
Equine health

Technical Report

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K A N N E G I E T E R E Q U I N E S P E C I A L I S T S

Equine Health Impact Assessment

New England REZ Network Infrastructure Project

(PROC 16046)

F I N A L

Prepared for

Energy Co, NSW Government

August 2026

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Executive Summary

This Equine Health Assessment considers the potential impacts of the New England REZ Network Infrastructure Project (the project) on identified equine receptors and sensitive equine land uses within the Equine Health Study Area, including the Upper Hunter Equine Critical Industry Cluster (CIC).

The assessment was informed by project-specific technical studies prepared for the Environmental Impact Statement, including the Noise and Vibration Impact Assessment (SLR, 2026), Air Quality Impact Assessment (Airen Consulting, 2026) and Electric and Magnetic Field Study (Aurecon, 2026). The assessment considered both construction and operation of the project.

The project has been designed to minimise interactions with identified equine facilities and paddocks within the CIC where practicable. Most equine properties, including the majority of major thoroughbred breeding operations within the Upper Hunter Equine CIC, are located several kilometres from the project and are unlikely to be affected by construction or operation of the transmission line.

A small number of identified equine receptors located closest to the project, including Scone Polo Club, Kitchwin Hills, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine, have the potential for interaction with construction activities. Of these receptors Kitchwin Hills has the greatest potential for interaction with project activities due to its proximity to, and potential overlap with, sections of the project area. This would be associated with access tracks and road upgrades along Waverly Road as well as proximity to the transmission corridor.

Any potential impacts to receptors are expected to be localised, temporary and manageable through implementation of the proposed mitigation measures.

Key Findings

Construction Phase

Construction activities have the greatest potential to affect identified equine receptors due to temporary increases in noise, dust, vehicle movements, construction machinery and helicopter operations. Potential responses may include short-term startle reactions, heightened vigilance, avoidance behaviour, temporary changes in grazing or resting patterns and short periods of stress associated with unfamiliar activities.

The assessment identified a small number of equine receptors located closest to the project as having the greatest potential for interaction with construction activities. Potential impacts are primarily associated with temporary behavioural responses, including startle and avoidance as well as short-term disruption to normal horse behaviour. These responses are expected to be temporary and are not anticipated to result in long-term impacts on equine health.

The identified equine receptors located closest to the project comprise Scone Polo Club, Kitchwin Hills, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine. Kitchwin Hills has the greatest potential for interaction with construction activities due to its proximity to, and potential

overlap with, sections of the project area associated with access tracks and road upgrades along Waverly Road and proximity to the transmission corridor. Construction noise, construction plant and equipment, helicopter operations and dust may result in temporary behavioural responses, including increased vigilance, startle responses and temporary avoidance behaviours. However, these potential impacts are expected to be localised, temporary and manageable through implementation of the proposed mitigation measures.

There may be temporary exposure to construction dust at equine receptors located closest to active construction works. While elevated dust levels can result in temporary irritation and upper respiratory tract, horses are routinely exposed to dust from paddock environments, hay, feed and bedding as part of normal management practices. However, the Air Quality Impact Assessment (Airen Consulting, 2026) concluded that residual dust impacts would not be significant following implementation of the proposed dust management measures. The predicted levels of construction (inorganic) dust are below that which would have any adverse impact on equine health. Given the temporary nature of construction activities, the outdoor environment and the natural respiratory clearance mechanisms of horses, adverse health effects associated with dust exposure are not expected.

Blasting may be required at a limited number of locations in the project area where rock excavation is necessary for transmission tower foundations. Blasting activities are not expected to occur in proximity to identified equine receptors. The nearest identified equine facility is located 6.2 kilometres from potential blasting locations and, accordingly, impacts associated with blasting are expected to be negligible.

Construction vibration is expected to be intermittent and localised and is not expected to adversely affect equine health, welfare or behaviour. No routine night works are proposed in proximity to identified equine receptors and impacts associated with construction lighting are expected to be negligible.

Overall, potential construction-related impacts on equine health, welfare and management are expected to be low and largely limited to temporary behavioural responses at the identified equine receptors located closest to the project.

Operational Phase

Operational impacts are expected to be substantially lower than construction impacts.

Operational noise associated with corona discharge is predicted to remain below the thresholds identified in the literature review as being associated with adverse effects on horses. Kitchwin Hills (Bottom Farm) has the greatest potential for exposure to operational transmission line activities due to its proximity to the transmission corridor. However, predicted operational noise levels remain below thresholds identified in the literature review and adverse effects on equine health, welfare or performance are not anticipated.

All identified equine receptors are located beyond the transmission corridor and would experience lower noise levels than those predicted directly beneath the conductors. While some horses may initially detect operational noise, horses are generally expected to habituate to predictable and

consistent noise sources over time and adverse effects on equine health, welfare or performance are not anticipated.

Operational dust, vibration, lighting, EMF and EMI are not expected to affect equine health, welfare or management. Operational dust generation would be negligible and is not expected to result in respiratory or other health effects. Although no controlled studies have specifically examined the effects of EMF on horses, available evidence from livestock studies has not identified adverse effects on animal health, reproduction, productivity or welfare at environmental exposure levels associated with transmission infrastructure. Risks associated with induced or stray voltages on metallic infrastructure would be managed through standard design, grounding and isolation measures.

The principal operational consideration relates to infrequent inspection and maintenance activities, including helicopter inspections. These activities may result in temporary behavioural responses at a small number of equine receptors located closest to the transmission corridor, including short-term startle responses, increased vigilance or temporary avoidance behaviours. However, proposed mitigation measures, including prior notification of such activities, will minimise potential for such impacts. Overall, operational impacts on equine health, welfare and management are expected to be negligible to low.

Conclusion

The assessment found that the project has been designed to minimise interaction with identified equine facilities and paddocks where practicable. Potential impacts are primarily limited to temporary behavioural responses associated with construction activities and infrequent maintenance activities at a small number of equine receptors located closest to the project, particularly Kitchwin Hills, Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine.

Kitchwin Hills has the greatest potential for interaction with project activities due to its proximity to, and potential overlap with, sections of the project area associated with access tracks and road upgrades along Waverly Road and proximity to the transmission corridor. However, potential impacts are expected to be localised, temporary and manageable through implementation of the proposed mitigation measures.

Potential impacts are primarily limited to temporary behavioural responses associated with construction activities and infrequent maintenance activities at a small number of equine receptors located closest to the Project, particularly Scone Polo Club, Kitchwin Hills, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine.

Construction-related impacts are expected to be localised, temporary and manageable through implementation of the proposed mitigation measures. Operational impacts, including those associated with noise, vibration, lighting, dust, EMF and EMI, are expected to be negligible to low.

Overall, the project is not expected to result in adverse long-term impacts on equine health, welfare or management, with impacts expected to be low during construction and negligible to low during operation.

Limitations

A limitation of this assessment was the inability to undertake site inspections of equine facilities or consult directly with affected property owners despite multiple attempts to do so.

Consequently, the location and extent of some equine facilities and paddocks could not be fully verified and were identified using publicly available information, aerial imagery, land use mapping and observations made during a private visit to the project area. Verification of identified equine facilities and paddocks is recommended prior to construction to inform implementation of the mitigation and management measures described in this assessment.

This assessment focuses on equine health, welfare and management and does not assess visual amenity impacts or the loss of agricultural land associated with the project.

1 Introduction

This report has been prepared by Kannegieter Equine Surgeons as part of the Environmental Impact Statement (EIS) for the New England Renewable Energy Zone Network Infrastructure Project (the project). The purpose of this Equine Health Impact Assessment is to identify and assess the potential impacts of the construction and operation of the project on equine health, welfare and management associated with sensitive equine land uses and to outline proposed management measures and commitments.

1.1 Background

Energy Corporation of NSW (EnergyCo) advise:

New South Wales (NSW) is entering a new phase of electricity generation due to technological changes and a need to decarbonise the economy. As existing coal-fired energy generators progressively close, markets are turning towards cleaner, cheaper and more reliable renewable energy sources. New sources of energy need to be established including new transmission infrastructure to connect these new energy sources to consumers. Providing reliable energy at the lowest possible cost and locating infrastructure in places that minimise potential impacts on regional and rural communities is a key priority of the NSW Government.

The Energy Corporation of NSW (EnergyCo), a NSW Government statutory authority, has been appointed as the Infrastructure Planner under the Electricity Infrastructure Investment Act 2020. EnergyCo is responsible for planning and coordinating the necessary network infrastructure (including transmission towers, transmission lines and energy hubs) required to connect renewable energy generator and storage projects to the grid. As part of this process, five Renewable Energy Zones (REZs) have been formally declared across NSW including the New England REZ.

The New England region has a range of attributes that make it an ideal location for a REZ within NSW, including:

- *some of the best natural energy resources in the country and suitable sites for pumped-hydro facilities.*
- *access to existing transmission lines that connect to the NSW east coast, Upper Hunter and Queensland.*
- *strong generator interest for sustainable energy projects connecting to the transmission network.*
- *the ability to increase NSW's energy resilience.*

The New England REZ will allow the region to play a pivotal role in supporting energy system reliability and bring with it significant jobs and investment for the region.

1.2 Project Description

1.2.1 Overview

EnergyCo is seeking approval for the project which includes the construction and operation of new high voltage electricity network infrastructure that is required to connect energy generation and

storage projects within the New England REZ to the National Electricity Market (NEM) at Bayswater Power Station.

The project extends from the central area of the New England REZ north of Armidale to the existing Bayswater Power Station near Muswellbrook. The project is located across the Local Government Areas (LGAs) of Armidale Regional, Uralla Shire, Tamworth Regional, Walcha Shire, Liverpool Plains Shire, Upper Hunter Shire, Muswellbrook Shire and Singleton.

The project would comprise the following key features:

- new transmission infrastructure including new dual 500 kilovolt (kV) transmission lines and associated infrastructure to connect the New England REZ to the NEM south of Muswellbrook NSW and new 500 kV and 330 kV lines to connect to the proposed energy hubs within the New England REZ.
- five energy hubs to connect future energy generation and storage projects within the New England REZ to the new 500 kV network infrastructure.
- a maintenance facility to support the operational requirements of the project.
- ancillary development to support the project, including:
 - establishment and/or upgrade of access tracks and public roads
 - upgrade and/or augmentation to existing electricity and utility infrastructure
 - installation and operation of communications infrastructure and facilities
- other construction related works and facilities, such as laydown and staging areas, earthworks material sites with crushing and screening plants, concrete batching plants, stringing sites, helicopter landing pads, site offices and workforce accommodation camps.

The project is illustrated in **Figure 1.1** with a project summary provided below. Detailed descriptions of the project components as well as how the project would operate and be constructed is provided in Section 3 of the EIS.

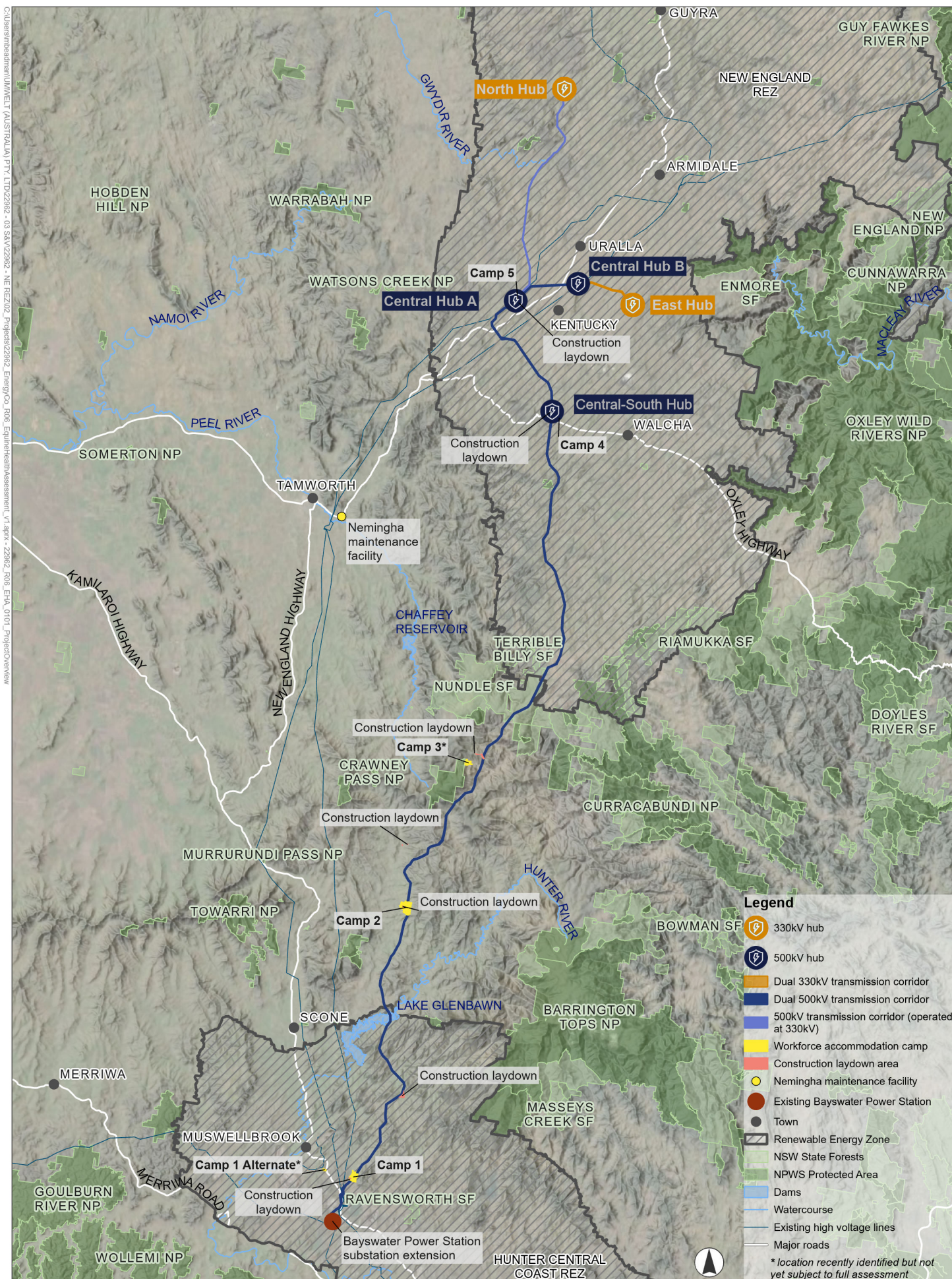


FIGURE 1.1 Project overview

1.2.2 Project elements

1.2.2.1 Transmission lines and towers

The project includes the construction of new high voltage double circuit transmission lines and related infrastructure, including:

- about 240 kilometres of dual 500 kV transmission lines from the central energy hubs (Central Hub A and Central Hub B) to the Bayswater Power Station
- about 50 kilometres of single 500 kV transmission lines (operated as 330 kV) from Central Hub A to the northern energy hub (North Hub)
- about 15 kilometres of dual 330 kV transmission lines from Central Hub B to the eastern energy hub (East Hub).

Typical easement widths would be 70 metres for single 500 kV lines, 120 metres for dual 330 kV lines and 140 metres for dual 500 kV lines.

The transmission towers would typically be between 45 metres and 75 metres high. On average towers are currently expected to be spaced about 450 metres apart, however, this can vary greatly depending on terrain.

1.2.2.2 Energy hubs, substations and switching stations

The project includes five energy hubs within the New England REZ, which would act as connection points between renewable energy projects and the wider New England REZ transmission network. The energy hubs include:

- North Hub (330 kV switching station) located about 16 kilometres north west of Armidale.
- Central Hub A (500/330 kV substation) located about 8 kilometres west of Kentucky.
- Central Hub B (500/330 kV substation) located about 7 kilometres north of Kentucky.
- East Hub (330 kV switching station) located about 13 kilometres south east of Uralla.
- Central South Hub (500/330 kV substation) located about 13 kilometres west of Walcha.

The project also includes an extension to the existing Bayswater Power Station Substation to connect the project to the NEM.

1.2.2.3 Road upgrades and access tracks

The project requires establishment and/ or upgrade of access tracks and upgrade of public roads.

1.2.2.4 Communications infrastructure

The project includes a communications system to provide interconnection between energy hubs and to link to external interfaces such as Transgrid and the Australian Energy Market Operator (AEMO). Communications infrastructure would include fibre optic cabling, repeater stations and microwave links.

1.2.2.5 Utilities

As part of ancillary infrastructure, utility relocations may be required where the new infrastructure would intersect existing utilities. Work may also be required to connect construction ancillary sites with existing utility services.

1.2.2.6 Maintenance facility

The project includes the construction and operation of a maintenance facility to support the operation and maintenance of the transmission lines and energy hubs. The facility would be located at the intersection of the New England Highway and Nundle Road in Nemingha and likely comprise a two-storey storage and workshop building with attached office and on-site car parking.

1.2.2.7 Construction ancillary sites

Temporary facilities used to support construction are required and may include: offices, amenities, parking, storage of plant and equipment, concrete batching plant, crushing grinding and screening plant, material stockpile areas, laydown and staging areas, helicopter landing pads and stringing sites.

1.2.2.8 Workforce accommodation camps

Project workforce would be accommodated across five workforce accommodation camps in locations in proximity to the transmission corridor and energy hubs. The workforce accommodation camps would be used for temporary housing and associated living facilities to house the construction workforce for the duration of construction.

Five workforce accommodation camp sites have been identified:

- Camp 1 – Inglewood Road, Muswellbrook (or a recently identified possible alternative location for Camp 1 (identified as Camp 1 Alternate) on New England Highway, Muswellbrook).
- Camp 2 – Waverley Road, Waverly.
- Camp 3 – Barry Road, Barry (recently identified).
- Camp 4 – Central South Hub, Walcha Road.
- Camp 5 – Central Hub A, Kentucky.

Camp 3 at Barry Road, Barry, and a possible alternative location for Camp 1 (identified as Camp 1 Alternate) at New England Highway, Muswellbrook, have only recently been identified by EnergyCo (refer to **Figure 1.1**). Section 3 in the EIS provides an overview of these recently identified camp locations.

Full assessment of the proposed locations for Camp 3 and Camp 1 Alternate will be undertaken as part of the Submissions Report/Amendment Report.

1.2.2.9 Workforce

At peak construction the project is expected to require a workforce of about 1,400 workers. The construction workforce required would vary depending on the stage of construction and associated activities.

The operational workforce is estimated to be up to 100 personnel consisting of both site and office based jobs.

1.2.2.10 Project timing

Construction of the main project elements is planned to commence in 2028 and is expected to take around six years in total to complete. Construction activities would occur across multiple work fronts, i.e. at any one-time construction activities would be occurring concurrently at several locations across the project area. Key construction activities for the project include:

- enabling works, such as access tracks and road upgrades and establishment of construction ancillary sites and workforce accommodation camps.
- vegetation clearing and removal in preparation for construction works.
- bulk earthworks, including excavation, formation of work areas and materials processing (such as blasting, concrete batch plants, trenching, under boring, crushing and screening)
- construction works associated with energy hubs, Bayswater Power Station substation extension works and supporting infrastructure and buildings.
- construction works associated with the transmission lines and ancillary facilities.
- pre-commissioning and commissioning of the project.
- demobilisation and rehabilitation of areas disturbed by construction activities.

The project would be energised in two stages. Stage 1 would provide 2.4 gigawatts (GW) of transfer capacity with an additional 3.6 GW of capacity delivered in Stage 2, for a total transfer capacity of 6 GW. Stage 1 is expected to be energised in 2032 and Stage 2 in 2034.

1.3 Purpose of this Technical Report

The project was declared a Critical State Significant Infrastructure (CSSI) project in July 2024 under Section 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This technical report has been prepared by Kannegieter Equine Specialists as part of the EIS for the project. The purpose of this technical report is to identify and assess the potential construction and operation impacts of the project in relation to equine health, welfare and management associated with sensitive equine land uses. The assessment focuses on sensitive equine land uses located within the Equine Health Study Area (refer to **Section 2.2.1**), including the Upper Hunter equine industry and other identified equine facilities where interactions with the project may occur.

1.4 Scope of Works

The assessment considers potential interactions between the project and sensitive equine land uses within the Equine Health Study Area. The scope of works includes:

- review existing literature and technical guidance relating to the physiological and behavioural responses of horses to electromagnetic fields (EMF), electromagnetic interference (EMI), noise, vibration, dust and lighting.
- identify thresholds of concern for the above factors based on available scientific evidence and assess their relevance to local equine practices identified equine receptors.
- identify and characterise sensitive equine land uses within the Equine Health Study Area that may interact with the project.
- review the findings of the relevant EIS technical assessments, including the EMF, Noise and Vibration, Air Quality and Lighting assessments, to determine whether project-related impacts may affect the health and welfare of horses located at identified sensitive equine land uses and identified equine facilities.
- evaluate short-term construction and long-term operational impacts.
- recommend mitigation, management and, where appropriate, monitoring measures to minimise or avoid potential impacts on the health and welfare of horses located within the Equine Health Study Area.

1.5 Report Structure

The report is structured so that each section builds on the last, moving from context and method, through the existing environment and the scientific evidence base, to the assessment of construction and operational impacts, and finally to mitigation and conclusion. The sections are as follows:

1 Introduction: describes the project, the purpose and scope of the Equine Health Impact Assessment, and how this report is organised.

2 Assessment Approach: sets out the legislative context and the methodology, including the Equine Health Study Area, approach to literature review and characterising the existing environment and assessing potential impacts on sensitive equine land uses.

3 Impact Avoidance and Project Design: describes how consideration of the equine industry informed route selection and project design, and how potential impacts on sensitive equine land uses have been avoided or minimised through route selection, field-limit design and easement layout.

4 Existing Environment: describes the Upper Hunter equine industry, including relevant equine sectors, critical industry clusters and other potentially sensitive equine land uses and equine facilities within the Equine Health Study Area.

5 Literature Review — Key Findings: summarises the scientific evidence relating to the response of horses to electromagnetic fields, noise, vibration, dust and light, drawing on equine, livestock and broader mammalian research.

6 Assessment of Potential Construction Impacts: assesses the potential equine health and welfare impacts of construction activities on identified sensitive equine land uses and, where required, recommends mitigation and management measures.

7 Assessment of Potential Operation Impacts: assesses the potential equine health and welfare impacts of project operation on identified sensitive equine land uses and, where required, recommends mitigation and management measures.

8 Mitigation and Management: consolidates the management, mitigation and monitoring measures recommended to avoid or minimise impacts on equine health and welfare associated with sensitive equine land uses during construction and operation.

9 Conclusion: summarises the findings of the assessment and the predicted impacts of the project on sensitive equine land uses.

2 Assessment Approach

The objective of this assessment is to identify and assess potential impacts arising from the construction and operation of the project on the health and welfare of horses associated with sensitive equine land uses and other identified equine facilities within the Equine Health Study Area. The assessment considers whether project-related impacts may adversely affect equine health, welfare, behaviour and management.

The assessment includes a review of the available literature relating to the response of horses to EMF, noise, vibration, dust and lighting, and considers how these factors may influence equine health, behaviour and management. Given the limited research available for horses, information from other relevant studies has also been considered where relevant. The assessment also draws on the findings of the relevant EIS technical assessments, including the EMF Study, Noise and Vibration Impact Assessment, Air Quality Impact Assessment and relevant assessments of lighting impacts, to evaluate the potential implications of project-related impacts for identified equine receptors.

This assessment has been prepared as a standalone document for stakeholders with an interest in equine health, welfare and management. As a result, some information may overlap with other parts of the EIS where relevant to assist in understanding the interactions between the project and sensitive equine land uses.

2.1 Legislative Context

There is no specific legislation dealing with the health and welfare of horses in relation to major infrastructure projects, nor any dealing with electromagnetic radiation and horses. The general legislation and guidelines considered in the preparation of this report include:

- **Prevention of Cruelty to Animals Act 1979 (NSW)** — establishes offences relating to failure to provide adequate food, water, shelter and exercise. It creates an obligation to ensure that fencing does not cause injury to animals and that confinement areas are of sufficient size to allow reasonable opportunity for adequate exercise.
- **Prevention of Cruelty to Animals Regulation 2025 (NSW)** — the updated regulation supporting the Act, which includes provisions relating to virtual fencing and other contemporary animal management technologies.
- **State Environmental Planning Policy (Mining Petroleum Production and Extractive Industries) 2007 (the Mining SEPP)** — establishes the mapping of Equine Critical Industry Clusters (CIC) in NSW. Relevant to this assessment is the Upper Hunter CIC, through which the project's transmission corridor passes. The corridor traverses the eastern and north-eastern parts of the cluster and is located in proximity to a number of identified equine receptors and sensitive equine land uses.
- **Dividing Fences Act 1991 (NSW)** — governs boundary fences between adjoining properties, including cost-sharing obligations and dispute resolution. Where boundary fences coincide with or cross transmission easements, both this Act and the transmission operator's easement conditions will apply.
- **Work Health and Safety Act 2011 (NSW)** — requires persons conducting a business or undertaking to manage risks associated with electrical hazards, including work near overhead power lines.

