

Appendix 13 - Water Resources Impact Assessment



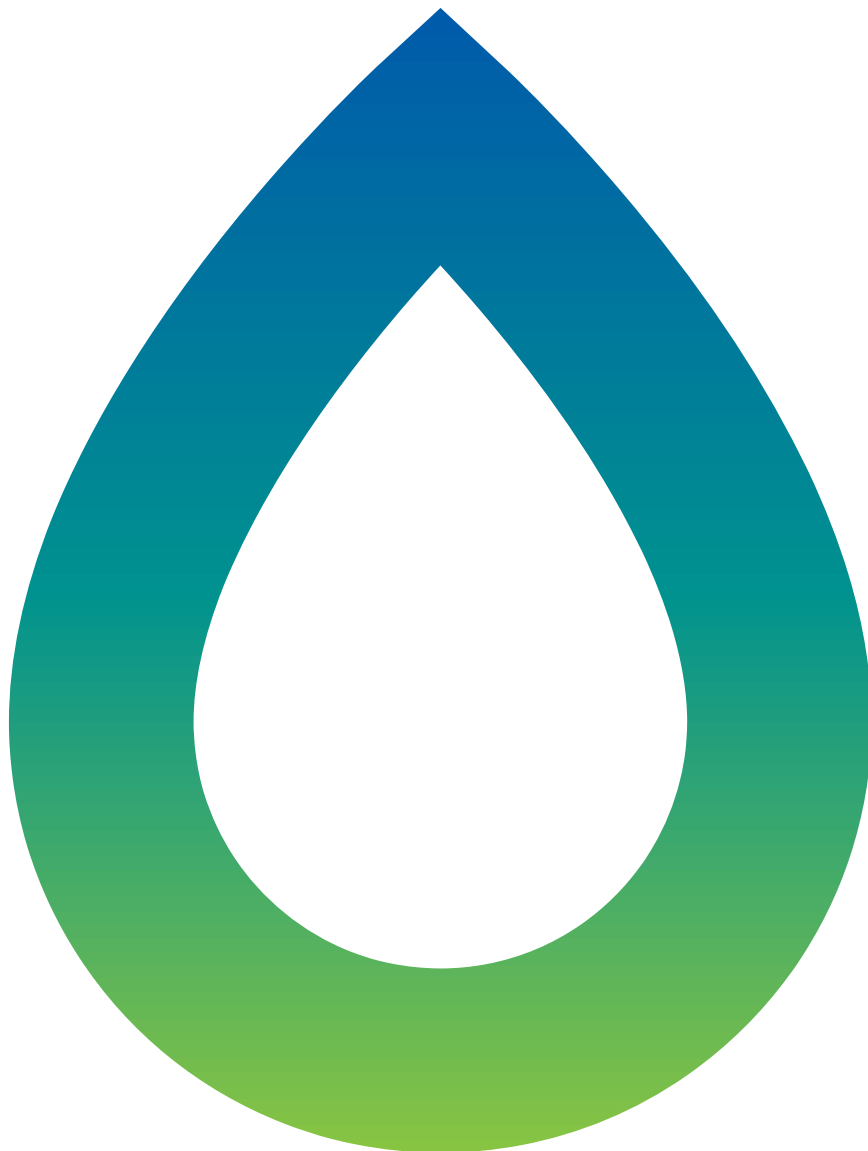
BULLAWAH WIND FARM PROJECT

Water Resources Impact Assessment

Umwelt (Australia) Pty Ltd

27 June 2024

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DETAILS

Report Title	Bullawah Wind Farm Project Water Resources Impact Assessment
Client	Umwelt (Australia) Pty Ltd

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Author	Lindsay Millard
Reviewer	DN

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NOTE ON FLOOD FREQUENCY TERMINOLOGY

A design flood is a probabilistic or statistical estimate, being generally based on some form of probability analysis of flood or rainfall data. An Annual Exceedance Probability (AEP) is attributed to the estimate. The frequency of flood events is expressed as an AEP, for example, a flood magnitude having 10% AEP, there is a 10% probability (or 1 in 10 chance) that there would be floods of that magnitude or greater each year. While a related concept Annual Recurrence Interval (ARI) is now outmoded due to the confusion it generates. A flood with a 10 year ARI, refers to floods that equal or of greater magnitude once in ten years on average. For very frequent events, the concept is referred to as Exceedances per Year (EY). The approximate correspondence between terminology, in particular the relationship between AEP and ARI applies to this study (ARR, 2019). The frequency of flood events can be grouped into five broad descriptive categories, as shown below.

Frequency Descriptor	EY	AEP (%)	AEP	ARI
			(1 in x)	
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/	
			PMP Flood	

Source: Australian Rainfall and Runoff Guidelines (Ball et al, 2019)

In this report, the frequency of flood events is referred to in terms of AEP for floods categorised as very rare, for example 1%, 0.2% or 0.5% AEP. These floods were calculated using the historical climate records. Over recent years, the climate record is showing the influence of non-stationarity. Evidence now exists that the magnitude of floods, i.e. those based on the historical record, are becoming more frequent. It is considered that this will continue as a warming climate will lead to

more moisture being held in the atmosphere. For planning purposes, it is prudent to consider a 0.5% AEP based on the historical record as a proxy of the 1% AEP flood event based on future climate depths.

The 1 in 2000 (0.05%) AEP event is considered the limit of credible extrapolation of the historical record. These floods are categorised as extreme with the limit being the concept of the Probable Maximum Flood (PMF). The PMF occurs as a result of the Probable Maximum Precipitation (PMP) and The PMP is the result of the maximum atmospheric carrying capacity of moisture and the efficiency of the storm mechanism to produce rainfall in a region. A PMF flood is not shown above as it is extreme and beyond the statistical limit. A PMF flood cannot have an AEP assigned to its magnitude as it applies the most conservative assumptions related to temporal patterns, losses and so on. Note also, that the PMF is not the same as the PMP Flood.

Very rare design events floods are useful for the purposes of planning as there is a remote chance that it may occur. Extreme floods are considered so far beyond the credible limit of record and contain so much inherent uncertainty that they exist only to provide a theoretical limit.

The approach to estimating an actual (or historic) flood from a particular rainfall event is quite different in concept and is of a deterministic nature. All causes and effects are directly related to the specific event under consideration. The actual antecedent conditions prevailing at the time of occurrence of the rain are directly reflected in the resulting flood and must be allowed for in its estimation. No real information on the probability of the historic flood can be gained from consideration of a single actual flood event.

ABBREVIATIONS AND DEFINITIONS

Term/ Abbreviation	Definition
AEP (Annual Exceedance Probability)	Annual Exceedance Probability. The change of a flood of a given or large size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding.
ADWG	Australian Drinking Water Guidelines.
AHD (mAHD)	Australian Height Datum. A common national surface level datum approximately corresponding to mean sea level.
ARR	Australian Rainfall and Runoff. Guidelines prepared by Engineers Australia for the estimation of design floods. The latest being ARR2019 (Ball et al, 2019)
ASC	Australian Soil Classification (Isbell, R. F.,2021)
BFEMOP	Bush Fire Emergency Management and Operations Plan.
BGL (mBGL)	Below Ground Level. A relative datum used in bore holes to measure depth to groundwater.
BSAL	Biophysical Strategic Agricultural Land
CEMP	Construction Environment Management Plan
CSWMP	Construction Soil and Water Management Plan
DEM	Digital Elevation Model
Development Corridor	This is the area within which all proposed Project infrastructure will be placed and all Project-related ground disturbance will occur. The Development Corridor is of variable width (to avoid key site constraints) and has been designed to provide some flexibility for micro-siting.
Disturbance Footprint	This is the actual disturbance area required for the Project. Please note that the Disturbance Footprint identified in the EIS is indicative. The actual location and extent of the Disturbance Footprint will be determined prior to construction, subject to the micro-siting provisions outlined in the EIS.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m ³ /s). Discharge is different from speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
EIS	Environmental Impact Statement
ESCP	Erosion Sediment Control Plan
EV	Environmental Value

Term/ Abbreviation	Definition
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 local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below: Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
GDE	Groundwater Dependent Ecosystem.
GW	Gigawatt.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
kL	Kilolitre, one thousand litres.
km	Kilometres.
kV	Kilovolt.
LSC	Land and Soil Capability.
mAHD	Metres Australian Height Datum (AHD).
m/s	Metres per second. Unit used to describe the velocity of floodwaters.

Term/ Abbreviation	Definition
m ³ /s	Cubic metres per second or “cumecs”. A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
ML	Megalitre, one million litres.
MNES	Matters of Nationale Environmental Significance.
MW	Megawatt.
PMF (Probable maximum flood)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land, that is, the floodplain.
PMP (Probable maximum precipitation)	The greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends.
Project Area	The Project Area encompasses all land within and including the Project Boundary.
REZ	Renewable Energy Zone. The equivalent of modern-day power stations, combining new renewable energy infrastructure, including generators (such as solar and wind farms), storage (such as batteries and pumped hydro) and then high-voltage transmission infrastructure
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual, it is the likelihood of consequences arising from the interaction of floods, communities, and the environment.
Runoff	The amount of rainfall which ends up as a streamflow, also known as rainfall excess.
RUSLE	Revised Universal Soil Loss Equation.
Scour	Erosion by mechanical action of water, typically of soil.
SSP (Shared Socioeconomic Pathways)	SSPs are climate change scenarios of projected socioeconomic global changes up to 2100 as defined in the IPCC Sixth Assessment Report on climate change in 2021. In terms of quantitative elements, they provide data accompanying the scenarios on national population, urbanization and GDP (per capita). The five scenarios are: SSP1: Sustainability ("Taking the Green Road") SSP2: "Middle of the Road" SSP3: Regional Rivalry ("A Rocky Road") SSP4: Inequality ("A Road Divided") SSP5: Fossil-fuelled Development ("Taking the Highway").
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.

EXECUTIVE SUMMARY

This report documents the assessment and findings related to water resource related aspects associated with the construction and operation of the Bullawah Wind Farm Project (the Project). The Project is located approximately 36 km southeast of Hay, within the South West Renewable Energy Zone (South West REZ). The Project Area is located within the Hay Shire, Murrumbidgee and Edward River Local Government Areas (LGAs). The location of the Project Area is shown in .

This WRIA was prepared in accordance with the NSW Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-50505215, issued on 12 December 2022). This report addresses the Secretary's Environmental Assessment Requirements relating to water resources as outlined in Section 1.2 and Appendix A. Section 1 provides an overview and context of the Project, as well as an outline of the purpose and structure of this report. Section 2 contains an outline of regulatory framework, legislation, policies and guidelines that were taken into consideration in the assessment.

This report has considered the potential impacts and appropriate measures to mitigate any potential impacts on water resources associated with the Project. The Project will have minimal impact on water resources as it involves limited ground disturbance, does not involve the storage or handling of large volumes of pollutants, and once constructed does not consume significant quantities of water.

Key potential issues relevant to the water resources impacts of the Project are summarised below:

- Potential impacts to surface water resources are primarily limited to the construction and decommissioning phases of the Project. These potential impacts can be mitigated to represent negligible risk as detailed in Section 7.
- The operational phase of the Project presents minimal risk provided that by the conclusion of the construction phase appropriate groundcover and drainage is established.
- The Project will not interact with the groundwater table and therefore, no impacts to groundwater resources or GDEs are expected.
- The Project Area does not contain any areas of major flood hazard.
- The large extent of the Project Area and distributed nature of minor impacts (if any) does not pose a risk to drainage features, downstream watercourses or receiving waters.

For these reasons, the key potential risks to surface water are only associated with the Project's construction. These risks can be adequately managed through the application of well-established construction environmental and safety management practices and appropriate design.

1 INTRODUCTION

1.1 OVERVIEW

Bullawah Wind Farm Pty Ltd (BWF) proposes to develop the Bullawah Wind Farm (the Project), located approximately 36 km southeast of Hay, within the South West Renewable Energy Zone (South West REZ). The location of the Project Area is shown in Figure 1.1. The Project Area is located within the Hay Shire, Murrumbidgee and Edward River Local Government Areas (LGAs).

