barbara Crossley 31 March 2000

Schedule 1 – Property Description

Local Government Area:	Muswellbrook Shire
County:	Brougham
Parish:	Durham

Table 1 – Land affected by Coal Operations Australia Limited Development Application

DP	Lot
701496	1,2,3,6,9
632691	11
793428	10
727767	110
842045	201
850818	64
Public road, 8 km south of Muswellbrook	

Table 2 – Land affected by Drayton Coal Development Application

DP	Lot
238862	1
241179	44, 45 (Part 1), 45 (Part 2)
701496	6
752486	1
812852	180
Public road, 8 km south of Muswellbrook	
Public road, 11.4 km southeast of Muswellbrook	
Railway land, 12 km southeast of Muswellbrook	
Conveyance No. 56 Book 2762 (Part 1 and Part 2)	
New England Highway, 8.6 km southeast of Muswellbrook	

PROJECT TEAM

Umwelt (Australia) Pty Limited – EIS Preparation

Barbara Crossley B.Nat.Res.(Hons)	Project Manager, Report Writing, General Environmental Assessment
Alice Howe B.Nat.Res.(Hons), B.Eng.(Hons)	Project Co-ordinator, Report Writing, Water Management, Community Consultation, General Environmental Assessment
Liz Crawford B.Sc.(Geol)(Hons), Grad. Cert. Ornith.	Soil Investigations, Topography, Geology, Avifauna
John Merrell B.Env.Sc.	Flora and Fauna
Allison Riley B.Sc.	Flora and Fauna

Various specialist investigations included in the EIS were conducted by:

Coakes Consulting	Socio-economic Investigations
Holmes Air Sciences	Air Quality Assessment
Southeast Archaeology	Aboriginal Archaeology and European Heritage
Wilkinson Murray	Noise Investigations

Studies undertaken on behalf of Coal Operations Australia Limited and referenced in EIS preparation included:

Bateman Brown & Root	Engineering Design
Dames & Moore	Baseline studies of Soils and Flora & Fauna for A171 area

Coal Operations Australia Limited, Drayton Coal Pty Ltd and Shell Coal Pty Ltd

The assistance of the following COAL, Shell Coal Pty Ltd and Drayton Coal personnel during preparation of this EIS is gratefully acknowledged. A number of personnel from these organisations provided details regarding the existing and proposed development and participated in community and authority liaison.

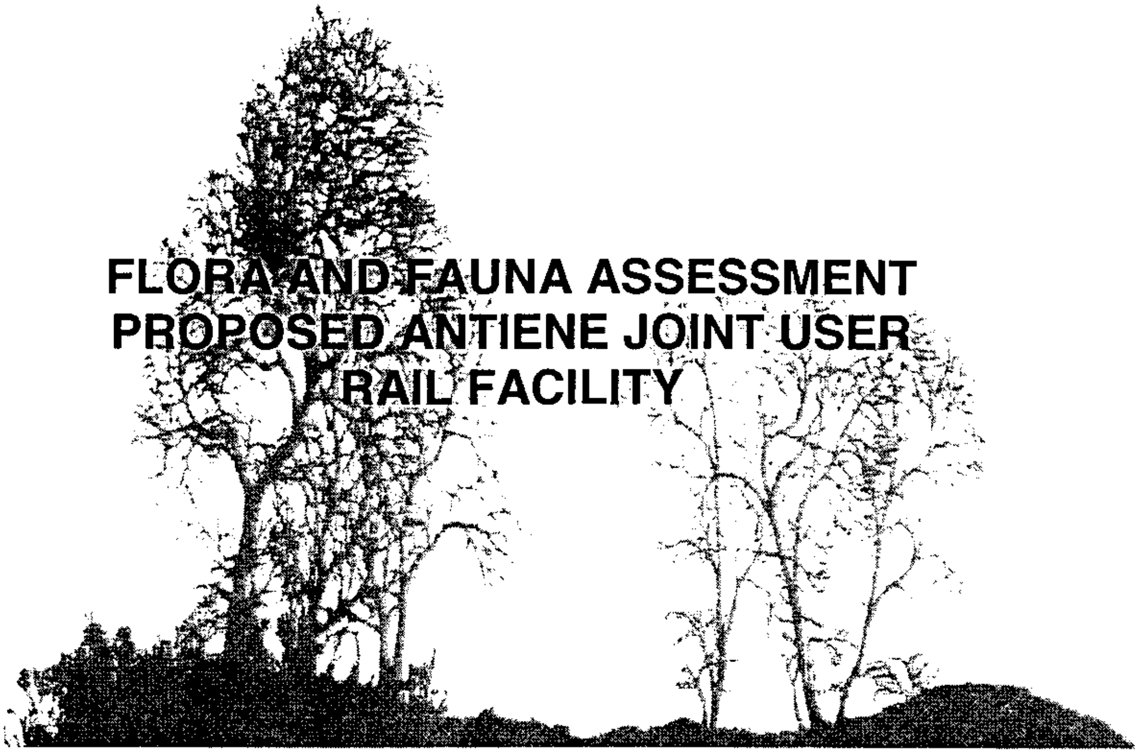
Greig Duncan	Project Manager (Shell Coal)
Michael Heath	Project Manager (COAL)
Bret Jenkins	Environmental Manager (COAL)
Andrew Kerr	Environmental Co-ordinator (Shell Coal)
Pam Simpson	Environment Co-ordinator (Drayton Coal)

APPENDIX 3

Flora and Fauna Assessment

DRAYTON COAL PTY LTD &
COAL OPERATIONS AUSTRALIA LIMITED

FLORA AND FAUNA ASSESSMENT PROPOSED ANTIENE JOINT USER RAIL FACILITY



Prepared by:

Umwelt (Australia) Pty Limited

Environmental and Catchment Management Consultants

March 2000

1323/R01/A3

Report No. 1323/R01/A3

Prepared for:

DRAYTON COAL PTY LTD &
COAL OPERATIONS AUSTRALIA LIMITED

FLORA AND FAUNA ASSESSMENT PROPOSED ANTIENE JOINT USER RAIL FACILITY

Umwelt (Australia) Pty Limited
Environmental and Catchment Management Consultants

PO Box 838
Toronto NSW 2283

Ph. (02) 4950 5322

Fax (02) 4950 5737

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APPENDICES

1.0 INTRODUCTION

Two development applications will be supported by the Environmental Impact Statement of which this flora and fauna assessment report forms part. The development applications will be lodged by Coal Operations Australia Limited and by Drayton Coal Pty Limited, with details of these proposals outlined below.

Coal Operations Australia Limited (COAL) propose to establish a rail loading facility adjacent to the existing Bayswater No 2 mine located approximately 6 kilometres south of Muswellbrook. The Bayswater rail loading facility will comprise a 4 kilometre rail corridor from the existing Antiene Rail Spur, off the Main Northern Railway; a balloon loop located on land between the northern boundary of the existing Bayswater No 2 mine and Thomas Mitchell Drive; a train loading bin; and a conveyor system to transport coal from stockpiles located on the Bayswater No 2 mine site (refer to **Figure 1.1**).

The rail loading facility will enable export coal from the Bayswater mine to be transported entirely by rail to the Port of Newcastle. Currently, coal from Bayswater mine is trucked via Thomas Mitchell Drive and the New England Highway to Ravensworth Coal Terminal for train loading to be railed to the Port of Newcastle. Coal Operations Australia Limited has made a commitment to cease all road haulage of export coal by mid 2001. The proposed rail loading facility is required in order to meet that commitment. The rail loading facility will also potentially be used by the Mount Arthur North Project, if approved, and other potential underground coal mines in the area.

The proposal also includes the establishment of an area of compensation habitat approximately 35.2 hectares in size, of which 15.3 hectares is existing vegetation, to replace the approximately 5.75 hectares of forested area to be removed by the construction of the proposed rail loop (refer to **Section 6.1** and **Section 8.0**). A habitat corridor is also proposed to be established as part of the project, linking the habitat compensation area to existing forest vegetation at the eastern end of the study area, with the project resulting in a total managed habitat area of 56.3 hectares.

The chosen route for the proposed rail loop was determined after careful consideration of a number of alternative routes, resulting in the disturbance of as little native vegetation as practicable. A full justification of the chosen route is presented in the Environmental Impact Statement (EIS) which has been prepared for the project.

Drayton Coal Pty Limited (Drayton) is seeking development approval to expand the operation of the existing Drayton Coal Rail Loop to transport up to 7 Mtpa of coal from the loop. Drayton is also seeking approval for the use of the Antiene Rail Spur to a limit of 20 Mtpa. This approval will provide capacity for increased saleable export production from the Drayton mine and from the proposed Saddlers Creek mine, if and when approval is sought and granted. There will be no additional infrastructure or construction work required as a result of any Drayton Coal approval, however, some upgrading of the existing track may be required.

The following flora and fauna assessment has been prepared by Umwelt (Australia) Pty Limited to provide information about the impact of the proposal on native flora and fauna occurring in the study area. The assessment also addresses any potential impacts on threatened species which occur in, or in the general vicinity of the study area. The study includes specific survey and assessment for the proposed disturbance area within and surrounding the Bayswater Rail Loop, and briefly discusses potential indirect impacts associated with the existing Drayton Rail Loop and Antiene Rail Spur and operation of the Bayswater Rail Loop.

Legend

- Existing Rail Loading Infrastructure
- Proposed Rail Loading Infrastructure
- Approved Infrastructure
- Mine Lease Boundary

0 250m 500m 750m 1000m

Umwelt (Australia) Pty Limited

FIGURE 1.1
Location of the Proposed Development

A3 Scale 1:14 000 | Ref No.:1323/R01_AP3/dra_034.dwg

2.0 METHODS

Flora and fauna survey of part of the current study area (Mining Authorisation Area 171) was undertaken as part of the proposed Mount Arthur North (MAN) Mine in 1998. The results of the relevant MAN surveys, completed by Dames and Moore Pty Limited over the period 15 to 21 November 1998, have been extended through the completion of survey work by Umwelt (Australia) Pty Limited during the months of October and November 1999. The Umwelt (Australia) Pty Limited surveys concentrated on the areas not assessed during the Dames and Moore survey, with additional work also being completed in the areas assessed during the MAN project. The majority of field work for the Umwelt (Australia) Pty Limited study was undertaken in the period 5 to 9 October 1999, with supplementary field work undertaken on 18 to 20 October 1999 and 20 December 1999.

2.1 FLORA

Prior to field studies being conducted, preliminary mapping of the vegetation communities in the study area was undertaken using recent aerial photographs (1998). A National Parks and Wildlife Service (NPWS) ATLAS database search combined with a review of existing studies from the local area were completed to identify locally occurring threatened flora species and general vegetation types. The results of the preliminary mapping phase were subsequently ground-truthed with vegetation community boundaries being adjusted as required.

The flora field surveys were undertaken in October 1999 and commenced with undertaking eight walking transects to determine species composition and level of disturbance of the vegetation, and to identify any threatened flora species occurring in the study area. These walking transects were also used to ground-truth the preliminary mapping phase, and to assess habitat quality. The walking transects were up to approximately 750 metres in length and covered each of the vegetation community areas identified (refer to **Figure 2.1**).

Following completion of the walking transects, a number of vegetation survey plots were completed in randomly selected areas within each of the vegetation community areas (refer to **Figure 2.1**). The location of each of these plots was recorded using a GPS. Six standard 20 x 20 metre vegetation quadrats were completed, allowing an accurate assessment of community structure and composition to be undertaken. Within each of these 20 x 20 metre quadrats ten 1 x 1 metre quadrats were assessed to provide information about species abundance and cover, with the information being recorded on standard survey sheets. Each of the species occurring in the larger quadrat areas were recorded, with information about canopy height, crown separation ratio and projective foliage cover also being recorded. Samples of all unknown plant species were collected in the field and were pressed and dried for later identification. Any unidentified plant species were sent to the Royal Botanic Gardens in Sydney for further identification. A flora species list for the study area is included in **Appendix A**.

Vegetation communities were classified according to Sphect et al. (1974 cited in McDonald et al., 1990) with community descriptions being included in **Section 3.0**. The flora surveys were also used to identify evidence of past disturbance of area, particularly including clearing activities, fire and rubbish dumping. General descriptions of the habitat quality were also completed at each site.

As discussed previously, the results of the Umwelt (Australia) Pty Limited surveys have been supplemented by the results of the Dames and Moore Pty Limited survey of the Mining Authorisation Area (A171), which was completed as part of the surveys for the MAN project. These surveys included two terrestrial flora sampling sites completed in the A171 area (refer to **Figure 2.1**). The surveys involved sampling from within a 20 x 20 metre plot with all data being recorded on standard data sheets. The results of the field surveys, along with the general site and community descriptions, were obtained from Dames and Moore to allow the results of the survey to be incorporated into the flora assessment for the rail loop proposal.

2.2 FAUNA

Prior to field work being completed a search of the NPWS's ATLAS database was undertaken to identify fauna species which have previously been recorded in the Muswellbrook area. A review of existing reports addressing fauna was also undertaken, enabling a list of threatened species potentially occurring in the region to be compiled (refer to **Section 5.2**). Survey methods were designed to include appropriate techniques to identify any threatened species which potentially occurred in the study area. All surveys were undertaken in appropriate weather conditions (refer to **Appendix B**) during October 1999.

Dames and Moore also undertook a range of faunal investigations in the A171 area including, spotlighting, bird surveys, reptile surveys and microchiropteran bat surveys, with these results being incorporated into the study.

2.2.1 Birds

2.2.1.1 Nocturnal Birds

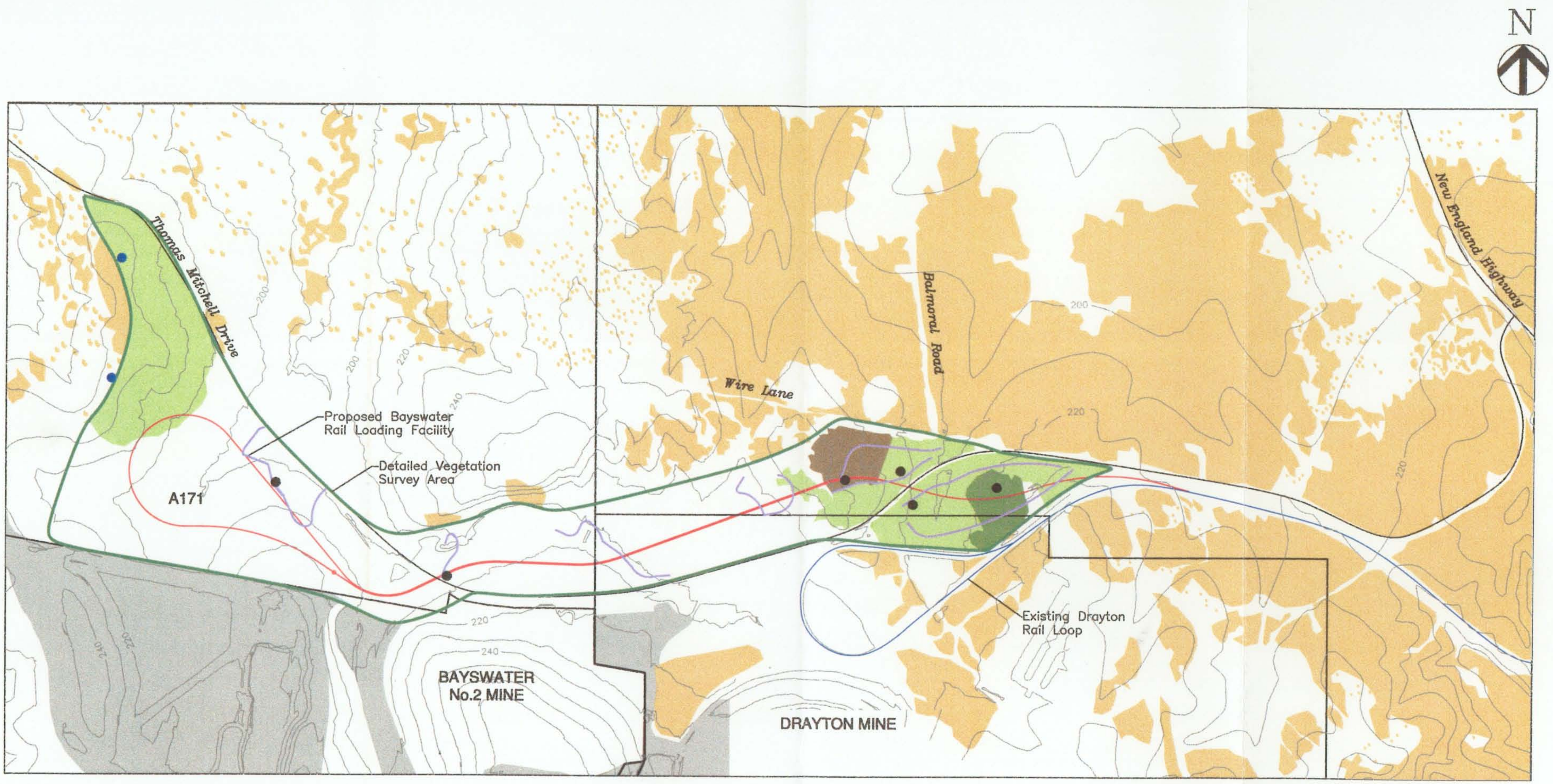
Three owl call playback sessions were conducted during the survey period, with spotlighting also being completed to determine the presence of nocturnal bird species. Each call playback session generally followed the method recommended by Forest Fauna Surveys *et al.* (1997), and included the calls of the Powerful Owl, Masked Owl, Sooty Owl and Barking Owl. Each call playback session commenced with a quiet listening period of approximately 15 minutes following which the first owl call was played. The broadcast of each owl call was followed by a quite listening period of 5 minutes, and then by approximately 5 minutes of spotlighting in the vicinity of the owl call playback site. The calls were broadcast using a directional loud hailer at 10 watts. Fourteen person hours of spotlighting were also completed in the study area, with the spotlighting targeting nocturnal bird species.

2.2.1.2 Diurnal birds

Diurnal bird surveys were undertaken in both the morning and evening between 18 and 20 October 1999. Surveys were undertaken in forest, grassland and wetland habitats to obtain an assessment of the diversity present in each habitat along the proposed rail loop (**Figure 2.2**). Each survey lasted 20 to 30 minutes, with two observers. Species were identified from characteristic calls and by observation, for a total of 14 person hours of surveying.

Opportunistic observations were also recorded during other aspects of the field survey, particularly during the checking of the trap lines each morning.

Dames and Moore also conducted a diurnal bird survey in the Mining Authorisation Area (A171). The surveys were conducted by random area searches within selected habitats, with counts generally being greater than 20 minutes in duration. Surveys were conducted during the early morning and late afternoon.



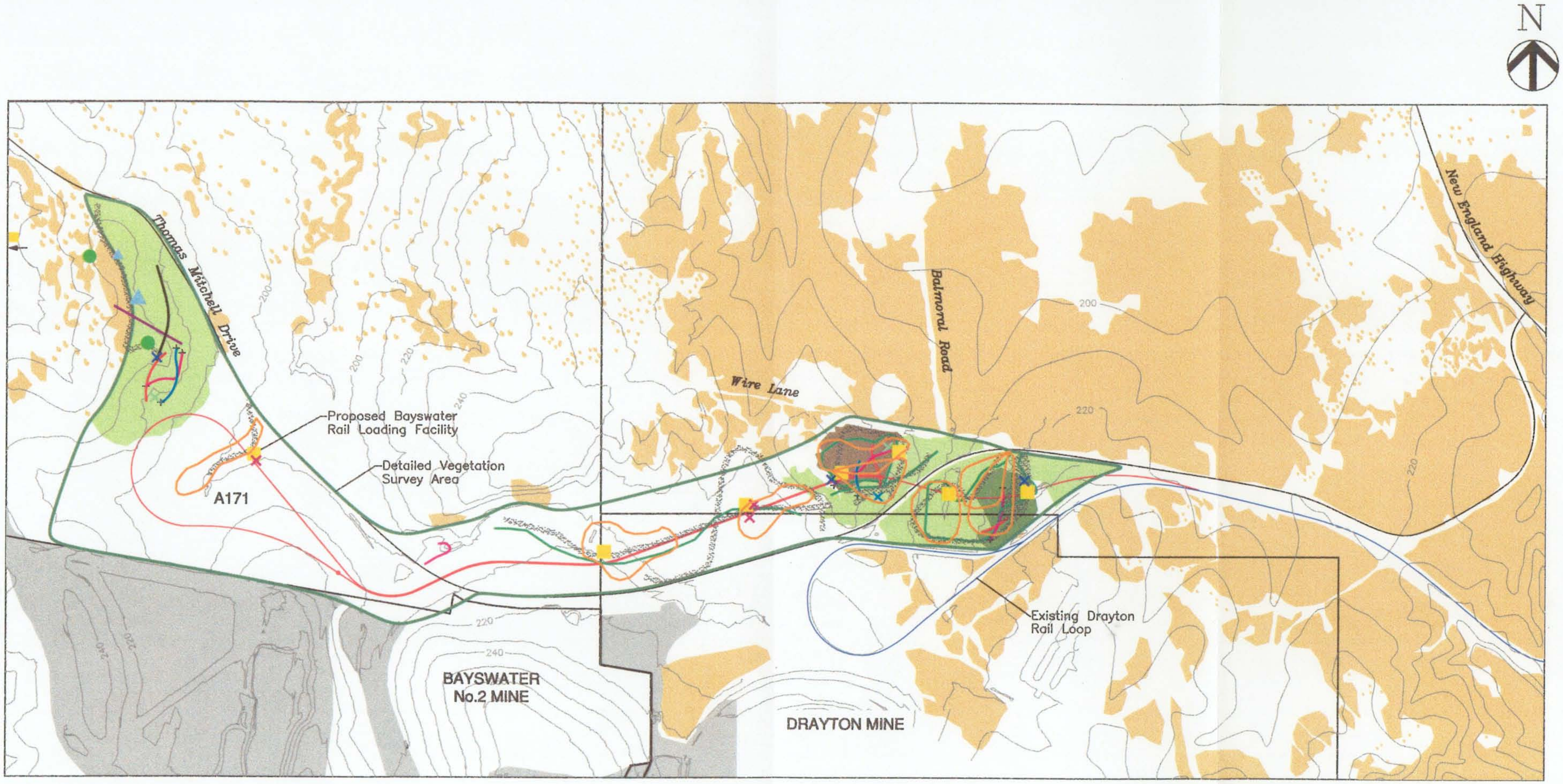
Legend

- Vegetation Quadrats
- Vegetation Walking Transects
- Dames & Moore Terrestrial Flora Sampling Sites

0 250m 500m 750m 1000m

FIGURE 2.1
Vegetation Survey Sites

A3 Scale 1:15 000 | Ref No.:1323/R01_AP3/dra_022.dwg



Legend

- Nocturnal Frog Search
- Diurnal Frog and Reptile Search
- Owl Call Playback
- Dames & Moore Reptile Area Search Site
- Dames & Moore Bird Area Search Site
- Bird Survey Transects
- Anabat Transects
- Elliot 'A' Transects
- Elliot 'B' Transects
- Hair Funnel Transects
- Dames & Moore Walked Transect Ecolocation Recording
- Dames & Moore Static Site
- Cagetraps
- Stagwatching Sites
- Dames & Moore Mist Net
- Dames & Moore Fixed Ecolocation Recording Point
- Spotlighting Transects

0 250m 500m 750m 1000m

Contour Interval 10m

FIGURE 2.2

Fauna Survey Sites

A3 Scale 1:15 000 | Ref No.:1323/R01_AP3/dra_024.dwg

Umwelt (Australia) Pty Limited

2.2.2 Herpetofauna

Diurnal target searches were conducted for reptile and amphibian species in likely habitat areas throughout the study site. Nocturnal searches were also conducted for amphibian species in and around the natural and artificial water bodies present on site (refer to **Figure 2.2**). Seven diurnal search areas were sampled during the survey period with each search being undertaken by two personnel in an approximate 1 hectare area for 15 to 20 minutes, resulting in a total sampling effort of 4 diurnal person hours. During each search likely microhabitats were examined with rocks and logs being rolled over and searches of tree bark, ground litter and wet soak areas being completed. The diurnal surveys were conducted in afternoon periods, typically between 1.30 pm and 4.30 pm.

Nocturnal amphibian surveys were also undertaken, with three sites being specifically targeted. Other water body sites were also visited to confirm that the species occurring in each area were generally similar. At each site, low watt hand-held and head torches were used to search in and around the waterbodies, including examining vegetation and other likely microhabitat areas. Locally occurring species were also recorded by identification of vocalising males. A tape recorder was also used to record calls at each site, while an alternative part of the site was searched, allowing later analysis to identify vocalising males. All surveys were undertaken in appropriate weather conditions, with some surveys being preceded by rain periods. A total of 3.5 nocturnal person hours were completed during the survey period, with approximately 45 minutes of recordings being taken for later analysis. Opportunistic observations, both nocturnal and diurnal, were recorded throughout the study.

The Dames and Moore survey conducted in the Mining Authorisation Area (A171) included two reptile search areas (refer to **Figure 2.2**). Each timed search was conducted for 20 minutes within a 1 hectare area, between 10.00 am and 4.00 pm. Active searching for reptiles included scanning of trees and ground, removal of cover such as rocks and fallen logs and peeling the bark from trees.

2.2.3 Mammals

A range of techniques were used to identify the mammals occurring in the study area. These methods included trapping, hair funnels, spotlighting, stagwatching and ultrasonic bat recordings. The Dames and Moore study in the Mining Authorisation Area (A171) included spotlighting, hair tubes, an ultrasonic bat detection walking transect, a fixed point ultrasonic bat detection site and a mist nest site. **Table 2.1** below indicates the total number of traps used during the survey while **Figure 2.2** indicates the location of the trap lines. A full description of the number of traps set in each section of the study area is included in **Appendix B.**

Table 2.1 – Number of mammal trap nights used during the study.

Trap Type	Trap Nights
Elliot class 'A'	160
Elliot class 'B'	40
Cage traps	8
Hair funnels	60
Dames & Moore hair tubes	24
Total Trap Nights	**292**

Both arboreal and ground traps were used during the survey with generally every third Elliot 'A' and every second Elliot 'B' being arboreal traps. Arboreal traps were mounted at a height of approximately 2 metres using angle brackets, and were set on trees with hollows or scratch marks where possible. Traps were set at intervals of 10 to 20 metres along the trap lines. Bedding material was placed in each trap to ensure any captured animals were able to maintain body temperature. Hair funnels were also used both as arboreal and ground traps, with the majority being set as arboreal traps. Hair funnels are a modification of hair tubes being shaped so as to allow hair from animals of any size to captured for later analysis. The hair tubes used by Dames and Moore were set both as arboreal and ground traps.

Elliot 'A' and hair funnels were baited with a standard mix of rolled oats, honey, peanut butter and vegetable oil, providing a nutritious meal for any captured mammals. Elliot 'B' traps were also set with this standard bait mix, with approximately half also containing a mixture of peanut butter and sardine cat food. Cage traps were set with a mixture of peanut butter and sardine cat food, with an Elliot 'A' bait also being included. The Dames and Moore hair tubes were baited with a mixture of rolled oats and honey. A honey emulsion (comprising honey and water) was sprayed daily onto each tree containing an arboreal trap, hair funnel or hair tube. The honey emulsion was also sprayed on nearby trees to act as an attractant.

Spotlighting was primarily conducted on foot using a 50 watt hand-held spotlight, with some areas also covered using spotlighting from a slow moving vehicle (refer to **Figure 2.2**). A total of 14 person hours spotlighting was conducted during the study. Spotlighting was undertaken generally between 9.00 pm and 12.00 am, however a limited amount of spotlighting was also conducted following dusk (7.00 pm to 8.00 pm). The Dames and Moore study also conducted spotlighting in the A171 area both on foot and from a slow moving vehicle. Spotlighting was undertaken using 50 watt hand-held spotlights, generally between the hours 8.00 pm and 1.00 am.

Stagwatching was also conducted at a limited number of sites (refer to **Figure 2.2**) to observe animals leaving hollows on dusk. This method was particularly used to target Squirrel Gliders and examine hollows affected by the proposal.

Searches for evidence of mammal use were also conducted with scats being collected and analysed as required. Trees were also examined for scratch marks and other evidence of use by arboreal mammals. All hair analysis, and scat analysis as required, was undertaken by Barbara Triggs of Genoa, Victoria. All opportunistic mammal observations during other aspects of the survey were also recorded.

2.2.3.1 Microchiropteran Bats

Four ultrasonic bat detection walking transects were conducted during the survey period using the Anabat II system developed by Titley Electronics, Ballina NSW. Each of these walking transects was 45 minutes in duration with all detected calls being recorded to tape for later analysis. Transects were located in all vegetation communities identified in the study area (refer to **Figure 2.2**), with a 50 watt hand-held spotlight being used during the survey to locate any megachiropteran bat species present. All Anabat recordings were analysed by Glen Hoye of Fly by Night Surveys Pty Limited.

The Dames and Moore study also conducted an extensive bat survey including conducting a 30 minute walking Anabat II transect, a fixed point Anabat II site with delay switch to record all night and one mist net site (refer to **Figure 2.2**). Free standing 9 metre monofilament mist nets were set along potential flyways and tracks within bushland remnants, while fixed point sampling sites were chosen to sample areas which represent potential flyways or other areas of high bat activity.

3.0 FLORA OF THE STUDY AREA

3.1 VEGETATION OF THE REGION

The Upper Hunter Valley has been largely cleared of native vegetation, primarily for agricultural and other land uses including urban and industrial development and mining. This is particularly true of the valley floodplain areas which are subject to intensive agricultural use. Similar land use patterns also occur in the vicinity of the study area, with the study site being surrounded by agricultural land, open cut coal mines and patches of remnant vegetation.

Two large National Park areas occur to the south of the Muswellbrook region being the Wollemi and Yengo National Parks. These National Parks contain large areas of native vegetation and offer a wide range of good quality fauna habitats. A smaller, yet significant area of National Park also exists to the northeast of the study area, being the Barrington Tops National Park. Combined these National Parks contain significant areas of remnant vegetation and important fauna habitats, providing potential habitat for a range of fauna species, particularly threatened species which are impacted by widespread habitat removal. An additional conservation area, the Manobalai Nature Reserve also exists to the northwest of the study area, with this reserve providing an additional area of regional flora and fauna habitat.

Several state forest areas also exist in region of the study area and although these areas cannot be considered to be conservation reserves, they do generally play an important role in providing habitat for a range of fauna species. A large complex of state forest areas adjoins the Barrington Tops National Park to the northeast of the study area, including the Stewarts Brook State Forest, Mount Royal State Forest, Masseys Creek State Forest and Chichester State Forest. The Ravensworth State Forest which occurs approximately 30 km east of the study area also provides important regional habitat for a range of species including several threatened species.

A number of significant remnant vegetation areas also exist in close proximity to the study area, however, clearing, primarily for agricultural purposes, has generally removed corridor linkages between these remnants. The lack of movement corridors somewhat reduces the fauna habitat potential of a number of these areas, however the remnants are still significant on local and regional scales. A relatively large area of remnant vegetation exists to the east and northeast of the study area, providing flora and fauna habitats similar to that found in the study area. This remnant is largely fragmented by clearing for infrastructure and agricultural activities, however it remains the largest somewhat connected remnant vegetation area in proximity to the study area.

Mount Arthur remains a significant remnant vegetation and fauna habitat area despite being surrounded by agricultural land and mining areas. This area contains a range of fauna habitats from dense vegetation to caves and other similar structures and is thought to provide core habitat for at least one threatened species, the Common Bent-wing Bat. Mount Ogilvie, which occurs to the east of Mount Arthur, also provides a significant area of remnant vegetation and fauna habitat. This area is however generally separated from the remnants in closer proximity to the study area, however, future mine rehabilitation works will improve connectivity to vegetation remnants remaining to the west of the study area.

The remaining remnant vegetation area, which has been previously discussed as providing a potential fauna movement corridor (Resource Planning, 1993), is Saddlers Creek. As discussed by Gunninah (1997), the vegetation along the Creek is generally highly disturbed with a number of sparsely vegetated and cleared areas which are likely to affect its operation as a fauna movement corridor. The area does however provide potential habitat for a range of species and is considered to be of some local significance. A management program that is currently being planned for Saddlers Creek is likely to improve the function of the area as a corridor linkage.

3.1.1 Drayton Colliery Wildlife Refuge

A wildlife refuge has been proclaimed on the Drayton Colliery area under Section 68 of the National Parks and Wildlife Act 1974. The entire Drayton Mine area, including disturbed mining areas, has been included in the Wildlife Refuge proclamation. The refuge area has been divided into three zones according to the major land use objectives of each zone. The three zones have been designated as:

a) Mining Area;

b) Grazing Area;

c) Natural Area.

A Plan of Management for the Drayton Wildlife Refuge has been prepared, with the plan outlining management practices to achieve the following objectives:

1. To preserve about 290 hectares of Woodland.

2. To preserve and develop wildlife habitat associated with the Upper Hunter Valley.

3. To establish and maintain genetic links between areas of natural vegetation within the Drayton Mine area and with other Wildlife Refuges in the vicinity.

4. To develop and maintain existing and proposed dams as waterfowl habitat and wildlife water supply.

5. To encourage the care, propagation, preservation, conservation and study of fauna, habitats and mans relationship to them.

The Natural Area zone designated by the proclamation is indicated on **Figure 3.1**, with part of the zone being affected by the proposed rail loop development. Drayton Colliery proposes to modify the Wildlife Refuge proclamation in order to allow the proposed rail loop development to proceed. An area of compensatory habitat will be established by Coal Operations Australia Limited to mitigate flora and fauna impacts and will also effectively replace the area of the existing wildlife refuge which is removed by the proposed development (refer to **Section 8.2**).

3.2 VEGETATION COMMUNITIES

Five vegetation communities were recorded in the study area with the distribution of these communities being shown on **Figure 3.2**. Three of the communities were forested, with the remaining two being pastoral grassland and aquatic vegetation. Each of the community areas showed relatively high levels of disturbance with evidence of past and ongoing clearing activities being observed. All community areas generally contained a significant number of weed species.

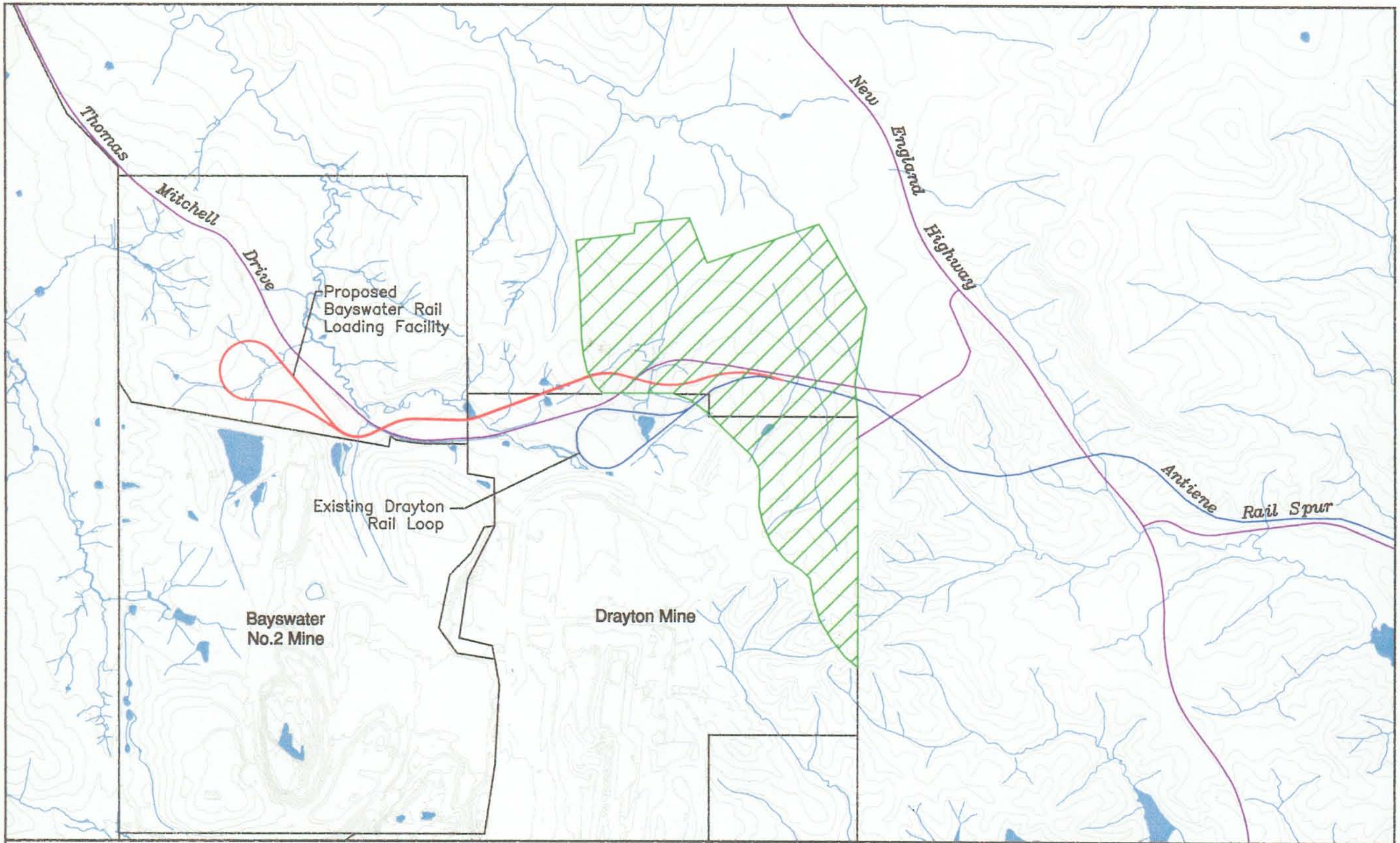
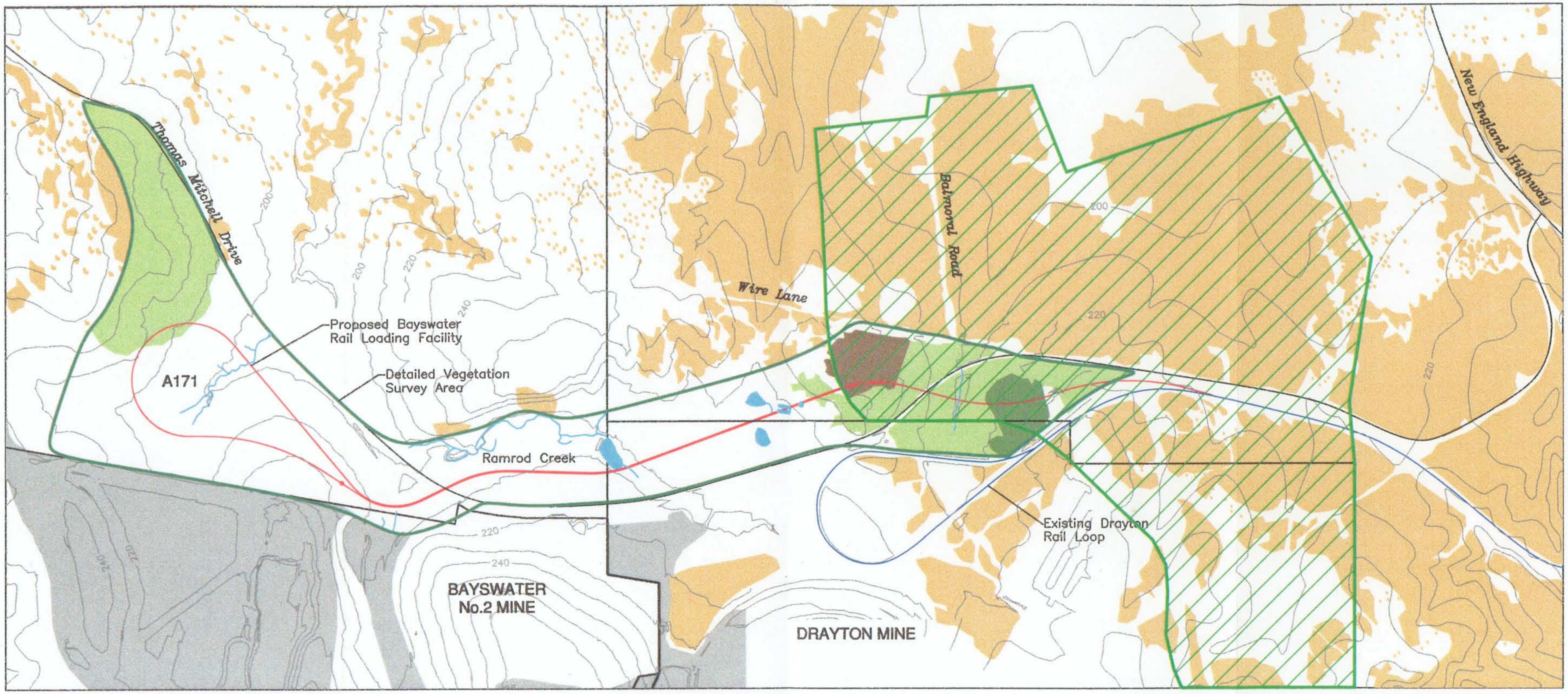


FIGURE 3.1
Drayton Wildlife Refuge – Natural Zone



Legend

- Mixed Eucalypt Woodland
- Pastoral Grasslands
- *Eucalyptus tereticornis* Woodland–Open Forest
- *Corymbia maculata* Woodland
- Detailed Vegetation Survey Area
- Undifferentiated Woodland–Open Forest
- Disturbed Areas
- Areas containing patches of Aquatic Vegetation
- Drayton Wildlife Refuge–Natural Zone

0 250m 500m 750m 1000m

Contour Interval 10m

FIGURE 3.2

Vegetation Community Distribution

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PLATE 1

Pastoral Grasslands

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PLATE 2
Mixed Eucalypt Woodland

PLATE 3
Mixed Eucalypt Woodland

PLATE 4
Eucalyptus tereticornis: Woodland – Open Forest

PLATE 5
Corymbia maculata Woodland

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Ref No.:1323/R01/plate3.dwg

(Yellow Burr Daisy), *Whalenbergia communis* (Tufted Bluebell), *Lomandra filiformis*, *Stipa aristiglumis*, *Danthonia teniour*, *Bothriochloa macra* and *Dichelachne micrantha*. A number of introduced species also occurred, including Prickly Pear (*Opuntia stricta**), which was common throughout the community area, and African Boxthorn (*Lycium ferocissimum**), which is listed on the Noxious Weed list, and was found scattered throughout the community area. Other introduced species included Dandelion (*Taraxacum officinale**), Catsear (*Hypochaeris radicata**), Pennywort (*Centella asiatica**), Black Nightshade (*Solanum nigrum**), Kikuyu (*Pennisetum clandestinum**) and Flax-leaf Fleabane (*Conyza bonariensis**). Ground cover typically ranged from 40 to 60%.

The community typically displayed a relatively high level of disturbance, with evidence of past clearing activities being observed. Ongoing tree felling is also occurring in some areas, with a number of areas being affected by fire wood collection. The portion of this community at the western end of the site, in Mining Authorisation Area (A171), is generally more highly degraded than the remaining community areas, with this area being part of a travelling stock route and being subject to moderately heavy use by cattle. This area also exhibited signs of frequent rubbish dumping and vehicle access. Stock were generally absent from the remaining community areas, with some grazing pressure still being applied due to the presence of a large population of Eastern Grey Kangaroos.

3.2.3 *Eucalyptus tereticornis* Woodland - Open Forest

This community was primarily composed of *Eucalyptus tereticornis*, with a small number of scattered *E. crebra*, *E. blakeyi* and *E. moluccana* individuals also occurring (refer to **Plate 4**). The upper storey of the community was typically to a height of 9 to 16 metres, with occasional taller individuals to 20 metres. The community was composed primarily of immature trees with some scattered mature trees also occurring. The crown separation ratio for the community was approximately 0.13, while the percentage foliage cover was approximately 30%. The shrub layer was generally absent, however, a number of eucalypt saplings did occur in this layer. The groundcover was generally open, and consisted primarily of *Themeda australis* (Kangaroo Grass), *Danthonia teniour* (Wallaby Grass), *Stipa aristiglumis* (Speargrass), Couch (*Cynodon dactylon**), Pennywort (*Centella asiatica**), *Viola hederacea* (Native Violet), *Lomandra filiformis*, *Wahlenbergia communis* (Tufted Bluebell), *Calotis lappulacea* (Yellow Burr Daisy) and *Glycine tabacina* (Love Creeper). A number of additional introduced species also occurred, with the most common being Prickly Pear (*Opuntia stricta**) and Black Nightshade (*Solanum nigrum**). A relatively good ground litter cover also occurred in the community area, with the litter layer generally consisting of 80% to 100% cover.

The community generally exhibited a relatively high level of disturbance, with the majority of trees being 10 to 30 cm in diameter. A number of large trees were, however, scattered throughout the community. There was also evidence of ongoing clearing observed in the community area, with trees being cut for firewood at a number of locations. Introduced flora species also occurred throughout the community.

3.2.4 *Corymbia maculata* Woodland

A small area of this community occurs adjoining the Drayton rail loop at the eastern end of the study area. The upper storey of the community consists almost entirely of *Corymbia maculata* to a height of 10 to 20 metres, with a small number of scattered *Eucalyptus crebra* also occurring (refer to **Plate 5**). The CSR of the community was 0.56, while the %FC was approximately 16%. The community generally contained trees of a good age mix, with several mature and medium sized trees occurring along with a number of immature trees.

The shrub layer was generally absent, with a few scattered *Corymbia maculata* juveniles occurring. The ground layer was very open, and comprised a mix of native and introduced

Soil issues

- Describe and assess the effectiveness or adequacy of any soil management and mitigation measures during construction and operation of the proposal including:
  - erosion and sediment control measures
  - proposals for the management of any acid sulfate soils .

F. EPA Licensing

- Identify licensing required by the EPA under environment protection legislation including details of all scheduled activities, types of ancillary activities and types of discharges (to air, land, water).

G. Compilation of mitigation measures

- Outline how the proposal and its environmental protection measures would be implemented and managed in an integrated manner so as to demonstrate that the proposal is capable of complying with statutory obligations under an EPA licence (eg outline of an environmental management plan).
- The mitigation strategy should include the environmental management and cleaner production principles which would be followed when planning, designing, establishing and operating the proposal. It should include two sections, one setting out the program for managing the proposal and the other outlining the monitoring program with a feedback loop to the management program.

H. Justification for the Proposal

- Reasons should be included which justify undertaking the proposal in the manner proposed, having regard to the potential environmental impacts.

3.2.1 Pastoral Grassland

The majority of the study area is vegetated with pastoral grassland containing a mix of native and introduced grasses and groundcover species (refer to **Plate 1**). These grassland areas generally lacked tree and shrub vegetation with scattered immature eucalypt and She-Oak individuals occurring. The community showed great variability in species composition and abundance throughout, with the variability appearing to be generally dependent on the level of grazing and farming pressure applied to the land. The community was generally dominated by Spear Thistle (*Cirsium vulgare**), *Eragrostis brownii* (Browns Lovegrass), Barrel Medic (*Medicago truncatula**), White Clover (*Trifolium repens**), Subterranean Clover (*Trifolium subterraneum**), Dandelion (*Taraxaum officinale**), *Themeda australis* (Kangaroo Grass) and *Stipa aristiglumis* (Speargrass). A range of other species also occurred, including the introduced species Plantain (*Plantago lanceolata**), Saffron Thistle (*Carthamus lanatus**), Common Sowthistle (*Sonchus oleraceus**), Rhodes Grass (*Chloris gayana**), Varigated Thistle (*Silybum marianum**) and Curled Dock (*Rumex crispus**). A limited number of native ground cover species also occurred including *Glycine tabacina* (Love Creeper) and *Wahlenbergia communis* (Tufted Bluebell). Ground cover typically ranged from 70% to 90%, with some bare areas also occurring due to stock and other disturbances. Weed species generally accounted for a high proportion of the species recorded as occurring in the pastoral grassland community.

The pastoral grassland community areas exhibited signs of grazing pressure by both domestic (particularly cattle) and pest species (including rabbits and hares), and by native grazing mammals. Grazing patterns also appear to have affected species abundance, with non-preferred feed species being dominant in several areas. The pasture areas also appeared to be subject to periodic impact from agricultural activities including ploughing and weed control practices.

3.2.2 Mixed Eucalypt Woodland

This community covers the majority of the forested portion of the study area and consists of a varied mix of a number of Eucalypt species (refer to **Plate 2** and **Plate 3**), with *Corymbia maculata* also occurring throughout the eastern forested portion of the study area. This community also occurs in the A171 area where flora survey sites were completed by Dames and Moore, however *Corymbia maculata* does not occur in this area. The results of these survey sites have been included in the following description.

The upper storey of the community consists primarily of *Eucalyptus crebra*, *E. albens*, *E. moluccana E. tereticornis*, *E. blakelyi* and *Corymbia maculata* to a height of 10 to 15 metres, and with a Crown Separation Ratio (CSR) of 0.30 to 0.45, and a Percentage Foliage Cover (%FC) of 20-25%. A range of other canopy species also occurred in this community including *Eucalyptus dawsonii* and *Brachychiton populneus*. As discussed above, *Corymbia maculata* was generally restricted to the eastern end of the study area, with the other species varying in abundance throughout the community. Mature individuals were scattered throughout the community with the apparent dominance of a particular canopy species in any localised area being generally related to the presence of one mature tree and a number of immature individuals.

The shrub layer was generally absent throughout the community with scattered shrub or low shrub layer species occurring. Typical species included *Acacia decora, Acacia excelsa, Notelaea microcarpa, Acacia melanoxyon* and *Maireana microphyllum*. An open ground layer also occurred, with typical species including *Elymus scaber* (Common Wheatgrass), *Themeda australis* (Kangaroo Grass), *Cheilanthes sieberi* (Mulga Fern), *Calotis lappulacea*

* Introduced Species

species. Common species included *Wahlenbergia communis* (Tufted Bluebell), *Calotis lappulacea* (Yellow Burr Daisy), *Elymus scaber* (Common Wheatgrass), *Dianella revoluta*, *Themeda australis* (Kangaroo Grass) and Kikuyu (*Pennisetum clandestinum**). Other introduced species included Black Nightshade (*Solanum nigrum**) and Couch (*Cynodon dactylon**). There was a high level of leaf litter cover throughout the community, with cover generally being 80% to 100%. The community also showed signs of disturbance, particularly through grazing by Eastern Grey Kangaroos, with a large population being observed to use the habitats of the area.

3.2.5 Aquatic Vegetation

Aquatic vegetation occurs in the study area in both natural and constructed waterways. The vegetation ranges from grasses and rushes in intermittent waterways, to fully aquatic vegetation. Typically occurring species include *Typha orientalis* (Cumbungi), *Myriophyllum* sp. (Watermillfoil), *Phragmites australis* (Common Reed), *Paspalum distichum* (Water Couch), *Eleocharis acuta* (Spike-rush) and the introduced Spiny Rush (*Juncus acutis**), Umbrella Sedge (*Cyperus eragrostris**) and Water Buttons (*Cotula coronopifolia**). Other species also occur in intermittently wet areas including Paspalum (*Paspalum distichum**), Kikuyu (*Pennisteum clandestinum**), Couch (*Cynodon dactylon**) and *Agrostris avenaceus* (Beard Grass).

The main drainage line which occurs in the study area is Ramrod Creek which flows from the northwest corner of the Drayton Colliery Mining Lease through the A171 area, to the north of the study area. The Creek is joined by several small tributaries which drain surrounding areas. Several constructed waterways also occur in the study area, including farm dams and effluent treatment ponds, with the edges of these structures being affected by stock use. Stock impacts and severe erosion were also evident at a number of the natural waterways occurring in the study area, including Ramrod Creek. The ongoing erosion at some of these sites limits the potential for significant vegetation to occur in these areas.

3.3 THREATENED FLORA SPECIES

Several threatened flora species have been recorded in the Muswellbrook and Camberwell 1:100,000 map sheet areas (ATLAS Database), however, none have been recorded within a 15 km radius of the proposed development. None of these species were located in the study area, with none being expected to occur in the area (refer to **Section 5.1**). The proposed development will not significantly impact on any locally occurring threatened flora species.

4.0 FAUNA OF THE STUDY AREA

4.1 GENERAL FAUNA HABITAT

Three general habitat areas occur in the study area, being pastoral grassland habitat, woodland / open forest habitat and permanent and ephemeral waterbody habitat. Each of these habitat areas is generally degraded due to disturbances from the surrounding agricultural activities and activities associated with adjacent mining, and through other human activities such as clearing, rubbish dumping and fire wood cutting. The habitat areas do, however, provide habitat for a range of locally occurring native species as well as domestic and pest species.

The high level of disturbance in the pastoral grassland vegetation community results in an area of poor potential fauna habitat and limits the use of the community by native fauna species. Potential fauna habitat in these areas exists only for species able to exist in degraded areas, including a number of bird species such as magpies, crows and noisy miners, and grazing mammals such as the eastern grey kangaroo. Several domestic and pest species were also observed to occur in this area, with the area being grazed by cattle. Pest species present included the European Red Fox (*Vulpes vulpes*) and the Rabbit (*Oryctolagus cuniculus*).

A range of permanent and ephemeral waterways exist in the study area, including farm dams, effluent treatment ponds and natural waterways. These waterways offer habitat to a number of birds and other fauna species. Several frog species were recorded in the study area, as were eels and birds including the Australian Wood Duck and Masked Lapwing. In general fauna species abundance and diversity was observed to be greater in constructed waterways compared to natural waterways. This is likely to be due to the constructed waterways offering a larger area of permanent water than the natural waterways. The majority of natural waterway areas were observed to be affected by erosion, particularly due to stock impacts. Most also occurred in areas surrounded by pastoral grassland, further adding to the disturbance of these areas.

Two general areas of forested habitat occurred in the study area, being the western area of Open Forest – Woodland in the Mining Authorisation Area (A171) and the Open Forest – Woodland areas at the eastern end of the study area. The habitat quality of the vegetation in the A171 area is generally low, with the vegetation being relatively highly disturbed, and very open in nature. The community area lacks significant hollow resources, with a general lack of fallen timber, rocks, dense groundcover, dense shrub vegetation and other such habitat resources occurring. The area forms part of a travelling stock route and the movement of cattle through the area has generally degraded the vegetation and consequently the fauna habitat value. The site has also been used for illegal rubbish dumping, with evidence of this activity being observed throughout the community area. The A171 area was generally inhabited by species able to tolerate a relatively high level of disturbance, including the Australian Raven, Australian Magpie, Sulphur Crested Cockatoo, Noisy Miner and Eastern Grey Kangaroos, as well as the introduced fauna cattle and rabbits. A number of bat species were also recorded using the area as foraging habitat (refer to **Section 4.2.3**).

The eastern forested habitat areas can be divided into the area north of Thomas Mitchell Drive and the area south of Thomas Mitchell Drive. The area to the north of Thomas Mitchell Drive consists of the *Eucalyptus tereticornis* Woodland – Open Forest, and an area of the Mixed Eucalypt Woodland. Good quality fauna habitat within the *Eucalyptus tereticornis* Woodland – Open Forest community was limited with a general absence of tree hollows occurring. Limited hollows did however occur in this community area to the north west of the community extent. The open nature of the groundcover generally limited the ground dwelling fauna habitat quality of the area, however, areas of fallen and cut timber did offer some fauna habitat. A number of bird species were observed in this area, as were several brushtail possums and a threatened squirrel glider. Evidence was also observed throughout the community of use of the area by eastern grey kangaroos. Noise and light impacts from the nearby Drayton Colliery were also evident in this community area, however the impacts were not as great as that observed at the *Eucalyptus maculata* Open Forest community to the south of Thomas Mitchell Drive.

The Mixed Eucalypt Woodland area to the north of Thomas Mitchell Drive contained moderate to good habitat quality in the context of the study area. A number of mature trees exist in this area which is primarily dominated by immature canopy vegetation. Several of these mature trees contain hollows which are potentially used by a range of fauna species, including the threatened squirrel glider, which was recorded in the adjoining vegetation community. This area also contains scattered fallen logs which may provide shelter for ground dwelling fauna. There was evidence of firewood cutting throughout the northern portion of this area, with a number of mature trees being removed by this activity. As with the *Eucalyptus tereticornis* community discussed above, some noise and light impacts from the nearby Drayton Colliery were observed to occur in this habitat area, however, the impact was not as great as that on the southern side of Thomas Mitchell Drive.

The eastern forested area to the south of Thomas Mitchell Drive contains two vegetation communities, being the *Corymbia maculata* Woodland and an area of the Mixed Eucalypt Woodland. The Mixed Eucalypt Woodland area contains moderate fauna habitat and is comprised of fewer mature trees than the area north of Thomas Mitchell Drive. No significant hollows were noted in this area, with evidence of past timber cutting activities being observed throughout. Some ground dwelling fauna habitat resources were observed, including fallen timber, however these resources were generally limited. The area showed evidence of heavy use by Eastern Grey Kangaroos and use by cattle. Substantial noise and light impacts were evident in this habitat area from the nearby Drayton Colliery.

The *Corymbia maculata* community generally consisted of low to moderate habitat quality with the general absence of a shrub layer and open nature of the groundcover resulting in a lack of habitat for many local native species. A number of bird species have however been identified as using the habitats offered in the area, with a large number of Eastern Grey Kangaroos also being observed in the locality. Evidence of heavy grazing pressure from Eastern Grey Kangaroos was observed in the community, with evidence of cattle use also being noted. As with the community area discussed above, substantial noise and light disturbances from the nearby Drayton Colliery were evident in the community area. These impacts may potentially reduce the quality of the potential fauna habitat in the area.

4.2 SITE RECORDS

4.2.1 Birds

A total of 66 bird species was recorded in the study area, including one nocturnal species (Tawny Frogmouth – *Podargus strigoides*) and several water birds. No threatened bird species were recorded in the study area. Of the birds recorded, seven can be classed as waterbirds, being the Australian Wood Duck (*Chenonetta jubata*), Pacific Black Duck (*Anas superciliosa*), Grey Teal (*Anas gracilis*), Australasian Grebe (*Tachybaptus novaehollandiae*), Dusky Moorhen (*Gallinula tenebrosa*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), and Australian Pelican (*Pelecanus conspicillatus*). A number of wading birds were also recorded, including the White-faced Heron (*Egretta novaehollandiae*), Black-winged Stilt (*Himantopus himantopus*), Black-fronted Dotterel (*Elseyornis melanops*) and Masked Lapwing (*Vanellus miles*).

Several raptor species were also recorded in the study area, including the Wedge-tailed Eagle (*Aquila audax*), Little Eagle (*Hieraaetus morphnoides*), Brown Falcon (*Falco berigora*) and Nankeen Kestrel (*Falco cenchroides*). A large number of species also occurred in the forested portions of the site, with generally greater species abundance and diversity being found in the eastern forested areas, where a total of 42 species was recorded. Species commonly occurring in these forested communities included the Galah (*Cacatua roseicapilla*), Sulphur-crested Cockatoo (*Cacatua galerita*), Eastern Rosella (*Platycerus eximius*), Pallid Cuckoo (*Cuculus pallidus*), Laughing Kookaburra (*Dacelo novaeguineae*), Sacred Kingfisher (*Todiramphus sanctus*), Spotted Pardalote (*Pardalotus punctatus*), Yellow Thornbill (*Acanthiza nana*), Speckled Warbler (*Chthonicola sagittata*), Noisy Friarbird (*Philemon corniculatus*), Noisy Miner (*Manorina melanocephala*), Willie Wagtail (*Rhipidura leucophrys*), Black-faced Cuckoo-shrike (*Coracina novaehollandiae*), Pied Butcherbird (*Cracticus nigrogularis*), Australian Magpie (*Gymnorhina tibicen*), Pied Currawong (*Strepera graculina*), Australian Raven (*Corvus coronoides*) and White-winged Chough (*Corcorax melanorhamphos*).

A relatively high diversity of species (33 species) was also recorded in the pastoral grassland community and associated waterbodies, within the study area. Species recorded in this area included the Brown Quail (*Coturnix australis*), Crested Pigeon (*Ocyphaps lophotes*), Sulphur-crested Cockatoo (*Cacatua galerita*), Horsfield's Bronze-Cuckoo (*Chrysococcyx basalis*), Superb Fairy-wren (*Malurus cyaneus*), Magpie-lark (*Grallina cyanoleuca*), Willie Wagtail (*Rhipidura leucophrys*), Australian Magpie (*Gymnorhina tibicen*), Pied Currawong (*Strepera graculina*), Australian Raven (*Corvus coronoides*), Welcome Swallow (*Hirundo neoxena*), Clamorous Reed-warbler (*Acrocephalus stentoreus*), Tawny Grassbird (*Megalurus timoriensis*), Rufous Songlark (*Cinclorhamphus mathewsi*) and Brown Songlark (*Cinclorhamphus cruralis*).

Species diversity was highest in the eastern forested portions of the study area, where 42 species were recorded. The portion of forest to the south of Thomas Mitchell Drive had higher species diversity than the portion to the north of Thomas Mitchell Drive (37 and 22 species respectively), probably because of more diverse vegetation in the southern portion and the presence of water in the creek line. The forested portion in A171 at the western end of the proposed rail loop had lower species diversity, with a total of 14 species being identified.

4.2.2 Herpetofauna

Seven amphibian species were identified in the study area, with all species being recorded, with one exception, in aquatic or temporary aquatic habitat areas. The exception was one Smooth Toadlet (*Uperoleia laevigata*) which was located beneath fallen bark in the *Eucalyptus tereticornis* Woodland – Open Forest community. This species was also located in some of the aquatic habitats present in the area.

The most commonly occurring amphibian species occurring in the study area were the Spotted Grass Frog (*Lymnodynastes tasmaniensis*), the Common Eastern Froglet (*Crinia signifera*) and the Eastern Dwarf Tree Frog (*Litoria fallax*). Other species recorded were Tylers Toadlet (*Uperoleia laevigata*), the Broad-palmed Rocket Frog (*Litoria latopalmata*) and Peron's Tree Frog (*Litoria peronii*). Species diversity and abundance was generally observed to be greatest in areas containing permanent standing water including farm dams and the larger pools in drainage lines. Areas containing periodic aquatic habitat had lower species diversity, typically being limited to two species, the Spotted Grass Frog (*Lymnodynastes tasmaniensis*) and the Common Eastern Froglet (*Crinia signifera*).

Nine Reptile species were also identified in the study area, including one Tortoise (Long-necked Tortoise – *Chelodina longicollis*), seven lizards and one snake. Of these species only one, the Eastern Water Skink (*Eulamprus quoyii*), was recorded in the pastoral grassland community area. The remainder of species, excepting the Long-necked Tortoise, were found in the forested portions of the study site. Species recorded in the forested areas included the Wood Gecko (*Diplodactylus vittatus*), Bearded Dragon (*Pogona barbata*), Striped Skink (*Ctenotus robustus*), Tree Skink (*Egemia striolata*), Eastern Water Skink (*Eulamprus quoyii*), Grass Skink (*Lampropholis delicata*), Eastern Blue-tongued Lizard (*Tiliqua scincoides*) and the Red-bellied Black Snake (*Pseudechis porphyriacus*). The occurrence of reptile species throughout the forested sections of the study area was generally evenly distributed, with no particular area providing generally higher quality habitat.

4.2.3 Mammals

A total of 22 mammal species were recorded in the study area, including two probable identifications (Swamp Wallaby – *Wallabia bicolor* [scat] and Sugar Glider – *Petaurus breviceps* [Hair]), and five introduced species (Fox, Rabbit, Brown Hare and Cattle). Of these 22 species, three are listed as Vulnerable in Schedule 2 of the Threatened Species Conservation Act 1995, being the Squirrel Glider (*Petaurus norfolcensis*), Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) and the Common Bent-wing Bat (*Miniopterus norfolkensis*). The most commonly occurring mammal species recorded in the area were the Eastern Grey Kangaroo and the Common Brushtail Possum, with the most commonly recorded microchiropteran bat species including the Southern Freetail Bat (*Mormopterus planiceps*), Gould's Wattled Bat (*Chalinolobus gouldi*) and the Chocolate Wattled Bat (*Chalinolobus morio*).

Mammal diversity and density was higher in forested communities when compared with pastoral grasslands, particularly in the forested communities at the eastern end of the study area. The western forested area (Mining Authorisation Area (A171)) was generally more highly degraded than the remaining forested portions of the site, with fewer species being recorded in this area. The pastoral grassland community was limited in use to the Eastern Grey Kangaroo (*Macropus giganteus*) and Common Wallaroo (*Macropus robustus*), with several introduced species, including the House Mouse (*Mus musculus**), Fox (*Vulpes vulpes**), Rabbit (*Oryctolagus cuniculus**) and Cattle (*Bos taurus**) also occurring. Other local macropod species are also considered likely to use the pastoral habitat areas, however, no microchiropteran bat species were recorded in the pastoral grassland area.

4.3 THREATENED FAUNA SPECIES

Three threatened species were recorded in the study area during field surveys completed for the proposed development, being the Common Bent-wing Bat, Yellow-bellied Sheathtail Bat and Squirrel Glider. The location at which each of these species was recorded in the study area is indicated on **Figure 4.1**.

4.3.1 Squirrel Glider

One male Squirrel Glider (*Petaurus norfolcensis*) was captured in the *Eucalyptus tereticornis* Woodland – Open Forest community during field surveys conducted on site (refer to **Figure 4.1**). A glider was also observed during stagwatching undertaken in the Mixed Eucalypt Woodland community in the vicinity in which the male Squirrel Glider was captured, however due to the short period of sighting a positive identification could not be made. The individual was observed to glide and land on a hollow bearing tree shortly after dusk indicating that it had not nested in that particular tree during the daylight period. Two hair funnels, which were located in the area between Wire Lane and Thomas Mitchell Drive to

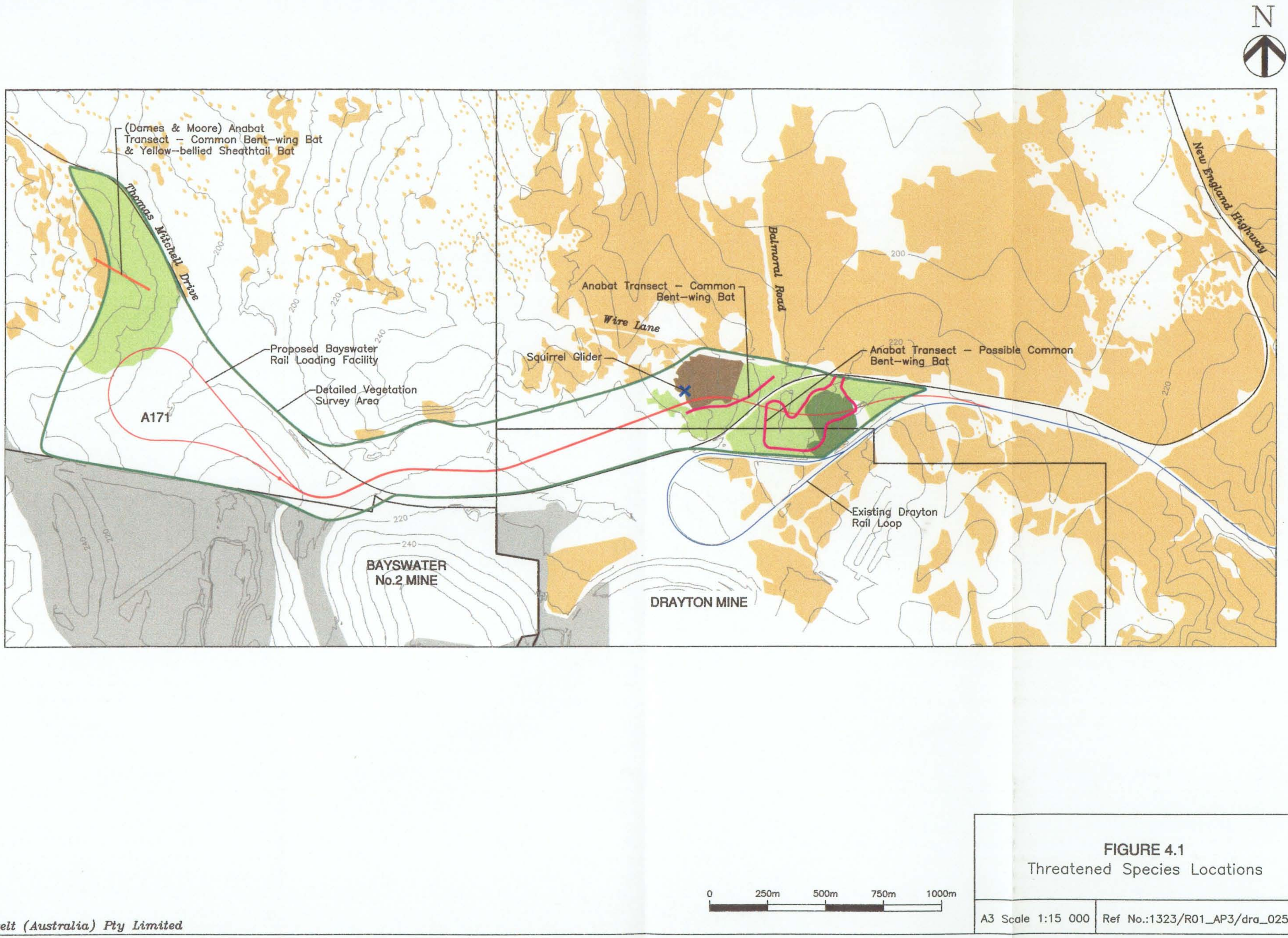

FIGURE 4.1
Threatened Species Locations

A3 Scale 1:15 000 | Ref No.:1323/R01_AP3/dra_025.dwg

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the east of the *Eucalyptus tereticornis* Woodland – Open Forest community area, contained hair samples from a *Petaurus* sp., thought to probably be a Sugar Glider (*Petaurus breviceps*). Hair sample analysis was undertaken by Barbara Triggs of Genoa Victoria, with the samples being identified as a probable Sugar Glider due to the shortness of the hair in the sample. Squirrel Gliders also, however, have short hairs on certain parts of their body, including their head, resulting in the samples not being positively identified to species level (Barbara Triggs, pers. com.).

A number of potential nesting sites exist in the area where the Squirrel Glider was captured, with one hollow bearing tree being located in the area proposed to be cleared for the rail loop construction. This tree contains several dead limbs which contain large and medium sized hollows, known to provide nesting sites for up to four Brushtail Possums. As discussed above, a glider was observed to land on the hollow bearing tree shortly after dusk indicating that it had not nested in the tree during the preceding day. The remaining hollow bearing trees will be unaffected by the proposed development, with approximately 6 hollow bearing trees (approximately 10 hollows) containing hollows potentially suitable for use by Squirrel Gliders present in the area of known habitat of the species. Stagwatching, trapping and spotlighting activities in the area have not positively identified the nest site of the individual recorded, however it is considered that a number of sites may be being utilised. Potential habitat for this species in the study area consists of the eastern forested area, with the areas to the north of Wire Lane outside the study area also considered to provide potential habitat.

Squirrel Gliders nest in colonies of 2–9 individuals, typically in female dominated groups (Quin, 1995). Quin (1995) observed nesting groups to be female dominated in a population having a male biased sex ratio, suggesting that some male Squirrel Gliders must nest alone, potentially whilst attempting to find a vacant position in a group into which they can be recruited. Male Squirrel Gliders are also known to disperse from their natal area at approximately one year of age, potentially due to dominant adult male aggression (Quin, 1995).

Home ranges of Squirrel Gliders vary depending on habitat characterises and abundance of food resources. Habitat ranges from a study undertaken north of Port Macquarie on the east coast of NSW were recorded as being 3.08 $\pm$ 0.41 ha (estimates by harmonic mean (HM) method), using a grid trapping system (Quin, 1995). A study being undertaken in the vicinity of the study area, using radio tracking, has determined the home ranges of two Squirrel Glider colonies as being 37.74 ha and 28.66 ha (estimated using the harmonic mean method) (Geoff Maskey, Environmental Officer Mt Owen Mine, pers. com.). It is considered that a habitat range in the vicinity of that recorded by the second study is likely to be used by the Squirrel Glider captured in the study area due to the proximity of this study to the proposal area, and the general similarity of the habitat types located in both areas.

4.3.2 Common Bent-wing Bat

The Common Bent-wing Bat was recorded at three locations in the study area, including in the forested portion of the Mining Authorisation Area (A171) by Dames and Moore. The species was also recorded in the eastern forested area to the north of Thomas Mitchell Drive and possibly also recorded in the forested area south of Thomas Mitchell Drive (refer to **Figure 4.1**). The Common Bent-wing Bat is a cave roosting species which is thought to roost on Mount Arthur, however no roosting sights have been positively identified, despite a number of previous investigations (Resource Planning, 1993, Gunninah 1997, Dames & Moore, 1999). The species is typically found in well-timbered valleys where it forages above the tree canopy (Dwyer, 1998). During spring adult females move from scattered roosts to specific nursery caves that provide high temperatures and humidity throughout the year. Disturbance of these nursery caves may place the survival of widespread populations in jeopardy (Dwyer, 1998). The species is also vulnerable to disturbance of roosts used for hibernation, with any such disturbance potentially increasing winter mortality (Dwyer, 1998).

4.3.3 Yellow-bellied Sheathtail Bat

The Dames and Moore study also recorded the Yellow-bellied Sheathtail Bat in the A171 area during a walking Anabat II transect (refer to **Figure 4.1**), with the species being recorded a relatively small number of times. The species was not recorded in the remainder of the study area. The Yellow-bellied Sheathtail Bat is a tree roosting species which feeds above the canopy and is thought to be migratory in southern Australia (Richards, 1998). It would appear that the species is restricted in distribution in the study area to the forested portion of the Mining Authorisation Area (A171).

The Yellow-bellied Sheathtail Bat is typically a solitary species, however it occasionally occurs in colonies of less than ten individuals. It typically roosts in tree hollows, however it has also been found in the abandoned nest of Sugar Gliders and occasionally on the walls of buildings in broad daylight (Richards, 1998). It is thought that the species is migratory in southern Australia (Richards, 1998).

5.0 THREATENED SPECIES RECORDED IN THE REGION

5.1 THREATENED SPECIES ASSESSMENT – FLORA

A number of threatened flora species are known to occur in the vicinity of the Bayswater Rail Loop proposal area. Several of these species are, however, considered unlikely to occur in the study area, with potential habitat for these species generally being limited. An assessment of each of the threatened flora species recorded in the Muswellbrook 1:100,000 map sheet area, and the southeastern section of the Camberwell 1:100,000 map sheet area (NPWS Atlas database), is included in **Table 5.1** below with an indication of whether full assessment under Section 5A of the Environmental Planning & Assessment Act, 1979 is required. No threatened flora species have been recorded in a 16 km radius area around the study site despite numerous studies in the immediate area.

Table 5.1 – Threatened Flora Assessment

Species	Habitat Requirements	Impact Assessment
Ozothamnus tessellatus	Dense shrub to 1 metre with woolly branches. Grows in Eucalypt woodland in the area north of Rylstone. It typically occurs on Narrabeen Group Sandstones, and is unlikely to occur in the study area (Travis Peak, Hunter Remnant Vegetation Project, HCMT, pers. com.).	The study area lacks the required habitat characteristics of this species, and does not occur on Narrabeen Group Sandstones. The species was not recorded in the study area and is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Prostanthera cineolifera	Erect shrub 1-4 metres high, aromatic with pale mauve to dark purple-mauve flowers, darker in the throat. The distribution of this taxon is uncertain but it appears to grow in sclerophyll forest. The species occurs in the region on Narrabeen Group Sandstones, and is unlikely to occur in the study area (Travis Peak, Hunter Remnant Vegetation Project, HCMT, pers. com.).	The study area lacks the required habitat characteristics of this species, with the study area lacking a Narrabeen Group Sandstone substrate. The species was not recorded in the study area and is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Prostanthera cryptandroides	Low shrub 0.5-2 metres high, strongly aromatic with lilac to mauve flowers. Grows in dry sclerophyll forest, often in rocky sites. In the Denman – Gungal and Widden – Baerami Valley areas the species grows on rocky ridgelines on Narrabeen Group Sandstones (NPWS, 1999).	The study area lacks the required habitat characteristics of this species, lacking rocky habitats and Narrabeen Group Sandstone substrates. The species is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Eucalyptus pumila Pokolbin Mallee	Mallee to 6m high with smooth grey or grey-brown bark, shedding in short ribbons. Grows in sclerophyll shrubland, and is known from a single stand on skeletal soil on sloping sandstone near Pokolbin.	The distribution of this species is known to be limited, with the habitats of the study area not meeting its known requirements. The species was not found in the study area and is unlikely to occur. No significant impact will occur, no further assessment is required.

Table 5.1 – Threatened Flora Assessment (cont)

Species	Habitat Requirements	Impact Assessment
Bothriochloa biloba	Erect or decumbent caespitose perennial to 1m high, with racemes having white or purplish hairs. Grows in woodland on poorer soils. The species has been recorded approximately 16 km east of the study area in 1960, occurring in the Hunter River floodplain north of Denman.	This species was not located in the study area and is considered unlikely to occur due to the degraded nature of the vegetation, particularly taking into account the relatively high percentage of weed species. Also, the habitats of the study area are not consistent with those of its only recorded regional occurrence, with the species being considered unlikely to occur. No significant impact will occur, no further assessment is required.
Lasiopetalum longistamineum	Spreading shrub to 1.5m high. Flowers crowded in spike-like branches, flowering in spring. Grows in rich alluvial deposits in the Gungal to Mt Danger.	The species was not recorded in the study area with the lack of rich alluvial deposits within the study area indicating that the species is unlikely to occur. No significant impact will occur.
Rulingia procumbens	Prostate shrub with slender trailing stems to 30cm long arising from woody stolons. Grows in sandy sites mainly confined to the Dubbo-Gilgandra region, also in Pilliga and Nymagee areas.	The species was not recorded in the study area, with the area lacking the sandy sites preferred by this species. It is unlikely to occur, and no significant impact will occur, no further assessment is required.
Pomaderris queenslandica	Shrub 2-3m high, stems whitish, shortly stellate-tomentose with scattered hairs. Flowers cream. Not collected since 1904, with specimens only from Mt Danger and Gloucester district (Harden, 1990). The species was also recently recorded north of Sandy Hollow in the vicinity of the Manobalai Nature Reserve. The species is known to occur in the region on Narrabeen Group Sandstones, and is unlikely to occur in the study area (Travis Peak, Hunter Remnant Vegetation Project, HCMT, pers. com.).	The study area lacks the required habitat characteristics of this species, and does not occur on Narrabeen Group Sandstones. The species was not recorded in the study area and is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Philotheca ericifiolia	A spreading shrub to 1-2 metres with sparsely glandular-warty stems. It occurs in dry sclerophyll forest and heath on damp sandy flats and gullies in the upper Hunter Valley and Pilliga to Peak Hill district.	The habitats in the study area do not meet the requirements of this species, with an absence of damp sandy flats and gullies occurring in the study area. The species was not located and is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Diuris pedunculata	A terrestrial orchid with 2 linear to filiform leaves and nodding pale yellow flowers with orange labellum and dark striations on the dorsal sepal. Grows in moist grassy areas in sclerophyll forest chiefly from Port Jackson to Tenterfield.	The species was not recorded in the study area with the degraded vegetation types found in the study area not being consistent with records of the species' known habitat, lacking moist grassy areas. The species is unlikely to occur, and no significant impact will occur, no further assessment is required.

References: *Harden, 1990, 1991, 1992, 1993, and NSW NPWS, 1999.*

5.2 THREATENED SPECIES ASSESSMENT - FAUNA

A number of threatened fauna species are known to occur in the vicinity of the Bayswater Rail Loop proposal area. Several of these species are considered unlikely to occur in the study area, with potential habitat for these species generally being limited. An assessment of each of the threatened fauna species recorded in the Muswellbrook 1:100,000 map sheet area, and the southeastern section of the Camberwell 1:100,000 map sheet area (NPWS Atlas database), is included in **Table 5.2** below with an indication of whether full assessment under Section 5A of the Environmental Planning & Assessment Act, 1979 is required. Some additional threatened species considered to potentially occur within in the region are also included in the assessment.

A full assessment for those species requiring further assessment under Section 5A of the Threatened Species Conservation Act 1995 is included in **Section 7.0**.

Table 5.2 – Threatened Fauna Assessment

Species	Habitat Requirements	Impact Assessment
Turquoise Parrot *Neophema pulchella*	Occurs in open grassy woodland with dead trees near permanent water and forested hills. May also occur in coastal heaths and pastures with exotic species. Feeds quietly in low grass. It is commonly recorded in woodland or open forest adjoining cleared areas (Forshaw & Cooper, 1981).	The Turquoise Parrot is a wide ranging species which is unlikely to be affected by the removal of a small area of forested vegetation given the extent of similar vegetation in the region. The species was not recorded in the study area, however it has been recorded in the region and is considered further in **Section 7.0**.
Glossy Black Cockatoo *Calyptorhynchus lathami*	She-oaks in woodlands, forests, and timbered watercourses. Nests in large hollows high up within the tree.	Little potential habitat for the species occurs in the study area, with She-oaks being very sparsely scattered in the area. The species was not recorded in the study area, with the nearest recording being approximately 27.5 km from the study area. The species is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Powerful Owl *Ninox strenua*	Open forests, woodland, riparian habitats and closed forests. Extensive home range (up to 1000 hectares). Nests on decayed debris in a large hollow in trunk or large branch.	The species was not recorded in the study area despite target surveys, with the nearest record of the species being 30 km from the proposal area. The species is considered unlikely to occur in the area, with no potential nesting sites occurring in the area to be removed under the proposal. The proposal will not remove a significant area of potential foraging habitat for the species. No significant impact will occur, no further assessment is required.

Table 5.2 – Threatened Fauna Assessment (cont)

Species	Habitat Requirements	Impact Assessment
Masked Owl *Tyto novaehollandiae*	Forests, woodlands and farmlands with large trees, and adjacent cleared country. Also found in timbered watercourses, paperbark woodlands and caves. Nests in hollow eucalyptus or in caves.	The species was not recorded in the study area despite target surveys, with no regional records existing for the species. The species is considered unlikely to occur in the area, with no potential nesting sites occurring in the area of vegetation to be removed under the proposal. The area may form part of a home range, however the proposal will not remove a significant area of foraging habitat. No significant impact will occur, no further assessment is required.
Red Goshawk *Erythrotriorchis radiatus*	Open forests and woodlands, especially near rivers and wetlands. It also inhabits rainforest fringes. Rarely seen south of the Q-NSW border. Nests in stick nests in heavy forks of *Eucalyptus* or *Melaleuca* to a height of 10-20m+.	The species was not recorded in the study area with the nearest record being approximately 31 km from the study area. The lack of forested habitat near rivers and wetlands results in their being little or no potential habitat in the study area. The species is considered unlikely to occur. No significant impact will occur, no further assessment is required.
Swift Parrot *Lathamus discolor*	Inhabits forests, woodlands, plantations, banksia etc., also street trees parks and gardens. Breed only in Tasmania with nests in tree hollows 6-20 metres high.	The nearest recording of the species is in 1968 approximately 30 km north of the proposed development area. Some potential foraging habitat may occur in the study area, however the species is wide-ranging with only a small area of degraded vegetation to be removed. The development will not impact on breeding of the species. No significant impact will occur, no further assessment is required.
Bush Stone-curlew *Burhinus grallarius*	Found in open woodland, dry watercourses with fallen branches, leaf litter and sparse grass; sandplains with spinifex and mallee; coastal scrub and mangrove fringes, golf courses and rail reserves; also suburbs and towns, cities in Queensland and resort islands. Lays eggs on bare ground.	The species was not recorded in the study area during surveys conducted on site, with the nearest record for the species being in 1978 approximately 30 km from the study area. The species is considered unlikely to occur in the study area especially due to the presence of predators including the European Red Fox. No significant impact will occur, no further assessment is required.
Freckled Duck *Stictonetta naevosa*	Inhabits large well-vegetated swamps, moving to lakes in dry periods. Breeds mostly in irregularly flooded lignum swamps in western NSW. Disperses into southeast and south coastal areas.	No potential habitat occurs on site with only small waterbodies present. The species is considered unlikely to occur. No significant impact will occur, no further assessment is required.

Table 5.2 – Threatened Fauna Assessment (cont)

Species	Habitat Requirements	Impact Assessment
Regent Honeyeater *Xanthomyza phrygia*	Temperate Eucalypt woodlands and Open Forests including forest edges. Associations of Red Ironbark, White Box, Yellow Box, Yellow Gum and Red Box appear essential. Swamp Mahogany and River Oak may be used locally.	The vegetation communities in the study area do not meet the requirements of this species, with it not being recorded in the Muswellbrook 1:100,000 map sheet area. The species is considered unlikely to occur. No significant impact will occur.
Green and Golden Bell Frog *Litoria aurea*	Occurs in large permanent swamps and ponds with plenty of emergent vegetation, especially bullrushes. It will occasionally inhabit ornamental ponds and farm dams where these are close to the preferred habitat.	The species was not recorded in the study area despite comprehensive surveys undertaken in suitable conditions. The nearest record of the species is approximately 17 km from the study site, with the species considered unlikely to occur at this site. Further assessment is however undertaken in **Section 7.0**.
Koala *Phascolarctos cinereus*	Habitat consists of Eucalypt forest and woodlands containing particular species including Red Gum, Grey Gum, Manna Gum, Tallowwood, and Swamp Mahogany.	SEPP 44 assessment indicates that although part of the forested portion of the study area does form potential Koala habitat, there is no core Koala habitat located in the study area (refer to **Section 5.3**). Targeted searches failed to find any indication of the species presence. The species is therefore unlikely to occur, and no significant impact will occur, no further assessment is required.
Squirrel Glider *Petaurus norfolcensis*	Occurs in wet and dry sclerophyll forests and woodlands. Nests in tree hollows and has a home range of 20 to 30 hectares. Feeds on insects, acacia gum and eucalypt sap released by incising the bark.	The species was recorded in the study area. Refer to **Section 7.0** for further assessment.
Brush-tailed Rock Wallaby *Petrogale penicillata*	Rocky sites in sclerophyll forests with a grassy understorey. This species shelters in caves, rocky crevices and dense stands of Lantana during the day. Most commonly, sites occupied by this species have a northerly aspect.	The lack of dense understorey and diurnal shelters in rocky crevices and caves means that the species is unlikely to occur in the area. No significant impact will occur, no further assessment is required.
Parma Wallaby *Macropus parma*	Inhabits rainforest and sclerophyll forests with a dense understorey and grassy areas, normally in mountain areas. They rest under shrubs in dense vegetation during the day.	Species tentatively recorded in the vicinity of the study area (Dames and Moore). Refer to **Section 7.0** for further assessment.
Tiger Quoll *Dasyurus maculatus*	A mainly nocturnal marsupial carnivore recorded in rainforest, open forest, woodland, coastal heathland and inland riparian forest. Den sites have been recorded in caves, rock crevices and hollow logs.	The species was not recorded in the study area with the nearest recorded locations being to the north of Muswellbrook (approx. 15 km from study area), and to the west of Denman (5.5 km west of Denman). The study area generally lacks potential den sites, with the species considered unlikely to occur. No significant impact will occur, no further assessment is required.

Table 5.2 – Threatened Fauna Assessment (cont)

Species	Habitat Requirements	Impact Assessment
Eastern Little Mastiff Bat *Mormopterus norfolkensis*	The habitat preferences of this species are unclear, however most records are from dry eucalypt forest and woodland east of the Great Dividing Range. The species is thought to be predominantly tree-dwelling, however one individual has been recorded roosting in the roof of a hut.	The species was not recorded in the study area, and was also not recorded by the Dames and Moore Study, or any other adjacent studies (Resource Planning, 1993 and Gunninah, 1997). It is considered unlikely that the species occurs in the study area with only a small area of potential habitat being affected. No significant impact will occur, no further assessment is required.
Large-footed Myotis *Myotis adversus*	The species is typically cave roosting, however it may also roost in buildings and in dense foliage. It typically forages over waterbodies and along streams.	Limited, highly degraded potential foraging habitat occurs in the study area, with the species not recorded and unlikely to occur. No potential cave roosting sites occur in the study area, with only a small area of marginal habitat being affected. No significant impact will occur, no further assessment is required.
Great Pipistrelle *Falsistrellus tasmaniensis*	Found in wet and dry sclerophyll forests, preferring highland areas. Nests in caves, abandoned buildings and tree hollows. It is a highly mobile species which forages in and above the upper canopy.	The species was not recorded in the study area, and was also not recorded by the Dames and Moore study, or any other adjacent studies. The species is considered unlikely to occur with only limited marginal habitat being affected. No significant impact will occur, no further assessment is required.
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	Found in rainforests, sclerophyll forests and woodlands, this species roosts alone or with up to 10 others in large hollow trees, the abandoned nests of Sugar Gliders or in buildings. It hunts high above the forest canopy and in clearings.	This species has been recorded in the study area. A full assessment is present in **Section 7.0.**
Common Bent-wing Bat *Miniopterus schreibersii*	Wet and dry sclerophyll forests and rainforests. This species generally hunts above the forest canopy, and roosts in caves, mine tunnels and buildings.	This species has been recorded in the study area. A full assessment is present in **Section 7.0.**

References: *Mammals – Cronin, 1991 and Strahan, 1998; Frogs – Robinson, 1993; Birds – Pizzey & Knight, 1997.*

5.3 SEPP 44 ASSESSMENT

The proposed rail loop development is subject to assessment under State Environmental Planning Policy (SEPP) No. 44 (Koala Habitat Protection) as it lies in a local government area listed in Schedule 1 of the policy. SEPP 44 aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline. Any development application in an identified local government area, affecting an area 1 hectare or greater, must be assessed under the policy.

Assessment under SEPP 44 is based on an initial determination of whether the land constitutes potential koala habitat. This is determined by assessing whether the Eucalypt species present in Schedule 2 of the policy constitute 15% or more of the total number of trees in the upper or lower strata of the tree component. If potential koala habitat is present, the area must be further assessed to determine if the land is core koala habitat.

The species listed in Schedule 2 of the policy are:

Scientific Name	Common Name
Eucalyptus tereticornis	Forest Red Gum
Eucalyptus microcorys	Tallowwood
Eucalyptus punctata	Grey Gum
Eucalyptus viminalis	Ribbon or Manna Gum
Eucalyptus camaldulensis	River Red Gum
Eucalyptus haemastoma	Broad Leaved Scribbly Gum
Eucalyptus signata	Scribbly Gum
Eucalyptus albens	White Box
Eucalyptus populnea	Bimble Box or Poplar Box
Eucalyptus robusta	Swamp Mahogany

Two SEPP 44 habitat tree species were located in the study area, being *Eucalyptus albens* (White Box) and *Eucalyptus tereticornis* (Forest Red Gum). *Eucalyptus albens* was present in the Mixed Eucalypt Woodland community which occurs as the largest portion of the forested communities on site, while *Eucalyptus tereticornis* was found in both the *Eucalyptus tereticornis* Woodland – Open Forest and the Mixed Eucalypt Woodland communities. The Mixed Eucalypt Woodland community contains *Eucalyptus albens* and *Eucalyptus tereticornis* to varying abundance, with the eastern A171 portion of this community generally containing the highest proportion of *Eucalyptus albens*. The entire area covered by both of these vegetation communities is considered to provide potential Koala habitat as defined under the policy, however the percentage of SEPP 44 species in some areas of the Mixed Eucalypt Woodland is relatively low, with Koala habitat being non-existent or marginal in some portions.

As potential Koala habitat occurs in the study area, the policy requires that it must be determined whether the area forms core Koala habitat. Core Koala habitat is defined as; "*an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population*". Comprehensive diurnal and nocturnal searches were conducted throughout the area comprising potential Koala habitat with no Koalas being recorded. Searches were also conducted in the area of potential Koala habitat to locate any indications of Koalas use of the site, including examination of trunks for scratch marks, and searches for scats. No such evidence was found during the surveys, with it being concluded that there is not a resident population of Koalas in the study area.

Existing Atlas database (NPWS) records for the Muswellbrook region were also examined to determine whether there were any records of a historical population occurring in the study area. Three historical Koala records exist in the Muswellbrook 1:100,000 map sheet area, however none of these records occur in the study area or adjoining areas (Atlas database). The nearest record to the study area is in 1954 approximately 7.5 km to the south, with other records being approximately 14.5 km to the northeast in 1949 and 20.5 km to the southwest in 1967. Therefore although there are sparse historical Koala records for the Muswellbrook region, there are no records existing in the study area.

The fauna surveys undertaken in the study area have determined that there is not currently a resident population of Koalas occurring at the study site, with no evidence of Koala use of the area being observed. There are also no historical records of Koalas occurring in the study area, although limited regional historic records do exist. The area is therefore not considered to be core Koala habitat as defined under SEPP 44, with the preparation of a Koala Plan of Management not being required. SEPP 44 does not therefore place any constraints on the proposed development.

6.0 IMPACTS OF THE PROPOSAL

6.1 IMPACT ON FLORA

The proposed rail loop development has been designed to avoid areas of woodland – open forest vegetation where possible with the majority of the disturbance area being restricted to pastoral grassland. The areas of each vegetation community to be affected by the proposed development are indicated in **Table 6.1** below, with a total of 5.75 hectares (approximately 12.4% of the total forested portion of the study area) of forested areas being affected. Approximately 13.9 hectares of pastoral grassland will also be affected by the development, however a large area of this community will remain, with significant areas of pastoral land also occurring throughout the region.

In addition to the portion of the study area that will remain unaffected by the development, large areas of similar vegetation occur in adjacent areas. These adjoining areas include substantial areas of pastoral grassland and several areas of aquatic vegetation. A large area of interconnected woodland – open forest vegetation also adjoins the study area, with approximately 235 hectares existing in the area bound by Thomas Mitchell Drive to the south and the New England Highway to the east. Additional areas of similar vegetation also exist to the south of Thomas Mitchell Drive and to the east of the New England Highway. The area of vegetation affected by the proposed development is therefore considered to be relatively small in the context of the wider study area.

The forested vegetation communities found in the study area are generally characteristic of the communities found in the region, with *Eucalyptus crebra / Corymbia maculata* and *Eucalyptus crebra / E. albens* vegetation associations being recorded throughout the area (Dames and Moore, 1999; Resource Planning, 1993; Gunninah 1997; ERM Mitchell McCotter, 1997). The floral diversity of the vegetation remnants in the study area is similar to other vegetation remnants in the region, with the communities not being considered to be floristically significant. The forested vegetation areas do however have some significance due to a large portion of the region being cleared of remnant native vegetation.

Although each patch of remnant vegetation in the study area has some significance due to the generally high regional percentage of cleared pastoral areas, only a small area of approximately 5.75 hectares will be cleared under the proposal. It is not considered that the removal of this small area of vegetation is significant on a local or regional scale, particularly taking into account the relatively large area of proposed compensatory habitat (refer to **Section 8.1**). The development of approximately 35.2 hectares (including 15.3 hectares of existing vegetation) of compensatory habitat and the establishment of a habitat corridor consisting of 21.1 hectares of vegetation, taking into account the proposed removal of approximately 5.75 hectares of remnant vegetation, will result in a net gain of approximately 41 hectares of native Woodland – Open Forest vegetation in the study area. The long-term development will therefore result in an increase in the area of native woodland – open forest vegetation in the region, with the short-term loss of 5.75 hectares not being considered significant in a regional perspective.

Table 6.1 – Area Affected by the Proposal by Community Type

Community Type	Existing Area (in vegetation study area)	Area Affected	% Area Affected
Pastoral Grassland	105.3 ha	13.9 ha	13.2%
Mixed Eucalypt Woodland	37.8 ha	4.25 ha	11.2%
Corymbia maculata Woodland	4.5 ha	0.5 ha	11.1%
Eucalyptus tereticornis Woodland – Open Forest	4 ha	1 ha	25%
Aquatic habitat	4.4 ha	0.46 ha	10.5%

6.2 IMPACT ON FAUNA

The proposal is generally considered unlikely to have a significant impact on the fauna habitat in the region, with only a relatively small area of forested habitat (approximately 5.75 hectares) and pastoral grassland (13.9 hectares) habitat being affected. The development will also only have a minimal impact on the aquatic habitats in the study area as discussed below (**Section 6.2.3**). The potential impacts of the proposed development on the threatened species identified as occurring or potentially occurring in the study area are not addressed in this section, and are fully assessed in **Section 7.0**.

6.2.1 Pastoral Habitats

As discussed in **Section 4.1**, the pastoral grassland areas offer only poor quality fauna habitat and are typically only used by species able to adapt to degraded habitat areas. These areas are not considered to provide core habitat for the majority of locally occurring native fauna species. A range of introduced fauna species also use the pastoral grassland community area, with large areas of similar pastoral grassland vegetation remaining undisturbed in the study area and surrounding areas. The removal of approximately 13.9 hectares of this pastoral vegetation is therefore considered to be insignificant on both a local and regional scale from a fauna habitat perspective.

