WIND PROSPECT

ENERGY FORMS

WILLATOOK WIND FARM

Planning Application Report

Appendix G Hydrology and hydrogeology

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Willatook Wind Farm Hydrogeological and Hydrological Investigation

Willatook Wind Farm Pty Ltd

20 April 2022

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

EXECUTIVE SUMMARY

Willatook Wind Farm Pty Ltd commissioned Water Technology to conduct groundwater and surface water investigations and to assess potential impacts to ground and surface water values as a result of proposed Willatook Wind Farm, located in south western Victoria. The proposed wind farm consists of 59 wind turbines, supporting ancillary infrastructure including an on-site quarry.

The proposed development area is located in south west Victoria, approximately 22 kilometres north of Port Fairy, 32 kilometres northwest of Warrnambool and extends across both sides of the Woolsthorpe–Heywood Road. The development area is spread across the Eumeralla-Shaw River and Moyne River catchments, within the Glenelg Hopkins Catchment Management Authority (GHCMA) management area. Much of the site is low lying and has a poorly defined natural drainage systems with some constructed drainage. The Moyne River and Shaw River are the two most major waterways flowing through and near to the site, with Back Creek a tributary of the Moyne River also flowing through the east of the site. Land use within development area and upstream catchments is a mixture of private and public land that is largely used for agriculture, predominantly sheep and cattle grazing with some cereal and fodder crops.

It is likely that surface water bodies may be gaining and losing in different reaches and that this will change according to the season. The existing hydrogeological environment consists of undulating volcanic plains of variably weathered Newer Volcanic Group overlying the Port Campbell Limestone. This basalt is variably fractured and weathered, which leads to a complex relationship between surface water and groundwater.

A baseline understanding of the existing environment was determined through a review of the existing surface and groundwater information, including a review of the available climatic, topographic, groundwater and surface water data. This enabled a characterisation of the existing surface water and groundwater systems though detailed investigation and modelling.

Surface and groundwater investigations were undertaken and included:

- Surface water
  - Flood modelling of the Moyne River, Shaw River, Back Creek and all areas within the Willatook Wind Farm development area.
  - An assessment of 1% and 10% AEP flood depth at the proposed turbine locations.
  - Calculation of 1% and 10% AEP flow rates at each of the proposed waterway crossing locations.
  - Water balance modelling at the temporary on-site quarry.
- Groundwater
  - Characterisation of the site geology.
  - Preparation of a hydrogeological conceptual model and groundwater level maps.
  - Consideration of groundwater quality.
  - Estimation of inflow rates and drawdown around the temporary on-site quarry.

Characterisation of the existing site conditions enabled identification of potential impact pathways. The most relevant surface and groundwater pathways were identified as:

The impact pathways relevant to WWF are changes to streamflow hydrology (flow rate and volume) and water quality. More specifically they include:

- Surface Water
  - Hydrological changes to surface water flows due to:

- Project infrastructure with the introduction of impermeable surfaces – turbines and hardstands.
- Physical disturbance - waterway crossings for tracks and cables.

- Water quality reductions (e.g., turbidity, dissolved oxygen) due to:
  - Surface water runoff (erosion) and sedimentation due to stockpiles and earthworks for infrastructure, tracks and hardstands.
  - Damage to stream beds and banks leading to surface water runoff (erosion) and sedimentation - waterway crossings for tracks and cables.
  - Disposal of poor quality into waterways or waterbodies - collected during construction of turbines and hardstands.
  - Accidental spills of hazardous waste during construction and operation.
  - Uncovering of acid sulfate soil during earthworks for infrastructure, tracks and hardstands.

- Groundwater
  - Dewatering of groundwater during construction and lowering the water table resulting in groundwater drawdown that affects water availability.
  - Disruption of groundwater recharge and flow, such as from introduction of impermeable surfaces and physical barriers in the form of wind turbine foundations.
  - Disruption of groundwater discharge to waterways or waterbodies by intersecting groundwater discharge water features (e.g., natural springs) or from a reduction in groundwater availability (e.g. due to dewatering).
  - Groundwater contamination, including from accidental spills or formation of acid sulfate soils.

An assessment and quantification of the potential impact pathways assisted in determination of proposed mitigation measures and management controls which may be used to reduce impacts. This was followed by an assessment of residual impacts.

Construction and operation of the project has the potential to impact surface water systems and supporting environmental values through distinct impact pathways, which may result in lowering of the watercourse crossings, reduced water quality and altered flows.

Flood behaviour within the project catchments was used to inform the siting of infrastructure to avoid areas of potential flooding. Other design mitigations include designing the project with buffers around all mapped wetlands, and minimisation of watercourse crossings through siting of access tracks. Assuming detailed designs have been completed in accordance with best practice guidelines and in consultation with relevant authorities the residual effects of watercourse crossings and to a lesser extent reduced water quality from construction works were assessed to be localised and temporary.

Construction and operation of the project also has the potential to impact groundwater in near-surface Newer Volcanic Group basalts and supporting environmental values through distinct and localised impact pathways, which may result in localised lowering of the water table, altered groundwater recharge and flows, and reduced water quality.

To minimise the potential for the Project to impact local GDEs, the design has incorporated a minimum 100 m buffer from aquatic ecosystems and 25 m buffer from terrestrial systems when placing turbine foundations. The quarry site has been located away from sensitive receptors, including groundwater bores and mapped potential GDEs.

Management measures have been proposed for the construction, operational and decommissioning phases of the project to further manage potential groundwater impacts. With the implementation of these measures, the impacts to groundwater users and groundwater quality were considered to range from negligible to low.

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GLOSSARY AND ABBREVIATIONS

Term	Definition	Abbreviation
Action/Activity	Part of the project, such as installing infrastructure in a certain manner, that may have an impact on receptors	
Acid Sulfate Soils	Acid sulphate soils are natural sediments that contain iron sulphides. However, if the soils are drained, excavated or exposed to air by a lowering of the water table, the sulphides react with oxygen to form sulfuric acid	ASS
Assess	To consider an action and the likely effects of that action	-
Annual Exceedance Probability	The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.	AEP
Australian Height Datum	The datum that sets mean sea level as zero elevation.	AHD
Average Recurrence Interval	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration.	ARI
Beneficial Uses	Specific environmental values/receptors/assets protected by legislation. These may include environmental matters such as natural resources or ecosystems. SEPP (Waters) refers to Beneficial Uses which has been updated to Environmental Values in the Environmental Reference Standard.	-
Department of Environment, Land, Water and Planning	Department of Environment, Land, Water and Planning	DELWP
Design Flood	A significant event to be considered in the design process; various works within the floodplain may have different design event requirements. E.g., some roads may be designed to be overtopped in the 1 in 10 year or 10% AEP flood event.	-
Digital Elevation Mode	A bare-earth elevation model of the earth's surface, with features such as vegetation, bridges and roads filtered out	DEM
Digital Terrain Model	A DTM is a mathematical representation of the ground surface. A DTM augments a DEM by including linear features of the bare-earth terrain	DTM
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.	-
Effect	The outcome of an event or a circumstance that is likely to occur. It may be caused directly or indirectly by an action. It can also be termed a consequence. The significance of the effect may vary.	-
Environment Effects Statement	Statement required under the Environment Effects Act (1978)	EES
Environmental Management Framework	The framework setting the limits and objectives for the scope of the EES prepared by WWF	EMF

Term	Definition	Abbreviation
Environmental Value	Particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits	-
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.	-
Flood Frequency Analysis	A technique to predict flow values corresponding to specific return periods or probabilities along a watercourse or flow path	FFA
Foundation	A 12.5 m radius, 3.0 m deep excavation filled with impervious material used as a foundation for a turbine tower. While groundwater may be dewatered from the excavation, these are not classed as bores.	Foundation
Glenelg Hopkins Catchment Management Authority	The Glenelg Hopkins Catchment Management Authority	GHCMA
Groundwater dependent ecosystems	Flora and fauna relying on a groundwater source to survive	GDEs
Groundwater flow systems	Local, intermediate and regional groundwater flow systems described by GHCMA and documented in Dalhaus et. al 2002	GFS
Hydrograph	A graph that shows how discharge changes with time at any particular location.	-
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs.	-
Impact	An adverse effect	-
Intensity Frequency Duration	An intensity-duration-frequency curve is a mathematical function that relates the rainfall intensity with its duration and frequency of occurrence	IFD
Light Detection and Ranging	A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth	LiDAR
Matter of national environmental significance	Listed threatened species or ecological community	MNES
metres Australian Height Datum	Elevation of point relative to National datum	mAHD
metres below natural surface	Depth the natural ground level	mBNS
Milligram per litre, Total Dissolved Solids	The measure of the salinity of water, by the conversion of the measured electrical conductivity of the water,	mg/L (TDS)
Moyne Shire Council	Moyne Shire Council	Shire
Peak Flow	The maximum discharge occurring during a flood event.	-
Potential Acid Sulphate Soils	ASS which has not been oxidised by exposure to air	PASS
Receptors	Entities that may be impacted by a water affecting activity, such as GDEs or people. Also termed values or assets.	-
Reduced water level	The water level reported to a common datum; in this case m AHD	RWL

Term	Definition	Abbreviation
Risk	A description of the effects of an action	-
Regional Flood Frequency Estimation	Methods used to estimate design floods in ungauged and poorly gauged catchments. It is a data-based empirical procedure which attempts to compensate for the lack of temporal data at a given location by spatial data	RFFE
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.	-
Salinity Management Overlay	Areas mapped by the CCMA as land requiring salinity management for infrastructure and farming	SMO
Significance	The relevance of an effect on the values held by a stakeholder. Significant matters are usually protected by legislation or raised by stakeholders during consultation.	-
Southern Rural Water	Southern Rural Water	SRW
Stakeholders	Entities potentially affected by the proposed activities, represented by the GHCMA, Shire, DELWP, SRW groups	Stakeholders
State Environment Protection Policy (Waters) 2018	Legislation governing [principles of environment protection, and guidance on the protected values of groundwater and inland waters	SEPP (Waters)
Static/standing water level	The natural water table water level in a bore, measure as metres below natural surface	SWL
State observation bore network	Bores used to monitor groundwater data across Victoria	SOBN
Willatook Turbine	Unique turbine identification number	WTG
Willatook Wind Farm Pty Ltd	Willatook Wind Farm Pty Ltd, the proponent	WWF

1 INTRODUCTION

Willatook Wind Farm Pty Ltd (WWF) engaged Water Technology to investigate the potential groundwater and surface water changes from a proposed wind farm at Willatook, 30 km north of Port Fairy, in southwestern Victoria (Figure 1). The proposed wind farm is located within an area of private and public land that is largely used for agriculture, predominantly sheep and cattle grazing.

The proposed wind farm would harness strong and reliable winds to generate renewable energy through the construction and operation of up to 59 wind turbines generators (WTGs) and would operate for a period of at least 25 years following a two-year construction period. Other infrastructure would include an on-site quarry, a battery energy storage system (BESS) and an operations and maintenance (O&M) facility.

1.1 Purpose and scope

The purpose of this report is to provide an assessment of likely effects to surface and groundwater as a result of the proposed wind farm to support the project's Environmental Effects Statement (EES).

The scope of the report includes:

- Characterisation of the existing site conditions and available background data.
- Identification of potential impact pathways
- Assessment and quantification of the potential impact pathways.
- Proposal of mitigation measures and management controls which may be used to reduce impacts.
- Assessment of residual impacts.

This report considers planned activities associated with the construction, operation and decommissioning of development concept and is intended to be used to both inform the approval and future design process. Early stages of the assessment informed the planning and the infrastructure layout to avoid and minimise potential impacts to the environment and community.

1.2 Overview of the study area

The proposed WWF development area is located in south west Victoria, approximately 22 kilometres north of Port Fairy, 32 kilometres northwest of Warrnambool and extends across both sides of the Woolsthorpe–Heywood Road. The development area is spread across the Eumeralla-Shaw River and Moyne River catchments, within the Glenelg Hopkins Catchment Management Authority (GHCMA) management area. Much of the site is low lying and has a poorly defined natural drainage systems with some constructed drainage. The Moyne River and Shaw River are the largest waterways in the site, with Back Creek a tributary of the Moyne River also flowing through the east of the site. Land use within development area and upstream catchments is a mixture of private and public land that is largely used for agriculture, predominantly sheep and cattle grazing with some cereal and fodder crops.

The Project is located on the southern margin of the Western Volcanic Plain. This volcanic region is part of a broad basaltic lava province active over the past six million years and referred to as the Newer Volcanic Province, a major geological unit of southern Australia.

The surface geology within the Project area predominantly consists of the Newer Volcanic Group basalt flows. The depth to groundwater within the Newer Volcanic Group basalts varies both spatially and seasonally, influenced by rainfall and longer-term climatic conditions. In general, groundwater is shallow across the Project Site, estimated to be between 1 to 12 metres below ground level. Localised areas of shallow groundwater (less than 3 metres below ground level) are likely to occur, particularly in topographic lows.

Detailed context on the existing environment is provided in Section 2; however, the values relevant to water are extracted into Table 1. The likely processes in the study area affecting these values are the focus of this study.

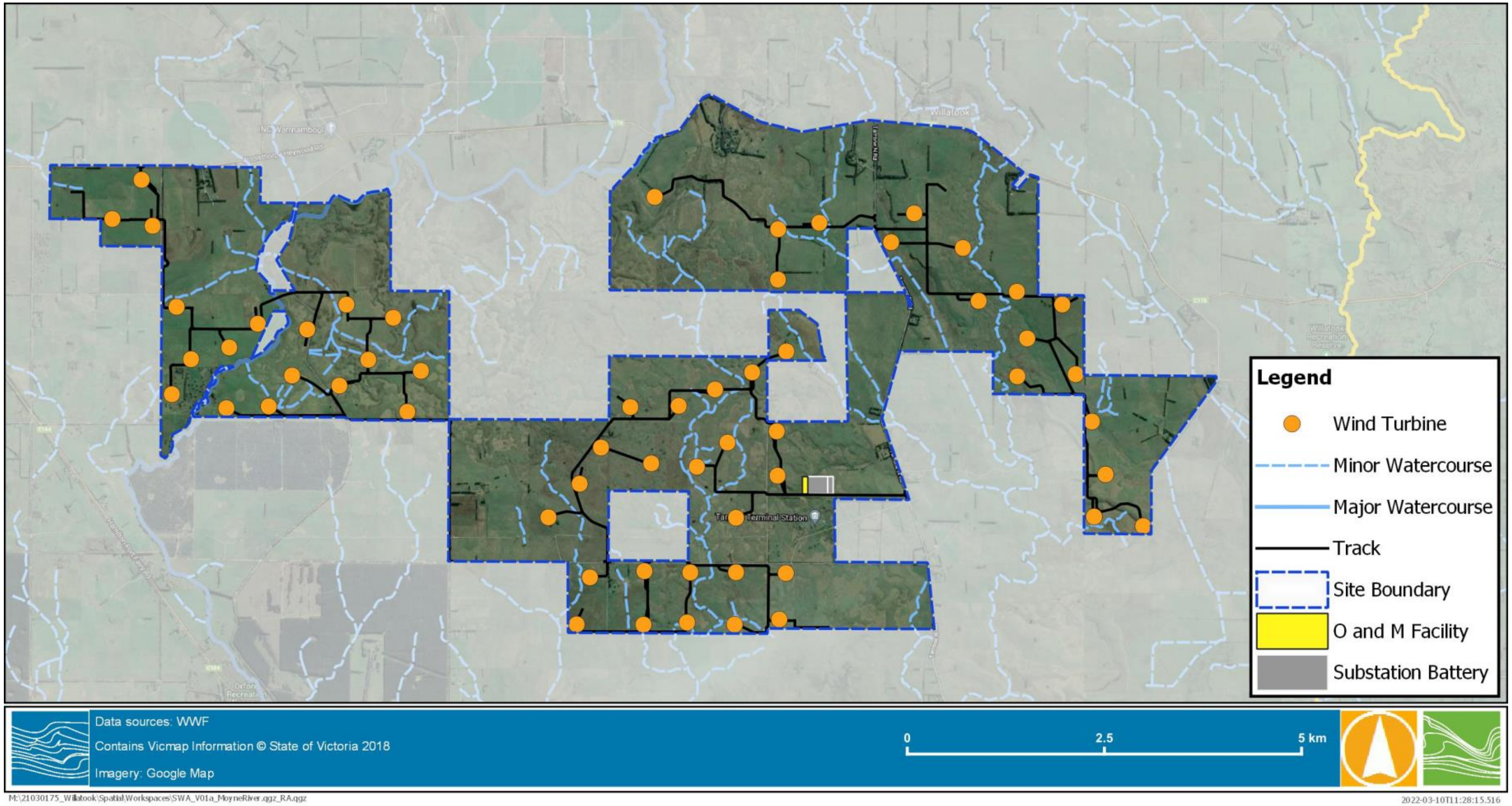

FIGURE 1 SITE MAP SHOWING WATERWAYS, PLANNED SITE BOUNDARY AND TURBINES

1.3 EES Scoping Requirements

The EES Scoping Requirements specific to Catchment Values and Hydrology are shown in Table 1.The analysis in this report feeds into other specific specialist reports addressing the Biodiversity and Habitat and Land use and socioeconomic scoping requirements.

TABLE 1 ENVIRONMENTAL OBJECTIVES, KEY ISSUES AND LIKELY EFFECTS, MODIFIED FROM THE EES SCOPING REQUIREMENTS (2019)

Key Issues	Existing environment	Like effects	Design and mitigation	Performance objectives
Catchment values and hydrology - Potential for the project to have a significant effect on surface water and/or groundwater and its beneficial uses, including through the temporary on-site quarry.				
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 Potential for the project to have a significant effect on surface water and/or groundwater and its environmental values, including through the temporary on-site quarry. Potential for the project to have significant impact on wetland systems, including, but not limited to, Seasonal Herbaceous Wetlands (EPBC Act listed community), and the ability for wetland systems to support habitat for flora species listed under the FFG Act and EPBC Act.	Characterise the groundwater (including depth quality and availability to licence/ use) and surface water environments and drainage features in the project area. Characterise the wetland systems in and around the project site and the type, distribution and condition of wetlands that could be impacted by the project, having regard to terrestrial and aquatic habitat and habitat corridors or linkages. Characterise soil types and structures in the study area and identify the potential location of acid sulphate soils, including hydrological requirements and their acceptable limits for change.	Assess the potential effects of the project on surface water and groundwater environments and environmental values, including on permanent and ephemeral wetland systems (both on-site and adjacent to the proposal), and surface water and groundwater flow and quality. Identify and assess potential effects of the project on soil stability, erosion and the exposure and disposal of any waste or hazardous soils.	Identify proposed measures to mitigate any potential effects, including any relevant design features or preventative techniques to be employed during construction.	Describe proposed measures to manage and monitor effects on catchment values and identify likely residual effects. Describe contingency measures for responding to unexpected impacts resulting from disturbed acid sulphate soils.

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1.3.1 Legislation

Legislation relevant to the EES Scoping Requirements are shown in Table 2.

TABLE 2 ACTS RELEVANT TO DRAFT EVALUATION OBJECTIVES

Legislation / policy	Key policies / strategies	Implications for water at the project	Acronym
Catchment and Land Protection Act 1994	Provides a framework for the integrated management and protection of catchments	Considers adverse groundwater effects due to extraction on receptors Guidance for works on waterways	C&LP Act
Environment Effects Act 1978	Provides a framework for investigation of projects that may significantly affect the environment	Provides a framework for investigation under a range of outcomes Requires methods for mitigating adverse environmental effects and risks The Minister will assess this project against the Act	EE Act
Environment Protection Act 1970 & 2017	Established the legislative framework for protecting the environment in Victoria	Regulations regarding protection of environmental values including the beneficial uses for and of the environment ensuring the project demonstrates its implementing measures so far as 'reasonably practicable' to meet the general environmental duty	EPA Act
Environmental Reference Standard (2021)	Principles of environment protection	Environment Reference Standard (ERS) incorporated State Environment Protection Policy (Waters) (SEPP (Waters)) in 2021. ERS includes environmental values, indicators and objectives	ERS
Flora and Fauna Guarantee Act 1988	Protect threatened species	Examine potential effects on biodiversity and ecological values	FFG Act
Planning and Environment Act 1987	Establishes a framework for planning the use, development and protection of land	Identifies areas of significance. Considers adverse groundwater effects due to extraction on ecological receptors	P&E Act
Water Act 1989 (Vic)	Provides the legal framework for managing Victoria's water resources	Authorises Catchment Management Authorities (CMAs) various powers for the control, management and authorisation of works and activities in or over designated waterways in the CMA's waterway management district.	W Act
Extractive Industries Development Act 1995	Requires the extractive industry to meet safe operating standards and ensures rehabilitation of quarried land to an appropriate, stable landform.	Enables the Earth Resources Regulator to oversee the operation of the quarry	EID Act
Water (Irrigation Farm Dams) Act 2002	Water Act 1989 Guidelines for Quarries and Mines 2004	Regulates the management of farm dams (the decommissioned quarry pit)	W (IFD) Act

Legislation / policy	Key policies / strategies	Implications for water at the project	Acronym
Environment Protection and Biodiversity Conservation Act 1999	Protect significant species	Significant species on site to be protected by DELWP under the bilateral agreement	EPBC Act

The Environment Protection and Biodiversity Conservation Act (1999) enables the Australian Government to legislate environment and heritage protection and biodiversity conservation. It refers responsibility to the states for matters that are not of national environmental significance. The wind farm proposal was viewed as a controlled action under the EPBC Act (1999) and hence requires investigation and approval under the Act. The relevant provisions under the Act are listed threatened species and ecological communities which are Matters of National Environmental Significance (MNES). The findings from this report have informed the assessment of MNES by Nature Advisory.

Southern Rural Water (as the delegated authority under the *Water Act 1989*) confirmed that an approval to Take or Use groundwater would not be required for dewatering where groundwater will not be intentionally encountered (A. Ramsay pers. comm. 10/7/19). WWF will apply for a Take and Use Licence to dewater the quarry. Permits and any associated investigations will be required if groundwater is targeted as a water supply.

The Environment Reference Standard (ERS) incorporated State Environment Protection Policy (Waters) (SEPP (Waters)) in 2021. The ERS sets a statutory framework for the protection of uses and values of Victoria's fresh and marine waters. The ERS (Water) aims to ensure that catchments, rivers and coasts are managed in an integrated manner so that actions in the catchment do not have detrimental impacts on water quality in fresh and marine environments. To achieve this, ERS identifies protected environmental values and sets out a series of environmental water quality objectives and indicators to ensure the environmental values of waters are protected.

The ERS refers to environmental values, whereas SEPP (Waters) refers to beneficial uses. While the ERS is the most updated reference, in some parts of the report there is reference to beneficial uses as the base data refers to SEPP (Waters) definitions e.g. Visualising Victoria's Groundwater database.

1.3.2 Guidelines and Standards

Several guidance documents and standards were used in the development of this report. These are outlined in Table 3

TABLE 3 RELEVANT GUIDELINES AND STANDARDS GUIDING THE ASSESSMENT

Source	Description	Implications for water at the project
Glenelg Hopkins Catchment Management Authority	The Glenelg Hopkins Catchment Management Authority has developed the following relevant strategies: • 'Glenelg Hopkins Waterway Strategy 2014-2022', which provides a single planning document for river, estuary and wetland management in the region. • 'Glenelg Hopkins Regional Floodplain Management Strategy 2017', which seeks to improve management and reduce flood risks across the region. The revised Glenelg Hopkins Catchment Management Authority 'Regional Catchment Strategy (2013-2019)' is currently under development.	The project is located within the Glenelg Hopkins Catchment Management Authority boundary. Works would be undertaken in accordance with Glenelg Hopkins Catchment Management Authority Works on a Waterway permit licence requirements.
Australian and New Zealand Governments (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality	The Australian and New Zealand Guidelines for Fresh and Marine Water Quality were prepared as part of Australia's National Water Quality Management Strategy, and contain guidelines for water and sediment chemical and physical parameters, and biological indicators to assess water quality. The key aim of the guidelines is to develop management frameworks for protecting environmental values of water resources in Australia and New Zealand.	Where indicators and objectives are not prescribed in the ERS, trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems (lowland rivers) were used in the assessment of water quality.
EPA Victoria (2020) Publication 1834 Civil construction, building and demolition guide	Outlines controls for civil construction and earthworks to manage risks and obligations under the general environmental duty in relation to air, noise, land and water. This includes controls regarding the management of stormwater flows, stockpiles, works within waterways, and storage and handling of chemicals.	Measures for the management of surface water developed in accordance with controls contained in EPA Victoria Publication 1834.
EPA Publication 668: Hydrogeological Assessment (Groundwater Quality) Guidelines	Describes a Hydrogeological Assessment (HA) as a process to determine any existing groundwater contamination and resulting risk to beneficial uses of groundwater, and any potential risk to groundwater quality and beneficial uses	Provides guidance on assessment of potential groundwater related impacts.
EPA Victoria (2020) 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 considered the treatment train an approach have been proposed.

Source	Description	Implications for water at the project
EPA Victoria (2020) 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 (2020) Publication 1896 Working within or adjacent to waterways	Provides information about how to eliminate or reduce the risk of harm from erosion, sediment and dust when working within or adjacent to waterways.	Measures for conducting works within or adjacent to waterways have been proposed.
Western Region Sustainable Water Strategy (Department of Sustainability and Environment 2011)	The Western Region Sustainable Water Strategy (Department of Sustainability and Environment 2011) identifies actions to ensure sustainable water supply and management during the next 50 years for the Western Region of Victoria. A key action of the strategy is to improve groundwater management, including: • 'Using a risk-based approach to consider the needs of groundwater dependent ecosystems in management decisions. Protecting the health of groundwater resources with long-term, viable and cost-effective groundwater monitoring.'	The project is within the Portland Coast region river basin and the 'South-west Coast' sub-region identified in the Western Region Sustainable Water Strategy. The approach to considering the needs of groundwater dependent ecosystems and protecting the health of groundwater.
South West Limestone Local Management Plan (Southern Rural Water 2016)	The South West Limestone Local Management Plan (Southern Rural Water 2016) seeks to ensure the groundwater resources in the south-west Victorian upper mid-Tertiary limestone aquifer (referred to as the South West Limestone Groundwater Management Area) are sustainably managed. This management area replaces former management units for the region.	The project site lies within the Portland Coast River Region in the South West Limestone Groundwater Management Area. This Groundwater Management Area includes the Port Campbell Limestone.

1.3.3 Identification of Values/Assets/Receptors/Environmental Values

The EES Scoping Requirements note Key Issues in the Environmental Objectives. These reflect the values/assets/receptors listed as Beneficial Uses under SEPP (Waters). Applicable tables from SEPP (Waters) showing these values are provided as Table 4. Since the scoping requirements were established, the Environment Reference Standard (ERS) incorporated State Environment Protection Policy (Waters) (SEPP (Waters)) in 2021. The ERS sets a statutory framework for the protection of uses and values of Victoria's fresh and marine waters. The ERS (Water) aims to ensure that catchments, rivers and coasts are managed in an integrated manner so that actions in the catchment do not have detrimental impacts on water quality in fresh and marine environments. The ERS refers to environmental values, whereas SEPP (Waters) refers to beneficial uses. While the ERS is the most updated reference, in some parts of the report there is reference to beneficial uses as the base data refers to SEPP (Waters) definitions e.g. Visualising Victoria's Groundwater database.

Receptors were discussed with stakeholders at a site meeting in Port Fairy on 28th June 2019. At that meeting it was confirmed that water would not impact ESO4 and ESO 5 – special use zones provide for construction of electrical substations.

The Victorian Planning and Local Planning provisions were considered to identify any matters related to water as well as the Western Region Sustainable Water Strategy (DSE, 2011). The GHCMA is within the Murray and Western Plains segment and is not included in any of the additional Schedules of Areas of High Conservation Value. Any special water supply catchment area listed in Schedule 5 of the Catchment and Land Protection Act 1994 (neither the Shaw nor the Moyne Rivers are listed in Schedule 5).

By considering all these sources, including the likely quality of the surface and groundwater at the site, Water Technology highlighted those environmental values to be considered in this report in Table 4 for both surface and groundwater. Relevant segments are shown, with ticks indicating possible environmental values. Those environmental values identified during the project consultation phase at the site are highlighted in red boxes. Those not highlighted will still be protected by the required impact mitigation measures (as they focus on ensuring avoiding or minimising all impacts), they have not been highlighted to ensure focus on specific issues during consultation and/or assessment of the existing environment. The major waterways all have the same general beneficial uses/environmental values (Water dependent ecosystems, and species, cultural and spiritual values and agriculture and irrigation); however, the specific environmental values for each waterway as determined by the Flora and Fauna Assessment undertaken for the WWF development[1] include:

- Surrounding wetlands – Brolga, Eastern Great Egret, Eastern Cattle Egret, Plumed Egret.
- Back Creek – Growling Grass Frog, Little (Dwarf) Galaxias, Yarra Pygmy Perch and Hairy Burrowing Crayfish.
- Shaw River –Little (Dwarf) Galaxias, Yarra Pygmy Perch.
- Moyne River - Swamp Skink, Growling Grass Frog, Little (Dwarf) Galaxias, Yarra Pygmy Perch and Hairy Burrowing Crayfish.

The assessment of impact pathways (Section 3) and effects (Section 4) aim at reducing the impact of the development to the minimum level possible regardless of the sensitivity of the environmental values of each waterway or wetland.

[1] Nature Advisory (2022), Willatook Windfarm, Flora and Fauna Assessment.

TABLE 4 USES FOR GROUNDWATER (ERS) SHOWING APPLICABLE SEGMENT AVAILABLE DATA (VVG, 2019)

BENEFICIAL USE	SEGMENT (TDS mg/L)						
	A1 (0-600)	A2 (601-1,200)	B (1,201-3,100)	C (3,101-5,400)	D (5,401-7,100)	E (7,101-10,000)	F (>10,001)
Water dependent ecosystems and species	✓	✓	✓	✓	✓	✓	✓
Potable water supply (desirable)	✓						
Potable water supply (acceptable)		✓					
Potable mineral water supply	✓	✓	✓	✓			
Agriculture and irrigation (irrigation)	✓	✓	✓				
Agriculture and irrigation (stock watering)	✓	✓	✓	✓	✓	✓	
Industrial and commercial	✓	✓	✓	✓	✓		
Water-based recreation (primary contact recreation)	✓	✓	✓	✓	✓	✓	✓
Traditional Owner cultural values	✓	✓	✓	✓	✓	✓	✓
Cultural and spiritual values	✓	✓	✓	✓	✓	✓	✓
Buildings and structures	✓	✓	✓	✓	✓	✓	✓
Geothermal properties	✓	✓	✓	✓	✓	✓	✓

Applicable segment

ENVIRONMETAL VALUES OF INLAND WATERS (ERS)

Beneficial uses	Water Segment	Aquatic Reserves	Rivers and Streams						Wetlands
		Aquatic Reserves	Highlands	Uplands A	Uplands B	Central Foothills and Coastal Plains	Urban	Murray and Western Plains	Lakes and Swamps
Water dependent ecosystems and species that are:	Largely unmodified	✓	✓	✓	✓				
	Slightly to moderately modified					✓		✓	✓
	Highly modified						✓		
Human consumption after appropriate treatment		where water is sourced for supply in accordance with the special water supply catchments area set out in Schedule 5 of the **Catchment and Land Protection Act 1994** or the **Safe Drinking Water Act 2003.**							
Agriculture and irrigation			✓	✓	✓	✓	✓	✓	✓
Human consumption of aquatic foods		✓	✓	✓	✓	✓	✓	✓	✓
Aquaculture		✓ where the environmental quality is suitable and an aquaculture licence has been approved in accordance with the **Fisheries Act 1995**							
Industrial and commercial				✓	✓	✓	✓	✓	
Water-based recreation (primary contact)		✓*	✓	✓	✓	✓	✓	✓	✓
Water-based recreation (secondary contact)		✓*	✓	✓	✓	✓	✓	✓	✓
Water-based recreation (aesthetic enjoyment)		✓*	✓	✓	✓	✓	✓	✓	✓
Traditional Owner cultural values		✓	✓	✓	✓	✓	✓	✓	✓
Cultural and spiritual values		✓	✓	✓	✓	✓	✓	✓	✓
Navigation and shipping									

Note: If a segment is marked with a tick that is asterisked there is an exclusion identified in Table 5 (see clause 1(4) of this Schedule).

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Table 5 summarises the values identified, and the data sources used to identify their locations. This context is likely to be relevant for both the EES assessment and plans such as the EMP. For example, this process precludes consideration of effects for groundwater such as water-based recreation in the remainder of this report.

TABLE 5 RECEPTOR/VALUE/ASSET TYPES

Receptor/Asset/Value	Identified from	Comment
Irrigation	Consultation	*No irrigation within the site identified*
Stock water	**Registered bore database/VVG**	**Only shallow (<40 m) bores likely to target the basalt aquifer.**
Industry	Planning zones from VicPlan online maps and Moyne Shire Council Overlay	Special use zones are identified, *but are not relevant to groundwater*
Ecosystem protection	**GDE Atlas from BoM Explorer** **Surface water environments – Moyne River, Shaw River, Back Creek, numerous internal wetlands.**	**Ecosystems mapped by BoM have the potential to exist and the potential to be significant. More work is required to verify this.** **All receiving surface waters**
Potable mineral, recreation, Traditional Owner cultural, cultural and spiritual, geothermal properties	WWF Consultation	*None identified: considered by other EES technical studies*
Buildings and structures		Geotechnical matters are outside of scope; however, WWF's turbines are considered in the flood assessment
Cultural/spiritual values	Aboriginal cultural heritage impact assessment (Ecology and Heritage Partners, 2022)	Impacts to water availability or quality within the Shaw River could impact the cultural or spiritual use of the waterway.

Water Technology considers the two values in bold font to inform the likely effects. As noted in Section 1.1, the significance of effects on species will be assessed in other EES chapters using this work.

1.4 Description of Proposed Development (the activity)

The Willatook Wind Farm would harness strong and reliable winds to generate renewable energy through the construction and operation of up to 59 wind turbines generators (WTGs) and would operate for a period of at least 25 years following a two-year construction period. The wind farm would generate more than 1,300 gigawatt hours (GWh) of renewable electricity to the National Electricity Market (NEM) each year.

Approximately 60 kilometres of accessways (both new and existing) would be required to provide access from the public road network to each WTG and supporting infrastructure. These accessways provide access for Project construction and maintenance vehicles and can be used by emergency vehicles and by landowners for their farming operations.

Electricity produced by the Project will be fed through underground cables to the on-site substation, from where it will be exported to the NEM via the Tarrone Terminal Station and the existing Moorabool to Heywood 500 kilovolt (kV) transmission line.

Other Project infrastructure would include:

- An on-site quarry for basalt rock that will be used to provide aggregate for access tracks and hardstand areas.
- A battery energy storage system (BESS) located immediately to the west of the substation.
- An operations and maintenance (O&M) facility consisting of site offices and amenities.

Figure 2 provides an example of the proposed land use changes in the areas affected.

FIGURE 2 SITE LANDSCAPE & EXAMPLE OF A LAYDOWN HARDSTAND UNDER CONSTRUCTION (WIND PROSPECT, 2019)

TABLE 6 INFRASTRUCTURE CONSIDERED AND SHAPEFILE REFERENCE

#	Infrastructure	Dimensions	Permeability	Duration of footings
1	59 turbines with tip height of 250 m. Turbine foundations consist of concrete gravity foundations	Excavation diameter of 27 metres x 3.0 m deep	Impermeable	Permanent
2	59 hardstand and laydown areas	50 m x 60 m x 0.5 m deep	Impermeable	Permanent
3	On-site quarry	Extraction area of 10.5 hectares with a maximum depth of 14 metres. The total disturbance area of 24.7 hectares including 10 hectares of hardstand areas	Variable	Variable
4	Internal access tracks	60 km x 6 m wide	Low	Rehabilitated on decommissioning
5	Substation and battery energy storage system	400 m x 170 m x 0.5 m deep	Impermeable	Permanent
6	Five meteorological monitoring masts	Tethered by 6 guy wires ~1m diameter x 1m deep	Impermeable	Permanent
7	Construction office comprising carparking, storage and amenity infrastructure	100 m x 70 m x 0.5 m deep	Impermeable	Rehabilitated after construction
8	Underground cabling	~62 km in 1 m deep trenches with a maximum disturbance width of 21 m	No change	Immediately backfilled using material with permeability of the original material
9	3 concrete batching plants	50 m x 100 m x 0 m deep	Impermeable	Rehabilitated after construction
10	3 construction compounds	200 m x 200 m x 0.5 m deep	Impermeable	Rehabilitated after construction
11	2 overhead power poles	20 m diameter x 1.5 m deep	Impermeable	Permanent
12	4 staging areas	15 m x 320 m x 0 m deep	Impermeable	Rehabilitated after construction

* The designs for the hardstand and laydown areas are not yet finalised. A 50 m radius for the 3,000 m^2 impermeable areas are assessed. Figure 2 shows an example of a laydown hardstand.

1.5 Assumptions

The project has been assessed using the following approved operational and construction assumptions:

- Excavations:
  - The proposed quarry Work Authority area is approximately 30 hectares, with the extraction area being 10.5 hectares with a maximum depth of 14 metres. The total disturbance area of the quarry is estimated to be 24.7 hectares including 10 hectares of hardstand areas. The quarry excavation would be used for a period of between 12 and 24 months and then left to be naturally filled with groundwater as a dam.
  - Underground cable trenches are dug and filled in a continuous operation before being backfilled with material of the same permeability as that disturbed.
  - The 3.0 m deep, 27 m diameter turbine foundations would be progressively constructed within a two-year construction period. The excavated area may require low-level blasting where firm rock is encountered. If rock anchor foundations are required, the construction of the foundation for each WTG would involve less excavation. The rock anchor cores are drilled into the bedrock prior to the concrete pour. Blasting would be undertaken by qualified specialists subject to relevant statutory requirements being met. Each foundation would take:
    - Two days to dig then be capped with impervious screed over a clean, blinding layer; then
    - Infilled with steel and concrete within a two week period; then
    - Covered with a thin soil/crushed rock layer enabling vadose runoff flow.
  - Half of the foundation would be covered by impermeable hardstand after construction. Foundations are shaped to allow rainwater to run-off and re-establish natural recharge.

FIGURE 3 EXAMPLE OF TURBINE CONSTRUCTION (SOURCE: WWF)

- Turbine foundations: The WTG foundations are anticipated to be either a gravity foundation or rock anchor foundation. The final designs of individual foundations will be determined by detailed geological and geotechnical investigations to establish the nature of the subsurface at each location.
- Duration of project: decommissioning would occur ~25 years after construction, with below ground foundations left in the ground and minimal other groundwater impacts.
- Consideration of cumulative land use impacts (aside from other wind farms) are outside the scope.

- Management of construction traffic, laydown areas and temporary works.

2 EXISTING ENVIRONMENT

This Chapter characterises the existing site environment. This enables an understanding of the baseline groundwater and surface water conditions and how the WWF will interact with groundwater and surface water. It forms the conceptualisation of pathways linking proposed actions to effects.

2.1 Historic Rainfall Data

The subject site is within a temperate climate region, with no distinct dry season while experiencing warmer temperatures within the summer months (BOM 2020). The site experiences an average annual rainfall of 743 mm/year and a mean annual (actual) evapotranspiration of 789 mm/year[2], as shown in Figure 4. The mean annual rainfall extracted from the SILO database was compared to the closest rainfall gauge at Hawkesdale Post Office (station number 90045 – daily rainfall record spanning from 1884 to 2021), which had mean annual rainfall of 703 mm/yr., approximately 5% lower than the SILO data. This is a relatively close match between the SILO database and observed data.

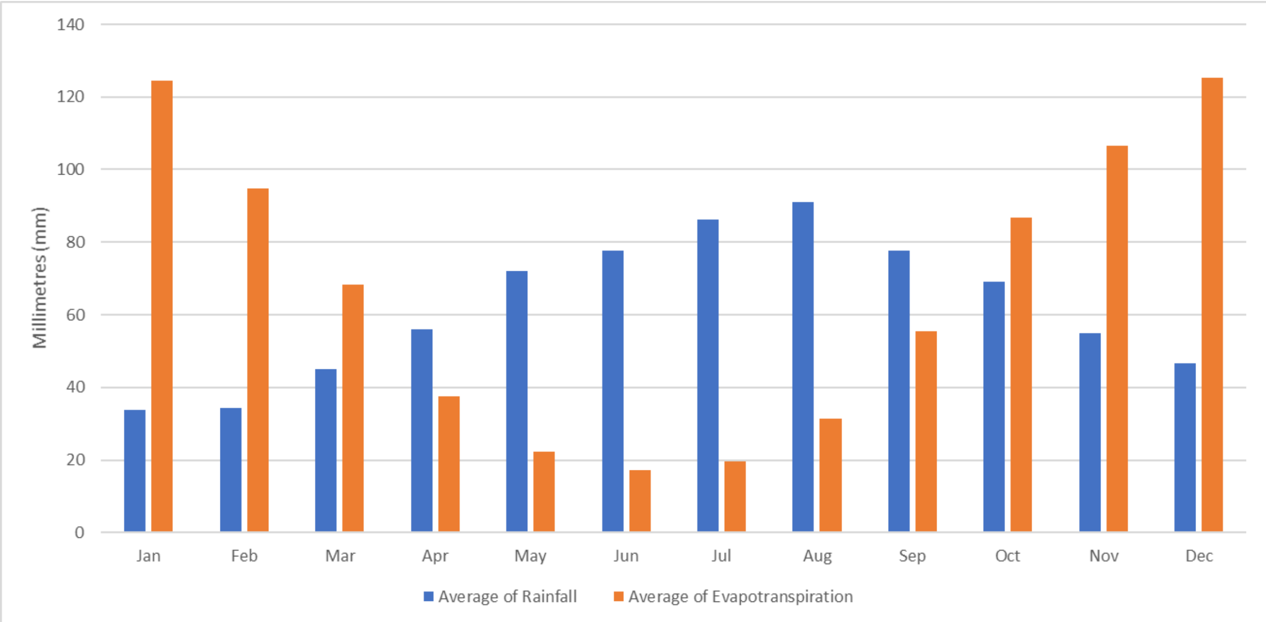

FIGURE 4 AVERAGE MONTHLY RAINFALL & EVAPOTRANSPIRATION (BASED ON SILO DATA)

On a long and short term basis, the rainfall record at the Hawksdale gauge has had a relatively consistent annual total with the recorded annual total rainfall records shown in Figure 5, not indicating any discernible trend in rainfall. There is a clear low period of annual rainfall through the Millennium Drought, in the late 1990s and early 2000s.

[2] Based on 100 years of meteorological data (rainfall and evapotranspiration) derived using SILO data from Bureau of Meteorology - https://www.longpaddock.qld.gov.au/silo/

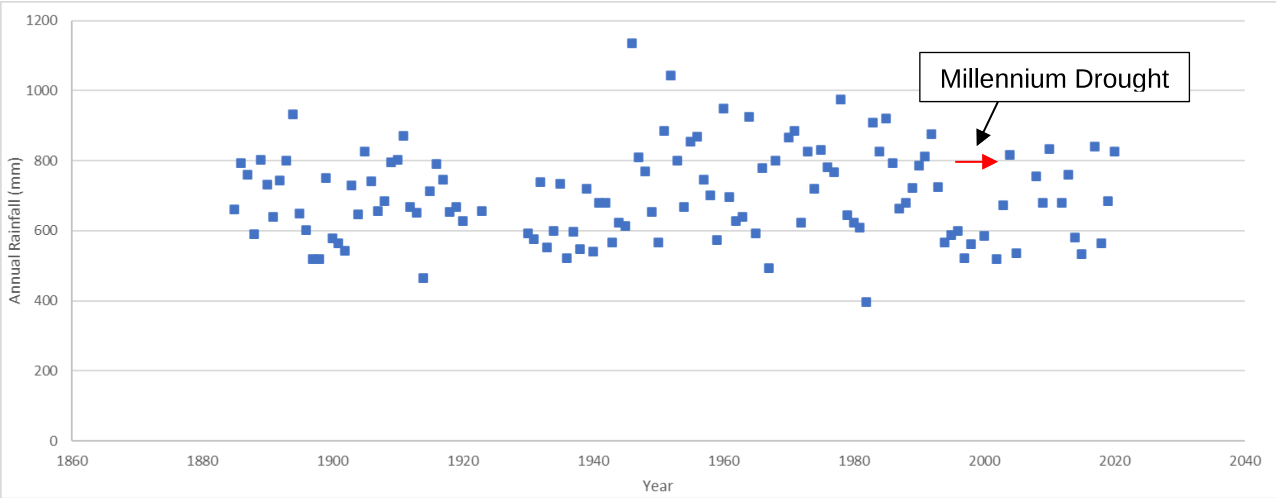

FIGURE 5 ANNUAL RAINFALL TOTALS AT HAWKESDALE POST OFFICE (STATION NUMBER 90045)

2.2 Characterisation of waterways, wetlands and site drainage

2.2.1 Overview

Lying between the Grampians to the north and Bass Strait to the south, the site lies on the Western District Plains and is within the Portland Coast Basin[3]. The Portland Coast Basin comprises of the Moyne, Eumeralla-Shaw, Fitzroy and Surrey rivers and is within the Glenelg Hopkins Catchment Management Authority (GHCMA) management region.

There are several waterways in proximity to the WWF development area, the dominant land use within the catchments to these waterways is sheep/cattle grazing and cereal cropping. There are also smaller vegetated areas planted for forestry or as environmental works. The major waterways interacting with the WWF development are:

- The Moyne River (flows into Port Fairy Bay at Port Fairy) - flowing east of the WWF development site with limited interaction with the development.
- Back Creek (tributary of the Moyne River) – flowing through the WWF development site on the eastern side.
- Shaw River (flows in the Lake Yambuk along with the Eumeralla River) - flowing through the WWF development site on the western side.

There is also a complex series of ephemeral wetlands within and surrounding the WWF development area which can become linked during periods of high rainfall, the most major of these known as the Cockatoo Swamp Complex.

2.2.2 Waterway classifications

Mapping of waterways/watercourses and wetlands can be separated into two distinct types:

- VicMap watercourses - VicMap watercourses are a visual representation of drains, channels, creeks, rivers and water storages. The layer is maintained by DELWP and is purely for mapping display purposes (i.e., there is no regulatory control for works on VicMap watercourses unless they are also designated

[3] As classified by the Australian Water Resources Council (AWRC)

waterways). The layer generally includes, but is not limited to, Designated Waterways (see below) and constructed channels. VicMap waterways are generally displayed in figures and maps as "Waterways" and are included in some maps within this report. The VicMap watercourses layer gives a better representation of potential overland flow paths than Designated Waterways because it covers drainage lines and smaller flow paths which are not included in the Designated Waterway definition.

- *Designated Waterways* - The *Water Act 1989* defines a 'designated waterway' as "a natural channel in which water regularly flows, whether or not the flow is continuous". Within Victoria, each Catchment Management Authority (CMA) has a mapping of its designated waterways. Glenelg Hopkins CMA has statutory responsibilities under the *Water Act 1989* and 'By-law No.2 Waterway Protection 2014' to monitor, manage, enforce, and administer control over all works which may impact upon designated waterways throughout the Wimmera region to ensure works undertaken do not adversely affect the health of those waterways.

  Not only natural waterways fall within the classification of a designated waterway, man-made channels can also feature in the Glenelg Hopkins CMA designated waterway mapping.

  Works and activities on or near a designated waterway require a licence from the CMA. Works and activities relevant to WWF include:

  - Building a crossing – culverts, bridge or ford.
  - Connecting to a waterway by pipe or drain.
  - Cleaning out the waterway – removing weeds and silt.

Unfortunately, there is no digital (i.e., Geographic Information Systems (GIS) layer) of designated waterways within the Glenelg Hopkins CMA management area. However, the WWF project area is within Map 11 on their online mapping available as an image[4]. A recreation of the designated waterways within the WWF development area is show in Figure 6. These designated waterways are all tributaries of the Moyne and Shaw Rivers (predominantly the Shaw River).

[4] https://info.ghcma.vic.gov.au/wp-content/uploads/2017/06/Area11.jpg

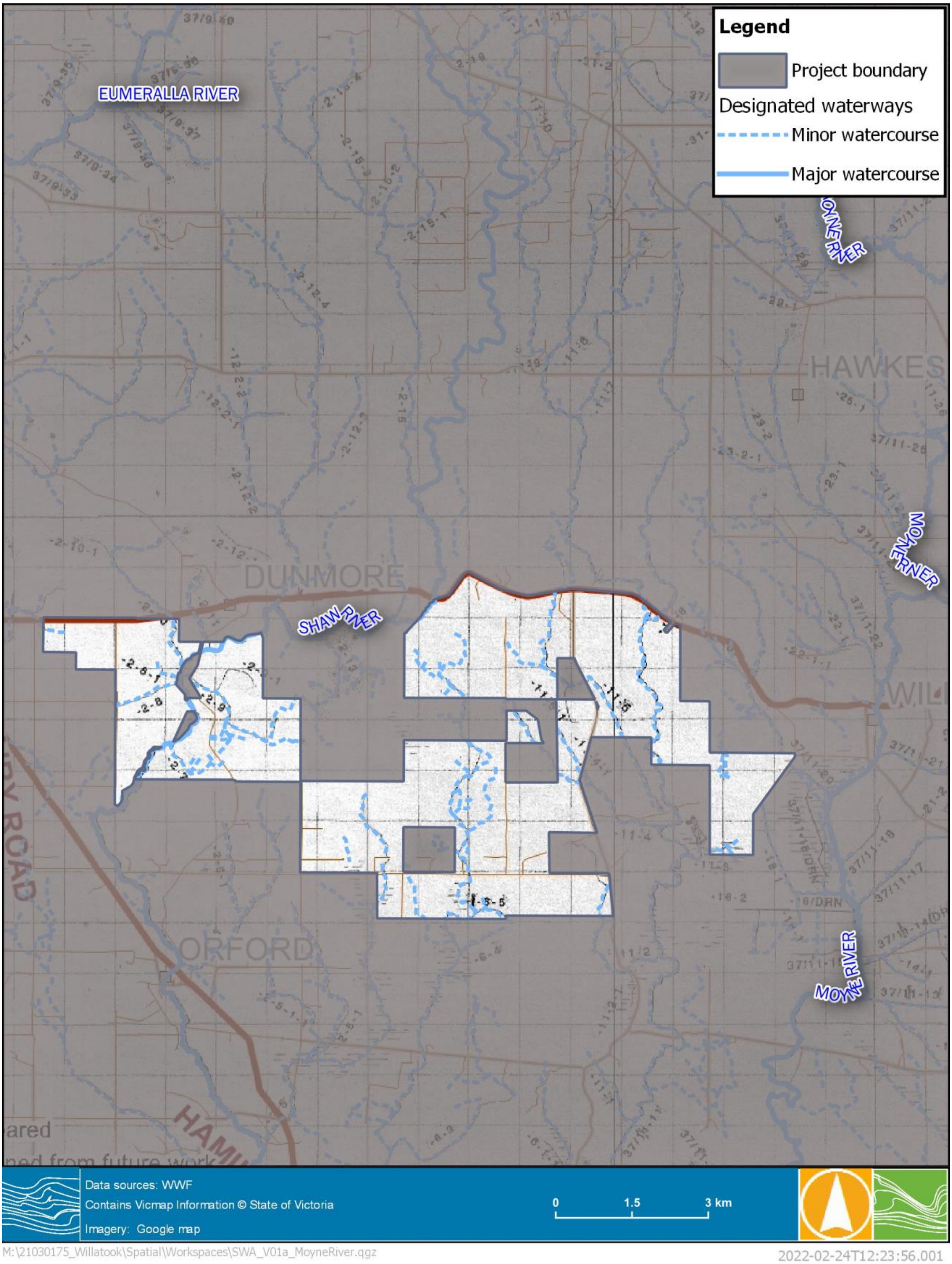

FIGURE 6 DESIGNATED WATERWAYS WITHIN THE WWF DEVELOPMENT AREA

2.2.3 Stream condition

The Victorian government, in conjunction with the Catchment Management Authorities (CMAs), have undertaken a state-wide benchmark of the environmental condition of Victoria's major rivers and streams. The benchmarking process provides an integrated measure of river condition – the Index of Stream Condition. The Index of Stream Conditions provides scoring on five key aspects (or sub-indices) of river condition:

- Hydrology – refers to the amount of water within the river channel at a specific location and point in time. Considers seasonality and variability of flows.
- Streamside zone – measures characteristics of woody vegetation within 40 metres of the river's edge, including fragmentation, tree cover and presence of weeds.
- Physical form – considers the condition of the riverbank and instream habitat, including presence of artificial barriers.
- Water quality – considers Total Phosphorus, turbidity, salinity (electrical conductivity) and pH levels.
- Aquatic life – based on the number and type of aquatic macroinvertebrates in the river.

Each sub-index is scored out of 10, with higher scores indicating better river condition. These scores are combined to give an overall Index of Stream Condition Score between 0 and 50, which are then categorised into five broad condition bands (i.e., excellent, good, moderate, poor or very poor) for sections of rivers in Victoria, referred to as 'reaches'.

The latest Index of Stream Condition report found that the majority (84%) of stream lengths within the Portland Coast basin were in moderate condition, with 15% in poor condition and 0.4% in very poor condition.

A summary of the latest Index of Stream Condition report findings for reaches within the Portland Coast Basin (DEPI, 2013) is provided in Table 7.

TABLE 7 SUMMARY OF STREAM REACH SUB-INDICES ASSESSED WITHIN THE PORTLAND COAST BASIN (DEPI 2013)

Sub-indices	Summary
Hydrology	Basin has some of the most climate-stressed streams in Victoria. Drought-affected streams were Shaw River, Eumeralla River and Fitzroy River. Drought affected reaches included the Shaw River, Eumeralla River and Fitzroy River. All streams showed moderate variations to natural flow regimes.
Physical Form	Physical condition of reaches predominantly either excellent (46%) or good (46%). Two reaches (8%) scored moderately, with poor levels of instream woody habitat, poor bank stability and/or fish barriers.
Streamside Zone	Majority of reaches were in poor (50%) or moderate (42%) condition, with one reach rated as good and one in near reference condition. Poor condition of streamside vegetation and a lack of large trees along most reaches.
Water Quality	The two reaches were found to be in moderate and excellent condition. One reach had extremely high levels of phosphorus and salinity.
Aquatic Life	23% of reaches were in good or excellent condition. This reflects the extent of land cleared for agriculture and urban development.

