Hexham Wind Farm

Chapter 13

Landform and Soils

WIND PROSPECT

13.1 Overview

This chapter describes the regional geological context and assesses the landform and soil values of the project site. It considers potential impacts of construction on these values and measures taken to avoid and minimise these impacts. It is also intended to provide a high-level overview of geotechnical considerations to be considered during construction and potential contamination within the project site. This chapter is based on the findings of the report prepared by WSP Australia Pty Ltd (WSP), provided in Appendix A – ***Soil and Landform Assessment***.

The project site is in an area of south-west Victoria known for its volcanic plains, with the geology of the area (Newer Volcanic Group) formed by volcanic activity that occurred during the last 4.6 million years. There is one geologically significant feature mapped within the project site, 'Limestone Creek Complex', which is associated with a geological unit that forms part of the Newer Volcanic Group.

Acid sulfate soils are naturally occurring soils, sediments and peats that contain iron sulfides. When exposed to oxygen, iron sulfides can produce sulfuric acid that causes impacts to the environment (e.g., reduced water quality and biodiversity loss), land use (e.g., reduced agricultural productivity), infrastructure (e.g., corrosion of concrete and steel structures) and human health (e.g., drinking water contamination and skin irritation). If not managed properly, development on saline and sodic dispersive soils can also cause tunnel or surface erosion, which can increase the risk of damage to infrastructure and impact waterway quality.

The construction of the project has the potential to impact existing landforms and result in soil-related issues from the earthworks associated with the foundations for wind turbines, cable trenches and other structures (e.g., concrete batching plants and on-site terminal station), on-site quarry development, and construction of access tracks and hardstand areas. Potential impact pathways are modifications to the existing landform from excavation and civil engineering works, ground settlement following construction due to unstable soils, erosion of exposed soils, and exposure and disposal of waste or hazardous soils. While some of these impacts would be temporary, others would be restricted to the construction phase or occur over the life of the project.

Prior to the finalisation of the detailed design, a site-specific geotechnical investigation will be undertaken to determine the local geotechnical conditions. This assessment will inform the design of infrastructure foundations for wind turbines and other structures (e.g., terminal station, and site offices), excavation methods, and pavement requirements for access roads and hardstand areas, and determine whether potential acid sulfate soils, actual acid sulfate soils and soil contamination are present.

With the incorporation of recommended management measures, the significance of impacts to landform and soil values are predominately considered to be very low or low. However, should preparation of access road pavements and hardstand areas occur during the wetter months of the year, surface drainage paths or ponded water may result in poorer performance of the surface beneath these areas and lead to increased ongoing maintenance of roads and access tracks. As construction during dry weather is not always possible, the significance of impacts associated with the preparation of these areas are considered low to medium.

13.2 EES objectives and key issues

There is no specific evaluation objective outlined in the EES scoping requirements relevant to landform and soils. However, as part of the catchment values and hydrology matters to be investigated, the EES scoping requirements outline the requirements listed in Table 13.1 relevant to the landform and soils assessment.

The objective of the landform and soils assessment was to identify potential geotechnical, contamination and/or hydrogeological constraints associated with the project site, and how impacts may be avoided, minimised or mitigated.

Table 13.1 Requirements of the EES scoping requirements relevant to landform and soils

Evaluation objective	
Catchment values and hydrology: *To maintain the functions and values of aquatic environments, surface water and groundwater quality and stream flows and avoid adverse effects on protected environmental values*	
Key issues	Potential for the project to have a significant effect on hydrology and affect existing sedimentation and erosion processes leading to land and aquatic habitat degradation.

13.3 Legislation, policy and guidelines

Key legislation, policies and guidelines relevant to the ***Landform and Soils Impact Assessment*** (Appendix A) are summarised in Table 13.2

Table 13.2 Relevant legislation, policies and guidelines

Legislation and guidelines	Description	Relevance to project
Planning and Environment Act 1987	The purpose of the *Planning and Environment Act 1987* is to establish a framework for planning the use, development and protection of land in Victoria. The Act sets out the process for obtaining permits under schemes, settling disputes, enforcing compliance with planning schemes and permits, and other administrative procedures.	The land within the project site is subject to the requirements of the Moyne Planning Scheme. The Moyne Planning Scheme contains the following Clauses relevant to the landform and soils assessment: • 13.04-2S Erosion and landslip: key strategy to "*prevent inappropriate development in unstable areas or areas prone to erosion*". • 13.04-3S Salinity: key strategy to "*prevent inappropriate development in areas affected by groundwater salinity*". • 14.02-2S Water quality: key strategy to "*discourage incompatible land use activities in areas subject to … severe soil degradation, groundwater salinity or geotechnical hazards where the land cannot be sustainably managed to ensure minimum impact on downstream water quality or flow volumes….*". • 35.07 Farming Zone: decision guidelines include consideration of whether the proposed use or development will adversely affect soil quality and agricultural production. • 52.32 Wind Energy Facility: includes the requirement for an environmental management plan (outlining rehabilitation and monitoring requirements) to be submitted as part of the design response for a wind energy facility.