6.2.2 Forested Habitats

As discussed in **Section 6.1**, a comparatively small area of forested habitat will be affected by the proposed development, with the establishment of compensatory habitat likely to further reduce any potential impacts. These forested areas provide habitat for a range of fauna species, however the habitat provided in the areas to be impacted is not considered to be significantly different to the adjacent habitat areas which will be retained. There are also substantial areas of similar Woodland – Open Forest vegetation outside the study area (refer to **Figure 3.2**) which result in the small area of forested vegetation to be removed being insignificant at a regional scale.

It is also considered that there will not be a significant loss of forest fauna habitat on a local scale with only approximately 12.4% of the Woodland – Open Forest vegetation within the study area being affected. As discussed previously, the study area is also connected to an area of approximately 235 hectares of woodland – open forest vegetation resulting in the area of vegetation to be removed being approximately 2% of the local forested habitat area. These areas of adjoining forested habitat are located to the north of Wire Lane, which is a narrow, little used road that is unlikely to be a significant barrier to fauna movement.

The proposed path of the rail loop has also been designed to maximise avoidance of hollow bearing trees, with only one hollow bearing tree being located in the area proposed to be cleared for the rail loop construction. This tree contains several dead limbs which contain large and medium sized hollows. The remaining hollow bearing trees found in the eastern forested portion of the study area will be unaffected by the proposed development, with approximately 15 hollow bearing trees being retained, several of which containing a number of hollows. No hollow bearing trees will be removed from the western forested portion of the study area (A171 area). The majority of the hollows found in the study area are located in the general vicinity of the hollow bearing tree affected by the proposal. The re-erection of the hollows to be removed, combined with the use of nest boxes (refer to **Section 9.0**) will result in there being no net loss of tree hollow roosting and nesting sites in the study area.

The establishment of compensatory habitat areas in the immediate vicinity of the forested portions to be impacted is also considered likely to further reduce any local loss of fauna habitat. The establishment of this compensatory habitat area will result in a net long-term gain of fauna habitat in the local area with the proposed development considered unlikely to have an impact on the long-term availability of fauna habitat within the study area.

The proposed development is also considered unlikely to significantly affect the ability of local fauna to move through the forested portions of the proposed development area, with the vegetation in the study area currently being of a generally discontinuous nature. The eastern forested portion of the study area is currently dissected by the Drayton Colliery rail loop to the south, Wire Lane to the north and Thomas Mitchell Drive to the north and between the Drayton rail loop and Wire Lane (refer to **Figure 1.1**). The proposed path of the rail loop is between these existing structures, and is therefore considered unlikely to significantly add to the discontinuity of the vegetation in the area. The proposed rail loop will therefore not prevent the movement of any fauna through the study area, with any species currently moving through the existing dissected vegetation able to cross the proposed rail line structure.

Due to the relatively small forested area to be affected, the retention of adjacent habitat areas and the construction of compensatory habitat, the proposed rail loop development is considered unlikely to result in the removal of a significant area of fauna habitat either on a local or regional scale, or in a short-term or long-term timeframe.

Drayton Colliery Wildlife Refuge

The construction of the proposed Bayswater Rail Loop will require the modification of the existing Drayton Colliery Wildlife Refuge proclamation. Drayton Colliery, as the owner of the land subject to the proclamation, has the right to modify the proclamation or amend the plan of management at any time. The construction of the proposed Bayswater Rail Loop will require the removal of vegetation from within the existing Natural Zone of the Wildlife Refuge, however as discussed above, the removal of Woodland – Open Forest vegetation from this area is considered unlikely to have a significant impact on any local fauna species. The establishment of a substantial area (35.2 hectares) of compensatory habitat, and an associated habitat corridor, will reduce the impact of the loss of vegetation within the Wildlife Refuge, resulting in a 29.8 hectare increase in the total area of vegetation managed for conservation purposes in the study area.

6.2.3 Aquatic Habitats

The development will have a minimal impact on aquatic habitats in the study area with the majority of existing aquatic habitats to be retained. The only areas to be affected by the development are the effluent treatment ponds located in the pastoral grassland community area, and some areas of periodic aquatic habitat occurring in the ephemeral drainage lines in the study area. These ponds will be drained and filled in, as discussed in Section 4.7.3.1 of the EIS. The removal of these ponds is not considered to be significant due to their degraded nature and the presence of two large farm dams in close proximity. The effluent ponds were observed to provide habitat for amphibian species, however, no significant species were recorded, with the species diversity and abundance observed in the ponds not being significantly different to that observed in the adjacent farm dams. The removal and rehabilitation of these ponds is therefore considered unlikely to significantly affect any fauna species relying on local aquatic habitats.

The only other aquatic habitat areas to be affected by the proposal are some of the ephemeral drainage lines which will be crossed by the proposed rail loop, including the edge of a dam which is present in Ramrod Creek. The more defined ephemeral drainage lines contain areas of periodic aquatic habitat following rainfall periods. The proposed rail loop will cross these ephemeral drainage lines using culverts which have been designed to ensure that the existing periodic flow will not be obstructed. There are three ephemeral drainage line crossing points considered to periodically provide small areas of aquatic habitat, with the habitat found in these areas being of a lesser quality than that found in the more permanent drainage lines. These areas were observed to provide habitat for a small number of amphibian species, however it is considered to be poor quality habitat compared to the more permanent aquatic habitat areas on site, which contained greater species diversity and abundance. The majority of ephemeral drainage lines in the study area will however remain unaffected by the proposed development, ensuring that a significant area of this periodic aquatic habitat remains.

6.3 INDIRECT FLORA AND FAUNA IMPACT

The proposed development does not require the disturbance of any currently undisturbed areas outside the flora and fauna assessment study area, however, it will result in additional trains using existing infrastructure. The number of train trips per day of operation will increase, as will the number of operating days for the existing Antiene Rail Spur and Drayton Rail Loop. Coal trains are sources of noise, night-time light and potentially dust, however it is not considered that the increase in usage of the Antiene Rail Spur and Drayton Rail Loop will result in a significant impact on any flora or fauna currently living in the vicinity of the existing rail infrastructure.

It is considered unlikely that the proposed increased use of the Antiene Rail Spur and Drayton Rail Loop will result in any dust impacts on flora adjoining the existing rail line. There is expected to be minimal dust generated by coal trains using the rail line with the proposed increase in the number of coal trains unlikely to have any significant effect on adjacent flora.

Fauna currently occupying habitat areas adjacent to the Antiene Rail Spur and Drayton Rail Loop have adapted to existing in proximity to coal train activity, or are unaffected by such activity, and are unlikely to be affected by an increase in train traffic. It is considered unlikely therefore that the proposal will result in any significant indirect impacts on fauna occurring adjacent to rail infrastructure.

In addition to the potential for indirect impacts from existing rail infrastructure, similar potential exists for indirect impacts from the Bayswater Rail Loop when it becomes operational. As with the potential indirect impacts discussed above however, these impacts are considered unlikely to significantly effect the flora and fauna occurring in proximate areas.

7.0 THREATENED SPECIES ASSESSMENT

7.1 *Saccolaimus flaviventris* - YELLOW-BELLIED SHEATHTAIL BAT

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

The Yellow-bellied Sheathtail Bat was recorded in the study area, by Dames and Moore, and appears to be limited to the habitats in the forested portion of the Mining Authorisation Area (A171) (refer to **Figure 4.1**). The species is known to roost in tree hollows or other similar structures, with no hollows occurring in the area of the A171 forested portion to be affected by the proposal. The species is usually solitary and is thought to be migratory in southern Australia (Richards, 1998).

Yellow-bellied Sheathtail Bats are known from fewer than ten sites in the Hunter Region (Forest Fauna Surveys et al, 1997), although the species is distributed over much of eastern and northern Australia. Richards (1998) considers the species to be rare in widespread habitat, and suggests that the apparent rarity of the species is probably due to its flying so high and fast that it is seldom collected.

There will be only limited clearing (approximately 0.35 hectares) of vegetation from the edge of the Mixed Eucalypt Woodland community in the Mining Authorisation Area (A171) with this area forming potential foraging habitat for the Yellow-bellied Sheathtail Bat. There are no potential roosting hollows located in the portion of the A171 area to be removed by the proposed development, with the proposal therefore not having any impact on potential roosting sites in the area in which the species was recorded. The only possible impact of the development will therefore be a small reduction in potential foraging area. The proposed development will, however, remove only a small area of potential foraging habitat, affecting approximately 0.35 hectares of the 35.3 hectares of the Mixed Eucalypt Woodland community within the A171 area.

The eastern forested portion of the study area is also considered to provide potential habitat for the Yellow-bellied Sheathtail Bat, although it has not been recorded in this area. Approximately 5.4 hectares of woodland – open forest vegetation in this area will be affected by the proposed development, with one hollow bearing tree being removed. This tree has been observed to be occupied by up to four Brushtail Possums, with it considered unlikely that the hollows provide potential roosting habitat for the Yellow-bellied Sheathtail Bat. It is considered unlikely therefore that the proposal will result in the removal of potential roosting habitat for the species, with only a relatively small area of potential habitat being removed.

The removal of a small area of potential habitat is considered unlikely to significantly impact on the species due to the retention of larger adjacent habitat areas and the establishment of the habitat compensation area, which will involve the management of the existing vegetation in the A171 area, and the establishment of an additional 19.9 hectares of potential habitat. It is also considered likely that the 21.1 hectares of vegetation which will be established for the habitat corridor will provide potential habitat for the species in the long term. The proposal is therefore unlikely to have a significant impact on the life cycle of the Yellow-bellied Sheathtail Bat.

b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.

Currently, only a few specific populations have been identified as endangered under the Threatened Species Conservation Act 1995, none of which are relevant to the study area.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The Yellow-bellied Sheathtail Bat was recorded in the Mining Authorisation Area (A171) by Dames and Moore during their 1998 survey. The entire forested portion of the A171 area is comprised of the Mixed Eucalypt Woodland community, with each of these forested areas considered to provide potential habitat for the species. Of the 35.3 hectares of Mixed Eucalypt Woodland in the A171 area, only 0.35 hectares on the edge of the forested area will be affected. It is not considered that this small area, which accounts for less than 1% of the Woodland community within the A171 area, constitutes a significant area of potential habitat.

Approximately 5.4 hectares of woodland – open forest vegetation will also be removed from the eastern forested portion of the study area, however the species is not known to occur in this area. The majority of the eastern forested portion will however be retained, with it therefore being considered that the proposal will not result in the removal or modification of a significant area of known habitat.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species population or ecological community.

The rail loop will not act as a barrier to the distribution of any Yellow-bellied Sheathtail Bats occurring in the vicinity of the study area, with any individuals present being able to easily cross the proposed rail line. The proposal is also considered unlikely to separate any areas of known habitat of the species, with the small area of vegetation to be removed from the A171 area occurring on the edge of the forest vegetation community adjoining pastoral grassland. The species has not been recorded in the pastoral grassland community area, with the proposed rail loop therefore being on the edge of the area used by this species.

It is therefore considered that the proposal will not result in any areas of known habitat being isolated from currently interconnecting or proximate areas.

e) Whether critical habitat will be affected.

No areas of critical habitat have currently been designated under the Threatened Species Conservation Act 1995.

f) Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are few records regarding the occurrence of this species in conservation reserves in the region, however it is considered unlikely that the species is adequately conserved in conservation reserves in the region.

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.*

The proposed activity is not listed as a threatening process, with no currently listed threatening processes being relevant to the proposed development.

h) *Whether any threatened species, population or ecological community is at the limit of its known distribution.*

The Yellow-bellied Sheathtail Bat is known to occur in all mainland states and territories. It is distributed throughout all of NSW and Victoria, and the majority of Queensland and the Northern Territory. The species is not at the limit of its known distribution in the study area.

7.2 *Miniopterus schreibersii* – COMMON BENT-WING BAT

a) *In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.*

The Common Bent-wing Bat was recorded foraging throughout the majority of forested areas within the study area. The species was not, however, recorded foraging above the pastoral grassland community. The Common Bent-wing Bat is a cave roosting species with no potential roosting sites being located in the study area. The species is thought to roost in caves, rock crevices or other similar structures on nearby Mt Arthur, although no roosting sites have been recorded. The proposed rail loop development will not impact on any potential roosting sites for the species.

The Common Bent-wing Bat has been recorded in several locations in the Hunter Valley, including by several studies in the vicinity of the study area (Dames & Moore, 1999, Resource Planning, 1993). The species is distributed along the entire eastern and south eastern coast of Australia from Cape York to South Australia, and is also found in northern areas of Western Australia and the Northern Territory. It also occurs in Europe, Africa and Asia (Dwyer, 1998). Dwyer (1998) regards the current status of the species as abundant.

The proposed development will result in a small reduction (approximately 12.4%) in the area of Woodland – Open Forest vegetation in the study area, with these vegetation types being used by the Common Bent-wing Bat as foraging habitat. The study area is also surrounded by significantly larger areas of similar Woodland – Open Forest vegetation, with these areas not being impacted by the proposal. The proposed development is therefore not considered to be removing a significant area of foraging habitat either in the context of the study area or the wider area as a whole. The proposed habitat compensation area will further reduce any potential impact of the loss of a small area of local habitat, with a net long-term habitat gain being achieved (refer to **Section 8.1**).

The proposed rail loop will not impact on any potential roosting sites, with the only potential impact being a small reduction in the area of foraging habitat. This small reduction in foraging habitat is considered unlikely to be significant either in the context of the study area or the wider area, with significant areas of similar quality potential foraging habitat remaining. Consequently, the proposal will not place at risk of extinction a 'viable local population' of the Common Bent-wing Bat.

b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Currently, only a few specific populations have been identified as endangered under the Threatened Species Conservation Act 1995, none of which are relevant to the study area.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

A small area (5.75 hectares) of known foraging habitat of the Common Bent-wing Bat will be removed by the proposal, however no potential roosting sites will be affected. The removal of this small area of vegetation is considered unlikely to be significant in the context of the study area, with only approximately 12.4% of Woodland – Forest Vegetation in the study area being affected. The retention of the remaining Woodland – Open Forest areas should ensure that there is no impact on the local Common Bent-wing Bat population. The construction of 35.2 hectares of compensation habitat, including approximately 15.3 hectares of existing vegetation, will replace the area of habitat lost in the long term, with habitat construction in this area likely to be relatively quick due to the presence of existing scattered trees and tree clumps (refer to **Section 8.1**).

The area to be removed is also not considered to be significant in the context of the surrounding areas of known and potential habitat. The vegetation of Mount Arthur and the areas to the north and east of the study area provide large areas of similar quality potential foraging habitat for the species, as that found in the study area. It is considered therefore that in the context of this wider area a significant area of known habitat will not be removed.

The Woodland – Open Forest vegetation found in the study area provides foraging habitat for the Common Bent-wing Bat, with approximately 5.75 hectares to be cleared for the proposed rail loop. This relatively small area to be cleared is not however considered to be significant considering the size of the foraging habitat areas to be retained (approximately 40.5 hectares) and the extent of similar habitat provided in nearby areas. It is considered therefore that the proposal will not result in the removal of a significant area of known habitat of the Common Bent-wing Bat.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species population or ecological community.

The proposal will not result in the isolation of any foraging habitat areas in the study area from currently interconnecting or proximate areas. The Common Bent-wing Bat is a highly mobile species which is thought to be roosting in caves or other similar structures on Mount Arthur resulting in individuals currently having to cross disturbed mine areas, agricultural land and roadways to reach the foraging habitats found in the vicinity of the study area. The construction of the proposed rail loop is therefore considered unlikely to inhibit the movement of the species between foraging habitat areas. The proposed development will not result in known habitat of the species being isolated from currently interconnecting areas.

e) Whether critical habitat will be affected.

No areas of critical habitat have currently been designated under the Threatened Species Conservation Act 1995.

f) Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

Available records indicate that the Common Bent-wing Bat is not currently adequately represented in conservation reserves in the region, however the species has been recorded in low numbers in the Barrington Tops and Yengo National Parks (NSW NPWS Website, accessed 30/11/99).

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Only three threatening processes are currently listed under the Threatened Species Conservation Act 1995, with none being relevant to this proposal.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Common Bent-wing Bat occurs throughout the coastal strip of Eastern Australia extending from Cape York to Adelaide. The species is also found in the northern regions of the Northern Territory and Western Australia (Dwyer, 1998). The species is not at the limit of its known distribution in the study area.

7.3 *Macropus parma* - PARMA WALLABY

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

A Parma Wallaby was tentatively recorded by Dames and Moore to the northeast of the study area through hair and bone fragments contained in a fox scat. The remains were positively identified as *Macropus* sp. by Barbara Triggs of Genoa Victoria, and tentatively identified as *Macropus parma* (Parma Wallaby). The species inhabits wet and dry forests and occasionally rainforests, but typical habitat appears to be wet sclerophyll forest with a thick, shrubby understorey associated with grassy patches (Maynes, 1998). It is primarily nocturnal taking cover during the day in areas of thick undergrowth (Cronin, 1991).

There would appear to be very limited habitat for this species in the general vicinity of the study area, with there being some doubt about the tentative identification of the remains. Several other Macropus species occur in the vicinity of the study area, none of which are listed as threatened species under the Threatened Species Conservation Act 1995. It is considered possible that the remains are from one of these species. The species has not been recorded by any of the other numerous studies undertaken in the vicinity of the study area, and is not listed on the National Parks and Wildlife Service Atlas database as being recorded in the Muswellbrook 1:100,000 map sheet area.

Although it is considered unlikely that the species occurs in the general vicinity of the study area, if the species is present in the region, it is considered highly unlikely to be present in the study area due to the lack of suitable habitat. The forested areas of the study site are not comprised of the wet sclerophyll forest typically inhabited by this species, and lack a dense shrub layer. The shrub layer is generally absent in the vegetation communities present in the study area, with the site therefore being considered to provide little potential habitat for the species.

The species is considered unlikely to occur in the region, with there also being a general lack of suitable habitat in the study area. The proposed development is therefore considered unlikely to have a significant impact on the life cycle of the species.

b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Currently, only a few specific populations have been identified as endangered under the Threatened Species Conservation Act 1995, none of which are relevant to the study area.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The study area does not form known habitat of the Parma Wallaby, and as discussed above, is also considered unlikely to provide potential habitat. The species was tentatively recorded to the north west of the study area by Dames and Moore, however there is a degree of doubt regarding the tentative identification. The proposed development will not therefore remove a significant area of known habitat.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species population or ecological community.

The areas to be impacted under the proposal do not form known habitat for the Parma Wallaby, and are also considered unlikely to provide potential habitat due to the lack of suitable habitat characteristics including a dense understorey layer. It is also considered that the proposal is unlikely to isolate any areas of potential habitat, with the area presently being dissected by a number of similar structures including Thomas Mitchell Drive, Wire Lane and the Drayton Colliery rail loop. The proposed rail infrastructure will not therefore significantly add to the dissection of the vegetation in the area.

The study area does not contain any areas of suitable habitat for the Parma Wallaby, with the proposed development not isolating any areas of known habitat from currently interconnecting or proximate areas.

e) Whether critical habitat will be affected.

No areas of critical habitat have currently been designated under the Threatened Species Conservation Act 1995.

f) Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is a general lack of information assessing the conservation status of the Parma Wallaby in the region of the study area, however it has been recorded in the Barrington Tops National Park (NSW NPWS Website, accessed 30/11/99). It is considered unlikely that the species is adequately conserved in the region.

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Only three threatening processes are currently listed under the Threatened Species Conservation Act 1995, with none being relevant to this proposal.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Parma Wallaby occurs in New South Wales from at least the Watagan Mountains in the south to the Gibraltar Range in the North. The species is not at the limit of its known distribution in the study area.

7.4 *Petaurus Norfolcensis* - SQUIRREL GLIDER

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

As outline in **Section 4.3.1**, a single male Squirrel Glider was positively recorded in the *Eucalyptus tereticornis* Woodland – Open Forest Community in the area indicated on **Figure 4.1**. The section of remnant vegetation within which the Squirrel Glider was captured consists of approximately 12 hectares of suitable habitat for the species. Squirrel Gliders are known to use home ranges of size 3.08 $\pm$ 0.41 hectares (Quin, 1995), to 37.74 hectares (Geoff Maskey, Environmental Officer Mt Owen Mine, pers. com.). It is considered likely that the home range of the Squirrel Glider individual recorded in the study area will be generally similar to that recorded in a nearby study (refer to **Section 4.3.1**), being between 28.66 hectares and 37.74 hectares, due to the generally similar habitat found in the two areas.

Quin (1995) observed nesting groups of two to nine Squirrel Glider individuals to be female dominated in a population having a male biased sex ratio. This suggests that some male Squirrel Gliders must nest alone, potentially whilst attempting to find a vacant position in a group into which they can be recruited. Male Squirrel Gliders are also known to disperse from their natal area at approximately one year of age, potentially due to dominant adult male aggression (Quin, 1995).

One hollow bearing tree is located in the area proposed to be cleared for the rail loop construction. This tree contains several dead limbs which contain large and medium sized hollows (approximately 3 suitable nesting hollows which are considered likely to be interconnected), known to provide nesting sites for up to four Brushtail Possums. Three nights of stagwatching were completed at this site with four Brushtail Possums being observed leaving the hollows on each occasion. No other fauna species were observed to be using the hollows, however an unidentified glider was observed to land on the tree shortly after dusk (as outlined in **Section 4.3**) indicating that it had probably nested to the north east of the stagwatching point. Several hollow bearing *Eucalyptus crebra* are known to occur to the north east of the stagwatching point, with all being located outside the proposed disturbance zone. It is considered, however, due to the results of the stagwatching survey which targeted the hollow bearing tree proposed to be removed, that the Squirrel Glider located in the study area is nesting in alternative hollows. Approximately 6 hollow bearing trees containing hollows potentially suitable for use by Squirrel Gliders (approximately 10 hollows) are present in the area of known habitat of the species not affected by the proposal. Stagwatching, trapping and spotlighting activities in the area have not positively identified the nest site of the individual recorded, however it is considered that a number of sites may be potentially being utilised. It is considered possible that the Squirrel Glider individual may periodically nest in the hollow bearing tree to be affected by the proposal. However, due to its use of at least one other hollow in the area, and taking into account the availability of a number of suitable hollows in close proximity, the removal of one hollow bearing tree is considered unlikely to significantly affect the species.

Although the hollow bearing tree to be affected by the proposal does not provide known nesting sites for the Squirrel Glider, the removal and re-erection of hollows and the use of nest boxes will ensure that there is no net loss of potential nesting sites in the study area. The hollows to be affected will be salvaged where possible and re-erected in nearby habitat areas within the area of known Squirrel Glider habitat. Specially designed nest boxes will also be erected to provide potential nesting sites for Squirrel Gliders, with a net gain of nesting hollows being achieved. Nest boxes will be erected prior to the commencement of clearing.

As discussed above it is considered likely that the home range of the male individual captured in the study area is a minimum of approximately 29 hectares, and potentially as large as approximately 38 hectares. The area in which the Squirrel Glider was located, being the triangle shaped area of remnant vegetation between Thomas Mitchell Drive and Wire Lane, is approximately 12 hectares in size, and would therefore not provide sufficient home range area for the individual captured. It is assumed therefore that the individual must be crossing either Wire Lane or Thomas Mitchell Drive or both, to move into adjacent habitats to meet its home range requirements. As Wire Lane is a less significant barrier to movement, it is considered likely that the Squirrel Glider individual captured in the study area is utilising these northern habitat areas, although it is considered that the individual may cross both roads.

It is considered unlikely that the removal of approximately 2.5 hectares of habitat for the Squirrel Glider will significantly affect the lifecycle of the individual, due to the availability of significant areas of potential habitat for the species in and adjacent to the study area. Approximately 9.5 hectares of the triangle of remnant vegetation in which the species was located will be retained, with significant areas of potential habitat existing to the north of Wire Lane (approximately 235 hectares). As discussed previously it is considered likely that the individual is using these potential habitats due to its home range requirements, with large areas of connected habitat being available in this area. Approximately 150 hectares of connected remnant vegetation is available to the north of Wire Lane on the eastern side of Balmoral Road (refer to **Figure 3.2**). This large remnant area is bounded by Thomas Mitchell Drive to the south and the New England Highway to the east. To the western side of Balmoral Road an area of approximately 75 hectares of remnant vegetation exists, with this area also potentially providing habitat for the Squirrel Glider individual. Additional areas of potential habitat also exist to the south of Thomas Mitchell Drive and to the east of the New England Highway. The removal of 2.5 hectares of habitat is therefore considered to be insignificant given the availability of approximately 235 hectares of known and potential habitat connected to areas currently used by the individual.

In addition to the large areas of potential habitat which are currently connected to the area being used by the Squirrel Glider individual, an area of habitat will be reconstructed adjoining the existing known habitat area as part of the habitat corridor discussed in **Section 8.1** and **Section 8.2**. The total area of habitat within this corridor will be 21.1 hectares, in addition to a habitat compensation area totalling 35.2 hectares being established at the western end of the habitat corridor, resulting in a total managed habitat area of 56.3 hectares. Approximately 3 hectares of the vegetation established for the habitat corridor will be within 250 metres of the area that currently provides habitat for the Squirrel Glider, with this area resulting in the replacement of the 2.5 hectares of habitat proposed to be affected by the development. The remainder of the habitat corridor and habitat compensation area will also be available for use by Squirrel Gliders, resulting in an overall increase in potential habitat within the study area. Fauna nest boxes will be included in the habitat compensation area, including a number specifically designed for Squirrel Gliders, to ensure sufficient roosting and nesting areas are present.

It is considered unlikely that a viable population of Squirrel Gliders is currently existing in the area to be impacted by the proposal, with a single male individual being identified in the study area. It is considered that the triangle of remnant vegetation in the study area does not currently consist of sufficient habitat to support a Squirrel Glider population. A population may exist in adjacent remnant vegetation areas, however the proposed development will not impact on these areas.

The proposed development is therefore considered unlikely to have a significant impact on the Squirrel Glider individual recorded in the study area. The proposed development is also considered unlikely to have a significant impact on a viable population of the species, with no firm evidence of a population of Squirrel Gliders being recorded in the study area.

b) *In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.*

Currently, only a few specific populations have been identified as endangered under the Threatened Species Conservation Act 1995, none of which are relevant to the study area.

c) *In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The only area of known habitat in the study area is the 12 hectare triangle of remnant vegetation between Wire Lane and Thomas Mitchell Drive. It is also considered that the remnant vegetation areas to the north of Wire Lane provide likely habitat for the species due to its home range requirements. There is therefore an area of 225 hectares of potential habitat available for use by the species in connecting remnant vegetation areas.

It is not considered that the removal of approximately 2.5 hectares of known habitat will result in the removal of a significant area of known habitat from the region, given the retention of 9.5 hectares of habitat in the immediate vicinity of the affected area and approximately 225 hectares of potential habitat to the north of the study area. Additional significant areas of potential habitat also occur to the south of Thomas Mitchell Drive and to the east of the New England Highway. The proposal will not therefore, in relation to the regional distribution of potential habitat for the species, result in the removal of a significant area of habitat.

d) *Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species population or ecological community.*

The habitat area within which the Squirrel Glider was captured consists of a large area of remnant vegetation which is dissected by transport infrastructure including the Drayton Rail Loop, Thomas Mitchell Drive, Wire Lane and Balmoral Road. The construction of the proposed rail loop will add to this current dissection, however it is considered unlikely to separate an area of known habitat from currently interconnecting or proximate areas.

A study being undertaken in the vicinity of the proposal area (approximately 20 km from the study area), which involves radio tracking an individual from each of two colonies of Squirrel Gliders, recorded a glider traversing across open pasture habitat by gliding between a series of isolated trees, often separated by distances of up to 130 metres. The maximum recorded gliding distance between trees was 70 metres, with distances greater than 70 metres often being traversed by gliding the maximum possible distance, landing on the ground and running to the next stand of trees (Geoff Maskey, Environmental Officer Mt Owen Mine, pers. com.). The proposed rail line, at its narrowest point in the triangle of remnant vegetation which forms known habitat of the species, will be approximately 12 to 15 metres wide and will be able to be easily crossed by the Squirrel Glider without it being required to leave its preferred arboreal habitat. At its wider points the cutting for the proposed rail line may be too wide for the Squirrel Glider to cross without landing on the ground, however as observed by the above study, distances between trees greater than the species gliding extent do not prevent the movement of the species through these areas. It is considered likely however that the Squirrel Glider recorded in the area would avoid crossing in these wider sections, preferring the narrow arboreal crossing points.

The Squirrel Glider individual recorded in the study area will be able to cross the proposed rail loop to reach southern potential habitat areas if required, however it is considered more likely that the species will utilise the potential habitats to the north of Wire Lane. To reach these areas the individual must cross Wire Lane, with this forming a less significant obstacle to movement than Thomas Mitchell Drive, which separates the southern habitats of the study area. Wire Lane is a narrow road which is subject to only light traffic (provides access to approximately six residences), with only a small gap in canopy cover being present due to the road. The proposed rail line will not affect the potential for the species to move into these northern habitat areas, with the proposal considered unlikely to have a significant impact on the species.

In order to facilitate the movement of Squirrel Gliders across the proposed rail line, existing vegetation will be retained as close as possible to the proposed development areas. This strategy will also be used for the existing roadways, with existing vegetation being retained, and with plantings being undertaken where required. The retention or establishment of significant vegetation along the boundaries of these structures will facilitate the movement of Squirrel Gliders through the area.

The existing known and potential habitats of the Squirrel Glider recorded in the study area are currently dissected by existing roadways and rail facilities. The individual must however, due to its home range requirements, be crossing one or all of these structures to reach adjacent habitat areas. The proposed rail line is not considered likely to prevent the movement of Squirrel Gliders to these adjacent habitat areas, providing no barrier to movement to the north, and being able to be crossed at a number of locations to provide access to the south. The species will be able to cross the proposed rail line at narrow points without landing on the ground, and will still be able to cross wider cutting sections through gliding and running where required, although this is considered unlikely to occur given the presence of preferred arboreal crossing points.

The proposed rail loop is therefore considered unlikely to result in the isolation of any potential habitat areas from areas of known habitat with any Squirrel Glider individuals occurring in the study area being able to cross the proposed rail line to access southern habitats, with access to more significant northern habitats not being affected.

e) Whether critical habitat will be affected.

No areas of critical habitat have currently been designated under the Threatened Species Conservation Act 1995.

f) Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is a general lack of information assessing the conservation status of the Squirrel Glider in the region of the study area, however it has been recorded in two National Parks in the wider region being the Barrington Tops National Park and the Wollemi National Park (NSW NPWS Website, accessed 30/11/99). It is however considered that the species is unlikely to be adequately conserved in the region.

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Only three threatening processes are currently listed under the Threatened Species Conservation Act 1995, with none being relevant to this proposal.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

Squirrel Gliders are known to occur in eastern Australia from inland Victoria to the base of Cape York in the north (Suckling, 1995). The species is not at the limit of its known distribution in the study area.

7.5 *Neophema pulchella* - TURQUOISE PARROT

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

The Turquoise Parrot is a small slim parrot which inhabits the foothills of the Great Dividing Range, including steep rocky ridges and gullies, rolling hills, valleys and river-flats, and sometimes nearby plains. The species typically occurs in Eucalypt Woodlands and Open Forests (typically containing *Callitris* and *Eucalyptus* assemblages) with a groundcover of grasses and sometimes a low understorey of shrubs. The species often occurs in farmland areas, mainly in pasture with remnant trees, living or dead. (Higgins, 1999). The species nests in tree hollows, primarily of Eucalypts and occasionally in Casuarinas, often near water and close to cleared land. Laying occurs in the period August to January (Higgins, 1999). The species is considered to be part nomadic (Pizzey and Knight, 1998).

Bird surveys completed in the study area, including targeted surveys of woodland – open forest, and forest – grassland ecotone habitats, failed to find any indication of the existence of this species. The species was also not recorded by Dames & Moore in their 1998 surveys in adjacent habitat areas. A Turquoise Parrot was tentatively identified in 1992 by Fly by Night Bat Surveys, during surveys undertaken for the Bayswater No. 3 Mine EIS, however further targeted surveys in the area failed to confirm the presence of the species (Resource Planning, 1993). One regional record also exists for the Turquoise Parrot to the northeast of Denman, approximately 22 km from the study area.

As outlined above the Turquoise Parrot nests in tree hollows, typically near waterbodies and cleared land. The proposed development will only result in the clearing of a single hollow bearing tree which contains several hollow limbs. The hollows were however observed during field surveys completed in the known nesting period of the species to provide nesting sites for up to four Brushtail Possums, indicating that the hollows are highly unlikely to be used by the Turquoise Parrot. Other potential nesting resources are located in the study area, however none of these will be affected by the proposed development, with the proposal therefore considered unlikely to have any impact on the breeding of the species.

It is considered that the Woodland – Open Forest vegetation of the study area may provide periodic foraging habitat for the Turquoise Parrot, however the species has not been recorded in the area and is unlikely to frequently or permanently occur. The species is partly nomadic and it is considered possible that individuals moving through the region may use the habitat resources of the study area for short periods. As the species is only likely to occur in the study area periodically if at all, the removal of a small area of potential habitat (5.75 hectares) is unlikely to have a significant impact on the life cycle of the species, particularly taking into account the area of habitat to be retained, the significant areas of similar habitat surrounding the study area, and the 35.2 hectares (including 15.3 hectares of existing vegetation) of proposed habitat compensation area. The erection of suitable nest boxes in the habitat compensation area will also provide potential nesting sites for the species.

As no nesting sites for the species will be disturbed, and only a relatively small area of potential habitat will be affected, it is considered unlikely that the proposed development will have a significant impact of the life cycle of the Turquoise Parrot.

b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.

Currently, only a few specific populations have been identified as endangered under the Threatened Species Conservation Act 1995, none of which is relevant to the project area.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The areas to be impacted by the proposed rail loop development do not constitute known habitat of the Turquoise Parrot. The Woodland – Open Forest vegetation area may provide some periodic habitat for the species, however there is no indication of substantial use of the area by the species. The relatively small area of forested vegetation to be affected by the development is considered unlikely to result in a significant loss of local or regional habitat resources for the species, taking into account the areas to be retained in the study area and surrounding vegetated areas. The proposed development will therefore not remove or modify a significant area of known habitat for the species.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species population or ecological community.

As discussed previously, the areas to be impacted under the proposal do not form known habitat for the Turquoise Parrot, although it is possible that the area provides periodic habitat for individuals moving through the area. The proposed development is considered unlikely to significantly add to the current dissection of the habitat found in the vicinity of the study area with historic clearing being undertaken for infrastructure such as roads and existing rail lines, and for agricultural activities. The Turquoise Parrot is a highly mobile species which is easily able to cross these structures and will not be limited in movement by the construction of a rail loop in the proposal area.

e) Whether critical habitat will be affected.

No areas of critical habitat have currently been designated under the Threatened Species Conservation Act 1995.

f) Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is little information available regarding the occurrence of Turquoise Parrots in conservation reserves in the region, however the species has been recorded in both the Wollemi and Yengo National Parks which occur south of the study area (NSW NPWS Web site, accessed 22/12/99). It is considered unlikely, however, that the species is adequately conserved in the region.

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Only three threatening processes are currently listed under the Threatened Species Conservation Act 1995, with none being relevant to this proposal.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Turquoise Parrot is distributed throughout the eastern half of NSW and into southern Queensland and northern Victoria. The species is not at the limit of its known distribution in the study area.

7.6 *Litoria aurea* - GREEN AND GOLDEN BELL FROG

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

The Green and Golden Bell Frog was formerly a commonly encountered species, well known to locals throughout its range. Species numbers have, however, dramatically declined in recent years to the stage where it is now listed as Endangered under the Threatened Species Conservation Act, 1995. The species typically occurs in large permanent swamps and ponds with plenty of emergent vegetation, especially bullrushes. It is active by day and by night and will occasionally inhabit ornamental ponds and farm dams, where these occur close to preferred habitat areas (Robinson, 1995). The species has a distinctive call and is usually heard from August through to January (Robinson, 1995).

A comprehensive study into the habitat requirements of the Green and Golden Bell Frog by Pyke and White (1996a) involved examining almost all known locations of the frog in NSW. The study determined that for a location to support a population of the Green and Golden Bell Frog in NSW it should have the following attributes:

- There should be a grassy area reasonably near to any water bodies, and other nearby vegetation should be woodland or lower in maximum height;
- The substrate should be sand (alluvial) or rock;
- The water bodies should be still, shallow, ephemeral and unpolluted. Such water bodies are most likely to occur in areas which experience disturbance (either natural or unnatural) and where surface water runoff from local unpolluted area collects to form temporary ponds;
- The water bodies should be unshaded and free of *Gambusia* and other predatory fish;
- There should be aquatic plants present, preferably *Typha* sp.; and,
- There should be a range of possible diurnal shelter sites available, including vegetation and rocks.

The Green and Golden Bell Frog has been recorded approximately 17 km to the south of the study area in 1995 in the Hunter River or immediate vicinity (Atlas database). The habitat found in this area is significantly different to that found in the study area, with only limited areas of aquatic habitat being affected by the proposed development. The species has not been identified by any surveys undertaken in the locality of the study area (Dames & Moore, 1999, Resource Planning, 1993, Gunninah Environmental Consultants, 1997).

A comprehensive amphibian survey was conducted in the study area in appropriate seasonal and weather conditions for the species to be detected (refer to **Section 2.2.2**). The species was not, however, recorded during these surveys and is considered unlikely to occur due to a general lack of preferred habitat areas. As discussed above, the species prefers shallow waterbodies with sand or rock substrates, with the effluent treatment ponds not being considered to provide potential habitat for the species. The removal of these ponds will not therefore have any impact on the life cycle of the species.

Several sections of ephemeral drainage lines will also be affected by the proposed development, however a significant portion of these habitat areas will remain unaffected. Culverts will be used to ensure that the current periodic flow along these drainage lines is not affected. Relatively low species diversity was observed in these ephemeral drainage line areas with generally only two species occurring, being the Spotted Grass Frog (*Lymnodynastes tasmaniensis*) and the Common Eastern Froglet (*Crinia signifera*). It is considered unlikely that any Green and Golden Bell Frogs occur in these ephemeral drainage line areas with the areas to be disturbed generally lacking significant emergent vegetation. Although the species is considered unlikely to occur, the majority of ephemeral drainage line areas will remain unaffected by the proposed development, ensuring that the proposal will not have a significant impact on the lifecycle of the species. The proposed development will not therefore place at risk of extinction a local viable population of the Green and Golden Bell Frog.

b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.

Currently, only a few specific populations have been identified as endangered under the Threatened Species Conservation Act 1995, none of which are relevant to the project area.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The areas to be impacted by the proposed rail loop do not constitute known habitat for the Green and Golden Bell Frog. As discussed above, the study area is also considered unlikely to provide significant potential habitat for the species due to a general lack of preferred habitat areas. The proposed development is also considered unlikely to remove a significant area of aquatic habitat, with only the degraded effluent treatment ponds and some relatively small sections of ephemeral drainage line being affected. The proposed development will not therefore modify or remove a significant area of known habitat of the Green and Golden Bell Frog.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species population or ecological community.

As discussed previously, there are no areas of known habitat occurring in the study area with it also being considered unlikely that the study area provides potential habitat for the species. The proposal will not therefore result in an area of known habitat being isolated from currently interconnecting or proximate areas. It is also considered unlikely, that the proposed development will result in the isolation of any areas of aquatic habitat from currently interconnecting areas. The provision of culverts at each of the drainage lines crossed by the proposed rail line route, will ensure that any amphibian species occurring in the study area will be able to move easily between aquatic habitat area along existing drainage lines. The proposal will not therefore result in the isolation of any currently interconnecting areas of aquatic habitat for amphibian species.

e) Whether critical habitat will be affected.

No areas of critical habitat have currently been designated under the Threatened Species Conservation Act 1995.

f) Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

The species is only known to occur in four National Parks in NSW (Clancy, 1996), none of which occur in the region of the project area. The species is considered unlikely to be adequately reserved in the region.

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The only threatening process relevant to the Green and Golden Bell Frog is predation by *Gambusia holbrooki** (Mosquito Fish). The proposed development will not, however, result in any change in the distribution or abundance of Mosquito Fish in the study area. The development proposed is not classed as a threatening process.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Green and Golden Bell Frog is distributed in NSW from near Byron Bay in the north to the Victorian border in the south (White and Pyke, 1996b). The species also occurs in the East Gippsland area of Victoria, extending from the border with NSW to Lake Wellington (Gillespie, 1996). The species is not at the limit of its known distribution in the study area.

8.0 MANAGEMENT REQUIREMENTS

A range of management strategies will be used to further limit any impact of the proposed development on the remaining vegetated portions of the study area. These will include both short-term and long-term strategies and will incorporate the proposed development area into the existing environmental management framework.

The proposed development area will be flagged during the construction period to ensure that the minimum required area is affected. Access to the development site will be by existing tracks and roadways where possible, ensuring that minimal clearance occurs. All contractors employed for the construction period will be informed of their responsibility to minimise clearing and other disturbances where possible. Any ongoing maintenance which is required for the new or existing sections of the rail line will be undertaken within the existing rail corridor with no further clearing being undertaken.

The forested portions of the study area which will be retained under the proposed development will be fenced, or current fencing will be maintained and upgraded, to ensure that access into the study area will be restricted for unauthorised personnel. The aim of this strategy is to ensure that the ongoing unauthorised clearing which is being undertaken in the study area, including fire wood cutting will be stopped, ensuring that the retained habitat areas are not gradually degraded. It is considered that unauthorised clearing is a major threat to habitat resources within the study area due to the targeting of mature trees. This program will be undertaken with co-operation between Bayswater and Drayton Collieries, as both are landholders of the proposed development area.

Vegetation cleared from the forested portions of the development area will be removed and used in the proposed habitat compensation area. Any hollow branches which will form suitable nesting or roosting structures will be removed and re-erected in the proposed habitat compensation area, or in the existing forested areas. Some of the removed vegetation may be chipped or shredded to provide mulch material for the restoration area, with other larger tree sections being used to provide potential ground habitat resources.

Nest boxes will be installed in both the existing habitat areas and the habitat compensation area to ensure that there is a net gain of potential nesting and roosting sites, and that the habitat compensation area contains suitable hollow resources. The nest boxes erected will be designed to provide suitable nesting and roosting sites for Squirrel Gliders, Brushtail Possums, tree roosting bats and a range of bird species.

The areas surrounding the proposed development area will be included in the existing Bayswater Colliery and Drayton Colliery weed control programs. This will include both the forested and pastoral grassland portions of the site, and will ensure that the proposed development does not result in deterioration of the vegetation quality of the surrounding areas.

The proposed rail line will be stabilised, as outlined in the EIS prepared for the proposal, to prevent erosion. The rail line will also be regularly inspected for the necessity for sediment and erosion control during its operational period (refer to Section 4.7.3.4 of the EIS prepared for the project). This will prevent sediment mobilisation and deposition having a significant impact on the surrounding retained remnant vegetation areas.

8.1 REHABILITATION

The area to be disturbed during the construction of the proposed rail loop will be limited to the minimum area required, with there therefore being little post construction rehabilitation required. The rehabilitation requirements of the proposed development will therefore be limited to establishing vegetation on batter slopes and the establishment of screening vegetation.

Both cut and fill operations will be used during the construction of the proposed rail loop, with a number of batter areas being created. Each of these batter areas will be stabilised to prevent erosion, with grass cover being established following creation of the required landform. Shrub and tree species will not be used on the batter areas as they are considered a hazard to the safe operation of the rail loop.

A vegetated screen is required to be constructed to screen views of the rail loop and associated facilities from Thomas Mitchell Drive. This screen is particularly important to prevent cars using Thomas Mitchell Drive at night being impacted by lights from the rail loop. The establishment of this screening vegetation provides an opportunity to establish a habitat corridor adjacent to the proposed rail loop. This vegetation corridor will be planted to establish a corridor which is generally approximately 80 metres wide, 2.5 km long and provides a total area of 21.1 hectares. The corridor will connect the habitat compensation area to the forested areas at the eastern end of the study area, being the area currently designated as a Natural Zone by the Drayton Colliery Wildlife Refuge proclamation (refer to **Figure 8.1**). The method of establishment of the habitat corridor is discussed further in **Section 8.2** below.

8.2 HABITAT COMPENSATION

8.2.1 Habitat Compensation Area

It is proposed to establish an area of compensatory habitat to replace the 5.75 hectares of 'forest' vegetation which will be removed for the construction of the proposed rail loop. The compensatory habitat area will be approximately 35.2 hectares in size, including an area of existing vegetation approximately 15.3 hectares in size (refer to **Figure 8.1**). The existing vegetation has been included in the habitat compensation area as it will be actively conserved and managed by Bayswater Colliery Company to provide habitat for local flora and fauna species, compensating for the section of the Drayton Colliery Wildlife Refuge affected by the proposed development. The remaining 19.9 hectares of the proposed habitat compensation area, which currently consists of scattered trees and clumps of trees in pastoral grassland, will be rehabilitated to provide an additional area of local habitat. The occurrence of existing trees in this area will enable the timeframe required to construct effective habitat to be minimised.

As described in **Section 3.2.2** and **Section 4.1**, the existing woodland vegetation in the A171 area has been degraded by stock impacts and human activities including rubbish dumping. The management of the habitat compensation area will aim to improve the habitat quality of the existing vegetation and increase the area of available habitat by regenerating the adjoining degraded area.

The proposed habitat compensation area will be fenced to prevent the access of stock and unauthorised people, reducing the potential for degrading activities and allowing natural regeneration to occur. Fencing will be undertaken without using barbed wire, as this fencing material can be hazardous to some native fauna. Plantings of endemic species will also be used to supplement natural regeneration, with areas lacking canopy cover being targeted.

The natural regeneration of the site will be encouraged through the use of material cleared during the construction of the proposed rail loop. A proportion of the trees cleared from nearby areas will be placed in the proposed habitat compensation area to promote regeneration in bare sections. The trees will provide a local seed source enhancing the natural regeneration of the area, and will also provide potential habitat structures for ground

Legend

- Existing Rail Loading Infrastructure
- Proposed Rail Loading Infrastructure
- Approved Infrastructure
- Mine Lease Boundary
- Habitat Corridor
- Habitat Compensation Area

0 250m 500m 750m 1000m

Umwelt (Australia) Pty Limited

FIGURE 8.1
Habitat Compensation and Habitat Corridor Areas

A3 Scale 1:14 000 | Ref No.:1323/R01_AP3/dra_013.dwg

dwelling fauna. Other cleared material will be chipped and used as mulch in rehabilitation planting areas, providing a valuable source of local seed. Detailed planting guidelines will be prepared prior to establishment of the habitat compensation area, however, the plantings will generally be of species present in the adjoining Mixed Eucalypt Woodland community (refer to **Appendix A**).

It is considered likely, due to the occurrence of existing trees and clumps of trees in the habitat restoration area, that an area of potential habitat for a range of locally occurring species can be created relatively quickly.

Hollow resources are likely, however, to be generally limited, due to the majority of trees in the area being immature. The use of nest boxes is therefore proposed, with these structures being designed to provide roosting and nesting sites for a range of locally occurring fauna. Specifically, nest boxes suitable for Squirrel Gliders, Brushtail Possums, tree roosting bats and a range of bird species will be erected on existing mature trees in the area. Nest boxes will also be placed in the portion of the habitat compensation area with existing vegetation to improve the availability of hollow resources in this area. The nest boxes will be installed during the initial period of works for the construction of the rail loop.

8.2.2 Habitat Corridor

As discussed in **Section 8.1**, an area of native vegetation approximately 21.1 hectares in size will be constructed to provide both screening of the proposed rail loop and a habitat corridor (refer to **Figure 8.1**), resulting in the total area of habitat establishment for the project being 41 hectares. The area will be planted using species which occur in the adjacent vegetation communities (both tree and shrub species, with groundcover species as required), with the general principles for habitat establishment being similar to those used in the habitat compensation area. The vegetated corridor areas will be fenced to prevent stock assess, and will be established using plantings due to the absence of existing native vegetation remnants.

Both the habitat compensation area and the habitat corridor will be managed to improve plant survival rates and control weed species. Following completion of plantings in these areas regular inspections will be undertaken to examine the health of planted individuals and undertake watering, fertiliser application and replacement plantings where required. The regular inspections will also be used to examine the area for the occurrence of weed species, with both listed noxious weeds and bushland weeds being recorded. Weed control works will be undertaken as required.

The proposed habitat corridor will provide a linkage between the existing Drayton Colliery Wildlife Refuge Natural Zone and surrounding remnant vegetation areas, and the habitat compensation area. This linkage will complement the local corridors which will be constructed during rehabilitation of Bayswater and Drayton Collieries and which are outlined in the NSW Department of Mineral Resources (DMR) Synoptic Plan for Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley (DMR, 1999). The local corridor linkages in this plan connect the A171 area (habitat compensation area) with the remnant vegetation on Mt Arthur and to remnants to the west of Bayswater Colliery. Linkages also occur through Drayton and Bayswater Collieries southwest along Saddlers Creek and from Drayton Colliery north to existing vegetated areas. The addition of the habitat corridor along the northern edge of Drayton and Bayswater Collieries will complement the local corridors outlined in the DMR's plan, resulting in an improved network of corridors in the local area.

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APPENDIX A

Flora Species List

FLORA SPECIES LIST

Site Records

Two columns of site records exist in the following flora species list;

- Umwelt Study: Provides a record of all species recorded during the Umwelt (Australia) Pty Limited flora survey completed for the rail loop project.
- D & M Study: Provides a record of all species recorded by Dames and Moore in the Woodland – Open Forest community which occurred in the A171 area, and also in other areas of the MAN study area.

Status

Introduced (Intro.) – Refers to exotic species which have been introduced to the study area.

W1, W2, W3, W4 – Refers to the 'Action for Control Category' for weed species listed on the Noxious Weed List for the Muswellbrook Shire Council Local Government Area.

(No flora species listed on the Threatened Species Conservation Act, 1995 are present in the study area)

Nomenclature is consistent with Harden (1990 – 1993).

Family / Genus	Species	Common Name	Status	Umwelt Study	D&M Study
ACANTHACEAE					
Brunoniella	*australis*	Blue Trumpet			X
AIZOACEAE					
Tetragonia	*tetragonioides*	New Zealand Spinach			X
ALISMATACEAE					
Nothoscordum	*gracile*	Onion Weed		X	
APIACEAE					
Apium	*leptophyllum*	Slender Celery		X	X
Centella	*asiatica*	Pennywort		X	X
ASCLEPIDACEAE					
Gomphocarpus	*fruticosus*	Balloon Cottonbush	Introduced		X
ASTERACEAE					
Ambrosia	*artemisiifolia*	Annual Ragweed	Introduced		X
Ambrosia	*tenuifolia*	Lacy Ragweed	Introduced		X
Bidens	*pilosa*	Cobblers Pegs	Introduced	X	X
Brachysome	*angustifolia*	A Daisy			X
Brachysome	*multifida*	Cut-leaf Daisy			X
Calotis	*cuneifolia*	Purple Burr Daisy			X
Calotis	*lappulace*	Yellow Burr Daisy		X	X
Carduus	*nutan*	Nodding Thistle	Intro. (W2)	X	X
Carthamus	*lanatus*	Saffron Thistle	Introduced	X	
Cirsium	*vulgare*	Spear Thistle	Introduced	X	X
Conyza	*bonariensis*	Flax-leaf Fleabane	Introduced	X	X
Cotula	*coronopifolia*	Water Buttons	Introduced	X	
Craspedia	*variabilis*	Billy Buttons			X
Galinsoga	*parviflora*	Potato Weed	Introduced		X
Glossogyne	*tannensis*	Cobblers Tack			X
Gnaphalium	*coarctatum*	Cudweed	Introduced	X	
Gnaphalium	*involucratum*	Star Cudweed			X
Gnaphalium	*sphaericum*	Common Cudweed			X
Hedypnois	*rhagadioloides*	Cretan Weed	Introduced	X	X
Hypochaeris	*radicata*	Catsear	Introduced	X	X
Lactuca	*saligna*	Willow-leaf Lettuce	Introduced		X
Podolepis	*jaceoides*	Copperwire Daisy			X
Psuedognaphalium	*luteoalbum*	Jersey Cudweed			X
Senecio	*madagascariensis*	Fireweed			X
Silybum	*marianum*	Variegated Thistle	Introduced	X	
Soliva	*sessilis*	Bindii	Introduced		X
Sonchus	*oleraceus*	Common Sowthistle	Introduced	X	X
Taraxacum	*officinale*	Dandelion		X	
Vittadina	*triloba*	Fuzzweed		X	X
BORAGINACEAE					
Cynoglossum	*sauveolens*	Hounds Tongue			X
BRASSICACEAE					
Lepidium	*africanum*	Perrecress	Introduced		X
CACTACEAE					
Eriocereus	*martinii*	Harissia Cactus	Introduced	X	X
Opuntia	*stricta*	Prickly Pear	Intro. (W4)	X	X
CAMPANULACEAE					
Wahlenbergia	*communis*	Tufted Bluebell		X	
Wahlenbergia	*stricta*	Tall Bluebell		X	X
CARYOPHYLLACEAE					
Petrorhagia	*velutina*		Introduced	X	
Silene	*gallica* var. *gallica*	French Catchfly	Introduced	X	
CASUARINACEAE					
Allocasuarina	*littoralis*	Black She-oak		X	
Allocasuarina	*luehmannii*	Bull-oak		X	X
Allocasuarina	*torulosa*	Forest Oak		X	X

Family / Genus	Species	Common Name	Status	Umwelt Study	D&M Study
CHENOPODIACEAE					
Enchylaena	*tomentosa*	Ruby Saltbush			X
Maireana	*micophylla*	Eastern Cottonbush		X	X
CLUSIACEAE					
Hypericum	*gramineum*	St Johns Wort	Intro. (W2)	X	X
COMMELINACEAE					
Commelina	*cyanea*	Wandering Jew		X	X
CONVOLVULACEAE					
Convulvulus	*erubescens*	Birdweed			X
CYPERACEAE					
Cyperus	*eragrostris*	Umbrella Sedge	Introduced	X	
Eleocharis	*acuta*	Spike-rush		X	
Fimbristylis	*dichotoma*	woodland			X
EUPHORBIACEAE					
Phyllanthus	*virgatus*	Phyllanthus			X
FABACEAE					
Desmodium	*varians*	Slender Tick Trefoil			X
Hardenbergia	*violacea*	False Sarsparilla		X	X
Glycine	*microphylla*	Love Creeper		X	X
Glycine	*tabacina*	Slender Glycine		X	X
Medicago	*polymorpha*	Burr Medic	Introduced		X
Medicago	*truncatula*	Barrel Medic	Introduced	X	X
Melilotus	*indica*	Sweet Melilot	Introduced		X
Pultanea	*micophylla*			X	
Swainsona	*galegifolia*	Smooth Darling Pea			X
Trifolium	*repens*	White Clover	Introduced	X	
Trifolium	*subterraineum*	Subterrainean Clover	Introduced	X	X
GENTIANACEAE					
Centaurium	*erythraea*	Common Century	Introduced		X
GERANIACEAE					
Erodium	*sp.*	A crowfoot	Introduced		X
Geranium	*solanderi* var *solanderi*	Native Geranium		X	X
Perlargonium	*inodoratum*	Perlargonium	Introduced		
HALORAGACEAE					
Myriophyllum	*sp.*	A Watermilfoil		X	
JUNCACEAE					
Juncus	*acutus*	Spiny Rush	Introduced	X	
Juncus	*usitatus*	Common Rush		X	
LAMIACEAE					
Marrubium	*vulgare*	Horehound	Introduced		X
Plecranthus	*parviflorius*	Plactrathus			X
LILIACEAE					
Dianella	*revoluta*	Flax lily		X	X
Dichopogon	*fimbriatus*	Nodding Chocolate Lily		X	X
LINACEAE					
Linum	*usitatissimum*	Linseed	Introduced		X
LOMANDRACEAE					
Lomandra	*confertifolia*	Mat-rush			X
Lomandra	*filiformis*	Wattle Mat-rush		X	
LORANTHACEAE					
Amyema	*cambagei*	Mistletoe			X
LUZURIAGACEAE					
Eustrephus	*latifolius*	Wombat Berry			X

Family / Genus	Species	Common Name	Status	Umwelt Study	D&M Study
MALVACEAE					
Modiola	*caroliniana*	Red Flowered Mallow	Introduced	X	X
Sida	*corrugata*	Prostate Flannel Weed			X
Sida	*rhombifolia*	Flannel Weed	Introduced		
MIMOSACEAE					
Acacia	*binervia*	Coastal Myall			X
Acacia	*brownei*	A Wattle		X	
Acacia	*decora*	Western Golden Wattle		X	X
Acacia	*excelsa*	Ironwood		X	
Acacia	*longissima*	A Wattle		X	
Acacia	*melanoxyon*	Blackwood		X	
Acacia	*podalyrifolia*	Queensland Silver Wattle		X	
MYOPORACEAE					
Eremophila	*debilis*	Winter Apple; Amulla		X	X
MYRTACEAE					
Angophora	*floribunda*	Rough-barked Apple		X	
Corymbia	*maculata*	Spotted Gum		X	
Eucalyptus	*albens*	White Box		X	X
Eucalyptus	*blakelyi*	Blakely's Red Gum		X	X
Eucalyptus	*crebra*	Narrow – leaved Ironbark		X	X
Eucalyptus	*dawsonii*	Slaty Gum			X
Eucalyptus	*moluccana*	Grey Box		X	X
Eucalyptus	*tereticornis*	Forest Red Gum		X	
OLEACEAE					
Notelaea	*microcarpa*	Native Olive			X
ORCHIDACEAE					
Diuris	*tricolor*			X	
OXALIDACEAE					
Oxalis	*pes-caprae*	Soursob	Introduced		X
PITTOSPORACEAE					
Bursaria	*spinosa*	Blackthorn			X
PLANTAGINACEAE					
Plantago	*lanceolata*	Plantane	Introduced	X	X
POACEAE					
Agrostris	*avenacea*	Beard Grass		X	X
Aristida	*personata*	A Wiregrass			X
Aristida	*ramosa*	Three-awn Speargrass	Introduced	X	X
Austrodanthonia	*fulva* (prob)			X	
Avena	*barbata*	Bearded Oats		X	
Bothrichloa	*macra*	Red Grass	Introduced	X	X
Bromus	*molliformis*	A Soft Brome	Introduced	X	
Chloris	*gayana*	Rhodes Grass		X	
Chloris	*truncata*	Windmill Grass		X	X
Cymbopogon	*refractus*	Barbed Wire Grass	Introduced	X	
Cynodon	*dactylon*	Common Cooch		X	
Danthonia	*richardsoni*	A Wallaby Grass			X
Danthonia	*longifolia*	A Wallaby Grass		X	
Danthonia	*sp.*	A Wallaby Grass			X
Danthonia	*teniour*	A Wallaby Grass		X	X
Dichelachne	*micrantha*	Shorthair Plumegrass	Introduced	X	X
Echinopogon	*caespitosus* var. *caespitosus*	A Hedgehog Grass		X	
Elymus	*scaber*	Common Wheatgrass	Introduced	X	X
Eragrostis	*brownii*	Browns Lovegrass		X	
Eragrostis	*leptostachya*	Paddock Lovegrass	Introduced	X	X
Hordeum	*leporinum*	Barley	Introduced		X
Paspalum	*dilatatum*	Paspalum		X	
Paspalum	*distichum*	Water Cooch		X	
Pennisetum	*clandestinum*	Kikuyu Grass		X	

Family / Genus	Species	Common Name	Status	Umwelt Study	D&M Study
POACEAE (cont)					
Phragmites	*australis*	Common Reed		X	X
Poa	*annua*	Winter Grass			
Poa	*labillardieri*	Tussock		X	
Polypogon	*monspeliensis*	Annual Beardgrass	Introduced	X	
Sorghum	*leiocladum*	Wild Sorghum		X	
Sporobolus	*creber*	Slender Rats Tail			X
Stipa	*aristiglumis*	Plains Grass		X	
Stipa	*scabra*	Speargrass		X	
Stipa	*verticillata*	Slender Bamboo Grass		X	X
Themeda	*australis*	Kangaroo Grass		X	X
Urochloa	*panicoides*	Liverseed Grass	Introduced	X	
Vulpia	*muralis*		Introduced	X	
POLYGONACEAE					
Rumex	*crispus*	Curled Dock	Introduced	X	
PRIMULACEAE					
Anagallis	*arvensis*	Pimpernal	Introduced		X
RANUNCULACEAE					
Ranunculus	*inundatus*	Common Rannunculus	Introduced		X
SANTALACEAE					
Exocarpus	*cupressiformis*	Native Cherry			X
SINOPTERIDACEAE					
Cheilanthes	*austrotenuifolia*	Rock Fern		X	
Cheilanthes	*sibereri*	Mulga Fern		X	X
SOLANACEAE					
Lycium	*ferocissimum*	African Boxthorn	Intro. (W3)	X	X
Solanum	*brownii*	Violet Nightshade			X
Solanum	*nigrum*	Blackberry Nightshade	Introduced	X	X
STACKHOUSIACEAE					
Stackhousia	*viminea*	Slender Stackhousea			X
STERCULACEAE					
Brachychiton	*populneus*	Kurrajong		X	X
TREMANDRACEAE					
Tetratheca	*ericifolia*	Black Eyed Susan		X	
TYPHACEAE					
Typha	*orientalis*	Cumbungi		X	
VERBENACAE					
Verbena	*bonariensis*	Common Purpletop	Introduced	X	
VIOLACEAE					
Viola	*hederacea*	Native Violet		X	

APPENDIX B

Weather Conditions
Survey Methods
Trapping Results

Weather Details

Date	Temperature Average	Temperature Maximum	Temperature Minimum	Average Wind Speed	Average Wind Direction	Rainfall
5/10/99	14.3	16.7	12.2	17.4	ESE	0.0
6/10/99	14.4	19.4	10.7	15.6	ESE	0.0
7/10/99	14.4	19.1	11.0	14.6	ESE	0.0
8/10/99	16.4	25.1	7.7	8.8	SSE	0.0
9/10/99	20.2	29.6	11.9	8.9	S	0.0
18/10/99	13.6	30.2	11.0	10.1	SE	0.0
19/10/99	14.4	17.3	11.0	13.4	SSE	0.0
20/10/99	19.9	20.3	8.6	11.1	S	0.01

Survey Methodology

Figure A indicates the study area sections which are referred to in this appendix.

Site A

- There were a total of 40 trap nights for Elliot class A traps;
- A total of 20 trap nights for Elliot class B traps;
- One cage trap for a total of four trap nights;
- Five Hair funnels were set at Site A, with three in located on trees approximately 2.5 meters off the ground, and two on the ground, for a total of 20 trap nights;
- One Owl call playback session;
- Two person hours of spotlighting;
- Two Anabat transects were recorded;
- Opportunistic bird survey.

Site B

- Elliot A traps B1 to B10 for a total of 40 trap nights;
- 1 Anabat recording was conducted at the site;
- Three person hours of spotlighting;
- Three and a half person hours of nocturnal frogs;
- Two person hours of diurnal reptile and frog searches;
- Two person hours and 10 minutes of diurnal bird surveys;
- Opportunistic bird survey.

Site C

- Elliot A traps A11- for a total of 40 trap nights. Three Elliot A traps were placed in trees approximately 2.5 metres above the ground;
- Five Elliot B traps for a total of 20 trap nights. Three traps were placed in trees, approximately 2.5 metres above the ground;
- Eleven Hair funnels were set for a total of 28 trap nights with 10 in trees, approximately 2.5 metres off the ground and 1 on the ground within leaf litter;
- One cage trap baited with peanut butter and sardine cat food set in the gully, for a total of 4 trap nights;
- Seven person hours of spotlighting was undertaken at the site;
- Six hours of stag watching;
- One owl call playback;
- Two Anabat transects;
- One and a half person hours of diurnal bird surveys.
- One person hour of reptile searching was performed;
- Opportunistic bird survey.

Site D

- Elliot A traps B11 to B20 for a total of 40 trap nights. Three of the traps were set in trees, approximately 2.5 metres above the ground;
- Four hair tubes were placed within the site for a total of 12 trapping hours. Three traps were placed on trees with large hollows or scratch marks and one was placed on the ground;
- One Anabat transect;
- One owl call playback;
- Two person hours of spotlighting;
- Two person hours of directed reptile searches.
- A total of 2 person hours for diurnal bird survey;
- Opportunistic bird survey.

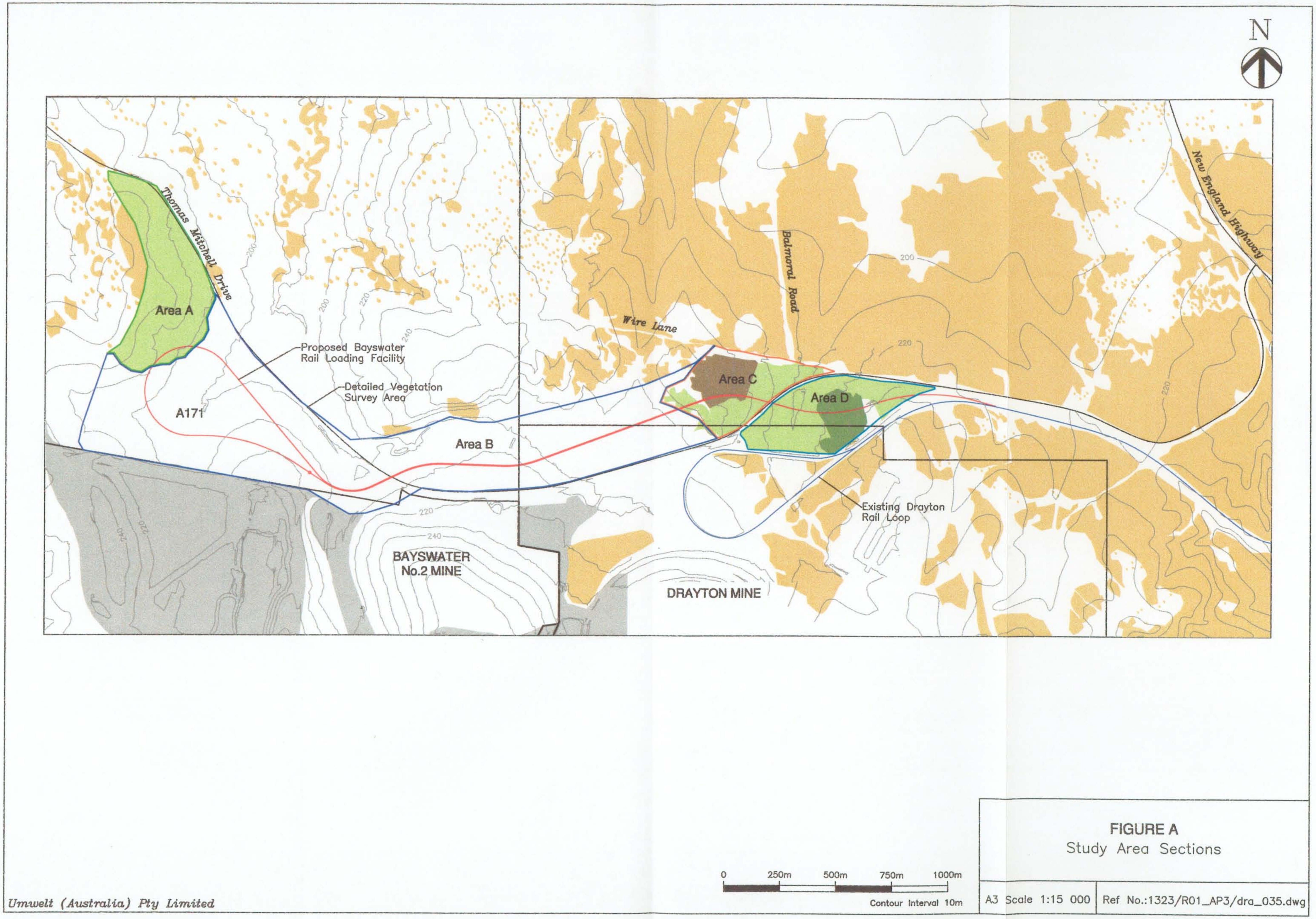

FIGURE A
Study Area Sections

A3 Scale 1:15 000 | Ref No.:1323/R01_AP3/dra_035.dwg

Umwelt (Australia) Pty Limited

Trapping Results

Date	Trap Number	Species	Community
7/10/99	A11	Squirrel Glider *Petaurus norfolcensis*	Area C
7/10/99	A14	Yellow Footed Antechinus *Antechinus flavipes* Female (teats visible)	Area C
8/10/99	C8	Yellow Footed Antechinus *Antechinus flavipes* Female -carrying young	Area C
8/10/99	B8	House mouse *Mus musculus*	Grassland, Area B
9/10/99	C8	Yellow Footed Antechinus *Antechinus flavipes* Female- carrying young	Area C
20/10/99	Hair tube 1	Common Ringtail Possum *Trichosaurus vulpecula*	Area C
20/10/99	Hair tube 2	Common Ringtail Possum *Trichosaurus vulpecula*	Area C
20/10/99	Hair tube 3	*Petaurus sp.*	Area C
20/10/99	Hair tube 4	*Petaurus sp.*	Area C

APPENDIX C

Fauna Species List

TERRESTRIAL FAUNA SURVEY RESULTS

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
AMPHIBIANS								
Common Eastern Froglet	*Crinia signifera*	P		X			A,C,E,F,G	X
Ornate Burrowing Frog	*Limnodynastes ornatus*	P					A,C,F	X
Brown-striped Frog	*Limnodynastes peronii*	P					A,C,F	
Spotted Grass Frog	*Limnodynastes tasmaniensis*	P		X			A,C,E,F	X
Smooth Toadlet	*Uperoleia laevigata*	P		X	X		A,E,F	
Tylers Toadlet	*Uperoleia tyleri*	P		X			A,F	
Green Tree Frog	*Litoria caerulea*	P					A,E,G	
Eastern Dwarf Tree Frog	*Litoria fallax*	P		X			A,C,D	X
Freycinet's Frog	*Litoria freycineti*	P					A,E,F	
Broad-palmed Rocket Frog	*Litoria latopalmata*	P		X			A,C	X
Person's Tree Frog	*Litoria peronii*	P		X			A,C,E,F	X
Total Amphibians	**11**							
REPTILES								
Long-necked Tortoise	*Chelodina longicollis*	P		X			A,C,E,F,G	X
wood gecko	*Diplodactylus vittatus*	P	D				A	X
Robust Velvet Gecko	*Oedura robusta*	P					A,F	X
Thick-tailed Gecko	*Underwoodisaurus milii*	P					A,C,E	X
Jacky Lizard	*Amphibolurus muricatus*	P					A,F,H	X
Eastern Water Dragon	*Physignathus lesuerii*	P					G	
Bearded Dragon	*Pogona barbata*	P					A,C,H	X
Lace Monitor	*Varanus varius*	P					C,E,F,H	X
Two-clawed Worm-skink	*Anomalopus leuckartii*	P					E	
a skink	*Anomalopus swansoni*	P					C,E,F,H	
Southern Rainbow Skink	*Carlia tetradactyla*	P					A,G	
Striped Skink	*Ctenotus robustus*	P	D				A,C,E,F,G	X
Copper-tailed Skink	*Ctenotus taeniolatus*	P					A,F	X
Eastern Rock-skink	*Egernia modesta*	P					A,C,E	
Tree Skink	*Egernia striolata*	P	D				A,C,E,F,G	X
White's Skink	*Egernia whitii*	P					C,E,H	X
Eastern Water Skink	*Eulamprus quoyii*	P		X	X			
Grass Skink	*Lampropholis delicata*	P			X	X		X

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Eastern Blue-tongued Lizard	*Tiliqua scincoides*	P	X				A,F,G,H	
a blind snake	*Ramphotyphlops proximus*	P						X
Brown-snouted Blind Snake	*Ramphotyphlops wiedii*	P						X
Carpet Python	*Morelia spilota spilota*	P						X
Red-naped Snake	*Furina diadema*	P					A,C	X
Spotted Black Snake	*Pseudechis guttatus*	P						X
Red-bellied Black Snake	*Pseudechis porphyriacus*	P				X	C,G	
Eastern Brown Snake	*Pseudonaja textilis*	P					A,G	X
Eastern Small-eyed Snake	*Rhinoplocephalus nigrescens*	P					A,F	
Spectacled Hooded Snake	*Suta spectabilis*	P					F	
	Suta spectabilis dwyeri	P						X
Bandy Bandy	*Vermicella annulata annulata*	P						X
Total Reptiles	**30**							
BIRDS								
Stubble Quail	*Coturnix pectoralis*	P					C,G	X
Brown Quail	*Coturnix australis*	P		X			C,	
Plumed Whistling-Duck	*Dendrocygna eytoni*	P						X
Freckled Duck	*Stictonetta naevosa*	V						X
Black Swan	*Cygnus atratus*	P					C,F,G	
Australian Shelduck	*Tadorna tadornoides*	P						X
Australian Wood Duck	*Chenonetta jubata*	P		X			A,B,C,D,E,F,G,H	X
Pacific Black Duck	*Anas superciliosa*	P		X			A,D,E,F,G	X
Grey Teal	*Anas gracilis*	P		X			D,G,H	X
Hardhead	*Aythya australis*	P					F,G	X
Australasian Grebe	*Tachybaptus novaehollandiae*	P		X			A,C,D,E,F	X
Hoary-headed Grebe	*Poliocephalus poliocephalus*	P						X
Little Pied Cormorant	*Phalacrocorax melanoleucos*	P		X				X
Pied Cormorant	*Phalacrocorax varius*	P					C	
Little Black Cormorant	*Phalacrocorax sulcirostris*	P					C	
Great Cormorant	*Phalacrocorax carbo*	P						X
Australian Pelican	*Pelecanus conspicillatus*	P	X				G	X
White-faced Heron	*Ardea novaehollandiae*	P		X			A,C,G,H	X
White-necked Heron	*Egretta pacifica*	P					C,D,E,F	X
Great Egret	*Ardea alba*	P						X

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Cattle Egret	*Ardea ibis*	P					D	X
Nankeen Night Heron	*Nycticorax caledonicus*	P					D	
Australian White Ibis	*Threskiornis molucca*	P					H	X
Straw-necked Ibis	*Threskiornis spinicollis*	P					B,D	X
Yellow-billed Spoonbill	*Platalea flavipes*	P					H	X
Pacific Baza	*Aviceda subcristata*	P						X
Black-shouldered Kite	*Elanus axillaris*	P					C	X
Black Kite	*Milvus migrans*	P					G	X
Whistling Kite	*Haliastur sphenurus*	P					C,G	X
Spotted Harrier	*Circus assimilis*	P					B	X
Brown Goshawk	*Accipiter fasciatus*	P						X
Red Goshawk	*Erythrotriorchis radiatus*	E						X
Wedge-tailed Eagle	*Aquila audax*	P		X			A,C,E,F,G,H	X
Little Eagle	*Hieraaetus morphoides*	P		X	X	X	E,F	X
Brown Falcon	*Falco berigora*	P		X	X	X	A,C	X
Australian Hobby	*Falco longipennis*	P					A,C	X
Nankeen Kestrel	*Falco cenchroides*	P		X			A,C,G,H	X
Black Falcon	*Falco subniger*	P						X
Buff-banded Rail	*Gallirallus philippensis*	P					G	
Ballion's Crake	*Porzana pusilla*	P					G	
Purple Swamphen	*Porphyrio porphyrio*	P					A	
Dusky Moorhen	*Gallinula tenebrosa*	P		X			G	X
Eurasian Coot	*Fulica atra*	P					C,F,G	X
Bush Stone-curlew	*Burhinus grallarius*	V						X
Black-winged Stilt	*Himantopus himantopus*	P		X				
Black-fronted Dotterel	*Elseyornis melanops*	P		X				
Banded Lapwing	*Vanellus tricolor*	P					G,H	X
Masked Lapwing	*Vanellus miles*	P		X			A,C,D,E,R,F	X
Rock Dove*	*Columba livia*	X						X
Crested Pigeon	*Ocyphaps lophotes*	P		X			A,C,D,E,G,H	X
Peaceful Dove	*Geopelia placida*	P					G	X
Bar-shouldered Dove	*Geopelia humeralis*	P					G	X
Glossy Black Cockatoo	*Calyptorhynchus lathami*	V						X
Galah	*Cacatua roseicapilla*	P			X		A,C,D,E,F,G,H	X
Sulphur-crested Cockatoo	*Cacatua galerita*	P	X	X	X	X	A,C,D,E,F,G,H	X
Cockatiel	*Nymphicus hollandicus*	P						X

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Rainbow Lorikeet	*Trichoglossus haemotodus*	P					E	
Australian King-Parrot	*Alisterus scapularis*	P					A,C	X
Crimson Rosella	*Platycercus elegans*	P					C	X
Eastern Rosella	*Platycerus eximius*	P	X,D		X		A,B,C,D,E,F,G,H	X
Red-rumped Parrot	*Psephotus haematonotus*	P					B,C,D,G	X
Turquoise Parrot	*Neophema pulchella*	V					C	X
Pallid Cuckoo	*Cuculus pallidus*	P			X	X		X
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	P		X		X		X
Common Koel	*Eudynamys scolopacea*	P					A,E	X
Channel-billed Cuckoo	*Scythrops novaehollandiae*	P					A	X
Powerful Owl	*Ninox strenua*	V					C	X
Southern Boobook Owl	*Ninox novaeseelandiae*	P					A,C	X
Barn Owl	*Tyto alba*	P					E,H	
Tawny Frogmouth	*Podargus strigoides*	P			X		A,D,E,F,G,H	X
White-throated Nightjar	*Caprimulgus mysticalis*	P						X
Australian Owlet-nightjar	*Aegotheles cristatus*	P					A,F,G	X
White-throated Needletail	*Hirundapus caudacutus*	P					G	X
Azure Kingfisher	*Alcedo azurea*	P						X
Laughing Kookaburra	*Dacelo novaeguineae*	P			X	X	A,B,C,D,E,F,G,H	X
Sacred Kingfisher	*Todiramphus sanctus*	P			X	X	A,F	
Rainbow Bee-eater	*Merops ornatus*	P			X			X
Dollarbird	*Eurystomus orientalis*	P						X
Superb Lyrebird	*Menura novaehollandiae*	P						X
White-throated Treecreeper	*Cormobates leucophaeus*	P					C,F,G	X
Brown Treecreeper	*Climacteris picumnus*	P				X		X
Superb Fairy-wren	*Malurus cyaneus*	P		X		X	A,C,D,E,F,G,H	X
Variegated Fairy-wren	*Malurus lamberti*	P						
Striated Pardalote	*Pardolotus striatus*	P				X	A,B,D,E,G	
Spotted Pardalote	*Pardolotus punctatus*	P			X	X	A,C,F	X
Rockwarbler	*Origma solitaria*	P						X
White-browed Scrubwren	*Sericornis frontalis*	P						X
Speckled Warbler	*Chthonicola sagittata*	P				X	G	X
Weebill	*Smicrornis brevirostris*	P			X	X	A	
Western Gerygone	*Gerygone fusca*	P						X
White-throated Gerygone	*Gerygone olivacea*	P					A,F,G	
Brown Thornbill	*Acanthiza pusilla*	P					A,F	X

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Buff-rumped Thornbill	*Acanthiza reguloides*	P			X	X	C	X
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	P		X			A,C,D,E,G	X
Striated Thornbill	*Acanthiza lineata*	P					G	X
Red Wattlebird	*Anthochaera carunculata*	P				X		X
Little Wattlebird	*Anthochaera chrysoptera*	P				X		
Yellow Thornbill	*Acanthiza nana*	P			X	X	A,G	X
Stiped Honeyeater	*Plectorhyncha lanceolata*	P						X
Noisy Friarbird	*Philemon corniculatus*	P			X	X	A,E,G	X
Noisy Miner	*Manorina melanocephala*	P	X,D		X		A,B,C,D,E,F,G,H	X
Lewin's Honeyeater	*Meliphaga lewinii*	P						X
Yellow-faced Honeyeater	*Lichenostomus chrysops*	P				X	C,G	X
White-eared Honeyeater	*Lichenostomus leucotis*	P						X
Yellow-tufted Honeyeater	*Lichenostomus melanops*	P						X
Fuscous Honeyeater	*Lichenostomus fuscus*	P					G	X
White-plumed Honeyeater	*Lichenostomus penicillatus*	P			X	X	A,C,F,G	X
Brown-headed Honeyeater	*Melithreptus brevirostris*	P				X	G	
White-naped Honeyeater	*Melithreptus lunatus*	P					A	
Eastern Spinebill	*Acanthorhynchus tenuirostris*	P					A	X
Scarlet Honeyeater	*Myzomela sanguinolenta*	P				X		
Jacky Winter	*Microeca fascinans*	P					C,D,G	X
Scarlet Robin	*Petroica multicolor*	P					C	
Red-capped Robin	*Petroica goodenovii*	P						X
Flame Robbin	*Petroica phoenicea*	P						X
Rose Robin	*Petroica rosea*	P					G	
Hooded Robin	*Melanodryas cucullata*	P					A,C,G	
Eastern Yellow Robin	*Eopsaltria australis*	P						X
Grey-crowned Babbler	*Pomatostomus temporalis*	P					C,F,G	X
Spotted Quail-thrush	*Cinclosoma punctatum*	P						X
Varied Sittella	*Daphoenositta chrysoptera*	P					G	X
Golden Whistler	*Pachycephala pectoralis*	P						X
Grey Shrike-thrush	*Colluricincla harmonica*	P				X		X
Satin Flycatcher	*Myiagra cyanoleuca*	P				X		
Restless Flycatcher	*Myiagra inquieta*	P					C,G	
Grey Fantail	*Rhipidura fuliginosa*	P				X	A,C,D,F,G,H	X
Rufous Whistler	*Rhipidura rufiventris*	P					A	X
Magpie-lark	*Grallina cyanoleuca*	P	D	X			A,C,D,E,F,G	X

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Willie Wagtail	*Rhipidura leucophrys*	P	X,D	X	X	X	A,C,D,E,F,G,H	X
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	P	D		X	X	A,B,C,D,E,F,G,	X
White-bellied Cuckoo-shrike	*Coracina papuensis*	P					E	
White-winged Triller	*Lalage sueurii*	P					B	X
Varied Triller	*Lalage leucomela*	P						X
Olive-backed Oriole	*Oriolus sagittatus*	P			X	X		X
White-browed Woodswallow	*Artamus superciliosus*	P						X
Dusky Woodswallow	*Artamus cyanopterus*	P			X	X	G	X
Grey Butcherbird	*Cracticus torquatis*	P	X				F	
Pied Butcherbird	*Cracticus nigrogularis*	P	D		X	X	A,C,D,F,G,H	X
Australian Magpie	*Gymnorhina tibicen*	P	X,D	X	X	X	A,B,C,D,E,F,G,H	X
Pied Currawong	*Strepera graculina*	P	X	X	X	X	A,F	X
Grey Currawong	*Strepera versicolor*	P						
Australian Raven	*Corvus coronoides*	P	D	X		X	A,C,D,E,F,G,H	X
White-winged Chough	*Corcorax melanorhamphos*	P	D		X	X	A,B,C,D,F,H	X
Skylark	*Alauda arvensis*	X					A	
Richard's Pipit	*Anthus novaeseelandiae*	P		X			A,B,C,E,F,G	X
House Sparrow*	*Passer domesticus*	X					E,G	X
Zebra Finch	*Taeniopygia guttata*	P					A,D,E	X
Red-browed Finch	*Neochmia temporalis*	P					A,C,F,G	X
Diamond Firetail	*Stagonopleura guttata*	P					A,C	X
European Goldfinch*	*Carduelis carduelis*	X						X
White-backed swallow	*Cheramoeca leucosternus*	P						X
Mistletoebird	*Dicaeum hirundinaceum*	P				X	A,C,F	X
Barn Swallow	*Hirundo rustica*	P					H	
Welcome Swallow	*Hirundo neoxena*	P	D	X			A,C,E,F,G,H	X
Tree Martin	*Hirundo nigricans*	P		X		X	G	X
Fairy Martin	*Hirundo ariel*	P					A,F	X
Clamrous Reed-warbler	*Acrocephalus stentoreus*	P		X				
Tawny Grassbird	*Megalurus timoriensis*	P		X			G	
Little Grassbird	*Megalurus gramineus*	P					G	
Rufous Songlark	*Cincloramphus mathewsi*	P		X		X	F	X
Brown Songlark	*Cinchlorhamphus cruralis*	P		X			B,E	
Golden-headed Cisticola	*Cisticola exilis*	P		X				
Silvereye	*Zosterops lateralis*	P					A,C,H	X
Common Starling*	*Sturnus vulgaris*	X					A,C,D,E,F,G	X

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Common Myna*	*Acridotheres tristis*	X					A,E,F,H	X
Total Birds	155							
MAMMALS								
Short-beaked Echidna	*Tachyglossus aculeatus*	P					E,F,H	X
Spotted-tailed Quoll (Tiger Quoll)	*Dasyurus maculatus*	V						X
Yellow-footed Antechinus	*Antechinus flavipes*	P			X			X
Brown Antechinus	*Antechinus stuartii*	P						X
Common Dunnart	*Sminthopsis murina*	P					H	X
Northern Brown Bandicoot	*Isoodon macrourus*	P					A?	
Long-nosed Bandicoot	*Perameles nasuta*	P					A	
Koala	*Phascolarctos cinereus*	V					G	X
Common Wombat	*Vombatus ursinus*	P					A,C,F	X
Sugar Glider	*Petaurus breviceps*	P			X*		C,H	X
Squirrel Glider	*Petaurus norfolcensis*	V			X			
Common Brushtail Possum	*Trichosurus vulpecula*	P			X	X	A,C,E,F,G,H	X
Eastern Grey Kangaroo	*Macropus giganteus*	P		X	X	X	A,C,D,E,F,G,H	X
Parma Wallaby	*Macropus parma*	V					A	
Common Wallaroo	*Macropus robustus*	P		X			A,C,G	X
Red-necked Wallaby	*Macropus rufogriseus*	P				X	A,C,F	X
Brush-tailed Rock-wallaby	*Petrogale penicillata*	V						X
Swamp Wallaby	*Wallabia bicolor*	P					C	X
Grey-headed Flying-fox	*Pteropus poliocephalus*	P					C,E	
Little Red Flying Fox	*Pteropus scapulatus*	P					C,E	
Eastern Horse-shoe Bat	*Rhinolophus megaphyllus*	P					C	
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*	V	D				A,C	
Eastern Little Mastiff Bat	*Mormopterus norfolkensis*	V					C,E	
Large Bentwing-bat	*Miniopterus schreibersii*	V	D		X	X*	A,C	
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	P					A,C,F	
Gould's Wattled Bat	*Chalinolobus gouldii*	P			X		A,C,F	X
Chocolate Wattled Bat	*Chalinolobus morio*	P	D		X	X	A,C,F	
Eastern Broad-nosed Bat	*Scotorepens orion*	P	D				A,C,E	
Broad-nosed Bat	*Scotorepens sp.*	P					C	
Eastern Forest Bat	*Vespadelus pumilus*	P						X
Southern Forest Bat	*Vespadelus regulus*	P	D			X	A,C	

Common Name	Scientific Name	Conservation Status NSW	Umwelt Study				Regional Studies	Atlas Data
			A	B	C	D		
Little Forest Bat	*Vespadelus vulturnus*	P			X	X	A,C,E,F	X
Southern Freetail Bat	*Mormopterus planiceps*	P	D		X		A,C,E	
White-striped Freetail Bat	*Nyctinomus australis*	P	D				A	
House Mouse*	*Mus musculus*	X			X		A,C	X
Bush Rat	*Rattus fuscipes*	P					A	
Fox*	*Vulpes vulpes*	X		X			A,C,D,E,F,G,H	X
Dog*/ Dingo	*Canis familaris/ C. f. dingo*	X					A,E,F	X
Cat*	*Felis catus*	X					E,G	X
Rabbit*	*Oryctolagus cuniculus*	X	X	X	X		A,B,C,D,E,F,G,H	X
Brown Hare*	*Lepus capensis*	X					A,F,G,H	X
Horse (Brumby)*	*Equus caballus*	X					C,E,G	
Feral Pig*	*Sus scrofa*	X					C,E,G	X
Cattle*	*Bos taurus*	X					A,C,E,F,G	X
Feral Goat*	*Capra hircus*	X					C	
Total Mammals	**45**							

APPENDIX 4

Air Quality Assessment

AIR QUALITY IMPACT ASSESSMENT

PROPOSED JOINT USER RAIL LOADING FACILITIES
AT ANTIENE, HUNTER VALLEY, NSW

3 March 2000

Prepared
for
Umwelt (Australia) Pty Ltd

by

Holmes Air Sciences

Suite 2B, 14 Glen St
Eastwood NSW 2122
Phone : (02) 9874 8644
Fax : (02) 9874 8904
holmair@ozemail.com.au

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1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for Umwelt (Australia) Pty Limited. It provides an assessment of the air quality impacts likely to arise as a result of construction and operation of a rail loop, train loading facility and 40,000 t coal stockpile planned for development approximately 2 km to the west of the existing rail loop and coal stockpiles operated by Drayton and immediately to the north of the existing Bayswater No. 2 mine (see **Figure 1**). In addition the report considers the effects of simultaneous operation of the existing Drayton rail loading facility, which will become a common user facility.

A complete description of the proposal is provided in a briefing paper prepared by **Umwelt (Australia) Pty Limited (2000)**. In summary, the Antiene Joint User Rail Facility will comprise two stockpile areas, two-rail load out bins and two rail loops. (Note the Bayswater coal stockpile is already an approved facility.) The locations of the rail loops are shown in **Figure 1**. These will be operated as a common user facility and will seek approval to load approximately 20 Mt of coal per annum, which will be shared between Drayton Coal and Coal Operations Australia Limited (COAL).

The assessment uses a computer-based dispersion model, with local meteorological data and estimated dust emissions, to predict the concentration and deposition rate of particulate matter from the proposed facility and from other mines and other dust sources currently operating in the area. To assess impacts, the predicted concentration and deposition levels are compared with air quality goals that apply in New South Wales (NSW).

A number of other mining developments in the area are in advanced planning stages. These mines are expected to make use of the joint facilities. However these mines will be subject to separate approvals processes and will assess cumulative effects throughout their operating lives. These assessments will include the emission from this project.

Even though achieving a through put of 20 Mtpa is conditional on other mining projects being developed, this report does not consider emissions from these future mines, and is confined to the effects of the joint rail load out facilities. In summary the report provides information on the following:

- The way in which the new facility will be constructed and the way in which it will be operated with the existing Drayton facility with a focus on those aspects that will assist in understanding how these activities will affect air quality
- The surrounding mines that are expected to operate during the life of the project
- The existing air quality conditions in the area
- Air quality goals that need to be met to protect the air quality environment
- The existing meteorological conditions in the area
- The methods used to estimate dust emissions and the way in which dust emissions from the facility will disperse and fallout, both during construction and operation.

As will become apparent (see **Section 7)**, dust emissions from the operation of the rail loop, train loading facilities and stockpiles and will be minor compared with emissions during construction. For this reason, the primary focus of the assessment has been on the contribution that the facility will make to dust concentrations and dust deposition levels in the area during construction.

Finally, other studies undertaken for nearby mines, in particular the Mount Arthur North Project will affect very similar areas of land and operate in very similar environments as far as dispersion conditions are concerned. The report makes use of material common to these two projects.

2. AIR QUALITY GOALS

2.1 Preamble

Air quality goals cover a wide range of emissions. The most significant emissions for this facility will be particulate matter. In addition there will be minor emissions of nitrogen oxides (NO_x) and sulfur dioxide (SO_2) from the use of diesel fuels, but these will occur at such low levels that no detailed study is required to demonstrate that the relevant air quality goals will be met.

The way in which emissions such as particulate matter affect the environment is complex. Particulate matter has the capacity to affect health and to cause nuisance effects.

To assist in interpreting how air quality goals are used some background discussion on the potential harmful effects is provided here.

2.2 Air pollutants and mining

Particulate matter can be categorised by size and/or by chemical composition. The harmful effects depend on both.

The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 μm from reaching the more sensitive parts of the respiratory system. Particles with aerodynamic diameters less than 10 μm are referred to as PM_{10}. Particles larger than 10 μm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals still refer to measures of the mass of all particles in the air. This is referred to as Total Suspended Particulate matter (TSP). In practice particles larger than 30 to 50 μm settle out of the atmosphere too quickly to be regarded as air pollutants and the upper size range for TSP can be taken as 50 μm. TSP includes PM_{10}. Also of concern are fine particles with aerodynamic diameters of 2.5 μm or less. These particles are referred to as $PM_{2.5}$. Just as PM_{10} particles are a sub-component of TSP, so too $PM_{2.5}$ particles are a sub-component of PM_{10} and therefore a sub-component of TSP. $PM_{2.5}$ can penetrate deep into the respiratory system and there is evidence that particles in this size range are more harmful than the coarser component of PM_{10} namely the 2.5 to 10 μm fraction.

At this stage there are no air quality goals in Australia for $PM_{2.5}$ particles, but it is relevant to note $PM_{2.5}$ particles are mainly derived from combustion processes. The dust generated in mining by the abrasion and mechanical disturbance of rocks and soils, contains relatively minor quantities of $PM_{2.5}$ particles - typically less than 5% (**SPCC, 1986**). It would be reasonable to expect that air quality impacts from mining operations would be adequately covered by reference to PM_{10} goals alone. For this reason the dispersion of $PM_{2.5}$ is not discussed detail in this report. However, the US EPA's $PM_{2.5}$ Standards are listed in **Table 1** (see later) to provide a benchmark against which, $PM_{2.5}$ monitoring data collected by the Muswellbrook Council can be assessed. These data support the statements made above concerning the fact that mining and related rail loading activities are a relatively minor source of $PM_{2.5}$ emissions.

2.3 Air quality management and goals in NSW

The NSW Environment Protection Authority (EPA) is responsible for the management of air quality in NSW. In practice this means that the EPA specify the operating conditions for activities likely to cause air pollution and advise government on policy issues and laws/regulations that need to be implemented to maintain air quality at acceptable levels. Thus EPA advice includes such things as the appropriate measures of air quality; the need for unleaded petrol and catalytic converters on motor vehicles; the emission limits with which industry must comply; and the particular controls and operating rules that should be implemented at industrial facilities such as coalmines and related facilities.

The EPA notes and makes reference to a number of air quality goals for particulate matter that are relevant to this study. The goals are:

- the US EPA's 24-hour PM_{10} Standard (revised July 1997)[1].
- the US EPA's annual average PM_{10} Standard (revised July 1997).
- the Australian National Environment Protection Council's (NEPC) National Environment Protection Measure (NEPM) specified as a reporting standard for 24-hour PM_{10}.
- the NSW EPA's 24-hour PM_{10} reporting standard (similar to the NEPC 24-hour PM_{10} reporting standard).
- the NSW EPA's annual PM_{10} "Action for Air long-term reporting goal" (**EPA, 1998**).
- the National Health and Medical Research Council's (NHMRC) annual average goal for Total Suspended Particulate matter (TSP).
- The NSW EPA's annual average dust deposition goal for insoluble solids.

2.4 Form of the goals

Each of the above goals and standards are applied in different contexts.

The US EPA 24-hour PM_{10} Primary Standard, which in the context of US EPA legislation is a Standard set at a level "requisite to protect the public health" with an "adequate margin of safety" is commonly said to be 150 $\mu g/m^3$. Strictly, the standard is met when the 99th percentile of 24-hour PM_{10} concentrations, averaged over three years, is below 150 $\mu g/m^3$. The standard therefore allows about eleven 24-hour PM_{10} concentrations above 150 $\mu g/m^3$ over a three-year period, or about three to four occasions per year. The purpose of this standard is to protect against short-term exposure to coarse fraction particles (**US EPA, 1997**).

The US EPA annual standard for PM_{10} is based on an assessment of health and other available information. The Standard is met when the annual PM_{10} concentration of PM_{10} is below 50 $\mu g/m^3$. The standard is to protect against effects from both long- and short-term exposure to coarse fraction particles (**US EPA, 1997**).

The NEPM 24-hour PM_{10} Standard is a reporting standard to be used in assessing PM_{10} concentrations at a performance monitoring station (**NEPC, 1998 – Section 13.8**). Performance monitoring stations will collect air quality data representative of a region (**NEPC, 1998 – Section 7.4**). In the same section of the NEPM Impact Statement it is noted that the NEPM standards are not intended to address the monitoring requirements associated with source impact management programs. In other words they are not standards to be used at the boundaries of industrial facilities.