- **Land Acquisition (Just Terms Compensation) Act 1991 (NSW)** — establishes the process for the acquisition of land and easements for public purposes, including electricity transmission infrastructure.

In addition to legislation, the following codes and guidelines provide detailed standards for horse welfare and management:

- **NSW Animal Welfare Code of Practice No. 3** — sets standards for the care and management of horses in riding centres and boarding stables, including fencing specifications.
- **NSW DPI Factsheet 16** — Guidelines for Minimum Standards for Keeping Horses in Urban Areas.
- **Racing NSW Minimum Standards and Guidelines of Equine Welfare (2020)** — provides minimum standards and guidelines for fencing, gates, shelter and paddock management.
- **RSPCA Australia Standards** — welfare standards that go beyond minimum legal requirements.
- **Victoria Code of Practice for the Welfare of Horses (Revision 1)** — provides cross-jurisdictional guidance on fencing materials, paddock size and shelter.
- **ACT Code of Practice for the Welfare of Horses (2021)** and the associated **Animal Welfare (Welfare of Horses in the ACT) Mandatory Code of Practice 2024**.
- **NSW Department of Planning, Housing and Infrastructure Strategic Regional Land Use Policy (SRLUP) - Strategic Agricultural Land – Equine** — recognises the significance of the Upper Hunter Equine CIC as a region of strategic importance to the NSW equine industry and provides guidance relevant to the assessment of potential impacts on sensitive equine land uses.

For structures and activities within or near transmission line easements, the following guidelines were used:

- **Transgrid Easement Guidelines** — conditions for living and working with electricity transmission lines.
- **Transgrid Fencing Guidelines** — specific requirements for the installation, earthing and isolation of fencing near transmission infrastructure.
- **ISSC 20 — Guideline for the Management of Activities within Electricity Easements** — industry guideline governing structures and activities near electricity infrastructure, categorising activities as permitted, controlled or prohibited.
- **SafeWork NSW — Work Near Overhead Power Lines Code of Practice** — specifies safe approach limits and clearance distances for persons, vehicles and machinery working near overhead power lines.

2.2 Methodology

2.2.1 Equine Health Study Area

The Equine Health Study Area was defined to capture identified sensitive equine land uses that may interact with project activities, with particular focus on the Upper Hunter Equine CIC due to the concentration of sensitive equine land uses in proximity to the project. The Equine Health Study Area consists of:

- All land containing identified equine facilities and paddocks within the Upper Hunter CIC.

- For the remainder of the project area where it is located outside of the Upper Hunter CIC, all equine facilities within 3 kilometres of the project area.

While the study area comprises a broad area, detailed assessment of potential impacts has focused on identified equine receptors within 800 metres of the project, the distance from which this assessment has concluded potential project impacts may occur based on the outcomes from other relevant technical assessments completed for the project EIS.

2.2.2 Literature review

An extensive literature review was undertaken to evaluate the potential effects of EMF, dust, noise, vibration and light on horses. The findings are provided in **Section 5**.

The following databases were searched in compiling the literature review:

- PubMed.
- ScienceDirect.
- Wiley Online Library.
- Medline (1950 to present).
- Personal database, N. Kannegieter.
- EBSCO Veterinary Source Database.

2.2.3 Determination of the existing environment

The existing environment was characterised through desktop investigations and a visual inspection of the project area in the Upper Hunter Valley from publicly available locations, with a particular focus on the Upper Hunter Equine CIC. The Upper Hunter Equine CIC supports a range of equine land uses, including breeding, training, agistment, grazing and competitive equestrian activities.

Equine facilities and paddocks within the Equine Health Study Area were characterised based on their location relative to project infrastructure, surrounding land uses and the nature of their equine activities undertaken. This information was used to identify sensitive equine land uses and inform the assessment of potential construction and operational impacts.

A limitation of the assessment was the inability to undertake inspections of individual equine properties or consult directly with potentially affected landowners, despite multiple attempts to do so. Consequently, the extent and use of some equine facilities and paddocks could not be verified and were instead identified using publicly available information, aerial imagery, land use mapping and observations made during a visit to the project area.

2.2.4 Impact Assessment Methodology

Potential equine health impact pathways were identified through the literature review, including noise, dust, vibration, lighting, EMF, EMI, vehicle movements and helicopter operations. Relevant EIS technical assessments, including the Noise and Vibration Impact Assessment (NVIA) (SLR, 2026), Air Quality Impact Assessment (Airen Consulting, 2026) and EMF Assessment (Aurecon, 2026), were reviewed to characterise and quantify the nature and extent of project-related impacts that may be experienced at identified equine receptors during construction and operation. The findings of these assessments were considered in the context of the literature review to determine the potential for impacts on equine health, welfare and management. The assessment also considered receptor characteristics, proximity to project infrastructure and activities.

3 Impact Avoidance and Project Design

This section describes the principal avoidance measures incorporated into the project design including route selection, avoidance of equine facilities and paddocks where practicable, easement and setback design, conductor design to minimise corona effects, and the adoption of EMF design criteria consistent with relevant public exposure guidelines. These measures reduce the potential for interactions between the project and identified equine facilities and paddocks and minimise the residual impacts requiring management during construction and operation (refer to **Sections 6 and 7** respectively) and through the mitigation measures described in **Section 8**.

3.1 Route Selection and Prudent Avoidance

The transmission corridor has been strategically sited to avoid key hubs within the Upper Hunter CIC, including Scone and other areas central to the operation of the Thoroughbred breeding industry. The project generally follows existing transport and infrastructure corridors and public roads, including sections of Hunter Road, Rouchel Road, Waverly Road and Timor Crawney Road, thereby reducing interaction with sensitive equine land uses. While the project area intersects parts of the Upper Hunter CIC near Gundy, it avoids the principal breeding and associated equine industry hubs that underpin the regional and international significance of the cluster.

No identified equine facilities or paddocks are located within the transmission corridor, maintaining separation between project infrastructure and sensitive equine land uses.

3.2 Field-limit Design and Determination of EMF levels

The project has been designed in accordance with recognised EMF design criteria, with electric and magnetic field levels assessed as part of the EIS EMF Study (Aurecon, 2026). Adoption of these design criteria is an avoidance measure that assists in limiting potential exposure to EMF.

The EMF Technical Report (Aurecon, 2026) concluded that electric and magnetic field levels associated with the project would remain within the adopted project design criteria and relevant public exposure guidelines. Field levels at the easement boundary are predicted to remain well below applicable guideline values, and interactions with existing transmission infrastructure are not expected to materially alter the field environment.

These design outcomes reduce the potential for interactions between the project and nearby equine facilities and paddocks.

Consistent with the evidence reviewed in **Section 5.1**, EMF is not expected to adversely affect equine health, welfare or behaviour. Any potential risks associated with induced or stray voltages on metallic infrastructure would be managed through appropriate grounding and earthing measures (refer to **Section 7.5**).

3.3 Setback and Easement Layout

The project has been designed to avoid direct interaction with identified equine facilities and paddocks. No identified equine facilities or paddocks are located within the project area and, as such, no direct access to equine facilities is required for operation of the transmission line. This

maintains separation between project infrastructure and identified sensitive equine land uses within the Equine Health Study Area.

3.4 Conductor Design to Limit Corona

Corona discharge and the associated audible noise, ozone and radio interference has been minimised through appropriate conductor design including the selection of bundled conductors and conductor diameters. Designing the transmission line to minimise corona discharge reduces the primary source of operational transmission line noise and assists in limiting ozone and nitrogen oxide (Nox) generation. The potential implications of corona discharge for identified equine receptors are discussed further in **Section 7.2**.

4 Existing Environment

The equine industry in NSW is substantial in both economic scale and geographic extent. Assessment of the potential impacts of a major transmission line project on equine health, welfare and management requires an understanding of the industry's diversity and significance as part of a broader industry and from a project-specific perspective, together with the identification of sensitive equine land uses and identified equine facilities within the Equine Health Study Area.

This section provides an overview of the NSW equine industry and describes the existing environment within the Equine Health Study Area.

4.1 Overview of the NSW Equine Industry

The NSW equine industry is economically significant, with the Thoroughbred breeding sector alone contributing over \$750 million annually to the state's economy (IER 2025 Measurement of Economic Impact of the Australian Thoroughbred Breeding Industry, AgriFutures Australia, Canberra). Equine activities are distributed throughout rural and regional NSW, meaning large linear infrastructure projects may interact with a diverse range of equine land uses and enterprises.

The industry extends well beyond Thoroughbred breeding to encompass Standardbred breeding and harness racing, equestrian sport, polo and polocrosse, camp drafting and stock horse activities, recreational riding, pony clubs, equine tourism and agritourism, horse training and education.

4.2 Regional Context of the Equine Industry

The distribution of equine activities across the project area is not uniform. Distinct regional clusters occur throughout the project area, reflecting differences in land use, industry focus and the scale of equine enterprises. Understanding the location and characteristics of these clusters provides important context for identifying equine receptors and assessing potential project interactions.

The Upper Hunter, centred on Scone, Aberdeen and Muswellbrook, forms the core of the Thoroughbred breeding industry and represents the most sensitive equine land use within the project area. Moving north, the character of equine activity shifts progressively from intensive Thoroughbred breeding towards a broader mix of Standardbred operations, equestrian sport, camp drafting, pony club, endurance and polocrosse activity around Walcha, Uralla, Nundle, Armidale and Guyra.

The regional distribution of equine activities is relevant to the assessment because the nature and sensitivity of equine receptors varies across the project area. In the Upper Hunter, high-value breeding operations with strict biosecurity and presentation requirements dominate; in the New England tablelands, community and sporting equine facilities are more prominent.

4.2.1 Regional sectors and activities

The principal sectors and activities that may be conducted on or adjacent to rural properties in proximity to the project area include:

- **Thoroughbred breeding and stud operations** — stallion management, mare reproductive programmes, foaling, weanling and yearling preparation, and sales preparation. These operations are concentrated in the Hunter Valley but are distributed across regional NSW.
- **Standardbred breeding and harness racing** — approximately 5,000 Standardbred horses are foaled and registered in Australia each year, with breeding and training facilities throughout regional NSW (Harness Racing NSW).
- **Equestrian sport** — dressage, show jumping, eventing (combined training), show riding, and endurance riding. NSW hosts numerous competitions from club level to state championships across these disciplines (Equestrian NSW).
- **Polo and polocrosse** — played at dedicated grounds and club facilities across rural NSW, these sports require large open fields that may be situated in areas traversed by transmission infrastructure.
- **Camp drafting and stock horse activities** — camp drafting, team penning, and working stock horse competitions are prominent in regional NSW. Australian Stock Horses are used extensively for mustering and general livestock management on pastoral properties (Royal Agricultural Society of NSW).
- **Recreational riding and pony clubs** — Pony Club NSW operates clubs statewide, providing training and competition in multiple disciplines including trail riding, mounted games, and horse care education (Pony Club NSW). Private recreational riding on rural properties is widespread.
- **Equine tourism and agritourism** — stud farm tours, horse riding experiences, and equine-themed tourism contribute to regional economies, particularly in the Hunter Valley and rural areas of southern and central NSW.
- **Horse training and education** — private training establishments, riding schools, and equine education facilities operate throughout NSW.

4.2.2 Upper Hunter Equine Critical industry cluster

NSW has identified a number of Critical Industry Clusters (CICs) for industries of regional and state significance. The Upper Hunter Equine CIC is one such cluster and represents the second-largest Thoroughbred breeding area in the world, concentrated in the Muswellbrook and Upper Hunter LGAs. The Upper Hunter accounts for 28% of all NSW stud horses. Sporting and leisure facilities within the cluster include the Scone Polo Club (established 1891), endurance riding, dressage, and polocrosse centres.

The Equine CIC is defined by the NSW Department of Planning, Housing and Infrastructure SRLUP - Strategic Agricultural Land – Equine as follows:

“The horse breeding cluster includes a highly integrated concentration of horse breeding facilities and related infrastructure covering Thoroughbred and stock horse breeding centres and numerous other equine developments and support services, such as a specialised veterinary centre.

Industry clusters that meet the following criteria: - there is a concentration of enterprises that provides clear development and marketing advantages and is based on an agricultural product; - the productive industries are interrelated; - it consists of a unique combination of factors such as location, infrastructure, heritage and natural resources; - it is of national and/or international importance; - it is an iconic industry that contributes to the region’s identity; and - it is potentially substantially impacted by coal seam gas or mining proposals.”

The Upper Hunter Equine CIC is relevant to this assessment as it represents the most significant concentration of sensitive equine land uses within and adjacent to the Equine Health Study Area. Accordingly, identified equine receptors have been considered in the context of their location relative to the CIC and the nature of the equine activities undertaken.

Identified equine facilities within the Equine Health Study Area are detailed in **Table 4.1** and shown on **Figure 4.1**. These include facilities associated with the Upper Hunter Equine CIC (refer to **Figure 4.2**), as well as other identified equine land uses in proximity to the project.

Table 4.1 Identified Equine Receptors within the Equine Health Study Area

Facility Name	Location	Located within Upper Hunter Equine CIC	Type	Proximity to project area ¹ (km)	Proximity Transmission Corridor ² (km)	Detail
Vinery Stud	Segenhoe Valley, NSW	Yes	Thoroughbred Breeding/Stud	~ 8.7	~9.8	Encompasses 2,300 acres with 3 kilometres of Pages River frontage; provides elite agistment and sales preparation. Located in the high-density stud corridor of the Segenhoe Valley.
Kia Ora Stud	Scone, NSW	Yes	Thoroughbred Breeding/Stud	~ 6.7	~7.3	Established in 1914, Kia Ora is one of Australia's most historic and successful Thoroughbred studs, with a century-old tradition of breeding champions.
Segenhoe Stud	Segenhoe Valley, NSW	Yes	Thoroughbred Breeding/Stud	~ 5.3	~5.8	Historic Thoroughbred nursery in the Segenhoe Valley and critical part of the regional equine identity.
Holbrook Thoroughbreds	Segenhoe, NSW	Yes	Thoroughbred Breeding/Stud	~ 4.9	~7.9	Race training and breeding facility located within the high-density stud corridor of the Segenhoe Valley on Gundy Road.
Scone Polo Club ³	Waverly, NSW	Yes	Polo Club	Adjacent to public road portion of project area	~2.1	Scone Polo Club was established in 1891 and reports that it is currently the largest polo club in Australia. The club runs a competitive calendar across the polo season.
Kitchwin Hills (Bottom Farm) ³	Waverly, NSW	Yes	Thoroughbred Breeding/Stud	~ 0.0	~0.0	Major thoroughbred breeding facility. Contains the stallion barn, veterinary facilities and associated breeding and foaling activities. Most of the Kitchwin Hills operational infrastructure is located on this property.
Kitchwin Hills (Top Farm) ³	Waverly, NSW	Yes	Thoroughbred Breeding/Stud	~ 0.0	~ 2.6	Part of the Kitchwin Hills thoroughbred operation. Contains the yearling barn and ancillary facilities used for the preparation of young thoroughbreds for sale.

Facility Name	Location	Located within Upper Hunter Equine CIC	Type	Proximity to project area ¹ (km)	Proximity Transmission Corridor ² (km)	Detail
Turangga Farm	Near Scone, NSW	Yes	Thoroughbred Breeding/Stud	~ 8.0	~10.8	Integrated part of the Hunter Valley Thoroughbred breeding landscape in the Scone district.
Newgate Farm	Near Aberdeen, NSW	Yes	Thoroughbred Breeding/Stud	~ 7.9	~9.1	Prominent stud in the Muswellbrook/Aberdeen interface; critical contributor to the Equine Critical Industry Cluster.
Muswellbrook Harness Racing Club	Muswellbrook, NSW	Yes	Standardbred Breeding/Harness Racing	~ 9.6	~11.4	Long-standing country club that has conducted harness racing meetings for many decades and formed part of the NSW country harness racing circuit under the administration of Harness Racing NSW.
Walcha Pony Club, Camp drafting	Walcha, NSW	No	Recreational Riding and Pony Club	~ 1.6	~15.6	Pony club operating from the Walcha Showground precinct. Serves the Walcha community's equestrian needs.
Walcha Polocrosse Grounds & Jockey Club ³	Walcha, NSW	No	Polocrosse	~ 0.4	~13.7	Two of the most significant equestrian facilities in the New England region of New South Wales, reflecting Walcha's long association with horses, grazing, and rural sport. Walcha is regarded as one of Australia's historic polocrosse centres and the district has been associated with the sport since its early expansion across rural NSW following its development in the late 1930s.
Uralla Showground Equine Precinct	Uralla, NSW	No	Equestrian Sport (Multi-discipline)	~ 1.7	~ 6.9	Showground with multiple horse rings (Rings 1, 2, 3 and 5), stabling, and powered campsites for equine events. Recently upgraded with a new multi-purpose arena

Facility Name	Location	Located within Upper Hunter Equine CIC	Type	Proximity to project area ¹ (km)	Proximity Transmission Corridor ² (km)	Detail
						servicing more than seven horse and rodeo disciplines. Funded upgrades totaling \$389,392 have created a premier equine events venue.
Timor Polo Club	Timor, NSW	Yes	Polo	Adjacent to public road portion of project area	~3.1	World Class Polo Club in the Upper Hunter Valley.
Gundy Park Equine ³	Gundy, NSW	Yes	Equine Rehabilitation & Fitness	Adjacent to public road portion of project area	~2.5	Purpose-built state of the art, bespoke Equine Rehabilitation & Fitness Centre.
Ellerston Onassis Polo Club	Ellerston, NSW	No	Polo	~16	~16	Polo club associated with Ellerston, in the upper reaches of the Pages Creek valley east of the corridor.
Barragunda Performance Horses	Woolooma, NSW	No	Campdrafting/Cutting/Breeding	~5.7	~13	Specialises in producing quality competition and pleasure horses from well-performed Campdraft and Cutting mare lines.
Bydand Stock Horses	Davis Creek, NSW	Yes	Australian Stock Horse Breeding	~ 1.3	~1.3	Breeds Australian Stock Horses.
Main Camp (Brooker)	Rouchel Brook, NSW	Yes	Australian Stock Horse Breeding	~ 0.9	~1.3	The Brookers have been breeding horses and cattle on Main Camp for over 100 years. Main Camp is a well recognised Australian Stock Horse stud, with an emphasis on camp drafting and polocrosse.

Notes:

¹ potential for interaction with construction activities, primarily comprising road upgrades, access tracks to the transmission corridor and associated works.² potential for interaction with construction and operational activities, including transmission line construction, line stringing, helicopter operations, inspection, operations and maintenance activities.³ Sensitive equine receptor identified as having the potential to experience project-related impacts due to its proximity to the project area and/or transmission corridor. Receptors located within 800 metres of the project were subject to detailed assessment.

Figure 4.1 - Identified equine receptors within the equine health study area

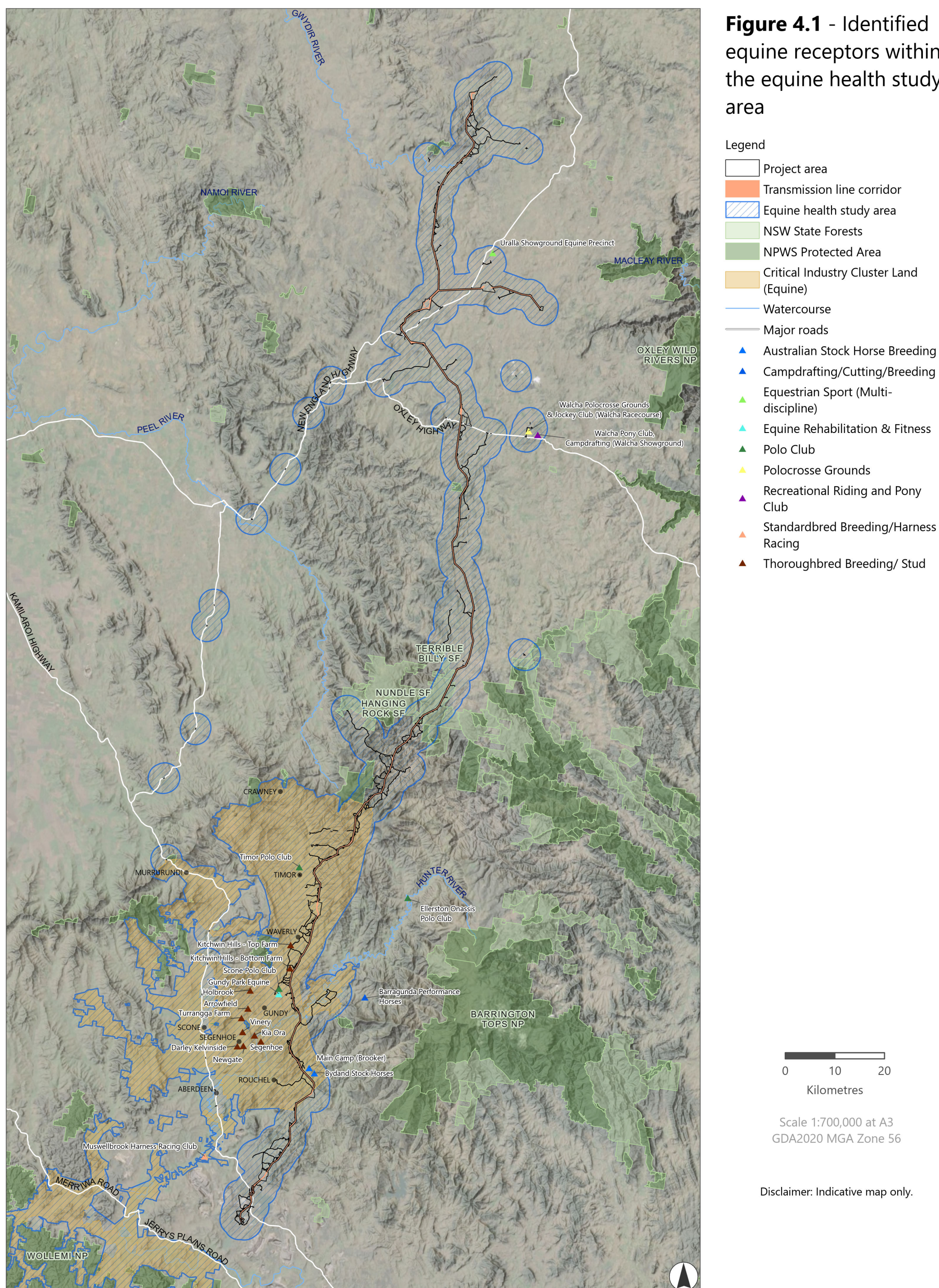
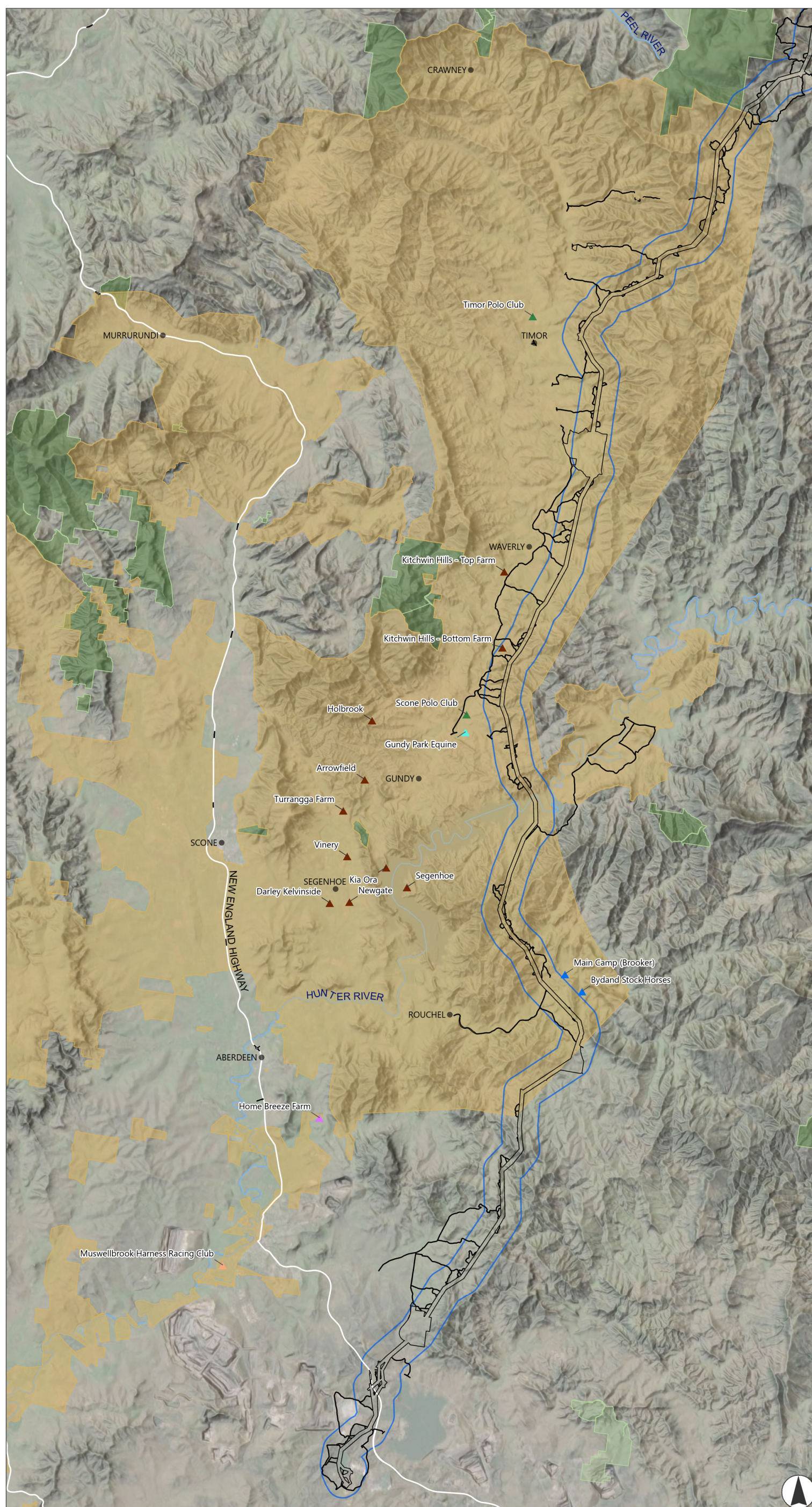


Figure 4.2 - Equine CIC



Legend

-  Project area
-  Equine health study area
-  NSW State Forests
-  NPWS Protected Area
-  Critical Industry Cluster Land (Equine)
-  Watercourse
-  Major roads
-  Australian Stock Horse Breeding
-  Equine Rehabilitation & Fitness
-  Horse agistment
-  Polo Club
-  Standardbred Breeding/Harness Racing
-  Thoroughbred Breeding/ Stud

0 5 10
Kilometres

Scale 1:250,000 at A3
GDA2020 MGA Zone 56

Disclaimer: Indicative map only.