Legislation and guidelines	Description	Relevance to project
Environment Protection Act 2017	The *Environment Protection Act 2017* establishes the legislative framework for protecting the environment in Victoria. The subsequent *Environment Protection Amendment Act 2018* introduced the general environmental duty in relation to risks of harm to human health and the environment from pollution or waste. The Environment Reference Standard (ERS), made under the *Environment Protection Act 2017*, identifies environmental values to be achieved and maintained, and how these values are to be assessed.	The project is being developed under the provisions of the *Environment Protection Act 2017* that relate to the project's general environmental duty and is required to demonstrate it is implementing measures so far as 'reasonably practicable' to meet the general environmental duty. Part 4 of the ERS relates to the protection of environmental values for land, which includes land quality that is suitable to protect soil health and ecosystem biodiversity, and that is not corrosive to buildings / structures. The project design and construction would need to consider and apply the ERS relevant to the project.
Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils (DSE, 2010)	The Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils provides a risk framework for assessing and managing potential acid sulfate soils and actual acid sulfate soils.	Areas such as swamps, lakes and along watercourses within the project site may present a high hazard for potential acid sulfate soils and actual acid sulfate soils. The Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils requires that management of high hazard areas is documented in an Environmental Management Plan, which includes an Acid Sulfate Soil Management Plan. Best practice management strategies for acid sulfate soils are described in Section 10 of the Guidelines.
Glenelg Hopkins Regional Catchment Strategy 2021-2027 (Glenelg Hopkins CMA, 2021)	The Glenelg Hopkins Regional Catchment Strategy 2021-2027 outlines policy directions, challenges and opportunities for the community, water, biodiversity, land, and marine and coast. Specific processes relevant to landform and soils that have been identified in the Regional Catchment Strategy for priority attention at a regional level include: • Soil acidification. • Inadequate groundcover in erosion susceptible areas • Sodic soils • Soil contaminants, such as salt and acids • Soil structure decline • Improving knowledge and understanding of the distribution of coastal acid sulphate soils	The project is located within the Glenelg Hopkins Catchment Management Authority boundary, and the local areas of the South Eastern Coastal Plains and North Eastern Volcanic Plans of the Regional Catchment Strategy.
EPA Victoria Publication 655.1: Acid sulfate soil and rock	Provides guidance on identifying, classifying and managing acid sulfate soils and rock.	Soil sampling and testing for acid sulfate soils would be undertaken in accordance with methods outlined in EPA Victoria Publication 655.1.
EPA Victoria Publication 1893: Erosion, sediment and dust: treatment train	Outlines measures to eliminate or reduce the risk of harm from erosion, sediment and dust using a treatment train approach.	Measures to limit erosion and sedimentation of surface water, considering the treatment train approach, have been proposed.

Legislation and guidelines	Description	Relevance to project
EPA Victoria Publication 1894: Managing soil disturbance	Provides information about managing soil disturbance and how to eliminate or reduce the risk of harm from erosion, sediment and dust.	Measures to reduce the risk of harm from erosion, sediment and dust from ground disturbance have been proposed.
EPA Victoria Publication 1895: Managing stockpiles	Provides information about managing stockpiles and how to eliminate or reduce the risk of harm from erosion, sediment and dust.	Measures for managing stockpiles to reduce the risk of harm from erosion, sediment and dust have been proposed.
EPA Victoria Publication 275: Construction Techniques for Sediment Pollution Control	Provides construction techniques (e.g., for earthworks, stockpiles and dust control) to assist in protecting the environment from soil erosion and sedimentation.	The Construction Environmental Management Plan will outline the procedures, Environmental Reference Standards and best practice guidelines to manage erosion and sedimentation including controls to reduce sediment transport on construction sites in accordance with EPA Victoria Publication 275.
Geotechnical Guidelines for Terminal and Rehabilitated Slopes (DJPR, 2020)	The Geotechnical Guidelines for Terminal and Rehabilitated Slopes provides guidance on the geotechnical design of slopes to be included in work plans for extractive industries.	Decommissioning of the on-site quarry will be undertaken in accordance with the Geotechnical Guidelines for Terminal and Rehabilitated Slopes.

13.4 Investigation area

The investigation area considered for the study was primarily restricted to the current project site boundary, however the wider geological setting of the project site within south-west Victoria and the features therein were studied. The investigation area relative to the regional setting is shown in Figure 13.1.