[1] At the time of writing, the 1997 US EPA goals for PM_{10} have been set aside following a legal challenge to the new goals by the American Trucking Association. The legal argument that led to this decision relates to the power of the US Congress to delegate the making of laws to agencies such as the US EPA. The legal questions in no way relate to the scientific basis of the goals and consequently this report continues to make reference to the goals. **Debra and Frank (1999)** provide a more complete discussion on this issue. Interested readers should refer to this article.

The NSW EPA 24-hour average PM_{10} "Action for Air interim goal" and "Long-term reporting goal" are part of a suite of goals intended to guide the development of control strategies and for reporting purposes (**NSW EPA, 1998 - Page 13**).

The NHMRC annual 90 $\mu g/m^3$ goal for TSP is an old goal recommended by the NHMRC at their 92nd session in October 1981. It was developed before the more recent results of epidemiological studies had demonstrated the relationship between health impacts and exposure to PM_{10} concentrations. In mining areas where PM_{10} particles are approximately 40 to 50% of the TSP mass, the goal is consistent with a PM_{10} goal of 36 to 45 $\mu g/m^3$ and is thus slightly more stringent than the current US EPA PM_{10} goal of 50 $\mu g/m^3$. For urban areas, where the PM_{10}:TSP ratios are often higher it may not be as stringent as current goals.

Given this background to the air quality goals, the assessment in the current study-has been made using the US EPA 24-hour 150 $\mu g/m^3$ and annual goal of 50 $\mu g/m^3$ as goals that should be met at the closest residences. The NEPM 24-hour Standard of 50 $\mu g/m^3$, the NSW EPA 24-hour goal of 50 $\mu g/m^3$ and the NSW EPA annual goal of 30 $\mu g/m^3$ have been interpreted as goals for PM_{10} that should be met generally within the region, where the main centres of population are located.

The NHMRC annual goal for TSP of 90 $\mu g/m^3$ has been interpreted as a goal that should be met at all locations where there are residences.

Finally, the NSW EPA makes reference to goals for the deposition of insoluble solids. Although the goals for deposition are only intended to protect the community against the nuisance effects of particle pollution, in some circumstances these goals are the most difficult to meet for mining operations. They are therefore, important in the context of identifying land considered to be impacted by mining proposals. In effect the EPA goal says that residential areas begin to experience dust related nuisance impacts when annual average dust (insoluble solids) deposition levels exceed 4 g/m^2/month, and that dust impacts would be at unacceptable levels when they reached 10 g/m^2/month (**SPCC - now EPA, 1983**). In the early 1990s the EPA (**Dean et al., 1990**) refined these criteria. They are now expressed in terms of an acceptable increase in dust deposition over the existing background. For example, in residential areas with annual average deposition levels of between 0 and 2 g/m^2/month, an increase of up to 2 g/m^2/month would be permitted before it is considered that degradation of air quality has occurred.

2.5 Summary

Table 1 and **2** summarise the goals that are relevant to this study.

Table 1 - Health-based air quality standards/goals for particulate matter concentrations		
POLLUTANT	STANDARD/GOAL	AGENCY
Total suspended particulate matter (TSP)	**90 µg/m³ (annual mean)**	**NHMRC**
Particulate matter < 10 µm (PM_{10})	**150 µg/m³ (average of 99th percentile of 24-hour averages over three years)** **50 µg/m³ (annual mean)** 50 µg/m³ (24-hour maximum) 30 µg/m³ (annual mean) 50 µg/m³ (24-hour average, 5 exceedances permitted per year)	**US EPA Standard** **US EPA Standard** NSW EPA reporting standard NSW EPA long-term reporting goal NEPM reporting standard
Particulate matter < 2.5 µm ($PM_{2.5}$)	65 µg/m³ (98th percentile of 24-hour averages over three years) 15 µg/m³ (1-year average)	US EPA Standard US EPA Standard

It should be remembered that the air quality goals relate to the total dust burden in the air and not just the dust from the project.

Table 2 shows the maximum acceptable increase in dust deposition over the existing dust levels.

Table 2 - EPA criteria for dust fallout		
Existing dust fallout level (g/m²/month)	Maximum acceptable increase over existing fallout levels (g/m²/month)	
	Residential	Other
2	2	2
3	1	2
4	0	1

The criteria for dust fallout levels in **Table 2** are set to protect against nuisance impacts.

3. DISPERSION METEOROLOGY

The computer-based dispersion model ISCST3 has been used in this study. This model requires data on wind speed, wind direction, atmospheric stability[2] class and mixed-layer

[2] In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme (as used in this study) there are six stability classes, A through to F. Class A relates to unstable conditions, such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

height[3]. Hourly data for 1995 and 1996 have been collected at the former Pacific Power meteorological station (now Macquarie Generation) at Mt. Arthur North near to the study area. These data have been used to assess meteorological conditions at the site. Data for the period 5 November 1995 to 4 November 1996 have been used in modelling study. A total of 7080 hours of data were available for the study. This corresponds to 81% of the data potentially available in a year. The data provide information on wind speed, wind direction, and other parameters required for dispersion modelling, for each hour.

Additional data are available from Bayswater No. 3's weather station and from Bengalla's weather station on Overton Ridge and from Bengalla's 90 m mast on the river flats north of the Denman Road and from Drayton's weather station located approximately 1 km to the east of the existing Drayton rail loop. The locations of each of these sites are shown on **Figure 1**. **Figures 2, 3** and **4** show annual and seasonal wind roses prepared from the Macquarie Generation data and from the Bayswater No. 3, weather station data. The reason for choosing the Macquarie Generation data for the study is that it is the closest source of weather data to the construction activity where the new rail loop and stockpile pad will be constructed. As will be seen later this is the most significant source of dust emission associated with the project. In practice however, all of these monitoring sites indicate similar patterns of wind and the selection of which data set to use is not critical to the assessment.

Over the year the prevailing winds can be seen to be aligned along a NW-SE axis. This is common for most sites in the Upper Hunter Valley. Summer winds are generally from the SE. In winter NW winds are more common. This pattern is replicated at all sites. Considering the location of the potential dust emissions sources associated with construction and operation relative to residential areas, it can be seen that the residences in the Antiene subdivision, which lie generally to the N or NE of the proposed stockpiles and rail loading facilities, are located favourably from the point of view of dust emissions.

4. EXISTING AIR QUALITY

4.1 Concentration

Measurements of 24-hour concentrations of PM_{10} using high-volume samplers with size selective inlets have been made at six sites in the area. These are referred to as Calool, Edderton Road, Windmill, Roxburgh Road, Racecourse and School. In addition 24-hour TSP measurements are available from three sites near the Drayton mine - the Oval, Lot 9 Antiene and the (Drayton) Met Station. The Oval and Lot (Antiene) are the most relevant for the current assessment. The Met Station is too close to the Drayton stockpile to be considered representative of residential areas. Approximate values of PM_{10} concentrations can be inferred from TSP measurements by assuming that PM_{10} concentrations are approximately 40% of TSP concentrations. This relationship applies approximately in most areas near mining operations in the Hunter Valley. The monitoring sites are shown on **Figure 1**. The data are presented graphically in **Figure 5**. The PM_{10} concentrations provided for the Oval, Lot 9 and Met Station are derived from TSP measurements. All other results are direct measurements. Note, not all sites operated for the full period covered by the graph.

[3] The term mixed-layer height, refers to the height above the ground through which ground-based emissions will eventually be dispersed once a plume has been thoroughly mixed. An elevated plume, initially above the mixed-layer height will remain isolated from the ground until such time as the mixed-layer height reaches the height of the plume. In general the mixed-layer height will increase during the day as the sun causes convection to deepen the turbulent layer of the atmosphere close to the ground. Mixed-layer height will also increase if the wind speed increases because higher wind speeds will increase turbulence as the wind blows over the rough ground.

It can be seen that the 24-hour maximum PM_{10} concentration recorded to date has been 97 µg/m³ at the School in March 1998. This figure is well below the US EPA 24-hour goal of 150 µg/m³, but it would count as one of the five exceedances, allowed annually in application of the 24-hour average NEPM 50 µg/m³ standard[4]. Interestingly the highest PM_{10} concentration of 97 µg/m³ recorded at the School monitor occurred on 17 March 1998. The 17th was a warm day with a maximum temperature of 30 °C. Winds for the whole day were from directions between 79 and 199 degrees, that is generally in the SE quadrant. It would seem unlikely that local mines were a significant contributor to dust on that day.

The next highest 24-hour average shown in **Figure 5** is 92 µg/m³, which occurred on 5 December 1997. Meteorological conditions for this day are unknown. However, the Muswellbrook Council's 24-hour $PM_{2.5}$ data for 7 December 1997 (two days later) shows a high $PM_{2.5}$ concentration and the notes accompanying the data note that smoke from bushfires in the area was a significant contributor. It would appear likely that the PM_{10} level was also affected by bush fire smoke. The other two 24-hour PM_{10} concentrations above 50 µg/m³ occurred on the same day, 23 March 1998, at the School monitor (51 µg/m³) and the Racecourse monitor (56 µg/m³). March 23 1998 was a hot day, maximum temperature 38 °C, with winds from 19 to 290 degrees, that is generally from the NW. Mining activities may have contributed to these moderately high levels.

In summary there are only 4 days (5 recordings) when the 24-hour PM_{10} concentrations exceeded 50 µg/m³. In any one year the maximum number of exceedances of the 50 µg/m³ 24-hour level has been two. This suggests that air quality in the area currently complies with the NEPM standard of 50 µg/m³ with no more than 5 exceedances per year.

It is also interesting to compare annual average PM_{10} and TSP concentrations with the relevant goals. As noted earlier the monitors most relevant for the current study are the monitors located at the Oval and Lot 9 (Antiene). These results along with the data from the Met Station monitor are presented in **Table 3.**

Table 3. 24-hour TSP (inferred PM_{10}) concentrations - µg/m³

Site	1996	1997	1998	1999
Oval	-	51.9 (20.7)	42.3 (16.9)	51.1 (20.4)
Lot 9 (Antiene)	57.9 (23.2)	25.0 (10.0)	13.3 (5.3)	19.3 (7.7)
Met Station	58.1 (23.2)	87.5 (43.8)	42.7 (17.1)	48.0 (19.2)

Annual TSP and PM_{10} concentrations are within the respective air quality goals of 90 µg/m³ for TSP and 50 µg/m³ for PM_{10}.

4.2 Deposition

Several monitoring networks exist in the area. The monitoring results from 1994 to 1999 for Bayswater No. 2 and Bayswater No. 3 are presented in **Table 4** and **5. Table 6** presents the results of the Drayton dust monitoring network. Gauges 2197, 2230, 2347, 2208, 2235 and 2175 are the most relevant for the Antiene residential area. Gauges 2197 and 2157 are

[4] NEPM monitoring will require <u>continuous</u> monitoring using approved monitoring methods. The current requirements for mine monitoring only specify monitoring every sixth day. This makes it impossible to make definitive statements about compliance, or otherwise, with the NEPM standard from the existing database. It should also be noted that NEPM monitoring will generally only be undertaken in areas with population greater than 25,000.

not strictly within the residential area, but the other gauges would be expected to provide representative data. The locations of all deposition gauges are shown in **Figure 1**.

Table 4 - Dust deposition monitoring for the Bayswater No. 2 network (1994-1999)

	D1	D2	D8	D11	D12	D18	D26	D27
Jan-94	4.7	2.5	2.2	3.0	2.6	1.3	1.7	2.1
Feb-94	5.2	3.6	2.7	7.2	1.6	1.3	2.2	3.9
Mar-94	2.0	2.1	1.7	8.5	1.8	1.3	1.5	1.5
Apr-94	1.9	2.4	1.1	1.9	1.9	0.8	2.6	1.1
May-94	2.1	1.6	2.1	3.6	1.8	1.6	1.7	1.3
Jun-94	1.5	2.3	1.2	2.1	-	1.5	1.8	1.1
Jul-94	7.1	0.6	0.2	0.9	0.8	0.5	-	0.6
Aug-94	1.4	1.7	2.4	3.2	1.6	1.1	2.1	1.1
Sep-94	1.8	1.3	1.2	1.5	0.8	1.4	-	1.0
Oct-94	1.9	3.3	4.6	-	3.5	-	-	2.7
Nov-94	3.0	3.1	4.8	-	3.9	3.0	-	2.5
Dec-94	5.3	4.0	3.3	3.1	2.1	4.2	-	3.9
Average	**3.2**	**2.4**	**2.3**	**3.5**	**2.0**	**1.6**	**1.9**	**1.9**
Jan-95	-	3.4	2.1	3.4	1.4	-	-	3.8
Feb-95	-	-	2.9	-	2.7	-	4.6	3.5
Mar-95	-	2.7	2.4	5.6	3.2	-	3.1	2.0
Apr-95	-	-	3.5	-	1.5	-	-	1.8
May-95	4.5	1.5	3.2	3.2	0.9	-	-	1.1
Jun-95	-	1.1	1.1	-	1.0	-	-	0.9
Jul-95	1.0	0.5	2.1	0.7	0.4	-	0.6	0.9
Aug-95	1.4	1.4	-	3.5	-	-	-	1.3
Sep-95	1.8	-	1.8	1.6	1.7	-	5.0	1.4
Oct-95	1.8	2.0	1.2	-	-	-	2.8	1.8
Nov-95	-	-	2.2	-	1.0	-	1.4	1.8
Dec-95	-	-	-	-	-	-	-	1.3
Average	**2.1**	**1.8**	**2.3**	**3.0**	**1.5**	**-**	**2.9**	**1.8**
Jan-96	-	-	2.3	-	1.9	-	3.9	2.0
Feb-96	-	-	3.7	-	1.2	-	3.5	2.8
Mar-96	7.7	-	3.7	-	1.7	-	-	-
Apr-96	2.5	2.3	1.8	-	1.4	-	-	1.4
May-96	1.7	-	4.8	-	1.1	-	-	1.2
Jun-96	1.3	1.4	0.6	0.9	0.7	-	1.7	1.0
Jul-96	1.9	1.9	-	0.9	0.7	-	1.6	0.7
Aug-96	0.6	1.5	0.5	1.1	0.3	-	0.5	0.4
Sep-96	2.7	2.5	-	-	1.9	-	2.3	2.3
Oct-96	1.4	1.3	0.9	2.4	0.7	-	2.1	1.1
Nov-96	-	-	2.6	-	1.5	-	2.4	2.0
Dec-96	-	-	1.6	3.6	0.7	-	2.2	2.0
Average	**2.5**	**1.8**	**2.3**	**1.8**	**1.2**	**-**	**2.2**	**1.5**
Jan-97	-	3.4	2.6	4.5	1.2	-	3.6	1.6
Feb-97	-	-	2.1	4.6	-	-	4.4	2.1
Mar-97	2.7	-	2.0	-	-	-	4.2	2.6
Apr-97	-	-	2.6	1.5	-	-	4.1	2.0
May-97	-	4.5	4.6	3.8	7.7	-	-	2.3
Jun-97	-	3.4	1.8	1.7	1.3	-	-	1.2
Jul-97	-	-	1.6	5.1	-	-	2.8	1.0
Aug-97	0.9	-	-	0.9	-	-	1.7	-
Sep-97	1.2	1.3	-	1.5	-	-	2.2	1.9
Oct-97	2.0	-	-	-	1.4	-	3.7	-
Nov-97	3.0	-	-	2.3	-	-	6.1	2.5
Dec-97	2.5	3.6	-	2.9	-	-	3.7	2.2

Average	**2.1**	**3.2**	**2.5**	**2.9**	**2.9**	**-**	**3.7**	**1.9**
Jan-98	-	-	-	4.8	2.9	-	-	4.1
Feb-98	3.0	-	-	4.8	4.8	-	7.0	3.2
Mar-98	8.5	-	-	-	-	-	-	2.3
Apr-98	2.0	-	-	3.5	-	-	3.8	1.7
May-98	1.5	-	-	2.9	0.9	-	2.0	1.0
Jun-98	-	3.5	3.5	1.9	1.0	-	1.3	0.6
Jul-98	0.8	-	-	1.6	1.2	-	0.7	0.4
Aug-98	-	1.1	-	2.2	1.7	-	2.3	0.6
Sep-98	1.2	-	1.6	1.4	1.3	-	1.8	0.7
Oct-98	-	-	-	-	-	-	-	1.0
Nov-98	1.9	-	-	3.5	-	-	-	1.5
Dec-98	2.2	-	-	6.0	3.9	-	-	2.2
Average	**2.6**	**2.3**	**2.6**	**3.3**	**2.2**	**-**	**2.7**	**1.6**
Jan-99	-	-	-	2.6	7.2	-	-	1.0
Feb-99	3.2	-	-	5.2	-	-	2.0	1.1
Mar-99	-	3.0	-	3.4	-	-	-	1.2
Apr-99	-	-	-	-	-	-	-	-
May-99	-	-	-	-	-	-	3.3	1.2
Jun-99	-	-	3.6	2.0	3.4	-	1.1	0.6
Jul-99	3.2	3.0	-	1.9	-	-	0.6	0.5
Aug-99	1.6	-	1.1	1.3	-	-	1.1	0.6
Sep-99	1.4	-	3.4	3.5	-	2.8	1.2	1.0
Oct-99	1.4	3.9	-	2.0	-	-	1.0	0.8
Nov-99	-	-	-	1.6	3.4	-	1.7	1.3
Dec-99	-	-	-	3.7	-	2.5	3.3	1.7
Average	**2.2**	**3.3**	**2.7**	**2.7**	**4.7**	**2.7**	**1.7**	**1.0**

Table 5 - Dust deposition monitoring for the Bayswater No. 3 network (1994-1999)

	G1	G2	G3	G4	G5	G6	G7	G9	G9A	G10	G11	G12	G13
Jan-94	2.2	-	1.8	3.5	-	1.2	1.7	3.4	1.3	1.7	1.3	2.9	1.0
Feb-94	8.3	1.2	1.3	1.2	2.2	1.0	3.1	4.9	1.4	6.7	1.4	-	0.8
Mar-94	1.0	0.8	0.7	-	-	0.9	4.1	1.8	0.9	0.7	0.7	-	0.6
Apr-94	5.0	1.8	1.2	-	1.0	0.7	0.9	-	1.0	0.8	1.2	-	0.6
May-94	-	-	0.8	4.1	0.9	1.0	1.3	1.0	1.0	-	-	-	-
Jun-94	0.5	0.5	0.6	-	0.6	1.0	2.6	1.8	1.2	0.7	0.9	0.7	-
Jul-94	0.2	0.5	5.1	-	0.5	0.9	0.8	-	0.4	-	0.5	0.7	0.6
Aug-94	0.8	0.6	5.2	-	0.5	0.7	1.3	-	1.2	0.7	0.8	0.7	0.9
Sep-94	0.8	1.3	0.6	0.6	0.5	1.2	3.2	-	0.9	1.0	-	1.0	0.9
Oct-94	2.9	-	2.9	2.0	2.2	2.0	-	-	-	-	2.1	1.9	1.8
Nov-94	-	-	-	-	2.5	2.3	-	-	2.4	2.1	2.0	2.0	2.4
Dec-94	-	1.8	1.0	-	2.1	2.0	-	-	-	1.0	1.6	1.7	1.6
Average	**2.4**	**1.1**	**1.9**	**2.3**	**1.3**	**1.2**	**2.1**	**2.6**	**1.2**	**1.7**	**1.3**	**1.5**	**1.1**
Jan-95	4.9	1.6	1.0	-	0.8	2.6	-	-	2.8	0.8	1.2	2.6	1.3
Feb-95	-	2.1	1.2	1.8	1.2	1.5	-	-	1.8	1.0	1.7	-	1.6
Mar-95	-	1.9	1.0	2.2	1.2	2.1	-	-	-	-	1.6	1.3	1.4
Apr-95	-	1.0	0.7	-	1.0	1.4	-	-	-	1.1	1.6	1.2	-
May-95	-	1.9	0.6	1.3	0.6	1.9	-	-	-	-	1.1	0.5	3.3
Jun-95	-	0.8	0.3	0.5	0.6	0.7	-	-	0.8	-	-	0.4	0.6
Jul-95	1.0	0.3	0.4	-	0.5	0.6	-	-	-	0.5	0.5	0.3	0.4
Aug-95	1.0	0.6	0.7	-	0.8	1.3	-	-	1.1	0.5	1.2	0.7	0.7
Sep-95	-	1.8	0.8	-	0.8	-	-	-	1.5	0.7	1.1	0.6	2.3
Oct-95	1.1	0.9	0.7	-	1.0	-	-	-	1.4	1.7	-	0.8	1.3
Nov-95	-	0.9	0.7	-	0.8	2.6	-	-	2.0	-	1.3	1.5	1.1
Dec-95	-	1.3	1.1	-	1.1	2.8	-	-	1.7	1.2	1.4	2.4	-

Average	**2.0**	**1.3**	**0.8**	**1.5**	**0.9**	**1.8**	**-**	**-**	**1.6**	**0.9**	**1.3**	**1.1**	**1.4**
Jan-96	-	1.8	1.2	-	1.7	-	-	-	3.1	-	2.1	2.6	3.4
Feb-96	-	-	-	-	1.1	-	-	-	2.2	-	-	1.8	-
Mar-96	1.6	1.9	0.9	-	1.2	2.2	-	-	-	-	-	1.3	-
Apr-96	-	-	-	-	1.2	4.0	-	-	-	-	1.5	1.1	-
May-96	1.0	1.1	2.1	1.3	0.9	-	-	-	-	-	0.8	1.2	1.5
Jun-96	0.9	0.6	0.5	0.6	0.7	-	-	-	-	-	0.5	2.4	0.9
Jul-96	2.0	0.5	0.4	0.5	0.5	-	-	-	-	0.2	0.3	0.2	0.3
Aug-96	-	0.3	0.4	0.5	0.7	1.0	-	-	0.6	0.3	0.3	0.7	0.4
Sep-96	3.1	2.1	1.7	3.0	2.3	-	-	-	1.6	1.3	1.3	1.7	1.7
Oct-96	-	0.8	1.5	0.7	0.7	1.1	-	-	1.1	0.8	1.0	0.6	1.2
Nov-96	-	1.6	1.4	1.3	-	-	-	-	3.0	2.2	2.0	1.6	1.6
Dec-96	-	0.4	3.7	1.1	-	-	-	-	2.1	0.6	1.1	9.1	1.7
Average	**1.7**	**1.1**	**1.4**	**1.1**	**1.1**	**2.1**	**-**	**-**	**2.0**	**0.9**	**1.1**	**2.0**	**1.4**
Jan-97	-	0.5	3.1	0.9	-	-	-	-	2.5	1.0	1.3	1.7	1.9
Feb-97	-	1.0	1.3	1.0	-	-	-	-	-	1.0	-	-	1.4
Mar-97	-	1.5	1.5	-	-	-	-	-	1.5	1.0	1.4	-	1.3
Apr-97	2.8	1.0	0.8	0.8	-	3.7	-	-	1.1	1.7	-	0.9	-
May-97	-	1.6	1.1	2.7	1.1	4.9	-	-	1.8	1.3	1.6	1.9	1.5
Jun-97	-	0.6	-	0.8	0.9	0.8	-	-	-	0.6	0.7	1.3	-
Jul-97	1.4	0.9	0.7	1.0	2.0	1.6	-	-	1.4	0.9	0.9	-	1.6
Aug-97	-	0.9	1.3	0.7	1.1	-	-	-	0.7	0.7	1.3	0.7	-
Sep-97	-	0.6	0.4	0.5	0.6	-	-	-	0.8	-	0.6	-	-
Oct-97	-	1.1	0.9	2.4	1.6	-	-	-	1.8	1.8	1.5	-	-
Nov-97	-	2.6	2.0	1.7	-	-	-	-	-	2.7	2.2	-	-
Dec-97	-	7.1	3.1	-	3.2	11.4	-	-	2.7	1.5	2.4	-	-
Average	**2.1**	**1.6**	**1.5**	**1.3**	**1.5**	**4.5**	**-**	**-**	**1.6**	**1.3**	**1.4**	**1.3**	**1.5**
Jan-98	3.3	1.4	1.3	-	1.1	9.7	-	-	1.9	1.0	2.0	-	-
Feb-98	-	1.7	1.6	2.0	-	-	-	-	2.4	2.1	2.5	-	-
Mar-98	-	1.0	0.5	0.6	1.2	-	-	-	1.6	1.2	1.0	-	1.6
Apr-98	-	2.4	1.3	1.5	1.4	-	-	-	1.6	-	1.8	3.1	-
May-98	1.0	0.5	0.6	-	0.9	1.3	-	-	0.8	-	0.7	-	-
Jun-98	1.9	0.6	0.5	0.5	0.7	1.0	-	-	-	0.8	1.0	8.4	1.6
Jul-98	-	0.4	0.2	0.4	0.6	0.7	-	-	0.5	0.8	0.4	1.0	-
Aug-98	0.6	0.6	-	0.6		9.6	-	-	0.7	1.1	0.5	0.5	0.8
Sep-98	1.8	0.6	0.9	0.4	2.4	0.5	-	-	2.3	-	0.5	1.8	-
Oct-98	3.8	3.3	0.8	0.9	0.9	2.2	-	-	1.3	-	1.2	1.3	-
Nov-98	-	1.1	0.9	1.2	-	-	-	-	1.7	-	2.2	3.2	-
Dec-98	1.9	1.5	1.0	-	-	-	-	-	1.6	1.2	1.6	-	-
Average	**2.0**	**1.3**	**0.9**	**0.9**	**1.2**	**3.6**	**-**	**-**	**1.5**	**1.2**	**1.3**	**2.8**	**1.3**
Jan-99	1.9	1.4	1.2	-	1.4	1.6	-	-	2.2	1.2	1.7	1.6	4.8
Feb-99	1.9	6.1	1.2	-	0.8	6.5	-	-	1.9	1.1	2.0	-	2.5
Mar-99	-	1.3	2.8	-	-	-	-	-	-	-	-	-	-
Apr-99	-	-	-	-	-	-	-	-	-	-	-	-	-
May-99	1.1	0.9	0.8	1.0	-	2.8	-	-	1.2	-	1.1	-	-
Jun-99	0.8	0.5	0.5	0.5	-	1.5	-	-	0.9	0.5	1.6	2.6	-
Jul-99	1.0	-	0.7	0.5	1.4	1.3	-	-	0.8	0.4	2.5	1.8	-
Aug-99	1.4	1.7	0.8	0.6	1.0	1.1	-	-	3.2	1.0	1.0	1.4	-
Sep-99	1.2	1.6	0.9	0.9	1.3	1.7	-	-	1.7	1.0	1.1	1.8	-
Oct-99	1.4	1.1	0.9	0.9	3.3	-	-	-	3.7	3.7	1.5	3.5	-
Nov-99	1.7	1.4	1.9	2.3	2.9	-	-	-	1.7	-	-	-	2.6
Dec-99	-	1.4	1.3	1.8	2.6	1.2	-	-	-	1.1	1.2	-	3.3
Average	**1.4**	**1.7**	**1.2**	**1.1**	**1.8**	**2.2**	**-**	**-**	**1.9**	**1.3**	**1.5**	**2.1**	**3.3**

Table 6. Dust deposition monitoring for the Drayton monitoring network (1994-1999)						
Period	**2197**	**2230**	**2247**	**2208**	**2235**	**2175**
Jan-94	3.1	3.5	1.9	3.5	2.4	2.7
Feb-94	3.2	2.1	2.9	2.5	1.3	14.4
Mar-94	1.7	0.7	0.8	0.6	0.6	0.5
Apr-94	1.8	1.1	0.6	1.1	0.8	0.9
May-94	2.0	1.2	1.0	0.8	0.8	1.3
Jun-94	1.2	1.8	0.7	1.9	1.1	1.1
Jul-94	7.7	2.7	1.4	2.8	1.7	2.1
Aug-94	2.2	1.3		3.0	0.9	2.2
Sep-94	1.3	1.0	1.4	1.3	1.7	1.5
Oct-94	1.7	3.0	0.6	4.3	2.1	2.3
Nov-94	2.3	2.3	2.3	8.9	2.6	3.0
Dec-94	1.2	1.5	0.8	1.6	1.3	1.8
Average	**2.5**	**1.9**	**1.3**	**2.7**	**1.4**	**2.8**
Jan-95	0.6	0.8	0.2	0.6	2.4	3.9
Feb-95	2.5	1.1	0.6	0.3	0.7	0.9
Mar-95	0.6	0.7	1.2	0.8	0.3	0.1
Apr-95	3.7	0.7	0.2		1.4	
May-95	1.6	0.9		1.2	0.8	0.4
Jun-95	1.7	1.3	0.8		0.6	1.4
Jul-95	2.2	0.7		2.8	1.0	1.7
Aug-95	1.1	1.2	0.9	1.3	0.9	
Sep-95	2.2	1.2	2.0	0.5	0.8	2.0
Oct-95		0.9	0.8	1.6	12.2	2.0
Nov-95	3.3	1.4	1.5	1.6	3.8	2.3
Dec-95	13.1	1.4	2.0	4.3	1.3	1.0
Average	**3.0**	**1.0**	**1.0**	**1.5**	**2.2**	**1.6**
Jan-96	3.3	2.4	1.6	2.0	1.7	2.1
Feb-96	3.7	3.5	1.6	1.2	4.9	2.4
Mar-96	1.6	2.4	0.7	0.5	0.8	0.8
Apr-96	1.6	0.7	0.6	0.7	0.8	1.2
May-96	1.1	1.6	0.6	1.3	0.4	0.7
Jun-96	1.2	0.7	0.9		1.2	1.8
Jul-96	2.9	2.3	1.4	5.9	2.5	2.1
Aug-96	1.3	0.7	0.9	4.2	1.1	1.5
Sep-96	1.5	1.8	1.7	1.0	1.7	2.3
Oct-96	2.5	1.0	0.3	1.1	1.6	1.1
Nov-96	14.0	0.9	0.8	1.0	1.7	1.5
Dec-96	2.2	1.2	0.4	1.5	1.8	0.5
Average	**3.1**	**1.6**	**1.0**	**1.9**	**1.7**	**1.5**
Jan-97	3.0	2.5	2.4	2.3	1.4	3.6
Feb-97	1.6	0.8	0.8	0.5	0.6	0.7
Mar-97	1.0	2.2	0.9	3.2	0.8	1.0
Apr-97	1.8	1.6	1.1	0.7	1.0	1.6
May-97	1.7	1.9	1.5	0.8	0.8	0.9
Jun-97	4.6	1.7	0.8	2.8	0.7	0.8
Jul-97	1.5	0.5	0.6	3.5	0.5	1.1
Aug-97	0.6	0.6	1.6	0.5	1.1	1.8

Sep-97	1.1	0.6	1.3	1.1	1.0	0.6
Oct-97	1.4	0.8	0.6	0.8	1.1	0.8
Nov-97	3.0	1.9	1.4	1.4	1.9	1.9
Dec-97	4.1	2.0	1.6	13.6		2.3
Average	**2.1**	**1.4**	**1.2**	**2.6**	**1.0**	**1.4**
Jan-98	2.7	2.9	2.6	3.3	1.5	2.1
Feb-98	3.3	1.5	1.5	2.4	1.8	6.9
Mar-98	2.6	1.7	7.3	1.9	1.0	1.5
Apr-98	3.3	1.1	1.1	2.9	1.0	1.2
May-98	1.3	1.2	1.0	2.8	0.4	1.7
Jun-98	1.2	1.1	1.2		0.9	3.5
Jul-98	0.2	0.3	0.2	0.5	0.4	0.5
Aug-98	0.4	0.3	0.3	0.7	0.5	1.1
Sep-98	2.4	0.2	6.7		0.7	2.0
Oct-98	0.9	0.3	1.1		0.8	0.8
Nov-98	2.4	1.0	1.3	3.8	1.6	1.0
Dec-98		1.1	1.0	2.3	1.2	
Average	**1.9**	**1.1**	**2.1**	**2.3**	**1.0**	**2.0**
Jan-99	1.3	1.2	0.7	0.6	0.9	
Feb-99	6.8	1.2	1.8			1.4
Mar-99	2.6	0.8	0.9		0.5	1.5
Apr-99	12.8	1.2	1.2		1.2	1.9
May-99	1.6	2.9	1.3	0.8	0.8	1.2
Jun-99	0.6	1.1	0.8	1.8	0.6	1.3
Jul-99	0.7	1.0	1.4	1.7	1.0	1.9
Aug-99	1.3	0.5	1.6		1.7	1.2
Sep-99	2.3	1.3	1.1	2.1	1.9	3.4
Oct-99	1.6	0.6	0.5	2.0	1.4	0.8
Average	**3.2**	**1.2**	**1.1**	**1.5**	**1.1**	**1.6**

Of the Drayton dust deposition measurements the maximum annual deposition rate in the last six years has been 3.2 g/m^2/month (Gauge 2197) and the minimum 1.0 g/m^2/month (Gauge 2247). Gauge 2197 is not within the residential area and from these data it would appear that an increment of 2 g/m^2/month (annual average) could be accepted before deterioration in air quality would be noted.

5. ESTIMATED EMISSIONS

5.1 Pre-amble

From an air quality perspective the project will involve two distinct phases namely (1) construction and (2) operation. The model requires estimates of particulate matter emission rates for each activity that will generate dust from each of these two phases.

During construction, emissions will occur from earthwork using dozers and excavators and from loading, transporting, emplacing and shaping of material required to develop the appropriate land form for the rail loop and stockpile pad.

During operations emissions will occur from, loading coal to the stockpile, recovering coal from the stockpile, loading coal from the overhead bin to trains, wind erosion from exposed areas and from minor clean up activities around the periphery of the stockpile or the use of a dozer to push the coal into the underground reclaim system.

5.2 Emissions during construction

To estimate emission it is necessary to develop a model for the construction of the Bayswater Rail Loop (note that there are no construction activities required for Drayton).

The model assumed is as follows. Construction will take approximately nine months and will take place during daylight hours. Major earthworks will be done using four D11 dozers and two excavators and trucks. A list of equipment expected to be used during construction is provided in **Table 7**.

Table 7. Expected equipment required for construction

Item	Number
Bulldozer D11 or equivalent	*4*
Grader	*3*
Backhoe	*2*
Front end loader	*4*
Rock breaker	Required occasionally
Dump truck	*4*
Roller	Required occasionally
Compactor	3
Water trucks	3
Pile driver	Required occasionally
Hydraulic/Pneumatic drill	Required occasionally
Semi-trailer	Required occasionally
Crane	2
Welding equipment	Required occasionally
Generator	1

Those items which are considered to be capable of generating significant quantities of dust and which have been included in the emissions inventory are shown in italics.

Emissions from all these sources have been determined in accordance with emission factors developed in the US (**US EPA, 1985** and revisions) and in Australia (**NERDDC 1988**).

The works require the construction of 7.3 km of new track commencing from a point on the northern side of the Antiene spur line and about 400 m west to the commencement of existing Drayton rail loop, which presently forms the end of the Antiene spur line. The new works will create a new line and loop, the western end of which will be approximately 2.5 km west of the existing Drayton loop. The locations of the existing and proposed rail lines are shown in **Figure 1**.

In addition to constructing the rail loop, earthworks will be required to create the stockpile pad and to construct the dirty water dam.

Rail line East of Thomas Mitchell Drive

In total 350,000 m^3 of material will be required for the project rail line east of Thomas Mitchell Drive. Most of this (about 320,000 m^3) will be from locally balanced cut and fill which dozers will move. The 30,000 m^3 of additional material required to fill the area adjacent to the Drayton loop will be provided from the Bayswater mine over a four to six week period. It will require truck movements across the Thomas Mitchell Drive. **Figure 7** shows the locations of cut and fill areas. The additional 30,000 m^3 of material will be supplied from the Bayswater mine in 250 t trucks, which will establish an overburden stockpile in the rail loop (see **Figure 7**). The material will be transferred to the required locations in smaller 20 to 40 t dump trucks. For all calculations involving secondary handling of material it has been conservatively assumed that the smaller 20 t trucks are used.

Rail loop West of Thomas Mitchell Drive
Overall there will be a net deficit of material; 30,000 m^3 deficit for the part of the rail loop to the west of Thomas Mitchell Drive. This will be supplied from Bayswater mine by 250 t trucks.

Coal stockpile pad and dirty water dams
Approximately 93,000 m^3 of fill will be required for the stockpile pad and dirty water dam to the west of Thomas Mitchell Drive. The additional material for both areas will be supplied from the Bayswater mine in 250 t trucks.

Summary
Bayswater mine will be required to supply 153,000 m^3 of material to make up for the deficits as follows:

- 30,000 m^3 to make up for deficit for the area to the north of the Drayton loop
- 30,000 m^3 to make up for deficit for the rail loop
- 93,000 m^3 required for stockpile pad and dirty water dams.

The amount of material to be moved for locally balanced cut and fill operations is estimated to be as follows:

- 320,000 m^3 along the rail line in the area to the north of the Drayton loop
- 90,000 m^3 for the rail loop
- 60,000 m^3 in the area where the stockpile pad and dirty water dams will be located.

In all a total of 623,000 m^3 of material will be moved during the nominal nine-month construction period.

In estimating the dust emissions inventory for the project dust generated in loading overburden in Bayswater mine has been ignored. This activity has been taken to be part of the approved mining activity that has already been assessed in the Bayswater EIS. Dust generated in the last kilometer of transport from the mine to the dump stockpile and the dust generated in dumping to the stockpile has been included in the inventory. The 30,000 m^3 of this material required on the eastern side of Thomas Mitchell drive has been assumed to be double handled and delivered to its final destination by 20 t trucks. The material required for use on the western side of Thomas Mitchell Drive has been assumed to be dumped where required and not double handled. Dozers have been assumed to be used to spread this material.

Table 8. Summary of estimated dust (TSP) emissions during construction			
Location/Activity	Description of activity and statement of assumptions used in calculations	Emission factor after controls if applicable- see Appendix A	Emission rate[5]
Dozers on earthworks east of Thomas Mitchell Drive	Assume all four dozers operate 7 days/week 12 hours/day for nine months (39 weeks) then the total dust generated will be 539,885 kg. Assume that the quantity in the east is in proportion to the volume of overburden handled in the east namely 56%. (12 h/day x 39 weeks x 7 days/week x 4 dozers x 41.2 kg/dozer h x 0.56 = 302,335 kg)	41.2 kg/h	302,335 kg/39 weeks or 12.818 g/s
Dozer on earthworks west of Thomas Mitchell Drive	As above, assume all four dozers operate 7 days/week 12 hours/day for nine months (39 weeks) then the total dust generated will be 539,885 kg. Assume that the quantity in the west is in proportion to the volume of overburden handled in the east namely 44%. (12 h/day x 39 weeks x 7 days/week x 4 dozers x 41.2 kg/dozer h x 0.44 = 237,549 kg)	41.2 kg/h	237,549 kg/39 weeks or 10.071 g/s
Last 1 km of transport of overburden from Bayswater to overburden stockpile	Assume 153,000 m^3 with density 2.4 t/m^3 is transported in 250 t trucks from Bayswater mine to meet the fill deficit at the western end of the rail loop and the stockpile pad. Consider only the return trip in the last 1 km of the delivery route. (2 kg/VKT x 2 km/trip x (153,000 m^3 x 2.4 t/m^3)/250 t = 5,875).	2 kg/VKT	5,875 kg/39 weeks or 0.249 g/s.
Dumping 153,000 m^3 of Bayswater overburden at 30,000 m^3 overburden stockpile and at other required locations at stockpile pad water control structures.	Assume 153,000 m^3 with density 2.4 t/m^3 is dumped. (153,000 m^3 x 2.4 t/m^3 x 0.0067 kg/t = 2,460 t).	0.0067 kg/t	2,460 kg/39 weeks or 0.104 g/s
Re-load 30,000 m^3 at overburden stockpile to 20 t trucks	Assume 30,000 m^3 with density 2.4 t/m^3 is re-loaded in four weeks. (30,000 m^3 x 2.4 t/m^3 x 0.0067 kg/t = 482 t).	0.0067 kg/t	482 kg/39 weeks or 0.020 g/s

[5] Emission rates are expressed in g/s assuming continuous operations. In the model all source emission rates, except those for wind erosion, are assumed to occur over 12 hours (6 am to 6 pm) and are therefore doubled. Wind erosion occurs continuously and is made to vary as the third power of the wind speed. For operations lasting less than 39 weeks (eg transporting overburden across Thomas Mitchell Drive) assume that the g/s rate calculated over four weeks rate applies for the whole period. This allows the worst-case 24-hour concentrations to be assessed.

Transport 30,000 m^3 of overburden for fill to east of Thomas Mitchell Drive	Assume 30,000 m^3 with density 2.4 t/m^3 is transported in 20 t trucks and consider the return trip is 5 km. Also assume this work is completed in four weeks. (2 kg/VKT x 5 km x 30,000 m^3 x 2.4 t/m^3/20 t = 36,000 kg).	2 kg/VKT	36,000 kg/4 weeks or 14.881 g/s
Dump 30,000 m^3 of overburden for fill to east of Thomas Mitchell Drive	Assume 30,000 m^3 with density 2.4 t/m^3 is dumped. Also assume this work is completed in four weeks. (30,000 m^3 x 2.4 t/m^3 x 0.0067 kg/t = 482 t).	0.0067 kg/t	482 kg/4 weeks or 0.199 g/s
Drilling and blasting	Assume negligible (may be some blasting at western end of balloon loop)	-	
Wind erosion for rail loop west of Thomas Mitchell Drive	Assume 30 ha of exposed area and an emission factor of 0.4 kg/ha/h. (30 ha x 0.4 kg/ha/h x 39 weeks x 7 days/week x 24 hours/day = 78,624 kg).	0.4 kg/ha/h	78,624 kg/39 weeks or 3.333 g/s
Wind erosion for rail line east of Thomas Mitchell Drive	Assume 3 ha of exposed area and an emission factor of 0.4 kg/ha/h. (3 ha x 0.4 kg/ha/h x 39 weeks x 7 days/week x 24 hours/day = 7,862 kg).	0.4 kg/ha/h	7,862 kg/39 weeks 0.333 g/39 weeks
Total			671,669 kg/39 weeks

5.3 Emissions during operation

Operations involve both the operation of the proposed stockpile and rail-loading facilities discussed in **Section 5.2** and the existing Drayton facility. Approval is sought to operate these facilities jointly to handle up to 20 Mtpa. For the purpose of assessment it has been assumed that the new Bayswater rail loading facility will handle 13 Mtpa and the Drayton facility 7 Mtpa.

During operation of the stockpile there will be far less dust generated than during construction. The main sources of dust emission will be:

- Wind erosion (controlled by water sprays)
- Emissions from loading coal to and unloading coal from the stockpile
- Emissions from loading trains
- Emissions from clean-up operations around the edge of the stockpile and pushing coal to underground reclaim.

Table 9 provides details of the estimated emissions.

Table 9. Summary of estimated dust (TSP) emissions during operation			
Location/Activity	Measure of activity	Emission factor after controls if applicable- see Appendix A	Emission rate[6]
Proposed facility			
Wind erosion	Assume 40,000 t stockpile pad occupies 2.1 ha. (2.1 ha x 0.2 kg/ha/h x 8768 h/year = 3,679 kg/y)	0.2 kg/ha/h assume 50% control	3,679 kg/y or 0.117 g/s
Load up to 13 Mtpa coal to stockpile	Assume 70% control due to use of chute or luffing stacker or equivalent control. (0.3 x 13,000,000 t x 0.00068 kg/t = 2,652 kg).	0.00068 kg/t	2,652 kg/y or 0.084 g/s
Load up to 13 Mtpa coal to trains	Assume 70% control due to use of chute or luffing stacker or equivalent control. (0.3 x 13,000,000 t x 0.00068 kg/t = 2,652 kg).	0.00068 kg/t	2,652 kg/y or 0.084 g/s
Clean up pushing coal using dozer	Assume coal has 10% moisture and 5% silt and assume dozer required for 4 hour per day that is 1,460 hours per year. (12.3 kg/h x 1,460 h/year =17,958 kg).	12.3 kg/h	17,958 kg/y or 0.569 g/s
Sub-total			**26,941 kg/y**
Drayton facility			
Wind erosion	Assume 240,000 t stockpile pad occupies 6 ha. (6 ha x 0.2 kg/ha/h x 8760 h/year = 3,679 kg/y)	0.2 kg/ha/h assume 50% control	10,512 kg/y or 0.333 g/s
Load up to 7 Mtpa coal to stockpile	Assume 70% control due to use of chute or luffing stacker or equivalent control. (0.3 x 7,000,000 t x 0.00068 kg/t = 1,428 kg).	0.00068 kg/t	1,428 kg/y or 0.045 g/s
Load up to 7 Mtpa coal to trains	Assume 70% control due to use of chute or luffing stacker or equivalent control. (0.3 x 13,000,000 t x 0.00068 kg/t = 1,428 kg).	0.00068 kg/t	1,428 kg/y or 0.045 g/s
Clean up pushing coal using dozer	Assume coal has 10% moisture and 5% silt and assume dozer required for 2 hour per day that is 730 hours per year. (12.3 kg/h x 730 h/year =8,979 kg).	12.3 kg/h	8,979 kg/y or 0.285 g/s
Sub-total			**15,514 kg/y**
TOTAL			**42,455**

[6] Emission rates are expressed in g/s assuming continuous operations. In the model all source emission rates, except those for wind erosion, are assumed to occur over 12 hours (6 am to 6 pm) and are therefore are input to the dispersion model at double the 39-week average, but are only allowed to occur for 12 hours per day. That is the emission rate is set to zero for the hours 6 pm to 6 am. Wind erosion occurs continuously and is made to vary as the third power of the wind speed. For components of the construction operations that last less than 39 weeks (eg transporting overburden across Thomas Mitchell Drive, which will occur over a four week period) assume that the g/s rate calculated over four weeks rate applies for the whole period. This emission rate is also doubled, as above, to account for the 12 hour per day working period. This allows the worst-case 24-hour concentrations to be assessed.

The total estimated annual TSP emission due to operation of both facilities over a year is 42,455 kg. This approximately 6% of the emissions during construction.

5.4 Approach to modelling

In the past, the assessment of dust impacts has focussed largely on a comparison of predicted long-term dust concentration and deposition levels with the appropriate long-term goals. However, recent health research has linked adverse health effects with exposure to short-term concentrations of PM_{10} and $PM_{2.5}$. This has changed the emphasis from the long-term to the short-term. This provides a challenge for modellers in that short-term concentrations are more difficult to estimate than long-term concentrations. Dust sources such as wind erosion and materials loading and unloading operations, depend on meteorological conditions. This means that emissions must be provided to the model in a way that reflects the hour by hour changes in the emission rates, which occur as meteorological conditions change. This is different from the historical approach in which annual average emission rates were used.

Time-varying emission rates have been used in the current study for wind erosion sources and for the loading and unloading of coal and overburden.

5.5 Effects of controls

Modelling is used to assess impacts and to determine the type of controls required to achieve air pollution levels, which comply with the goals. In undertaking this work it has been assumed that a high level of dust control will be required. These will include watering of all trafficked areas, the application of speed limits on all vehicles traveling on unsealed surfaces, the delineation of acceptable routes for traffic over exposed work areas and cessation of dust generating activities should extreme weather conditions result in the generation of excessive dust. The reason for these stringent controls is to minimize impacts that might arise cumulatively from other dust sources in the area. Emissions from these sources will be very much larger than the emissions from this project.

6. METHODOLOGY

The short-term industrial source complex model (ISC3-ST - Version 99155) has been used in this study. The model is an advanced Gaussian dispersion model approved by the US EPA for use in regulatory assessments undertaken within the United States. It is one of the most widely used regulatory models in the world. A complete description of the model is provided in US EPA publications (**US EPA 1995A** and **1995B**). These two volumes provide user instructions (Volume 1) and a comprehensive technical description of the algorithms used in the model (Volume 2). For convenience, a very brief description of the model is provided below.

The model uses the Gaussian dispersion equation to simulate the dispersion of a plume from either point area or volume sources. The model takes account of dry and wet deposition and includes algorithms to account for retention of dust within an open pit and includes mechanisms for determining the effect of terrain on plume dispersion. The model works on an hourly time step. This means that it requires a meteorological file that provides wind speed, wind direction and other dispersion parameters on an hourly basis. For each hour the dispersion of plumes is determined using the conventional Gaussian model assumptions. These model assumptions have some limitations and it is worth noting some of these at this point.

One of the most significant limitations of the Gaussian model is that it assumes that a steady state dispersion condition is reached instantaneously. That is, if one were to imagine that the plume is simulating for a particular hour, one would see each source of dust producing a plume, which extends indefinitely in the downwind direction to the edge of the prediction grid. In reality, under very light wind conditions, this is an inappropriate assumption.

Consider for example a condition where the wind speed is 0.5 m/s. At the end of one hour any emission that occurred at the beginning of the hour will have travelled approximately 1.8 km from the source (0.5 m/s x 3,600 s). Thus, under these light wind conditions, the dust will have travelled 1.8 km from the source. The model assumes the dust will have travelled to the edge of the prediction grid, which in this case may be up to 10 km from the source. In the next hour the meteorological conditions may remain the same or, more likely, the wind direction will change and the light wind condition may still persist. The model then assumes that a new equilibrium is established instantaneously and the plume travels in the new downwind direction at the new wind speed.

Because for surface sources the worst-case dispersion conditions are associated with light winds the model has the potential to significantly overstate impacts at long distances downwind from the source. Since this problem leads to an overstatement of impacts rather than an understatement of impacts, this does not create a significant problem for environmental impact assessment. However, it should be borne in mind that there is a potential to overstate impacts at more distant receptors.

The ISC model also has the capacity to take into account emissions that vary in time, or with meteorological conditions. This has proved particularly useful for simulating emissions on mining operations where wind speed is an important factor in determining the rate at which dust is generated.

For the current study the facility was represented by a series of four volume sources. Each volume source was a combination of all dust emissions from activities in the general area. Estimates of emissions for each volume were developed on an hourly time step. Thus, for each source, for each hour, an emission rate was determined which depended upon the intensity of dust generation activity and the wind speed. It is important to do this in the ISC model to ensure that long-term average emission rates are not combined with worst-case dispersion conditions which are associated with light winds. Light winds in a mining area correspond with periods of low dust generation and also correspond with periods of poor dispersion. If these measures are not taken then the model has the potential to significantly further overstate impacts.

7. ASSESSMENT OF IMPACTS DUE TO DUST EMISSION

This section provides an interpretation of the predicted contours of dust concentration and deposition levels. Simulations were undertaken for both the 39-week construction phase and the operation phases. For each year isopleth diagrams have been produced showing the following:

1. the predicted maximum 24-hour average PM_{10} concentration
2. the predicted annual average PM_{10} concentration
3. the predicted annual average TSP concentration, and
4. the predicted annual average dust deposition.

The simulations have been repeated for both cases. The first considers the construction and the second the operation phase assuming a total throughput of 20 Mtpa with 7 Mtpa being handle by the Drayton facility and 13 Mtpa through the new Bayswater facility.

7.1 Construction

The model results for the construction phase are shown in **Figures 8** to **11**. These figures indicate the dust levels that will be contributed when the construction operation is considered alone.

The closest residences, not owned by mining companies, are located in the Antiene subdivision and the area around the Racecourse and SW Muswellbrook. As will be seen from the impact analysis only the residences in the Antiene subdivision are close enough to warrant detailed review.

While proximity is not the only factor determining impacts, the position of residences taking account of prevailing winds is also important. It can be seen that emissions from construction operations will be well below all NSW EPA air quality goals at all residential locations.

24-hour PM_{10}

The most affected residence during construction is marked 12 in **Figure 8**. It is predicted to experience a maximum 24-hour PM_{10} concentration of approximately 55 $\mu g/m^3$ due to emissions from the project. This is well below the 24-hour 150 $\mu g/m^3$ US EPA goal that applies for PM_{10}. It would allow a 24-hour PM_{10} concentration of 95 $\mu g/m^3$ from other sources before the Standard was exceeded. The data in **Figure 5** suggests that background PM_{10} concentrations (24-hour) above 95 $\mu g/m^3$ are extremely rare, occurring no more than 3 times since 1996. Thus air quality impacts are predicted to be at acceptable levels during construction and no non-mine owned properties are expected to be impacted.

Annual average PM_{10}

The most affected residence during construction, marked 20 on **Figure 9**, is predicted to experience an annual average PM_{10} concentration of approximately 2 $\mu g/m^3$ due to emissions from the project. This is well below the US EPA's annual PM_{10} standard of 50 $\mu g/m^3$ for PM_{10}. It would allow a annual background PM_{10} concentration of 48 $\mu g/m^3$ from other sources before the Standard was exceeded. The data in **Table 3** suggests that the highest the annual average background PM_{10} concentration is unlikely to exceeds 23 $\mu g/m^3$ and consequently the Standard is predicted to be complied with at all non-mine owned properties.

Annual TSP

The most affected residence during construction, marked 20 on **Figure 10**, is predicted to experience an annual average TSP concentration of approximately 4 $\mu g/m^3$ due to emissions from the project. This is well below the NHMRC's annual TSP goal 90 $\mu g/m^3$. It would allow a annual background TSP concentration of 86 $\mu g/m^3$ in the Antiene residential area from other sources before the Standard was exceeded. The data in Table 3 suggests that the highest the annual average background PM_{10} concentration is unlikely to exceeds 58 $\mu g/m^3$ and consequently the Standard is predicted to be complied with at all non-mine owned properties.

Annual Deposition

Finally, the most affected residence, marked 20 on **Figure 11**; during construction is predicted to experience an annual average deposition rate of less than 0.2 g/m^2/month due to emissions from the project. This is well below the EPA's goal of 2 g/m^2/month (increase) and consequently the goal is predicted to be complied with at all non-mine owned properties.

7.2 Assessment of impacts due to routine operations

Emissions during operations have been calculated to be approximately 6% of those generated during construction. Since impacts during construction indicate compliance with all NSW EPA goals it can be inferred than impacts during operation will similarly comply. Inspection of **Figures 12** to **15** show that this is the case.

24-hour PM_{10}

The maximum 24-hour PM_{10} concentration predicted to be experienced at any residence due to emissions from operation of the facility is 0.5 $\mu g/m^3$ at see Residence Nos. 3 and 4 (see **Figure 12**). This well below the U EPA Standard 24-hour PM_{10} of 150 $\mu g/m^3$ and would allow a substantial background level to apply from other dust sources before the goal was exceeded.

Annual PM_{10}

The residence predicted to experience the highest annual average TSP concentrations due to emission from the facility is Residence No. 3 (see **Figure 13**). The predicted level is 0.02 $\mu g/m^3$. This can be compared with the US EPA annual P_{10} standard of 50 $\mu g/m^3$. Again a substantial background PM_{10} could apply before emissions from the facility would cause the standard.

Annual TSP

The residence predicted to experience the highest annual average TSP concentration due to emission from the facility is Residence No. 3 (see **Figure 14**). The level is 0.03 $\mu g/m^3$. This can be compared with the annual NHMRC annual goal for TSP of 90 $\mu g/m^3$. Again a substantial background TSP concentration could apply before emissions from the facility would cause the goal to be exceeded.

Deposition

Finally, the residence predicted to experience the highest dust deposition levels due to emissions from the facility is also Residence No. 3, which is predicted to experience a dust deposition level of .0005 g/m^2/month from the facility. This is well within the NSW EPA's annual incremental goals of 2 g/m^2/month for dust deposition.

8. MONITORING AND MITIGATION MEASURES

A monitoring program will be developed in association with the EPA to ensure that air quality impacts are well understood in a quantitative way and that all impacts remain within acceptable levels as defined by nationally and internationally recognised air quality goals.

It is envisaged that the monitoring program necessary to verify environmental performance will incorporate the following:

- six to twelve deposition gauges
- one PM_{10} monitor

- one meteorological station.

Note this monitoring program is essentially in place at present and would only require the addition of a PM_{10} monitor to provide a satisfactory monitoring network.

Standard best practice dust control measures will be employed. These will include:

- The marking of traffic routes over disturbed surfaces
- The watering of roads and other areas susceptible to wind erosion
- The application of speed limits on vehicles as required
- The rehabilitation of disturbed areas at the earliest opportunity
- A commitment to cease dust-generating activities under extreme weather conditions.

9. CONCLUSIONS

The above analysis examines the expected air quality impacts due to construction and operation of the proposed Antiene Joint User Rail Facility to service initially Bayswater and Drayton and potentially Mt. Arthur North and Saddlers Creek mines. Air quality impacts examined are those due to emissions of various classes of particulate matter (TSP, PM_{10} and deposition of insoluble solids).

All long-term and short-term air quality goals, namely those for 24-hour PM_{10} and annual average PM_{10}, TSP concentrations and dust deposition, are predicted to be complied with for both construction and operation.

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APPENDIX A
EQUATIONS USED IN CALCULATING EMISSIONS

LOADING AND DUMPING OVERBURDEN FOR USE AS FILL

Each tonne of material loaded will generate a certain amount of dust, depending on the wind speed and the moisture content. **Equation 2 (US EPA, 1985)** shows the relationship between these variables.

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right)$$

where,

k = 0.74

U = wind speed(m/s)

M = moisture content(%)

(where $0.25 \le M \le 4.8$)

Equation 1

Assuming moisture content of 1.0% for overburden, the Emission Factor is therefore given by;

$$E_{TSP} = 0.00312 \times \left(\frac{U}{2.2}\right)^{1.3} \text{ kg/t}$$

Equation 2

A "wind speed factor", (that is the $(U/2.2)^{1.3}$ part of Equation 2), will vary from hour to hour. This factor has been calculated for each hour in the 1996 meteorological data file. The annual average is 2.08. The emissions factor, averaged over the year, from loading overburden to trucks will be approximately 0.0065 kg/t (0.00312 x 2.08).

DOZERS ON FILL

The TSP emission factor equation for bulldozers working on overburden with silt content of 10% and moisture content of 1% is can be estimated using the **US EPA (1985)** emission factor equation (see **Equation 5**).

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}}$$

where,

s = silt content of material in percent and

M = moisture content in percent.

Equation 3

Equation 3 has been tested over the range 2.2 to 16.8 percent for moisture and 3.8 to 15.1 for silt. Taking s to be 10% and M to be 1% the emission factor is 41.2 kg/hour.

DOZERS ON COAL

The TSP emission factor equation for bulldozers working on coal with silt content of 5% and moisture content of 10% is can be estimated using the **US EPA (1985)** emission factor equation (see **Equation 5**).

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.3}}$$

where,

s = silt content of material in percent and

M = moisture content in percent.

Equation 4

Equation 3 has been tested over the range 2.2 to 16.8 percent for moisture and 3.8 to 15.1 for silt. Taking s to be 5% and M to be 10% the emission factor is 12.3 kg/hour.

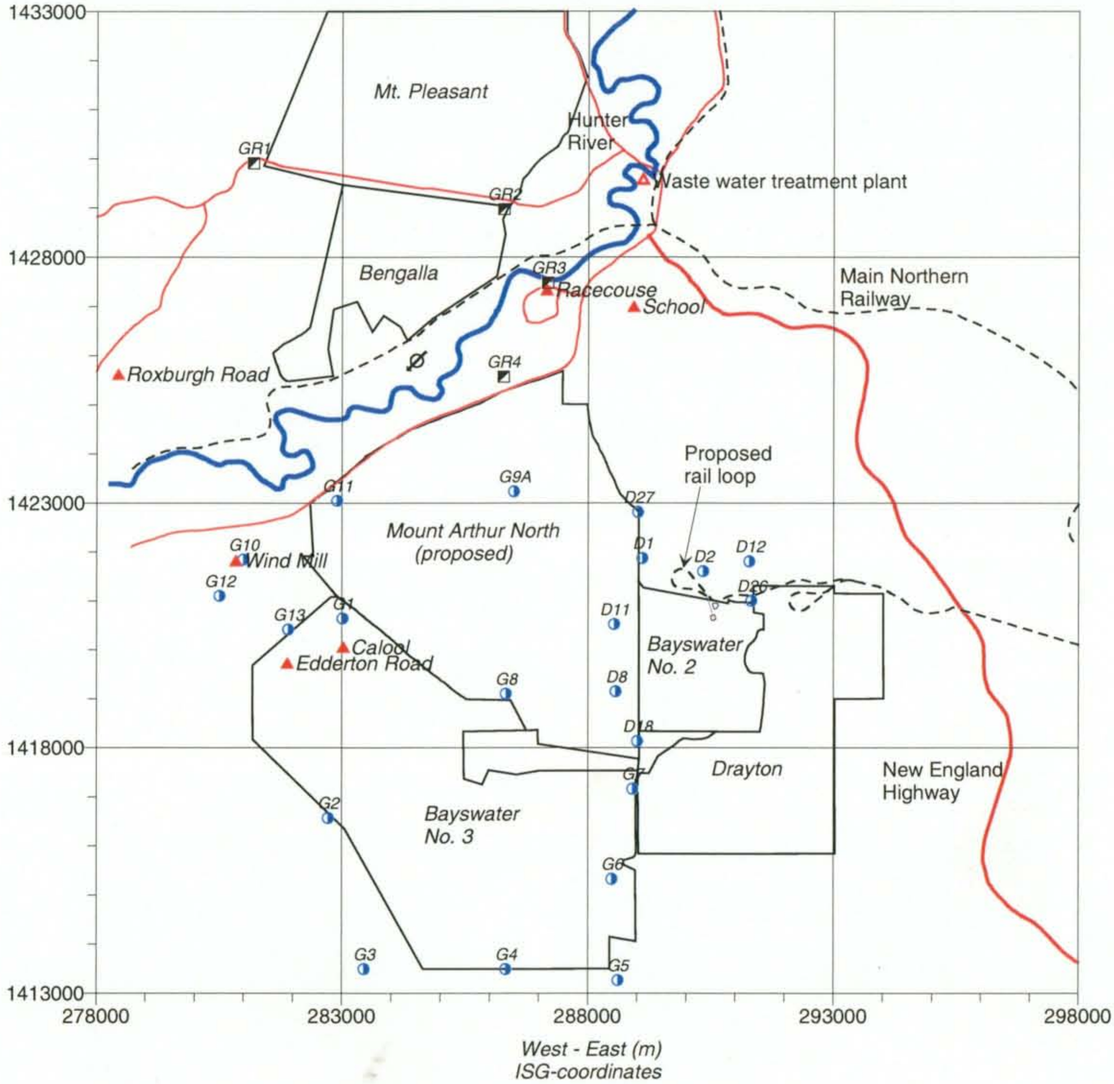
LOADING COAL TO TRAINS

The emission factor equation for loading coal to trains is the same as **Equation 2** with appropriate values substituted for coal moisture levels. For the current work a moisture level of 10%. **Equation 2** has only been tested up to moisture levels of 4.8% and using 4.8% the emission factor is 0.0007 kg/t. Note 70% control is assumed due to the use of a self-choking chute.

WIND EROSION FROM COAL STOCKPILES

It is assumed that the stockpile is operated full for the whole year and that the area susceptible to wind erosion is the same as the area of the stockpile pad. Water sprays are assumed to provide 50% control. An emission factor of 0.4 kg/ha/hour has been assumed.

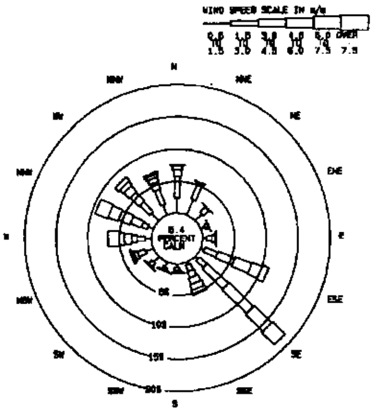
FIGURES



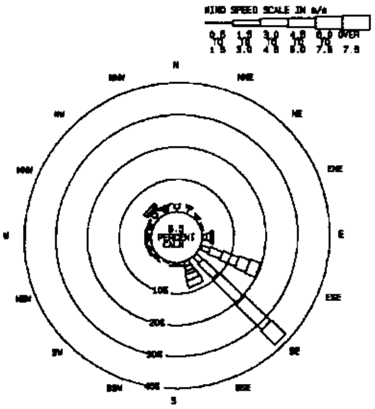
Location of study area

Figure 1

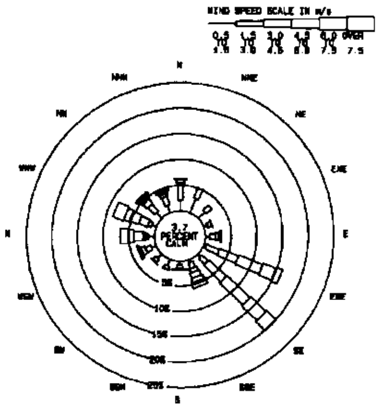
Seasonal and annual windroses for Mt. Arthur North meteorological station - 1995 (Macquarie Generation data)



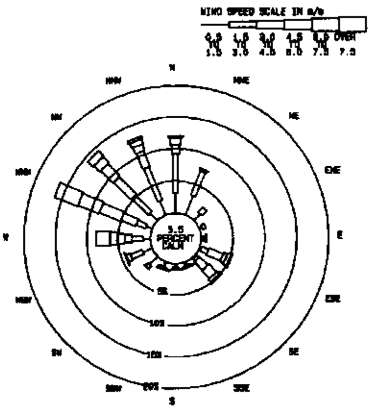
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Annual 1995



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Summer 1995



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Autumn 1995



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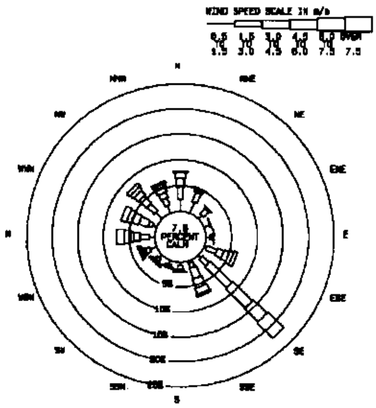
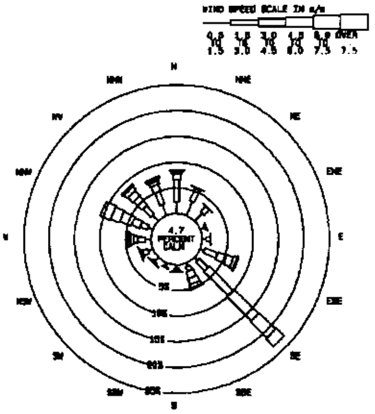
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Winter 1995



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Spring 1995

Figure 2

Seasonal and annual windroses for Mt. Arthur North meteorological station - 1996 (Macquarie Generation data)



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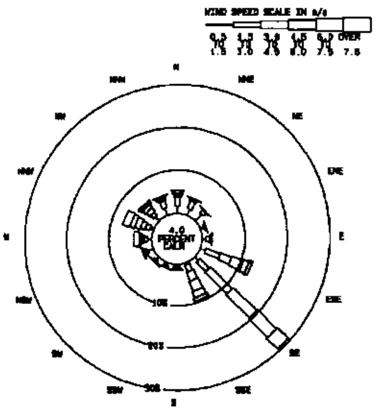
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Annual 1996



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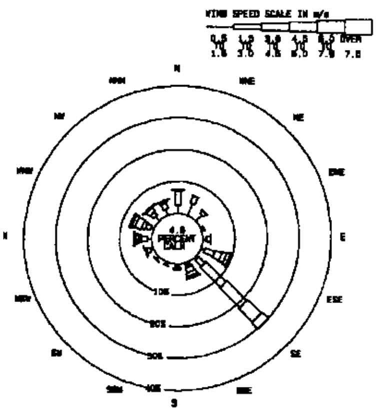
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Summer 1996



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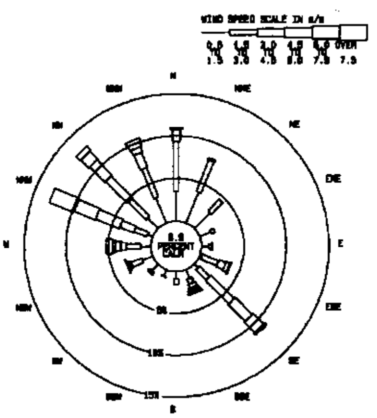

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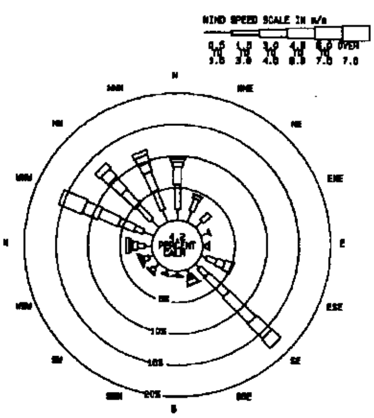
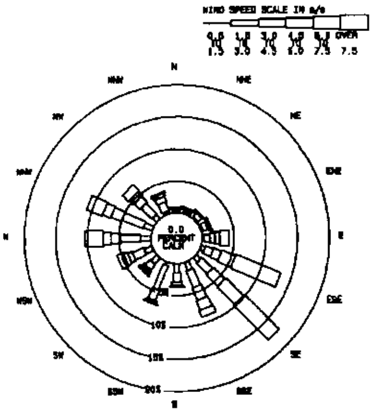
Mt Arthur North - Winter 1996



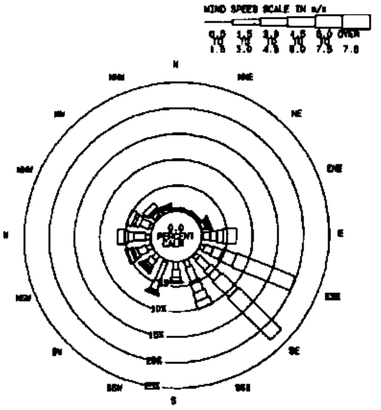
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Mt Arthur North - Spring 1996

Figure 3

Seasonal and Annual Windroses for Bayswater Meteorological Station 1998



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Bayswater - Annual 1998



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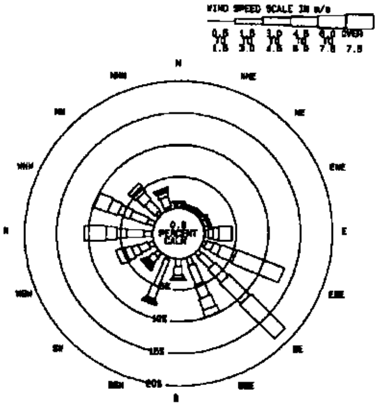
Bayswater - Summer 1998



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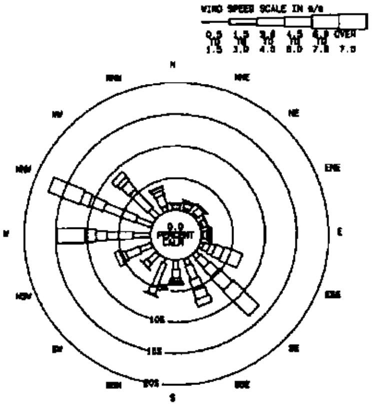
Bayswater - Autumn 1998



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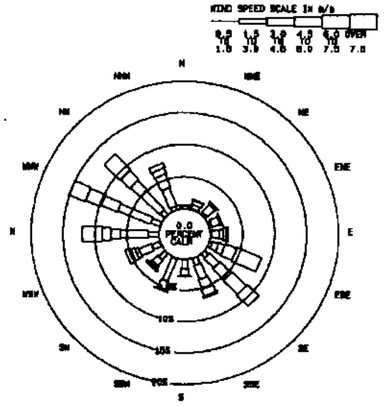
FREQUENCY OF OCCURRENCE IN PERCENT
Bayswater - Winter 1998



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Bayswater - Spring 1998

Figure 4

24-hour PM_{10} measurements from 1996 to 1999

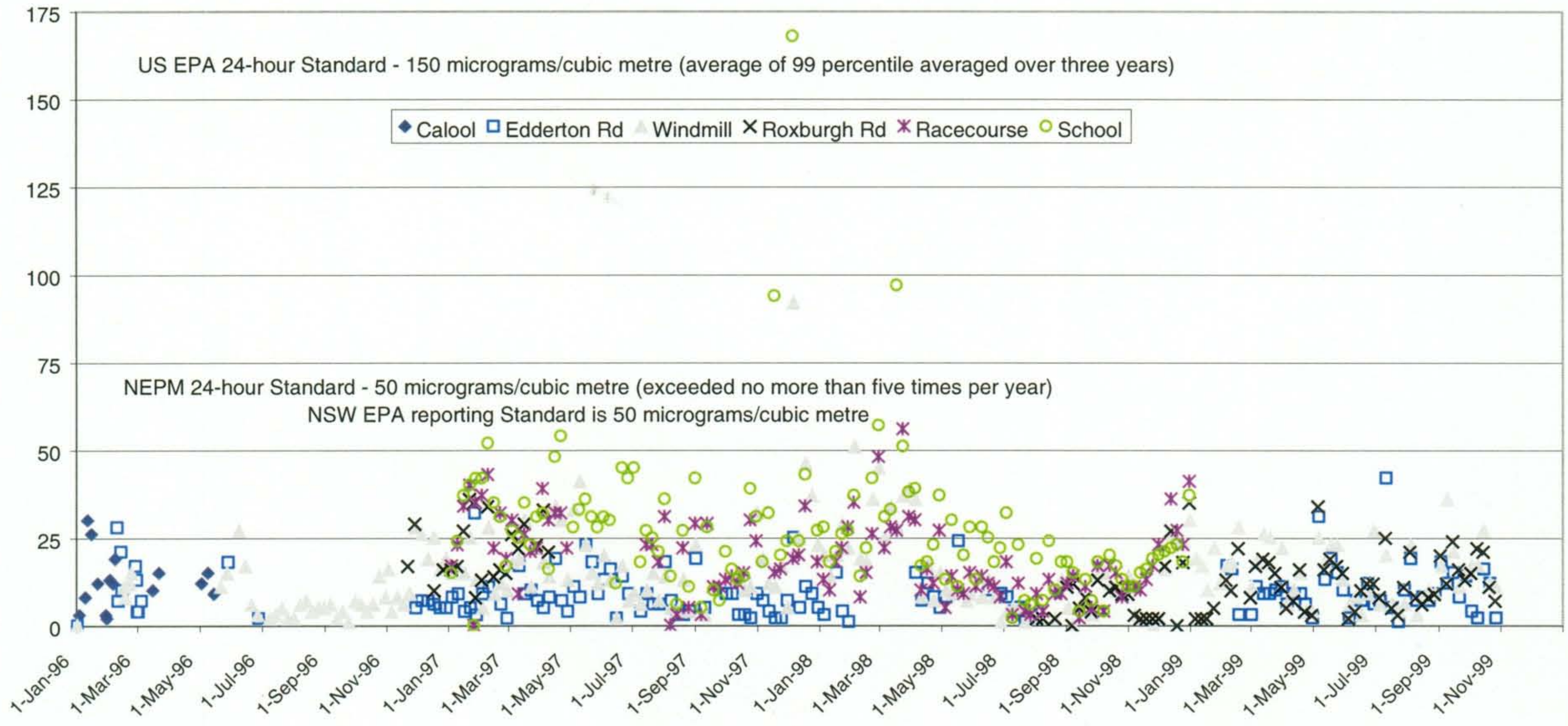


Figure 5

Monthly $PM_{2.5}$ monitoring data from the Muswellbrook City Council site (Scott Street - Northern end of Muswell brook)

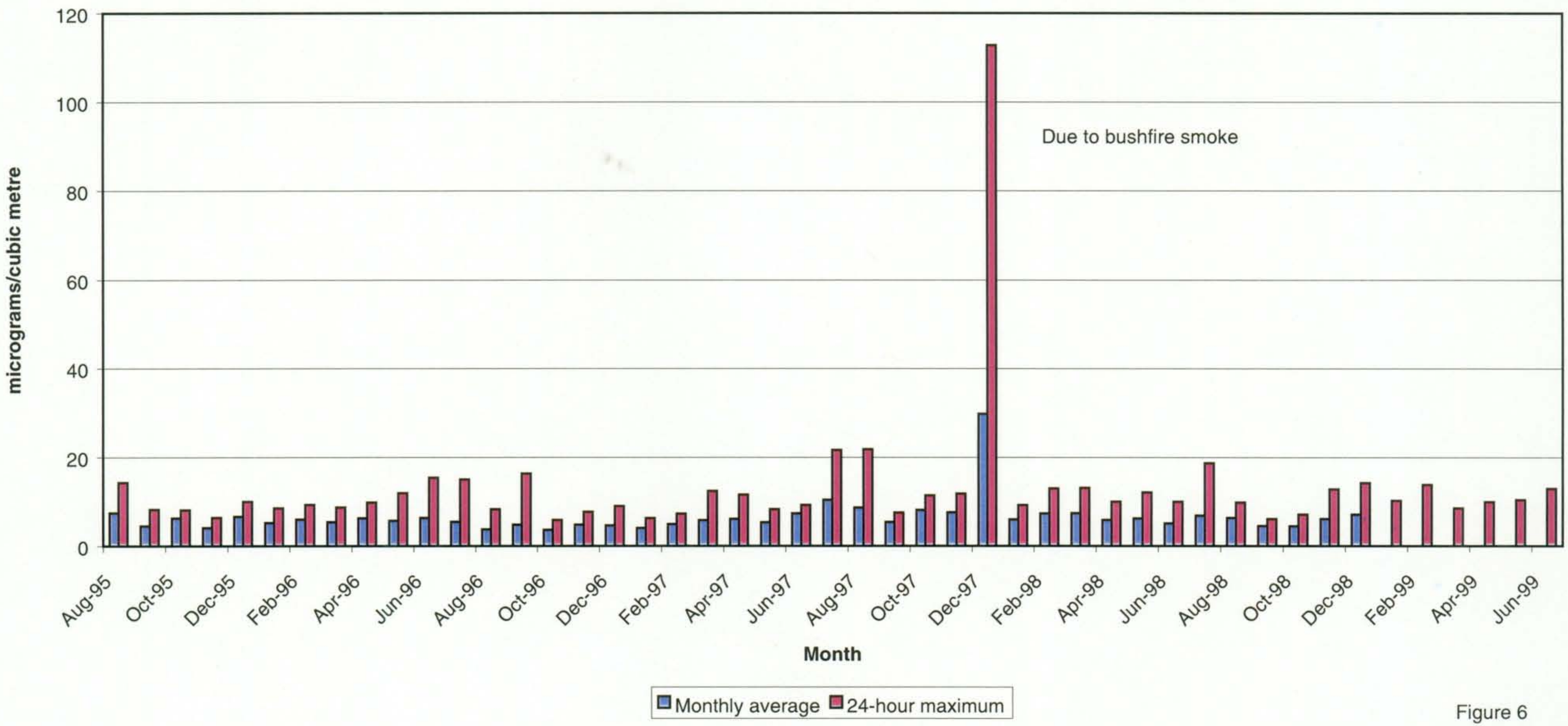
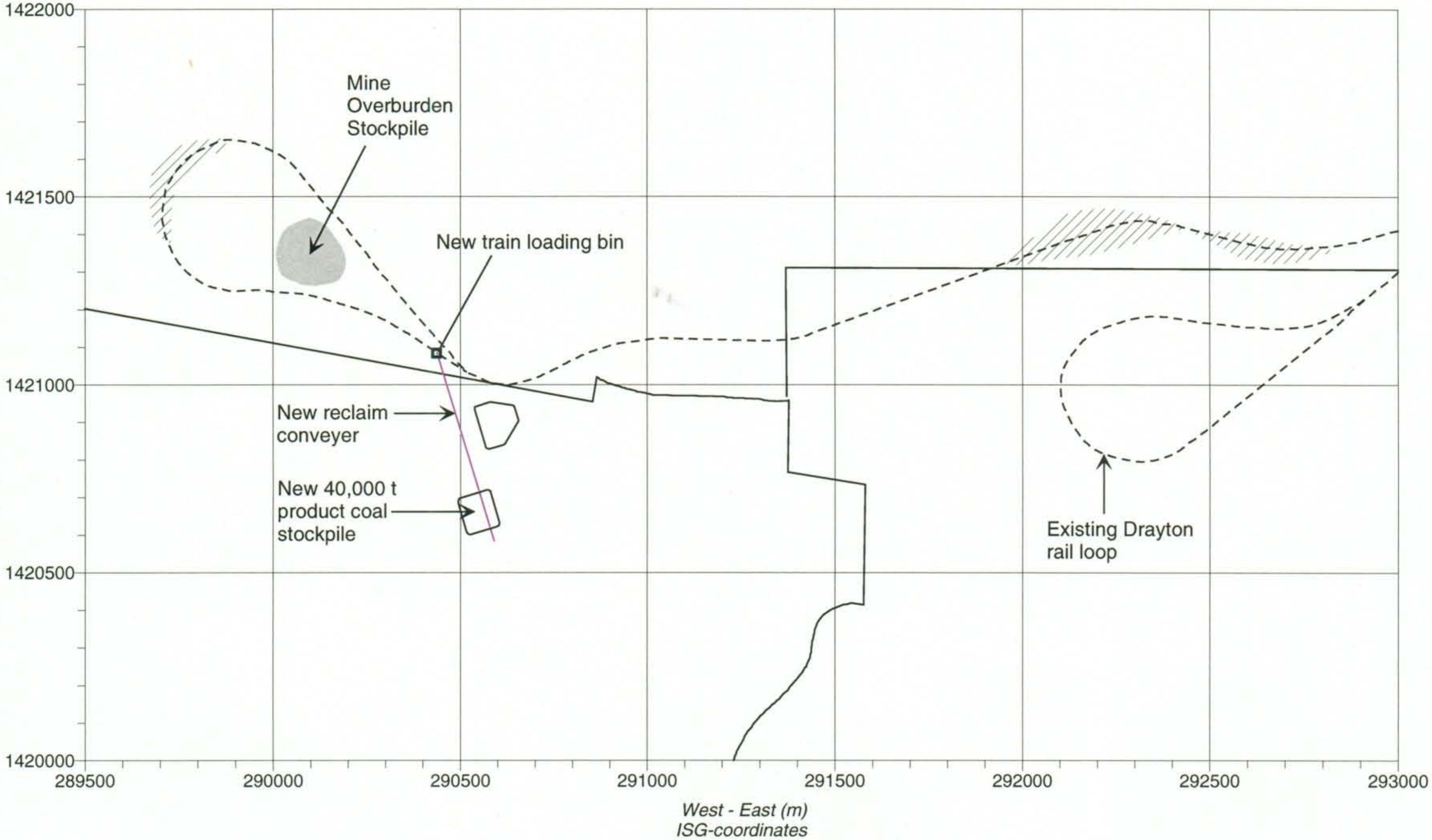
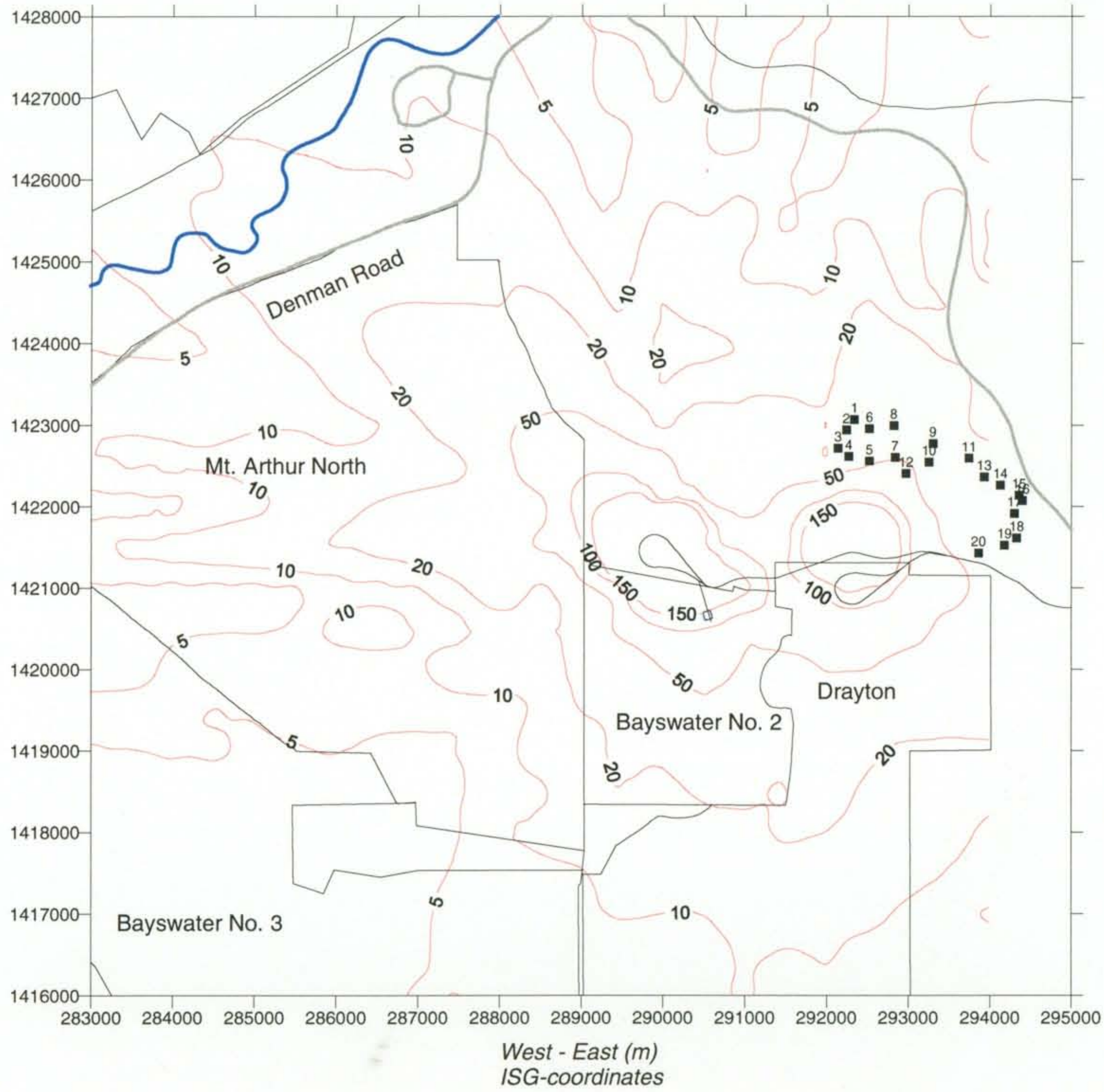


Figure 6



Detailed plan of the new rail loop showing cut and fill areas

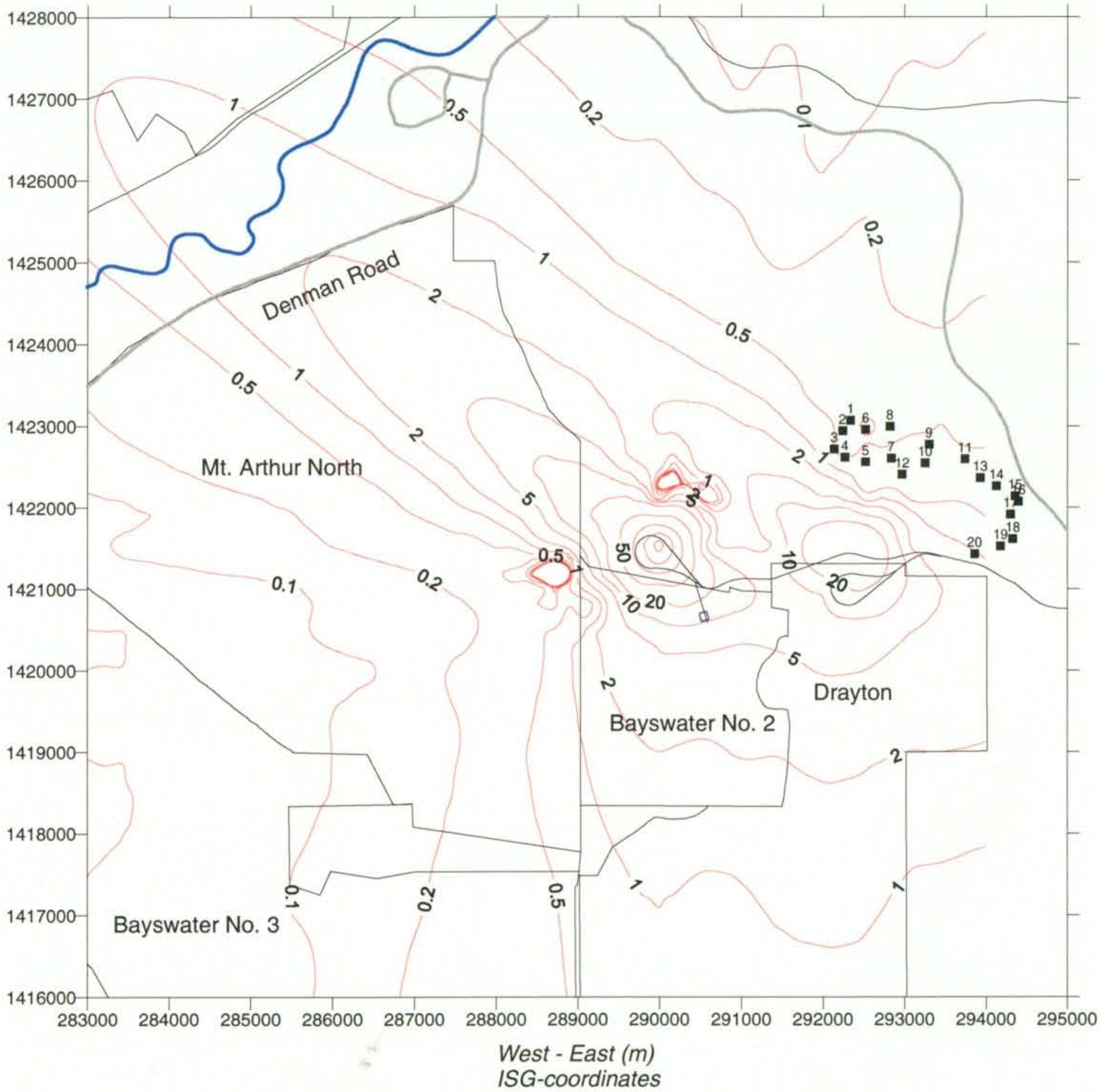
Figure 7



Predicted maximum 24-hour average PM_{10} concentrations due to emissions from stockpile and rail loop construction work - micrograms/cubic metre

■ Residences

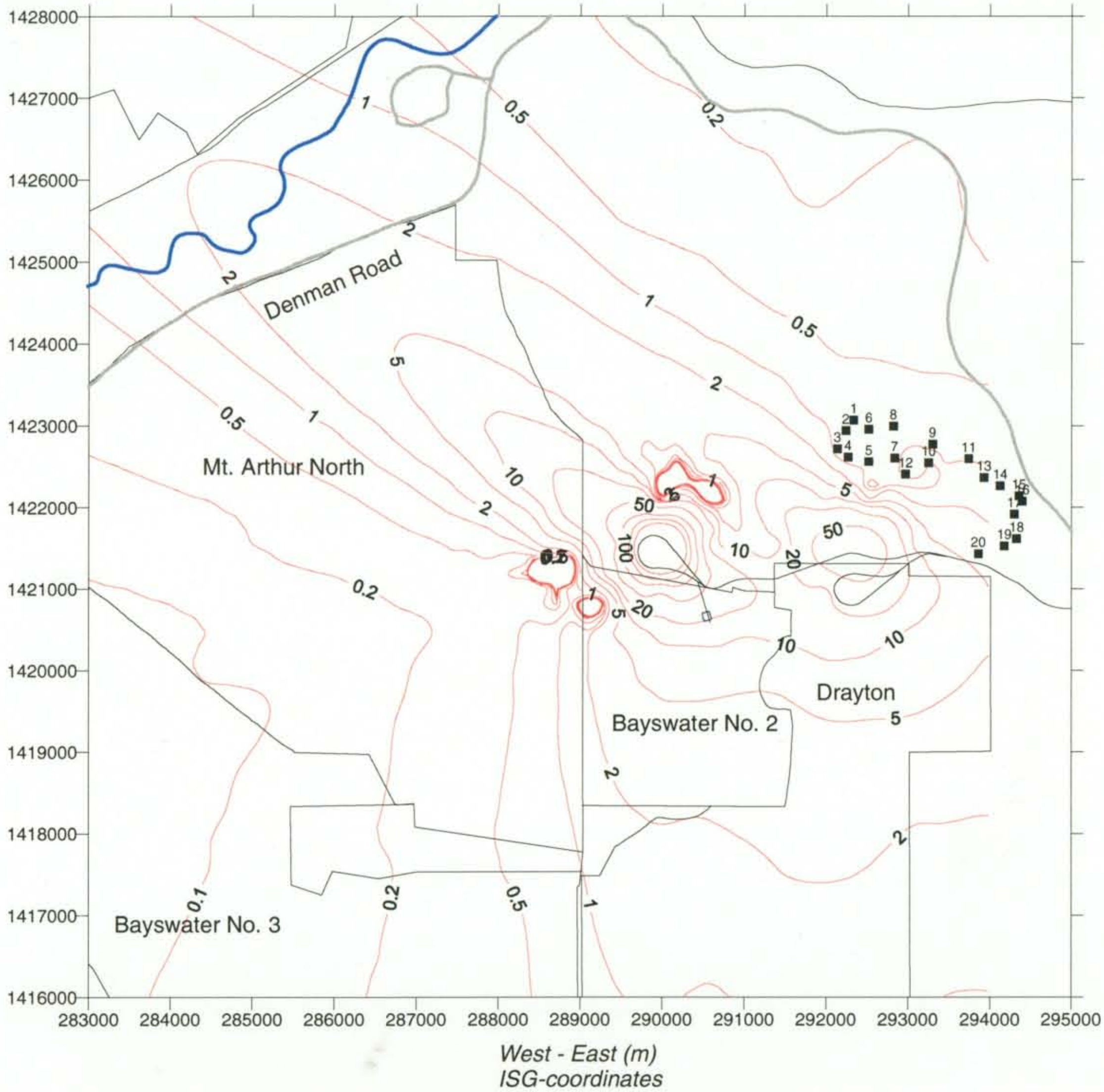
Figure 8



Predicted annual average PM_{10} due to emissions from stockpile and rail loop construction work - micrograms/cubic metre

■ Residences

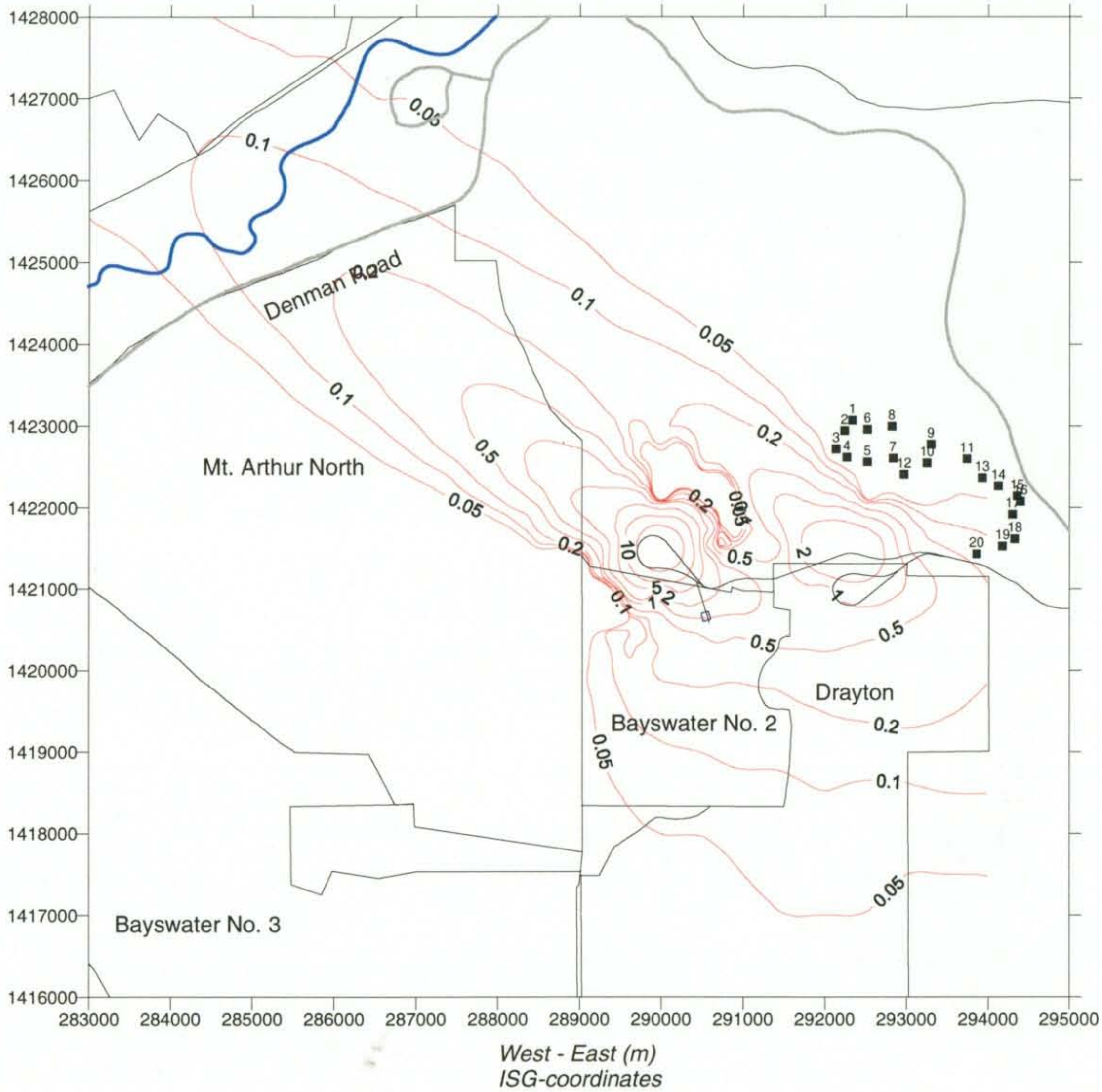
Figure 9



Predicted annual average TSP concentrations due to emissions from stockpile and rail loop construction work - micrograms/cubic metre