4.2.3 Sensitive Equine Land Use and Identified equine receptors

The equine sectors and activities described above provide important context for understanding the diversity of equine land uses that occur within the Equine Health Study Area. While these sectors are broadly represented across the Equine Health Study Area, the nature, scale and sensitivity of individual operations vary considerably. Accordingly, specific sensitive equine land uses and identified equine receptors were identified to support the assessment of potential project impacts on equine health, welfare and management.

The Equine Health Study Area was established to identify and characterise sensitive equine land uses that may interact with project activities and to provide context regarding the distribution of equine operations, particularly within the Upper Hunter Equine CIC. A subset of equine facilities and paddocks located within 800 metres of the project were identified as equine receptors due to their greater potential to experience project-related impacts and were subject to detailed impact assessment in **Sections 6 and 7**.

The 800 metre distance was adopted as a conservative screening criterion informed by the literature review and relevant EIS technical assessments. The literature review identified helicopter operations, including helicopter stringing activities, as having the greatest potential to elicit behavioural responses in horses over the largest distance. Accordingly, receptors located within 800 metres of the project were considered to have the greatest potential for interaction with project construction activities and were selected for detailed assessment.

Five equine receptors identified in **Table 4.1** and shown on **Figure 4.1** above are located within 800 metres of the project, including:

- Scone Polo Club, located about 200 metres proposed road upgrade works.
- Kitchwin Hills (Bottom Farm), located immediately adjacent to, and in some areas potentially overlapping with required access tracks and road upgrades along Waverly Road and the transmission corridor.
- Kitchwin Hills (Top Farm), located immediately adjacent to proposed road upgrade works.
- Walcha Polocrosse Grounds & Jockey Club, located about 400 metres from proposed road upgrade works.
- Gundy Park Equine, located about 500 metres from proposed road upgrade works.

These receptors were subject to detailed assessment due to their proximity to either the transmission corridor or project area infrastructure, including road upgrades, and their consequent potential for interaction with construction and operational project activities.

5 Literature Review — Key Findings

An extensive literature review was undertaken to determine how horses might respond to the environmental factors associated with the construction and operation of the project. Given the limited research available for horses, relevant studies involving other livestock, laboratory mammals and humans were also reviewed where appropriate.

The key findings for each factor are summarised below and are applied to the project's construction and operational phases in **Sections 6 and 7**.

EMF and interference: EMF from a 500 kV line falls rapidly with distance. At the easement edge EMF is comparable to domestic levels and well within international guidelines. No controlled equine studies exist, but the weight of livestock and mammalian evidence indicates no adverse health effect at environmental levels.

Noise: horses hear frequencies from approximately 55 Hz to 33.5 kHz and may respond to novel or unpredictable sounds with a flight response, although habituation commonly occurs where noise sources are regular and predictable. Noise levels below 65 dB(A) are unlikely to result in adverse effects on horses in stable environments, while short-duration overpressure events and lower-level operational noise are generally considered unlikely to result in sustained behavioural responses.

Vibration: there is little evidence that vibration at levels typically associated with blasting or vehicle movements has adverse effects on horses. Available studies suggest horses are tolerant of comparable vibration levels experienced during transport, and low-grade whole-body vibration may even have beneficial musculoskeletal effects.

Dust and air quality: equine asthma is primarily associated with chronic exposure to organic dust, endotoxins and poor ventilation in stabled environments. Horses are routinely exposed to much higher dust concentrations from stable management, bedding and hay than those typically encountered in outdoor environments. Temporary increases in dust associated with construction activities are therefore unlikely to adversely affect equine health under normal conditions.

Light: mares are photoperiod-sensitive and rely on changing day length to regulate their breeding cycle. Artificial lighting, particularly blue-spectrum light, may influence reproductive activity at illuminance levels of approximately 10 lux, whereas levels below 3 lux are unlikely to affect mare cyclicity.

5.1 Electromagnetic Fields and Electromagnetic Interference

This section reviews the scientific literature on the electrical environment created by the operation of a 500 kV alternating current high voltage transmission line at power frequency (50 Hz), the phenomena associated with corona discharge, and induced and stray voltages, and then examines the evidence for biological effects on mammals and horses. As no guidelines exist for horses, the guidelines and recommendations developed for humans are included as a guide. The general EMF science is addressed only to the extent necessary with more detail provided in **Appendix A**.

5.1.1 Summary of fundamentals, exposure guidelines and general health effects

The potential biological effects of extremely low frequency (ELF)-EMF have been a focus of intense scientific debate for over 50 years, with approximately 3,000 studies conducted globally. This body of research is periodically reviewed by peak health organisations to determine whether there is a causal link between field exposure and adverse health outcomes. The review here draws on guidelines from the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the World Health Organization (WHO), the International Agency for Research on Cancer (IARC), the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), and the European Commission's scientific advisory committees (SCENIHR and SCHEER). It is acknowledged that these organisations provide guidelines for humans, and there is no evidence that they are directly applicable to horses; however, in the absence of species-specific data, they serve as a useful comparison.

The scope of the review, which is detailed in **Appendix A**, encompasses the fundamentals of electric and magnetic fields at 50 Hz and the distinction between EMF and electromagnetic radiation; natural and background sources; the field characteristics of high voltage transmission lines and typical field levels for 500 kV lines; the ICNIRP, WHO, IARC, Australian and European exposure guidelines and regulatory positions; the general health effects of ELF fields (established effects, epidemiological and experimental evidence, perception, and current scientific consensus); corona discharge effects; and induced and stray voltages. The principal findings of the review are as follows:

- EMF from 500 kV transmission lines decrease rapidly with distance. At the edge of a typical easement, levels are comparable to those found in domestic environments and are well below the general public exposure reference levels established by ICNIRP (5 kV/m for electric fields, 200 μ T for magnetic fields at 50 Hz).
- The IARC has classified ELF magnetic fields as “possibly carcinogenic” (Group 2B) based on a consistent but unexplained epidemiological association with childhood leukaemia at average residential exposures above 0.3–0.4 μ T. No causal mechanism has been identified, and the association is not supported by experimental animal studies. The WHO, ARPANSA, SCENIHR and SCHEER have all concluded that the weight of evidence does not establish EMF at environmental levels as a confirmed health hazard. This leukaemia would not be an issue in horses.
- Corona discharge effects, including audible noise, ozone and nitrogen oxide production, and radio interference, can be managed through conductor design (bundled conductors, adequate diameter) and are generally within acceptable limits at the easement boundary. Ground-level ozone and NO_x concentrations from corona are negligible relative to ambient background levels.
- Induced and stray voltages on metallic structures within the corridor are effectively managed through standard grounding practices, which reduce contact voltages to levels below human and animal perception thresholds.
- The available scientific evidence does not support the suggestion that EMF from transmission lines adversely affects livestock health at environmental exposure levels.
- A precautionary approach, as recommended by the WHO, involving low-cost measures to reduce exposure where practicable, is consistent with current Australian practice and should be reflected in the design and siting of the project.

5.1.2 Equine sensory and behavioural characteristics

An assessment of the potential effects of EMF on horses begins with an understanding of the sensory capabilities and behavioural characteristics that determine how horses respond to environmental stimuli.

5.1.2.1 Sensory capabilities

Horses possess a highly developed sensory apparatus that differs in several important respects from that of humans. Saslow (2002) and Hanggi et al (2007) have described equine sensory modalities in detail. Horses have panoramic visual capacity, with sight similar to that of red-green colour-blind humans, and auditory abilities that in some respects exceed human hearing, with an estimated frequency range of approximately 55 Hz to 33.5 kHz (Heffner and Heffner, 1983). Their olfactory sense is highly developed, and tactile sensitivity varies between individuals as a stable personality trait (Lansade et al., 2008). The relevance to EMF assessment is that horses may perceive environmental stimuli, including electric field effects such as hair deflection or tingling, differently from humans. However, no published research has demonstrated that horses can directly perceive magnetic fields at the intensities produced by transmission lines.

5.1.2.2 Flight response and stress reactivity

Horses are prey animals with a strongly developed flight response. When confronted with a stimulus perceived as threatening, the dominant behavioural response is to flee rapidly. This response is influenced by the novelty, intensity and unpredictability of the stimulus, and young or unfamiliar horses tend to exhibit heightened reactivity (Christensen et al., 2005; Lansade et al., 2008). The relevance to transmission line impacts is twofold. First, construction activity and the introduction of novel structures (towers, conductors) may trigger stress responses, although these are expected to diminish with habituation. Second, if EMF or corona effects were to produce perceptible stimuli (such as audible noise or hair movement in strong electric fields), the flight response could pose a risk of injury, particularly to young or unfamiliar horses. This risk is heightened if the horse is being ridden at the time. These considerations are discussed further in **Sections 6 and 7**.

5.1.2.3 Magnetic alignment disruption

Magnetoreception, the ability to perceive the earth's geomagnetic field, has been demonstrated in a range of animals, including birds, fish, reptiles and some mammals. A review by Pophof (2022) discussed this, along with many other aspects of the biological effects of EMF on fauna and flora and found that in some species there may be disruption to magnetoreception by EMF from power lines. Begall et al. (2008) used satellite imagery to demonstrate that grazing and resting cattle and deer tend to align their bodies along a north–south axis, consistent with sensitivity to the geomagnetic field. A subsequent study by the same group (Burda et al., 2009) found that this preferential alignment was disrupted in cattle and roe deer grazing on pastures under or near high voltage power lines, suggesting that the alternating magnetic fields from the lines interfered with the animals' magneto receptive sense. These findings have been replicated and defended against methodological criticism (Begall et al., 2011).

Evidence for magnetoreception in horses is limited and largely anecdotal. Magnetic compass orientation has been suggested for horses, but the evidence remains inconclusive (Begall et al., 2013). No controlled experimental studies have demonstrated magneto receptive sensitivity in horses to alternating fields at transmission-line intensities. Nevertheless, given the closeness of some

genetic traits between horses, cattle and deer, and the likelihood that magnetoreception is a widespread mammalian trait, it is reasonable to consider that horses may also possess some degree of geomagnetic sensitivity that could, in principle, be affected by proximity to high voltage transmission lines. While the disruption of magnetic alignment does not in itself constitute a health effect, it demonstrates that transmission-line EMF can produce a measurable behavioural change in large mammals under field conditions. Whether similar alignment behaviour exists in horses, and whether its disruption would have practical consequences for equine welfare or management, has not been investigated. Even if there were some disruptions, it is unlikely to result in any welfare or other issues for horses.

5.1.2.4 Comparative dosimetry — bipeds versus quadrupeds

A critical factor in assessing equine risk is the difference in body shape and grounding between humans (bipeds) and horses (quadrupeds). Research by Kaune (1981) and Kaune and Phillips (1980) indicates that the exposure of four-footed livestock to the electric fields directly beneath a transmission line is considerably lower than that of a human. Modelling and some measurement suggests that horses experience approximately 56% of the electric field intensity perceived by a human in the same location (Kaune (1981); Eirgrid, 2025). Conversely, because horses have a larger body mass, magnetic fields can induce slightly larger internal currents than in humans, although these levels remain well below the thresholds required for nerve or muscle stimulation.

5.1.3 Effects of EMF on mammals

5.1.3.1 Biological effects on fauna and flora

A workshop report published by ICNIRP (Bodewein et al., 2022) reviewed the biological effects of electric, magnetic and electromagnetic fields from 0 to 100 MHz on fauna and flora. The review noted that many organisms possess magneto receptive capabilities. Two principal hypotheses have been proposed: a magnetite-based mechanism (light-independent) and a radical-pair mechanism (light-dependent). Both of these are thought to operate at field intensities around or below that of the natural geomagnetic field (approximately 50 μ T), and neither have been demonstrated to be affected by the much weaker alternating magnetic fields produced by transmission lines at the distances relevant to fauna. Certain migratory species, particularly some fish (such as salmon and eels) and birds, use geomagnetic cues for navigation; research on submarine power cables has shown that migratory fish can detect the magnetic fields produced by such cables and may temporarily alter their swimming direction in the immediate vicinity, although their overall migratory behaviour is only minimally affected (Bodewein et al., 2022). For terrestrial fauna, the evidence of overt behavioural responses to weak ELF alternating magnetic fields is limited.

5.1.3.2 Melatonin and circadian rhythm

The suggestion that ELF magnetic fields may suppress melatonin secretion, and thereby disrupt circadian rhythm, has been extensively investigated. Melatonin, produced by the pineal gland primarily during darkness, plays a critical role in regulating seasonal reproduction in photoperiod-sensitive species, including horses. Early laboratory studies in rats reported that chronic exposure to 60 Hz electric fields affected night-time melatonin production (Wilson et al., 1981). However, subsequent research has produced highly inconsistent results. A comprehensive review by Touitou et al. (2012) found that approximately one-third of published studies reported a decrease in melatonin secretion following ELF EMF exposure, while two-thirds found no effect. Notably, studies of workers

chronically exposed to occupational ELF EMF for periods of 1 to 20 years showed no alteration in melatonin secretion, suggesting that cumulative long-term effects are unlikely (Touitou et al., 2012). A study of calves by Burchard et al. (2004) found a seasonal interaction, with an inhibitory effect on melatonin secretion in winter but an increase in summer, further complicating interpretation. The current scientific consensus is that the melatonin hypothesis remains unproven at environmental exposure levels (WHO, 2007; SCENIHR, 2015).

5.1.3.3 Reproductive effects

Potential effects of ELF EMF on mammalian reproduction have been investigated in both laboratory and field settings. Rodriguez et al. (2003) studied dairy cows exposed to 60 Hz electric and magnetic fields and found that the mean oestrous cycle duration was extended from 19.5 ± 0.4 days in controls to 21.3 ± 0.4 days in exposed animals, with a corresponding extension of the luteal phase (15.4 ± 0.4 days vs 17.2 ± 0.4 days). However, a Swedish retrospective study of cattle on 106 farms near 400 kV transmission lines found no significant differences in artificial insemination outcomes or culling rates due to reduced fertility (Algers and Hennichs, 1985). In vitro studies have reported effects of ELF EMF on sperm motility and acrosome integrity in boars at exposures above 0.5 mT (Bernabò et al., 2010); these field intensities are substantially higher than those encountered at ground level beneath transmission lines. The WHO (2007) concluded that the evidence for reproductive effects in mammals at environmental exposure levels was inadequate to draw firm conclusions. No studies of reproductive effects of ELF EMF on horses have been published.

5.1.3.4 Immune and nervous system effects

A systematic review of in vivo experimental studies by Mahdavi et al. (2023) found that ELF EMF exposure can produce measurable effects on multiple organ systems in laboratory animals, including the nervous, immune and endocrine systems. However, the field intensities used in the majority of these studies (typically 0.1–10 mT) substantially exceed those present at ground level beneath a 500 kV transmission line (typically less than 50 μ T directly beneath the line and less than 5 μ T at the edge of the easement). The relevance of high-intensity laboratory findings to environmental exposure scenarios is therefore uncertain.

5.1.4 Effects of EMF on horses

Direct scientific evidence on the effects of power-frequency EMF on horses is extremely limited. No controlled studies have examined equine health, reproduction, behaviour or performance in relation to proximity to transmission lines. The assessment of potential effects on horses must therefore rely on general mammalian evidence, studies on other livestock species (principally cattle), and limited indirect evidence from therapeutic applications.

5.1.4.1 Livestock analogue studies

The potential effects of transmission line EMF on livestock have been studied for several decades, driven largely by community concern about dairy cattle productivity. The Bonneville Power Administration (BPA) published an extensive review of the scientific literature on the electrical and biological effects of transmission lines (BPA, 1989), which concluded that while some biological effects of EMF exposure could be demonstrated in laboratory settings, the field strengths involved were generally much higher than those encountered under normal transmission line conditions, and no adverse effects on livestock health or productivity had been established at environmental

exposure levels. Powerlink Queensland (2023) states that information from well-recognised scientific sources indicates no reason for concern about the effect of EMF on animals or plants, and that EMF has no adverse effect on livestock health.

The most relevant direct evidence comes from studies on cattle near transmission lines. A 30-month study by Angell et al. (1990) of beef cattle maintained beneath a ± 500 kV direct-current transmission line found no significant differences in productivity or health status between exposed and control animals. Measures assessed included feed consumption, mineral and water intake, breeding, conception, calving rates, calf birth weight, average daily gain, weaning weight, cow condition, carcass weight and mortality. Similarly, an epidemiological study by Martin et al. (1986) of Holstein dairy cows near a high-voltage DC power line found no significant differences in milk production or reproductive performance. A study of sheep exposed to transmission line EMF found no significant differences between exposed and control groups for cortisol levels, rate of gain or wool growth (New Mexico State University, 1999). A number of studies conducted by Hydro-Québec in Canada, including investigations, database analyses and extreme case studies on cattle, pigs, sheep and horses (Ralaigh, 1988; Ganskopp et al., 1991; Lee et al., 1993; Lee et al., 1995; Thompson et al., 1995; Burchard et al., 1996; Burchard et al., 1998), observed no harmful effects on the health, productivity, fertility, reproduction or behaviour of livestock exposed to electric and magnetic fields. The Amstutz and Miller (1980) livestock survey reported no observed influence of a 765 kV transmission line on the health, performance or behaviour of livestock, which included horses, but did not separate out horses in the analysis. These livestock studies, while not all directly applicable to horses, are relevant because they demonstrate that at the field intensities typically present under and near operating transmission lines, no adverse effects on mammalian health, productivity or reproduction have been readily observed.

5.1.4.2 Indirect evidence from PEMF therapy

Pulsed electromagnetic field (PEMF) therapy is widely used in equine veterinary practice for the treatment of musculoskeletal injuries. While therapeutic PEMF devices produce much higher field intensities and different waveforms than transmission lines, the published equine PEMF literature provides some insight into how horses respond physiologically to electromagnetic stimulation. A study by Zidan et al. (2025) found that a commercial PEMF therapy blanket did not significantly reduce salivary cortisol levels or stress behaviours in horses, despite the considerably higher field exposure compared with environmental EMF. Similarly, Burdette et al. (2022) found no significant effect of PEMF treatment on equine salivary cortisol concentrations. The absence of measurable stress or cortisol responses to these substantially higher exposures provides indirect evidence that horses are unlikely to exhibit stress responses to the much lower-intensity fields present in the vicinity of a transmission line. However, therapeutic PEMF studies are not designed to assess the effects of chronic, continuous low-level exposure, and caution is warranted in extrapolating from acute therapeutic to chronic environmental scenarios. Many studies of pulsed EMF for medical use in horses, reviewed by Auer et al. (1983) and extensively by Gaynor et al. (2018), indicate a beneficial effect of pulsed EMF for veterinary use. While the benefits of this therapy are not yet fully understood there appear to be no documented adverse effects.

5.1.4.3 Reproductive considerations for horses

Horses are seasonally polyoestrous, with mare reproductive cyclicity governed by photoperiod — specifically by the duration of daily light exposure and its effect on melatonin secretion and circadian

rhythm. The theoretical concern regarding EMF and equine reproduction is that if ELF magnetic fields were to suppress or disrupt melatonin secretion this could in principle affect the onset or regularity of the oestrous cycle in mares. However, as discussed above, the melatonin hypothesis remains unproven, and the weight of evidence, including studies of chronically exposed workers and livestock near transmission lines, does not support the concept that environmental EMF at transmission-line intensities affects melatonin secretion or circadian rhythm (WHO, 2007; Touitou et al., 2012). The effect of light on the breeding cycle is discussed in **Section 5.5**.

In relation to stallion fertility, in vitro studies have reported effects of ELF EMF on spermatozoa in some species, including acrosome damage in boar sperm at exposures above 0.5 mT (Bernabò et al., 2010); however, the field intensities used are more than 100 times greater than the magnetic field at the edge of a typical 500 kV easement. No in vivo studies of EMF effects on stallion fertility have been published, and field studies of cattle fertility near transmission lines have not demonstrated adverse effects (Algers and Hennichs, 1985). On the current evidence, there is no scientific basis for concluding that proximity to a 500 kV transmission line would affect stallion fertility. In relation to foal development, no published studies have specifically examined the effects of environmental ELF EMF on foetal development or foal health in horses; studies of livestock offspring exposed to transmission-line EMF have found no harmful effects on growth or reproduction (New Mexico State University, 1999), and the WHO (2007) review found the evidence for developmental effects in mammals at environmental exposure levels to be inadequate.

5.1.5 Effects of EMF on pastures and fodder crops

Horses maintained near a transmission corridor depend on pasture and locally grown fodder crops for a substantial portion of their nutritional intake, so any effect of the electrical environment on the growth, yield or nutritional quality of these forages would have indirect implications for equine health. The weight of evidence from field studies near transmission lines, regulatory reviews and controlled-exposure studies indicates that EMF from a 500 kV transmission line does not pose a material risk to the quality or productivity of equine pastures and fodder crops at environmental exposure levels, and that corona-generated ozone makes only a negligible contribution to ground-level ozone.

5.1.6 Key findings — EMF and horses

- No controlled studies have examined the effects of EMF on horses. The evidence base for equine-specific effects is entirely absent, and assessments must rely on extrapolation from other mammalian species, principally cattle.
- Extensive livestock studies, including a 30-month study of beef cattle beneath a ± 500 kV DC line (Angell et al., 1990) and multiple epidemiological studies of dairy cattle near transmission lines, have consistently found no adverse effects on health, productivity or reproduction at environmental EMF exposure levels.
- The melatonin/circadian rhythm hypothesis, which is of particular relevance to photoperiod-sensitive species such as horses, remains unproven. The weight of evidence from human and animal studies does not support the contention that environmental EMF at transmission-line intensities materially affects melatonin secretion (WHO, 2007; Touitou et al., 2012).