2.2.4 Waterways and wetlands

2.2.4.1 Moyne River/Back Creek

The Moyne River catchment covers a rural area of approximately 758 km^2 with Port Fairy being the largest township within the catchment, located at the catchment outlet to Port Fairy Bay (the Southern Ocean). The Moyne River originates at north of Gerrigerrup, being fed by various tributaries before it discharges into the Moyne River estuary and the ocean at Port Fairy. Most of the catchment area is agricultural land used for a mixture of dryland sheep and cattle grazing and cereal cropping. The catchment is characterised by relatively gentle grades with a maximum elevation of approximately 250 m AHD and an average slope of 0.003. The catchment features significant floodplain storage in the form of large wetlands and swamps.

Most of the catchment is dominated by landforms of volcanic origin with volcanic ash and lava flows particularly evident. The large number of catchment wetlands mostly correspond to stony rises associated with lava flows (valley filling basalts) along the western side of the catchment. The remainder of the catchment consists of better drained volcanic soils and in the south of the catchment an area of marine sediments (limestone).

There have been numerous large floods on the Moyne River, these have included: 1946 (largest on record), 1951, 1953, 1955, 1976, 1978 and 2001. There are two stream flow gauges on the Moyne River: Moyne River at Willatook (237208) and Moyne River at Toolong (237200) which provide water quality data as well as streamflow. The Willatook gauge has recorded flow data from 1974 to 1985 while the Toolong gauge has flow data spanning from 1948 to present day.

The eastern region of the subject site is within the Moyne River catchment and is approximately 2km west of Moyne River at its closest point, as displayed in Figure 7. Back Creek, a major tributary of the Moyne River, flows through the WWF development area. The Moyne River is a larger waterway with a more defined floodplain while Back Creek is narrower and with reaches that have relatively undefined banks.

The Moyne River and Back Creek are deemed designated waterways by Glenelg Hopkins CMA, their respective waterway reference numbers are Waterway 37/11-23 and Waterway 37/11-23 and 37/11-11.

Three reaches assessed in the Index of Stream Condition report are located on Moyne River and one on Back Creek, with the Index of Stream Condition parameters for these sites shown in Table 8.

An image of Back Creek within the development site is shown in Figure 8.

TABLE 8 MOYNE RIVER AND BACK CREEK INDEX OF STREAM CONDITIONS

River	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	Index of Stream Condition
Moyne River upstream	5	9	3	Not assessed	7	Moderate
Moyne River downstream	5	10	4	6	7	Moderate
Moyne River downstream (at coast)	6	10	3	Not assessed	7	Moderate
Back Creek	7	6	3	Not assessed	5	Poor

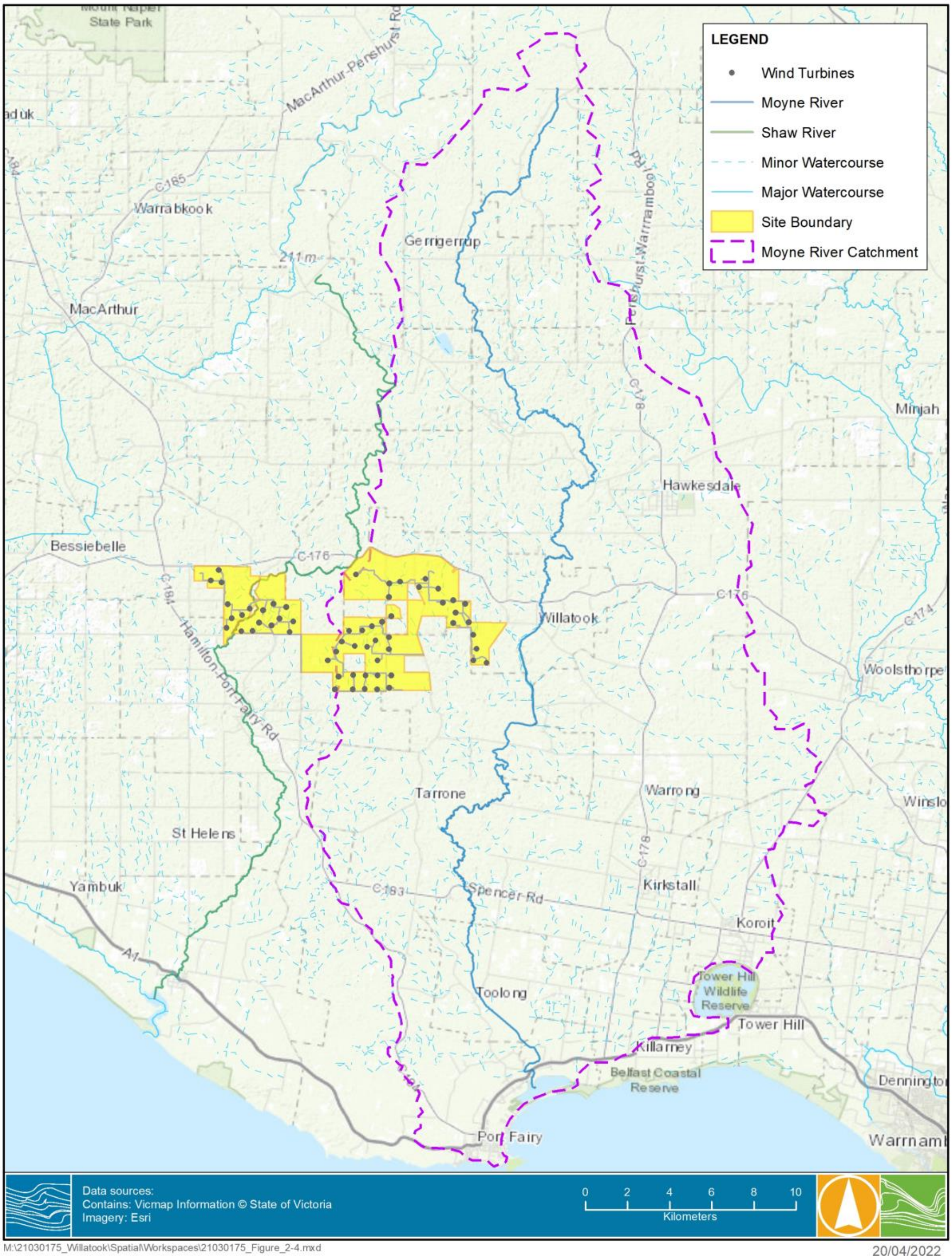

FIGURE 7 MOYNE RIVER CATCHMENT

FIGURE 8 BACK CREEK TOWARDS THE SOUTHERN EXTENT OF THE PROJECT SITE, LOOKING NORTH-WEST (SOURCE: WWF)

2.2.4.2 Shaw River

The Shaw River catchment covers a rural area of approximately 234 km^2, originating near Ripponhurst, being fed by Kangaroo Creek and Carmichael Creek upstream of the site, before it discharges into Lake Yambuk and then Portland Bay. The Shaw River is generally considered in combination with the Eumeralla River (flowing parallel to the west) as they both flow into Lake Yambuk. The Shaw River flows through the Cockatoo Swamp Complex, Figure 9 shows the location of the Shaw River catchment.

The Shaw River catchment is comprised largely of agricultural land, similar to the Moyne River agricultural use is dominated by dryland sheep and cattle grazing as well as dryland cereal cropping. The catchment also contains various existing windfarms in its upper reaches. Approximately 25% of the WWF wind turbines and associated infrastructure and the on-site quarry are located within the Shaw River catchment

The Shaw River catchment contains no streamflow gauges but there have been numerous anecdotal large floods on the Eumeralla/Shaw River system, these have included: 1946 (largest on record), 1976, 1978, 1983 and 1954. The watercourse form is relatively narrow, typically between 5 and 10 metres in width, has a mixture of substrate types and a diversity of isolated pools located along its length during summer.

The Shaw River is a perennial designated waterway by Glenelg Hopkins CMA (Waterway 37/09-02). Images of the Shaw River are shown in Figure 10 and Figure 11.

Two reaches assessed in the Index of Stream Condition report are located on the Shaw River, with the Index of Stream Condition parameters for these sites shown in Table 9.

TABLE 9 SHAW RIVER INDEX OF STREAM CONDITIONS

River	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	Index of Stream Condition
Shaw River (upstream)	7	9	5	Not assessed	6	Moderate
Shaw River (downstream)	7	7	4	Not assessed	4	Moderate

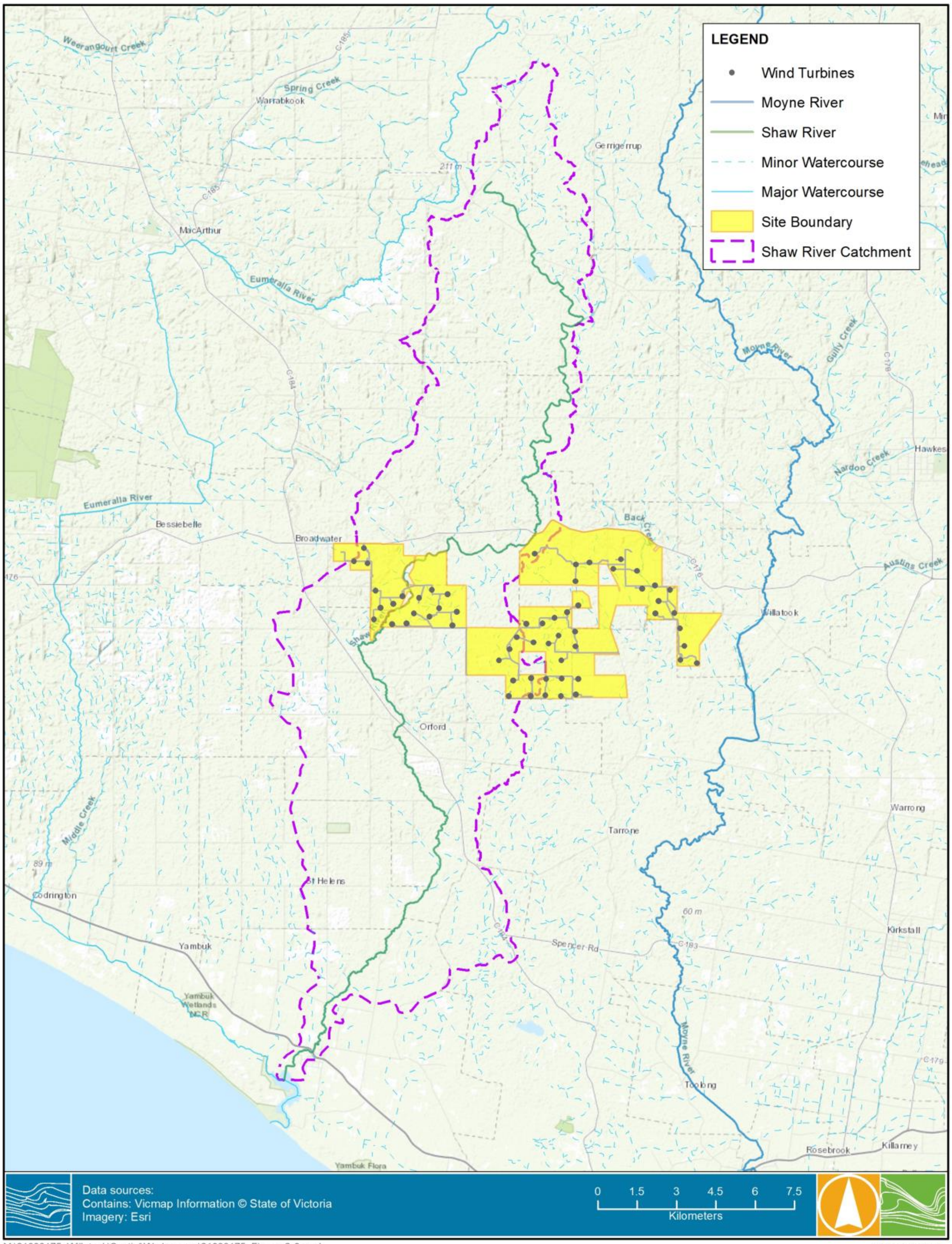

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FIGURE 9 SHAW RIVER CATCHMENT

FIGURE 10 SHAW RIVER IN THE WESTERN AREA OF THE SITE, LOOKING NORTH-WEST (UPSTREAM) (SOURCE: WWF)

FIGURE 11 SHAW RIVER IN THE SOUTHWEST AREA OF THE SITE, LOOKING SOUTH (DOWNSTREAM) (SOURCE: WWF)

2.2.4.3 Wetlands

Several wetlands have been identified by DELWP within and surrounding the site, as shown Figure 12 and Figure 13. These areas are mostly within the Shaw River catchment. There is a particularly dense area of wetlands within the WWF development site, known as the Cockatoo Swamp Complex. This area has been avoided in the development of the WWF, as highlighted in Figure 12.

There are no Ramsar listed wetlands located within the project site, with the closest being the Glenelg Estuary and Discovery Bay Wetlands approximately 60 kilometres east of the project site.

Wetlands within the WWF development area generally capture localised runoff from isolated catchment areas, there are some which receive flood overflows from the Shaw River. The wetlands are linked through both natural and constructed channels, in many cases wetlands have been drained to increase the area of land available for agricultural production. Wetland drainage has been both to other wetlands as well as to larger drainage systems or waterways. The assessment in this report has modelled these wetlands and their catchments based on the available topography data and has not included detail around specific wetlands, the habitat they provide or their specific hydraulic regimes, this has been assessed in other components of the EES.

Due to the nature of the topography most of the depressions within the development site are inundated during in some years during winter and spring but largely dry out during summer. Larger areas are known to hold water for three to four months, then dry (through both natural flow paths and manmade drains) and form modified grasslands, which are grazed by sheep and cattle. During drier years these area do not fill and remain modified grasslands.

Modelling undertaken by Water Technology assessed the potential duration of inundation across all potential wetland areas, assessing if they were able to hold water for more than 120 consecutive days between the 2009-2019 period. The purpose of this modelling was to inform detailed assessment of potential brolga breeding and night roosting habitat. The modelling used the same hydraulic modelling as presented in this report (detailed in Section 2.5) to identify potential wetland areas, then modelled those which had the potential to hold water for a sustained period. The wetlands which had the potential to hold water for a sustained period were then modelled using an eWater Source water balance model. The hydraulic modelling identified 804 areas that held water post a flood event, of these:

  - 12 had an incorrect topographic representation within the model.
  - 145 had constructed drainage from the invert of the depression.
  - 41 had very limited size, depth and catchment area. This combination of low depth, the size being close to 0.1 Ha and the small catchment mean these areas would dry quickly.
  - 38 were farm dams – automatically meeting the inundation criteria.
  - 26 were deemed to require further assessment of their longer term potential to hold water.
- The detailed water balance assessment determined 17 of the 26 wetlands sustained water within them for more than consecutive 120 days within the 2009-2019 period, making them hydrologically suitable for brolga breeding and night roosting.

Detail around this assessment can be found in the detailed Nature Advisory specific brolga assessment report.

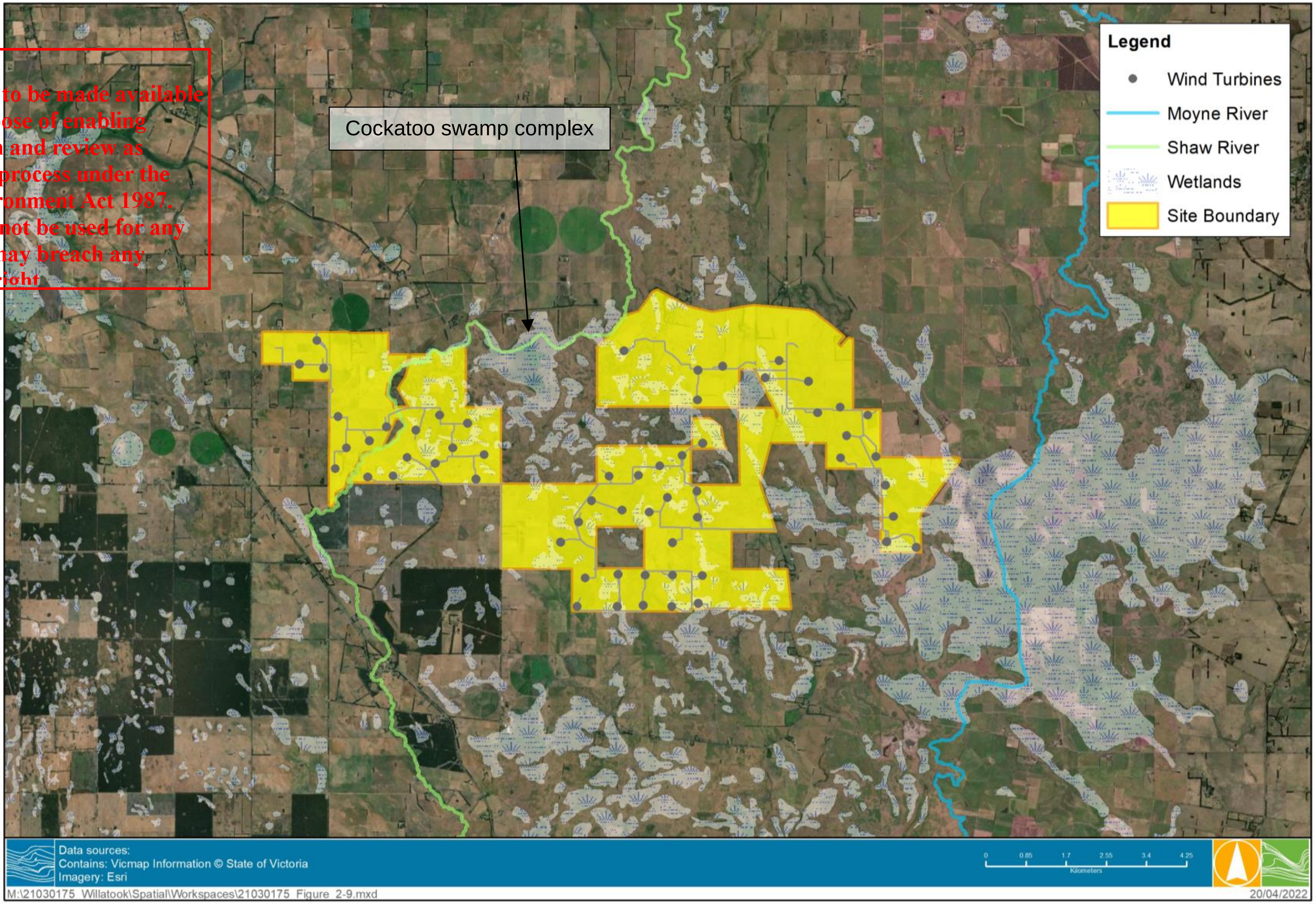


FIGURE 12 DELWP IDENTIFIED WETLANDS

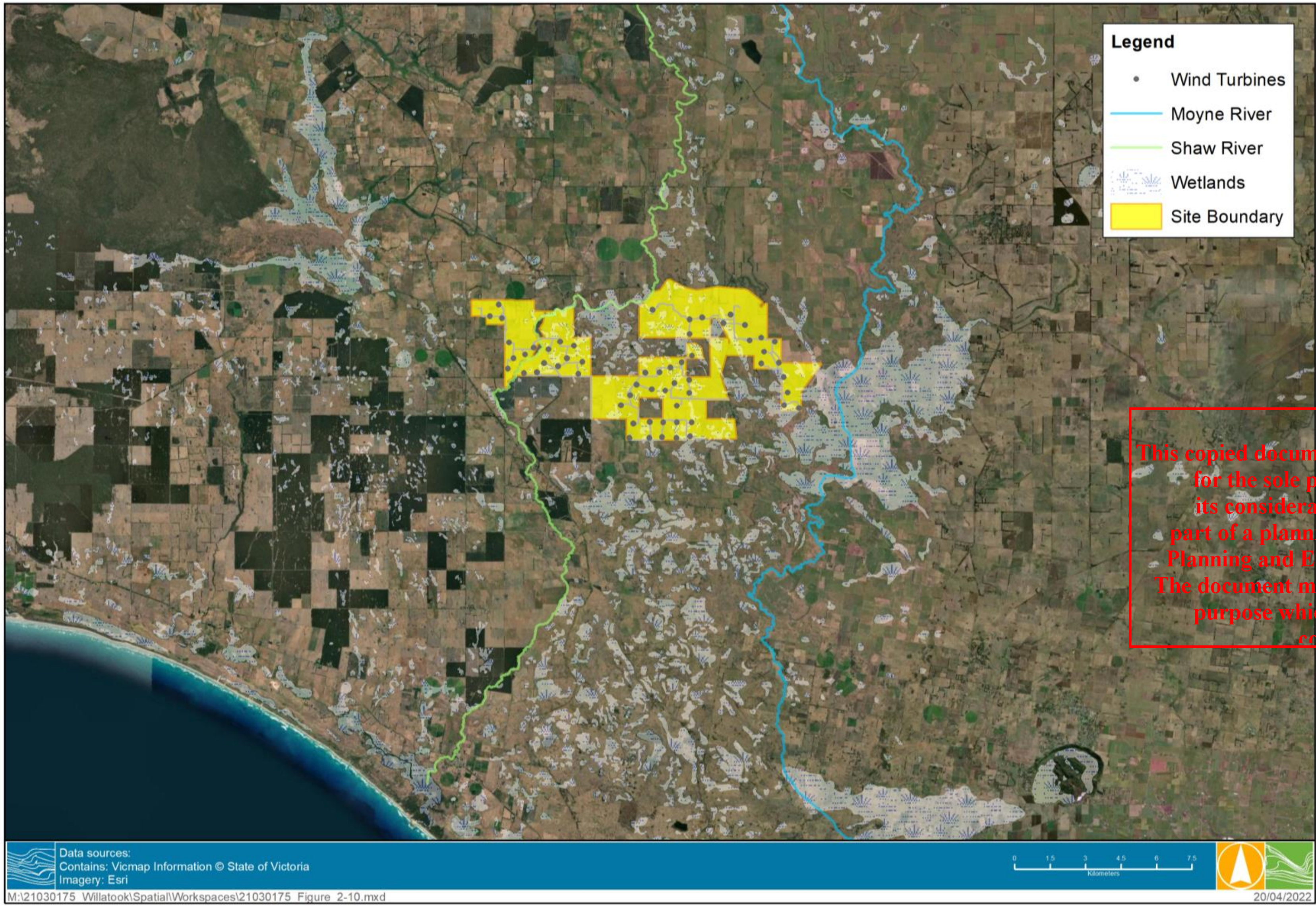


FIGURE 13 DELWP IDENTIFIED WETLANDS (REGIONAL VIEW)

2.3 Topography

Two topographic datasets were available for the development site: the statewide VicMap 20 m DTM (Digital Terrain Model) covering site and broader surrounds, and a 1 m resolution LiDAR (Light Detection and Ranging) dataset flown specifically for the WWF development covering the development area. These datasets were merged for use in the hydraulic modelling completed as part of this project. The WWF 1 m project LiDAR was used in preference (within the development site), with the VicMap 20 m DTM used around the outside the windfarm development. There were some minor adjustments made to the course 20m DTM to ensure it merged accurately with the 1m LiDAR. No verification of the LiDAR data was undertaken as part of this project, this was assumed to occur as part of the supplier Quality Assurance program. An overview of the WWF project LiDAR data coverage is shown in Figure 14; the 20 m DTM is available for all of Victoria.

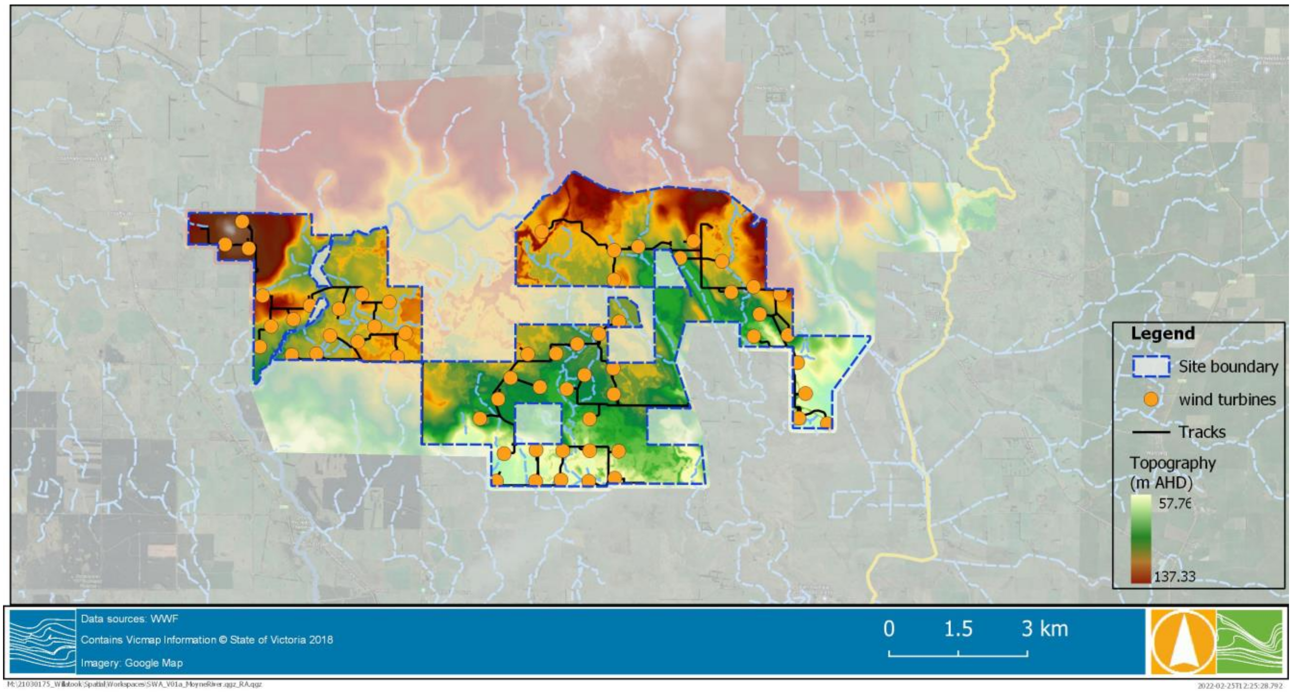


FIGURE 14 LIDAR DATA COVERING THE WWF DEVELOPMENT SITE

2.4 Land and Water Use

2.4.1 Comparison of landscape with other wind farms

A comparison between the WWF landscape and the Ryan Corner and Stockyard Hill windfarm projects is included here for reference.

The ~3,600 ha Ryan Corner wind farm is located some 15 km south of WWF and has a ground elevation ~80 m lower. The site is bordered by the Shaw River to the west and is ~5 km from the coastal dunes to the south and comprises Western District Volcanic Plains. Basaltic 'stony rises' of the Pleistocene Mt Rouse-Port Fairy lava flow traverse the site with intervening depressions containing ephemeral wetlands (Moyne Shire Council, 2008).

The 15,600 ha. Stockyard Hill windfarm project is approximately 300 m higher than WWF and located close to Black Lake and Lake Goldsmith. There are more landholders associated with this project than WWF, but these are also generally in relation to grazing and cropping. The Stockyard Hill area is also covered by undulating volcanic rocks and contains native vegetation near the Trawalla State Forest in the north of the site. Like at WWF, timber plantations occur in the general locality which for terrestrial ecosystems accessing groundwater.

2.4.2 Agriculture

Grazing of sheep and cattle is the main land use within the site which is classed as 'Grazing Modified Pastures'. Farm dams are common across the site.

There are nine bores interpreted to be completed in the Newer Volcanic Group basalts (less than 40 m deep) within the Project site that are registered by Southern Rural Water as unmetered bores for stock and domestic use. These domestic and stock bores are assumed to extract 2 ML/a (SRW, 2016) per bore, giving a total extraction volume within the site of 22 ML/a. Unregistered bores in various states of operation may also be present.

Over the past ~30 years, plantation forestry has had a strong influence on groundwater recharge and abstraction (DSE, 2019), however, a groundwater allocation is not made under the groundwater management plan (SRW, 2016).

2.4.3 Ecological land use

Potential habitat zones for ecosystems (including aquatic and terrestrial GDEs) have been mapped by the Bureau of Meteorology (GDE Atlas). This database (which does not include subterranean GDEs) is the reference for this report.

In addition, based on field investigations over the last decade a range of water dependent ecosystems may support significant ecological communities and species, such as:

- Seasonal herbaceous wetland.
- Migratory shorebirds.
- Growling grass frog.
- Swamp skink.

These values (species protection) were considered when conducting the investigation to ensure the potential changes to groundwater and surface water regimes were considered in sufficient detail for the likely effects to be assessed in the ecology section of the EES.

2.4.4 Surrounding land and water use

Outside the site, irrigation and wash-downs for dairy cattle may attract groundwater allocations under the South West Limestone Local Management Plan. The site lies within the Portland Coast River Region within the South West Limestone groundwater management unit (GMU), with a Permissible Consumptive Volume (PCV) of 85,000 ML/a (SRW, 2016). The Portland GMU underlies the South West Limestone GMU from a depth of 200 m. The site is also within the Hawkesdale Groundwater Management Area (GMA) (SRW, 2016) which has a PCV of 16,161 ML/a with extraction generally from the Port Campbell Limestone Aquifer (DSE, 2011). SRW runs an online groundwater trading register called Watermatch that enables water trading within the South West Limestone GMU. This helps to ensure an efficient allocation of groundwater from the GMU. The Hawkesdale GMA (SKM, 2007) lists the resources, demands and threats to local aquifers which are further explored in Section 3.

The Macarthur Wind Farm is located 2 km to the north of the site boundary, and regional groundwater flow appears to be north to south. As such, there is no likelihood that the proposed WWF development will impact the Macarthur Wind Farm groundwater quality or quantity.

Two areas within WWF are zoned for electrical substations under the Victorian Planning and Local Planning provisions (ESO4 to the south west and ESO5 to the south east).

2.5 Surface water modelling

2.5.1 Overview

Flood behaviour within and surrounding the development area was assessed using two types of modelling:

- A runoff routing hydrologic model was used to determine inflows for the Moyne River, modelling was completed in the hydrologic modelling package known as RORB, originally developed during the Port Fairy Regional Flood Study5. The RORB model was used to determined inflows to the hydraulic model. This is discussed further in Section 2.5.2.3.
- A rain-on-grid hydraulic model was developed for the Shaw River and the local catchment area within development site. The rain-on-grid hydraulic model was developed specifically for this project using the hydraulic modelling package TUFLOW HPC (Heavily Parallelised Compute).

Both modelling software types and packages are widely used and are the preferred modelling packages for the GHCMA and are often specified as compulsory choice in the flood modelling projects they manage (i.e. Upper Mt. Emu Creek Flood Investigation (Water Technology, 2018), Ararat Flood Investigation (Water Technology, 2017)).

Two types of modelling packages were used for two major reasons:

- The previously developed RORB model allowed for adoption of flows already established for the Moyne River.
- Using RORB flows for the Moyne River enabled a smaller hydraulic model domain. If the entire Moyne River catchment was included in the hydraulic model, it would be too large to run without an increase to the topographic grid cell size, reducing the accuracy of the model results.

[5] Water Technology (2008) – Port Fairy Regional Flood Study

2.5.2 Data Collection and Review

2.5.2.1 Overview

Data used in the model development was collected from various sources as detailed below:

- Rainfall data – Bureau of Meteorology (BoM).
- RORB Model – Water Technology (2008).
- Topographic data - LiDAR and Shuttle Radar Topography Mission (SRTM) data – VicMap and WWF.
- Moyne Shire Council Planning Zones – VicMap.

Each of these data sources is discussed in detail in the following sections.

2.5.2.2 Rainfall data

RORB modelling of the Moyne River was completed using 1987 BoM recommended Intensity Frequency Duration (IFD) parameters and associated temporal patterns, the RORB model was calibrated to a Flood Frequency Analysis (FFA) at the Moyne River at Toolong (237200) streamflow gauge. The Australian Rainfall Runoff 1987 (ARR1987)[6] parameters associated with the original RORB modelling were considered fit for purpose and were not updated to the Australian Rainfall and Runoff 2019 (ARR2019)[7] recommendations. This was considered appropriate given the limited interaction the WWF development has with the Moyne River.

The hydraulic modelling component was completed using rainfall depths and losses recommended in ARR2019. The modelling undertaken considered the 1% and 10% Annual Exceedance Probability (AEP) events. Storm durations for the associated AEPs ranged from 2 hours to 72 hours. The recommended BoM 2019 IFD depths are shown in Table 10.

TABLE 10 BOM 2019 ADOPTED IFD PARAMETERS

Duration	Depth (mm)	
	10% AEP	1% AEP
1 hour	26.9	46.8
2 hour	33.5	57.2
3 hour	38.1	64.6
4.5 hour	43.4	73.5
6 hour	47.6	80.8
9 hour	54.2	92.9
12 hour	59.4	103
18 hour	67.3	117
24 hour	73.3	129
30 hour	78	137
36 hour	81.8	144

[6] Engineers Australia (1987) Australian Rainfall and Runoff: A Guide to Flood Estimation, Vol. 1, Editor-in-chief D.H. Pilgrim, Revised Edition 1987 (Reprinted edition 1998), Barton, ACT
[7] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia

Duration	Depth (mm)	
	10% AEP	1% AEP
48 hour	87.7	154
72 hour	95.5	165

ARR2019 recommends modelling of 10 temporal patterns and adoption of the temporal pattern which determines the median peak flows across each event duration. However, this recommendation is generally for rainfall runoff models, and is not considered appropriate for use in large rain-on-grid hydraulic models where the model run times are much longer, therefore an investigation of the applicability of the temporal patterns was undertaken.

Three temporal patterns were selected for each event duration and AEP reducing the number of model runs required. The three patterns were chosen by reviewing the available 10 patterns and adopting those which fit into categories considered to be 'front loaded', 'mid loaded' or 'back loaded'. The definition of these patterns is when most of the rain falls across the pattern. An example of this analysis is shown in Figure 15, where the temporal patterns 2, 5 and 7 were adopted. The adopted temporal patterns for each event duration are shown in Table 11.

TABLE 11 ADOPTED TEMPORAL PATTERNS

Temporal pattern shape	Event duration					
	1hr	2hr	3hr	12hr	24hr	72hr
Front loaded	TP04	TP02	TP03	TP05	TP02	TP02
Consistent	TP02	TP09	TP04	TP07	TP07	TP01
Back Loaded	TP09	TP06	TP10	TP02	TP08	TP08

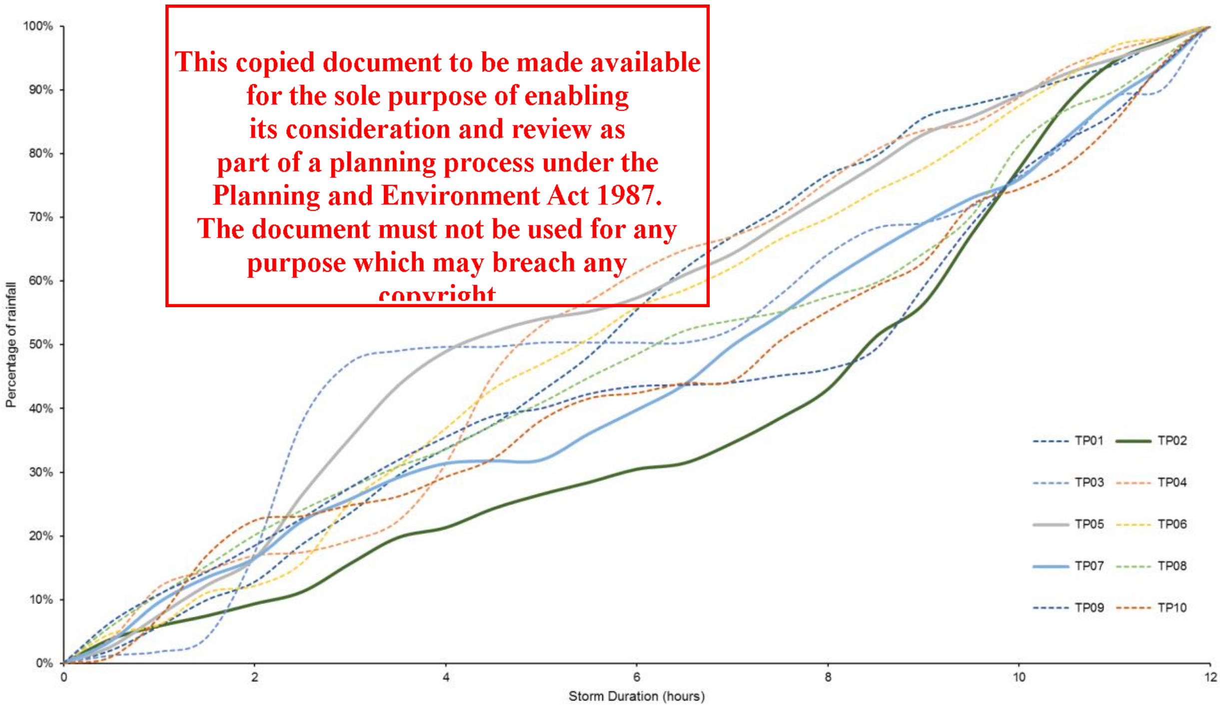


FIGURE 15 TEMPORAL PATTERN COMPARISON FOR THE 12 HOUR EVENT

2.5.2.3 Moyne River RORB model

Modelling of the Moyne River was completed using a RORB model built and calibrated during the Port Fairy Regional Flood Study[5]. The model was calibrated to flood events in 1975, 1976, 1978, 1983 and 2001 using gauge flows along Moyne River at Willatook and Toolong. Design modelling was completed by adjusting the RORB model losses to match a FFA at the Moyne River at Toolong gauge. The ARR1987 recommended Intensity Frequency Duration (IFD) parameters and temporal patterns were applied in the design modelling. This is different to those adopted in the hydraulic modelling, which used ARR2019 recommended temporal patterns and BoM 2019 recommended IFD parameters.

It was appropriate to use the older RORB modelling with ARR1987 recommendations given the design modelling was verified to the FFA design estimates and the relatively minor area of the site is impacted by Moyne River. This is shown in Figure 16 highlighting the location of the development site with respect to the broader Moyne River catchment and hydrograph extraction location. The adopted RORB model parameters are shown in Table 12 with the IFD values shown in Table 13.

The Port Fairy Regional Flood Study model was rerun for all previously modelled AEPs and durations with a print point inserted at the development boundary. The 36 hour event was determined as the critical duration in the Moyne River at this location.

TABLE 12 RORB MODEL PARAMETERS

Parameter	Value
Kc upstream of Willatook	32
Kc upstream of Toolong	48
M	0.8
Initial loss (mm)	15
Continuing loss (mm/hr)	1.85
Temporal Pattern	Zone 6

TABLE 13 RORB MODEL IFD VALUES

Parameter	Value
1 hour duration 2 year ARI	15.85 mm/hr
12 hour duration 2 year ARI	3.33 mm/hr
72 hour duration 2 year ARI	0.89 mm/hr
1 hour duration 50 year ARI	30.06 mm/hr
12 hour duration 50 year ARI	5.65 mm/hr
72 hour duration 50 year ARI	1.60 mm/hr
Regional skew G	0.59
Geographic factor F2	4.33
Geographic factor F50	14.62
Zone	6
1 hour duration 2 year ARI	15.85 mm/hr

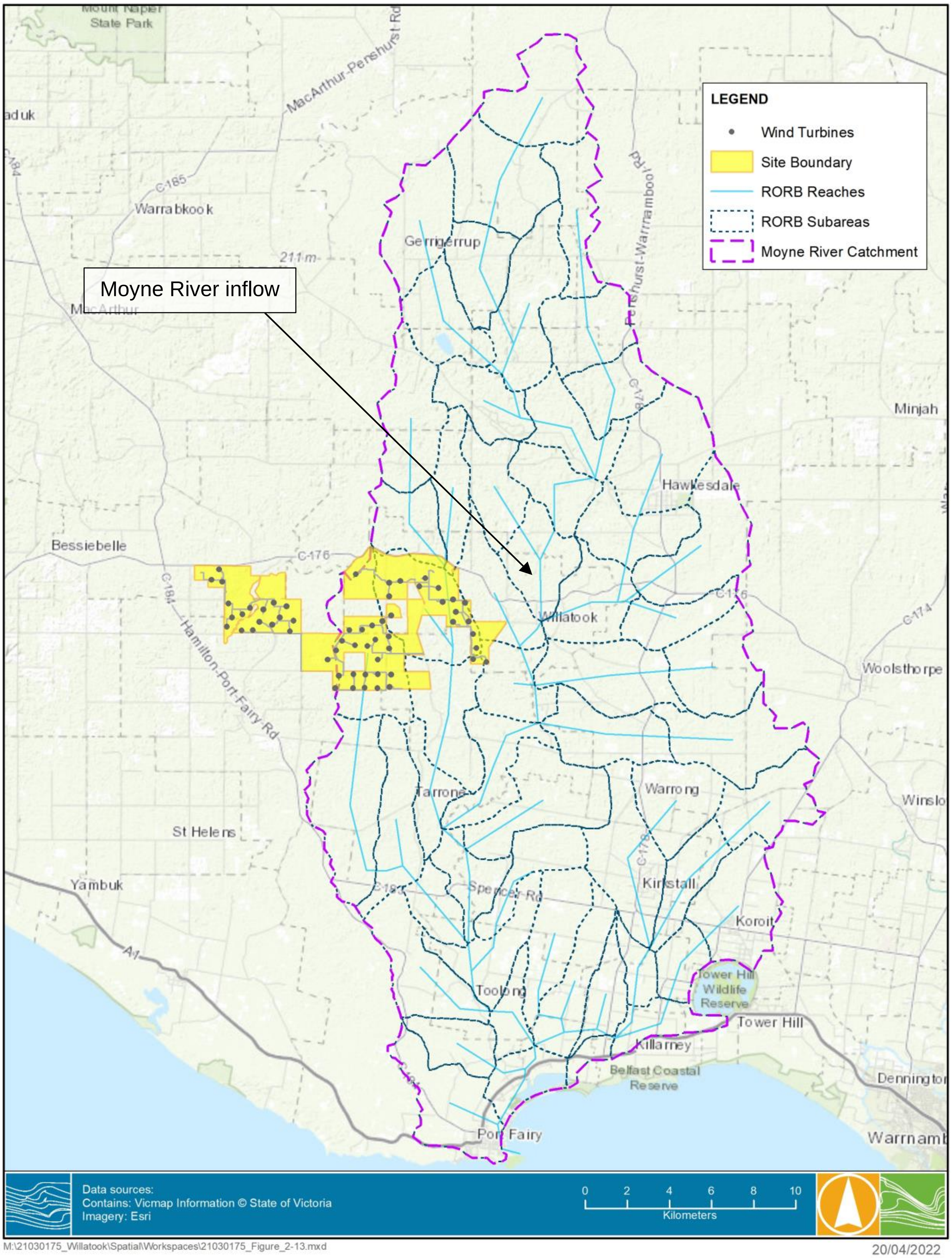


FIGURE 16 MOYNE RIVER RORB MODEL AND HYDRAULIC MODEL INFLOW BOUNDARY

2.5.3 Climate Change

To assess the potential influence climate change may have on inundation within the development, sensitivity testing was completed including the predicted hydrologic changes for south west Victoria.

There are a set of 40 global climate projection models used to assist in the analysis and representation of future temperature, evaporation, and rainfall. These models relate results to the Representative Concentration Pathway (RCP) projections and the specific locations throughout Australia. There are predictions for four RCPs, these are as follows:

- RCP8.5 - a future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100.
- RCP6.0 – lower emissions, achieved by application of some mitigation strategies and technologies. CO_2 concentration rising less rapidly (than RCP8.5), but still reaching 660 ppm by 2100 and total radiative forcing stabilising shortly after 2100.
- RCP4.5 - CO_2 concentrations are slightly above those of RCP6.0 until after mid-century, but emissions peak earlier (around 2040), and the CO2 concentration reaches 540 ppm by 2100.
- RCP2.6 - the most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining. Such a pathway would require early participation from all emitters, including developing countries, as well as the application of technologies for actively removing carbon dioxide from the atmosphere. The CO_2 concentration reaches 440 ppm by 2040 then slowly declines to 420 ppm by 2100) (Detlef P. van Vuuren et. al. (2011), The representative concentration pathways: An Overview).

The future impacts from anthropogenic greenhouse gas and aerosol emissions remains highly uncertain with many known and unknown influences and of the above scenarios none is considered more likely given these uncertainties. A graphical comparison of the pathways is represented in Figure 17 below.

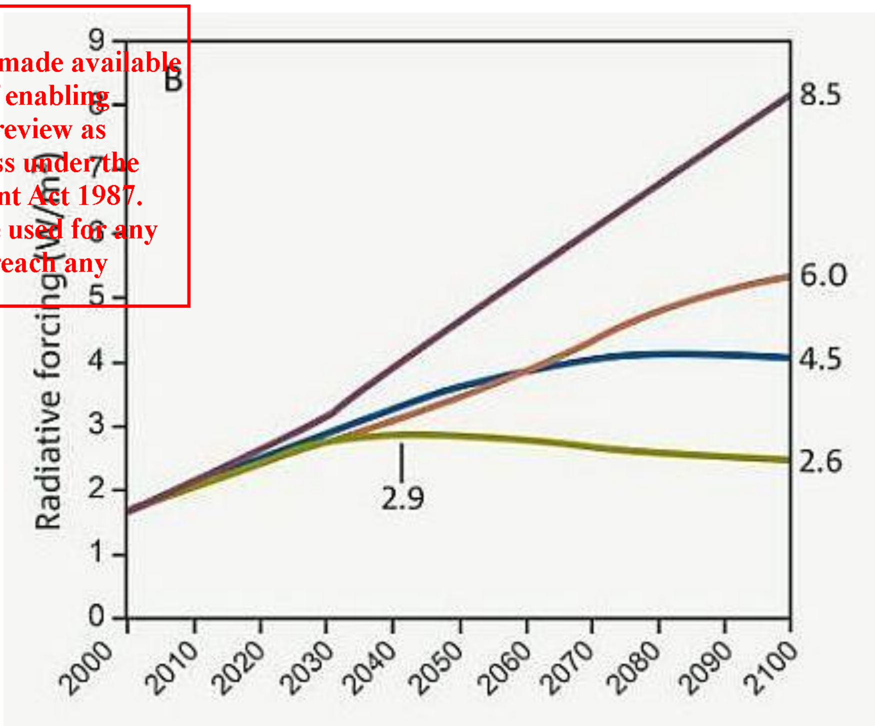


FIGURE 17 RADIATIVE FORCING FOR THE DIFFERENT RCPS. THE NUMBERS ON THE RIGHT SHOW THE FINAL RADIATIVE FORCING AT 2100 AND GIVE EACH SCENARIO ITS NAME (8.5, 6.0, 4.5, AND 2.6 W/M^2) (CLIMATE CHANGE IN AUSTRALIA TECHNICAL REPORT

Given the uncertainty about which RCP scenario will be relevant in the future it was determined that RCP 8.5 would be modelled giving the highest RCP scenario to achieve the most conservative assessment. Modelling all the available scenarios was not considered useful, just adding to the numerous uncertainties. Modelling of the RCP 8.5 demonstrates the worst case of the four options

Predicted climate change rainfall was extracted via the ARR2019[8] plugin tool which downloads data directly from the ARR Data Hub and Bureau of Meteorology. How these depths were determined for existing climatic conditions is detailed in Section 2.5.2.2.

2.5.4 Hydraulic roughness and losses

The hydraulic roughness layer (expressed as Manning's 'n') used in the hydraulic model was determined using the Moyne Shire Council Planning Scheme layers and verified using aerial imagery and land use types. The adopted roughness values and rainfall losses are shown in Table 14.

Roughness values were chosen based on the recommendations outlined in Open Channel Hydraulics, (Chow, V T, 1959) and the Melbourne Water Corporation Flood Mapping Projects Guidelines and Technical Specifications (Melbourne Water, 2016).

The recommended losses were determined based on the ARR2019 recommended losses[8] (initial loss – 24 mm, continuing loss 4.6 mm/hr), land use and demonstrations made in other broadscale rain on grid modelling projects that the required initial losses in a rain on grid model are much lower than those required in a rainfall runoff model due to the catchment storage is represented in the model topography (Natimuk Flood Investigation, 2012).

TABLE 14 MANNING ROUGHNESS COEFFICIENTS AND LOSSES

Manning 'n'	Initial Loss	Continuing Loss	Land Use Type
0.35	10	1.5	Residential - Urban (higher density) - when building footprints and remainder of parcel are modelled together (with one roughness value)
0.15	10	2.0	Residential - Rural (lower density) - when building footprints and remainder of parcel are modelled together (with one roughness value)
0.4	2.0	0.5	Residential Footprint - Urban (higher density) - when building footprints are modelled separately to remainder of parcel
0.1	10	2.0	Residential - Urban (higher density) - when building footprints are modelled separately to remainder of parcel
0.4	15	2.5	Residential Footprint - Rural (lower density) - when building footprints are modelled separately to remainder of parcel
0.05	20	2.5	Residential - Rural (lower density) - when building footprints are modelled separately to remainder of parcel
0.3	5.0	1.0	Industrial/Commercial or large buildings on site
0.05	15	2.0	Significant Drainage Easement (regardless of zone type)
0.04	10	4.6	Open Space or Waterway - minimal vegetation
0.06	10	4.6	Open Space or Waterway - moderate vegetation
0.09	10	4.6	Open Space or Waterway - heavy vegetation
0.06	10	4.6	Open water (with reedy vegetation)
0.02	0	0	Open water (with submerged vegetation)
0.02	2.5	0.5	Car park/pavement/wide driveways/roads

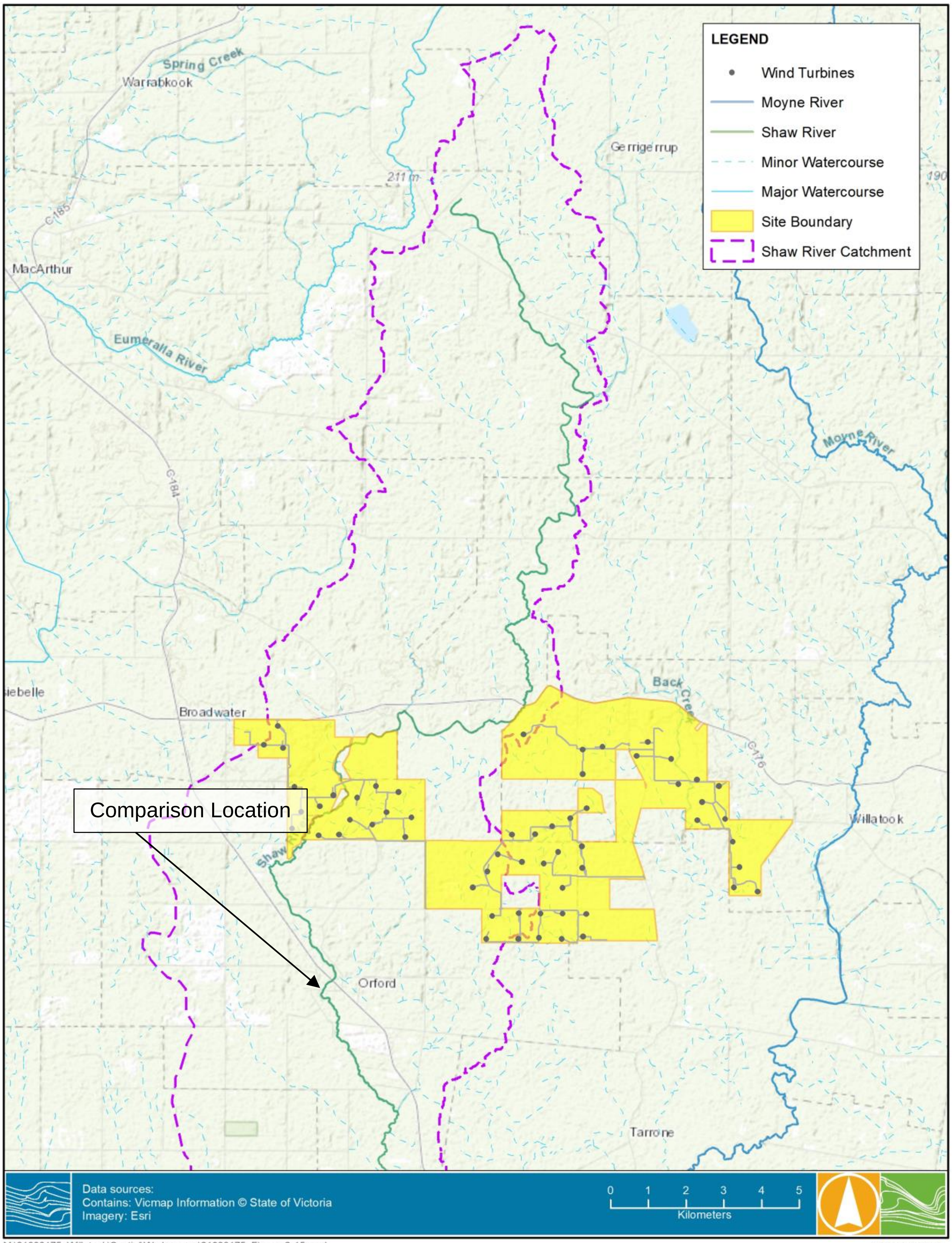
[8] https://data.arr-software.org/

Manning 'n'	Initial Loss	Continuing Loss	Land Use Type
0.125	5.0	1.0	Railway line
0.016	1.0	0	Concrete lined channels

2.5.5 RFFE Verification

To verify the hydraulic model results a comparison was made between the 1% AEP modelled peak flow and a Regional Flood Frequency Estimation Tool[9] estimate. The comparison was made on the Shaw River at the edge of the hydraulic model. The catchment area was 130.7 km², as shown in Figure 18.

[9] https://rffe.arr-software.org/



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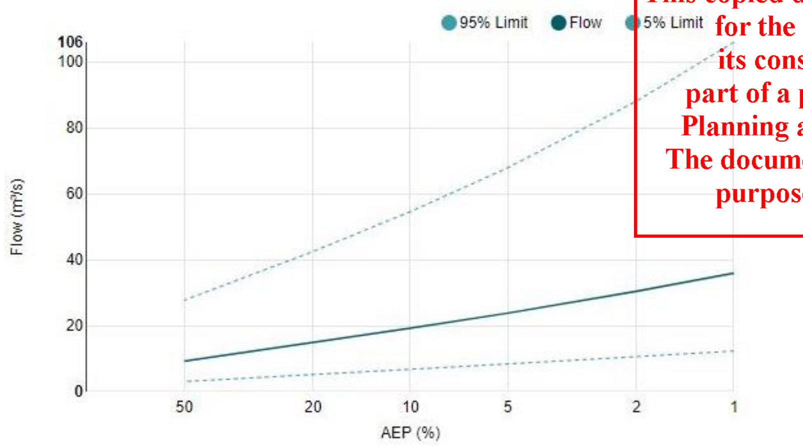
20/04/2022

FIGURE 18 RFFE CATCHMENT

The RFFE results are shown in Figure 19, indicating a 1% AEP peak flow of 35.9 m³/s, with large 95% confidence limits ranging from a lower limit of 12.3 m³/s to an upper limit of 106 m³/s.