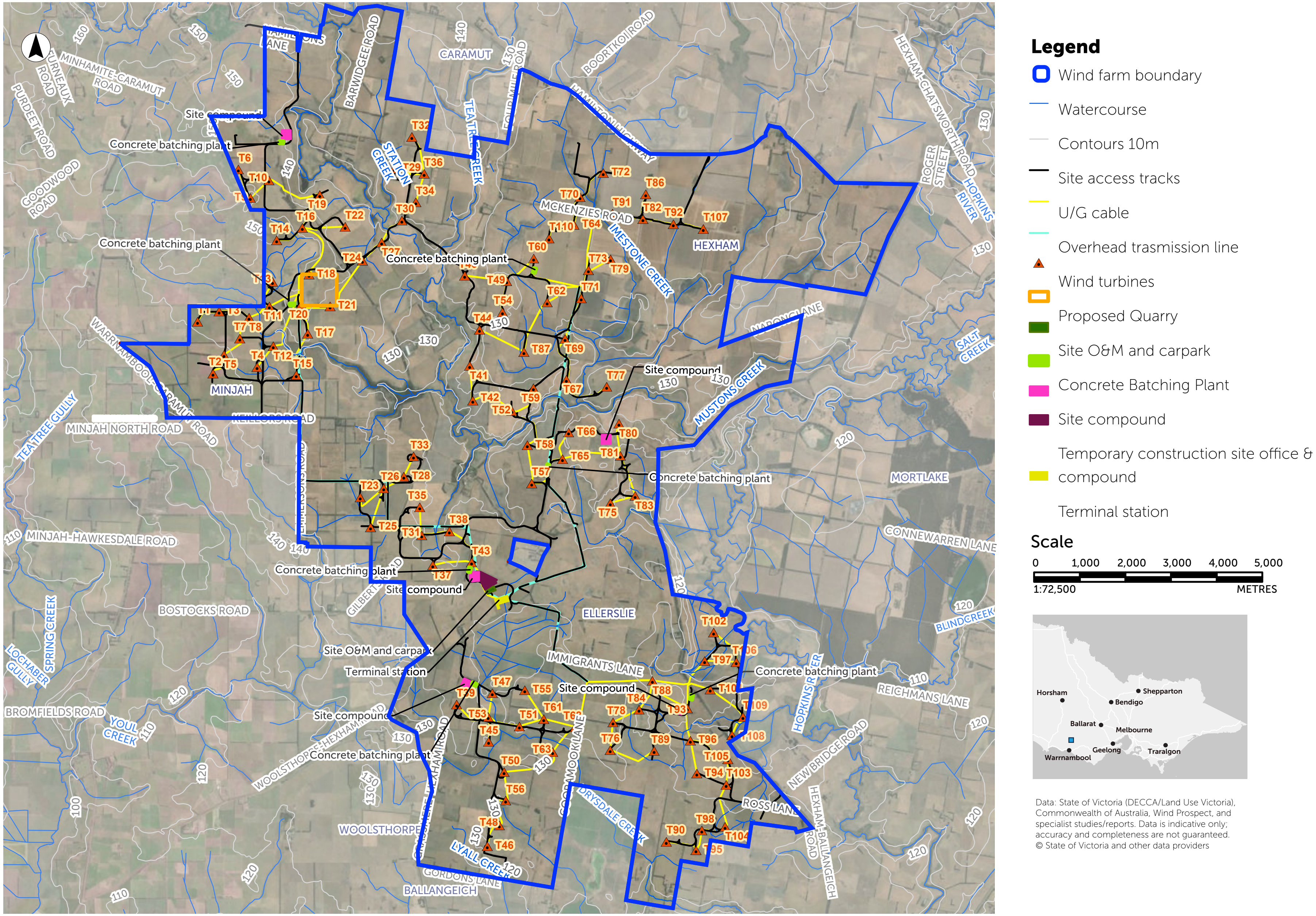

Figure 13.1 Landform and soils investigation area

13.5 Method

The landform and soils assessment was undertaken by experienced geotechnical personnel and consisted of a desktop review and site walkover. No specific or invasive field testing or sample collection was undertaken during the site walkover.

The desktop review included a review of the following information and databases:

- Historical aerial photographs of the site from 1947 and satellite images from 2006 and 2020
- Review of mapping on the GeoVic (Resources Victoria, Department of Energy, Environment and Climate Action) website
- Review of registered groundwater bore and water quality data via the Visualising Victoria's Groundwater website
- Environmental Protection Authority (EPA) Victoria databases including:
  - EPA Victoria Priority Sites register
  - EPA Victoria Environmental Audits records
  - Records of active and historical landfills
  - Records of EPA Victoria licenced sites.
- Published geological and geomorphological information, including geological maps and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Soil Resource Information System database to determine the potential for the project site to be within an acid sulfate soil risk area
- The Bureau of Meteorology Groundwater Dependent Ecosystems Atlas
- Moyne Planning Scheme.
- The site walkover was undertaken in March 2023 by an engineering geologist from WSP.

13.6 Existing conditions

13.6.1 Geology and geomorphology

The project site is in an area of south-west Victoria known for its volcanic plains. The geology of the area primarily consists of basalt of the Pliocene to Pleistocene (late Tertiary to Quaternary) aged Newer Volcanic Group (Neo). This group was formed by volcanic activity during the last 4.6 million years, with lava flows spreading from an eruption point and building up a series of overlapping layers. Groundwater bores from the Visualising Victoria's Groundwater website indicate the basalt varies between around 1 metre and 30 metres thick.

Pliocene aged materials of the Brighton Group (Nb), comprised of gravel, sand and silt, are present at the surface in the eastern and south-eastern parts of the project site. Visualising Victoria's Groundwater bore data indicates this material is around 20 metres thick.

In the north-eastern part of the project site the basalt is expected to be overlain by Quaternary aged alluvial terrace (Qa2) floodplain deposits, also comprised of gravel, sand and silt. Bore data indicates this material is around 11 metres thick. Quaternary aged alluvium (Qa1) and swamp and lake deposits (Qm1) are also mapped within the project site associated with mapped waterways.

The geology of the project site at the surface is shown in Figure 13.2, and site photographs from the project site of the surface geology are provided in Figure 13.3, Figure 13.4 and Figure 13.5.

Heytesbury Group (Nh) material is expected to be present below the Newer Volcanic Group and Brighton Group, however it is not mapped at the surface in the project site. This group consists of Miocene aged Port Campbell Limestone overlying Gellibrand Marl and Cambrian aged granite and amphibolite (metamorphosed volcaniclastic sandstone).