- Magnetic alignment disruption in cattle and deer near power lines (Begall et al., 2008; Burda et al., 2009) is the most direct evidence of a behavioural effect of transmission-line EMF on large mammals. Whether this effect extends to horses, and whether it has practical consequences for equine welfare, is unknown but considered unlikely.
- EMF levels at the edge of a 500 kV transmission line easement are well within international guideline levels (ICNIRP: 5 kV/m electric, 200 μ T magnetic) and are comparable to those found in domestic environments. Occupational exposure of equine workers would similarly remain well within guideline levels.

5.2 Noise and Hearing in Horses

Both the construction and the operation of the project have the potential to generate noise from a range of sources. Exposure to elevated noise levels, as may occur during construction activities, may elicit stress responses and behavioural disturbances, potentially raising concerns for equine health and welfare (Padalino and Raidal, 2020).

Horses, and young Thoroughbreds in particular, can behave unpredictably at any time, and individual differences in temperament and reactivity influence responses to noise (Visser et al., 2001). The fight-or-flight response is strongly flight-dominated in equine behaviour, and when confronted with unusual or unfamiliar stimuli, as may accompany construction activity, most horses will instinctively attempt to flee from what they perceive as a source of danger (Christensen, Rundgren and Olsson, 2006). Horses generally adapt relatively quickly to stimuli they encounter regularly, so the disturbance caused by construction noise will tend to diminish over time for animals that remain in the vicinity. Predictable, repetitive high-noise events are likely to be tolerated sooner than irregular noise, particularly if that irregular noise is accompanied by the appearance of large cranes or other unfamiliar visual stimuli immediately adjacent to a paddock.

The literature review on hearing in horses and habituation to noise can be viewed in **Appendix B**.

5.2.1 Key findings

5.2.1.1 Hearing range in horses

Horses hear in the range 55 Hz to 33.5 kHz, with best sensitivity between 1 kHz and 16 kHz (Heffner and Heffner, 1983). This range is relevant when assessing which components of transmission line and construction noise are likely to be perceptible to horses.

5.2.1.2 Noise measurement and comparisons

Noise is typically measured in decibels using A-weighting (dB(A)), which reflects how sound is perceived by humans and other mammals. When considering potential responses by horses, the character, duration and familiarity of a noise source are often as important as the noise level itself.

Horses are routinely exposed to a range of environmental and operational noise sources within rural and equine settings. For example, a lawnmower may generate noise levels approaching 90 dB(A) while passing trucks can generate around 80 dB(A). Research suggests that horses are often able to habituate to familiar and regularly occurring noise sources, particularly where such sounds are associated with normal agricultural, transport or property management activities.

Conversely, unfamiliar, unpredictable or sudden noise events may be more likely to elicit a behavioural response. The extent of any response depends on a range of factors, including the nature of the noise source, prior exposure, the surrounding environment and the temperament of individual horses.

Construction activities associated with the project would generate temporary increases in noise levels during specific activities. Consistent with the findings of the Noise and Vibration Impact Assessment, construction noise would generally be localised to active work areas and would reduce with increasing distance from the source. Helicopter stringing represents one of the construction activities most likely to be perceived at greater distances due to its elevated noise source and movement through the landscape.

5.2.1.3 Characteristics of corona and operational noise

Corona discharge is the dominant source of audible noise from operating HV transmission lines (Li et al., 2023; He et al., 2021), and as this is likely to be the only source of operational noise that may affect horses, it is the focus here. Typical corona noise levels are up to approximately 50 dB(A) at 15 m from the outermost conductor under fair-weather conditions (He et al., 2021). Under heavy rain noise levels are significantly higher and a 1000 kV UHV line can produce 100 Hz pure-tone levels of 61.4 dB outside 10 m from the outer phase (He et al., 2021; Zhang et al., 2017). The EirGrid (2016) report noted that audible noise from electricity infrastructure generally falls within four categories: corona noise from high voltage transmission lines (heard as crackling and hissing); noise associated with dirty, damaged or cracked insulators; noise associated with substation equipment; and “Aeolian” noise associated with wind blowing through the infrastructure.

To assess the significance of operational transmission line noise for horses it is useful to place the levels in context as shown in **Table 5.1**. Corona noise levels (up to approximately 50 dB(A) in fair weather and 61 dB(A) in rain) are well below the acute startle threshold of 95 dB(A) identified for wildlife, and below the 65 dB(A) LAeq threshold recommended by Huybregts (2008) for horses in stables. However, they may exceed quiet rural background levels by 15–25 dB, making the noise perceptible, particularly at night, during rain, and in conditions of low ambient sound. Sound from a line source decreases at approximately 4–6 dB per doubling of distance (IEEE, 2018). At 30 metres from the outermost conductor, fair-weather corona noise would typically be 44–46 dB(A); at 60 metres, 38–42 dB(A) which is approaching or within rural background; and at 120 metres, approximately 32–38 dB(A) which is effectively indistinguishable from background in most rural settings.

Table 5.1 Noise levels in context (approximate)

Noise source / setting	Approximate level	Reference / note
Quiet rural background	25–35 dB(A)	Typical rural ambient
Moderate suburban background	40–50 dB(A)	Typical suburban ambient
Corona noise at 15 m, fair weather	up to ~50 dB(A)	He et al. (2021)
Corona noise at 15 m, heavy rain (UHV)	~61 dB(A)	Engel and Wszolek (1995)
Recommended threshold for horses in stables	65 dB(A) LAeq	Huybregts (2008)
Passing trucks	~80 dB(A)	
Lawnmower	Approaching 90 dB(A)	
Acute startle threshold for wildlife	95 dB(A)	US National Park Service (2004)

5.2.1.4 Effects of operational noise on horses

No published studies were identified that specifically examine the effects of operational transmission line noise (corona discharge, hum, etc) on horses. Any assessment must therefore rely on extrapolation from the measured noise levels and frequency characteristics of transmission line noise, known equine auditory capabilities and noise sensitivity thresholds, and studies of chronic low-level noise exposure in mammals generally. The 100 Hz tonal component of corona noise falls within the equine hearing range but in a region of relatively lower sensitivity, whereas the broadband crackling component (above 1 kHz) falls within the region of best equine hearing and would therefore be more perceptible. Frequency-specific stress responses suggest that the high-frequency crackling component (8–16 kHz) may be more physiologically significant than the low-frequency hum, as higher frequencies have been shown to elevate cortisol within 30–40 minutes of exposure (Schust, 2004; Kight and Swaddle, 2011).

The noise from corona discharge is continuous during operation and increases during wet weather. While the levels are moderate, the character of the noise, being a persistent hum with crackling, is likely novel and unfamiliar to horses, and unfamiliar noise types are more likely to provoke initial stress responses than familiar sounds at the same level (Christensen et al., 2006; Wiśniewska et al., 2022). Thoroughbred horses may be disproportionately affected, as research indicates they show stronger internal reactions and emotional agitation to unfamiliar sounds compared with other breeds (Visser et al., 2001; Lansade and Simon, 2010). Habituation is likely for the continuous, steady component of corona noise, consistent with the existing literature on habituation to predictable, non-threatening noise. However, the variable component during wet weather and the novelty of the sound character may delay habituation for some individuals, and a proportion of horses (estimated at approximately 22% based on Riva et al., 2022) display persistent noise anxiety that does not resolve with exposure.

Over the longer term, horses will generally adjust to more consistent noise levels; however isolated events such as sudden loud noises may continue to startle animals and potentially cause injury. The combination of continuous operational noise with intermittent maintenance activities (particularly helicopter inspections) may limit habituation by reintroducing occasional unpredictable noise events (Christensen et al., 2006). Potential implications for identified equine receptors and associated mitigation measures are discussed in **Section 8**.

5.3 Vibration

There is little scientific data regarding the effect of ground vibration on equine health. The Vibration Literature Review can be found in Appendix C. While little is known specifically of the effects of ground vibration, there have been many studies evaluating the effects of whole-body vibration (WBV) in people and animal models (Crewther et al., 2004). There is a growing body of evidence, both anecdotal and scientific, that WBV can be used as a performance-enhancing tool; in most studies it has been found that vibration can positively influence maximal strength, force output, power output and vertical jump height. The use of WBV has been found effective in the prevention of bone loss and/or increasing bone density in various animal models, and, considering its stimulatory effect upon bone, may be a potential treatment for osteoporosis and other related bone disorders.

The amount of vibration associated with intermittent blasting, and possibly heavy vehicle movements, that might be experienced by horses close to the project would seem to be less than that which animals may experience during transport. Unfortunately, little objective work has been done to evaluate any potential adverse effects (Randall, 1992). Given that horses are regularly transported long distances in both aircraft and vehicles without any ill effects or concern, it is likely that vibration from blasting will also cause no concern to horses in the area. There may also be beneficial effects from low-grade whole-body vibration, which makes it even more unlikely that vibration from the project will have any detrimental effect on equine health. Low-level vibration has regularly been evaluated for potential positive effects on the human and equine musculoskeletal system and had there been an obvious deleterious effect on health, it would be expected that the many studies evaluating the effect of vibration on health would have detected it. In the absence of other data, it is extremely unlikely that vibration from the project would have any adverse effect on horses.

5.4 Dust and Air Quality

The Dust and Air Quality Literature Review can be found in **Appendix D**.

5.4.1 Equine respiratory disease — current terminology

The terminology used to describe chronic non-infectious lower respiratory disease in horses has changed considerably over the past two decades. Historically, conditions such as inflammatory airway disease (IAD), recurrent airway obstruction (RAO), heaves, chronic obstructive pulmonary disease (COPD), and summer pasture-associated obstructive pulmonary disease were considered separate disorders (Bond et al., 2018). However, increasing evidence has demonstrated that these diseases share common pathological features, including chronic airway inflammation, bronchial hyperresponsiveness, mucus accumulation and variable airflow obstruction (Couëtil et al., 2020). As a result, the umbrella term *equine asthma* (EA) is now widely accepted to encompass these related syndromes (Bond et al., 2018).

Current terminology generally divides equine asthma into two major categories: mild-to-moderate equine asthma (mEA) and severe equine asthma (sEA). Mild-to-moderate EA corresponds largely to the condition previously referred to as IAD, whereas severe EA encompasses RAO, heaves and summer pasture-associated RAO (Lascola, 2023). Horses with mild-to-moderate EA often present with subtle clinical signs such as poor performance, occasional coughing and excess tracheal mucus without respiratory effort at rest. In contrast, severe EA is characterised by marked airway obstruction, increased respiratory effort at rest, nasal flaring, and the development of a “heave line” due to chronic expiratory effort (Bond et al., 2018). While there is currently some consensus, controversy remains regarding whether mild disease inevitably progresses to severe asthma, as evidence for a continuous progression pathway remains limited (Johns, 2026). Equine asthma is closely associated with environmental exposure to organic dusts, mould spores, endotoxins, respirable particulate matter and aeroallergens present within stables and equestrian facilities (The British Horse Society, 2026); poor ventilation, dusty forage, straw bedding, indoor arenas and high concentrations of airborne particulates are recognised risk factors for both mild and severe forms of the disease.

5.4.2 Key findings from the literature review

Following the literature review, it was concluded that the very high amount of dust to which horses are exposed, both from being fed hay and, in particular, from being kept in a stabled environment, is essentially an occupational hazard. There are undoubtedly effects of this dust on the respiratory tract, including in some cases equine asthma; however, it is well documented that the most severe effects of dust are mostly a result of the endotoxins attached to the dust particle, rather than the inorganic dust component itself. Concerns have recently been expressed about silica exposure from soils; however, given the short exposure times and that most horses will be in an open environment, the increased risk above background levels is considered insignificant. The key points from the research data with which to compare the potential effects of the project are summarised below:

- The minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m³ (0.02 µg/m³) (McGorum et al., 1998).
- Total dust concentration in a normal pasture environment for horses has been measured at 0.17 mg/m³ (170 µg/m³), respirable dust at 80 µg/m³, and endotoxin at 0.00129 µg/m³ in total airborne dust (McGorum et al., 1998).
- The recommended maximum value for inhalable dust in a stable is probably of the order of 2.5 to 3.0 mg/m³ (2,500–3,000 µg/m³). Concentrations of respirable dust in stables range from 0.15 to 9.28 mg/m³ (150–9,280 µg/m³), with a recommended maximum value of 0.23 mg/m³ (230 µg/m³) (Cargill, 1999).
- Racehorses spend most of their time (up to 22 hours) in looseboxes and are exposed to aerosolised foreign dusts and gases almost continuously, so any effects are likely to be cumulative. There can be peaks of dust exposure up to 50 times greater than background levels depending on bedding, feed, activity and stable management (Malakides and Hodgson, 2003).
- Forty percent of horses develop inflammatory airway disease within the first two weeks of entering racetrack stables for training — a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing (Malakides and Hodgson, 2003).
- More than a third of horses entering racetrack stables had some form of airway inflammation prior to transport, but these horses were not necessarily at greater risk of continued inflammation or further respiratory disease (Malakides and Hodgson, 2003).
- Contrary to expectation, many dust-generating activities and sources are not associated with inflammatory airway disease (Malakides and Hodgson, 2003).

The scientific literature evaluating exposure to noxious gases in stables or from general air pollution, and the role they may play in equine airway inflammation and disease, is very limited. Threshold values for any noxious gas for horses are unknown; however, they are not considered likely to be an issue during either the construction phase or the operation of the project.

The implications of dust generation during the construction phase are addressed in **Section 6.5**.

5.5 Light

Horses are seasonally polyoestrous; their reproductive cycle is governed by photoperiod. As daylight hours lengthen through the transition from winter to spring and into summer, mares initiate their breeding cycle. In winter, cyclical activity ceases, and approximately 60 days of progressively increasing light exposure, mimicking the natural lengthening of days, are required before cycling

resumes. A threshold of approximately 16 hours of light per day is generally necessary. In Australia, this process of increasing light periods commences around the winter equinox (late June) and must be sustained until mares begin cycling in September.

Supplementary artificial lighting of broodmares is a well-established management technique for extending the effective breeding season by suppressing melatonin secretion and modifying circadian rhythm (Burkhardt, 1947; Palmer and Guillaume, 1992). The original photoperiod protocol of 16 h light: 8 h dark used a 100 W incandescent bulb in a 3.65 × 3.65 metre stable, colloquially described as “enough light to read the fine print in a newspaper” and equivalent to an illuminance of approximately 100 lux.

Walsh et al. (2013) investigated the minimum light intensity needed to reliably suppress melatonin secretion and found that equine photoreceptors are most responsive to short-wavelength (blue) light. An illuminance of just 10 lux delivered via a blue-spectrum LED mounted in a facemask was sufficient to influence mare cyclicity. Below 3 lux, no effect on the breeding cycle was detected. Dell et al. (2000) provided representative illuminance values for outdoor work areas at night: a full moon on a clear night, 0.27–1 lux; a private car park, 10 lux; mine loading bays, 150 lux; and inspection areas (requiring the highest illuminance for workplace safety), 1,000 lux.

Illuminance diminishes with distance from the light source in accordance with the inverse square law, that is, it decreases in proportion to the square of the distance. By way of illustration, if a one-metre-square area directly beneath the brightest light on a 10-metre pole receives 1,000 lux, an equivalent area 100 metres away will receive only 10 lux (one-hundredth of the intensity), and at one kilometre the illuminance falls to just 0.1 lux. These values do not account for supplementary mitigation measures such as directional light shields or physical barriers. Since illuminances as low as 10 lux may influence the breeding cycle of some mares, lighting from any source has the potential to cause reproductive disruption. The potential effects of construction and operational lighting on mares in adjacent paddocks, and the associated management measures, are discussed in **Sections 6 and 7**.

6 Assessment of Potential Construction Impacts

This section assesses the potential impacts of construction activities on identified equine receptors and sensitive equine land uses within the Equine Health Study Area. The assessment considers potential construction impacts associated with noise, vibration, plant and equipment, helicopters, blasting, dust and temporary changes to fencing and property access.

6.1 Construction Noise and Vibration

Construction activities have the potential to generate temporary increases in noise from vegetation clearing, access track construction, foundation works, tower assembly, vehicle movements and where required, rock breaking. Based on the literature review (refer **Section 5.2**), the principal concern for horses is the potential for sudden, unfamiliar or unpredictable noise to trigger behavioural responses, including startle and flight responses.

The NVIA (SLR, 2026) prepared for the EIS indicates that construction noise decreases rapidly with distance from active works. Based on the 65 dB(A) threshold identified in the literature review (refer **Section 5.2**), construction noise levels are predicted to reduce below this level at approximately 140 metres for access track construction, 160 metres for vegetation clearing, 200 metres for foundation works involving rock breaking and 35 metres for tower assembly.

Construction traffic has also been considered in the NVIA (SLR, 2026). Traffic noise levels are predicted to reduce below 65 dB(A) within approximately 5 metres of sealed roads and 8 metres of unsealed roads. Traffic noise is therefore unlikely to result in adverse behavioural responses. In addition, vehicle movements would generally occur on existing roads where horses are already accustomed to traffic noise.

Most identified equine receptors are located hundreds of metres to several kilometres from the project area. As a result, they are unlikely to experience construction noise levels associated with behavioural disturbance. The major Thoroughbred breeding operations within the Upper Hunter Equine CIC closest to the project area, including Vinery Stud, Kia Ora Stud, Segenhoe Stud, Turangga Farm and Newgate Farm, are located several kilometres away. Potential construction noise impacts on these operations are therefore expected to be negligible.

Kitchwin Hills (Top Farm and Bottom Farm) has the greatest potential to experience construction noise impacts due to its proximity to project activities, as portions of the property overlap with, or are immediately adjacent to, the project area and transmission corridor. As a Thoroughbred breeding operation activities undertaken at the property may include breeding, foaling, and the management of mares and young stock, which may be more sensitive to disturbance during certain periods.

Construction noise associated with road upgrade works, vehicle movements, earthworks, transmission line construction and helicopter operations may result in temporary behavioural responses where works occur within or adjacent to actively managed paddocks. Potential responses may include increased vigilance, startle responses, temporary avoidance of paddocks closest to construction activities, and short-term disruption to normal grazing, resting or management practices.

The mitigation measures outlined in **Section 8**, including advance notification of higher-impact activities, ongoing consultation with property managers and the temporary management or relocation of horses from paddocks most likely to interact with construction activities where required, would further reduce the potential for adverse behavioural responses.

In contrast to Kitchwin Hills, the remaining identified equine receptors are located in proximity to proposed road upgrade works but are separated from the transmission corridor and other major construction activities. Scone Polo Club (approximately 200 metres from proposed road upgrade works), Walcha Polocrosse Grounds and Jockey Club (approximately 400 metres from proposed road upgrade works) and Gundy Park Equine (approximately 500 metres from proposed road upgrade works) are the closest identified equine receptors. While temporary increases in construction noise may occur during nearby road upgrade works, these facilities remain beyond the distances at which the 65 dB(A) threshold is predicted to be exceeded for most construction activities. Any behavioural responses are expected to be temporary, localised and limited to short-term startle, vigilance or avoidance behaviours. More distant equine facilities, including Main Camp (Brooker), Bydand Stock Horses and Timor Polo Club, are expected to experience negligible construction noise impacts.

Ground vibration associated with construction activities is expected to be intermittent and localised. Consistent with the findings of **Section 5.3**, vibration is unlikely to adversely affect equine health, welfare or behaviour and may, in some circumstances, provide beneficial musculoskeletal effects.

Overall, construction noise may result in temporary behavioural responses at a small number of equine facilities located closest to the project area, namely Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, Gundy Park Equine and Kitchwin Hills (Top and Bottom Farm). Of these receptors, Kitchwin Hills has the greatest potential to experience construction-related disturbance due to its proximity to, and partial overlap with, project activities. Potential impacts are expected to be limited to short-term behavioural responses, including increased vigilance, startle reactions and temporary avoidance of paddocks closest to construction activities. However, given the temporary nature of construction activities, the absence of night works in proximity to identified equine facilities and paddocks, and the mitigation measures outlined in **Section 8**, impacts on equine health, welfare and management are expected to remain localised, temporary and manageable.

6.2 Construction Plant and Equipment

Construction plant and equipment, including excavators, bulldozers, cranes and trucks, may result in temporary behavioural responses where horses are exposed to unfamiliar equipment operating in proximity to paddocks.

Kitchwin Hills (Top Farm and Bottom Farm) has the greatest potential for interaction with construction plant and equipment, as portions of the property overlap with, or are immediately adjacent to, the project area and transmission corridor. Construction activities at Kitchwin Hills may include earthworks, transmission line construction, tower foundation works, vehicle movements and other heavy machinery operating within or adjacent to actively managed paddocks. Temporary behavioural responses may include increased vigilance, startle responses and temporary avoidance of areas closest to construction activities.

Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine are located in proximity to proposed road upgrade works and therefore have a lower potential for interaction with

construction machinery. Any responses at these locations would be expected to be limited to temporary behavioural reactions to vehicle movements and road construction equipment operating in the vicinity of paddocks.

Most other identified equine receptors are located at distances where visual disturbance from construction machinery is unlikely. Any behavioural responses are expected to be temporary and are likely to diminish as horses become accustomed to construction activities. Potential impacts can be further reduced through the mitigation measures outlined in **Section 8**, including consultation with property managers and consideration of sensitive operational periods, such as foaling, where practicable.

Overall, Kitchwin Hills has the greatest potential to experience behavioural disturbance associated with construction plant and equipment due to its proximity to, and partial overlap with, project activities. However, responses are expected to be temporary and manageable, and potential impacts on equine health, welfare and management are expected to be low.

6.3 Helicopters

Helicopters may be used during construction for stringing activities and access to remote sections of the transmission corridor. Compared with other construction activities, helicopters have the potential to affect horses over greater distances due to their visibility, movement and noise.

The NVIA (SLR, 2026) indicates that helicopter noise may exceed 65 dB(A) within approximately 550 metres of helicopter operations. Accordingly, equine facilities and paddocks located closest to sections of the project's transmission corridor where helicopter-assisted stringing activities may occur have the greatest potential for interaction with helicopter activities.

Within the Equine Health Study Area, Kitchwin Hills (Bottom Farm) has the greatest potential for interaction with helicopter activities, as identified paddocks are located immediately adjacent to, and may partially overlap with, sections of the transmission corridor where helicopter stringing activities may occur. Kitchwin Hills (Top Farm) is located on the boundary of proposed road upgrade works but is not located adjacent to the transmission corridor. Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine are located in proximity to proposed road upgrade works but are not located in close proximity to the transmission corridor where helicopter stringing activities would occur. No identified equine facilities or paddocks are located within the transmission corridor.

At Kitchwin Hills (Bottom Farm), helicopter activities may result in temporary behavioural responses, including increased vigilance, startle responses, temporary avoidance of paddocks closest to helicopter operations and short-term disruption to normal grazing, resting or management practices. Management measures such as advance notification of helicopter activities, consultation with property managers and the temporary management or relocation of horses from paddocks adjacent to helicopter operations, where required, would further reduce the potential for disturbance.

Helicopter activities would be intermittent and of short duration. Consultation with affected landowners or property managers, and consideration of sensitive equine activities where practicable would further reduce the potential for disturbance.

On this basis, temporary behavioural responses may occur at equine facilities and paddocks located closest to helicopter operations, with the greatest potential at Kitchwin Hills (Bottom Farm) due to its proximity to the transmission corridor and helicopter stringing activities. Potential impacts are expected to be limited to short-term behavioural responses, including increased vigilance, startle reactions and temporary avoidance of paddocks closest to helicopter operations. However, given the intermittent and short-term nature of helicopter activities and the mitigation measures outlined in Section 8, impacts on equine health, welfare and management are expected to remain localised, temporary and manageable.

6.4 Blasting

Blasting may be required in limited locations where rock excavation is necessary for transmission tower foundations. Blast overpressure is measured in dB(L) and is not directly comparable to audible dB(A) noise.

The literature review identified a study undertaken during a road construction project at Berry, NSW, which assessed horse responses to blasting at a property located approximately 635 metres from the blast source. While an initial startle response was observed during the first blast, subsequent blasting events resulted in little or no behavioural response, indicating a degree of habituation under the observed conditions (Kannegieter, 2015).

Table 6.1 Summary of vibration and noise readings and horse reactions during blasting at the Heath property, Berry NSW, approximately 635 metres from the blast (Kannegieter, 2015)

Blast No.	Vibration (mm/sec)	Noise dB(L)	Approx. dB(A) equivalent	Horse reaction
Blast 1 (data recorded at 80 m from blast)	23.250	135.0	75	Moderate response, 15 seconds duration, canter approx. 80 m
Blast 2	0.325	108.8	48	No reaction
Blast 3	0.270	108.0	48	No reaction
Blast 4	0.312	110.9 (0.878 secs)	50	Lifted their heads for 8–10 seconds
Blast 5	0.688	123.4 (1.426 secs)	63	Very mild reaction for 15 seconds and less than 15–20 metres of movement

The nearest identified equine receptor being Uralla Showground Equine Precinct is located approximately 6.2 kilometres from the nearest potential blasting location. As a result, the identified equine receptors are unlikely to be exposed to blast overpressure or vibration levels capable of causing behavioural disturbance. In addition, blasting would be infrequent, of short duration and limited to specific locations where geotechnical conditions require its use.