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	9.21	3.04	27.7
20	14.9	5.17	42.5
10	19.2	6.76	54.6
5	23.8	8.38	67.9
2	30.4	10.6	88.1
1	35.9	12.3	106

FIGURE 19 DISCHARGES FOR DIFFERENT ANNUAL EXCEEDANCE PROBABILITIES

As discussed in Section 2.5.2, the hydraulic model was run for a range of durations and temporal patterns. For the 1% AEP event, within the Shaw River catchment (used for comparison to the RFFE), the critical duration was 12 hours at the comparison location. For a 12-hour event the modelled peak flow varied from 13.7 to 29.9 m³/s, as shown in Table 15. These values were within the RFFE confidence limits and compared relatively well to the 1% AEP estimate of 35.9 m³/s. The modelling produced lower peak flows than the RFFE estimates, this is likely to be a result of the amount of catchment storage the wetlands provide across the Shaw River catchment. This storage is included in the modelling but not necessarily included in the RFFE tool assessment as it is dependent on FFA undertaken at surrounding gauges. The hydraulic model was determined fit for purpose and of sufficient accuracy to produce reasonable design flow estimates within and upstream of the WWF development site.

TABLE 15 RFFE COMPARISONS

Duration	RFFE peak flow (m^3/s)	Temporal pattern peak flow (m^3/s)		
		Front loaded	Consistent	Back loaded
1-hour	35.9 m³/s	6.5	7.4	7.9
2-hour		11.5	10.6	12.4
6-hour		15.6	14.4	20.5
12-hour		13.7	16.8	29.9

Duration	RFFE peak flow (m^3/s)	Temporal pattern peak flow (m^3/s)		
		Front loaded	Consistent	Back loaded
24-hour		12.1	10.8	17.2
72-hour		5.4	0.7	7.02

2.5.6 Model Results – Current Conditions

The existing 1% AEP and 10% AEP modelled flood depths covering the development area are shown in Figure 20 and Figure 21 respectively.

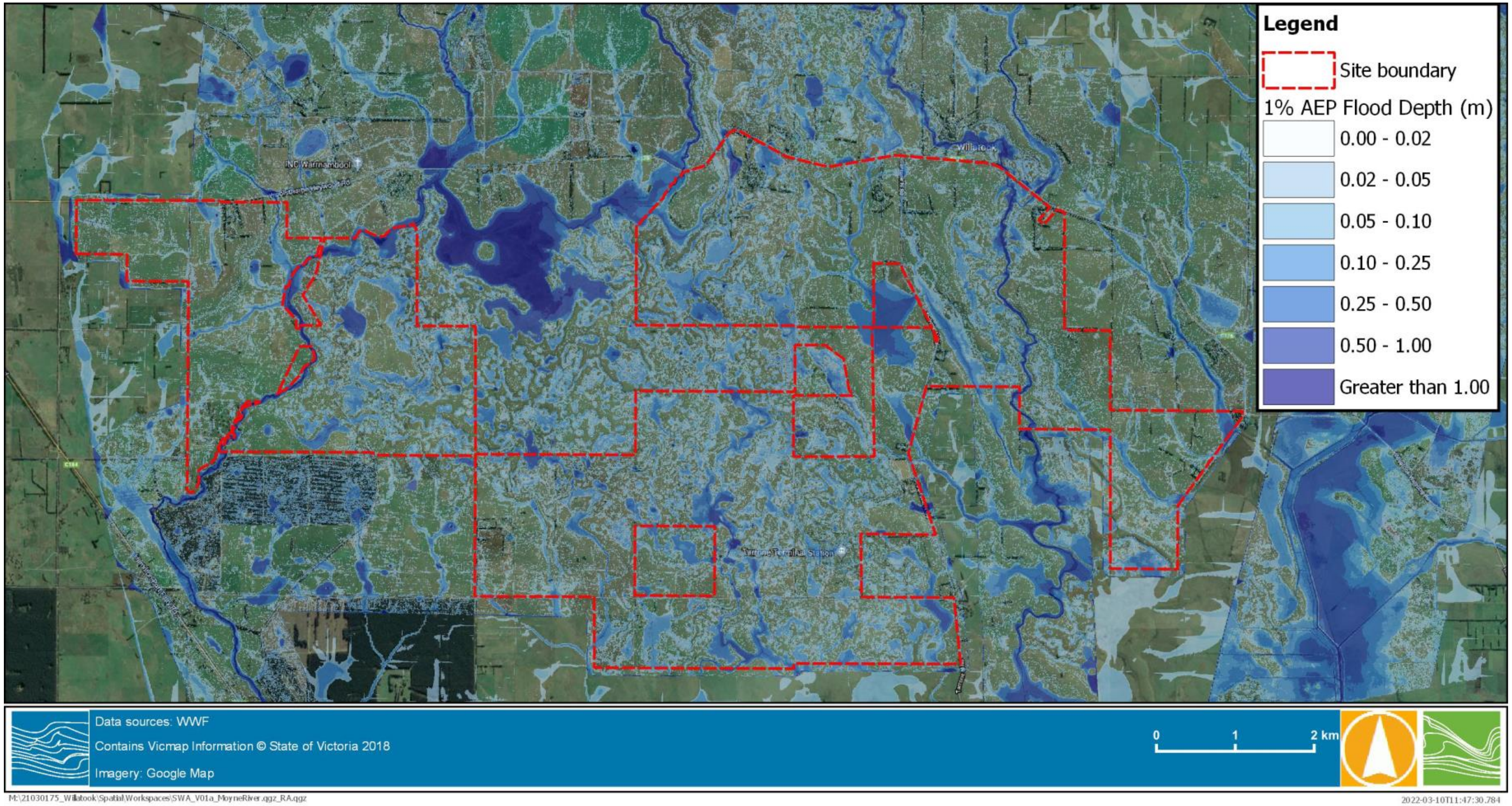


FIGURE 20 1% AEP FLOOD DETHS COVERING THE WWF DEVELOPMENT AREA

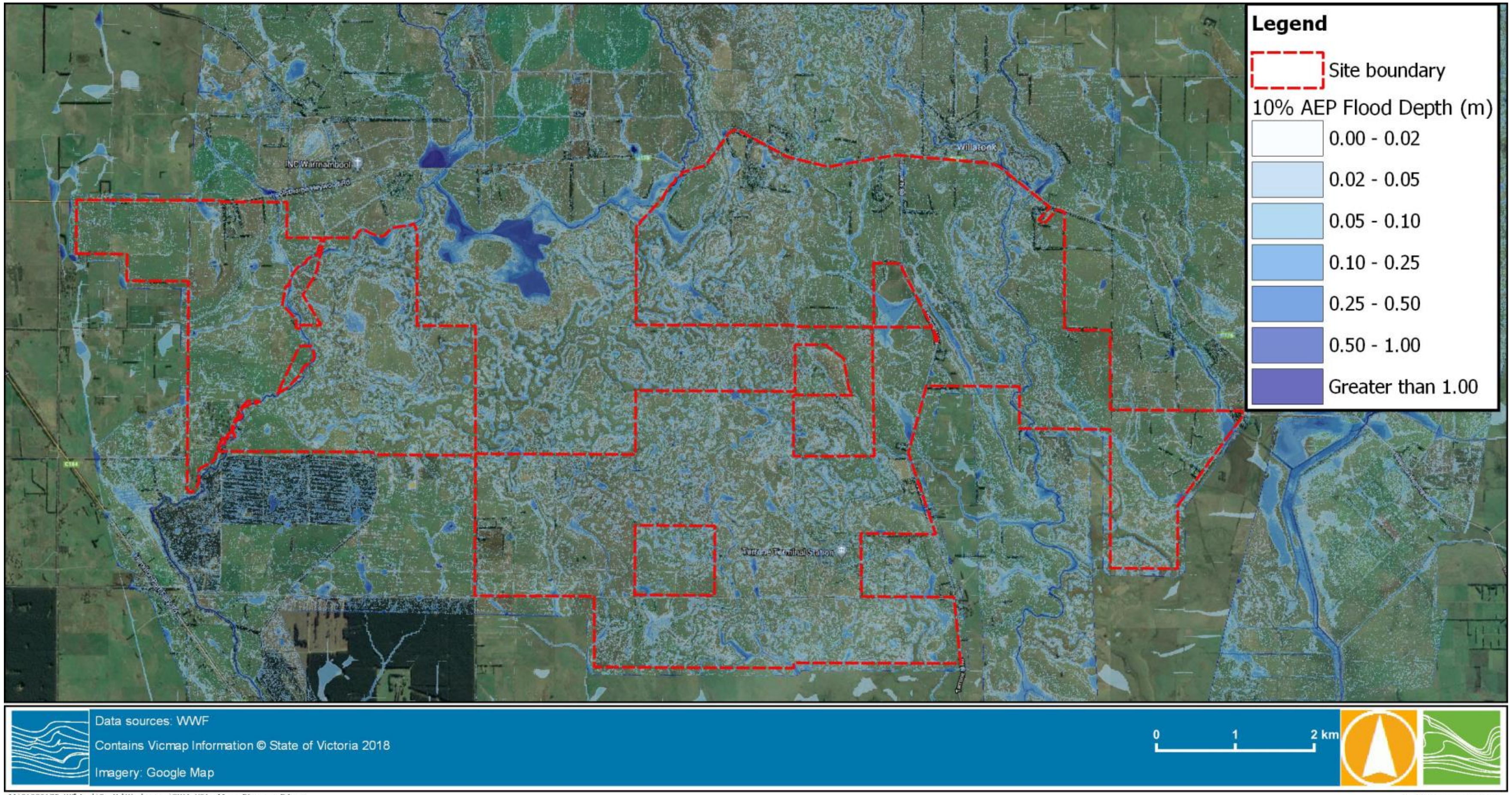


FIGURE 21 10% AEP FLOOD DEPTHS COVERING THE WWF DEVELOPMENT AREA

2.5.7 Model Results - Climate Change Conditions

As discussed in Section 2.5.3, climate change modelling was completed using a conservative 2090 RCP 8.5 scenario. The change in flood levels across the site due to climate change for the 1% AEP and 10% AEP events are shown in Figure 22 and Figure 23 respectively.

The changes show relatively minor increases in flood depth across the development area. The largest increases are within lower depressions and wetlands, including the Cockatoo Swamp Complex (not within the development boundary). Across both the 10% and 1% AEP scenarios, there is only one turbine location with a depth increase of more than 20cm, three with increases of 10-20cm in the 1% AEP event and the remainder generally under 20mm. This indicates a minor likely increased impact due to climate change at the turbine locations.

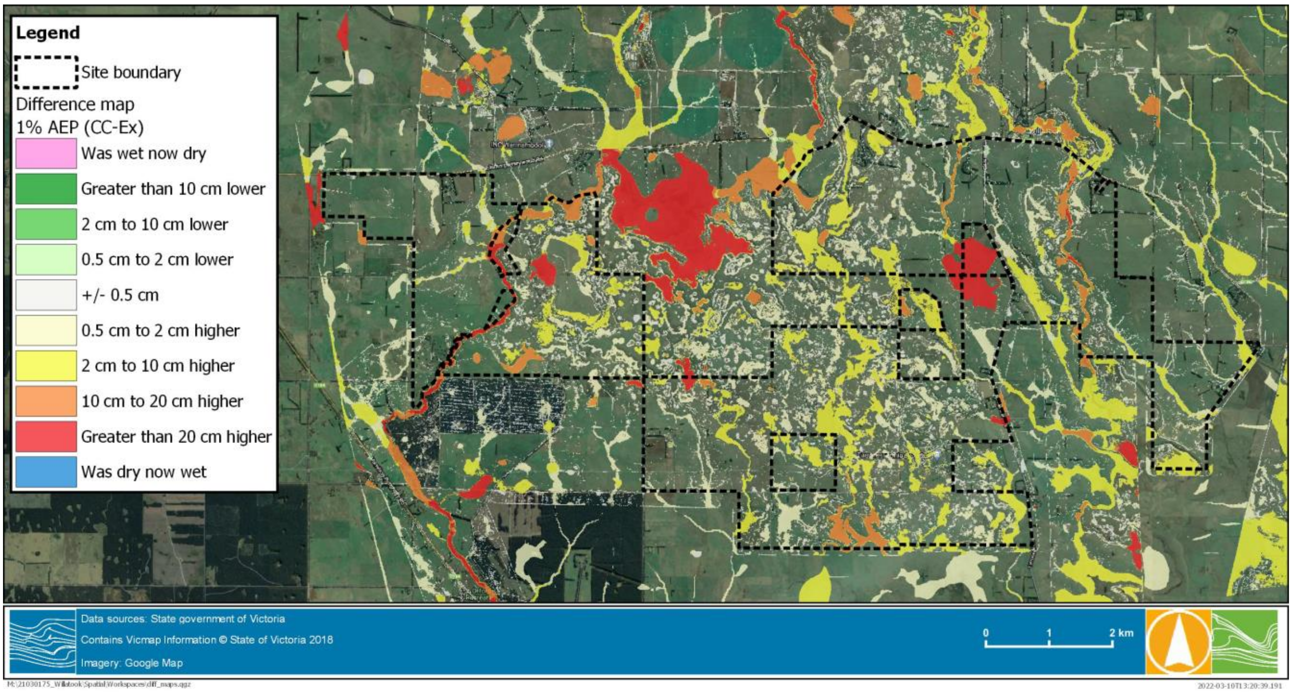


FIGURE 22 CHANGE IN FLOOD LEVEL UNDER A 1% AEP, 2090 RCP 8.5 CLIMATE CHANGE SCENARIO

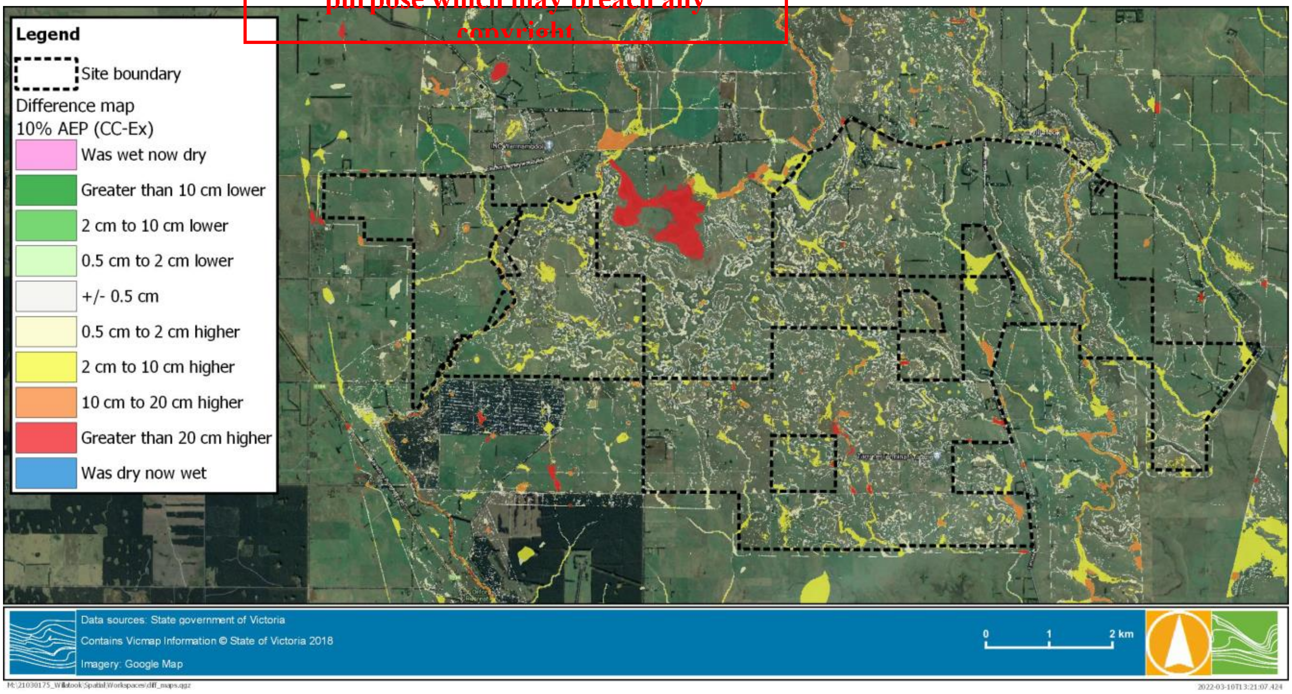


FIGURE 23 CHANGE IN FLOOD LEVEL UNDER A 10% AEP, 2090 RCP 8.5 CLIMATE CHANGE SCENARIO

2.6 Acid Sulphate Soil Investigation

2.6.1 Overview

The disturbance to surface soils through excavation and construction in the development area presents a potential impact to the environment through exposure and acidification of soil.

This investigation evaluate potential impacts to groundwater and surface water based on the investigation criteria, including undertaking a preliminary investigation to identify the presence or otherwise of acid sulfate soils (ASS).

The preliminary investigation is confined to an investigation of soils in representative locations to identify high level risk, and not at specific locations of disturbance. Further investigation during design phases of the development may be necessary in locations where intrusive activity is likely to pose higher risk, as in deep excavations, and quarrying.

2.6.2 Methodology

The investigation of ASS includes the following investigation:

- A desktop investigation to determine potential for the site to be an acid sulfate soil risk area based on:
  - whether acid sulfate soil has been previously identified at or near the site
  - whether the site is located in a Prospective Land Zone as indicated by the Coastal Acid Sulfate Soil hazard maps, or
  - whether the site, or area to be disturbed, is at or below 5 mAHD and the natural ground surface is below 20 mAHD.
- Site investigation

- visual inspection for presence of sulfides, and field indicators for soil and water to assist in the identification of acid sulfate soils, including field soil pH testing.
- soil sampling and analysis to determine presence of acid soils and proposed management.
- representative locations based on land type and areas proposed for disruptive or intrusive activity.
- field and laboratory testing to identify Potential ASS (PASS) horizons and determine potential acidity generation.

2.6.3 Acid Sulfate Soils

ASS are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials (EPA 2009). These soils are most commonly found in low-lying land bordering the coast, in estuarine and saline wetlands, and in freshwater groundwater dependent wetlands throughout Victoria.

In an anoxic state, these materials remain benign and do not pose a significant risk to human health or the environment. However, the disturbance of ASS, and its exposure to oxygen, has the potential to cause significant environmental and economic impacts. When PASS are disturbed or exposed to oxygen, the iron sulfides are oxidised to produce sulfuric acid and the soil becomes strongly acidic (usually below pH 4). The effects of this can include:

- Loss of biodiversity in wetlands and waterways;
- Contamination of groundwater resources by acid, arsenic, heavy metals and other contaminants;
- Loss of agricultural productivity; and
- Corrosion of concrete and steel infrastructure by acidic soil and water.

Disturbance of acid sulphate soils can adversely affect land use and development and can adversely impact land, water and ecosystems in the following ways (EPA 2009):

- Environmental quality — affecting soil quality, surface and groundwater quality, and aquatic habitats.
- Agricultural practices — loss of rural productivity, loss of commercial and recreational fisheries, the cost of additional lime and fertilizer requirements and degradation of drainage systems.
- Engineering and landscaping works —– the corrosion of concrete and steel and the design of transport structures (i.e., road or rail), buildings, embankments and drainage systems to avoid impacted areas.
- Human health — skin and eye irritation, contamination of drinking water and occupational health and safety risks.

The potential environmental impact of acid sulphate soils depends on a number of factors, including the following:

- Exposure to oxidising conditions — ASS cannot commence generating acidic discharges unless exposed to oxygen and water.
- The volume, texture and sulfidic characteristics of the soil being disturbed — higher volumes of disturbance, greater porosity (i.e., sands), or higher percentages of sulfide often result in higher rates of acid generation and greater impacts.
- Capacity for self-neutralisation — acidic discharges may be neutralised as they occur, depending on the content and nature of neutralising material present in the soil, including organic material and/or carbonates (e.g., fine-grained shell matter or lime).
- The acid buffering capacity of the receiving environment — for example, some water environments. Acid buffering capacity of soil and water is often limited, so may not provide neutralising capacity in the long term.

- The concentrations of aluminium, iron and other metals in soils or rock and the potential for acidic discharges to dissolve these metals.

2.6.4 Desktop ASS investigation

The VRO Coastal Acid Sulfate Soil hazard maps (Coastal Acid Sulfate Soils Distribution - Map 3 for Central Coast of Victoria) was examined, which indicates the site is outside of the area of influence of the coastal ASS zone.

Australian Soil Resource Information System (ASRIS) maps for the region indicate areas of probability of the presence of ASS. The mapping indicates there is an extremely low probability of ASS existing in the subject site but recorded with low confidence, as indicated in Figure 24.

An area of high ASS probability is indicated in Cockatoo Swamp in the northern wetland area but is outside of the area of the proposed development.

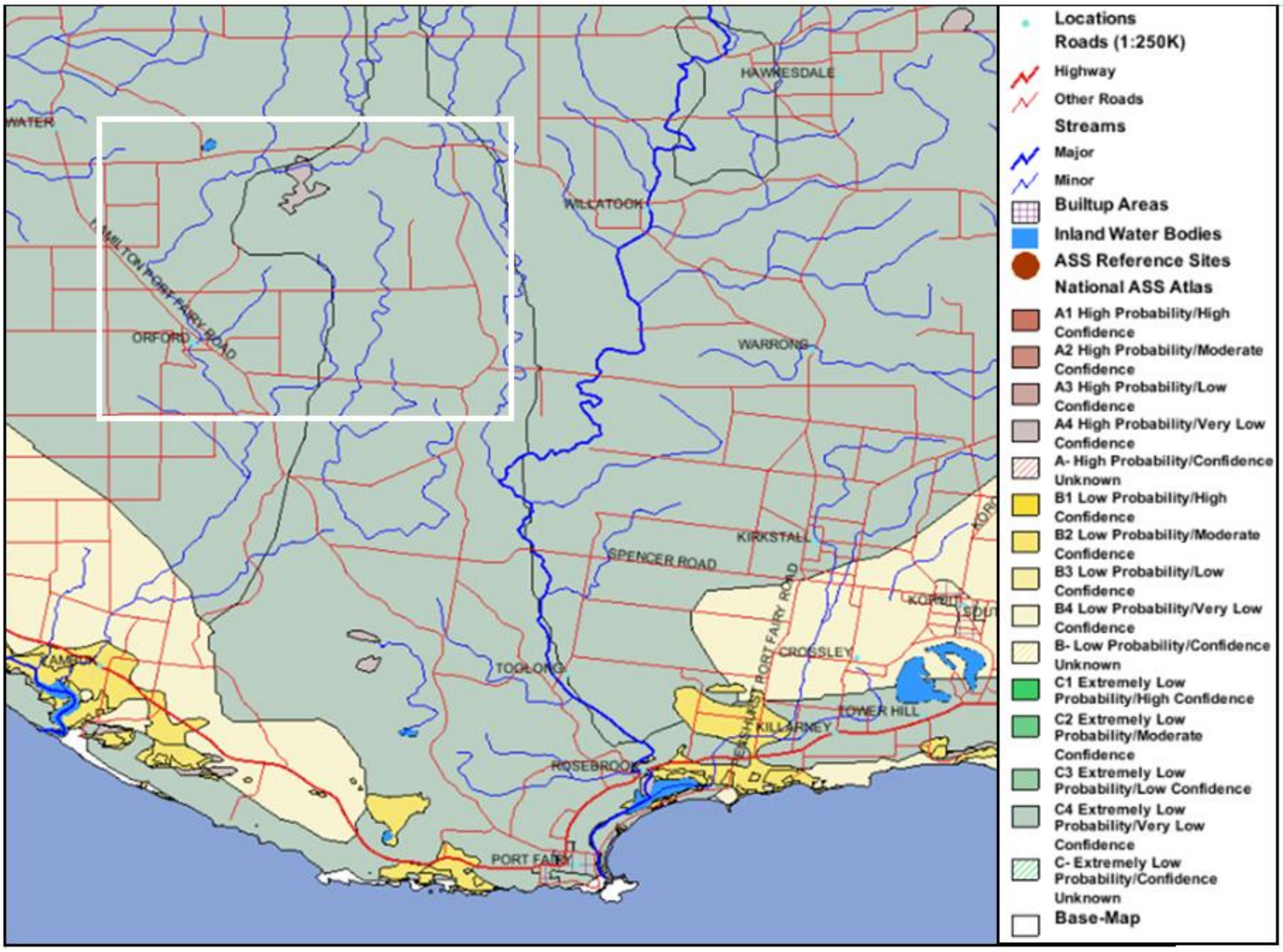


FIGURE 24 ASRIS MAPPING ACID SULFATE SOILS PROBABILITY

2.6.5 Site investigation

A site inspection and soil sampling were undertaken on 20th and 21st of March 2021. The weather was fine with daytime temperature approximately 25°C with light breezes.

Permission from landowners to enter the properties for the inspection was granted prior to visiting. Four sampling sites were visited, identified as PASS#1 – PASS#4, locations indicated in Table 16 and Figure 25.

TABLE 16 SAMPLE LOCATIONS

Sample ID	Site	Location	Access
PASS #1	Quarry site	38.17°S, 142.12°N	Old Dunmore Rd
PASS #2	Adjacent turbine location	38.18°S, 142.15°N	Riordans Rd
PASS #3	Brolga wetland	38.16°S, 142.15°N	Landers Ln
PASS #4	General grazing property	38.14°S, 142.18°N	Tarrone North Rd

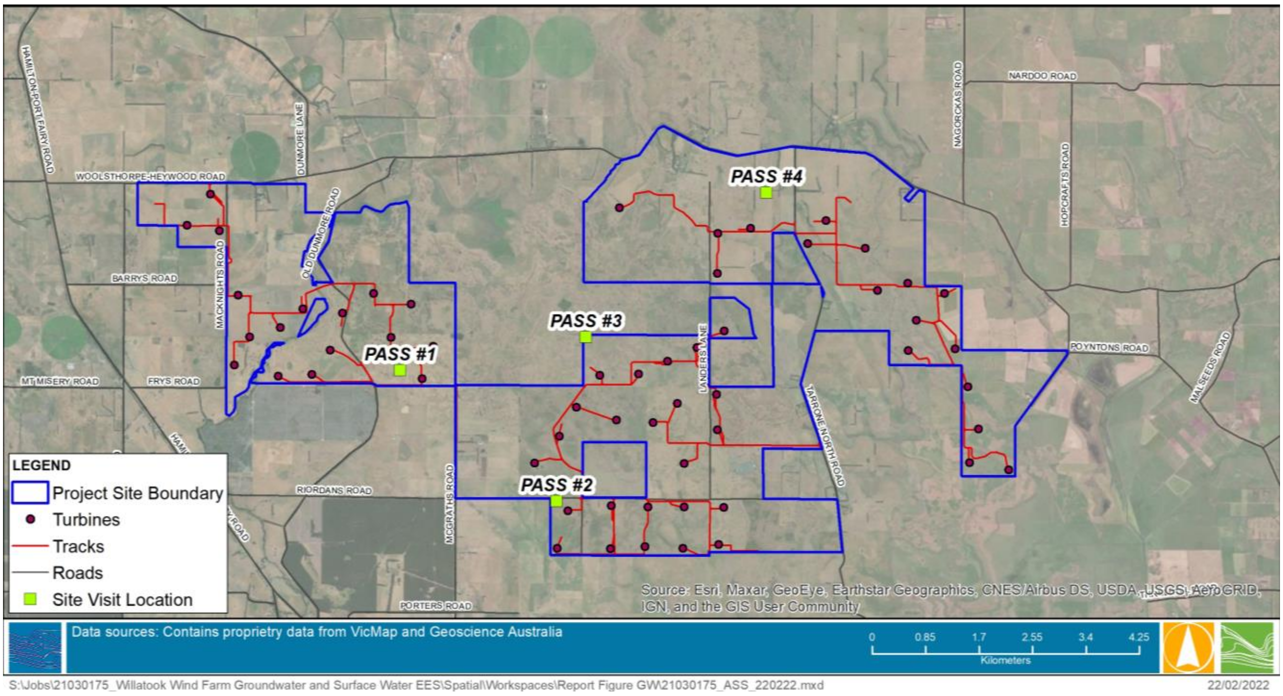


FIGURE 25 SOIL SAMPLING SITES

Photos of each site are presented in Figure 26 to Figure 29.

FIGURE 26 PASS#1 – QUARRY SITE

FIGURE 27 PASS#2 – ADJACENT RIORDANS ROAD

FIGURE 28 PASS#3 – 'BROLGA' WETLAND

FIGURE 29 PASS#4 – PROPERTY ADJACENT TARRONE NORTH ROAD

2.6.5.1 Soil sampling

The sampling and testing were undertaken in accordance with methods outlined in Victorian EPA information bulletin IB-655.1 – Acid Sulfate Soil and Rock (EPA 2009).

Each location was sampled to a depth of approximately 1200mm which is considered appropriate for the majority of road preparation and service construction.

A 75mm hand operated auger was used to sample soils, the auger used and sample bag are shown in Figure 30.

Soil samples were placed into zip lock bags supplied by Eurofins Laboratory, and refrigerated. Air was expelled from the bags before sealing, and the samples for testing were delivered to Eurofins laboratory.

Each sample was analysed for the SPOCAS suite (Suspension Peroxide Oxidation Combined Acidity and sulfur) to give detailed acid-base accounting to allow a determination of the acidification potential of soils (if any) and treatment rates for acidic soils (if required).

2.6.5.2 Soil characteristics

The soil samples at each site were examined and classified based on Unified Soil Classification (USC) – Field Methodology, to determine clay content in fine-grained soils. The results are provided in Table 2-2.

TABLE 17 SOIL PHYSICAL CHARACTERISTICS

Sample ID	Description	Colour	Texture/Structure	USC symbol	Est. Clay content
PASS #1	Sandy silt some clay to 600mm abrupt over dark brown medium clay		Weak medium to heavy clay	CH	40-50%
PASS #2	Sandy silt some clay to 300mm over brown to mottled orange medium clays		Weak light to medium clay	CH	35-40%
PASS #3	Sandy silty clay to 200mm over dark brown silty clay to clay		Weak medium to heavy clay	CH	40-55%
PASS #4	Sandy silty clay over friable brown yellow sandy clay		Granular moderate structured medium clay	CL	25-35%

FIGURE 30 PASS#4 – PROPERTY ADJACENT TARRONE NORTH ROAD

2.6.6 ASS Assessment

2.6.6.1 SPOCAS test suite

The Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) test is a self-contained suite allowing a detailed acid-base accounting in soil. SPOCAS compares the pH, titratable acidity, sulfur and cations on two sub-samples of a soil, where one sub-sample is oxidised with hydrogen peroxide and the other is not.

The differences between the two sub-samples for the various SPOCAS parameters are then calculated, providing twelve individual analytes plus five calculated parameters, "enabling the quantification of some key fractions in the soil sample, leading to better prediction of its likely acid generating potential".

The most important analytical parameter for determining acid sulphate soil status is Net Acidity, which is calculated using the following method:

Net Acidity = All forms of acidity (potential, actual and retained) - Acid Neutralising Capacity

"The Net Acidity leached to the environment when ASS is disturbed depends not only on the amount and rate of acid generation, but also on the amount and reactivity of the neutralising components of the soil" (DER 2013).

2.6.6.2 ASS assessment criteria

Analytical results from the SPOCAS test were assessed against criteria outlined in Appendix 3 of IB-655.1 (EPA 2009), which presents texture-based Net Acidity action criteria for classification of Acid Sulphate Soil.

The criteria differ as a function of soil texture. To classify ASS, three soil textures are recognised:

- Sands to loamy clays.
- Sandy loams to light clays.

- Medium to heavy clays and silty clays.

As IB-655.1 states, “the criteria relate to soil texture. The clay content of soil influences the amount of sulphuric acid generated after soil disturbance. Clay rich soils generally have a higher natural pH buffering capacity (Acid Neutralising Capacity or ANC) than clay-poor soils. This means they can neutralise more acid than clay-poor soils.”

Assessment criteria presented in IB-655.1 (EPA 2009) are also based on the quantity of soil likely to be displaced. In this project, the volume likely to be displaced is not yet known.

The analytical results were therefore assessed against criteria presented in Table 18.

TABLE 18 TEXTURE BASED ACTION CRITERIA FOR CLASSIFICATION OF ACID SULFATE SOIL

Soil or sediment texture	Approx. clay content (%)	NET ACIDITY CRITERIA			
		1-1000 tonnes		1000 tonnes	
		%S (oven-dry basis)	mol H+/tonne (oven-dry basis)	%S (oven-dry basis)	mol H+/tonne (oven-dry basis)
Sands to loamy clays	< 5	0.03	18	0.03	18
Sandy loams to light clays	5 - 40	0.06	36	0.03	18
Medium to heavy clays and silty clays	> 40	0.1	62	0.03	18

2.6.7 Results and analysis

The laboratory Certificates of Analysis and Chain of Custody (CoC) documentation are provided in Appendix F. Surface soils indicate a dark brown clay with some silts. Soils were generally plastic and moist in low lying areas.

2.6.7.1 Acid Sulfate

The soils have been classified as medium to heavy clay with an approximate clay content of greater than 40%. In accordance with the texture-based criteria for determining ASS, a net acidity criterion of greater than 18 mol H+/tonne would indicate the presence of ASS.

The sample testing indicates net acidity of between 29 and 50 mol H+/tonne (samples PASS#1 - PASS#3), and net sulfur percentage of 0.08%, or less.

While the SPOCAS results indicate the potential for ASS, field indicators determined there was no evidence of discolouration associated with ASS, and no pyrite visible in the soils, and no obvious sulfureous odour was detected. There was evidence of some mottling.

Laboratory results showed that the sampling locations reported pH at or greater than 5, suggesting that it was unlikely that these were acidogenic soils (i.e., less than pH of 4). Following peroxide oxidation, pHOX either increased or fell by 0.6 units, again suggesting that it was unlikely that these were acidogenic soils, though Potential ASS appears to be evident.

2.6.7.2 Potential Acid Sulfate Soil (PASS)

The results from the SPOCAS testing found that samples from locations PASS#1 - PASS#3 had:

- Net Acidity exceeding 0.03 (%S units), and net acidity units of 48, 29, and 50 mol H+/tonne;
- pH of 5.0, and 5.1;
- Actual titratable acidity <2 mol H+/tonne, with values reported between 20 and 38 mol H+/tonne;
- Peroxide oxidisable sulphur exceeding 0.03 %S in PASS#1 sample

The results of the SPOCAS testing indicates a potential for the presence of PASS in samples #1, #2, and suspected in sample PASS#3.

Liming rates (calculated from the SPOCAS test results, assuming that the CaCO3 used was 100% effective neutralising the acidity) greater than 1 kg CaCO3 per tonne of soil – the values for PASS#1 to PASS#3 are between 4.0, 2.0, and 4.0kg CaCO3 per tonne of soil.

2.7 Groundwater availability and origin

2.7.1 Geology

The Project Site is located on the southern margin of the Western Volcanic Plain. This volcanic region is part of a broad basaltic lava province active over the past six million years and referred to as the Newer Volcanic Province, a major geological unit of southern Australia.

The surface geology within the Project area consists of the Newer Volcanic Group basalt flows (Qbn) with isolated occurrences of Alluvium (Qa) and Colluvium (Qrc) restricted to lower lying areas. Other surface geological layers mapped within the Project region, but outside the Project Site and immediate surrounds, are the Molineaux Sand (Qd) and Port Campbell Limestone (Czipc). The spatial distribution of these formations is illustrated in Figure 31 with lithological descriptions and estimated thicknesses summarised in Table 19.

TABLE 19 SURFACE GEOLOGY AND STRATIGRAPHY (SOURCE: GEOSCIENCE AUSTRALIA)

Symbol	Name	Lithological Description	Estimated Thickness (m)
Qa	Alluvium	Channel and flood plain alluvium; gravel, sand, silt, clay; may be locally calcreted.	0 to 5
Qrc	Colluvium	Colluvium and/or residual deposits, sheetwash, talus, scree; boulder, gravel, sand; may include minor alluvial or sand plain deposits, local calcrete and reworked laterite	0 to 5
Qd	Dunes	Dunes, sandplain with dunes and swales; may include numerous interdune claypans; may be locally gypsiferous.	0 to 5
Qbn	Newer Volcanic Group	Cinder cones - scoria, minor ash and agglutinates; Lava flows - tholeiitic to minor alkaline and basanitic lavas. High permeability where clays from weathered basalt are sparse.	0 to 50
Czipc	Port Campbell Limestone	Marine calcarenite, marl; bryozoans and molluscs abundant.	20 to 200

http://www.ga.gov.au/products-services/data-applications/reference-databases/stratigraphic-units.htm

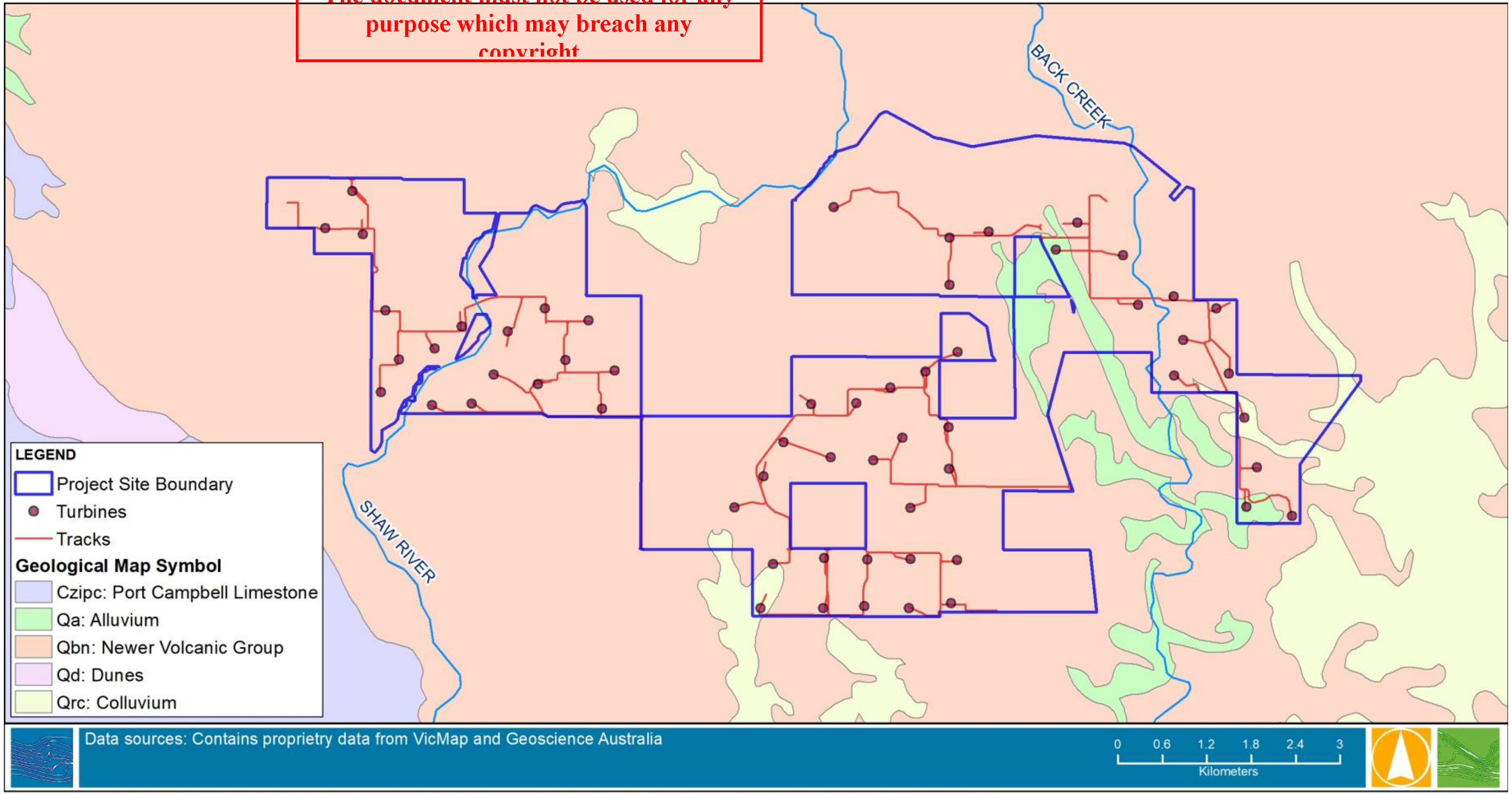


FIGURE 31 SURFACE GEOLOGY (GEOSCIENCE AUSTRALIA) WITH SITE OUTLINE AND PROPOSED TURBINE LOCATIONS

2.7.2 Aquifers

2.7.2.1 Overview

Within the Newer Volcanic Province, a number of subsurface geological units form aquifers. The primary aquifer units that occur in the Project Site are associated with the following geological layers:

- Unconsolidated alluvium and colluvium deposits (Quaternary Aquifer)
- Newer Volcanic basalts (Upper Tertiary/Quaternary Basalt)
- Port Campbell Limestone (Upper mid-Tertiary Aquifer, part of the Upper Middle/Limestone Aquifer).

These hydrogeological units are further described below, with a conceptual cross-section of the aquifer layers shown in Figure 32.

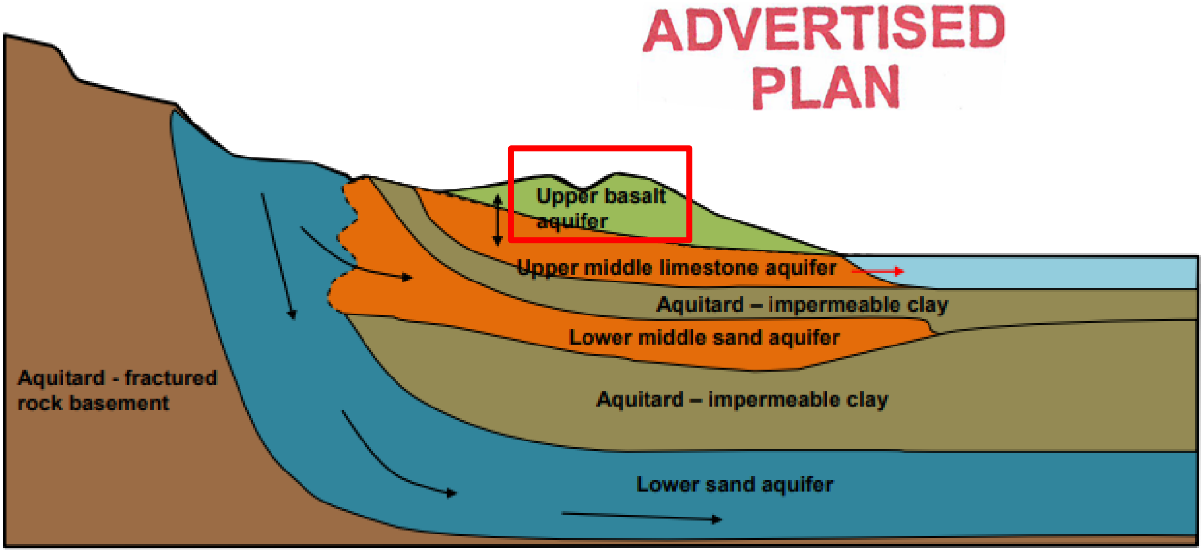


FIGURE 32 REGIONAL CONCEPTUAL MODEL WITH INDICATION OF PROJECT LOCATION HIGHLIGHTED (SOURCE: SOUTH WEST VICTORIA GROUNDWATER ATLAS SRW, 2011)

2.7.2.2 Unconsolidated alluvium and colluvium deposits (Quaternary Aquifer)

The unconsolidated alluvium and colluvium deposits (or Quaternary Aquifer) are comprised of gravels, sands and silts forming a thin layer of material in low-lying areas near drainage channels and floodplains and on the base of hillslopes. Where present, these deposits are located from surface to a depth of around 5 metres.

Within the Project Site, unconsolidated alluvium and colluvium deposits are located near Tarrone North Road, associated with a drainage line that feeds into Back Creek, and swamp/lake deposits south of Woolsthorpe-Heywood Road associated with Shaw River and Cockatoo Swamp (Figure 31). The unconsolidated alluvium / colluvium deposits overlie the Newer Volcanic Group basalts in the Project Site. These deposits are discontinuous and are not regionally extensive.

2.7.2.3 Newer Volcanic Group basalts (Upper Tertiary/Quaternary Basalt)

The Newer Volcanic Group basalts (or Upper Tertiary/Quaternary Basalt) comprises the Newer Volcanic Group basalt flows, overlain locally by stony rises and scoria. These basalt flows and stony rises comprise the majority of the Project Site surface geology and are the main aquifer system considered in this assessment (Figure 31). The Newer Volcanic Basalts are located from surface to a depth of around 50 metres based on surfaces developed by GHD (2012) accessed through Visualising Victoria's Groundwater (VVG) database.

Stony rises occur in areas within the Project Site where lava flows buried soil that was present on previous lava flows. The Stoney rises are reported to be less weathered and more fractured, allowing for higher volumes of groundwater recharge and storage (Nolan et al., 1990). The mapped areas of Stony rises are shown in Figure 33.

Across the project area, the Newer Volcanic Group basalt and stony rises behave as an unconfined fractured rock aquifer. In these aquifers, groundwater flow is controlled by fracture zones through which groundwater infiltrates and flows, as well as the rock type, level of rock deformation and undulations of the land surface. While both basalt flow and stony rise aquifers are important for groundwater supply, the aquifer potential in stony rises is reported to be higher (Nolan et al., 1990).

2.7.2.4 Port Campbell Limestone (Upper mid-Tertiary Aquifer)

Beneath the Newer Volcanic Group basalts is the Port Campbell Limestone which occurs from depths of around 20 to 200 metres below ground level and comprises marine silts and clays. This aquifer is typically around 100 to 200 metres thick across the South-west Coast sub-region and is a major aquifer in the region. The Port Campbell Limestone outcrops (is present at the surface) to the west of the study area (Figure 31). Within the study area it is overlain by the Newer Volcanic Group basalts. The Port Campbell Limestone aquifer is classified as 'partially confined' in areas where it is overlain by Newer Volcanic Group basalts.

2.7.2.5 Other regional geological units

Other aquifer units that occur in the vicinity of the Project Site include:

- Clifton Formation (Lower mid-Tertiary Aquifer): a confined limestone aquifer, typically 15 to 25 metres thick, located throughout most of the Otway Basin. It is considered that the Clifton Formation is not hydraulically connected to the Port Campbell Limestone aquifer.
- Dilwyn Formation (Lower Tertiary Aquifer): located up to 1,000 metres below the surface in some areas, this aquifer provides the water supply for the townships of Portland, Port Fairy, Heywood and Dartmoor. Due to the depth of this aquifer, it is not extensively used (unlike the limestone and basalt aquifers).

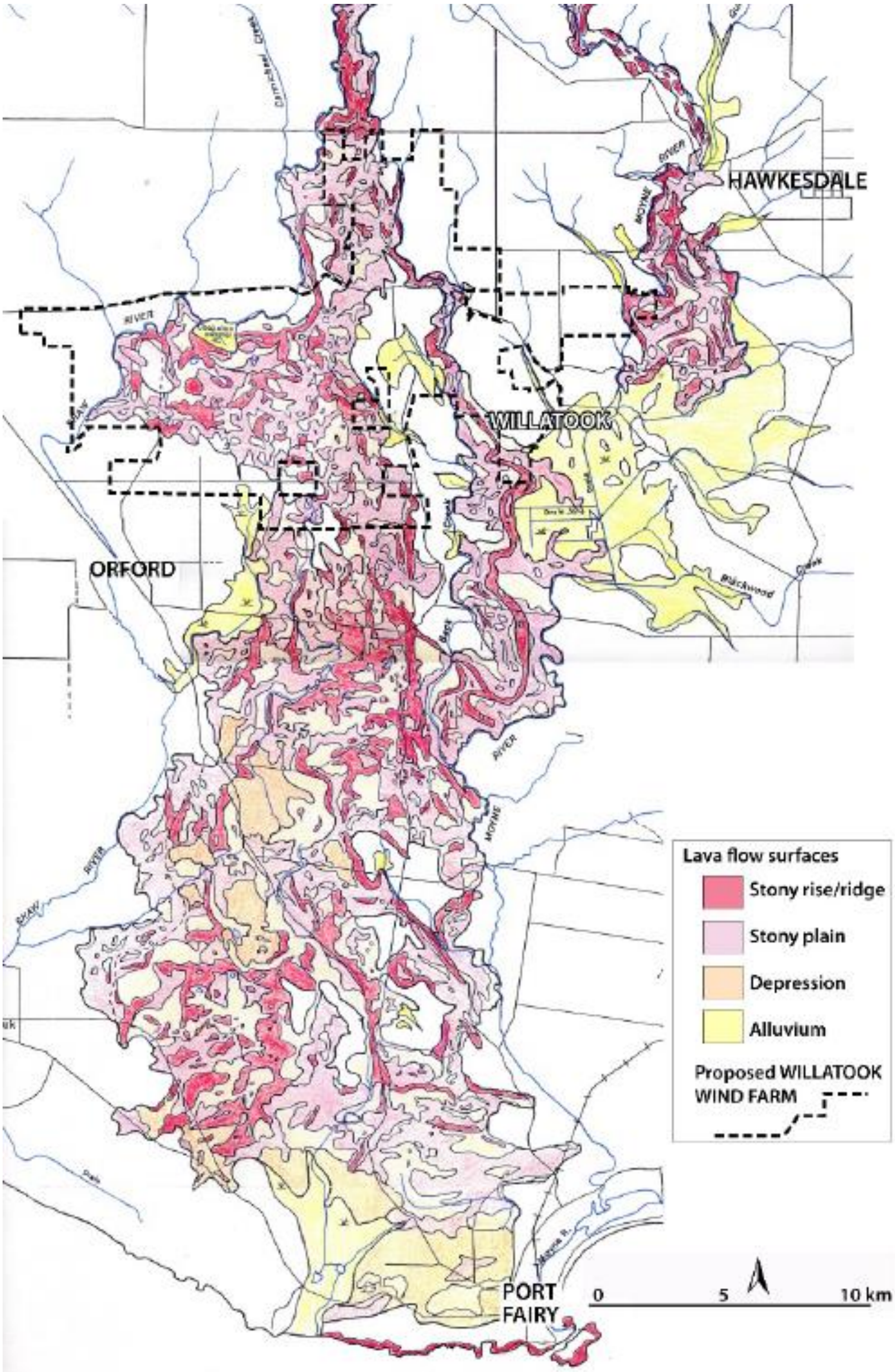


FIGURE 33 LAVA FLOW SURFACES AND INDICATIVE WWF LAYOUT (SUTALO, 1996)

2.7.3 Hydrogeology

2.7.3.1 Depth to Groundwater

The depth to groundwater within the Newer Volcanic Group basalts varies both spatially and seasonally, influenced by rainfall and longer-term climatic conditions. In general, groundwater is shallow across the Project Site, estimated to be between 1 to 12 metres below ground level. Localised areas of shallow groundwater (less than 3 metres below ground level) are likely to occur, particularly in topographic lows.

The project site is located in an area which has undergone extensive clearance of native vegetation in the past. The clearance of native deep rooted vegetation has resulted in increased recharge, elevated groundwater levels, and the potential for land salinisation due to evapo-concentration of shallow groundwater. The process of land clearance leading to rising groundwater levels is shown schematically in Figure 34. This is important when considering impacts as the existing groundwater environment has experienced considerable change since European settlement, with current groundwater levels higher than what would have otherwise been experienced.

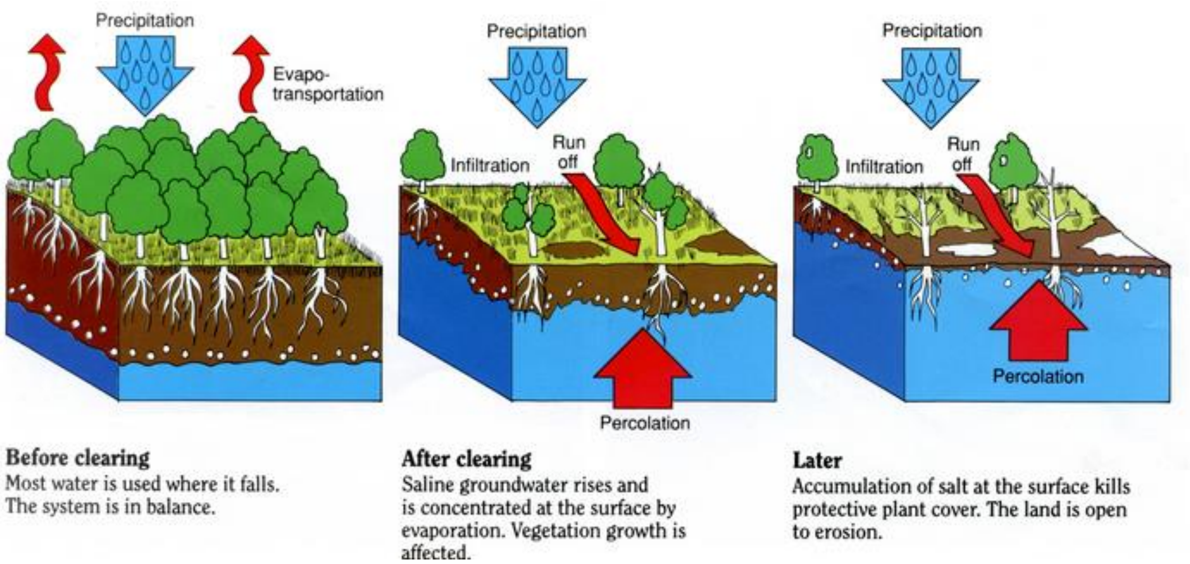


FIGURE 34 DRYLAND SALINITY (VRO, 2019)

A regional interpretation of average depth to groundwater from Visualising Victoria's Groundwater database is shown in Figure 35. This figure shows that across the Project Site there are areas where groundwater is shallow and is expected to be within 5 metres of ground level. These areas coincide with topographic lows and drainage lines. Away from drainage lines where the surface topography is higher, the depth to groundwater is greater and is in the range of 5 to 20 metres as depicted in Figure 35. Areas of deeper groundwater are predominately located in the north-eastern and eastern parts of the Project Site. Based on observations of the Site, shallow aquifers that intercept the surface may also be present as small, saturated wetland areas or springs.