■ Residences

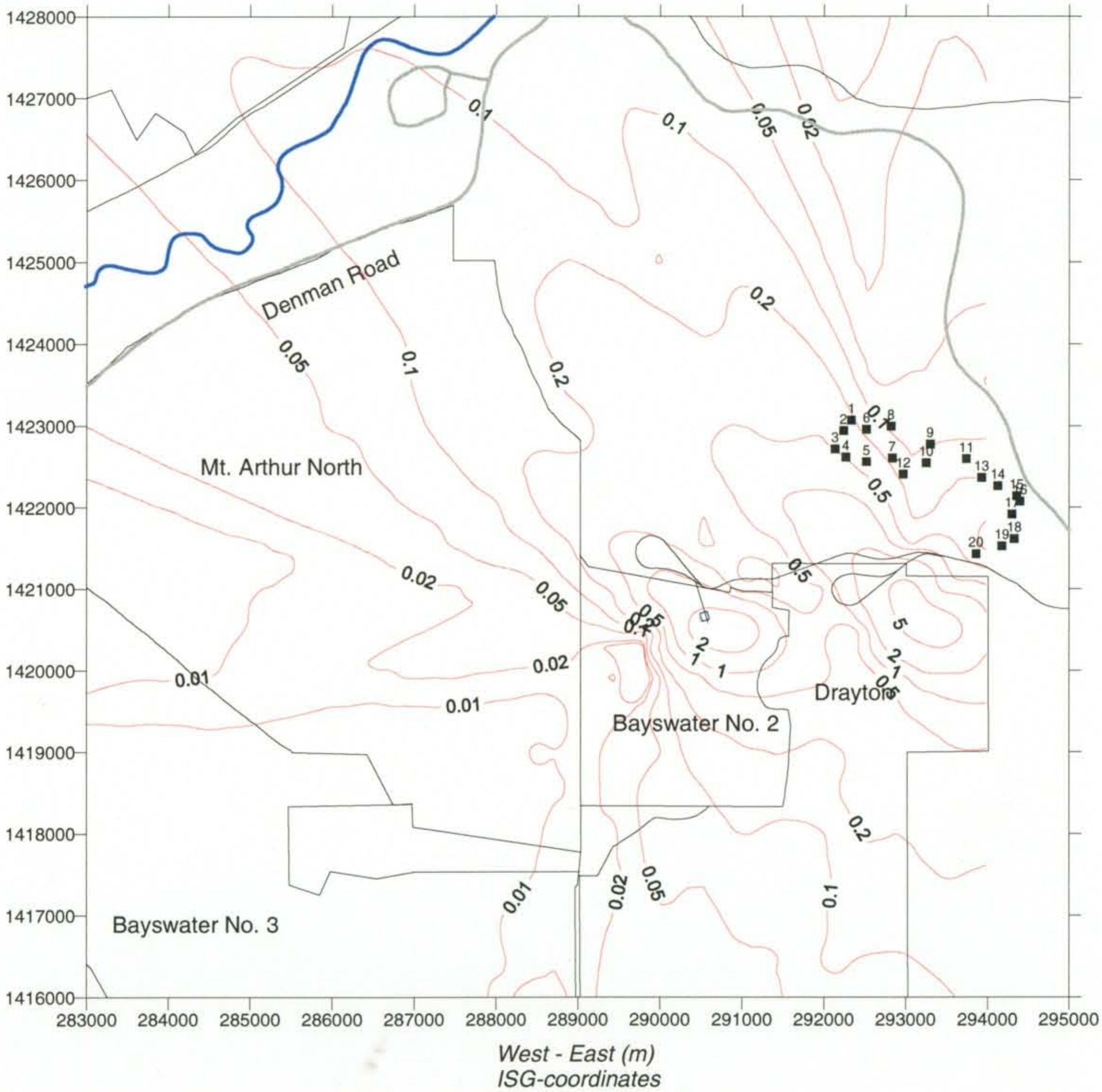
Figure 10



Predicted annual average dust deposition due to emissions from stockpile and rail loop construction work - g/square metre/month

■ Residences

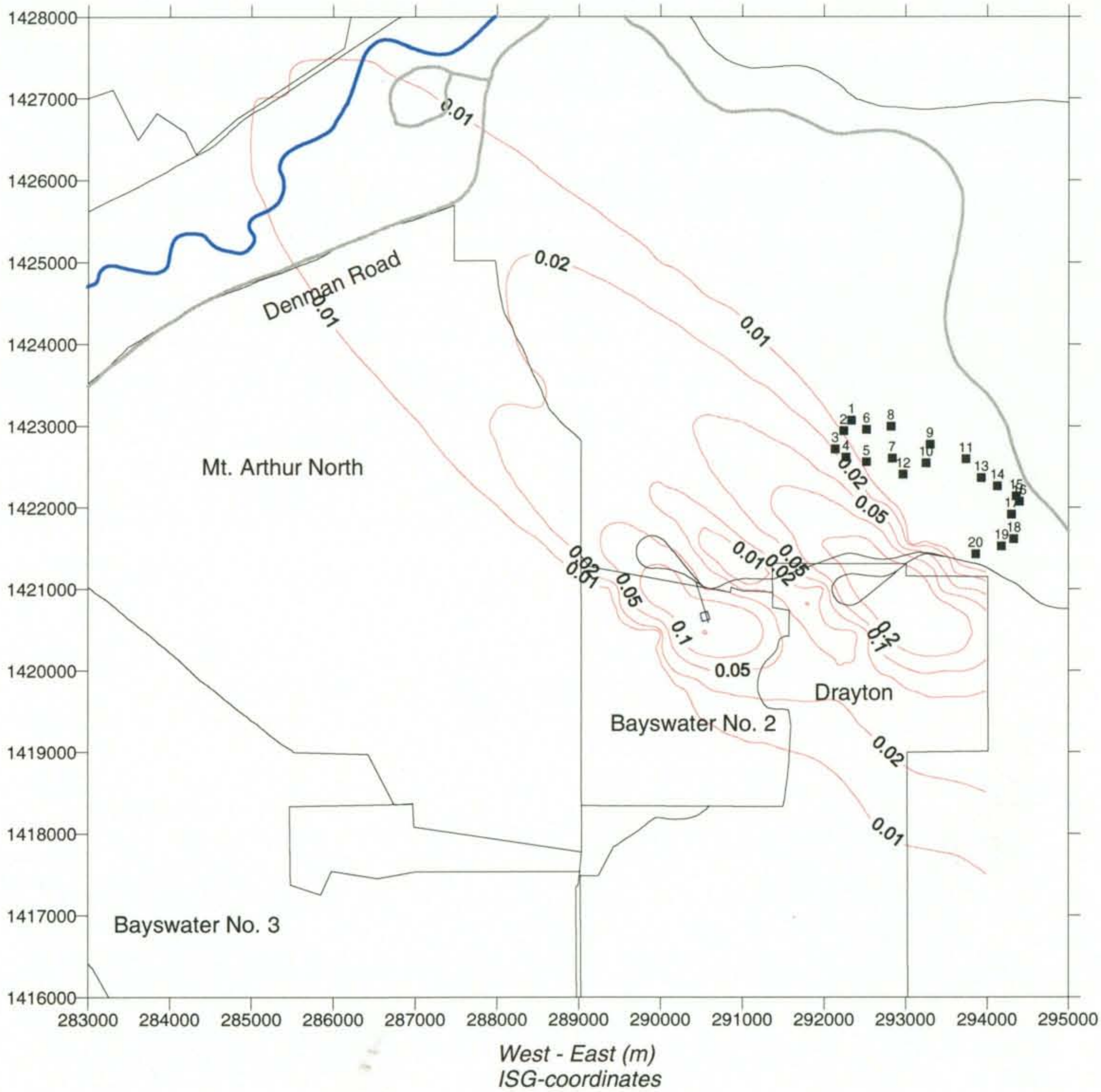
Figure 11



Predicted maximum 24-hour average PM_{10} concentrations due to emissions from stockpile and rail loop operations - micrograms/cubic metre

■ Residences

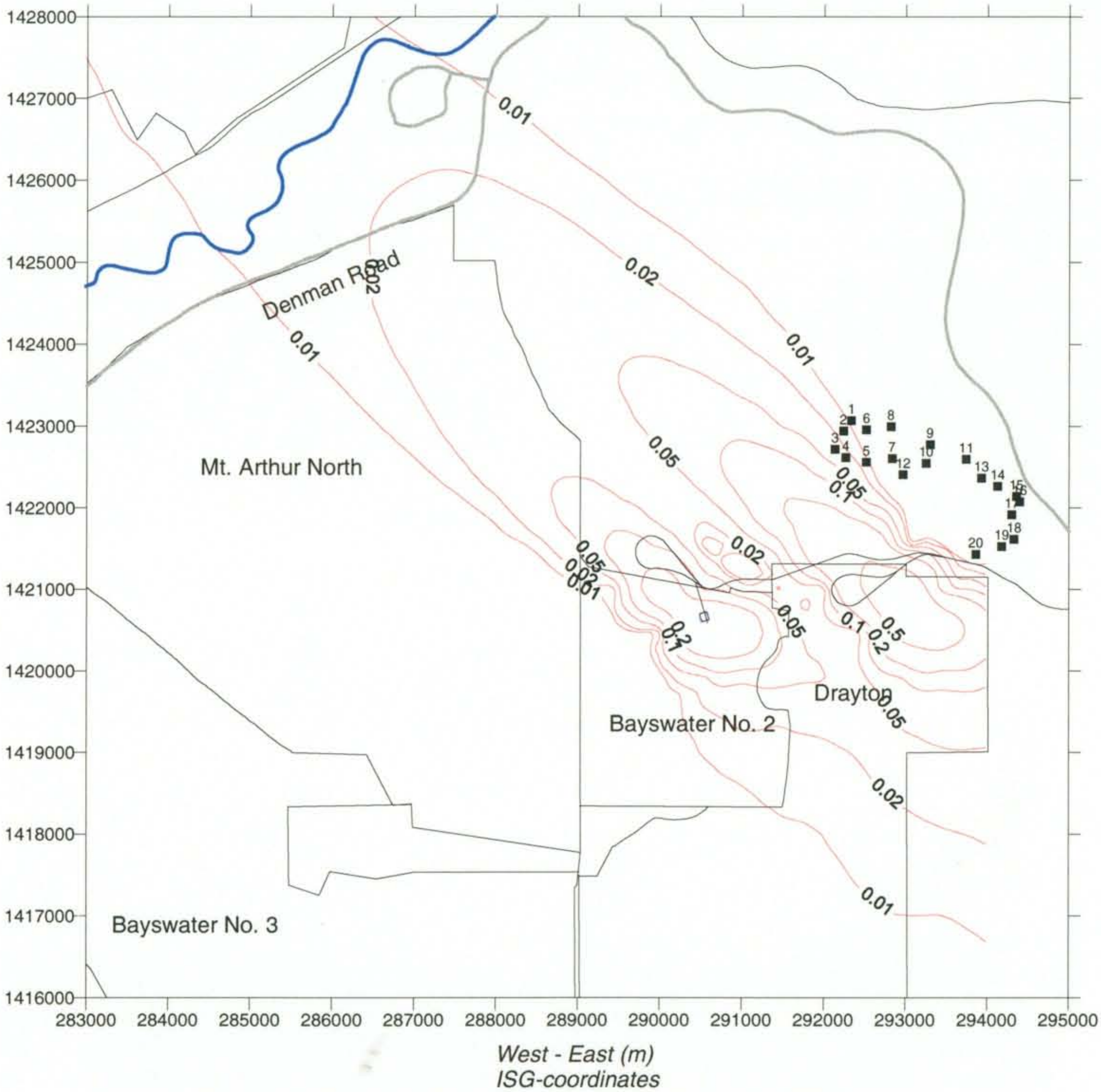
Figure 12



Predicted annual average PM_{10} concentrations due to emissions from stockpile and rail loop operations - micrograms/cubic metre

■ Residences

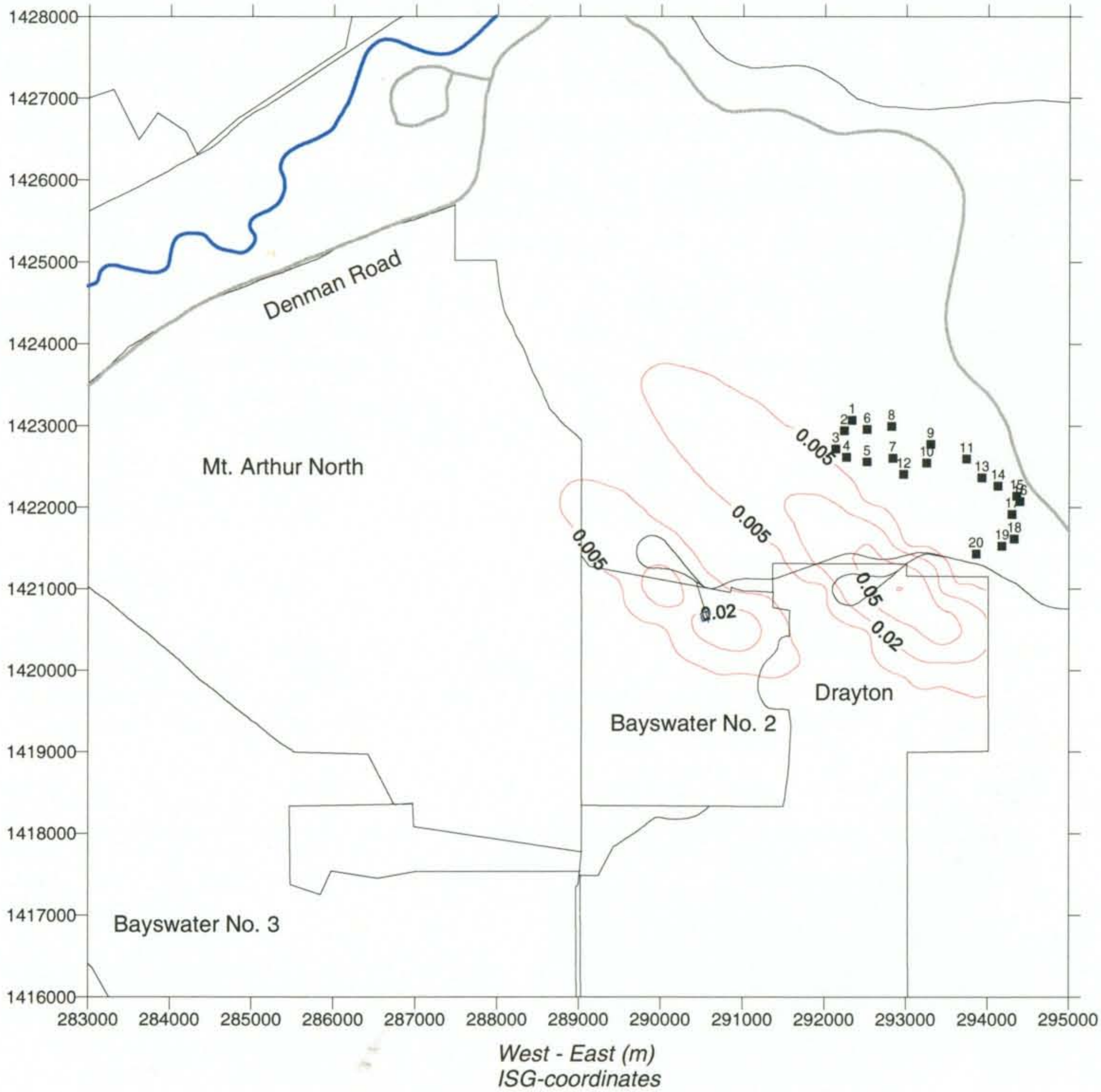
Figure 13



Predicted annual average TSP concentrations due to emissions from stockpile and rail loop operations - micrograms/cubic metre

■ Residences

Figure 14



Predicted annual average dust deposition due to emissions from stockpile and rail loop operations - g/square metre/month

■ Residences

Figure 15

APPENDIX 5

Archaeology Assessment

APPENDIX 5A

Aboriginal Archaeological Assessment

AN ABORIGINAL ARCHAEOLOGICAL ASSESSMENT OF THE PROPOSED BAYSWATER RAIL LOADING FACILITY, NEAR MUSWELLBROOK, HUNTER VALLEY, NEW SOUTH WALES

A report to

UMWELT (AUSTRALIA) Pty Limited

PO Box 838
TORONTO NSW 2283

by

Peter J. Kuskie
SOUTH EAST ARCHAEOLOGY

24 Bamford Street
HUGHES ACT 2605

Telephone: 02-6260 4439

MARCH 2000

EXECUTIVE SUMMARY

Umwelt (Australia) Pty Limited has been commissioned by Coal Operations Australia Limited to prepare an Environmental Impact Study for the proposed development of the Antiene Rail Loading Facility, near Muswellbrook, in the Hunter Valley of New South Wales. The proposal involves continued use of the existing Drayton Rail Loading Facility, for which heritage investigations were not required, and construction of the Bayswater Rail Loading Facility, which is the subject of this investigation. The study area is located seven kilometres south of Muswellbrook, in the Central Lowlands of the Hunter Valley.

The Bayswater Rail Loading Facility proposal will involve construction of a rail loop and coal loading facility in Authorisation A171, a 155 hectare area adjacent to Bayswater #2 Colliery. A three kilometre rail line will also be constructed to link the loading facility with the existing Antiene rail spur east of Drayton Colliery's rail loop. Construction of the rail loop and loading facility will cause impacts to the ground surface over an area of less than 35 hectares, while the rail link will affect an area of less than 20 hectares. The proposed alignment of the rail route has been designed with the objective of minimising impacts to areas of heritage potential along Ramrod Creek.

South East Archaeology was commissioned by Umwelt (Australia) Pty Limited to undertake an archaeological assessment of Aboriginal heritage in relation to this proposal. The study was undertaken between January and March 1999, as a component of a separate investigation at Mount Arthur North, and in October 1999 specifically for this project.

The principal aims of the archaeological investigation were to identify and record Aboriginal heritage evidence or locations of potential evidence within the study area, assess the impacts of the proposal on this evidence, assess the significance of this evidence, and formulate recommendations for the conservation and management of this evidence, in consultation with the local Aboriginal community.

The investigation proceeded by recourse to the archaeological, historical and environmental background of the locality, followed by construction of a predictive model of site location. A field survey of the A171 portion of the study area was undertaken by South East Archaeology and the Wonnarua Tribal Council in January and February 1999, involving a total of 8 person-days. It was undertaken as a component of a study into the adjacent Mount Arthur North mining lease application area (Kuskie in prep). Field investigations of the proposed rail link were undertaken in October 1999, using a similar methodology.

The study area was subdivided into 64 *archaeological survey areas*, all of which were sampled. All different environmental contexts were sampled, including the range of landform elements (five in total), classes of slope, archaeological terrain units (ten in total), geological formations and soil units present.

The investigation focused on identifying the nature and distribution of heritage items throughout the study area, particularly in relation to environmental variables. The individual artefact was used as the basic unit of analysis.

Surface visibility was low on average across the surveyed terrain, and very low in the remainder of the property, which was not subject to direct inspection. Vegetation is noted as being the primary detection-limiting factor.

and also in higher order drainage lines. Stone artefacts are predicted to occur much more widely over the study area than has been identified during the survey, including areas that are densely vegetated or were not sampled. Deposits of artefacts are predicted to occur extensively within a sub-surface context, with the depths of deposit relating to the variable depth of the A horizon soil unit.

The results of the survey support predictions that there is a low or very low potential for scarred tree, mythological/spiritual or stone arrangement sites to occur. There remains some potential, albeit low to very low, for skeletal remains to occur within alluvial sediments along Ramrod Creek. Minimal sandstone bedrock was identified within the study area, hence the potential for grinding groove sites is revised to very low. Outcrops of stone suitable for lithic procurement are also limited, indicating a low potential for this site type.

In general terms, the evidence is typical of that from the Central Lowlands of the Hunter Valley, although specific differences may exist with evidence reported from other localities. Taken individually, none of the items or contexts located within the study area appear to be unique in the region.

The scientific significance of the evidence is provisionally assessed, using a 'cultural landscape' approach, based on archaeological terrain units. Criteria used to assess scientific significance include the potential usefulness of the heritage evidence to address further research questions, the representativeness of the evidence, the nature of the evidence and its state of preservation. The scientific value of evidence within the ten archaeological terrain units is assessed as ranging from moderate to high within a local context and low to moderate within a regional context.

The Aboriginal heritage evidence recorded within the study area is protected under the terms of the *National Parks and Wildlife Act 1974*. Recommendations are presented for each of the archaeological terrain units (potential resource) and identified heritage sites within the study area. The recommended strategies involve a combination of avoidance of impacts, unmitigated destruction and salvage, in relation to an application for a Consent to Destroy and Permit to Salvage to be submitted to the National Parks and Wildlife Service that covers all of the evidence and land to be impacted by the proposal. The proposal will directly affect seven identified Aboriginal sites and potential resources within ten archaeological terrain units. Further consultation with the Wonnarua Tribal Council and National Parks and Wildlife Service is recommended in relation to this report and any future Consent application. It is also recommended that the proponent consider any reasonable request by the Wonnarua Tribal Council to monitor the initial removal of topsoil from within the alluvial soil deposits along several watercourses, for the presence of skeletal remains, and to collect surface artefacts that will be affected by the proposal.

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1. INTRODUCTION

Umwelt (Australia) Pty Limited has been commissioned by Coal Operations Australia Limited to prepare an Environmental Impact Study for the proposed development of the Antiene Rail Loading Facility, near Muswellbrook, in the Hunter Valley of New South Wales. The proposal involves continued use of the existing Drayton Rail Loading Facility, for which heritage investigations were not required, and construction of the Bayswater Rail Loading Facility, which is the subject of this investigation. The study area is located seven kilometres south of Muswellbrook, in the Central Lowlands of the Hunter Valley (Figure 1).

The Bayswater Rail Loading Facility proposal will involve construction of a rail loop and coal loading facility in Authorisation A171, adjacent to Bayswater #2 Colliery (Figure 2). A three kilometre rail line will also be constructed to link the loading facility with the existing rail spur at Drayton Colliery's rail loop. Construction of the rail loop and loading facility will cause impacts to the ground surface over an area of less than 35 hectares, while the rail link will affect an area of less than 20 hectares. The proposed alignment of the rail route has been designed with the objective of minimising impacts to areas of heritage potential along Ramrod Creek.

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The Aboriginal heritage investigation proceeded by recourse to the archaeological, historical and environmental background of the locality, followed by a comprehensive field survey undertaken in conjunction with the Wonnarua Tribal Council.

The general aims of the Aboriginal heritage assessment were to:

- undertake an archaeological survey to identify and record any Aboriginal heritage evidence or locations of potential evidence within the study area;
- assess the potential impacts of the proposal upon any identified Aboriginal heritage evidence or locations of potential evidence;
- assess the significance of any Aboriginal heritage evidence identified;
- provide details of any Aboriginal heritage evidence in accordance with NSW National Parks and Wildlife Service requirements;
- consult with the Traditional Owners organisation of the local Aboriginal community (Wonnarua Tribal Council);
- present recommendations for the conservation and management of any identified Aboriginal heritage evidence and potential heritage resources; and
- prepare a formal archaeological report to meet the requirements of the NSW National Parks and Wildlife Service.

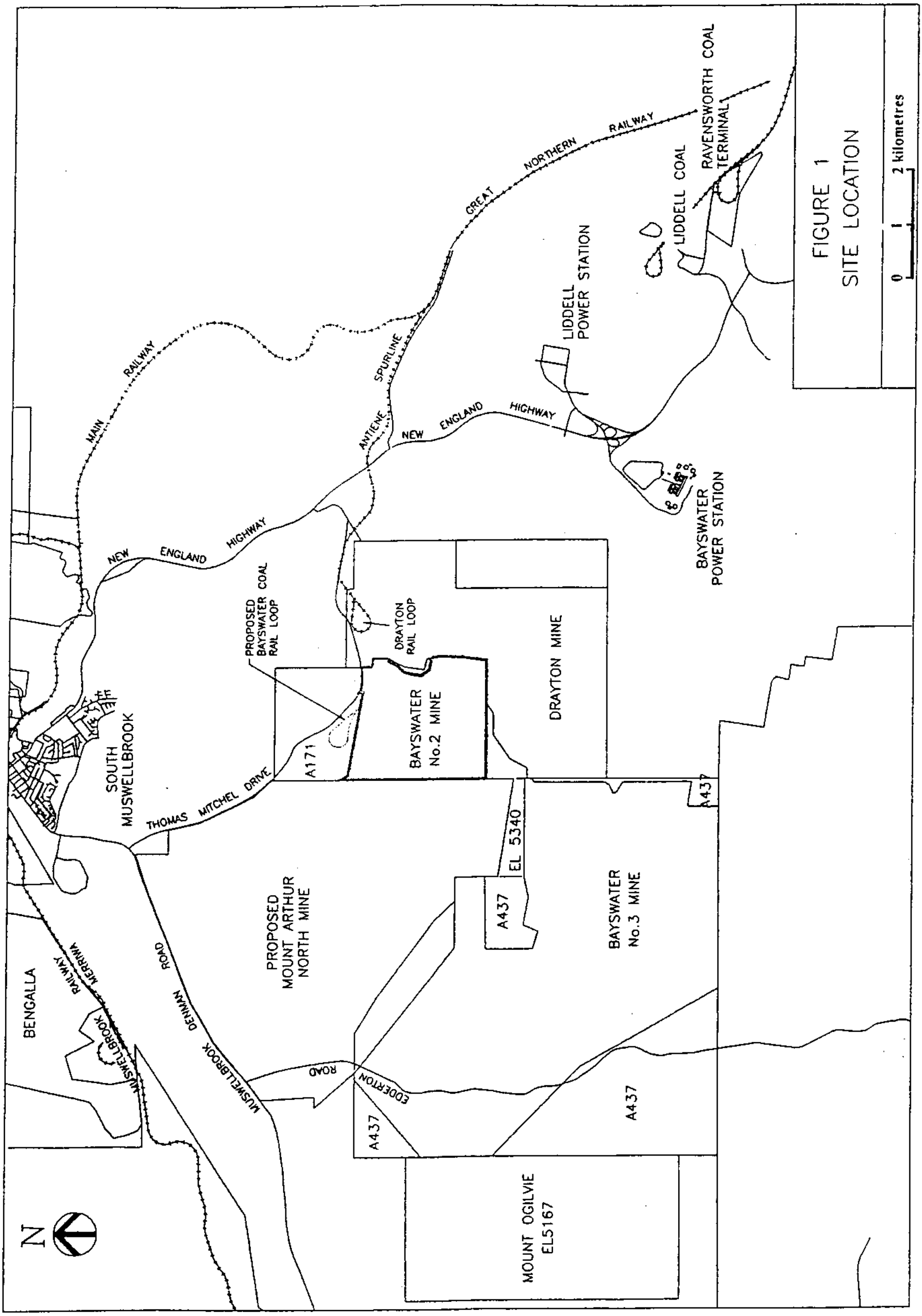

Figure 1: Location of study area (courtesy Umwelt).

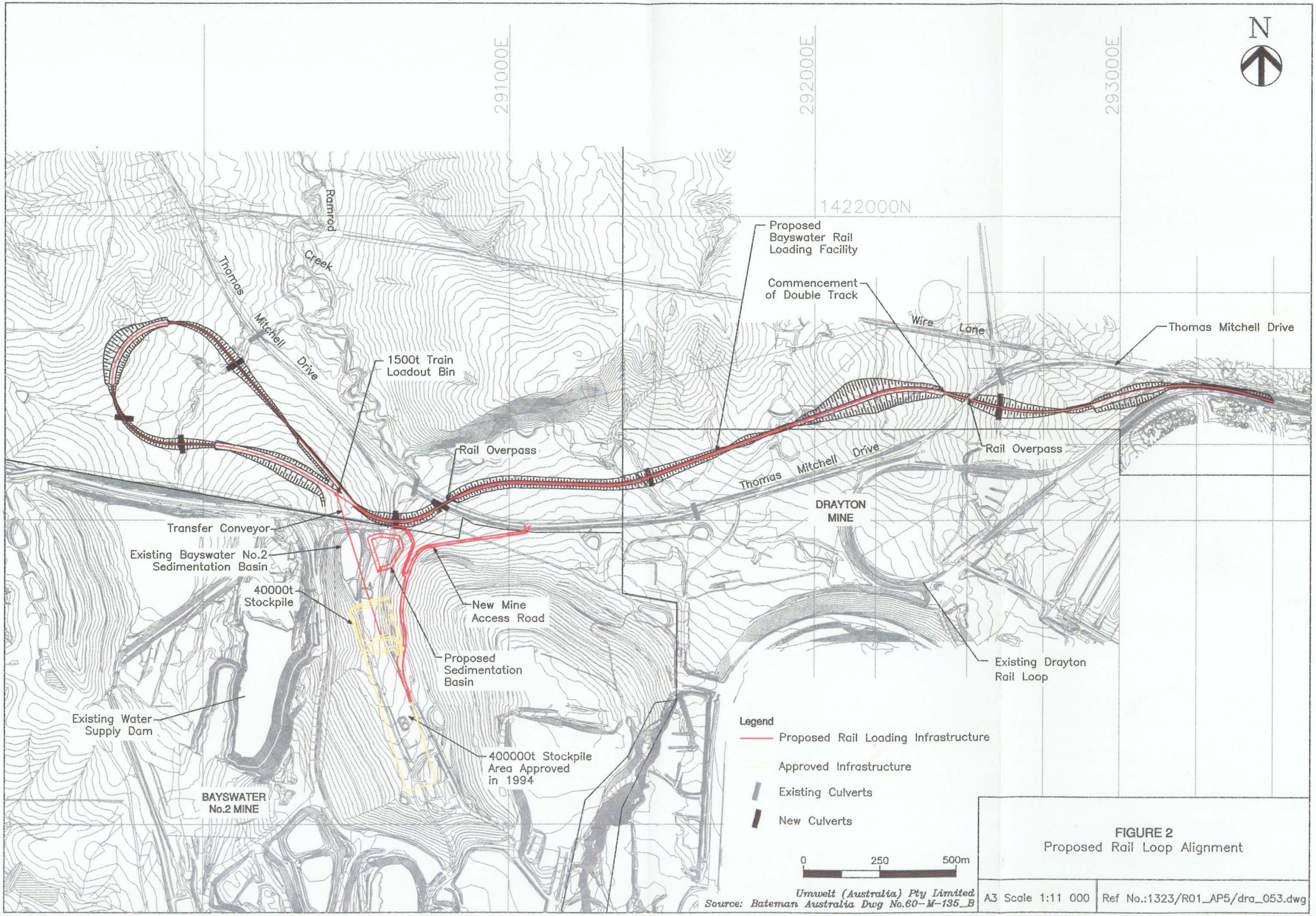

FIGURE 2
Proposed Rail Loop Alignment

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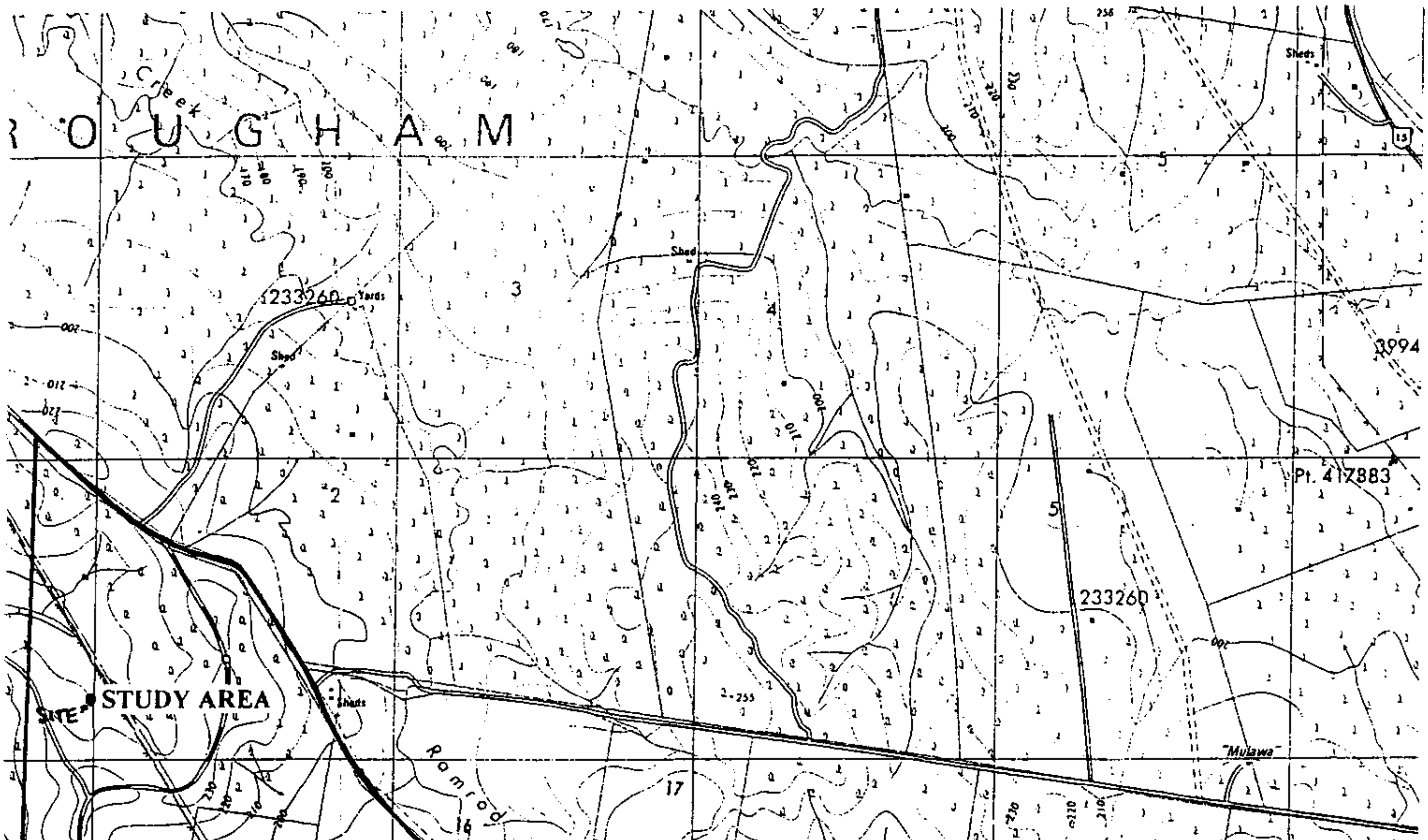


Figure 3: Topographical context of study area and location of previously recorded Aboriginal sites (Muswellbrook 9033-II-N 1:25,000 topographic map).

2. ENVIRONMENTAL CONTEXT

2.1 Location

The study area is located about seven kilometres south of Muswellbrook, in the mid-upper section of the Hunter Valley of New South Wales (Figures 1, 3).

The study area incorporates portions of Authorisation A171 and Drayton mine lease, along with land owned by Coal Operations Australia Limited. The portion of A171 that comprises the study area is bounded to the north by Thomas Mitchell Drive, south by Bayswater #2 Colliery and west by the Mount Arthur North mining lease application area. The proposed rail loading facility and rail loop is located in the eastern section of this area (Plate 1). A rail line that will link these facilities with the Antiene Spurline at the Drayton Rail Loop extends eastward for three kilometres, generally parallel to Thomas Mitchell Drive (Plate 2).

The total area investigated and reported on measures approximately 173 hectares, although a substantially smaller area will be affected by the proposal (less than about 55 hectares).

2.2 Topography

The topographical context of the study area is discussed to identify factors potentially relevant to patterns of Aboriginal land use. Land systems, along with other environmental information, are used in the construction of predictive models of Aboriginal site location. Predictive models are based upon the assumption that environmental factors provided distinctive sets of constraints which influenced Aboriginal land use patterns. Following from this is the expectation that Aboriginal land use patterns may differ between each environmental zone, because of differing environmental constraints, and that this may result in the physical manifestation of different spatial distributions and forms of archaeological evidence (*cf.* Hall & Lomax 1993, Kuskie 1994a, Packard 1991, 1992).

The study area is located in the region defined by Galloway (1963) as the Central Lowlands. The Central Lowlands region is described as a belt of lowlands extending through the centre of the Hunter Valley between Newcastle and Murrurundi, developed on relatively weak sedimentary rocks. It comprises an undulating or gently hilly landscape, with an abrupt transition to the steeper Southern Mountains to the south and North-eastern Mountains to the north (Galloway 1963:92).

Essentially the study area consists of gently undulating terrain, interspersed by several drainage lines. Ramrod Creek (a second and third order watercourse in the vicinity of the study area) is traversed by the rail route, along with several of its first and second order tributaries (Plates 1, 3 & 4). Elevation within the study area varies from 190 to 240 metres Above Height Datum (AHD).

During the course of the archaeological survey, the distribution of *landform elements* across the study area was mapped (refer to the Survey Areas in Appendix 5). Landform elements are defined following McDonald *et al* (1984) (refer to Glossary in Appendix 1). Elements identified within the study area include ridge crests (including hill crests), spur crests, simple slopes (including upper, middle and lower slopes), drainage depressions (including gullies) and flats. The proportion that each landform element comprises of the overall study area is listed in Table 1. Microtopographical variations were discounted during the study. Simple slopes and to a lesser extent drainage depressions are dominant within the study area.

Table 1: Landform elements as a percentage of the total study area.

Landform Element	# hectares	% of Total Study Area
ridge crest	12.8	7.4%
spur crest	10.8	6.2%
simple slope	104.7	60.6%
flat	2.6	1.5%
drainage depression	41.9	24.2%

For the purposes of the archaeological analysis, three *classes of slope* were delineated across the study area, following McDonald *et al* (1984):

1. level to very gently inclined slopes of less than 3% (1°45′);
2. gently inclined slopes greater than 3% (1°45′) and less than 10% (5°45′); and
3. moderately inclined and steep slopes greater than 10% (5°45′).

Most of the study area (59%) comprises gently inclined slopes. Moderate and steep slopes account for 34% of the study area. Level to very gently inclined slopes, associated with the main watercourses and portions of ridge and spur crests, occupy 6% of the study area.

Typically, Aboriginal camp sites are located on level or gently inclined ground. In the Central Lowlands, many archaeologists have identified that occupation appears to have been focused along watercourses (refer to Section 3). However, as discussed within Section 3, most archaeological investigations have also focused on watercourses, opening the possibility of sampling error.

2.3 Geology

The nature of the local geological formations has several implications for Aboriginal land use, primarily concerning the procurement of stone materials for manufacturing and modifying stone tools. The Aboriginal procurement and use of stone materials and their potential sources are discussed in greater detail in Section 3.

Two geological units have been identified within the A171 portion of the study area, based on the Hunter Coalfield Regional Geology Map and other investigations, and two additional units occur along the rail route (refer to EIS, Figure 2.6):

- Rowan Formation (Pr) - siltstone, sandstone and coal seams of the Middle Permian Greta Coal Measures. It outcrops over the western portion of the proposed rail loop;
- Mulbring Siltstone - siltstone, claystone and minor fine grained sandstone of the Middle Permian Maitland Group. It outcrops over the eastern portion of the proposed rail loop and western portion of the proposed rail route;

- Branxton Formation (Pb) - conglomerate, sandstone and siltstone of the Middle Permian Maitland Group. It outcrops over the eastern two-thirds of the proposed rail route; and

- Skeletar Formation - Pellet claystone, siltstone and chert. It outcrops in two minor localities along the proposed rail route.

A significant feature of the locality is the presence of stone materials suitable for manufacturing Aboriginal tools. Tuff (indurated rhyolitic tuff) commonly occurs as tabular cobbles within the Jerrys Plains Subgroup, on ridge and spur crests and many hill slopes, within the adjacent Mount Arthur North lease area. Silcrete, another material favoured for manufacturing tools, is also present within the Mount Arthur North lease as rounded cobbles on hill slopes, ridge crests and spur crests, particularly near the Hunter River. Quartzite is far less common at Mount Arthur North, occurring as isolated cobbles and stones, which may represent Permian era glacial erratics (*dropstones*). Pebbles of quartz, chert, tuff, silcrete and quartzite can also occur in drainage depressions.

2.4 Soils

Soils present within the study area, along with the processes affecting them, are described to identify their nature and their relationship to the survival, location and antiquity of evidence of Aboriginal occupation.

Four soil types have been identified within the A171 portion of the study area on the basis of testing for the Mount Arthur North Environmental Impact Study and previous work by Veness (1980):

1. Red Duplex Soils - mostly *in situ* red and yellowish duplex (texture-contrast) soils: typically dark brown, hard setting acidic loam to clay loam A horizons over acidic, neutral and alkaline light to medium well-structured clay B horizons. These soils occur over the vast majority of the A171 portion of the study area;

2. Brown, Yellow-Brown, Grey and Dark Coloured Duplex Soils - weakly developed duplex soils with brown to dark brown thin loamy or clay loam A horizons, sharply changing to moderately well structured, brown, yellowish-brown or grey-brown sometimes acidic to neutral but frequently alkaline, light to medium clay B horizons. These soils occur within a small area in the north-western section of A171;

3. Earthy Sands - uniform or gradational earthy sand: sandy earth soils with a fine sandy loam acidic surficial soil horizon grading to a brown fine sandy clay loam subsoil. This unit occurs in a very small portion of the A171 study area, along a drainage line in the north-western portion; and

4. Uniform or Gradational Clays - predominantly finer-textured, dark coloured, dark grey-brown, dark brown and dark yellow-brown structured light to medium clay soils: clay loam, fine sandy clay loam or light clayey A horizons overlie light to medium well-structured neutral to alkaline clay B horizons. This unit occurs in a very small portion of the A171 study area, along drainage lines in the western portion.

Soil mapping undertaken by Umwelt (Australia) along the proposed rail route indicates that three soil types are present (refer to EIS, Figure 4.10):

1. Yellow duplex soils developed on the Branxton Formation, along the western third of the proposed rail route;

2. Grey-brown and red-brown duplex soils, along the central portion of the proposed rail route; and

3. Yellowish duplex soils developed on the Greta Coal Measures, along the eastern third of the proposed rail route.

The soil mapping reveals that duplex, or texture-contrast, soils occur over most of the study area. Most of these soils may be pedogenetic, having developed *in situ* through weathering and clay illuviation (Gavin Renfrew, Dames & Moore, pers. comm. 1998). They are apparently not derived from lateral movement of sediment down-slope onto a different material.

Extensive sheet erosion is present within parts of the study area, particularly on moderately and steeply inclined slopes and along several drainage depressions. In these localities, part or all of the A horizon soil may have been removed by sheetwash erosion. Archaeological evidence may also have been removed, or remains as a stone layer on the surface of the B horizon. Gully erosion is also present along watercourses, with stream bank erosion evident along major creeks. Gully and stream bank erosion can both remove and expose archaeological evidence.

The removal of native vegetation since European settlement has promoted gully and stream bank erosion, accompanied by rapid deposition of sediment on the middle and lower reaches of watercourses. Consequently, along the middle and lower reaches of major creeks, sediment deposition in historical times may have obscured any evidence of Aboriginal occupation.

Soils older than 5,000 years of age are not expected to occur within the study area. The landscape is predominantly erosional and the depth of soil is generally minimal. Older soils have almost certainly been removed by geomorphological processes associated with higher rainfall following the last glacial maximum (c. 18,000 years ago) (*cf.* van de Graaff 1963).

2.5 Vegetation

The distribution of vegetation and potable water, which affect faunal habitats, are primary factors influencing patterns of Aboriginal land use, the preservation of evidence after its deposition and the ability to detect that evidence by surface inspection.

European settlers extensively cleared the original native vegetation from much of the study area. Presently, most of the area is covered by grass and thistles. Scattered woodland/forest occurs in the north-central section of the A171 study area and along parts of the rail route (eastern end). Some of this forest is regrowth vegetation and some is remnant native vegetation.

Originally the area may have been vegetated by a eucalypt savannah woodland, dominated by Box, Gum and Ironbark. Species such as Grey Box (*Eucalyptus moluccana*), Yellow Box (*E. melliodora*), White Box (*E. albens*), Forest Red Gum (*E. tereticornis*), Spotted Gum (*E. maculata*), Slaty-Red Gum (*E. dawsonii*), Broad-Leaved Ironbark (*E. fibrosa*), oaks (*Casuarina* spp.) and Kurrajong (*Brachychiton populneum*) may have occurred. A ground cover of grasses was probable, including species such as Kangaroo Grass (*Themeda* *australis*), Wiregrass (*Aristida* spp.), Wallaby Grass (*Danthonia* spp.), *Chloris* spp., *Dicanthium* spp. and *Stipa* spp. (Story 1963:33).

Consequently, the conditions of surface visibility are expected to be generally low throughout the study area, apart from exposures created by erosion scours or ground disturbance. In addition, it is anticipated that heritage evidence is likely to have been affected to some extent by processes of bioturbation, the mixing and mounding of soil by the activities of plants and animals. One resource zone (woodland) would have dominated the study area, although smaller riparian zones may have been present along the watercourses.

2.6 Environmental History

Reconstructing the landscape prior to European settlement assists with understanding the nature of Aboriginal occupation in the region and the post-depositional processes that may have affected any evidence of occupation. As archaeological evidence indicates that Aboriginal people were present in the region within at least the past 20,000 years (Koettig 1987, Kuskie in prep.), knowledge of changes to the regional climate, landforms and floral and faunal resources is important.

The Hunter Valley is a mature riverine estuary. Formation of the estuary is closely related to glacio-eustatic fluctuations in sea level that have occurred many times over the past million years. These cycles have frequencies of 100,000 years and amplitudes of 100-120 metres. The last commenced 125,000 years ago in a period of high sea levels and warm temperatures (Roy *et al* 1995). Slow cooling of temperatures and falling sea levels followed, culminating in the last glacial maximum about 24,000 to 17,000 years ago (Roy *et al* 1995:70-71, Thom *et al* 1981). The climate was much cooler and drier than at present.

Deglaciation and melting of ice sheets occurred rapidly from 18,000 years ago and the Hunter River slowly incised its valley. Much of the Pleistocene age floodplain deposited around 120,000 years ago was removed by subaerial weathering and lateral migration of the river channels. Most, if not all, of the soil units present within the study area were also removed from the predominantly erosive landscape, during periods of high runoff. Post-glacial sea levels rose quickly up to 8,000 years Before Present (BP), before slowing between 8,000 and 6,500 BP and then stabilising (Roy & Boyd 1996:11).

This information highlights the dynamic nature of environmental conditions in the locality of the study area, over the possible time period of human occupation. During the last glacial maximum, 24,000 to 17,000 years ago, the climate was cooler and drier than at present and winds may have been strong. From 18,000 years ago temperatures rose, glaciers melted, precipitation increased and a corresponding rise in sea level occurred. During the past 5,000 years the climate has been generally similar to that of the present. Since European settlement, the nature of the study area has again been transformed, in response to changes in the vegetation and hydrology.

3. ABORIGINAL ARCHAEOLOGICAL CONTEXT

3.1 Site Register Search

Various searches were undertaken of the NSW National Parks and Wildlife Service Aboriginal Site Register, including one large search between grid coordinates 290000-310000 east and 6410000-6430000 north. A total of 556 Aboriginal sites are listed on the register within this 400 km² area, including 513 artefact scatters (open camp sites), 31 isolated artefacts, 7 scarred trees, 2 shelters with deposit, 2 grinding groove sites and a lithic quarry.

Only two Aboriginal sites are listed on the NPWS register as being situated within or in the immediate vicinity of the study area (Figure 3). Site #37-2-172 and #37-2-167, both artefact scatters, were recorded by Hughes (1981) during a survey of Bayswater #2 Colliery (refer to Section 3.2). However, examination of the original records of Hughes (1981) indicate that the grid reference ascribed to this site by the NPWS is incorrect (placed one kilometre further east than it actually is). Hence, this site is located outside of the A171 portion of the present study area and will not be affected by the proposal.

The site register search indicates that stone artefacts are the primary form of cultural evidence recorded to date and expected to occur within the present study area.

3.2 Previous Archaeological Research

Numerous archaeological surveys and excavations have been undertaken in the vicinity of the present study area, principally in relation to environmental assessments for the coal mining industry (Figure 1). Brief discussion of the most relevant investigations will highlight the range of site types and variety of site contents in the region, identify typical site locations, and assist with the construction of a predictive model of site location for the study area.

3.2.1 Mount Arthur North

3.2.1.1 Pre-1998 Investigations

Dyall (1980), Koettig and Hughes (1985:Vol. 1-3) and more recently Kuskie (in prep) have investigated the Mount Arthur North Coal Lease, which lies adjacent to the present study area.

Mount Arthur North was initially investigated by Len Dyall in 1980, during a brief four day survey. Dyall (1980) identified 20 artefact scatters, two grinding groove sites and a low density background scatter of artefacts along sections of the main watercourses. The sites are located along watercourses, reflecting the survey sample which was limited to Whites Creek, Fairford Creek and Quarry Creek and several tributaries. Six of the artefact scatters were noted as containing in excess of 100 artefacts each. The grinding groove sites comprised a single groove on a boulder in a creek west of Mount Arthur, and two grooves on sandstone bedrock in the head-water stream of a Whites Creek tributary, adjacent to Mount Arthur. Dyall (1980:3) noted that very few artefacts were visible in the lower section of Whites

Creek, a result of either low surface visibility, sediment deposition or removal of evidence by flooding.

Dyall (1980) reports that artefacts primarily comprised flakes and blades, but ground-edge axes, bondi points, geometric microliths and flaked-edge axes were present. Dyall (1980) reports that several 'bulga knives' are present, although he notes that distinguishing between human and natural ground-edges on the limestone material is problematic. Dyall (1980) identified most of the stone flakes as 'rhyolite', which may in fact be rhyolitic tuff. The presence of cobbles and boulders of this material within the study area was noted by Dyall (1980).

Koettig and Hughes (1985: Vol. 1-3), undertook a more comprehensive investigation of the Mount Arthur North lease area, involving a survey in 1983 and salvage collections and excavations in 1984. The surface survey was almost entirely focused on sections of Whites Creek, Fairford Creek, Quarry Creek and their major tributaries, along with several streams draining into the Hunter River floodplain. Conditions of surface visibility were generally low at the time of Koettig and Hughes' (1985) survey, due to the cover of pasture grasses.

Recording procedures involved (Koettig & Hughes 1985):

- at 43 sites, an analytical level of recording in which artefact details (or samples in larger sites) were noted;
- at 27 sites, a summary level of recording in which only 'subjective' estimates of approximate artefact densities and stone materials were noted;
- at 23 sites, a detailed summary level of recording in which all artefacts at a site, or a sample, were counted, but only limited characteristics noted;
- recording of environmental and summary information at every site;
- artefact occurrences were recorded as sites (refer below) or observed as 'background scatter' which was generally not recorded; and
- eroded areas between sites were noted (dimensions and artefact count) to identify the amount of surface exposures along the watercourses and quantify the nature of 'background scatter'.

Koettig and Hughes (1985) defined *sites* as localities where artefacts occurred at a density higher than the 'background scatter'. They note that sites tended to correspond in area to the surface exposures in which they were identified. *Background scatter* was defined as the sparse scatter of artefacts that occurred beyond the limit of 'sites'. Typically background scatter equated to areas of low surface visibility, or erosion scours in which few artefacts were present. As a general rule, areas with less than 0.01 artefacts/m² were defined as background scatter.

Comparison of these measures with those used in the present investigation are problematical for reasons including:

- delineating 'site' boundaries (primarily done on the basis of surface visibility, but this ignores sub-surface deposits and evidence that is obscured by vegetation);
- the recorded 'sites' do not necessarily represent 'cultural sites' in the sense of discrete, culturally defined units beyond which cultural material is absent (they instead reflect the distribution of erosion scours);

- activities represented by the evidence are not considered in the definitions - therefore, as alluded to above, a 'site' may include overlapping or partial evidence from many different and totally unrelated discrete cultural events or periods of occupation;

- activities represented by background scatter may be related (in the sense of a cultural site) or may have some analytical value, but this evidence has mainly been ignored; and

- if conditions of low surface visibility were present and a background scatter identified, it may represent evidence of focused occupation that could not be detected because of the vegetation cover.

These issues are not solely related to this particular survey. However, they have considerable significance in terms of the present study and are discussed further in Sections 7 and 8.

Other issues have been identified with the survey recording and sampling procedures that make predictive modelling or comparison with the subsequent study results (Kuskie in prep) problematical.

These include:

- the inconsistency in levels of information recorded between different sites;

- the overwhelming bias of the sample to watercourses and consequently the limited assessment of simple slopes and ridges, which actually comprise the vast majority of the development area;

- the misidentification of some stone materials (notable 'indurated mudstone', which is in fact indurated rhyolitic tuff); and

- the recording of site and survey areas in terms of square metres of ground surface, in which variables such as surface visibility and detection limiting factors were not taken into consideration. Therefore, any variations in surface or archaeological visibility (visible ground surface with potential for artefacts) between sites renders Koettig and Hughes' (1985) density calculations invalid for comparative use (as partly noted by Koettig & Hughes Vol.2:47-48). The number of artefacts visible within a given unit is dependent upon surface visibility (normally expressed as a percentage of that unit) and archaeological visibility. As an example of the relationship between surface and archaeological visibility, a cutting into the B horizon soil may have 100% surface visibility but 0% archaeological visibility, because all of the surface with potential for artefacts has been removed) (refer to Section 7).

A total of 93 artefact scatters were identified by Koettig and Hughes (1985). They note that the distribution of sites along watercourses partly reflects conditions of surface visibility. Koettig and Hughes (1985:38) concluded from their results that artefact scatters occur along all creek systems, but fewer are located on the headwaters of minor creeks. Sites were considered to be more frequent along Fairford Creek than one of the main tributaries of Whites Creek. Along the lower section of Whites Creek, the distribution of sites was interpreted as reflecting the real pattern of distribution. However, the paucity of evidence along the mid-section, despite numerous surface exposures, was interpreted as reflecting the general absence of creek flats due to the intrusion of a hill slope. Low density background scatter was identified at many places along the watercourses.

Koettig and Hughes (1985) concluded that while artefacts occur on slopes and ridge crests, they tend to decline in density away from the watercourses. Densities were also noted as being lesser along the lower section of Whites Creek. As noted above, the nature of the density calculations does not permit assessments such as these to be made (although this does not necessarily imply that the conclusions are incorrect).

Silcrete and tuff (misidentified as 'indurated mudstone') were the most common stone materials, with porcellanite, quartz, petrified wood, chert, quartzite, volcanics and other materials also occurring.

Most flaked artefacts recorded by Koettig and Hughes (1985) measured less than 50 millimetres in size. Cores tended to have multiple striking platforms and were made of a variety of stone materials. At the larger sites, Koettig and Hughes (1985) identified that more flakes were longer than wide, with many being notably elongated.

The frequency of artefacts with retouch/use-wear in the analytical samples varied between 1% and 50%, although 3-10% was the common range. It is important to note that backed artefacts (eg. bondi points) are included within this category (comprising 29% of its total), even though the backing retouch is related to the style/function of the artefact, not a result of modifications to the working margin. The percentage of retouched/utilised artefacts within each stone material class varied:

- chert - 14%;
- tuff - 7%;
- petrified wood - 6%;
- silcrete - 4%;
- porcellanite - 4%; and
- quartzite - 1.5%.

Koettig and Hughes (1985) concluded that silcrete (the most common stone material) was less favoured or used for making implements.

Backed artefacts were made of silcrete (37%), tuff (29%), chert (11%), porcellanite (10%), petrified wood (7%) and quartz (6%). The percentage of backed artefacts within each stone material class varied:

- chert - 5%;
- petrified wood - 5%;
- tuff - 2%;
- porcellanite - 2%;
- silcrete - 1%; and
- quartz - 1%.

Koettig and Hughes (1985) concluded that petrified wood and chert may have been favoured materials for making backed implements.

Several ground-edge axes were located, including one with grooves useful for attaching a wooden handle.

A total of 22 knapping floors, concentrations of debris resulting from the manufacture of artefacts, were identified at 19 sites, including 11 along the upper section of Whites Creek. Knapping floors were mostly of silcrete (10 out of 22), but also porcellanite (5), tuff (2), petrified wood (2), chert, quartz and volcanics. Artefact density varied between 8 and 120 artefacts/m^2. Notably, many knapping floors were either isolated or associated with low density background scatter.

Based on their survey results, Koettig and Hughes (1985) proposed that artefact scatters can be subdivided into two sub-types at Mount Arthur North:

- isolated knapping floors, with few other artefacts apart from low density background scatter; and

- concentrations of artefacts, which often extend over large areas and do not contain obvious or distinct knapping floors.

Koettig and Hughes (1985) query whether this apparent distinction is due to different technological processes or repeated occupation. However, another possibility is that distinct knapping floors were once present within broader sites, but have subsequently been obscured by post-depositional processes.

Hearths were recorded at seven sites (MAN 9, 10, 32, 33, 44, 67 and 68) and at two locations of background scatter (MAN 16 and 17).

Salvage excavations and/or surface collections were undertaken at fifteen sites by Koettig and Hughes (1985: Volume 3). The primary aim of the salvage excavations was to obtain a well-documented collection of archaeological evidence that is representative of the entire study area and available for future research. The sites were selected on the basis of their contents and landscape context. The primary aim of the surface collections (particularly of knapping floors) were to include examples of different stone materials, in different parts of the study area, both with and without associated backed implements, and both isolated knapping floors and those which are part of a broader site. In addition, it was intended to collect a sample of backed blades, excavate potential hearths and collect stone axes and axe blanks.

At the excavated sites, the A horizon soil was typically less than 0.15 metres deep. Minimal excavation was undertaken of the B horizon soil. Most excavation involved wet-sieving deposit through 2.5 millimetre mesh. Small samples of soil and hearth deposits were retained without sieving.

Analysis of the artefacts was undertaken by Peter Hiscock (Hiscock & Koettig 1985:Vol. 3). Several knapping floors were assigned to particular chronological phases on the basis of technological attributes (*cf.* Hiscock 1984). This was undertaken through visual, not quantitative assessment. Hiscock and Koettig (1985) concluded that most evidence did not correspond with the chronological phases.

Limited analysis has been undertaken or reported on for these excavations. Several conclusions are presented, including:

- most samples contained a mix of stone materials;

- silcrete tended to be broken much more than tuff (explained in terms of the relative hardness, elasticity and rigidity of the stones, or application of different forces during reduction, or by the heat treatment of silcrete);

- the majority of evidence is concentrated in the lower section of the A horizon soil; and

- the relative ages of twelve knapping floors were estimated by comparison of the presence and frequency of certain technological attributes with documented and dated assemblages from rock shelter sites.

3.2.1.2 Post-1998 Investigations

Peter Kuskie, of South East Archaeology, undertook a comprehensive survey of the Mount Arthur North mining lease application area in 1998 and 1999. Coal Operations Australia Limited are proposing to develop the Mount Arthur North Coal Mine, within a total mining lease application area of approximately 35.4 square kilometres. This area varies slightly in size and shape to the areas previously investigated (Kuskie in prep).

The principal aims of the archaeological investigation were to identify and record Aboriginal heritage evidence or locations of potential evidence within the study area, assess the impacts of the proposal on this evidence, assess the significance of this evidence, and formulate recommendations for the conservation and management of this evidence, in consultation with the local Aboriginal community.

The investigation proceeded by recourse to the archaeological, historical and environmental background of the locality, followed by construction of a predictive model of site location. A field survey of the Mount Arthur North study area was undertaken by South East Archaeology and the Wonnarua Tribal Council over a period of five weeks in December 1998 and January and February 1999, along with two days in September 1999, involving a total of 216 person-days.

The total field survey study area includes the proposed mining lease application area and an additional 1.55 km^2 of land to the east of the mining lease application area, which comprises the A171 portion of the present study area. Subsequent to the initial survey, the proposal was modified to exclude most of A171 apart from an Access Road. A number of small areas in the adjacent Bayswater #2 and #3 Collieries were included, such as the Bayswater #3 Corner, Infrastructure Area, Export Coal Stockpile and Coal Conveyor. The Coal Conveyor and Export Coal Stockpile areas are located adjacent to the A171 portion of the present study area.

The field survey involved direct coverage of 242 hectares (6.6%) of the initial 37 square kilometre study area, resulting in an effective survey sample (accounting for archaeological visibility) of 0.68%.

The revised study area was subdivided into 520 survey areas, all of which were sampled. All different environmental contexts were sampled, including the range of landform elements, classes of slope, archaeological terrain units, geological formations and soil units present.

Surface visibility was low on average across the surveyed terrain, and very low in the remainder of the property, which was not subject to direct inspection. Vegetation is noted as being the primary detection-limiting factor.

The initial survey resulted in the identification of 294 Aboriginal heritage sites, all artefact occurrences, within 1,177 separate loci. Of these, 9 of the 12 sites located within A171 will not be affected by the Mount Arthur North proposal. A further 11 sites were identified in the additional survey areas, bringing the revised total number of sites that may be affected by the Mount Arthur North proposal to 296. All 112 previously reported sites within the study area (including additional survey areas) comprise part of this total. The identified sites occupy about 82% of the Mount Arthur North study area. The only non-artefact site type identified during the survey is a grinding groove site in the corner of the Bayswater #3 lease.

Artefacts are widely distributed across the study area, within all landform elements, classes of slope, archaeological terrain units, geological formations and soil units. Artefacts were identified at a mean density of 0.069 artefacts per square metre of effective survey coverage (accounting for visibility), across the entire study area sample. When exposures that do not contain evidence are excluded, the mean density (of individual site loci) is 2.6 times higher.

A total of around 17,342 stone artefacts were identified during the initial investigation, of which 15,970 artefacts were recorded in detail.

Artefacts are distributed widely, in a virtual continuum, but with variations in density relating to different environmental factors and cultural behaviour. Several patterns in the distribution of evidence have been identified. Artefacts occur at substantially higher densities within the valley flat landform element, on level to very gently inclined slopes, within fifty metres of a watercourse (particularly if it is a higher order stream) and on the level/very gentle valley flat archaeological terrain unit.

The combined site assemblage is dominated by two stone materials, silcrete (51%) and indurated rhyolitic tuff (34.6%). Thirteen other stone materials occur in much lower frequencies. Sources of silcrete were identified within the study area, mostly in the western portion bordering the Hunter River floodplain. Sources of tuff occur widely within the study area, in association with the Jerrys Plains Subgroup geological formation. Alluvial and colluvial gravels and other isolated occurrences of silcrete, tuff and to a lesser extent materials such as quartzite and quartz, were also noted within the study area.

A total of 37 different types of artefacts were recorded within the Mount Arthur North study area. The assemblages are dominated by flakes and portions of flakes (53.4% of combined artefact total) and flaked pieces (15.1%). This evidence represents the dominance of non-specific stone flaking activities within the study area. Evidence of microblade manufacturing is also common, comprising 16% of the total database. A very low frequency of utilised and/or retouched flaked artefacts is present (1.65% of the database). Tuff was preferentially selected over silcrete to manufacture these tools. Very few spear barbs (bondi points) were identified. Very low frequencies of tools indicative of activities such as the discard of non-microlith tools (eg. flaked or ground-edge axes, eloueras) or the discard/accidental loss of microlithic tools were located (eg. flaked or ground-edge axes, eloueras, etc). The flaked artefacts tend to be small in size (often less than 50 millimetres in maximum dimension).

This evidence is interpreted as suggesting that the major watercourses (Whites Creek, Fairford Creek and their main tributaries), were the focus of Aboriginal occupation in the study area. Level to very gently inclined ground was preferred for camping. Camp sites tended to be located within 50 metres of a watercourse, particularly third or fourth order streams. However, the possible importance of vantage points on elevated ground is noted. The results indicate that the entire landscape was utilised to varying extents, with hunting, gathering and other activities occurring away from, as well as within, camp sites.

The assemblages indicate that tool production was mostly casual and opportunistic, meeting the requirements for tools on an 'as needed' basis. More organised production of artefacts probably occurred, in relation to the manufacturing of microblades. The presence of larger flake and core artefacts, along with the distribution of stone sources, indicates that procurement of stone from sources within the study area occurred, in addition to surrounding sources (eg. alluvial gravels). It also tends to indicate that rationing of stone material was not a priority of the knappers. Considering the abundance and relative ease of obtaining materials, this is not surprising. Circumstantial evidence exists that deliberate thermal alteration of silcrete took place within the study area.

It is probable that much of the Aboriginal heritage evidence within the Mount Arthur North study area has been affected to some extent by human or natural post-depositional processes. However, it is possible that many potential deposits are of sufficient integrity to be of research value, particularly where the impacts of post-depositional processes can be identified and controlled for. Importantly to note, it is those deposits still subject to vegetation cover that are likely to be of higher integrity than most of the recorded site loci, in which visibility has been created by impacts that are also detrimental to site integrity.

From the existing circumstantial evidence it would appear that most, if not all, of the cultural evidence within the Mount Arthur North study area relates to the past 5,000 years of human occupation.

The results of the survey were used to reassess and refine the predictive model of site location for the study area. A substantial body of Aboriginal heritage evidence potentially exists within the Mount Arthur North study area, only a fraction of which has been identified during the surface investigation.

The scientific significance of the evidence has been provisionally assessed, using a 'cultural landscape' approach, based on archaeological terrain units. Criteria used to assess scientific significance include the potential usefulness of the heritage evidence to address further research questions, the representativeness of the evidence, the nature of the evidence and its state of preservation. The scientific value of evidence within the sixteen archaeological terrain units was assessed as ranging from low to high within a local context and low to moderate within a regional context.

A number of management strategies were discussed and a series of recommendations presented. In order to mitigate and minimise the substantial and irreversible impacts of the proposal to the identified and predicted Aboriginal heritage resources, the primary recommendation was that a representative sample of identified and potential Aboriginal heritage resources within the proposed Mount Arthur North mining lease should be subject to a combination of salvage, conservation and unmitigated destruction (Kuskie in prep).

3.2.2 Drayton Mine Lease

Kamminga (1978) undertook a brief (2.5 day) reconnaissance survey of the 2,279 hectare Drayton lease, which is located adjacent to the south and partially within the present study area (Figure 1).

Kamminga (1978) did not locate any heritage evidence. Kamminga (1978) attributed this result to the environmental context of the area and the levels of ground disturbance, arguing that sites are focused on the Hunter River alluvial plain and the lower reaches of its tributary streams. The only streams of this nature within the Drayton lease had been impacted by the construction of an ash pond.

3.2.3 Black Hill

Brayshaw (1982) surveyed the 650 hectare area of the proposed Black Hill Coal Mine, bordering Thomas Mitchell Drive and the Muswellbrook Industrial Estate, adjacent to the north and partially within the present study area (Figure 1).

Dyall (1980b) had initially surveyed the area, including parts of Ramrod Creek and located several artefact scatters.

Brayshaw (1982) located six artefact scatters and four isolated artefacts, in addition to two previously recorded sites. All of the heritage sites are located along Ramrod Creek and contain mostly silcrete and tuff flakes, flaked pieces and cores. Reported artefact densities varied between 0.005 and 0.2 artefacts/m², although these calculations probably do not account for variations in surface or archaeological visibility. The artefacts were identified in exposures, mostly along creek banks or low gradient slopes bordering the creek.

No sites were identified on crests or slopes, despite reasonable exposures. The survey did not incorporate any ground that is part of the present study area.

3.2.4 Bayswater #2

The Bayswater #2 Mine lies immediately to the south of the western portion of the present study area. It was initially surveyed by Hughes (1981) during a very brief two day period. The study area of Hughes (1981) measured approximately 700 hectares in size and incorporated a proposed extension that encompasses the A171 portion of the present study area and the western end of the proposed rail route.

Hughes (1981) inspected very little of the present study area, mainly a 1.7 kilometre foot transect through the western portion of A171. Hughes (1981) located seven artefact scatters and several isolated artefacts. All except one of the sites in the Bayswater #2 lease area were located along Ramrod Creek (mostly north and north-west of the present study area). No evidence was identified on ridge crests or hill slopes. The five sites along Ramrod Creek ranged in size from 75 to 225 m² and contained between 4 and 375 artefacts. Density varied between 0.025 and 5 artefacts/m² at these sites, although these calculations may not account for variations in surface or archaeological visibility. Silcrete was the dominant stone material.

According to NPWS grid references, two of the sites recorded by Hughes (1981) lie within or in the immediate vicinity of the present study area. However, examination of the original records of Hughes (1981) indicates that the grid reference ascribed to site #2 (37-2-172) by the NPWS is incorrect (placed one kilometre further east than it actually is). Hence, this site is located outside of the A171 portion of the present study area and will not be affected by the proposal (Figure 3). Site #7 (37-2-167), an artefact scatter, is located at grid reference 302600:6420400 adjacent to the present study area (Figure 3). Four flakes of tuff and quartz were identified within a 25 x 5 metre exposure. This site is discussed further in Section 8.

3.2.5 Bayswater #3

Investigations at Bayswater #3 Mine, south-west of the present study area, have been undertaken by Appleton 1994, Davidson *et al* 1993, ERM Mitchell McCotter 1994, Fife 1995, MacDonald 1997 and others.

An initial survey of the Bayswater #3 Lease was undertaken over 12 days in 1993 (Davidson *et al* 1993). The 4,700 hectare area consists of undulating terrain, low hills, gullies and watercourses. An extremely small sample of 0.024% of the study area was surveyed. Almost half of the coverage was along watercourses.

A total of 84 artefact occurrences were identified. Sites ranged in size from 1 to 62,500 square metres. Artefact densities at sites ranged from 0.0007 to 0.72 artefacts per square metre (although it is uncertain if this refers to the total site area or effective site area).

Minimal analysis has been undertaken of the recorded sites. Of the larger assemblages, flake portions (40%) and flakes (30%) are the dominant types, with flaked pieces (20%), retouched flakes (7%) and cores (3%) also present. Volcanic tuff (incorrectly termed 'indurated mudstone') was the dominant stone material (50-70% of larger sites), with silcrete also being common (20-30% of larger sites).

Four scarred trees were identified, although the nature of their origin (Aboriginal or natural) appears uncertain. Two axe-grinding groove sites were identified.

ERM Resource Planning (1994) undertook investigations of a proposed haul road and bulk sample program in the Bayswater #3 Lease. A total of 31 sites were identified within the 123 hectare study area. Gross survey coverage equated to 4.7% of the study area. Curran (ERM Resource Planning 1994) claims that artefact densities were apparently higher along the creek/gully and creek flat units. However, the existence of higher surface visibility in these localities was also noted.

Site Bobagul Hills 2 (BH2), recorded in the Bayswater #3 Lease by Davidson *et al* (1993), was salvaged by Appleton (1994). A total of 19 excavation units of varying size were excavated, for a total of 21.5 square metres. A total of 763 artefacts were retrieved from the excavation, along with 348 artefacts collected from the surface. Of these, 54% are made from silcrete and 32% from tuff. The assemblage was dominated by flakes (59%) and flaked pieces (34%).

A second salvage project was undertaken by Fife (1995) at the LFG complex of sites. These extend over an area of 3 hectares, about 1.5 kilometres south of Mt Arthur. A total of 21 square metres were excavated in eight separate localities to reveal 278 artefacts. A further 618 artefacts were collected from the surface. Tuff (incorrectly termed 'indurated mudstone') was the dominant stone material from the surface collection, but silcrete was dominant in the sub-surface sample.

Further investigations have been undertaken into the Bayswater #3 sites, including a survey, collection and test excavations reported on by MacDonald (1997). At site Edderton Road 2, MacDonald (1997) reports that flake portions (56% of the assemblage) and complete flakes (19%) were the dominant artefact types. Implements exhibiting retouch and/or use-wear comprised 9% of the assemblage, but these features were only identified macroscopically. Silcrete was the dominant stone material (50%) but tuff was more frequently used for making tools (53% of tools).

Sub-surface testing was undertaken in a locality known as the MacDonald Road South area. A systematic random sampling strategy was used. A total of 121 test units, measuring 0.25 x 0.25 metres in area, were excavated by shovel. Only nine of the units contained artefacts, mostly only one or two. A single unit contained 17 artefacts. The artefacts were identified on flats and very gently inclined lower, mid and upper slopes. No artefacts were identified within 22 test units adjacent to watercourses (including areas where surface artefacts were present). No explanations were forwarded by MacDonald (1997), although the small nature of the sample is probable a major factor. The depth of the A horizon deposit was found to vary between 0 and 0.51 metres. Very low conditions of surface visibility were noted by MacDonald (1997).

Further testing at MacDonald Road South involved the excavation by backhoe of 120 test units, each measuring 1 x 1 metres. Several squares were randomly selected across the entire locality, while others were randomly selected within defined 100 x 100 metre areas. A mechanical sieve was used, but not found to be of any assistance in processing the clayey soils. A total of 298 artefacts were retrieved, although from how many units is not stated. The maximum number of artefacts retrieved from a unit was 60. Artefacts tended to be more common at 0.05-0.10 metres below the surface, which MacDonald (1997) suggests is due to the effects of ploughing. The possible effects of bioturbation are not explicitly considered.

MacDonald (1997) also reports on the testing of a large artefact scatter located adjacent to MacDonald Creek. A total of 155 test units measuring 0.25 x 0.25 metres in area were excavated, resulting in the retrieval of only 70 artefacts. The distribution of artefacts was generally comparable to the distribution of surface artefacts at this site.

A larger hand excavation was undertaken at site MRS Ex 1, situated on a low ridge crest. This involved an area of fifteen square metres, excavated in 0.25 x 0.25 metre units. A total of 840 artefacts were retrieved. A second hand excavation at site LGH06 was undertaken. This site is located adjacent to a spring fed waterhole. Grinding grooves are also present. A five square metre trench was excavated and 283 artefacts recovered. In contrast to many other sites, quartz was identified as the dominant stone material. A trench measuring five square metres was excavated in the MacDonald Road South 3 locality, resulting in the retrieval of 587 artefacts.

During a surface survey, constrained by low conditions of visibility, MacDonald (1997) identified a fragment of a porcelain jar at site Edderton Catena 2. MacDonald (1997:92) claims this item was flaked by Aboriginal people and retouched, and has possible evidence of use-wear. During the survey, 35 artefact scatters were located, mostly in close proximity to tributary watercourses, in areas of high surface visibility due to erosion.

3.3 Research Themes

Key research themes involved in archaeological analyses of the Hunter Valley, which have arisen from the large quantity of Environmental Impact Assessment projects, particularly within the vicinity of the current study area, are discussed briefly below. This discussion highlights the research issues that may be relevant to the Aboriginal heritage sites within the present study area. It is particularly useful in identifying the research potential of sites, a component of the assessment of site significance.

3.3.1 Variation in Assemblages and Site Structure

Numerous researchers have investigated aspects of Aboriginal artefact scatter sites in the Central Lowlands, aiming to identify and explain patterns and trends in site contents, structure and distribution.

In relation to site structure and distribution, Koettig (1994:17) observed at Bulga and elsewhere in the Central Lowlands, that:

- sites range from dense continuous scatters of artefacts extending over hundreds of square metres to sites with widely spaced discrete archaeological features - both patterns occurring along watercourses;

- knapping floors/artefact concentrations are generally not structured, with debitage, implements and backed blades all present. Occasionally however, spatial separation of reduction and subsequent tool production occurs;

- some knapping floors are associated with archaeological features (pits); and

- specialised sites can be identified (for exploitation of specific resources) on the basis of the types of archaeological features present.

In relation to site content and technology, Koettig (1994:17) also observed at Bulga and elsewhere in the Central Lowlands region that:

- there may be regional variation in reduction strategies;
- stone material availability was not a constraint on artefact production;
- heat treatment of silcrete was common, but tuff was also heat treated in some locations;
- there were different methods of heat treatment (whole cobbles or blocks of stone, flake core bodies, and the flakes to be made into backed blades);
- backed blades commonly occur in sites in the Central Lowlands, as do other artefacts that have been used and/or retouched. Backed blades are not necessarily the most common type of tool used, just the most obvious;
- the production of backed blades was characterised by standardised reduction techniques, indicative of highly patterned behaviour;
- the reduction strategies associated with backed blade production were varied and reflected the specific character of the core body;
- elongation was not necessarily a characteristic feature of reductions associated with backed blades;
- the manufacturing process producing backed blades might be distinct from the reduction of cores to produce other types of tools in some areas (specialised versus opportunistic strategies);
- both backed tools and other used/retouched artefacts may result from the one reduction sequence and even strategy;
- different assemblages could represent different stages of production;
- certain types of cross sections may be a useful indicator of backed blade production (low angled, weak and strong ridging: *cf.* Hiscock & Koettig; flat, thin: *cf.* Witter);
- individual technological attributes may be useful chronological markers (eg. faceted platforms, or other attributes indicating high degrees of platform preparation, or the absence of platform preparation: *cf.* Hiscock); and
- sample composition can result in different characterisation of the evidence, which may bias the interpretation of results (Koettig 1994:17).

Koettig (1994:35) reports that variation between assemblages in the Central Lowlands has been explained in terms of:

- stone material rationing (Hiscock 1986);
- different reduction strategies resulting from either:

- changes through time (Hiscock 1988);

- different outcomes/products (Baker 1992, Baker & Gorman 1992, Witter 1992);

- local/regional conditions such as stone material quality and availability (Witter 1992, Haglund 1989); and

- behaviour/tradition (eg. standardisation of process and/or outcomes) (Hiscock 1985, 1986, Witter 1992).

The analysis of artefact assemblages through examination of technological attributes was pioneered in the Hunter Valley by Peter Hiscock (1984, 1985, 1986). Several archaeological studies in the Hunter Valley have subsequently focused on replicating Hiscock's methods and testing his results, or on using different approaches of technological attribute analysis to examine variation within and between assemblages and methods of stone reduction (*cf.* Baker 1992, Baker & Gorman 1992, Haglund 1989, Koettig 1992, 1994, Witter 1992).

Hiscock (1984) analysed assemblages from sites Redbank Creek (RBC) 5 and 12, along Redbank Creek, a tributary of Wollombi Brook. The sites are located within the United Collieries Lease, over 25 kilometres from the present study area. Hiscock (1984) argued that while there are inter-site variations in artefact sizes and density, the Redbank Creek technology is essentially similar. Hiscock (1984) identified that virtually all of the stone knapping related to microblade production (bondi points) and that:

- complex procedures were involved in the procurement, transportation, reduction and use of stone;

- variations were present in the use of different stone materials, (eg. silcrete was heat treated but tuff was not); and

- only one type of reduction sequence was present (named the 'Redbank A Strategy').

Hiscock (1985) reanalysed the artefacts excavated by Moore (1970) at the Sandy Hollow 1 rock shelter site and based on the analysis of attributes, defined three temporally distinct technological phases (Pre-Bondaian, Bondaian Phase I and Bondaian Phase II). Hiscock (1986) argued that detailed technological attribute descriptions of assemblages could allow for dating of open sites by analogy with the technology of dated sites and could identify individual stone knappers and explain intra-site and inter-site variation.

Through conjoining and classification and measurement of individual technological attributes, Hiscock (1985, 1986) determined types of reduction sequences and variations between reduction sequences. The generalised reduction sequence identified by Hiscock (1986:36-40) contains six stages:

1. selection of stone material;

2. initial reduction that produces large flakes;

3. selection of flakes for further reduction;

4. 'tranchet' reduction;

5. selection of flakes for backing; and

6. backing.

Tranchet reduction is the knapping theme identified in the three collections examined by Hiscock from Redbank Creek, involving:

1. initial removal of a large, thick flake from a core;

2. retouch of the flake by blows to the ventral surface that remove small flakes from the dorsal surface: retouch on the lateral margins acts to establish potential platforms and retouch on the proximal and distal ends establishes ridges and removes unwanted mass;

3. blows are applied to the platforms established on the lateral margins in step #2, removing flakes from the ventral surface of the 'tranchet' retouched flake; and

4. Stages #2 and #3 are alternated to enable reduction to continue (Hiscock 1986:70).

Hiscock (1986:71) asserts that these 'rules of stone-working' were strictly followed by the knappers, but individual variation could occur with the timing and extent of knapping behaviour. Hiscock (1986) suggests that stone knapping was organised as a 'production line', with initial reduction of several sizable cores, before heat treatment of a large number of resulting flakes prior to tranchet reduction. These steps could take place in different locations (eg. initial reduction at an alluvial gravel source, heat treatment at sandy creek beds or banks, and reduction elsewhere along watercourses).

At Mount Arthur North, Hiscock (1985) assigned several knapping floors to particular chronological phases on the basis of technological attributes. However, this was undertaken through a visual, not a quantitative assessment and Hiscock and Koettig (1985) concluded that most samples did not correspond with the identified chronological phases.

Haglund (1989) undertook research aimed at testing Hiscock's methods of technological analysis and his conclusions. Haglund (1989) analysed tuff flakes from three sites on the Merriwa River (a major tributary of the Goulburn River) using the system adopted by Hiscock at Sandy Hollow.

Haglund (1989) encountered major problems interpreting Hiscock's definitions and using his methods to calculate results. It was identified that methods of measuring some traits were based on a personal assessment of what was likely to have happened, a factor Haglund (1989) suggests makes such measures unlikely to be replicated accurately by others. Haglund (1989:22) concluded that the type of analysis described by Hiscock can give valid and useful information, but:

- definitions require clarification;

- traits identified as diagnostic vary with regard to value (particularly if the sample is small); and

- the identification and evaluation of these traits reflects the analyst's bias and experience to varying degrees.

Haglund (1989:24-25) raised other important concerns, including the:

- very small nature of her and Hiscock's samples;

- arbitrary nature of those samples selected for analysis;

- possibility that the samples represent one or more types of activity, which the debris from may have changed over time;

- uncertainty about deposition rates of artefacts and sediment (continual low intensity use or occasional intensive use);

- suggested minimum of fifty flakes is too small a sample (Haglund suggests 100 - 150 flakes would be better);

- provenance of individual flakes is a problem; and

- basing divisions on typological (ie. intrinsic) traits, in the absence of clear stratigraphic separation, may lead to circular arguments.

Haglund (1989:19) and Hughes (1984:85) also make the significant point that the dates from the Sandy Hollow 1 site are to some extent questionable. Therefore, once margins of error are accounted for, the time span of the proposed technological phases does not appear sufficiently fine-grained for application to open sites.

Other attempts have been made to characterise open artefact scatters using Hiscock's methodology, however none have been successful (*cf.* Koettig 1992, Dean-Jones 1992 & Rich 1991).

Baker (1992:62) tested Hiscock's method of flake analysis using statistical techniques such as correspondence analysis. These revealed that only one of the attributes used by Hiscock to define chronologically distinct technological phases showed no overlap between phases (percentage of flakes with several scars on the platform) (Baker 1992:62). Distinct boundaries as suggested by Hiscock (1986:45), including a two-phase division of the Bondaian, were not supported by Baker & Gorman's (1992) analysis. However, Baker (1992:69-72) did identify the presence of marked differences in the mean size of flakes between Bondaian assemblages. A graduated decrease in size occurs from Bondaian Phase 1 to Bondaian Phase 2 and then Group 3 (a smaller grouping proposed by Baker).

Koettig (1992) undertook a detailed technological attribute analysis of tuff flakes excavated at Camberwell. Koettig (1992:55) identified internal consistency within the Camberwell assemblages, but claims they do not correspond to the Bondaian phases identified by Hiscock (1985) at Sandy Hollow.

Koettig (1994) also undertook detailed technological attribute analysis of several assemblages at Bulga. Koettig (1994:45) identified that the following factors influenced assemblage composition at Bulga, and thus affected technological attribute descriptions:

- types of reduction sequence and reduction strategy;

- number and variety of reduction sequences and strategies within any one knapping floor;

- type of stone material;

- amount of breakage;

- number of flakes retouched to produce backed blades; and

- number of flakes removed from the knapping floor.

On the basis of the technological attribute analysis of the Bulga assemblages, Koettig (1994:74-75) concluded that:

- a broad range can be present in the values of various attributes within different assemblages and reductions;
- some assemblages are characterised by a number of different reduction strategies - therefore the total assemblage is a combination of different reduction strategies and the technological attribute description is of this pooled material;
- artefacts from a specific type of reduction strategy may or may not produce a distinctive 'technological character'; and
- if assemblages are characterised by a high incidence of breakage, then whole flakes are unlikely to be indicative of the types of flakes produced on a knapping floor.

Larson and Ingbar (in Hofman & Enloe 1992:154) also highlight the limitations of technological attribute analysis:

> Since site or level assemblage analyses combine variables and attributes into categories, such analyses tend to mask variability and emphasise similarity. In order to understand variability, analysis must begin with the finest grained units that reflect the relationship between the organisation of technology and patterns observed in the archaeological record.

Other attempts at comparing assemblages through technological analysis have been made (*cf.* Witter 1992). Witter (1992) views stone technology as a dynamic system, with artefacts changing size and shape during the reduction process. The relative thickness of the artefacts and debitage produced are seen to be reflective of the overall reduction strategy. Witter (1992) defined this in a reduction chart, a scattergram involving the plotting of √Block Length x Block Width (X-axis) against Block Thickness (Y-axis). The chart was intended as a visual representation of an assemblage, not as a statistical technique. It provides a summary of the size and shape of an assemblage.

Witter (1992:14) identified eight methods of reduction associated with backed blade production, not all of which were necessarily present in the Hunter Valley. However, Witter (1992) basically concluded that 'the technology existed to instantly produce flakes with a standardised cross-section for backing purposes' and noted that elongated flakes were not necessarily characteristic of microblade reduction strategies.

In recognition of the serious deficiencies of assemblage characterisation and comparison through technological attribute analysis, Rich (1995) developed new concepts in the Hunter Valley relating to individual discard events. This approach is based in technological organisation, defined by Nelson (1991:57) as 'the study of the selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance'. Stone artefacts are viewed as 'the discarded components of stone tool kits'. Stone tools served functional roles, debitage was produced in the context of managing those tools and those activities occurred in spatial and temporal contexts (Rich 1995:8).

Rich (1995:8-13) recognises that artefacts were discarded as part of individual stone using events. By identifying and analysing the artefacts from these events, information can be revealed about the nature of stone use and the artefacts can be linked with the actions of Aboriginal people. The procedure involves stone material identification and conjoining to assign artefacts to discard events.

Rich (1995:10) identifies eight possible discard activities, the nature of each having implications for what was imported to, discarded and removed from a site:

- import and discard with or without on-site use (item is imported, item is discarded, nothing removed);
- tool retouching (tool is imported, retouching debitage and possibly tool are discarded, tool or no items may be removed);
- stage of reduction; eg. decortification, core preparation, heat treatment (core or tool preform is imported, discarded item is debitage, core or tool may be removed);
- flake production, typically 'casual' or production of a few flakes for use as 'instant tools' (core or core-tool is imported, flakes and used flakes and possibly core are discarded, core may be removed if not discarded);
- backed blade production (core is imported, moderate to high numbers of debitage result from core preparation, unsuitable blades and backing flakes and possibly the core are discarded, suitable backed blades and possibly the core are removed);
- caching or discard for possible future use (item is imported, item is discarded in a form still useful as a core or tool, nothing is removed);
- recycling (no item is imported, the item and possibly debitage are discarded, removal of items is uncertain); and
- core reduction.

Some items may be imported to a site, used, then removed and discarded elsewhere, thereby leaving no evidence.

The reduction process might use:

- different forms of stone as cores;
- different reduction techniques (unidirectional, bifacial, bipolar);
- heat treatment;
- different ways of orienting cores;
- core preparation (decortication, overhang removal, platform faceting, ridge straightening);
- features of core morphology (ridges on core face used, blows placed relative to distance from platform edge); and
- rationing techniques to prolong core life (rotation, change to bipolar) (Rich 1995:16-17).

Therefore, artefact analysis needs to identify individual stone using discard events, identify the nature of those events, identify tools, determine types and quantities of stone material used, and determine something of the technology used (Rich 1995:17-18). To identify individual stone using events, an analysis would need to:

- identify stone material type;
- code individual artefacts to retain provenance information;
- group on the basis of similar characteristics; and
- conjoin (Rich 1995:17-18).

To identify the nature of discard, an analysis would need to:

- identify complete or near complete flakes <10 mm and 10-20 mm in size;
- identify blade flakes >10 mm in size;
- quantify the number of artefacts in assemblage of each event; and
- quantify the number of conjoins in assemblage of each event (Rich 1995:17-18).

To examine tool function and design, the analysis would need to:

- identify retouch and/or use-wear; and
- identify broad 'design types' of artefacts (Rich 1995:17-18).

To investigate the management of stone materials, the analysis would need to record:

- stone material type and identify its discard event;
- weight of artefacts of each discard event;
- information on tool function in relation to each discard event; and
- information on reduction techniques in relation to each discard event (Rich 1995:17-18).

To investigate reduction strategies, attributes must be recorded (Rich 1995:17-18).

The concepts and methods developed by Rich to investigate and explain assemblage composition and variation are most applicable to samples retrieved through controlled excavation. However, these concepts can be partially useful in interpreting the evidence obtained during systematic surface surveys.

3.3.2 Stone Materials

Research issues examined in the Hunter Valley include the:

- identification of stone material types;
- characterisation of assemblages by proportions of stone material types;
- availability of stone materials;
- procurement behaviour at stone material sources, and

- relationship of stone material type to the management of the stone, including reduction techniques and artefact functions.

Identification of stone material types in studies in the Hunter Valley has primarily followed classifications by Hughes (1984:77-79). Samples were analysed by Dr Alan Watchman, as hand specimens and by using thin section analysis. Watchman concluded that a similar suite of materials was available within the Central Lowlands, at least upstream from Branxton. The major stone materials in the Central Lowlands were identified as 'indurated mudstone' and silcrete, with minor frequencies of quartz, fossilised wood, chert, porcellanite and local volcanics (Hughes 1984:77-79).

Recent research by Kuskie and Kamminga (*in prep.*) has revealed that what most researchers have referred to as 'indurated mudstone', or even 'chert', is in fact *indurated rhyolitic tuff*. X-ray diffraction, thin-section analysis and hand-inspection were used to correctly identify this stone type.

Indurated rhyolitic tuff is a fine grained, isotropic stone formed after a cloud of ash was ejected in an explosive volcanic eruption. The ash settled to the ground or through ponded water. After burial, some tuff beds became indurated, through a low-grade metamorphic process (probably involving pressure) in which the stone recrystallised to a more stable structure. Tuff samples examined from the lower and upper Hunter are rhyolitic in chemical composition (quartz and potassium-feldspar, occasionally with layer silicate or goethite).

Indurated rhyolitic tuff is typically grey in colour in the lower Hunter (a function of grain size, not a reference to individual grains, which can be of a variety of colours). However, tuff is porous enough for the diffusion of iron bearing solution, with iron precipitating out to give a yellow, red or orange colour. Variations to the surface colouration can also result from weathering processes. Much of the tuff found in Aboriginal sites in the Upper Hunter is red, yellow or orange in colour.

Volcanic tuffs occur in widespread seams throughout the Hunter Valley and are occasionally exposed in drainage lines or in cliff faces, or the cobbles become worked into river gravels (eg. Hunter River and its tributaries) where they represent a readily available source of the material.

While tuff is perhaps the dominant stone material of the Hunter Valley, silcrete was also commonly used.

Silcrete is a brittle, intensely indurate rock composed mainly of quartz clasts cemented by a matrix which may be well-crystallized quartz, cryptocrystalline quartz or amorphous (opaline) silica (Langford-Smith 1978:3). The texture of silcrete reflects that of the host rock and clasts may range in size from very fine grains to boulders. Silcrete is produced by an absolute accumulation of silica, which can be precipitated from solution by evaporation, cooling, the neutralisation of strongly alkaline solutions, reaction with cations, adsorption by solids and the life-processes of organisms (Summerfield 1983:76). In weathered profiles, downward percolation of silica released through bedrock weathering and clay mineral authigenesis, together with water-table fluctuations, are suitable conditions for formation (Summerfield 1983:80). Silcrete is normally grey in colour, but can be whitish, red, brown or yellow. It shatters readily into sharp, angular pieces with a conchoidal fracture and newly broken rocks have a semi-vitreous sheen (Langford-Smith 1978:4).

Silcrete was an attractive material to the local Aboriginal people because of its flaking properties and availability. Archaeological and geological studies in the Central Lowlands have identified various terrestrial and alluvial sources of silcrete, including at nearby Mount Arthur North (Kuskie in prep), Bengalla (Rich 1993), Saltwater Creek (Koettig & Hughes

1985), Bulga (Koettig 1994), Lemington (Brayshaw *et al* 1996, Kuskie in prep.), Jerrys Plains, Singleton and terraces along the Hunter River (Raggatt 1938).

Aboriginal knappers may have encountered problems when reducing silcrete to manufacture small tools, because of the presence of quartz clasts. To overcome this problem it appears that deliberate thermal alteration (heat treatment) of silcrete was undertaken. This process was in widespread use in the Hunter Valley (*cf* Baker 1992, 1996, Haglund 1992, Haglund & Rich 1995, Hiscock 1986, Koettig 1992, 1994, Kuskie 1994b, Kuskie & Kamminga *in prep*, Rowney 1992 and Silcox & Ruig 1995). Controlled heating to specific temperatures and slow cooling alters the flaking qualities. The original poorly ordered, strongly interlocking microfabric becomes more equigranular and crystallised (Domanski & Webb 1992:612).

In the Hunter Valley, heat treatment is often accompanied by a change in colour of the stone to red or pink, as iron oxides are altered to haematite, and it also may result in a distinctive vitreous lustre. Questions relating to the nature of the heat treatment process, its effects on the stone material, consequences for stone reduction, reasons for undertaking the procedure, regions where it was undertaken, the antiquity of the process and variations between different regions and over time, have been investigated.

3.3.3 Site Integrity

The integrity of Aboriginal artefact scatter sites and the natural and cultural post-depositional processes that potentially effect evidence have been discussed in archaeological studies in the Central Lowlands. Understanding the potential integrity of a sub-surface deposit is an important factor in identifying the research potential of a site and therefore its significance, along with suitable management strategies. It is also critical to the analysis of survey and excavation results.

Once deposited, evidence of human occupation can be affected by a range of processes including natural factors (erosion, weathering & bioturbation) and cultural factors (impacts by site occupants & impacts from recent land use practices such as cultivation, grazing, mining and vegetation removal). As Gollan (1992:44) observed, the archaeological resource is 'constantly in a state of flux, being made (exposed and discovered) and un-made (by impacts, random and non-random, cultural and natural), but generally trending towards loss of systematic informational content'. It is important to identify the range of processes that may have affected a site, in order to account for possible effects to the horizontal and vertical spatial distribution of evidence.

The primary natural processes that may effect open sites within the Central Lowlands include erosion/deposition, bioturbation and weathering (thermal, mechanical and chemical).

The physical movement of soil down-slope can be facilitated by various agencies including rainsplash, hillwash, soil creep, tillage and bioturbation (Allen 1991). Rainsplash is important because the physical kinetic energy of rain drop impact enables the detachment of soil particles which can then be entrained (Allen 1991). Sheetwash, where water washes off the soil surface in sheets, enables fine material to be transported in suspension once entrained and coarser particles to be moved down-slope by gravitational force (Allen 1991:44). Small stones (<6 mm), of low density, can also be moved by sheetwash. Sheetwash erosion is common in the Hunter Valley, including parts of the present study area. Its effects are most noticeable where recent land use practices have removed the vegetation or disturbed the ground surface.

Dean-Jones (Resource Planning 1991:27-28) notes that sheet erosion is most apparent on foot-slopes and where drainage lines intersect low bedrock spurs. With minor or moderate sheet erosion, some lateral displacement of artefacts would be expected and all artefacts from the upper part of the topsoil may be collapsed into a single stratigraphic level (Resource Planning 1991:27-28). Severe sheet erosion, in which the subsoil (B horizon) may be exposed as the ground surface, is common on steep slopes and low gradient basal slopes which have long straight slopes above them. More substantial lateral displacement of artefacts could be expected (Resource Planning 1991:28).