Where blasting is required, activities would be managed in accordance with the mitigation measures outlined in **Section 8**, including communication with affected landowners where appropriate.

On this basis, potential impacts on equine health, welfare and management associated with blasting are expected to be negligible.

6.5 Construction Dust

Construction activities have the potential to generate dust during vegetation clearing, earthworks, access track construction, foundation works and vehicle movements. For horses, the principal concern is temporary exposure to elevated dust levels during nearby construction activities.

The Air Quality Impact Assessment (Airen Consulting, 2026) prepared for the EIS identified dust generation during construction as the principal air quality consideration for the project. The assessment concluded that potential impacts would not be significant following implementation of the proposed dust management measures.

As discussed in **Section 5.4**, horses are generally considered to have a low sensitivity to dust impacts, with potential effects typically associated with prolonged exposure to elevated dust concentrations. Most identified equine facilities and paddocks are located outside the project area and transmission corridor. Consequently, exposure would generally be limited to indirect impacts at nearby equine facilities and paddocks. Kitchwin Hills (Top Farm and Bottom Farm) has the greatest potential for temporary dust exposure, as portions of the Bottom Farm are located immediately adjacent to, and may partially overlap with, sections of the transmission corridor and proposed road upgrade works, while the Top Farm is located immediately adjacent to proposed road upgrade works. Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine are located in proximity to proposed road upgrade works. However, dust levels would decrease with distance from active work areas, and construction activities associated with individual transmission towers and road upgrades would be temporary and progressive in nature. As a result, dust exposure at any given location would be limited in duration.

Construction dust is also relevant to foal health because dry and dusty conditions may increase the risk of exposure to *Rhodococcus equi* where the pathogen is already present in soils. However, this risk is generally associated with existing horse-related land uses and is not expected to represent a significant project-related risk.

On this basis, temporary dust-related impacts may occur at a limited number of equine facilities and paddocks located closest to active construction works. Potential impacts are likely to be limited to temporary irritation and short-term behavioural responses associated with localised dust generation. However, given the low sensitivity of horses to short-term dust exposure, the temporary and progressive nature of construction activities, the separation distances to most equine facilities and paddocks, and the mitigation measures outlined in **Section 8**, potential impacts on equine health, welfare and management are expected to be low. Potential impacts associated with silica-containing dust are expected to be negligible due to the short duration of works at individual construction locations.

6.6 Fencing

Construction activities have the potential to temporarily affect existing fencing where works occur within or adjacent to paddocks used for horse management. Kitchwin Hills (Bottom Farm) has the greatest potential for interaction with project activities from a fencing perspective, as portions of the property overlap with, or are immediately adjacent to, sections of the transmission corridor, required access tracks and proposed road upgrade works. Other identified equine receptors, including Scone

Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine, are located in proximity to proposed road upgrade works and may have limited potential for interaction with construction activities.

Where construction activities require temporary removal, modification or disturbance of fencing, works would be undertaken in consultation with the relevant landowner or property manager to maintain livestock containment and property operations. In the event that construction activities result in damage to fencing, or new fencing is required, the issue would be managed in accordance with the mitigation measures outlined in **Section 8**, including the timely repair, replacement or reinstatement of fencing where required.

Guidelines for appropriate equine fencing are provided in **Appendix E**.

On this basis, potential impacts on equine health, welfare and management associated with fencing are expected to be low and primarily limited to temporary disruption of horse management practices during construction. With implementation of the proposed mitigation measures, impacts are expected to remain localised, temporary and manageable.

6.7 Construction Lighting

Artificial lighting has the potential to influence reproductive cycling in mares where horses are exposed to elevated light levels for extended periods. While construction activities would generally occur during daylight hours, any night works would be subject to project management measures and would not be undertaken in proximity to identified equine facilities and paddocks where practicable.

Given the limited duration of any night works, the temporary and localised nature of construction lighting, and the management measures outlined in **Section 8**, project-related lighting is not expected to affect horse breeding, foaling or management activities.

On this basis, potential impacts on equine health, welfare and management associated with construction lighting are expected to be negligible.

7 Assessment of Potential Operation Impacts

This section assesses the potential impacts of project operation on identified equine receptors and sensitive equine land uses within the Equine Health Study Area. The assessment considers potential effects associated with operational noise, vibration, corona discharge, inspection and maintenance activities, dust, EMF/EMI and fencing.

7.1 Operational Noise and Vibration

The dominant source of operational noise from the transmission line would be corona discharge. Corona discharge occurs when air surrounding an energised conductor becomes electrically charged, producing a low-level hum and occasional crackling noise. As discussed in **Section 5.2**, horses may respond to unfamiliar or unpredictable sounds. However, habituation generally occurs where noise sources are continuous and predictable.

The NVIA (SLR, 2026) predicts that operational noise levels associated with the transmission line would not exceed approximately 55 dB(A) directly beneath the conductors under normal operating conditions. This is below the 65 dB(A) threshold identified in **Table 5.1**. Kitchwin Hills (Bottom Farm) has the greatest potential for exposure to operational transmission line noise due to its proximity to the transmission corridor. However, even at this location, operational noise levels are expected to remain below the threshold identified in the literature review as being associated with adverse behavioural responses in horses. Other identified equine receptors are located further from the transmission corridor and would experience lower operational noise levels.

While some horses may initially notice the unfamiliar hum or crackle associated with corona discharge, operational noise is expected to be continuous and predictable in nature. Potential responses are therefore expected to be limited to short-term awareness or behavioural adjustment, with horses likely to habituate to transmission line noise over time.

Operation of the transmission line is not expected to generate measurable ground vibration.

On this basis, operational noise and vibration are not expected to affect equine health, welfare or management. Although Kitchwin Hills (Bottom Farm) has the greatest potential for exposure to operational transmission line noise, predicted noise levels remain below the behavioural response threshold identified in the literature review and impacts are expected to be negligible.

7.2 Inspection and Maintenance Activities

Inspection and maintenance activities may include helicopter inspections, conductor washing, vegetation management and periodic vehicle access along the transmission corridor. Compared with routine operation of the transmission line, these activities have a greater potential to result in temporary behavioural responses because they are intermittent and less predictable.

The identified equine receptor with the greatest potential for interaction with inspection and maintenance activities is Kitchwin Hills (Bottom Farm), due to its proximity to, and potential overlap with, sections of the transmission corridor. Temporary behavioural responses may occur during helicopter inspections, conductor washing, vegetation management or other infrequent

maintenance activities. Potential responses are expected to be limited to increased vigilance, startle reactions and temporary avoidance of areas closest to maintenance activities.

Other identified equine receptors are located further from the transmission corridor and would have a lower potential for interaction with inspection and maintenance activities. Most identified equine receptors, including the major Thoroughbred breeding operations within the Upper Hunter Equine CIC, are located several kilometres from the transmission corridor and are unlikely to be affected by routine inspection and maintenance activities.

Inspection and maintenance activities would be infrequent and short in duration. Where activities occur in proximity to identified equine receptors, advance notification, consultation with landowners or property managers, and consideration of sensitive equine activities such as breeding, foaling and the management of young stock would assist in minimising disruption to equine operations. These measures outlined are in **Section 8**.

On this basis, potential impacts on equine health, welfare and management associated with inspection and maintenance activities are expected to be low.

7.3 Operation Dust

Operation of the project is not expected to generate dust emissions that would affect identified equine receptors. The Air Quality Impact Assessment (Airen Consulting, 2026) concluded that operation of the project is not expected to result in air quality impacts.

On this basis, potential impacts on equine health, welfare and management associated with operational dust are expected to be negligible.

7.4 EMF and EMI

The operational EMF environment of the project has been assessed as part of the EIS EMF Study and is summarised in **Section 5.1**. EMF levels are predicted to remain within the adopted project design criteria and relevant public exposure guidelines.

Based on the literature review, EMF and EMI associated with the project are not expected to adversely affect equine health, welfare or behaviour. Similarly, no effects on pasture growth, fodder production or equine property management are anticipated.

Kitchwin Hills (Bottom Farm) has the greatest potential for exposure to project-related EMF due to its proximity to, and potential overlap with, sections of the transmission corridor. However, EMF levels at this location are expected to remain within the adopted project design criteria and well below levels identified in the literature as being associated with adverse effects on animal health or behaviour. Other identified equine receptors are located further from the transmission corridor and would experience lower EMF exposure levels.

The principal operational consideration relates to induced or stray voltages on metallic infrastructure located within or near the transmission easement. However, no identified equine receptors are located within the transmission easement. Where fencing, gates, water infrastructure or other conductive assets are located within or adjacent to the easement, induced and stray voltage risks would be managed through the design, grounding and isolation measures outlined in **Section 8**.

On this basis, potential impacts on equine health, welfare and management associated with EMF, EMI, induced voltages and stray voltages are expected to be negligible.

7.5 Fencing

Metal fencing located close to transmission infrastructure has the potential to be affected by induced or transferred voltages if not appropriately designed and installed. In some circumstances, these voltages have the potential to result in electric shocks to horses and handlers and may influence horse behaviour around fences, gates or water points.

The identified equine receptors are all located outside the transmission easement and are not expected to be affected by induced or transferred voltages under normal operating conditions. Where fencing is installed, modified or maintained in proximity to transmission infrastructure, fencing design and earthing requirements would be implemented in accordance with the project design standards and mitigation measures outlined in **Section 8**.

On this basis, potential impacts on equine health, welfare and management associated with fencing are expected to be negligible.

7.6 Operational Lighting

No permanent project lighting is proposed in proximity to identified equine receptors. As a result, operation of the project is not expected to affect horse breeding, foaling or management activities.

On this basis, potential impacts on equine health, welfare and management associated with operational lighting are expected to be negligible.

8 Mitigation and Management

This section describes the measures proposed to avoid or minimise potential impacts on identified equine facilities, paddocks and sensitive equine land uses during detailed design, construction and operation of the project.

The project has been designed to minimise interaction with identified equine facilities and paddocks where practicable. While most identified equine facilities and paddocks are located outside the project area and transmission corridor, Kitchwin Hills (Top Farm and Bottom Farm) is located immediately adjacent to, and in some areas may partially overlap with the project area. Accordingly, the mitigation measures outlined below focus on the management of potential impacts at identified equine receptors located closest to the project, particularly Kitchwin Hills, Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine.

These measures would be implemented through the project's Construction Environmental Management Plan (CEMP), Operational Environmental Management Plan (OEMP) and ongoing consultation with affected landowners and property managers, where required.

The recommended mitigation measures for equine health, welfare and management are summarised in **Table 8.1**.

Table 8.1 Mitigation and Management Measures

Reference	Impact	Environmental management measure	Timing	Relevant location(s)
EH1	Equine Management	Prior to construction, the location and extent of equine facilities and paddocks associated with identified equine receptors should be verified through consultation with landowners, property managers and/or field verification. This information should be used to confirm receptor locations, refine construction management measures and inform notification and consultation requirements where construction activities may occur in proximity to equine facilities and paddocks.	Detailed design	All equine facilities and paddocks located within 800 metres from the project area
EH2	Equine Management	Consultation with affected landowners or property managers should be undertaken during detailed design, construction and operation where activities have the potential to affect equine management, access or property operations.	All stages	All equine facilities and paddocks located within 800 metres of the project area
EH3	Equine Management	Where construction activities are proposed within, or immediately adjacent to, actively managed paddocks at identified equine receptors, consultation should be undertaken with the relevant landowner or property manager regarding the timing of works and any temporary horse management measures considered necessary.	Detailed design and construction	Kitchwin Hills (Top and Bottom Farm)
EH4	Construction noise	At least 72 hours' notice should be provided for substantial noise-generating activities e.g. helicopter stringing occurring in proximity to identified equine receptors, allowing property owners or managers to implement horse management measures where considered necessary.	Construction	All equine facilities and paddocks located within 800 metres from the transmission corridor

Reference	Impact	Environmental management measure	Timing	Relevant location(s)
EH5	Construction and operational noise	Where reasonably practicable and identified through consultation with affected landowners or property managers, the timing of substantial noise-generating activities e.g. helicopter stringing, helicopter inspections and or conductor washing should consider sensitive equine activities, including breeding, foaling and the management of young stock.	Construction and Operation	All equine facilities and paddocks located within 800 metres from the transmission corridor
EH6	Construction Dust	Implement the dust management measures identified in the project CEMP, including watering, speed restrictions and management of exposed surfaces where required.	Construction	Active construction areas
EH7	Erosion and sediment control	Implement erosion, sediment and water quality management measures in accordance with the project Construction Environmental Management Plan to minimise the risk of sediment, contaminants and construction-related runoff entering grazing areas.	Construction	Active construction areas
EH8	Fencing	In the event that construction or maintenance activities result in damage to fences, gates or other livestock management infrastructure, the affected landowner or property manager should be notified as soon as practicable and the damaged infrastructure repaired, reinstated or replaced to its pre-existing condition.	Construction and Operation	As required
EH9	Induced voltages on conductive infrastructure	Ensure metallic fences, gates, water troughs and other conductive infrastructure within and adjacent to the easement are appropriately earthed in accordance with transmission network operator requirements.	Construction	Conductive infrastructure located within or adjacent to the transmission easement within the Equine CIC

9 Conclusion

With implementation of the recommended mitigation measures, the project is not expected to result in long-term impacts on equine health, welfare or management.

The greatest potential for interaction with identified equine receptors would occur during the construction phase of the project, which (with the exception of energy hub and construction ancillary sites) would be largely transient and temporary in nature. Construction noise, construction plant and equipment, helicopter operations and dust may result in temporary behavioural responses at a small number of identified equine receptors located closest to construction activities namely Kitchwin Hills (Top Farm and Bottom Farm), Scone Polo Club, Walcha Polocrosse Grounds and Jockey Club, and Gundy Park Equine. Of these receptors, Kitchwin Hills has the greatest potential for interaction with project activities due to its proximity to, and potential overlap with, sections of the project area and transmission corridor. Potential impacts are expected to be localised and temporary in nature and are not anticipated to result in adverse long-term impacts on equine health, welfare or performance. Overall, potential impacts on equine health, welfare and management during construction are expected to be low.

The potential for operational impacts are expected to be substantially lower than potential construction impacts. Operational noise, dust, lighting, EMF and EMI are not expected to adversely affect equine health, welfare or management. The principal operational consideration relates to infrequent inspection and maintenance activities, including helicopter inspections, vegetation management and periodic vehicle access. Kitchwin Hills (Bottom Farm) has the greatest potential for interaction with these activities due to its proximity to the transmission corridor. Temporary behavioural responses may occur during infrequent maintenance activities; however, these responses are expected to be short-term and limited to behavioural changes such as increased vigilance, startle reactions and temporary avoidance behaviours. Overall, potential impacts on equine health, welfare and management during operation are expected to be negligible to low.

Potential risks associated with induced or stray voltages on metallic infrastructure can be effectively managed through standard design, grounding and isolation measures.

Implementation of the recommended mitigation measures and ongoing consultation with affected landowners and property managers would further minimise disruption to equine operations and support the ongoing safe management of horses in proximity to the project.

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Appendix A: Fundamentals of Electric and Magnetic Fields

A1 Electric Fields

An electric field is produced by the voltage on an electrical conductor. It exists whenever a conductor is energised, regardless of whether current is flowing. The strength of an electric field is expressed in volts per metre (V/m) or kilovolts per metre (kV/m) and is proportional to the voltage of the source. Electric field strength diminishes rapidly with increasing distance from the source, in a manner similar to the attenuation of sound with distance. Importantly, electric fields are readily shielded by most solid objects, including buildings, vegetation, fences, and even human or animal bodies. As a consequence, indoor electric field levels from external sources such as transmission lines are typically much lower than those measured at the same distance outdoors.

A2 Magnetic Fields

A magnetic field is produced by the flow of electric current through a conductor. Unlike electric fields, magnetic fields are present only when current is flowing, and their strength is proportional to the magnitude of the current rather than the voltage. Magnetic field strength is expressed in microtesla (μT) or, in some jurisdictions, milligauss (mG), where 1 μT equals 10 mG. Like electric fields, magnetic fields decrease with distance from the source. However, magnetic fields are not significantly attenuated by most common materials, including buildings, trees, and soil. This characteristic means that magnetic fields from transmission lines penetrate structures in a way that electric fields do not.

Some typical electric and magnetic fields associated with high voltage transmission lines are shown in **Table A1**.

Table A1 **Representative field decay profiles for 500kV double-circuit transmission lines based on standard Australian modelling**

Distance from Centerline (500kV)	Estimated Electric Field (kV/m)	Estimated Magnetic Field (mG)
Directly Beneath Conductors	7.0 - 9.1	80 - 200
20m (Edge of Typical Easement)	1.0 - 1.5	10 - 50
50m from Centerline	0.3 - 0.5	5 - 15
100m from Centerline	0.05 - 0.1	1 - 4
200m from Centerline	< 0.01	< 0.5

A2.1 EMF Distinguished from Electromagnetic Radiation

Electric and magnetic fields at power frequency (50 Hz in Australia) are sometimes confused with electromagnetic radiation (EMR), but they are different phenomena. Power-frequency EMF is classified as non-ionising as it does not carry sufficient energy to break chemical bonds or damage DNA through direct interaction. By contrast, electromagnetic radiation in the form of radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays involves the propagation of energy as waves at much higher frequencies. Only the highest-frequency forms (ultraviolet, X-rays, gamma rays) are ionising. The distinction is important as the biological mechanisms by which power-frequency EMF might affect living organisms are entirely different from those associated with ionising radiation.

A2.2 Natural and Background Sources

Electric and magnetic fields are not unique to transmission lines. The earth's natural static magnetic field is approximately 50 μT (varying with latitude), and the natural atmospheric electric field at ground level ranges from approximately 100 to 300 V/m in fair weather, rising to thousands of V/m during thunderstorms. In addition, every electrical appliance and wiring circuit in a building produces 50 Hz EMF. Typical magnetic field levels from common household appliances include 0.2–3 μT from ovens, 0.2–0.5 μT from refrigerators, 0.2–1 μT from toasters and laptop computers, and 1–7 μT from hair dryers (Powerlink Queensland, 2023). These values provide useful context when assessing the significance of EMF levels from transmission lines.

A2.3 EMF from High Voltage Transmission Lines

A2.3.1 Electric Field Characteristics

The electric field beneath a high voltage transmission line is determined primarily by the operating voltage and the height of the conductors above ground. For a given line design the electric field at ground level is relatively stable because the voltage remains essentially constant during operation. Electric field strength is greatest directly beneath the conductors and decreases with lateral distance from the centreline. At the edge of a typical easement for a 500 kV line, the electric field is substantially reduced and is typically within the range encountered in domestic and commercial environments. Vegetation, structures, and terrain features between the line and the point of measurement further decrease the strength of the field.

For 500kV infrastructure, field strengths are most concentrated directly beneath the lines at the point of maximum conductor sag and typically return to background levels found in standard urban environments within 50 to 100 metres from the easement boundary.

A2.3.2 Typical Magnetic Field Levels for 500 kV Lines

Measured and modelled EMF levels for 500 kV transmission lines consistently show that fields at the edge of an easement are well within international guideline levels. At the edge of a high voltage transmission line easement, magnetic field levels are typically in the range of 0.2–5 μT —comparable to or below the levels produced by common household appliances at close range (Powerlink Queensland, 2023). At a distance of approximately 200 metres from either a 275 kV or 500 kV transmission line, the magnetic field is so small that it cannot readily be distinguished from the

background fields produced by nearby electrical appliances and wiring (Powerlink Queensland, 2023).

Homes located more than 50 metres from a high voltage transmission line are generally not expected to experience magnetic field levels higher than typical residential background levels (ARPANSA, 2024). All magnetic field measurements from Australian transmission lines are reported to be well below the general public exposure guideline limit of 200 μT (Powerlink Queensland, 2023; ARPANSA, 2024).

Modeling results for 500kV double-circuit lines indicate that even under worst-case "emergency" conditions, magnetic fields directly beneath the conductors (approx. 627–680 mG) remain at less than 35% of the ICNIRP public exposure limit. Under typical average loading, the magnetic field at the edge of an 80-meter easement is approximately 43 mG, or roughly 2% of the guideline limit.

Table A2 Comparison of magnetic fields from common household sources versus 500kV transmission infrastructure

Source of Exposure	Magnetic Flux Density (μT)	Magnetic Flux Density (mG)
Microwave Oven (at 30cm)	1.7 - 23.6	17 - 236
Vacuum Cleaner (at 30cm)	2.0 - 20.0	20 - 200
Hairdryer (at 30cm)	1.0 - 7.0	10 - 70
Electric Oven (at 30cm)	0.2 - 3.0	2 - 30
500kV Line (Edge of Easement)	0.2 - 5.0	2 - 50
500kV Line (Directly Under)	1.0 - 20.0	10 - 200

A2.3.3 Comparison of 275 kV and 500 kV Lines

It is a common misconception that higher-voltage lines necessarily produce proportionally greater EMF at ground level. For magnetic fields, the field strength depends on current, not voltage, and the normal design of 500 kV lines (with greater conductor height and spacing) means that at the edge of the easement, EMF levels are broadly comparable between 275 kV and 500 kV lines. Powerlink Queensland (2023) reported that at the edge of an easement for both 275 kV and 500 kV lines, EMF levels are similar to those present in a standard home and significantly below relevant guidelines.

A2.3.4 Underground Versus Overhead Lines

Underground transmission cables eliminate the electric field at ground level because the metallic sheath of the cable provides effective shielding. However, because underground cables are closer to ground level than overhead conductors, and because magnetic fields are not shielded by the cable sheath or surrounding soil, underground cables can produce magnetic field levels at the surface that are similar to or in some cases greater than—those from equivalent overhead lines (Powerlink Queensland, 2023). Magnetic fields from underground cables do, however, decrease more rapidly with lateral distance than those from overhead lines, owing to the closer spacing of phase conductors in a cable trench.

A2.3.5 Magnetic Field Characteristics

Magnetic fields from a transmission line are proportional to the current carried by the conductors, which varies continuously with electrical load. Consequently, magnetic field levels fluctuate over the course of a day and across seasons as demand patterns change. Like electric fields, magnetic fields are highest directly beneath the conductors and decrease with distance. However, because magnetic fields are not effectively shielded by intervening objects, the field profile is smoother and more predictable than that of the electric field. The rate of decrease with distance depends on the conductor geometry and phase configuration of the line.

A2.4 Exposure Guidelines and Regulatory Framework

A2.4.1 ICNIRP Guidelines

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an independent scientific body that establishes guidelines for limiting exposure to non-ionising radiation. The ICNIRP guidelines for low-frequency fields (1 Hz to 100 kHz) set reference levels for general public exposure at 50 Hz of 5 kV/m for electric fields and 200 μ T for magnetic fields (ICNIRP, 2010). Occupational exposure limits are set higher, at 10 kV/m and 1000 μ T respectively. These reference levels are designed to prevent the established acute effect of nerve and muscle stimulation by induced electric currents in the body, with substantial safety margins incorporated.

The ICNIRP guidelines are adopted or referenced by the majority of national regulatory bodies worldwide and form the basis of the Australian approach to EMF exposure management.

A2.4.2 World Health Organization (WHO) Position

The WHO published Environmental Health Criteria Monograph 238 (EHC 238) in 2007, providing a comprehensive health risk assessment of extremely low frequency (ELF) fields. It was concluded there were no substantive human health issues related to ELF electric fields at levels generally encountered by the public. For magnetic fields, EHC 238 acknowledged the consistent epidemiological finding of an approximately two-fold increase in childhood leukaemia risk associated with average residential exposures above 0.3–0.4 μ T, but noted that this association could not be confirmed by experimental studies and no causal mechanism had been identified (WHO, 2007).

The WHO recommended that national authorities adopt an EMF management programme based on ICNIRP guidelines, supplemented by a precautionary approach involving low-cost measures to reduce exposure where practicable, provided these do not compromise other health, environmental, or economic objectives (WHO, 2007).