Groundwater level measurements taken during May 2016 for this project at six registered groundwater bores ranged from 1.0 to 11.7 metres below ground level. Additional measurements taken 5 February 2021 from five boreholes within the proposed quarry extraction site ranged from 2.1 to 5.2 metres below ground level. The data obtained as a part of this project is consistent with that presented in Figure 35.

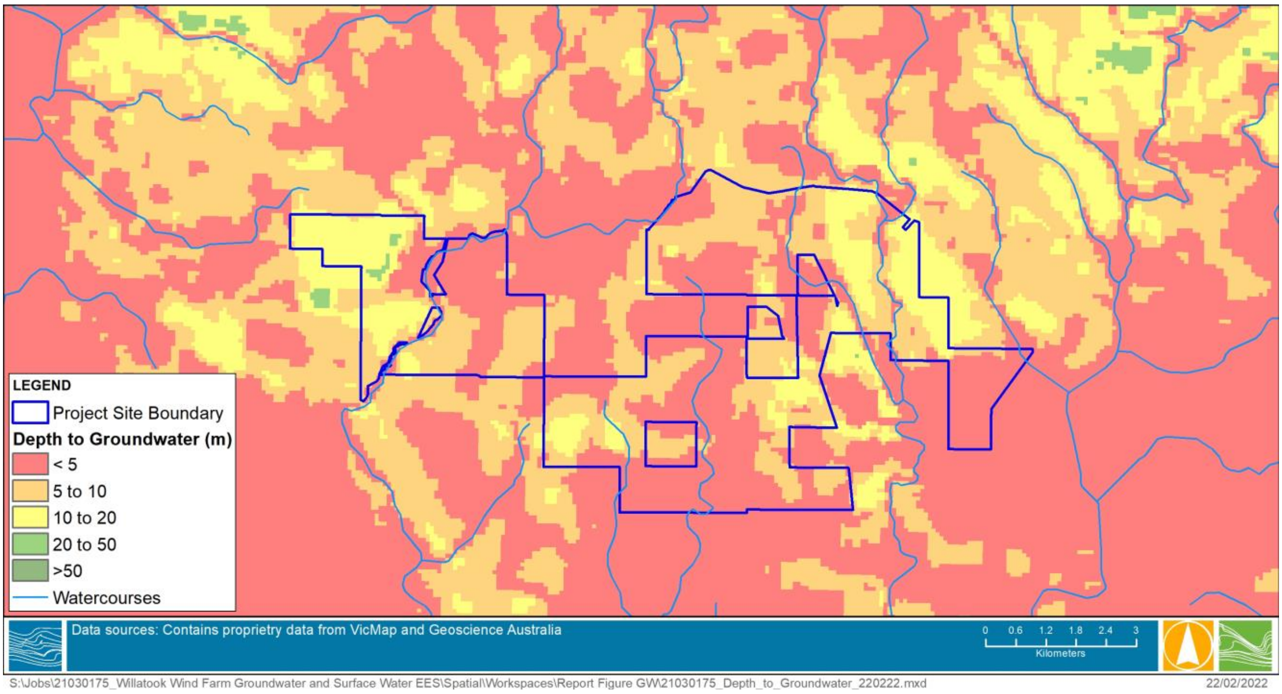


FIGURE 35 REGIONAL PREDICTED DEPTH TO WATER TABLE (SOURCE: VISUALISING VICTORIA'S GROUNDWATER (WWW.VVG.ORG.AU)

Groundwater levels are known to vary markedly between seasons, with the highest levels occurring in late spring following recharge by winter rainfall and the lowest levels occurring in late summer. Figure 36 shows the seasonal variability recorded at six registered groundwater bores located within the Project Site. This shows there is typically an annual fluctuation in groundwater depth of between 0.5 and 3.5 metres, depending on the location, between the beginning of spring when groundwater levels are highest and the end of summer when groundwater levels are at their lowest.

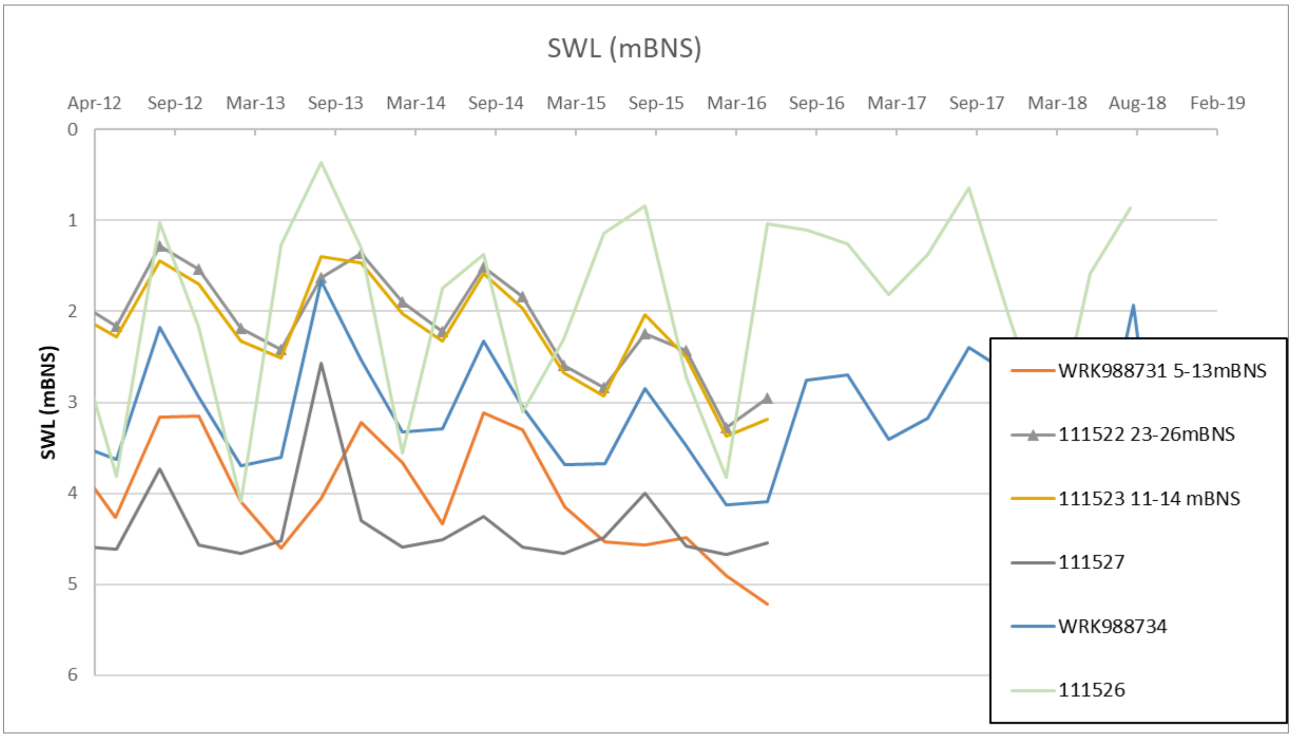


FIGURE 36 SEASONAL WATER LEVEL RANGE

2.7.3.2 Groundwater flow, recharge and discharge

On a regional scale, groundwater flow in the Newer Volcanic Group basalts (Upper Tertiary/Quaternary Basalt) is southwards towards the coast (see Figure 37). Groundwater flow is driven by recharge which predominantly occurs via infiltrating rain (during winter and spring), with estimates of between 10 to 40 millimetres per annum reported by Dahlhaus et al., 2002. In areas of stony rises, groundwater recharge is expected to be higher than within the basalt flows as they typically have a higher permeability and are more fractured. Scoria cones and stony rises play an important role in recharging the water table and often feeds lakes and wetlands in inter-rise depressions or feed stream baseflow (Dahlhaus, Heislers, & Dyson, 2002). The underlying Port Campbell Limestone aquifer is recharged via indirect rainfall infiltration where it is overlain by basalt aquifers, and via direct rainfall infiltration where the aquifer is expressed at the surface.

Discharge from the Newer Volcanic Group basalt aquifer occurs through evapotranspiration and groundwater extraction from wells, as well as at the edge of formations and topographic lows where surface expressions of groundwater (e.g. springs and freshwater meadows) are common. Local groundwater information provided by landowners indicates that most springs in the area fill during winter and dry up during summer. When full, springs along Shaw River discharge into the waterway and Cockatoo Swamp. Groundwater may also discharge into streams (as baseflow) and into unconsolidated alluvium / colluvium deposits (Quaternary Aquifer).

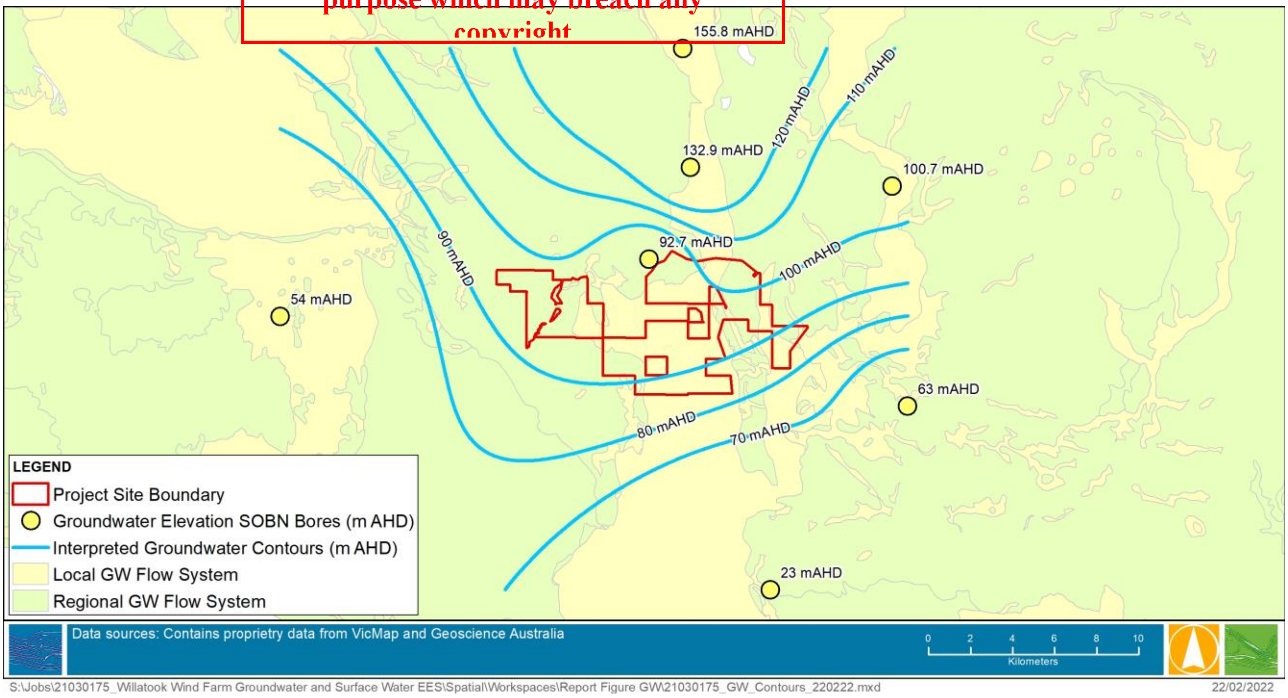


FIGURE 37 INFERRED GROUNDWATER CONTOURS

2.7.3.3 Aquifer Parameters

The Newer Volcanic Group basalt is the main aquifer within the Project area. Groundwater flow within this aquifer is variable, due to the inherent variability in hydraulic parameters that exist in aquifers of volcanic origin. The parameter of interest is hydraulic conductivity which represents the ease in which water can move through the pore spaces and fractures in the rock.

Estimates of hydraulic conductivity for groundwater flow systems at the Project Site are summarised in Table 20 and illustrated spatially in Figure 38 (after Dahlhaus et al., 2002). Hydraulic conductivity values are reported to range from 0.001 to 100 m/d for the Newer Volcanic basalt, with the lower estimate described as tight fractures and the upper estimate described as open fractures and lava tubes. The hydraulic conductivity range is consistent with the description that groundwater moves through the fractured rocks at highly variable rates (Dahlhaus et al., 2002). The stony rises are generally more permeable with a range of 0.1 to 100 m/d while the quaternary deposits exhibit a wider hydraulic conductivity range from 1 x 10^{-6} to 100 m/d.

SKM (2010) developed a groundwater model for the Glenelg Hopkins catchment whereby hydraulic conductivity values for the Newer Volcanic basalt of 1, 10 and 25 m/d were tested during model calibration. The adopted hydraulic conductivity for the groundwater flow model was 10 m/d, however, SKM concluded that the Quaternary Volcanics had a locally sensitive response that was not able to be captured with a regional scale model and hence there is likely to be significant variability in this parameter.

TABLE 20 GROUNDWATER FLOW SYSTEMS AND HYDRAULIC CONDUCTIVITY RANGES (AFTER DAHLHAUS ET AL., 2002)

Unit/System	Hydraulic Conductivity Range (m/d)
Quaternary Alluvium	10 to 100 m/d
Stony rises, lava barriers, scoria cones, maars, tuff	0.1 to 100 m/d

Unit/System	Hydraulic Conductivity Range (m/d)
Volcanic Plains Basalt	0.001m/d to 100 m/d
Port Campbell Limestone	0.01 m/d to 100 m/d
Sand Plains	0.01 m/d to 10 m/d

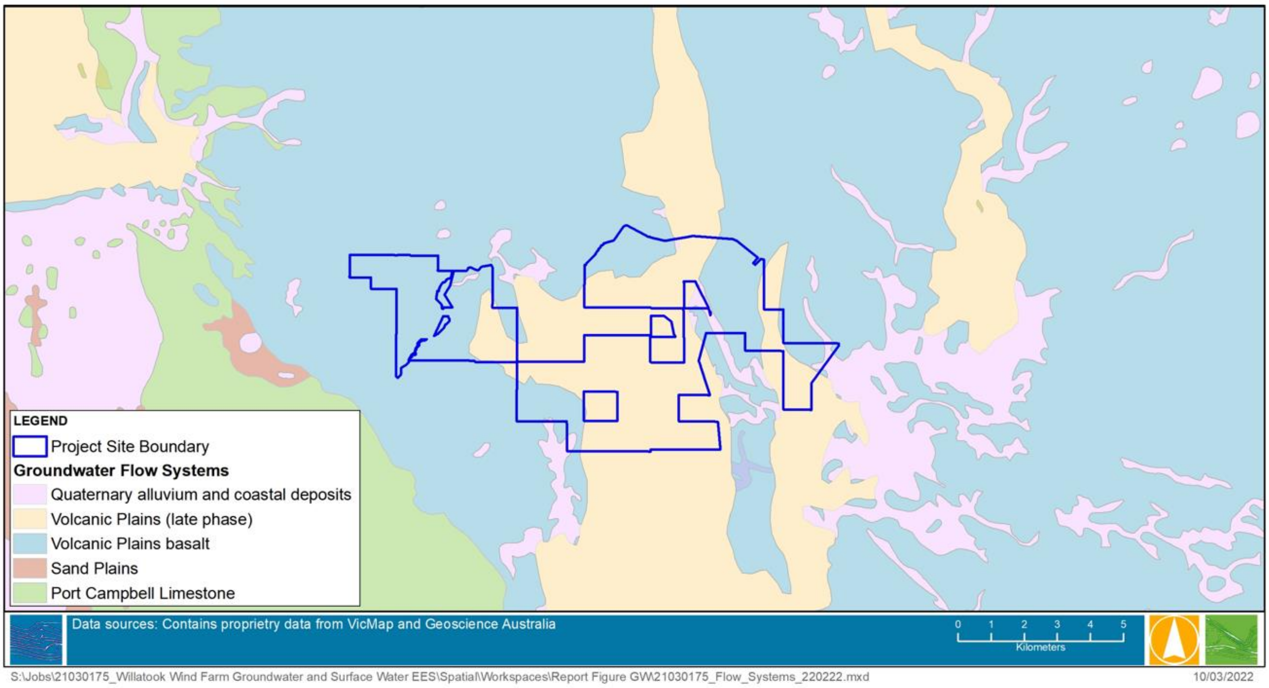


FIGURE 38 GROUNDWATER FLOW SYSTEMS AND HYDRAULIC CONDUCTIVITY RANGES (AFTER DAHLHAUS ET AL., 2002)

2.7.3.4 Groundwater Quality

The geology, water-rock interactions and groundwater flow systems can influence groundwater quality and recharge. Groundwater salinity (measured as electrical conductivity or as TDS) is generally used as a measure of quality, due to its implications for groundwater use and land management.

Using the beneficial use categories available through the Visualising Victoria's Groundwater database (Figure 39), groundwater salinity is expected to range from 1,001 to 3,500 mg/L in the water table aquifer over much of the Project Site. Isolated occurrences of lower salinity groundwater in the range of 501 to 1,000 mg/L are possible in the north and south of the Project Site (Figure 39). Groundwater in the underlying limestone aquifer is generally lower salinity, typically around 1,500 mg/L.

The beneficial use categories and hence salinity ranges available through the Visualising Victoria's Groundwater database represent the older SEPP Groundwaters of Victoria classifications systems, consisting of five 5 segments. The salinity ranges presented in Figure 39 correspond to Segments A2 to C in the updated SEPP Waters policy which consists of seven segments.

In general, groundwater in the Project Site is too brackish and hard for potable domestic use but of sufficient quality to be used for irrigation, stock and some industrial processes. No point source or regional groundwater contamination has been recorded in the vicinity of the Project.

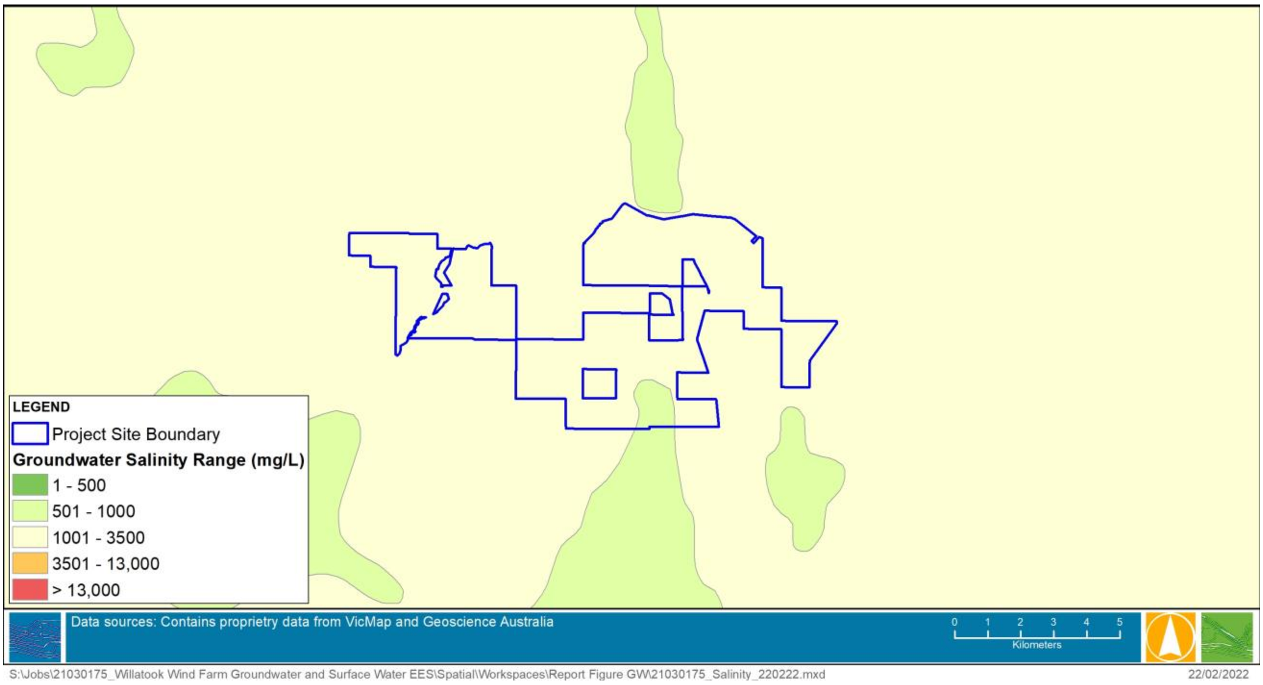


FIGURE 39 EXPECTED GROUNDWATER SALINITY RANGES FOR THE WATERTABLE AQUIFER (FROM VISUALISING VICTORIA'S GROUNDWATER DATABASE)

2.7.3.5 Groundwater Users

The Project Site lies within the Portland Coast River Region in the South West Limestone Groundwater Management Area, which includes the Port Campbell Limestone in the Western Region of Victoria. The Portland Groundwater Management Area underlies the South West Limestone Groundwater Management Area from a depth of 200 metres. Within the Western Region, the Project Site is located within the South-west Coast sub-region, which extends from the Otway Coast to South Australia. There are no Water Supply Protection Areas, declared under the *Water Act 1989*, within the Project Site.

The region has a history of pastoral and cropping land uses, and groundwater is used for domestic and agricultural purposes. Groundwater in the underlying limestone is predominately used for irrigation, as well as supplementing the local urban water supply. Regionally groundwater in deeper formations is used extensively for municipal supply. For example, supplies for Koroit and Warrnambool are sourced from the Port Campbell Limestone, and supply for Port Fairy and Portland is sourced from the Dilwyn Aquifer.

There are nine bores interpreted to be completed in the Newer Volcanic Group basalts (less than 40 m deep) within the Project site that are registered by Southern Rural Water as unmetered bores for stock and domestic use. The location of these bores is shown in Figure 40. Unregistered bores in operation may also be present within the Project Site. There are also several state observation bores located in the broader study area, however, none of these are located within the Project site boundary (Figure 40).

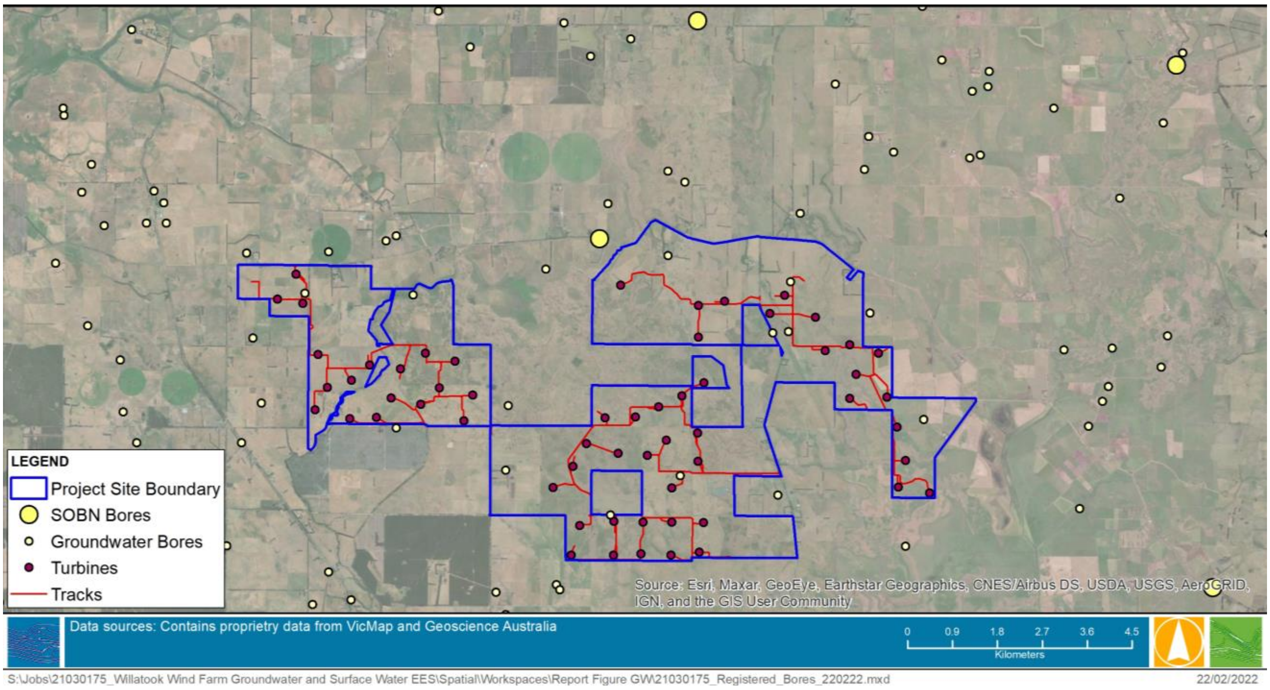


FIGURE 40 LOCATION OF REGISTERED GROUNDWATER BORES IN RELATION TO THE PROJECT SITE

2.7.3.6 Groundwater Dependent Ecosystems

The Bureau of Meteorology's Groundwater Dependent Ecosystems Atlas indicates the presence of aquatic and terrestrial groundwater dependent ecosystems (GDEs) in the Project area. These ecosystems are rated as having moderate to high likelihood of receiving groundwater inflows. No subterranean GDEs have been identified in the project area.

Aquatic GDEs include temporary freshwater marshes and meadows associated with Cockatoo Swamp, smaller isolated temporary freshwater marshes and meadows and a number of ephemeral wetlands. Terrestrial GDEs include six terrestrial vegetation wetland, woodland and shrubland communities typically in isolated fragments or along major watercourses. It is important to note that the GDE Atlas displays ecosystem polygons where groundwater interaction may occur, it does not suggest all vegetation within the polygon depends on groundwater (Doody et al. 2017).

Mapped potential aquatic and terrestrial GDEs within the Project Site are shown in Figure 41. The potential impacts of the Project on GDEs are further discussed in the Willatook Wind Farm Flora and Fauna Impact Assessment (Nature Advisory, 2022).

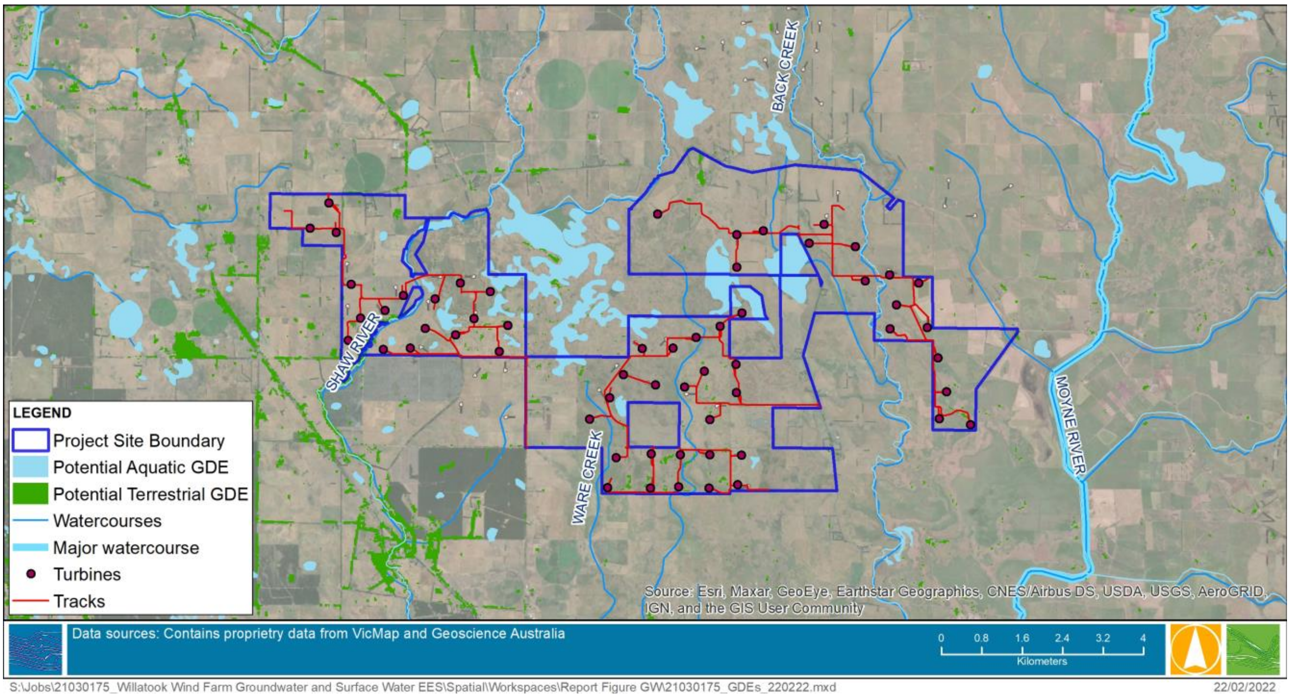


FIGURE 41 MAPPED POTENTIAL AQUATIC AND TERRESTRIAL GDES

2.8 Surface and groundwater quality

2.8.1 Surface water

As required by the *Environment Protection Act 2017, as amended by the Environment Protection Amendment Act 2018,* the ERS 2021 outlines beneficial uses and environmental values of the environment that the community wishes to protect. Beneficial uses / environmental values are defined as a use of the environment or any element or segment of the environment which:

- Is conducive to public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges, emissions or deposits or of the emission of noise; or
- Is declared in State environment protection policy to be an environmental value.

Environmental quality indicators and objectives for rivers and streams (Water Quality Objectives or WQOS) have been outlined in the ERS 2021 for defined segments of landscapes/catchments to protect these beneficial uses / environmental values (Victorian Government 2021). The regionalisation of environmental WQOs for different landscape segments accounts for natural variations due to processes related to soils, topography, meteorology and vegetation.

The surface water environments relevant to the project area fall within the Murray and Western Plains segment (Segment F). The Murray and Western Plains segment comprises river and stream reaches of lowlands (which are generally below 200 m in altitude) including the Surry, Glenelg, Hopkins and Portland basins. The water quality objectives for the basins are set out in Table 21. In the absence of specific indicators/objectives not prescribed in ERS, ANZG 2018 trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems can be used.

TABLE 21 ENVIRONMENTAL WATER QUALITY OBJECTIVES FOR THE PORTLAND BASIN (VICTORIAN GOVERNMENT 2018

Water quality indicator	Physical/Chemical objectives	
	ERS	ANZG 2018
Electrical Conductivity (EC) (µS/cm@ 25°C)	≤2000	125 – 2200[10]
Acidity/alkalinity (pH units)	≥7 and ≤8 (25th and 75th percentiles)	6.5 – 8.0
Total Phosphorus (µg/L)	≤55 (75th percentile)	50
FRP (µg/L)	-	20
Total Nitrogen (µg/L)	≤1000 (75th percentile)	500
Dissolved oxygen (percent saturation)	≥65 and 130 (25th percentile and maximum)	-
DO (% Sat.)	-	85 – 110
Turbidity (NTU)	≤20 (75th percentile)	6-50
Chl-a (µg/L)	-	5
Toxicants	-	95% protection

Historical water quality data were extracted from the DELWP data portal for two locations in the Portland Coast Basin (see Figure 42). Gauge details are presented in Table 22.

FIGURE 42 PORTLAND COAST BASIN (EXTRACTED FROM DELWP, 2021)

[10] Low values are found in eastern highlands of Vic. (125 µS/cm) and higher values in western lowlands and northern plains of Vic (2200 µS/cm).

TABLE 22 SURFACE WATER QUALITY GAUGE DETAILS

Gauge information	237207 Surry River @ Heathmere	237200 Moyne River @ Toolong
Site ID	237207	237200
Latitude	38°14'36.4"S	38°19'11.7"S
Longitude	141°39'47.6"E	142°13'35.1"E
Catchment area	310 sq. km	570 sq. km
Gaugings	288 gaugings between 29/04/1970 and 14/07/2020	435 gaugings between 05/07/1956 and 04/12/2019

A comparison of the surface water quality from gauges in the Portland Coast basin with the relevant ERS or ANZG 2018 water quality objectives (where they exist) are presented in Table 23 and Table 24. Values highlighted in red indicate recorded values which exceeded the prescribed water quality objectives.

The following indicators exceed the prescribed water quality guidelines:

- General indicators
  i. Electrical Conductivity;
  ii. Total Phosphorus; and
  iii. Total Nitrogen.
- Toxicants
  iv. Chlorine;
  v. Copper;
  vi. Iron; and
  vii. Zinc.

Note that the above indicators are for data made available through DELWP only.

TABLE 23 SURFACE WATER QUALITY INDICATORS VERSUS PRESCRIBED WATER QUALITY OBJECTIVES

Water quality indicator	Units	ERS /ANZG 2018	237207 Surry River @ Heathmere				237200 Moyne River @ Toolong			
			25th	75th	Median	Max	25th	75th	Median	Max
Temp	°C	-	12.3	16.9	15	26	11.5	18.3	15.1	25.6
Electrical Conductivity	µS/cm@ 25°C	≤ 2000	800	1002	977	3300	2200	3350	2890	5000
pH	pH units	≥ 7 and ≤ 8 (25th and 75th percentiles)	7.4	7.6	7.5	8.5	7.7	8	7.9	8.7
Total Phosphorus	mg/L	≤ 0.055 (75th percentile)	0.02	0.04	0.03	0.27	0.02	0.07	0.04	0.65
FRP	mg/L	≤ 0.02	0.005	0.02	0.01	0.14	0.004	0.02	0.01	0.46
Total Nitrogen	mg/L	≤ 1 (75th percentile)	0.1	0.60	0.24	2.57	0.5	1.3	0.6	7.4
Total NO2+NO3	mg/L	< 40	0.006	0.02	0.01	0.51	0.005	0.09	0.01	5.7
Kjeldahl N	mg/L	-	0.1	0.59	0.23	2.2	0.48	1.1	0.62	3
Dissolved oxygen	%	≥ 65 and 130 (25th percentile and maximum)	-	-	-	-	-	-	-	-
Dissolved oxygen	% Sat.	> 85 - 110	-	-	-	-	-	-	-	-
Dissolved oxygen	ppm	-	7.1	9.5	8.5	13.3	8.1	9.8	8.9	16.4
Turbidity	NTU	≤ 20 (75th percentile)	0.8	3.5	1.5	45	1.6	4.1	2.4	63.9
TSS	mg/L	-	2	3	2	62	2	6	4	53
Colour True	PCU	-	5	44.5	14	240	20	57.5	25	999
TDS	mg/l	-	-	-	-	-	2925	3175	3050	3300
Total Alkalinity	mg/l	-	-	-	-	-	280	280	280	280
Hardness as CaCO3	mg/l	-	-	-	-	-	893	898	895	900
Total Organic Carbon	mg/l	-	-	-	-	-	3.5	6.5	5	8
Calcium (total)	mg/l	-	-	-	-	-	142.5	147.5	145	150

TABLE 24 TOXICANT TRIGGER VALUES FOR 237200 MOYNE RIVER @ TOOLONG

Water quality indicator	Units	Trigger values for freshwater (95% species protection)	237200 Moyne River @ Toolong
Chlorine	mg/l	0.003	1000
Magnesium (total)	mg/l	-	130
Potassium	mg/l	-	5.05
Sodium	mg/l	-	398.5
Sulphates (SO4)	mg/l	-	44.7
Cadmium (total)	mg/l	0.0002	0.0002
Chromium (total)	mg/l	0.001	0.001
Copper (total)	mg/l	0.0014	0.01
Iron (total)	mg/l	0.0034	0.3055
Lead (total)	mg/l	0.0034	0.001
Manganese (total)	mg/l	1.9	0.096
Nickel (total)	mg/l	0.011	0.004
SiO2	mg/l		24.9
Zinc (total)	mg/l	0.008	0.02

There was also water quality data available as part of detailed aquatic surveys of the proposed Shaw River Power Station Project, located between Iona and Orford, Victoria. This data was collected by Ecology and Heritage Partners (EHP) as part of the Shaw River Power Station Project: Power Station and Gas Pipeline; Detailed Aquatic Survey on behalf of Shaw River Power Station Pty Ltd (). Water quality samples were collected in the following waterways:

- Port Campbell Creek
- Wallaby Creek
- Spring Creek
- Mosquito Creek
- Curdies River
- Whisky Creek
- Whisky Creek East Branch
- Whisky Creek West Branch
- Hopkins River
- Merri River
- Murray Brook
- Moyne River
- Back Creek
- Shaw River

Water quality was measured in situ in each waterway using a TPS 90FL datalogger to record conductivity (µS/cm @ 25°C), dissolved oxygen (mg/L and % saturation), pH, and temperature (°C). Water samples were taken at each site and analysed for turbidity, suspended solids, total nitrogen, nitrate, nitrite, ammonia, nitrogen oxide, total Kjeldahl nitrogen, total phosphorus and total dissolved solids. The water quality results are shown in Appendix F.

Of these waterways, Back Creek and the Shaw River are most relevant to WWF. Back Creek had one sampling location (east of Faulkners North Road, approximately 9.5km south east of WWF), while the Shaw River had two (at and south of Riordans Road, approximately 1.2km south of WWF). Reporting by EHP noted testing of Total Phosphorus, Electrical Conductivity and Dissolved Oxygen % were outside the SEPP/ANZECC guidelines for Back Creek, while Total Phosphorus, Electrical Conductivity and Dissolved Oxygen % were outside guidelines for the Riordans Road crossing of the Shaw River and Total Nitrogen, Total Phosphorus, Ammonia, Electrical Conductivity, Dissolved Oxygen % and Turbidity south of Riordans Road.

These results are similar to those shown in the Moyne River at Toolong, indicating water quality issues with Total Phosphorus, Total Nitrogen and Electrical Conductivity.

Waterwatch data[11] was available at three nearby sample collection locations, recording electrical conductivity, pH, reactive phosphorus, air and water temperature and turbidity. These locations and the availability of data is listed below:

- Shaw River Orford at Hamilton-Port Fairy Road "Bell's" Bridge, data available from November 2005 to September 2009 (17 samples)[12].
- Back Creek Tarrone @ Tarrone Lane Bridge, data available from March 2005 to February 2020 (47 samples)[13].
- Moyne River Willatook @ Woolsthorpe-Heywood Road Bridge, data available from March 2005 to February 2011 (48 samples)[14].

[11] https://www.vic.waterwatch.org.au/
[12] http://www.vic.waterwatch.org.au/site/1003770
[13] http://www.vic.waterwatch.org.au/site/1002663
[14] http://www.vic.waterwatch.org.au/site/1003756

All water quality results show similar water quality issues with Total Phosphorus, Total Nitrogen and Electrical Conductivity exceeding water quality indicators in numerous instances.

The water quality testing is only considered indicative of the water quality in receiving waterways, runoff from the WWF is likely to have site specific water quality issues dependent on the location within the WWF area and specific sampling would be required immediately post or during a rainfall event to determine the site based water quality. This water quality testing is difficult to achieve without having staff onsite ready to take samples.

2.8.2 Groundwater

For the shallower zone, Table 25 shows the chemistry of the groundwater in one area of the basalt. No trace contaminants are evident, and the water is suitable for sheep and cattle. The water quality will vary according to the time spent in contact with minerals as well as any evapo-concentration of salts.

The salinity is within the expected range for the Upper Tertiary / Quaternary Basalt (UTB) that is defined as having a depth of 0-41 m and a salinity between 1001-3500 mg/L in (DELWP, 2019), which is suitable for the beneficial uses of potable, irrigation, stock water, industry, ecosystem protection and building and structures (DELWP, 2019).

More detailed chemistry is provided below which fits the beneficial use category above.

TABLE 25 111523 GROUNDWATER QUALITY 20 MARCH 2014 (DELWP, 2019)

Parameter (mg/L unless stated)	8 October 2010	20 March 2014
Total phosphorus		0.06
Magnesium	210	244
Manganese		0.05
Turbidity (NTU)		6.8
Mercury		0
Potassium Ions	4.7	6
Kjeldahl Nitrogen		2.8
Total Nitrogen		2.8
Arsenic		0.001
Sodium Ions	550	382
Ammonia Nitrogen		0.05
Nitrite		0.01
Nitrate as N		0.02
Chloride ions	1500	1470
Calcium Ions	150	190
Alkalinity	440	250
Conductivity	5200	4990
Oxidised Nitrogen		0.02
Sulfate	53	
Hardness	1248	
Iron	3.1	
Total dissolved solids (TDS)		2970

2.8.3 Comparison of surface and groundwater

A comparison of available surface and groundwater data from around the site is included as Table 26. The data suggest that groundwater and surface water have similar water quality characteristics, specifically total dissolved solids, acidity/alkalinity, phosphorus and nitrogen. From this it can be interpreted that groundwater and surface water are likely to be well connected within the Project site.

TABLE 26 OVERVIEW OF WATER CHEMISTRY

Water quality indicator	Physical/Chemical objectives		Site data	
	ERS (Water) 2019	ANZG 2018	Surface water	Groundwater
Electrical Conductivity (EC) (µS/cm@ 25°C)	≤2000	125 – 2200[15]	800-5000	4,950 (using TDS/0.6)
Acidity/alkalinity (pH units)	≥7 and ≤8 (25th and 75th percentiles)	6.5 – 8.0	280	250-440
Total Phosphorus (mg/L)	≤55 (75th percentile)	50	0.02-0.65	0.06
FRP (mg/L)	-	0.02	0.005-0.46	-
Total Nitrogen (mg/L)	≤1 (75th percentile)	0.5	0.1-7.4	2.8
Dissolved oxygen (percent saturation)	≥65 and 130 (25th percentile and maximum)	-	-	-
DO (% Sat.)	-	85 – 110	-	-
Turbidity (NTU)	≤20 (75th percentile)	6-50	0.8-63.9	6.8
Chl-a (µg/L)	-	5	-	-
Toxicants	-	95% protection	-	-

15 Low values are found in eastern highlands of Vic. (125 µS/cm) and higher values in western lowlands and northern plains of Vic (2200 µS/cm).

3 SURFACE AND GROUNDWATER IMPACT PATHWAYS

3.1 Overview

This section investigates the likely impact pathways of the proposed activity on values related to surface and groundwater. The proposed infrastructure has the potential to impact surface and groundwater hydrology if appropriate management measures are not used, a large part of this mitigation is ensuring appropriate locations are chosen for turbines, waterway crossings and other infrastructure. WWF has been through a large number of design layouts evolving the designs during the investigation process to avoid and minimise impacts to the environment and community. Superseded alternative windfarm layouts are recorded in Appendix A.

3.2 Surface Water

3.2.1 Overview

The identification of proposed infrastructure placement (turbines, roads, tracks and waterway crossings) has been made by WWF with input from technical specialists. By overlaying the surface water modelling results on the proposed infrastructure layout an assessment of the inundation depth, velocity and flowrates can be made at each location. This provides an understanding of infrastructure requirements (i.e. culvert size, access track heights, if micro siting can remove inundation risk etc.) and the potential for construction, operation and decommissioning of the project to impact surface water environments and their capacity to support environmental values.

The impact pathways relevant to WWF are changes to streamflow hydrology (flow rate and volume) and water quality. More specifically they include:

- Hydrological changes to surface water flows due to:
  - Project infrastructure with the introduction of impermeable surfaces – turbines and hardstands.
  - Physical disturbance - waterway crossings for tracks and cables.
- Water quality reductions (e.g., turbidity, dissolved oxygen) due to:
  - Surface water runoff (erosion) and sedimentation due to stockpiles and earthworks for infrastructure, tracks and hardstands
  - Damage to stream beds and banks leading to surface water runoff (erosion) and sedimentation - waterway crossings for tracks and cables
  - Spills of poor quality into waterways or waterbodies - collected during construction of turbines and hardstands
  - Accidental spills of hazardous waste during construction and operation.
  - Uncovering of acid sulfate soil during earthworks for infrastructure, tracks and hardstands.

There is also a potential level of flood risk to infrastructure that should be considered to prevent damage. Figure 43 displays an overview of the 1% AEP flood depth and extent within the WWF development and the maximum flood depth found at each proposed turbine location.

3.2.2 Flood Risk

The turbine locations are spread across the WWF development area and are located on both rises and lower areas of topography. It is likely the construction of the turbines will require minor earth works to ensure a flat and stable base to build from, in some cases this base is within the 1% AEP flood extent.

Inundation across the development area is generally less than 300 mm in a 1% AEP event, with some localised areas exceeding 1m due to ponding (e.g., wetlands) and the major flow paths. Proposed buildings such as the site office and storage facility are affected by localised inundation less than 150 mm. Inundation depths at the turbines vary across the site. As shown in Figure 43, 3 out of 7 proposed turbine footprints are inundated by a maximum inundation of more than 1m. These turbines are located at or adjacent to flow paths. Most of the proposed turbines are affected by inundation less than 500mm. Construction of the inundated turbine locations will be particularly important to ensure not water is able to enter excavations during construction and impacted water unable to flow offsite. A closer perspective of the turbines are associated infrastructure is shown in Appendix G.

A level of inundation and some flood risk is found at some proposed turbine and access track locations. Some sections of access track would need to be raised to allow safe access and egress during flood events and the likelihood this inundation will happen more frequently should be considered (i.e., mapping shows the maximum 1% AEP inundation but may be inundated to a lower depth much more frequently).

The modelling developed as part of this assessment has been used to guide the location and design of each proposed asset (by WWF). It is anticipated that where turbines/hardstands are inundated risk can be addressed through elevation of the hardstand areas and drainage. The specifics of the design will be determined during detailed design.

3.2.3 Hydrological changes

The construction of roads and larger infrastructure has the potential to alter existing drainage patterns through diversion of flow. Changes to drainage patterns, either increasing or decreasing flow to a given area can lead to ecologic changes.

Depending on the watercourse characteristics and construction crossing method, there may be temporary disruption to surface water flows. During construction, partial or complete diversion may be required if the watercourse is flowing at the time of construction. Construction of impervious hardstand areas and infrastructure (e.g., wind turbines) also has the potential to alter flow paths; however, they have been designed in locations where overland flow is minimised.

3.2.4 Water quality reductions

There are numerous access tracks and cables crossing both waterways and overland flow paths, as well as turbines located in areas of potential inundation. These works and their ongoing operation have the potential to impact water quality, if unmitigated, through the following:

- Excavation, stripping of topsoil and track construction mobilising sediment into downstream waterways/wetlands.
- Erosion/mobilisation of sediment at track and cable waterways crossings.
- Water entering excavations and then impacted water spilling to downstream waterways/wetlands.
- Spills of fuel and oil entering downstream waterways/wetlands.
- Impacted water spilling from the quarry to downstream waterways and wetlands.

These potential impacts are the same as you would expect for typical road construction and or excavation works, the location of these potential impacts has been highlighted by the surface water modelling and mapping enabling the design mitigation measures outlined in Section 4.2.1 to be targeted.

While the background water quality in receiving waterways has been assessed as best possible, it is important to note all potential reductions in water quality should be avoided regardless of the water quality indicators assuming the presence of significant flora and fauna species...

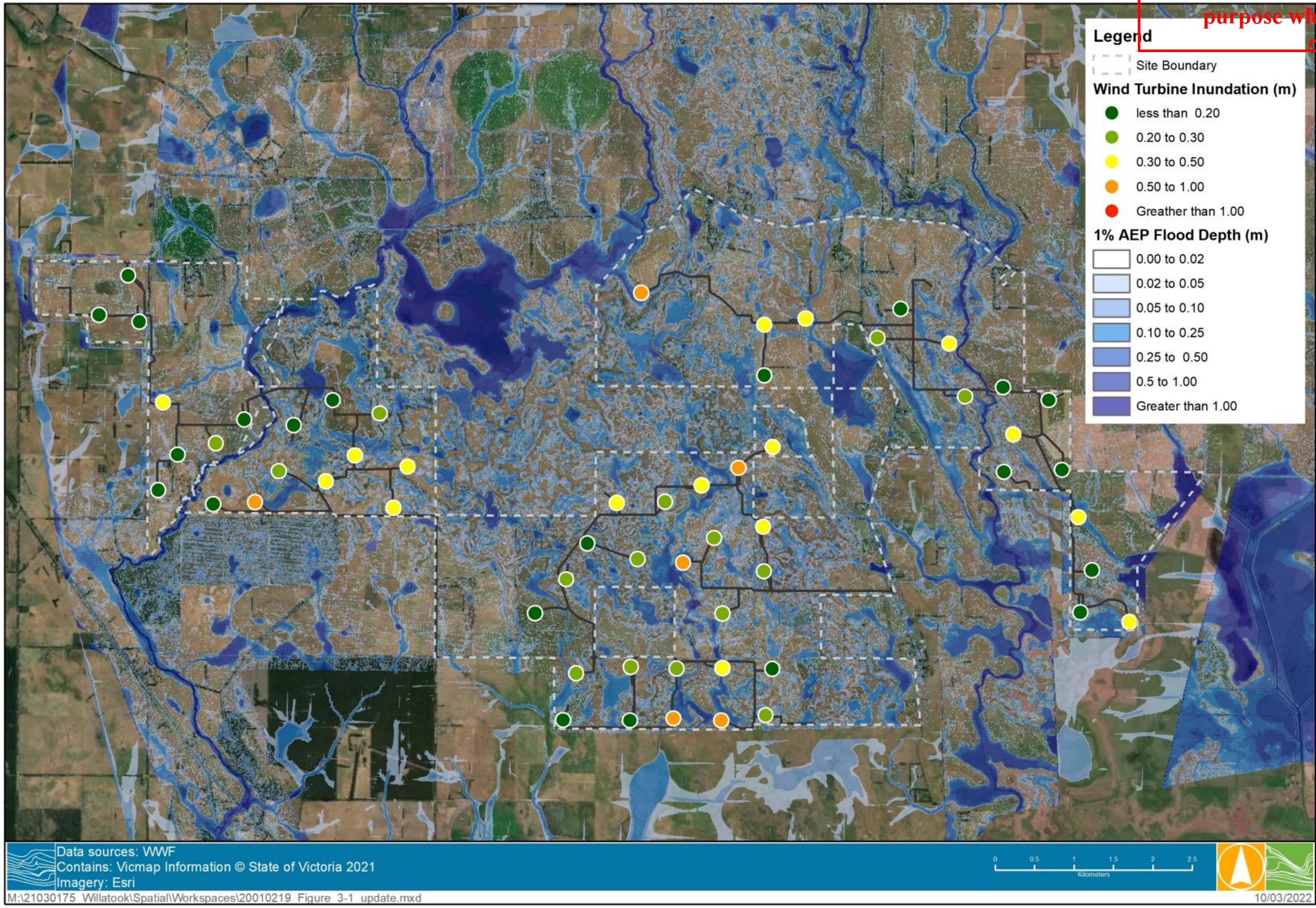


FIGURE 43 WWF 1% AEP INUNDATION OVERVIEW AND TURBINES INUNDAITON

3.3 Groundwater

3.3.1 Overview

The potential for groundwater-related issues associated with the construction and operation of the Project relate to the potential for adverse impacts to existing users of groundwater and to GDEs, because of reduced levels or supply of groundwater, reduced groundwater quality or both.

These impacts could occur through the following potential impact pathways:

- Dewatering of groundwater during construction and lowering the water table resulting in groundwater drawdown that affects water availability.
- Disruption of groundwater recharge and flow, such as from introduction of impermeable surfaces and physical barriers in the form of wind turbine foundations.
- Disruption of groundwater discharge to waterways or waterbodies by intersecting groundwater discharge water features (e.g., natural springs) or from a reduction in groundwater availability (e.g. due to dewatering).
- Groundwater contamination, including from accidental spills or formation of acid sulfate soils.

The degree of impact will depend on the reliance that existing users and GDEs have on groundwater and the extent, timing and duration of impacts resulting from project activities.

3.3.2 Dewatering and disposal of extracted groundwater (drawdown)

Groundwater extraction is required to be limited to locations where a perched or very shallow aquifer is encountered during the construction. Excavation during construction will typically be to depths of less than 3.5 metres, except at the quarry site. If shallow groundwater is intercepted during construction of turbine foundations and trenches, localised groundwater from the uppermost zones may seep into the excavated area. Groundwater abstraction via pumping (termed ‘dewatering’ of the excavation) may be required to create a safe work area in some instances. If required, dewatering may temporarily lower the water table until the concrete foundations are laid, however, as the construction period for turbine foundations is short (i.e., up to two weeks), impacts are unlikely to materially affect groundwater users. Side wall stability is not expected to pose a danger to construction workers for the one metre deep cable trenches.

As the proposed quarry excavation depth extends below the water table level, dewatering is expected to be required for this site during operation as discussed in the quarry investigation report (Appendix D). This will be managed under the Take and Use Licence, to be approved by Southern Rural Water as the delegated authority under the *Water Act 1989*.

A summary of the proposed excavation depths for Project infrastructure and the approximate depth to groundwater at these locations is provided in Table 27.

TABLE 27 PROPOSED PROJECT EXCAVATION DEPTHS OF ONE METRE OR MORE, AND APPROXIMATE DEPTH TO GROUNDWATER AT THESE LOCATIONS

Project Activity/Infrastructure	Proposed excavation depth	Approximate depth to groundwater
Quarry excavation	14 metres maximum within a 10.5 hectare extraction area	Assumed to be 3 metres below the natural surface.
Excavation for foundations	3.5 metres	Foundations may intercept shallow groundwater less than 3 m below the natural surface, particularly during winter and early spring.
Underground cabling	1 metre	Cable trenches may intercept very shallow groundwater less than 1 m

Project Activity/Infrastructure	Proposed excavation depth	Approximate depth to groundwater
		below the natural surface during winter and early spring in isolated areas.

3.3.3 Disruption of groundwater recharge and flow

Infrastructure foundations have the potential to decrease the permeability of the ground surface, resulting in altered rates of infiltration and groundwater recharge. Vegetation removal can also influence groundwater recharge rates; however, this is not expected given the scale of vegetation removal required for this project.

After foundations are in place, these structures may influence the lateral flow of groundwater, however, this would be highly localised (in the order of tens of metres) and is unlikely to materially affect groundwater availability and levels at the Site.

3.3.4 Disruption of groundwater discharge

Direct impacts to groundwater discharge may occur if the placement of Project infrastructure intersects groundwater discharge features, such as springs. Earthworks or waterway crossings have the potential to intersect the groundwater table, which may result in indirect impacts to these groundwater discharge features due to changes in groundwater availability and baseflow.

3.3.5 Groundwater contamination

Contamination could occur if significant quantities of fuels, chemicals or other substances were accidentally released from contained areas onto the ground. During construction and operation of Project, the use of fuels and chemicals can pose a threat to groundwater quality if not managed appropriately. Bulk liquid chemicals, including fuels and lubricants, will also be stored on site.

Groundwater contamination may also occur from exposure and oxidation of potential acid sulfate soils (PASS), which may arise during excavation of trenches in PASS zones (see Section 2.6). The release of acidic waters may adversely impact groundwater quality and downgradient receiving environments or users.