The Project will include the installation, operation, maintenance and decommissioning of wind turbine generators (WTGs), ancillary infrastructure and temporary facilities associated with construction of the Project. The Project design incorporates up to 143 wind turbines, with a maximum blade-tip height of 300 m above ground level, and an installed capacity of up to 815.1 megawatts (MW).

WRM Water & Environment Pty Ltd (WRM) has been engaged by Umwelt (Australia) Pty Ltd (Umwelt) to prepare this Water Resources Impact Assessment (WRIA) for inclusion within the Environmental Impact Statement (EIS) for the Project.

The Project Area encompasses approximately 20,628 hectares (ha) of predominantly grazing land and adjoins the Oolambeyan National Park, which is located directly north. The Project Area is zoned as RU1 Primary Production within the Hay Local Environment Plan (LEP) 2011, the Murrumbidgee LEP 2013 and Conargo LEP 2013. Within the Project Area, BWF has identified:

- a Development Corridor of approximately 4,311 ha, which will contain all proposed Project infrastructure and all Project related ground disturbance
- an indicative Disturbance Footprint of approximately 642 ha, which equates to approximately three (3) percent of the total Project Area.

The Project Area is situated in a region with low population density and a limited number of nearby rural residences. The Project Area and surrounds was historically cleared for agricultural use and is generally homogenous agricultural land. The Project is compatible with existing pastoral land uses, with minimal impact to current agricultural activities.

1.2 PROJECT CONTEXT

The Project is a State Significant Development (SSD) as defined under *State Environmental Planning Policy (Planning Systems) 2021* (Planning Systems SEPP) and will require development consent under Part 4 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The Project's conceptual layout is provided in Figure 1.1. The key components of the Project include:

- up to 143 (three (3) blade) WTGs with a maximum blade-tip height of 300 metres (m) above ground
- a 359 MW / 718 MWh battery energy storage facility
- permanent ancillary infrastructure including internal roads, hardstands, main and collector substations, a switchyard, operations and maintenance facilities (O&M), underground and overhead electricity transmission lines and poles, telecommunications facilities and utility services, permanent meteorological masts and water storage tanks
- temporary facilities including temporary workforce accommodation (if required), site offices, amenities, construction compounds and laydown areas, on-site borrow pits, rock crushing facilities, concrete or asphalt batching plants, minor 'work front' construction access roads, erosion and sediment control structures, temporary meteorological masts and signage

- off-site road works, involving upgrades to the proposed local transport route and establishment of site access points to facilitate delivery of wind turbine components to the Project Area as required.

Project construction and grid connection will occur in two (2) stages. The conceptual staging plan for the Project involves:

- Stage 1 (South), located mostly south of North Boundary Road, connecting to the existing 220 kV transmission line which runs through the Project Area
- Stage 2 (North) located north of North Boundary Road, connecting to the approved (but not yet constructed) 330 kV Eastern Section of Project EnergyConnect, which will also run through the Project Area.

The WTGs have an expected operating life of approximately 30 years and the agreements with the host landholders provide for the operations to continue for 30 years. At the end of that 30 year period, three (3) options will be considered:

- Option 1. continued use of the Project Area as a wind farm utilising the existing WTGs and other facilities (subject to contractual agreement with the host landholders and condition of equipment)
- Option 2. replace the WTGs with technology current at that time and continue the wind farm operation for a further term (subject to contractual agreement with the host landholders and further development consent)
- Option 3. decommission the wind farm and remove the WTGs and other infrastructure.

The conceptual layout for the Project has been designed to maximise wind turbine performance whilst avoiding impacts on areas of high biodiversity value and minimising impacts to proximal landholders in regard to noise and visibility, surface water resources (including flooding) and cultural heritage constraints.

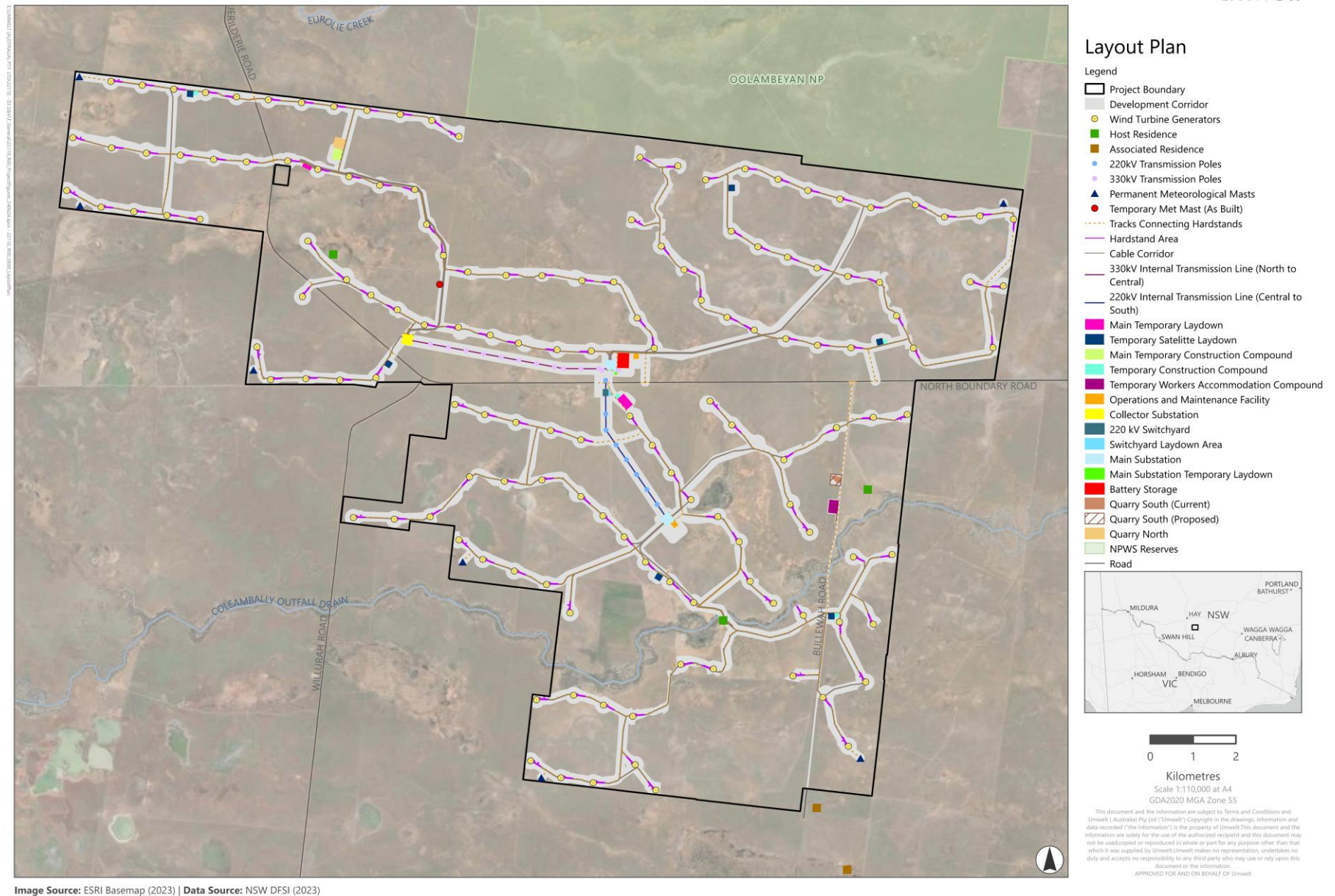


Figure 1.1 Project Layout

1.3 PURPOSE AND SCOPE

This WRIA was prepared by WRM in accordance with the NSW Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-50505215, issued on 12 December 2022). The requirements of the SEARs, as they relate to water resources, are presented in Table 1.1.

The WRIA provides an assessment of the potential impacts of the Project on the water resources in the vicinity of the Project Area. The assessment considers surface water, groundwater, water quality and hydrology impacts associated with the construction and operation of the Project and includes the following scope:

- Assessment of the potential impacts on:
 - flooding for the 10%, 1%, 0.5%, 0.2% Annual Exceedance Probability (AEP) events for the current climate
 - future 1% AEP flood risk under a changing climate projected over 30 years depending on the actual emissions trajectory is likely to be between the bookends of:
 - 0.5% AEP current climate as a proxy for SSP1: very-low emissions
 - 0.2% AEP current climate as a proxy for SSP5: high emissions
 - Probable Maximum Flood (PMF) was modelled using the Probable Maximum Precipitation (PMP) depths to determine the extreme flood event
 - erosion and sedimentation
 - surface water and groundwater quality
 - water users and supply
- Confirming the environmental values and water quality objectives associated with surface water resources
- Describing appropriate mitigation measures to manage the potential impacts.

The SEARs for the Project identify key issues and referenced guidelines that must be addressed in the EIS. Table 1.1 outlines where the specific SEARs requirements for water resources are addressed in this report. Appendix A summarises Agency Advice appended to the SEARs and outlines how this advice has been addressed in this Report.

Table 1.1 Planning Secretary’s Environmental Assessment Requirements (SSD-50505215)(SEARs)

SEARs Key Issues - Water and Soils:	Location
a site water balance for the development, quantify water demand, identify water sources (surface and groundwater), including any licensing requirements, and determine whether an adequate and secure water supply is available for the development;	Section 4
an assessment of the likely impacts of the development (including flooding and flood modelling) on surface water and groundwater resources traversing the site and surrounding watercourses (including their Strahler Stream Order), drainage channels, wetlands, riparian land, farm dams, groundwater dependent ecosystems and acid sulphate soils, related infrastructure, adjacent licensed water users and basic landholder rights, and measures proposed to monitor, reduce and mitigate these impacts;	Sections 6 to 7
where the project involves works within 40 metres of the high bank of any river, lake or wetlands (collectively waterfront land), identify likely impacts to the waterfront land, and how the activities are to be designed and implemented in accordance with the DPI <i>Guidelines for Controlled Activities on Waterfront Land</i> (2018) and (if necessary) <i>Why Do Fish Need to Cross the Road? Fish Passage Requirements for Watercourse Crossings</i> (DPI 2003); and <i>Policy & Guidelines for Fish Habitat Conservation & Management</i> (DPI, 2013);	Sections 5 to 7
a description of the measures to minimise surface and groundwater impacts, including how works on erodible soil types would be managed and any contingency requirements to address residual impacts in accordance with the Managing Urban Stormwater: Soils and Construction series of guidelines.	Section 7

1.4 REPORT STRUCTURE

This report is structured as follows:

- Section 2 provides details of the regulatory framework
- Section 3 provides details of the existing surface water environment
- Section 4 describes water management and demand for the Project
- Section 5 describes the methodology and results of the flood assessment
- Section 6 presents an assessment of the impacts of the Project
- Section 7 outlines the proposed management and mitigation measures
- Section 8 presents the conclusions of the assessment
- Section 9 is a list of references
- Appendix A outlines and addresses Agency Advice on the Project SEARs
- Appendix B contains flood mapping
- Appendix C provides soil data for the Project Area.