A2.4.3 IARC Classification

In 2002, the International Agency for Research on Cancer (IARC), a specialised agency of the WHO, classified ELF magnetic fields as “possibly carcinogenic to humans” (Group 2B) based on pooled analyses of epidemiological studies reporting a statistical association with childhood leukaemia (IARC, 2002). The Group 2B classification denotes limited evidence of carcinogenicity in humans combined with less than sufficient evidence from experimental animal studies. Importantly, Group 2B is the third of five categories used by IARC; substances in this group include coffee, pickled

vegetables, and talc—agents for which evidence is suggestive but not conclusive. ELF electric fields were classified as “not classifiable as to their carcinogenicity to humans” (Group 3) (IARC, 2002).

A2.4.4 Australian Regulatory Position

Australia does not have formal legislated exposure limits for power-frequency EMF. However, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) references the ICNIRP guidelines and recommends their adoption as the basis for exposure management (ARPANSA, 2024). ARPANSA’s position is that the scientific evidence does not establish that exposure to EMF found around the home, office, or near power lines constitutes a hazard to human health, while acknowledging that some epidemiological studies have reported a possible association between prolonged ELF magnetic field exposure at levels above typical, but below guideline limits, and increased rates of childhood leukaemia (ARPANSA, 2024).

The Energy Networks Australia (ENA) EMF Management Handbook (2016) provides the electricity industry with practical guidance on EMF measurement, communication, and management, based on the ICNIRP guidelines and the prudent avoidance principle. Australian transmission network operators design and locate their infrastructure in accordance with the technical recommendations of this handbook, including siting transmission lines away from habitable buildings where practicable (Energy Networks Australia, 2016).

A2.4.5 European Scientific Reviews

Two major reviews by European Commission scientific advisory committees have assessed the evidence since the WHO and IARC publications. The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) concluded in 2015 that more recent epidemiological studies were consistent with the earlier finding of an association between residential ELF magnetic field exposure above 0.3–0.4 μT and childhood leukaemia, but that no biological mechanism had been identified and methodological limitations of the studies prevented a causal interpretation (SCENIHR, 2015).

The successor committee, the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), published an updated opinion in 2023 covering frequencies from 1 Hz to 100 kHz. SCHEER found weak to moderate evidence of an association between ELF magnetic field exposure and childhood leukaemia, moderate evidence (mainly from occupational studies) of an association with amyotrophic lateral sclerosis (ALS), weak evidence for Alzheimer’s disease and dementia, and no convincing evidence for self-reported symptoms. Distinguishing the effects of magnetic field exposure from those of electric shock events in the workplace remains a challenge (SCHEER, 2023).

The committee confirmed that general population exposure in Europe remains below ICNIRP reference levels (SCHEER, 2023).

Given that these conditions are not readily recognised in horses they are not considered potential equine health issues.

A2.5 General Health Effects of ELF Electric and Magnetic Fields

A2.5.1 Established Effects and Biological Mechanisms

There have been no scientific studies in horses on the potential health effects of EMF so that examination of human data is summarised.

The only well-established biological mechanism by which power-frequency EMF interacts with the human body is the induction of electric currents in conductive tissues. Time-varying magnetic fields induce circulating currents within the body, while exposure to external electric fields causes surface charge accumulation and internal current flow. At sufficiently high levels, these induced currents can stimulate nerves and muscles. This mechanism is well characterised and forms the scientific basis of the ICNIRP exposure guidelines, which set reference levels with substantial safety margins to prevent such stimulation (ICNIRP, 2010).

No other mechanism by which ELF EMF at environmental exposure levels could produce adverse health effects has been established, despite extensive research. Proposed mechanisms, including effects on melatonin production, oxidative stress, and gene expression, have been investigated but not confirmed at exposure levels relevant to transmission line environments (WHO, 2007; SCENIHR, 2015).

A2.5.2 Experimental Evidence

Long-term animal carcinogenicity studies have not demonstrated that ELF magnetic field exposure causes or promotes cancer. The IARC (2002) assessment noted that the evidence for carcinogenicity in experimental animals was inadequate. Subsequent reviews by SCENIHR (2015) and SCHEER (2023) have not altered this conclusion. In vitro studies (cell culture experiments) have reported various biological effects, but these have not been consistently replicated and their relevance to whole body health outcomes is uncertain.

The absence of experimental support for the epidemiological association with childhood leukaemia is a critical consideration. Without a confirmed biological mechanism and without supporting evidence from controlled animal studies, the epidemiological association, however consistent, cannot be regarded as establishing a causal relationship under standard criteria for causal inference (WHO, 2007; SCENIHR, 2015).

A2.5.3 Perception and Short-Term Effects

In strong electric fields, individuals may experience perceptible effects such as tingling or vibration of body hair and, less commonly, mild skin sensations. These effects result from the interaction of the electric field with charged hair and with surface charges on the skin. Stimulation of hair follicle nerves is considered the primary mechanism (Bonneville Power Administration, 1989). In the vicinity of 500 kV transmission lines, such perceptible effects may be experienced directly beneath the conductors under certain conditions but are unlikely at the edge of the easement or beyond.

Sensitivity to electric current varies among species. Humans can generally perceive alternating current at approximately 1 mA through fingertip contact, with discomfort thresholds at higher levels. Livestock species tend to be more sensitive: dairy cattle can perceive alternating currents as low as 1 mA between the mouth and hooves, and behavioural effects (such as flinching or avoidance) have been observed at currents above 3 mA (Lefcourt, 1991). This heightened sensitivity in cattle is attributed to lower body resistance and the absence of insulating footwear. Swine and sheep show similar sensitivities, with behavioural changes reported at contact voltages above 5 V (Reinemann et al, 2003). No studies have been done on horses however it would seem likely that horses may have similar sensitivity to cattle and that horses with metal horseshoes may be at risk of increased sensitivity.

A review by New Mexico State University's Cooperative Extension Service (Ramsey and Duesterhaus, 1999) similarly concluded that the available evidence did not support the contention that EMF from transmission lines adversely affects livestock health or production. The review noted that behavioural responses to strong electric fields (such as avoidance of areas directly beneath conductors) had been observed in some studies but that these effects were transient and did not translate into measurable health or productivity impacts.

This could potentially be an issue for horses located direct under transmission lines under certain conditions and consideration may need to be given to this issue.

Conditions that might predispose to perceptible effects from EMF would include being directly under or near the transmission line, higher current flowing through the wires (i.e. when demand is higher such as very hot or cold days), when there might be reduced line height (Sag) such as during high temperatures (due to thermal expansion/sag), and heavy rain or high humidity.

Perceptible effects from magnetic fields at environmental exposure levels have not been reported. The ICNIRP reference levels are set well below the thresholds at which induced currents could stimulate nerves or muscles (ICNIRP, 2010).

A2.5.4 Current Scientific Consensus

The scientific consensus, as articulated by the WHO (2007), ICNIRP (2010), SCENIHR (2015), SCHEER (2023), and ARPANSA (2024), may be summarised as follows:

- The only established biological mechanism for ELF EMF effects on the body is the induction of electric currents, which can stimulate nerves and muscles at high exposure levels. Existing exposure guidelines are designed to prevent this effect with substantial safety margins.
- A consistent but unexplained statistical association exists between residential ELF magnetic field exposure above 0.3–0.4 μT and childhood leukaemia. This association has not been confirmed by animal studies or supported by an established biological mechanism.
- The weight of evidence does not establish that ELF EMF at levels encountered in the environment, including in the vicinity of high voltage transmission lines operating within guideline levels, causes adverse health effects.
- A precautionary approach is recommended, involving low-cost measures to reduce exposure where practicable, without implying that a health hazard has been established.

A2.6 Corona Discharge Effects

A2.6.1 Nature of Corona Discharge

Corona discharge occurs when the electric field gradient at the surface of a high voltage conductor is sufficient to ionise the surrounding air. The localised ionisation produces a luminous glow (visible in darkness), audible noise, chemical by-products, and electromagnetic interference. Corona activity is strongly influenced by weather conditions: it is primarily a wet-weather phenomenon, occurring most intensely during rain, fog, snow, and conditions of high humidity. In fair weather, corona activity on well-maintained conductors is typically minimal. The use of bundled conductors (multiple sub-conductors per phase) is reported as standard practice on extra-high voltage (EHV) lines of 345 kV and above, including 500 kV lines, specifically to reduce the surface voltage gradient and thereby minimise corona effects.

The weather conditions that promote corona discharge are frequently experienced along the route of the project, including snow in the New England Tablelands.

A2.6.2 Audible Noise

Corona discharge generates audible noise characterised by a crackling or hissing sound, sometimes accompanied by a 100 Hz hum (twice the power frequency). The frequency spectrum of corona-generated noise extends from the low audible range up to approximately 20 kHz. Noise levels are highly weather-dependent and for a 500 kV transmission line fair-weather audible noise levels at a distance of 20 metres from the outer conductor are typically in the range of 18–35 dB(A), well below the level of conversational speech (approximately 60 dB(A)). During heavy rain, levels may increase to 50–55 dB(A) at the same distance, comparable to light rainfall noise itself.

Audible noise from corona decreases with distance from the line. At the edge of a typical 500 kV easement, noise levels during wet weather are generally consistent with background environmental noise levels. The design of modern 500 kV lines, with large-diameter bundled conductors, is specifically intended to keep audible noise within acceptable limits at the easement boundary.

Consideration should be given to the potential effects of corona discharge on the behaviour of horses, in particular those that are being ridden.

A2.6.3 Ozone and Nitrogen Oxide Production

The ionisation of air during corona discharge produces small quantities of ozone (O₃) and nitrogen oxides (NO_x). These gases are produced at the conductor surface and are dispersed by wind, diluting rapidly with distance. Studies of operating transmission lines have found that peak ozone and nitrogen oxide concentrations near the conductors can exceed background levels by up to 13% and 30% respectively (Electrical Engineering Portal, 2023). However, at ground level beneath the line, and particularly at the edge of the easement and beyond, concentrations are indistinguishable from ambient background levels. The quantities produced are negligible compared to other sources such as motor vehicle emissions, and no health or environmental concerns have been identified at the ground-level concentrations associated with transmission line corona.

Consideration of the potential effects of ozone and nitrogen oxide on horse health are discussed elsewhere in this report.

A2.7 Induced and Stray Voltages

A2.7.1 Mechanisms of Induction

Conductive objects located within or near a transmission line easement, such as metallic fences, pipelines, building components, and irrigation systems, may acquire a voltage through two mechanisms. Electrostatic (capacitive) induction occurs when an object is placed within the electric field of the line and acquires a charge proportional to its size, shape, and proximity to the conductors. Electromagnetic (inductive) coupling occurs when a conductive object runs parallel to the line for an appreciable distance, with the alternating magnetic field inducing a voltage along its length. The magnitude of induced voltages depends on the line voltage and current, the shape and length of the affected object, its distance from the line, and whether it is grounded.

In the context of a 500 kV transmission line, the potential for stray voltage effects on livestock or other animals is managed through standard grounding practices and the maintenance of adequate clearances, as discussed in the section on management procedures.

A2.7.2 Microshocks and Contact Currents

Microshocks are physically similar to the static shock one might receive from a car door or walking across a carpet. While they can be startling or annoying, they are not a long-term health hazard. In high-field areas directly beneath 500kV conductors, standard industry practice involves the professional "earthing" or grounding of metallic structures (sheds, fences, etc.) to drain off these induced charges and eliminate the potential for shocks.

A2.7.3 Stray Voltage and Livestock

Stray voltage is a specific concern in agricultural contexts, particularly where livestock may come into contact with metallic surfaces that have a small potential difference to the ground. Due to the unexpected and unusual nature of an electric shock most animals, especially horses with their well-established flight response, can be more sensitive than humans to these currents, particularly at contact points like water troughs or feeders. Mitigation for the project includes ensuring that all metallic infrastructure crossing or running within the 300 kilometre corridor is tested and properly grounded.

Appendix B: Hearing in Horses

B1 Hearing Literature Review

Relatively few published studies have assessed the hearing capabilities of horses or their behavioural response to noise. Anecdotal evidence indicates that horses react strongly to sudden noise increases and are susceptible to a “flight” response that can lead to self-inflicted injury.

Horses exhibit a broad auditory frequency range, typically between 50 Hz and 33 kHz (Heffner and Heffner, 1983; Odberg, 1978). This range allows detection of both low-frequency environmental sounds and high-frequency signals beyond human perception.

Heffner and Heffner (1983) carried out one of the more thorough investigations of equine hearing. Their comparison of horses and humans revealed that, although the majority of sounds audible to one species are also audible to the other, notable differences exist. Horses exhibit lower sensitivity to low-frequency sounds than humans, whose low-frequency range reaches down to 29 Hz (at 60 dBA). This reduced sensitivity extends into the mid-frequency range from 500 Hz to 8 kHz: humans achieve a lowest threshold of -4 dBA at 4 kHz, compared with the horse’s lowest threshold of 7 dBA at 2 kHz. Above 8 kHz, however, equine hearing is clearly superior, with the human 60 dBA high-frequency limit being 19 kHz (see Figure B1).

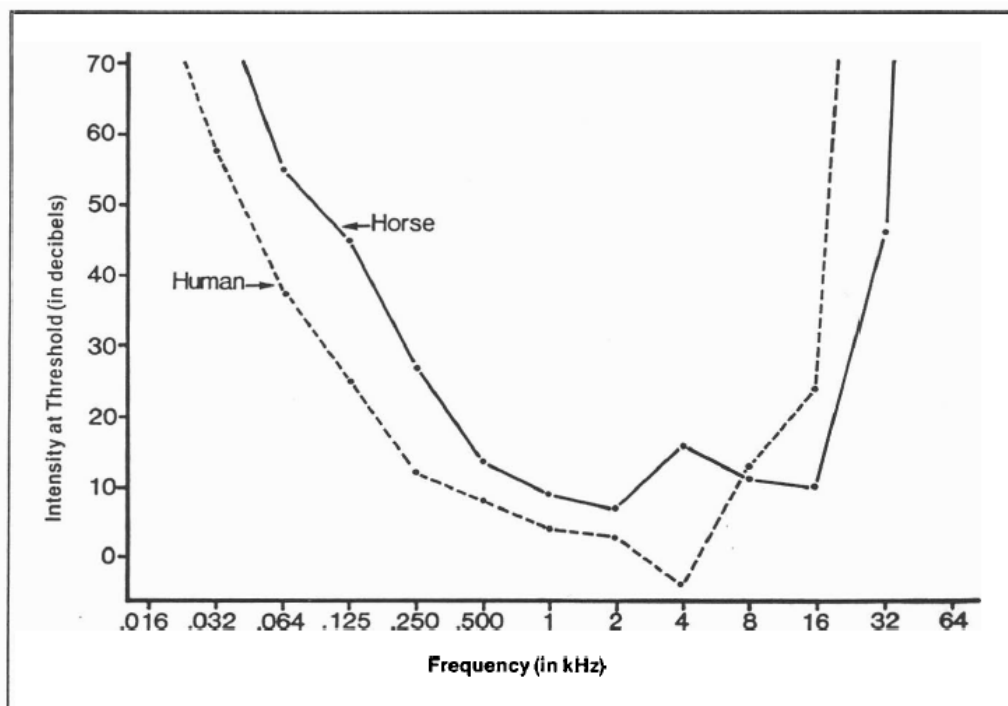


Figure B1 Comparative hearing ability of horses and humans

In a more detailed study of hearing in cattle and horses, Heffner and Heffner (1983a) reported that horses can hear frequencies ranging from 55 Hz to 33.5 kHz. The region of greatest sensitivity lies between 1 kHz and 16 kHz, where the lowest threshold recorded was 7 dB(A). Audiograms demonstrated a gradual improvement in sensitivity up to approximately 500 Hz, beyond which the curve flattened across a broad region of best sensitivity from 1 kHz to 16 kHz, interrupted by a dip at

4 kHz. Sensitivity falls off sharply above 16 kHz until the upper audibility limit is reached. At an intensity of 60 dB the overall hearing range of horses spans 55 Hz to 33.5 kHz.

Christensen et al (2005) examined how horses respond to loud, unexpected noise together with novel visual and olfactory stimuli. In the auditory component of their study, a novel white noise signal (10–20,000 Hz, 60 dBA) was presented as horses approached a feeder. Heart rate rose modestly (control: 52+/-2, noise: 62+/- 2.28), yet there was minimal adverse locomotion and no flight response was observed. A negative correlation was found between time spent eating and all other response variables: horses that continued feeding showed the least reaction to the stimulus.

A comprehensive review of the probable effects of aircraft fly-over noise on animals, with a particular focus on wildlife, was published by the United States National Park Service (2004). The report drew a distinction between chronic exposure, where the primary concerns relate to energy conservation in animals, and acute exposure, which can trigger startle and panic responses. It concluded that “acute responses... occur in most wildlife species evaluated at noise levels greater than 95 dBA.”

Huybregts (2008) conducted a detailed noise impact assessment in connection with a proposed music festival at Flemington Racecourse. Noise exposure (LAeq,15 minutes) of horses during major race events was recorded at 58-62 dBA in the stables (increasing to 66-68 dBA during helicopter flyovers) and 65-70 dB (A) in the race stalls. On-course horses at Randwick Racecourse were exposed to 76 dBA LAeq, 6h and at Flemington to 85 dBA LAeq, 6h. Horses on the track experienced rapid fluctuations in noise levels, with peaks reaching 100 dBA. Noise monitoring near stables at Randwick Racecourse indicated LAeq, 15 minutes levels of 50-65 dBA on non-race days and approximately 51-68 dB(A) on race days.

The Huybregts report (2008) noted:

- That the circumstances of the exposure to concert noise would be somewhat unfamiliar;
- That the noise would not be associated with any danger and if there is any initial startle responses, habituation may occur quickly; and
- That the horses at the two race events investigated were exposed to “average” noise levels of 65-70 dB(A) in the stalls and 70-90 dB(A) when moving in and out of the stalls.
- The report concluded that, although definitive criteria for exposing Thoroughbred horses to noise could not be established, a practical threshold level would be valuable. The authors recommended that “it appears that use of Flemington Racecourse as a concert venue would be acceptable provided that the LAeq noise level in the stables did not exceed 65 dBA”.

Accompanying recommendations included:

- Fireworks or other activities causing loud bangs should not be permitted because of the association of visual with auditory stimulus; and
- Noise levels should be monitored in the stables to confirm that the LAeq noise levels do not generally exceed 65 dB (A).
- Noise exposure (LAeq, 15 minutes) measured in the stables during the subsequent music festival at Flemington Racecourse ranged from 54-70 dB(A). Horses displayed minimal reaction to the music noise, except where it coincided with visible stimuli or was of a particularly alarming character, such as short bursts of high-pitched singing.

B2 Habituation to Noise

Habituation is an additional factor that warrants consideration. Repeated exposure to auditory stimuli may lead to habituation; however, this process is often stimulus-specific and influenced by context (Christensen, Rundgren and Olsson, 2006). Some horses instead exhibit sensitisation, showing increased responsiveness over time (Visser et al., 2001).

Generally when noise is familiar and not perceived as threatening, an animal's response will progressively diminish. A well-known illustration of this principle is the often-ineffective deployment of scare guns to deter pest species such as cockatoos from crops or seagulls from airports. Among horses, habituation is widely observed, for example in animals used for large-scale performance events, shows, and police work.

Further research on the effects of noise on animals was documented in a New Zealand report (Proposed Mining And Related Activities - Mt William North Assessment of Noise & Vibration Effects, 2011), which reached the following conclusions:

1. Once animals become habituated to noise, especially when it is steady and associated with clearly non-threatening activity, they demonstrate little adverse response. This is particularly true with cattle, horses and other livestock.
2. Similarly, birds appear to readily adapt to noise and whilst very loud events can startle birds, noise events that meet applicable criteria for human exposure, are extremely unlikely to cause startle or similar effects.
3. The response of birds, animals and livestock to noise will also depend on the character and duration of the sound and observations suggest that steady broad band noise will create less negative response than transient, intermittent or tonal sounds.

Recent work suggests that social context can determine fear responses, with socially motivated horses displaying reduced reactivity to sudden sounds (Janicka, Wilk and Próchniak, 2023).

The available literature indicates that habituation to a particular noise type takes approximately one month for an animal that has not previously been exposed to it.

B2.1 Physiological Responses to Noise

Noise exposure activates physiological stress pathways, resulting in measurable changes such as increased heart rate and cortisol secretion (Fazio et al., 2008). Controlled studies demonstrate that different types of auditory stimuli produce distinct cardiovascular responses, suggesting that horses discriminate between sounds rather than responding uniformly (Hole et al., 2023).

Transportation exposes horses to a combination of stressors, including noise, vibration and confinement. These conditions are associated with increased heart rate, behavioural agitation and oxidative stress (Padalino et al., 2015; Padalino and Raidal, 2020).

Appendix C: Vibration

C1 Vibration Literature Review

Using animal models it has been shown that low level vibration can double bone formation rates, inhibit disuse osteoporosis and increase the strength of trabecular bone by 25% (Rubin et al 2001). Considering that the magnitude of these mechanical signals are several orders of magnitude below those which cause damage to the bone tissue, it was proposed that this modality could be useful in the treatment of metabolic bone diseases.

A comprehensive review of investigations in the literature provided evidence of the effectiveness of WBV in enhancing skeletal mass in the elderly, in individuals with low-bone mineral density, and adolescents (Prisby et al 2008).

More recently Mikhael et al (2010) in an extensive review of the literature regarding WBV felt there was some indication that high-frequency mechanical strain elicited by WBV may have an anabolic effect on bone and muscle. They reported that the inconsistency in study design made comparison of results difficult but that further research was warranted.

The amount of vibration associated with intermittent blasting that might be experienced by horses close to the project would seem to be less than that which may be experienced by animals during transport. Unfortunately, little objective work has been done to evaluate any potential effects (Randall, 1992). Given that horses are regularly transported long distances in both planes and motor vehicles without any ill effects or concern, it is likely that vibration from blasting will also cause no concern to horses in the area.

The potential advantages documented in human and animal models have prompted a number of companies to promote the benefits of vibration therapy for horses. One such company is “Vitafloor” (<http://dutchdreamhorses.com/products/vita-floor>) which produces vibrating surfaces for horses to stand on. The company advises as follows:

The Swedish University of Agricultural Sciences (SLU) in Uppsala has carried out extensive research and testing programs on the Vita-floor® since 2003, with close consideration towards possible negative side-effects, of which none were found.

Unfortunately, the work undertaken by the Swedish University quoted does not appear to have been published in the scientific literature. However there may be beneficial effects from low grade whole body vibration which makes it even more unlikely that the vibration from the project will have any detrimental effect on equine health.

A comprehensive review by Bergh et al (2021) identified eight papers (Buchner et al, 2017, Halsberghe 2017, Carstanjen et al 2013, Hulak et al 2015, Hyatt et al 2017, Nowlin et al 2018, Maher et al 2017, Mackechnie Guire et al 2018) that had evaluated vibration therapy in both lame and sound horses. In the study on horses with chronic lameness, there was no difference in lameness seen after 30 or 60 days of WBV (moderate-to-high risk of bias). The seven studies on sound horses (moderate to high risk of bias), which used radiographs measuring bone mineral content and laboratory blood analysis of different blood variables as outcome measures, showed a decrease in

gamma-glutamyl transferase, serum cortisol, and creatinkinase values, but there were no changes in the other registered variables. No adverse effects were reported.

A commercially available equine vibration plate was evaluated by Buchner et al (2017) and found that Actual plate vibration frequency was 7 or 11 Hz with a maximum peak-to-peak displacement of 9 mm in longitudinal direction. WBV exercise induced no increase in electromyographic activity, clinical parameter, or body surface temperature. It was concluded that plate vibration had no significant effect.

In the controlled study by Nowlin et al (2018) horses stood on a platform vibrating at 50 Hz for 30 minutes, and CO horses stood on an adjacent platform that was not turned on for 30 minutes. Data were analysed using PROC MIXED in SAS with horse, treatment, test, and day differences. Findings suggest no differences from pre- to post-treatment between VT and CO groups in any parameters measured ($P > .05$). Qualitative behaviour observations suggested that all VT horses stood calmly and appeared more relaxed throughout the treatment period, while CO horses were comparatively restless. It could be questioned whether this observed change warrants VT treatment given few other measured differences but it could explain the growing belief in the horse industry that the treatment is beneficial.

Ellis et al (2024) found that WBV may exacerbate pain in horses with thoracolumbar pain when used short-term (<14 days). Long-term use (4 weeks) is needed to improve thoracolumbar pain. Four weeks of once daily WBV is sufficient to improve postural stability and increase multifidus muscle cross sectional area.

Carvalho J et al (2025) concluded that a single whole-body vibration session did not enhance recovery of lactatemia or acid-base balance in horses after intense treadmill exercise.