Disposal of collected groundwater and its management is a potential issue due to variable groundwater quality, including elevated salinity. The quality of collected groundwater will determine the disposal method, including discharge to surrounding land or environmental value (e.g., stock water and irrigation). A reduction in groundwater quality, due to contamination, may extend to existing users or GDEs depending on the aquifers affected.

4 ASSESSMENT OF EFFECTS

4.1 Overview

The study has shown several areas where proposed infrastructure has the potential to impact surface and groundwater environments, as discussed in Section 3.2.1 significant effort has gone into the avoidance of potential impacts to the environment and the community through iterative changes to the WWF layout. Following all practical changes to the WWF layout, all remaining potential impacts have been targeted by mitigation and management measures. The aim of the design mitigation measures is to protect identified ground and surface water values and meet the EES scoping requirement evaluation objectives. The detail provided in this report should be used to ensure infrastructure is designed and constructed appropriately, meeting Council, DELWP and Glenelg Hopkins CMA requirements. This section considers methods to control or mitigate likely impacts that were unavoidable through the location of infrastructure, including any relevant design features or preventative techniques that can be employed during construction.

The impact assessment was developed through consultation with WWF and involvement in the design process. This was undertaken using the following stages:

- Stage 1 – Initial WWF concept design layouts were presented and compared to the existing conditions technical assessment undertaken (as described in Section 2).
- Stage 2 – The potential impact pathways were determined based on the concept design and existing condition comparison (as described in Section 3).
- Stage 3 – A number of design changes were made to the WWF layout on the basis of the understood impact pathways and existing conditions assessment (these changes were made partly in response to surface water, groundwater and inputs from other technical studies). The changes avoided impact pathways wherever possible.
- Stage 4 – An assessment of further design and management controls were developed through consultation with WWF and input from TRG to mitigate and minimise potential impact pathways (as described in Section 4).
- Stage 5 – A final assessment of effects made with all design and management controls assumed to be implemented (as described in Section 4).

4.2 Surface water

4.2.1 Design mitigation

4.2.1.1 General

The infrastructure throughout the site intersects with flow paths (both overland and riverine), creating a potential pathway between infrastructure and waterways and wetlands. Construction, operation and decommissioning works in these areas need to be managed to minimise land disturbance, soil erosion and the discharge of sediments and other pollutants to surface waters. To enable this, construction managers will need to implement effective management practices that are consistent with guidance from the Environment Protection Authority, including that provided in the *Erosion, sediment and dust: treatment train* (2020). Where construction activities adjoin or cross surface waters, construction managers need to monitor affected surface waters, to assess if environmental values are being protected. The risk of adverse impacts can be managed during the design and construction phases by the design/implementation of turbines, bridges/culverts and cable crossings.

4.2.1.2 Bridges and culverts

Flow paths were identified and reviewed to allow design considerations to be understood for affected infrastructure. At the scale provided in this report it is difficult to present the detail required for design at crossing location as they are very specific, but the information contained in this report can establish impact mitigation design criteria and inform detailed design. Each crossing has a different inundation length, depth, velocity and significance to the WWF development. This information has been provided to WWF for inclusion in the design process.

All waterway crossings (tracks and cables) and culvert/bridge designs should conform to local Council and Glenelg Hopkins CMA guidelines. Council will have internal design requirements while the Glenelg Hopkins CMA Works on Waterways Licence requirements will also apply, as outlined in Appendix D.

Two concept structure designs have been completed for the Shaw River and Back Creek crossings, designed to ensure no overtopping in a 10% AEP event. These are the two most major waterways within the wind farm boundary.

Design guidelines vary dependent on the size of the watercourse and its potential classification as a Designated Waterway. Regardless the remaining structure designs (i.e. aside from the concept designs completed for the Shaw River and Back Creek) should be sized to accommodate the required design capacity (a commonly adopted design recurrence is a 10% AEP) and ensure they are not damaged during a flood event i.e., culverts/bridges must be designed to enable access to a recurrence WWF are comfortable with and structural/erosion control measures must be designed to prevent damage to the structure. A typical culvert design capacity (still enabling vehicle access) used across other windfarms within Victoria is a 10% AEP, this has been discussed with GHCMA[16]. A higher level of recurrence should also be used for suitable erosion control design, preventing damage and emergency repairs. A series of discharge calculations have been made throughout the model (81 locations), the location and peak discharge for each of these locations is detailed for both the 1% AEP and 10% AEP events, the layers used for these tables have maps has also been provided to WWF. These flow rates can be used as a basis for culvert capacity design along with the provided GIS depth and velocity information. There are 12 designated waterway crossings within the WWF development, as shown in Figure 44. Table 28 shows the peak flow and discharge at each of the designated waterway crossings along with the waterway name/number (as per the designated waterway numbering made by Glenelg Hopkins CMA).

TABLE 28 SURFACE WATER FLOWS AT DESIGNATED WATERWAYS

Number	1% AEP Flow (m^3/s)	10% AEP Flow (m^3/s)	Waterway name/number	Likely flow conditions
14	41.21	2.25	Shaw River and 37/09-02	Potential for sustained flow. Low flow in summer.
15	0.14	0.04	-2-9	Intermittently flowing after rain.
16	2.9	0.5	-2-8	
18	0.28	0.02	-2-9	
33	1.50	0.11	-2-5	
38	1.98	0.01	Upstream of 1-6-5	
41	4.17	0.11	Upstream of 1-6-5	
50	2.98	0.09	Upstream of 1-6-5	
56			Upstream of 1-6-5	
58	6.15	0.02	Upstream of 1-6-5	
73	39.04	3.36	37/11-11	Potential for sustained flow. Low flow in summer
100	12.1	5.2	-11-6	Intermittently flowing after rain.

[16] Pers. Comm. Graeme Jeffery (GHCMA)

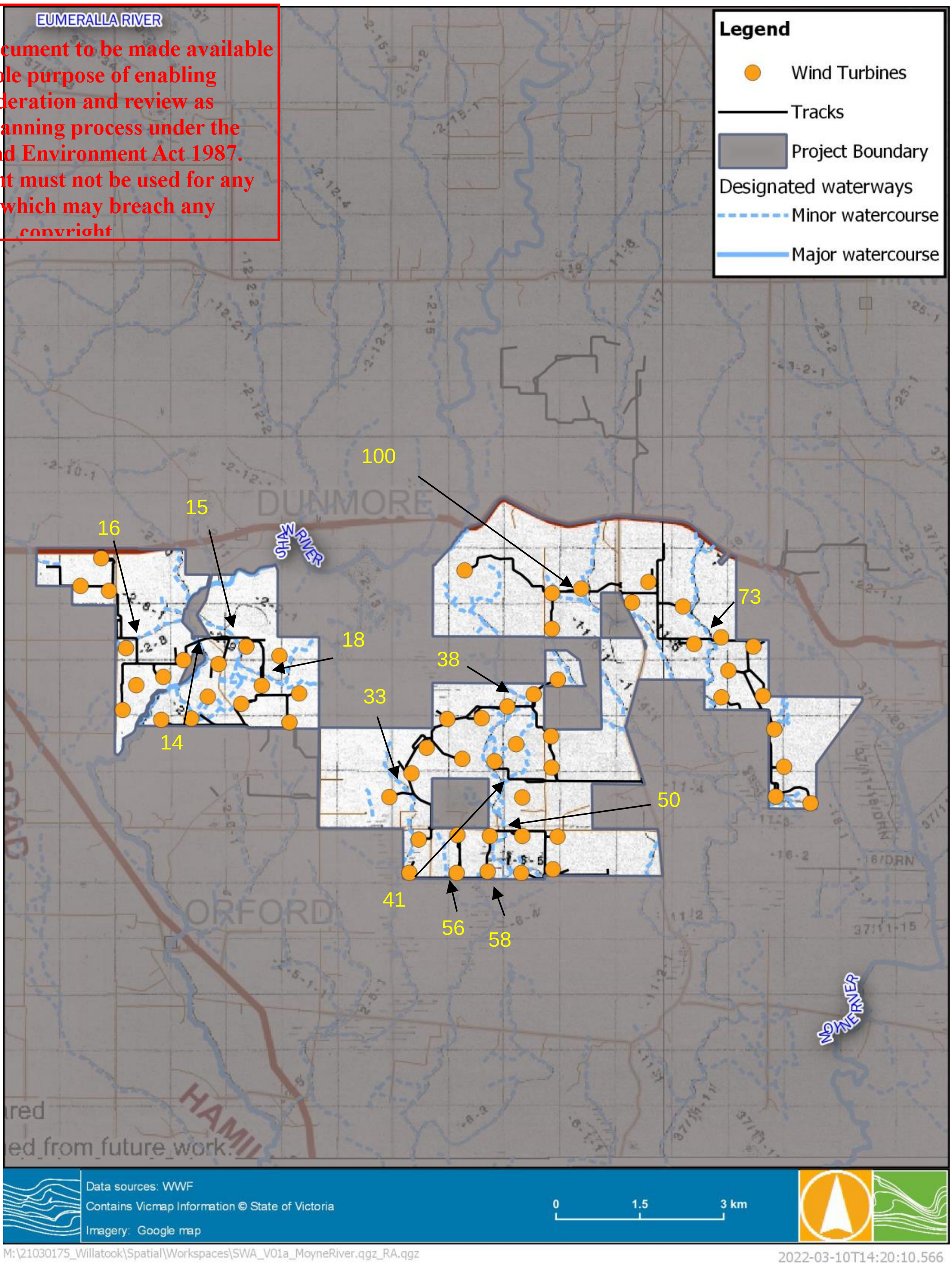


FIGURE 44 INTERNAL ACCESS TRACKS AND CABLES INTERACTING WITH DESIGNATED WATERWAYS

Bridges and culverts are required to be designed to allow flow beneath the roads along their natural flow paths with the required erosion control to ensure no sediment can be transported downstream. Dependent on the size of the flow path a bridge or culverts may be used, and some overtopping of the structure may be allowed to occur during high flows provided there is no erosion potential and safe access and egress can be achieved at the structure design capacity, currently recommended to be a 10% AEP. As mentioned above, the two major structures (Back Creek and Shaw River) have been designed using the flowrate, water level and velocity information determined by the analysis undertaken in this report.

Recommendations have been made in this report as to how the potential for impact can be minimised, but site-specific design will be required for each crossing prior to construction. It is not generally expected this level of detail will be made available through the EES; however, it has been competed for the Shaw River and Back Creek, the recommendations made in this report should be considered for each of the remaining structure designs. If these works are to occur on a Designated Waterway (as discussed in Section 2.2.2) a Works on Waterways Licence will be required and the crossing design should meet the requirements set out by Glenelg Hopkins CMA, we have included a set of Glenelg Hopkins CMA design criteria as Appendix C.

The following mitigation measures to be considered during the design phase. The designer's brief should include:

- Avoid areas identified as potential habitat for threatened aquatic species, where possible (Yarra Pygmy Perch, Little Galaxias and the Growling Grass Frog, as detailed in the Willatook Wind Farm Flora and Fauna Impact Assessment - Nature Advisory 2022).
- Microsite infrastructure proposed in identified flow paths to reduce risk of erosion, sediment transfer, affected access and inundation of infrastructure.
- Design of infrastructure to consider resilient design for flooding, including mitigating measures such as culverts beneath access roads and building threshold levels relative to anticipated water levels.
- Confirming that the underground cabling trenches are refilled with material of the same permeability will mitigate land salinisation and induced groundwater flows
- Design criteria such as:
  - Accessibility for all access roads to be maintained for a recommended 10% AEP, or as determined following development of maintenance and inspection requirements.
  - Gully crossings to ensure modelled design flows at any location can be passed for a recommended 10% AEP.
  - Operating parameters.
  - Accessibility and operational requirements.
  - Functional requirements (e.g. turbine operating parameters).
  - Flood protection requirements.
  - Standards, guidelines and reference documents.
- Contribution to information contained in the Construction Specifications to guide appropriate construction management requirements, such as method statements, Contractor's Environmental Management Plan and Traffic Management Plan.

4.2.1.3 Cable crossings

Cable crossings are required to be designed to limit the potential for erosion. There are numerous construction methods available, and the chosen method will be site specific. These options include:

- Trenching – Trenching requires works within the drainage line or waterway, creating an open excavation through the flow path. Trenching is generally used for ephemeral overland flow paths due to its invasive nature. It should also be avoided in areas with high velocities. The Construction Management Plan and Environmental Management Plan should highlight a construction methodology for construction of trench excavations and restoration of fill to natural surface with the required material and compaction.
- Directional drill – Directional drilling is less invasive (in appropriate ground conditions, it may not be feasible in some circumstances) than trenching and uses directional bore to drill a cable alignment underneath a road, railway or waterway. A directional drill is typically used for major waterways where flows are occurring and difficult to manage from an environmental and cost

perspective. This option may not be possible due to the presence of rock at many the crossings.

- Designing structures to accommodate cables – if a waterway crossing is large enough there is potential for the cables to be attached to the structure removing the need for additional crossing construction (i.e., a trench or directional bore).

4.2.1.4 Turbines

Several turbines are being shown as within the 1% AEP flood extent. Construction and operation of these turbine foundations will need to be completed in a way which removes the risk of inundation. These are as follows:

- Construction
  - Flood water must be prevented from interacting with excavations through levees or bunds. These structures can be earthen, constructed of clean fill with adequate clay content, constructed with sufficient compaction and have a level at least 300mm above the 1% AEP flood level. They must also allow for free drainage of flood water post a flood event (i.e., not trap floodwater behind them). The Victorian Levee Management Guidelines (DELWP, 2015) can be used as guidance for the construction standards of earthen embankments.
  - Drains should be constructed allowing water to flow around construction works, all drains should have erosion and sediment control measures put in place.
- Operation
  - All drains should be maintained with grassed or rocked inverts and sides to limit the potential for erosion. Inspection of these assets should be undertaken as part of a regular maintenance program and enable the ability for landholders to report or provide feedback on asset condition.

4.2.1.5 Construction phase management

Mitigation measures to be considered during the construction phase have been identified. As part of the EMP, a Contractor's Environmental Management Plan (CEMP) could be prepared by the designer and included as part of the construction tender package. A typical list of contents for a Contractor's Environmental Management Plan has been included in Appendix F.

Generally, the CEMP describes how activities undertaken during the construction phase will be managed to avoid or mitigate environmental or nuisance impacts, and how those environmental management requirements will be implemented.

In addition, contractor's method statements will be required for Health and Safety, constructability, environmental or nuisance protection, and to protect groundwater and surface water should include:

- Dewatering during construction, including discharge location and quality of water, pollution control and management of sediment in line with EPA approvals processes
- Construction activities and temporary works that may impact on permeability, groundwater and surface water.
- How GHCMA's Waterways Licensing requirements will be met.

4.2.1.6 Quarry

The WWF temporary quarry is designed to be a *'zero discharge'* site with all surface water and groundwater managed within the quarry site using retention basins, either infiltrating or evaporating stored water. The onsite storage requirements to manage surface water and groundwater inflows were assessed using a MUSIC model for the operational and post operational phases of the project, as detailed further in Appendix B.

To minimise the risk of surface water or a mixture of surface water and groundwater the following recommendations have been made.

- The storage be properly designed by an accredited dam engineer and constructed to meet the relevant construction standards.
- A weekly record of storage water levels should be kept throughout the operation of the quarry. When the storage reaches within 1.5 m of the dam spillway height, monitoring should be undertaken on a daily basis. Water management strategies such as water reuse or deep injection should be in place should monitoring indicate any change to the planned zero discharge off site is required.
- The dam's detailed design should be assessed under the relevant design guidelines (e.g., ANCOLD for large dams). All onsite water use, within the quarry and across the windfarm should be taken from the water storage where possible (i.e., if it meets relevant water quality standards) to reduce the risk of exceeding the storage capacity.
- Metering of site water usage and internal transfers should be undertaken weekly to reconcile the estimates provided in this study.
- Development of a small starter pit (e.g., 30 x 30 m) which extends to the base of the quarry to be used to validate the groundwater inflow estimates prior to excavation of the broader quarry area.
- The three wells which are outside the drawdown extent should be checked to validate their purpose and status. These may be used as water level monitoring wells (monthly during quarry operation and quarterly for 12 months afterwards) to verify the drawdown estimate.
- In the event that inflows are greater than predicted in this study, the following contingency measures could be enacted:
  - Add additional water storage retention basins within the quarry site.
  - Partition areas within the pit to provide additional storage.
  - Consider recharge to the aquifer through groundwater wells (subject to permissioning under the Environment Protection Regulations).
  - Consider options for off-site disposal to waterways subject to analysis of source and receiving water quality.
  - Increase usage of pit and retention basin water for off-site water requirements, subject to licensing approval.
- The detailed design of the proposed road alignment of the track from Old Dunmore Rd to the works authority area may require the road to be raised to at least 88.5 m AHD, for safe access
- If the quarry operator detects Potential Acid Sulphate Soils (PASS) during excavation, an appropriate management plan should be prepared along with further pH testing. The Contractor's Environmental Management Plan should include management recommendations to avoid disturbing soil from any areas identified as high risk of PASS.

4.2.2 Management controls

Engineering design measures are required to avoid potential surface water impacts. To further minimise potential impacts to surface water features (and their supporting values) management controls are required to be implemented during the design, construction, operation and decommissioning of the project. Recommended management measures are outlined in Table 29.

TABLE 29 SURFACE WATER MANAGEMENT CONTROL MEASURES

Surface water impact	Project phase	Management measures
Alternation of existing drainage lines and flow paths	Detailed design	Development of the detailed drainage design in consultation with the Glenelg Hopkins Catchment Management Authority, considering best practice design guidelines. Design measures is required to include, but not be limited to: • Permanent surface structures designed to maintain existing overland flow paths and not cause increased upstream flood levels. • Culverts be installed parallel to the alignment of the banks of the waterway • Use of a reduced-width construction right of way at watercourse crossings and aim to avoid any standing water • Micro-siting crossings of Back Creek to avoid deeper pools where practicable to prevent potential effects on the Yarra Pygmy Perch, Little Galaxias and the Growling Grass Frog (Nature Advisory, 2022).
	Construction	Works within a designated watercourse require a Works on a Waterway licence from Glenelg Hopkins Catchment Management Authority. Works be undertaken in accordance with the requirements of the Catchment Management Authority licence.
	Construction	Where essential wind farm infrastructure (e.g., access tracks) crosses a creek, measures for avoiding and minimising impacts are required to be documented in the Construction Environmental Management Plan, including: • Where watercourse trenching is required, preferentially schedule works during drier months of the year and lowest flow of the waterway. • Avoiding undertaking of works when high rainfall events are expected. • Maintaining adequate flow rates and water levels in waterway to be crossed (as determined in consultation with the relevant authorities) to minimise impacts on aquatic ecosystem and environmental values. • Restoration of temporarily disturbed waterways and vegetation (removing any obstructions to waterway flow) as soon as practicable following the open cut trenching works to at least its pre-construction condition. • Design measures to minimise future erosion in areas where trenching occurred (e.g., use of riprap made of stones to stabilise the waterway, geofabric to prevent erosion and scour until establishment of vegetation.

Surface water impact	Project phase	Management measures
Erosion and sedimentation (surface water runoff, destabilisation of waterway banks)	Design, Pre-construction, Construction	Development and implementation of a Sediment, Erosion and Water Quality Management Plan, in consultation with the Glenelg Hopkins Catchment Management Authority and in accordance with EPA Victoria Publications 1834 *Civil construction, building and demolition guide* and 1894 *Erosion, sediment and dust: treatment train*. Erosion and sediment control measures within the construction site are required to include, but not be limited to: • Water quality testing during detailed planning, construction and operation phases. • Phasing of ground-disturbing works to periods of lower rainfall, where possible. • Minimising clearance of vegetation, particularly along drainage lines, waterways and steep slopes. Vegetation, including within the watercourse and riparian zones, be reinstated as quickly as practicable as open cut trenching works are completed. • Design and designate an area for stockpiles before construction commences. Stockpiles to be left inactive for longer periods, establish vegetation or grass. • Ensuring that stockpiles and batters are designed with slopes no greater than 2:1 (horizontal/vertical). • Stabilising exposed soils as appropriate. • Installing sediment fencing during construction to protect riparian zones if works are to be undertaken within 30 metres of creeks. • Installing sediment treatment control measures as appropriate (including around stockpiles) to adequately capture sediment loads. • Managing vehicle movements to designated roads and access areas. • Directing stormwater within a constructed lined channel or sediment basin where applicable to reduce the velocity of run-off water. • Monitoring surface water quality upstream and downstream from the works area and confirm effectiveness of established controls and if environmental values are being protected. • Development of contingency measures for works within a waterway or floodplain, including controls to be implemented when a storm event is forecast. • Implementation of management controls for stockpiles as per EPA Guidance Sheet 2: *Managing stockpiles.* • Implementation of management controls for construction works within or near waterways as per EPA Guidance Sheet 1: *Working within or adjacent to waterways*.

Surface water impact	Project phase	Management measures
	Design, Construction, Operation, Decommissioning	A Quarry Work Plan is required and be implemented, it is required to include measures to manage and monitor surface water impacts in accordance with the Work Authority. These measures shall include, but are not limited to: • Dam storage be properly designed by an accredited dam engineer and constructed to meet the relevant construction standards. • Weekly record of storage water levels should be kept throughout the operation of the quarry. • Management of surface water inflows through in-pit sump pumping during quarry operation.
Exposure of acid sulfate soil	Construction	Implement risk-based approach to management of potential acid sulfate soil, in accordance with EPA Victoria Publication 655.1 (2009) *Acid sulfate soil and rock*, which may include: • Identification of high-risk locations through mapping and soil testing. • Implementing targeted measures at high-risk locations such the handling and stockpiling of material, protocols to neutralise soil acidity, monitoring and contingencies. • Development of an acid sulfate soil management plan. If acid sulfate soil is to be removed and disposed of offsite, approval from EPA Victoria would be required.
Waterway contamination (from accidental spills)	Construction, Operation, Decommissioning	Measures to manage potential pollutants from entering waterways include: • Spills risk assessment and response plan, incorporating measures for the use, storage, transfer and disposal of hydrocarbons and chemicals (in accordance with EPA Victoria Publication 1698: *Liquid storage and handling guidelines*). • Storage of liquid fuels and chemicals within containment facilities (e.g., bunded areas) more than 50 metres from waterways in designated areas within the project site. • Spill response kit, to be located at waterway crossings, at locations where machinery/plant are operating, and refuelling and fuel/chemical storage areas during construction • Incorporation of spill containment measures into the drainage design.
Disposal of collected water	Construction	Water collected dewatering of excavations shall be managed in accordance with the Environment Protection Regulations 2021. These measures should be incorporated into the Construction Environmental Management Plan and should include, but not be limited to: • Monitoring of water quality of captured water (e.g. pH, salinity, suspended solids). • Approval should be sought from relevant authorities to discharge water. • Disposal of water would be at a site that is lawfully able to receive it.

Surface water impact	Project phase	Management measures
		• Use sediment control devices, where required. The EPA would be consulted in the preparation of the Construction Environmental Management Plan.

4.2.3 Residual effects

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

TABLE 30 IMPACT SIGNIFICANCE CRITERIA FOR SURFACE WATER IMPACTS

Very low / negligible	Low	Moderate	High	Very high
Project results in negligible changes to waterway flow and/or quality. **Negligible reduction in the extent of a water resource that:** • **Has a negligible impact on the current or future utility of the water resource for third-party users, and/or** • **Results in negligible or temporary adverse effect on aquatic ecosystems.**	Project results in minor (isolated) changes to waterway flow and/or quality. Minor reduction in the extent of a water resource that: • Results in a short-term (temporary) reduction of the current or future utility of the water resource for third-party users, and/or • Results in short-term adverse effect on aquatic ecosystems.	Project results in changes to waterway flow and/or quality in a local area. Reduction in the extent of a water resource that • Results in a medium-term (temporary) reduction of the current or future utility of the water resource for a number of third-party users, and/or • Results in medium-term adverse effect on aquatic ecosystems.	Project results in significant changes to waterway flow and/or quality in local and downstream areas. Significant reduction in the extent of a water resource that: • Results in a long-term reduction of the current or future use of the water resource for a number of third-party users, and/or • Results in long-term adverse effect on aquatic ecosystems.	Project results in extensive changes to waterway flow and/or quality in the catchment. Significant reduction in the extent of a water resource that: • Results in a permanent reduction of the current or future utility of the water resource for a number of third-party users, and/or • Results in permanent adverse effect on aquatic ecosystems.

The greatest likelihood of impacts to the waterways and wetlands is from construction activities associated with watercourse crossings, and to a lesser extent, from general construction activities. These activities have the potential to result in physical streambed disturbance and also in stormwater runoff containing sediments entering waterways.

The following section assesses the likely residual effects to key surface water assets assuming design measures outlined in Section 4.2.1, and management controls outlined in Section 4.2.2, are implemented.

The EPA will be consulted on the Environmental Management Plan before construction and will be subject to their approval / endorsement.

4.2.3.1 Shaw River

4.2.3.1.1 SHAW RIVER CROSSING

A vehicle and cable crossing of the Shaw River is unavoidable (as determined by WWF); however, these impacts will be localised to the single crossing (crossing 14, as outlined in Section 4.2.1.2), occur for a short duration, and be of low severity in the context of the existing conditions. Considering the moderate physical and ecological condition of this waterway within the project site and the existing water quality, the significance of this impact was assessed to be **low**. WWF have completed a conceptual engineering design for this crossing on the basis of the discharge, water level and velocity results determined in this assessment.

4.2.3.1.2 RUN-OFF ENTERING SHAW RIVER

During construction there is the potential for a temporary increase in sedimentation (and to a lesser extent other contaminants), which has the potential to reduce water quality, which can cause impacts for other users of a watercourse or for aquatic and semi-aquatic flora and fauna.

Sedimentation is most likely to occur from runoff from stockpiles or cleared areas including hardstand areas, access tracks and cable trenches. This would most likely occur during periods of intense rainfall. Through the implementation of watercourse buffers, most project infrastructure are located away from tributary drainage channels, except for a small number of watercourse crossings for access tracks and cables. With the implementation of sediment control measures and avoiding watercourse crossings during high flow periods the impacts to the Shaw River via transport of poor water quality in drainage channels was assessed to be localised and unlikely to reach Shaw River itself, for a short duration during periods of high rainfall and of low severity/intensity. Considering the existing condition and the temporary and localised effects predicted within the project site the significance of this impact was assessed to be **low**.

4.2.3.1.3 ALTERATION OF EXISTING DRAINAGE PATTERNS

The construction of roads and hardstand areas has the potential to alter existing drainage patterns if not accounted for during design. Hydrological effects have the potential to occur over a larger area, due to the nature of the shallow topographical relief of floodplain systems. Hydrological flood modelling was used to inform the placement of turbine locations outside of water flow paths and size culverts to ensure flow pathways are not altered. There was one crossing of the Shaw River identified (crossing 14) and 11 other designated waterway crossings in the Shaw River catchment (as highlighted in Section 4.2.1.2). With the implementation of these measures at the crossing and within the catchment of the Shaw River the magnitude of potential impacts to altering the hydrology within the Shaw River catchment was assessed to be of **very low** significance, with any impacts likely to be localised, for a short duration and of low severity. The detailed road and culvert designs would include updated modelling to ensure hydrological connectivity is maintained and culverts are placed at appropriate locations.

4.2.3.1.4 IMPACTS OF ON-SITE QUARRY

The on-site quarry is located within the Shaw River catchment. Flood modelling has shown the quarry is not within the 1% AEP area of inundation, with limited localised depressions predicted to experience up to 300 millimetres in the localised depressions and flow paths across the site.

The quarry has been designed as a zero-discharge facility. Water entering the site via overland flows, groundwater and rainfall would not flow (or be discharged) from the work authority area. In terms of water management of the quarry during its operation, water collecting at the quarry sump (i.e., low point) would be pumped to a storage dam or tanks close to the processing plant.

Two water retention basins are proposed to capture water run-off from the quarry site and to contain water from quarry dewatering. The onsite storage requirements to manage surface water and groundwater inflows were assessed using a model for the operational and post operational phases of the project. Water balance modelling demonstrated during operation a 1.75-hectare storage can hold both a 90th and 99th percentile surface water inflow per year and the predicted groundwater inflow. If inflows are greater than predicted.

Post operation, the quarry pit is proposed to be converted to a water storage. The risk of over topping was assessed and was highly conservative by assuming the quarry is full of water at the start of the model period. The analysis assumed a depth of 3 metres and a surface area of 10 hectares, with a storage capacity of 300 ML. The analysis showed that due to the large surface area, evaporation prevented the storage from overtopping throughout the 120-year modelled period. The results showed that the volume of water within the storage on would increase slightly each year (if no use was proposed). Spills from the dam are not considered to be an issue as by the decommissioned quarry would essentially comprise of natural inflows and undisturbed water. Spills would occur over a grassed spillway as per standard agricultural dam design. Considering the volume and that groundwater recharge will occur when the pond level increases above the groundwater level, the risks of impact were considered to be **negligible**.

Water within the quarry and the on-site storages will be a combination of groundwater and surface water. Groundwater salinity is expected to be in the order of 1,000 mg/L (suitable as use for livestock water) based on regional salinity mapping and salinity of agricultural bores located in proximity to the quarry. When mixed with surface water, lower salinities can be expected. Turbidity within the storages is likely to be dependent on the type of drains and operational management of the quarry and surrounds. Some settling of suspended solids will occur during the life of the storages and they will be designed to ensure no external site discharge.

Through the incorporation of conservative assumptions and contingency measures into the design of the quarry, no impacts are predicted to receiving waters within the Shaw River catchment as a result of the quarry.

4.2.3.2 Back Creek

4.2.3.2.1 BACK CREEK CROSSINGS

The key impact pathway to the Back Creek is physical disturbance to the creek bed and associated aquatic habitats at a single crossing point for an access tracks and cable (as highlighted in Section 4.2.1.2). To minimise potential environmental impacts, these waterway crossings are required to be designed and constructed to maintain appropriate flow capacity of drainage lines, minimise the extent of disturbance and vegetation removal within the waterway, and rehabilitate disturbed areas following completion of works to the satisfaction of the Glenelg Hopkins Catchment Management Authority. Construction works should be timed to avoid periods of high flow periods, where possible.

Crossing of Back Creek is required to provide access between wind turbines, the crossing is proposed to consist of culverts with co-located cables. A concept design of the structure has been completed, sized to accommodate a 10% AEP, as per the flowrates described in Section 4.2.1.2. The design also conforms to relevant local Council, GHCMA, EPA Victoria and DELWP guidelines.

If the creek is flowing at the time of construction, water must be diverted through use of a temporary upstream coffer dam with piped flow around the construction works area. Excavation through a dry creek bed could occur followed by installation of the culvert or cable followed by immediate reinstatement and rehabilitation of the creek banks. Downstream sediment control measures including sediment traps, are required in accordance with best practice guidelines outlined. Water pollution must be minimised or avoided by reducing land disturbance and maintaining areas of vegetation. As such, a reduced working space (10 metres in width) is required at the approaches and exits of the Back Creek crossings.

Back Creek runs in a north-south direction through the project site, as such there is also the potential for run-off from construction work areas (e.g., stockpiles or cleared areas) to reach the creek during construction, which may reduce its water quality. The most effective measure to limit this potential impact is the implementation of watercourse buffers from these works' areas.

With the implementation of design and control measures, the potential impacts to the Back Creek via physical disturbance of waterway crossings and generation of poor water quality runoff was assessed to be localised (mainly at crossing points), for a short duration (expected to be over several weeks) and of **low** severity.

4.2.3.2.2 RUN-OFF ENTERING BACK CREEK

During construction (particularly the crossing of Back Creek) there is the potential for a temporary increase in sedimentation (and to a lesser extent other contaminants), which has the potential to reduce water quality, which can cause impacts for other users of a watercourse or for aquatic and semi-aquatic flora and fauna.

Sedimentation is most likely to occur from runoff from stockpiles or cleared areas including hardstand areas, access tracks and cable trenches. This will most likely occur during periods of intense rainfall. Through the implementation of watercourse buffers, most project infrastructure are located away from tributary drainage channels, except for a small number of watercourse crossings for access tracks and cables. With the implementation of sediment control measures and avoiding watercourse crossings during high flow periods the impacts to the Back Creek via transport of poor water quality in drainage channels was assessed to be localised and unlikely to reach Back Creek itself, for a short duration during periods of high rainfall and of low severity/intensity. Considering the degraded condition of this drainage channels within the project site the significance of this impact was assessed to be **low**.

4.2.3.2.3 ALTERATION OF EXISTING DRAINAGE PATTERNS

During operation of the project, impacts to Back Creek would largely relate to potential hydrological modification in the catchment as a result of altered drainage patterns, if these are not accounted for during design. With the implementation of the management controls outlined in Section 4.2.2, potential impacts associated with altering the hydrology of Back Creek was assessed to be localised around wind turbines are unlikely to alter the overall dynamics of the catchment.

The construction and operation of the project is not predicted to impact the physical form (via hydrological modification) of Back Creek. With measures in place, the significance of these impacts was considered to be **low** during construction, reducing to **very low** during operations.

4.2.3.3 Moyne River

4.2.3.3.1 RUN-OFF ENTERING MOYNE RIVER

The Moyne River is similar to other major waterways within the region, it meanders within a broad floodplain, which is defined by stony rises to the west and undulating terrain to the east. The Moyne River is located approximately 2 kilometres west of proposed infrastructure at its closest point. As such direct impacts to this watercourse in terms of physical disturbance are not predicted. However, most of the project is located within the Moyne River catchment and therefore any changes to downstream water quality or hydrological impacts to its tributaries located within the project site, including Back Creek, may indirectly impact Moyne River.

During construction there is the potential for a temporary increase in suspended sediments (and to a lesser extent other contaminants), which has the potential to reduce water quality. This is most likely to occur immediately downstream of stockpiles or cleared areas during periods of intense rainfall. The most effective measure to limit this potential impact is the implementation of watercourse buffers from these works' areas. Other key measures to limit potential impacts to this waterway include the installation of cut-off or intercept drains to redirect stormwater away from cleared areas, installing erosion and sediment control measures prior to construction in accordance with best practice standards, and rehabilitating disturbed areas promptly. With these measures in place, changes to water quality in the Moyne River as a result of the project are not predicted. Any downstream transport of sediments would likely settle in grassed swales within agricultural areas before reaching the main Moyne River approximately 3 to 10 kilometres downstream.

4.2.3.3.2 ALTERATION OF EXISTING DRAINAGE PATTERNS

During the project design, hydrological flood modelling was used to inform the placement of turbine locations. Similarly, modelling of flood and flow velocity has been considered for the sizing of culverts to ensure flow pathways are not affected by the project. As such, permanent changes to hydrological drainage patterns within the Moyne River catchment are not predicted. During construction, earthworks and stockpiles also have the potential to impede natural drainage. Measures required include avoiding the creation of continuous rows of stockpiled materials and providing gaps to allow flow, and minimising the length that stockpiles are in place to minimise this hazard.

Considering the nature and scale of works, required to construct the project, hydrological changes are not predicted to impact the Moyne River, with any changes highly localised and temporary around ephemeral drainage channels within the project site. The significance of these changes was predicted to be **very low**.

4.2.3.4 Ephemeral wetlands

Potential impacts to ephemeral wetlands as a result of the construction and operation of the project are:

- Disruption of hydrology and flows reaching these areas influencing the inundation of these areas.
- Runoff of poor water quality (e.g., suspended sediments) altering water quality of these ephemeral systems.

To avoid and minimise potential impacts to ephemeral wetlands a 100-metre buffer was placed around all DELWP mapped wetlands by WWF to exclude all project infrastructure as a means of avoiding physical disturbance to wetlands and their fringes and to limit the likelihood of poor-quality surface water runoff from construction works zones reaching these areas. A single, larger turbine free buffer was placed around a series of wetlands that form the Cockatoo Swamp by WWF. The total buffered area proposed is more than 2,000 hectares and includes areas between these wetlands. In addition, two isolated wetlands to the east of the project site were also buffered to limit potential impacts to Brolga.

During the project design undertaken by WWF, the hydrological flood modelling presented in this report was used to inform the placement of project infrastructure, including turbine locations. Similarly, modelling of flood and flow velocity was considered for the sizing of culverts to ensure flow pathways are not affected by the project. Providing the recommended design requirements are met no permanent changes to the hydrological regime for the Shaw River or Moyne River catchments within the project site, including ephemeral wetlands, is predicted.

4.2.4 Impact Assessment Summary

A summary of the surface water impact assessment is shown in Table 31.

TABLE 31 SURFACE WATER IMPACT ASSESSMENT SUMMARY

Watercourse	Impact pathway	Project phase	Mitigation and management	Likely impact (considering magnitude, extent and duration)	Significance rating and justification
Shaw River and associated tributaries	Reduced water quality (e.g., turbidity, dissolved oxygen) due to bridge crossing of Shaw River, culvert crossings of tributary drainages, and sedimentation due to stockpiles and earthworks for infrastructure, tracks and hardstands	Construction	• Hydrological buffer for all infrastructure excluding crossings • Bridge design based on hydrological modelling • Crossing structures would conform to relevant local Council, Glenelg Hopkins Catchment Management Authority and DELWP guidelines • Placement of flow diversion banks upstream of works areas • Installation of sediment control devices	One access track crossing of Shaw River. Impacts would be localised (within tens of metres), occur for a short duration (weeks), and be of low severity in the context of the existing conditions Temporary increase in sedimentation (and to a lesser extent other contaminants), from runoff from stockpiles or cleared areas. This would most likely occur during periods of intense rainfall which has the potential to reduce water quality.	**Low** Considering the moderate physical and ecological condition of this waterway within the project site and the poor to moderate existing water quality, the significance of this impact was assessed to be low. Impacts to the Yarra Pygmy Perch and Little Galaxias from the project are assessed in Willatook Wind Farm Flora and Fauna Impact Assessment (Nature Advisory, 2022).
	Hydrological changes to surface water flows due to project infrastructure with the introduction of impermeable surfaces, and waterway crossings for tracks and linear infrastructure.	Construction, Operation	• Detailed design incorporating hydrological modelling. • Exclusion of wind turbines and other infrastructure from the entire Cockatoo Swamp • Flows have been considered for the sizing of culverts	The magnitude of impacts predicted localised (within tens of metres), occur for a short duration (weeks) and of low severity.	**Low** The magnitude of any hydrological alterations outside turbine free buffers was assessed to be of very low significance

Watercourse	Impact pathway	Project phase	Mitigation and management	Likely impact (considering magnitude, extent and duration)	Significance rating and justification
	Quarry development influencing downstream water quality and hydrology	Construction, operation and post closure	• 'Zero discharge' site (all surface water and groundwater managed using retention basins) • Surface water management using swale drains, bunding, sediment traps and sumps • Water retention basins to capture water run-off	Quarry is located within the Shaw River catchment. Quarry is not affected by the 1% AEP flood event. With the implementation of measures into the design of the quarry, no impacts from quarry construction and operation are predicted to receiving waters within the Shaw River catchment.	**Very low** Impacts to surface water are not anticipated
Back Creek	Reduced water quality (e.g., turbidity, dissolved oxygen) due to bridge crossing of Back Creek, culvert crossings of tributary drainages, and sedimentation due to stockpiles and earthworks for infrastructure, tracks and hardstands	Construction	• Hydrological buffer for all infrastructure excluding crossings • Minimisation of crossing points in the design process • Crossing design based on hydrological modelling • Placement of flow diversion banks upstream of works areas • Installation of sediment control devices • Minimisation of crossing construction width	One access track/cable crossing of Back Creek Localised physical disturbances due to watercourse crossings and resulting sedimentation and temporary (weeks) water quality changes.	**Low** Sensitive due to presence of threatened fish species, and habitat for Growling Grass Frog (*Litoria raniformis*), only one crossing with manageable construction established impact mitigation techniques.

Watercourse	Impact pathway	Project phase	Mitigation and management	Likely impact (considering magnitude, extent and duration)	Significance rating and justification
	Hydrological changes to surface water flows due to project infrastructure with the introduction of impermeable surfaces, and waterway crossings for tracks and linear infrastructure.	Construction, Operation	• Hydrological flood modelling was used to inform the placement of turbine locations • Modelling of flood and flow velocity has been considered for the sizing of culverts	Temporary (weeks) modification of hydrological drainage (for example during watercourse crossings). No permanent impact the physical form (via hydrological modification) of Back Creek predicted.	**Low** significance of these impacts was considered to be **low** during construction, reducing to very low during operations.
Moyne River and associated tributaries	No direct impact Potential indirect impacts to water quality and hydrological changes during project construction and operation	Construction, Operation	• Watercourse buffers from works areas. • Placement of flow diversion banks upstream of works areas • Installation of sediment control devices	Localised (tens of metres) change to sedimentation, change to flood levels and/or change to flow regime up or downstream of the modification location.	**Very low** Any downstream transport of sediments would likely settle in grassed drainage channels within agricultural areas before reaching the main Moyne River approximately 3 to 10 kilometres downstream.
			• Hydrological flood modelling was used to inform the placement of turbine locations • Avoiding the creation of continuous rows of stockpiled materials and providing gaps to allow flow.	Permanent changes to hydrological drainage patterns within the Moyne River catchment are not predicted. Any changes highly localised and temporary around ephemeral drainage channels within the project site	**Very low** Any hydrological changes would be limited to tributary drainage lines.

Watercourse	Impact pathway	Project phase	Mitigation and management	Likely impact (considering magnitude, extent and duration)	Significance rating and justification
Ephemeral wetlands (including Cockatoo Swamp)	Disruption of hydrology and flows	Construction	• Turbine free buffer around Cockatoo Swamp • 100-metre buffer around all mapped wetlands to exclude all project infrastructure • Detailed design incorporating hydrological modelling	Permanent changes to hydrological drainage patterns are not predicted. Temporary modification of flows around project infrastructure (weeks), particularly during construction, but these would be unlikely to effect the inflows to these wetlands overall.	**Negligible** Changes to hydrological drainage patterns are not predicted
	Potential impacts to water quality and hydrological changes during project construction and operation	Construction, Operation	• Installation of sediment control devices • Placement of flow diversion banks upstream of works areas • Installation of sediment control devices • Implementing an acid sulfate soil management plan	Any changes highly localised (tens of metres) and temporary (weeks) around ephemeral drainage channels within the project site.	**Negligible** Impacts to surface water are not anticipated
All	Waterway contamination from accidental spills of hazardous waste, resulting in impacts to water quality	Construction, Operation	• Implement a spills risk assessment and response plan • Storage of liquid fuels and chemicals within containment facilities more than 50 metres from waterways	With control measures in place any spills are predicted to be localised and could be readily remediated.	**Low** Uncontrolled releases are unlikely using best-practice construction and operational management measures.

Watercourse	Impact pathway	Project phase	Mitigation and management	Likely impact (considering magnitude, extent and duration)	Significance rating and justification
			• Spill response kit, to be located at waterway crossings, at locations where machinery/plant are operating, and refuelling. • Incorporation of spill containment measures into the drainage design		

4.3 Groundwater

4.3.1 Design mitigation

Based on known environmental constraints, design measures are required to avoid potential groundwater impacts to local groundwater users and environmental values. The required design measures were determined in consultation with WWF and include:

- A 100-metre buffer around all mapped potential aquatic GDEs to exclude all Project infrastructure within the buffered area. This area is required as a means of avoiding physical disturbance to the GDEs and their fringes, and to limit surface water runoff, and entrained sediment loads reaching these GDEs from construction work zones.
- A 25-metre buffer around mapped potential terrestrial GDEs when placing turbine foundations. A smaller buffer area compared to the aquatic GDEs is required as a means of limiting potential physical disturbance and deposition of eroded sediments. This buffer distance is based on a defined tree protection zone buffer (DELWP, 2017).
- Locating the quarry in an area which will minimise impacts on sensitive receptors, including groundwater bores and potential GDEs.
- Minimising the construction time of turbine foundations and hence reducing the time required to manage groundwater (if intersected).

Because GDEs have a high likelihood of being inflow systems (i.e., they depend on local surface water inflows), the hydrological modelling of the site completed in this assessment was considered by WWF during the project design to ensure natural flow paths (hydrological connectivity) are not interrupted by the project as a means of impact avoidance.

4.3.2 Residual effects

Following the development of design measures, 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.

Potential groundwater impacts from the project construction, operation and decommissioning were assessed for each identified groundwater asset within the development area, based on the findings of the technical analysis detailed in Section 2. The significance of groundwater impacts was assessed against the impact ratings outlined in Table 32.

TABLE 32 SIGNIFICANCE RATING CRITERIA FOR GROUNDWATER IMPACTS

Very low / negligible	Low	Moderate	High	Very high
Project results in negligible groundwater drawdown. Negligible reduction in the extent of the groundwater resource quality that: • has a negligible impact on the current or future utility of the water resource for third-party users, and/or • results in negligible or temporary adverse effect on aquatic ecosystems.	Project results in minor (highly localised) groundwater drawdown. Minor reduction in the extent of the groundwater resource that: • results in a short-term (temporary) reduction of the current or future utility of the water resource for third-party users, and/or • results in short-term adverse effect on aquatic ecosystems.	Project results in groundwater drawdown in a local area. Reduction in the extent of the groundwater resource that: • results in a medium-term (temporary) reduction of the current or future utility of the water resource for a number of third-party users, and/or • results in medium-term adverse effect on aquatic ecosystems.	Project results in groundwater drawdown that extends into the regional area. Significant reduction in the extent of the groundwater resource that: • results in a long-term reduction of the current or future utility of the water resource for a number of third-party users, and/or • results in long-term adverse effect on aquatic ecosystems.	Project results in groundwater drawdown on a regional scale. Significant reduction in the extent of the groundwater resource that: • results in a permanent reduction of the current or future utility of the water resource for a number of third-party users, and/or • results in permanent adverse effect on aquatic ecosystems.

4.3.2.1 Quaternary aquifer

Four crossings for accessways and cables are proposed for the area of Quaternary Alluvium surrounding Back Creek. Additionally, two wind turbines are mapped in Quaternary Alluvium. The key impact pathway for the Quaternary Aquifer is surface disturbance. Disturbance in the accessways and cable crossing areas would be minimal (in a localised area) and temporary, limited to the construction period for these crossings. If saturated, direct disturbance may require dewatering to enable construction for a short period of time (i.e., two weeks). This in turn may temporarily lower the water table for the duration of construction activities. The magnitude of impacts predicted within the Quaternary Alluvium are highly localised (tens of metres) and any impacts are predicted to be short term (weeks). These effects are unlikely to impact agricultural bores or aquatic GDEs.

Disturbed areas would be rehabilitated following completion of works to the satisfaction of the Glenelg Hopkins CMA. No permanent impacts are anticipated.

4.3.2.2 Newer Volcanic Group Basalts Aquifer

4.3.2.2.1 DEWATERING AND DISPOSAL OF EXTRACTED GROUNDWATER (DRAWDOWN)

The Newer Volcanic Group basalts aquifer will be intersected by the proposed on-site quarry. The quarry has a proposed depth of 14 m, with the water table estimated to be around 3 m below ground level. An assessment of groundwater inflow and drawdown from quarry dewatering is presented in the quarry investigation report in Appendix B. Groundwater inflows are proposed to be managed through in-pit sump pumping (i.e., in-pit dewatering). Groundwater inflows in the quarry excavation site are expected to be around 77 cubic metres per day during operation; however, groundwater inflows could be higher if hydraulic conductivity is greater than anticipated. This would equate to 521 cubic metres

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Drawdown due to pit dewatering is predicted to extend out to 518 metres from the quarry for the base case scenario and up to 1,080 metres for the high hydraulic conductivity (worst case) scenario (Figure 45). This distance represents the point at which the drawdown is predicted to be zero. Approximately 1,000 metres west of the proposed quarry pit is groundwater bore ID 69405, the closest registered bore to the quarry site (Figure 45). At this location drawdown from quarry operations is not predicted to make a material impact under the high hydraulic conductivity scenario. Noting the uncertainties surrounding the hydraulic conductivity, groundwater levels will be monitored at this and other nearby wells to validate the drawdown predictions.

Under the base case scenario, there is one aquatic GDE (ephemeral wetland) that may experience some drawdown (Figure 45). The drawdown at this GDE is predicted to be around 2 m. Another four GDEs may experience some drawdown, however, these predictions are based on parameter sets which are considered possible, but less likely. Appendix B provides the predicted maximum drawdown at each of the five wetlands under each scenario. Under the worst-case scenario, drawdown may be up to 6 m at the closest wetland. This wetland (ID 4439978 from Figure 45) represents 2% of the potential aquatic GDE area within the Project Site Boundary, while the five wetlands make up 15% of the potential aquatic GDEs area.

The duration of impacts may last for several years (high hydraulic conductivity scenario) up to several decades (low hydraulic conductivity scenario). These recovery times assume that the entire footprint of the quarry (10.4 hectares) is dewatered at a single point in time. In reality this won't be the case and the quarry will be partitioned into discrete working areas, some of which will be dry (dewatered) and some of which will contain water. This operating regime will facilitate quicker recovery as there will be some water held within the quarry itself throughout operations. This method of quarrying is used at the Tarrone Basalt Quarry located 10 km to the southeast. It is recommended that groundwater and surface water inflows are closely monitored during the first few weeks and months of quarry development to validate the conceptualisation presented in this assessment.

When considering the impacts to potential aquatic GDEs it is important to consider several factors including the surface water contribution to the GDEs, seasonal groundwater level variations and other historic landscape changes that have influenced these systems. Surface water modelling suggests that these systems are predominately surface water driven with inundation only occurring during winter month (Water Technology, 2022). During summer, these systems are dry, which confirms that groundwater does not provide a permanent water source. This conceptualisation is consistent with groundwater level variations at the site which show seasonal highs in winter and groundwater levels which are around 1.5 m lower in summer (refer to Figure 36). It is also worth noting that these systems have been heavily modified since European settlement, and groundwater levels are reported to be higher than pre-European times due to increased recharge as a result of land clearance (Dahlhaus et al., 2002). The potential effects on GDEs and wetland ecology are assessed in the ecology section of the WWF EES.

During turbine foundation construction, it is important to have a clean excavated foundation base until blinding concrete (thin layer of concrete to preserve excavation founding material and create level surface for works) is poured. This is typically achieved by pumping the water out using a sump at the base of the excavation.

During construction of infrastructure foundations, dewatering may temporarily lower the water table before the concrete foundations are laid. If observed, drawdown would be expected to last for weeks rather than months or years. Anecdotal observations made during other windfarm construction projects have indicated groundwater inflow will be generally minimal in the form of minor seepage into the foundations. However, instances where some active pumping (dewatering) was necessary in locations where inflows were more substantial. This was sporadic and occurred mainly in the winter months when groundwater levels were highest.

Given the limited extent and duration (i.e., up to two weeks) of dewatering for foundation excavations, measurable impacts to groundwater bore water levels are considered to be very low. If active pumping is required, groundwater inflow monitoring would be required as part of the Construction Environmental Management Plan (CEMP). Following dewatering the water table is predicted to recover quickly over several weeks.

Groundwater drawdown near aquatic GDEs is not expected to occur as a result of foundation excavations being located at least 100 m from potential aquatic GDEs. Any drawdown from foundation excavation dewatering (if required) would be expected to be highly localised (within tens of metres of foundations)

Dewatering for cable excavations in isolated areas may be required where groundwater levels are less than 1 metre below the natural surface during winter and early spring. Given this would be limited to isolated area, and the excavations for the underground cables will be open for less than three hours, impacts to groundwater levels from these works are not anticipated to occur.

Post-operation, the quarry pit is to be converted to a water storage. During this time, the rate of inflow will be controlled by losses from evaporation, water usage and the permeability of the Newer Volcanic Group basalt aquifer.

4.3.2.2.2 DISRUPTION OF GROUNDWATER RECHARGE AND FLOW

The surface area of wind turbine foundations will be approximately 27 x 27 metres and hardstands (next to each wind turbine) will be approximately 50 x 60 metres. To minimise impacts, turbine foundations are shaped to allow rainwater run-off and to re-establish natural recharge to the aquifer adjacent to these features. Considering the surface area for foundations and hardstands is small, the estimated reduction in groundwater recharge will be highly localised and can be offset by appropriate drainage design.

Given the unconfined nature of the Newer Volcanic Group basalt aquifer, and existing seasonality of groundwater recharge and flow, any impacts to groundwater flow around infrastructure foundations are anticipated to be localised and minor, and during times when groundwater levels are high. With design buffers of 100 metres around wetlands, and even larger buffers around Brolga breeding wetlands, any changes to groundwater flow and recharge caused by infrastructure foundations are unlikely to affect ephemeral wetlands and springs. These buffers would also likely reduce the likelihood of impacts to groundwater discharge to watercourses and wetlands.

If cable trench backfill material has a higher hydraulic conductivity than the surrounding undisturbed soils, there is a potential to create a preferential flow path (where groundwater flows faster through the backfill material than in surrounding material). To mitigate this risk, the trench should be backfilled with the excavated material. As such, there will be no change to surface permeability and recharge rates in these areas.