2 REGULATORY FRAMEWORK

2.1 OVERVIEW

This section describes the regulatory framework (legislations, policies and standards) at Commonwealth and State level that would apply to water management at this Project¹:

- *Water Management Act 2000* (WM Act) (NSW Government, 2000).
- *Water Act 1912* (Water Act) (NSW Government, 1912).
- Flooding:
 - Australian Rainfall and Runoff Guidelines 2019 (ARR 2019) (Commonwealth of Australia (Geoscience Australia), 2019)
 - Floodplain Risk Management Manual and Guideline LU01² (NSW Government 2023).
- Surface Water:
 - NSW Government Water Quality and River Flow Objectives at <http://www.environment.nsw.gov.au/ieo/>
 - Australian Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia, 2018) (ANZG, 2018)
 - Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom, 2004) and Volume 2 (Department of Environment and Climate Change, 2008)
 - Storing and Handling Liquids: Environmental Protection – Participants Handbook (Department of Environment and Climate Change, 2007).
- Policy & Guidelines for Fish Habitat Conservation & Management (Department of Primary Industries, 2013).
- Guidelines for Controlled Activities on Waterfront Land:
 - Guidelines for riparian corridors on waterfront land (Department of Planning and Environment (DPE) Water, 2018)
 - Guidelines for instream works on waterfront land (DPE Water, 2022)
 - Guidelines for vegetation management plans on waterfront land (DPE Water, 2022)
 - Guidelines for watercourse crossings on waterfront land (DPE Water, 2022)
 - Controlled Activities on Waterfront Land: Controlled activity exemptions on waterfront land (DPE Water, 2022).

¹ <https://www.planning.nsw.gov.au/Policy-and-Legislation/Planningreforms/Rapid-Assessment-Framework/Improving-assessment-guidance>

<https://www.planningportal.nsw.gov.au/major-projects/assessment/policiesand-guidelines>

<http://www.environment.gov.au/epbc/publications#assessments>

² <https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Floodplains/flood-risk-management-impact-risk-assessment-230234.pdf>

- Groundwater:
 - NSW State Groundwater Policy Framework Document and component policies (Department of Planning, Industry and Environment)
 - *NSW Aquifer Interference Policy* 2012 (Department of Primary Industries Office of Water)
 - National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ/ANZECC).

2.2 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) outlines the requirements relating to the management and protection of matters of national environmental significance (MNES).

‘Controlled actions’ are those actions that the Minister decides have, will have or are likely to have a significant impact on one or more protected matters and therefore require assessment and approval under the Act. The protected matters upon which the action may have a significant impact are called the ‘controlling provisions’ or ‘triggers’ for assessment and approval under the Act, for that controlled action.

The Project has been declared a controlled action (EPBC 2022/09423) as it has been assessed as likely to have a significant impact on listed threatened species and communities under the EPBC Act. The Project’s impacts to MNES have been comprehensively assessed in the Biodiversity Development Assessment Report prepared for inclusion in the Project’s EIS (Umwelt, 2024) and are therefore not considered in detail in this Report.

2.3 Water Management Act 2000

The WM Act is the primary legislation for the management of water in the Project Area. The WM Act contains provisions for the licensing of water access and use. Groundwater quality protection is also achieved through consideration of both the objects and principles of the WM Act.

In general, the WM Act governs the issue of water access licences (WALs) and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where Water Sharing Plans (WSPs) exist. Additional groundwater sources and WSPs underlie the upper-most groundwater source and WSP. However, these deeper groundwater sources and WSPs are not applicable as Project works are not proposed at depths that would influence these deeper groundwater systems.

3 EXISTING ENVIRONMENT (SURFACE WATER AND GROUNDWATER)

3.1 CATCHMENT CHARACTERISTICS

The Project Area is located south of the Murrumbidgee River, within the lower Murrumbidgee River Catchment in southern NSW. The Murrumbidgee River flows in a south-westerly direction from its headwaters in Kosciuszko National Park. The topography of the Project Area is relatively flat and homogeneous ranging between 94 and 105 metres Australian Height Datum (mAHD) see Figure 3.1. Figure 3.2 shows the Project Area is drained by several larger watercourses namely Abercrombie and Eurolie Creeks in the north, and Coleambally Outfall Drain in the south.

The Project Area is located mostly east of the Jerilderie Road, North Boundary Road and Willurah Road junction, either side of the existing 220 kV Balranald to Darlington Point transmission line, and south of the Oolambeyan National Park. The closest population centre is Hay, 36 km northwest of the Project Area. Smaller townships of Darlington Point, Jerilderie and Coleambally are nearer to the Project Area.

The Cobb Highway is situated approximately 32 km northwest of the Project Area and Conargo Road is 8.5 km east of the Project Area. Jerilderie Road traverses the Project Area in a north to south direction until intersecting with North Boundary Road and Willurah Road. North Boundary Road crosses the middle section of Project Area in an east to west direction. Willurah Road is adjacent to the western side of the southern extent of the Project Area.

No known flood prone land or flood management areas are identified within the Project Area. No previous flood studies have been undertaken within the Project Area and it is not mapped as flood prone. The Murrumbidgee River has experienced 12 (recorded) major historical flooding events between 1870 and 2022. There may be the potential for flows from the Murrumbidgee River to be conveyed through the interconnected floodway network in major flood events.

3.1.1 Topography and drainage

The local topography of the Project Area (20,628 ha) based on LiDAR survey dated December 2014 is shown in Figure 3.1. The Project Area is generally flat with ground levels varying between 94 and 105 mAHD. The average elevation of the Project Area is 99.8 mAHD. The topography of the Project Area is undulating, sloping gently down gradient to the southwest.

The terrain to the south of the Murrumbidgee River (as shown in Figure 3.2) generally falls in a west to south-westerly direction. During major to rare flood events, there is potential for floodwaters to break out from the watercourses, with the breakouts in some areas having the potential to contribute to flooding in the Project Area. Floodwaters would drain according to the fall of the land and via the watercourses, eventually draining via the Coleambally Outfall Drain to reach the Murray River 50 to 60 km to the west of the Project Area. Flood water that does not reach drainage lines may become trapped in low points of the floodplain and become lost from the floodplain via infiltration or evaporation.

Flooding of the Murrumbidgee River in the Hay area was documented shortly after European settlement of the area in 1859. Between the 1890s and 1930s major dams, levee and irrigation scheme were undertaken in the upstream catchments of the Murrumbidgee River. The flood of record for the area occurred in 1956. Historic newspaper articles indicate that notable flood events occurred in the Hay area in the following years: 1870, 1878, 1890, 1897, 1922, 1931, 1950, 1956, 1959, 1974, 1990, 2010 and 2022. The consequences of historical flooding has not resulted in construction of flood mitigation infrastructure near to the Project Area.

The Coleambally Outfall Drain in the south of the Project Area is part of the Coleambally Irrigation area which covers 30 km² and provides irrigation to around 500 farms. The water supply is via an open and gravity-controlled channel network within the region between the town of Coleambally and

Billabong Creek near the locality of Bundyulumbulah. The water supply is regulated under the Murrumbidgee River Water Sharing Plan.