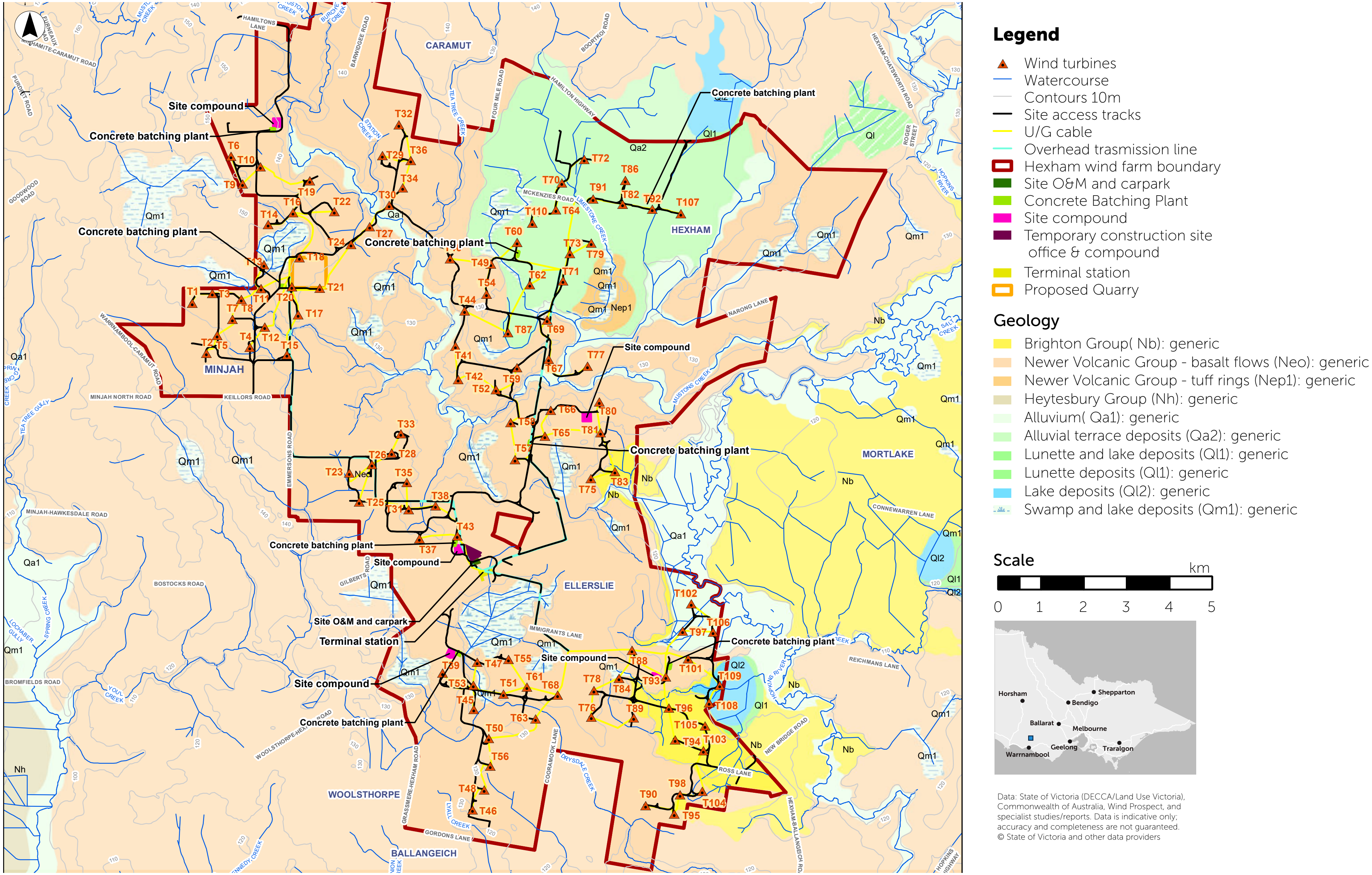

Figure 13.2 Surface geology in relation to the project site

Figure 13.3
Basalt rock outcrop in the upper slope of the Mustons Creek valley
(Source: WSP)

Figure 13.4
Swamp soil deposit
(Source: WSP)

Figure 13.5
Road cutting on Hamilton Highway adjacent to Burchett Creek crossing at the north-western project site boundary
(Source: WSP)

13.6.2 Sites of geological significance

There is one geologically significant feature mapped within the project site (Figure 13.1). This feature is associated with a geological unit that forms part of the Newer Volcanic Group and is described as *"maars surrounded by tuff rings and containing lake deposits in their craters"* and is listed as a feature of regional significance on the GeoVic website.

13.6.3 Landform and soils

Geomorphology (landforms) and soil types

Geomorphology refers to the study of the Earth's surface features (i.e., landforms) and the processes that shape them.

The Victorian Geomorphology Framework provides a three-tiered classification system of landforms and landscapes within Victoria. The project site is within the Western Plains division (tier 1) geomorphic unit, which comprises of volcanic plains, sedimentary plains, and hills and low hills (tier 2). Of relevance to the project site are volcanic plains and sedimentary plains, which correspond to three tier 3 geomorphic units. These are summarised in Table 13.3.

Table 13.3 Geomorphic (landform) units mapped within the project site

Geomorphic unit				
Tier 1 (code)	**Tier 2 (code)**	**Tier 3 (code)**	**Predominant soil type**	**Location in relation to project site**
Western Plains (6)	Volcanic plains (6.1)	Plains with poorly developed drainage and shallow regolith (6.1.3)	Vertosols	Majority of project site
		Terraces, floodplains and lakes, swamps and lunettes and their deposits (6.1.5)	Sodosols	Localised areas around Mustons Creek, Limestone Creek, Lyall Creek, and unnamed watercourse channels and streams in the south and east of the project site
	Sedimentary plains (6.2)	Plains and plains with low rises (6.2.4)	Kandosols	South-east portion of project site

The corresponding soil types are described as:

- Vertosols: clay soils with shrink/swell properties that display strong cracks when dry, with a moderate susceptibility to rill erosion
- Sodosols: soils with strong texture contrast between the A and B horizons (i.e., the topsoil and subsoil), with a moderate susceptibility to gully erosion
- Kandosols: soils lacking strong texture contrast, with massive or only weakly structured B horizons (i.e., subsoil), with a moderate susceptibility to rill and wind erosion.

During the site visit, no signs of rills, gullies or dispersive soils were observed in sloping areas near the Hopkins River or the creeks within the project site.

Types of erosion

- Rill: when water runoff down a slope results in the formation of small channels (less than 0.3 metres deep)
- Gully: formation of channels deeper than 0.3 metres from the concentration of strong flowing water runoff
- Wind: when strong winds result in removal of small, loose soil particles.

Acid sulfate soils

A review of the CSIRO Australian Soil Resource Information System database indicates there is a low probability of acid sulfate soil existing across the majority of the project site and localised areas of high probability of occurrence, with very low confidence. The areas of high probability for acid sulfate soil are associated with lakes or swamps (Figure 13.6).

The proposed on-site quarry is located in an area mapped as having low potential for acid sulfate soils.

Based on field observations by WSP, soils in mapped swamp, lake and alluvial deposits are considered to have high potential for acid sulfate soils, while soils derived from the weathering of basalt are considered very low risk.

Acid sulfate soil are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials. Without oxygen, these materials remain and do not pose a significant risk to human health or the environment. However, if acid sulfate soil is disturbed and exposed to oxygen, the iron sulfides in the material produces sulfuric acid. The acidification of the soil from this process can impact the environment, land use, infrastructure and human health.

Salinity and sodicity

Saline soils can present risks to infrastructure if the salts are aggressive to concrete or steel. Salts are typically higher at depth in the soil, but changes in groundwater flows can mobilise salts to the surface where they accumulate as water evaporates.

Sodic soils are those with a high proportion of sodium ions, relative to other positively charged ions. Soils are often considered sodic when the amount of sodium in the soil affects its structure. The salt found in saline soils is often sodium chloride. As such, salinity and sodicity are often discussed together. Saline soils are prone to erosion as they can prevent the establishment of vegetation and cause soil to disperse (rather than clump).

If not managed properly, development on saline and sodic dispersive soils can lead to tunnel and surface erosion, resulting in an increased risk of damage to infrastructure from undermining of foundations and/or slumping and collapse of ground, and adverse impacts to waterways from reduced water quality and/or changes to flow volumes or intensity.

The project site is located entirely within Salinity Province 81, Mortlake Caramut, in the Glenelg Hopkins Catchment Management Region (Victorian Resources Online, Agriculture Victoria). Areas of salinity recorded within the project site generally correspond with areas mapped as quaternary alluvium, such as swamps and lakes and along watercourses.