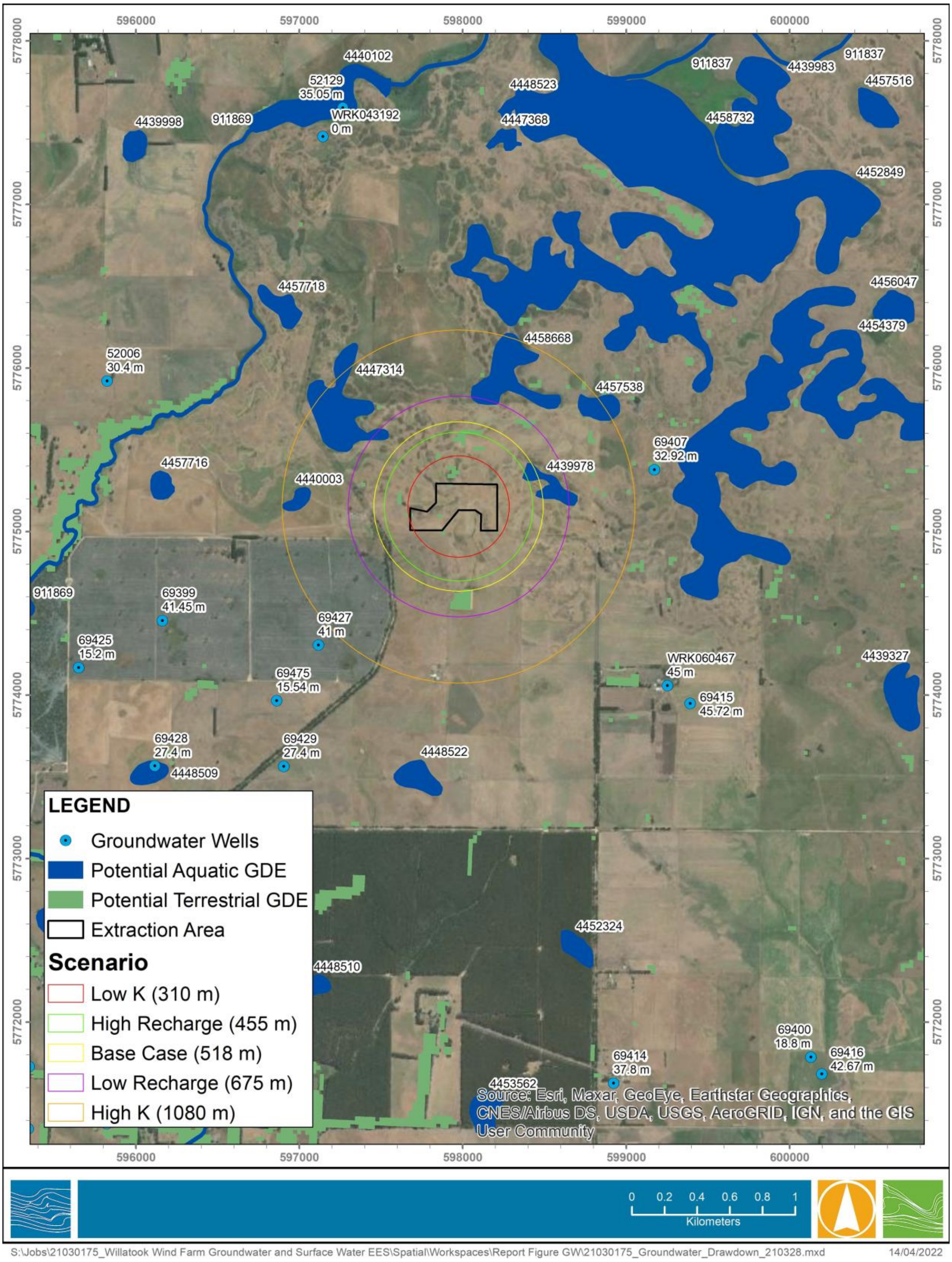

FIGURE 45 QUARRY PIT DRAWDOWN EXTENT AND GROUNDWATER RECEPTORS WITHIN THE PROJECT REGION

4.3.2.2.3 GROUNDWATER CONTAMINATION

If construction controls and spill prevention and abatement techniques are not properly implemented, accidental spills of hydrocarbons or other chemicals have the potential to result in contamination of the groundwater system, impacting surrounding groundwater users including GDEs and groundwater bores. The impact of an uncontrolled release of hazardous material is predicted to be highly localised near the spill. Measures are required to be outlined in the Construction Environmental Management Plan (CEMP) to prevent, manage and contain spills. As such, impacts are predicted to be low. Uncontrolled releases are considered unlikely with the implementation of best-practice construction and operational management approaches (outlined in Section 4.3.1).

There is potential for shallow groundwater to flow into foundations and open trenches, particularly during winter and early spring. As such, it may be necessary to pump water (dewater) from these excavations. This water is required to be tested for turbidity, salinity, pH and, if it meets the relevant ERS / ANZECC water quality indicators, could either be pumped into a neighbouring farm dam or discharged to adjacent land. If it exceeds acceptable limits, the water should be treated or disposed of by alternative means such as to an EPA Victoria licensed facility.

The exposure of PASS can acidify water and impact groundwater quality and resources. The impact from acid sulfate soils is further discussed in Section 2.6.

4.3.2.3 Port Campbell Limestone aquifer

It is assumed that uniform clay layers, identified during exploration drilling at the proposed quarry site, will prevent hydrogeological interaction with the Port Campbell Limestone aquifer. Additionally, the base of the quarry pit, proposed at 14 metres, will be well above the Port Campbell Limestone formation. As such, impacts to this aquifer from the quarry site are not anticipated.

Due to the anticipated lack of connectivity with the Newer Volcanic Group basalt aquifer and depth to the Port Campbell Limestone aquifer, impacts of the Project on groundwater drawdown, flows, recharge and contamination are not predicted for this aquifer.

4.3.3 Impact assessment summary

A summary of the groundwater impact assessment is shown in Table 33.

TABLE 33 GROUNDWATER IMPACT ASSESSMENT SUMMARY

Aquifer	Environmental Value	Impact pathway	Likely effect (magnitude, extent and duration)	Residual impact significance
Quaternary Aquifer	GDEs	Direct disturbance and dewatering leads to lowering of groundwater level	Aquifer restricted to areas surrounding a drainage line that flows into Back Creek as well as Cockatoo Swamp. Four crossings for accessways and cables are proposed for the area of Quaternary Alluvium surrounding Back Creek, and two wind turbines are mapped in this Quaternary Alluvium. Disturbance and potential impacts on groundwater levels would be highly localised (tens of metres) and temporary (weeks).	Very low
Newer Volcanic Group basalt aquifer	Groundwater bore users GDEs	Quarry excavation and dewatering leads to lowering of groundwater level	The nearest groundwater bore to the quarry is approximately 1,000 metres away (this aligns with the 0 metre drawdown contour for the high hydraulic conductivity scenario). As such, impacts to water levels in groundwater bores from quarry dewatering and drawdown are not anticipated to occur. Under the base case scenario, there is one aquatic GDE (ephemeral wetland) that may experience some drawdown. Drawdown at this GDE is predicted to be 2 m. Another four GDEs may experience some drawdown, however, these predictions are based on parameter sets which are considered possible, but less likely (refer to Appendix B for further details). The duration of impacts may last for several years up to several decades depending on the rate in which the quarry water level recovers. As groundwater is not the primary water source for these aquatic GDEs, it is considered unlikely	Low

Aquifer	Environmental Value	Impact pathway	Likely effect (magnitude, extent and duration)	Residual impact significance
			that any drawdown from the Project would detrimentally impact GDEs and wetlands which are surface water dominated features.	
	Groundwater bore users GDEs	Foundation excavations leads to lowering of groundwater level	Dewatering of excavations, if required, would be during times of high groundwater levels in winter and spring. Due to the shallow nature of the excavations (3 m) and the low permeability of the weathered basalts, any drawdown would be highly localised (tens of metres) and temporary given the short duration of turbine excavation (i.e., up to two weeks). The nearest groundwater well to a turbine is 170 m, and drawdown from foundation excavations is not expected to impact on existing wells. Similarly the 100 m buffer that has been established between foundations excavations and GDEs will prevent drawdown at these receptors.	Very low
	Groundwater bore users GDEs	Foundation excavations intersects shallow water table and alters groundwater flow and recharge	Any impacts to groundwater flow around infrastructure foundations are anticipated to be localised and minor, and during times when groundwater levels are high (winter and spring). Any reduction in groundwater recharge will be localised and will be mitigated by appropriate drainage design. Any changes to groundwater flow and recharge are unlikely to affect bores or ephemeral wetlands and springs.	Very low
	Groundwater bore users GDEs	Accidental spills of hazardous materials reduce water quality	If accidentally released, fuels and chemicals stored within the Project Site could result in localised contamination of the groundwater system.	Low

Aquifer	Environmental Value	Impact pathway	Likely effect (magnitude, extent and duration)	Residual impact significance
			The impact considered to have a possible high magnitude and extent, and long-term effect. Uncontrolled releases are considered unlikely with the implementation of best-practice measures.	
Port Campbell Limestone aquifer	Groundwater bore users	No linkage.	Due to the shallow nature of the proposed works, the limited connectivity with the Newer Volcanic Group basalt aquifer and the depth to the Port Campbell Limestone aquifer, no impact is anticipated.	N/A

4.3.4 Management of residual effects

WWF has included a number of engineering design measures to mitigate potential groundwater impacts where an impact pathway could not be avoided. With consideration of these design measures groundwater impacts in the investigation area are predominately low, very low or negligible.

To further manage potential impacts to groundwater, the following management measures outlined in Table 34 are required for the project construction, operation and decommissioning.

TABLE 34 GROUNDWATER MANAGEMENT MEASURES

Groundwater impact pathway	Project Phase	Management measures
Excavation and dewatering leads to lowering of groundwater level	Pre-construction	The contractor shall obtain a Work Authority (through approval by Earth Resources, Department of Jobs, Precincts and Regions) for the quarry construction and operation and adhere to its requirements.
		Consultation with relevant landowners regarding potential impacts to bores, including loss of access, should occur prior to commencement of construction.
	Construction, Operation, Decommissioning	An EMP should be developed and implemented by the contractor, and approved by the Responsible Authority, prior to the commencement of Project construction. The EMP will respond to any final design details and ensure all risks are appropriately managed. The EMP should include, but not be limited to: • dewatering procedures (including discharge location and quality of water, pollution control and management of sediment) in line with EPA approval processes • a site-specific risk analysis for the quarry where excavation dewatering rates exceed 77 cubic metres per day • procedures for groundwater inflow monitoring in accordance with EPA Publication 669: *Groundwater sampling guidelines* • Guidance provided in EPA Publication 668: *Hydrogeological Assessment (Groundwater Quality) Guidelines*
		The use of quarry water should be in accordance with the Take and Use licence under Section 51 of the *Water Act 1989* and in accordance with the of Environmental Protection Regulations 2021.
Foundation excavations intersect shallow water table and alters groundwater flow and recharge	Pre-construction, Construction	Further groundwater monitoring and mapping using exiting bores prior to and during construction to establish local groundwater levels and groundwater quality.
	Operation, Decommissioning	Construction activities and temporary works that may impact on surface permeability and groundwater should be included within the contractors Construction Environmental Management Plan (CEMP). Measures to minimise groundwater recharge and flow related impacts relating to these activities and works should include, but not be limited to: • revegetation of disturbed areas • backfilling using excavated material were possible.
	Pre-construction, Construction	Collected water from dewatering excavations would be managed in accordance with Environment Protection Regulations 2021. These measures should include, but would not be limited to: Monitoring of water quality of captured water (e.g. pH, salinity and suspended solids).

Groundwater impact pathway	Project Phase	Management measures
		Approval would be sought from relevant authorities to discharge water. Disposal of water would be at a site that is lawfully able to receive it.
Infrastructure (tracks and hardstands) and accidental spills of hazardous materials reduce water quality	Construction	In areas of predicted elevated salinity, groundwater should be tested to determine the appropriate disposal method.
	Construction, Operation, Decommissioning	To manage potential impacts to groundwater quality, mitigation measures to be implemented (in accordance with relevant guidelines and procedures) would include, but not be limited to: • a site-specific risk analysis for any hazardous chemicals (batteries, explosives etc.) under relevant guidelines including EPA 1698: *Liquid storage and handling guidelines* • storage of fuels and chemicals within containment facilities (e.g., self-bunded, above ground in a suitable covered area), outside floodplains or watercourse areas, in accordance with relevant legislative requirements • spill kits for fuel, chemical and oil spills to be maintained on site • chemical handling training for construction personnel • spill response procedure, to be contained within the CEMP • rehabilitation of any areas where a spill has occurred.

4.4 PASS Management

It is recommended that an appropriate management plan is prepared for soils removed from these locations, and further pH testing is undertaken in excavated sites during construction to manage increased potential. The Contractor's Environmental Management Plan should also include management recommendations to avoid disturbing soil from those areas identified as high risk of PASS.

4.4.1 Management Options for PASS

The EPA 2009, Acid Sulfate Soil and Rock, Information Bulletin 655.1, include the following hierarchy of PASS management (in order of preference):

- Avoiding disturbance.
- Minimising disturbance.
- Preventing oxidation.
- Treating to reduce or neutralise acidity.
- Offsite reuse or disposal.

For the proposed construction works generally, it is recommended that treatment on site will permit the material removed during excavation to be reused on the site.

4.4.2 PASS Management Strategy

The laboratory results of the ASS testing including liming rates for neutralisation are provided in Appendix F. As the results indicate there is a potential for acidic conditions to occur in the excavated soil, appropriate management of removed sediment should be observed.

It is recommended that an ASS management strategy be developed to address the following:

- Bunding of stockpiles,
- Limiting the exposure of the stockpile to a minimum by staging the works,
- Developing protocols to neutralise soil acidity of the stockpile using the proper liming rates and soil blending techniques,
- Regularly monitoring the pH of the stockpile and surface water accumulated on site,
- Monitoring stockpile volumes and exposure periods to ensure backfilling or disposal prior to oxidation occurring,
- Developing contingencies for rain events,
- Developing protocols for offsite disposal of the stockpile, if necessary.

The proposed works should include stockpiling excavated material into bunkered areas so that lime can be added to neutralise the material. Lime ($CaCO_3$) should be added in layers during the excavation process.

The bunkered areas should consist at least of a silt fence staked around the perimeter of the spoil piles which will provide protection from wind blow and runoff. The bunkers need to remain in place until soil has stabilised and can be reused. The soil is stabilised when the pH remains above 5. The pH can easily be tested using Universal pH test strips.

The recommended management measures discussed above should be incorporated in the Construction Environmental Management Plan (CEMP) for the project.

4.5 Conclusions

4.5.1 Surface water

Construction and operation of the project has the potential to impact surface water systems and supporting environmental values through distinct impact pathways, which may result in lowering of the watercourse crossings, reduced water quality and altered flows.

Flood behaviour within the project catchments was used to inform the siting of infrastructure to avoid areas of potential flooding. Other design mitigation measures include designing the project with buffers around all mapped wetlands, and minimisation of watercourse crossings through siting of access tracks. Assuming detailed designs have been completed in accordance with best practice guidelines and in consultation with relevant authorities the residual effects of watercourse crossings and to a lesser extent reduced water quality from construction works were assessed to be localised and temporary.

4.5.2 Groundwater

Construction and operation of the project has the potential to impact groundwater in near-surface Newer Volcanic Group basalts and supporting environmental values through distinct and localised impact pathways, which may result in localised lowering of the water table, altered groundwater recharge and flows, and reduced water quality.

To minimise the potential for the project to impact local GDEs, the design has incorporated a minimum 100 m buffer from aquatic ecosystems and 25 m buffer from terrestrial systems when placing turbine foundations. The quarry site has been located away from sensitive receptors, including groundwater bores.

Management measures have been proposed for the construction, operational and decommissioning phases of the project to further manage potential groundwater impacts. With the implementation of these measures, the impacts to groundwater users and groundwater quality are considered to be low.

4.5.3 PASS

Acid Sulfate Soils (ASS) are not indicated in the development area based on grab samples and site observations. There is evidence that PASS may exist in soils disturbed by excavation. The evidence suggests that PASS is relatively mild and easily treated on site by application of lime (CaCO3). A simple pH test of selected material may be sufficient to identify PASS during the works; the testing and quarantining and treatment of disturbed soil should be undertaken as outlined in Section 4, including preparation of a PASS management plan.

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APPENDIX A
ALTERNATIVE INFRASTRUCTURE LAYOUTS

During the groundwater and surface water investigations, potential issues were identified in the original infrastructure layout (shown below). The layout has since been modified to avoid potential issues with bore users or GDEs. This appendix documents a small part of this iterative process.

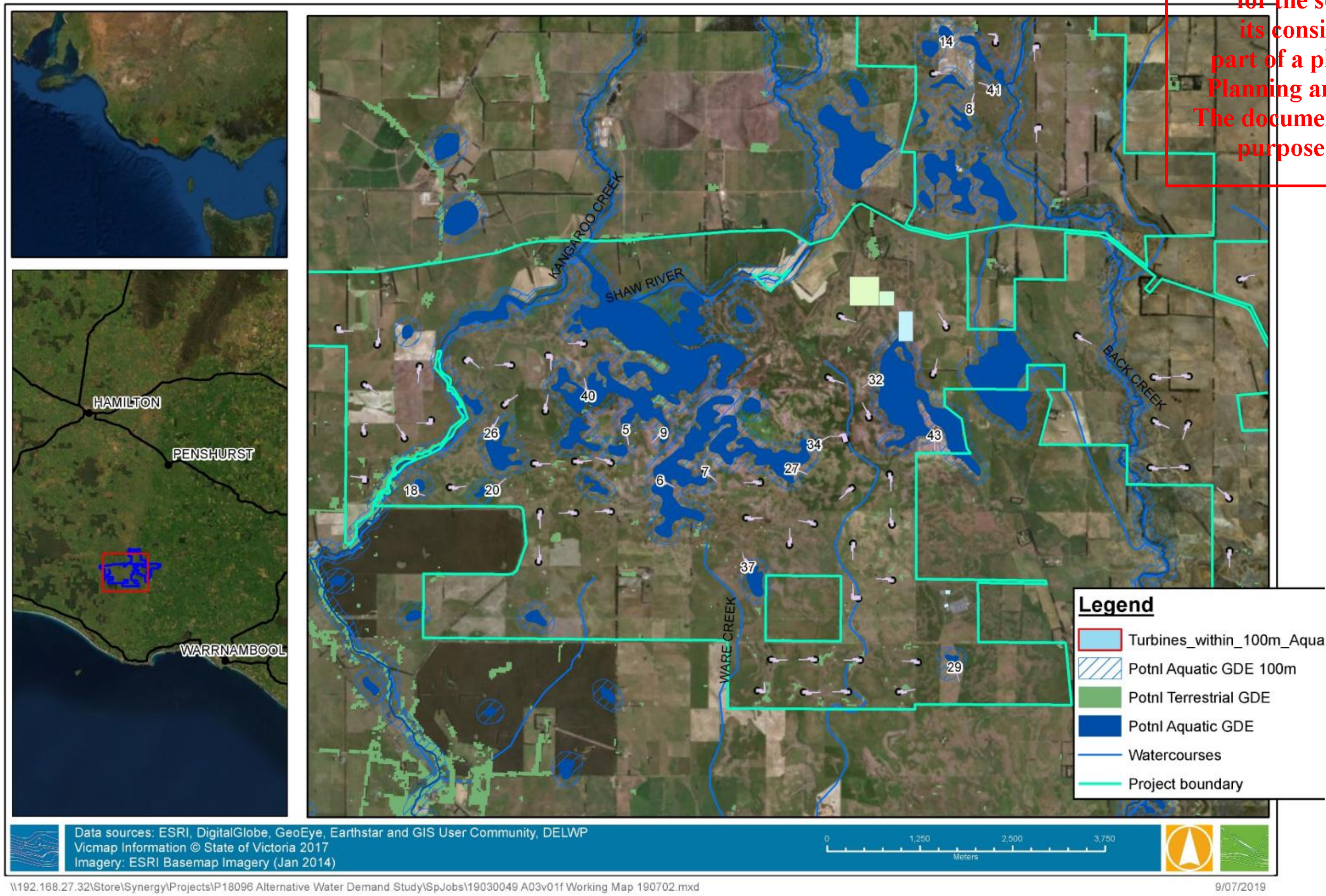

FIGURE 46 TURBINES WITHIN 100 M OF POTENTIAL AQUATIC GDES THAT WERE RELOCATED IN 2019

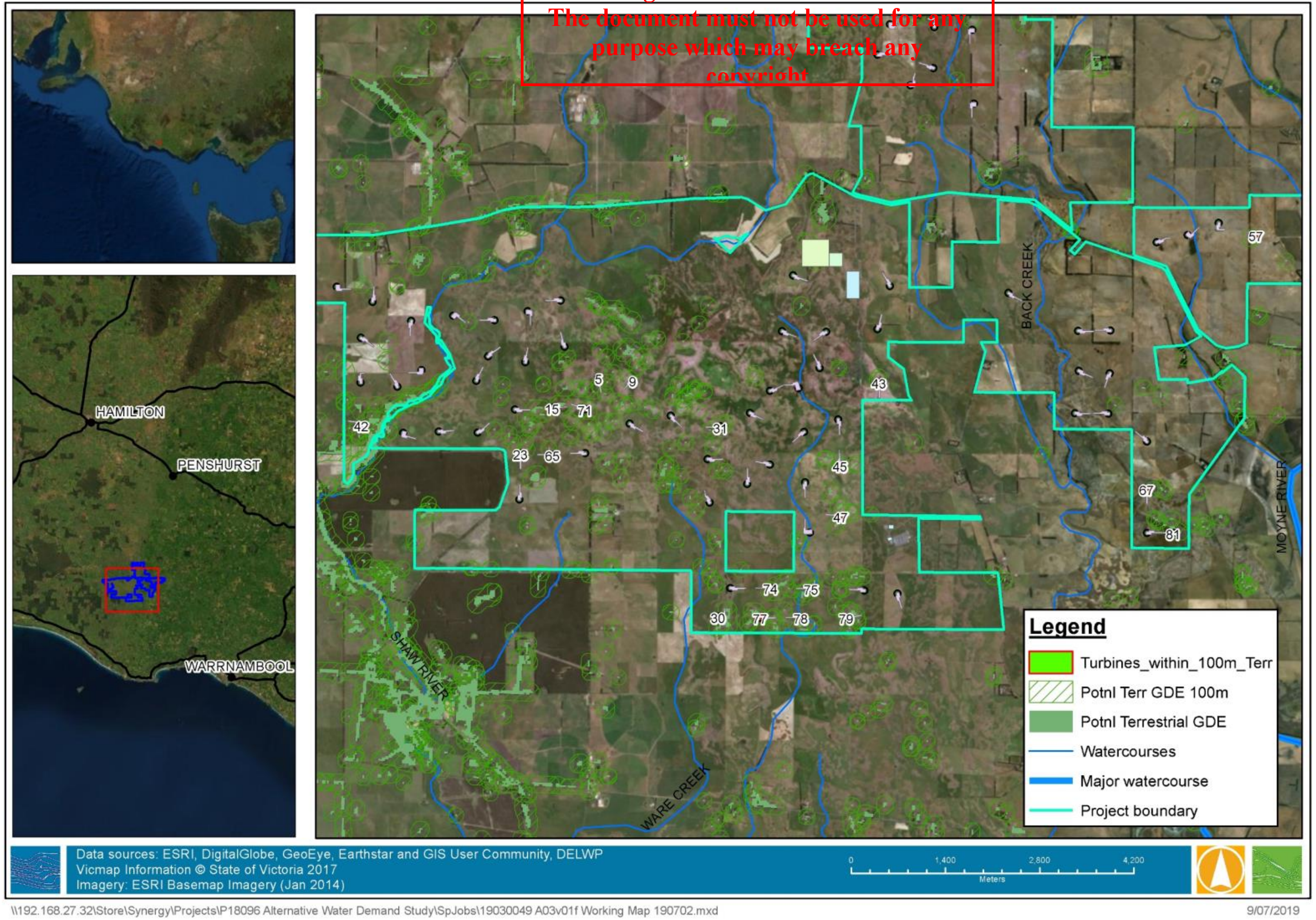

FIGURE 47 TURBINES WITHIN 100 M OF POTENTIAL TERRESTRIAL GDES 10/7/19 THAT WERE RELOCATED

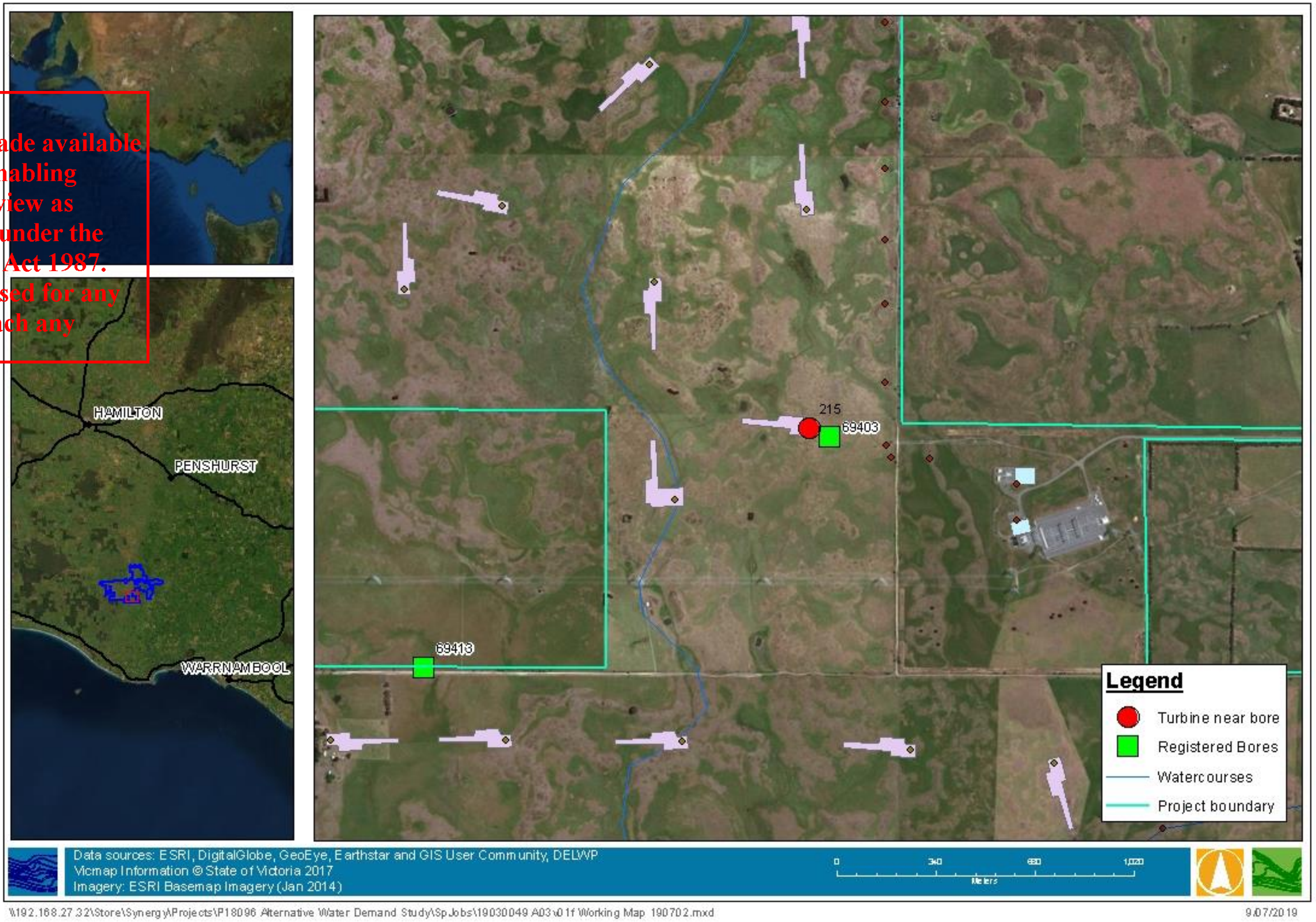

FIGURE 48 TURBINE 215 WITHIN 100 M OF REGISTERED GROUNDWATER BORE ON 10/7/19 THAT WAS RELOCATED

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APPENDIX B
QUARRY INVESTIGATIONS

B-1 Introduction

B-1-1 Overview

Willatook Wind Farm Pty Ltd (WWF) is developing Willatook Wind Farm located between Orford and Hawkesdale in south-west Victoria (Figure 49). To support construction, WWF is proposing a temporary on-site quarry in the southwest of the project area from which basalt will be quarried. The proposed quarry is located approximately 25 km north west of Port Fairy and approximately 45 km south of Hamilton, on the eastern side of Old Dunmore Road (Figure 49). Currently, the proposed location is used for stock grazing and is zoned for farming.

B-1-2 Description of Proposed Development

The proposed Works Authority Area (WAA 007290) for the quarry covers approximately 30 hectares (ha), with an extraction area of 10.4 ha, stockpile, plant, dam area of 13 ha and amenities/parking/weigh bridge area of approximately 1 ha. Details of the proposed quarry are summarised below:

- Extraction area of 10.4 ha.
- Maximum excavation depth of 14 m.
- Working batter profiles of approximately 1V:0.3H (75 degrees).
- Rehabilitation batter profile of at least 1V:4H (approximately 14 degrees) to quarry floor.
- Method of extraction to include traditional drill and blast.
- Operational life of up to 24 months, then decommissioned as farm dam.
- A preliminary water requirement of 15 ML/yr for dust suppression.

B-1-3 Purpose of the report

This report provides an assessment of the surface water and groundwater considerations related to the proposed quarry development. The objectives of this assessment are summarised below:

- Assess the likely surface water contribution to the site.
- Estimate the likely range of groundwater inflows and area of groundwater drawdown.
- Provide recommendations on the preferred surface water and groundwater management strategy.

Detailed engineering designs and consideration of constructability of infrastructure are outside the scope of this assessment.

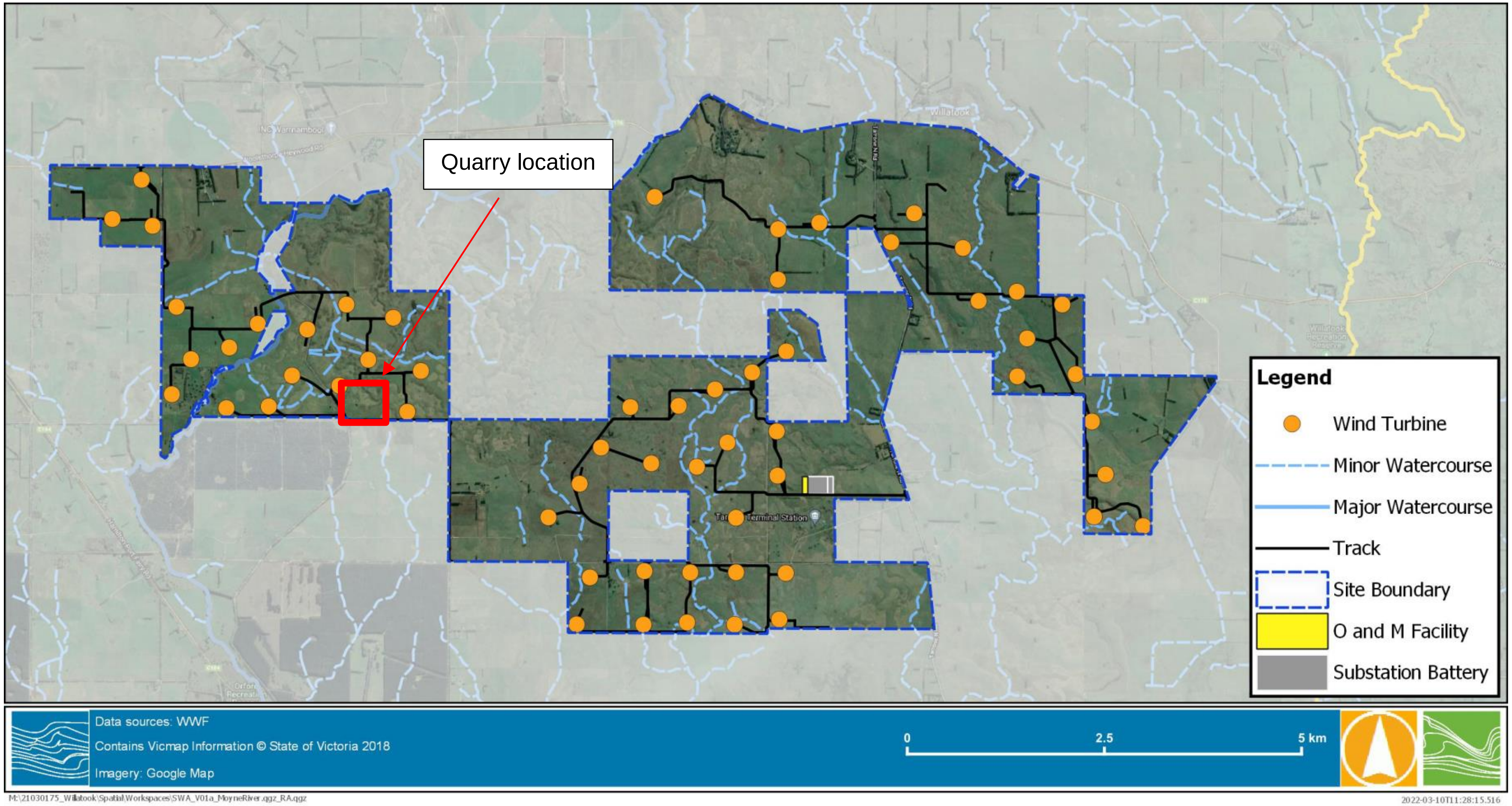


FIGURE 49 SITE LOCALITY

B-2 Context Setting

B-2-1 Topography

The topography of the site and surrounding area is relatively flat and is characterised by an undulating surface with a series of small depressions with informal drainage lines, creating several small independent localised catchments. These catchments are susceptible to periods of inundation and reliant on infiltration and evaporation to disperse the water. The site itself is located over a ridge and has no upstream catchment, with the site draining via depressions located towards the north-western and southern boundary and a flow path draining to the eastern boundary in north-eastern corner of the site. The site has an elevation difference of around 6 m between the highest point along the north boundary (95.0 m AHD) and lowest point along the north-western boundary (88.7 m AHD). The topography of the site is shown in Figure 50 along with the proposed site infrastructure including the extraction area, stockpile area, works authority boundary and site access and parking.

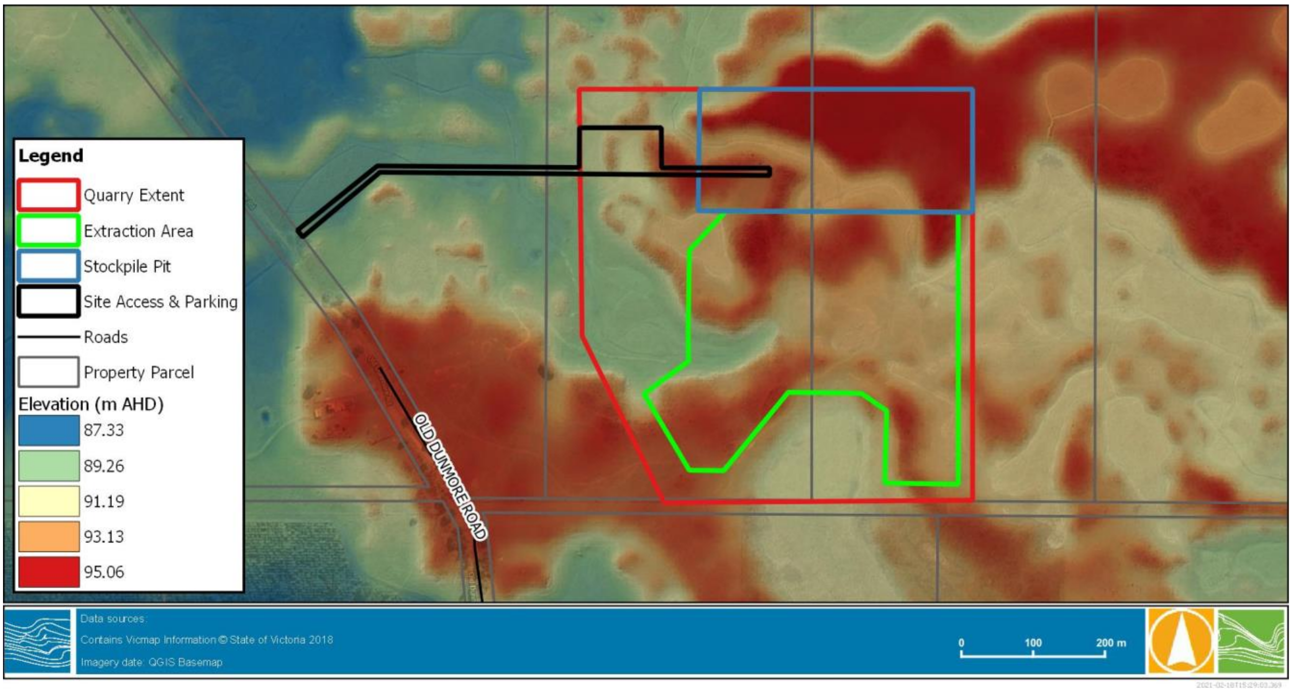


FIGURE 50 SITE TOPOGRAPHY

B-3 External Catchment Surface Water Impact

B-3-1 Surface Water Methodology

Water Technology previously undertook hydraulic modelling of the WWF project area and upstream catchment using TUFLOW. TUFLOW is one of the most widely used hydraulic modelling software packages in Australia and is the preferred modelling package for the Glenelg Hopkins Catchment Management Authority (CMA), in which WWF is located within. The software was considered an appropriate modelling tool for assessing surface water changes at the site. A rain-on-grid approach was used, allowing the simulation of runoff generated from local rainfall on a two-dimensional grid representative of the site topography. Results of the hydraulic modelling were used to assess the potential external catchment surface water changes to the quarry site for the 1% Annual Exceedance Probability (AEP) event.

B-3-2 Quarry Investigation

Hydraulic model results for the 1% AEP event demonstrate that the proposed quarry is not influenced by an external catchment. The site experiences inundation up to a maximum of 300 mm in the localised depressions and flow paths across the site (Figure 51). Flood levels across the site range from 89.0 m AHD along the northern boundary to a maximum of 92.7 m AHD within the site (Figure 52). Due to the topography of the site and height difference between the ridge and depressions/flow paths, some areas of the site experience velocities up to 0.4 m/s. Flow velocities quickly reduce to under 0.2 m/s once in the depressions/flow paths (Figure 53). The product of flood depth and velocity (depth x velocity) does not exceed 0.3 m^2/s across the entire site (Figure 54), classifying it as Low Hazard (H1[17]).

The proposed extraction area is mainly influenced by localised rainfall, though the area marginally intercepts a flow path in the north-eastern corner (Figure 51). Apart from this flow path which can be diverted or stored on-site, the flood behaviour for the extraction area is localised inundation and these areas are not affected by flow from the broader site extent. The influence on these proposed areas is minor but should be managed by either storage or diversion.

The proposed quarry access track with the works authority area is not influenced by inundation.

Overall, the influence of surface water across the quarry is localised and should be able to be managed as part of development, through drainage infrastructure be it storages or diversion. It should be noted that this investigation was based upon existing topography and surface water behaviour is likely to change as part of the construction of the quarry. However, as the site has no external catchment the assessment outlined here demonstrates challenges and works required to inform the planning process.

[17] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia, Book 6, Chapter 7.

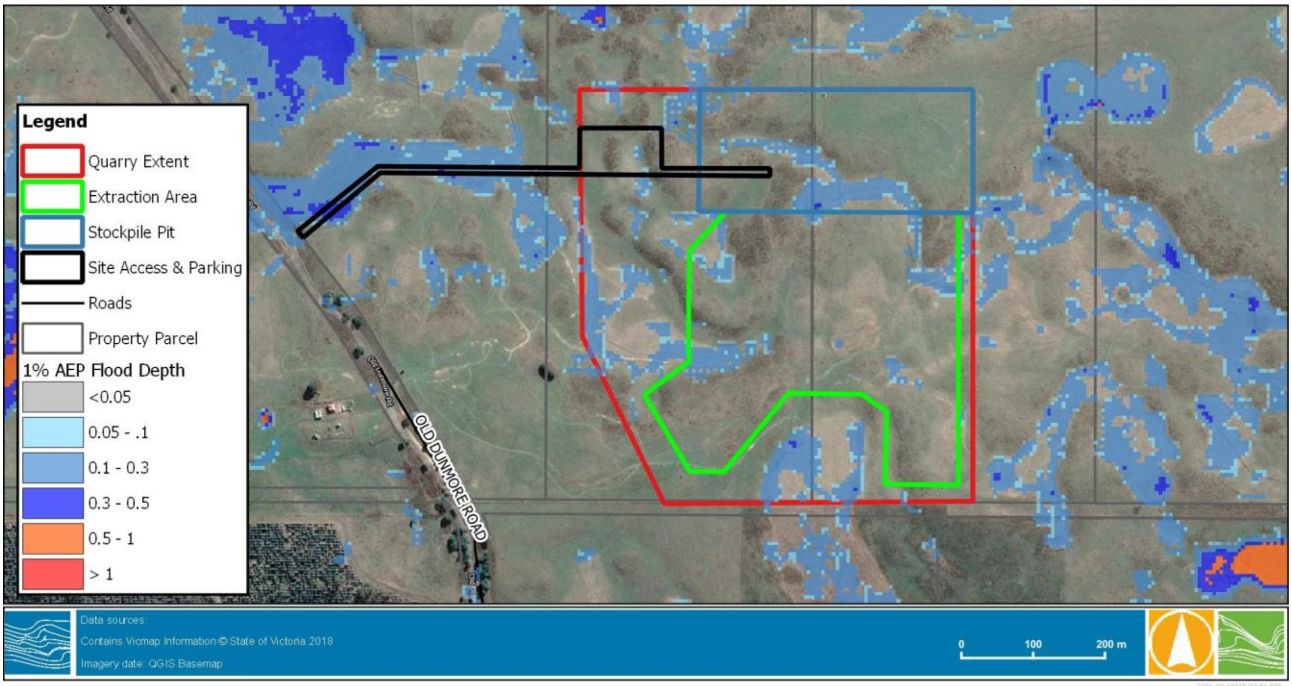


FIGURE 51 1% AEP FLOOD DEPTHS (DEPTHS IN METRES)

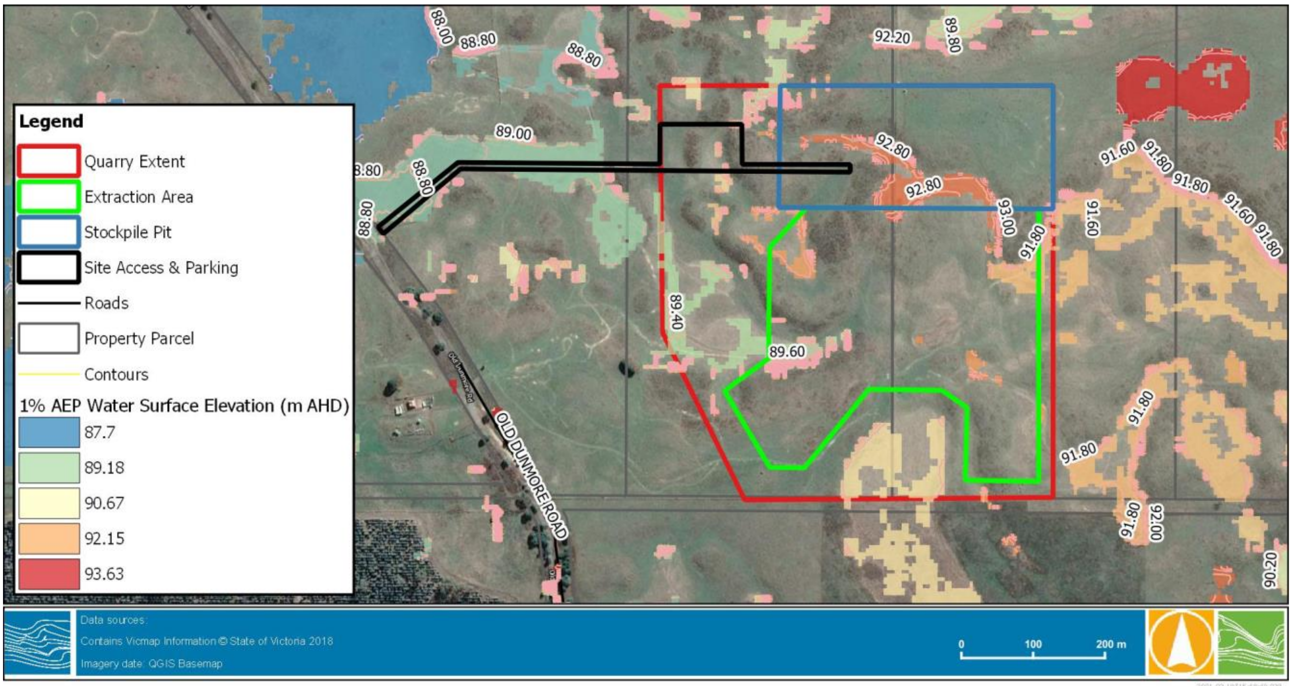


FIGURE 52 1% AEP WATER SURFACE ELEVATION

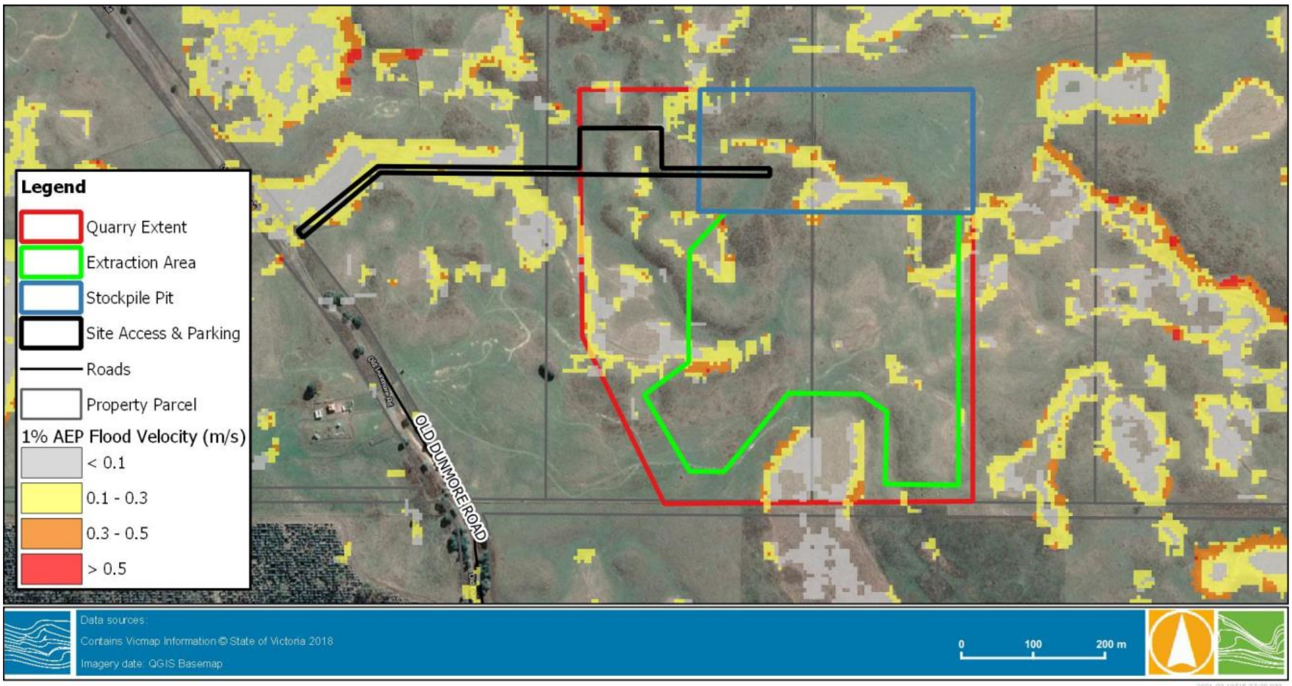


FIGURE 53 1% AEP FLOOD VELOCITY

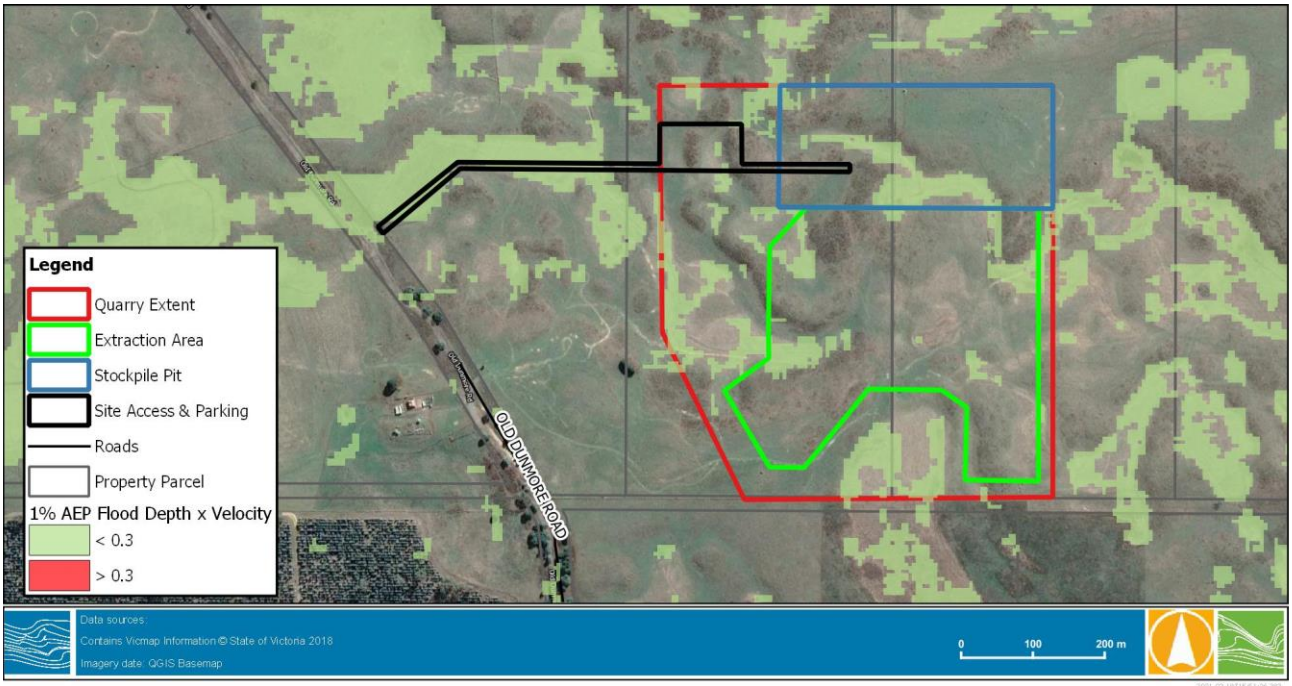


FIGURE 54 1% AEP FLOOD HAZARD

These maps are included for reference only as modelling indicates that no infrastructure will have an effect on surface water.

B-4 Hydrogeology

B-4-1 Geology

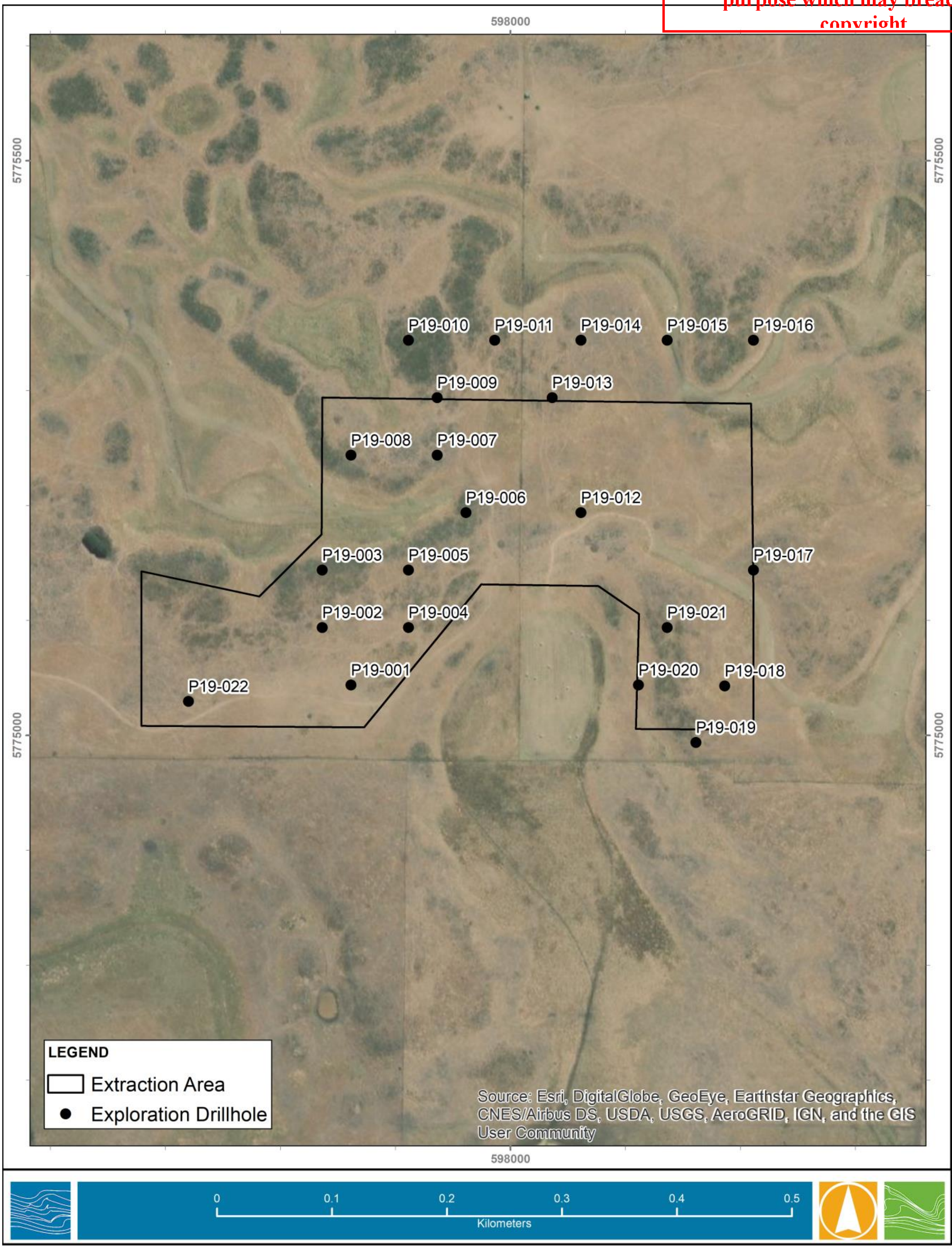
The surface geology of the site is dominated by the weathered plains and stony rise basalts of the Newer Volcanic Group. The basalt rocks that make up the majority of the volcanic plains were formed by volcanic eruptions between 4 million and 7 thousand years ago (Dahlhaus et al., 2002). The uppermost fractured, fine-grained crystalline rocks are reported to have rapidly weathered, forming a blanket of clay soil of variable thickness overlying the basalt (Dahlhaus et al., 2002).

To estimate the thickness of the Newer Volcanic basalt at the quarry site, the spatial layers available through Visualising Victoria's Groundwater (VVG) where interrogated. Based on the information from VVG, the Newer Volcanic basalt is expected to be around 40 m thick in the vicinity of the proposed quarry site. The nearest wells with geological logs (69407 and 69415) (Table 35) suggest that the basalt is present down to 32 m below ground level at these locations (refer to Figure 58 for well locations). Below the Newer Volcanic basalt is the Port Campbell Limestone. The proposed quarry depth is 14 m, and hence the base of the pit will be well above the Port Campbell Limestone formation.