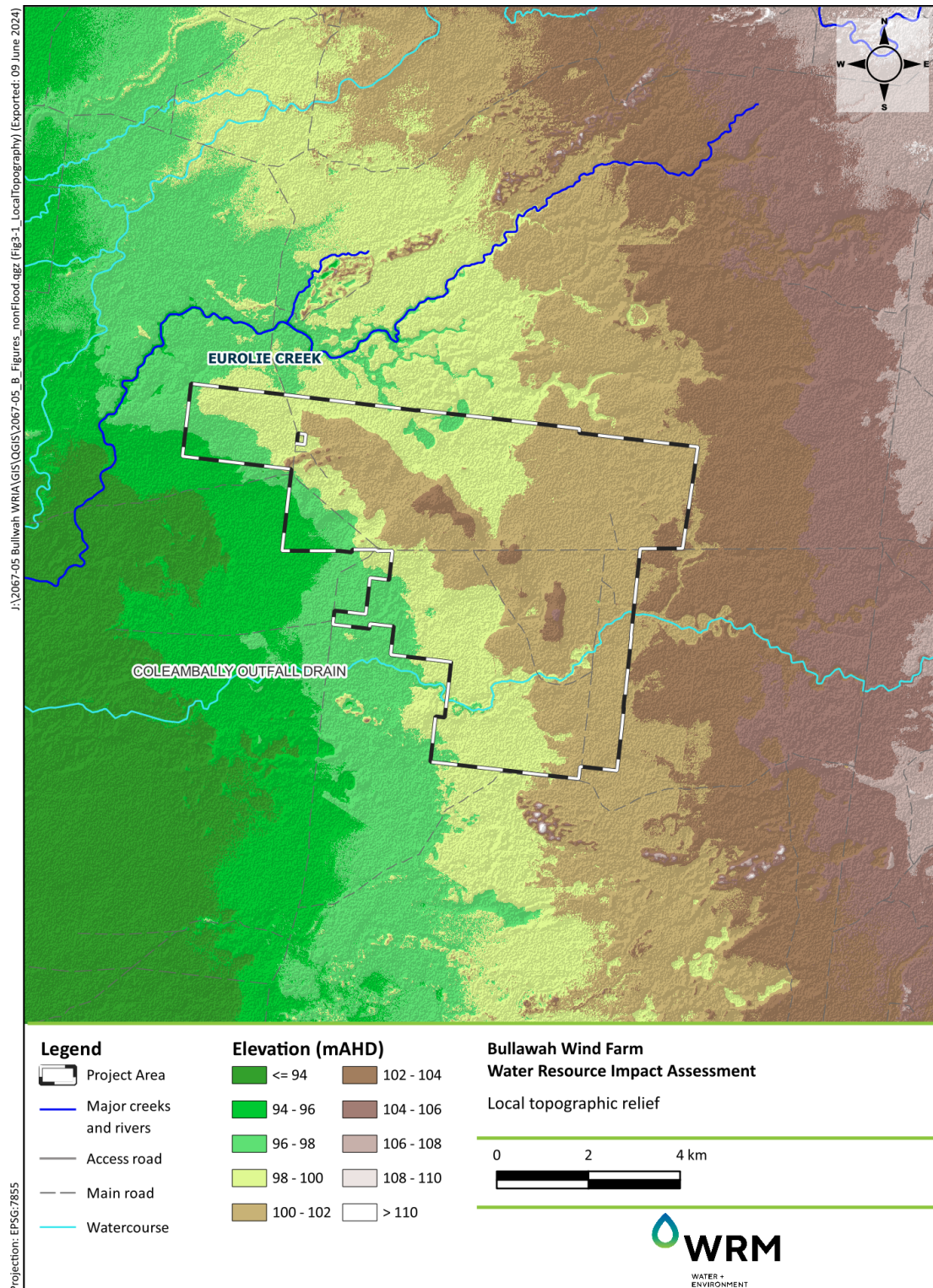


Figure 3.1 Local topography

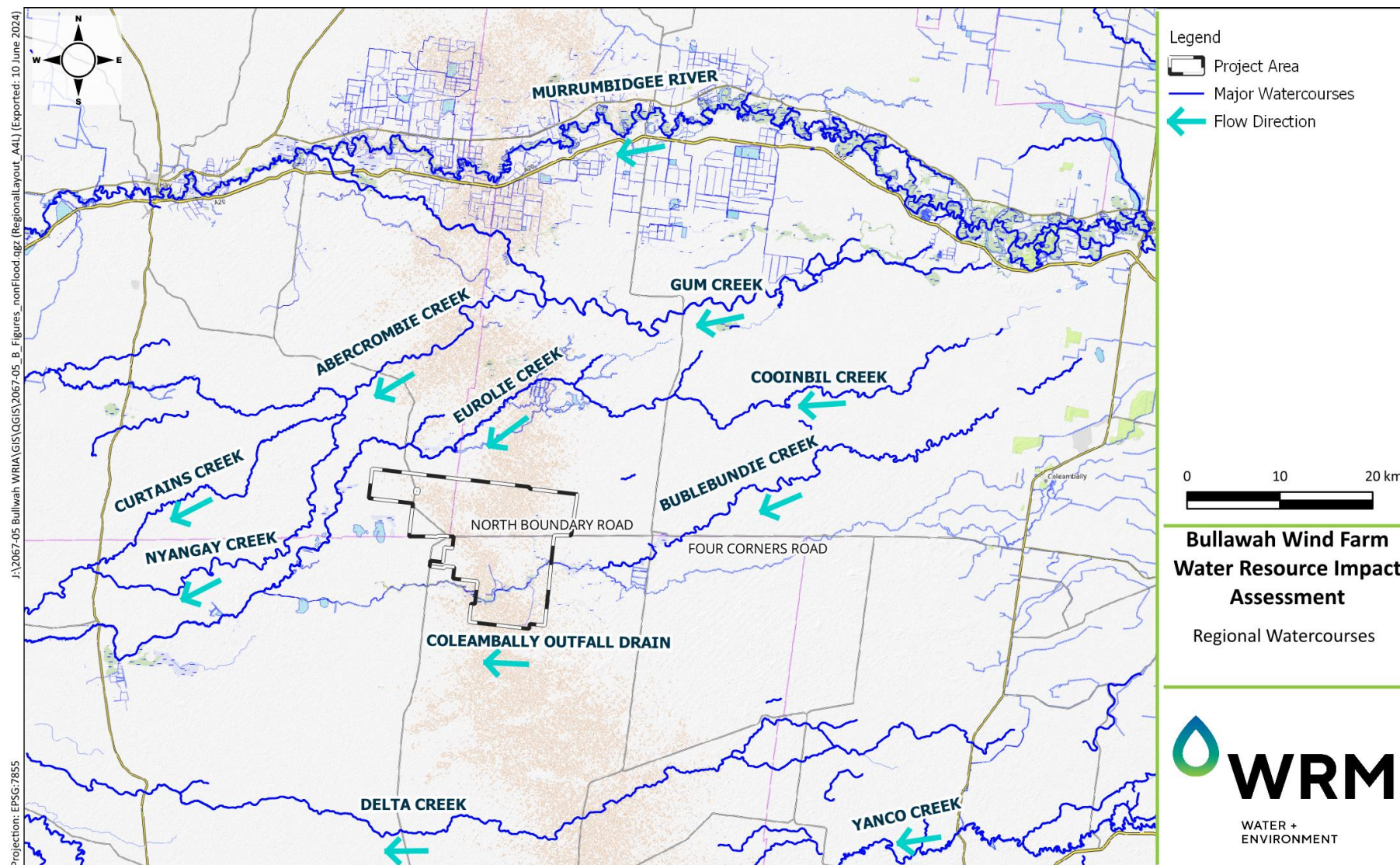


Figure 3.2 Regional watercourses

3.1.2 Land use

The Project Area is zoned as RU1 (Primary Production) under the Hay Local Environment Plan (LEP) 2011, the Murrumbidgee LEP 2013 and Conargo LEP 2013. The majority of land that surrounds the Project Area is also zoned RU1 Primary Production. The Oolambeyan National Park is directly north and adjacent to the Project Boundary and is primarily zoned as C1 National Parks and Nature Reserves, with small areas of RU1 Primary Production land also present. The Project Area is currently used for various agricultural activities including sheep and cattle grazing, irrigated cropping, and groundwater extraction. Additionally, portions of the Project Area contain native vegetation.

There are three (3) host residences located within the Project Area. Additionally, scattered associated and non-involved residences are located within the surrounding area.

The Project Area includes numerous public and private access roads used by residents and for agricultural purposes.

3.1.3 Regional landform

The Project Area is within the Murray Basin (Riverina) is a large low-lying basin containing unconsolidated sediments and sedimentary rocks. The Murray Basin comprises three major rivers, namely the Murray, Murrumbidgee and Lachlan Rivers. The underlying geology of the Project Area consists of Shepparton Formation which formed in a fluvio-lacustrine environment between the Pleistocene and Holocene (Minesoils, 2024). The dominant lithology consists of alluvial floodplain deposits, see Figure 3.3. The Shepparton Formation consists of unconsolidated to poorly consolidated clay, silt, silty-clay, with lenses of fine to coarse sand and gravel. The formation has been partially modified by groundwater table fluctuation (Minesoils, 2024).

Soil features originated by water and wind (aeolian) geomorphological processes. Riverine features of the alluvial fans and fluvial complexes which vary rapidly both laterally and in depth. The most common aeolian landforms are those which involve accumulation, especially of sandy material, occurring as dunes, lunettes or sand-ridges.

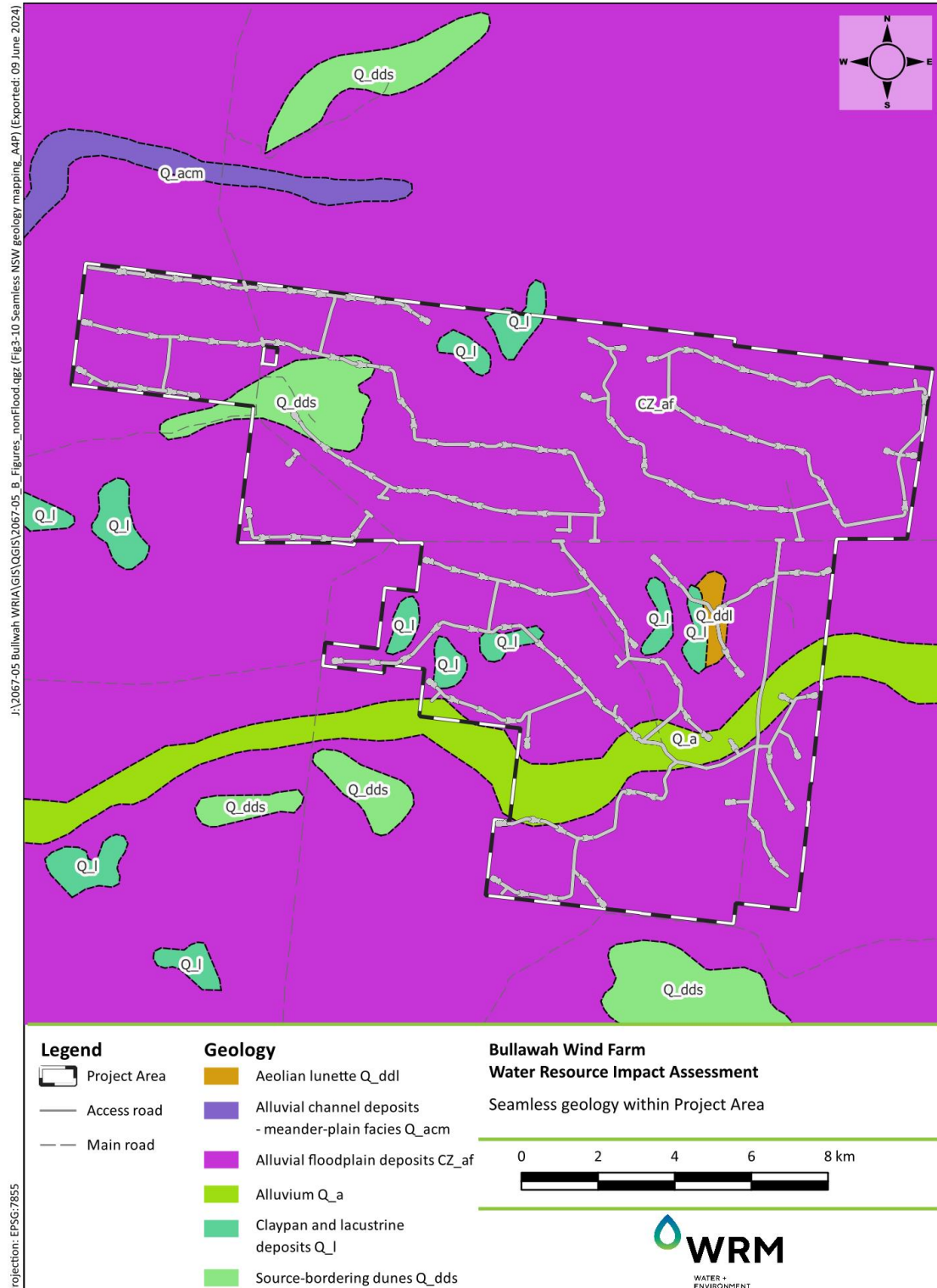


Figure 3.3 Seamless NSW geology mapping

Source: NSW DRNSW 2019

3.2 CLIMATE

The nearest open Bureau of Meteorology (BoM) daily rainfall gauge to the Project Area is 60 km north of the Project Area at Hay (Airport GS075019). The Airport gauge opened in June 2007 and overlaps the much longer gauge at Hay (Miller St GS075031) which opened in May 1877 and closed in June 2015. The gauge data from both gauges was merged to produce a continuous record of 146 years from June 1877 to March 2024. Given the proximity of both gauges to the Project Area, the recorded data is considered representative of the local region rainfall patterns.

Climate data was obtained from the SILO database of historical climate records for Australia hosted by the Queensland Government's Department of Environment and Science (DES). This service interpolates raw rainfall and evaporation records obtained from the Bureau of Meteorology (BOM) to provide a spatially and temporally complete climate dataset. Climate data was obtained for SILO grid point -34.75 Latitude and 145.15 Longitude which is the grid point closest to the Project Area between 01/01/1889 to 31/01/2024.

Table 3.1 and Figure 3.4 present the annual rainfall and evaporation statistics based on the Project Area climate data sourced for SILO grid point. Table 3.2 and Figure 3.5 present the monthly rainfall and evaporation statistics based on data for the SILO grid point. The median annual rainfall is 359.6 millimetres and median evaporation is 1845 mm.

Utilising the climate database, the average total rainfall for each calendar month from 1889 to 2024 was calculated and is summarised in Table 3.2. Figure 3.5 shows there is only a moderate level of seasonality to rainfall within the Project Area, and that rainfall is typically low in most months. Lowest average rainfall is recorded in April and May. Highest monthly rainfall is recorded in March, June and November. Between July and October there is very little variation between monthly rainfalls.

Table 3.1 Annual Rainfall and Evaporation (mm) for Project Area

Statistic	Rainfall ^a	Evaporation (Class A Pan) ^a
10 th percentile	214.8	1698
50 th percentile	359.6	1845
90 th percentile	511.5	1981

^a Data source: <https://www.longpaddock.qld.gov.au/silo/>

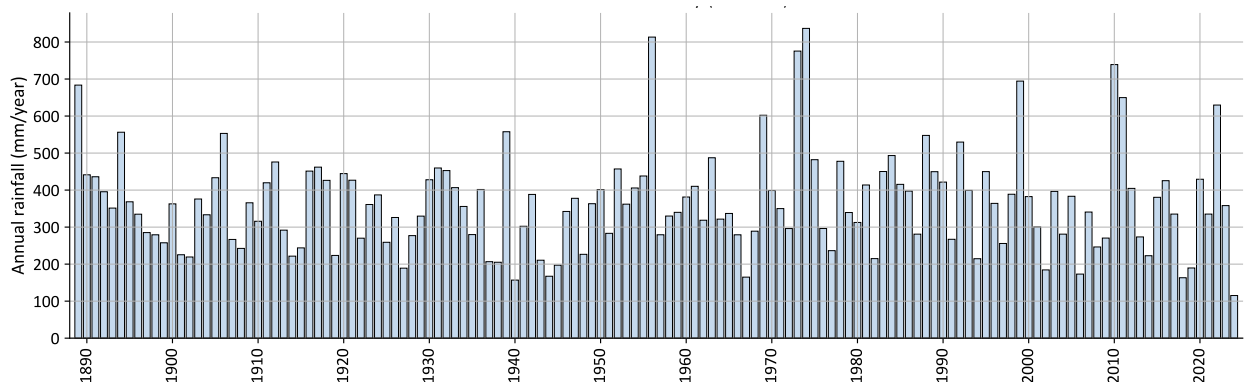


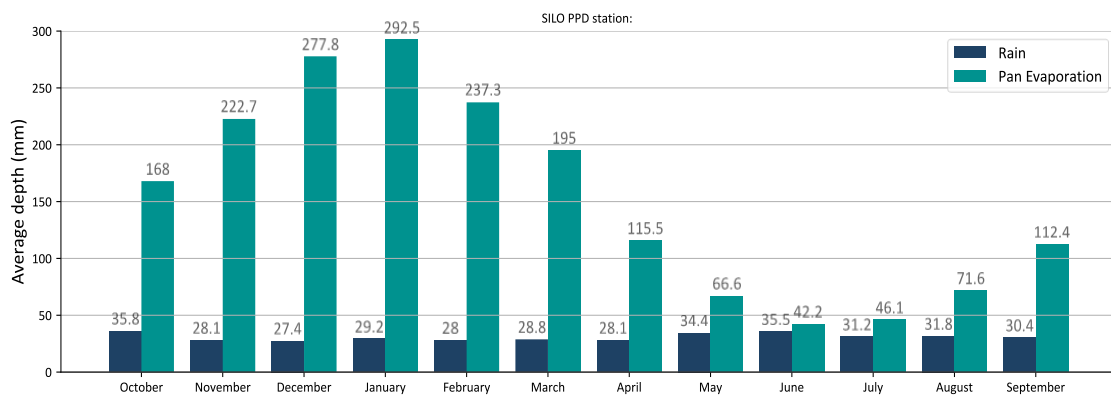
Figure 3.4 Annual rainfall totals at Project Area