Appendix D: Dust and Air Quality

D1 Dust Literature Review

A review of relevant literature found there is very little published scientific information which evaluates the effects of dust of topsoil or crustal origin on the health of pastured horses. In contrast there is a large amount of data that examines the effects of dust from bedding, feed and the environment on stabled horses. This review evaluated the available data in both areas. There is also a vast amount of information regarding the effects of dust and pollution on human health. As this was not the focus of the study and there would appear to be sufficient differences between equine and human responses to dust exposure, this area was not reviewed as reliable conclusions cannot be made from the human literature in regard to equine respiratory tract health and disease. Reed et al (2006) compiled a detailed account of Australian regulatory standards governing dust in agricultural industries as they relate to human health; this resource may be consulted for applicable human health guidelines.

The primary aim of the review was to provide information on known sources of dust as well as the composition and effect of this dust on the equine lower respiratory tract (LRT). Considerable data has been presented in regards to dust in a stabled environment even though this may not seem totally applicable to the situation in pastured horses, as generally exists in the horse studs immediately adjacent the project. This has been done for two reasons. Firstly to provide data on “occupational” background dust levels experienced by horses that undertake any athletic career and secondly to examine the effects that different levels and types of dust may have on the LRT

The term “dust” is used imprecisely in both the human and veterinary literature. Studies frequently report on “dust” without specifying its composition, and this variability in definition makes it difficult to draw reliable comparisons across the research base.

Inspirable Dust – Inspirable (inhalable) dust refers to material that may be deposited anywhere along the respiratory tract. The aerodynamic diameter of such particles can range from 0 to 100 µm (ACGIH, 2005).

Respirable Dust – Respirable dust encompasses the fraction of airborne particles that, when inhaled, can penetrate to the unciliated airways of the lung. The median particle diameter is 4.25 µm, and the respirable fraction is defined by ISO 7708 (AS2985, 2004) (Reed et al 2006).

Particulate matter originates from a variety of sources:

- Background crustal dust from both local and distant areas.
- Biologically derived material;
- ‘Hay dust’ generated at horse stud infrastructure, and
- Pollen, plant fragments and insect debris carried in ambient air from local and distant areas.
- Combustion-derived particulates (e.g. vehicle exhaust, industrial boiler emissions, smoke from domestic and grass/bush fires).
- Dust generated by construction activity.

In practice, airborne dust is commonly a mixture of several of these sources, both organic and inorganic, and the construction of high voltage transmission lines has the potential to introduce or amplify all of them.

D1.1 Airborne Pollutants

The potential effects of airbourne pollutants on equine health has received relatively little attention over the last few decades however recently there has been renewed focus on this issue.

One of the earliest reports was by Newman (1979) who documented large numbers of outbreaks of pollution causing problems in many species, including horses. Despite a long list of documented pollution associated incidents in a variety of species, all were associated with specific pollutants rather than the general effects of dust. They concluded that some of the major effects of industrial air pollution on wildlife included direct mortality, debilitating industrial-related injury and disease, physiological stress, anaemia, and bioaccumulation.

An example is given below

Table D1 Early incidents involving the adverse effects of industrial air pollutants on domestic animals (Wildlife, Biol. Conserv. 15:181-190)

<i>Date</i>	<i>Location</i>	<i>Pollutant(s)</i>	<i>Effects</i>	<i>Reference</i>
1873	England	Sulphur dioxide	Death of cattle	Schwabe (1969)
1878	England	Smoke	Blinding of cattle near copper works	Royal Commission (1878)
1908	Montana, USA	Arsenic	Widespread sickness and death to cattle and horses	Formad (1908); Harkins & Swain (1908)
1914	England	Industrial smoke	Respiratory problems in cattle and reduced wool production in sheep	Anon. (1914)
1915	California, USA	Lead	Widespread respiratory problems in horses near smelter	Haring & Meyer (1915)
1930	Belgium	Smoke and fog	Death of cattle from respiratory failure	Alexander (1931); Rubay (1932)
1931	Austria	Iron-containing flue gases	Stomach and intestinal disorders in cattle	Henneman (1931)
1935	Italy	Fluoride	Death of cattle and goats	Bardelli & Menzani (1935)
1939	Germany	Arsenic	Widespread sickness in cattle, sheep, horses and poultry	Bischoff (1939); Wiemann (1939)

Mazan et al (2001) found that horses from urban areas did not have increased airway inflammation or bronchoconstriction compared with horses from rural locations.

Deaton and Marlin (2004) undertook a review of the potential effects of general industrial pollution on equine respiratory health but provided no actual data. This report is speculative and based mainly on experiences in people. They summarised that despite numerous publications on the effects of dust from the housing environment in humans that the effects of chemical pollutants on equine lung function were largely unknown. The concentration and type of pollutants to which horses are exposed to in any situation is affected by factors such as time of day of exercise, wind direction and other environmental factors, including sunlight, temperature and cloud cover. Also the responses between horses to airborne pollutants are likely to be highly variable. They concluded that the effects of airborne pollutants on airway inflammation and performance, if they occurred at all, were

likely to be sub-clinical and impossible to differentiate from other causes of airway inflammation such as transport, heat or pre-existing airway inflammation.

A study on the general effects of pollution on racing TBs in US was undertaken by Gates (2007). It was concluded that the impact of pollution on the Thoroughbred racing industry was minimal and that only under the most hazardous ozone levels were race times markedly slower, and such conditions were rarely encountered on race day.

Inflammatory airway disease was common in stabled horses with a prevalence of 17.3% in Michigan pleasure horses Berndt et al (2010). This was a result of stable dust that was rich in endotoxin and which may induce neutrophilic airway inflammation. In this study endotoxin exposure was about 8 times higher in stables than on pasture. Mean values obtained of endotoxin concentrations in the breathing zone of stabled horses was 7.08×10^3 EU/m³ and for horses on pasture was 0.85×10^3 EU/m³. On pasture, endotoxin varied widely, despite constant climatological conditions. It was suggested that a primary source of endotoxin in both stables and at pasture was manure.

In recent years, growing attention has been directed to the role of airborne pollutants in equine health and performance, particularly with regard to equine asthma. Deterioration in air quality may involve elevated levels of PM₁₀, PM_{2.5}, and gaseous pollutants such as NO₂, occurring individually or in combination. High levels of many noxious gases are found in normal stable environments (Kwiatkowska-Stenzel et al 2014). This body of research has significantly advanced the understanding of how pollution may compromise equine respiratory health.

In a study of pastured horses Davis and Sheats (2019) identified an unexpectedly high prevalence of mild to moderate asthma and considered that susceptibility may have been increased by “exposure to air pollution due to pasture location in an urban setting and the close proximity of pasture to a heavily travelled 4-lane road”. Their conclusion was that “Air pollution is another cause of increased particulate concentration. In people, there is a strong association between air pollutant levels and increased frequency and severity of asthma attacks. Similar to humans, traffic pollution has also been associated with airway inflammation in horses.”

Branston et al (2020) demonstrated that higher mean levels of PM_{2.5} and NO₂ were linked to greater proportions of lower airway granulocytes, concluding that these “results extend the present understanding of the health effects of PM_{2.5} and NO₂ exposure in horses by providing evidence that ambient pollutants are associated with lower airway inflammation”.

In a large-scale study in Chile, Araneda (2022) presented a preliminary analysis in which it was observed there was a trend indicating the level of performance in 1000-1200mtr races was decreased by increasing concentrations of PM₁₀, PM_{2.5}, NO₂, NO, and CO in the air. The author acknowledged there were a lot of variables associated with the study but that future investigations were warranted.

Mankowska and Waitkowska (2024) reviewed the principal environmental risk factors associated with equine asthma and made the following observations:

“During exercise and at rest, horses are exposed to many potentially harmful substances in the air, including organic and inorganic particulate matter (<PM₁₀, especially <PM_{2.5}); gaseous admixtures such as ammonia (NH₃), nitrogen oxides (NO₂ and NO), sulfur dioxide (SO₂), carbon monoxide (CO), and ozone (O₃); and microorganisms (bacteria and fungi) as well as their toxins and viruses. These

components are inhaled by horses and have a negative impact on their health, due to the sensitivity of the respiratory tract (Arenda and Cavada 2022).

Some pollutants have been found to affect lung function. It should be emphasized that inhaled air also contains naturally occurring pollutants. Their concentrations vary depending on the time of day, season, and geographical location. Araneda and Cavada (2022) studied the influence of environmental factors, including pollutant concentration, humidity, and temperature, on the performance of racing horses. They found that good performance in sports was negatively correlated with the concentration of pollutants in the air and confirmed that air pollutants compromised the performance of racing horses.

Researchers emphasize that many gases that are harmful to both animals and humans are odorless. Oxides (NO and NO₂) induce a pro-inflammatory response (in humans) and increase airway resistance. In turn, CO affects performance by inducing changes in the conjugation of oxygen to hemoglobin, which may affect the functioning of the heart and other organs.

The impact of dust on the equine respiratory system

Many studies have shown that excessive dust levels in stable air are associated with the occurrence of allergic reactions and respiratory diseases, including equine asthma (EA). Aerosol concentrations, their biological and chemical characteristics, and their location in the respiratory system have to be determined to assess horses' exposure to inhaled particles. Exposure to organic dust elicits a strong reaction in horses with EA, which indicates that the EA-induced impairment of lung function is similar to that noted in asthmatics and farmers chronically exposed to dust. At rest, a horse has a lung capacity of 78 liters of pumped air per minute. Dust particles enter specific structures of the respiratory system, depending on airflow characteristics, which are largely influenced by the geometry of the respiratory tract, the rate and pattern of breathing, and particle characteristics. Large particles (over 10 µm) are usually retained in the upper respiratory tract and are less likely to penetrate the lower respiratory tract. The smallest soluble particles potentially pose the greatest threat to the respiratory system. Solid particles with a diameter below 10 µm and below 2.5 µm (<PM₁₀ and <PM_{2.5}, respectively) are pro-inflammatory, irritating substances that promote bronchoconstriction. Exposure to respirable dust with a particle size < 2.5 µm, which can reach the bronchi and alveoli when air is inhaled, is the most dangerous for horses. Exposure to increased amounts of PM_{2.5} is associated with an increase in granulocyte counts in the lower air tract [104]. High levels of PM_{2.5} in air decrease the efficiency of the respiratory system and undermine horse performance in sports. Not only particle size but also solubility dictate where these pollutants are deposited in the respiratory tract. Extremely fine aerosols can mediate the phagocytosis-induced apoptosis of macrophages or can avoid phagocytosis and gain access to the blood stream directly through the alveolar wall. The recommended dust levels for horses are based on standards developed for human occupational medicine: 4 mg/m³ for all inhalable fractions and 3–10 mg/m³ for the alveolar fraction.”

Kim et al (2025) recently investigated the relationship between ambient air pollution, specifically fine particulate matter (PM_{2.5}), and racing performance. Their analysis encompassed 31407 winning Thoroughbred races over a 10-year period and revealed that, across a PM_{2.5} range of 4 to 23.6 µg/m³ race speed declined by 0.0008 m/s (95% CI: 0.0014562 to 0.00018) for each 1 µg/m³ increment in PM_{2.5}.

Research over the past six years suggests that elevated PM₁₀, PM_{2.5} and NO₂ levels may have detrimental effects on equine health and performance. Notably, adverse effects have been documented at PM_{2.5} concentrations as low as 4.5 µg/m³, indicating that even marginal increases in pollutant levels warrant attention.

D1.2 Silicosis

Recent research has identified respirable crystalline silica (RCS) as a potential inorganic contributor to airway inflammation.

Silicosis is a chronic fibrosing respiratory disease caused by the inhalation of crystalline silica particles, including quartz, cristobalite, and tridymite (Young and Stover, 2023). Although relatively uncommon in horses, the condition has been reported most frequently in animals living in areas with silica-rich soils, particularly in California in the United States (Arens *et al.*, 2011). Inhaled silica particles accumulate in the alveoli, where they are engulfed by macrophages, leading to chronic inflammation, granuloma formation, and progressive pulmonary fibrosis (Young and Stover, 2023). Silicosis is classified as a form of pneumoconiosis, which refers to chronic lung diseases caused by inhalation of mineral or inorganic dusts.

Horses are commonly exposed to silica through environmental dust originating from sandy or arid soils, dry paddocks, unsealed roads, racetracks, and overgrazed pastures (Romolo *et al.*, 2024). Activities such as riding, lunging, transport, and stable cleaning can aerosolise respirable silica particles, increasing inhalation risk. Bedding materials, poor stable ventilation, and feeding dusty hay or haylage may further contribute to respiratory exposure (Lascola, 2023). Horses living in drought-prone environments or regions with naturally high soil silica content are considered at greater risk of chronic exposure (Young and Stover, 2023).

Equestrian arena surfaces may also represent an important source of respirable silica exposure. Many riding arenas and racetracks utilise silica sand because of its drainage properties, stability, and shock absorption characteristics (Setterbo *et al.*, 2011). During riding or training, hoof impact and mechanical disturbance of the footing generate airborne dust particles that can be inhaled by both horses and riders. Fine particulate matter produced from dry or poorly maintained arena surfaces may contain respirable crystalline silica, particularly where high-silica sand is used (Hobbs *et al.*, 2014). Indoor arenas with inadequate ventilation may further increase dust concentrations and prolong exposure times (Ivester *et al.*, 2018). Repeated inhalation of these particles has been associated with airway inflammation and may contribute to chronic respiratory disease, including silica-induced pneumoconiosis in susceptible horses (Romolo *et al.*, 2024).

Construction and earthmoving activities near equine facilities may increase the risk of silica exposure in horses as they can generate large quantities of respirable crystalline silica dust, particularly in dry weather conditions (Safe Work Australia, 2024). Windborne dust generated during these activities can travel considerable distances and contaminate paddocks, arenas, feed, and stable environments. Horses housed near construction zones may therefore experience prolonged inhalation exposure, especially where ventilation is poor or dust suppression measures are inadequate. Construction-related particulate matter may also exacerbate pre-existing respiratory conditions such as equine asthma and inflammatory airway disease (Ivester *et al.*, 2018). Young horses, performance horses undergoing frequent exercise, and animals with chronic respiratory compromise may be particularly susceptible to the harmful effects of airborne silica particles.

Silica-induced pneumoconiosis in horses develops when chronic inhalation of respirable mineral dust overwhelms pulmonary clearance mechanisms. Horses affected by silica-induced pneumoconiosis may also develop silicate-associated osteoporosis (SAO), suggesting systemic effects associated with chronic silica exposure (Arens *et al.*, 2011).

Affected horses can remain asymptomatic for long periods or clinical signs associated chronic coughing, exercise intolerance and respiratory distress may be observed (Lascola, 2023).

Currently, there is no curative treatment for silicosis or silica-induced pneumoconiosis in horses. Management is largely supportive and includes minimising further exposure to silica-containing dust, reducing exercise demands, improving environmental ventilation, and administering anti-inflammatory or bronchodilator therapy where appropriate (Lascola, 2023). Preventive management strategies, including dust suppression on arena surfaces, regular watering of work areas, vegetation cover maintenance, and reducing exposure to nearby construction dust, remain the most effective measures for limiting disease progression.

D1.3 Normal Background Levels of Dust

Work by McGorum *et al* (1998) gives a good indication of base line levels for dust in a pasture management system for horses although the pasture setting was in Edinburgh (UK) so dust levels may be low compared with general Australian conditions. It was found that as total airborne endotoxin concentrations exceeded 20 ng/m³ (0.02 µg/m³) in half the stables examined that even healthy horses in these environments may be exposed to sufficient endotoxin to cause airway inflammation and bronchial hyperresponsiveness. However, as normal horses do not develop detectable pulmonary inflammation or hyper-responsiveness when housed in conventional stables (Derksen *et al*, 1985; McGorum *et al*, 1993), it is likely that the minimal total airborne endotoxin concentration causing LRT disease in normal horses exceeds 20 ng/m³ (0.02 µg/m³).

Table D2 Airborne dust concentration (mg/m³), airborne endotoxin concentration (ng/m³), and endotoxin content of dust (ng/mg) in 3 equine management systems (median and range)"
(Source Equine Vet. J 30:431)

Management system	Sample type	Airborne dust concentration (mg/m ³)	Airborne endotoxin concentration (ng/m ³)	Endotoxin content of dust (ng/mg)
Conventional (Hay + straw)	Total dust	2.74 (2.19–5.48)	19.76 (7.52–60.53)	7.57 (3.43–11.04)
	Respirable dust	1.10 (0.44–2.20)	1.67 (1.25–11.27)	1.52 (0.73–25.70)
Low dust (Shavings + silage)	Total dust	0.80 (0.29–2.78)	3.91 (2.12–17.41)	6.90 (3.07–12.40)
	Respirable dust	0.22 (0.15–0.29)	0.11 (0.09–0.56)	0.70 (0.30–1.90)
Pasture	Total dust	0.17 (0.08–0.17)	1.29 (0.25–1.57)	4.85 (0.59–9.40)
	Respirable dust	0.08 (0.08–0.17)	0.11 (0.04–0.16)	1.10 (0.10–1.70)

Equine Exposure to Dust

Horses are exposed to large amounts of dust from many sources. These are well reviewed in the report of Malikides and Hodgson (2003) as follows:

Factors Contributing to Dust Exposure - In order to be inhaled and cause an effect, dusts must be aerosolised such that solid particles (dusts or smoke) or liquid droplets (mists) of sufficiently small

diameter maintain stability as a suspension in air. In racehorse environments this is achieved by machinery (e.g., mechanical walkers), ventilation air, or movement of humans and horses in and around stables. Particles that are aerosolised (e.g., large viruses, fungal spores and small to medium sized bacteria, fine feed or bedding dust, smoke and motorised pollution) usually range between 0.1 to 10 μm in diameter. They are cleared from air via direct removal by ventilatory airflow (particularly small fungal spores), removal of pathogenic potential while airborne (egg, death of infectious agent) or by reaching an equilibrium and subsequently falling out of the air. Although aerosolised bacteria and viruses may die within seconds, viruses being particularly sensitive to changes in relative humidity, many species still maintain their pathogenicity, antigenicity and ability to induce airway inflammation. This is an important mechanism for certain bacteria, which after death release endotoxin and (1 $\rightarrow$ 3)- β -D-glucan, potent pro-inflammatory agents when inhaled into airways. In general, clearance of airborne dusts takes many hours whereas gases such as ammonia or ozone diffuse through air and can remain airborne in still air for much longer. Racehorses, who spend most of their time (up to 22 hours) in looseboxes, are therefore exposed to aerosolised foreign dusts and gases almost continuously and any effects these agents have would likely be cumulative. However, it is important to note that these “steady state” dust levels do not reflect the true levels to which racehorses are exposed due to large variation induced by horse behaviour in loose boxes, horse and human activity in and outside looseboxes, and stable ventilation, bedding type and management. This large variation in concentrations of dusts can occur within horse looseboxes, between looseboxes in the same stable and particularly around the horse’s head. Airborne concentrations of dusts in looseboxes, (mostly small fungal and actinomycete spores), regardless of quality of ventilation, can be 2-50 times higher when bedding in looseboxes is being changed and cleaned. On average, this increase in concentration is higher when horses are bedded on straw rather than wood shavings or paper. As well, short periods lying and resting on dust rich bedding exposes horses to massive quantities of infectious and non-infectious particles. Sweeping laneways or stable corridors, catching and moving horses, delivery of feed and bedding to stables, and proximity to roads and urban environments also contribute to increasing exposure of horses to airborne dusts.

Work by McGorum et al (1998) gives a good indication of base line levels for dust in a pasture management system for horses although the pasture setting was in Edinburgh (UK) so dust levels may be low compared with general Australian conditions. It was found that total airborne endotoxin concentrations exceeded 20 ng/m³ (0.02 $\mu\text{g}/\text{m}^3$) in half the stables examined, and that even healthy horses in these environments may be exposed to sufficient endotoxin to cause airway inflammation and bronchial hyper-responsiveness. However, as normal horses do not develop detectable pulmonary inflammation or hyper-responsiveness when housed in conventional stables (Derksen et al, 1985; McGorum et al, 1993), it is likely that the minimal total airborne endotoxin concentration causing LRT disease in normal horses exceeds 20 ng/m³ (0.02 $\mu\text{g}/\text{m}^3$).

Malikides and Hodgson (2003) reported that under normal outdoor circumstances low concentrations of endotoxin are inhaled. However, the respiratory tract has efficient defence mechanisms to counteract this airborne endotoxin. It is only when high concentrations of dusts containing endotoxin are inhaled and deposited within the airways that inflammation develops.

Reed et al (Reed et al (2006) in a review of Australian facilities reported dust levels as follows.

Table D3 Average Dust and Bioaerosol Exposures Reported in Australia in Horse Facilities (RIRDC Publication No 06/1071289)

Activity	Dust		Bioaerosols		Endotoxins		Source
	Inhalable Dust (mg/m ³)	Respirable Dust (mg/m ³)	Fungi (CFU/m ³)	Bacteria (CFU/m ³)	Inhalable Endotoxin (EU/m ³)	Respirable Endotoxin (EU/m ³)	
Preparing feed for horses	14.97	1.08	1.494 x 10 ³	8.64 x 10 ²			Reed et al. 2003b
In stall	0.70-2.55	0.20-0.44					Cargill 1999
In barn	0.20-0.95						
Conventional stable	2.19-5.48	0.44-2.20					
In pasture	0.08-0.17	0.08-0.17					
Stables: sawdust	0.397						Banhazi et al. 2002a
Straw bedding	0.606						
Horse Nappy	0.287						
Stables	1.13	0.35					Banhazi et al. 2002a
Stable cleaning	1.20-2.81				50-82		Davidson 2004

D1.4 Comparative Air Quality in Racing and Breeding Locations Worldwide

In all environments that horses are raised or raced there is a background level of dust. This is inevitable due to the agricultural nature of raising horse stock as well as the necessity to provide food, bedding and protection from the elements for horses in race training. Information on background dust levels experienced by horses as part of their normal environment was documented in the literature review.

To date there has been no comprehensive evaluation of dust levels at different geographic locations around the world. Therefore an evaluation of dust levels at various established and well recognised racing and breeding locations was undertaken and the report entitled “Comparative review of air quality backgrounds near horse breeding and racing areas” prepared by PAEHolmes, 2012, is attached as Appendix 2. It was considered important to determine dust levels from other horse racing and breeding sites to enable comparison on a wider basis and to understand how they compared to the existing climate of the Hunter Valley and that of the project being assessed.

The review evaluated established and well recognised racing and breeding locations within Australia and internationally. Locations identified as fitting the criteria included:

- Australia;
 - Hunter Valley, NSW;
 - Randwick, NSW; and
 - Flemington, Victoria.
- United States of America;
 - Louisville, Kentucky; and
 - Lexington, Kentucky.
- Ireland;

- Kildare;
- Tipperary; and
- Meath.
- United Kingdom;
 - Newmarket.
- Saudi Arabia;
- Hong Kong.
 - Sha Tin; and
 - Happy Valley.

Based on this information, background data for particulate matter finer than 10 microns (PM₁₀) was determined at monitoring stations close to these sites and are reproduced in the Table D1.

Table D5 PM₁₀ Annual Average Concentrations

Location		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		PM ₁₀ Annual Average Concentration (µg/m ³)										
Saudi Arabia	Saudi Arabia	148	143	137	128	118	112	107	104	-	-	-
Hong Kong	Sha Tin	-	-	-	-	53	53	51	50	45	45	-
	Eastern	-	-	-	-	49	47	49	46	43	43	-
Australia	Footscray	-	-	-	-	21	22	20	21	22	-	-
	Singleton	-	-	-	-	-	-	-	-	-	20	19
	Muswellbrook	-	-	-	-	-	-	-	-	-	20	19
	Tamworth	-	-	-	-	-	18	16	16	18	12	13
	Randwick	-	-	-	-	-	22	18	17	20	16	15
United States of America	Louisville	-	-	25	23	26	23	25	22	-	-	-
	Louisville 2	-	-	23	21	24	22	24	21	-	-	-
	Lexington-Fayette	-	-	23	21	24	21	23	19	-	-	-
	Elizabethtown	-	-	19	18	21	17	-	-	-	-	-
	Richmond	-	-	20	18	21	18	-	-	-	-	-
Ireland	Cork, Old Station Road	-	24	26	22	19	16	15	16	18	22	-
	Cork, Heatherton Park	-	21	20	19	17	18	17	15	15	18	-
	Dublin, Dun Laoghraine	-	-	-	-	-	-	-	15	15	15	-
	Tipperary, Clonmel	-	-	-	20	19	-	-	-	-	-	-
	Kildare, Naas	-	-	17	17	-	-	-	-	-	-	-
	Kildare, Newbridge	-	-	-	-	-	-	-	-	14	20	-
	Meath, Navan	-	-	-	-	-	-	23	-	-	-	-
United Kingdom	Newmarket Racecourse	-	-	-	21	20	17	17	16	16	16	16

This review concluded that the majority of horse breeding and racing businesses within Australia and internationally operate in similar and comparable PM₁₀ air quality backgrounds, typically ranging between 15 and 26 µg/m³. As might be expected, Saudi Arabia and Hong Kong, had higher concentrations of between 104 and 148 µg/m³ and 53 and 43 µg/m³, respectively.