To define the resource grade and characteristics of the basalt material, a series of 23 percussion drill holes were drilled within the quarry footprint (Figure 55). Drillhole depths ranged from 6.9 to 21.3 m below ground level. Assessment of the geological logs from these drillholes shows variably weathered basalt from its original state as fresh (rock shows no sign of decomposition) through and slightly weathered (rock is slightly discoloured but generally shows no change from fresh rock) and moderately weathered (rock is moderately discoloured, generally showing noticeable change from fresh rock).

The majority of the percussion drill holes were reported to be terminated in clay, with the exception of P19-016 which was terminated in fresh basalt. From the available data it is unclear whether this denotes the base of the basalt or a weathered layer within it, however, given the depths discussed above, the latter has been assumed in the absence of any further data.

At the surface, weathering of the basalt material to clay is observed in the percussion drillhole logs at depths of up to 3.3 m. The weathered material occurs predominantly in the centre and south of the work authority area, with the exception of one hole in the northeast of the WAA.



S:\Jobs\21030175_Willatook Wind Farm Groundwater and Surface Water EES\Spatial\Workspaces\Report Figure GW\21030175_Exploratio

FIGURE 55 PERCUSSION DRILLHOLES AND PROPOSED QUARRY EXTENT (BCA, 2021)

B-4-2 Aquifers

The Newer Volcanics basalt is reported to behave as a fractured rock aquifer (Dahlhaus et al., 2002). Groundwater flow in fractured rock aquifers is strongly controlled by the presence, continuation, and connectivity of fracture zones through which groundwaters infiltrate and flow. Host rock types, the degree of deformation and land surface undulations also influence recharge and discharge processes of fractured rock aquifer systems.

Dahlhaus et al. (2002) completed a review of groundwater flow systems within the Glenelg Hopkins CMA region and through this work delineated 18 groundwater flow systems with similar hydrogeological characteristics. The proposed quarry site is located within the regional and intermediate flow systems in the Volcanic Plains basalt (GFS 14). Within this zone, groundwater is reported to move through the fractured rocks at highly variable rates in both regional and intermediate flow systems (Dalhousie et al., 2002).

B-4-3 Groundwater Levels and Flow

Groundwater levels range from 2.14 to 5.17 m below groundwater level based on water level gauging undertaken on 05 February 2021 from five cased drillholes located within the proposed extraction area. The groundwater levels equate to elevations of 89.83 to 93.85 m AHD (Figure 56). The available groundwater elevation data suggests a groundwater flow gradient from the northwest to the east, southeast and south of the extraction area.

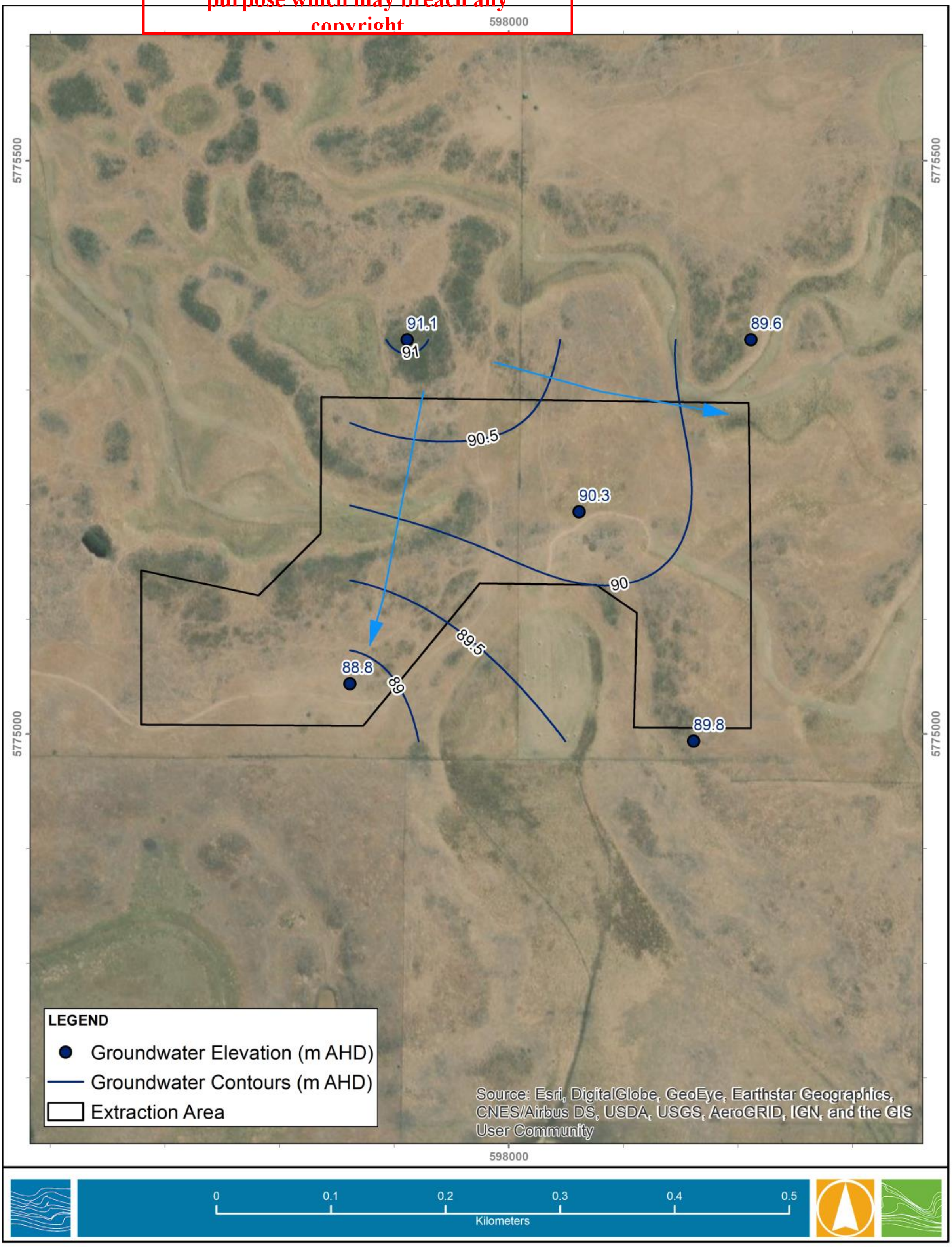


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FIGURE 56 GROUNDWATER LEVELS (05 FEBRUARY 2021)

B-4-4 Hydraulic Conductivity

Dahlhaus et al., (2002) presents a range of hydraulic conductivity values from 0.001 to 100 m/d for the Newer Volcanic basalt, with the lower estimate described as tight fractures and the upper estimate described as open fractures and lava tubes. The basis for the hydraulic conductivity estimates provided by Dahlhaus et al., (2002) is not provided in the available reporting. The hydraulic conductivity range is consistent with the description that groundwater moves through the fractured rocks at highly variable rates (Dahlhaus et al., 2002). Further to this, Nolan et al., (1990) reports that the Newer Volcanic basalt has generally poor aquifer characteristics and can be locally quite variable, concluding that the stony rises are less weathered and more fractured than the low transmissivity plains basalt, allowing considerable volumes of groundwater generation.

SKM (2010) developed a groundwater model for the Glenelg Hopkins catchment whereby hydraulic conductivity values for the Newer Volcanic basalt of 1, 10 and 25 m/d were tested during model calibration. The adopted hydraulic conductivity for the groundwater flow model was 10 m/d, however, SKM concluded that the Quaternary Volcanics had a locally sensitive response that was not able to be captured with a regional scale model and hence there is likely to be significant variability in this parameter.

There are currently no site specific values of hydraulic conductivity available at the site. The observations from the percussion drilling suggests that the hydraulic conductivity is more likely to be in the low to moderate range. This interpretation is based on:

- The low to moderate degree of weathering observed in the drill cuttings, which suggests that no significant fractured zones were intersected.
- The anecdotal evidence during drilling described the cuttings as damp to moist, as opposed to saturated which would be more consistent with a highly fractured aquifer.
- The slow recovery of the cased drill holes is an indicator of low hydraulic conductivity.

Based on the above observations, it is considered that a representative hydraulic conductivity range for the Newer Volcanic basalt at the quarry site is 0.01 to 1.0 m/d. It is recognised that both higher and lower hydraulic conductivities may exist outside of this envelope. Anisotropy may also occur along the strike of stony ridges where fracture networks are connected. The adopted range is considered to provide a realistic representation over the area in which the quarry will be the developed (around 400 m x 400 m) taking into account the above anecdotal evidence and the observations from the Tarrone basalt quarry discussed in Section B-4-7.

B-4-5 Groundwater Recharge

Groundwater recharge within the Volcanic Plains basalt (GFS 14) is reported to be between 10 mm and 40 mm annually (Dahlhaus et al., (2002). Recharge is reported to occur largely in winter and spring, with significantly more recharge in wetter years, when extensive soil waterlogging can occur (Dahlhaus et al., 2002).

B-4-6 Groundwater Quality

Dahlhaus et al., (2002) reports that groundwater salinity within the Volcanic Plains basalt (GFS 14) ranges from 500 to 10,000 (mg/l). Further to this, Visualising Victoria's Groundwater platform (VVG) provides a spatial layer of TDS for the water table aquifer. Based on this data, groundwater salinity falls in the 1,000 to 3,500 mg/L range. It is noted that this data has been generated by extrapolation between limited data points.

Groundwater salinity data for the nearest wells to the quarry is provided below in Table 35 (refer to Figure 58 for well locations). This data suggests that salinities are around 1,000 mg/L, noting that the samples were taken in the 1980s. The wells are recorded to be used for stock purposes.

TABLE 35 GROUNDWATER SALINITY IN WELLS CLOSEST TO THE QUARRY

Well ID	Distance from Quarry (m)	Purpose	Depth (m)	SWL (m)	Aquifer	Salinity (mg/L)	Salinity Date
69475	Southwest 1170 m	Stock	15.54	-	Basalt	1077	1988
69407	East 1160 m	Stock	32.92	-	Basalt	994	1982
69405	West 1000 m	Stock	42.7	-	-	-	-
69415	Southeast 1570 m	Stock	45.72	-	Basalt and Limestone from 33.48 m	-	-

Notes: (-) Denotes no data

B-4-7 Tarrone Basalt Quarry

The Tarrone basalt quarry located 10 km southeast of the proposed Willatook quarry is the nearest operating quarry to the proposed site. Water management at the Tarrone quarry is used to inform the water management approach at the Willatook quarry. The site is situated within the same geological unit (Newer Volcanic basalt) and has very similar hydrological and hydrogeological characteristics to those at Willatook. The following information relating to the Tarrone quarry has been noted following discussions with the quarry manager.

- The pit is up to 17 m deep and has intersected the water table.
- Inflows (interpreted to be a combination of surface water and groundwater) are highly seasonal, with peak inflow occurring during winter.
- Water is managed using a series of in-pit and external pit water storages. The depth of the water storages with respect to the groundwater level at the Tarrone quarry is not known.
- The water is not readily lost once pumped into water storages.
- Above average summer rains can cause inflows which need to be managed through pumping to water storages.
- There is no requirement for off-site discharge of water.

The following can be inferred from the above anecdotal evidence:

- The seasonal nature of pit inflow suggests that direct rainfall input, runoff and seasonal groundwater seepage are the main inputs to the pit.
- Lower inflows during summer suggests that groundwater flows are inconsistent and not the dominant inflow mechanism.
- Inflows can be managed through transferring water to various water storages within the works authority (i.e. no off-site discharge). The area of disturbed land (excavations, stockpiles, water storages etc) is estimated to be around 35 Ha at Tarrone quarry, compared to a proposed works authority area of 30 Ha for Willatook.

- Given the similarities in the hydrogeological characteristics of the Tarrone Quarry and the Willatook site, a similar management approach of internal transfers may well be effective at the proposed Willatook quarry.

B-5 Groundwater Inflow and Drawdown Analysis

B-5-1 Analysis Method

An estimation of the steady state groundwater inflow to the pits and the extent of drawdown has been made using the Marinelli and Niccoli (2000) method. The analytical method assumes a simplification of the hydrogeological environment and is used to provide a 'broad' range of inflows and drawdown. This analytical solution is useful in situations where rainfall recharge is the principal factor in groundwater flow, such is the case for the Newer Volcanic basalt aquifer. The method is based on the Dupuit – Forchheimer approximation. The flow into the pit is divided into two zones as shown below in Figure 57, with Zone 1 representing the inflow from the pit walls and Zone 2 the inflow from the base of the pit.

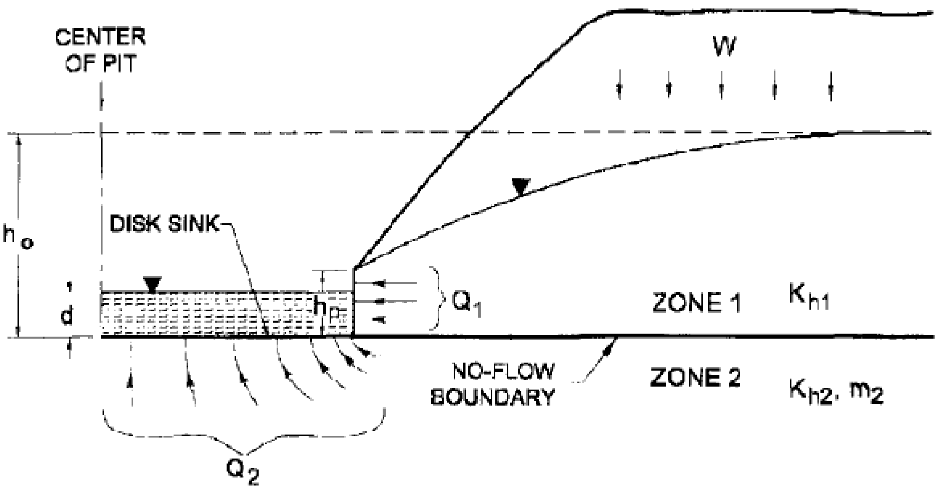

FIGURE 57 PIT INFLOW MODEL (MARINELLI AND NICCOLI, 2000)

The following equations are used to estimate the inflow and drawdown (Marinelli and Niccoli., 2000):

Zone 1

$$Q1 = W\pi(r_o^2 - r_p^2)$$

Zone 2

$$Q2 = 4r_p\ (K_{m_2}^{k_{h2}})(h_o - d)$$

$$h_o = \left(h_p^2 + \frac{W}{K\left[r_o^2 \ln\left(\frac{r_o}{r_p}\right)\right) - (\frac{r_o^2 - r_p^2}{2})]}\right)1/2$$

$$m_2 = (\frac{k_{h2}}{k_{v2}})$$

Where:

h_o = Initial pre-mining aquifer saturated thickness (metres above base of pit)

h_p = Saturated thickness at the pit wall (metres above base of pit)

W = Distributed rainfall recharge flux (metres per day)

K_{h1} = Horizontal hydraulic conductivity Zone 1 (metres per day)

K_{h2} = Horizontal hydraulic conductivity Zone 2 (metres per day)

K_{v2} = Vertical hydraulic conductivity Zone 2 (metres per day)

r_p = Effective pit radius (metres)

r_o = Radius of influence (metres)

d = Depth of the pit lake (metres)

B-5-2 Input Parameters and Scenarios

Several of the input parameters such as quarry depth, pit radius, saturated aquifer thickness and the depth of the water in the pit are well constrained, and as such a single value has been used for these input parameters. Aquifer hydraulic conductivity and recharge are less well constrained. To account for the uncertainties and inherent variability in these parameters, multiple scenarios have been assessed to provide a range of possible groundwater inflows and drawdown extents.

The adopted hydraulic conductivity range for the Newer Volcanics basalt is 0.01 to 1.0 m/d as discussed above, with the middle value representing the design scenario. It is recognised that both higher and lower hydraulic conductivities may exist outside of this envelope, however, the adopted range is considered to provide a realistic representation based on the anecdotal evidence from the percussion drilling and the observations from the Tarrone basalt quarry.

The hydraulic conductivity for Zone 2 is estimated to be 10% of the Zone 1 hydraulic conductivity to account for the presence of clay at the base of the pit as reported in the percussion drillholes logs. The assumption significantly impacts the predicted inflow rate. It is possible that if the clay layer is either thin or discontinuous that the inflow rates may be higher than expected. Further drilling and testing would be required to validate this assumption.

Vertical hydraulic conductivity for Zone 2 adopts an anisotropy (ratio of horizontal to vertical conductivity) factor of 0.1. The input parameters and ranges used to estimate pit inflow and drawdown extent are provided in Table 36.

TABLE 36 MARINELLI AND NICOLI (2000) INPUT PARAMETERS

Parameter	Description	Value/Range	Comment
h_o	Saturated thickness of basalt aquifer above the base of the pit	11 (m)	Depth of water assumed to be 3 m, base of pit at 14 m.
h_p	Saturated thickness above Zone 1	5 (m)	Set at half the saturated thickness of the aquifer.
W	Distributed recharge flux	10 to 40 mm/a	From Dahlhaus et al., 2002.
K_{h1}	Horizontal hydraulic conductivity in Zone 1	1 to 0.01	Low to moderate range reported in Dahlhaus et al., 2002.
K_{h2}	Horizontal hydraulic conductivity in Zone 2	10% of K_{h1}	One order of magnitude lower than Zone 1 to reflect the presence of clay at the at the base of the pit as reported in the percussion drillholes logs.
K_{v1}	Vertical hydraulic conductivity in Zone 2	10% of K_{h2}	Standard anisotropy relationship between K_h and K_v.
r_p	Radius of pit	200 (m)	Assumed to be cylindrical.
d	Depth of water in the pit above Zone 1	0	Assumed to be dry.

The following scenarios were assessed to account for the uncertainties and inherent variability in hydraulic conductivity and recharge and to provide a range of possible groundwater inflows and drawdown extents:

- Base Case: Represents the median value for the adopted hydraulic conductivity and recharge range.
- Low K: Represents the lower estimate of the hydraulic conductivity range and the median of the recharge range.
- High K: Represents the upper estimate of the hydraulic conductivity range and the median of the recharge range.
- Low Recharge: Represents the lower estimate of the recharge range and the median hydraulic conductivity value.
- High Recharge: Represents the higher estimate of the recharge range and the median hydraulic conductivity value.

B-5-3 Groundwater Inflow and Drawdown Extent Estimates

The predicted groundwater inflow volumes and drawdown extents for each of the adopted scenarios are provided in Table 37. Under the base case scenario, inflows are expected to be around 77 m^3/d. However, sensitivity analysis of key parameters suggests that inflows of 15 to 521 m^3/d cannot be discounted at this stage. The wide range reflects the uncertainty in the hydraulic conductivity of the basalt material. Groundwater inflows are proposed to be managed through in-pit sump pumping. The analysis shows that the predictions are most sensitive to hydraulic conductivity and that uncertainty in the recharge rate results in marginal changes to the predicted pit inflow volume.

Drawdown as a results of pit inflow is predicted to extend up to 518 m for the base case scenario and up to 1,080 m for the high hydraulic conductivity scenario (Figure 58). This distance represents the point at which the drawdown is predicted to be zero. Groundwater well 69405 located around 1,000 m west of the pit coincides with the zero metre drawdown contour under the high hydraulic conductivity scenario. Although this well is not predicted to be effected, it is recommended that this and other wells within 1,500 m of the quarry are surveyed to confirm their location and status. It is also recommended that baseline conditions are established in these wells and that monitoring is undertaken during and after quarrying operations to validate an assessment of impacts. Discussion of the wells to be included in the survey and those that may require monitoring is addressed in the WWF EES.

There are several potential aquatic Groundwater Dependent Ecosystems (GDEs) within the predicted drawdown extent (Figure 58). GDE data is sourced from the Bureau of Meteorology's Groundwater Dependent Ecosystem Atlas which is based on a broad scale national assessment. Assessment of the impacts to GDEs is provided in the ecology section of the WWF EES.

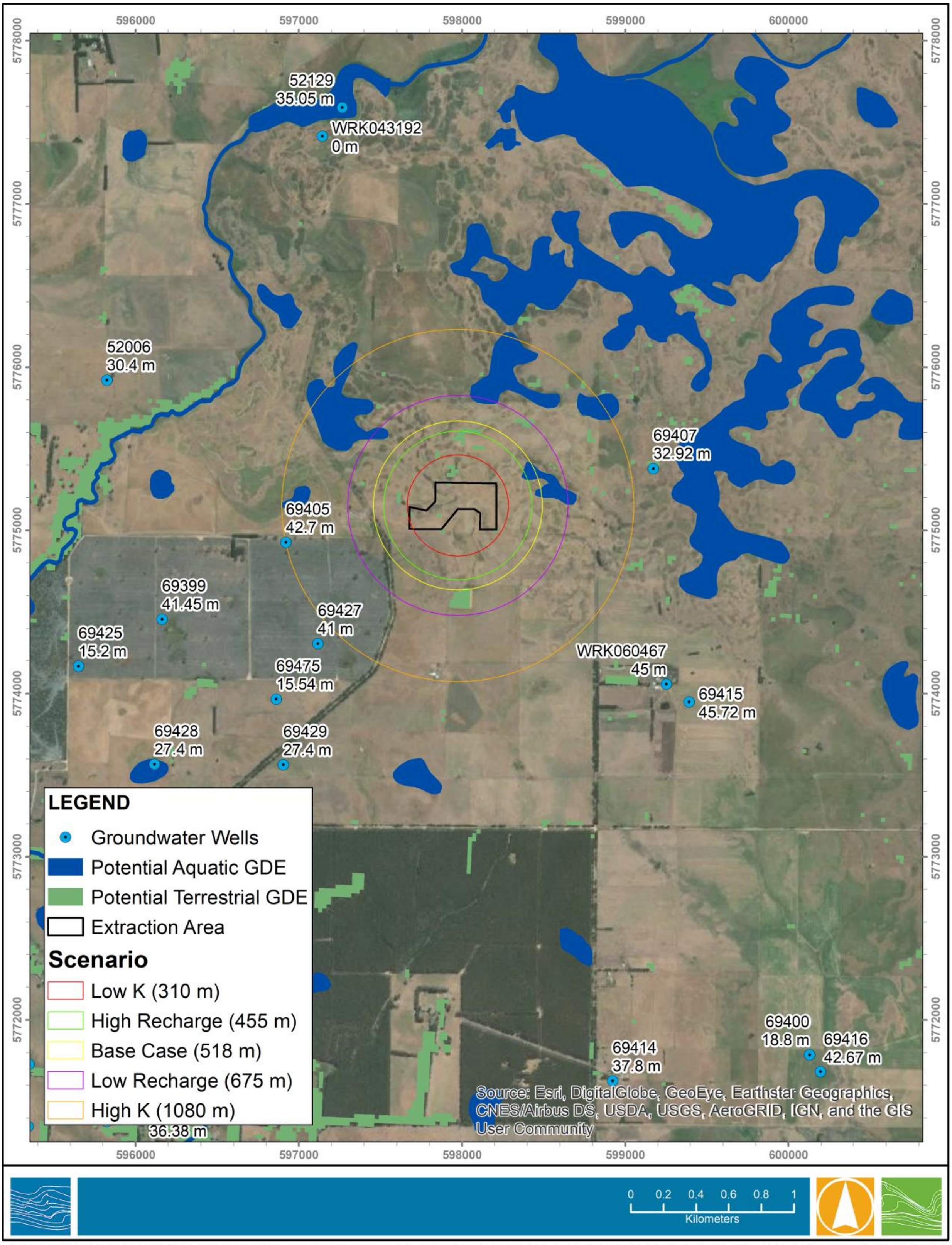

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FIGURE 58 PIT DRAWDOWN EXTENT AND GROUNDWATER RECEPTORS

TABLE 37 PREDICTED GROUNDWATER INFLOW AND DRAWDOWN EXTENT

Scenario	Effective Pit Radius (m)	Recharge (mm/d)	Hydraulic Conductivity (m/d)			Radius of Influence (m)	Zone 1 Groundwater Inflow (m^3/day)	Zone 2 Groundwater Inflow (m^3/day)	Total Groundwater Inflow (m^3/day)
			K_{h1}	K_{h2}	K_{v1}				
Base Case	200	25	0.1	0.01	0.001	518	49	28	77
Low k	200	25	0.01	0.001	0.001	310	12	3	15
High k	200	25	1.0	0.1	0.01	1080	242	278	521
Low Recharge	200	10	0.1	0.01	0.001	675	36	28	64
High Recharge	200	40	0.1	0.01	0.001	455	58	28	86

B-5-4 Model Limitations and Uncertainty

The groundwater inflow and drawdown extent assessment requires application of hydrogeological judgement and simplification of the hydrogeological environment. The largest degree of uncertainty relates to the hydraulic conductivity of the basalt material. To account for this uncertainty, a range of hydraulic conductivity values have been used. Despite this, it is possible that higher than expected groundwater inflows occur if significant water producing structures are intersected which have higher than assumed permeability. It is also possible that groundwater inflow rates could be lower than the modelled estimates if the quarried area proves to have lower than assumed permeability. Either of these scenarios could impact the planned water management regime for the mining operation. To constrain the inflow estimates and drawdown impacts, further drilling and testing is required including but not limited to installation of test production wells and aquifer testing.

The analysis also draws on the anecdotal evidence from the Tarrone basalt quarry (discussed in Section B-4-7) located 10 km to the southeast. This quarry has similar physical (depth and area) and hydrological characteristics and operates without the need for off-site discharge. Anecdotal evidence suggests the values used in the base case analysis may be of a similar order of magnitude to those at Tarrone Quarry.

B-6 Site Water Management

B-6-1 Overview

The site is proposed to be a *'zero discharge'* site, with all surface water and groundwater managed within the WAA using retention basins. While the basins will have 'zero discharge', stored water will be used for dust suppression and other processing activities. A water use of 15 ML/yr was determined by WWF. Water Technology has estimated the storage requirements considering surface and groundwater contributions, evaporation, seepage and use. Key assumptions provided by WWF are outlined below:

- The storage is sized to account for all surface runoff within the site and groundwater inflow to the pit (to be pumped from the pit to the storage) over a 24-month period (January to December).
- Once the proposed quarry is decommissioned it will no longer be actively managed for surface water and groundwater inflow. The proposed retention dams will be rehabilitated, and the remaining quarry pit is proposed to form a permanent dam.

Using the groundwater inputs from Sections B-4 and B-5 above, the likelihood that the quarry pit will overtop from surface water and groundwater inflow post decommissioning has also been assessed.

B-6-2 MUSIC Model Set-Up

A conceptual water quality model was built for the site using MUSIC Version 6.3.0. The MUSIC model was developed with the following assumptions:

- 100 years of meteorological data (rainfall and evapotranspiration) was derived using SILO data from Bureau of Meteorology[18]. The rainfall time series has a mean annual rainfall of 743 mm/year and a mean annual evapotranspiration of 789 mm/year.
  - This data was previously used as part of the wetland analysis undertaken by Water Technology for the proposed WWF.
- "Urban" source nodes were used to represent the catchments.

[18] https://www.longpaddock.qld.gov.au/silo/

- Surface Area (ha) was based upon the provided plan, assuming all site runoff remained on site.
- Impervious Area was assumed as outlined in Table 38. Note that the assumed Total Impervious Area (TIA) was adjusted to Effective Impervious Area (EIA) based upon Table 4.2 in "Using MUSIC in Sydney Drinking Water Catchment, WaterNSW 2019"[19].
- Zoning was set to "mixed".
- Soil parameters were set as 94 mm and 70 mm for Soil Storage Capacity and Field Capacity, respectively. These are the recommended values for an upper subsoil texture of Medium to Heavy Clays as outlined in Table 4.4 of the WaterNSW report. The upper subsoil texture was determined based upon Agriculture Victoria's map (Table 38).
- The recommended Rainfall Threshold as outlined in Table 4.3 of the WaterNSW report, was adopted (Table 38).

- All MUSIC models were run at a daily timestep.

Additional assumptions were made for each of the conceptual solutions identified and are outlined in their respective sections below.

TABLE 38 MODEL NODE AREAS

Node	Total Area (ha)	Assumed TIA (ha)	EIA (ha)	Modelled Impervious Area (%)	Rainfall Threshold (mm)
Quarry	10.445	5.22	2.611	25%	1
Stockpile	2.084	1.042	0.521	25%	1.5
Parking & Access	1.232	0.616	0.616	50%	1.5
Remaining Area	11.317	1.132	1.132	10%	1

[19] MUSIC Modelling Guidelines (waternsw.com.au)

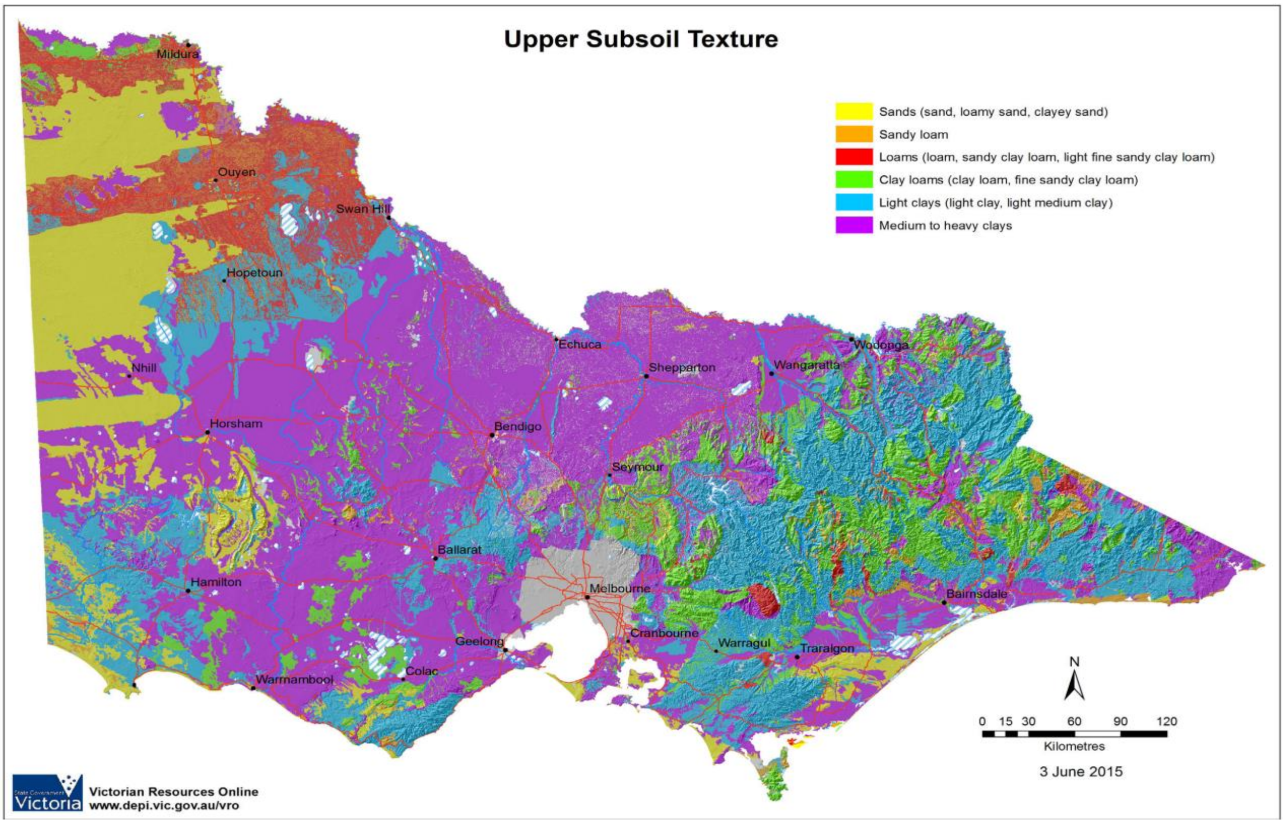

FIGURE 59 AGRICULTURE VICTORIA UPPER SUBSOIL TEXTURE (SOURCE: AGRICULTURE VIC)

B-6-3 On-site Storage – During Operation

To assess the required on-site storage during the proposed 24 month quarry operation, the following adaptions were made to the MUSIC model:

- Groundwater Inflow (Referred to as "Baseflow" in MUSIC)
  - Secondary links were used to separate baseflow from surface water run-off across the site. The baseflow component was then effectively removed from the model, to allow groundwater inflow to be manually defined based upon Table 37. A base case scenario of 77 m^3/day was adopted, with 521 m^3/day used to represent a conservative sensitivity analysis. Further information on how these values were defined is detailed in Section B-5.
- Storage
  - A "Pond" treatment node was used to represent the proposed storage. The exfiltration rate of the pond was set to 0.36 mm/hr as a base case for medium clays, with 0.036 mm/hr adopted to represent a conservative sensitivity analysis. Infiltration rates are based on those provided in the Engineers Australia Handbook (2006) for the corresponding soil types. The model assumes that water lost through exfiltration is either stored in or lost via groundwater throughflow.
  - Further information on the sizing methodology is provided in Section B-7-1.
  - An annual dust suppression re-use demand of 15 ML/yr was applied, with a monthly demand variation, based upon the following methodology:
    - Daily Demand for Dust Suppression = Daily Evaporation Rate – Daily Rainfall (when >0)[20].
      - The average monthly demand was determined over the entire dataset and was adopted for as the expected demand. The average monthly dust suppression demand is provided in Table 39.

A schematic diagram of the MUSIC model set up is presented in Figure 60.

TABLE 39 AVERAGE DUST SUPPRESSION DEMAND

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
mm	107.93	81.25	53.35	23.56	9.75	6.42	6.38	11.93	29.49	57.59	81.04	102.53
%	18.90	14.22	9.34	4.12	1.71	1.12	1.12	2.09	5.16	10.08	14.19	17.95

[20] https://environment.des.qld.gov.au/__data/assets/pdf_file/0027/107397/app0050143-appendix-a.pdf

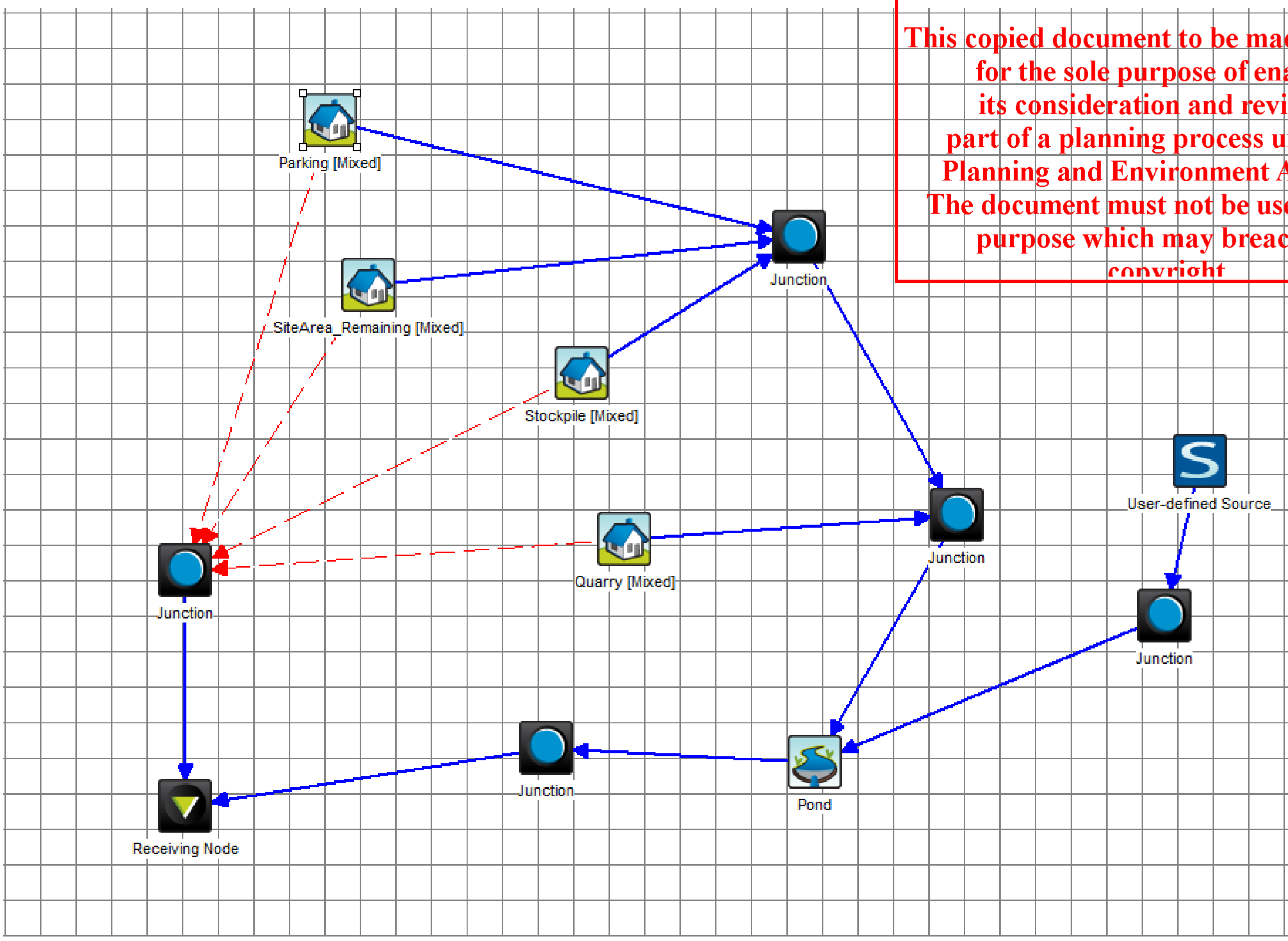

FIGURE 60 MODEL SCHEMATIC – DURING OPERATION

B-6-4 Quarry Pit Storage – Post Decommissioning

To assess the likelihood of the quarry pit overtopping after decommissioning of the quarry (i.e. the quarry has become a dam) the following adaptions were made to the MUSIC model:

- Catchment
  - Based upon the topography of the site, it is expected that the quarry will not receive surface water runoff from other areas of the site, with diversion and catch drains designed to capture and direct elsewhere.
  - Sensitivity analysis assuming surface water contribution from the entire quarried site was also undertaken.
- Groundwater inflow
  - Groundwater levels remain static around 3 m below the natural surface and were maintained at that level within the quarry pit storage modelling, i.e. groundwater was maintained at a constant level of 3m below natural surface within the pit storage.
- Storage (Quarry Pit)
  - A “Pond” treatment node was used to represent the proposed decommissioned quarry. As the quarry is expected to intersect the ground water table, an exfiltration rate of 0 was applied.
  - Further information on the sizing methodology is provided in Section B-7-2.

A schematic diagram of the MUSIC model set up is presented in Figure 61.

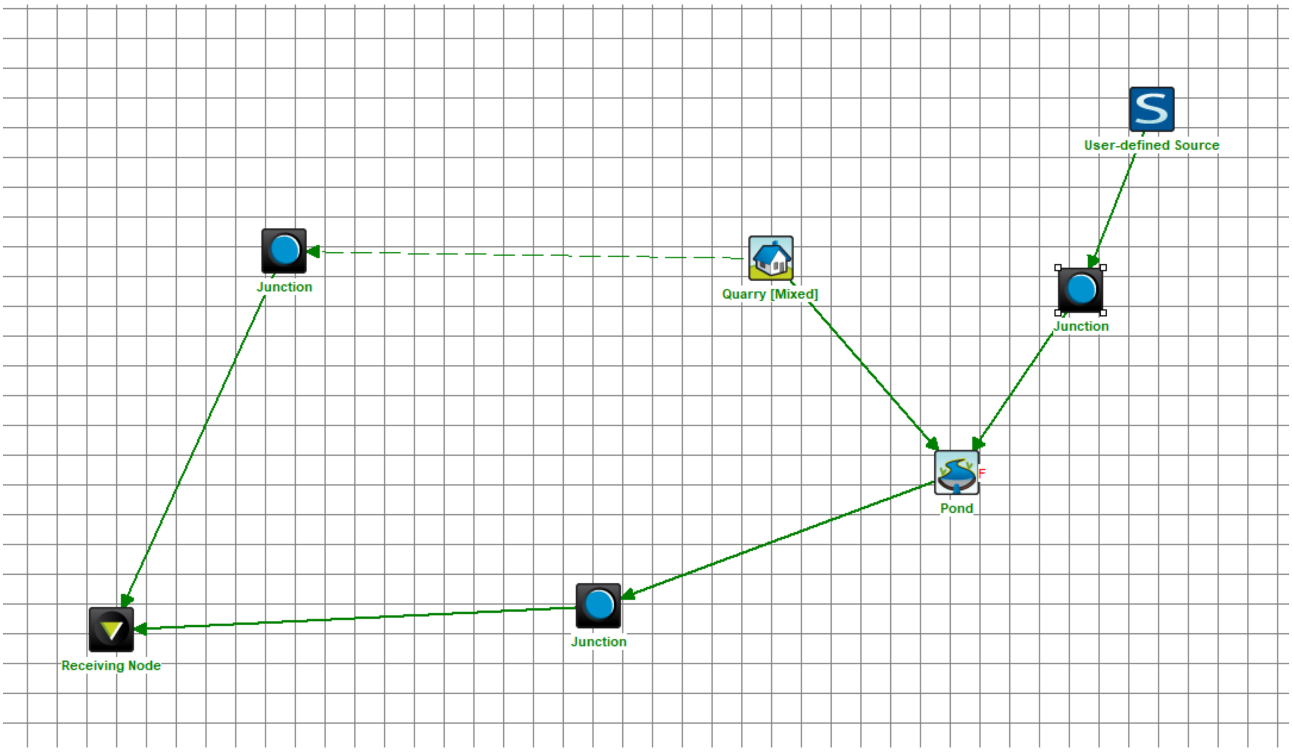

FIGURE 61 MODEL SCHEMATIC – AFTER DECOMMISSIONING

B-7 Storage Sizing and Analysis

B-7-1 During Operation

The MUSIC model was initially run for the entire available period of rainfall data (1900-2020) to allow an assessment of annual catchment water yield. The water yield for the proposed storage across a 24-month period for several percentiles is presented in Table 40. Note the water yield analysis assumed the following preliminary parameters:

- Storage surface area of 1.75 ha with an arbitrary depth of 10 m.
- Infiltration rate and groundwater inflow: 0.36 mm/hr & 77 m^3/day.

These parameters were adopted to determine the information presented in Table 40, it is noted the values presented may vary slightly from the design yields as due to variation in evaporation and seepage loss because of a variation in surface area and depth.

A series of designs were modelled to determine the required surface area of the storage, based upon a storage depth of 3 m. As groundwater is expected to be shallow in the location, the design of the storage was based upon the assumption that the excavation could not exceed 1.5 m below surface level to maintain an adequate buffer between the base of the storage and the groundwater level. The excavated spoil is proposed to be used to construct the dam wall (assuming it is of suitable material) at least 2.5 m high. This leaves a maximum depth before the storage spills of 4.0 m

The storage was assessed to ensure no overtopping in both the 90^{th} and 99^{th} percentile events. The storage was sized to account for the expected conditions with an infiltration rate and groundwater inflow of 0.36 mm/hr & 77 m^3/day, respectively.

To assess the uncertainty in the input parameters, the following four scenarios were run iteratively to size a storage, which did not overtop in Scenarios 1 & 2 as outlined below:

- Scenario 1 (Base Case & Design Scenario) – Used to assess the impact of the 90^{th} percentile annual water yield.
  - 1963 – 1964 24-month period.
  - Infiltration rate and groundwater inflow: 0.36 mm/hr & 77 m^3/day.
  - Dust Suppression demand of 15 ML/yr.
- Scenario 2 (Design Scenario) – Used to assess the impact of the 99^{th} percentile annual water yield.
  - 1951 - 1952 24-month period. Note rainfall was increased by 10% to adjust the 24-month to be representative of the 99^{th} percentile water yield.
  - Infiltration rate and groundwater inflow: 0.36 mm/hr & 77 m^3/day.
  - Dust Suppression demand of 15 ML/yr.
- Scenario 3 – Used to assess impact of low infiltration rate.
  - 1963 – 1964 24-month period.
  - Infiltration rate and groundwater inflow: 0.036 mm/hr & 77 m^3/day.
  - Dust Suppression demand of 15 ML/yr.
- Scenario 4 – Used to assess the impact of high groundwater inflow.
  - 1963 – 1964 24-month period.
  - Infiltration rate and groundwater inflow: 0.36 mm/hr & 521 m^3/day.

- Dust Suppression demand of 15 ML/yr.

The assessment determined a storage 3 m deep required a minimum surface area of 1.75 ha to hold 24 months of surface and groundwater inflow. It should be noted the MUSIC model assumed a constant stage-storage relationship (i.e. a rectangular storage) and site conditions will vary. Variation from the proposed surface area will result in a variation in losses, additional modelling should be undertaken for any proposed design – noting that increasing the area will reduce the risk and vis vera.

Results of the analysis are presented in Table 41, storage water levels for Scenario 1 & 2 are presented in Figure 62 and Figure 63 respectively. The management of potential overflows highlighted in Scenarios 3 & 4, is discussed in Section B-9.

Table 40 shows negative numbers in the minimum and 10th percentile years because use and losses are higher than inflow (i.e. 28.3 ML is the largest deficit of inflows versus use and losses).

TABLE 40 ANNUAL WATER YIELD (BASED ON SURFACE AREA OF 17,500 M^2)

Percentile	Water Yield (ML/yr)
Min	-28.3
10%	-10.8
50% (Median)	1.0
90%	14.8
99%	65.3
Max	76.4

TABLE 41 STORAGE ANALYSIS RESULTS

Scenario	Maximum Storage (ML)	Maximum Depth (m)	Overflow Volume (ML)
S1 (Design)	19.22	1.10	0
S2	67.97	3.88	0
S3	>70	>4	16.4
S4	>70	>4	242.8

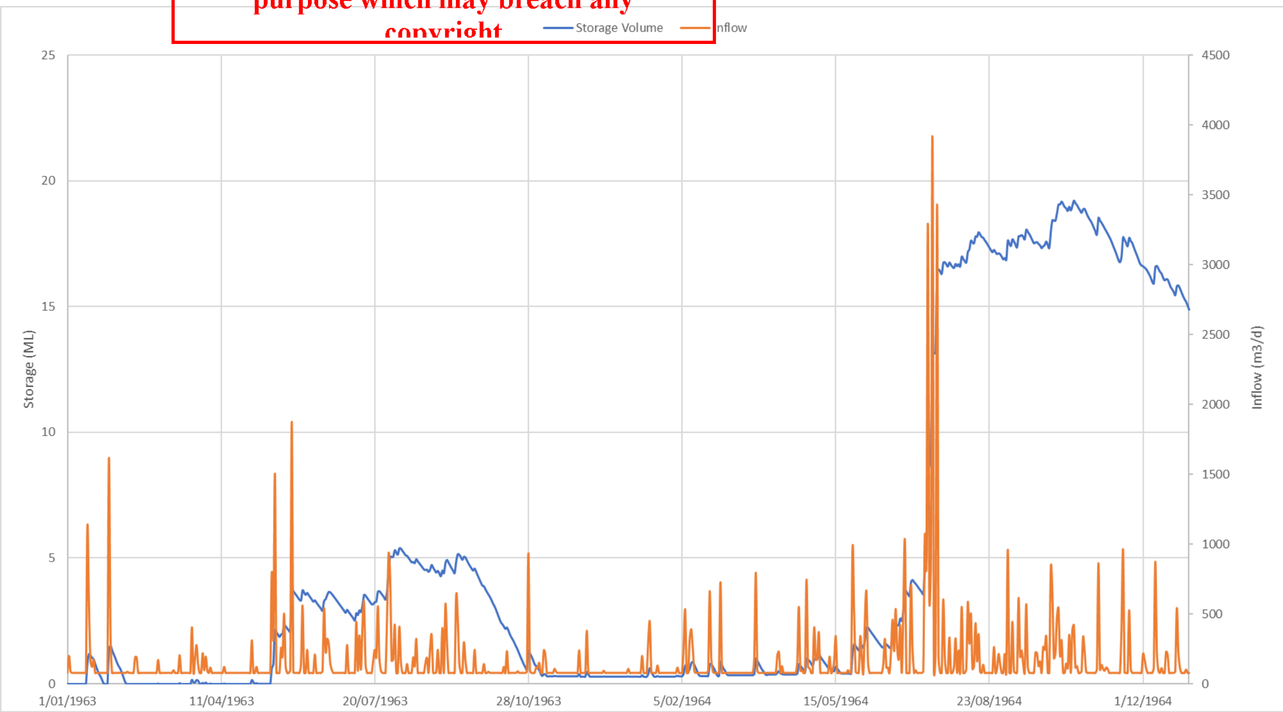

FIGURE 62 SCENARIO 1 – 63/64 BASE CASE STORAGE VERSUS TIME

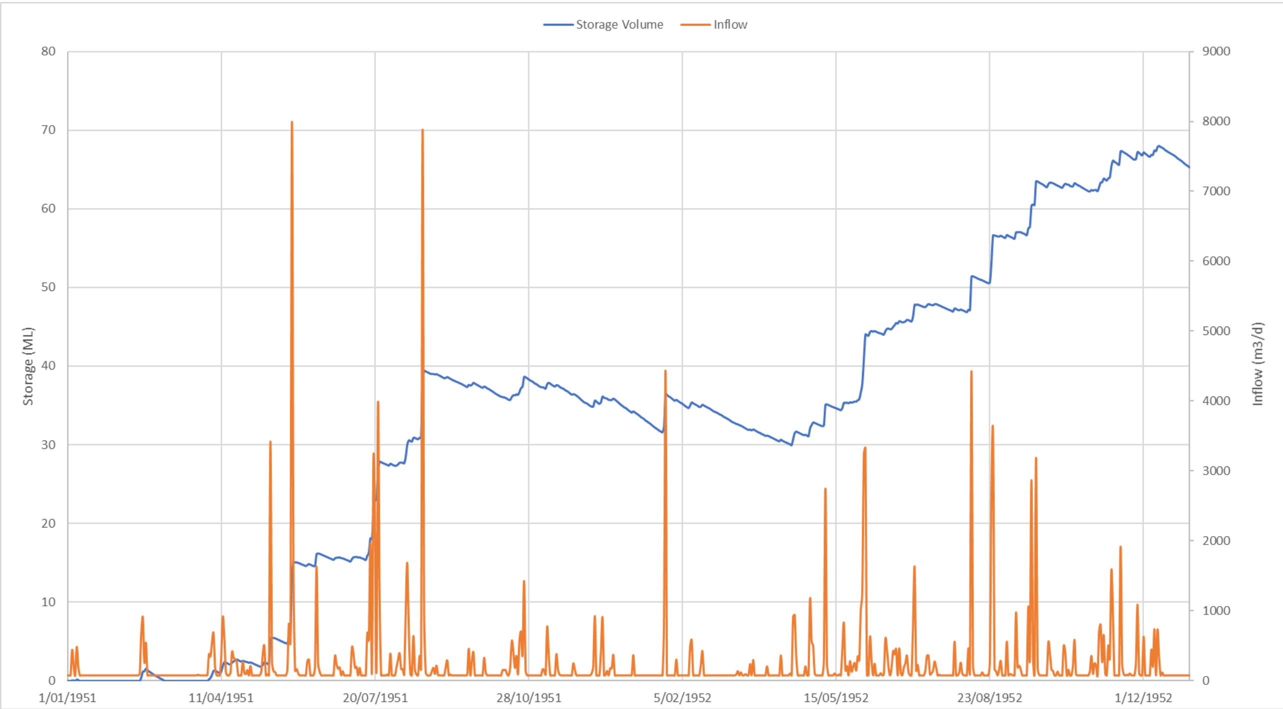

FIGURE 63 SCENARIO 2 – ADJSUTED 51/52 STORAGE VERSUS TIME

B-7-2 Post Operations

The MUSIC model was run for the entire available period of rainfall data (1900-2020) with the "Pond" effectively designed to represent the quarry pit.

The results were used to determine the risk of overtopping. As the exact design of the quarry is unknown the analysis assumed a depth of 3 m and a surface area of 10 ha, with a storage capacity of 300 ML.

The analysis showed that due to the large surface area, evaporation prevented the storage from overtopping throughout the 120-year period. The results showed that the volume of water within the storage on average increased but considering the volume and that groundwater recharge will occur when the pond level increases above the groundwater level (3 m).

As a sensitivity analysis two scenarios were run for the determined storage, as outlined below:

- Scenario 1 – Base Case (Design Scenario).
- Scenario 2 – Used to assess impact of entire site contributing flows.

The results of the analysis are presented in Table 42.

TABLE 42 QUARRY ANALYSIS - POST DECOMMISSIONING

Scenario	Maximum Storage Achieved (ML)	Time Period to Overtop	Average Annual Increase (ML)
S1 (Design)	32 ML	120 + years	0.0001
S2	88 ML	120 + years	0.0005

B-8 Water Budget Summary

B-8-1 During Operation

A summary of the water budget based upon the base case (design) scenario is provided in Table 43.

TABLE 43 DURING OPERATION - BASE CASE SCENARIO WATER BUDGET

Period	Total Surface Flow (ML)	Total Groundwater Flow (ML)	Evaporation Loss (ML)	Seepage Loss (ML)	Dust Suppression (ML)
63/64	69.8	56.2	15.8	95.29	27.0
51/51 Adjusted	135.8	56.2	21.3	105.3	30.0

B-8-2 Post Operation

A summary of the average annual surface water inputs and evaporative losses from the pit lake post operation is provided in Table 44. Once pit dewatering has stopped, groundwater will flow into the pit until such point as it reaches hydraulic equilibrium with the water level in the aquifer. For this reason, the post operation scenario starting point was set at 3 m below ground level, consistent with the pre-quarrying groundwater level. Under this scenario, groundwater inflows and outflows are negligible as there is no hydraulic gradient driving flow into or out of the pit. The post operation scenario has been completed with the primary purpose of addressing the risk of overtopping.

TABLE 44 POST OPERATION - BASE CASE SCENARIO WATER BUDGET

Average Surface Flow (ML)	Average Evaporation Loss (ML)	Water Yield (ML)
17.34	17.29	0.05

B-8-3 Water Quality

Water quality within the quarry and the onsite storages will be a combination of groundwater and surface water. Comparison of available groundwater and surface water quality data suggest that these two water sources have similar water quality characteristics, specifically total dissolved solids, acidity/alkalinity, phosphorus and nitrogen (refer to EES Section 2.8.3 for a comparison of available groundwater and surface water data). From this we can infer that (1) groundwater and surface water are likely to be well connected within the Project site and (2) mixing of two water sources with similar water quality characteristics is unlikely to result in undesired impacts.