Allen (1991) argues that sheetwash erosion will probably not result in significant down-slope movement of artefacts, but will cause an overall decrease in soil depth on crests and slopes and a gradual increase on basal slopes. Thus artefacts would be artificially concentrated (per unit of volume) on crests/upper slopes because the soil has been removed, while artefact density down-slope would become artificially lower.

Erosion and sedimentation can also affect archaeological deposits by:

- altering the horizontal and vertical relationship of artefacts;
- altering assemblage contents through the effects of sheetwash erosion on small artefact size classes;
- dispersal of features such as hearths; and
- deposition of sediments burying (and therefore obscuring evidence of) archaeological deposits.

Bioturbation (disturbance to the soil profile by plants and animals) is important in three ways: through mineral turnover in the nutrient cycle, physical movement of soil by mixing and mounding, and the creation of micro-relief (ant and termite mounds, tree-fall pits and mounds) (Mitchell 1988:52). Gollan (1992:44) highlights the impact of tree growth as a post-depositional process affecting artefact scatter sites. Gollan (1992:44) hypothesises that in a forest of 100 trees per hectare, the time for every part of the forest floor to be disturbed by new tree growth would be approximately 2,500 years. However, Dean-Jones and Mitchell (1993:43-44) note that while tree fall tends to cause the movement of stone upwards, a large proportion of Australian trees do not disturb the soil by falling, because the trunk breaks after weakening by fire, fungi and termites, and remains *in situ*.

Dean-Jones and Mitchell (1993:43) note another important effect of bioturbation and rainwash processes: the development of stone layers between the A and B horizons of texture-contrast soils. These processes thicken the topsoil and bury larger fragments at the level where the bioturbation agents usually cease operating. In general, stones larger than the diameter of burrows will 'sink' through the soil in time (Dean-Jones & Mitchell 1993:43). If Mitchell's (1988) model is correct, artefacts will act in the same way as natural stone and will be subject to surface dispersion, down-slope movement and differential burial or exposure, and will commonly form a stone layer (Dean-Jones & Mitchell 1993:44).

Consequently, minimal potential exists for well stratified open deposits in the Central Lowlands. However, open sites can have reasonably high integrity, where they have been subject to minimal post-depositional processes. Open sites of low integrity can also be of research value, where the post-depositional processes can be adequately controlled for during analysis.

Impacts to Aboriginal artefact scatter sites can also result from a range of human activities, both from the Aboriginal occupants after the time of deposition and from European land use practices of the previous two centuries. Impacts can occur to the spatial relationship of artefacts and features, or to the artefacts and features themselves.

Hughes and Lampert (1977) offer the term 'occupational disturbance' to refer to the mixing about of a deposit at a site by the inhabitants of the site during the course of their daily activities. Examples include:

- trampling (*cf.* Stockton 1973);
- scuffage and treadage;
- camp fires (may unintentionally thermally alter artefacts, and digging of pits for fires can disturb deposits); and
- re-use of artefacts (artefacts deposited during an earlier episode of occupation may be re-used; eg. additional flakes removed from a core);

Since European settlement, a range of other human activities have potentially affected archaeological deposits, including:

- vegetation removal (promotes erosion);
- mining (results in substantial impacts equating to total site destruction);
- agriculture (breaks artefacts, affects spatial structure and promotes erosion);
- pastoral uses (damages artefacts and promotes erosion);
- hydrological changes (cause erosion and deposition); and
- focalised impacts such as essential services or urban development (can equate to total destruction of evidence).

Mining and focalised impacts tend to cause the greatest disturbance to the spatial integrity of artefact scatters and maximum breakage of artefacts. The effects of cultivation vary, depending upon the equipment used, frequency and direction of ploughing, degree of slope and size of artefacts present. Various experimental studies have been undertaken into the effects of ploughing on open sites (*cf.* Clark and Schofield 1991, Lewarch 1979, Lewarch & O'Brien 1981a, 1981b, Roper 1976). Lewarch and O'Brien (1981a, 1981b) have demonstrated that five types of impact can occur:

- horizontal displacement of artefacts;
- vertical displacement of artefacts;
- changes in artefact class frequencies after ploughing;
- changes in the condition and preservation of assemblages; and
- destruction or alteration of features and layers.

Hoofed grazing animals such as cows can be important agents of geomorphological changes that subsequently affect archaeological sites. In sloping terrain, heavy grazing compacts the soil, reduces infiltration, increases runoff and increases erosion and sediment yield. However, light and moderate grazing can have far less significant effects (Trimble & Mendel 1995). In riparian zones, grazing decreases erosional resistance by reducing vegetation and exposing more vulnerable substrate. Trampling directly erodes banks, thus increasing turbulence and consequent erosion (Trimble & Mendel 1995). The direct force of cattle hoofs can be high: a 530 kg cow can exert 250 kPa of vertical stress while walking on level ground (Trimble & Mendel 1995:235). Hence, breakage of individual artefacts can result from trampling. In addition, trampling can damage edges with evidence of utilisation.

3.3.4 Age of Occupation

The dating of archaeological evidence and the virtual paucity of recorded sites dating to the Pleistocene period (>10,000 years Before Present), as compared to the abundance of sites from the more recent Holocene period, have been considered during studies in the Central Lowlands.

Haglund and Rich (1995) and Brayshaw (1994) report that almost all directly dated sites in the Hunter Valley are of Holocene age and contain artefacts of the 'Small Tool and Scraper Tradition'. Many researchers, using geomorphological and typological criteria, assign a mid-late Holocene age (last 5,000 years) for artefact scatter sites that cannot be directly dated.

Two possible Aboriginal sites of Pleistocene age have been recorded in the Central Lowlands. Koettig (1987) identified a deposit during monitoring of site SGCD 16 at Glennies Creek. Test excavations had earlier revealed the presence of artefacts in the B horizon of a texture-contrast soil. A geomorphologist identified the possible age of this soil unit as between 10,000 and 30,000 years Before Present (BP). Charcoal recovered from a depth of 0.45 - 0.55 metres within the B horizon was dated to 13,020±360 years BP, but was not directly associated with the artefacts. During monitoring, a hearth feature was uncovered and dated to >20,200 years BP (Beta-20056) (only a minimum date because of the small sample size) (Koettig 1987).

Kuskie (in prep.) identified artefacts in the B horizon clay of a former river terrace, within the Lemington mine lease near Wollombi Brook. The artefacts were initially identified through careful stripping of the surface with a dozer. Hand excavations were undertaken in three areas where artefacts were identified in clay. A total of 20 m^2 was excavated. Direct dating was not possible, but the project geomorphologist, Dr Wayne Erskine, confirmed beyond reasonable doubt that:

- the artefacts definitely occur in clay;
- the artefacts have not worked their way into the clay through any post-depositional processes;
- the clay has major cracking that could only have occurred during very cold conditions of the last glacial maximum; and
- the clay and associated artefacts are almost certainly between 18,000 and 30,000 years of age.

The paucity of older sites, along with the geomorphological nature of the Hunter Valley, would confer a very high representative value to any Pleistocene sites that could be identified.

The Central Lowlands are dominated by texture-contrast soils, many of which are considered to be younger than 3,000 years of age (*cf.* Dean-Jones & Mitchell 1993). Depending upon the environmental conditions at a particular locality, a texture-contrast soil may be formed *in situ* as a pedogenetical entity, or arise through superpositioning of soil by lateral movement of sediments. Soils formed by the latter process are typically assumed to date to within the last 3,000 years. Several researchers hypothesise that periods of extreme erosion prior to this date may have substantially affected soil profiles in erosional contexts (and therefore any archaeological evidence) (*cf.* Dean-Jones & Mitchell 1993).

In contrast, soils formed as pedogenetical entities in depositional contexts have the potential to be of considerable age (eg. 10,000 - 30,000 years). Koettig (1986) has identified several texture-contrast soils in the Hunter Valley that are of Pleistocene age (in lower parts of the North-eastern Mountains, portions of the Goulburn Valley and within the Central Lowlands). Aeolian and alluvial soils of Pleistocene age have also been identified within the Hunter Valley (*cf.* Erskine 1986, Roy *et al* 1995 & Story *et al* 1963).

3.3.5 Models of Occupation

Understanding the general pattern of Aboriginal occupation in the Central Lowlands is essential to facilitate explanation of the nature and pattern of archaeological evidence on a regional scale and in terms of individual localities. General theories concerning Aboriginal land use patterns and the relationship between such patterns and the resulting archaeological evidence have been examined. Specific models of occupation for the Central Lowlands have also been formulated. However, limited testing has been undertaken of these models and theories during archaeological surveys or excavations in the valley.

Koettig (1992, 1994) postulates a model of occupation based on evidence from her salvage excavations at Camberwell and Bulga and ethnographical data from Central Australia (*cf.* Gould 1968, O'Connell 1987). Koettig (1994:78) argues that camps were ordered according to strict rules based on the location of water sources, size and composition of the group and length of stay. Koettig (1994) argues that these rules would have been applicable across Australia and notes that camping could be spread over very large areas.

Koettig's (1994:79) interpretation of the ethnohistorical evidence is that:

- where occupation is infrequent, archaeological features at a site may be widely distributed and relatively infrequent;

- if, over time, occupation episodes are overprinted at the same site, then the evidence from different activity areas would be closer together and even be superimposed; and

- the longer the stay of groups at a campsite, the more types of activities should be reflected and the greater the disturbance of occupation debris on the ground will be.

Therefore, at sites where separate features are close together and their distribution is fairly continuous, repeated occupation may have occurred. Where features are widely spaced and limited in number, one or a small number of occupation episodes may be represented, but it does not imply that the size of the group was small, as larger groups would simply occupy a larger area. The frequency of occupation of any one location is likely to relate to the availability of certain resources (Koettig 1994:64).

Witter (NPWS Workshop 1995) proposed a model interpreting most open artefact scatter sites in the Hunter Valley as being largely peripheral to one or more base camps near the Hunter River or its major tributaries. The base camps would contain evidence of more intensive and/or long term use by large groups of people. Men would have ranged widely to hunt with spears barbed with backed blades, while women remained around the domestic camps.

Sites on Doctors Creek and Sandy Hollow Creek are interpreted by Haglund (1991, 1992) as having resulted from numerous brief visits by small groups of people, possible spread over considerable periods of intermittent or frequent use. Haglund (1992) proposes a model of behaviour based on residue analysis results, traditional gender divisions of labour and assumptions regarding the use of backed blades for hunting:

> Particularly during drier periods the valley was probably home to numerous kangaroos, wallabies, and other large and small game, and visited occasionally by small hunting parties of men. They would when needed or while waiting sit down, usually close to the water or with a good view of the creek below and get their spears and other hunting equipment ready, mending what has been damaged, shaving wood smooth and making some spares such as backed blades. When the visits were infrequent, the debris left behind would soon be incorporated in the turf or buried by leaf litter and Casuarina needles. During wetter periods when the water was running and more drinkable and moisture dependant plants growing well, family groups would visit. Women and children would collect and process plant foods such as various ferns, yams and other tubers. These would be cleaned, prepared and perhaps cooked or baked near the creek. Some equipment such as grindstones may have been brought along, but in general they probably made flakes, etc, as needed or picked up and used discarded pieces and left overs from the preparation and mending of hunting equipment, including backed blades, discarded stone hatchet heads, etc. Such pieces may well at times have been exposed by scuffing or local erosion (Haglund 1992:49-50).

Dean-Jones & Mitchell (1993:59) suggest that 'occupation could be associated with ridgelines because they provide linkage routes across the landscape and elevated positions . . . favoured for sight lines'. 'Terraces and other mid-slope positions could have been favoured over valley floor positions because of winter temperature differentials (frost hollow effects) or because of greater exposure to summer breezes which may have reduced insect nuisance problems'. Larger sites tend to occur in major valleys, because of the presence of additional resources and other factors (Dean-Jones & Mitchell 1993:59). The influence of saline groundwater (which occurs in Permian Coal Measures) on Aboriginal land use patterns is questioned by Dean-Jones and Mitchell (1993:59): 'It may have affected the seasonality of occupation in some catchments and this may be reflected in the types and densities of artefacts present'.

Rich (1995:3) argues (after Torrence 1983) that Aboriginal people used technological solutions in conjunction with other strategies for survival. Groups were residentially mobile, moving people to resources, rather than resources to people. Size of residential groups, length of time residential bases were occupied and the extent of foraging areas varied considerably. Managing resources by the use of facilities (eg. fish and eel traps) and fire (encourage new grass to attract kangaroos or manage cycads) were additional strategies aimed at increasing the reliability and productivity of food resources (Rich 1995:4). Social strategies for managing uncertainty and risk included flexible group composition and size (*cf.* Peterson 1976), while complex kinship networks and reciprocity ensured access to resources in times of stress or which had regionally restricted distributions. Rich's concepts are developed further through the analysis of individual discard events (refer to Section 3.3.1).

3.3.6 Methodological Issues

The quantity of archaeological studies in the Hunter Valley, driven by Environmental Impact Assessment requirements of the past two decades, has led to review of the methods and techniques used to identify, excavate, record and analyse archaeological evidence.

Surface surveys are the traditional form of assessing a study area. The nature of the surface survey (sampling strategy, level of survey coverage, method of inspection) generally depends upon a number of factors, including:

- the size of the study area;
- the environmental context of the study area (topography, geomorphology, geology, soils, vegetation, levels of ground disturbance and land use history);
- predicted types of evidence (based implicitly or explicitly on a predictive model of site location, developed from data recorded in previous surveys, knowledge of traditional Aboriginal land use patterns, present day cultural knowledge of the local Aboriginal community and identification of land systems and environmental variables);
- conditions of access (restrictions on vehicle access or property access);
- conditions of surface visibility;
- time/financial constraints;
- requirements of the client/project (nature of and potential impacts of a proposed development); and
- views of the Aboriginal community.

Archaeologists have come to recognise that the majority of archaeological evidence lies within a sub-surface context and is generally only identified on exposures created by sheet erosion or from other ground disturbance (Dean-Jones & Mitchell 1993).

The implications for surface surveys of development areas (including the present study area) are significant. *A surface survey is only likely to result in the identification of surficial evidence within ground exposures, and only within those areas sampled during the survey. It will not identify surficial evidence where surface visibility is limited (eg. by vegetation) or in areas not directly sampled during a survey, neither will it identify sub-surface deposits (the majority of archaeological evidence probably occurs within a sub-surface context).*

To address the limitations of surface surveys and to further test and refine predictive models of site location, various techniques of sub-surface exploration have been used. These have included test units and trenches excavated by hand (shovel, trowel) and machinery (backhoe, bobcat), along with surface scrapes (undertaken with a dozer or grader). Reasons typically forwarded for the use of sub-surface testing include the need to:

- define the extent of a 'site';
- improve understanding of the integrity of a site;
- improve knowledge about the contents of a site; and

- identify if Aboriginal heritage evidence is present in localities where low surface visibility has limited the effectiveness of a surface survey.

These factors can be of assistance in making an assessment of the significance of a site and formulating appropriate management recommendations. The application and usefulness of these methods has been discussed by various researchers (*cf.* Dean-Jones 1995, Kuskie & Kamminga *in prep.*).

3.4 Overview

Numerous archaeological surveys have been undertaken within the Central Lowlands, often in relation to coal mining proposals or other developments. Typically these surveys have involved large areas (eg. Bayswater #3, Bengalla, Hunter Valley #2, Lemington, Mount Arthur North, Mount Arthur South, Mount Pleasant, Plashett Dam, United Collieries, etc). They have often resulted in the location of numerous open artefact scatters, on ground surfaces exposed by erosion or disturbance (eg. 56 at Bengalla Mine {Rich 1993}, 56 in the Mt Thorley Authorisation Area {Hughes & Silcox 1983}, 66 in United Collieries Lease {Koettig & Hughes 1983}, 135 at Mount Arthur South, 93 at Mount Arthur North, 86 at Saltwater Creek/Plashett Dam {Koettig & Hughes 1985}, 296 at Mount Arthur North {Kuskie in prep} and 98 at Swamp Creek, Hebden {Resource Planning 1991}).

Typically the sites are dominated by indurated rhyolitic tuff, but also contain a substantial proportion of silcrete (eg. Mt. Thorley Authorisation Area {Hughes & Silcox 1983}, Hunter Valley #2 {Brayshaw 1981, Haglund 1982, Brayshaw & Haglund 1983}, Mount Arthur North and Mount Arthur South {Koettig & Hughes 1985, Kuskie in prep}, United Collieries Lease {Koettig & Hughes 1983} and Warkworth {Haglund & Rich 1995}).

Artefact occurrences tend mostly to be identified near watercourses. Fewer instances are reported of artefact occurrences along ridgelines (*cf.* Swamp Creek, Hebden {Resource Planning 1991}, Narama {Brayshaw McDonald 1992}, Bulga {Koettig 1991} and Mt. Thorley {Brayshaw 1994}). However, the majority of surveys have obtained a grossly disproportionate sample of watercourses in relation to other environmental contexts (as measured by the level of coverage relative to the total amount of a study area covered by each unit).

Individual open sites can range in artefact quantity from one to many hundred, or even several thousand artefacts (*cf.* The Salt Pan, >3,500 {Hughes & Silcox 1983}). Flakes, flaked pieces, cores and debitage, relating to non-specific stone flaking and the production of microblades, are the typical items found in open artefact scatters.

Three typical patterns of site structure have been identified:

- low density background scatter;
- isolated knapping floors/artefact concentrations, with minimal other evidence apart from background scatter; and
- denser concentrations of artefacts extending over large areas, without distinct knapping floors (Koettig & Hughes 1985:48).

Frequently the assemblages are interpreted as representing flake and blade production or microblade production, with lesser frequencies of artefact types related to other activities having been recorded. Features other than stone artefacts have been identified at sites, including hearths/fireplaces and possible heat treatment pits or ovens.

The key research themes that have been involved in archaeological studies within the Central Lowlands include:

- inter-site and intra-site variations in contents and spatial structure;
- stone working technology;
- stone material procurement and management;
- age of occupation;
- models of occupation;
- methodology; and
- post-depositional processes.

Aboriginal occupation within the Central Lowlands of the Hunter Valley commenced at least twenty thousand years ago (*cf.* Koettig 1987, Kuskie in prep.). In surrounding regions, Aboriginal occupation has been dated to at least 19,000 years ago on the Liverpool Plains (Gorecki *et al* 1984), 11,000 years ago in the upper Mangrove Creek catchment of the Hawkesbury River (Attenbrow 1987) and 17,000 years ago at Moffats Swamp near Raymond Terrace (Baker 1994). However, the majority of archaeological sites in the Hunter Valley are commonly assumed to be less than 4,000 years of age (*cf.* Brayshaw 1994:15).

4. HISTORICAL CONTEXT

Discussion of the history of land use since European settlement of the locality assists with identifying activities that may have affected the land surface and therefore the integrity of any Aboriginal heritage evidence, and assessing the potential for heritage evidence relating to the contact period.

The Hunter region was identified by Lieutenant John Shortland, of HMS Reliance, on 16 September 1797. The region was declared a coal and timber (cedar) reserve in 1801 (Davidson & Lovell-Jones 1993:7).

Free selecting of land commenced on a small scale on the Hunter River in 1821 or 1822 (Windross & Ralston 1897). After the penal settlement of Newcastle was transferred to Port Macquarie in 1823, Assistant Surveyor Henry Dangar was instructed to survey the valley with the view to opening it to settlement (Hartley 1995). Within a year of Dangar's survey, all of the land along the Hunter River had been granted, sold or reserved by the government (Wood 1972:72). Initial settlement further up the valley in the Central Lowlands was generally confined to the main valleys, until the 1830s. From the 1840s to 1870s settlement extended from the main valleys into the hilly terrain (Dean-Jones & Mitchell 1993:2).

Most of the Mount Arthur North locality, adjacent to the present study area, was initially alienated in 1824, following a grant of land to George Forbes, brother of the Chief Justice of the Colony, Dr Francis Forbes (Wood 1972:73). The initial order was made on 1 September 1824, following the offer of a grant of 2,000 acres. A further 4,000 acres was reserved for purchase in 1825.

George Forbes was the first to introduce stock onto this property and by 1828 was grazing 4,700 sheep and 270 cattle (Wood 1972:181). Forbes sold Edinglassie to James White in 1837 and White built the first homestead on the property in 1840, close to the Hunter River (Muswellbrook & Upper Hunter Historical Society 1981:3-4). In order to increase pasture, Edinglassie was subject to land clearance and trees were ringbarked in widespread areas. The surveyor John Neill noted these factors in 1866 and 1872. He also reported in 1872 that a Box dominated woodland was partially present and that part of the property had been cultivated. Grazing sheep and cattle were typical activities of the early settlers, but along the riverine floodplains, maize, potatoes, wheat, barley and later tobacco were cultivated (Dean-Jones & Mitchell 1993:2).

In 1910, 1936, 1948 and subsequent years, Edinglassie was increasingly subdivided.

In the upper Hunter region, coal mining was undertaken on a limited scale from the early 1900s and expanded rapidly with open cut mining from the 1950s (Dean-Jones & Mitchell 1993:2). Several coal mines (Bayswater #2 and 3, Drayton) lie adjacent to the study area.

The landscape itself is in a sense a relic of European settlement. It reflects a sequence of occupation of the locality over the past 175 years, including initial settlement, land clearance and stock management. Recent land use practices/impacts to the study area include:

- the widespread clearing of native vegetation (possibly undertaken in the 1800s by non-mechanised means such as tree felling and ringbarking);
- pastoral activities (including the grazing of sheep and cattle, excavation of farm dams, fencing and erosion control measures);

- erosion of hill-slopes and watercourses and the subsequent deposition of soils on the middle and lower portions of major drainage lines (subsequent to the removal of native vegetation and introduction of hoofed animals);

- agricultural activities (cultivation of crops may have affected small portions of the study area);

- provision of essential services and transport (formed roads and unformed vehicle tracks, electricity transmission line easements, telecommunications cables); and

- mining (Drayton rail loop and excavation of settlement ponds).

Hence, the survival and integrity of Aboriginal heritage evidence may have been affected to varying extents by these activities and their subsequent effects on natural processes such as erosion (refer to Sections 3.3.3 and 8.3.4).

5. LOCAL ABORIGINAL CULTURE

5.1 Group Identity and Boundaries

Traditional Aboriginal culture in south-eastern Australia was complex and varied. The present state of knowledge is based partially on studies of contemporary Aboriginal communities in northern and central Australia and on observations of the south-eastern communities after the immense disruption caused by European settlement (Thompson 1985).

Peterson (1976) describes Aboriginal society as being comprised of a hierarchy of organisational levels and groups, with fluid boundaries between them. The smallest group in the hierarchy is the family, comprising a man with one or more wives, their children and frequently some of their parents. On the second level are bands, small groups consisting of members of several nuclear families who perform the normal hunting and gathering tasks together for most of the year (Peterson 1976). At the next level are regional networks, consisting of a number of bands. Members of these regional networks usually share beliefs in a common ancestor and/or have a common language dialect. Network members assemble for specific ceremonies, when the subsistence resources of a locality are plentiful enough to support a large number of people over a period of time. The 'tribe' is at a higher level in the organisational hierarchy. 'Tribes' are generally recognised as a linguistic unit with flexible territorial boundaries. At the broadest level of social organisation, or the pinnacle of the hierarchy, is the 'cultural area'. All groups within a 'cultural area' share certain cultural characteristics, such as a common initiation ceremony, and speak closely related languages (Peterson 1976).

The nature of organisation of Aboriginal groups within the Hunter Valley is unclear, due to the limited ethnohistorical records and the immense disruption to traditional culture that had already occurred by the time these observations were made. Earlier observers used the term 'tribe' to refer to anything from ten to five hundred people. Aborigines themselves used a variety of names that might have referred to dialects, territories of other groups, local bands or regional networks (Brayshaw 1986).

The study area lies within the territory of the Wonnarua 'tribe', as defined by Tindale (1974). Tindale (1974) stated that the Wonnarua people occupied a 5,200 km² territory in the upper Hunter region from just west of Maitland to the Great Divide, south to the Darkinjung's territory on the divide north of Wollombi, and north to Muswellbrook (Tindale 1974). It must be noted however, that conflicting reports exist about the Wonnarua groups' boundaries, and in any case, there was probably a degree of flexibility about them. James Miller (1985), a member of the Gringai sub-group of the Wonnarua, wrote in detail about the history of his people. Miller (1985) considers that the nearby Gringai and Geawegal people and possibly the Awabakal were sub-groups of the Wonnarua.

5.2 Subsistence Resources

A wide variety of subsistence resources were available to the local Aboriginal population, from the savannah woodland and riparian zones along creeks and the nearby Hunter River. Several ethnohistorical observations have been recorded of the use of plants and animals in the Hunter region. While these observations have tended to focus on visible activities, they have often omitted details of less visible (and predominantly female) plant gathering activities (Brayshaw 1986).

Ethnohistorical and other evidence suggests that the diet of the local Aboriginal people would have included kangaroos, wallabies, echidna, emu, possum, flying fox, birds, wildfowl, goanna, snakes, yam, ferns, berries, native orange, cabbage palm heart and wild honey. No references are reported by Brayshaw (1986) of the seeds of kangaroo grass (*Themeda australis*) being ground, although their occurrence is widespread in the valley. However, Wood (1972:112) reports that William Ogilvie, a settler on friendly terms with the Aborigines on the Hunter River west of Mount Arthur, observed grass seeds being gathered in wooden vessels and ground on the slightly concave surface of a flattish stone. To be consumed, the seeds (that are available from December to March) are normally ground and baked (Isaacs 1987:229).

5.3 Material Culture

The material culture of the local Aboriginal population would have included a range of items related to subsistence, cultural and social activities and shelter. However, in the archaeological record, few of these items are preserved. Stone, bone and shell are the materials most frequently represented in archaeological sites.

Brayshaw (1986) lists ethnohistorical observations of the use of canoes, fishing lines, fish nets, fish hooks, weirs, possum skin cloaks and belts, waddies, digging sticks, wooden bowls, water carriers, wooden shields, spears, spear-throwers, clubs, hafted stone hatchets, boomerangs, baskets, dilly bags, bark huts and bone awls.

Despite stone artefacts making up the vast majority of evidence of Aboriginal occupation, few ethnohistorical references describe their existence, manufacture or use. Reverend Threlkeld (in Gunson 1974:67) mentions the use of quartz flakes, and later broken glass, to form serrated edges along fighting spears. Barrallier (1802:81 in Brayshaw 1986) also noted fighting spears with 'pieces of sharp quartz stuck along the hard wood joint on one side so as to resemble the teeth of a saw'.

Stone hatchets were observed by Threlkeld (1834, in Gunson 1974), Barrallier (1802) and Dawson (1830). Dawson (1830:202) observed grooved heads with a handle fastened by adhesive gum. Dawson (1830) stated that gum from wattle or grass trees was used in the manufacture of much equipment. The stone was mainly basalt or diorite and ground at the edge. Hatchets were used to cut saplings for building gunyahs, for stripping bark from trees, cutting notches in trees for climbing, and cutting toe-holds in trees to procure animals or honey from bee nests (Mathews 1894).

However, apart from quartz spear barbs and stone hatchets, no mention is made in the ethnohistorical literature of other types of stone artefacts. None of the ethnohistorical accounts explain the profusion of bondi points within archaeological sites, nor do they identify the large core and flake component as having been used within the historical period (Brayshaw 1986:68). Brayshaw (1986) suggests that this may be due to these items having escaped the attention of observers, or that they were not in use at the time of contact, having been replaced by shell, wood or bone. Dean-Jones (1990:68) suggests that it was because most observations were made from a distance and the stone tools were too small to be seen. For whatever reason, the procurement, manufacture and use of stone artefacts, which make up the majority of evidence in archaeological sites, is scantly documented.

5.4 Aboriginal History

Many initial encounters between the European settlers, cedar getters and explorers and the local Aboriginals in the early 1800s involved conflict. The behaviour of the settlers in the Wollombi area in felling trees (believed to house the souls of Aboriginals awaiting rebirth) and killing animals (food source and local totems) led to Aboriginals taking settlers' cattle and sheep (Needham 1981). Several settlers were killed and numerous Aboriginals were murdered, including at a site on the southern side of Mount Arthur, known as 'The Pocket' (Davidson & Lovell-Jones 1993, Gollan 1993, Miller 1985). Gollan (1993) reports official documentation demonstrates that in 1826 the Wonnarua people began a 'concerted campaign of resistance' against the European settlers. This resistance was met rapidly by the Government, with brutal force (Gollan 1993).

However, other encounters were less hostile, such as those involving trading or exchange of goods and the services of Aboriginal guides. For example, in 1819, Governor Lachlan Macquarie considered it necessary to seek a route over the ranges from the Hawkesbury to the Hunter River. Chief Constable of Windsor, John Howe, set out in October 1819 with a party including an Aboriginal named Myles. The area of the Hunter reached was called 'Coomery Roy' (Kamilaroi) by Myles (Wood 1972). In 1822 J. Mudie had asked Henry Dangar for instructions to find his way to Patrick's Plains (Singleton), also with the assistance of Aboriginal guides (Wood 1972).

The effects of the European arrival were disastrous for the local Wonnarua people. The rapid spread of European diseases, which the Aboriginal population had not hitherto been exposed to or developed immunity to, was a major factor. Smallpox, typhoid, influenza, scarlet fever, measles, diphtheria, whooping cough and croup contributed to the deaths of many Aboriginal people (Wood 1972). Major smallpox epidemics occurred between April and May 1789 and again from 1829 to 1831 (Butlin 1983). E. M. McKinlay of Dungog and Joseph Docker of Scone stated that an epidemic of smallpox swept through the Aboriginal population in the upper Hunter in 1835 (Miller 1985).

Factors other than disease contributed to the rapid decimation of the Aboriginal population and traditional life, including the loss of traditional hunting grounds and a decrease in the abundance of food resources.

Turner and Blyton (1995) and Miller (1985) argue that violence perpetrated by non-Aboriginal men against Aboriginal women was a major cause of the decline in population. Violent encounters and abuse have been documented historically and were a source of early conflict (Miller 1985). The effects of rape on Aboriginal women included the transmission of diseases, some of which may have led to infertility, and the production of offspring of mixed Aboriginal and European blood, that may have been very undesirable for the Aboriginal parent. However, Miller (1985) reports that the Wonnarua were possibly the first Aboriginal group to allow the children of mixed parentage to live, a factor that contributed to their survival.

The rapid deaths of many Aboriginal people through disease also acted to destroy the complex structure of their traditional society. Systems of kinship, marriage, order and subsistence were thrown into disarray. By the 1840s, many of the remaining local Aborigines were dependent upon the settlers for old clothing, money and rations (Wilton in NSW Legislative Council 1846, Wood 1972). Aboriginal people were employed by the settlers to cut wood, draw water, about the house, to run errands, or on farms to gather maize or burn off (Backhouse 1843:389, NSW Legislative Council 1846).

The destruction of their traditional society and the increasing reliance on the settlers led some Aboriginals into a life of alcohol abuse. Increased hostility among Aboriginal people resulted from these pressures on their society, the integration of groups that historically had hostile relationships and the effects of alcohol (*cf.* Hartley 1995).

However, the Wonnarua people survived. In the 1850s and 1860s, Wonnarua people at Muswellbrook were recorded as being one of the main groups of the Wonnarua in the valley (Miller 1985:63).

In the latter part of the Nineteenth Century there was growing concern in New South Wales about the plight of the Aboriginal people. The Aborigines Protection Association was formed and in 1881 a Protector of Aboriginals appointed. In 1883 the Government established a Board for the Protection of Aborigines to achieve a 'more systematic and enlightened treatment of Aborigines'. Rural stations were created so that Aboriginal people could remain on their tribal territory (Turner & Blyton 1995). However, the Board quickly resorted to forcible movement of Aboriginal people onto various missions, often in different tribal areas (Miller 1985). Wonnarua people were moved onto stations near Singleton (Mount Olive/St. Clair), Taree (Purfleet), Kempsey (Burnt Bridge) and elsewhere (Miller 1985).

By the 1940s people moved to the urban areas to escape the oppression of the Aboriginal Protection Board and to find employment. Thousands of Aboriginal children were removed from their families between 1909 and 1967 and placed in institutions. Aboriginal people outside of the missions tended to live in shanty settlements on the fringes of European communities or in tent villages alongside railway lines (Turner & Blyton 1995).

Many people were important in initiating a recovery for the Wonnarua people and today a vibrant Aboriginal population exists in the central and upper Hunter Valley. Members of the Wonnarua Tribal Council, the Traditional Owners of the Wonnarua land, take an active interest in all matters relating to their cultural heritage and land. Consultation with this organisation is documented in Section 9.

6. PREDICTIVE MODEL OF SITE LOCATION

A predictive model of site location is constructed to identify areas of high archaeological potential (ie. locations where there is a high probability of Aboriginal heritage evidence occurring), so it can be used as a basis for the planning and management of Aboriginal heritage. Predictive modelling involves reviewing existing literature to determine basic patterns of site distribution. These patterns are then modified according to the specific environment of the study area to form a predictive model of site location. A sampling strategy is employed to test the predictive model and the results of the survey used to confirm, refute or modify aspects of the model.

The use of land systems and environmental factors in predictive modelling is based upon the assumption they provided distinctive sets of constraints that influenced Aboriginal land use patterns. Following from this is the expectation that land use patterns may differ between each zone, because of differing environmental constraints, and that this may result in the physical manifestation of different spatial distributions and forms of archaeological remains (Hall & Lomax 1993:26).

The predictive model is based on information from the sources discussed in preceding sections:

- identification of land systems and landform units;
- previous archaeological surveys conducted within the region;
- distribution of recorded sites and known site density;
- traditional Aboriginal land use patterns; and
- known importance of any parts of the study area to the local Aboriginal community.

In certain circumstances, such as where low surface visibility or recent sediment deposition precludes effective assessment of the potential archaeological resource, sub-surface testing may be a viable alternative for further testing the predictive model and assessing the study area.

The study area is located within the Central Lowlands of the Hunter Valley and is comprised of landform elements including ridge crests, spur crests, simple slopes, flats and drainage depressions/watercourses. The following predictions of site location are made in relation to the study area:

ARTEFACT SCATTERS: Artefact scatters are the most common site type in the locality and the broader Central Lowlands region. In most archaeological contexts, an artefact scatter has been defined as either the presence of two or more stone artefacts within 50 or 100 metres of each other, or a concentration of artefacts at a higher density than surrounding low density 'background scatter'. Neither definition can successfully define a true 'cultural site', evidence of an occupation that is spatially and temporally related. Previous survey results lend support to the argument that artefacts are distributed across the landscape in a virtual continuum (refer to Section 7.6). The definition of an artefact scatter 'site' is often an arbitrary one, which offers benefits for planners and cultural resource managers, but is a source of various theoretical/analytical problems for archaeologists.

Due to the nature of the underlying evidence, its identification only within exposures created by erosion or disturbance, and the inability of existing definitions and methods of analysis to identify artefact scatters as true 'cultural sites', artefact scatter sites are defined within this study as the presence of one or more stone artefacts within an *archaeological survey area* (refer to Section 7). The boundaries of the site are defined by the boundaries of the 'survey area', regardless of the visible extent of artefacts. The survey areas are based on discrete, repeated environmental contexts termed *archaeological terrain units* (refer to Section 7.3).

An artefact scatter may consist of surface material only, which has been deflated by erosion to form a stone layer on top of a culturally sterile B horizon soil, or it more typically involves a sub-surface deposit of varying depth. Within the young texture-contrast soils that dominate the study area, artefact deposits are only expected to occur in the A horizon soil. Other features may be present within artefact scatter sites, including hearths or stone-lined fireplaces and heat treatment pits. Artefact scatters may represent the evidence of:

- camp sites, where everyday activities such as habitation, maintenance of stone or wooden tools, manufacturing of stone or wooden tools, management of raw materials, preparation and consumption of food and storing of tools has occurred;
- hunting or gathering events;
- other events spatially separated from a camp site (eg. tool production or maintenance); or
- transitory movement through the landscape.

The detection of artefact scatters depends upon conditions of surface visibility and ground disturbance and whether recent sediment deposition has occurred (*cf.* Dean-Jones & Mitchell 1993). Vegetation cover and deposition of sediments generally obscures artefact scatter sites and prevents their detection during surface surveys. High levels of ground disturbance can also obscure or remove evidence of a site.

Within the present study area there is a high potential for artefacts scatters to occur across the level to gently inclined portions of landform elements (ridge crests, spur crests, flats, drainage depressions and simple slopes) within close proximity (<50 metres) to watercourses. The potential for artefact scatter sites to occur on these landform elements further than 50-100 metres from a watercourse, or where the gradients is moderate or steep, is considered to be lower. Artefact scatter sites may contain anything from one to hundreds or thousands of artefacts, at varying densities. Other features such as hearths or stone-lined fireplaces or heat treatment pits may be present. The artefact assemblages will predominantly consist of silcrete and tuff, with minor quantities of other stone materials. Assemblages will be dominated by amorphous flakes, blades, cores and flaked pieces, but a component of many is likely to relate to the production of microblades.

BURIALS: Human remains tended to be placed in hollow trees, caves or sand deposits. However, ethnohistorical evidence (Breton 1833:203-204) suggests that other methods of burial were also used, such as internment in mounds. Usually burials are only identified when eroding out of sand deposits or alluvial soils along watercourses, or when disturbed by development. The probability of detecting skeletal remains during a surface survey is extremely low.

The potential for burial sites to occur within the study area is considered to be low, with the possible exception of alluvial sediments along Ramrod Creek.

GRINDING GROOVES: Elongated narrow depressions in soft rocks (particularly sedimentary), generally associated with watercourses. The shaping and sharpening of ground-edge axes creates the depressions. Several grinding groove sites have been recorded on bedrock and boulders in watercourses near Mount Arthur.

Potential exists for grinding grooves to occur in sedimentary bedrock along watercourses within the study area, where rock is outcropping.

MYTHOLOGICAL & SPIRITUALLY SIGNIFICANT SITES: Mythological sites, or sites of traditional significance to Aboriginal people, can occur in any location. Often natural landscape features may be related to important mythological stories. Other sites of spiritual or deep cultural significance to the local Aboriginal community can include places where the murder or massacre of local Aboriginals occurred, historical camp sites and locations where evidence of contact with early settlers is present. Oral and historical evidence indicates that a group of Wonnarua people were killed at a location on the southern side of Mount Arthur, known as 'The Pocket' (Gollan 1993).

Consultation with the local Aboriginal community is essential to identify the presence of spiritually significant sites relating to cosmological beliefs or historical activities. Locations with evidence of the contact period, in the form of artefacts manufactured from introduced materials (eg. porcelain or glass), can be confirmed by the presence of such items. After consultation with the Wonnarua Tribal Council, the potential for these sites to occur within the study area is considered to be low.

QUARRY SITES: In a general sense, a quarry or stone procurement site is the location of an exploited stone source (Hiscock & Mitchell 1993:32). In a more specific sense, a lithic quarry refers to outcrops of bedrock where there is clear evidence of procurement activity such as pits, discarded hammerstones and large deposits of primary flaking debris. Sites will only occur where exposures of a stone type suitable for use in artefact manufacturing occurs. A silcrete quarry has been identified at Bengalla, on the opposite side of the Hunter River to Mount Arthur (Rich 1993).

Within the study area, stone procurement sites have potential to occur if outcrops of tuff and silcrete are present. Evidence of lithic exploitation may occur in relation to the presence of isolated quartzite cobbles (glacial erratics) and pebbles of other materials, which may derive from decomposed conglomerate rock or alluvial gravels.

SCARRED TREES: Scarred trees contain scars caused by the removal of bark for use in manufacturing canoes, containers, shields or shelters. Other trees may exhibit carvings made in relation to burial practices or spiritual beliefs. While several scarred trees have been recorded in the locality, the origin of the scars (natural or Aboriginal) is not certain.

Mature trees, remnants of stands of the original vegetation, have the potential to contain scars. The potential for scarred trees to occur within the study area is assessed as being low, because the vast majority of mature trees have been removed during historical times.

STONE ARRANGEMENTS & CEREMONIAL SITES: Stone arrangements include circles, mounds, lines or other patterns of stone arranged by Aboriginal people. Some were associated with bora grounds or ceremonial sites and others with mythological sites.

Ridge crests and valley flats that contain stone outcrops and have been subject to minimal impacts from recent land use practices, are potential locations for stone arrangements or ceremonial sites. Within the study area, this potential is assessed as being very low, due to the widespread impacts of recent land use practices.

7. METHODS

7.1 Rationale and Survey Aims

The primary objectives of the archaeological assessment are to:

- identify what Aboriginal heritage resources are present within the study area:
- identify the impacts of the mining proposal on the Aboriginal heritage resource;
- assess the significance of the resource; and
- formulate recommendations for the management of the resource.

In order to achieve these objectives, it is necessary to develop a predictive model of site location for the study area. The predictive model (refer to Section 6) is based on:

- information recorded during previous surveys;
- known site locations and densities in the region;
- information about traditional Aboriginal land use patterns;
- information from the local Aboriginal community; and
- environmental factors.

A comprehensive field survey is necessary to test the predictive model of site location.

Several specific objectives form part of the survey strategy and subsequent analysis:

- identification of the nature and distribution of heritage items throughout the study area, particularly in relation to environmental variables (landform unit, slope, distance to watercourse, type of watercourse, geology and soils) and using the individual artefact as the basic unit of analysis;
- identification of types of stone used;
- identification of heat treated stone;
- identification of types of artefacts present and their nature;
- identification of stone knapping floors;
- identification of hearths;
- identification of heat treatment pits;
- identification of activities represented by the heritage evidence;
- assessment of implications for regional models of occupation;

- assessment of the research potential of recorded sites and locations of potential heritage;
- assessment of the integrity of potential deposits and the effects of natural processes on the evidence; and
- comparison of the evidence within a regional context.

7.2 Sampling Strategy and Survey Procedures

In order to address the objectives of the survey and the desired outcome of the Wonnarua Tribal Council (for an investigation that thoroughly identifies and documents the heritage resources present within the study area), the following requirements for the survey sampling strategy were identified:

- the need to sample all different environmental contexts within the study area, not simply the watercourses;
- the need to obtain a sample of 100% of the study area;
- the need to maximise productivity through focusing, where possible, on ground surfaces with higher archaeological visibility;
- the need to inspect mature trees for evidence of Aboriginal scarring, stone outcrops for evidence of extraction and sandstone bedrock for evidence of grinding grooves; and
- the need to inspect any places specifically requested by the Aboriginal community.

The resulting survey strategy involved the following components:

- division of the entire study area into particular combinations of environmental variables, that are assumed to relate to Aboriginal usage of the area (*archaeological terrain units* - refer to Section 7.3);
- designation of individual *archaeological survey areas* that consist of an area of a single archaeological terrain unit that is bounded on all sides by different archaeological terrain units. Multiple *survey areas*, located in separate portions of the study area, may comprise an *archaeological terrain unit*. For example, 9 *survey areas* may comprise the total 'moderate/steep drainage depression archaeological terrain unit'. These survey areas can be combined as a single archaeological terrain unit, but each is surveyed and reported on separately because they are in different locations and are bounded by different terrain units (eg. moderate/steep simple slope). Despite very suitable mapping for the A171 portion of the study area (1:2,000 scale), delineation of survey areas was best achieved by individual archaeologists during the course of, rather than prior to, the field survey. Each survey area was assigned a unique reference number, after the recorders initials and a sequential number (eg. PK1, PK2, RP1, RP2 . . .);
- within each *archaeological survey area*, recording separately the different types of surface exposures (eg. vehicle track, erosion scour) as separate *components*, and identifying each component with a sequential number after the survey area number (eg. PK1/3, PK1/4 . . .);

- completion of a *survey recording form* for each archaeological survey area inspected, recording details about environmental conditions and the nature of the sample (Appendix 2 & Section 7.5);

- completion of an *Aboriginal heritage site recording form* for each Aboriginal site identified (Appendix 3 & Section 7.5). An Aboriginal *artefact scatter site* would be defined by the presence of one or more stone artefacts within a *survey area*. The boundaries of the Aboriginal site would be defined by the boundaries of the survey area, regardless of the visible extent of artefacts (refer to Section 7.5). Spatially separated locations of heritage evidence within a survey area would be recorded as separate *loci*, within the one site (eg. site PK1 Locus A, PK1 Locus B etc). Artefacts/features clearly associated and occurring as a discrete event (eg. a knapping floor) would also be recorded as separate loci;

- completion of a *lithic item recording form* for the stone artefacts identified within each Aboriginal site (Appendix 4 & Section 7.5), recording details about provenance, stone material, artefact type, size class, cortex and other relevant attributes (particularly for implements);

- recording of the location of heritage sites and survey areas on topographical base maps;

- in general, assigning a two survey person team, comprising a qualified archaeologist and a Wonnarua Tribal Council representative, to each 'archaeological survey area';

- each team generally traversing their allotted survey area on foot and inspecting any surface exposures identified, along with samples of ground with low visibility;

- each team completing the inspection of their allotted survey area before proceeding to the next survey area;

- where feasible within time constraints, surveying as many surface exposures within a survey area as possible (a targeted level of surface inspection for each survey area was not designated, as the nature of surface exposures varies considerably and sufficient survey coverage of each archaeological terrain unit was expected to occur as a result of the scale of the survey); and

- defining as *modified* any substantial areas of disturbed ground, in which the potential for heritage evidence to exist is negligible, and not undertaking any further assessment of those areas.

7.3 Archaeological Terrain Units

Archaeological Terrain Units are defined on the basis of two important environmental attributes, that are assumed to relate to the way in which Aboriginal people occupied the land. These are discrete, recurring areas of land for which it is assumed that the Aboriginal land use and resultant heritage evidence in one location may be extrapolated to other similar locations.

Archaeological Terrain Units are defined on the basis of two environmental variables:

- firstly, *landform element* (following the definitions of McDonald *et al* 1984; refer to Appendix 1); and

- secondly, *class of slope* (following McDonald *et al* 1984).

Landform elements identified within the study area are ridge crests (including hill crests), spur crests, simple slopes (including upper, middle and lower slopes), drainage depressions (including gullies, stream banks and channels)and flats (refer to Appendix 1 and Table 1).

Three classes of slope were delineated across the study area:

- Class 1 (level/very gentle) - level to very gently inclined slopes of less than 3% (1°45′);
- Class 2 (gentle) - gently inclined slopes greater than 3% (1°45′) and less than 10% (5°45′); and
- Class 3 (moderate/steep) - moderately inclined and steep slopes greater than 10% (5°45′).

Archaeological terrain units consist of all of the *survey areas* with a particular combination of landform element and slope. A total of ten *archaeological terrain units* were identified within the study area (refer to Table 3).

As each *survey area* is by definition part of a single *archaeological terrain unit* (although a number of similar 'survey areas' can make up a total 'archaeological terrain unit'), it is possible to compare and analyse other environmental variables on a fine-scale between each survey area and on a broader-scale between each archaeological terrain unit. Such variables, which may also be strongly related to the manner in which Aboriginal people occupied the land, include distance to and type of watercourse, geological formations and soils.

7.4 Survey Details and Information Sources

A field survey of the A171 portion of the study area was undertaken by South East Archaeology and the Wonnarua Tribal Council in January and February 1999, involving a total of 8 person-days. It was undertaken as a component of a study into the adjacent Mount Arthur North mining lease application area (Kuskie in prep). The additional 2.7 kilometre section of the rail route was inspected by South East Archaeology and the Wonnarua Tribal Council on one additional day in October 1999, bringing to eleven the number of person-days involved in the field investigation.

Prior to the field survey, South East Archaeology consulted with the National Parks and Wildlife Service in relation to the project aims, survey strategy, survey methodology, sample size, terminology, recording forms, potential outcomes and NPWS requirements. A search was undertaken of the NPWS Aboriginal Site Register. Research was undertaken into the archaeological, historical and environmental context of the locality. The Wonnarua Tribal Council was consulted to arrange for their involvement in the project.

The extent and nature of the survey coverage is described in Section 8.1 and Appendix 5.

A range of documentation and other information was used in the project, obtained from the following sources:

- personal communication with members of the local Aboriginal community;
- database, site records and archaeological reports held by the NPWS Aboriginal Site Registry;

- personal communication with NPWS staff;

- personal communication with and documents provided by local residents and members of the Muswellbrook and District Historical Society;

- personal communication with and documents provided by staff of Umwelt (Australia), Dames & Moore and Coal Operations Australia Ltd;

- reports, publications and theses stored at the Australian National University library, National Library of Australia, University of Newcastle library, Australian Institute of Aboriginal and Torres Strait Islander Studies library and elsewhere; and

- base mapping (1:2,000 scale) and other mapping and aerial photography provided by Terra-Scene Graphics Pty Limited (Brisbane), Umwelt (Australia) and Dames & Moore.

7.5 Information Recorded and Database Composition

Three forms of data require separate recording: survey details, Aboriginal site details and stone artefact details.

Comprehensive details of the surface survey are included in Appendix 6. The recorded information includes:

- *survey area* (an area of a single archaeological terrain unit that is bounded on all sides by different archaeological terrain units). These are numbered sequentially after the recorders initials (eg. PK1, PK2, . . .). The missing numbers in the sequences either relate to those areas solely within the Mount Arthur North mining lease application area, or were not used, or have subsequently been amalgamated with adjacent survey areas as it became apparent that they were part of the same archaeological terrain unit;

- *component* (different types of surface exposures, such as a vehicle track, erosion scour or grassed surface, were recorded as separate components within a survey area, each identified with a sequential number after the survey area number (eg. PK1/3, PK1/4 . . .). To facilitate ease of recording and minimise unnecessary paperwork, details of multiple occurrences of a type of exposure (eg. erosion scour) were often recorded as a single component (size and visibility characteristics were noted separately to enable accurate calculation of effective survey coverage);

- *landform element* (14 categories were used on the recording form, following the definitions of McDonald *et al* [1984]). However, some elements are not present within the study area and others have been amalgamated, often because it was too difficult to reliably define their boundaries in the field (eg. upper slope, mid-slope and lower slope were all merged with simple slope). Microtopographical variations were generally ignored where they were small in extent;

- *slope* (the class of slope was noted, often being defined by visual inspection, identification on 1:2,000 base maps and/or use of a clinometer). Generally micro-topographical variations were ignored where they are small in extent;

- *distance to watercourse* (as estimated from the closest part of the survey area to the watercourse, in classes of <50 metres, 50-100 metres or >100 metres). This measure gives a general indication of distance only, as for many survey areas, the distance to a watercourse varied over the survey area;

- *order of watercourse* (the order of the watercourse, after McDonald *et al* 1984, as determined by observations in the field or subsequent analysis of base mapping). The order of a watercourse was generally not identified where it is located over 100 metres from the survey area;

- *archaeological terrain unit* (the specific combination of landform element and slope; refer to Section 7.3);

- *geology* (underlying geological formation as identified in base mapping);

- *soils* (soil formation as identified in base mapping);

- *vegetation* (present vegetation structure as identified in the field; eg. modified grass/crop, native grass, scattered woodland and open woodland). Distinguishing between modified and native grass may have been problematical;

- *land surface* (erosion type or depositional or modified). The type of exposure as observed during the field survey. Generally, different land surfaces were recorded as different survey area components;

- *exposure type* (identification during the field survey of the exposed soil units; eg. A horizon, A and B horizons or B horizon);

- *total sample area* (the quantity of ground surface within a *component* physically inspected in such a manner as to reliably enable the detection of heritage evidence). The measure is generally obtained by multiplying the recorded dimensions of a component with the *percentage of the component sampled.* For a component that includes multiple exposures, each was calculated separately to obtain the *total sample area* of the *component.* Typically, areas of higher visibility were completely sampled. In a number of *survey areas*, one *component* may represent coverage of surfaces with very low visibility. Often the *total sample area* of such a *component* was calculated by multiplying the *percentage* of the component area estimated to have been inspected with the *total survey area* (less the *total sample areas* of other *components*). This measure is considered to be less accurate, as minor variations in the estimate of *percentage of the component sampled* can radically affect the calculation of *total sample area*;

- *surface visibility* (a mean estimate of the percentage of visible ground surface within a *total sample area*). Where a single component's *sample area* is comprised of multiple exposures, the surface visibility and sample area were recorded separately on the survey form and the range of the surface visibility percentages noted in the database;

- *detection limiting factors* (these are factors that act to reduce surface visibility and archaeological visibility [refer below]). For example, an area of ground disturbance with 100% surface visibility may have been impacted to such an extent that no potential exists for artefacts to remain, rendering archaeological visibility nil;

- *archaeological visibility* (a mean estimate of the percentage of visible ground surface within a component *sample area*, that has potential to contain evidence of Aboriginal heritage). Where a single *sample area* is comprised of multiple exposures, the archaeological visibility was recorded separately on the survey form for each exposure, and percentages noted as a range in the database;

- *ground disturbance* (an estimate of the extent of recent human impacts and impacts of natural processes, noted in low, moderate or high categories, modified after McDonald *et al* 1984:69). The low category includes no effective disturbance, minor vegetation removal and low intensity grazing and minimal erosion. The moderate category includes extensive vegetation removal, improved pasture grasses and moderate levels of erosion. The high category includes complete vegetation removal and cultivation, extensive erosion, and areas where the A horizon soil has been removed. Determining levels of ground disturbance can be subjective (as the ground can reconsolidate and appear less disturbed than it has been in the past) and different types of disturbance can impact on artefact scatters in different ways (refer to Section 3.3.3);

- *effective survey coverage* (calculated after the field survey, by multiplying the *total sample area* of a *component* with the percentage of *archaeological visibility*). For a *total sample area* that includes multiple exposures, the *effective survey coverage* of each exposure was calculated separately and added to produce the reported figure. *Effective survey coverage* represents a measure of the quantity of visible ground physically inspected within a *sample area* (eg. a *component*), with potential to contain Aboriginal heritage evidence;

- *number of artefacts* (the total number of artefacts recorded within a component);

- *artefact density per square metre of effective survey coverage* (the basic calculation for all further analysis and comparison, obtained by dividing the *number of artefacts* by the *effective survey coverage*). For each component it represents the mean number of artefacts within each square metre of visible ground surface with potential to contain Aboriginal artefacts (ie. 1 m x 100% archaeological visibility), that is physically inspected; and

- *comments* (such as the presence and nature of stone material sources, or additional notes on any of the issues listed above).

Comprehensive details about the Aboriginal heritage sites identified during the survey are included in Appendix 7. The recorded information includes component, landform element, slope, vegetation, order of watercourse, land surface, exposure type and ground disturbance, as described above, along with:

- *site number* (numbered sequentially after the recorders initials [eg. PK1, PK2, . . .]). As the area of a single site was defined by the *survey area* itself, the site number always corresponds to the survey area number;

- *locus* (name of each spatially separate location of heritage evidence within a site; eg. site PK1, Locus A, Locus B etc). Artefacts/features clearly associated and occurring as a discrete event (eg. a knapping floor) were also recorded as separate *loci*;

- *distance to watercourse* (as estimated from the closest part of each *site locus* to a watercourse, in classes of <50 metres, 50-100 metres or >100 metres). This measure gives a general indication of distance only, as some site loci occupy substantial areas over which the distance to watercourse varies;

- *visible extent of surface exposures* (the approximate dimensions of a surface exposure in which a *site locus* has been identified). Defining the extent of a surface exposure is problematical when surface visibility is very low or a series of exposures are connected;

- *visible extent of artefacts* (for each site locus, the approximate dimensions of the area in which artefacts are visible, as estimated or more often measured by pacing);

- *visible site area* (for each site locus, the gross surface area in which artefacts are visible, calculated by multiplying the dimensions of the *visible extent of artefacts*);

- *mean surface visibility of site locus* (an estimate of the mean visible ground surface within a site locus, as a percentage of the *visible site area*);

- *mean archaeological visibility of site locus* (an estimate of the mean visible ground surface within a site locus that has potential to contain evidence of Aboriginal heritage [expressed as a percentage of the *visible site area*]);

- *effective site area* (a measure of the area of a *site locus* containing visible ground with potential for Aboriginal heritage items to occur). Calculated after the survey for each *locus* by multiplying the *visible site area* with the percentage of the locus physically inspected [normally 100%] and *mean archaeological visibility*;

- *number of artefacts* (the total number of artefacts recorded within a site locus);

- *number of artefacts/m² of effective site area* (the mean artefact density within a site locus, obtained by dividing the *number of artefacts* by the *effective site area*, and expressed as # artefacts/1 m² of effective site area). For each site locus it represents the average number of artefacts recorded within each square metre of visible ground surface with potential to contain Aboriginal artefacts (ie. 1 m x 100% archaeological visibility), that is physically inspected;

- *number of knapping floors* (the number of discrete knapping floors of a single stone material identified within a site locus);

- *sub-surface deposit* (personal recorder observations of the potential for sub-surface deposits to occur, expressed in terms of unlikely, possible or probable); and

- *comments* (expanding upon any of the issues listed above).

Details of the lithic items recorded are included in Appendix 8. The recorded information includes the site number and locus (as defined above), along with:

- *lithic item reference number* (a unique sequential number applied to each recorded lithic item in the combined artefact database for Mount Arthur North and the Bayswater Rail Loading Facility). Many numbers are not present in the database as they refer only to artefacts outside of the present study area;

- *stone material* (identification within the categories listed in the Glossary);

- *lithic item type* (identification of formal artefact type based on the categories listed in the Glossary);

- *size class* (maximum dimension of the item, described within size classes representing 10 millimetre units). For example, an item measuring 1-10 mm is recorded in size class 1 or an item measuring 11-20 mm in size class 2, etc.);

- *cortex amount and type* (the amount of the original surface of the stone material as a percentage of the item's total surface, along with its type). Three types are identified: pebble (rounded waterworn surface), tabular (smooth tabular shaped surface, may be waterworn) and terrestrial (rough cortex not consistent with tabular or waterworn surface); and

- *comments* (additional information on the stone material, presence of attributes indicative of thermal alteration, artefact type, number of platforms and negative scars on cores, type of core, backing on tools and amount and nature of retouch and use-wear on tools).

7.6 Analysis

The individual artefact has been used as the basic unit of analysis and an arbitrary definition of 'site' has been used. These approaches were adopted for a variety of reasons.

Many surveys in eastern Australia have identified a virtually continual distribution of artefacts across the landscape, but at varying densities (*cf.* Hall 1991, 1992, Hall & Lomax 1993, Packard 1991, 1992). The results of previous large area surveys lend support to arguments that the landscape should be viewed as an archaeological continuum, in which 'cultural sites' represent points where higher frequencies of activities have occurred (*cf.* Foley 1981).

However, defining a 'site' is problematical, due to the manner in which the evidence is exposed and the nature of the underlying human behaviour that has created the evidence. In the Hunter Valley, almost all evidence is exposed within areas of erosion or ground disturbance. Therefore, delineating the extent of an open artefact scatter site is not realistically possible without extensive sub-surface testing. The recorded evidence has typically been affected by post-depositional processes to such an extent that definition of a *cultural site* may not be possible (a discrete, culturally defined unit beyond which cultural material is absent). At such locations where artefacts have been identified, unless the items can be demonstrated to be culturally and temporally associated, the evidence cannot be said to represent a *cultural site*. Instead, the evidence may reflect a number of different occupational events that are spatially superimposed or mixed by post-depositional processes, but are not temporally or culturally related. In addition, the 'site' locations and boundaries would simply reflect the distribution and size of surface exposures. The definition of a 'site' is therefore an arbitrary one, which offers benefits in terms of planning and management, but does not necessarily reflect the underlying human behaviour that created the evidence (*cf.* Dunnell & Dancey 1983).

Many studies in the Hunter Valley have used arbitrary definitions such as 'two or more artefacts within 100 metres of each other' or 'concentrations of artefacts at a higher density than *background scatter*'. Neither concept is appropriate in the context of the present study area. In recognition of the problems of 'site' definition discussed above, for Mount Arthur North and the Rail Loading Facility, an Aboriginal artefact scatter site will be defined 'as the presence of one or more stone artefacts within a *survey area*'. The survey area will always equate to a discrete environmental unit, bounded by different environmental units or the border of the study area (refer to Section 7.3: *archaeological terrain units*). The boundaries of the Aboriginal site would be defined by the boundaries of the survey area, regardless of the visible extent of artefacts.

This definition of a 'site' overcomes the problem of the nature of exposure of evidence (ie. 'sites' equate to 'surface exposures'). It is based on the assumption that different environmental contexts provided different sets of constraints to Aboriginal occupation, which resulted in different patterns of land use (refer to Section 6). Following from this is the expectation that land use patterns may differ between environmental zones and that this may result in the physical manifestation of different spatial distributions and forms of archaeological evidence. It is assumed that if the specific environmental context is repeated elsewhere within the study area, that similar evidence would exist in both locations, reflecting the similar underlying behaviour.

However, the proposed site definition cannot resolve the complex issue of superimpositioning of evidence and enable identification of *cultural sites*. It does have the benefit of explicitly identifying that without detailed study (eg. conjoining and accurate provenancing of material), identification of *cultural sites* is not possible. In any case, definition of culturally and temporally discrete episodes of occupation may not be possible for most artefact scatter sites in the Hunter Valley, because:

- the extent of post-depositional disturbance may not permit adequate provenancing of material; and

- only a portion of the occupational event may be exposed (the other evidence being hidden by vegetation or soil).

Therefore arbitrary definitions of a 'site' may be the only ones that can be successfully used.

Following from these issues, it is apparent that concentrations of artefacts may represent many different and unrelated episodes of occupation. Therefore, by focusing the analysis on individual artefacts, issues of 'intra-site' spatial context become less critical.

It is possible to compare the frequency of individual artefact and stone material types (measured against a constant unit of area, such as a square metre of visible ground surface with potential to contain evidence) with environmental variables, in order to test and refine the predictive model of site location.

It is extremely important to note that the calculation of artefact density involves numerous variables, each with its own inherent margin of error, which may render the final calculation inaccurate. Therefore, the ***measure of artefact density only provides a general indication of density: it is not an accurate statistical measure.***

Factors relating to each variable that may create a margin of error are listed below:

- Total sample area: the calculated surface area of a sample may not be accurate, due to:

    - the skill or accuracy of recorders in measuring the size of a survey component or site locus;

    - discrepancies between the survey area boundaries identified in the field with those marked on the 1:2,000 scale base mapping (can occur when natural boundaries are not distinct, as is often the case, or when the underlying topography/mapping contains no distinct features to enable accurate plotting of location);

    - the inability to account for increased surface areas where moderate or steep slopes are involved (when calculated from two-dimensional maps, the surface area was not adjusted in relation to the degree of slope: steeper slopes will actually have a greater surface area than what is calculated from the base maps);

    - percentage estimates of the amount of the sample area inspected may not be accurate (particularly for larger areas, a small variation in the estimate of sample size can significantly affect the calculation of artefact density); or

    - errors in calculation;

- archaeological visibility: the estimate of archaeological visibility of a sample may not be accurate, due to:

  - the skill or accuracy of recorders (it is very difficult to accurately quantify the percentage of archaeological visibility without precise measurement, and the estimate will always involve a degree of subjectivity); or

  - problems in identifying or quantifying the extent of detection limiting factors;

- artefact density and effective survey coverage or site area: the calculation of effective survey coverage or artefact density may not be accurate, due to:

  - errors or omissions in calculations;

- number of artefacts:

  - errors or omissions in calculations;

  - previous collections of surface artefacts; or

  - recorder error/omission during the field survey;

The type of activity that created an artefact can be identified and compared with environmental factors or used to assist with interpretation of site use. While it is not possible to identify *activity areas* during this surface investigation, the activity behind individual discard events can be identified. Activity areas can represent concentrations of artefacts produced by activities carried out by people following some form of organisational strategy during a particular occupation. Individual activities can include tool manufacture and repair, cooking, food processing and disposal of refuse. Some activities are indicated by general categories of lithic items (eg, relatively non-descript artefacts such as flakes and flaked pieces), others by more distinctive artefact types that are indicators of very specific activities.

Individual lithic items were assigned to one of five general activity categories (Table 2). These groupings categorise the type of behaviour that may have produced or resulted in the discarded evidence:

- non-specific stone flaking: general or non-specific knapping activity (artefacts do not identify a more specific activity; includes debitage from primary flaking events and from making flake tools);

- bipolar flaking: a method of making flakes or retouched flake tools by breaking a piece of stone, rested on a stone surface and repeatedly striking the core from above with a hammerstone;

- microblade production: a method of making small microlithic implements (eg. bondi points, geometric microliths) from regular blades struck from a small core;

- loss or intentional discard of microliths: the discard of microlithic implements either during manufacture, after use or unintentionally;

- discard of non-microlith tools: intentional discard after use or caching for future use of implements other than microliths. This category is of high interpretative value, as the items can represent a diverse range of tool-use activities, such as food procurement and processing and artefact manufacture and repair.

In relation to the activity classes, it is important to note that different activities result in the production of different quantities of evidence. Therefore, without reconstructing every single *activity area*, it is not possible to accurately identify the number of *activity events* that resulted in the discarded evidence.

For example, microblade production can result in tens or hundreds of artefacts from a single knapping event. Bipolar flaking can also result in substantial debitage, if the core is totally reduced. Non-specific stone flaking can involve anything from a single to tens or even hundreds of discarded items. Different stone materials can also result in different quantities of debitage, due to the mechanical and fracture properties of the stone. The technique of reduction (*eg*. way blows are applied) can also result in different numbers of artefacts.

In contrast with these three categories, loss or intentional discard of microliths and discard of non-microlith tools generally involve low numbers of discarded artefacts, which may correspond more closely with the number of activity events.

Table 2: Categories of activities represented by lithic item types.

LITHIC ITEM TYPE	ACTIVITY	CODE
lithic fragment	non-specific stone flaking	1
flake	non-specific stone flaking	
flake portion - proximal	non-specific stone flaking	
flake portion - medial	non-specific stone flaking	
flake portion - distal	non-specific stone flaking	
flaked piece	non-specific stone flaking	
core	non-specific stone flaking	
core fragment	non-specific stone flaking	
bipolar flake	bipolar flaking	2
bipolar flake portion	bipolar flaking	
bipolar core	bipolar flaking	
microblade	microblade production	3
microblade portion - proximal	microblade production	
microblade portion - medial	microblade production	
microblade portion - distal	microblade production	
microblade core	microblade production	
bondi point	loss or intentional discard of microliths	4
bondi point proximal portion	loss or intentional discard of microliths	
bondi point medial portion	loss or intentional discard of microliths	
bondi point distal portion	loss or intentional discard of microliths	
utilised/retouched chord bondi point	loss or intentional discard of microliths	
geometric microlith	loss or intentional discard of microliths	
utilised geometric microlith	loss or intentional discard of microliths	
backed segment (including portion)	loss or intentional discard of microliths	
hammerstone	discard of non-microlith tools	5
anvil	discard of non-microlith tools	
split pebble	discard of non-microlith tools	
utilised/retouched flake/microblade (incl. portion)	discard of non-microlith tools	
ground-edge axe	discard of non-microlith tools	
elouera	discard of non-microlith tools	
utilised core	discard of non-microlith tools	
ochre	discard of non-microlith tools	
chopper/pebble chopper	discard of non-microlith tools	
flaked axe/axe blank	discard of non-microlith tools	
flake from ground-edge axe	discard of non-microlith tools	
utilised/retouched flaked piece	discard of non-microlith tools	
thumbnail scraper	discard of non-microlith tools	

Several issues have been identified with the databases and subsequent analysis that require clarification:

- several survey or component areas and site loci were subsequently combined with other similar units, upon reassessment after fieldwork. Hence, some survey area, component and site numbers are absent from the 'numerical' sequences;

- within survey areas minor variations in slope or landform can occur. Microtopographical features were discounted, due to the nature of the survey objectives;

- mapping of soil units and geological formations may involve unspecified margins of error;

- as is generally the case with surface surveys, the proportion of larger artefacts identified is normally higher than that obtained during sub-surface excavations. A proportion of smaller artefacts (eg. <10 mm in size), may not have been identified during the survey;

- as with any survey, errors by recorders, such as the misidentification of stone materials or artefact types, and inaccuracy or inconsistency in visibility or surface area estimates, may have occurred. To attempt to control these factors to the extent possible, field archaeologists were required to have appropriate qualifications and experience and quality control procedures were undertaken during the course of the survey;

- as with any artefact inspection in which microscopy is not routinely used, there is likely to be a proportion of artefacts with fine use-wear or residues that were not identified. Many items with edge damage that was suspected to be a result of cattle trampling were not recorded as 'utilised', possibly in contrast to other investigations within the region;

- very minor discrepancies may occur in tables and calculations, due to the inclusion or exclusion of certain sets of data, however none is expected to materially affect the outcomes or conclusions;

- effective survey area calculations involving multiplication of the total survey/component area (as derived from the base mapping) with estimates of the percentage sampled and archaeological visibility, can be misleading. For example, if a large sample (eg. 10,000 m^2 x 100% inspected) was obtained of an area of low archaeological visibility (eg. 1%), the resulting effective survey coverage would be 100 m^2. However, the actual potential for finding artefacts is considered to be lower than in similar but contiguous areas of higher visibility (eg. 200 m^2 x 100% inspected x 50% visibility); and

- margins of error associated with recording variables and calculating effective survey coverage and artefact density (as discussed above).

Table 3: Summary of survey coverage in relation to archaeological terrain units.

ATU #	Archaeological Terrain Unit	Landform	Slope	Total ATU Area (m²)	% Each ATU Comprises of Total Study Area	Total Sample Area (m²)	% Sampled of Each ATU	Total # Artefacts	Effective Survey Coverage Total (m²)	% Effective Survey Coverage of Each ATU	Artefact Density (# artefacts per m² effective survey coverage)
2	gentle ridge crest	ridge crest	2	128704	7.4	6800	5.3	21	1948	1.5	0.0108
4	level/very gentle spur crest	spur crest	1	13800	0.8	990	7.2	0	27	0.2	0
5	gentle spur crest	spur crest	2	94014	5.4	12839	13.6	3	1073	1.1	0.0028
7	level/very gentle simple slope	simple slope	1	41021	2.4	4102	10.0	0	205	0.5	0
8	gentle simple slope	simple slope	2	624672	36.1	76588	12.3	80	3623	0.6	0.0221
9	moderate/steep simple slope	simple slope	3	381902	22.1	23303	6.1	11	2185	0.6	0.0050
11	level/very gentle flat	flat	1	26280	1.5	2628	10.0	0	26	0.1	0
14	level/very gentle drainage depression	drainage depression	1	29706	1.7	6084	20.5	3	204	0.7	0.0147
15	gentle drainage depression	drainage depression	2	176896	10.2	39345	22.2	152	2181	1.2	0.0697
16	moderate/steep drainage depression	drainage depression	3	212456	12.3	15298	7.2	1	689	0.3	0.0014
				1729451	100	187977		271	12161	0.7	0.0223

Table 4: Grouping of survey areas within archaeological terrain units.

Archaeological Terrain Unit	Survey Areas
gentle ridge crest	RL14, RP64
level/very gentle spur crest	RL2, RL3
gentle spur crest	RL7, RL10, RL16, RL21, RL23, RP52, RP69, RP76
level/very gentle simple slope	RP85
gentle simple slope	PK139, RL1, RL5, RL6, RL9, RL11, RL13, RL17, RL20. RL22, RP83, RP86, RP88, RP90, RP92, RP98
moderate/steep simple slope	PK133, PK136, RP70, RP77, RP80
level/very gentle flat	RP93
level/very gentle drainage depression	RL4, RP95, RP96, RP97
gentle drainage depression	RL8, RL12, RL15, RL18, RL19, RP46, RP72, RP73, RP74, RP81, RP82, RP84, RP87, RP89, RP91, RP94
moderate/steep drainage depression	PK134, PK135, PK137, PK138, PK141, RP71, RP75, RP78, RP79

Table 5: Surface areas of Archaeological Survey Areas.

Survey Area	**Surface Area (m^2)**
PK133	81547
PK134	24809
PK135	9810
PK136	209606
PK137	67440
PK138	66953
PK139	51314
PK141	18000
RP46	25000
RP52	30000
RP64	126304
RP69	32356
RP70	42384
RP71	7369
RP72	2221
RP73	7516
RP74	10192
RP75	5612
RP76	12258
RP77	42571
RP78	6075
RP79	6388
RP80	5794
RP81	4335
RP82	14418
RP83	45522
RP84	21384
RP85	41021
RP86	65649
RP87	12155
RP88	18041
RP89	17775
RP90	36484
RP91	13832
RP92	42302
RP93	26280
RP94	19668
RP95	6015
RP96	2343
RP97	8148
RP98	261360
RL1	41200
RL2	9000
RL3	4800
RL4	13200
RL5	5200
RL6	10000
RL7	1600
RL8	3800
RL9	6200
RL10	1600
RL11	5400
RL12	4600
RL13	7200
RL14	2400
RL15	9200
RL16	6000
RL17	11000
RL18	3600
RL19	7200
RL20	12800
RL21	6000
RL22	5000
RL23	4200
TOTAL:	1729451

Table 6: Landform elements - survey coverage and artefact density summary.

LANDFORM ELEMENT	Total Landform Element Area (m²)	% Each Landform Element Comprises of Total Study Area	Total Sample Area (m²)	% Sampled of Each Landform Element	Total # Artefacts	Effective Survey Coverage Total (m²)	% Effective Survey Coverage of Each Landform Element	Artefact Density (# artefacts per m² effective survey coverage)
ridge crest	128704	7.4	6800	5.3	21	1948	1.5	0.0108
spur crest	107814	6.2	13829	12.8	3	1100	1.0	0.0027
simple slope	1047595	60.6	103993	9.9	91	6013	0.6	0.0151
flat	26280	1.5	2628	10.0	0	36	0.1	0
drainage depression	419058	24.2	60727	14.5	156	3074	0.7	0.0507
	1729451		187977		271	12171		0.0223

Table 7: Vegetation type - survey coverage and artefact density summary.

Vegetation Type	Total Sample Area (m²)	Total # Artefacts	Effective Survey Coverage Total (m²)	Proportion of each Vegetation Type Within Total Sample Area (%)	Artefact Density (# artefacts per m² effective survey coverage)
modified grass/crop &/or native grass	90333	232	4577	48	0.0507
scattered woodland	59472	33	6263	32	0.0053
open woodland	38172	6	1320	20	0.0045
	187977	271	12160	100	0.0223

Table 8: Land surfaces - survey coverage and artefact density summary.

Land Surface	Total Sample Area (m²)	Total # Artefacts	Effective Survey Coverage Total (m²)	Proportion of Effective Survey Coverage of each Exposure Type as a Percentage of Each Total Sample Area (%)	Artefact Density (# artefacts per m² effective survey coverage)
1 (sheet erosion)	32475	93	4855	14.9	0.0192
3 (gully erosion)	6948	65	1176	16.9	0.0553
4 (stream bank erosion)	1040	83	417	40.1	0.1990
6 (modified)	1475	0	45	3.0	0
7 (vegetation)	82776	1	1246	1.5	0.0008
	124714	242	7739		0.0313

*Survey Areas with multiple land surfaces are excluded.

Table 9: Exposure type - survey coverage and artefact density summary.

Exposure Type	Total Sample Area (m²)	Total # Artefacts	Effective Survey Coverage Total (m²)	Artefact Density (# artefacts per m² effective survey coverage)
A Horizon	105586	6	2374	0.0025
A/B Horizons	81096	265	9765	0.0271
B Horizon	975	0	20	0
	187657	271	12159	

8. RESULTS AND DISCUSSION

8.0 Overview

The survey coverage is discussed in Section 8.1. The survey areas inspected and heritage sites recorded are described in Appendices 6 and 7 and their locations are marked on Appendix 5.

8.1 Survey Coverage

The survey obtained coverage of every *archaeological terrain unit* and every *survey area* within a terrain unit. The locations of individual survey areas are marked on Appendix 5.

The overall study area measures approximately 1,729,451 m² (173 hectares) in size (as derived from two-dimensional base mapping), although in reality it would be slightly larger if the true ground area of sloping surfaces was calculated. It has been subdivided into a total of 64 *survey areas* (listed by archaeological terrain unit in Table 4 or by area in Table 5). The size of *survey areas* ranged from 1,600 to 261,360 m² (Appendix 6), with a mean of 27,022 m².

A *total sample area* of approximately 187,977 m² (19 hectares) was surveyed, representing about 10.9% of the entire study area. The *sample areas* obtained from individual *components* ranged in size from 20 to 18,832 m², with a mean of 2,506 m² (refer to Appendix 6).

Surface visibility varied between 0 and 90% and archaeological visibility varied between 0 and 65%. Surface visibility was limited in most areas by grass cover and other vegetation (Plates 1-4). Archaeological visibility was also limited by vegetation, along with leaf litter, gravel and sediment deposition or excavation (refer below). Outside of the sample areas inspected, surface visibility tended to be very low.

A total *effective survey coverage* of approximately 12,161 m² (1.2 hectares) was obtained, representing about 0.7% of the entire study area. The *effective survey coverage* of each *component* ranged between 0.2 and 1,922 m², with a mean of 162 m².

On average, effective survey coverage (accounting for visibility and detection limiting factors) is about fifteen times less than gross survey coverage (amount of area inspected). This is primarily a result of vegetation (grass) cover. The calculations indicate that the survey covered a very high proportion of the total exposed ground surface within the study area (supported by personal observation). Remaining portions of the study area that were not directly inspected tended to have a dense vegetation cover and very low surface visibility.

Artefacts were identified at a mean density of 0.0223 artefacts/m² of effective survey coverage, across the entire study area sample.

Survey coverage was obtained of each *landform element* and each *archaeological terrain unit* within the study area.

The proportion of the sample inspected (as a percentage of the total area of each *landform element*) was between 5 and 15% for every *landform element* (Table 6). *Effective survey coverage* totals varied between 0.1 and 1.5% of the total area of each landform element.

The proportion of the sample inspected (as a percentage of the total area of each *archaeological terrain unit*) was between 5 and 23% for every *archaeological terrain unit* (Table 3).

In terms of vegetation, areas classified during the survey as modified grass/crop and/or native grass account for 48% of the total sample area (Table 7). Grassed surfaces with scattered trees account for another 32% of the total sample area and woodland or forest account for the remaining 20% of the sample area. Outside of the sample area (ie. the remaining 89.1% of the study area) conditions of surface visibility were generally extremely low.

An analysis of *detection limiting factors* noted during the survey confirms that vegetation was the primary impediment to effective survey coverage. This conclusion is supported by comparison of the proportion of effective survey coverage within each *land surface* (Table 9).

Comparison of artefact density between different *land surfaces* indicates a very strong trend for higher artefact density on surfaces with stream bank erosion and to a lesser extent gully erosion (Table 8). This reflects the concentration of evidence along watercourses, where these types of exposures are prevalent (refer to Section 8.2).

Another aspect of artefact detectability is the *exposure type* (ie. visible soil horizon). Artefact densities tends to be significantly higher when a combination of A & B horizon soil is exposed, rather than only A horizon soil (Table 9). This result can be explained by reference to sub-surface testing in the locality (eg. Koettig & Hughes 1985, MacDonald 1997), which has identified that artefacts tend to be concentrated in the lower portion of the A horizon soil (possibly due to bioturbation). However, when erosion has removed most or all of the A horizon soil, to leave artefacts in a lag gravel deposit on the B horizon surface, artefact densities could be expected to be higher.

Inspection was also undertaken for other, more obtrusive site types such as grinding grooves and scarred trees. Very few areas of sandstone bedrock were identified in watercourses, but these were inspected for grinding grooves. Few mature native trees of sufficient age to host scars of Aboriginal origin were identified within the study area. Where identified, mature trees were inspected for evidence of scarring.

The levels and nature of effective survey coverage are considered satisfactory to present an effective assessment of the Aboriginal heritage resources identified and potentially present within the study area. Therefore the survey provides a valid basis for determining the probable impacts of the proposal and formulating recommendations for the management of the identified and potential Aboriginal heritage resources.

8.2 Artefact Distribution in Relation to Environmental Factors

8.2.0 Overview

Each *survey area component* involved a discrete landform element, class of slope and archaeological terrain unit. Other environmental variables were recorded or identified from base mapping within the survey area components, including distance to and type of watercourse, geology and soils. However, multiple types of each of these variables may exist within a survey area component (eg. two classes of soils). Artefact densities can be analysed in relation to these environmental variables to test and refine the predictive model of site location and to identify trends in the distribution of artefactual evidence within the study area.

8.2.1 Landform Element

The sample area and effective survey coverage totals obtained for each landform element are presented in Table 6, along with calculations of mean artefact density.

Excluding the 'flat' landform element, which only comprises 1.5% of the study area, there is a distinct trend for higher artefact densities to occur along drainage depressions (Table 6). This trend supports the hypothesis that occupation was focused along watercourses. Evidence presented in section 8.2.4, identifying a strong trend for higher artefact densities with increased order of a watercourse, also supports this hypothesis. Drainage depressions comprise about 24% of the study area.

Artefact densities were lower than expected on spur crests. The evidence possibly suggests that spurs within the study area, although frequented to some extent, may not have been major focal points of activity (at least activity that resulted in evidence being discarded).

Overall, the artefact densities are relatively low across the study area. However, artefacts are distributed in a virtual continuum, with varying densities. Only the 'flat' landform element did not contain any visible artefacts, although the level of effective survey coverage of this unit was very low (0.1%).

8.2.2 Slope

The sample area and effective survey coverage totals obtained for each class of slope are presented in Table 10, along with calculations of mean artefact density. There is a distinct trend for higher artefact densities to occur on gentle slopes (>3-<10%). In contrast to Mount Arthur North (Kuskie in prep), the artefact density is significantly lower on level/very gently inclined surfaces. However, this is likely to be a result of the small sample size (Table 10) and may also reflect the absence of valley flats and major watercourses from the study area.

The trend for increased artefact density on low gradient slopes is predictable. Overwhelming evidence from archaeological and ethnographical studies indicates that level or gently inclined surfaces were preferred for focused occupation (ie. camping). Increased artefact density would result from more frequent occupation, but also activities such as stone reduction, which were commonly associated with camping. The possible types of activities that occurred on gentle slopes are discussed in Section 8.4.

Table 10: Class of slope - survey coverage and artefact density summary.

Slope	Total Sample Area (m^2)	Total # Artefacts	Effective Survey Coverage Total (m^2)	Artefact Density (# artefacts per m^2 effective survey coverage)
level/very gentle (1)	13804	3	463	0.0065
gentle (2)	135572	256	8825	0.0290
moderate/steep (3)	38601	12	2873	0.0042
	187977	271	12171	0.0223

Table 11: Distance to watercourse - survey coverage and artefact density summary.

Distance to Watercourse	Total Sample Area (m^2)	Total # Artefacts	Effective Survey Coverage Total (m^2)	Artefact Density (# artefacts per m^2 effective survey coverage)
<50 metres	61717	156	3092	0.0504
50-100 metres	124460	115	8992	0.0128
>100 metres	1800	0	77	0
	187977	271	12161	0.0223

*Order of Watercourse is based on the highest order when multiple streams are located within the specified distance of a survey area.

Table 12: Distance to and type of watercourse - survey coverage and artefact density summary.

Distance to Watercourse	Order of Watercourse	Total Sample Area (m^2)	Total # Artefacts	Effective Survey Coverage Total (m^2)	Artefact Density (# artefacts per m^2 effective survey coverage)
<50 metres	1	36192	0	678	0
<50 metres	2	16887	70	1636	0.0428
<50 metres	3	8638	86	778	0.1105
50-100 metres	1	53170	32	5332	0.0060
50-100 metres	2	41793	2	1719	0.0012
50-100 metres	3	29497	81	1941	0.0417
>100 metres		1780	0	77	0
		187957	271	12161	0.0223

*Order of Watercourse is based on the highest order when multiple streams are located within the specified distance of a survey area.

Table 13: Geological units - survey coverage and artefact density summary.

Geological Unit	Total Sample Area (m^2)	Total # Artefacts	Effective Survey Coverage Total (m^2)	Artefact Density (# artefacts per m^2 effective survey coverage)
Pb (Branxton Formation)	62022	33	5204	0.0063
Pr (Rowan Formation)	56074	158	1406	0.1124
Pb, Pr	46309	74	3593	0.0206
Pb, Qa (Quaternary Deposits)	1200	1	240	0.0042
Pb, Qa, Cz (Cainozoic Slopewash Deposits)	400	2	120	0.0167
	166005	268	10563	0.0254

Figure 4: Comparison of artefact density between archaeological terrain units.

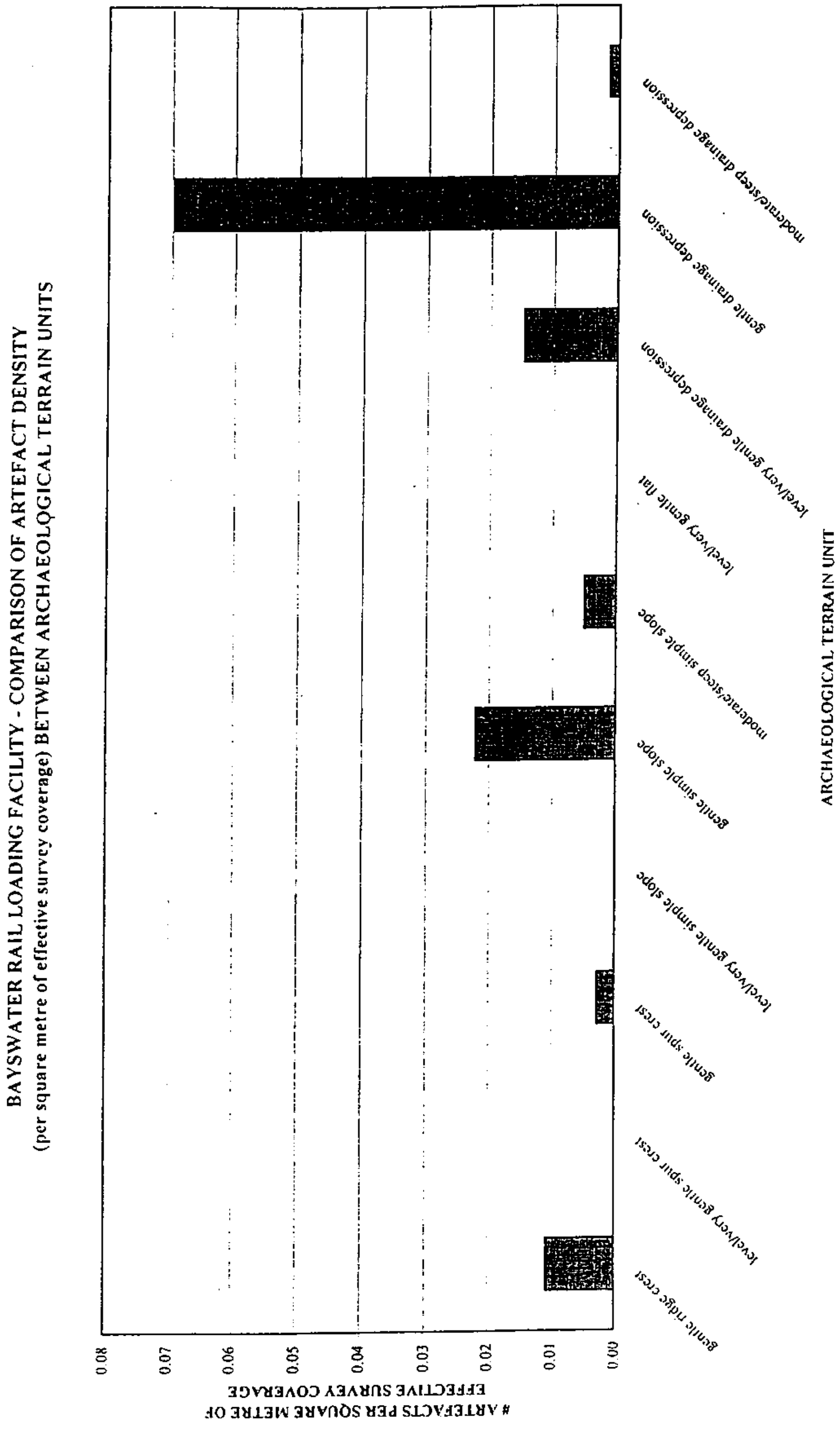


Figure 5: Comparison of artefact density in relation to distance from and order of watercourse.

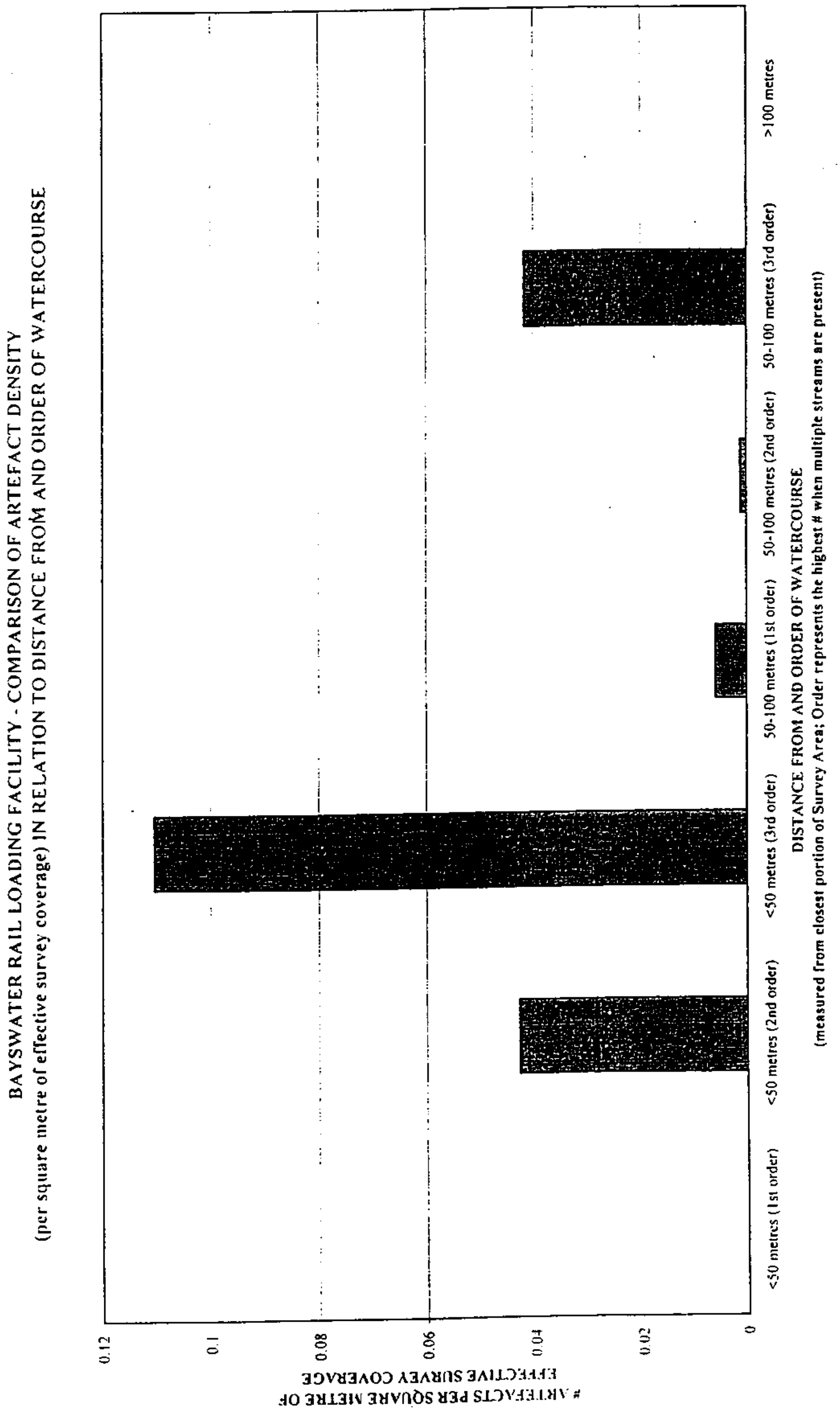
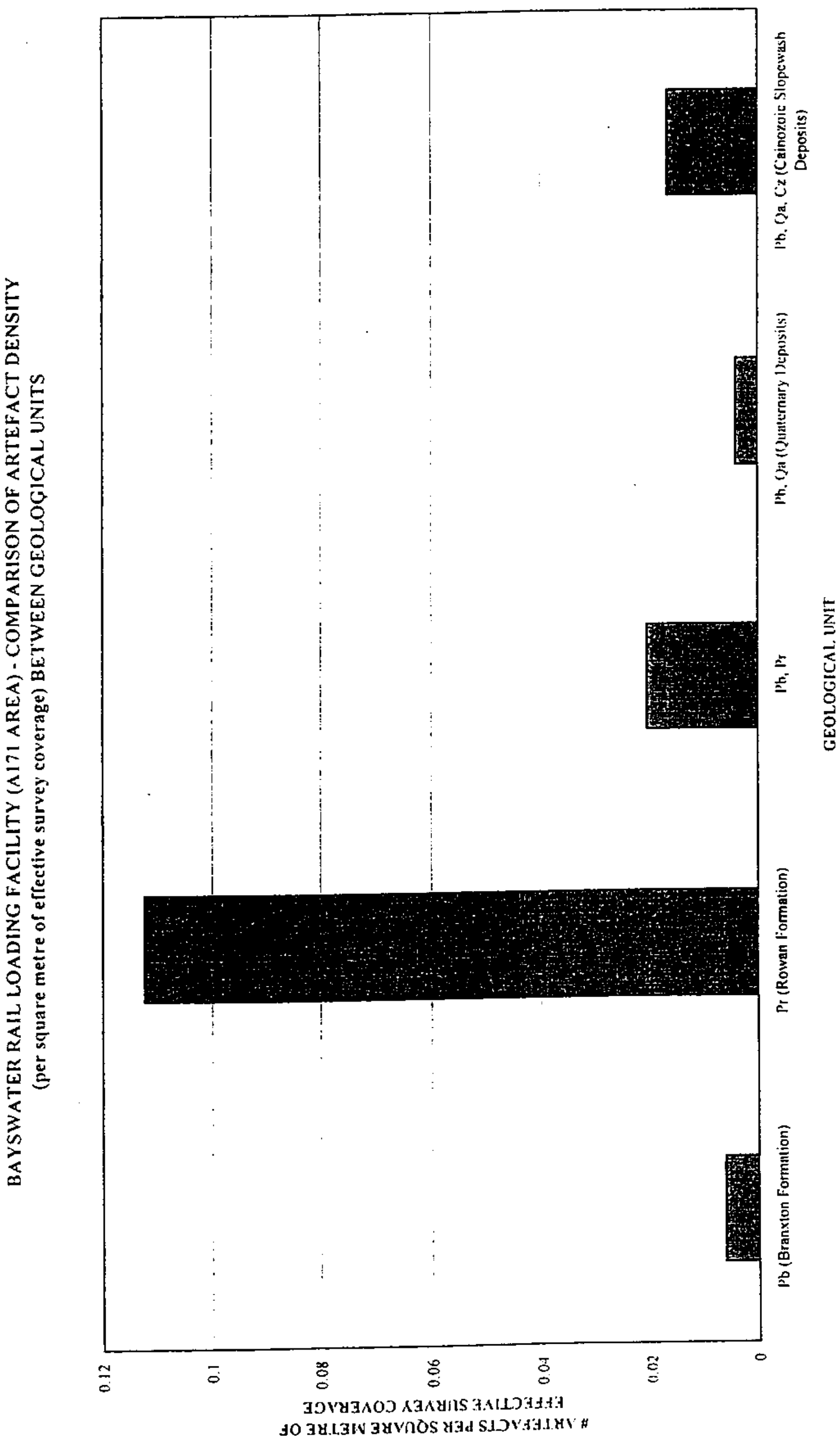


Figure 6: Comparison of artefact density in relation to underlying geology.



8.2.3 Archaeological Terrain Unit

Each *survey area* was a discrete unit, with the characteristics (ie. landform element and slope) of a single *archaeological terrain unit. Survey areas* with similar characteristics (eg. all survey areas that are gentle ridge crests) are combined to form a total *archaeological terrain unit* (Table 4).

The sample area and effective survey coverage totals obtained for each archaeological terrain unit are presented in Table 3, along with calculations of mean artefact density.

Gentle simple slopes dominate over one-third (36.1%) of the study area. Moderate/steep simple slopes are also relatively common (22.1%), with lower proportions of moderate/steep drainage depressions (12.3%), gentle drainage depressions (10.2%), gentle ridge crests (7.4%) and gentle spur crests (5.4%). The remaining archaeological terrain units occupy <3% each of the total study area and involve low levels of effective survey coverage.

Comparison of artefact densities between archaeological terrain units (Table 3, Figure 4) identifies a strong trend for higher artefact densities to occur on gentle drainage depressions. Excluding the three units in which no artefacts were recorded and small samples were obtained (level/very gentle spur crest, level/very gentle simple slope and level/very gentle flat), densities on gentle simple slopes tend to correspond to the overall mean, while lower densities occur on gentle ridge crests, gentle spur crests, level/very gentle drainage depressions and moderate/steep simple slopes. The small nature of the sample limits interpretation of these results.