Bore data from Visualising Victoria's Groundwater and 14 wells within the project site indicates that salinity within the project site is typically between 1,001 milligrams per litre and 3,500 milligrams per litre.

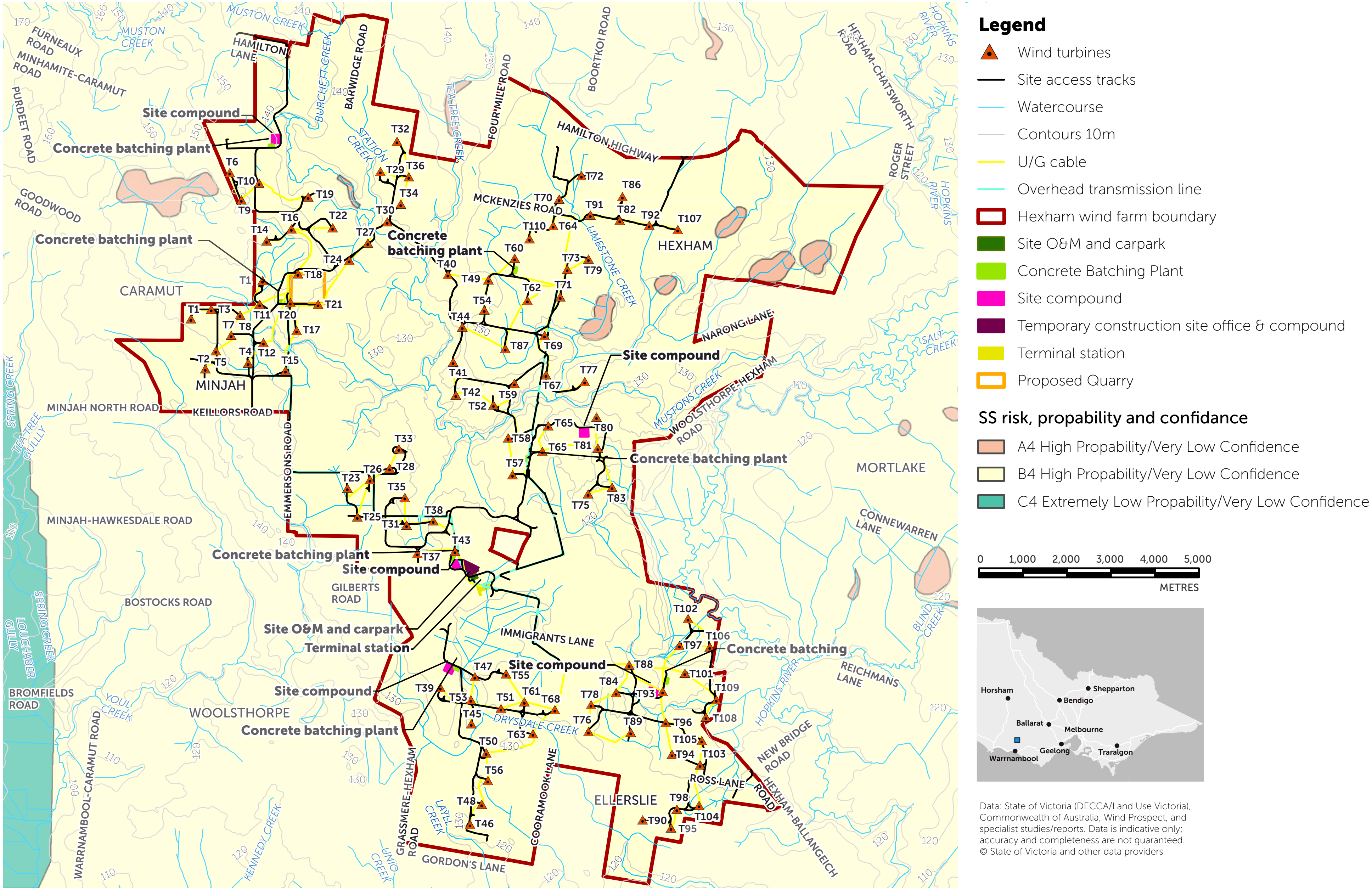

Figure 13.6 Acid sulfate soil probability in relation to the project site

13.6.4 Potential contamination

A review of aerial imagery from 1947 and 2006 shows there have been no significant changes in land use during this time. A review of 2020 aerial imagery showed similar land use to the earlier imagery, with further evidence of cropping near creek lines. No significant farm infrastructure was identified within the project site that may pose a potential source of contamination.

Within the project site there were no EPA Victoria records for sites identified as a former landfill or an EPA Victoria licensed site or known or having the potential for contamination from current or historical activities and requiring ongoing management and/or clean up.

13.7 Impact assessment

This section describes the potential impacts to landform and soils from the project construction, operation and eventual decommissioning, how they will be mitigated in the detailed design, and what residual impacts may occur that need further management. When evaluating the potential impacts of the project on landform and soils, the significance ratings outlined in Table 13.4 were considered.

Table 13.4 Significance criteria

Rating	Criteria
Very low	Residual impacts are negligible or very minor. Very unlikely to have an impact on the project or environment.
Low	Residual impacts are minor. Unlikely to have a major impact on the project or environment. Potential for minor loss of productivity/time during construction.
Medium	Residual impacts are significant enough that they may or may not result in environmental degradation, construction issues, major loss of productivity/time, or other negative impacts to the project.
High	Residual impacts are major and are likely to result in environmental degradation, construction issues, major loss of productivity/time, or other negative impacts to the project.

13.7.1 Impact pathways

The construction of the project has the potential to impact existing landforms and result in soil-related issues from the earthworks associated with the foundations for wind turbines, cable trenches and other structures (e.g., concrete batching plants and on-site terminal station), on-site quarry development, and construction of access tracks and hardstand areas.

Potential impact pathways associated with landform and soils include:

- Modifications to the existing landform from excavation and civil engineering works (while some of these impacts would be temporary, others would be restricted to the construction phase or occur over the life of the project)
- Unstable soils (e.g., reactive and/or susceptible to shrink-swell movements) or shallow groundwater, leading to ground settlement following construction
- Erosion of exposed soils
- Exposure and disposal of waste or hazardous soils, including:
  - Acid sulfate soil
  - Saline and sodic soil
  - Contaminated soil.
- These impacts may be restricted to the construction phase (i.e., short term) or result in longer-term impacts (e.g., loss of topsoil, channel instability, decreased water quality).