Source: SILO, 2024

Table 3.2 Monthly climate statistics, 1890 to 2024

Month	Evaporation (mm) (Class A Pan)	Rainfall (mm)
October	168	35.8
November	222.7	28.1
December	277.8	27.4
January	292.5	29.2
February	237.3	28
March	195	28.8
April	115.5	28.1
May	66.6	34.4
June	42.2	35.5
July	46.1	31.2
August	71.6	31.8
September	112.4	30.4

Source: SILO, 2024


Figure 3.5 Monthly rainfall and evaporation

Source: SILO, 2024

Figure 3.6 presents a timeseries of daily rainfall accumulation starting on 1 October each year to represent the water year. There is minimal variance between the 25th to 75th percentile annual rainfall total. It is possible for annual rainfall sequences to generate four times the median rainfall as occurred in the 1974/75 water year.

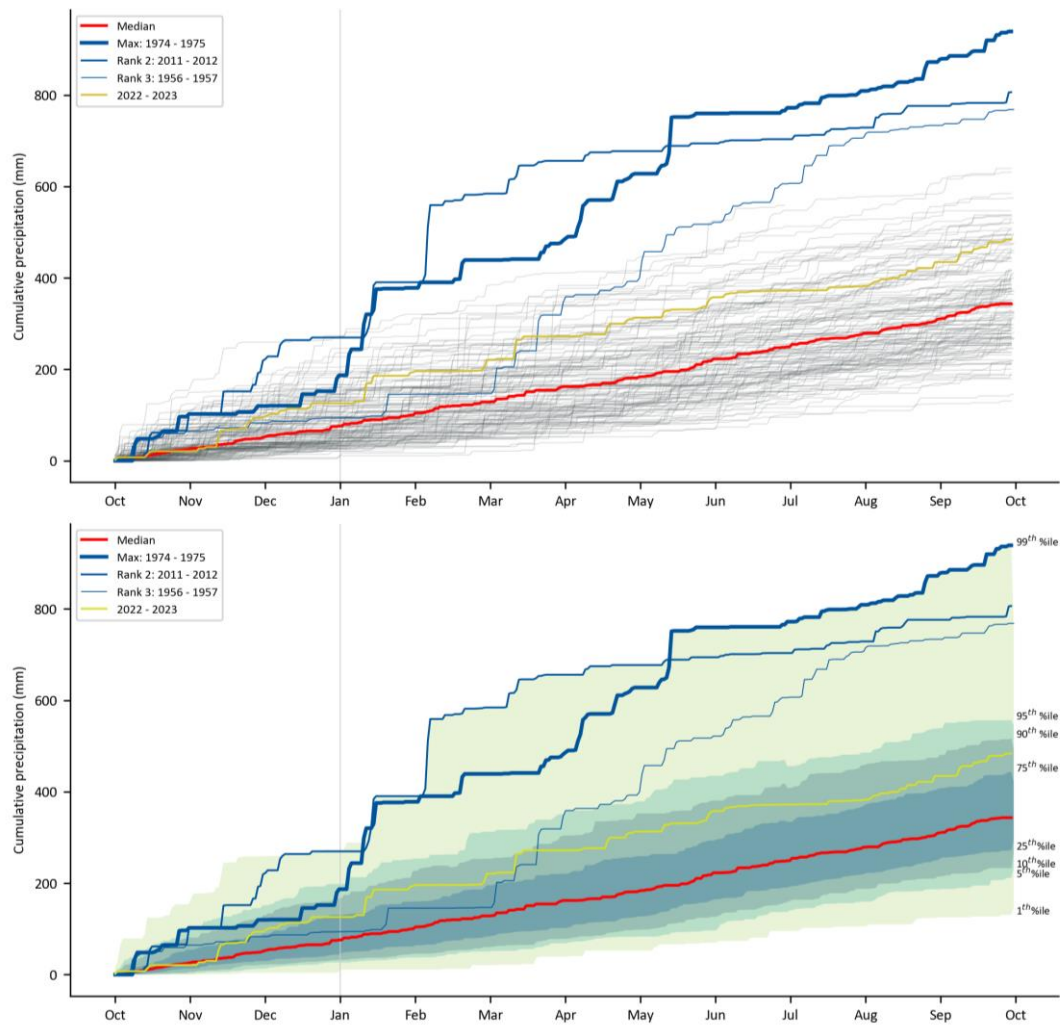


Figure 3.6 Rainfall variability at Project Area

source: SILO, 2024

3.3 WATERCOURSES

The watercourse network traversing the Project Area is shown in Figure 3.7, including numerous minor watercourses of 1st and 2nd Strahler order based on NSW hydroline spatial data.

The Project Area is drained by several ephemeral watercourses, the higher stream orders being Eurolie Creek (4th order) and Coleambally Outfall drain (9th order). Further ephemeral depressions are noted throughout the Project Area and numerous small farm dams are present. The drainage from the Project Area is predominantly in a south western direction following the Coleambally Outfall drain to Billabong Creek. From there, flows reach the Edward River and then the Murray River.

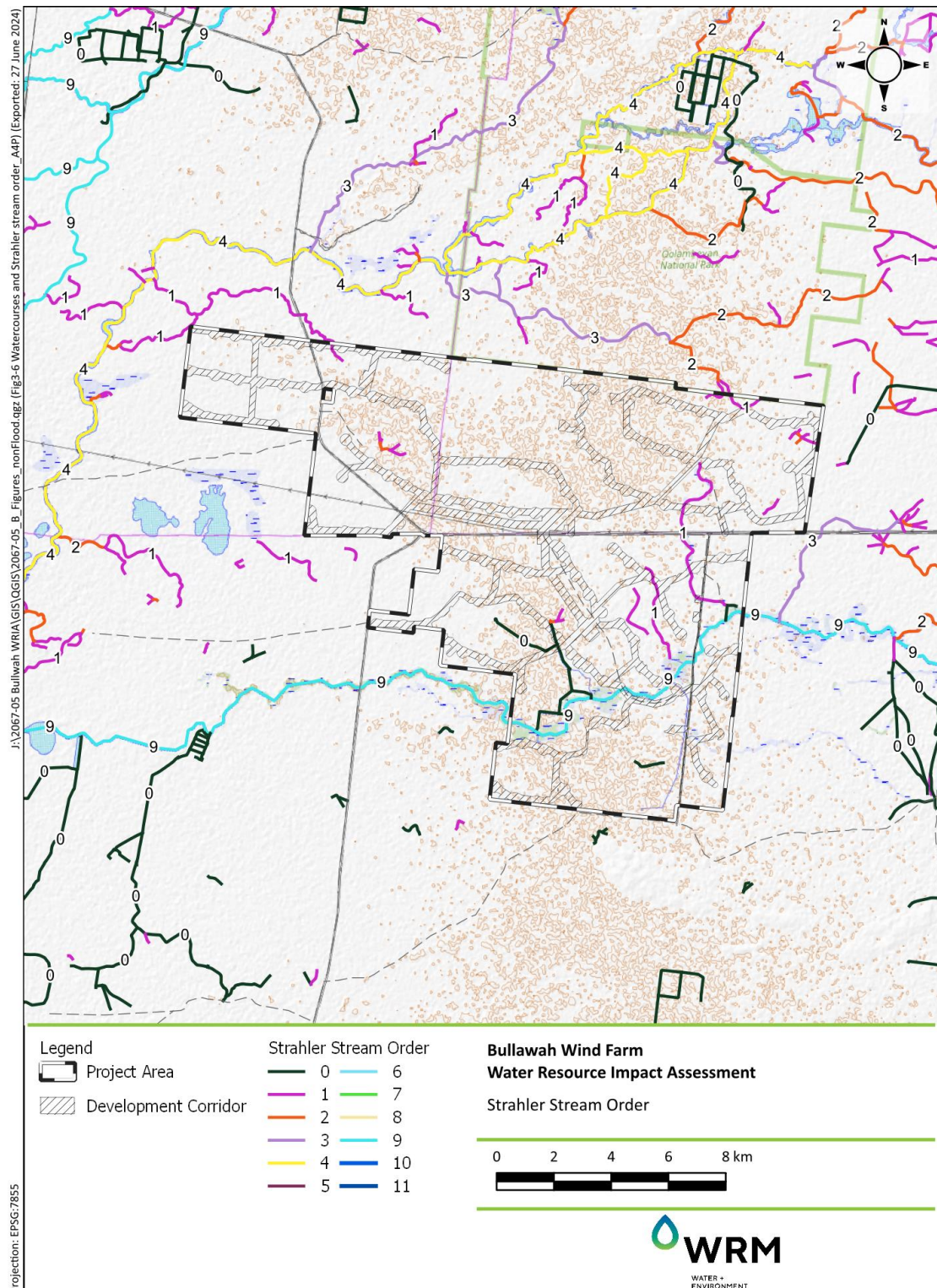


Figure 3.7 Watercourses and Strahler stream order

3.4 SOIL LANDSCAPES

The following section presents the NSW state government regional mapping data for soil types, inherent soil fertility and Land and Soil Capability (LSC) as applied to the Project Area (NSW and Department of Planning, Industry and Environment, 2022). Minesoils Pty Ltd (Minesoils) was engaged by Umwelt to conduct a Soil, Land and Agricultural Impact Assessment of the Project located in the Riverina region of New South Wales. The baseline soil and agriculture resources are detailed within the *Soil and Agricultural Impact Assessment* report (Minesoils, 2024). Appendix C contains soil profile descriptions collected from within the Project Area.

3.4.1 Soil Types

A soil survey undertaken by Minesoils found the Project Area to contain two (2) dominant soil mapping units (as shown in):

- Soil Unit 1: Vertosols – covering 13,430 ha.
- Soil Unit 2: Dermosols – covering 7,198 ha.

Laboratory testing results, including sodicity and dispersibility, indicate there is moderate to high potential risk for soil dispersion where soil impacts occur. Higher impact activities such as where earthworks are necessary for construction of sub-station pads or site facilities are very likely to result in increased dispersive behaviour when soil is remoulded, compacted or pulverised. However, due to the nature of the landform, the risk of erosion and sedimentation impacts as a result of the Project remains a low.

3.4.2 Land and Soil Capability

Land capability, as detailed in LSC scheme, is the inherent physical capacity of the land to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources. Failure to manage land in accordance with its capability risks degradation of resources both on- and off-site, leading to a decline in natural ecosystem values, agricultural productivity, and infrastructure functionality.

The Project Area was also subject to a site verification assessment LSC, in accordance with the LSC scheme, and was found to contain two (2) LSC classes:

- LSC class 6: low capability land – covering 15,596 ha.
- LSC class 7: very low capability land – covering 5,032 ha.

LSC mapping (as verified by Minesoils, 2024) is shown in . Soil and landscape information was available through SEED Dataset provided by the former Department of Planning and Environment (2021).