This data is important in that it provides a background level of dust that horses currently experience during racing and breeding. As noted in the literature review, the level of endotoxins attached to the

dust is of more importance to equine health. To date, there is no data on endotoxin levels from soil in association with the project. Research from other projects in the Hunter Valley (Kannegieter 2012) indicate that endotoxin levels in normal soil are extremely low and not present in any levels that would cause disease. Further evaluation may be required if any very wet soil, particularly with a lot of spoiled vegetation or other endotoxin rich sources, is encountered during the construction process.

D1.5 Effects of Dust on Equine Health and Performance

Published scientific literature on the effects of topsoil or crustal-origin dust on pastured horses is extremely limited. By contrast, a substantial volume of research addresses the impact of dust from bedding, feed and the indoor environment on stabled horses.

D1.5.1 Inflammatory Airway Disease and Equine Asthma

It is noted that currently the term equine asthma (EA) is used to describe Inflammatory Airway Disease (IAD). In this report where the term IAD was used by the original authors it will continue to be used in describing their work.

The most common disease of the lower respiratory tract of horses in Australia is IAD, or mild asthma. In Australia well over 20-55% of horses in any form of athletic endeavour may have EA. The incidence in pastured horses is much lower. EA is a very general response to a wide variety of stimuli. Causes include viruses, bacteria, fungi, stable dust, etc. The effects that EA has on horse health and performance vary greatly from no effect through to death in cases that become complicated. EA is primarily a disease of stabled horses and is considered to be more a response to the presence of irritant material in the lower airways.

EA is a very general response to a wide variety of stimuli which can include viruses, bacteria, fungi, stable dust, etc. The effects that EA has on horse health and performance vary greatly from no effect through to death in cases that become complicated. EA is primarily a disease of stabled horses and is considered to be more a response to the presence of irritant material in the lower airways with any allergic response not clearly defined.

There are a large number of potential causes of lower respiratory tract disease in horses.

The following figure from Spendlove et al (2008) summarises these causes.

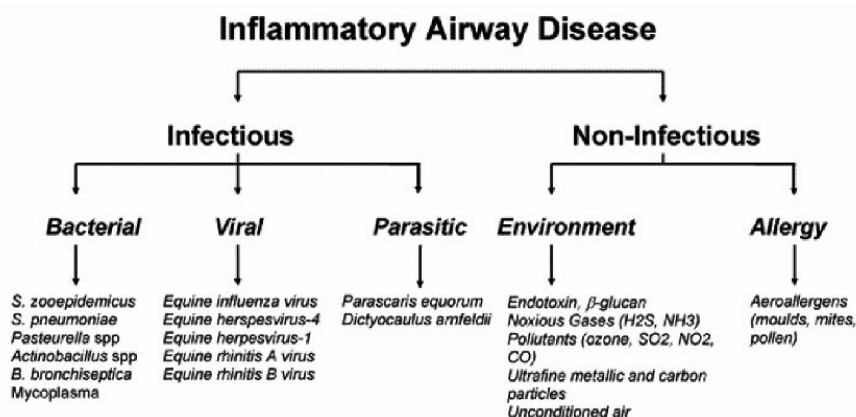


Figure 2: Potential causes of lower airway inflammation in horses.

Figure D1 Potential causes of lower airway inflammation in horses (RIRDC Publication No 08/051)

As EA is a non-specific response to general irritants this is potentially a disease that can have an increased incidence directly as a result of increased exposure to dust. The concentration and composition of dust the horses might be exposed to in a paddock situation needs to be evaluated before any conclusion can be drawn as to the potential risk of EA in pastured horses

The report of Malakides and Hodgson (2003) provides comprehensive information on IAD in horses. They found that endotoxin was primarily responsible for IAD. The source of endotoxin is from degenerate gram-negative bacteria and as such endotoxin is ubiquitous in nature and is commonly present on surfaces of plants and animals. Variable concentrations of endotoxins are found in agricultural environments such as housing for pigs, chickens, cows and horses, as well as sources such as bedding, hay, grains, straw, and bird droppings. Most environments in which horses have contact potentially can be contaminated with dusts with adherent bacteria and their cell-wall fragments, which subsequently may become aerosolised and inhaled. Endotoxin from dust sources (such as feed, bedding and sources outside boxes) in stables is associated with IAD in Thoroughbred racehorses in Australia.

Malikides and Hodgson (2003) provided a very detailed report regarding dust and IAD in horses. They reported that during normal breathing more than 95% of inhaled particles greater than 5 µm (e.g. small hay and straw fibres, fine wood shaving fibres, sand, pollens, plant spores, and larger bacteria, such as Streptococci) are filtered in the nasal passages, pharynx and tracheal bifurcation as a result of collision and impaction between high velocity particles within the airflow and changing airway anatomy. In the nasal passages, soluble noxious gases are concomitantly removed and neutralised via buffering by fluid and protein found in nasal mucus, and the air is humidified and warmed before entering the smaller lower airways. Once a particle impacts upon the moist nasal respiratory epithelium, it is trapped by mucus and removed by ciliary transport. It is important to note that even though few particles larger than 5 to 15 µm enter the trachea and more distal airways, those travelling with high velocity and volume of air can reach these airways and induce an inflammatory response. This response may be cleared or worsen depending on the agents' toxicity and concentration, particularly if particles contain or have adherent toxins such as bacterial endotoxin. As air reaches the small bronchi and terminal bronchioles of the LRT, total airway cross-

section increases and air velocity drops. Deposition of smaller particles, between 0.5 to 5 μm (e.g. large viruses, fungal spores and small to medium sized bacteria, fine feed or bedding particle, smoke and motorised pollution) subsequently occurs by sedimentation onto airway surfaces under the force of gravity where, under certain circumstances, they may induce pulmonary inflammation.

In general, slow, deep breathing (at rest) enhances sedimentation and leads to relatively uniform deposition of particles throughout the LRT. However, rapid breathing with increased airflow as occurs in horses during exercise increases impaction in the larger lower airways producing high local particle concentrations (100 times more) around the bifurcation carinas of these airway compared to airway walls. This pattern and nature of deposition of potentially harmful particles may therefore be an important determinant of distribution of inflammatory responses in the LRT of racehorses (e.g. diffuse or localised to airways with major branches).

When air reaches the level of the respiratory bronchioles and alveoli, most particles $< 0.5 \mu\text{m}$ do not contact the respiratory epithelium and are expelled in exhaled air. However, because air velocity is very low in the gas exchanging structures, particles with a diameter $< 0.1 \mu\text{m}$ (e.g. gas molecules, endotoxin molecules, viruses, proteins, combustion nuclei, ultra-fine particles) are subject to random thermal kinetic buffeting (Brownian motion/diffusion) and have time to diffuse to the walls of surrounding air surfaces.

Malikides and Hodgson (2003) also performed a number of experiments and concluded that 40.3% (range 30-50%) of horses developed IAD within the first 2 weeks of entering racetrack stables for training. This represents a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing. In half these horses the problem persists and may develop into clinical disease as a result of training and management stresses. More than a third of horses entering racetrack stables for training had some form of airway inflammation prior to transport to racetrack stables. The conditions that young racehorses are placed in and their health management (particularly with regard to regular anthelmintic treatment) prior to transport to racetrack stables may influence whether or not horses arrive with some form of IAD. However, the high proportion of young racehorses that develop IAD prior to arrival at racetrack stables are not necessarily at greater risk of continuation of inflammation or further respiratory disease.

A further key conclusion was that contrary to expectation, many dust-generating activities and sources were not associated with EA.

Buechner-Maxwell (1993 a,b) found that airway hyper responsiveness in horses was due to many factors, but dust alone not cited as a major cause. In a later report the same author (Buechner-Maxwell et al, 1996) found that short term exposure (4 weeks) to a stabled environment did not increase any inflammatory mediators in normal horses, although there were some limitations to this study.

Hoffman et al (1993) examined the incidence of distal respiratory tract disease in TB foals in breeding farms in Canada. The study found that 82% (+/- 5%) of foals were affected at one time by lower respiratory tract disease over a 7 month period with bacterial infection the most common inciting factor.

Hoffman et al (1993b) considered that respiratory tract infection in young foals was regarded as enzootic on horse breeding farms. Bacteria, in particular strep zooepidemicus, were primarily responsible. Dust may also be involved in the spread of infections within stables, and it was

suggested that stables need to be at least 100 to 150 metres apart to prevent dust-driven disease spread between buildings (Collins and Algers, 1986).

D1.5.2 *Rhodococcus equi* (Rattles)

A disease of particular concern in this context is “Rattles,” the most prevalent dust-transmitted disease of foals. Caused by *Rhodococcus equi*, Rattles is a common lower respiratory tract (LRT) infection. Its incidence increases in dry, dusty conditions, as dust particles can transport *R. equi* bacteria over substantial distances. The primary reservoir of *R. equi* is considered to be the manure of “carrier” mares; once compacted into soil, the organism can become airborne in dry conditions and be inhaled by foals at close quarters, such as in stock yards. As the foal’s immune system is poorly developed, they are susceptible to the disease.

Muscatello et al (2006) published a comprehensive review of this disease, identifying laneways and holding pens as the highest-risk areas on studs. They noted that limiting the time foals spend in these environments may assist disease control. Properties with low pasture cover, sandy soils, dry conditions and acidic soils were found to present elevated risk.

A potential risk to foals therefore exists from increased short-term dust exposure, especially where *R. equi* bacteria may be present in significant concentrations within the topsoil of areas earmarked for construction.

Appendix E: Fencing

E1 Fencing, Gates and Paddock Design Guidelines

These guidelines provide detailed recommendations for the design, construction and maintenance of fencing, gates, paddocks, water facilities and shelter structures on properties where high voltage (HV) transmission lines and towers are present. They address the particular requirements of different horse types, including breeding horses, pleasure horses, foals and stallions. The presence of HV transmission infrastructure introduces specific hazards not present on typical horse properties including the risk of contact with tower structures and foundations, induced electrical currents in metal fencing, electromagnetic field exposure, and restrictions on the height and materials of structures within easements. These issues must be managed in conjunction with standard equine welfare and fencing requirements. The recommendations draw on guidelines published by NSW DPI, Racing NSW, RSPCA Australia, Agriculture Victoria, the ACT Government, TransGrid, EnergyCo NSW, SafeWork NSW and the Industry Safety Steering Committee (ISSC). Individual consultation with each property owner is essential, as no two properties will have identical requirements.

E1.1 Fencing around transmission towers

Any transmission tower located in a paddock accessible by horses must have appropriate fencing erected around it (see Attachment 1). The base pad and the individual legs of each tower represent a major hazard: horses may collide with tower legs, become trapped between structural members, rub against sharp edges, or injure themselves on bolts, brackets and other protrusions. Tower fencing must prevent horses from making physical contact with any part of the tower structure (legs, cross-braces, foundations and guy wires); provide sufficient clearance for maintenance access; be clearly visible to horses under all conditions, including low light; be constructed of materials appropriate for horse containment; and not impede the transmission operator's access.

The shape of tower fencing is a significant safety consideration. Fencing that creates acute internal angles (less than 90°) can create entrapment hazards where a horse pursued by a dominant paddock mate becomes trapped in a pointed corner. Octagonal or curved fencing around towers is strongly preferred over square or rectangular fencing, as it eliminates acute internal angles and allows a pursued horse to move continuously along the fence. Where octagonal or curved fencing is impractical, square fencing may be used provided no internal angle is less than 90°. Any fence line extending from the tower fencing into the broader paddock should meet at angles of 90° or greater, and junctions with paddock boundary fences should use rounded or angled transitions rather than sharp corners.

TransGrid's Fencing Guidelines require that metal fences be located at least 25 metres from any part of a transmission line structure. This clearance reduces the risk of transferred voltages reaching the fence from the tower earthing system and provides adequate working space for the operator. For non-metallic fencing (timber post-and-rail or PVC), the minimum clearance should be determined in consultation with the operator, but should be sufficient to prevent horses from reaching any part of the tower and to allow safe passage of maintenance vehicles. Stock yards, loading ramps and other livestock-handling facilities must be located outside the earthing and centreline exclusion zones established by the operator.

E1.2 Fencing standards for horses

Visibility

All fences in horse paddocks must be highly visible. Horses have wide-angle monocular vision with limited depth perception and can fail to see fences, particularly in low light or when moving at speed. Recommended visibility measures include a white or light-coloured top rail or rail cap; white sight wires on wire fencing; contrasting colours that stand out against the surrounding landscape; and broad tape or ribbon rather than thin wire where electric stand-off wires are used.

Height

Minimum fence heights depend on the type of horse. For general horses (pleasure, riding, broodmares), a minimum of 1.5 metres is recommended (the Victoria Code of Practice and NSW DPI recommend a minimum of 1.25 to 1.5 metres depending on the size of the horse). For stallions, a minimum of 1.8 metres, preferably up to 2.0 metres, is recommended. Foal fencing must be of standard height but with reduced spacing between the lower rails. Large or athletic horses known to jump may require fencing higher than 1.8 metres, assessed case by case.

Materials

The selection of fencing materials near HV transmission infrastructure must take into account both equine safety and electrical safety.

Preferred materials: timber post-and-rail (the preferred material in all guidelines reviewed, non-conductive, highly visible and solid, with rails on the inside of the posts); steel pipe post-and-rail (acceptable but must be earthed if within or near a transmission easement); and high-quality PVC flexible rail (non-conductive, visible, and suitable for use within easements).

Materials to avoid: barbed wire (prohibited by all equine welfare guidelines as it causes severe lacerations and entanglement injuries); high-tensile wire (2.8 mm or 2.5 mm), which can act as a cutting wire when a horse becomes entangled; prefabricated wire fencing such as ringlock or hinged joint, which presents entrapment hazards for hooves; and narrow-gauge wire, which is difficult for horses to see.

Conditional materials: star pickets (steel Y-posts) are not recommended, but if used must have plastic safety caps fitted and should not be the sole fence support; electric stand-off wires should only be used with the landowner's agreement, must be clearly sign-posted, and where used within an easement must be battery-powered rather than mains-powered.

Construction specifications

Recommended dimensions for post-and-rail horse fencing, adapted from NSW DPI and Racing NSW guidelines: post spacing 2.40 to 2.75 metres centre to centre; overall fence height 1.50 to 1.80 metres including cap rail; three to four rails; maximum interval between rails 230 mm; bottom rail height 380 to 460 mm above ground level; rails fixed to the inside (paddock side) of the posts; and all fences smooth, sturdy and free from protrusions such as loose wires, sharp nails, exposed bolts or splintered timber. The RSPCA recommends that fencing be capable of withstanding damage and be properly maintained, noting that a poorly maintained fence is more dangerous than no fence at all.

Foal-safe fencing

Paddocks housing foals require additional consideration, as foals are smaller, more curious and more likely to attempt to pass through or under fencing. Bottom rail clearance should be 200 to 300 mm (8 to 12 inches) above ground level and low enough to prevent foals rolling under, but high enough to avoid trapping hooves. Rail spacing should be 150 to 230 mm (6 to 9 inches), particularly in the lower portion of the fence. Where mesh is used, the aperture must not exceed 50 mm × 100 mm to prevent hooves becoming caught, and fence openings must be either too small for a hoof to penetrate (less than 75 mm) or large enough that a hoof, leg or head cannot become trapped. Foal paddock fencing should be inspected more frequently than adult paddock fencing.

Stallion fencing

Stallion paddocks require the strongest and tallest fencing on the property. The minimum height is 1.8 metres, preferably 2.0 metres. Double fencing is strongly recommended: stallion paddocks should be separated from paddocks containing mares or other horses by two parallel fence lines with a lane of at least 3 metres between them, wide enough for vehicle and equipment access and ensuring horses cannot reach across to fight. Fencing must be strong enough to withstand a charging or rearing horse, with timber post-and-rail or steel pipe construction preferred. Where stallion paddocks are within or near an easement, non-conductive materials (timber or PVC) are strongly preferred to avoid earthing complications.

E1.3 Gates

Gates are a common source of injury. Racing NSW Standard G7.4 requires that gateways give easy and safe passage of horses. The minimum gate width is 1.2 metres (Racing NSW, Victoria Code of Practice); NSW DPI recommends 1.3 metres for gates to stables, yards and paddocks, and 3.0 metres for paddock access gates where vehicles and equipment also require passage. Gates must be free from projections that may cause injury; must have secure, horse-proof fastenings (such as spring-loaded or cam-action latches); should be of the same height and construction standard as the surrounding fence; and should be sited on firm, well-drained ground, as horses congregate and pace near gates. Where gates are within an easement, the same earthing and material requirements as for fencing apply.

E1.4 Paddock size, shape and design

Adequate paddock size is essential for the physical and psychological welfare of horses. The following minimum sizes are recommended, drawing on NSW DPI, RSPCA and industry guidelines: grazing paddocks (pasture as primary feed), 1 to 2 acres (0.4 to 0.8 hectares) per horse, or 2 to 3 acres where pasture quality is poor or seasonal; exercise paddocks (hay-supplemented), a minimum of 0.1 to 0.5 acres (approximately 400 to 2,000 square metres) per horse; and, for a single horse or pair, 2 to 4 acres, with at least 30 metres × 30 metres as an absolute minimum for a single horse. Where transmission towers and their exclusion fencing occupy space within a paddock, the usable area must be calculated after deducting the fenced tower area, and if the remaining area falls below the minimum, boundaries should be adjusted or stocking density reduced.

Paddock shape directly affects safety. Square or rectangular paddocks are preferred, and long, narrow paddocks should be avoided as they concentrate horse movement and increase the risk of cornering. All internal fence angles should be 90° or greater; where acute corners are unavoidable,

they should be blocked off with additional fencing to create a curved or chamfered corner. A buffer zone or laneway of 2 to 3 metres between adjacent paddocks is desirable, as it reduces fighting over fences, minimises entanglement injuries, provides a safe corridor for moving horses, and allows fence maintenance. Racing NSW Guideline G7.2 notes that alleys and stand-off fencing can reduce entanglement injuries.

E1.5 Electrical safety — fencing near HV transmission lines

The mechanisms of induced and transferred voltage, and the core earthing and isolation requirements, are set out in Section 7.8. In summary, metal fences must be located at least 25 metres from any transmission structure; fences crossing an easement must have earthing and isolation panels with earthing on both sides; fences running parallel past a structure must have earthing and isolation panels 25 metres either side of the structure; earth rods must be driven to at least 1,200 mm; and metal fences must never touch any transmission structure. Landowners must contact the transmission operator before installing any new fencing near an easement.

Long metallic wire fences that run parallel to a 500 kV line for several kilometres act as unintended receivers for both electrostatic and electromagnetic induction; a well-insulated fence can acquire a voltage relative to earth, and a grounded person or animal touching the wire completes a circuit and receives a discharge. For the project, this risk is mitigated through a fencing and earthing strategy involving grounding rods installed at regular intervals along any fence line that enters the easement, together with isolation panels or non-conductive sections where a fence crosses the centreline. In rural areas, 500 kV lines may run parallel to lower-voltage (11 kV or 22 kV) distribution lines and can induce currents into the neutral wires of the distribution system, contributing to stray voltage at the customer's point of use; utilities manage this through isolation transformers that separate the primary and secondary neutrals, and through increased separation between the 500 kV route and existing distribution corridors.

TransGrid recommends that all fencing within an easement be made from timber or other non-conductive materials, which eliminates the risks of induced and transferred voltage and removes the need for complex earthing. Suitable non-conductive options include timber post-and-rail (the preferred option in all circumstances), PVC flexible rail systems, and composite materials designed for equine fencing; these must still comply with all equine welfare requirements for height, visibility, spacing and strength. Electric fence stand-off wires or tapes may be used within easements to teach horses to respect fences, provided the energiser is battery-powered (not mains-powered), the fence is clearly sign-posted, the installation is agreed with the landowner, and the electric fence is used in conjunction with a physical barrier rather than as a standalone fence.

E1.6 Water facilities

Horses must have continuous access to clean, fresh water; the Prevention of Cruelty to Animals Act 1979 makes it an offence to fail to provide proper drink. Water troughs, dams and other sources must be accessible to all horses (including foals), located where horses can approach without risk of injury, free from sharp edges and entrapment hazards, regularly cleaned, and protected from contamination by construction activities. Near HV infrastructure, non-metallic troughs (polyethylene, fibreglass or concrete) are preferred, as they eliminate the risk of stray voltage or induced current being transmitted to horses through the water or trough body; horses are highly sensitive to stray voltage and may refuse to drink from affected troughs, and the Merck Veterinary Manual notes that

animals can feel one-tenth the voltage that humans can perceive. If metal troughs must be used, they should be properly earthed by a licensed electrician, with equipotential bonding of all nearby metal components, and any piped supply within the easement should use non-conductive pipe. Troughs should be located outside the tower exclusion zone and away from tower structures — preferably at the periphery of the easement or outside it entirely. Automated watering systems must be installed by a licensed electrician, include ground-fault (GFCI/RCD) protection and be properly earthed, as insurance policies may not cover electrocuted animals if the installation was not carried out under an electrical permit.

E1.7 Shelter facilities

Horses in paddocks must have access to sufficient protection from sun, wind, rain and temperature extremes, as required under the Prevention of Cruelty to Animals Act 1979. Shelter may be provided by natural tree shade, constructed run-in sheds, windbreaks, or rugs. NSW DPI Factsheet 16 specifies that stables should be at least 2.5 metres high with a minimum floor area of 12 square metres for horses (9 square metres for ponies and donkeys). Within HV easements, shelter structures are subject to significant restrictions under TransGrid's Easement Guidelines and ISSC 20: structures must not exceed 2.5 metres in height if non-climbable and more than 30 metres from a transmission structure (structures exceeding 4.3 metres are generally not approved); sheds exceeding 8 square metres in floor area, or within 30 metres of any transmission structure, will generally not be approved; structures within the centreline zone must be non-metallic; mains electrical connection will not be approved; and structures must not impede the operator's access. Given these restrictions, shelter within easements may need to rely on natural tree shade, small non-metallic run-in shelters (under 2.5 metres and 8 square metres, at least 30 metres from any structure), portable shade structures, or rugs. Where adequate shelter cannot be provided within the easement, the paddock layout should ensure shelter is available in areas outside the easement.

E1.8 Electromagnetic fields and horse welfare

High voltage transmission lines generate electric and magnetic fields, and there is considerable public concern about potential health effects on animals. As reviewed in Section 4.1, the available scientific evidence provides limited support for claims of adverse health effects on livestock. A three-year study by the American Electric Power Service Corporation of cattle and livestock on farms near 765 kV lines found no significant effects on feed and water consumption, breeding, conception, calving, weight gain, body condition, carcass weight or mortality; a survey of 125 livestock owners grazing animals under 765 kV lines recorded only two specific observations of concern; and New Mexico State University concluded that there is very little to no scientific evidence supporting claims of adverse health effects on livestock from transmission line EMF. Some behavioural observations have been noted: horses and other livestock may receive "nuisance" or "startle" shocks from ungrounded conductive objects within the electric field (a result of capacitive coupling, managed through proper earthing), and some anecdotal reports suggest horses may initially avoid areas directly beneath conductors but typically habituate over time. Consistent with the precautionary principle, water and feed facilities should be located away from the area directly beneath conductors where the electric field is strongest; shelter and loafing areas should, where practicable, be located outside the easement; and owners should monitor horses for behavioural changes after installation and report any concerns.

E1.9 Safe approach and clearance distances

The following safe approach and clearance distances apply to persons, vehicles and structures near HV transmission lines and are relevant to the placement of fencing, shelters, water facilities and construction activities: persons (unqualified), minimum 3.0 metres from any conductor (SafeWork NSW); vehicles and machinery, voltage-dependent clearances exceeding the safe approach limit for persons, to be confirmed with the operator; metal fencing, minimum 25 metres from any transmission structure (TransGrid); non-metallic structures exceeding 2.5 metres in height, minimum 30 metres from any structure; and stock yards and loading ramps, outside the earthing and centreline exclusion zones. Aerial power lines can swing in wind and sag in heat, so clearance distances must account for worst-case conductor movement, not just static conditions.