The results lend support to the argument that occupation was focused along watercourses. However, it is not possible to test whether occupation was focused along higher order watercourses, because only a small portion of a third order stream is present within the study area. Analysis of density in relation to the distance from and type of watercourse is presented in Section 8.2.4.

8.2.4 Distance to and Type of Watercourse

Artefact densities were compared between different categories of distance to watercourse (as measured from the nearest margin of a component area and in three classes: <50 metres, 50-100 metres and >100 metres) (Table 11). A strong trend is apparent for artefact densities to increase with decreasing distance from a watercourse. Units within 50 metres of a watercourse have a mean artefact density of 0.0504/m^2, which decreases to 0.0128/m^2 at 50-100 metres. An insufficient effective sample was obtained of units greater than 100 metres from a watercourse.

To investigate this trend further, the order of watercourses was examined in relation to distance (Table 12, Figure 5). For the units within 50 metres of a watercourse, there is a very strong trend for artefact densities to increase with the order of the watercourse. First and second order watercourses tend to be intermittent drainage depressions and gullies. Third order watercourses tend to have well defined creek channels and traverse flats or areas suitable for camping. Water is more likely to be present in third order watercourses for substantially longer periods of time and in much greater quantities than in first or second order streams.

These results can be interpreted as indicating that:

- occupation within the study area tended to be focused near sources of water (as the density calculations indicate, within 50 metres of a source); and
- occupation within the study area tended to be more focused near sources with reliable or more frequently available water (ie. third order streams);

A similar pattern is can be observed between units 50-100 metres from a watercourse.

8.2.5 Soils and Geology

Almost the entire A171 portion of the study area lies within the Red Duplex soil unit, limiting comparison on the basis of soil type.

Comparison of artefact density per square metre of effective survey coverage between geological formations is presented in Table 13 and Figure 6. A significantly higher artefact density occurs within the Rowan Formation. A similar trend was observed in the broader Mount Arthur North study (Kuskie in prep).

The higher artefact density within the Rowan Formation is problematic to explain. This formation occupies the eastern-most portion of A171. It covers several different archaeological terrain units and only minor watercourses are present. Sampling error is a possibility, as the results may have been biased by the identification of two larger sites in this area (RP84 and RP98), although the possibility that other factors contributed to this result cannot be discounted.

8.3 Aboriginal Heritage Sites

8.3.0 Overview

Artefact scatter sites are defined by the presence of one or more stone artefacts within a *survey area* and the boundaries of the site therefore correspond to the boundaries of the *survey area* (refer to Section 7). Spatially separate locations of artefacts or features (eg. knapping floors) within a *site* have been recorded as separate *loci*. The locations and boundaries of recorded heritage sites and loci within the study area are marked on Appendix 5. Details of the recorded site loci are presented in Appendices 7 and 8. The nature of this evidence is discussed in detail below.

A total of 14 Aboriginal heritage sites have been identified within the study area, all scatters of stone artefacts (Appendix 7). These sites comprise a total of 30 loci (spatially separate locations of recorded evidence). Typically, a *site locus* recorded during the present investigation is comparable to what has been termed a 'site' during previous investigations in the region. In total, 271 artefacts have been recorded within the study area.

No types of Aboriginal evidence other than artefact scatters were identified during the survey.

Artefacts are widely distributed across the study area, but can only be identified through surface inspection where visibility conditions permit. Artefacts were identified at a mean density of 0.0223 artefacts per square metre of *effective survey coverage* (accounting for visibility), across the entire study area sample. When exposures (survey components) that do not contain evidence are excluded, the mean density (of individual *site loci*) is twelve times higher (0.2782).

The total size of individual *sites* corresponds to the size of the *survey areas* in which they are recorded. It is assumed that within the same topographical context (eg. *survey area* equating to *archaeological terrain unit*), evidence has an equal probability of occurring at any particular location within that area. The locations (*site loci*) that have been identified during the survey are considered to reflect the distribution of surface exposures, rather than the real distribution of evidence. This is not to assume that artefactual evidence *is* equally distributed across each site: rather the *probability* of evidence occurring is predicted to be similar across each site. Of course, variations in artefact density and the nature of evidence will occur within each site, in relation to the nature and location of activities and location of repeated activities.

Total *site areas* (equivalent to the corresponding *survey area*) range in size from about 12,258 m^2 (Site RP76) to 261,360 m^2 (Site RP98). The identified sites occupy 92 hectares or 53.4% of the total study area.

The identified locations of evidence within each site (*site loci*) range in area (*visible site area*) from 1 to 1,500 m^2, with a mean area of 150 m^2 per loci (refer to Appendix 7). The total combined *visible site area* for all site loci equates to about 4,509 m^2, or 0.26% of the entire study area.

Once archaeological visibility is taken into account, the *effective site loci areas* range from 0.1 to 350 m^2, with a mean of 32 m^2 (refer to Appendix 7). The combined *effective site area* for all site *loci* equates to about 974 m^2, or 0.06% of the entire study area.

The combined *visible site areas* equate to about 37% of the *total effective survey coverage*. As the survey coverage is considered to have sampled most exposed ground surface within the study area (refer to Section 8.1), the survey is also likely to have resulted in the recording of most locations with exposed evidence that exist within the study area.

Surface visibility varied between 20 and 90% within *site loci* and archaeological visibility varied between 10 and 60%. On average, detection limiting factors such as vegetation resulted in *effective site areas* being about 4.6 times less than *visible site areas*. Interestingly, this is significantly lower than the ratio of *effective survey coverage* to *total sample area* (15 times lower), indicating that evidence tended to be recorded in surface exposures (rather than more densely vegetated ground).

Most site loci were recorded on surfaces exposed by sheet erosion. Artefacts were also identified in areas of stream bank erosion, gully erosion, rill erosion and dense vegetation. Comparison of artefact density between *site loci* reveals that the mean densities are significantly higher in loci exposed by stream bank erosion. This result corresponds to the trend for higher artefact density along drainage depressions and a similar comparison for the *effective survey sample* (refer to Section 8.1).

Only one Aboriginal site had previously been accurately recorded on the National Parks and Wildlife Service Aboriginal Site Register as being located within or near the study area (refer to Section 3.1). This site (#37-2-167) is an artefact scatter recorded by Hughes (1981) at grid reference 302600:6420400. Four flakes of tuff and quartz were identified within a 25 x 5 metre exposure. Insufficient information is available to accurately determine the location of this site, although Hughes (1981) appears to indicate that it is situated along Ramrod Creek, not on the adjacent hill slopes. In this case, the site would not be affected by the rail proposal. No evidence was identified along the proposed rail route in this locality.

8.3.1 Artefact Density

A total of 271 stone artefacts were identified during the investigation (refer to Appendix 8).

The mean artefact densities of site *loci* vary considerably, from 0.025 to 15 artefacts per square metre of effective site area, with a mean of 0.278 artefacts/m². This average artefact density of the combined *site loci* is 12 times higher than the average density for all *survey components* (which includes exposures without artefacts).

Within individual *loci* recorded during the present study, artefact numbers range from 1 to 73. The artefact totals for *sites* (all loci within a survey/site area combined) also ranged from 1 to 73.

Only one distinct knapping floor, spatially discrete debris from the reduction of one or more cores of the same stone material, was identified. This result was lower than expected, but may reflect the fact that most artefacts are present within erosion scours, in which post-depositional processes may have obscured, removed or mixed evidence.

8.3.2 Stone Materials

The nature of the stone material of every recorded lithic item is documented in Appendix 8. A comparison of total counts for stone material types against lithic item types is presented in Table 14.

Within the study area, a total of eight stone material types were identified. Two types (tuff and silcrete) were divided into four sub-types each, on the basis of colour.

Indurated rhyolitic tuff ('tuff') is the stone material most commonly represented in the combined artefact database, comprising 134 items or 49.4% of the combined database (Table 14). Silcrete is also commonly represented in the combined artefact database, comprising 75 items (27.7%). Porcellanite (6.3%), other volcanics (5.9%), quartzite (4.8%), quartz (3.3%), chert (1.5%) and banded rhyolite (1.1%) are also present in low frequencies.

The dominance of tuff within the combined databases contrasts sharply with the adjacent Mount Arthur North area, in which silcrete is dominant (Kuskie in prep). However, the sample within the present study area is small and the result may be partially due to sampling error. The result may also accurately reflect more common usage of tuff.

Both silcrete and tuff were available from sources in the nearby Mount Arthur North area. Several silcrete cobbles were also identified in Survey Areas RP74 and RP75 in the present study area. Silcrete sources have also been reported along the Hunter River (Raggatt 1938, Rich 1993) and within the alluvial gravels of the river and its tributaries. It is not possible to determine on the basis of the present results whether the stone materials used to make artefacts within the study area was procured from local sources or obtained from other terrestrial sources or alluvial gravels within the region. It is possible that all sources were utilised to varying extents. Examination of items with cortex (original stone surface) reveals that only 65 of the artefacts (24%) exhibited cortex, which is too small a sample to draw reliable conclusions from (Table 15). The results tentatively indicate that tuff was procured from alluvial gravels and tabular sources (eg. within Jerrys Plains Subgroup geological formation).

In terms of colouration, red/pink/purple and cream/yellow colours of silcrete were most frequent, followed by grey. The silcrete sources within the Mount Arthur North area exhibit a similar range of colours. Red and yellow colours can result from the presence of haematite or goethite respectively. Oxidisation of minute quantities of iron oxide to form haematite, which creates a red/purple/pink colour, can result from intentional heat treatment or unintentional heating (eg. bush fires, camp fires).

The structural nature of the local silcrete ranges from uniform fine clasts to stone with minimal silicon matrix and large rounded or angular clasts of other materials (eg. volcanics and chert). The presence of large clasts is a hindrance to the production of small tools (such as bondi points - spear barbs). However, by controlled heating of the stone to specific temperatures, followed by slow cooling, the internal structure can become more equigranular and crystallised (*cf.* Domanski & Webb 1992:612). This enables more controlled flaking and greater success in producing desired products.

Heat treatment is considered to have been in widespread use in the Hunter Valley (refer to Section 3.2.2) and may have been undertaken at various locations within the study area. No direct evidence of heat treatment pits was detected during the survey. However, it is possible that a proportion of silcrete artefacts have been altered by intentional heat treatment. It is also possible that the colouration of many items could have resulted from unintentional alteration, or that insufficient quantities of iron oxide are present in other samples to enable haematite to form (and therefore the colour to change).

Indurated rhyolitic tuff is present to a minor extent within the Branxton Formation, which occupies the western section of A171, and is relatively more common in the Jerrys Plains Subgroup within the adjacent Mount Arthur North area. The stone commonly possesses a smooth tabular cortex. Yellow or brown tuff dominates the combined assemblage (Table 15). These colours occur in the outcrops within the Mount Arthur North area.

Stone materials other than silcrete or tuff occur in low frequencies (Table 15). Porcellanite, a material for which the identification of Hughes and Watchman (Hughes 1984) appears uncertain, may have derived from Tertiary volcanics and become incorporated into alluvial gravels.

Quartzite, a hard, silica rich metamorphic stone, comprises only 4.8% of the combined assemblage. Several cobbles and boulders of this material have been observed within the adjacent Mount Arthur North area (Kuskie in prep). These may represent Permian era glacial erratics.

Quartz only represents 3.3% of the combined artefact database. Quartz pebbles were noted in several localities within the study area, but are not common. Pebble cortex is the dominant cortex type, indicating that this material was probably procured from alluvial or colluvial gravels, either locally available or situated outside of the study area.

8.3.3 Artefact Types

The type of every recorded lithic item is documented in Appendix 8. A comparison of total counts for lithic item types against stone material types is presented in Table 14.

A total of 18 different types of artefacts were recorded in the study area (Table 14). Flakes are the most commonly occurring type in the combined artefact database, comprising 100 items (36.9%). Lithic fragments are the second most common lithic item type (12.9%), but not all are certain of being artefactual in origin. Proximal portions of flakes also occur (10.7%) along with lesser frequencies of distal flake portions (7.7%), cores (6.3%), flaked pieces (5.2%), microblades (3.3%), microblade portions (proximal 3.7%, medial 1.5%, distal 3%), microblade cores (2.2%), medial flake portions (2.2%), utilised and/or retouched flakes/flaked pieces/microblades (2.2%), bondi points (0.7%) and a single utilised geometric microlith, utilised/retouched flaked piece, flake from ground-edge axe and core fragment (Table 14).

The dominance of flakes, flake portions and flaked pieces (62.7% of the total database) indicates that the majority of evidence relates to general or non-specific knapping activities (refer to Section 8.4). This evidence is indicative of casual and opportunistic behaviour, meeting requirements for stone tools on an 'as needed' basis.

Manufacturing of microblades was also another frequent activity within the study area, with microblades, microblade portions and microblade cores comprising 13.7% of the total database (refer to Section 8.4).

While production of flakes and microblades can result in large quantities of by-products, or debitage, for every intended outcome (eg. a flake tool with a sharp cutting edge), other implements which occur in very low frequencies within the study area can be equally or more informative.

A total of 7 utilised and/or retouched flakes, microblades and flaked pieces were identified within the study area, comprising 2.6% of the total assemblage. Without the routine use of low powered microscopy, several tool edges with fine evidence of utilisation or retouch may not have been identified.

Of the utilised and/or retouched flakes, flaked pieces and microblades, there is a distinct trend for the use of tuff (6 out of 7 items) over silcrete (Table 15). Utilised and/or retouched flakes, flaked pieces and microblades comprise 4.5% of all tuff artefacts, but the same types only comprise 1.3% of all silcrete artefacts. These items may have been used for processing plant or animal foods or in the maintenance or production of wooden tools.

Only two bondi points were identified in the study area, one made of silcrete and one of tuff. Bondi points were hafted to spear shafts, with the aid of resin, for use in hunting spears. A single geometric microlith was found, which exhibits evidence of utilisation.

A volcanic flake from a ground-edge axe was also identified. Stone hatchets were an essential part of a male's tool-kit. They were used to cut saplings for building gunyahs, for stripping bark from trees, cutting notches in trees for climbing, and cutting toe-holds in trees to procure animals or honey from bee nests (Mathews 1894).

The count of artefacts in each size class for each artefact type is compared in Table 16. Artefacts range from class 1 (<10 millimetres) to class 10 (90-100 mm) in size. The modal class for artefact size is class 3 (30-40 mm). The largest artefacts comprised low numbers of flakes, cores and microblade cores. The trend for most artefacts to measure between 10 and 50 millimetres in maximum size dimension is evident in a comparison of size classes for flakes (Figure 7).

The presence of larger items possibly indicates procurement from sources within the study area. It also tends to indicate that rationing of stone material may not have been a high priority of the knappers. Considering the abundance and relative ease of obtaining materials from the locality, this is not surprising.

Notably, a very low proportion of artefacts measuring <10 mm were recorded. This is typical of surface surveys and not considered to be a true reflection of the underlying evidence. Controlled excavation would tend to reveal a much higher proportion of small size classes.

Further discussion of artefact types and the activities they represent is presented in Section 8.4.

8.3.4 Site Integrity

The integrity of the study area and therefore evidence of Aboriginal occupation has been affected by a number of factors, as described in detail in Sections 3.3.3 and 4. These probably include:

- removal of native vegetation (promotes erosion and affects spatial structure);
- agricultural activities (breaks artefacts, affects spatial structure and promotes erosion);
- pastoral activities (damages artefacts and promotes erosion);
- hydrological changes (cause erosion and deposition);
- erosion (predominantly sheetwash, affects the spatial structure of sites, disperses artefacts and features and alters density per unit of volume);
- bioturbation (affects the vertical relationship of artefacts by tending to produce stone layers at the basal level where bioturbation agents cease operating);

- occupational disturbance (treadage, scuffage, re-use of items by site occupants and camp fires); and
- focalised impacts such as roads, essential services and mining (can equate to partial or total destruction of evidence).

Levels of ground disturbance were recorded within three categories during the survey: low, moderate and high (refer to Section 7.5). Three-quarters of the total sample area was of units of moderate ground disturbance (Table 17). A distinct trend occurs for higher artefact density per square metre of effective survey coverage with increased levels of ground disturbance (Table 17).

This trend highlights the nature of the exposure of archaeological evidence. As controlled excavations in the locality have demonstrated, artefacts tend to be concentrated in the lower portion of the A horizon soil (*cf.* Koettig & Hughes 1985, MacDonald 1997). They have probably been worked there over a period of time, along with other natural gravels, by processes of bioturbation. Once vegetation has been removed or thinned (eg. by direct impacts such as grading, or more commonly through tilling of the soil for establishment of pasture grasses), the potential for erosion to occur is increased. Erosion then acts to remove more of the upper soil horizon and leave artefacts exposed on a mix of A and B horizon soils, or exposed as a lag deposit on a B horizon surface. The spatial integrity of deposits is affected (lateral and vertical displacement of artefacts occurs), possibly along with the proportions of size classes and artefact densities. When erosion is extreme (eg. stream bank or gully erosion) entire cultural deposits may be removed. The process of erosion also acts to bury occupational deposits in other locations, particularly the lower portions of major creeks.

It is probable that all of the Aboriginal heritage evidence within the study area has been affected to some extent by human or natural post-depositional processes. The level of impacts in individual localities may only be determined by detailed reference to historical documents and/or by sub-surface testing.

It is possible that a number of sites or potential deposits within the study area are of sufficient integrity to be of research value, particularly where the impacts of post-depositional processes can be identified and controlled for. Importantly to note, it is those deposits still subject to vegetation cover that are likely to be of higher integrity than most of the recorded site loci, in which visibility has been created by impacts that are also detrimental to site integrity.

Table 14: Summary of lithic item types by stone material types.

Stone Material	bondi point	core	core fragment	flake	flake distal portion	flake from ground-edge axe	flake medial portion	flake proximal portion	flaked piece	lithic fragment	microblade	microblade core	microblade distal portion	microblade medial portion	microblade proximal portion	utilised geometric microlith	utilised/retouched flake/ microblade (incl. portion)	utilised/retouched flaked piece	Grand Total
banded rhyolite				1						1	1								3
chert				2				2											4
other volcanic		2		5	1	1		2	1	2	1		1						16
porcellanite				3	1			1	2	4	2	1	2	1					17
quartz				7				1				1							9
quartzite		2		4	1		1	3	1			1							13
silcrete 1	1	2	1	6	2			4	1	5	2		1	2	2		1		30
silcrete 2		2		10	5		1	4		2	2			1	1				28
silcrete 3		1		10				2	1			1			1				16
silcrete 4												1							1
tuff 1		1		3				2	3	4	1								14
tuff 2	1	2		28	8		2	4	3	13		1	3		3	1	5	1	75
tuff 3		3		13	2		1	3	2	3			1		2				30
tuff 4		2		8	1		1	1		1					1				15
Grand Total	2	17	1	100	21	1	6	29	14	35	9	6	8	4	10	1	6	1	271

Table 15: Comparison of frequency of cortex types within each class of stone material.

	CORTEX TYPE AND COUNT OF ARTEFACTS			
STONE MATERIAL	PEBBLE	TABULAR	TERRESTRIAL	Total #
banded rhyolite		1		1
chert		1		1
other volcanic	3		5	8
porcellanite	1		2	3
quartz	3			3
quartzite	1			1
silcrete	4		5	9
tuff	23	15	1	39
Total #	35	17	13	65

Table 16: Count of artefacts in each size class for each artefact type.

Lithic Item Type	SIZE CLASS										
	1	2	3	4	5	6	7	8	9	10	Grand Total
bondi point		1	1								2
core			3	3	3	3	4			1	17
core fragment					1						1
flake	1	20	35	15	15	6	4	1	3		100
flake distal portion	2	8	8	3							21
flake from ground-edge axe					1						1
flake medial portion		2		3	1						6
flake proximal portion		9	9	8	1	1		1			29
flaked piece		1	6	3	3	1					14
lithic fragment	3	10	16	3	3						35
microblade			5	4							9
microblade core				3		1	1			1	6
microblade distal portion	2	5			1						8
microblade medial portion		4									4
microblade proximal portion		5	5								10
utilised geometric microlith		1									1
utilised/retouched flake/ microblade (incl. portion)	1	1	1	1	2						6
utilised/retouched flaked piece					1						1
Grand Total	9	67	89	46	32	12	9	2	3	2	271

Table 17: Survey coverage and artefact density in relation to levels of ground disturbance.

Ground Disturbance	Total Sample Area (m²)	Total # Artefacts	Effective Survey Coverage Total (m²)	Artefact Density (# artefacts per m² effective survey coverage)
1 (low)	28710	4	1097	0.0036
2 (moderate)	135787	36	6920	0.0052
3 (high)	12655	227	2973	0.0764
	177152	267	10990	0.0243

*2/3 (moderate/high) combination excluded.

Figure 7: Frequency in size classes of flakes.

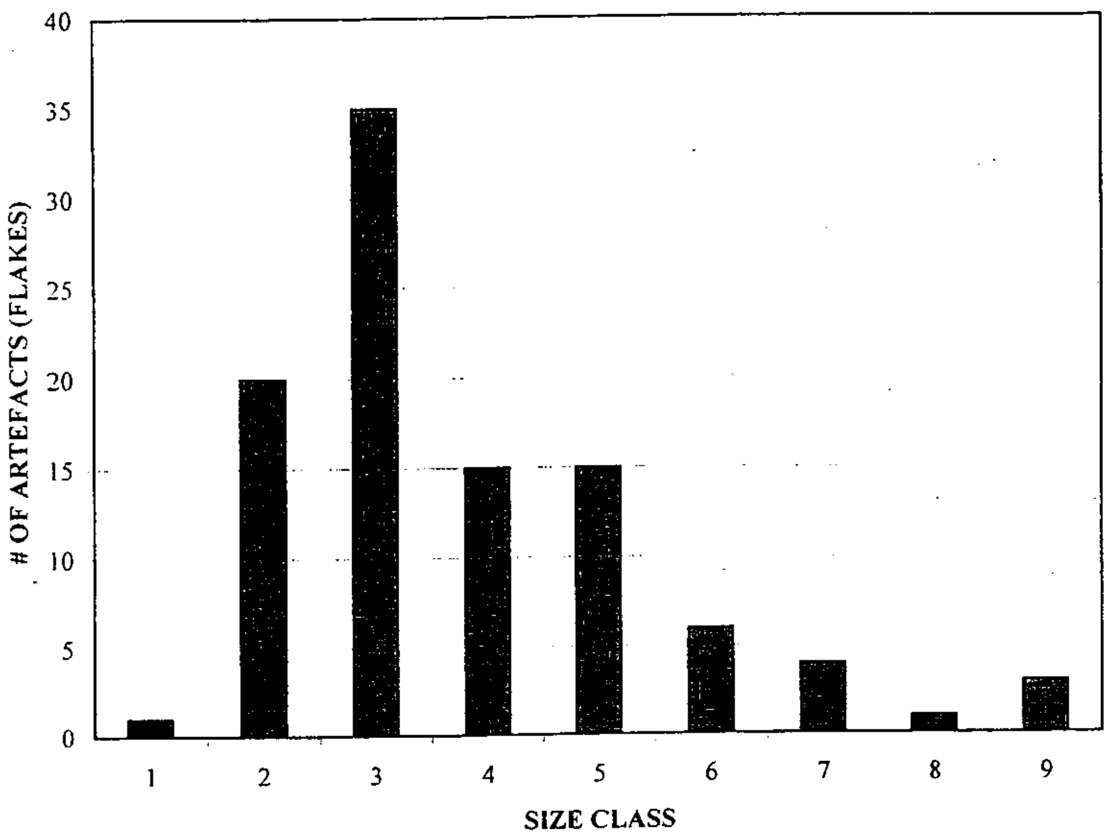
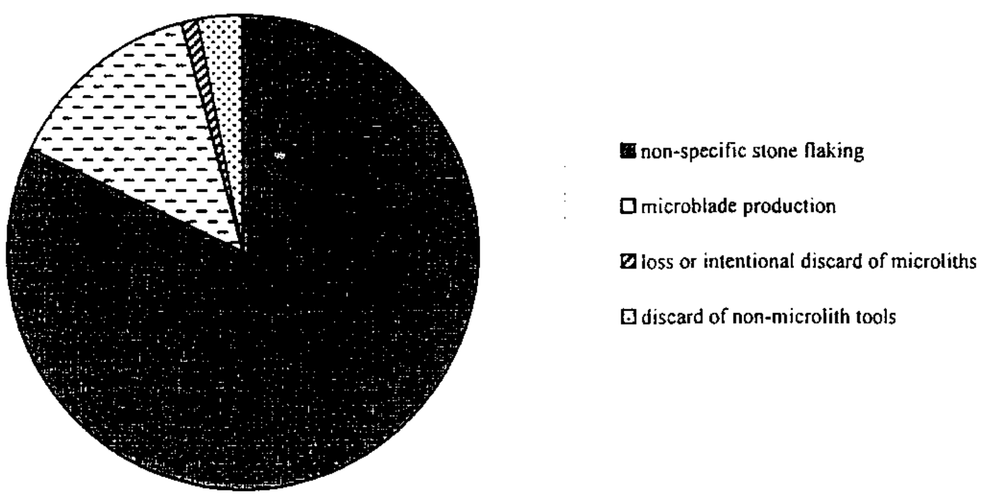


Figure 8: Comparison of counts of activity events within total study area.



8.4 Activities

The artefacts identified within the study area were assigned to one of five basic categories of *activity* (refer to Section 7.6 & Table 2). These groupings categorise the type of behaviour that may have produced the discarded artefact. By analysing the frequencies of *activity/discard events*, it may be possible to identify patterning in the distribution of activities throughout the study area. However, it is essential to note that each activity can result in the discard of relatively different quantities of evidence. For example, microblade production could result in tens or hundreds of artefacts from a single knapping event, while discard of a microlithic tool could represent a single event. Therefore, while it is not possible to identify *activity areas* during this surface investigation, the activities resulting in individual discard events can be identified.

A comparison of total activity event numbers within the combined database is presented in Figure 8. Comparison of frequencies of activity numbers between environmental factors is constrained by the small nature of the sample.

The results reflect the overwhelming dominance of non-specific stone flaking within the entire study area (82%). Microblade production also occurred, but to a much lesser extent (representing 14% of the combined database). Discard of non-microlithic tools accounts for only 3% of the combined database, while loss or intentional discard of microliths accounts for 1%.

8.5 Antiquity of Evidence

There is no reliable means of dating the surface evidence that has been identified within the study area. Cultural evidence can be directly dated by radiometric or other means (eg. radiocarbon, thermoluminescence and optically stimulated thermo-luminescence), when samples of datable cultural material (eg. charcoal) are retrieved from deposits through controlled excavation. This is not possible within the context of a surface survey. Dates that have been obtained from evidence in similar environmental contexts within the region (A horizon of texture-contrast soils) all relate to the late Holocene period (up to 5,000 years of age).

Geomorphological evidence can be used to date surface scatters, through identification of the age of soil units. Within texture-contrast soils, such as those present across much of the study area, although many may have been formed *in situ*, it is unlikely that they are older than 5,000 years or so in age (*cf.* Dean-Jones & Mitchell 1993, van de Graaff 1963). This is because most of the study area comprises erosive landform elements, and severe periods of erosion in the Pleistocene and early-mid Holocene are thought to have removed much of the soil that existed at that time. It is unlikely that older, *in situ*, soils exist within the few depositional contexts present in the study area. Many of the artefacts are characteristic of the *Australian small tool and scraper tradition* that has been reliably dated to around 5,000 years of age.

From the existing circumstantial evidence it would appear that most, if not all, of the cultural evidence within the study area relates to the past 5,000 years of human occupation.

8.6 Models of Occupation

The nature and distribution of heritage evidence within the study area can be interpreted in relation to general patterns of Aboriginal occupation and specific models of occupation. However, insufficient evidence exists to substantiate many conclusions on the sole basis of the survey area data.

Kuskie (in prep) has proposed a model of occupation for the locality. It is noted that the human behaviour, which underlies the pattern of evidence, is of itself highly variable in nature. This model of occupation can only be regarded as tentative, as it is based on many variables and assumptions that cannot be guaranteed to be correct (refer to Section 7.6). Hence, not all elements of the model proposed below may hold true, or they could require modification in view of further investigation results.

The most relevant aspects of the proposed model of occupation include:

- members of the Wonnarua 'tribe' predominantly occupied the study area, within the past 5,000 years. Members of neighbouring cultural groups may also have sporadically occupied the area and occupation may have extended as far back as 30,000 - 40,000 years (although it is very unlikely that any evidence for this would remain);
- Aboriginal people used and occupied the entire study area, but at varying intensities and at different times of the year and different periods within the total time-span of occupation;
- occupation within the study area was most frequent within 50 metres of watercourses, particularly higher order streams. The Aboriginal occupants held a strong preference for camping on level ground, adjacent to reliable water sources and potentially more abundant subsistence resources. Individual camp sites were mainly occupied by single family groups and multiple family groups (bands). As higher order streams are mainly absent from the study area, a greater frequency of camping would have taken place along nearby Whites Creek and lower portions of Ramrod Creek. Larger gatherings of people may have taken place along the nearby Hunter River flats. A greater range and frequency of activities were undertaken at the camp sites, rather than in the surrounding landscape. Camp sites along the major watercourses (primarily outside of the present study area) were occupied by these small groups of people for varying lengths of time, during both the course of the seasonal round and in different years. Occupation of these camp sites and the entire study area was predominantly sporadic, rather than continuous. The Wonnarua people ranged over a broad territory, of which the Bayswater Rail Loading Facility study areas only comprises a small part. Over the course of thousands of years, many different individuals, and different cultural groups, occupied the study area for varying lengths of time;
- occupation, such as focused camping, also occurred along lower order drainage depressions. These sources of water were likely to be intermittent (containing water after occasional heavy rain in summer, but possibly retaining standing water for longer periods of time during lower rainfall periods in winter, because evapotranspiration was significantly less: *cf.* Tweedie 1963). Occupation along the lower order streams may have only occurred when standing water was available. Most camp sites involved overnight visits of small hunting parties, rather than entire family groups;

- occupation, other than focused camping, occurred widely across the locality. It tended to involve hunting activities (larger game) by small parties of men, and gathering activities by small parties of women and children, along with transitory movement, procurement of stone, or cultural activities. However, the utilisation of areas such as simple slopes, ridge crests, spur crests and minor watercourses) was less intense, compared to the valley flats where base camps were situated. Simple slopes were used during hunting or gathering activities in the course of the normal daily or seasonal round, or occasionally to access higher ground or stone resources, or to move between camp sites. Ridge and spur crests were also used for these purposes, in addition to accessing vantage points or moving to ceremonial sites;

- vantage points were important to the Aboriginal occupants of the area, particularly along ridges and upper slopes near Mount Arthur (outside of the present study area). At vantage points, game could be sighted, tools could be repaired and hunting activities could be planned. However, hunting parties were not the only groups to access vantage points. People may have occasionally accessed them to sight or communicate with other groups, or for cultural reasons (eg. story-telling);

- Aboriginal occupants of the area had a strong preference to utilise two stone materials, tuff and silcrete. Both are locally available and were probably procured from local sources during the course of the normal daily or seasonal round, or by undertaking 'special purpose' visits. These stone materials were also procured from other sources within the region, most notably the alluvial gravels of the nearby Hunter River;

- other stone materials were used, such as chert, quartz, quartzite, volcanics, banded rhyolite and porcellanite. They were either procured from sources in the locality or obtained from other sources, probably during the course of the normal seasonal round;

- silcrete was deliberately thermally altered to improve its flaking properties. This process may have been undertaken at single locations (eg. at a camp site adjacent to a major watercourse), or in different locations reflecting the stages of procurement, heat treatment, reduction and use;

- manufacturing stone tools, particularly flaked implements for use in making or maintaining wooden tools or butchering or processing foods, was generally a casual or opportunistic activity, meeting requirements on an 'as needed' basis. Non-specific stone flaking was a very common activity. There was little emphasis on rationing or conservation of the use of most stone materials, due to the ease of procuring them;

- manufacturing microblades, typically for use as barbs on hunting spears, was also undertaken. It was more likely to be a planned and organised activity, but it did not necessarily occur at base camps. Microblade production also occurred in places traversed during the course of hunting expeditions. When it occurred away from base camps, the production of microblades may have involved more casual or opportunistic behaviour, such as replacing a few spear barbs when needed;

- tuff was the preferred material for making flaked tools, many of which were used for processing plant and animal foods, and manufacturing and maintaining wooden tools (which comprised a very important part of an Aboriginal persons tool-kit); and

- tuff and silcrete were both used for making stone barbs, which were attached to hunting spears by the use of resin.

This model of Aboriginal occupation relates only to a small locality, which comprises a fraction of the total Wonnarua Tribal territory. On a regional scale, some differences in the nature of occupation could be expected, such as:

- a greater focus of activity on major watercourses such as the Hunter River, which are not present within the study area, possibly with seasonal variation in use;
- not withstanding the point above, widespread, generally low intensity, usage of the entire Tribal territory; and
- a greater diversity of activities, particularly ceremonial ones, in relation to the location of important spiritual sites in the region.

In view of the model of occupation proposed for the locality, several predictive statements made by other researchers can be examined (refer to Section 3.3.5).

The model involves a number of similarities with a model used by Haglund (1992) to interpret sites on Doctors Creek and Sandy Hollow Creek near Singleton (refer to Section 3.3.5). This includes elements such as repeated visits by small groups of people, possibly over considerable periods of intermittent or frequent use, and opportunistic tool production. However, Haglund's (1992) model only relates to a comparatively small area. Her predictions about seasonal differences (family groups only camping during wetter periods) may only apply in the present study area in relation to minor watercourses, not the third or fourth order streams where water is likely to have been more permanent.

8.7 Reassessment of Predictive Model of Site Location

The quantity of evidence located within the study area is only a fraction of what potentially exists there. The effective survey coverage (once visible ground surface with potential for evidence is taken into consideration) only equates to 0.7% of the total study area. About 10.2% of the remainder of the study area was inspected, but detection limiting factors prevented the identification of any evidence. The remaining 89.1% of the study area was not directly sampled during the investigation and typically has such low conditions of ground visibility that detection of evidence would not be possible (from surface inspection).

Evidence within the study area has only been identified when exposed by erosion or ground disturbance. The vast majority of potential evidence would still lie buried beneath vegetation and topsoil.

Nevertheless, the inescapable conclusion is that a substantial body of Aboriginal heritage evidence potentially exists within the study area, only a fraction of which has been identified during the surface investigation.

Using the results of this survey, the predictive model of site location (Section 6) can be reassessed and refined in greater detail.

The results of the survey support predictions that there is a low or very low potential for scarred tree, mythological/spiritual or stone arrangement sites to occur. There remains some potential, albeit low to very low, for skeletal remains to occur within alluvial sediments along Ramrod Creek. Minimal sandstone bedrock was identified within the study area, hence the potential for grinding groove sites can be revised to very low. Outcrops of stone suitable for lithic procurement are also limited, indicating a low potential for this site type.

Stone artefacts remain the primary form of cultural evidence expected to occur within the study area. Artefacts will occur in generally low densities, across all archaeological terrain units, landform elements, classes of slope, geological formations and soil units. A higher frequency of evidence is expected along watercourses, particularly within 50 metres and also in higher order drainage lines. Stone artefacts are predicted to occur much more widely over the study area than has been identified during the survey, including areas that are densely vegetated or were not sampled. Deposits of artefacts are predicted to occur extensively within a sub-surface context, with the depths of deposit relating to the variable depth of the A horizon soil unit. The integrity of deposits will relate to the extent of post-depositional disturbance, but many deposits may be of sufficient integrity to reveal scientifically useful information. Items representing non-specific stone flaking are expected to continue to dominate the artefact types.

8.8 Regional Context

Examination of the survey results within a regional context reveals that a number of similarities exist with the reported evidence from other localities, including the adjacent Mount Arthur North area.

Notable similarities include:

- stone artefacts being the dominant form of Aboriginal heritage evidence;
- the identification of evidence only in locations exposed by erosion or ground disturbance;
- comparable numbers of artefacts within individual site loci;
- a generally low mean density of artefacts, with significant variations between individual site loci;
- the focus of evidence along watercourses;
- dominance of non-specific stone flaking and to a lesser extent microblade production in overall assemblages;
- similar range of stone material types (although proportions vary);
- similar range of artefact types (although proportions vary); and
- estimated antiquity of the evidence.

In very broad terms, the evidence is generally typical of that from the Central Lowlands of the Hunter Valley, although many specific differences exist with the evidence reported from other localities. Taken individually, none of the items or contexts located within the study area appear to be unique within the region.

8.9 Synthesis

The Aboriginal heritage survey of the Bayswater Rail Loading Facility study area has involved coverage of 19 hectares (10.9%) of the 173 hectare study area, resulting in an effective survey sample (accounting for archaeological visibility) of 0.7% of the total area.

The study area was subdivided into 64 survey areas, all of which were sampled. All different environmental contexts were sampled, including the range of landform elements, classes of slope, archaeological terrain units, geological formations and soil units present. Surface visibility was low on average across the surveyed terrain, and very low in the remainder of the study area that was not subject to direct inspection. Vegetation is noted as the primary detection limiting factor. Artefact density is substantially higher on soils that have been eroded, confirming the strong relationship between surface visibility and detection of evidence.

The levels and nature of effective survey coverage are considered satisfactory to present an effective assessment of the Aboriginal heritage resources identified and potentially present within the study area. Therefore it is concluded that the survey provides a valid basis for determining the probable impacts of the proposal and formulating recommendations for the management of the identified and potential Aboriginal heritage resources.

A total of 14 Aboriginal heritage sites have been identified within the study area, all scatters of stone artefacts. These sites comprise a total of 30 loci (spatially separate locations of recorded evidence). In total, 271 artefacts have been recorded within the study area. Artefacts were identified at a mean density of 0.0223 artefacts/m^2 of effective survey coverage, across the entire study area sample.

Artefact densities tend to be higher along watercourses, particularly higher order streams and within 50 metres of a drainage line.

Indurated rhyolitic tuff ('tuff') is the stone material most commonly represented in the combined artefact database, comprising 134 items or 49.4% of the combined database. Silcrete is also commonly represented in the combined artefact database, comprising 75 items (27.7%). Porcellanite (6.3%), other volcanics (5.9%), quartzite (4.8%), quartz (3.3%), chert (1.5%) and banded rhyolite (1.1%) are also present in low frequencies.

A total of 18 different types of artefacts were recorded within the study area. Flakes are the most commonly occurring type in the combined artefact database, comprising 100 items (36.9%). Lithic fragments are the second most common lithic item type (12.9%), but not all are certain of being artefactual in origin. Proximal portions of flakes also occur (10.7%) along with lesser frequencies of distal flake portions (7.7%), cores (6.3%), flaked pieces (5.2%), microblades (3.3%), microblade portions (proximal 3.7%, medial 1.5%, distal 3%), microblade cores (2.2%), medial flake portions (2.2%), utilised and/or retouched flakes/flaked pieces/microblades (2.2%), bondi points (0.7%) and a single utilised geometric microlith, utilised/retouched flaked piece, flake from ground-edge axe and core fragment.

The dominance of flakes, flake portions and flaked pieces (62.7% of the total database) indicates that the majority of evidence relates to general or non-specific knapping activities. This evidence is indicative of casual and opportunistic behaviour, meeting requirements for stone tools on an 'as needed' basis. Manufacturing of microblades was also another frequent activity within the study area, with microblades, microblade portions and microblade cores comprising 13.7% of the total database.

Inspection was also undertaken for other, more obtrusive site types such as grinding grooves and scarred trees. Very few areas of sandstone bedrock were identified in watercourses, but these were inspected for grinding grooves. Few mature native trees of sufficient age to host scars of Aboriginal origin were identified within the study area. Where identified, mature trees were inspected for evidence of scarring. No types of Aboriginal evidence other than artefact scatters were identified during the survey.

From the existing circumstantial evidence it would appear that most, if not all, of the cultural evidence within the study area relates to the past 5,000 years of human occupation.

It is probable that much of the identified or potential Aboriginal heritage evidence within the study area has been affected to some extent by human or natural post-depositional processes. However, it is possible that some sites, or potential deposits, within the study area are of sufficient integrity to be of research value, particularly where the impacts of post-depositional processes can be identified and controlled for. Importantly to note, it is those deposits still subject to vegetation cover that are likely to be of higher integrity than most of the recorded site loci, in which visibility has been created by impacts that are also detrimental to site integrity.

The results of the survey were used to reassess and refine the predictive model of site location for the study area. Stone artefacts remain as the dominant identified and predicted form of cultural evidence. Artefacts will occur in generally low densities, across all archaeological terrain units, landform elements, classes of slope, geological formations and soil units. A higher frequency of evidence is expected along watercourses, particularly within 50 metres and also in higher order drainage lines. Stone artefacts are predicted to occur much more widely over the study area than has been identified during the survey, including areas that are densely vegetated or were not sampled. Deposits of artefacts are predicted to occur extensively within a sub-surface context, with the depths of deposit relating to the variable depth of the A horizon soil unit.

The results of the survey support predictions that there is a low or very low potential for scarred tree; mythological/spiritual or stone arrangement sites to occur. There remains some potential, albeit low to very low, for skeletal remains to occur within alluvial sediments along Ramrod Creek and an unnamed watercourse traversing the proposed loading facility/rail loop. Minimal sandstone bedrock was identified within the study area, hence the potential for grinding groove sites can be revised to very low. Outcrops of stone suitable for lithic procurement are also limited, indicating a low potential for this site type.

In general terms, the evidence is typical of that from the Central Lowlands of the Hunter Valley, although specific differences may exist with evidence reported from other localities. Taken individually, none of the items or contexts located within the study area appear to be unique in the region.

9. ABORIGINAL INVOLVEMENT

Involvement of Aboriginal stakeholders in the management of their cultural heritage is a primary policy prerequisite of the Government authority responsible for legal protection of Aboriginal sites, the NSW National Parks and Wildlife Service (refer to Byrne 1997).

It stems from recognition that Aboriginal people are the rightful cultural owners of Aboriginal heritage information, sites and relics, and that Aboriginal people have the right to protect, preserve and promote their cultural heritage.

The National Parks and Wildlife Service recognises that 'Aboriginal owners' (Traditional Owners) have a particular interest in and attachment to Aboriginal heritage evidence, over and above that of other members of local Aboriginal community groups (eg. Local Aboriginal Land Councils). Aboriginal owners are defined under the *National Parks and Wildlife Amendment (Aboriginal Ownership) Act 1996* as Aboriginals named as persons having a cultural association with the land in a register of Aboriginal Owners maintained under Section 8A of the *Aboriginal Land Rights Act 1983*.

The identified Aboriginal owners of the land that encompasses the study area are represented by the Wonnarua Tribal Council Incorporated. This area is also under the administration of the Wanaruah Local Aboriginal Land Council (LALC).

The proponent of this project has undertaken consultation with both Aboriginal organisations. In relation to the cultural heritage assessment, the proponent advised South East Archaeology that further consultation should be pursued with the Wonnarua Tribal Council, as they had expressed a desire for continued involvement in this process.

Mr Victor Perry and Mr Tom Miller, representatives of the Wonnarua Tribal Council, were consulted with during the initial stages of the archaeological investigation. The requirements of the Tribal Council for the survey were discussed, along with issues regarding survey strategy and methodology. Arrangements were made with the Wonnarua Tribal Council for the participation of representatives alongside archaeologists in a joint heritage investigation.

The field survey was undertaken in January, February and October 1999. Representatives of the Tribal Council that participated during the field investigation of the Mount Arthur North and Bayswater Rail Loading Facility areas include Victor Perry, Tom Miller, John Miller, Laurie Perry, Tracey Miller, Dean Miller, Glen Miller, Natalie Anderson and Barry Anderson. All had detailed knowledge of their cultural heritage and were very familiar with archaeological survey procedures. Aboriginal representatives were present during every day of the survey.

The Wonnarua Tribal Council has been engaged separately to prepare a report detailing their involvement in this Aboriginal heritage project, their knowledge of the locality, an assessment of the cultural values of the heritage evidence, and their preferred management strategies. Copies of the archaeological report have been forwarded to the Wonnarua Tribal Council for their review and further comment. Upon the receipt of comments from the Wonnarua Tribal Council, copies of correspondence will be forwarded to the National Parks and Wildlife Service. The views of the Tribal Council will be taken fully into consideration in ongoing management of the Aboriginal heritage evidence in relation to this proposal.

10. SIGNIFICANCE ASSESSMENT

10.1 Assessment of Significance of Aboriginal Heritage Evidence

The information contained within this report, along with assessment of the significance of the Aboriginal heritage evidence, provides the basis for the NSW National Parks and Wildlife Service to make informed decisions regarding the management and degree of protection which should be afforded to specific heritage sites or environmental contexts.

The significance of Aboriginal heritage evidence can be assessed along the following criteria, widely used in Aboriginal heritage management, derived from the relevant aspects of the ICOMOS Burra Charter and NSW Department of Urban Affairs and Planning's 'State Heritage Inventory Evaluation Criteria and Management Guidelines':

a) scientific (archaeological) value;

b) importance to Aboriginal people (cultural value);

c) educational value;

d) historic value; and

e) aesthetic value.

Greater emphasis is generally placed on scientific and cultural criteria when assessing the significance of Aboriginal heritage evidence in Australia.

Scientific value refers to the potential usefulness of heritage evidence to address further research questions, the representativeness of the evidence, the nature of the evidence and its state of preservation.

Research potential refers to the potential for information derived from further investigation of the evidence to be used for answering current or future research questions. Research questions may relate to any number of issues concerning past human culture, human behaviour generally or the environment. Numerous locations of heritage evidence have research potential. The critical issue is the threshold level, at which the identification of research potential translates to significance/importance at a local, regional or national level.

Several key questions can be posed for each location of heritage evidence:

- Can the evidence contribute knowledge not available from any other resource?
- Can the evidence contribute knowledge, which no other such location of evidence can?
- Is this knowledge relevant to general questions about human history, past environment or other subjects?

Assessing research potential therefore relies on comparison with other evidence in local and regional contexts.

The nature of the heritage evidence is related to representativeness and research potential. The less common the type of evidence is, the more likely it will have representative value. The nature of the evidence is directly related to its potential to be used in addressing present or future research questions.

The state of preservation of the evidence (integrity) is also related to representativeness and research potential. The higher the integrity of evidence, the greater the level of scientific information likely to be obtained from its further study. This translates to greater importance for the evidence within a local or regional context, as it may be a suitable example for preservation within a sample representative of the entire cultural resources of a region.

Aboriginal (cultural) significance refers to the value placed upon Aboriginal heritage evidence by the local Aboriginal community. All heritage evidence tends to have some contemporary significance to Aboriginal people, because it represents an important tangible link to their past and to the landscape. Heritage evidence may be part of contemporary Aboriginal culture or be significant because of its connection to spiritual beliefs or as a part of recent Aboriginal history. Consultation with the Traditional Owners of an area is essential to identify the level of Aboriginal significance.

Educational value refers to the potential of heritage evidence to be used as an educational resource for groups within the community.

Historic value refers to the importance of heritage evidence in relation to the location of an historic event, phase, figure or activity.

Aesthetic value includes all aspects of sensory perception. This criterion is mainly applied to art sites or mythological sites.

10.2 Representativeness and Cumulative Impacts

Representativeness is generally assessed at local, regional and national levels. It is an important criterion, because the primary goal of cultural resource management is to afford greatest protection to a representative sample of Aboriginal heritage throughout a region. The more unique or rare evidence is, the greater its value as being representative within a regional context.

Issues involved in assessing the value of representativeness include:

- whether the evidence is a very good example of a type of place or period of history within a region;
- the state of preservation and integrity of the evidence;
- the educational and demonstrative potential of the evidence; and
- the vulnerability of the specific type of evidence.

Hence, assessment of representativeness depends on the extent of knowledge of existing evidence within a region.

However, to determine what constitutes a representative sample, the population (ie. the base data) must be known. Yet, despite numerous studies relating to Environmental Impact Assessments in the Central Lowlands region, a regional overview has not been produced in recent years. Such a study, which is fundamental to the assessment of representativeness, is necessary to identify:

- the range of environmental/cultural contexts present within the region;

- the identified heritage resources and potential resources relating to these environmental/cultural contexts;

- the distribution of environmental/cultural contexts;

- the size of environmental/cultural contexts and proportion each comprises of the region;

- the extent of existing impacts and potential future impacts on heritage resources in these environmental/cultural contexts; and

- the extent of existing or proposed conservation areas encompassing these environmental/cultural contexts.

Such an assessment is essential in order for any specific heritage evidence to be adequately or quantitatively assessed within a regional context, particularly in terms of its significance and representativeness. The absence of a regional synthesis is a serious constraint to every archaeological study in the Central Lowlands and only permits representativeness of specific evidence to be assessed by individual archaeologists, all of whose skills and knowledge vary, and neither of whom possess sufficient quantitative data to strongly substantiate any particular arguments (*cf.* Byrne 1997).

A regional study into the cumulative impacts of recent land uses on Aboriginal heritage has not been undertaken within the Central Lowlands region. Several cumulative impact studies have been prepared (eg. *Upper Hunter Cumulative Impact Study* DUAP, 1996; *Cumulative Impact Assessment of Coal Mining in Muswellbrook Shire* NECS, 1998) but none have included an assessment of Aboriginal heritage.

The absence of quantitative baseline data is a serious constraint to addressing the issue of cumulative impacts on Aboriginal heritage in relation to specific development proposals. Without this information, it is not possible to identify the cumulative impacts on specific environmental/cultural contexts, which is critical for assessing the:

- extent to which the environmental/cultural contexts that are to be affected by the proposal are represented elsewhere in the region;

- level of existing impact on these contexts elsewhere in the region;

- land tenure of these contexts elsewhere in the region (eg. is a sample already contained within a National Park or conservation zone?); and

- potential future impacts of mining and other land uses on these contexts elsewhere in the region.

By using aerial photography, topographical mapping, mine plans and other information, it is possible to identify in very general terms the extent of impacts on the entire Aboriginal heritage resource within the Central Lowlands region and potential future impacts.

This region is a belt of lowlands stretching through the centre of the Hunter Valley, between Newcastle and Murrurundi. The Hunter Valley measures about 22,000 square kilometres in area, of which the Central Lowlands covers around 4,200 km^2 (19%).

Within the Central Lowlands, it is possible that focalised impacts (areas in which heritage is unlikely to survive, such as urban areas, mines and roads) may have affected around 5-20% of the region. Other non-focalised land use impacts (such as agriculture, grazing, horse agistment and timber harvesting) may have affected around 80-95% of the region. Areas set aside for conservation (eg. National Parks and registered conservation zones) probably amount to less than 1% of the region.

In the longer term, virtually the entire region may be subject to potential future land uses that will be unsympathetic to the conservation of Aboriginal heritage. These activities will be subject to local and state land planning legislation and assessment and include agriculture (crops, vineyards, timber), urban development, pastoral uses/livestock agistment, tourism developments, mining and infrastructure. Focalised activities such as mining and urban development would cause the greatest impacts to Aboriginal heritage (for a given area), whereas non-focalised uses such as agistment would most likely affect broader areas of land, but to a lesser extent. At least fifteen mining proposals (including extensions and underground proposals) are currently in the planning, including Carrington, Cheshunt, Cooranbong, Dartbrook, Donaldson, Glendell, Glennies Creek, Hunter Valley, Kayuga, Lachlan, Mount Pleasant, Nardell, Newstan, Ravensworth West and South Lemington.

The cumulative affect of all future development in the Central Lowlands will be the progressive loss of more of the identified and potential Aboriginal heritage resources, including destruction of the only remaining samples of some environmental/cultural contexts.

10.3 Significance of Aboriginal Heritage Located within the Study Area

In terms of the cultural significance attributed to the identified and potential Aboriginal heritage evidence within the study area, a separate statement will be prepared by the Traditional Owners organisation, the Wonnarua Tribal Council. It is noted that the Wonnarua Tribal Council considers the evidence to be of interest and contemporary value to the Aboriginal community. Aboriginal heritage evidence represents a tangible link with the traditional past and with the lifestyle and values of community ancestors.

The remainder of this assessment focuses on the potential scientific values of the identified and potential heritage evidence. No historic or aesthetic values are attributable to this evidence.

The archaeological terrain units present within the Rail Loading Facility study area are identical to those present in the nearby Mount Arthur North lease area and the majority (90% by area) lie within the A171 area, for which significance has been assessed by Kuskie (in prep). The scientific significance assessment of these archaeological terrain units is adopted, with further revision in relation to the specific evidence located along the proposed rail route. This assessment relates only to artefact scatters and deposits, the only form of evidence identified within the study area.

Typically, Aboriginal heritage evidence is assessed in terms of individual localities (sites). In the context of a broad-area study, significance is assessed on a different scale, that of 'cultural landscapes'. A number of justifications exist for using this approach, including:

- the objectives of the investigation;
- the patterns of evidence identified within specific combinations of environmental attributes (archaeological terrain units) and in relation to other environmental factors (eg. distance to and type of watercourse);

- the prediction that each and every locality within a similar environmental context (archaeological terrain unit) has equal potential for comparable types of evidence to occur;

- the recognition that individual site loci recorded during the present and previous investigations are primarily a function of conditions of surface visibility and ground disturbance, not a reflection of the true distribution of the underlying cultural evidence (*potential resource*);

- the prediction that the vast majority of Aboriginal heritage evidence within the study area constitutes a *potential resource*, that cannot be identified during a surface survey because it is obscured by vegetation and soil; and

- the recognition that individual site loci recorded during the present and previous investigations may generally be of lower integrity than surrounding potential deposits, by virtue of them having been exposed by erosion and disturbance.

A preliminary assessment of scientific significance of individual archaeological terrain units (inclusive of the identified and potential heritage evidence within them) is presented below and summarised in Table 18. The assessment of scientific significance is problematical. The assessment is not definitive. Only limited evidence (primarily surface scatters subject to relatively more post-depositional disturbance than potential deposits) is available on which to base the assessment:

2. *Gentle ridge crest*: Relatively low numbers of artefacts are present, representing a moderate range of stone materials and a common suite of artefact types, but including several less common tool types. Soil deposits are predicted to be generally shallow on this unit, limiting the extent of potential sub-surface cultural deposits. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. Few detailed archaeological investigations have occurred within this unit in the region. In a local context, several research questions can be addressed by evidence from this unit, which may not be possible from other localities. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain but it is assumed to be represented elsewhere. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a relatively undisturbed context. The scientific significance of the gentle ridge crest unit is provisionally assessed as moderate-high within a local context and low-moderate within a regional context;

4. *Level/very gentle spur crest*: Low numbers of artefacts are present, representing a limited range of stone materials and a common variety and limited range of artefact types. Soil deposits are predicted to be generally shallow on this unit, limiting the extent of potential sub-surface cultural deposits. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. Minimal detailed archaeological investigation has been undertaken of this unit within the region. In a local context, several research questions can be addressed by evidence from this unit, which may not be possible from other localities. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain but it is assumed to be represented elsewhere. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a relatively undisturbed context. The scientific significance of the level/very gentle spur crest unit is provisionally assessed as moderate within a local context and low-moderate within a regional context;

5. *Gentle spur crest*: Relatively high numbers of artefacts are present, representing a diverse range of stone materials and a wide range of mostly common artefact types. However, several less common tool types and one regionally rare type are also present. Soil deposits are predicted to be generally shallow on this unit, limiting the extent of potential sub-surface cultural deposits. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. Minimal detailed archaeological investigation has been undertaken within this unit in the region. In a local context, several research questions can be addressed by evidence from this unit, which may not be possible from other localities. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain but it is assumed to be represented elsewhere. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a relatively undisturbed context. The scientific significance of the gentle spur crest unit is provisionally assessed as moderate-high within a local context and moderate within a regional context;

7. *Level/very gentle simple slope*: Moderate numbers of artefacts are present, representing a broad range of stone materials, including several less common varieties, and a common suite of artefact types, with several uncommon types. Soil deposits are predicted to vary from shallow to moderately deep on this unit, suitable for sub-surface cultural deposits with potentially higher integrity. The integrity of deposits may be affected by post-depositional factors, but worthwhile information may still be derived from further studies if these factors can be identified and controlled for. In a local context, several research questions can be addressed by evidence from this unit, which may not be possible from other localities. Several archaeological investigations have been undertaken of this unit within the region, primarily basal slopes near watercourses. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit may be relatively high. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a less-disturbed context. The scientific significance of the level/very gentle simple slope unit is provisionally assessed as moderate within a local context and low within a regional context;

8. *Gentle simple slope*: Very high numbers of artefacts are present, representing a diverse range of stone materials and artefact types, mostly of common varieties but also with a number of uncommon types. Soil deposits are predicted to be shallow to moderate on this unit, suitable for sub-surface cultural deposits to occur. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. In a local context, a number of research questions can be addressed by evidence from this unit, which may not be possible from other localities. Several archaeological investigations have been undertaken of this unit within the region, primarily close to watercourses. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit may be relatively high. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a relatively undisturbed context. The scientific significance of the gentle simple slope unit is provisionally assessed as moderate-high within a local context and low-moderate within a regional context;

9. *Moderate/steep simple slope*: Relatively high numbers of artefacts are present, representing a broad range of stone materials and a common suite of artefact types, but including a number of uncommon tool types. Soil deposits are predicted to be generally shallow on this unit, limiting the extent of potential sub-surface cultural deposits. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. In a local context, several research questions can be addressed by evidence from this unit, which may not be possible from other localities. Very little archaeological investigation has been

undertaken within this unit in the region. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain but it is assumed to be represented elsewhere. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a relatively undisturbed context. The scientific significance of the moderate/steep simple slope unit is provisionally assessed as moderate-high within a local context and moderate within a regional context;

11. *Level/very gentle flat*: Relatively little effective survey coverage was obtained of this unit and very few artefacts were identified. The artefacts are made of only one stone material and are common types. However, the depositional nature of this unit renders it possible that substantially more evidence exists within a sub-surface context, which may be of moderate to high integrity. In a local context, a number of research questions can be addressed by evidence from this unit, which may not be possible from other localities. Several archaeological investigations have been undertaken of this unit within the region, primarily near watercourses. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain but it is assumed to be represented elsewhere. However, the effects of European occupation have almost certainly reduced the extent to which this unit exists in a relatively undisturbed context. The scientific significance of the level/very gentle flat unit is provisionally assessed as moderate within a local context and low-moderate within a regional context;

14. *Level/very gentle drainage depression*: Low numbers of artefacts are present, representing a range of stone materials and a common, but limited range of artefact types. The artefacts occur at a relatively high density. Soil deposits are predicted to be variable within this unit, but conditions suitable for sub-surface cultural deposits probably exist. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. In a local context, several research questions can be addressed by evidence from this unit, which may not be possible from other localities. A number of archaeological investigations have been undertaken of this unit within the region, although not necessarily of all orders of watercourse. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain, but several sub-types exist in relation to the order of the watercourse and all are likely to be present elsewhere. The effects of European occupation (and subsequent erosion) have almost certainly reduced the extent to which this unit occurs in a relatively undisturbed context. The scientific significance of the level/very gentle drainage depression unit is provisionally assessed as moderate within a local context and low-moderate within a regional context;

15. *Gentle drainage depression*: Very high numbers of artefacts are present, representing a diverse range of stone materials and a broad range of artefact types, mostly common varieties but including a number of uncommon tool types. Soil deposits are predicted to be variable within this unit, but conditions suitable for sub-surface cultural deposits probably exist. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. In a local context, a number of research questions can be addressed by evidence from this unit, which may not be possible from other localities. A number of archaeological investigations have been undertaken of this unit within the region, although not necessarily of all orders of watercourse. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain, but several sub-types exist in relation to the order of the watercourse and all are likely to be present elsewhere. The effects of European occupation (and subsequent erosion) have almost certainly reduced the extent to which this unit occurs in a relatively undisturbed context. The scientific significance of the gentle drainage depression unit is provisionally assessed as high within a local context and moderate within a regional context;

16. *Moderate/steep drainage depression*: Moderate numbers of artefacts are present, representing a range of stone materials and a broad range of artefact types, mostly common varieties but including several uncommon tool types. Soil deposits are predicted to be variable within this unit, but conditions suitable for sub-surface cultural deposits probably exist. The integrity of deposits may not be high, but through control of post-depositional factors, worthwhile information may be derived from further studies. In a local context, a number of research questions can be addressed by evidence from this unit, which may not be possible from other localities. A number of archaeological investigations have been undertaken of this unit within the region, although not necessarily of all orders of watercourse. In the context of the mid-upper Hunter Central Lowlands region, the prevalence of this archaeological terrain unit is uncertain, but several sub-types exist in relation to the order of the watercourse and all are likely to be present elsewhere. The effects of European occupation (and subsequent erosion) have almost certainly reduced the extent to which this unit occurs in a relatively undisturbed context. The scientific significance of the moderate/steep drainage depression unit is provisionally assessed as moderate within a local context and low-moderate within a regional context.

Table 18: Summary of provisional scientific significance assessments of each archaeological terrain unit (including identified and potential evidence of artefact scatters/deposits).

ARCHAEOLOGICAL TERRAIN UNIT	SCIENTIFIC SIGNIFICANCE (LOCAL CONTEXT)	SCIENTIFIC SIGNIFICANCE (REGIONAL CONTEXT)	IDENTIFIED SITES
gentle ridge crest	moderate-high	low-moderate	RP64
level/very gentle spur crest	moderate	low-moderate	
gentle spur crest	moderate-high	moderate	RP76
level/very gentle simple slope	moderate	low	
gentle simple slope	moderate-high	low-moderate	PK139, RP86, RP98
moderate/steep simple slope	moderate-high	moderate	PK136, RP70, RP77
level/very gentle flat	moderate	low-moderate	
level/very gentle drainage depression	moderate	low-moderate	RL4
gentle drainage depression	high	moderate	RP46, RP82, RP84, RP94
moderate/steep drainage depression	moderate	low-moderate	PK141

11. STATUTORY OBLIGATIONS

The NSW *National Parks and Wildlife Act 1974* (as amended) provides the primary basis for the legal protection and management of Aboriginal sites within New South Wales. Implementation of the Aboriginal heritage provisions of this Act is the responsibility of the Aboriginal Heritage Division of the NSW National Parks and Wildlife Service.

The rationale behind the Act is to prevent unnecessary or unwarranted destruction of relics and to protect and conserve relics where such action is considered warranted.

With the exception of some artefacts in collections, the Act generally defines all relics to be the property of the Crown. The Act then provides various controls for the protection, management and destruction of these relics.

A 'relic' is defined as

> 'any deposit, object or material evidence (not being a handicraft made for sale) relating to indigenous and non-European habitation of the area that comprises New South Wales, being habitation both prior to and concurrent with the occupation of that area by persons of European extraction' [Section 5(1)].

In practice, archaeologists generally subdivide the legal category of 'relic' into different site types, which relate to the way Aboriginal heritage evidence is found within the landscape. The archaeological definition of a 'site' may vary according to survey objectives, however it should be noted that even single and isolated artefacts are protected as relics under the Act.

Under the terms of the NSW *National Parks and Wildlife Act 1974* (as amended), it is an offence for a person to:

- knowingly destroy, damage or deface an Aboriginal relic or place, or knowingly cause or permit the destruction, defacement or damage to an Aboriginal relic or place, without first obtaining the consent of the Director-General of the NSW National Parks and Wildlife Service;

- disturb or excavate any land, or cause any land to be disturbed or excavated, for the purpose of discovering a relic, without first obtaining the consent of the Director-General of the NSW National Parks and Wildlife Service; and

- collect on any land a relic that is the property of the Crown, other than a relic under the control of the Australian Museum, without obtaining appropriate authorisation from the Director-General.

Penalties for infringement of the Act include up to 50 penalty units or imprisonment for six months, or both (or 200 penalty units in the case of a corporation).

Consents regarding the use or destruction of relics are managed through a National Parks & Wildlife Service permit system. The issuing of permits is dependent upon adequate archaeological assessment and review, together with an appropriate level of Aboriginal community liaison and involvement.

To excavate or disturb land for the purposes of discovering a relic, approval of a 'Preliminary Research Permit' application is typically required. To enable unmitigated destruction of relics, a 'Consent to Destroy Permit' must be obtained. To enable the mitigated destruction of relics, involving measures such as collection or salvage excavation, a 'Consent to Destroy and Permit to Salvage' is required.

The Director-General may attach any terms and conditions they see fit to any Consent granted for the above activities. Failure to comply with a term or condition is deemed to be a contravention of the Act.

An appeals process is available whereby an applicant, dissatisfied with the refusal of the Director-General to grant Consent, or with any conditions or restrictions attached to Consent, may appeal to the Minister. The Minister may refuse to grant an appeal or partially or wholly grant an appeal. The decision of the Minister on the appeal is final and is binding on the Director-General and the appellant.

Under the *National Parks and Wildlife Act 1974*, 'Archaeological Areas' may also be declared over private land, where relics or Aboriginal places are located, with the consent of the owner or occupier.

While the primary legislation offering protection to Aboriginal heritage in New South Wales is enacted by the state, several Acts administered by the Commonwealth may also be relevant.

The *Aboriginal and Torres Strait Islander Heritage Protection Act, 1984*, provides for the protection of areas and objects which are of significance to Aboriginal people in accordance with Aboriginal tradition. The Act allows Aboriginals to apply to the Minister to seek protection for significant Aboriginal areas and objects. The Minister has broad powers to make such a declaration should the Minister be satisfied that the area or object is a significant Aboriginal area or object and is under immediate threat of injury or desecration. An 'emergency declaration' can remain in force for up to thirty days. It is an offence under the Act to contravene a provision of a declaration. Provisions are made for penalties of up to $50,000 for a corporation found guilty of contravening the Act and up to $10,000 and imprisonment for a maximum of five years, for a person found guilty of contravening the Act.

Under the Act, 'Aboriginal tradition' means:

> 'the body of traditions, observances, customs and beliefs of Aboriginals generally or of a particular community or group of Aboriginals, and includes such traditions, observances, customs or beliefs relating to particular persons, areas, objects or relationships' (Section 3).

A 'significant Aboriginal area' refers to:

> an area of land or water in Australia being of 'particular significance to Aboriginals in accordance with Aboriginal tradition' (Section 3).

A 'significant Aboriginal object' refers to:

> an object (including Aboriginal remains) of 'particular significance to Aboriginals in accordance with Aboriginal tradition' (Section 3).

For the purposes of the Act, an area or object is considered to be injured or desecrated if:

> a) in the case of an area, it is used or treated in a manner inconsistent with Aboriginal tradition; or the use or significance of the area in accordance with Aboriginal tradition is adversely affected by reason of anything done in or near the area; or passage through or over, or entry upon the area by any person occurs in a manner inconsistent with Aboriginal tradition; and

b) in the case of an object, it is used or treated in a manner inconsistent with Aboriginal tradition (Section 3).

Under the *Aboriginal and Torres Strait Islander Heritage Protection Act, 1984*, the discovery of Aboriginal burials must be reported to the Minister.

No declarations made under the *Aboriginal and Torres Strait Islander Heritage Protection Act, 1984* are currently in force within the study area.

The *Australian Heritage Commission Act 1975* established the Australian Heritage Commission as the Commonwealth Government's adviser on the protection of Australia's National Estate. The 'National Estate' encompasses those places in the natural, historic or Aboriginal and Torres Strait Islander environments which the Commission considers should be conserved because of their 'aesthetic, historic, scientific or social significance or other special value for future generations as well as for the present community' (Section 4.1).

The Australian Heritage Commission maintains a Register of National Estate places and advises the Commonwealth Minister and Government on all matters concerning the National Estate. The Australian Heritage Commission's advisory role is primarily related to the actions of the Commonwealth Government and its departments and authorities. The Act states that such government bodies should ensure their actions do not adversely affect the national estate values of places in the Register, unless there are no feasible and prudent alternatives, in which case all reasonable measures should be taken to minimise the adverse affect. Hence, the Act does not place legal constraints or controls over the action of State or Local Governments, or private owners.

No Aboriginal heritage items listed on the Register of the National Estate occur within the study area.

12. MITIGATION AND MANAGEMENT STRATEGIES

12.1 Impacts of the Proposal

The proposal will involve construction of a rail loop and coal loading facility in Authorisation A171, adjacent to Bayswater #2 Colliery. A three kilometre rail line will also be constructed to link the loading facility with the existing Antiene rail spur east of Drayton Colliery's rail loop. Construction of the rail loop and loading facility will cause impacts to the ground surface over an area of less than 35 hectares, while the rail link will affect an area of less than 20 hectares.

Therefore, a substantial portion of the A171 section of the study area will not be affected by the proposal. This area measures over 118 hectares or 68% of the total study area. Apart from construction of an access road, this area will also not be affected by the adjacent Mount Arthur North Coal Mine proposal.

12.2 General Strategies

General management strategies that are available in relation to further assessment of the evidence and its significance, the identification of potential heritage resources, and conservation and management of the evidence, are discussed below. Specific options for the study area are discussed in Section 12.3 and the recommended strategies are presented in Section 13.

Option A (Further Investigation):

In circumstances where artefact deposits are predicted to occur through application of a predictive model of site location, sub-surface test excavations may be appropriate to identify whether such deposits exist, along with their nature, extent, integrity and significance.

Testing may also be appropriate in circumstances where heritage evidence has been identified, but its extent, nature, integrity and/or level of significance cannot be adequately assessed solely through the surficial evidence.

Test excavations can take the form of auger holes, shovel pits, mechanically excavated trenches or surface scrapes. A Preliminary Research Permit is required from the NSW National Parks and Wildlife Service to undertake sub-surface testing. Approval can take up to eight weeks or longer, following receipt by the NPWS of all necessary information. A research design specifying the aims and intended methods, is an essential component of a Permit application. A letter of comment is also required from the relevant local Aboriginal Traditional Owners organisation (as represented by the Wonnarua Tribal Council).

This is a pro-active strategy, which should result in the identification, assessment and management of the potential Aboriginal heritage resource prior to any development activity occurring. Following the assessment of any evidence that is identified, other management strategies such as conservation, mitigated destruction or unmitigated destruction can be considered.

Option B (Unmitigated Destruction):

A development proponent can apply to the NSW National Parks and Wildlife Service for a Consent to Destroy Permit for any known relics. This permit must be obtained prior to the commencement of works affecting the evidence, because all relics are protected under the terms of the *NSW National Parks and Wildlife Act, 1974.*

In circumstances where artefact deposits are predicted to occur, but the evidence is expected to be comparable to other evidence within the region or is in a state of low integrity, no further assessment may be required.

Adequate consultation with the Traditional Owners organisation (Wonnarua Tribal Council) is essential and must be documented in a Consent to Destroy Permit application. The informed consent of the Traditional Owners to the proposed impacts should be sought and obtained.

This strategy is typically suitable when the heritage evidence is of low scientific significance, the relevant Aboriginal owners holds no objections, and/or it is unfeasible to implement any other strategy.

Option C (Mitigated Destruction):

Mitigated destruction (salvage) can be considered in circumstances where the identified or potential Aboriginal heritage evidence:

- is assessed as being of moderate or high scientific significance;
- is of cultural significance to the local Aboriginal owners; or
- its study may yield valuable information that cannot be obtained from any other sources;

  and

- the potential for conservation is limited.

Salvage may include the collection of surface artefacts or systematic excavation of deposits.

A Consent to Destroy and Permit to Salvage must be obtained from the National Parks and Wildlife Service. Approval can take up to eight weeks or longer, following receipt by the NPWS of all necessary information. A detailed research design, specifying the aims and intended methodology, is an essential component of a Permit application.

Adequate consultation with the Traditional Owners organisation (Wonnarua Tribal Council) is essential and must be documented in a Permit application. The informed consent of the Traditional Owners to the proposed impacts and salvage should be sought and obtained.

This strategy is the primary means of minimising impacts from proposed developments to Aboriginal heritage resources, where the option of conservation is not feasible.

Option D (Conservation):

The basic goal of cultural resource management is to preserve a representative sample of the Aboriginal heritage resources that exist within a region.

Conservation strategies can involve two approaches:

- a site-specific approach, focusing on discrete localities which contain identified and/or potential evidence (eg. individual Aboriginal sites); or
- an area-based approach, focusing on conserving representative portions of the total landscape (eg. a suite of separate or adjoining archaeological terrain units).

Both approaches involve the avoidance of development impacts (to the ground surface).

The area-based strategy relies on the concept that Aboriginal behaviour was continuous across space. Therefore the physical evidence of that behaviour is widely distributed and is variable in nature, and typically correlated, at least in part, with environmental factors. With area-based management, the emphasis shifts to decision-making on what areas, rather than sites, are representative. By preserving a representative suite of environmental contexts (such as landform elements or archaeological terrain units), the range of Aboriginal heritage evidence across the landscape is preserved, regardless of the precise nature of variations in the density and distribution of relics (*cf.* Byrne 1991). Protection is therefore afforded to samples of the potential heritage resource, as well as to the identified resource.

The strategy of conservation is suitable for all Aboriginal heritage evidence, but particularly evidence or localities of high scientific and/or cultural significance or representative value.

Option E (Monitoring):

Monitoring for heritage evidence during the initial stages of development (surface disturbance works) can be undertaken in two contexts:

- monitoring of alluvial soils or other deposits for the presence of skeletal remains; or
- monitoring for artefact deposits.

Monitoring is the primary strategy for managing the possible occurrence of Aboriginal skeletal remains. Monitoring of development by suitably trained Aboriginal community representatives and/or qualified archaeologists can be undertaken in those landform elements where there is a potential for skeletal remains to be unearthed.

Monitoring for the presence of stone artefacts is a reactive strategy, that is not normally preferred within the context of a development or an archaeological investigation because it can result in:

- substantial and costly delays to construction;
- late revisions to development plans; and
- cause undesirable impacts to evidence of cultural or scientific significance.

Practical experience indicates that monitoring for artefacts has very few benefits, unless soil is passed through wire mesh sieves.

12.3 Assessment of Specific Options for the Bayswater Rail Loading Facility Study Area

Specific strategies can be considered for the management of the identified and potential Aboriginal heritage resources within the study area.

The proposal will directly affect:

- all 10 of the archaeological terrain units located within the study area;
- 39 archaeological survey areas (RL1-RL23, RP77-RP86, RP93-RP98); and
- 7 Aboriginal heritage sites (RL4, RP77, RP82, RP84, RP86, RP94, RP98).

However, the overall impacts of the project will not be substantial (less than 55 hectares) and are unlikely to cause significant detrimental impacts to the overall resource of identified and potential Aboriginal heritage resources within the Central Lowlands.

The evidence (taken as a whole) is not considered to be of sufficient scientific significance or uniqueness to warrant its total conservation. However, specific elements of the evidence are significant within local and/or regional contexts and the future study of this evidence may yield valuable information that cannot be obtained from other sources. Therefore, the conservation and/or salvage of a representative sample of this evidence may be warranted.

<u>Strategy A: Conservation:</u>

The suitability of conservation as a management option has long been recognised (*cf.* Burton, Koettig & Thorpe 1990:8).

The archaeological terrain units and Aboriginal heritage evidence identified in the study area are not unique within the region. All terrain units and types of evidence are replicated elsewhere in the region, typically on a larger scale. None of the units or evidence is of very high integrity.

For these reasons, conservation of part or all of the identified and potential evidence within the c. 55 hectare zone of impact of the proposal is not considered warranted. Conservation by relocating the rail link and/or loading facility is also not warranted for these reasons, along with the fact that any realignment would merely impact the same terrain units and types of evidence in adjacent ground.

The possibility that a substantial portion of the identified and potential evidence within the total study area will be conserved is strongly enhanced by the avoidance of impacts to at least 120 hectares of the A171 portion. The only impacts to occur in this area will be from the construction of an access road for the Mount Arthur North proposal (Kuskie in prep). These impacts will be minor in extent. Within this area, impacts to seven identified heritage sites and potential resources in six archaeological terrain units will be avoided.

The avoidance of impacts does not guarantee the permanent conservation of this portion of the A171 area. However, it serves to offset the impacts of the proposal on the identified and potential heritage resources.

Strategy B: Mitigated Destruction (Salvage):

Mitigated destruction (salvage) can be considered for all identified and potential evidence within the zone of impact, but particularly evidence that cannot be conserved and is of high significance or not well represented elsewhere in the region.

Salvage may include the collection of surface artefacts, a strategy that may be requested by the Aboriginal community. Surface collection would enable the mitigation of impacts to the identified evidence within the zone of impact.

Salvage may also involve the systematic excavation of deposits. Salvage excavation would be most suitable in mitigating the impacts of the proposal on the potential resource. The identification of locations for salvage needs to be made with reference to the:

- significance assessment (bias towards 'high significance');
- levels of ground disturbance (bias towards 'low/moderate' disturbance);
- extent to which contexts are represented elsewhere in the region (bias towards units which are not well represented);
- extent to which archaeological studies have been undertaken of identical contexts (bias towards units which have not been thoroughly investigated);
- consideration of the views of the Aboriginal owners, as represented by the Wonnarua Tribal Council; and
- minimal impacts of the proposal.

Holdaway (1993) identifies the two primary rationale for salvage investigations:

- heritage evidence may be investigated from a research perspective, with the aim of investigation relevant research questions and contributing to the writing of a regional prehistory; or
- heritage evidence may be investigated for the purpose of curation, by excavating and storing samples of evidence.

In relation to the Bayswater Rail Loading Facility proposal, the primary objective of a salvage program should be to retrieve a representative sample of heritage evidence (in locations meeting the criteria listed above) for the benefit of present and future generations of Aboriginal people and the broader community. However, a secondary objective of the salvage program should also comprise the basic documentation and analysis of this evidence in terms of relevant research questions, particularly those of interest to the Aboriginal community. Greater emphasis should be directed towards salvaging and conserving a representative sample of evidence, rather than investigating research questions that can easily be addressed by future researchers who examine the salvaged sample.

The specific aims of the salvage and the methodology could only be finalised after extensive consultation with the Wonnarua Tribal Council and the National Parks and Wildlife Service, in relation to an application for a Consent to Destroy with Permit to Salvage. The application would need to address the views and policy and legislative requirements of these key stakeholders.

Strategy C: Unmitigated Destruction:

The strategy of unmitigated destruction involves the proponent making application to the NSW National Parks and Wildlife Service for a Consent to Destroy Permit for any known relics that will be affected by the proposal. This permit must be obtained prior to the commencement of works affecting the evidence, because all relics are protected under the terms of the *NSW National Parks and Wildlife Act, 1974*.

A total of seven identified sites/relics will be affected by the proposal. The identification of which sites are appropriate for unmitigated destruction needs to be made with reference to the:

- significance assessment (bias towards 'low/moderate significance');
- levels of ground disturbance (bias towards 'moderate/high' disturbance);
- extent to which contexts are represented elsewhere in the region (bias towards units which are already well represented);
- extent to which archaeological studies have been undertaken of identical contexts (bias towards units which have already been thoroughly investigated elsewhere);
- consideration of the views of the Aboriginal owners, as represented by the Wonnarua Tribal Council; and
- minimal impacts of the proposal.

Other Strategies:

The strategy of further investigation (ie. sub-surface testing) may not be warranted for the identified and potential heritage evidence within the zone of impact. Surface surveys and excavations in the region have enabled the establishment of a robust predictive model of site location for the study area (*cf.* Kuskie 1999). Therefore the likely distribution and nature of the potential heritage resources can be identified with some confidence (refer to Section 8).

Further testing may be justified within the context of a salvage excavation, in order to determine the most suitable location to excavate within an archaeological terrain unit or site.

The strategy of monitoring may be suitable, but only in relation to the possible presence of skeletal remains within alluvial sediments. Few localities in the study area have potential for such evidence. These comprise the crossing of Ramrod Creek and a watercourse that traverses the proposed rail loop within A171.

13. RECOMMENDATIONS

The following recommendations are made on the basis of legal requirements under the *NSW National Parks and Wildlife Act 1974*, the results of the archaeological investigation as detailed within the preceding sections of this report, and preliminary consultation with the Aboriginal owners as represented by the Wonnarua Tribal Council.

The Bayswater Rail Loading Facility proposal will directly affect:

- 7 identified Aboriginal heritage sites (RL4, RP77, RP82, RP84, RP86, RP94, RP98); and
- potential heritage resources within 10 archaeological terrain units (archaeological survey areas RL1-RL23, RP77-RP86, RP93-RP98).

In order to comply with relevant legislation and mitigate the impacts of the proposal to the identified and predicted Aboriginal heritage resources, it is recommended that:

- The proponent make application to the Director-General of the NSW National Parks and Wildlife Service for a Consent to Destroy and Permit to Salvage for all identified Aboriginal relics and all land within the entire zone to be impacted by the proposal, including the seven recorded Aboriginal sites. Locality specific recommendations for the potential and identified evidence are presented in Table 19;
- The nature and scope of samples for archaeological salvage needs to be finalised in consultation with the Wonnarua Tribal Council and National Parks and Wildlife Service, in relation to the Consent application;
- Further consultation should be pursued with the Wonnarua Tribal Council in relation to this proposal and report. Their continued involvement in the management of their heritage resources should be promoted;
- Any further investigation involving archaeological salvage collections or excavations should only be undertaken by archaeologists qualified and experienced in Aboriginal heritage, in full consultation with the Wonnarua Tribal Council. A Consent to Destroy and Permit to Salvage must be obtained from the National Parks and Wildlife Service prior to any impacts occurring. Approval can take up to eight weeks or longer, following receipt by the NPWS of all necessary information. A detailed research design, specifying the aims and intended methodology, is an essential component of a Permit application. Adequate consultation with the Traditional Owners organisation (Wonnarua Tribal Council) is essential and must be documented in such a Permit application. The informed consent of the Traditional Owners to the proposed impacts and salvage measures should be sought and obtained prior to submitting an application. The application should cover the entire surface area to be impacted by the proposal;
- The proponent should consider any request by the Wonnarua Tribal Council to collect surficial heritage evidence identified within the zone of impact (sites RL4, RP77, RP82, RP84, RP86, RP94, RP98);
- The proponent should consider engaging representatives of the Wonnarua Tribal Council to monitor the initial removal of topsoil from within the alluvial soil deposits along several watercourses (survey areas RL4, RL19, RP84, RP94-RP97; Appendix 5; Plates 1-3), for the presence of skeletal remains;

- If skeletal remains are identified during monitoring or construction, the proponent is required to immediately stop work and notify the appropriate authorities, including the State Coroner and the Minister responsible for the (Commonwealth) *Aboriginal and Torres Strait Islander Heritage Protection Act, 1984*;

- The Aboriginal heritage evidence recorded within the study area is protected under the terms of the *National Parks and Wildlife Act 1974*. The proponent is reminded that under the terms of the *National Parks and Wildlife Act, 1974* it is an offence to knowingly destroy, damage or deface an Aboriginal relic without obtaining the prior written permission of the Director-General of the NSW National Parks and Wildlife Service;

- Four copies of this report should be forwarded to:

  Aboriginal Heritage Manager
  Metropolitan Aboriginal Heritage Unit
  NSW National Parks and Wildlife Service
  PO Box 1967
  Hurstville NSW 2220

  and

- A single copy of this report should be forwarded to:

  Chairperson
  Wonnarua Tribal Council Inc.
  PO Box 184
  Singleton NSW 2330.

Table 19: Locality specific recommendations.

Archaeological Terrain Unit	Recommended Management Strategy	Rationale	Avoidance	Impact	Salvage
gentle ridge crest	avoidance of impacts to survey area RP64; unmitigated impact to survey area RL14	survey area RP64 lies outside of the zone of impact; survey area RL14 is very small in extent	x	x	
level/very gentle spur crest	unmitigated impact to survey area RL2; salvage of representative sample from survey area RL3	survey area RL2 is not of high significance; survey area RL3 is predicted to occur elsewhere in the region but this unit has been subject to minimal research/salvage; salvage through excavation will assist in mitigating impacts to the potential resource; sub-surface testing to identify the most suitable location for excavation may comprise part of the salvage program; testing prior to salvage is not warranted because options for avoidance of impact to this unit are very limited		x	x
gentle spur crest	avoidance of impacts to survey areas RP52 and RP76; unmitigated impact to survey areas RL7, RL10, RL16, RL21, RL23 and RP69	survey areas RP52 and RP76 lie outside of the zone of impact and are of sufficient scope that mitigation measures are not warranted for the other, small survey areas that will be impacted	x	x	
level/very gentle simple slope	unmitigated impact to survey area RP85	survey area RP85 is a unit which has been investigated elsewhere in the region and is not of high significance		x	
gentle simple slope	avoidance of impacts to survey areas PK139, RP88, RP90 and RP92; unmitigated impact to survey areas RL1, RL6, RL9, RL11, RL13, RL17, RL20, RL22, RP83 and RP86; salvage of representative sample from survey areas RL5 and RP98 (site)	survey areas PK139, RP88, RP90 and RP92 lie outside of the zone of impact and are of sufficient scope that mitigation measures are not warranted for most of the other survey areas that will be impacted (RL1, RL6, RL9, RL11, RL13, RL17, RL20, RL22, RP83 and RP86); survey area RL5 is predicted to occur elsewhere in the region but salvage through excavation will assist in mitigating impacts to a locality in which potential deposits of reasonable integrity and research value may exist; sub-surface testing to identify the most suitable location for excavation may comprise part of the salvage program; salvage of site RP98 Locus A through surface collection and excavation is recommended to mitigate impacts to the identified evidence; consent to destroy is necessary for site RP86	x	x	x
moderate/steep simple slope	avoidance of impacts to survey areas PK133, PK136 and RP70; unmitigated impact to survey areas RP77 (site) and RP80	survey areas PK133, PK136 and RP70 lie outside of the zone of impact and are of sufficient scope that mitigation measures are not warranted for the other survey areas that will be impacted; consent to destroy is necessary for site RP77	x	x	
level/very gentle flat	unmitigated impact to survey area RP93	unit is not of high significance or integrity		x	
level/very gentle drainage depression	unmitigated impact to survey areas RL4 (site), RP95, RP96 and RP97	survey areas RL4, RP95, RP96 and RP97 are units that have been investigated elsewhere in the region, are not of high significance or integrity; consent to destroy is necessary for site RL4		x	
gentle drainage depression	avoidance of impacts to survey areas RP46, RP72, RP73, RP74, RP87, RP89 and RP91; unmitigated impact to survey areas RL8, RL12, RL15, RL18, RL19, RP81 and RP94 (site); salvage of sites RP82 and RP84	survey areas RP46, RP72, RP73, RP74, RP87, RP89 and RP91 lie outside of the zone of impact and are of sufficient scope that mitigation measures are not warranted for most of the other survey areas that will be impacted; consent to destroy is necessary for site RP94; salvage of sites RP82 and RP84 through surface collection is recommended to mitigate impacts to the identified evidence	x	x	x
moderate/steep drainage depression	avoidance of impacts to survey areas PK134, PK135, PK137, PK138, PK141, RP71 and RP75; unmitigated impact to survey areas RP78 and RP79	survey areas PK134, PK135, PK137, PK138, PK141, RP71 and RP75 lie outside of the zone of impact and are of sufficient scope that mitigation measures are not warranted for the other survey areas that will be impacted	x	x	

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DISCLAIMER

The information contained within this report is based on sources believed to be reliable. Every effort has been made to ensure accuracy by using the best possible data and standards available. The accuracy of information generated during the course of this field investigation is the responsibility of the consultant.

However, as no independent verification is necessarily available, South East Archaeology provides no guarantee that the base data (NSW NPWS Site Register) or information from informants (obtained in previous studies or during the course of this investigation) is necessarily correct, and accepts no responsibility for any resultant errors contained therein and any damage or loss which may follow to any person or party. Nevertheless this study has been completed to the highest professional standards.

APPENDIX 1: GLOSSARY

Activity (in relation to *activity areas*) - the nature of behaviour that resulted in the discard of a lithic item. Five broad categories are identified within the study area and adjacent Mount Arthur North area: *non-specific stone flaking*, *bipolar flaking*, *microblade production*, *loss or intentional discard of microliths* and *discard of non-microlith tools*.

Activity area - a single location in which one or more *activity events* has resulted in the discard of items that constitute archaeological evidence. For example, an *activity area* may represent a single *activity* such as *microblade production*. However, this activity is comprised of numerous *activity events* (eg. each blow to the core can be described as an *activity event*), which result in multiple discarded items, each from different *activity events*.

Activity event (discard event) - the discard of lithic item(s) resulting from a single action performed during an *activity*. For example, a single blow to a core during a *non-specific stone flaking* event may result in the detachment of several flakes.

Alternate platforms - different flake initiation surfaces or platforms on a core (nucleus).

Anvil - usually a thick piece of quartzite or similar hard siliceous stone on which a core being reduced by percussive blows is rested. Commonly hatchet heads served as occasional small anvils for flaking stone or preparing food.

Archaeological site - any location that contains evidence of human activity.

Archaeological terrain unit - discrete, recurring areas of land (*survey areas*) in which the same combination of landform element and class of slope are present.

Archaeological visibility - a mean estimate of the percentage of visible ground surface within a component *sample area* or *site locus* that has potential to contain evidence of Aboriginal heritage. Where a single *sample area* is comprised of multiple exposures, the archaeological visibility was recorded separately for each exposure and percentages noted as a range in the survey or site database;

Artefact - an object, normally portable, made or modified by the human hand (refer also to *stone artefact*).

Artefact density per square metre of effective survey coverage - mean number of artefacts within each square metre of visible ground surface with potential to contain Aboriginal artefacts that is physically inspected. Calculated by dividing the *number of artefacts* by *effective survey coverage*.

Artefact scatter - a locality that contains evidence of Aboriginal occupation in the form of stone artefacts. Artefact scatters have commonly been defined as either the presence of two or more stone artefacts within 50 or 100 metres of each other, or a concentration of artefacts at a higher density than surrounding low density *background scatter*. Within the present investigation, artefact scatters are identified as the presence of one or more stone artefacts within an *archaeological survey area*. The boundaries of the site are defined by the boundaries of the *survey area*, regardless of the visible extent of artefacts. The survey areas are based on specific, repeated environmental contexts termed *archaeological terrain units*.

Backed blade - refer to *microlith*.

Background scatter - manuports and artefactual material that are insufficient either in number or in association with other material to suggest focused activity in a particular location.

Backing (*retouch*) - abruptly angled flaking (retouch) which has shaped a thick back part to an implement such as an elouera or a microlith. The process of flaking varies from bipolar impact (on some eloueras) to delicate application of pressure with a small stone ('chimbling' used to make microliths).

Bipolar core - a core (nucleus) that is supported on a stone anvil surface and struck repeatedly with a hammerstone from above. Diagnostic attributes of bipolar fracture damage are point or sinuous-ridge type initiation platforms, crushing, cracks and concentrated overlapping step fractures emanating from areas of hammer impact.

Bipolar flake - a flake retaining evidence of bipolar fracture damage on at least one end. Some of these are 'compression flakes' formed by substantial compressive force.

Bipolar flaking - activity category describing a method of making flakes or retouched flake tools by breaking a piece of stone, rested on a stone surface and repeatedly striking the core from above with a hammerstone.

Bondi point - A sub-type of microlith with abruptly angled backing retouch along one lateral margin (and often the butt end) so that it has an asymmetrical plan shape similar to a pen knife blade. This microlith type is commonly found east of the Great Divide as far north as Great Keppel Island. Broken portions are described as proximal, mid-section and tip sections.

Burial - placement of human remains after death, generally in hollow trees, caves or sand deposits or by interment in mounds.

Chalcedony - a compact variety of silica, formed of quartz crystallites, often fibrous in form and with sub-microscopic pores that contain water (about 1% of weight). Coloured varieties include carnelian (yellow-brown), sard (brown), agate (multicoloured) and jasper (red). Chalcedony can form veins or it can occur as pseudomorphs, resulting from solution infiltrating voids or cavities in rock, sometimes by gradually replacing decaying organic matter. Chalcedony, like fine quality chert, was a valued stone tool material.

Chert - a highly siliceous rock type formed biogenically from the compaction and precipitation of the silica skeletons of diatoms. Normally there is a high percentage of cryptocrystalline quartz. This rock type breaks by the process of conchoidal fracture and provides flakes that have sharp, durable edges.

Chord - the cutting edge of a microlith.

Clast - a grain or crystal inclusion within a finer-grained matrix (common in silcrete).

Cleavage - breakage along a flat plane.

Cobble - waterworn stones of diameter greater than 64 mm and less than 256 mm. Archaeologists often refer to cobbles as pebbles (refer also to *pebble*).

Component - a part of a *survey area*, with a different type of surface exposure such as a vehicle track, erosion scour or grassed surface. Each component was recorded separately and identified with a sequential number after the survey area number (eg. PK1/3, PK1/4). Often multiple occurrences of a type of exposure (eg. erosion scour) were recorded as a single component (size and visibility characteristics were noted separately to enable more accurate calculation of effective survey coverage).

Component area - depending on the context, can refer to the *total sample area* of a *component*, or the gross area of an individual component within a *survey area*, without taking into account conditions of visibility.

Conjoin analysis - refitting or 'conjoining' artefacts assists with reconstructing prehistoric events (such as tool manufacture, tool use activities and cutting-edge rejuvenation) and determining chronology and assessing site integrity.

Core (synonymous with *nucleus*) - a piece of stone, often a cobble or pebble, but also quarried stone, which has been used for striking flakes (refer also to *tabular nucleus*). These flakes are called 'primary flakes' and may be further shaped by finer flaking, called 'retouch'. The term 'nucleus' refers to cores and flakes or cores that have been retouched.

Core rotation - turning of a core (nucleus) on its side or end, so as to continue detaching useful flakes or blades off another surface. Usually this occurs when the previously flaked part of the core because unsuitable for further flake removal.

Cortex amount - amount of the original weathered surface of the stone material, expressed as a percentage of the item's total surface.

Cortex type - nature of the original weathered surface of the stone material. Three types are identified: pebble (rounded waterworn surface), tabular (smooth tabular shaped surface, may be waterworn) and terrestrial (rough cortex not consistent with tabular or waterworn surface).

Cultural site - a discrete, culturally defined unit beyond which cultural material is absent.

Debitage - commonly used term for the discarded debris from stone flaking. Usually there is a large quantity of flaking refuse or 'debitage' for every finished stone implement.

Detection limiting factors - factors that act to reduce *surface visibility* and *archaeological visibility*.

Discard - in relation to lithic scatters, discard means the incidental, intended or accidental placement of a lithic item on the ground surface.

Discard event - refer to *activity event*.

Discard of non-microlith tools - activity category comprising intentional discard after use or caching for future use of implements other than microliths.

Distal portion or end - the end of a flake or microblade (opposite to point of fracture origin on the ventral surface).

Distance to watercourse - as estimated from the closest part of the *survey area* or *site locus* to the watercourse, in classes of <50 metres, 50-100 metres or >100 metres. Within many *survey areas* and *site loci*, the distance to watercourse varied.

Dorsal face/facet - the outside surface(s) of a flake, opposite the inside (bulbar or ventral) surface, created during the formation of the flake (refer also to *ventral face*).

Drainage depression - landform element that typically comprises a shallow open depression with smoothly concave cross-section, rising to moderately inclined side slopes, eroded or aggraded by sheetwash (after McDonald *et al* 1984). For the purposes of the survey, this unit also includes gullies (drainage depressions subjected to gully erosion), along with ground approximately 50 metres either side of the centre of the drainage depression.

Dropstone - a piece of stone, usually a quartzite pebble or cobble, carried by a glacier, iceberg or ice raft and dropped at another location when the ice melts.

Edge-ground tool - a stone tool with a cutting edge formed by grinding. In south-eastern Australia these tools comprise hatchet heads, a range of smaller chisels and the *bulga knife*.

Edge rounding - rounding wear along the cutting edge of a stone tool resulting from its use. This use-wear can be described as continuous or discontinuous and moderate or pronounced (refer also to *use-wear*).

Effective site area - a measure of the area of a *site locus* containing visible ground with potential for Aboriginal heritage items to occur. Calculated for each *locus* by multiplying the *visible site area* with the percentage of the locus physically inspected and with *mean archaeological visibility*.

Effective survey coverage - a measure of the quantity of visible ground surface physically inspected within a *sample area* (eg. a *component*), with potential to contain Aboriginal heritage evidence. Calculated by multiplying the *total sample area* of a *component* with the percentage of *archaeological visibility*. For a *total sample area* that includes multiple exposures, the *effective survey coverage* of each exposure was calculated separately and added to produce the reported figure.

Elongated flake - a flake at least twice as long as it is broad, but not of normal microblade shape.

Elouera - an implement larger than a microlith and shaped like an orange segment. The cutting edge is usually blunted by extreme attrition, as would be expected in a silty work environment. The tool had been fixed onto a wooden handle or haft and probably used in obtaining or processing plant food, such as bracken rhizomes.