3.4.3 Soil Profiles

There is no Biophysical Strategic Agricultural Land (BSAL) present within or in the vicinity of the Project Area. Additionally, there is no land mapped Class 1-3 land, defined as capable of a wide variety of land uses under the LSC present within the Project Area. All land within the Project Area has been verified as Class 6 or Class 7, being low or very low capability land under the LSC Scheme (Minesoils, 2024). Existing agricultural activities within the host properties will continue and co-exist with the Project. There are no mapped high-risk areas for acid sulphate soils within the Project Area.

Table 3.3 presents the soil properties for the Project Area, sourced from the SEED Dataset (DPE, 2021).

Table 3.3 Soil Profile Properties

Parameter	Value	
	0 – 0.5 m Depth (Range)	0.25 – 0.35 m Depth (Range)
Electrical Conductivity (dS/m)	0.04-0.13	0.23-0.72
pH	5.8-8	7.3-8.7
Emerson Aggregate test SCS method	2(1)	2(1)-2(2)
Aggregate stability wet sieve	12.22-36.45	31.24-41.69
Clay Percentage (%)	19-52	54-61
Coarse Sand (%)	10-49	8-13
Fine Sand Percentage (%)	19-30	19-23
GR gravel Percentage (%)	0	0
Silt (%)	3-11	9-10
Organic Carbon (%)	0.758-1.496	0.359-0.551

The parameters presented in Table 3.3 indicate the Project Area soil:

- may have a mix of clay and coarse sand with small amounts of finer sand and silt textures in the topsoil and subsoil. The subsoil shows a lower concentration of coarse sand;
- are moderately erodible
- are moderately neutral in the topsoil and subsoil
- are non-saline.

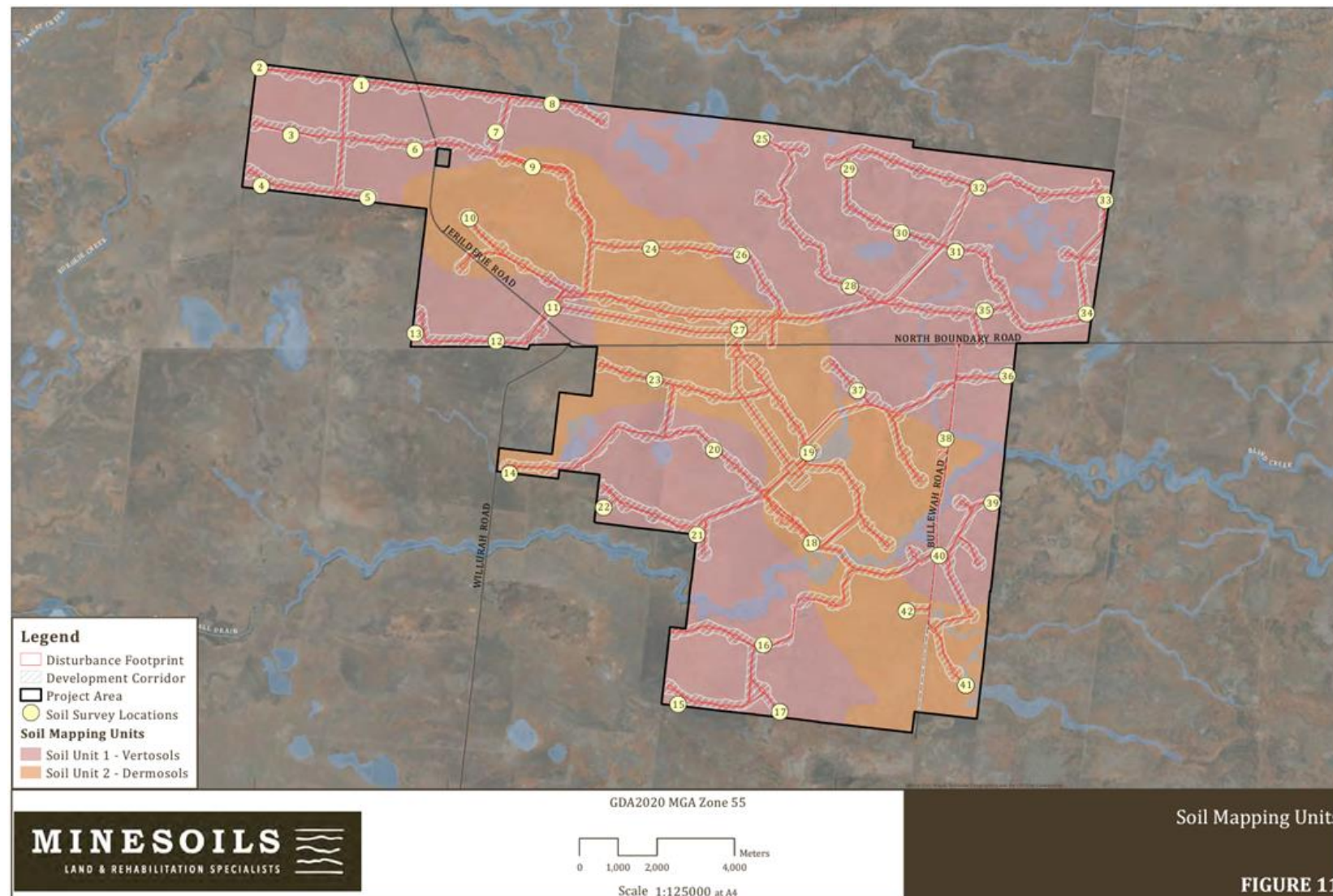


Figure 3.8 Soil Mapping Units

Source: Minesoils, 2024

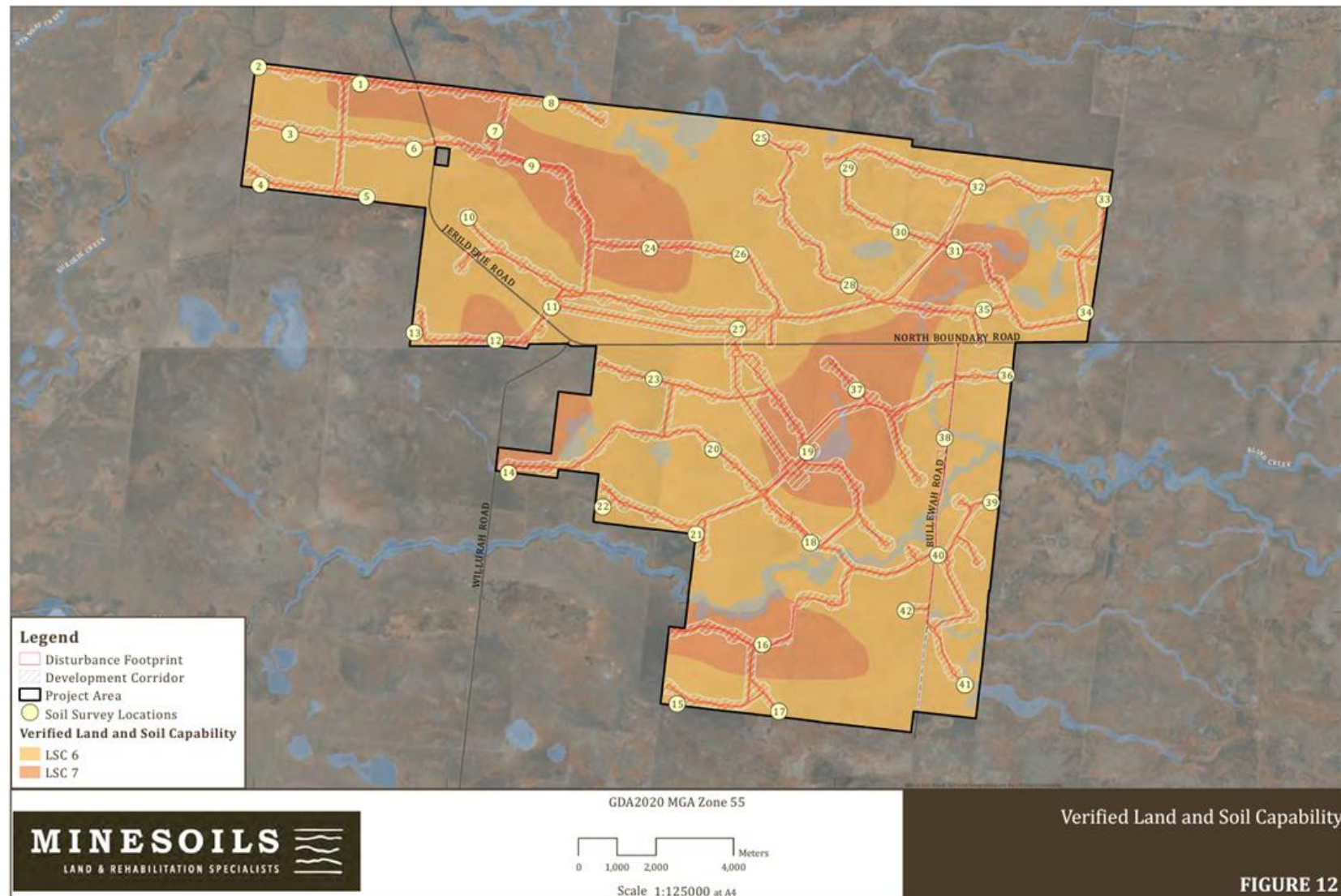


Figure 3.9 Land and soil capability

Source: Minesoils, 2024

3.5 WATER QUALITY

3.5.1 NSW Water Quality Objectives

The NSW Water Quality Objectives (WQOs) have been developed to guide plans and actions to achieve healthy watercourses. The WQOs are based on measurable environmental values (EVs) for protecting aquatic ecosystems, recreation, primary industries, drinking water and industrial water. The Murrumbidgee Catchment has its own specific WQOs³. In the absence of regionally defined objectives, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018 (ANZECC & ARMCANZ, 2018) was assessed to provide a guide for the WQOs for the Project Area. The WQOs have been developed to achieve suitable water quality for the protection of:

- aquatic ecosystems
- visual amenity
- primary and secondary contact recreation
- livestock water supply
- irrigation water supply
- homestead water supply
- drinking water
- aquatic foods.

Based on the likely construction activities and operations for the Project and the environmental values listed above, the WQOs are considered relevant to the Project. An assessment of the potential impact on water quality is presented in Section 6.1 and considers the estimated pollutant concentrations and loads in stormwater discharging from the Project Area.

3.6 WATER EXTRACTION AND USERS

WSPs have been developed under the WM Act to protect the environmental health of water sources, whilst securing sustainable access to water for all users. The WSPs specify maximum water extractions and allocations and provide licensed and unlicensed water users with a clear picture of when and how water will be available for extraction. A check was undertaken for the Lot and DP numbers within the Project Area and no WALs were returned from the database. Approval numbers associated with the Lower Murrumbidgee Shallow Groundwater Source and the Lower Murrumbidgee Deep Groundwater Source were returned. Table 3.4 summarises the WALs for the nearby water source.

³ <https://www.environment.nsw.gov.au/ieo/Murrumbidgee>

Table 3.4 Water Sharing Plan and Water Access Licences near Project Area

WAL No.	Licence Category	Share components	Water Source
7717	Coleambally Irrigation	117,342	Murrumbidgee Regulated River Water Source
11395	Coleambally Irrigation	3,500	Murrumbidgee Regulated River Water Source
24034	Coleambally Irrigation	9,158	Murrumbidgee Regulated River Water Source

3.7 GROUNDWATER

In total there are 34 registered groundwater bores located within the Project Area (BoM, 2022). However, only four (4) groundwater bores are listed as currently functioning, see Figure 3.11. One (1) (GW415943) is for water supply and three (3) (GW050414, GW052479, GW048908) are for stock and domestic purposes. The drilled depth of water supply and stock and domestic bores ranges between 24 m and 104 m below ground level (BGL).