13.7.2 Design mitigation

Elimination of potential impacts through design has been central to the development of the project. The approach has been to firstly avoid potential impacts if feasible and practical, then to minimise the severity of the impact over space and time, followed by the application of targeted management controls.

A geotechnical assessment will be undertaken prior to construction, during the detailed design phase, to avoid and minimise potential landform impacts and soil-related issues. This will include:

- Determining excavation conditions for site earthworks and soil condition for access road pavements and hardstand areas
- Assessing the grading of the soil (i.e., the proportion of clay, silt, sand and gravel) to determine cut and fill requirements, and the potential for the works to disturb soils and increase erosion
- Identifying the presence and depth profile of potential acid sulfate soils and actual acid sulfate soils [EMM LS02]
- Assessing the geological site conditions at the on-site quarry (including basalt thickness and quality) to confirm the suitability of the location.
- Based on the findings of the geotechnical assessment, infrastructure foundations for wind turbines and other structures (e.g., terminal station, site offices) will be designed and earthworks undertaken as appropriate to the local geotechnical conditions.

13.7.3 Environmental management measures

Where possible, engineering design measures have been included to avoid potential impacts on landform and soils. Where impacts are unavoidable, management measures are proposed to reduce each impact as far as is practicable.

Measures to manage residual effects to landform and soils would be carried out during the detailed design, construction, operation and decommissioning phases. Proposed management measures to address residual impacts on landform and soils are outlined in Table 13.5.

Table 13.5 Landform and soils management measures

Landform and soils impact	Project phase	Management measures	Number
Modification to landform Soil erosion	Construction	**Quarry Work Plan** 1. Prior to the development of an on-site quarry, the draft Quarry Work Plan (provided in Attachment II) will be finalised and submitted to Resources Victoria (Department of Energy, Environment and Climate Action) for approval. 2. The Quarry Work Plan will include measures to: a. manage and monitor surface water impacts b. manage noise emissions, in accordance with a Quarry Noise Management Plan [NV02] c. control emissions of dust or other particulates d. manage the carriage and deposition of dust, silt and clay by vehicles existing the work authority area e. manage erosion from topsoil and overburden stockpiles f. manage site rehabilitation. 3. Prior to blasting, the affected areas will be pre-wet to minimise dust emissions. Blasting would occur when winds are blowing away from the nearest sensitive receptors (i.e. from the north, south or west) and are consistent enough to encourage movement of dust away from the nearest receptors, but light enough to minimise emission generation and transport of dust off-site.	EMM07

Landform and soils impact	Project phase	Management measures	Number
Soil erosion	Construction	**Sediment, Erosion and Water Quality Management Plan** 1. Prior to the commencement of construction, develop and implement a Sediment, Erosion and Water Quality Management Plan as a sub-plan to the Construction Environmental Management Plan [EMM01] in consultation with Glenelg Hopkins Catchment Management Authority in accordance with EPA Publication 1834.2: Civil construction, building and demolition guide. 2. Erosion and sediment control measures within the construction site will adopt a treatment train approach and include: a. monitoring surface water quality upstream and downstream of the works area during detailed planning, construction and operation phases to confirm control effectiveness and protection of environmental values b. phasing ground-disturbing works to periods of lower rainfall, where possible c. minimising vegetation clearance, particularly along drainage lines, waterways and steep slopes d. reinstating vegetation in accordance EMM LS02 e. maintaining watercourse and wetland buffers (except at watercourse crossings) and implementing management controls for works near waterways in accordance with EPA Publication 1894: Managing soil disturbance f. installing primary, secondary and tertiary sediment control measures based on site-specific hazards, consistent with Publication 1893: Erosion, sediment and dust: treatment train g. designating areas for stockpiles prior to construction, ensuring stockpiles and batters have slopes no greater than 2:1 (horizontal/vertical) h. implementing stockpile management controls consistent with EPA Publication 1895: Managing stockpiles and establishing vegetation or grass on stockpiles to be left for longer periods i. stabilising exposed soils and applying soil disturbance controls in accordance with EPA Publication 1894: Managing soil disturbance j. installing sediment fencing to protect riparian zones where works occur within 30 metres of waterways k. installing sediment treatment controls (including around stockpiles) to adequately capture sediment loads l. restricting vehicle movements to designated roads and access areas m. directing stormwater through constructed lined channels or sediment basins to reduce runoff velocity n. developing contingency measures for works within waterways or floodplains, including controls to be implemented when storm events are forecast.	SW04
	Construction Operation	**Revegetation of disturbed areas** 1. Undertake revegetation of disturbed areas as quickly as practicable to limit erosion, instability and the generation of sediment. This will include: a. planting locally occurring native shrubs, trees and groundcover plants, selected in consultation with the Department of Energy, Environment and Climate Action, to recreate the target vegetation community b. incorporating rocks, logs, dead trees and stumps in the restoration and rehabilitation works to provide fauna habitat c. maintaining plantings in accordance with the rehabilitation sub-plan d. managing weeds and pest animals.	LS01