Environmental/cultural context - a specific context that exists (generally within an individual archaeological terrain unit), that may host a different range of evidence (reflecting different types and frequencies of activities) than other locations within the same archaeological terrain unit. For example, a level/very gentle simple slope within 50 metres of a watercourse may contain substantially different evidence to one further than 50 metres from a watercourse. This would reflect different usage of the locality in relation to the different context (eg. proximity of reliable water source and more diverse and abundant food resources).

Exposure type - identification during the field survey of exposed soil units; eg. A horizon, A and B horizons or B horizon.

Flake - a complete or substantially complete piece of lithic material detached from a core (nucleus), usually with evidence of hard indenter initiation, or occasionally bending initiation. The flake's primary fracture surface (ventral or inside surface) exhibits features such as fracture initiation, bulb of force, and undulations and lances. Very occasionally a conchoidal flake comprises only a bulb of force (refer also to *core*, *fracture initiation*, *bulb of force*, *lance*, *undulation* and specific flake types).

Flake fragment - A portion of a flake that does not retain an area of fracture initiation. These artefacts exhibit general shape characteristics and/or fracture surface attributes (usually conchoidal markings) indicative of artefactual status.

Flake portion - medial, proximal or distal portion of the original flake.

Flat - landform element that is neither a crest nor a depression and is level or very gently inclined (after McDonald *et al* 1984). Excludes *valley flats*.

Freehand percussion - striking a core held in one hand with a hammer (usually stone) held in the other.

Geology - underlying geological formation as identified on geological mapping.

Geometric microlith - a group of microliths distinguished by their various geometric plan-shapes such as triangle, trapeze and rectangle.

Goethite - a hydrated iron oxide, $FeTiO_3$, yellowish brown to dark brown in colour. It is a secondary mineral, formed in the oxidisation zones of veins containing iron minerals. It is a major constituent of the impure hydrated iron oxide, limonite.

Grinding grooves - elongated narrow depressions in soft rocks (particularly sedimentary), generally associated with watercourses. The shaping and sharpening of ground-edge axes creates the depressions.

Ground disturbance - an estimate of the extent of recent human impacts and impacts of natural processes, noted in low, moderate or high categories, modified after McDonald *et al* 1984:69. The low category includes no effective disturbance, minor vegetation removal and low intensity grazing and minimal erosion. The moderate category includes extensive vegetation removal, improved pasture grasses and moderate levels of erosion. The high category includes complete vegetation removal and cultivation, extensive erosion and areas where the A horizon soil has been removed.

Ground surface visibility - refer to *surface visibility*.

Hammerstone - a mass of stone, often quartzite or volcanic, and round or oval shaped, used as a hammer for flaking, or applying controlled pressure in retouching a tool's edge.

Hatchet head - a multipurpose implement of simple design, finished by grinding the edge on an abrasive stone. Waterworn pebbles were often used, as they could be turned into hatchet heads with minimal preparatory flaking. Most hatchet heads are made of tough volcanic stone and usually weigh around 500 grams. Some are grooved along their sides for the fitting of a short bent wooden handle. Stone hatchets do not appear in the archaeological record until about 4,500 years ago.

Heat crazed - irregular cracking of a stone by heat from a bush fire or camp fire.

Heat fracture - fractures cause by heating the stone, either from natural causes, a camp fire, or intentional heat treatment. Also termed *heat shatter* and *thermal fracture*. Attributes indicating heat fracturing include colour change, crazing, potlidding and highly irregular fracture surface topography.

Heat shatter - refer to *heat fracture*.

Heat treatment - the intentional slow heating of stone, particularly silcrete, above 300° Celcius, to alter its structure and thereby improve its flaking properties.

Implement (of stone) - synonym for a *stone tool*, usually denoting a tool that has been shaped by flaking (retouch).

Indurated mudstone - mudstone that has been altered by low-grade heat or pressure. Frequently archaeologists have misidentified *indurated rhyolitic tuff* as *indurated mudstone*, within the Hunter Valley. However, these stones are lithologically different and possess different mechanical properties. Refer to *mudstone*.

Indurated rhyolitic tuff - lithified volcanic ash with a chemical composition of rhyolite. This stone has been misidentified as *indurated mudstone* and *chert* within the Hunter Valley. Tuff is composed of fine ash which has been hurled from the vent of a volcano during a violent explosive eruption. The tuff is rhyolitic in chemical composition, being comprised of quartz and potassium-feldspar, sometimes with layer silicates. After settling to the land, or more likely ponded water, the tuff undergoes recrystallisation at low pressures. This 'indurated' rhyolitic tuff exhibits conchoidal fractures. Colour is predominantly grey but variation occurs when mineral bearing solutions pass through the rock and some minerals (e.g. goethite) precipitate out. Some tuff deposits show graded bedding, not unlike that of some sedimentary rocks. Lateral sorting also tends to occur, with coarser material settling closer to the volcanic vent and finer material further away. Volcanic tuffs occur in widespread seams throughout the Hunter Valley and are occasionally exposed in drainage lines, cliffs and other landform elements.

Initiation surface/platform - the surface of a stone that is struck with a hammerstone at a low angle, for the purpose of detaching a flake. This surface is where a flake-forming crack commences; commonly part of it is retained on the flake. The load applied to this surface may be delivered by a hammerstone or by continuous increasing pressure with a length of dense wood or bone.

Knapping floor - a series of flaking events (refer to *knapping event*) that are generally defined as involving a single stone core (but sometimes multiple cores of the same or different materials) and resulting in the deposition of stone flaking debris that may be later recorded in discrete areas or be mixed by post-depositional processes.

Knapping event - a single act of flaking a piece of stone, resulting in the *in-situ* deposition of stone flaking debris. Such an event may occur as part of a series of events (refer to *knapping floor*).

Landform element - specific type of topographical feature, following the definitions of McDonald *et al* 1984. Within the study area, *ridge crest*, *spur crest*, *simple slope*, *flat* and *drainage depression* landform elements were recorded.

Land surface - type of exposure as observed during the field survey.

Lateral margin - the thin sides of a flake or microblade.

Lithic - in an archaeological context, items of a hard, usually siliceous, stone of a type selected by Aborigines for tool making. These items are often nondescript fragments, but some are finely shaped implements.

Lithic assemblage (of stone) - a collection of whole and fragmentary stone artefacts and manuports obtained from an archaeological site, either by collecting items scattered on the present ground surface (refer to *lithic scatter*) or by controlled excavation (refer also to *stone artefact*).

Lithic fragment - a non-descript lithic item that does not have sufficient morphological attributes to identify it as a complete artefact or portion of an artefact. The lithic fragment category comprises items which are identified only to the level of manuport fragments, even though it contains non-descript flaking shatter and fragments of flakes not individually identifiable as such. The lithic fragment category includes fragments exhibiting attributes characteristic of heat stress from exposure to bush fires or camp fires, or from intentional heat treatment. Depending on the nature of the locality and non-Aboriginal land-use practices, this category may also contain a low number of natural fragments, which exhibit fresh fracture surfaces.

Lithic item - a piece of stone exhibiting fracture surfaces and not identified as a natural piece of stone.

Lithic item reference number - a unique sequential number applied to each recorded lithic item in the combined artefact database.

Lithic item type - formal category of an artefact (including lithic fragments).

Lithic quarry - a site of stone procurement, typically used in the specific sense to refer to outcrops of bedrock, where there is clear evidence of procurement activity such as pits, discarded hammerstones and large deposits of primary flaking debris. Refer also to *quarry, stone procurement site*.

Locus (site locus) - a spatially separate location of heritage evidence within a *site*. Artefacts/features clearly associated and occurring as a discrete event (eg. a *knapping floor*) were also recorded as separate *loci*;

Loss or intentional discard of microliths - activity category comprising the discard of microlithic implements either during manufacture, after use or unintentionally.

Lower slope - slope element adjacent above a flat or depression, but not adjacent below a crest or flat (after McDonald *et al* 1984) (refer to *simple slope*).

Manuport - an object, or fragment of an object (or 'item'), that has been brought by a human to the place where it has been collected.

Mean archaeological visibility of site locus - an estimate of the mean visible ground surface within a *site locus* that has potential to contain evidence of Aboriginal heritage [expressed as a percentage of the *visible site area*].

Mean artefact density (sites) - the average number of artefacts recorded within each square metre of visible ground surface with potential to contain Aboriginal artefacts that is physically inspected within a site or site locus. Obtained by dividing the *number of artefacts* by the *effective site or locus area* and expressed as a number of artefacts per square metre of effective site/locus area.

Mean surface visibility of site locus - an estimate of the mean visible ground surface within a *site locus*, as a percentage of the *visible site area.*

Microblade - an elongated flake with one or more longitudinal ridges and a length greater than twice the width. This type of specialised flake is detached from a microblade core. They were probably fashioned into spear barbs, during recent prehistoric times.

Microblade core - a small core from which regularly shaped bladelets have been struck. Some microblade cores have only one or two microblade facets; others have numerous facets emanating from more than one striking platform.

Microblade portion - a piece of broken microblade (either proximal, distal or longitudinal portion).

Microblade production - activity category describing a method of making small implements (eg. bondi points, geometric microliths) from regular blades struck from a small core.

Microdebitage - flaking waste or debris (debitage), up to 10 millimetres in maximum size. There is no uniform metrical definition of microdebitage and some archaeologists specify a maximum size of 5 millimetres.

Microlith - (synonymous with *backed blade*) - a variety of small, delicately retouched implements of various shapes, such as asymmetric (bondi) point, segment, crescent, triangle, trapeze, rectangle and oblique ended. These implements probably functioned as spear barbs.

Mid-slope - slope element not adjacent below a crest or flat, and not adjacent above a flat or depression (after McDonald *et al* 1984) (refer to *simple slope*).

Modified (ground) - any substantial areas of disturbed ground, in which the potential for heritage evidence to exist is negligible and were therefore not assessed further in this study.

Mudstone - a sedimentary rock typically consisting of more than 50% clay and silt. It is the lithified equivalent of mud. The term is often used when it is not possible to define the rock more precisely as a claystone, siltstone or shale.

Non-specific stone flaking - activity category of general or non-specific knapping activity. Artefacts do not identify a more specific activity. Includes debitage from primary flaking and from making flake tools.

Number of artefacts - in relation to the survey, the total number of artefacts recorded within a *component*, in addition to the estimated or counted number of artefacts that were observed but not recorded. In relation to a *site locus*, the total number of artefacts recorded within the locus, in addition to the estimated or counted number of artefacts that were observed but not recorded in detail.

Number of artefacts/m² of effective site area - refer to *mean artefact density (sites).*

Number of knapping floors - the number of discrete knapping floors of a single stone material identified within a site *locus*.

Order of watercourse - the order of the watercourse (1st, 2nd, etc), after McDonald *et al* 1984, as determined by observations in the field or from base mapping.

Original nucleus - a piece of stone (core) carried from its source to an *activity area*, for the purpose of knapping it to make stone implements.

Pebble - a waterworn stone less than 64 mm in diameter. Refer also to *cobble*.

Percentage of component sampled - an estimate of the percentage of an overall survey *component area* that has been physically inspected in such a manner as to reliably enable the detection of heritage evidence.

Platform faceting - a series of flakes removed transversely, to set up the platform of a microblade core. These flake detachments create ridges where the margins of the scars meet or overlap, and such ridges provide surface prominences that are the hammerstone's point of contact. These ridges allow for more precise flaking of microblades.

Platform preparation - flaking the surface of a core's initiation platform (*platform faceting*) and removal of any overhanging edge (spur removal) to create a suitable topography and geometry for microblade detachment (refer also to *platform faceting* and *spur removal flake*).

Potential resource - archaeological evidence predicted to occur through application of a predictive model of site location.

Potlid - a piece of lithic material that has a generally convex or dome-shaped ventral surface, often with evidence of fracture initiation from a location within the surface and not from the edge. Detached by heating and cooling, not percussive blows.

Proximal - the top part of a flake, beginning with the initiation surface or ridge. Likewise for an implement (or tool). The opposite end of the flake is termed the distal end.

Quarry (lithic quarry, stone procurement site) - a general term for the location of an exploited stone source (Hiscock & Mitchell 1993:32). Often in archaeological studies it is used in a more specific sense, to refer to places where stone was obtained by excavation from a bedrock source (*lithic quarry*).

Quartz - a mineral composed of crystalline silica (SiO_2). Quartz is a very stable mineral that does not alter chemically during weathering or metamorphism. It is hard, usually colourless or white ('milky'). In its massive form quartz occurs as geodes or veins, from which pebbles are formed by weathering. Despite the often irregular nature of fracture in quartz, the flakes tend to have sharp edges.

Quartzite - a hard, silica rich stone formed from sandstone that has been recrystallised by heat (metaquartzite) or strengthened by slow infilling of silica in the voids between sand grains (orthoquartzite). The essential difference between sandstone and quartzite is that a major fracture will propagate around the larger grains in sandstone and through the grains in quartzite.

Reduction process - the process of removing flakes from a core, or manufacturing an implement by flaking and/or grinding, or progressively rejuvenating a tool's working edge.

Reduction strategy - strategy of flaking and/or grinding a piece of stone in predetermined stages to produce an implement.

Residues on stone tools - residue analysis concerns the identification of tool use activities from preserved organic and inorganic residues of worked materials. These residues may be compacted into small flake scars on the edges of utilised artefacts or adhere strongly to their surfaces.

Retouch or *retouching* - an area of flake scars on an artefact resulting from intentional shaping or resharpening of a stone tool. In resharpening a cutting edge, the retouch is invariably found only on one side (refer also to *indeterminate retouched piece* and *retouch flake*).

Retouched flake/microblade - a flake or microblade retouched along a lateral margin.

Ridge crest - landform element that stands above most or all of the surrounding points in the adjacent terrain, typically smoothly convex upwards and with a length greater than the width of the landform element (after McDonald *et al* 1984). For the purposes of the survey this unit also includes hill crests.

Rhyolite - acid lavas containing free quartz. It is the fine-grained volcanic or extrusive equivalent of granite. Rhyolite is typically light in colour, relatively light in weight and often has a flinty appearance. Two principal varieties can be identified, banded rhyolite, which possesses coloured bands, and porphyritic rhyolite, which contains small, widely spaced crystal inclusions.

Sandstone - a cemented or compacted rock consisting of detrital grains, which range in size from 1/16 mm to 2 mm in diameter. Quartz typically comprises the majority of grains. The grains can be bound together by a cement of silica, carbonate or other minerals, or a matrix of clay minerals. The nature of the cement is denoted by terms such as argillaceous (clayey), calcareous, ferruginous and tuffaceous sandstone.

Scarred tree - scarred trees contain scars caused by the removal of bark for use in manufacturing canoes, containers, shields or shelters. Other trees may exhibit carvings made in relation to burial practices or spiritual beliefs.

Scuffage and treadage - a term used to describe the horizontal and vertical displacement of artefacts by normal human activity within a camp or other high activity area.

Silcrete - a brittle, intensely indurate rock composed mainly of quartz clasts cemented by a matrix which may be well-crystallized quartz, cryptocrystalline quartz or amorphous (opaline) silica (Langford-Smith 1978:3). The texture of silcrete reflects that of the host rock and clasts may range in size from very fine grains to boulders. Silcrete is produced by an absolute accumulation of silica, which is made available by chemical weathering. The formation of silcrete therefore requires the removal of most elements, other than silicon, in the host material. Silcrete is normally grey in colour, but can be whitish, red, brown or yellow. It shatters readily into sharp, angular pieces with a conchoidal fracture and newly broken rocks have a semi-vitreous sheen (Langford-Smith 1978:4). Silcrete is also known as 'grey billy' and a sub-type as 'porcellanite'.

Siltstone - a very fine grained sedimentary rock (mudstone) with a grain size ranging between 0.004 mm and 0.063 mm. Siltstone is more coarse grained than claystone, the other primary variety of mudstone.

Simple slope - slope landform element adjacent below a crest or flat and adjacent above a flat or depression (after McDonald *et al* 1984). For the purposes of the survey, this unit also includes *upper slopes*, *mid-slopes* and *lower slopes*.

Site - location of evidence of Aboriginal occupation. In the context of this report, site commonly refers to *artefact scatter*.

Site integrity - the extent to which the distribution of site contents corresponds to their spatial relationships at the time of deposition. Subsequent to deposition, a range of post-depositional processes affect the spatial relationships of items, and therefore site integrity.

Site locus - refer to *locus*.

Site number - Aboriginal heritage site identification label, numbered sequentially after the recorders initials [eg. PK1, PK2, . . .]. As the area of a single Aboriginal *site* is defined by the *survey area* itself, the site number corresponds to the survey area number;

Size class - maximum dimension of a lithic item, described within size classes representing 10 millimetre units. For example, an item measuring 1-10 mm is recorded in size class 1.

Slope (class of slope) - three classes of slope were delineated across the study area:

Class 1 (level/very gentle) - level to very gently inclined slopes <3% (1°45′);
Class 2 (gentle) - gently inclined slopes >3% (1°45′) and <10% (5°45′); and
Class 3 (moderate/steep) - moderately inclined and steep slopes >10% (5°45′).

Soils - soil unit as identified on soil mapping.

Spur crest - landform element comprising a very gently to steeply inclined *ridge crest* that descends from a dominant or main ridge crest to adjacent lower lying terrain (eg. *flats* or *valley flats*).

Stone artefact - a piece of stone with evidence of intentional human modification.

Stone arrangement - stone arrangements include circles, mounds, lines or other patterns of stone arranged by Aboriginal people.

Stone layer - a sheet, or layer, of gravel sized stones, found within a soil deposit. Commonly formed at the lower limit of bioturbation, or in the Hunter Valley, at the junction of the A and B horizon soils. The stone layer may also contain a concentration of stone artefacts.

Stone material - the geological type of stone from which an artefact is made. Synonymous with 'lithic material', 'stone type' and 'raw material', the latter of which is a less specific but commonly used term.

Stone procurement site (quarry) - a general term for the location of an exploited stone source. Sources can vary from alluvial gravels (where there may be little or no archaeological evidence of human activity) to extensively quarried outcrops of bedrock, where there is clear evidence of procurement activity such as pits, discarded hammerstones and large deposits of primary flaking debris (refer also to *quarry, lithic quarry*).

Stone tool - a piece of flaked or ground stone used in an activity or fashioned for use as a tool. A synonym of stone tool is *implement*, which is more often used to describe a flake tool fashioned by more delicate flaking (retouch).

Sub-surface deposit - identified or predicted deposits of artefacts buried under the surface, typically within the A horizon of texture-contrast soils in the Hunter Valley.

Surface visibility - a mean estimate of the percentage of visible ground surface within a *total sample area* or a *site locus*. Where a single component's *sample area* is comprised of multiple exposures, the surface visibility was recorded separately and the range of the surface visibility percentages noted in the survey or site database.

Survey area - an area sampled during the present survey, consisting of a single *archaeological terrain unit* that is bounded on all sides by different archaeological terrain units. Survey areas are numbered sequentially after the recorders initials (refer also to *component area*).

Tabular nucleus - a core (nucleus) selected from a tabular piece of rhyolitic tuff often <50 millimetres thick. These tabular pieces derive from surface weathering of layers of tuff.

Technological attribute analysis - methods of reconstructing reduction sequences in stone technology (refer to *reduction sequence*). Discrete and metrical attributes of artefacts are identified, recorded and examined mathematically.

Thumbnail scraper - a small flake implement about the size and shape of a human thumbnail. One end of the implement is retouched so that it has a convex, semi-circular plan shape.

Tip snapped - breakage of the distal (pointed) end of a bondi point. This fracture is normally initiated by bending force. It occurs during production of the implement and also during its use.

Total sample area - the quantity of ground surface within a survey *component* physically inspected in such a manner as to reliably enable the detection of heritage evidence. The measure is generally obtained by multiplying the recorded dimensions of a component with the *percentage of the component sampled.* For a component that includes multiple exposures, each was calculated separately to obtain the *total sample area* of the *component.*

Tuff - refer to *indurated rhyolitic tuff.*

Upper slope - slope element adjacent below a crest or flat, but not adjacent above a flat or depression (after McDonald *et al* 1984) (refer to *simple slope*).

Use fractures - breakages on the edges of stone tools resulting from tool use (refer also to *use-wear*).

Use-wear - microscopic and macroscopic damage to the surfaces of a stone implement resulting from its use. Examination for use-wear is aided by low-magnification microscopy. Major use-wear forms are edge fractures, use-polish and smoothing, abrasion, and edge rounding and bevelling.

Utilised flake/microblade - a flake or microblade displaying utilisation wear along one or more edges from use as a hand-held tool or as part of a composite wood and stone implement or weapon. The wear may be edge-rounding, surface polish, abrasive smoothing or abrasion such pitting and scratching ('striations').

Valley flat - a compound landform element comprising a gently inclined to level flat, aggraded or occasionally eroded by channelled or over-bank stream flow, typically enclosed by hill slopes (after McDonald *et al* 1984). For the purposes of the survey, this unit also includes stream beds, stream banks and stream channels where they exist within a valley flat.

Vegetation - in a survey context, the present vegetation structure as identified in the field.

Ventral face - the inside surface of a flake created during the flake's formation. The speed of the fracture ranges from about 200 metres to over 1000 metres per second (refer also to *dorsal face*).

Visible extent of artefacts - for each *site locus*, the approximate dimensions of the area in which artefacts are visible.

Visible extent of surface exposures - the approximate dimensions of a surface exposure in which a *site locus* has been identified.

Visible site area - for each *site locus*, the gross surface area in which artefacts are visible, calculated by multiplying the dimensions of the *visible extent of artefacts*.

Working edge - the edge of a tool in contact with the worked substance or material during its usage.

APPENDIX 2: SURVEY RECORDING FORM

KEY:

Listed below are descriptions of each code used within the Archaeological Survey Coverage Database (Appendix 6) and Recording Form. Definitions of technical terms are included within the report glossary (Appendix 1).

Slope:	1 - level/very gentle 2 - gentle 3 - moderate/steep
Order of Watercourse:	1 - first order 2 - second order 3 - third order 4 - fourth order
Geology:	Pb - Branxton Formation Pr - Rowan Formation Qa - Quaternary Deposits Cz - Cainozoic Slopewash deposits
Soils:	1 - Lithosols 2 - Earthy or Siliceous Sands or Alluvial Soils 3 - Earthy Sands 4 - Brown and Yellowish Brown Massive Earths 5 - Yellow Duplex Soils 6 - Red Duplex Soils 7 - Brown and Other Coloured Duplex Soils 8 - Uniform or Gradational Clays 6-8 - Association of groups 6, 7 and 8
Vegetation:	1 - modified grass/crop 2 - native grass 3 - scattered woodland 4 - open woodland 5 - absent
Land Surface:	1 - sheet erosion 2 - rill erosion 3 - gully erosion 4 - stream bank erosion 5 - aggrading 6 - modified 7 - densely vegetated
Detection Limiting Factors:	1 - vegetation 2 - leaf litter/gravel 3 - sediment deposition 4 - other

SURVEY RECORDING FORM

Survey Area (Archaeological Terrain Unit) #:.................................... Component #:............................

Landform Element:

ridge crest		upper slope		bench		stream bank		terrace (plain)	
spur crest		mid-slope		drainage depression		flat		other	
simple slope		lower slope		gully		valley flat			

Slope:

level-very gentle (<3%; <1.45°)		gentle (>3-10%; >1.45°-5.45°)		moderate or steep (>10%; >5.45°)	

Distance to Watercourse:

<50 metres		50-100 metres		>100 metres	

Type of Watercourse:

1st order		2nd order		3rd order		4th order	

Vegetation:

modified grass/crop		native grass		scattered woodland		open woodland		absent	

Land Surface:

sheet erosion		rill erosion		gully erosion		stream bank erosion		aggrading		modified	

Exposure Type:

A horizon exposed		A + B horizon exposed		B horizon exposed	

Overall Component Area (m): Length .... Width .... Total ....

Sample Size (% of Component Area inspected): ....%

Mean Surface Visibility (of Component): ....%

Detection Limiting Factors:

vegetation		leaf litter/gravel		sediment deposition		other (specify)	

Mean Archaeological Visibility (of component): ....%

Ground Disturbance:

low (natural, grazing, minor vegetation removal, minimal erosion)	
moderate (extensive vegetation removal, modified grasses, moderate erosion)	
high (extensive vegetation removal + cultivated, A horizon removed by erosion or human impact)	

- Mark location of Survey Area & Component on base map. Plate # ..../..........

Comments: (eg. Historical Heritage - description and location; stone materials available)

APPENDIX 3: ABORIGINAL HERITAGE SITE RECORDING FORM

Listed below are descriptions of each code used within the Aboriginal Heritage Site Database (Appendix 7) and Recording Form. Definitions of technical terms are included within the report glossary (Appendix 1).

Landform Element:	1 - ridge crest 2 - spur crest 3 - simple slope 8 - drainage depression 11 - flat
Slope:	1 - level/very gentle 2 - gentle 3 - moderate/steep
Distance to Watercourse:	1 - <50 metres 2 - 50-100 metres 3 - >100 metres
Order of Watercourse:	1 - first order 2 - second order 3 - third order 4 - fourth order
Vegetation:	1 - modified grass/crop 2 - native grass 3 - scattered woodland 4 - open woodland 5 - absent
Land Surface:	1 - sheet erosion 2 - rill erosion 3 - gully erosion 4 - stream bank erosion 5 - aggrading 6 - modified 7 - densely vegetated
Exposure Type:	1 - A horizon 2 - A & B horizons 3 - B horizon
Ground Disturbance:	1 - low 2 - moderate 3 - high
Sub-surface Deposit:	1 - unlikely 2 - possible 3 - probable

ABORIGINAL HERITAGE SITE RECORDING FORM

SITE #:........................ Archaeological Terrain Unit #:......................... Component #:.........................

Recording Intensity (total or sample - estimate total # artefacts):..

	Locus A	Locus....	Locus....	Locus....
Visible Extent of Artefacts (m):	..................:	......................:	......................:	....
Extent of Surface Exposures (m):	..................:	......................:	......................:	....
Mean Surf. Vis. (visible extent of site):	..................:	......................:	......................:	....
Mean Arch. Vis. (visible extent of site):	..................:	......................:	......................:	....

Artefact Density: Mean: ....artefacts/m² effective site area Sample Area:........x........metres

Highest:........artefacts/m² effective site area Sample Area:........x........metres

Sub-surface Deposit: | unlikely | | possible | | probable | | potential extent: x m |

Knapping Floor (record each separately):

Locus:	..................:	......................:	......................:	....
Stone Material:	..................:	......................:	......................:	....
Area (length x width):	..................:	......................:	......................:	....
Artefact Density (per m² effective site area):	..................:	......................:	......................:	....

Comments:

Hearth/Fireplace (if present, note stone material type, dimensions of feature, presence of charcoal and/or staining, integrity and association with other features, eg. knapping floors):

Stone materials available (eg. note silcrete cobbles, etc):

- Mark location of Site on base map. Plate # ..../..........

Site Plan (show north, Terrain Unit, Components, exposure distribution, artefact distribution, loci artefacts recorded in, location of other features):

APPENDIX 4: LITHIC ITEM RECORDING FORM

Listed below are descriptions of each code used within the Aboriginal Heritage Lithic Item Database (Appendix 8) and Recording Form. Definitions of technical terms are included within the report glossary (Appendix 1).

Size Class: maximum dimension of a lithic item, described within size classes representing 10 millimetre units. For example:

1 - artefact measuring 1-10 mm
2 - artefact measuring 11-20 mm
3 - artefact measuring 21-30 mm

LITHIC ITEM RECORDING FORM

SITE #: **DATE:**

Artefact #	Locus	red/pink/purple silcrete	cream/yellow silcrete	grey silc	other silcrete	grey tuff	yellow/brown tuff	red tuff	other tuff	porcellanite	quartz	quartzite	chalcedony	other (specify)	lithic fragment	flake	flake portion (specify)	bipolar flake/portion (specify)	microblade	microblade portion (specify)	flaked piece	core	bipolar core	microblade core	bondi point	bondi point portion (specify)	geometric microlith	hammerstone/anvil (specify)	other (specify)	Size Class (eg. 0-1cm = 1)	Cortex Amount (%)	Cortex Type (Peb/Terr/Tab)	COMMENTS: - retouch (type, amount, location) - use-wear (type, amount, location) - associated items - knapping floor (Ass.) - heat fracture attributes (HF) - cores: # platforms, flaking pattern (alternating, unidirectional, bipolar), # scars, platform preparation (faceted, tabular, cortical)
1																																	
2																																	
3																																	
4																																	
5																																	
6																																	
7																																	
8																																	
9																																	
0																																	
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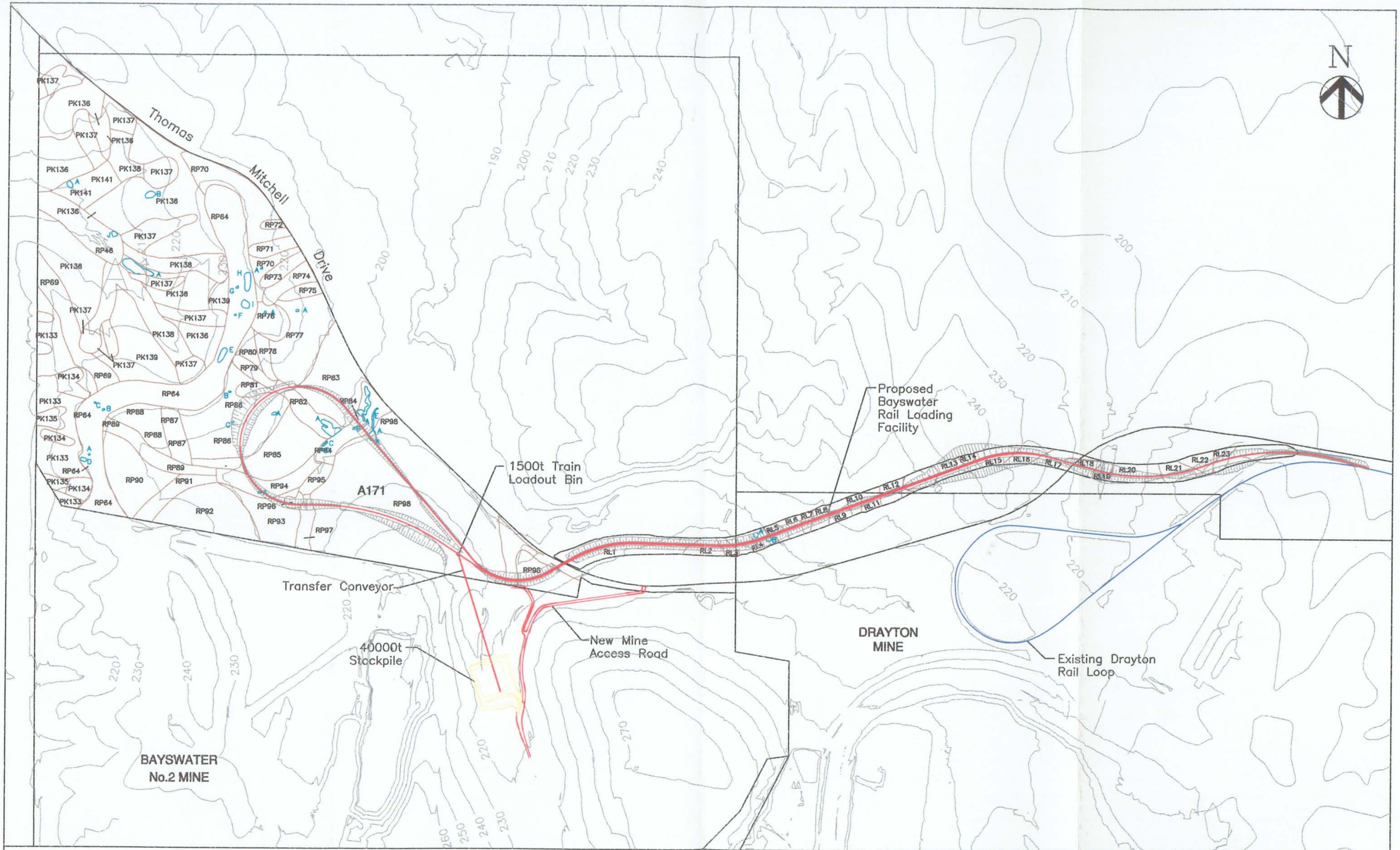
6																																	
7																																	
8																																	
9																																	
0																																	
1																																	
2																																	
3																																	
4																																	
5																																	

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 cm



Legend

- Proposed Rail Loading Infrastructure
- Existing Rail Loading Infrastructure
- Approved Infrastructure
- Survey Areas
- Aboriginal Sites

0 100 200 300 400 500m

Contour interval 10m

Umwelt (Australia) Pty Limited
Source: Bateman Australia Dwg No.60-M-135_B

APPENDIX 5
Location of Archaeological Survey Areas & Aboriginal Heritage Sites

A3 Scale 1:12 000 | Ref No.:1323/R01_AP5/dra_052.dwg

APPENDIX 6: BAYSWATER #2 RAIL LOADING FACILITY - SURVEY COVERAGE DATABASE

Survey Area	Component	Landform Element	Slope	Distance to Watercourse (metres)	Order of Watercourse	Archaeological Terrain Unit	Geology	Soils	Vegetation	Land Surface	Exposure Type (Horizon)	Total Sample Area (m²)	Surface Visibility (%)	Detection Limiting Factors	Archaeological Visibility %	Ground Disturbance	Effective Survey Coverage (m²)	# Artefacts	Artefact Density/m² of Effective Survey Coverage	Comments
PK133	1	simple slope	3	50-100	1, 2	moderate/slope	Pb	7	3	1, 6	A/B	545	10-80	1	5-60	mod	139	0	0	Rock outcropping with quartz veins
PK134	1	drainage	3	<50	1	moderate/drainage	Pb	7	3	1	A/B	70	70	1	20	mod	14	0	0	
PK135	1	drainage	3	<50	2	moderate/drainage	Pb	7	3	1	A/B	100	50	1	30	mod	30	0	0	
PK136	1	simple slope	3	50-100	1, 2, 3, 4	moderate/slope	Pb	6, 7	3	1	A/B	5900	20-80	1	20-40	mod	1570	8	0.0051	Loci A & B
PK137	1	drainage	3	<50	1, 2	moderate/drainage	Pb	6, 7	2, 3	1	A/B	928	70-90	1	10-40	mod	168	0	0	
PK138	1	drainage	3	<50	2	moderate/drainage	Pb	6, 7	2, 3	1	A/B	200	70	1	20	mod	40	0	0	
PK139	1	simple slope	2	50-100	1, 2	gentle/slope	Pb	6	2, 3	1	A/B	1700	30-80	1	20-25	mod, high	345	1	0.0029	Locus A
PK141	1	drainage	3	<50	3	moderate/drainage	Pb, Qa	3, 6, 7	2, 3	1	A/B	1200	40-70	1	20	mod, high	240	1	0.0042	Locus A
RP46	5	drainage	2	<50	3	gentle/drainage	Pb, Qa, Cz	3, 7	2, 3	1, 4	A/B	400	70	1	30	mod, high	120	2	0.0167	Locus J
RP52	2	spur crest	2	>100		gentle/spur crest	Pb	7	2	1	A/B	20	1	1	1	mod	0.2	0	0	
RP64	1	ridge crest	2	50-100	1	gentle/ridge crest	Pb	6	1, 2, 3	1, 7	A/B	5,525	10-50	1, 2	10-50	mod	1922	21	0.0109	Loci A, B, C, D, E, F, G, H & I
RP64	2	ridge crest	2	50-100	1	gentle/ridge crest	Pb	6	1	6	B	975	90	2	2	high	19.5	0	0	
RP69	1	spur crest	2	50-100	1	gentle/spur crest	Pb	6	1, 2, 3	1, 7	A/B	3,236	5	1, 2	2	mod	64.7	0	0	
RP70	1	simple slope	3	50-100	1	moderate/slope	Pb	6	2, 4	1, 7	A/B	4168	5	1, 2, 4	1	low	41.7	0	0	
RP70	2	simple slope	3	50-100	1	moderate/slope	Pb	6	2, 4	1	A/B	700	20-50	1, 2	20-50	mod	175	2	0.0114	Locus A
RP71	1	drainage	3	<50	1	moderate/drainage	Pb	6	2, 4	1, 5	A/B	3,684	5	1, 2, 4	1	low	36.8	0	0	
RP72	1	drainage	2	<50	1	gentle/drainage	Pb	6	2, 4	1, 5	A/B	1,110	5	1, 2	2	low	22.2	0	0	
RP73	1	drainage	2	<50	1	gentle/drainage	Pb	6	2, 3	1, 5	A/B	2,255	5	1, 2	2	low	45.1	0	0	
RP74	1	drainage	2	<50	1	gentle/drainage	Pb	6	2, 4	1, 3, 5	A/B	4,077	5	1, 2	2	mod	81.5	0	0	Sandstone boulders, quartz pebbles, silcrete cobbles
RP75	1	drainage	3	<50	1	moderate/drainage	Pb	6	2, 4	1, 3	A/B	2,245	3	1, 2	1	mod	22.5	0	0	Silcrete cobbles; quartz pebbles
RP76	1	spur crest	2	50-100	1	gentle/spur crest	Pb	6	2, 4	7	A	4,423	3	1	1	low	44.2	0	0	
RP76	2	spur crest	2	50-100	1	gentle/spur crest	Pb, Pr	6	2, 4	1	A	1,080	90	1, 2	60	low	648	3	0.0046	Locus A
RP77	1	simple slope	3	50-100	1, 2	moderate/slope	Pb	6	2, 4	7	A	8,514	2	1, 2	1	low	85.1	1	0.0118	Locus A

BAYSWATER #2 RAIL LOADING FACILITY - SURVEY COVERAGE DATABASE

Survey Area	Component	Landform Element	Slope	Distance to Watercourse (metres)	Order of Watercourse	Archaeological Terrain Unit	Geology	Soils	Vegetation	Land Surface	Exposure Type (Horizon)	Total Sample Area (m^2)	Surface Visibility (%)	Detection Limiting Factors	Archaeological Visibility %	Ground Disturbance	Effective Survey Coverage (m^2)	# Artefacts	Artefact Density/m^2 of Effective Survey Coverage	Comments
RP78	1	drainage	3	<50	1	moderate/drainage	Pb	6	2, 4	3	A/B	3,038	5	1, 2	2	mod	60.8	0	0	
RP79	1	drainage	3	<50	1	moderate/drainage	Pb	6	2, 4	1, 3	A/B	3,833	5	1, 2	2	mod	76.7	0	0	
RP80	1	simple slope	3	50-100	1	moderate/slope	Pb	6	2, 3	1, 7	A	3,476	10	1, 2	5	low	173.8	0	0	
RP81	1	drainage	2	<50	1	gentle/drainage	Pb	6	2, 4	3	A/B	1,300	5	1, 2	2	mod	26	0	0	
RP82	1	drainage	2	<50	2	gentle/drainage	Pb, Pr	6	2, 3	3, 7	A/B	3,605	3	1	1	mod	36.1	0	0	
RP82	2	drainage	2	<50	2	gentle/drainage	Pb, Pr	6	2	3	A/B	2,160	80	1	40	high	864	65	0.0752	
RP83	1	simple slope	2	50-100	2, 3	gentle/slope	Pr	6	1, 2	1, 7	A	9,104	2	1	1	mod	91	0	0	
RP84	1	drainage	2	<50	2, 3	gentle/drainage	Pr	6	1, 2	1, 3, 4	A/B	6,148	2	1	1	mod	61.5	0	0	
RP84	2	drainage	2	<50	1, 2, 3	gentle/drainage	Pr	6	1, 2	4	A/B	890	30-50	1	30-50	high	357	83	0.2325	Loci A, B, C, D & E
RP85	1	simple slope	1	50-100	1, 2	level/slope	Pb, Pr	6	1, 2	7	A	4,102	10	1	5	mod	205.1	0	0	
RP86	1	simple slope	2	50-100	1, 2	gentle/slope	Pb, Pr	6	1, 2, 3	7	A	18,832	2	1	1	mod	188.3	0	0	
RP86	2	simple slope	2	50-100	1	gentle/slope	Pb, Pr	6	1, 2	1, 2	A/B	2875	10-60	1, 2	10-60	high	1241	6	0.0048	Loci A, B & C
RP87	1	drainage	2	<50	1	gentle/drainage	Pb, Pr	6	1, 2	7	A	3,646	2	1	1	mod	36.5	0	0	
RP88	1	simple slope	2	50-100	1	gentle/slope	Pb, Pr	6	1, 2	7	A	2,706	15	1	5	mod	135.3	0	0	
RP89	1	drainage	2	<50	1	gentle/drainage	Pb, Pr	6	1, 2	7	A	3,155	2	1	1	high	31.6	0	0	
RP89	2	drainage	2	<50	1	gentle/drainage	Pb, Pr	6	1, 2	6	A/B	500	30	1, 2	5	high	25	0	0	
RP90	1	simple slope	2	50-100	1	gentle/slope	Pb, Pr	6	1, 2	7	A	3,648	10	1	5	mod	182.4	0	0	
RP91	1	drainage	2	<50	1	gentle/drainage	Pr	6	1, 2	7	A	2,766	1	1	1	mod	27.7	0	0	
RP92	1	simple slope	2	50-100	1	gentle/slope	Pr	6	1, 2	7	A	11,250	2	1	1	mod	112.5	0	0	
RP93	1	flat	1	50-100	1	level/flat	Pr	6	1, 2	7	A	2,628	2	1	1	mod	26.3	0	0	
RP94	1	drainage	2	<50	2	gentle/drainage	Pr	6	1, 2	7	A	3,793	2	1	1	mod	37.9	0	0	
RP94	2	drainage	2	<50	2	gentle/drainage	Pr	6	1, 2	3	A/B	450	70	1	50	high	225	0	0	
RP94	3	drainage	2	<50	2	gentle/drainage	Pr	6	1	1	A	250	20	1, 2	10	mod	25	2	0.08	Locus A
RP95	1	drainage	1	<50	2	level/drainage	Pr	6	1, 2	5, 7	A	1,759	2	1	1	mod	17.6	0	0	
RP95	2	drainage	1	<50	2	level/drainage	Pr	6	1, 2	4	A/B	150	75	1	40	high	60	0	0	
RP96	1	drainage	1	<50	1	level/drainage	Pr	6	1, 2	5, 7	A	1,171	5	1	2	mod	23.4	0	0	
RP97	1	drainage	1	<50	1	level/drainage	Pr	6	1, 2	5, 7	A/B	1,222	10	1	5	mod	61.1	0	0	
RP98	1	simple slope	2	50-100	1, 2, 3	gentle/slope	Pr	6	1, 2	7	A	12,993	2	1	1	mod	129.9	0	0	

Survey Area	Component	Landform Element	Slope	Distance to Watercourse (metres)	Order of Watercourse	Archaeological Terrain Unit	Geology	Soils	Vegetation	Land Surface	Exposure Type (Horizon)	Total Sample Area (m^2)	Surface Visibility (%)	Detection Limiting Factors	Archaeological Visibility %	Ground Disturbance	Effective Survey Coverage (m^2)	# Artefacts	Artefact Density/m^2 of Effective Survey Coverage	Comments
RP98	2	simple slope	2	50-100	3	gentle/slope	Pr	6	1, 2	1	A/B	1,500	20	1, 2	10	high	150	73	0.4867	Locus A
RL1	1	simple slope	2	>50-100	2	gentle/slope			1	1	A	2,400	2	1	2	mod	48	0	0	Dense thistle cover; steep bluff/slope on opposite side of Ramrod Creek; higher potential for significant deposits closer to creek
RL2	1	spur crest	1	>50-100	2	level/spur crest			1	1	A	900	2	1	2	mod	18	0	0	Elevated above nearby Ramrod Creek
RL3	1	spur crest	1	<50	2	level/spur crest			1	1	A	90	2	1	2	mod	9	0	0	Steep bank down to adjacent creek
RL4	1	drainage	1	<50	2	level/drainage			1	1	A/B	1,782	2-80	1, 3	1-30	mod	42	3	0.0714	Loci A & B; banks are steeply sloping and eroded; disturbance from excavation of adjacent farm dam; drainage channel appears modified; low potential for deposits on 30 metre wide flat or 1-2 m wide channel
RL5	1	simple slope	2	<50	2	gentle/slope			1	1	A	900	1	1	1	mod	9	0	0	Very high potential for deposits, possibly in situ; duplex soil is exposed in nearby creek bank, with average 0.25 metre deep A horizon overlying clayey B horizon
RL6	1	simple slope	2	>100	2	gentle/slope			1	1	A	600	<1	1	<1	mod	6	0	0	
RL7	1	spur crest	2	50-100	1	gentle/spur crest			1	1	A	200	<1	1	<1	mod	2	0	0	
RL8	1	drainage	2	<50	1	gentle/drainage			1	1	A/B	200	2	1	2	mod	4	0	0	
RL9	1	simple slope	2	>50-100	1	gentle/slope			1	1	A/B	750	3-70	1	2-60	mod	198	0	0	Several strips of exposure created by recent dozer movement
RL10	1	spur crest	2	>100	1	gentle/spur crest			1	1	A/B	280	1-2	1	1-2	mod	5	0	0	
RL11	1	simple slope	2	>50-100	1	gentle/slope			1	1	A/B	425	2-70	1	2-65	mod	24	0	0	
RL12	1	drainage	2	<50	1	gentle/drainage			1	7		320	<1	1	<1	mod	3	0	0	
RL13	1	simple slope	2	>50-100	1	gentle/slope			1	1, 6	A/B	1,325	10-90	1, 3, 4	1-50	mod, high	57	0	0	Duplex soil with very shallow A horizon; abundant sedimentary, volcanic and quartz gravels/pebbles; large modified area with deeply excavated sediment ponds and fill is excluded
RL14	1	ridge crest	2	>100	1	gentle/ridge crest			1	1	A/B	300	2	1	2	mod	6	0	0	
RL15	1	drainage	2	<50	1	gentle/drainage			2, 3	1	A/B	1,400	5	1	5	mod, high	70	0	0	Vegetation is partially regrowth
RL16	1	spur crest	2	>50-100	1	gentle/spur crest			2, 3	1	A	1,200	5	1	5	mod, high	60	0	0	Vegetation is partially regrowth; several mature trees but none exhibit evidence of Aboriginal scarring

BAYSWATER #2 RAIL LOADING FACILITY - SURVEY COVERAGE DATABASE

Survey Area	Component	Landform Element	Slope	Distance to Watercourse (metres)	Order of Watercourse	Archaeological Terrain Unit	Geology	Soils	Vegetation	Land Surface	Exposure Type (Horizon)	Total Sample Area (m^2)	Surface Visibility (%)	Detection Limiting Factors	Archaeological Visibility %	Ground Disturbance	Effective Survey Coverage (m^2)	# Artefacts	Artefact Density/m^2 of Effective Survey Coverage	Comments
RL17	1	simple slope	2	>50-100	2	gentle/slope			3	1	A/B	1,800	5	1	5	mod, high	90	0	0	Vegetation is partially regrowth
RL18	1	drainage	2	<50	1	gentle/drainage			3	1	A/B	200	5	1	5	mod	10	0	0	
RL19	1	drainage	2	<50	2	gentle/drainage			3	1, 4	A/B	720	15	1	10	mod	72	0	0	Includes small flat (up to 10 metres wide) adjacent to creek channel
RL20	1	simple slope	2	>50-100	1, 2	gentle/slope			3	1	A/B	3,000	20	1	20	mod	600	0	0	High visibility in large patches in forest
RL21	1	spur crest	2	>50-100	1	gentle/spur crest			1, 3	1	A/B	1,800	1-20	1	1-20	mod, high	189	0	0	
RL22	1	simple slope	2	>50-100	1	gentle/slope			3	1, 6	A/B	780	2	1	2	mod	16	0	0	
RL23	1	spur crest	2	>100	1	gentle/spur crest			3	1	A/B	600	10	1	10	mod	60	0	0	Southern part includes cutting for adjacent Drayton rail spur

APPENDIX 7: BAYSWATER #2 RAIL LOADING FACILITY -ABORIGINAL HERITAGE SITE DATABASE

Site #	Locus	Component	Landform Element	Slope	Distance to Watercourse	Order of Watercourse	Vegetation	Land Surface	Exposure Type	Ground Disturbance	Visible Extent of Surface Exposures: Length (m)	Visible Extent of Surface Exposures: Width (m)	Visible Extent of Artefacts: Length (m)	Visible Extent of Artefacts: Width (m)	Visible Site Area (m^2)	Mean Surface Visibility of Site (%)	Mean Archaeological Visibility of Site (%)	Effective Site Area (m^2)	# of Artefacts	# of Artefacts/m^2 of Effective Site Area	# of Knapping Floors	Sub-Surface Deposit	Comments
PK136	A	1	3	3	2	1, 2, 3, 4	3	1	2	2	80	30	40	30	1200	80	20	240	6	0.025		2	
PK136	B	1	3	3	2	1, 2, 3, 4	3	1	2	2	30	20	10	5	50	70	30	15	2	0.1333		2	
PK139	A	1	3	2	2	1, 2	2, 3	1	2	2, 3	70	50	1	1	1	90	30	0.3	1	3.3333		1	
PK141	A	1	8	3	1	3	2, 3	1	2	2, 3	20	15	1	1	1	40	20	0.2	1	5		2	
RP46	J	5	8	2	1	4	2, 3	1, 4	2	2, 3	70	20	3	2	6	70	30	1.8	2	1.1111		2	
RP64	A	1	1	2	2	1	1, 2, 3	1	2	2	40	30	1	1	1	70	30	0.3	1	3.3333		1	silcrete and quartz pebbles
RP64	B	1	1	2	2	1	1, 2, 3	1	2	2	60	15	1	1	1	70	40	0.4	1	2.5		1	silcrete and quartz pebbles
RP64	C	1	1	2	2	1	1, 2, 3	1	2	2	30	20	1	1	1	90	50	0.5	1	2		1	silcrete and quartz pebbles
RP64	D	1	1	2	2	1	1, 2, 3	1	2	2	2	2	2	2	4	80	40	1.6	6	3.75	1	1	silcrete and quartz pebbles
RP64	E	1	1	2	2	1	1, 2, 3	1	2	2	60	10	15	2	30	50	30	9	3	0.3333		1	silcrete and quartz pebbles
RP64	F	1	1	2	2	1	1, 2, 3	1	2	2	30	20	1	1	1	70	40	0.4	1	2.5		1	silcrete and quartz pebbles
RP64	G	1	1	2	2	1	1, 2, 3	1	2	2	15	15	1	1	1	20	10	0.1	1	10		1	silcrete and quartz pebbles
RP64	H	1	1	2	2	1	1, 2, 3	1	2	2	60	10	50	10	500	30	10	50	5	0.1		1	
RP64	I	1	1	2	2	1	1, 2, 3	1	2	2	40	20	5	5	25	80	50	12.5	2	0.16		1	
RP70	A	2	3	3	2	1	2, 4	1	2	2	10	5	1	1	1	80	50	0.5	2	4		1	silcrete cobbles, quartz cobbles
RP76	A	2	2	2	2, 3	1	2	1	1	1	40	30	4	1	4	90	60	2.4	3	1.25		2	
RP77	A	1	3	3	2, 3	1, 2	2, 4	7	1	1	2	2	1	1	1	30	10	0.1	1	10		1	silcrete cobbles, quartz pebbles
RP82	A	2	8	2	1	2	2	3	2	3	60	40	35	25	875	80	40	350	65	0.1857		2	small fragments of red & yellow ochre; one large piece of red ochre - 10 cm
RP84	A	2	8	2	1	3	1, 2	4	2	3	150	3	80	3	240	80	50	120	45	0.375		2	
RP84	B	2	8	2	1	3	1, 2	4	2	3	100	2	1	1	1	60	30	0.3	1	3.3333		2	
RP84	C	2	8	2	1	3	1, 2	4	2	3	25	2	1	1	1	50	30	0.3	1	3.3333		2	
RP84	D	2	8	2	1	3	1, 2	4	2	3	20	2	1	1	1	50	30	0.3	1	3.3333		2	
RP84	E	2	8	2	1	3	1, 2	4	2	3	25	2	25	2	50	50	30	15	35	2.3333		2	
RP86	A	2	3	2	2	1	1, 2	1, 2	2	3	10	5	2	1	2	20	10	0.2	3	15		1	ochre - small fragment; quartz pebbles, ironstone, sandstone
RP86	B	2	3	2	2	1	1, 2	1, 2	2	3	80	20	1	1	1	80	50	0.5	1	2		1	ochre - small fragment; quartz pebbles, ironstone, sandstone
RP86	C	2	3	2	2	1	1, 2	1, 2	2	3	15	5	3	1	3	70	40	1.2	2	1.6667		1	ochre - small fragment; quartz pebbles, ironstone, sandstone
RP94	A	1	8	2	1	2	1	1	1	2	25	10	4	1	4	20	10	0.4	2	5		2	

BAYSWATER #2 RAIL LOADING FACILITY -ABORIGINAL HERITAGE SITE DATABASE

Site #	Locus	Component	Landform Element	Slope	Distance to Watercourse	Order of Watercourse	Vegetation	Land Surface	Exposure Type	Ground Disturbance	Visible Extent of Surface Exposures: Length (m)	Visible Extent of Surface Exposures: Width (m)	Visible Extent of Artefacts: Length (m)	Visible Extent of Artefacts: Width (m)	Visible Site Area (m^2)	Mean Surface Visibility of Site (%)	Mean Archaeological Visibility of Site (%)	Effective Site Area (m^2)	# of Artefacts	# of Artefacts/m^2 of Effective Site Area	# of Knapping Floors	Sub-Surface Deposit	Comments
RP98	A	2	3	2	2	3	1, 2	1	2	3	50	30	50	30	1500	20	10	150	73	0.4867		3	quartz pebbles
RL4	A	1	8	1	1	2	1	1	2	2	7	2	2	1	2	80	30	0.6	2	3.3333		3	very high potential for adjacent simple slope (RL5) more so than creek bank
RL4	B	1	8	1	1	2	1	1	2	2	24	2	1	1	1	60	10	0.1	1	10		3	very high potential for adjacent simple slope (RL5) more so than creek bank

APPENDIX 8: BAYSWATER #2 RAIL LOADING FACILITY - ABORIGINAL HERITAGE LITHIC ITEM DATABASE

Site #	Locus	Lithic Item Reference #	Stone Material	Lithic Item Type	Size Class	Cortex Amount (%)	Cortex Type	Comments
PK136	A	8641	tuff 4	flake medial portion	5	15	tab.	
PK136	A	8642	quartz	flake proximal portion	3			
PK136	A	8643	quartzite	flake	7			
PK136	A	8644	silcrete 1	flake	3			
PK136	A	8645	silcrete 2	flake medial portion	4			
PK136	A	8646	chert	flake	4			
PK136	B	8647	tuff 4	flake distal portion	2			
PK136	B	8648	silcrete 3	flaked piece	5			
PK139	A	8649	tuff 3	flake proximal portion	3	10	tab.	
PK141	A	8650	tuff 3	core	4	10	tab.	1 scar, 1 platform.
RP46	J	11087	tuff 2	core	5	30	tab.	6 scars, 2 platforms.
RP46	J	11088	silcrete 3	microblade core	7			5 scars, 2 platforms.
RP64	A	11306	tuff 3	flake	3	5	tab.	hinge termination.
RP64	B	11307	silcrete 1	utilised/retouched flake/ microblade (incl. portion)	5			scraper; edge steep; distal margin - 25mm long, 5mm high.
RP64	C	11308	tuff 4	flake proximal portion	3			
RP64	D	11309	quartzite	flaked piece	6			
RP64	D	11310	quartzite	microblade core	10			5 scars, 1 platform
RP64	D	11311	quartzite	flake proximal portion	8			
RP64	D	11312	quartzite	flake proximal portion	6			
RP64	D	11313	quartzite	flake	3			
RP64	D	11314	quartzite	flake proximal portion	3			
RP64	E	11315	quartzite	flake	5			
RP64	E	11316	silcrete 3	core	7			3 platforms, 5 scars
RP64	E	11317	silcrete 3	flake	5			twin hertzian cores
RP64	F	11318	silcrete 4	microblade core	4			4 scars, 2 platforms, opposed
RP64	G	11319	silcrete 3	flake	8	15	peb.	
RP64	H	11320	tuff 1	flaked piece	4			
RP64	H	11321	silcrete 2	flake	9			
RP64	H	11322	silcrete 3	flake	9	40	peb.	
RP64	H	11323	quartzite	core	7	30	peb.	5 scars, 3 platforms
RP64	H	11324	quartzite	core	7			6 scars, 3 platforms
RP64	I	11325	silcrete 2	core	10	30	terr.	1 platform, 3 scars
RP64	I	11326	silcrete 3	flake	3	20	terr.	
RP70	A	11419	tuff 2	utilised/retouched flake/ microblade (incl. portion)	1			associated; retouch along 1 margin - appears to be a flake that has come off in use or treadage.
RP70	A	11420	tuff 2	utilised/retouched flake/ microblade (incl. portion)	4			associated; retroflex hinge termination - 15mm of retouch and use-wear along margin.
RP76	A	11421	tuff 3	flake medial portion	4			
RP76	A	11422	tuff 4	core	5	5	tab.	4 platforms, 11 scars, banded white & red/purple.
RP76	A	11423	tuff 3	lithic fragment	3			
RP77	A	11424	silcrete 1	core	4			6 scars, 2 platforms - opposed.
RP82	A	11425	silcrete 3	flake	4			
RP82	A	11426	silcrete 2	core	6			6 scars, 1 platform - 25mm of heavy step fracturing.
RP82	A	11427	tuff 2	flake	1			microlith backing flake.
RP82	A	11428	tuff 3	flake	3			
RP82	A	11429	porcellanite	microblade core	4			13 scars, 3 platforms.
RP82	A	11430	silcrete 3	flake	4			
RP82	A	11431	silcrete 1	microblade	3			
RP82	A	11432	tuff 4	flake	6	40	tab.	
RP82	A	11433	tuff 3	flake	2			
RP82	A	11434	silcrete 1	microblade	4			
RP82	A	11435	tuff 2	flake proximal portion	4			
RP82	A	11436	tuff 3	flaked piece	3	10	tab.	
RP82	A	11437	tuff 2	lithic fragment	3			
RP82	A	11438	tuff 1	flake	3			
RP82	A	11439	silcrete 1	lithic fragment	5	10	terr.	shatter.
RP82	A	11440	silcrete 1	microblade proximal portion	2			
RP82	A	11441	tuff 2	lithic fragment	2			
RP82	A	11442	silcrete 1	lithic fragment	3			

BAYSWATER #2 RAIL LOADING FACILITY - ABORIGINAL HERITAGE LITHIC ITEM DATABASE

Site #	Locus	Lithic Item Reference #	Stone Material	Lithic Item Type	Size Class	Cortex Amount (%)	Cortex Type	Comments
RP82	A	11443	tuff 2	flake proximal portion	2			
RP82	A	11444	other volcanic	flake from ground-edge axe	5			finely ground edge.
RP82	A	11445	silcrete 3	flake	4			
RP82	A	11446	silcrete 1	microblade proximal portion	2			
RP82	A	11447	tuff 1	core	6	20	tab.	3 scars, 1 platform.
RP82	A	11448	silcrete 1	flaked piece	5			
RP82	A	11449	tuff 2	flake	5	5	peb.	
RP82	A	11450	tuff 2	flake	3	5	peb.	hinge termination
RP82	A	11451	porcellanite	flaked piece	4	30	peb.	
RP82	A	11452	tuff 2	flake	5	40	tab.	
RP82	A	11453	porcellanite	lithic fragment	2			
RP82	A	11454	porcellanite	flake	2			
RP82	A	11455	tuff 2	utilised/retouched flaked piece	5			10mm of retouch, distal end.
RP82	A	11456	porcellanite	flake	2			
RP82	A	11457	porcellanite	microblade medial portion	2			
RP82	A	11458	porcellanite	microblade distal portion	2			
RP82	A	11459	tuff 3	flake	2			
RP82	A	11460	porcellanite	microblade distal portion	1			
RP82	A	11461	silcrete 1	lithic fragment	3			
RP82	A	11462	tuff 2	flake	3			
RP82	A	11463	porcellanite	lithic fragment	4	15	terr.	
RP82	A	11464	tuff 2	flake distal portion	2			
RP82	A	11465	silcrete 2	microblade	4			
RP82	A	11466	other volcanic	flake	4	15	terr.	
RP82	A	11467	tuff 2	lithic fragment	2			
RP82	A	11468	tuff 2	lithic fragment	2			
RP82	A	11469	tuff 2	flake	4			
RP82	A	11470	tuff 2	lithic fragment	2			shatter.
RP82	A	11471	tuff 2	flake	3			4 scars, 3 platforms
RP82	A	11472	tuff 4	core	4			
RP82	A	11473	tuff 1	flake	3			
RP82	A	11474	silcrete 1	flake	3			
RP82	A	11475	silcrete 2	lithic fragment	1			
RP82	A	11476	silcrete 2	flake distal portion	2			
RP82	A	11477	silcrete 2	flake	5			in 2 pieces
RP82	A	11478	tuff 3	flake	4			
RP82	A	11479	silcrete 1	flake	3			
RP82	A	11480	silcrete 2	microblade proximal portion	3			
RP82	A	11481	silcrete 2	microblade medial portion	2			
RP82	A	11482	quartzite	flake medial portion	4			broken longitudinally
RP82	A	11483	other volcanic	flake	5	10	terr.	
RP82	A	11484	quartz	flake	4	50	peb.	
RP82	A	11485	tuff 2	flake distal portion	4			
RP82	A	11486	tuff 3	flake	2			
RP82	A	11487	banded rhyolite	microblade	4			
RP82	A	11488	banded rhyolite	flake	3	10	terr.	
RP82	A	11489	tuff 3	flake proximal portion	2			
RP84	A	11490	tuff 2	flake	7	20	tab.	
RP84	A	11491	other volcanic	flake	5	15	terr.	
RP84	A	11492	other volcanic	flaked piece	4			
RP84	A	11493	tuff 3	flake distal portion	3			
RP84	A	11494	tuff 2	flake	5	40	peb.	
RP84	A	11495	tuff 2	microblade core	6	5	peb.	6 scars, 3 platforms, 2 scars with hinge termination.
RP84	A	11496	tuff 2	flake	2			
RP84	A	11497	porcellanite	flaked piece	3			
RP84	A	11498	silcrete 1	flake distal portion	2			
RP84	A	11499	silcrete 2	flake proximal portion	3	15	terr.	tip missing.
RP84	A	11500	quartz	flake	3			
RP84	A	11501	tuff 2	lithic fragment	2			

BAYSWATER #2 RAIL LOADING FACILITY - ABORIGINAL HERITAGE LITHIC ITEM DATABASE

Site #	Locus	Lithic Item Reference #	Stone Material	Lithic Item Type	Size Class	Cortex Amount (%)	Cortex Type	Comments
RP84	A	11502	tuff 2	flake	6			retroflex hinge termination.
RP84	A	11503	quartzite	flake	9			poor quality silcrete.
RP84	A	11504	silcrete 2	flake	3			
RP84	A	11505	silcrete 1	bondi point	2			fully backed.
RP84	A	11506	silcrete 2	flake distal portion	2			
RP84	A	11507	silcrete 1	microblade medial portion	2			
RP84	A	11508	tuff 1	microblade	3			
RP84	A	11509	silcrete 1	flake proximal portion	4			
RP84	A	11510	silcrete 2	flake proximal portion	4			
RP84	A	11511	silcrete 2	lithic fragment	4			
RP84	A	11512	silcrete 2	flake	6			redirecting flake.
RP84	A	11513	silcrete 1	microblade medial portion	2			
RP84	A	11514	tuff 2	flake medial portion	2			
RP84	A	11515	silcrete 2	flake proximal portion	4			
RP84	A	11516	silcrete 1	lithic fragment	3			
RP84	A	11517	silcrete 2	flake	5			
RP84	A	11518	tuff 2	flake medial portion	2			
RP84	A	11519	silcrete 3	flake	2			
RP84	A	11520	silcrete 1	flake proximal portion	2			
RP84	A	11521	tuff 1	flaked piece	5			
RP84	A	11522	tuff 1	lithic fragment	5	2	peb.	
RP84	A	11523	tuff 1	lithic fragment	5	10	peb.	
RP84	A	11524	tuff 1	flake proximal portion	5	10	terr.	
RP84	A	11525	tuff 3	flake	4	15	peb.	
RP84	A	11526	silcrete 3	microblade proximal portion	2			
RP84	A	11527	silcrete 3	flake proximal portion	2			
RP84	A	11528	silcrete 1	core	6			8 scars, 3 platforms.
RP84	A	11529	silcrete 1	lithic fragment	4			
RP84	A	11530	tuff 2	flake	5			
RP84	A	11531	tuff 2	utilised/retouched flake/ microblade (incl. portion)	5	40	peb.	scraper; 35mm scraper edge - utilised - fracturing on anterior side.
RP84	A	11532	silcrete 2	flake distal portion	3			
RP84	A	11533	silcrete 2	flake proximal portion	2			
RP84	A	11534	chert	flake	2			
RP84	B	11535	silcrete 2	flake	3			
RP84	C	11536	tuff 2	bondi point	3			20mm of light backing, 3mm wide, other margin, 18mm of use fracture.
RP84	D	11537	tuff 2	utilised/retouched flake/ microblade (incl. portion)	2	5	peb.	retroflex hinge termination, 18mm of use-wear on one margin, fracturing 3mm in on anterior surface.
RP84	E	11538	tuff 3	flake	2			
RP84	E	11539	tuff 4	flake	3			
RP84	E	11540	other volcanic	flake proximal portion	2	5	terr.	
RP84	E	11541	tuff 2	flake	2			
RP84	E	11542	silcrete 2	flake	6			redirecting flake.
RP84	E	11543	tuff 2	flake	3			
RP84	E	11544	other volcanic	core	7	10	terr.	3 scars, 1 platform.
RP84	E	11545	tuff 4	flake	4	5	tab.	
RP84	E	11546	tuff 2	flake	5	30	peb.	
RP84	E	11547	tuff 1	flaked piece	3	15	peb.	
RP84	E	11548	tuff 3	core	3			5 scars, 1 platform.
RP84	E	11549	tuff 1	flake proximal portion	4			
RP84	E	11550	tuff 2	flake	3			
RP84	E	11551	tuff 3	flake	3			
RP84	E	11552	tuff 2	flake	3			
RP84	E	11553	silcrete 3	flake	4			
RP84	E	11554	tuff 2	utilised/retouched flake/ microblade (incl. portion)	3			scraper; 25mm of retouch - distal margin.
RP84	E	11555	tuff 4	lithic fragment	3			
RP84	E	11556	porcellanite	flake	4			
RP84	E	11557	tuff 4	flake	3			hinge termination.

Site #	Locus	Lithic Item Reference #	Stone Material	Lithic Item Type	Size Class	Cortex Amount (%)	Cortex Type	Comments
RP84	E	11558	tuff 2	flake	4	50	peb.	
RP84	E	11559	porcellanite	microblade	3			
RP84	E	11560	other volcanic	flake	6			
RP84	E	11561	tuff 2	flake proximal portion	3			
RP84	E	11562	tuff 2	flake	3			
RP84	E	11563	porcellanite	microblade	3			
RP84	E	11564	tuff 2	flake	7	50	peb.	
RP84	E	11565	quartz	flake	3	10	peb.	
RP84	E	11566	tuff 3	flake	2			
RP84	E	11567	tuff 3	flake proximal portion	3			
RP84	E	11568	tuff 2	lithic fragment	3			
RP84	E	11569	tuff 4	flake	2			
RP84	E	11570	tuff 2	lithic fragment	2			
RP84	E	11571	tuff 2	flake distal portion	2			
RP84	E	11572	silcrete 1	flake	2			
RP86	A	11573	tuff 3	flake	2			hinge termination.
RP86	A	11574	tuff 4	flake	3	2	peb.	hinge termination.
RP86	A	11575	tuff 4	flake	3	5	peb.	hinge termination.
RP86	B	11576	quartz	flake	3			
RP86	C	11577	silcrete 1	flake	5	30	peb.	
RP86	C	11578	quartz	flake	4			
RP94	A	11579	tuff 2	flake	5	5	peb.	
RP94	A	11580	silcrete 2	flake distal portion	3			
RP98	A	11581	silcrete 1	core fragment	5			fragment of a core, ends of 4 scars - probably from same platform.
RP98	A	11582	tuff 3	flaked piece	3			very fine.
RP98	A	11583	porcellanite	flake proximal portion	4			almost complete.
RP98	A	11584	quartz	flake	3			pink tinge.
RP98	A	11585	quartz	flake	2	30	peb.	pink tinge.
RP98	A	11586	other volcanic	core	5	50	peb.	10 scars, 2 platforms - 1 of the scars is from preparation of the other platform which has 9 scars.
RP98	A	11587	porcellanite	flake distal portion	2			
RP98	A	11588	tuff 2	flake	3			
RP98	A	11589	tuff 2	flake distal portion	3	5	tab.	
RP98	A	11590	tuff 2	flaked piece	3	15	peb.	
RP98	A	11591	tuff 3	flake distal portion	3			
RP98	A	11592	tuff 2	microblade proximal portion	3			
RP98	A	11593	tuff 2	microblade distal portion	2			
RP98	A	11594	tuff 3	microblade proximal portion	2			
RP98	A	11595	tuff 2	microblade distal portion	1			
RP98	A	11596	tuff 2	microblade proximal portion	2			tip missing only.
RP98	A	11597	tuff 2	microblade proximal portion	3			
RP98	A	11598	porcellanite	lithic fragment	3	20	terr.	
RP98	A	11599	tuff 2	lithic fragment	3			
RP98	A	11600	tuff 2	flake distal portion	3			hinge termination.
RP98	A	11601	tuff 2	lithic fragment	1			
RP98	A	11602	tuff 2	flake	3			
RP98	A	11603	tuff 2	lithic fragment	3			
RP98	A	11604	silcrete 3	flake	7	10	terr.	
RP98	A	11605	chert	flake proximal portion	4			
RP98	A	11606	tuff 2	flake	2			
RP98	A	11607	tuff 2	lithic fragment	3			
RP98	A	11608	banded rhyolite	lithic fragment	2			
RP98	A	11609	other volcanic	flake	3			
RP98	A	11610	other volcanic	flake distal portion	2			
RP98	A	11611	other volcanic	flake proximal portion	2			
RP98	A	11612	other volcanic	lithic fragment	3	15	peb.	
RP98	A	11613	other volcanic	lithic fragment	2			
RP98	A	11614	tuff 2	flake	6	30	peb.	
RP98	A	11615	silcrete 2	flake	5			

BAYSWATER #2 RAIL LOADING FACILITY - ABORIGINAL HERITAGE LITHIC ITEM DATABASE

Site #	Locus	Lithic Item Reference #	Stone Material	Lithic Item Type	Size Class	Cortex Amount (%)	Cortex Type	Comments
RP98	A	11616	silcrete 1	flake proximal portion	3			
RP98	A	11617	silcrete 2	flake distal portion	4			
RP98	A	11618	other volcanic	microblade	4	15	peb.	
RP98	A	11619	silcrete 3	flake proximal portion	2	5	peb.	
RP98	A	11620	silcrete 2	flake	3			
RP98	A	11621	silcrete 2	flake	5			
RP98	A	11622	other volcanic	microblade distal portion	5			
RP98	A	11623	chert	flake proximal portion	3	5	terr.	scars on dorsal face run transverse.
RP98	A	11624	silcrete 1	flake	2			
RP98	A	11625	tuff 2	flake distal portion	1			
RP98	A	11626	tuff 2	utilised geometric microlith	2			12mm of use-wear.
RP98	A	11627	tuff 2	flake distal portion	1			
RP98	A	11628	tuff 3	microblade proximal portion	3			
RP98	A	11629	tuff 2	microblade distal portion	2	30	peb.	
RP98	A	11630	porcellanite	lithic fragment	3			
RP98	A	11631	tuff 2	flake	3			
RP98	A	11632	silcrete 1	microblade distal portion	2			
RP98	A	11633	tuff 4	flake	3			
RP98	A	11634	silcrete 1	flake proximal portion	4			
RP98	A	11635	tuff 3	core	3			9 scars, 3 platforms.
RP98	A	11636	tuff 3	lithic fragment	1			
RP98	A	11637	tuff 3	lithic fragment	3	15	peb.	potlidding on one surface.
RP98	A	11638	tuff 2	flake distal portion	3			
RP98	A	11639	silcrete 1	flake distal portion	3			
RP98	A	11640	tuff 1	lithic fragment	3			
RP98	A	11641	tuff 2	flake proximal portion	2			
RP98	A	11642	tuff 4	microblade proximal portion	3			
RP98	A	11643	tuff 2	flake	2			
RP98	A	11644	tuff 2	flaked piece	3	30	peb.	
RP98	A	11645	tuff 1	flake	2			
RP98	A	11646	quartz	microblade core	4			2 scars, 1 platform.
RP98	A	11647	tuff 1	lithic fragment	3			
RP98	A	11648	tuff 2	lithic fragment	2	40	peb.	
RP98	A	11649	tuff 2	core	3	5	peb.	6 scars, 3 platforms.
RP98	A	11650	tuff 3	microblade distal portion	2			
RP98	A	11651	tuff 3	flake	4			
RP98	A	11652	silcrete 2	microblade	3			
RP98	A	11653	tuff 2	flake	2			microlith backing flake - hinge termination.
RL4	A	15971	tuff 3	flake	3	5	tab.	
RL4	A	15972	tuff 2	flaked piece	2	20	tab.	
RL4	B	15973	quartzite	flake distal portion	4			tip snapped.

APPENDIX 9: PLATES

Plate 1: View of proposed Rail Loading Facility in eastern portion of Authorisation A171.

Plate 2: View south-west from Survey Area RL13 across rail link (Survey Areas RL13-RL1).

Plate 3: View south-west across Survey Areas RL5 (foreground), RL4 (drainage) and RL3 (rear).

Plate 4: View north-east across Survey Areas RL3 (foreground), RL4 (drainage), Site RL4 Loci A & B (exposures) and Survey Areas RL5 and RL6 (behind drainage).

APPENDIX 5A
Attachment 1

Wonnarua Tribal Council
Correspondence Provided Following Receipt of Archaeology Report Included in Appendix 5A

WONNARUA TRIBAL COUNCIL INC
PO Box 184
Unit 17 / 174 JOHN st
SINGLETON NSW 2330
Phone 02 6571 4888 Mobile 0408 225521
Fax 02 6571 4889 Mobile 0428 174946
TRADITIONAL LAND OWNERS

Mr M.J Heath
Project Manager
Coal Australia Operations Ltd
6 Maitland Street
MUSWELLBROOK NSW 2333

30th March 2000

RE; BAYSWATER COAL LOADING FACILITY

Dear Mike
As per our meeting in relation to the above Coal Loading Facility, the local Wonnarua people have decided to give in principal support to the development.

This is based upon the 4 point agreement that has been reached between Coal Australia Ltd and the Wonnarua Tribal Council.

Having stated this, the agreement will only stand as long as both sides keep to their word and work towards the agreement as soon as possible.

Yours Thankfully

Rhoda Perry
Wonnarua Elder
Wonnarua Tribal Council Inc

APPENDIX 5B

European Heritage Investigation

A EUROPEAN HERITAGE INVESTIGATION OF THE PROPOSED BAYSWATER RAIL LOADING FACILITY, NEAR MUSWELLBROOK, HUNTER VALLEY, NEW SOUTH WALES.

A report to

UMWELT (AUSTRALIA) Pty Limited

PO Box 838
TORONTO NSW 2283

by

Chris Carter & Peter J. Kuskie
SOUTH EAST ARCHAEOLOGY

24 Bamford Street
HUGHES ACT 2605

Telephone: 02-6260 4439

March 2000

EXECUTIVE SUMMARY

Umwelt (Australia) Pty Limited have been commissioned by Coal Operations Australia Limited to prepare an Environmental Impact Study (EIS) for the proposed development of the Antiene Rail Loading Facility, near Muswellbrook, in the Hunter Valley of New South Wales. The proposal involves continued use of the existing Drayton Rail Loading Facility, for which heritage investigations were not required, and construction of the Bayswater Rail Loading Facility, which is the subject of this investigation.

The Bayswater Rail Loading Facility proposal will involve construction of a rail loop and coal loading facility in Authorisation A171, adjacent to Bayswater #2 Colliery. A three kilometre rail line will also be constructed to link the loading facility with the existing Antiene rail spur east of Drayton Colliery's rail loop. Construction of the rail loop and loading facility will cause impacts to the ground surface over an area of about 35 hectares, while the rail link will affect an area of less than 20 hectares.

South East Archaeology was commissioned by Umwelt (Australia) Pty Limited to undertake an archaeological assessment of non-Aboriginal heritage in relation to this proposal. The study was undertaken between January and March 1999, as a component of a separate investigation at Mount Arthur North (Carter in prep, Kuskie in prep), and in October 1999.

The principal aims of the investigation were to identify and record any historical (non-Aboriginal) heritage sites within the study area, assess site significance and formulate recommendations for the conservation and management of any heritage resources present.

The investigation proceeded by recourse to the historical background of the locality, followed by a field survey initially involving a team of two persons (a qualified archaeologist and an Aboriginal community representative) systematically traversing the A171 portion of the study area on foot. The survey of the 1.55 square kilometre A171 portion involved eight person days. The remainder of the study area (the rail link) was investigated to a similar level of detail in one day.

Only one historical feature assessed as being over fifty years of age was identified in the study area. It consists of a scatter of fragments of glass and ceramics, located within proximity of the rail loop in A171. This site is assessed as being of low significance within a local context.

All relevant heritage registers were examined, including Schedules 1, 2, 3 and 4 of the Hunter Regional Environmental Plan 1989, the Australian Heritage Commission's Register of the National Estate, the Register of National Trust (NSW), Register of Significant Twentieth Century Architecture (RAIA), Department of Public Works' Heritage and Conservation Register, Heritage Council registers, NSW Government Department Heritage Register, NPWS Historic Sites Register and Institution of Engineers (NSW) Heritage Register, along with the *Muswellbrook Shire-wide Heritage Study* (Turner 1996). No items listed on these heritage registers or reported in the *Muswellbrook Shire-wide Heritage Study* lie within the present study area.

Recommendations are presented to mitigate the impacts of the proposal on European heritage, including:

- obtaining excavation permits from the Heritage Council of New South Wales prior to any excavation and removal of the item (Site H10) located within the study area;
- recording the relics within the study area in greater detail prior to any such removal;
- monitoring areas adjacent to the relics identified within the study area during any excavation and removal in order to identify any further cultural material that may exist in a sub-surface context; and
- disposing of excavated items in a manner approved by the Heritage Council of New South Wales and following consultation with the Muswellbrook and Upper Hunter Historical Society and Muswellbrook Shire Council.

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FIGURES

1. INTRODUCTION

Umwelt (Australia) Pty Limited has been commissioned by Coal Operations Australia Limited to prepare an Environmental Impact Study for the proposed development of the Antiene Rail Loading Facility, near Muswellbrook, in the Hunter Valley of New South Wales. The proposal involves continued use of the existing Drayton Rail Loading Facility, for which heritage investigations were not required, and construction of the Bayswater Rail Loading Facility, which is the subject of this investigation.

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South East Archaeology was commissioned by Umwelt (Australia) Pty Limited to undertake an archaeological assessment of non-Aboriginal heritage in relation to this proposal. The study was undertaken between January and March 1999, as a component of a separate investigation at Mount Arthur North (Carter in prep, Kuskie in prep), and in October 1999.

The study area is located within the Parish of Brougham, Denham Shire, County Durham. It is situated partially within Authorisation A171, the Drayton mine lease and land owned by Coal Operations Australia Limited.

The study area is located seven kilometres south of Muswellbrook, in the Central Lowlands of the Hunter Valley. It primarily consists of simple slopes, intersected by a number of drainage depressions, including Ramrod Creek and several of its tributaries. Native vegetation has been cleared from most of the study area. Moderate to severe sheet and gully erosion is evident in several localities and levels of ground disturbance are typically moderate or high, due to impacts that have occurred since European settlement.

2. HISTORICAL BACKGROUND

2.1 Alienation of Lands Within the Colony of New South Wales

When New South Wales was settled as a British Colony in 1788, all lands became the property of the Crown. A major component of the colonial process was the creation and maintenance of spatial order (Jeans 1966:205). The alienation of land was controlled at the discretion of the colonial government, initially under direction of the Colonial office in London. Grants, in the first instance, were offered to officers and civil servants as both reward and incentive to relocate. This was later extended after Governor Phillip was instructed to grant land for farming to discharged soldiers, free settlers and convicts who had served their term (Shaw 1970:11).

As the population and demand for land increased, measures were adopted by both the government and settlers to enable the spread of settlement and an increase in agricultural production. With a further increase in the population of settlers and livestock numbers after 1800, the demand for land continued to grow.

In 1822, J. T. Bigge filed his "Report to the Commissioner of Inquiry into the State of the Colony of New South Wales". Bigge had been dispatched to the Colony in 1819 by the British government to establish, *inter alia,* if the Colony was achieving its aims as a penal settlement and to consider its development and commercial viability (Crawford 1965:59). Exploration had indicated favourable areas for new settlement, including the Hunter Valley (Perry 1965:39). Bigge recommended an increase in land grants, but only to those who could contribute to an increase in pastoral production (Molony 1988:45). Assigned convict labour was intended to assist with the maintenance of pastoral properties granted under such a system.

Governor Macquarie continued to grant land to cater for the needs of increasing livestock numbers. Although alienation was not allowed without survey, by 1821 about 340,000 acres of land grants could not be located, as their issue had outpaced the ability of surveyors to accurately determine their placement (Perry 1965:44). In order to allow occupation of new lands, satisfy demand and maintain some control on the spread of settlement, in 1827 the government introduced 'tickets of occupation' to allow graziers rights over the lands they occupied (Carter 1994:9-10). These were replaced in 1828 by grazing licences. From here on, through a variety of means, some officially sanctioned but others not, settlement spread and Crown Lands began to be broken up into smaller portions.

Grants and sales, either directly or at auction, permitted the alienation of land. However demand outstripped supply. 'Squatters' began to occupy large tracts of land outside the settled districts beyond the control of the colonial government (Cannon 1988:9, Carter 1994:10-12). In order to wrest back control, various regulations were introduced to allow land to be leased or licensed for a fee to depasture stock. Sales as a result of improvements to land occurred later, along with sales at auction for a set minimum price per acre. Access to and availability of land, along with insufficient capital for many would-be land owners restricted expansion. The majority of suitable land remained in the hands of a wealthy few.

By 1850 settlement had spread throughout New South Wales and Victoria (Shaw 1970:45) and at that time 3,000 squatters had the use of over 70 million acres of Crown Land (Jeans 1966:212). It was during this period that political support began for the small rural land holder. Protests came from a number of quarters (Carter 1994:16):

- land owners seeking to restrict the squatters and capitalise on their own investments;
- tenant farmers seeking access to rural land;
- successful gold-miners with capital to invest in land if it were only available;
- agitated politicians fearful of the growing power of the 'squattocracy'; and
- independent shopkeepers who resented the squatters use of Sydney wholesalers.

In 1861, Sir John Robertson, the Minister of Lands, introduced legislation (*Crown Lands Occupation Act 1861* and *Crown Lands Alienation Act 1861*) to allow selection of land by any person under certain conditions, at a set price of one pound per acre. One quarter of the purchase price was required with the balance deferred as long as certain conditions were met. This legislation set minimum and maximum sizes for portions as well as orientation and boundary proportions. Selection could also take place prior to survey. The intention of this legislation was to allow access to land on fair and easy terms and promote closer settlement throughout the colony. Despite these intentions, the legislation failed in that loopholes and indiscriminate practices allowed the original land holders to maintain control of much of their original 'runs' (Carter 1994:21). By 1874 '...deserted farms are everywhere visible to the traveller...' (from Jeans 1972:213). Closer settlement has been attempted since that time and continued with large holdings being broken up in the 1890s followed by Soldier Settlement Programs taking place in the first half of the 20th Century.

The modern landscape not only reflects a sequence of occupation and activity through a number of phases of ownership, improved technology and changing farm management practices, but also evidence of the legislative and administrative controls governing alienation and land use.

2.2 Regional History and Local Settlement

The Hunter region was identified by Lieutenant John Shortland of HMS Reliance on 16th September 1797. The region was declared a coal and timber (cedar) reserve in 1801 (Davidson & Lovell-Jones 1993:7). After the penal settlement of Newcastle was transferred to Port Macquarie in 1823, Assistant Surveyor Henry Dangar was instructed to survey the valley with the view to opening it to settlement (Hartley 1995). Within a year of Dangar's survey all of the land along the Hunter River had been granted, sold or reserved by the government (Wood 1972:72).

From the 1840s to 1870s settlement extended from the main valleys into the hilly terrain (Dean-Jones & Mitchell 1993:2). Grazing sheep and cattle were the primary activities, but along the riverine floodplains, maize, potatoes, wheat, barley and later tobacco were cultivated (Dean-Jones & Mitchell 1993:2).

Timber getting was an important industry from the initial European settlement (Windross & Ralston 1897:17). In the 1820s cedar gangs were working 110 kilometres up the Hunter River (Goold 1981). Extensive tree clearing, ringbarking and sapping, to improve grazing capacity, occurred in the upper Hunter mainly after 1862 (Dean-Jones & Mitchell 1993:2). Improved pastures were widely established on river flats and irrigation was used to develop the dairy cattle industry (Dean-Jones & Mitchell 1993:2).

Coal mining was one of the first industries, commencing in 1798 in the lower Hunter Valley (Windross & Ralston 1897). In the upper Hunter region, coal mining was undertaken on a limited scale from the early 1900s and expanded rapidly with open cut mining after the 1950s (Dean-Jones & Mitchell 1993:2).

The majority of land in the locality of the study area was initially alienated in 1824, following a grant of land to George Forbes, brother of the Chief Justice of the Colony, Dr Francis Forbes (Wood 1972:73). A further 4,000 acres was reserved for purchase in 1825. The station was named 'Edinglassie' after the Forbes' ancestral home in Scotland and is located west of Denman Road.

George Forbes was the first to introduce stock onto this property and by 1828 was grazing 4,700 sheep and 270 cattle (Wood 1972:181). In order to increase pasture, Edinglassie was subject to land clearance and trees were ringbarked in widespread areas. The surveyor John Neill noted these factors in 1866 and 1872. He also reported in 1872 that a box dominated woodland was partially present and that part of the property had been cultivated. Forbes sold Edinglassie to James White in 1837 and White built the first homestead on the property in 1840 (Muswellbrook & Upper Hunter Historical Society 1981:3-4).

The introduction of the *Crown Lands Alienation Act* of 1861 had little impact on this locality. Free selectors were generally unsuccessful, as the majority of land in the Upper Hunter had already been alienated (Muswellbrook & Upper Hunter Historical Society 1981:14). Alienation had been allowed via land grants, pre-emptive purchases (*vide* improvements made to land held under lease) or sale at auction (Carter 1994:15). Early parish maps divide the area into numerous portions, however, few blocks were selected by persons other than those who already owned large tracts of land in the locality. The few portions that were selected by outsiders were generally further from permanent water and in steeper areas, probably unsuitable for successful farming ventures. There are no indications that any of these selections were settled for any time but the period set out under the conditions of purchase (one year).

Following selection, the Parish of Brougham was divided into 112 portions, with those fronting the Hunter River being alienated prior to 1861. Of those portions within proximity of the study area, only four were held by persons outside the White family or the Black family. The Blacks owned 'Ayredale', in an area that now forms part of Bayswater #2 Colliery. None of the portions selected by persons outside of the larger landowners were adjacent to major streams. They mainly consisted of steep to moderately steep hilly terrain.

In 1910, part of Edinglassie Estate was sub-divided into six lots and sold at auction. Edinglassie was further subdivided in 1936 when Mrs Dutton, a member of the White family, decided to dispose of her portion of the original holding (6,380 acres) (1936 brochure advertising sale). The portions relating to this sale are all situated between Thomas Mitchell Drive and the New England Highway. No dwellings relating to these portions are located within the study area. Brochures advertising these sales include comments relating to the nature of the land. Notably, large areas are described as being 'killed out; 'well killed' or 'cleared up'. 'Soldier Settlement' programs in 1948 resulted in further subdivision of Edinglassie.

3. STATUTORY OBLIGATIONS

The Hunter Regional Environmental Plan 1989 contains details of heritage items considered to be of state or regional significance. The Regional Plan contains controls against major alteration or demolition of such items without public evaluation and consent. The Regional Plan lists four schedules of heritage significance, including items of state significance (Schedule 1), items of regional significance (Schedule 2), items of local significance (Schedule 3), and items requiring further investigation (Schedule 4).

No listed items of state, regional or local significance are located within the present study area or its immediate vicinity.

Searches of all relevant heritage registers were examined, including Schedules 1, 2, 3 and 4 of the Hunter Regional Environmental Plan 1989, the Australian Heritage Commission's Register of the National Estate, the Register of National Trust (NSW), Register of Significant Twentieth Century Architecture (RAIA), Department of Public Works' Heritage and Conservation Register, Heritage Council registers, NSW Government Department Heritage Register, NPWS Historic Sites Register and Institution of Engineers (NSW) Heritage Register, along with the *Muswellbrook Shire-wide Heritage Study* (Turner 1996). No items listed on these heritage registers or reported in the *Muswellbrook Shire-wide Heritage Study* lie within the present study area.

The *Heritage Act 1977* is concerned with all aspects of protection and conservation of environmental heritage, which may include buildings, works, places or relics that are over fifty years of age and are of historic, scientific, cultural, social, archaeological, architectural, natural or aesthetic significance to the State of New South Wales (but not being related to aboriginal settlement).

The *Heritage Act 1977* also allows for the issuing of interim or permanent conservation orders to control damage to and/or demolition of heritage items. Where such orders have been issued, a person cannot demolish, damage, despoil, move, excavate, develop or alter the building, relic or place except with the approval of the Heritage Council. There are no orders in place under the *Heritage Act 1977* that affect any relics or places within the study area.

Section 139 of the *Heritage Act 1977* states that a person shall not disturb or excavate any land for the purpose of discovering, exposing or moving a relic, not being a relic subject to a conservation instrument, except in accordance with an excavation permit. Section 139 partially serves to protect relics that are not the subject of conversation orders. It is relevant to the non-Aboriginal heritage site identified within the study area, which is more than fifty years of age (refer to Section 4).

4. RESULTS OF ARCHAEOLOGICAL SURVEY

The investigation proceeded by recourse to the historical background of the locality, followed by a field survey initially involving a team of two persons (a qualified archaeologist and an Aboriginal community representative) systematically traversing the A171 portion of the study area on foot. The survey of the 1.55 square kilometre A171 portion involved eight person days. The remainder of the study area (the three kilometre rail link) was investigated to a similar level of detail on 18 October 1999.

The survey resulted in the identification of one relic/place that relates to the settlement of the locality and is believed to be in excess of fifty years of age (Figure 1; Site H10). It consists of a scatter of fragments of glass and ceramics, located within proximity of the rail loop in A171.

The landscape of the locality, including the study area, is in itself a relic of European settlement. It reflects a sequence of occupation over the past 175 years, including initial settlement, land clearance and stock management practices. One of the most significant impacts upon the landscape relating to European occupation includes the erosion of hill slopes and watercourses and the subsequent deposition of soils on the middle and lower portions of major drainage lines. This erosion and deposition occurred during the historical period, following the removal of native vegetation and introduction of hoofed animals. The removal of large tracts of native vegetation is noted on early maps and portion plans. Evidence of trees having been ringbarked for later removal is present in the locality and attests to the on-going practice of land clearance to increase grazing areas.

Local residents and members of the Muswellbrook Historical Society (Helen Ellis, Colin Ellis, Robert Tickle and Bill Spicer) were contacted during the separate Mount Arthur North investigation (Carter in prep). Despite intimate local knowledge, none were aware of any relics or places within the A171 portion of the study area relating to early settlement or being of heritage significance.

As no habitations (house structures, etc) have been identified within the survey area, the potential for uncovering material related to the lifestyles of the early settlers is low.

5. ASSESSMENT OF SIGNIFICANCE

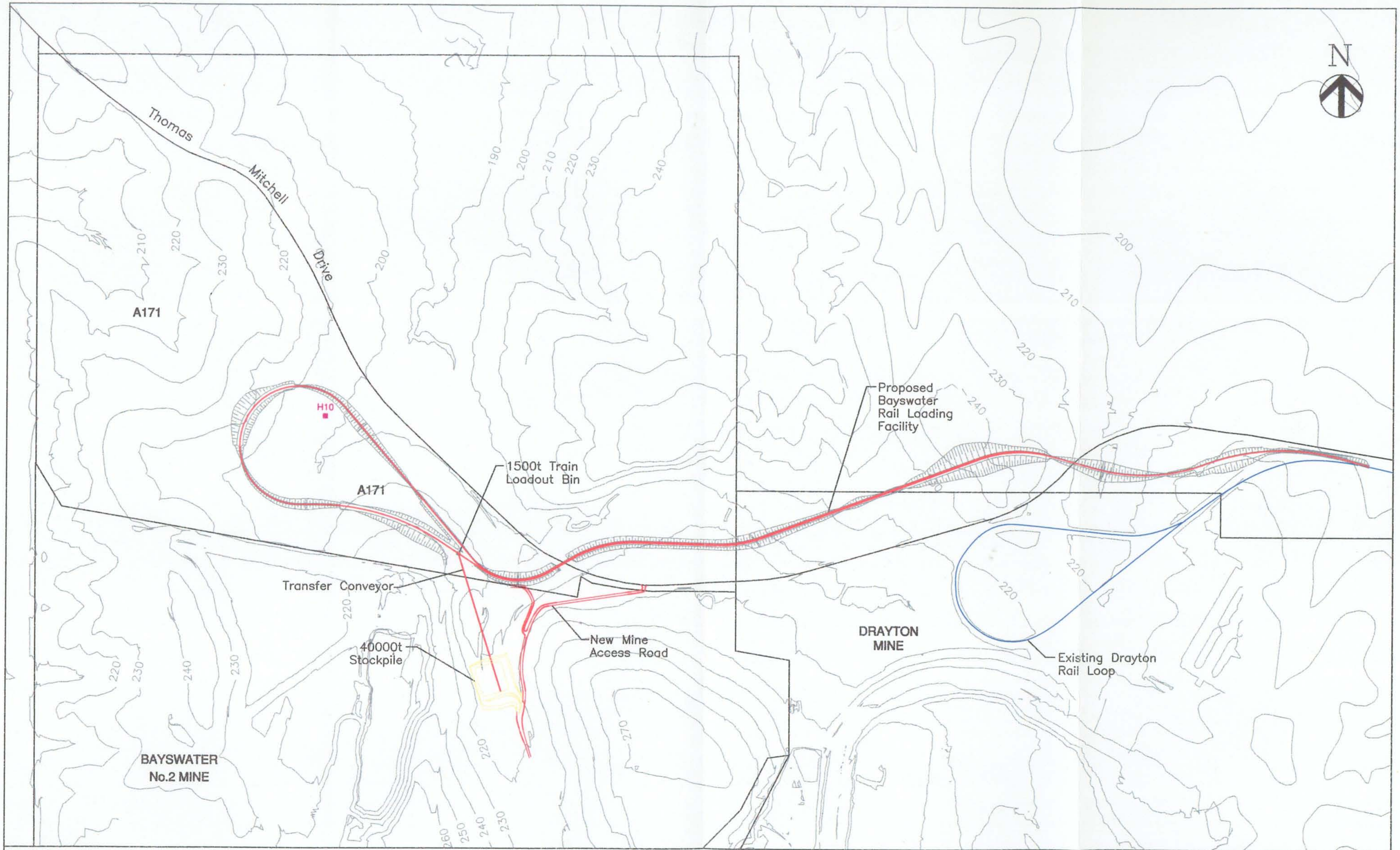
Under the NSW Department of Urban Affairs and Planning's State Heritage Inventory Evaluation Criteria, items of local significance are considered to have a special quality and interest to the local area, and contribute individually or as part of a group to the environmental heritage and character of an area. The relics located within the study area were assessed against the State Heritage Inventory Evaluation Criteria.

The single heritage site (H10) located within the study area is considered to be of general interest only and there are no indications that this item is of any local significance.

No other items of heritage significance listed on any registers or lists will be affected by the proposal.

6. RECOMMENDATIONS

- A copy of this report should be forwarded to the Heritage Council of New South Wales for their information and comment;
- An excavation permit must be obtained from the Heritage Council of New South Wales prior to the excavation and removal of the items comprising site H10, should it be impacted by the proposal;
- Site H10 should be recorded in greater detail prior to its excavation and removal;
- Areas adjacent to the relics identified within the study area (site H10) should be monitored during their excavation and removal in order to identify any further cultural material that may exist in a sub-surface context; and
- Items removed under the auspices of excavation permits should be disposed of in a manner approved by the Heritage Council of New South Wales and following consultation with the Muswellbrook and Upper Hunter Historical Society and Muswellbrook Shire Council.