The regional water table is relatively deep located at around 75 mAHD. Figure 3.10 shows the historic groundwater elevations at the centre of the Project Area at GW036235. Localised perched groundwater systems are still possible. Based on salinity data for registered bores, groundwater quality in the Project Area has a salinity ranging from 300 mg/L (fresh) to 3,000 mg/L (slightly brackish) (BOM Groundwater Explorer – Bore log).

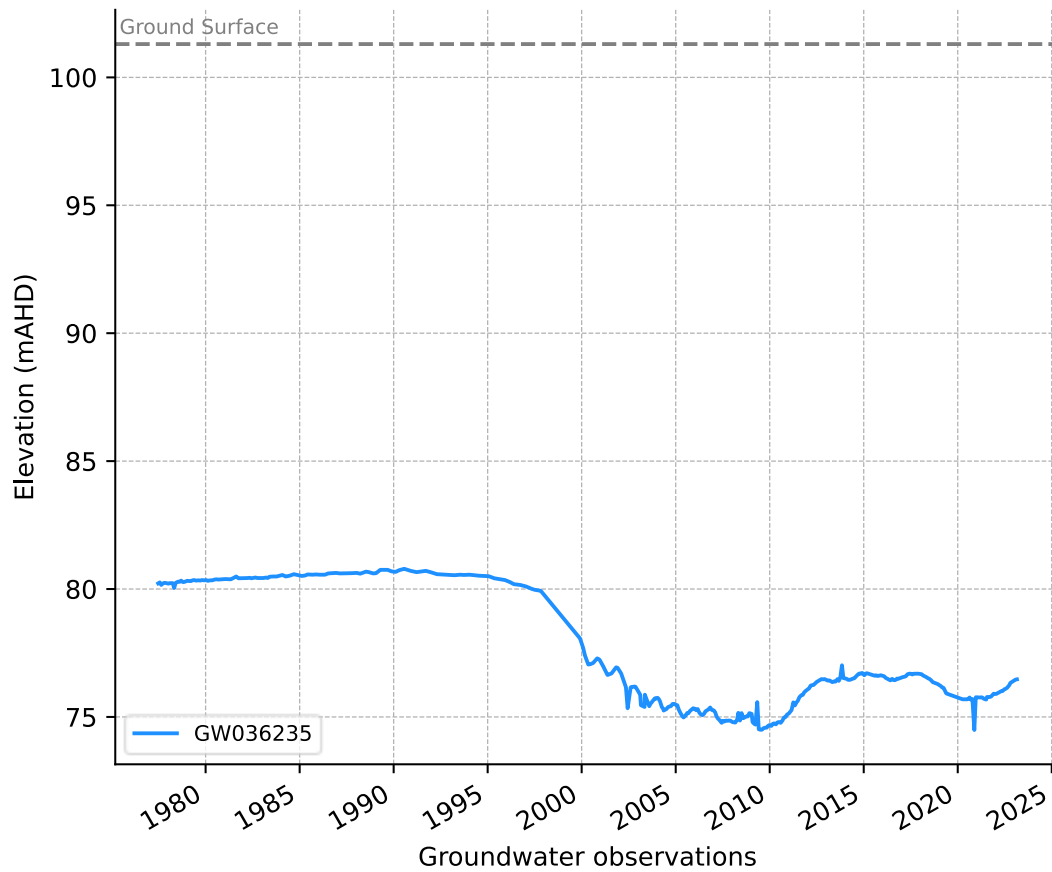


Figure 3.10 Groundwater elevation trend within Project Area

Source: bom.gov.au/water/groundwater/explorer

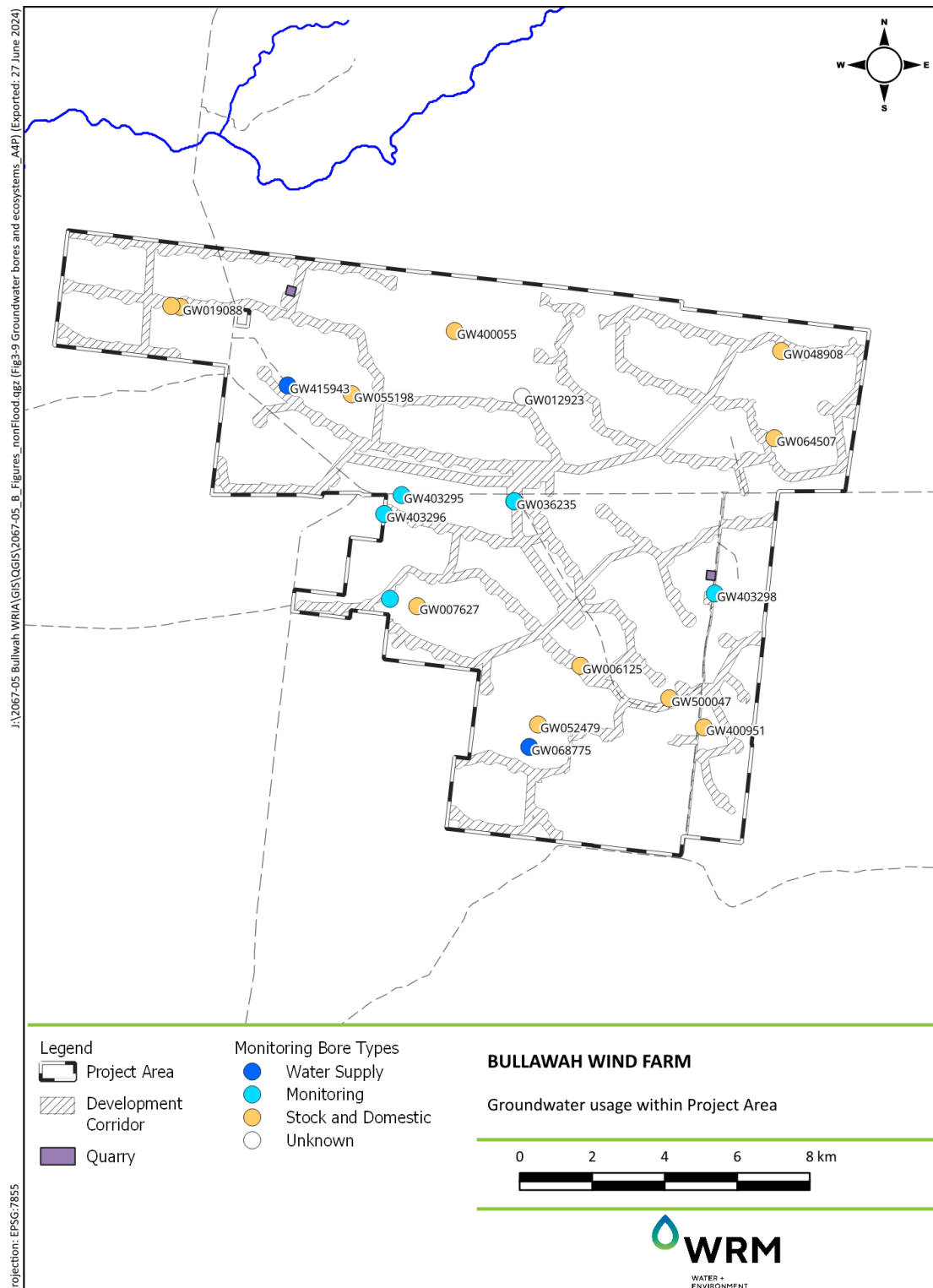


Figure 3.11 Groundwater bores

Source: bom.gov.au/water/groundwater/explorer

3.7.1 Potable Water Supply

Potable water demands for the Project would be supplied via water tanker and stored in on-site water tanks. Potable water storages would be routinely tested to ensure water quality meets the requirements of the Australian Drinking Water Guidelines (ADWG) (National Health and Medical Research Council, 2011) and an appropriate maintenance regime would be implemented to ensure water quality ADWG water quality standards are maintained.

3.7.2 Groundwater Dependent Ecosystem

A Groundwater Dependent Ecosystem (GDE) is an ecosystem which is dependent on the availability of groundwater to maintain structure and function. Terrestrial (including riparian vegetation) GDEs are dependent on the subsurface presence of groundwater to a depth of 10 m BGL. Aquatic GDEs are dependent on surface water's interaction with groundwater. Ecosystems are classified as:

- High potential ecosystems which have a high (strong possibility) of groundwater interaction
- Moderate potential ecosystems which have a moderate potential for groundwater interaction.
- Low potential ecosystems which have a low (unlikely) potential for groundwater interaction.

According to the GDE Atlas (NSW OHE, 2018), the Project Area is mapped as containing a low to high potential GDEs, see Figure 3.11. GDEs are present within the channels of Coleambally Creek and Eurolie Creek, which flow through the Project Area. The GDEs present are aquatic GDEs, recorded as high potential from a national assessment (DPE, 2012). Vegetation surrounding the Coleambally Outfall Drain is identified as a high potential terrestrial GDE (River Red Gum - Black Box woodland wetland of the semi-arid (warm) climatic zone), based on regional studies. Additionally, Eurolie Creek is identified as a low potential aquatic GDE. A reduction in groundwater level(s) or piezometric pressure beyond seasonal variation within this region may result in the permanent loss of defined habitat types (DPE, 2011).

3.7.3 Groundwater Vulnerability

Groundwater vulnerability is described by the NSW Government (2023) as the vulnerability or risk of aquifers to contamination, relating to physical characteristics of the location, such as the depth to the water table and soil type. Mapping provided by the NSW Government was reviewed for groundwater vulnerability within and surrounding the Project Area. There are no groundwater vulnerability areas mapped for the Project Area (DPE, 2014).