Landform and soils impact	Project phase	Management measures	Number
Waste or hazardous soils	Construction	**Acid Sulfate Soil Management Plan** 1. Prior to the commencement of construction, develop and implement an Acid Sulfate Soil Management Plan as a sub-plan of the Construction Environmental Management Plan [EMM01], following a risk-based approach to management of potential acid sulfate soil, actual acid sulfate soil and potentially contaminated soils in accordance with the National Acid Sulfate Soils Guidance series, Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils (Department of Sustainability and Environment, 2010), and EPA Victoria Publication 655.1: Acid sulfate soil and rock. This will include, but is not limited to: a. identification of high-risk locations through mapping and soil testing b. targeted measures at high-risk locations, including requirements for the handling and stockpiling of material, protocols to neutralise soil acidity, monitoring and contingencies. 2. If acid sulfate soil or contaminated soil is encountered it would be managed as a priority waste in accordance with EPA Victoria Publication 1968: Guide to classifying industrial waste.	LS02
	Construction	**Construction Environmental Management Plan - Discharge of collected water** 1. To minimise the risk of surface water contamination, water collected during quarry and foundation excavation dewatering activities will only be discharged to the environment in accordance with the Environment Protection Regulations 2021 and the following management measures, which would be documented in the Construction Environmental Management Plan [EMM01]: a. assessing the quality of groundwater to be disposed (in accordance with GW04) b. assessing the baseline quality of waterways that have the potential to receive collected water to determine the potential impact (in accordance with SW04) c. conducting a risk assessment in accordance with EPA Publication 1287: Guidance for environmental and human health risk assessment of wastewater discharges to surface waters, identifying management controls to prevent impacts to the environmental values of the waterway so far as reasonably practicable d. applying for EPA permission, if required under the Environment Protection Regulations 2021 e. implementing sediment control devices, where required.	SW05
	Construction	**Spoil Management Plan** 1. Prior to the commencement of construction, develop and implement a Spoil Management Plan as a sub-plan of the Construction Environmental Management Plan [EMM01], based on the soil re-use requirements of the project.	LS03

13.7.4 Residual impacts

Following the development of design measures and development of management controls, an assessment of residual effects and impacts was completed describing the changes to the environment brought about by the construction, operation and eventual decommissioning of the project and rating the significance of these effects.

Modification to landform

Based on other wind farm developments in Victoria, changes to the existing landform from the proposed project infrastructure are anticipated to be minor. As the project site is predominately flat, construction of access tracks and hardstand areas is unlikely to require high cut and fill batters. Generally, access tracks would be built slightly above the surrounding ground surface to be above defined flood levels and assist with surface drainage. Impacts associated with excavations for wind turbines other structure foundations and underground cable trenches would be short-term and temporary. While the excavation of the proposed on-site quarry would have a longer-term impact on the existing landform, rehabilitation of the quarry site post-closure (as specified in the Quarry Work Plan [EMM07]) is expected to limit impacts on the landform.

Batters: refers to the sloped sides of an excavation or embankment. A cut batter is created when material is removed to lower the surface level, while a fill batter is created when material is added to raise the surface level.

The angle of the batter is often determined by the type of soil and the project's requirements, and helps to stabilise the slope.

There is no infrastructure proposed within the mapped extent of the site of geological significance, Limestone Creek Complex. However, one wind turbine is proposed within approximately 50 metres of this site.

Unstable soils

Depending on the thickness of the residual clay at some locations it may be necessary to extend the excavation depth to the top of basalt rock. Investigations will be required at each wind turbine location to determine the depth of rock and engineering characteristics of the material [LSD01]. Piles may be required or the dimensions of shallow footings increased if residual basaltic clay at the proposed founding level is determined to have low strength.

Excavations for the wind turbines may encounter groundwater, which may require the dimensions of the concrete footing to be increased. The depth to groundwater would be established prior to construction through the installation and monitoring of groundwater monitoring wells.

High plasticity clay soils associated with the Newer Volcanics are potentially highly reactive and significant shrink-swell movements may occur due to seasonal changes in the soil moisture content. Impacts from highly reactive clays can be mitigated by factoring in the potential for movement with changes in moisture content when undertaking construction. This may include the use of lime and/or cement to stabilise the soil, and undertaking earthworks during drier conditions.

Soil erosion

The potential for soils to erode generally depends on the grading of the soil (i.e., the proportion of clay, silt, sand and gravel) and its organic content. Silt and fine sands tend to erode more readily eroded than clays, coarse sands or gravels, while soils supporting vegetation are typically less susceptible to erosion. As the soils within the project site are primarily basaltic clay, they are likely to have low susceptibility to erosion. However, erosion of the topsoil may occur following removal of vegetation.

Most of the project site has minimal evidence of surface erosion, and wind turbines are proposed to be located away from soils identified as having a higher risk of erosion risk (i.e., low lying swampy areas). The Sediment, Erosion and Water Quality Management Plan [EMM SW04] would contain measures to minimise surface disturbance, and would require the installation of appropriate sediment controls and reinstatement of vegetation as quickly as practicable as open cut trenching works are completed.

Given the generally flat landscape of the project site, and assuming the adoption of best-practice measures such as protection of exposed cut and fill batter slopes, drainage controls and the implementation of silt fences where required, erosion of cut and fill batters is not considered a significant issue for the project.

Waste or hazardous soils

Acid sulfate soil

Some access tracks and underground cabling are proposed in areas mapped as having a high probability of encountering acid sulfate soils. An Acid Sulfate Soil Management Plan [EMM LS02] would be developed, as part of the Construction Environmental Management Plan, and would include implementing targeted measures at high-risk locations such as the handling and stockpiling of material, and protocols to neutralise soil acidity.

Groundwater extraction via pumping (termed 'dewatering' of the excavation) for the installation of wind turbines and underground cables, if required, would be limited in duration and extent at tower footings and locations of shallow cable trenching. These temporary periods of dewatering would limit the potential for acid sulfate soils to form. Following construction, groundwater levels are expected to recover and re-submerge potential acid sulfate soils and actual acid sulfate soils.

The proposed on-site quarry is not located in an area identified as potential acid sulfate soils, actual acid sulfate soils, and the underlying basaltic soils and rock are not considered to be potential acid sulfate material. As the proposed quarry excavation depth extends below the water table level, dewatering is expected to be needed for this site during operation. This would be managed under a Take and Use Licence, to be approved by Southern Rural Water as the delegated authority under the *Water Act 1989* [EMM SW05].

Saline and sodic soil

The landform and soils impact assessment identified that risks related to saline and sodic soils, including from an increase discharge of saline groundwater, are low. Significant vegetation removal is not proposed and the use of water for construction is likely to be relatively minor in comparison to current water usage for farming purposes.

The quality of water collected during dewatering of excavations would be monitored for salinity to determine the appropriate disposal method [EMM LS07 and LS08].