Legend

- Proposed Rail Loading Infrastructure
- Existing Rail Loading Infrastructure
- Approved Infrastructure
- H10 European Heritage Site

0 100 200 300 400 500m

Contour interval 10m

Umwelt (Australia) Pty Limited
Source: Bateman Australia Dwg No.60-M-135_B

FIGURE 1
Plan of Proposed Antiene Rail Loading Facility & Location of European Heritage Site

A3 Scale 1:12 000 | Ref No.:1323/R01_AP5/dra_051.dwg

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ACKNOWLEDGEMENTS

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APPENDIX 6

Noise and Vibration Assessment

ANTIENE JOINT USER RAIL FACILITY:

NOISE ASSESSMENT

Report No 99187
Version D

2000

Prepared for

Umwelt (Australia) Pty Ltd

Prepared by

Wilkinson Murray Pty Limited
1st Floor, 123 Willoughby Road, Crows Nest, NSW 2065 Australia
Tel: (02) 9437 4611 Fax: (02) 9437 4393 Email: wmurray@tpgi.com.au

Report No 99187
Version D

ANTIENE JOINT USER RAIL FACILITY:

NOISE ASSESSMENT

2000

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1. INTRODUCTION

This report presents an assessment of noise impacts associated with the loading and transportation of up to 20MTPA of coal using the Antiene Joint User Rail Facility. This facility involves construction of a new rail loop and coal loader, to the north of the existing Bayswater mine, and increased use of the existing Drayton coal loader. The facility will enable coal rail haulage via the Antiene Spur Line, south on the Main Northern Railway by the existing Drayton and Bayswater collieries, and the proposed Saddlers Creek and Mount Arthur North mines. Impacts considered include operation of the loading facilities, operation of additional trains on existing track, and construction of the facilities.

Operational noise impacts are assessed generally in accordance with the EPA's recently-released Industrial Noise Policy (INP), with some modifications as described. Other impacts are assessed generally in accordance with the EPA's Environmental Noise Control Manual.

2. DESCRIPTION OF PROPOSAL

It is proposed to construct a coal loading facility to the north of the existing Bayswater No 2 mine, incorporating:

- a rail loop, joining the Antiene Spur (which serves the existing Drayton Coal Mine loop) and eventually the Main Northern Line north of Lake Liddell;
- a coal stockpile within an area previously approved as part of the Bayswater No 3 development for coal stockpile purposes, with an initial capacity of 40,000 tonnes and provision for expansion to 650,000 tonnes; and
- a 512m long conveyor between the stockpile and rail loading point, with associated drive station and loadout bin.

Note that this assessment addresses only the construction of a 40,000 tonne coal stockpile. Any future expansion of coal stockpile capacity would be the subject of a separate assessment.

The system would be initially intended to take coal from the Bayswater Coal Mine, which is currently transported by road to the Ravensworth Coal Terminal, amounting to approximately 3.5 MTPA. In addition, there would be provision for transfer of coal from the proposed Mount Arthur North mine and other developments, up to a total capacity of 20 MTPA for the Joint User Facility.

In addition to this new facility, it is proposed to extend loading operations at the existing Drayton coal loader from 3.3 MTPA to a potential 7 MTPA. This would not involve any new construction, apart from progressive rail line and sleeper track renewal. However, it would involve more frequent use of the existing loader.

All operations at both facilities, including stockpiling and conveyor operation as well as train loading, may be conducted on a 24-hour basis.

Trains using both loading facilities would operate from the Main Northern Line via the Antiene spur. The joint user facility would be operated such that no more than 20MT would be transported down the Antiene spur in any year.

Operations at each loader would be on a campaign basis, with each campaign transferring approximately 120,000 tonnes of coal. A campaign would involve approximately 19 trains and run for approximately 60 hours (for the Bayswater loader) or 70 hours (for the Drayton loader). Campaigns at the two loaders may run simultaneously.

Figure 2-1 shows the layout of the proposed facility. Properties are numbered arbitrarily.

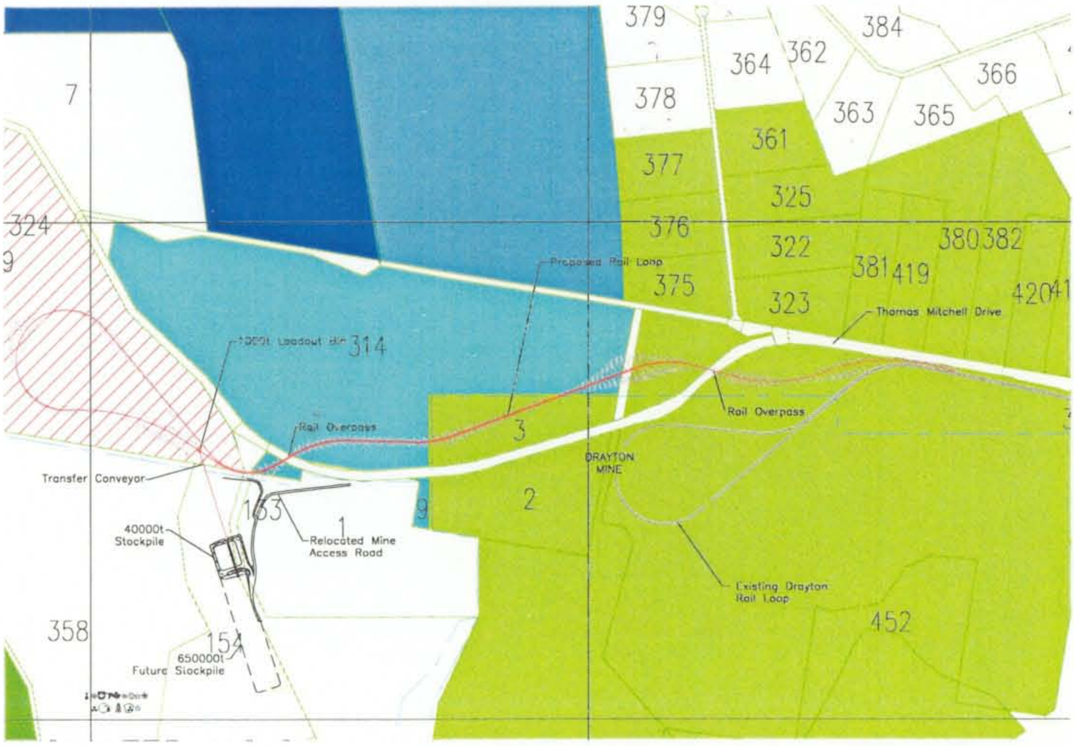


Figure 2-1 LAYOUT OF PROPOSED FACILITIES

3. EXISTING NOISE LEVELS

3.1 Measurement Procedures

Existing noise levels were monitored at six locations, representing the residences most likely to be affected by noise from the proposed facilities. These are shown in Figure 3-1. The monitoring period(s) for each location are shown in Table 3-1, together with a description of the noise sources most likely to influence the intrusive or background noise level, as noted on site visits.

The noise monitoring equipment used for these measurements consisted of Environmental Noise Loggers set to A-Weighted, Fast response continuously monitoring over 15 minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift occurred.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the ambient noise. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample time respectively. The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional passby of a heavy vehicle. The L_{A90} level is normally taken as the background noise level during the relevant period. The L_{Aeq} level is the Equivalent Continuous Sound Level and has the same sound energy over the sampling period as the actual noise environment with its fluctuating sound levels.

These noise levels were recorded every 15 minutes during the monitoring period. Full records of monitored noise levels for each monitoring day are available on the Wilkinson Murray web site:

www1.tpgi.com.au/users/wmurray.

3.2 Data Analysis

The Environment Protection Authority's Industrial Noise Policy (INP)[1] specifies methods for calculating a background noise level, known as the Rating Background Level (RBL), for use in determining noise criteria. A separate RBL is calculated for day (7am – 6pm), evening (6pm – 10pm) and night (10pm – 7am) periods.

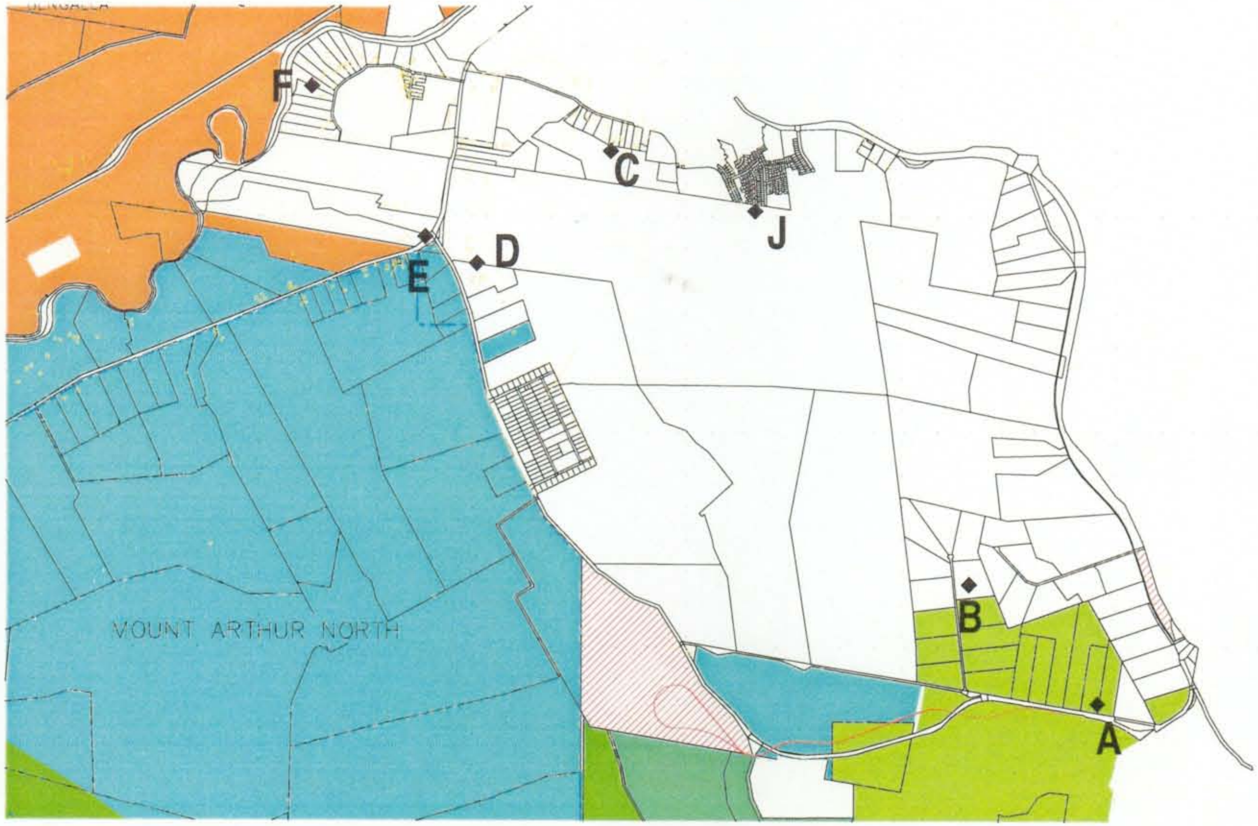


FIGURE 3-1 NOISE MONITORING LOCATIONS

Table 3-1: NOISE MONITORING LOCATIONS

Location	Monitoring Period(s)	Noise Sources
A: Thomas Mitchell Drive near Drayton Mine (40m from road)	15/6/99–30/6/99	Heavy vehicles on Thomas Mitchell Drive; Drayton Mine
B: Balmoral Road, Antiene	10/8/99–15/8/99[1]	Heavy vehicles on Thomas Mitchell Drive; Drayton Mine
C: Barnett residence, Skelletar Stock Route	15/6/99-30/6/99; 10/8/99-26/8/99	Heavy vehicles from Bayswater No 3 Mine; highway trucks
D: Webber residence, Thomas Mitchell Drive & Denman Rd	15/6/99-30/6/99; 10/8/99-26/8/99	Animal noises; mine noise very faint
E: Yaminee residence, Thomas Mitchell Drive & Denman Rd	15/6/99-30/6/99; 10/8/99-24/8/99	Heavy vehicles on Denman Road; occasional noise from Bengalla Mine
J[2]: Roxburgh residence, South Muswellbrook	10/12/99-16/12/99	Mining noise; highway trucks

(1) Measurements truncated due to vandalism of logger

(2) Site numbering is based on that used for the Mt Arthur North EIS

In calculating the RBL, measurements are excluded if they are affected extraneous noise, if the average wind speed during the measurement exceeds 5 m/sec, or if rain was recorded during the measurement. There are also complex rules whereby an entire day, evening or night period may be regarded as invalid depending on the number and pattern of excluded 15-minute samples within the period.

Meteorological data were provided by Holmes Air Sciences, based on results from the monitoring station at Bengalla Mine. This data set is used because it allows for estimation of wind speed at 1.5 m from the ground. Wind speeds during the monitoring period varied significantly, and were often greater than 5 m/sec, particularly during the daytime. This is shown in Table 3-2.

Table 3-2: EFFECT OF METEOROLOGICAL CONDITIONS ON NOISE MONITORING DATA

	Percentage of Recorded 15-Minute Intervals	
Period	**Wind > 5 m/sec**	**Rain**
Day	11%	7%
Evening	8%	5%
Night	0.5%	5%

The effect of the relatively high percentage of wind-affected data is that, under the INP rules, a large number of daytime periods would be excluded completely from the analysis (although they may contain some valid 15-minute samples). For this reason, data analysis was conducted in two ways:

- including only time periods which are considered acceptable under the INP rules; and

- including all 15-minute periods with valid noise readings, not affected by winds greater than 5 m/sec or rain.

Calculated Rating Background Levels using these two procedures, for each monitoring location, are shown in Table 3-3.

Noise levels at locations A and B are affected by existing noise from Drayton Coal Mine, and from trucks on Thomas Mitchell Drive. Because noise from trucks and trains is intermittent in nature, it can be assumed to have only a minor effect on measured background noise levels, and on the RBL. Based on the data in Table 3-3, RBL values at location A are estimated as 40dBA for day, evening and night periods, and 36dBA for all periods at location B.

With the exception of the easternmost residence, on property 417, residences on Thomas Mitchell Drive close to location A are owned by the Drayton Coal Mine, and hence are not considered in assessments below.

RBL values for locations C – E, to the north of the site, are relatively consistent. They could be reasonably estimated at 35, 32 and 31dBA for day, evening and night periods respectively.

At location J, in South Muswellbrook, RBL values can be reasonably estimated as 30dBA during day, evening and night periods.

Table 3-3: MEASURED RATING BACKGROUND NOISE LEVELS AND L_{Aeq} LEVELS

Location	Period	INP Data Exclusion Rules: RBL, dBA	INP Data Exclusion Rules: Valid Time Periods	All Valid 15-minute Noise Measurements: RBL, dBA	All Valid 15-minute Noise Measurements: Valid Time Periods	Overall L_{Aeq} Noise Level, dBA
A	Day	39	2	39	8	62
(Thomas	Evening	42	4	42	8	58
Mitchell Drive)	Night	47	3	40	10	58
B	Day	33	1	36	4	51
(Antiene)	Evening	36	5	36	5	48
	Night	33	1	36	5	45
C	Day	32	13	35	29	45
(Skelletar	Evening	34	25	33	30	45
Stock Route)	Night	32	15	32	30	40
D	Day	36	13	37	29	53
(Th. Mit. Dr. &	Evening	33	25	33	30	48
Denman Rd)	Night	32	16	31	31	47
E	Day	33	12	35	28	56
(Th. Mit. Dr. &	Evening	32	23	32	28	53
Denman Rd)	Night	33	14	33	29	55
J	Day	30	1	30	5	50
(South	Evening	33	3	36	5	55
Muswellbrook)	Night	31	4	30	6	44

These values are summarised in Table 4-1, together with noise level criteria derived from them.

4. NOISE LEVEL CRITERIA

4.1 Operational Noise Levels

The Industrial Noise Source Policy sets out two forms of noise criterion, which should both be met by any proposed development. These are described below.

4.1.1 Intrusiveness Criterion

The intrusiveness criterion specifies that the L_{Aeq} noise level from the proposed source, with adjustments for certain "modifying factors" related to the type of noise emission, should not exceed the RBL by more than 5dBA.

In the present case, the application of modifying factors is relevant for certain specific noise sources, namely an adjustment for tonality in the case of squealing of train carriage wheels (on the existing Drayton loop) and for truck reversing alarms (at both the existing and proposed loaders). These sources are both intermittent in nature. At other times, the overall noise at any residence due to all activities would be dominated by continuous or quasi-continuous sources such as conveyors and loading bins, and would be unlikely to attract such adjustments. Hence, the criterion noise level for these general sources is set equal to the RBL plus 5dBA, for the relevant time period.

This criterion should be met under specific meteorological conditions, which are detailed in the INP. Definition of appropriate conditions is discussed in detail in Chapter 5.

4.1.2 Amenity Criterion

The second type of criterion is an amenity criterion, and is intended to ensure that the total L_{Aeq} noise level from all industrial sources does not exceed specified limits. For rural residences, the recommended "acceptable" levels are:

Day	50 dBA L_{Aeq}
Evening	45 dBA L_{Aeq}
Night	40 dBA L_{Aeq}

(These time periods are as defined above for calculation of the RBL, with the exception that for the purpose of the amenity criterion only, the "night" period extends to 8:00am, rather than 7:00am, on Sundays and public holidays.)

The amenity criterion represents the cumulative impact of all existing and potential industrial noise sources affecting a location, and the appropriate criterion for a new source depends on the existing and future noise levels from other industrial sources. The Policy specifies explicitly how the above values should be reduced if the existing noise level from other industrial sources is known.

In this case, residences in Antiene are currently exposed to existing industrial noise associated with Drayton Coal Mine, while those on Denman Rd and Skelletar Stock Route are affected by noise from Bengalla and Bayswater No 3 Mines. At South Muswellbrook, observation indicates that noise from other industrial sources, while audible, makes only a small contribution to the total measured noise level, and existing L_{Aeq} noise levels from these sources would be well below the "acceptable" levels shown above.

Detailed modelling of future noise from the Drayton and Bengalla mines is beyond the scope of this study, and therefore L_{Aeq} noise levels from these sources cannot be specified at the time of writing this report. This means that the procedure specified in the INP for setting a reduced "amenity" criterion cannot be followed directly. Rather, in the present assessment, an alternative approach is adopted.

If noise at a point is due to two distinct sources, and if the L_{Aeq} noise level from each source is at least 3dBA below the amenity criterion, then total L_{Aeq} noise levels will be within the criterion. This is taken to represent a "fair sharing" of noise impact between the sources. Hence, at locations where the cumulative impact of noise from one other mine is important, the criterion adopted is that noise from the proposed development should not exceed a level 3dBA below the EPA's amenity criterion.

4.1.3 Summary of General Operational Noise Criteria

The operational noise level criteria for the proposed Joint User Facility, as described above, are summarised in Table 4-1. All these criteria should be met under specific meteorological conditions, which are described in the INP. These conditions are discussed in Chapter 5.

Table 4-1: CRITERIA FOR OPERATIONAL NOISE LEVELS, $L_{Aeq,15min}$ FROM JOINT USER FACILITY

Location	Period	RBL, dBA	Intrusiveness Criterion, dBA	Amenity Criterion, dBA
Antiene (property 217, on Thomas Mitchell Dr)	Day	40	45	47
	Evening	40	45	42
	Night	40	45	37
Antiene (remainder)	Day	36	41	47
	Evening	36	41	42
	Night	36	41	37
Skelletar Stock Route & Th. Mit. Dr./Denman Rd	Day	35	40	47
	Evening	32	37	42
	Night	31	36	37
Sth Muswellbrook	Day	30	35	50
	Evening	30	35	45
	Night	30	35	40

4.1.4 Locations Where Criteria will be Exceeded

The criteria set out in Table 4-1 indicate the point at which some noise impact will be experienced by residents, and all reasonable measures should be taken to reduce noise levels below this value. A range of impacts may be experienced, depending on factors including building construction, lifestyle considerations and individual noise sensitivity.

Where either or both of the intrusiveness and amenity criteria are predicted to be exceeded, the INP sets out a range of responses. These include:

- application of "feasible and reasonable" mitigation measures to reduce noise levels;
- negotiation with relevant government bodies and/or the affected community to determine reasonable limits based on the extent of any residual impacts and other factors such as social and economic benefits derived from the noise source; and
- in extreme cases, acquisition of affected properties.

4.2 Construction Noise – Bayswater Rail Loading Facility

The EPA's INSP explicitly does not cover noise from construction activities, and hence criteria for these activities are derived from the older Environmental Noise Control Manual.

The assessment of construction noise is dependent on the duration of construction in the vicinity of the potentially affected residential receiver. The Environmental Noise Control Manual suggests the following noise control guidelines.

Level Restrictions

- *Construction period 4 weeks and under.*
  The L_{A10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 20dBA.

- *Construction period greater than 4 weeks and not exceeding 26 weeks.*
  The L_{A10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 10dBA.

Time Restrictions

- *Monday to Friday* 7.00am to 6.00pm*
- *Saturday* 7.00am to 1.00pm if inaudible on residential premises, otherwise 8.00am – 1.00pm*
- *No construction work to take place on Sundays or Public Holidays.*

The background noise levels mentioned under "Level Restrictions" can be identified with the RBL values described above.

It is likely that construction of the proposed Bayswater facilities would take more than 26 weeks, and hence neither of the above noise level criteria would apply. In such cases, it can be assumed that the intrusiveness criterion for a continuously-operating source would apply, which, as described above, generally means that L_{Aeq} noise levels should not exceed the Rating Background Level by more than 5dBA. Because of the limited time period for construction noise, it is not considered appropriate to apply an amenity criterion for daytime construction work.

Construction activities would take place between the hours indicated above, and hence daytime background noise levels should be used in determining criteria. Relevant criteria for construction noise are shown in Table 4.2

Table 4.2 CRITERIA FOR BAYSWATER CONSTRUCTION NOISE LEVELS

Location	Daytime RBL, dBA (Table 4.1)	Maximum acceptable L_{A10} noise level from construction activities, dBA
Antiene (property 217)	40	45
Antiene	36	41
Skelletar Stock Route & Th. Mit. Dr./Denman Rd	35	40
Sth Muswellbrook	30	35

It is probable that some blasting will be required in the construction of the rail loop. The EPA recommends that at any residence, overpressure levels generated during blasting should not exceed 115dBLin for 95% of blasts, with no level exceeding 120dBLin. Peak particle velocity vibration levels should not exceed 5mm/sec for 95% of blasts, and should in no case exceed 10mm/sec. These criteria are designed to protect human amenity, and are lower than those required to prevent damage to normally-constructed buildings.

4.3 Rail Traffic Noise

Criteria for assessment of noise from transportation corridors, including railways, are also explicitly excluded from the INSP. This assessment is therefore based on criteria in the Environmental Noise Control Manual. These are:

Planning Levels: $L_{Aeq,24hr}$ = 55dBA
L_{Amax} = 80dBA

Maximum Levels: $L_{Aeq,24hr}$ = 60dBA
L_{Amax} = 85dBA

Because the proposed Bayswater rail loop is a new development, the planning noise levels above are used in assessment of noise from the newly-constructed sections.

The proposed development will also generate additional rail movements on the existing Antiene spur and on the Main Northern Line to the Newcastle Coal Loader. On these section of existing rail line, the "Maximum Level" criteria shown above are considered appropriate. However, where existing noise levels exceed these limits, an increase of up to 2 dBA in these existing noise levels is generally considered acceptable.

5. ACCOUNTING FOR METEOROLOGICAL FACTORS IN NOISE ASSESSMENT

At relatively large distances from a source, the received noise level will be influenced by meteorological conditions, particularly wind and temperature gradients, and hence will vary from hour to hour and night to night. The EPA's Industrial Noise Policy specifies that where such effects are significant, noise criteria should be met under adverse meteorological conditions, which are defined in terms of specific parameters to be used in assessment. Separate procedures are defined for assessment of temperature inversion and gradient wind effects, as outlined below.

The procedures described in the INP are directed toward finding a single set of meteorological conditions, representing generally adverse conditions for noise propagation, which should be used in noise assessment. In the present assessment, meteorological effects on noise propagation are taken into account generally in accordance with procedures in the INP. However, where a more detailed analysis is believed to be required, this is provided.

The remainder of this chapter gives details of meteorological conditions in the area of the proposed development, and the procedures used in this study to account for meteorological effects in assessment of operational noise. For rail traffic noise, these effects are not significant due to the shorter source-receiver distances involved.

5.1 Meteorological Data Available

Two meteorological data sets are available for analysis, as described below.

- Data from a mast in the Bengalla mine lease area. This mast is located to the north of the proposed Joint User Facility site, and provides direct, high-quality measurements of temperature gradient, as well as wind speed and direction, to a height of 90m at 15-minute intervals. However, recorded wind directions, in particular, may not be representative of low-speed drainage flow winds close to the Joint User Facility and nearby residences.

- Data from a monitor immediately to the north of the proposed facilities, operated by Macquarie Generation. Temperature gradient data are not directly available from this monitor, but temperature gradients represent a more widespread phenomenon, and data from the Bengalla mast are considered to be representative in this case. Hourly wind speed data at 10m above ground for the period December 1994 – November 1996 were used for analysis of wind speed and direction.

5.2 Effect of Temperature Inversions on Noise Assessment

During the night-time (10pm-7am), the INP requires assessment of the possible effects of temperature inversions and associated drainage-flow winds on noise propagation, as well as of any gradient winds which may occur in the absence of temperature inversions.

A temperature inversion is said to occur when temperature increases with height above the ground. Inversions are typically found during the night and early morning periods, and are most common in winter. Under these conditions, noise which would otherwise propagate away from the ground can be refracted downwards, increasing the noise level as heard on the ground. This effect can dramatically reduce the effectiveness of barriers and shielding in controlling noise.

According to the INP, inversions are required to be considered when moderate or strong inversions (associated with Pasquill Stability Class F or G, or a vertical temperature gradient of at least 1.5 degrees C per 100m) occur for at least 30% of the period from 6pm to 7am during June, July and August. For the Hunter Region, tables of inversion frequency are provided in the INP document, and these indicate that in the area of the proposal, such inversions occur for 30-35% of this time period. Measured temperature gradient data from the Bengalla mast indicate an even higher frequency of approximately 67% for such inversions. Hence, the influence of temperature inversions requires evaluation for night-time assessments under the INP.

In defining a single set of conditions to adopt in assessing noise levels against criteria, the INP allows for the use of either "default" meteorological parameters, or parameters based on measured data. In the Hunter Valley, the appropriate "default" conditions would be those for non-arid areas, namely:

- temperature inversion of strength 3^{o} C per 100m; and
- wind speed of 2 m/sec.

In defining "data-based" meteorological conditions for assessment, the parameters to be used are:

- the ninetieth percentile temperature gradient for the period 6pm-7am during June, July and August; and
- *"the wind speed associated with the chosen temperature gradient".*

Based on data from the Bengalla mast, the relevant ninetieth percentile temperature gradient is 8.2° C per 100m.

Figure 5-1 indicates the wind directions associated with night-time temperature inversion conditions from the Bengalla and Macquarie Generation data sets. (In the absence of direct measurements, the presence of an inversion can be inferred for Pasquill atmospheric stability class F.) At the Bengalla monitor, these "drainage flow" winds tend to be from the east, while at the Macquarie Generation monitor they tend to be from the north. This difference is believed to be related to the local topography close to the monitors.

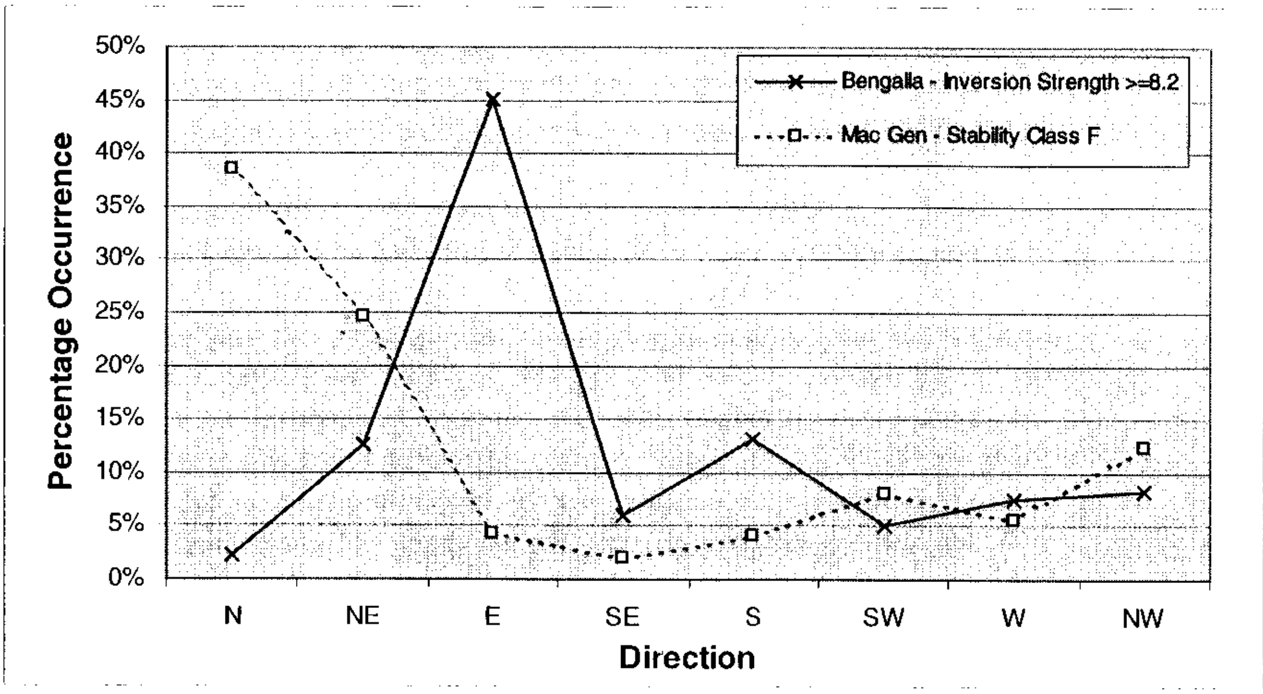


Figure 5-1: WIND DIRECTION AT 10m ABOVE GROUND, 10pm-7am IN WINTER, (from Bengalla and Macquarie Generation monitoring data)

However, the relevant "drainage flow" wind for noise assessment is not necessarily related to either of these values. Between the proposed loading facilities and residences at Antiene is a ridge, approximately 40m high, which would tend to negate any drainage flow in this direction. The INP indicates that wind should not be considered in temperature inversion conditions where there is intervening higher ground between the source and receiver. For residences to the north of the facilities, the Macquarie Generation data indicate that the likely wind direction under inversion conditions is from the north.

Hence, for noise sources located to the west of the ridge line near Antiene, it can be conservatively assumed in assessment that no drainage-flow wind would be present under inversion conditions.

However, the existing Drayton coal loader and part of the proposed new rail line are situated to the east of the ridge line near Antiene, and are uphill from the Antiene residences. Hence there is a possibility of drainage-flow wind from the south for these sources. (A light southerly wind was in fact observed here on two measurement nights.) Hence, in calculating noise levels from this source, a southerly wind was assumed. In the absence of any monitoring data at this specific location, the INP "default" value of 2m/sec was adopted.

For both groups of sources, the INP "data-based" value of 8.2°C per 100m was used for the inversion strength. This then gives the best estimate of the noise level which would be exceeded for 10% of the night-time period in winter.

5.3 Effect of Gradient Winds

Wind blowing from a source to a receiver has an effect on sound propagation which is similar to that of a temperature inversion, due largely to the fact that wind speed tends to increase with height.

The INP requires assessment under conditions of "gradient wind" for all time periods (day, evening and night) and all seasons. Wind is required to be considered when wind speeds of less than 3 m/sec, with a positive component from source to receiver, are present for at least 30% of the time in any assessment period during any season. Wind speeds are to be measured at 10m above ground.

Table 5-2, based on data from the Macquarie Generation monitor, indicates that wind speeds below 3 m/sec, for all directions combined, are not common in the area, with the exception of the night-time period. Further analysis was conducted to calculate the proportion of time when wind occurred with a speed below 3 m/sec together with a positive component in any of the eight standard directions. The only seasons and time periods when this proportion exceeded 30% for any of the standard wind directions were:

- during night-time (in all seasons); and
- during winter (in all time periods – day, evening and night).

Table 5-2 PERCENTAGE OF WIND SPEEDS (FROM ALL DIRECTIONS COMBINED) BELOW 3 m/sec

	Percentage Occurrence of Wind Speed < 3m/sec		
Season	**Day**	**Evening**	**Night**
Spring	32%	36%	62%
Summer	34%	24%	53%
Autumn	40%	37%	64%
Winter	44%	48%	72%

Hence, the influence of gradient winds requires assessment only during these periods.

The "default" condition specified in the INP for assessment of gradient winds is a wind speed of 3m/sec. A "data-based" assessment is also allowed for, but appears to apply only if wind speeds NEVER reach 3m/sec at the site, and hence is not relevant for this assessment.

During the night-time, although assessment is in principle required under gradient wind conditions, preliminary analysis indicated that noise levels under conditions of 3m/sec wind (in any direction) are always lower than those under the temperature inversion conditions described in Section 5.2. Hence, during the night-time period, only the more conservative temperature inversion conditions need to be considered for noise assessment.

During day and evening periods in winter, the distribution of wind directions at the Macquarie Generation monitor is shown in Figure 5-2, for wind speeds of 3 m/sec and below. During both periods, the predominantly northerly direction seen at night is still clear. Since relevant receivers are in all cases to the north of all relevant sources, the INP would indicate that zero wind speed should be used in daytime and evening noise assessments. (Consideration of a downhill direction for drainage-flow wind is relevant only under temperature inversion conditions.)

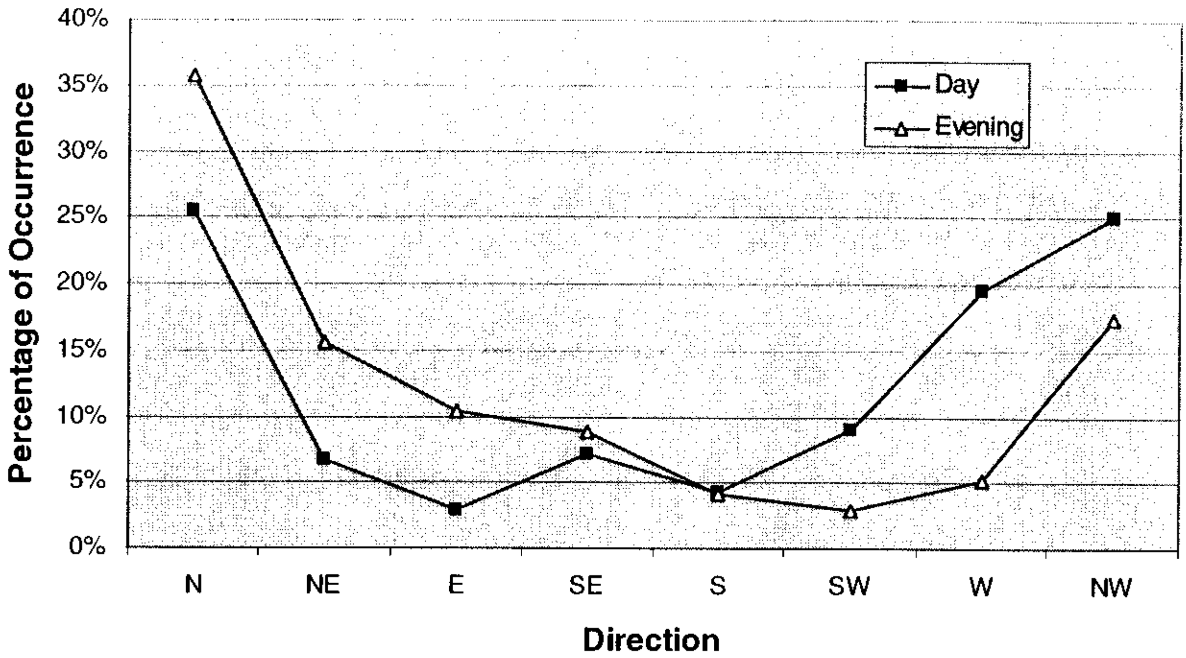


Figure 5-2: WIND DIRECTION AT 10m ABOVE GROUND, DAY AND EVENING PERIODS, FOR WIND SPEED <= 3m/sec, JUNE –AUGUST (from Macquarie Generation monitoring data)

Finally, it should be noted that the wind directions shown in Figure 5-2 apply only for relatively light winds. If all wind speeds are considered, south-east and north-west winds are prominent during the daytime, a result which is consistently found in this area. However, the INP indicates that winds speeds above 3m/sec may be associated with other effects such as an increase in background noise levels, and hence should not be considered in assessing noise enhancement effects.

5.4 Summary

In summary, for this project the noise criteria specified in Section 4.1.3 should be met at all residences and other noise-sensitive locations under the following meteorological conditions:

Night (10pm-7am): criteria should not be exceeded under conditions of 8.2^{o}C per 100m temperature inversion, and 2m/sec wind from the south applied only to sources to the east of the ridge near Antiene;

Day (7am-6pm) and Evening (6pm-10pm): criteria should not be exceeded under conditions of zero wind and zero temperature gradient;

In practice, the night-time assessment conditions are much more stringent, and the night-time noise criteria to be met are at least as stringent as those applying during the day and evening. Since the operation of the proposed facilities does not differ between day and night, only night-time operational noise impacts require assessment.

6. CALCULATED NOISE LEVELS – OPERATIONAL NOISE

6.1 Calculation Procedures

Noise levels due to operation of the proposed facilities were calculated using the ENM computer model. This model takes account of noise attenuation by geometrical spreading, atmospheric absorption and the effect of acoustically soft ground, sand also allows calculation of the enhancement or attenuation of noise due to wind and temperature gradients.

Levels from sources to the west of the ridge near Antiene were calculated under conditions of 8.2°C per 100m temperature inversion, at receiving locations on a 250m x 250m grid covering the area of interest. Levels from the Drayton loader, and from trains on the section of line east of the ridge line near Antiene, were calculated using the above temperature inversion plus a 2m/sec wind from the south, and the results combined at each receiver. The SURFER surface-generation package was then used to derive noise contours from the results.

6.2 Noise Sources and Control Measures

6.2.1 Bayswater Loader facilities

Noise sources associated with the proposed new facilities are listed in Table 6-1, together with their assumed sound power levels. In many cases, significant noise controls have been incorporated into the project design to reduce the emitted noise levels from these sources, as described in Table 6-1.

In all cases, source locations have been chosen to represent "worst case" conditions. In particular, it has been assumed that three triple-header coal trains are queued on the loop, with their locomotives situated in the most exposed possible locations. It should be noted, however, that due to signal positioning, locomotives would not stand for long periods on the single-track section east of chainage 1100. The L_{Aeq} noise level from trains moving on this section was calculated on the assumption that one train may pass by in a 15-minute period at a speed of 40km/h.

To control noise from locomotives, two sections of noise barrier will be constructed on the northern side of the track:

Table 6-1 OPERATIONAL NOISE SOURCES – BAYSWATER

Source	Location (see Fig. 2-1)	Sound Power Level, dBA	Comments
Train loadout bin	Loadout Bin	106	Requires 10dB control compared with a typical bin. This can be achieved using an enclosure around the loading point, lined with sheet steel with acoustic absorbing material on the inside facing.
Transfer conveyor	Between stockpile and loadout bin	79 per m (total length 517m)	Requires shielding near belt to achieve 5dB control compared with typical conveyors. Modelled as 10 point sources with appropriate heights.
Conveyor loading bin	At loading point over stockpile	106	Requires 10dB control compared with a typical bin. This can be achieved through sheet steel lining, extending from the top of the bin to below the conveyor, with acoustic absorbing material on the inside facing.
Truck at conveyor loading bin	At loading point over stockpile	113	Best available practice for noise level from haul trucks
Truck near stockpile	At NE corner of haul road (worst case)	113*	Best available practice for noise level from haul trucks
Dozer at stockpile	At NE corner (worst case)	110	Requires significant control compared with typical dozers, but considered possible. Consistent with assumptions for Mount Arthur North mine.
Conveyor Drives	Drive house (50m from loadout bin)	97	Requires 10dB control compared with typical equipment. This can be achieved using an enclosure around the drive house, lined with sheet steel with acoustic absorbing material on the inside facing.
Three loco-motives, idling	Bridge over Thom. Mit. Dr. (ch. 5500)	110	Consistent with previous measurements
Three loco-motives, idling	Bridge over Thom. Mit. Dr. (ch 2800)	110	Consistent with previous measurements
Three loco-motives, idling	ch 1500	110	Consistent with previous measurements
Three loco-motives at 40km/h	Line section between ch. 0 and 1000	112*	Consistent with previous measurements

* *L_{Aeq} level also dependent on time spent at location*

- over the eastern bridge over Thomas Mitchell Drive, from chainage 700 to 1100; and
- from the loadout bin (ch. 5200), across the western bridge over Thomas Mitchell Drive and continuing until the line enters a cutting at approximately ch. 6600.

The barriers would be at least 3m high, and constructed from profiled sheet steel or similar materials. In addition, both bridges over Thomas Mitchell Drive would be concrete structures, to ensure that re-radiated noise from the bridge structure does not add significantly to the total noise level.

All results described below include the effect of these measures.

6.2.2 Drayton Loader

Since the Drayton coal loader is an existing facility, noise levels were measured during normal operation on two nights – the early mornings of Tuesday 1 and Wednesday 2 February, 2000 – at a number of locations outside the site boundary. These are shown in Figure 6-1. Additional measurements were performed on 14 March, 2000 at 30m and 8m from the loader, to determine the emitted sound power level.

Equipment used consisted of CEL 593 and Bruel & Kjaer type 2231 sound level meters, which recorded both maximum noise levels during the loading of one rail car, and L_{Aeq} levels over appropriate time periods during this operation. The equipment was calibrated before and after each measurement, and no significant drift in calibration was detected.

From measurements conducted close to the loading point, the L_{Aeq} sound power level emitted by a loading operation over a 5-minute period ranged from 108.1 to 112.6dBA, depending on the level of product in loading bin. A value of 111.5dBA was taken as representative of the higher levels measured. The mean difference between the maximum level during loading of a single rail car and the L_{Aeq} level was 13.3dBA. This was used to convert maximum levels measured at other locations to equivalent L_{Aeq} levels.

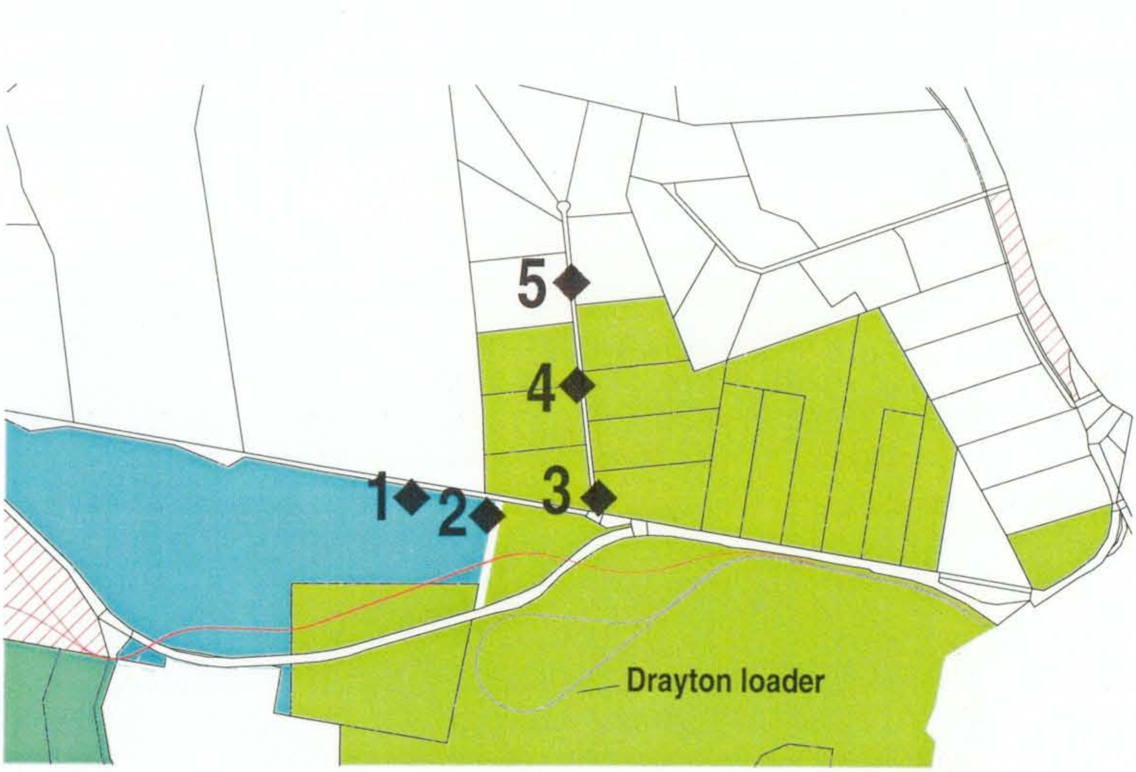


Figure 6-1 LOCATIONS FOR MONITORING NOISE FROM DRAYTON LOADER

Based on data from the Bengalla meteorological monitoring station, on both measurement nights the vertical temperature gradient was close to zero throughout the measurement period (varying from approximately –0.7 to +0.4°C/100m). The wind speed at the measurement locations was assessed as approximately 2m/sec from the south. Using these parameters, noise levels at each location were predicted using the ENM model, and compared with measured levels.

Figure 6-2 shows a comparison between measured and predicted noise levels at all locations outside the site boundary. The accuracy of the predictive model is seen to be acceptable, particularly at larger distances, closer to residences.

During some measurements, another noise source was noted – squealing of wheels on rail wagons as they traverse the loop. This was measured on four occasions, all at location 2. The $L_{Aeq,15min}$ sound power level from this source was estimated, based on the distance from the train, its length, and the time for which the noise was recorded, as approximately 108dBA. Because this source is clearly tonal in nature, this value should be increased by 5dBA, using the appropriate "modifying factor" specified in the INP, to give an effective sound power level of 113dBA.

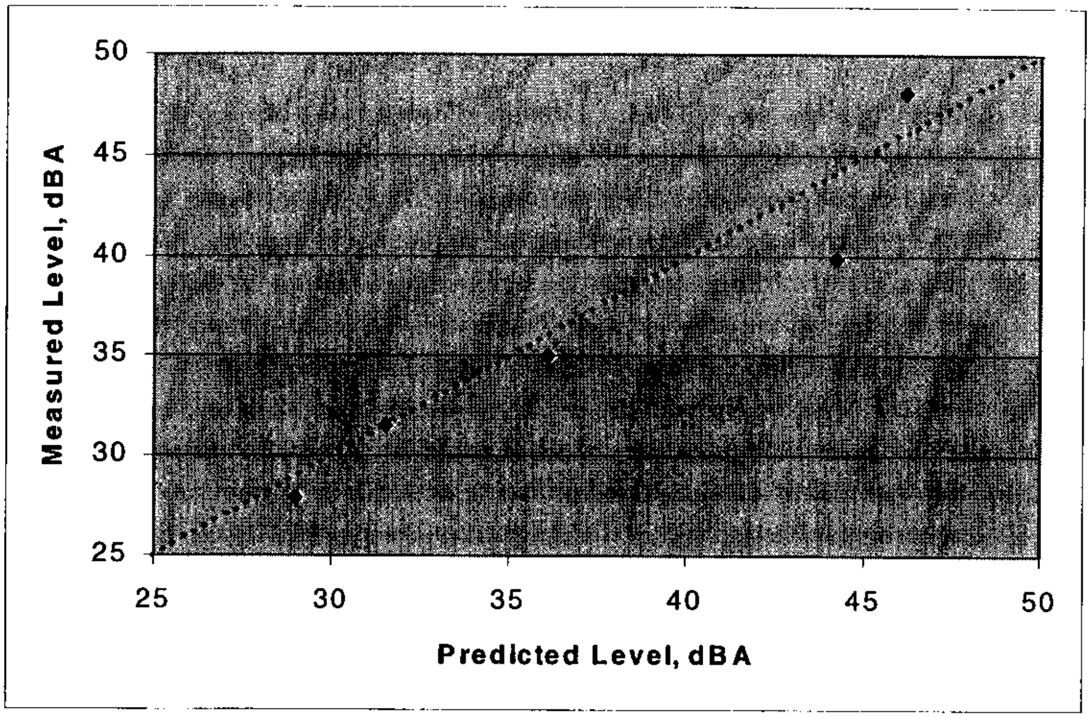


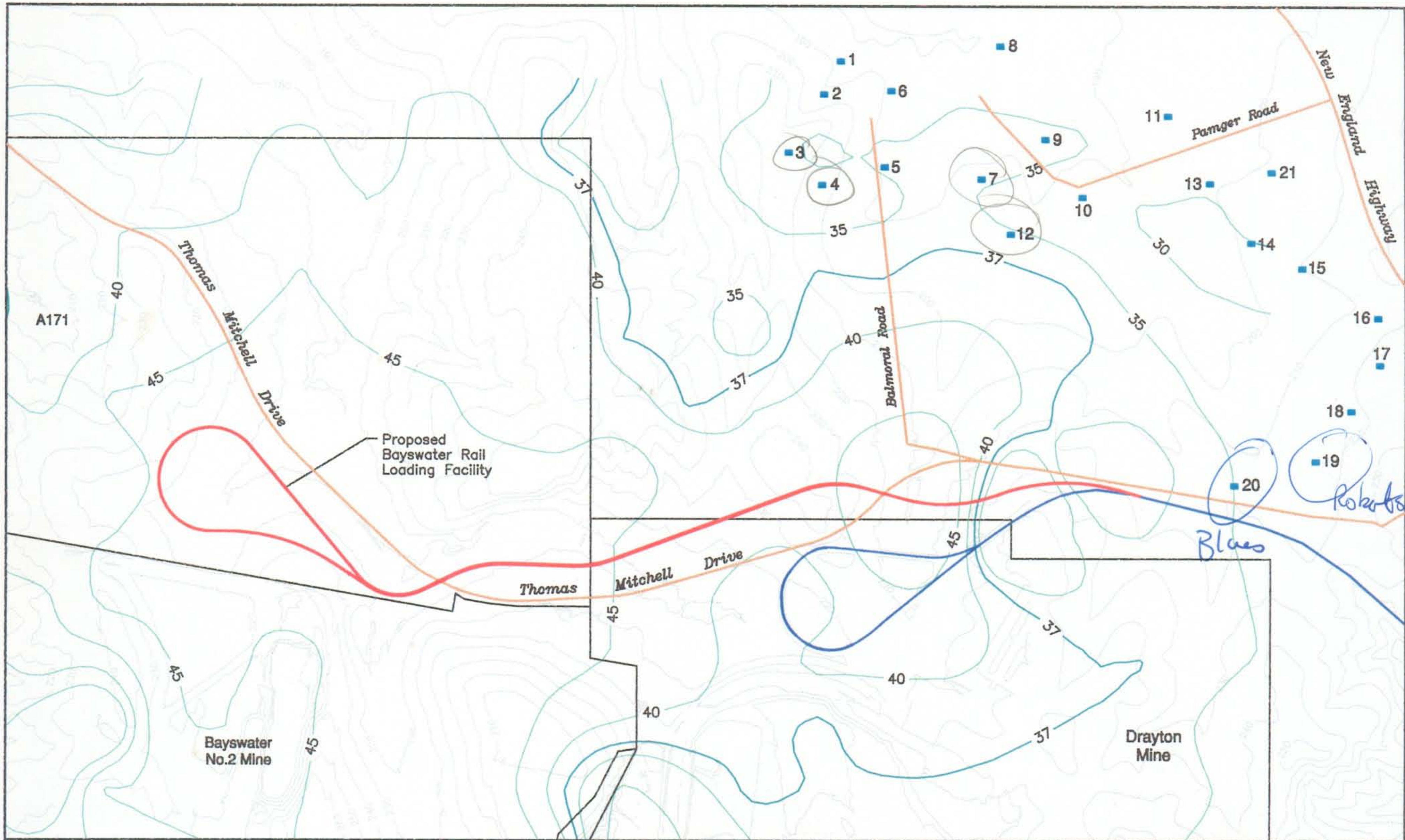
Figure 6-2: MEASURED AND PREDICTED L_{Aeq} NOISE LEVELS FROM DRAYTON LOADER

6.3 Results

Figure 6-3 shows calculated night-time noise level contours for sources associated with the proposed rail loop and Bayswater loader only (i.e. excluding the Drayton loader). The contours are shown for the area around Antiene. Here, the most stringent criterion is the amenity criterion of 37dBA (reduced from 40dBA on the basis of existing noise exposure from industrial sources).

From Figure 6-3, the criterion of 37dBA is predicted to be met at all residences, with the maximum noise level at any residence residences being 35dBA.

At residences in South Muswellbrook, on Skelletar Stock route, and near the intersection of Denman Rd and Thomas Mitchell Drive, calculated noise levels are below 30dBA, and well within the most stringent criterion of 35 or 36dBA applying in these areas.



Legend

- Existing Rail Loading Infrastructure
- Proposed Rail Loading Infrastructure
- Noise Contours
- Surface Contours
- Residences

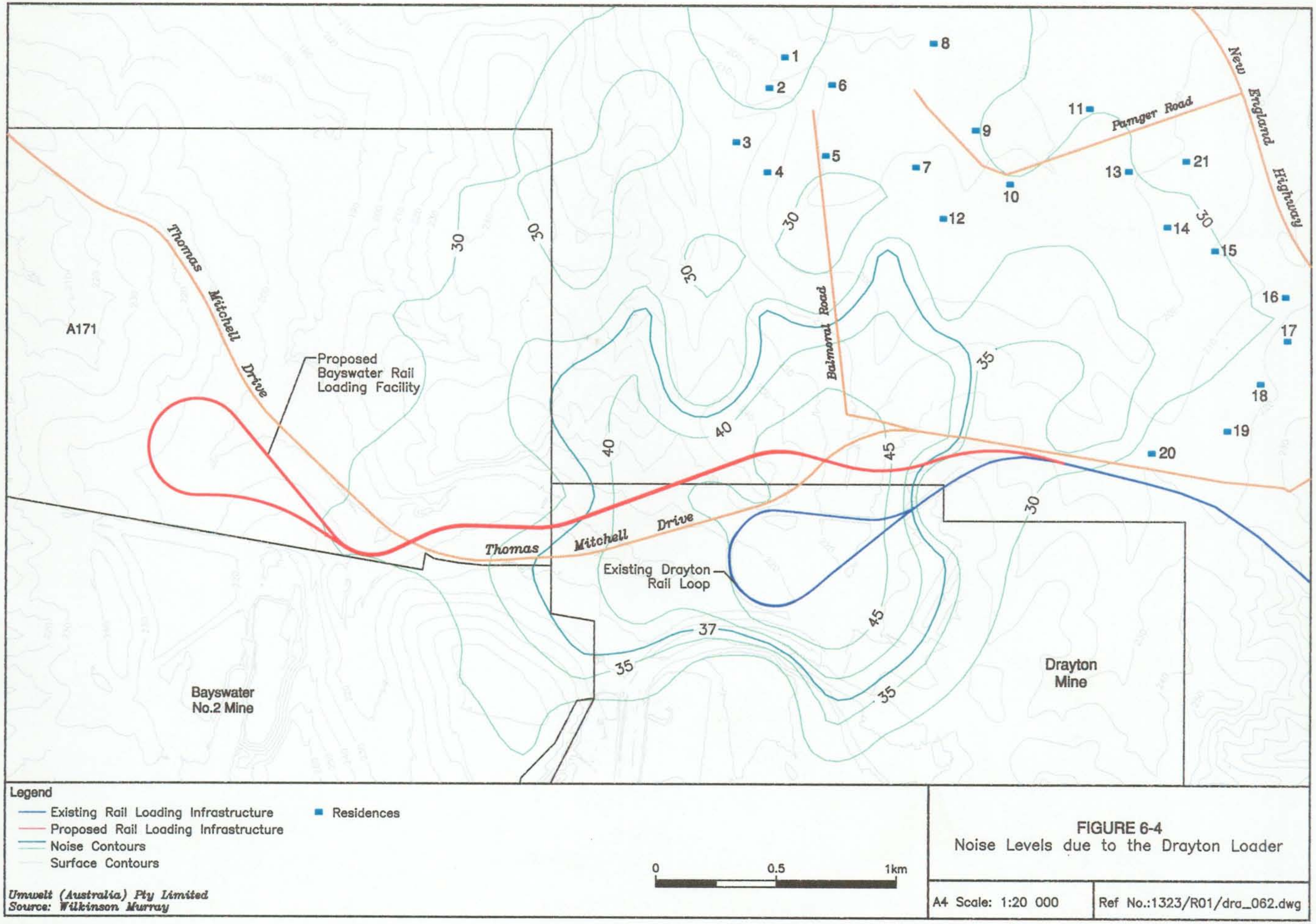
0 0.5 1km

Umwelt (Australia) Pty Limited
Source: Wilkinson Murray

FIGURE 6-3
Noise Levels due to Sources Associated with the Bayswater Loader

A4 Scale: 1:20 000

Ref No.:1323/R01/dra_061.dwg

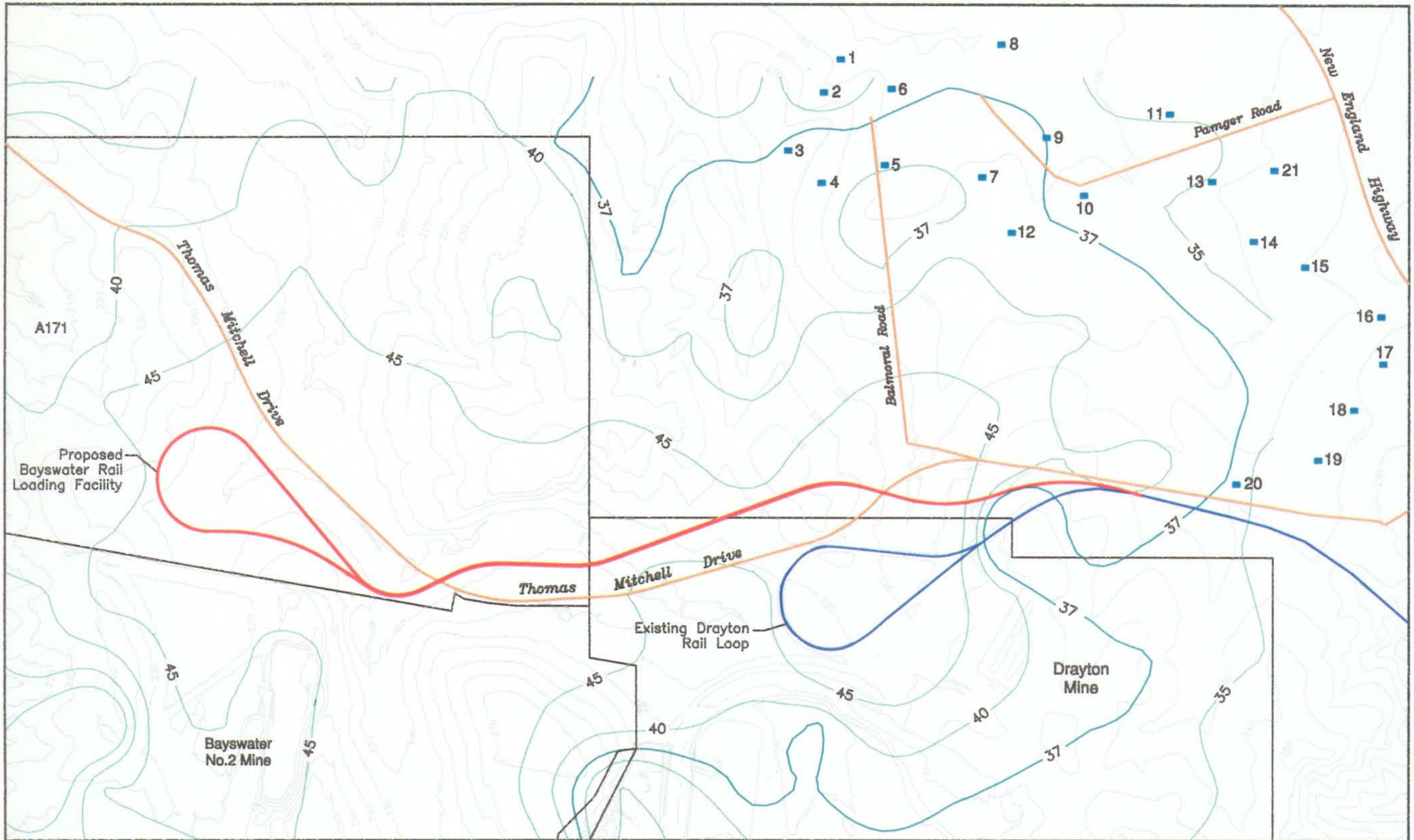


Umwelt (Australia) Pty Limited
Source: Wilkinson Murray

FIGURE 6-4
Noise Levels due to the Drayton Loader

A4 Scale: 1:20 000

Ref No.:1323/R01/dra_062.dwg



Legend
- Existing Rail Loading Infrastructure
- Proposed Rail Loading Infrastructure
- Noise Contours
- Surface Contours
- Residences

Umwelt (Australia) Pty Limited
Source: Wilkinson Murray

FIGURE 6-5
Noise Levels due to Bayswater & Drayton Loaders Operating Simultaneously

A4 Scale: 1:20 000

Ref No.:1323/R01/dra_063.dwg

6.4 Noise Levels from Intermittent Sources

As discussed above, a further source of intermittent noise which may result in sleep disturbance is reversing alarms on mobile plant operating at the stockpile and loading bin. Based on previous measurements, typical sound power levels from a reversing alarm are approximately 115dBA.

Assessment of potential sleep disturbance is difficult, and appropriate criteria are under discussion. However, the most conservative of recognised criteria is that set out in the EPA's Environmental Noise Control Manual, which indicates that to protect against sleep disturbance the L_{A1} noise level from any event should not exceed the L_{A90} background level by more than 15dBA. In this case, the minimum measured background noise level is 36dBA in Antiene and 30dBA elsewhere, giving a minimum criterion of 51dBA for Antiene, and 45dBA elsewhere, for the L_{A1} noise level from the above events. The L_{A1} level can be conservatively identified with the maximum noise level.

Noise levels from a reversing alarm at the Drayton loader, and at the proposed new loading bin, were calculated at the nearest residences, under the meteorological conditions described above for operational noise assessment. Calculated levels were at most 47dBA for any residence in Antiene, and less than 35 dBA elsewhere.

These calculated noise levels are below the relevant criteria, and it is concluded that their potential for disturbing the sleep of residents is minimal. It should be noted, however, that if residents are awake, these sources are likely to be audible under the conditions specified.

7. CALCULATED NOISE LEVELS - BAYSWATER CONSTRUCTION NOISE

Construction of the proposed facilities would be concentrated in three major areas – the stockpile, the loadout facilities and the bridge structures. Operations in these areas can be assumed to take place over a period greater than 26 weeks, and noise levels are assessed against intrusiveness criteria relevant for a continuous source.

Construction of the rail track and associated earthworks will also generate noise, which would be over a more limited period for any given receiver. Noise from this activity will be assessed against the specific construction noise criteria set out in the Environmental Noise Control Manual for construction requiring between 4 and 26 weeks. Other activities which would only occur over limited periods are those related to piling, blasting and rock breaking. It is also considered appropriate that noise associated with these activities be assessed against specific criteria for construction noise.

Equipment items expected to be used in construction, and typical measured sound power levels, have been provided. These items were distributed among the construction sites as shown in Table 7-1, representing a typical scenario during construction. To provide a worst-case assessment, bridge construction is assumed to be concentrated on the bridge at chainage 1000, which is closest to potentially-affected residences.

Noise levels due to this activity were modelled in a similar way to operational noise levels, as described above. However, in this case the activity will take place during daytime only, and hence, as described in Chapter 5, "neutral" meteorological conditions are assumed.

Note that the sound power levels listed in Table 7-1 represent L_{A10} levels. These are appropriate for assessment against construction noise criteria, but in the case of long-term construction, L_{Aeq} levels are required. These are assumed to be 2dBA below the quoted L_{A10} levels. It should also be noted that the assumed sound power level for a bulldozer is higher than was used for modelling operational noise, as it may not be possible to source quiet equipment for the purpose of construction.

Table 7-2 shows calculated noise levels from long-term sources at each of the receiver locations shown in Figure 6-3. All levels are well within the long-term construction noise criterion of 41dBA.

Table 7-1 EQUIPMENT USED IN CONSTRUCTION

Location	Equipment	Assumed L_{A10} Sound Power Level, dBA
Stockpile	Bulldozer	116
	Grader	107
	Front End Loader	113
	Dump truck	107
	Compactor	107
	Water Truck	107
	Welding Equipment	97
	Generator	103
Loadout facilities	Bulldozer	116
	Grader	107
	Front End Loader	113
	Dump truck	107
	Compactor	107
	Water Truck	107
	Crane	112
Bridge at chainage 1000	Bulldozer	116
	Backhoe	102
	Front End Loader	113
	Dump truck	107
	Crane	112
	Welding Equipment	97
	Generator	103
Rail loop construction	Bulldozer	116
	Grader	107
	Backhoe	102
	Front End Loader	113
	Dump truck	107
	Roller	106
	Compactor	107
	Water Truck	107
Short-term activities	Rockbreaker	120
	Pile driver	122
	Drill	112

Table 7-2 NOISE LEVELS FROM LONG-TERM CONSTRUCTION ACTIVITIES

Residence	L_{Aeq} Noise Level from Construction Activities, dBA – "Neutral" Met. Conditions
1	23
2	28
3	29
4	30
5	32
6	29
7	32
8	29
9	30
10	31
11	28
12	33
13-20	< 28
CRITERION	41

Calculated noise levels from short-term activities are shown in Table 7-3. From this table, noise levels from these activities are also predicted to be below relevant criteria in all cases, with the exception of a 1dBA exceedance due to rock-breaking at residence 12.

Overpressure and vibration levels from any required blasting would be controlled through blast design, to minimise the maximum instantaneous charge (MIC) used in any blast. The closest point to any residence at which blasting may occur is approximately 750m from the residence. Based on standard predictive equations, verified by results of blast monitoring conducted at Bayswater No 3 mine, in order to meet both the overpressure and ground vibration criteria for blasting at this distance, the MIC would need to be limited to approximately 30kg ANFO equivalent.

Maximum allowable MIC values for blasting at other distances from the nearest residence are shown in Table 7-4. Provided that charge sizes are limited to those shown in Table 7-4, both overpressure and ground vibration criteria are predicted to be met for at least 95% of blasts.

Table 7-3 NOISE LEVELS FROM SHORT-TERM CONSTRUCTION ACTIVITIES

Residence	Calculated L_{A10} Noise Level from Construction Activities, dBA – "Neutral" Met. Conditions		
	Rail Loop Construction	Rock-Breaking	Piling
1	34	34	22
2	35	36	29
3	40	41	29
4	43	44	31
5	45	46	33
6	39	39	31
7	45	46	33
8	39	39	31
9	41	41	31
10	44	45	32
11	40	41	28
12	46	47	34
13-20	< 40	< 40	< 28
CRITERION		46	

Table 7-4 MAXIMUM MIC FOR BLASTING TO ENSURE PREDICTED OVERPRESSURE AND GROUND VIBRATION LEVELS WITHIN RECOMMENDED CRITERIA

Distance from Blast to Nearest Residence, m	Maximum Acceptable MIC for Blast, kg ANFO equivalent
700	29
850	52
1000	85
1500	290
2000	680
2500	1330

Overpressure and vibration from any blasting which is required during construction would be monitored, and if necessary blasting design would be modified to ensure that the appropriate criteria are met.

8. CALCULATED NOISE LEVELS – RAIL TRAFFIC

After trains leave the new section of track, they will constitute additional movements on lines which already take existing rail traffic. In all cases, the speed and type of trains will be similar to those already in operation, and hence maximum noise levels at any nearby residences will not alter. However, 24-hour L_{Aeq} noise levels will be increased due to the greater number of movements.

Two distinct track sections require consideration – the Antiene spur, where maximum existing movements are approximately 13 per day during loading operations at Drayton Coal Mine, and the Main Northern Line, where existing coal train movements are approximately 70 per day[1]. The proposal would result in a maximum of an additional 18 movements per day.

The closest residence to the Antiene spur is to the north of Lake Liddell, at approximately 600m from the track, and shielded from it by an intervening rise. Based on previous measurements, the sound exposure level due to a typical passby of a coal train can be estimated at approximately 94dBA at 20m. Using conservative calculation procedures, the $L_{Aeq,24}$ level resulting from a total of 31 movements per day on the Antiene spur, at a distance of 600m from the track, would be les than 45dBA, and certainly well below the recommended planning criterion of 55dBA.

For movements on the Main Northern Line, the maximum additional daily movements would produce an increase in L_{Aeq} noise levels of 0.7dBA at all residences along the line. This will be within the recommended criterion, independent of the existing noise level at the residence.

It should be noted that while an increase of 0.7dBA in L_{Aeq} noise levels due to a single project may be negligibly small, the cumulative effect of a number of new projects may result in a more significant increase. This is an issue which affects all existing and potential coal mines and other industrial developments in the Hunter Valley. It is not considered possible, or indeed equitable, for a single project to bear responsibility for mitigation of cumulative increases in noise from a major transportation route. Rather, it is considered that some form of joint action, coordinated by a government body, is required to address

[1] Based on information in the Report of the Hunter Valley Railway Programs Task Force, November 1997

the cumulative impact of rail traffic noise from a number of new projects using the Main Northern Rail Line for access to the Newcastle area.

9. CONCLUSIONS

Potential noise impacts associated with the proposed Antiene Joint User Rail Facility comprise:

- impacts due to loading operations at the new Bayswater loader, including trains queuing on the rail loop;
- impacts due to increased use of the existing Drayton loader and associated rail loop;
- impacts associated with construction of the new facilities; and
- impacts associated with additional rail movements on existing lines.

To control noise impacts at residences in Antiene due to operations at the Bayswater loading facilities, a number of noise control measures are recommended, including:

- enclosure or shielding of the train loading bin, conveyor loading bin, conveyor drive house and conveyor to achieve emitted sound power levels as specified in Table 6-1; and
- construction of two barriers, at least 3m high, adjacent to the northern side of the new track, between chainages 700-1100 and 5200-6600. These could be constructed from profiled steel or other suitable materials.

In addition, both bridges over Thomas Mitchell Drive should be concrete structures, to ensure that re-radiated noise from the bridge structure does not add significantly to the total noise level.

With these control measures, predicted noise levels due to operation of the new facilities are within recommended criteria at all potentially-affected residences.

To control noise levels from the existing Drayton loader, it is recommended that cladding be added to the northern side of the facility, extending from ground level to the top of the conical section of both loading bins, with an internal facing of absorbing material and vibration isolated from the existing structure. This measure is designed to provide a reduction of approximately

8dBA in the sound power level emitted in this direction during a loading operation.

With this measure, noise levels from the Drayton loader are predicted to be within the criterion for a new noise source at all potentially-affected residences.

Calculated noise levels due to both facilities operating simultaneously exceed recommended criteria at four residences, by at most 1dBA. This minor exceedance under worst-case conditions is considered acceptable.

Calculated noise levels due to squealing of carriage wheels during train movements on the Drayton loop are also within relevant criteria.

Noise from both long-term and short-term construction activities is predicted to be within recommended criteria at all residences.

The operation of additional trains on the Antiene spur will not result in noise levels exceeding the recommended criterion at any residences. Additional operations on the Main Northern Line will increase existing L_{Aeq} noise levels by approximately 0.7dBA, which is considered acceptable. The cumulative impact of a number of developments, all resulting in additional movements on this major transportation route, is an issue which requires attention. However, this cannot be adequately addressed in the context of a single development, and is considered to require coordinated planning through a government agency.

In addition to the noise control measures described above, it is also recommended that noise levels from the facilities be monitored on a continuing basis, as part of a noise management plan for the Joint User Facility. Monitoring should concentrate on residences with the highest predicted noise levels (residences 3, 4, 5, 7, 12 and 20 in Figures 6-3 to 6-5). Particular attention should be paid to monitoring of noise from squealing of train wheels, which has variable noise level and can be a particular source of annoyance. Where noise levels in exceedance of the relevant criteria are found, procedures should be set out in the noise management plan to identify the source and introduce appropriate control measures.

Version	Date	Status	Prepared by	Checked by
B	21/02/00	DRAFT	RB	NG

APPENDIX 7

Soil Assessment

DRAYTON COAL PTY LTD &
COAL OPERATIONS AUSTRALIA LIMITED

SOILS ASSESSMENT

PROPOSED ANTIENE JOINT USER RAIL FACILITY

Prepared by:

Umwelt (Australia) Pty Limited

Environmental and Catchment Management Consultants

March 2000

1323/R01/A7

Report No. 1323/R01/A7

Prepared for:

DRAYTON COAL PTY LTD &
COAL OPERATIONS AUSTRALIA LIMITED

SOILS ASSESSMENT

PROPOSED ANTIENE JOINT USER RAIL FACILITY

Umwelt (Australia) Pty Limited
Environmental and Catchment Management Consultants

PO Box 838
Toronto NSW 2283

Ph. (02) 4950 5322

Fax (02) 4950 5737

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1.0 INTRODUCTION

Soils along the Bayswater Rail Loop were investigated to determine whether or not there were significant soil constraints on the proposed development. In this regard, the thickness and characteristics of the topsoil and immediate subsoil, in terms of their erodibility and suitability for revegetation, were considered. Four soil landscapes have been defined along the route, based on soil types and local topography. Although soils vary along the route, most are suitable for use in rehabilitation and do not pose any significant constraints on the development of the rail loop.

It should be noted that this study did not comprise a full geotechnical investigation. Such studies have been completed by Bateman Brown & Root on behalf of Coal Operations Australia Limited as part of the detailed design of the project.

2.0 FIELD METHODS

Soil profiles at sixteen locations along the Bayswater Rail Loop were investigated using a hand auger, on 19 – 20 October 1999. Fourteen soil profiles were investigated along the route east of the Bayswater mine access road. These profiles were spaced approximately 200 to 400 metres apart (see Figure 4.11 of the EIS). Two soil profiles were investigated west of the Bayswater mine access road, in the area formerly covered by Dames and Moore (pers. comm.) during preparatory field work for their proposed EIS for Mount Arthur North. Information from these two profiles was combined with information from the Dames and Moore survey in order to characterise the soils in this area.

Profile depths ranged from 0.21 m to 0.64 m. Soil properties were recorded on Soil Data Cards and are summarised in **Table 1**. During the survey, soil pH was determined in the field using Raupach indicator. Subsequent laboratory analysis of pH in selected samples indicated that field pH results were generally one pH unit higher than laboratory pH results. This difference is not significant in considering soil reaction trends for soil classification.

3.0 LABORATORY ANALYSIS

Representative samples of topsoil and subsoil from five soil profiles (Nos 1, 5, 9, 12 and 15) were analysed by the Scone Research Centre. The profiles were evenly spaced across the study area and were considered representative of the four landscapes defined along the rail loop route (see Figure 4.11 of the EIS).

Conductivity, pH and Emerson Aggregate Tests (EAT) were performed on the samples (**Table 2**).

Two soil profiles in Soil Landscape D have been described and analysed by Dames and Moore (pers. comm.). Results of their analyses of conductivity, pH and EAT are also included in **Table 2**, while additional analytical results are presented in **Table 3**.

Table 1A - Summary of Soil Profile Characteristics for Bayswater Rail Loop – Soil Landscape A (cont.)

Site No.	16	**Run-on rate**	Low	**Principal Profile Form**	Dy 3.21
Date	20/10/99	**Run-off rate**	Slow	**Great Soil Group**	Yellow Podzolic Soil
Landform	Upper slope	**Erosion, actual**	No appreciable erosion		
Slope	5%	**Erosion, potential**	Low		
Vegetation	Woodland	**Evidence of salinity**	None		
Geology	Branxton Formation	**Surface condition**	Hardsetting		

Depth (m)	**Soil Horizon**	**Boundary Distinctness**	**Texture**	**Strength**	**Pedality**	**Ped Type**	**Ped Size (mm)**	**Stones %**	**Roots**	**Segreg -ations**	**Munsell Colour**	**Colour**	**Mottles %**	**pH**	**EAT**
0.26	A1	Clear	Fine sandy loam	Very weak	Weak	Subangular blocky	20-50	20-40	Common	None	10YR3/2	Very dark greyish brown	0	5.5	NA
0.32	A2		Sandy loam	Very weak	Weak	Subangular blocky	20-50	40-60	Few	None	10YR6/3	Pale brown	0	5.5	NA
0.37+	B		Heavy clay								10YR5/6	Mottled yellowish brown	20		NA

NA – Not analysed

Table 1B - Summary of Soil Profile Characteristics for Bayswater Rail Loop – Soil Landscape B

Site No.	06	**Run-on rate**	Moderate	**Principal Profile Form**	Db 2.11
Date	19/10/99	**Run-off rate**	Medium	**Great Soil Group**	Grey-brown Podzolic Soil
Landform	Upper slope	**Erosion, actual**	No appreciable erosion		
Slope	10%	**Erosion, potential**	Low		
Vegetation	Grassland	**Evidence of salinity**	None		
Geology	Branxton Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.20	A	Sharp	Fine sandy loam	Weak	Moderate	Subangular blocky	50-100	2-10	Common	None	10YR4/2	Dark greyish brown	0	6.0	
0.38+	B		Heavy clay	Strong	Strong		100-200	<2	Few	None	5YR4/6	Mottled yellowish red	20	6.0	

Site No.	07	**Run-on rate**	Low	**Principal Profile Form**	Dr 3.22
Date	19/10/99	**Run-off rate**	Medium	**Great Soil Group**	Red-brown Earth
Landform	Upper slope	**Erosion, actual**	No appreciable erosion		
Slope	5%	**Erosion, potential**	Low		
Vegetation	Woodland	**Evidence of salinity**	None		
Geology	Branxton Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.05	A1	Clear	Fine sandy loam	Very weak	Moderate	Subangular blocky	50-100	None	Common	None	10YR4/2	Dark greyish brown	0	6.5	NA
0.25	A2	Gradual	Fine sandy loam	Weak	Weak	Subangular blocky	50-100	10-20	Common	None	7.5YR5/3	Brown	0	6.5	NA
0.31+	B		Medium clay	Strong	Strong			2-10	Few	None	5YR4/4	Mottled reddish brown	30		NA

NA – Not analysed

Table 1B - Summary of Soil Profile Characteristics for Bayswater Rail Loop – Soil Landscape B (cont.)

Site No.	09	**Run-on rate**	Low	**Principal Profile Form**	Db 2.21
Date	19/10/99	**Run-off rate**	Medium	**Great Soil Group**	Grey-brown Podzolic Soil
Landform	crest	**Erosion, actual**	No appreciable erosion		
Slope	3%	**Erosion, potential**	Low		
Vegetation	Woodland	**Evidence of salinity**	None		
Geology	Branxton Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.13	A1	Clear	Sandy loam	Very weak	Weak	Subangular blocky	50-100	None	Common	None	7.5YR4/4	Brown	0	6.0	3(1)
0.27	A2	Sharp	Sandy loam	Weak	Weak	Subangular blocky	50-100	2-10	Few	None	7.5YR4/6	Strong brown	0	6.0	3(2)
0.37+	B		Medium clay	Moderate	Moderate		50-100	None	Few	None	5YR4/6	Mottled yellowish red	10	5.5	5

Site No.	10	**Run-on rate**	Moderate	**Principal Profile Form**	Dy 3.12
Date	19/10/99	**Run-off rate**	Medium	**Great Soil Group**	Chocolate Soil
Landform	Lower slope	**Erosion, actual**	No appreciable erosion		
Slope	5%	**Erosion, potential**	Low		
Vegetation	Woodland	**Evidence of salinity**	None		
Geology	Branxton Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.17	A	Sharp	Loam	Weak	Moderate	Subangular blocky	50-100	40-60	Many	None	5YR3/2	Dark reddish brown	0	6.0	NA
0.27+	B		Heavy clay	Moderate	Strong			<2	Few	None	5YR5/6	Mottled yellowish red	30	7.0	NA

NA – Not analysed

Table 1B - Summary of Soil Profile Characteristics for Bayswater Rail Loop – Soil Landscape B (cont.)

Site No.	08	**Run-on rate**	High	**Principal Profile Form**	Uc 4.11
Date	19/10/99	**Run-off rate**	Medium	**Great Soil Group**	Sand/Lithosol
Landform	Drainage line	**Erosion, actual**	No appreciable erosion		
Slope	5%	**Erosion, potential**	Low		
Vegetation	Grassland	**Evidence of salinity**	None		
Geology	Branxton Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.10	T1	Sharp	Medium clay, sandy	Strong	Strong	Subangular blocky	50-100	2-10	Common	None	10YR5/4	Mottled greyish brown	50	6.5	NA
0.25	A1	Gradual	Sandy loam	Moderate	Moderate	Subangular blocky	50-100	None	Few	None	10YR5/2	Greyish brown	0	6.5	NA
0.61+	A2	Gradual	Sandy loam	Strong	Strong	Subangular blocky	50-100	None	None	None	10YR5/3	Mottled brown	30	7.0	NA

NA – Not analysed

Table 1C - Summary of Soil Profile Characteristics for Bayswater Rail Loop – Soil Landscape C

Site No.	12	**Run-on rate**	Low	**Principal Profile Form**	Dy 2.12
Date	20/10/99	**Run-off rate**	Slow	**Great Soil Group**	Non-calcic brown soil
Landform	Lower slope	**Erosion, actual**	No appreciable erosion		
Slope	3%	**Erosion, potential**	Low		
Vegetation	Grassland	**Evidence of salinity**	None		
Geology	Colluvium/alluvium on Skeletar Formation	**Surface condition**	Friable		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.10	A	Sharp	Silty clay loam	Weak	Weak	Subangular blocky	50-100	20-40	Common	Iron oxide inclus-ions	10YR4/2	Mottled dark greyish brown	20	6.5	3(1)
0.26+	B		Light medium clay					>60	Few	Iron oxide inclus-ions	10YR6/3	Pale brown	0	7.0	3(1)

Site No.	13	**Run-on rate**	Low	**Principal Profile Form**	Not determined
Date	20/10/99	**Run-off rate**	Slow	**Great Soil Group**	Not determined
Landform	Lower slope	**Erosion, actual**	No appreciable erosion		
Slope	3%	**Erosion, potential**	Low		
Vegetation	Grassland	**Evidence of salinity**	None		
Geology	Colluvium/alluvium on Skeletar Formation	**Surface condition**	Friable		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.12	A1	Sharp	Silty clay loam	Weak	Weak			2-10	Common	None	10YR4/2	Dark greyish brown	0	6.0	NA
0.45+	A2		Silty clay loam	Weak	Weak			>60	Few	None	7.5YR5/3	Brown	0	7.0	NA

NA – Not analysed

Table 1D - Summary of Soil Profile Characteristics for Bayswater Rail Loop – Soil Landscape D

Site No.	14	**Run-on rate**	Moderate	**Principal Profile Form**	Dr 2.12
Date	20/10/99	**Run-off rate**	Medium	**Great Soil Group**	Non-calcic brown soil
Landform	Mid-slope	**Erosion, actual**	No appreciable erosion		
Slope		**Erosion, potential**	Low		
Vegetation	Grassland	**Evidence of salinity**	None		
Geology	Rowan Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.13	A1	Clear	Silty clay loam	Weak	Moderate	Subangular blocky	20-50	2-10	Common	None	5YR4/2	Dark reddish grey	0	6.0	NA
0.34+	A2		Heavy clay	Strong	Strong		100-200	None	Few	None	5YR4/3	Reddish brown	0	7.0	NA

Site No.	15	**Run-on rate**	Moderate	**Principal Profile Form**	Dy 3.12
Date	20/10/99	**Run-off rate**	Medium	**Great Soil Group**	Yellow Podzolic Soil
Landform	Mid- slope	**Erosion, actual**	No appreciable erosion		
Slope		**Erosion, potential**	Low		
Vegetation	Grassland	**Evidence of salinity**	None		
Geology	Rowan Formation	**Surface condition**	Hardsetting		

Depth (m)	Soil Horizon	Boundary Distinctness	Texture	Strength	Pedality	Ped Type	Ped Size (mm)	Stones %	Roots	Segreg -ations	Munsell Colour	Colour	Mottles %	pH	EAT
0.18	A	Clear	Silty clay loam	Weak	Moderate	Subangular blocky	50-100	20-40	Common	None	5YR4/2	Dark reddish grey	0	6.5	3(2)
0.42+	B		Heavy clay	Moderate				<2	Few	None	5YR5/6	Yellowish red	15	7.0	2(1)

NA – Not analysed

Table 2 - Analytical Results for Soils Along the Bayswater Rail Loop

Soil Landscape	Soil Profile	Horizon	Depth (m)	Texture	EC (dS/m)	ECe (dS/m)	Salinity Rating	pH (water)	Level of Acidity[1]	EAT	Dispersibility
A	01	A	0-0.15	Loamy sand	0.06	1.02	Non-saline	4.8	Very strongly acid	3(2)	Slight
		B	0.15-0.31	Heavy clay	0.32	1.92	Non-saline	4.6	Very strongly acid	2(3)	Very high
	05	A1	0-0.10	Sandy loam	0.09	0.99	Non-saline	4.7	Very strongly acid	8/3(2)	Negligible/ slight
		A2	0.10-0.25	Clayey sand	0.09	1.53	Non-saline	4.6	Very strongly acid	2(1)	High to moderate
B	09	A1	0-0.13	Sandy loam	0.05	0.55	Non-saline	4.9	Very strongly acid	3(1)	Slight
		A2	0.13-0.27	Sandy loam	0.04	0.44	Non-saline	5.0	Very strongly acid	3(2)	Slight
		B	0.27-0.37	Medium clay	0.11	0.77	Non-saline	4.7	Very strongly acid	5	Slight
C	12	A	0-0.10	Silty clay loam	0.14	1.26	Non-saline	5.3	Strongly acid	3(1)	Slight
		B	0.10-0.26	Light medium clay	0.05	0.40	Non-saline	5.9	Moderately acid	3(1)	Slight
D	15	A	0-0.18	Silty clay loam	0.11	0.99	Non-saline	5.5	Strongly acid	3(2)	Slight
		B	0.18-0.42	Heavy clay	0.27	1.62	Non-saline	6.3	Slightly acid	2(1)	High to moderate
	DM07*	A1	0-0.05	Loam	0.1	1.9	Non-saline	4.8**	Strongly acid	6	Negligible
		A2	0.05-0.18	Silty loam	0.2	2.1	Slightly saline	5.4**	Moderately acid	2(1)	High to moderate
		B2	0.20-0.35	Light medium clay	0.2	2.3	Slightly saline	5.4**	Moderately acid	2(1)	High to moderate
		B3	0.40-0.60	Light clay	0.5	3.3	Slightly saline	5.0**	Moderately acid	2(2)	High
	DM08*	B1	0.01-0.09	Light medium clay	0.1	0.8	Non-saline	4.6**	Very strongly acid	8	Negligible
		B2	0.10-0.40	Medium clay	0.2	1.4	Non-saline	5.5**	Strongly acid	2(1)	High to moderate
		B3	0.60-0.80	Silty clay loam	1.2	10.8	Highly saline	7.0**	Neutral	2(1)	High to moderate

* DM07 – Data from Dames and Moore (pers. comm.)
** pH in $CaCl_2$ – rating is lower than the same pH value in water.
1 Levels of acidity are described according to Bruce and Rayment (1982) in Hazelton and Murphy (1992). These levels are normal for many soils in the Hunter Valley.

Table 3 – Analytical Results for Soil Samples from Soil Profile DM07 in Soil Landscape D (from Dames and Moore 1999)

Profile DM07								
Horizon	A1		A2		B2		B3	
Depth (m)	0.0 - 0.5		0.5 – 0.18		0.20 – 0.35		0.40 – 0.60	
	Results	**Interpretation**	**Results**	**Interpretation**	**Results**	**Interpretation**	**Results**	**Interpretation**
pH ($CaCl_2$)	4.8	Strongly acid	5.4	Moderately acid	5.4	Moderately acid	5.0	Moderately acid
N (ppm)	1570	Moderate						
P (ppm)	30.0	Moderate						
S (ppm)	14	Moderate						
Cu (ppm)	0.60	Moderate						
Zn (ppm)	7.30	High						
Mn (ppm)	27	Moderate						
B (ppm)	0.20	Very low						
ECe (dS/m)	1.9	Very low	2.1	Low	2.3	Low	3.3	Low
Cl (ppm)	80	Very low						
OM %	4.7	High						
eCEC (meq/100g)	6.4	Low	3.8	Very low	9.7	Low	6.6	Low
Ex Ca (meq/100g)	4.7	Low	2.1	Low	4.4	Low	3.0	Low
Ex Ca %	73	High	56	Moderate	46	Moderate	46	Moderate
Ex Mg (meq/100g)	1.2	Moderate	1.9	Moderate	5.3	High	3.7	High
Ex Mg %	19	Very high	49	Very high	55	Very high	56	Very high
Ex K (meq/100g)	0.5	Moderate	0.3	Moderate	0.4	Moderate	0.2	Low
Ex K %	9	Very high	9	Very high	4	Moderate	3	Moderate
Ex Na (meq/100g)	0.7	Moderate	0.3	Moderate	1.0	High	1.6	High
Ex Na % (ESP)	10.9	Sodic	6.9	Sodic	10.4	Sodic	24.0	Strongly sodic
Ca/Mg	3.8	Ca low	1.1	Ca low	0.8	Ca deficient	0.8	Ca deficient
Mg/K	2.2	Mg low	5.4	K low	13.3	K deficient	19.3	K deficient

4.0 INTERPRETATION OF RESULTS

Analytical results have been interpreted according to guidelines published by Hazelton and Murphy (1992). In order to assess the salinity of a soil, the electrical conductivity (EC) of a 1:5 soil/water suspension is converted to the electrical conductivity of the saturated extract (ECe). EC is converted to ECe by a multiplier factor based on the soil texture (**Table 4**). The salinity of each soil horizon is then estimated (**Table 5**). The dispersibility of each soil horizon was estimated from the Emerson Aggregate test (EAT) results (**Table 6**).

Table 4 – Conversion of 1:5 Electrical Conductivity (EC) to Saturated Extract (ECe)

Soil Texture	Multiplier Factor
Loamy sand, clayey sand, sand	17
Sandy loam, fine sandy loam, light sandy clay loam	11
Loam, loam fine sandy, silt loam, sandy clay loam	10
Clay loam, silty clay loam, fine sandy clay loam, sandy clay, silty clay, light clay	9
Light medium clay	8
Medium clay	7
Heavy clay	6

Source: Abbott (1990) and Shaw (1985) in Hazelton and Murphy (1992).

Table 5 – Interpretation of Electrical Conductivity of Saturated Extract

Rating	ECe (dS/m)	Effect on Plants
Non-saline	<2	Salinity effects mostly negligible
Slightly saline	2 – 4	Yields of sensitive crops affected
Moderately saline	4 – 8	Yields of many crops affected
Highly saline	8 – 16	Only tolerant crops yield satisfactorily
Extremely saline	>16	Only very tolerant crops yield satisfactorily

Source: Hazelton and Murphy (1992).

Table 6 – Relationship between Emerson Aggregate Test (EAT) and Soil Dispersion

EAT Class	Test Result	Interpretation
1	Slakes; complete dispersion.	Materials prone to erode severely when exposed and in contact with water
2	Slakes; some dispersion.	Materials will erode, but probably less severely than for Class 1 materials.
3	Slakes; some dispersion after remoulding.	Materials may be subject to erosion particularly when subject to reworking as a result of earthworks.
4	Slakes; no dispersion (carbonate or gypsum present).	Materials are essentially non-dispersive.
5	Slakes; dispersion in shaken suspension.	Turbid runoff likely, particularly when subject to reworking as a result of earthworks.
6	Slakes; flocculates in shaken suspension.	Materials are essentially non-dispersive.
7	No slaking; swells in water.	Materials are essentially non-dispersive.
8	No slaking; does not swell.	Materials are essentially non-dispersive.

5.0 DISCUSSION

Emerson Aggregate Test (EAT) results show that the topsoils and subsoils in Soil Landscapes B and C are slightly dispersible (**Table 2** - Soil profiles 9 and 12). In Soil Landscapes A and D, the topsoils are slightly dispersible but the subsoils are highly to moderately dispersible (**Table 2** - Soil profiles 1, 5 and 15). High to moderate dispersibility indicates that these subsoils may be sodic. In fact, analysis of soil samples from the profile DM07 (Dames and Moore pers. comm.) in Soil Landscape D, show that the A1, A2 and B2 horizons are sodic (**Table 3**).

The majority of topsoils are classified as Class (3) aggregates. If these soils are cultivated when wet, the clay present is liable to disperse when water is applied to the surface, resulting in crusting and possibly reduced germination of crops. Dispersion of surface soils can be prevented by applying gypsum (Hazelton and Murphy 1992). Therefore, it may be necessary to add gypsum to the soils when using them for rehabilitation of the batters associated with the rail loop, so that germination of cover crops is not inhibited by crusting.

Conductivity results show that the soils are non-saline and therefore the effect of salinity on plants grown on these soils will be negligible.

The pH results show that topsoils in Soil Landscapes A and B are very strongly acid (pH 4.7 to 4.9), while topsoils in Soil Landscapes C and D are strongly acid (pH 5.3 to 5.5). These results indicate that addition of lime would assist in revegetation.

6.0 CONCLUSION

The majority of soils occurring along the Bayswater Rail Loop are suitable for use as topdressing material, down to an average depth of 0.3 m. Addition of gypsum and lime pellet legume seed will assist in germination of initial cover crops and in stabilising soils used to rehabilitate batters on the rail loop.

7.0 REFERENCES

Abbott, T.S. (1990). Soil Test Interpretation. Proceedings of a Symposium, Dubbo, February 1990.

Bruce, R.C. and Rayment, G.E. (1982). Analytical Methods and Interpretations Used by the Agricultural Chemistry Branch for Soil and Land Use Surveys. Bulletin QB82004. Queensland Department of Primary Industries.

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Hazelton, P.A. and Murphy, B.W. (Eds) (1992). *What do all the numbers mean? A Guide for the Interpretation of Soil Test Results.* Department of Conservation and Land Management (incorporating the Soil Conservation Service of NSW), Sydney.

Shaw, R.J. (1985). Soil Salinity. In *Identification of Soils and Interpretation of Soil Data*, pp 145-174. Aust. Soc. of Soil Sci. Inc., Queensland Branch, Brisbane.

xviii. Ecologically Sustainable Development Principles

- ☐ Basic concepts of ESD are to be applied to the development as a whole and should be addressed in the EIS, including:
  - *the precautionary principle:* Show that decisions made for the proposal are predictable and transparent. Including:
    - making information available at an early stage and establishing appropriate conflict resolution mechanisms from project planning stage, assessment and determination process;
    - discussion of Best Practice Environmental Management techniques including the potential use of environmental management plans and environmental audits;
    - ensuring that best practice monitoring and enforcement procedure are proposed; and
    - identifying the responsibilities of the proponent and government agencies for environmental management and enforcement.
  - ***inter- and intra-generational equity:*** Overall project management and investment in plant and equipment that minimises pollution and waste and is energy efficient.
  - ***conservation of biodiversity and ecological integrity:*** Including:
    - identification and assessment of all environmental characteristics and habitat values that could be affected by the proposal;
    - likely environmental impacts on these characteristics and values;
    - implementation of measures designed to minimise likely environmental impacts; and
    - consideration given to adopting a whole-of-life cycle through use of environmentally benign materials, products and processes (e.g. fuel efficient motors, use of recyclable and recycled materials) and integrated waste minimisation, reuse and recycling.
  - ***valuation and pricing of resources:*** The costs and benefits of all aspects of the proposal should be considered. This should include non-economic environmental resources within a defined area around the subject site using methodologies such as contingency valuation.

    Consideration could be given to measuring positive environmental initiatives (e.g. energy savings) for possible use as a trade off for other environmental concessions.

xix. Rehabilitation

- ☐ The EIS should address the progressive rehabilitation of the site.

xx. On-going environmental management

- ☐ Outline proposed on-going management for the proposal. This should provide a comprehensive framework for managing or mitigating environmental impacts for the life of the operation. The plan should:
  - demonstrate strategies for sound environmental practice during construction, and operation;
  - identify all government licensing and approval requirements and demonstrate how the plan will facilitate compliance with these requirements; and
  - set out the framework of a monitoring program of all key impacts on the environment (this framework should indicate what specific information will be monitored, the monitoring intervals, procedures to be undertaken should the monitoring indicate an environmental problem, and the reporting procedures).