Near the quarry, groundwater salinity is expected to be in the order of 1,000 to 3,500 mg/L based on regional salinity mapping available through Visualising Victoria's Groundwater platform. Wells located closer to the quarry suggest that salinities may be at the lower end of this salinity range (around 1,000 mg/L). When mixed with surface water, lower salinities can be expected. Turbidity within the storages is likely to be dependent on the type of drains and operational management of the quarry and surrounds. Some settling of suspended solids will occur during the life of the storages and they will be designed to ensure no external site discharge.

B-9 Summary and Recommendations

B-9-1 Summary

The site is proposed to be a *'zero discharge'* site with all surface water and groundwater managed within the WAA using retention basins. Groundwater inflows are expected to be around 77 m^3/d under the base case scenario, with lower and upper values of 15 and 521 m^3/d derived from sensitivity analysis of key input parameters. The onsite storage requirements to manage surface water and groundwater inflows were assessed using a MUSIC model for the operational and post operational phases of the project. Modelling demonstrated the following key points:

- During operation:
  - Assuming an operational storage depth of 4.0 m (1.5 m excavation and 2.5 m depth above natural surface) a 1.75 Ha storage can hold both a 90th and 99th percentile surface water inflow year and a groundwater inflow of 77 m^3/d (assuming 24 months of inflow and water usage of 15 ML/yr).
    - Note depths of 1.10 m and 3.88 m were reached, respectively. The 99th percentile year reached within 0.12 m of the dam crest. It is expected additional risk management options would be utilised a 99th percentile inflow period, e.g. allow water to be stored in the mine pit.
  - Surface water and groundwater inflows can be managed through in-pit sump pumping.
- Post operation:
  - If the quarry pit is converted to a water storage and only the storage area can contribute runoff/inflow the storage will marginally gain volume (assuming groundwater is at a static level of 3 m below natural surface and there is no infiltration loss to groundwater).
  - If the quarry pit is converted to a water storage and the former quarry area (stockpiles, office, hard stand etc.) can contribute runoff/inflow the storage will marginally gain volume (assuming

groundwater is at a static level of 3 m below natural surface and there is no infiltration loss to groundwater).

- The post closure assessment has been used to assess the risk of over topping and is conservative in the fact that it assumes the quarry is full of water at the start of the model period. It is also possible that the water level in the quarry will not reach the pre-quarrying level of 3 m below groundwater level. The rate of post operational inflow will be controlled by the permeability of the basalt aquifer.

B-9-2 Recommendations

The following recommendations are provided:

- The storage be properly designed by an accredited dam engineer and constructed to meet the relevant construction standards.
- A weekly record of storage water levels should be kept throughout the operation of the quarry. When the storage reaches within 1.5 m of the dam spillway height, monitoring should be undertaken on a daily basis.
- The on-site storage detailed design should be assessed under the relevant design guidelines (e.g. ANCOLD for large dams). All onsite water use, within the quarry and across the windfarm should be taken from the water storage where possible (i.e. if it meets relevant water quality standards) to reduce the risk of exceeding the storage capacity.
- Metering of site water usage and internal transfers should be undertaken weekly to reconcile the estimates provided in this assessment.
- Development of a small starter pit (e.g. 30 x 30 m) which extends to the base of the quarry to be used to validate the groundwater inflow estimates prior to excavation of the broader quarry area.
- The wells within 1,500 m of the quarry should be checked to validate their purpose and status. These may be used as water level monitoring wells (monthly during quarry operation and quarterly for 12 months afterwards) to verify the drawdown estimate.
- In the event that inflows are greater than predicted in this assessment, the following contingency measures could be enacted:
  - Add additional water storage retention basins within the WAA.
  - Partition areas within the pit to provide additional storage.
  - Consider recharge to the aquifer through groundwater wells (i.e. managed aquifer recharge).
  - Consider options for off-site disposal to waterways subject to assessment of source and receiving water quality.
  - Increase usage of pit and retention basin water for off-site water requirements, subject to licensing approval.
- The detailed design of the proposed road alignment of the track from Old Dunmore Rd to the works authority area may require the road to be raised to at least 88.5 m AHD, for safe access.

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APPENDIX C
EXAMPLE CONTRACTOR'S ENVIRONMENTAL MANAGEMENT PLAN

This is a typical list of the anticipated contents of the Contractor's Environmental Management plan. It would be developed further to reflect the individual contractor's proposed methods of working.

  - Definitions, Terms & Acronyms
  - Purpose
  - Objectives of the Environmental Management Plan
  - Scope of Works
- Overview
- Site Activities
- Hours of Operation and Site Access
- Contractor Facilities
- Location of Project
  - Environmental Management System
- Integrated Management System
- Environmental Sub Plans
  - Resources, Roles, Responsibilities
- Management Responsibilities
- Operational Responsibilities
- Roles and Responsibilities of Project Personnel
- Subcontractors
  - Environment and Sustainability Objectives and Targets
- Organisational Commitments
- Key Performance Indicators/Targets
  - Contractual, Regulatory, and Legal Compliance
- Compliance with Client/ legislative Requirements
- Environmental Hold Points
- Environmental Approvals
- Legislative Updates
- Relevant Standards and Guidelines
- Environmental Documentation
  - Risk Assessment – Aspects and Impacts
- Significant Environmental Aspects
- Risk Assessment
- Management Plans (including Surface Water Management)
  - Environmental Protection Procedures
- Dilapidation Survey
- Soils & Materials

- Imported Soil and Materials
- Contaminated Material
- Acid Sulfate Soils
- Erosion and Sediment Control
- Water Management
- Air Quality
- Asbestos Management
- Cultural Heritage
- Flora Management
- Fauna Management
- Waste Management
- Environmental Reporting (Greenhouse Gas Emissions)
- Chemical Management
- Traffic Management
  - Awareness, Training, Competence and Communication
  - Monitoring, Inspection and Audits
  - Incident and Emergency Management
  - Reporting
  - Maintenance and Retention of Records
  - Environmental Management System Review

Typical Appendices:

- ISO 14001: 2008 Environmental Management System
- Contractor's Environmental Policy
- Contractor's Sustainability Policy
- Discovery of Aboriginal Heritage Procedure
- Environmental Weed Inspection Form
- Environmental Incident and Emergency Response Flowchart
- Incident and Emergency Response for Chemical, Oil and Fuel Spills
- Incident and Emergency Response for Encountering Wildlife
- Incident and Emergency Contact Details
- Environmental Inspection Form

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APPENDIX D
TYPICAL GLENELG HOPKINS CMA WORKS ON WATERWAYS LICENCE REQUIREMENTS

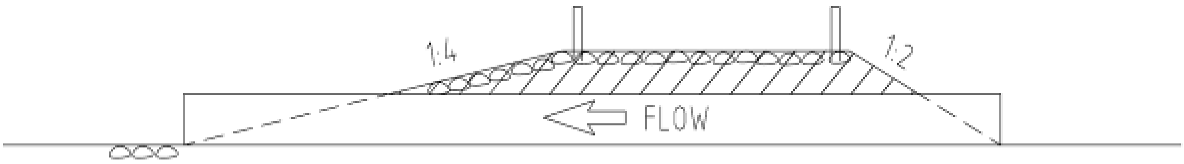
The General Works and Activities on Waterways Licence conditions are as follows:

1. The works shall be constructed in accordance with any plans approved by Glenelg Hopkins CMA. Any proposed amendments to the works including (but not limited to) changes to design, method of works or materials used must in writing be submitted to, and approved by, Glenelg Hopkins CMA.
2. The waterway shall not be deviated in any manner for construction purposes without the approval of the Glenelg Hopkins CMA.
3. Works should be undertaken during dry conditions and when water flow is minimal. All operations should cease if wet conditions prevail.
4. Construction machinery shall be washed down before arriving on-site, and upon completion of the works, to remove all soil, mud, seeds and other vegetative matter. Upon completion of the works, washing down of machinery shall be performed at least 25 metres from a waterway, or at least 5 metres from any drainage system connected to a waterway.
5. Machinery with defective and/or leaking fuel, lubrication or hydraulic systems must not be used to perform the works.
6. Disturbance of the bed and banks of the waterway and the use of construction plant and equipment is to be kept to a minimum.
7. Mitigation measures shall be implemented to prevent vegetation, silt, sediment, chemicals and spillage from construction activities either entering the waterway or moving downstream during or after the works. Sediment control measures to minimise any increase in water turbidity are of particular importance and may include provision of silt traps (*Australia Geotextile Silt Fence 2000 or approved equivalent*) and detention basins.
8. Works must comply with the following relevant EPA Guidelines where applicable:
9. "*Construction Techniques for Sediment Pollution Control*", Publication 275, May 1991.
10. *"Civil construction, building and demolition guide",* Publication 1834, November 2020.
11. "*Doing it Right on Subdivisions*", Publication 960, September 2004
12. Discharge of water polluting substances i.e., wastewater into the waterway is not permitted, unless specifically authorised by Glenelg Hopkins CMA.
13. The construction site and construction methods must comply with relevant OHS legislation and Work Safe Victoria industry standards.
14. Works shall cease immediately upon the discovery of any suspected human remains. The police or State Coroner's Office must be informed of the discovery without delay. If there are reasonable grounds to suspect that the remains are aboriginal, the discovery must also be reported to Aboriginal Affairs Victoria.
15. Works shall cease immediately upon the discovery of any aboriginal cultural material or if the site is suspected to be of aboriginal or archaeological cultural significance. Upon any such discovery 'First Peoples State Relations shall be notified immediately and works suspended until advice from Aboriginal Affairs Victoria is received.
16. It is the responsibility of the License holder to ensure that any person(s) conducting works be made aware of and comply with the requirements and conditions of this License. A copy of any Licenses and conditions shall be kept on site and be easily accessible for the duration of works.
17. The landowner or land manager shall always maintain the works in good order. Regular monitoring and maintenance of the site shall be undertaken to ensure the ongoing health of the waterway. Any concerns shall be reported to the Glenelg Hopkins CMA.

18. On completion of the works Glenelg Hopkins CMA must be contacted on planning@ghcma.civc.gov.au so that an inspection can be arranged.

The culvert Works and Activities on Waterways Licence conditions are as follows, these permit conditions relate to the construction of a culvert crossing, and are to be read in conjunction with the General Permit Conditions for Works on a Waterway listed above:

1. Culverts shall be installed parallel to the alignment of the banks of the waterway.
2. The culverts shall be placed with their inverts at or slightly below the invert of the waterway.
3. Rock protection is required on the bed and banks to at least the height of the crossing level, extending at least 4 times the culvert height downstream of the culvert.
4. Low level crossings shall have additional rock protection extending from top of bank to crossing surface.
5. The rock used for lining of bed and banks shall be dense, tough and durable. Rock size shall include a variety of diameters varying from fines to larger rock sizes and have an average diameter of 200 mm diameter. The lining thickness shall be a minimum of 400 mm with the surface of the rockfill finished flush with the bed of the waterway.
6. The embankment or trafficable surface and or access ramps over the culvert(s) shall comprise of the following:
   a. the crossing shall be surfaced with compacted rockfill or gravel;
   b. the slope of the embankment on the downstream side shall be graded and be no steeper than 4 horizontal to 1 vertical;
   c. the slope of the embankment on the upstream side shall be no steeper than 1 vertical to 2 horizontal and, where practicable, this upstream face shall be top soiled and planted with approved grasses.



7. Bank batters or embankment fill shall not encroach into the flow path of the culvert. . Batters shall be constructed at a grade no steeper than 1 vertical to 2 horizontal.
8. Side batters of the access track excavated into the stream bank shall be on a slope of 1 vertical to 2 horizontal or flatter to facilitate the establishment of a vegetative cover and planted with appropriate native grasses (contact DSE at www.dse.vic.gov.au for further information about appropriate vegetation)
9. Surface runoff from the access track including dairy crossings shall be managed to minimise the transport of sediment and nutrients into the waterway. Where possible, runoff shall be diverted away from the site or into the grassed filter zone adjacent to the waterway.
10. Waterway to be fenced out 30 meters either side of each culvert crossing, and 5 metres either side of the waterway if stock exclusion is required. The fenced out area is to be revegetated using indigenous species grown from seed of local provenance.

The bridge Works and Activities on Waterways Licence conditions are as follows, these permit conditions relate to the construction of a culvert crossing, and are to be read in conjunction with the General Permit Conditions for Works on a Waterway listed above:

1. All works including temporary works shall be constructed in accordance with any plans approved by Glenelg Hopkins CMA.
2. It is the responsibility of the permit holder to ensure that works are in accordance with all relevant Australian Standards or Bridge Design Codes.
3. Where the deck level of the bridge is below the estimated water surface level of a flood with an average recurrence interval of 100 years then:
    a) the bridge beams shall be securely anchored to piers and abutments by bolting or other approved means
    b) the bridge decking shall be securely pinned to the bridge beams
    c) the bridge shall be designed and constructed to withstand the combined forces of:
        i. hydraulic loading, including additional loading due to build-up of debris; and
        ii. impact loading of floating debris such as logs (based on the maximum weight of a log likely to be generated from the catchment).
4. Any side rails attached to the bridge crossing shall be designed to minimise the build-up of flood debris.
5. The bridge decking shall be constructed of concrete, timber or other non-erodible material.
6. The side slopes of any cut excavated into the bank of the waterway to obtain access to the crossing shall be no steeper than 2 horizontal to 1 vertical. At the completion of works all side slopes shall be top soiled and planted with approved grasses and shrubs.
7. To prevent erosion and transport of sedimentation and nutrients into the waterway, surface runoff from tracks leading to the bridge shall not be allowed to flow directly into the waterway. All such runoff shall be diverted away from the site or, into a grassed filter zone adjacent to the waterway.
8. In the case of access ramps cut into the bank, where runoff from the ramp will flow directly into the waterway, the access ramp shall be surfaced with compacted gravel to prevent scour of the track. Side drains shall be protected from scour with rockfill evenly graded from fines to 150 mm diameter.
9. Any temporary works must be removed as soon as is practicable on completion of bridge works.
10. If necessary, flows shall be pumped around the construction site or construction undertaken in stages with flow confined to one portion of the waterway.
11. That the areas of the existing bridge and adjoining road that are to be decommissioned are remediated through weed control and revegetation using indigenous species of local provenance.

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APPENDIX E
ACID SULFATE SOIL TESTING

eurofins | Environment Testing

Certificate of Analysis

Water Technology SA
Unit 1/198 Greenhill Rd
Eastwood
SA 5063

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Attention:	Craig Flavel
Report	781913-S
Project name	WILLATOOK WIND FARM
Project ID	21030175
Received Date	Mar 22, 2021

Client Sample ID Sample Matrix Eurofins Sample No. Date Sampled Test/Reference	LOR	Unit	PASS #1 Soil M21-Ma38991 Mar 20, 2021	PASS #2 Soil M21-Ma38992 Mar 21, 2021	PASS #3 Soil M21-Ma38993 Mar 21, 2021	PASS #4 Soil M21-Ma38994 Mar 21, 2021
SPOCAS Suite						
pH-KCL	0.1	pH Units	5.0	5.0	5.1	6.4
pH-OX	0.1	pH Units	4.2	4.4	5.5	7.0
Acid trail - Titratable Actual Acidity	2	mol H+/t	35	20	38	< 2
Acid trail - Titratable Peroxide Acidity	2	mol H+/t	49	18	< 2	< 2
Acid trail - Titratable Sulfidic Acidity	2	mol H+/t	14	< 2	< 2	< 2
sulfidic - TAA equiv. S% pyrite	0.003	% pyrite S	0.060	0.030	0.060	< 0.003
sulfidic - TPA equiv. S% pyrite	0.02	% pyrite S	0.08	0.03	< 0.02	< 0.02
sulfidic - TSA equiv. S% pyrite	0.02	% pyrite S	0.02	< 0.02	< 0.02	< 0.02
Sulfur - KCl Extractable	0.02	% S	0.03	0.02	0.04	< 0.02
Sulfur - Peroxide	0.02	% S	0.05	0.03	0.06	< 0.02
Sulfur - Peroxide Oxidisable Sulfur	0.02	% S	0.02	< 0.02	< 0.02	< 0.02
acidity - Peroxide Oxidisable Sulfur	10	mol H+/t	13	< 10	12	< 10
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
HCl Extractable Sulfur	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur - acidity units	10	mol H+/t	N/A	N/A	N/A	N/A
Net Acid soluble sulfur - equivalent S% pyrite[S02]	0.02	% S	N/A	N/A	N/A	N/A
Calcium - KCl Extractable	0.02	% Ca	0.09	0.04	0.23	0.17
Calcium - Peroxide	0.02	% Ca	0.10	0.05	0.26	0.19
Acid Reacted Calcium	0.02	% Ca	< 0.02	< 0.02	0.03	0.02
acidity - Acid Reacted Calcium	10	mol H+/t	< 10	< 10	16	< 10
sulfidic - Acid Reacted Ca equiv. S% pyrite	0.02	% S	< 0.02	< 0.02	0.03	< 0.02
Magnesium - KCl Extractable	0.02	% Mg	0.15	0.06	0.45	0.19
Magnesium - Peroxide	0.02	% Mg	0.15	0.06	0.46	0.22
Acid Reacted Magnesium	0.02	% Mg	< 0.02	< 0.02	< 0.02	0.03
acidity - Acid Reacted Magnesium	10	mol H+/t	< 10	< 10	< 10	23
sulfidic - Acid Reacted Mg equiv. S% pyrite	0.02	% S	< 0.02	< 0.02	< 0.02	0.04
Acid Neutralising Capacity (ANCE)	0.02	% CaCO3	N/A	N/A	N/A	0.34
Acid Neutralising Capacity - Acidity units (a-ANCE)	10	mol H+/t	n/a	n/a	n/a	68
Acid Neutralising Capacity - equivalent S% pyrite(s-ANCE)	0.02	% S	N/A	N/A	N/A	0.11
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
SPOCAS - Net Acidity (Sulfur Units)	0.02	% S	0.08	0.05	0.08	< 0.02
SPOCAS - Net Acidity (Acidity Units)	10	mol H+/t	48	29	50	< 10
SPOCAS - Liming rate	1	kg CaCO3/t	4.0	2.0	4.0	< 1

FIGURE 64 LABORATORY TEST RESULTS

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Client Sample ID			PASS #1	PASS #2	PASS #3	PASS #4
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			M21-Ma38991	M21-Ma38992	M21-Ma38993	M21-Ma38994
Date Sampled			Mar 20, 2021	Mar 21, 2021	Mar 21, 2021	Mar 21, 2021
Test/Reference	LOR	Unit				
Extraneous Material						
<2mm Fraction	0.005	g	130	120	37	63
>2mm Fraction	0.005	g	< 0.005	14	< 0.005	< 0.005
Analysed Material	0.1	%	100	89	100	100
Extraneous Material	0.1	%	< 0.1	11	< 0.1	< 0.1
% Moisture	1	%	23	14	33	28

FIGURE 65 CERTIFICATE OF ANALYSIS

CHAIN OF CUSTODY RECORD
Eurofins | Environment Testing ABN 50 005 085 521

☐ Sydney Laboratory — Unit F3 Bld.F 16 Mars Road Lane Cove West NSW 2066 — 02 9900 8400 EnviroSampleNSW@eurofins.com
☐ Brisbane Laboratory — Unit 1 21 Smallwood Place Murarrie QLD 4172 — 07 3902 4600 EnviroSampleQLD@eurofins.com
☐ Perth Laboratory — Unit 2 91 Leach Highway Kewdale WA 6105 — 08 9251 9600 EnviroSampleWA@eurofins.com
☐ Melbourne Laboratory — 6 Monterey Road Dandenong South VIC 3175 — 03 8564 5000 EnviroSampleVic@eurofins.com

Company	Water Technology	Project №	21030175	Project Manager	Craig Flavel
Address	1/198 Greenhill Road EASTWOOD SA 5063	Project Name	Willatook Wind Farm	EDD Format (ESdat, EQuIS etc)	
Sampler(s)	Dave Pennington	Handed over by	Roxanne Frost		
Contact Name	Dave Pennington	Email for Invoice	dave.pennington@watertech.com.au		
Phone №	08 8378 8000	Email for Results	dave.pennington@watertech.com.au		
Special Directions					
Purchase Order					
Quote ID №					

Analyses: Where metals are requested, please specify "Total" or "Filtered". SUITE code must be used to attract SUITE pricing.

Containers: Change container type & size if necessary.

Required Turnaround Time (TAT): Default will be 5 days if not ticked. ♦Surcharge will apply
☐ Overnight (reporting by 9am)♦
☐ Same day ♦ ☐ 1 day ♦
☐ 2 days ♦ ☐ 3
☑ 5 days (Standard)
☐ Other( )

№	Client Sample ID	Sampled Date/Time dd/mm/yy hh:mm	Matrix Solid (S) Water (W)	SPOCAS suite	Eurofins ASS plastic zip sealed bags	250mL Plastic	125mL Plastic	200mL Amber Glass	40mL VOA vial	500mL PFAS Bottle	Jar (Glass or HDPE)	Other (Asbestos AS4964, WA Guidelines)	Sample Comments / Dangerous Goods Hazard Warning
21	PASS #1	20/03/21		X	1								
22	PASS #2	21/03/22		X	1								
23	PASS #3	21/03/23		X	1								
24	PASS #4	21/03/24		X	1								
25													
26													
27													
28													
29													
30													
	Total Counts			4	4								

Method of Shipment: ☐ Courier (#) ☐ Hand Delivered ☐ Postal — Name — Signature — Date — Time

Laboratory Use Only						
Received By		SYD | BNE | MEL | PER | ADL | NTL | DRW	Signature	Date	Time	Temperature
Received By		SYD | BNE | MEL | PER | ADL | NTL | DRW	Signature	Date	Time	Report №

Eurofins Environment Testing Australia Pty Ltd

Submission of samples to the laboratory will be deemed as acceptance of Eurofins | Environment Testing Standard Terms and Conditions unless agreed otherwise. A copy is available on request.

QS3009_R10 Modified by: Dr. R Symons Approved by: G. Jackson Approved on: 8 August 2019

FIGURE 66 CHAIN OF CUSTODY RECORD

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Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
SPOCAS Suite			
SPOCAS Suite	Brisbane	Mar 25, 2021	6 Week
- Method: LTM-GEN-7050			
Extraneous Material	Brisbane	Mar 25, 2021	6 Week
- Method: LTM-GEN-7050/7070			
% Moisture	Brisbane	Mar 26, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

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ABN: 50 005 085 521 web: www.eurofins.com.au email: EnviroSales@eurofins.com

Australia
Melbourne: 6 Monterey Road, Dandenong South VIC 3175, Phone : +61 3 8564 5000, NATA # 1261, Site # 1254 & 14271
Sydney: Unit F3, Building F, 16 Mars Road, Lane Cove West NSW 2066, Phone : +61 2 9900 8400, NATA # 1261 Site # 18217
Brisbane: 1/21 Smallwood Place, Murarrie QLD 4172, Phone : +61 7 3902 4600, NATA # 1261 Site # 20794
Perth: 2/91 Leach Highway, Kewdale WA 6105, Phone : +61 8 9251 9600, NATA # 1261, Site # 23736
Newcastle: 4/52 Industrial Drive, Mayfield East NSW 2304, PO Box 60 Wickham 2293, Phone : +61 2 4968 8448

New Zealand
Auckland: 35 O'Rorke Road, Penrose, Auckland 1061, Phone : +64 9 526 45 51, IANZ # 1327
Christchurch: 43 Detroit Drive, Rolleston, Christchurch 767, Phone : 0800 856 450, IANZ # 1290

Company Name:	Water Technology SA	**Order No.:**	
Address:	Unit 1/198 Greenhill Rd Eastwood SA 5063	**Report #:**	781913
		Phone:	08 8378 8000
		Fax:	08 8363 7049
Project Name:	WILLATOOK WIND FARM	**Received:**	Mar 22, 2021 10:50 AM
Project ID:	21030175	**Due:**	Mar 29, 2021
		Priority:	5 Day
		Contact Name:	Craig Flavel

Eurofins Analytical Services Manager : Michael Cassidy

Sample Detail					SPOCAS Suite	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271						
Sydney Laboratory - NATA Site # 18217						
Brisbane Laboratory - NATA Site # 20794					X	X
Perth Laboratory - NATA Site # 23736						
Mayfield Laboratory						
External Laboratory						
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	PASS #1	Mar 20, 2021		Soil	M21-Ma38991	X	X
2	PASS #2	Mar 21, 2021		Soil	M21-Ma38992	X	X
3	PASS #3	Mar 21, 2021		Soil	M21-Ma38993	X	X
4	PASS #4	Mar 21, 2021		Soil	M21-Ma38994	X	X
Test Counts						4	4

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Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

**NOTE: pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 ml

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

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Quality Control Results

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery									
SPOCAS Suite									
pH-KCL			%	99			80-120	Pass	
Acid trail - Titratable Actual Acidity			%	103			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
SPOCAS Suite				Result 1	Result 2	RPD			
pH-KCL	B21-Ma41332	NCP	pH Units	7.1	7.2	<1	30%	Pass	
pH-OX	B21-Ma41332	NCP	pH Units	3.7	3.7	<1	30%	Pass	
Acid trail - Titratable Actual Acidity	B21-Ma41332	NCP	mol H+/t	< 2	< 2	<1	30%	Pass	
Acid trail - Titratable Peroxide Acidity	B21-Ma41332	NCP	mol H+/t	45	46	3.0	30%	Pass	
Acid trail - Titratable Sulfidic Acidity	B21-Ma41332	NCP	mol H+/t	45	46	3.0	30%	Pass	
sulfidic - TAA equiv. S% pyrite	B21-Ma41332	NCP	% pyrite S	< 0.003	< 0.003	<1	30%	Pass	
sulfidic - TPA equiv. S% pyrite	B21-Ma41332	NCP	% pyrite S	0.07	0.07	3.0	30%	Pass	
sulfidic - TSA equiv. S% pyrite	B21-Ma41332	NCP	% pyrite S	0.07	0.07	3.0	30%	Pass	
Sulfur - KCl Extractable	B21-Ma41332	NCP	% S	< 0.02	< 0.02	<1	30%	Pass	
Sulfur - Peroxide	B21-Ma41332	NCP	% S	0.16	0.17	1.0	30%	Pass	
Sulfur - Peroxide Oxidisable Sulfur	B21-Ma41332	NCP	% S	0.15	0.15	2.0	30%	Pass	
acidity - Peroxide Oxidisable Sulfur	B21-Ma41332	NCP	mol H+/t	95	96	2.0	30%	Pass	
HCl Extractable Sulfur	B21-Ma41332	NCP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur	B21-Ma41332	NCP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur - acidity units	B21-Ma41332	NCP	mol H+/t	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur - equivalent S% pyrite	B21-Ma41332	NCP	% S	N/A	N/A	N/A	30%	Pass	
Calcium - KCl Extractable	B21-Ma41332	NCP	% Ca	0.06	0.06	2.0	30%	Pass	
Calcium - Peroxide	B21-Ma41332	NCP	% Ca	0.07	0.07	1.0	30%	Pass	
Acid Reacted Calcium	B21-Ma41332	NCP	% Ca	< 0.02	< 0.02	<1	30%	Pass	
acidity - Acid Reacted Calcium	B21-Ma41332	NCP	mol H+/t	< 10	< 10	<1	30%	Pass	
sulfidic - Acid Reacted Ca equiv. S% pyrite	B21-Ma41332	NCP	% S	< 0.02	< 0.02	<1	30%	Pass	
Magnesium - KCl Extractable	B21-Ma41332	NCP	% Mg	0.08	0.08	1.0	30%	Pass	
Magnesium - Peroxide	B21-Ma41332	NCP	% Mg	0.10	0.10	1.0	30%	Pass	
Acid Reacted Magnesium	B21-Ma41332	NCP	% Mg	< 0.02	< 0.02	<1	30%	Pass	
acidity - Acid Reacted Magnesium	B21-Ma41332	NCP	mol H+/t	16	16	<1	30%	Pass	
sulfidic - Acid Reacted Mg equiv. S% pyrite	B21-Ma41332	NCP	% S	0.03	0.03	<1	30%	Pass	
Acid Neutralising Capacity (ANCE)	B21-Ma41332	NCP	% CaCO3	N/A	N/A	N/A	30%	Pass	
Acid Neutralising Capacity - Acidity units (a-ANCE)	B21-Ma41332	NCP	mol H+/t	n/a	n/a	N/A	30%	Pass	
ANC Fineness Factor	B21-Ma41332	NCP	factor	1.5	1.5	<1	30%	Pass	
SPOCAS - Net Acidity (Sulfur Units)	B21-Ma41332	NCP	% S	0.10	0.10	2.0	30%	Pass	
SPOCAS - Net Acidity (Acidity Units)	B21-Ma41332	NCP	mol H+/t	61	63	2.0	30%	Pass	
SPOCAS - Liming rate	B21-Ma41332	NCP	kg CaCO3/t	5.0	5.0	2.0	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	M21-Ma38994	CP	%	28	28	1.0	30%	Pass	

ADVERTISED PLAN

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Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S02	Retained Acidity is Reported when the pHKCl is less than pH 4.5

Authorised by:

Michael Cassidy	Analytical Services Manager
Myles Clark	Senior Analyst-SPOCAS (QLD)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

\- Indicates Not Requested
* Indicates NATA accreditation does not cover the performance of this service
Measurement uncertainty of test data is available on request or please click here.

Eurofins shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

FIGURE 67 EUROFINS LABORATORY QA DOCUMENTS

APPENDIX F
SHAW RIVER POWER STATION PROJECT ENVIRONMENT EFFECTS STATEMENT WQ RESULTS

Appendix 4 – Shaw River Power Station Project, Power Station and Gas Pipeline: Detailed Aquatic Survey, Water Quality Results (Ecology and Heritage Partners (009)

Appendix 4 – Water Quality Results

Table A4.1. Summary of water quality results for the study area

		TDS	SS	Turbidity	Ammonia	Nitrite	Nitrate	NOX	TKN	TN	TP	EC	pH	DO%
	Units	mg/L	mg/L	N.T.U	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µS/cm	Units	%Saturation
Approximate Kilometres of Pipeline	SEPP / ANZECC Guidelines			^10[2]	0.9[3]	0.04[b]	0.04[b]	0.04[b]		^0.9[2]	^0.04[2]	^1500[2]	^6.6[1]-8.3[2]	^85[1]-110[3]
4.4	Port Campbell Creek	927	42	24.8	0.01	BD	BD	BD	1.4	1.4	0.2	1751	7.78	112.1
10.3	Wallaby Creek	932	10	5.8	0.01	0.01	0.09	0.1	0.8	1	0.18	1809	7.46	42.6
13.5	Spring Creek	894	BD	21.3	0.02	BD	BD	BD	1.5	1.5	0.03	1038	7.62	64.8
16.3	Mosquito Creek	554	23	12.1	0.03	BD	BD	BD	2.1	2.1	0.22	1328	7.54	196.3
20.9	Curdies River	1850	BD	1	0.065	BD	0.09	0.09	BD	0.79	0.1	7550	7.5	62.5
CUUS	Curdies River	1700	BD	1.5	BD	BD	0.07	0.07	BD	0.69	0.07	8690	7.6	88.2
CUDS	Curdies River	2100	16	1.7	0.35	BD	0.05	0.05	BD	0.74	0.09	5550	7.6	62.9
22.4	Whiskey Creek	722	2	1.9	BD	BD	0.03	0.03	0.8	0.9	0.06	1247	8.08	46.1
24.5	Whiskey Creek East Branch	594	30	2.4	BD	BD	0.08	0.08	0.7	0.8	0.12	1143	7.94	90.6

		TDS	SS	Turbidity	Ammonia	Nitrite	Nitrate	NOX	TKN	TN	TP	EC	pH	DO%
	Units	mg/L	mg/L	N.T.U	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µS/cm	Units	%Saturation
Approximate Kilometres of Pipeline	SEPP / ANZECC Guidelines			^10[2]	0.9[3]	0.04[b]	0.04[b]	0.04[b]		^0.9[2]	^0.04[2]	^1500[2]	^6.6[1]-8.3[2]	^85[1]-110[3]
25	Whiskey Creek West Branch	586	9	15.8	BD	BD	0.02	0.02	0.7	0.7	0.16	686	7.63	59.4
50.2	Hopkins River	1600	2.6	1	0.02	BD	0.15	0.15	BD	0.67	0.08	2010	7.9	96.7
HOUS	Hopkins River	1550	3.2	2	0.02	BD	0.17	0.17	BD	0.61	0.07	2880	7.9	85.5
HODS	Hopkins River	1400	3.4	1.5	0.015	BD	0.14	0.14	BD	0.66	0.08	2080	7.9	84.1
59.6	Merri River	2500	BD	1.5	0.035	BD	0.21	0.21	BD	0.82	0.08	3640	7.6	94.1
MEUS	Merri River	2450	BD	1	0.03	BD	0.2	0.2	BD	0.81	0.06	3660	7.6	96.8
MEDS	Merri River	2500	BD	1.7	0.06	BD	0.21	0.21	BD	0.61	0.08	3620	7.6	90.4
76.3	Murray Brook	1780	122	0.2	0.02	BD	BD	BD	7	7	1.51	3560	7.92	91.9
78.4	Unnamed tributary of Murray Brook	1760	10	4.8	0.76	BD	BD	BD	0.9	0.9	0.15	-	-	156
85.9	Unnamed tributary of Moyne River	726	8	5.3	2.14	0.03	0.03	0.06	3	3	0.67	-	-	81

	Units	TDS mg/L	SS mg/L	Turbidity N.T.U	Ammonia mg/L	Nitrite mg/L	Nitrate mg/L	NOX mg/L	TKN mg/L	TN mg/L	TP mg/L	EC µS/cm	pH Units	DO% %Saturation
Approximate Kilometres of Pipeline	SEPP / ANZECC Guidelines			^10₂	0.9ₐ	0.04 ᵦ	0.04ᵦ	0.04ᵦ		^0.9₂	^0.04₂	^1500₂	^6.6₁-8.3₂	^85₁-110₃
87.5	Moyne River	2500	5.2	1.2	0.05	BD	BD	BD	BD	0.86	0.06	3240	7.7	103.8
MOUS	Moyne River	2650	BD	1	BD	BD	BD	BD	BD	0.57	0.08	3740	7.7	103.7
MODS	Moyne River	2600	3.2	0.8	0.035	BD	BD	BD	BD	0.51	0.05	3740	7.7	114
90.2	Back Creek	938	3	3	0.04	BD	BD	BD	BD	BD	1.87	2700	6.88	158.7
SHUS	Shaw River	1530	11	2.4	0.03	BD	BD	BD	1.2	1.2	0.04	2860	7.36	62.1
SHDS	Shaw River	1900	37	13.5	0.26	BD	BD	BD	2.7	2.7	0.15	1931	7.43	50.6

BD = Below Detection Limit; 1=25th Percentile, 2=75th Percentile, 3=Maximum;

^ = SEPP Guidelines

Shaded figures are those that were outside the responding guideline

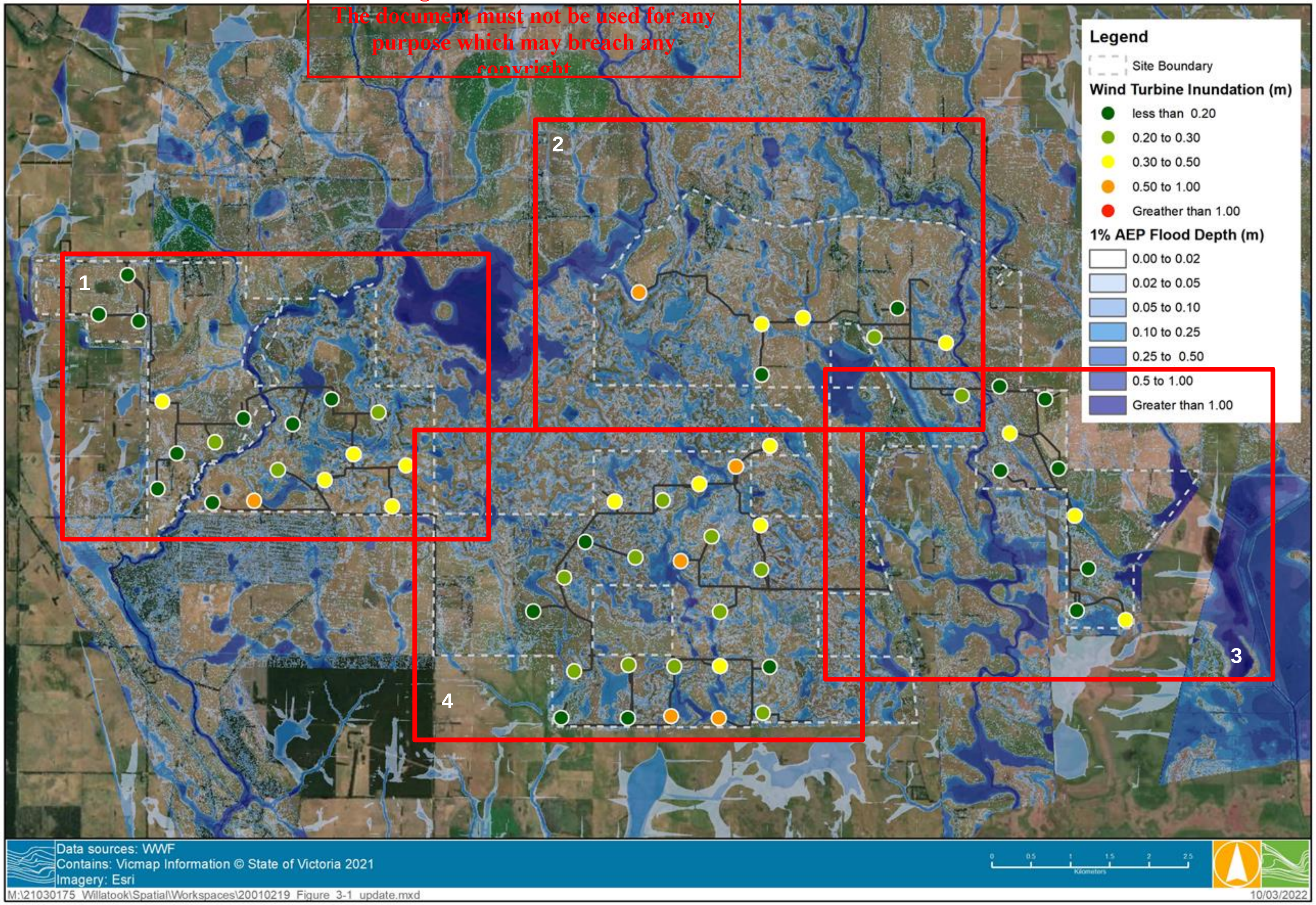
a = Trigger values for toxicants for are the trigger values applying to typical slightly–moderately disturbed systems; b = Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems; shading signifies that this value is outside the objective;

TDS = Total Dissolved Solids SS = Suspended Solids NOX = Oxides of Nitrogen TN = Total Nitrogen TP = Total Phosphorus EC = Electrical Conductivity DO% = Dissolved Oxygen Saturated; SEPP = State Environmental Protection Policy – Waters of Victoria (EPA, 2003); ANZECC = Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)

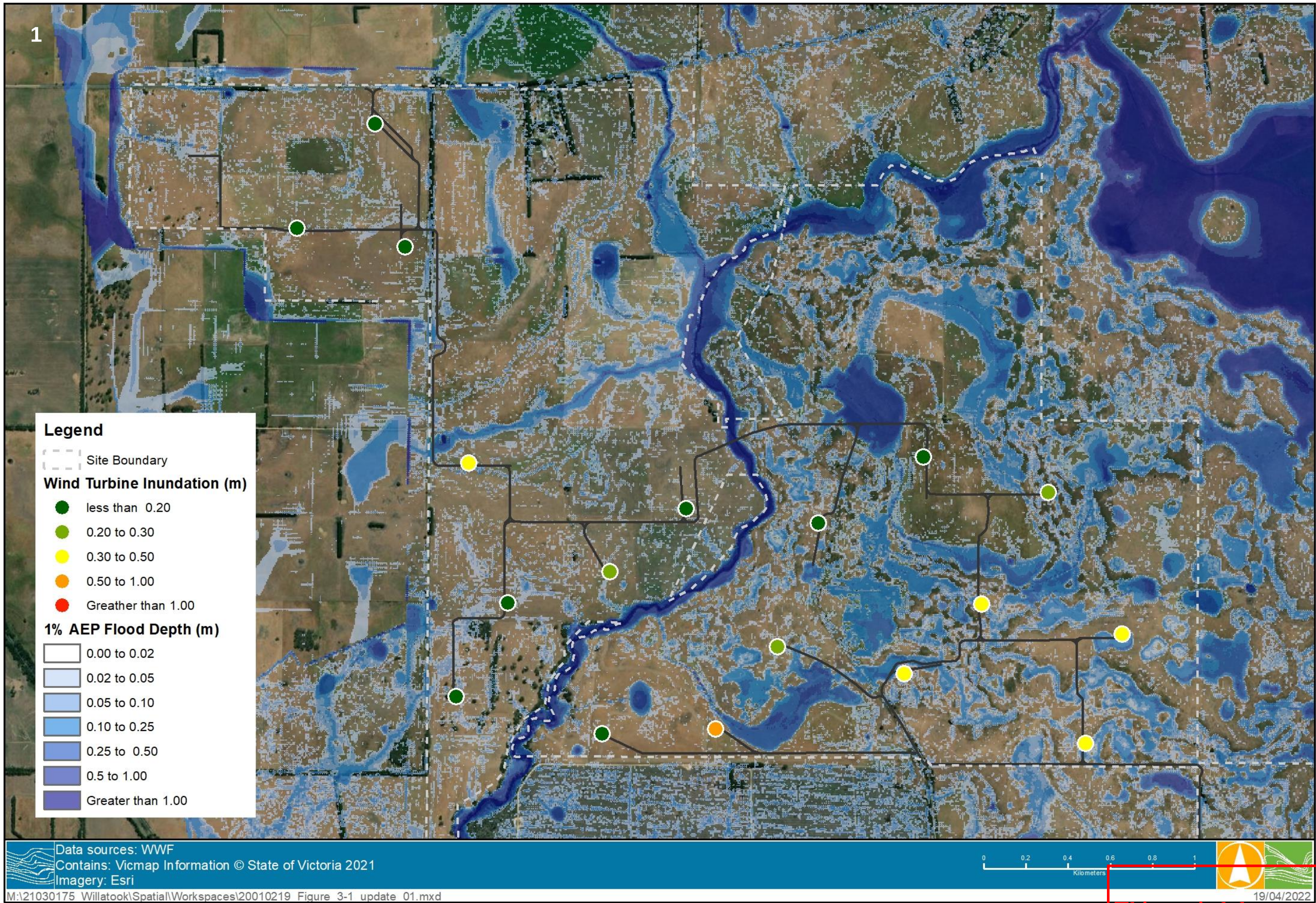
71%

APPENDIX G
FLOOD DEPTH MAPPING

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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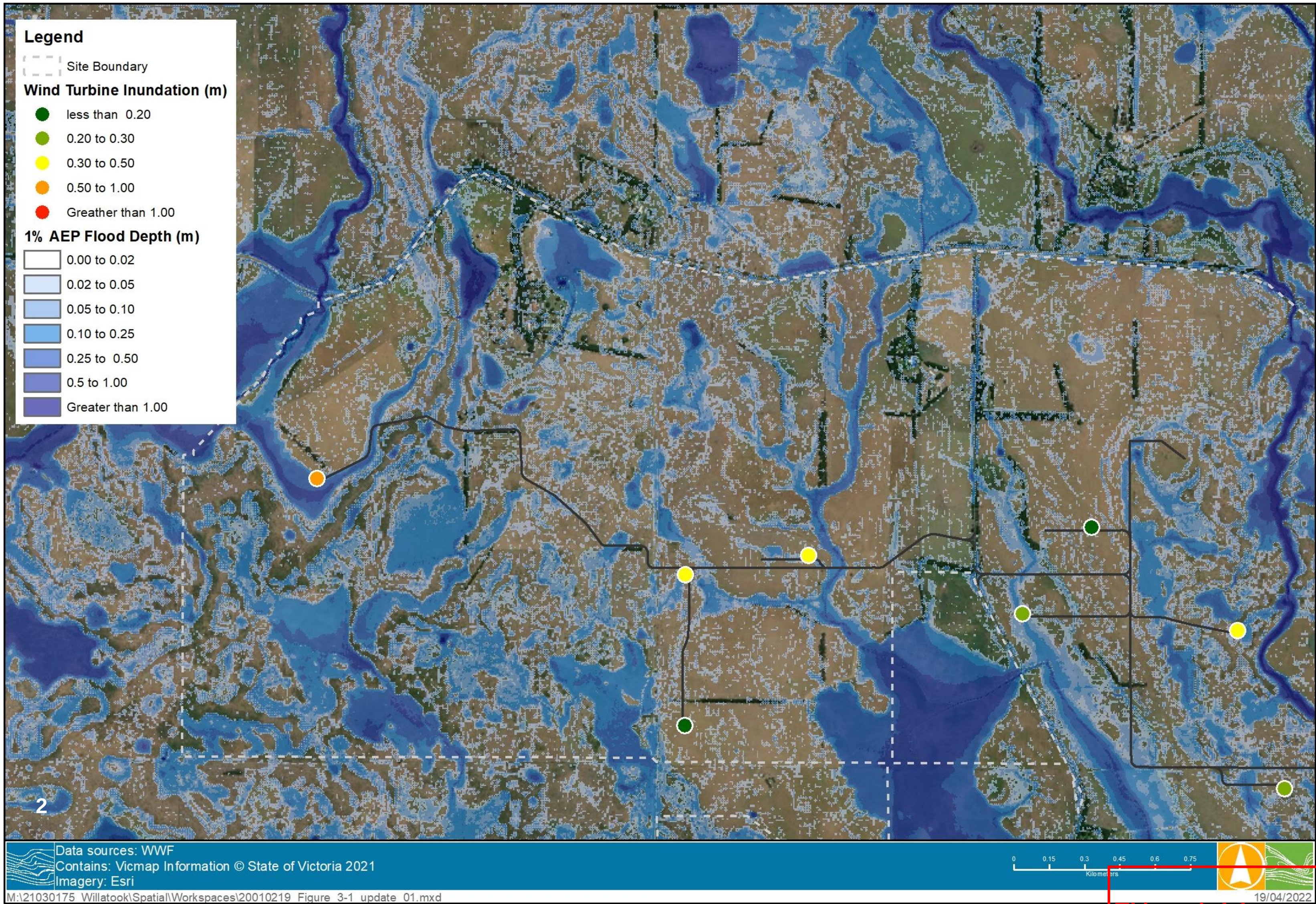

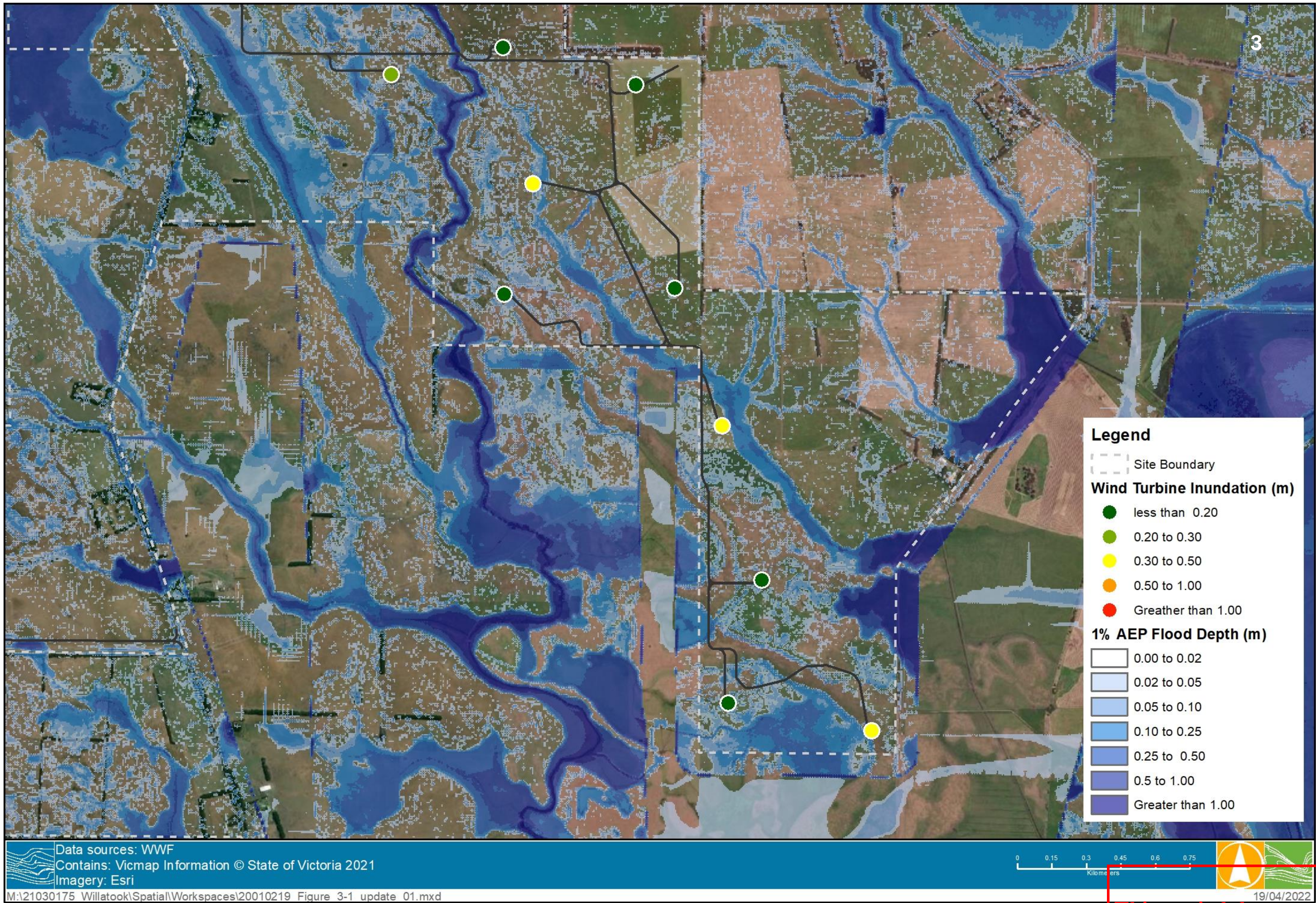
3
Legend
Site Boundary
Wind Turbine Inundation (m)
less than 0.20
0.20 to 0.30
0.30 to 0.50
0.50 to 1.00
Greather than 1.00
1% AEP Flood Depth (m)
0.00 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.25
0.25 to 0.50
0.5 to 1.00
Greater than 1.00
Data sources: WWF
Contains: Vicmap Information © State of Victoria 2021
Imagery: Esri
M:\21030175_Willatook\Spatial\Workspaces\20010219_Figure_3-1_update_01.mxd
19/04/2022

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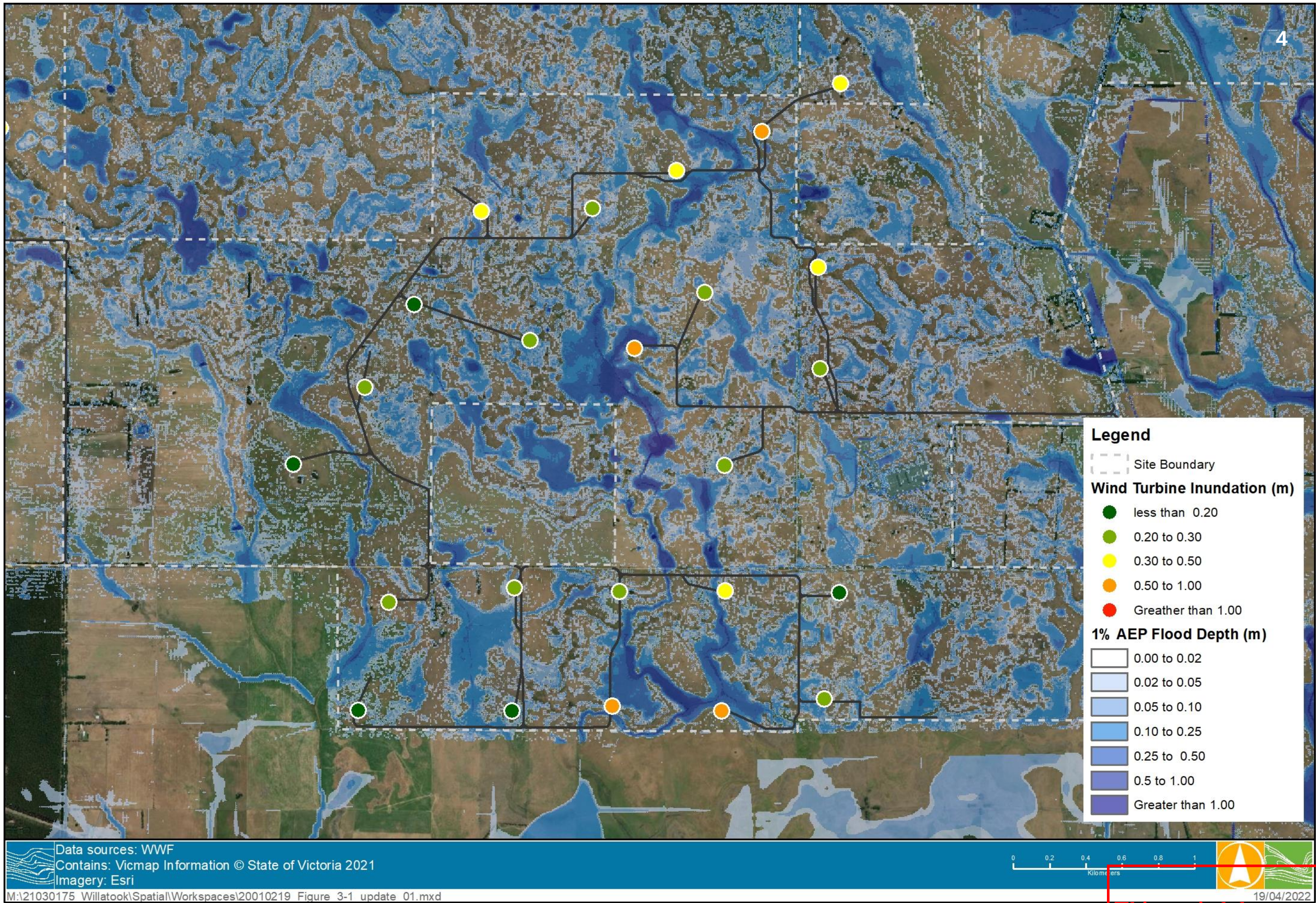

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