Contaminated soil

The land within the project site has predominantly been cleared for grazing, with some areas of cropping present. Soil contamination may be present due to the application of herbicides and fertilisers for these agricultural practices. However, the potential for contaminated soil to be encountered during construction works is considered low, and excavated soils are likely to be suitable for reuse within the project site (e.g., for backfilling of cable trenches). Any soil to be disposed would be defined as 'Industrial Wastes' and would require characterisation in accordance with EPA Victoria Publications 1827.2 Waste classification assessment protocol and 1828.2 Waste disposal categories – characteristics and thresholds. A Spoil Management Plan [EMM LS03] would identify soil reuse and disposal options, where required.

13.7.5 Impact assessment summary

A summary of the landform and soils residual impact assessment is shown in Table 13.6 with the full assessment presented in Appendix A –***Soil and Landform Assessment.***

Table 13.6 Landform and soils impact assessment summary

Potential impact pathway	Project phase	Likely impact (magnitude, extent and duration)	Mitigation	Significance rating and justification
Modifications to the existing landform from excavation and civil engineering works	Construction, operation and decommissioning	Impacts to the existing landform would be limited to within the project site boundary and would occur for the life of the project. Excavations for foundations and underground cable trenches would be temporary and short-term in duration.	• Quarry Work Plan would include details of how the quarry would be constructed, operated and decommissioned [EMM07].	Low Impacts would be limited to within the project site boundary for the life of the project.
Unstable soils or shallow groundwater, affecting foundations for wind turbines and other structures	Construction and operation	Construction on unstable soils or within areas of shallow groundwater may cause ground settlement, damage to wind turbines and/or instability of project structures. Impacts would be limited to within footprint of wind turbines for the duration of the project.	• Geotechnical investigations would be undertaken prior to construction to determine geotechnical conditions [LSD01] • Based on the geotechnical conditions, the detailed design would consider measures such as appropriate footing design and depths, and footing dimensions if groundwater is encountered.	Very low Assuming an appropriate design and construction methodology is adopted, the significance of impacts associated with unstable soils or shallow groundwater are considered very low.
Unstable soils or shallow groundwater, affecting preparation of access road pavements and hardstand areas	Construction and operation	Preparation of access road pavements and hardstand areas may be problematic where surface drainage paths or ponded water are present in areas of highly reactive clays. Should preparation of access road pavements and hardstand areas occur during the wetter months of the year it may result in poorer performance of the surface beneath these areas, and increased ongoing maintenance of roads and access tracks. Impacts would be short- to long-term, restricted to areas below access road pavements and hardstand areas.	• Reactive clays can be mitigated through construction practices such as stabilisation with the inclusion of lime and/or cement • Where possible, undertake earthworks during the drier months of the year.	Low to medium With the implementation of recommended management measures, the significance of impacts associated with the preparation of access road pavements and hardstand areas are considered low to medium (as construction during dry weather is not always possible).

Potential impact pathway	Project phase	Likely impact (magnitude, extent and duration)	Mitigation	Significance rating and justification
Erosion of exposed soils	Construction, operation and decommissioning	Most of the project site has minimal evidence of surface erosion, and wind turbines are proposed to be located away from soils identified as having a higher erosion risk. Impacts would be short- to long-term, restricted to the location of earthworks and the on-site quarry.	• Appropriate erosion and sediment control measures would be implemented as per the requirements of the Sediment, Erosion and Water Quality Management Plan [EMM SW04] • Disturbed areas would be revegetated [EMM LS01] • Quarry Work Plan would include details of how the quarry would be constructed, operated and decommissioned [EMM07].	Very low to low With the implementation of recommended management measures, the significance of impacts from soil erosion are considered very low to low.
Exposure and disposal of acid sulfate soils	Construction	Some access tracks and underground cabling are proposed in areas mapped as having a high probability of encountering acid sulfate soils. Impacts would be limited to excavation areas but may also impact surrounding waterways if acidification of the groundwater occurs. The proposed on-site quarry is not located in an area identified as having potential acid sulfate soils or actual acid sulfate soils.	• Acid Sulfate Soil Management Plan [EMM LS02] • Site-specific soil testing will be required to assess for potential acid sulfate soils and actual acid sulfate soils • Water collected dewatering of excavations would be managed in accordance with the Environment Protection Regulations 2021 and tested to determine the appropriate disposal method [EMM SW05].	Low With the implementation of recommended management measures, and if potential or actual acid sulfate soils are not detected during soil testing, the significance of impacts from acid sulfate soils are considered low.
Exposure and disposal of saline and sodic soils	Construction, operation and decommissioning	Wind turbines are not proposed to be constructed on soils identified as having a high erosion risk.	• Appropriate erosion and sediment control measures would be implemented as per the requirements of the Sediment, Erosion and Water Quality Management Plan [EMM SW04] • Disturbed areas would be revegetated [EMM LS01].	Low With the implementation of recommended management measures, the significance of impacts from saline and sodic soils are considered low.

Potential impact pathway	Project phase	Likely impact (magnitude, extent and duration)	Mitigation	Significance rating and justification
Exposure and disposal of contaminated soil	Construction	The potential for contaminated soil to be encountered during construction works is considered low. Excavated soils are expected to comprise largely natural or re-worked natural soils and are therefore likely to be suitable for reuse on the site.	• Spoil Management Plan is required to identify soil reuse and disposal options [EMM LS03] • Contaminated soil, if encountered, would be managed as a priority waste in accordance with EPA Victoria Publication 1968: Guide to classifying industrial waste [EMM LS02].	Low The risk of encountering contaminated soils is low.

13.8 Conclusions

The landform and soils context of the project site was characterised, and the potential effects of the project on soil stability, erosion and the exposure and disposal of any waste or hazardous soils assessed.

The construction of the project has the potential to impact existing landforms and result in soil-related issues from earthworks for wind turbine foundations, cable trenches, on-site quarry development, and construction of access tracks and hardstand areas.

Measures to manage potential impacts to landform and soils would be carried out during the detailed design, construction, operation and decommissioning phases. With the incorporation of recommended management measures, the significance of impacts to landform and soil values are predominately considered to be very low or low. However, should preparation of access road pavements and hardstand areas occur during the wetter months of the year, surface drainage paths or ponded water may result in poorer performance of the surface beneath these areas and lead to increased ongoing maintenance of roads and access tracks. As construction during dry weather is not always possible, the significance of impacts associated with the preparation of these areas are considered low to medium.