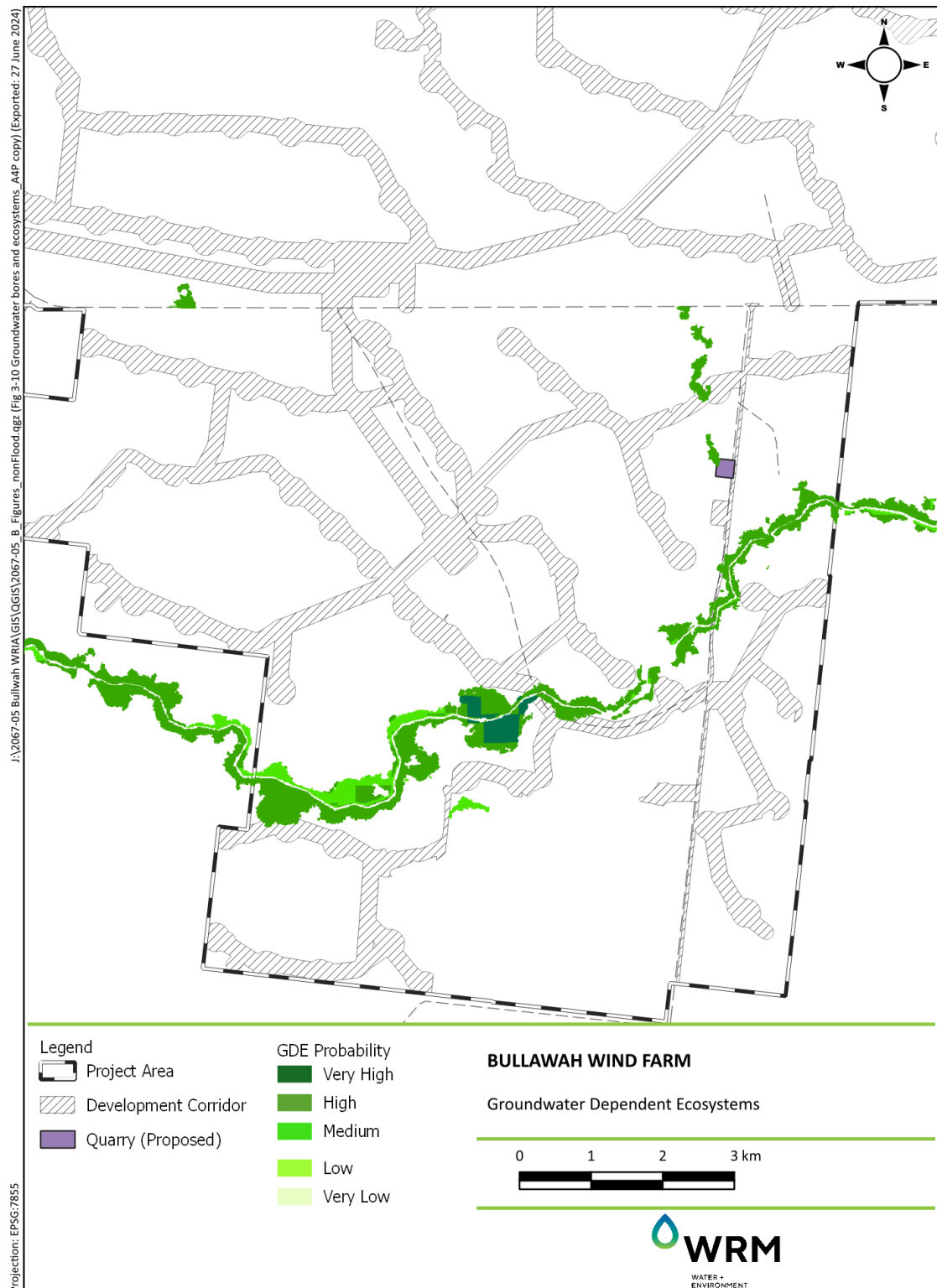


Figure 3.12 Groundwater Dependent Ecosystems

Source: NSW OHE, 2018

4 WATER MANAGEMENT

4.1 OVERVIEW

The Project will require a water supply during the construction, operational and decommissioning phases. During construction, water will primarily be used for revegetation and dust suppression. The associated water demand during the construction phase is estimated to be approximately 224 ML for the duration of construction. Unfavourable (dry and windy weather) and unanticipated circumstances (stringent dust suppression conditions) may see water demand exceed 300 ML. The water demand during operations is expected to be significantly lower in the range of 0.5 to 2 ML per annum.

4.2 WATER DEMAND

4.2.1 Construction Water Demand

The greatest water demand would be during the construction phase of the Project. Project water demands include:

- Soil and fill conditioning
- Dust suppression
- Concrete production
- Concrete washout
- Vehicle and equipment wash down, and
- Temporary workers accommodation.

A preliminary assessment of water demands has been made based on the current design and a number of assumptions outlined in Table 4.1. Water demand during construction phase will increase gradually, peak and then decline gradually as the Project reaches practical completion. Maximum water demand is expected towards the end of the first year of construction. This coincides with the main period of construction of access tracks, foundations and hardstand areas. Over the first half of the construction phase, the average monthly demand is approximately four (4) to five (5) times higher than the consumption expected in the final half. Water demand during the initial operational phase will be lower again. The assumed average and maximum daily breakdown of water requirements for the construction period:

- Peak daily demand of 800 kL/day raw with 40 kL/day potable water; and
- Average daily demand of 350 kL/day raw with 20 kL/day of potable water.

These values are based on a bottom-up calculation for the purposes of impact assessment and based on the assumptions outlined below. Detailed assessment of water demands will be undertaken during detailed design of the Project to optimise methodology and minimise water demand.

Table 4.1 Construction water balance assumptions

Water Demand	Water Usage Assumptions
Dust suppression	Active work areas only - assume 5% of total tracks at any one time. An allowance of 200 kL per day was used to balance evaporation, refer Section 3.2
Construction – road	6.5m wide by 115 km. Rip to 300mm and re-compact - add 8% water content to condition. 300mm road base - add 12% water content to condition
Washdown - concrete	Approx. 125 L per m ³ of concrete poured
Washdown - vehicle	Allowance 5 kL/day typical, 10 kL/day (wet days), refer Section 3.2
Construction – Concrete	22 ML to cover balance transmission footings/ battery storage/ main and collector substations
Construction - Turbine Foundations	143 units excavation and foundation construction period 270 m ³ / WTG approx. 100 L water per tonne 1 week curing - 5 L/m ² (mixing curing compound)
Potable	Construction workforce: Median 150 personnel, Peaking at 380 personnel Allowance 40 L/pers/day - 6 day week

Table 4.2 Construction Phase Total Water Demand (indicative only)

Water Demand	Total Water Usage (ML)
Construction – stabilised pavement	14
Construction – Battery storage/ switchyard/ transmission	22
Construction - Concrete foundations	21
Washdown - Concrete plant	5
Washdown - Vehicle	5
Potable	11
Subtotal demand	78
Dust suppression (nett. Evap)	146 (222)
Total demand (likely) (high)	224 (301)

¹ Numbers in brackets indicate a high (90th percentile) evaporation scenario. This represents an approximate upper limit for water demand.

4.2.2 Operational Water Demand

During operations, up to 2 ML per year would be required for ongoing maintenance activities such as amenities and potable purposes by operational staff, and equipment washing down, if required. Washing would not require any detergent or cleaning agents. A static water supply, with the capacity to be determined during the detailed design phase, will also be established and maintained for fire protection.

4.3 WATER SUPPLY SOURCES

The majority of raw/non-potable water required to meet Project water demands would be sourced on site from licensed groundwater bores under agreement with host landholders. Host landholders currently hold WALs permitting groundwater extraction in excess of 870 ML per year, or approximately 2.4 ML per day, which exceeds their current water usage requirements.

If required, supplementary water supplies may also be sourced via:

- Commercial suppliers in the nearby region (via water truck)
- Groundwater from licenced bores under agreement with neighbouring landholders
- Harvested runoff from disturbed areas captured in excavations or sediment basins/traps constructed to prevent sediment transport off-site
- Recycling and reusing water.

The largest water demands, such as for dust suppression, soil conditioning, and asphalt and/or concrete batching, are all non-recoverable water uses. Where possible, water would be recycled and reused as far as practical.

Any water supplied to the Project from existing groundwater bores will be sourced under agreement with relevant landholders while ensuring any WALs, works approvals and water use approvals required under the WM Act are obtained.

Water sources would be determined prior to the commencement of construction in consultation with suppliers and landholders.

4.3.1 Amenities Wastewater

Wastewater from amenities during all phases of the Project will be captured in a tank and transferred periodically by a suitably licensed contractor to an appropriate wastewater treatment facility.

4.4 SITE WATER BALANCE

The Project will require water to be supplied from a variety of sources. The water demands were quantified in Section 4.2 and the possible supply sources were outlined in Section 4.3. An indicative summary detailed site water balance is shown in Table 4.3.

All on site storages required as part of the water supply were assumed to be constructed during the construction phase, i.e., prior to the commencement of operations. The purpose of each reservoir is determined by the water usage and quality. If there is insufficient on site storage, an external water source would be required to meet site water demand during dry periods.

Table 4.3 Site water balance (indicative)

Type	Feature	Construction Phase (total)	Operation (annual)
Water Demands	TOTAL	224 ML	2 ML
	Dust suppression (likely)	146	
	Construction input	57	-
	Washdown	10	< 1
	Potable	11	< 1
Water Supply	Rainfall	30 - 90 ML refer Table 3.1	2 ML
	External raw water	Balance acquired from licenced sources or via agreement	Min.
	External potable water	11 ML Purchased	~0.1 ML Purchased

4.5 EROSION AND SEDIMENT CONTROL

Throughout the construction phase of the Project, erosion and sediment controls (ESCs) will be established in general accordance with *Managing Urban Stormwater – Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2C: Unsealed Roads* (Department of Environment and Climate Change, 2008) (i.e. the 'Blue Book'). The following sections outline the Project ESC design standards and anticipated ESCs to be implemented for the Project. Should the Project be approved and constructed, a suitably qualified person will prepare detailed Soil and Water Management Plans (SWMPs) to facilitate implementation of best practice ESCs during all phases of the Project.

4.5.1 Construction on Waterfront Land

Approved SSD projects are exempt from the requirement to acquire Controlled Activity Approvals (CAAs) for works on waterfront land (works within 40 m of the top of bank of a watercourse) under s.4.41(1)(g) of the *Environmental Planning and Assessment Act 1979*. While a CAA is not required, all works on waterfront land for the Project will be undertaken in accordance with the former DPE's *Guidelines for Controlled Activities on Waterfront Land*.

4.5.2 Erosion hazard assessment

An erosion hazard assessment has been undertaken in accordance with Chapter 4.4.1 of Volume 1 of the 'Blue Book'. The Australia Natural Resource Atlas provides gridded factor values within the Project Area. The Project Area slope was estimated based on the geospatial analysis to determine the average site slope of the existing landform. These gridded values were averaged and are presented in Table 4.4 and were used to assess erosion hazard for the entire Project Area.

The annual soil loss for the Project Area was estimated from the Revised Universal Soil Loss Equation (RUSLE). The annual soil loss rate is classified as a high or low erosion hazard. The erosion hazard assessment for the Project Area predicts that it can be classified as low erosion hazard. As such, standard erosion control measures will be applied during construction.

Table 4.4 Annual soil loss calculation

	Description	Value	Range
R	Annual average rainfall erosivity factor	471.6	459.4 – 485.5
k	Soil erodibility factor	0.038	0.024 - 0.057
LS	Slope length gradient factor based on Table A1 of <i>Managing Urban Stormwater Volume 1</i> (Landcom, 2004)	0.050	0.030 - 0.370
C	Ground cover factor sourced from Figure A5 of <i>Managing Urban Stormwater Volume 1</i> (Landcom, 2004)	0.049	0.017 - 0.104
P	Erosion control practise factor sourced from Table A2 of <i>Managing Urban Stormwater Volume 1</i> (Landcom, 2004)	1.3	Compacted and smooth
A	Calculated annual soil loss rate (RUSLE), tonnes/ha/year	0.063	0.012 - 0.702

The calculated annual soil loss rate for the Project Area corresponds to a very low erosion hazard, (soil loss class 1). Classification of soil loss is provided in Volume 1 of the Blue Book (Landcom, 2004) at Table 4.2. The Blue Book's Figure 4.9 indicates that the Project Area is located in rainfall distribution zone 12. Consulting *Lands where special erosion control measures apply* in the Blue Book's Table 4.3 indicates that for zone 12 and soil loss class 1, there are no time of year restrictions applicable to the majority of the Project Area.

At the southern extent of the Project Area, the disturbance zone is mapped as crossing the Coleambally Outfall drain. The Blue Book instructs that all land within 40 m of the bank of a defined watercourse (Stream Order higher than 4) is to be considered as a very high erosion hazard (soil loss class 6). Figure 3.7 provides Strahler Stream Orders. Table 4.5 presents the recommended timing restrictions for soil loss class 6 lands in rainfall distribution zone 12 adapted from the *Table 4.3* of the 'Blue Book'. These timing restrictions would apply to the crossing of the Coleambally Outfall drain and 40 m from top of its bank. As such, the timing restrictions apply to works in this Core Riparian Zone between October and April.

Table 4.5 Timing Restrictions for Soil Loss Class 6 Lands in Rainfall Distribution Zone 12

Half of Month	1 st	2 nd
January	Yes	Yes
February	Yes	Yes
March	Yes	Yes
April	Yes	No
May	No	No
June	No	No
July	No	No
August	No	No
September	No	No
October	No	Yes
November	Yes	Yes
December	Yes	Yes

Source: Adapted from Table 4.3 of *Managing Urban Stormwater Volume 1* (Landcom, 2004)

Where scheduling of works during periods where the three-day forecast indicates that rain is likely, erosion control measures should aim to protect disturbed lands with 60% ground cover. Where non-forecast rainfall arrives, site management techniques should endeavour to ensure that site erosion is minimised and mitigated within 24 hours.

4.6 GENERAL EROSION AND SEDIMENT CONTROL STRATEGY

The detailed design phase will finalise drainage sizing and alignments. Once this information is known, and prior to construction, a construction Erosion and Sediment Control Plan (ESCP) will be developed. This will specify the locations of all necessary ESCs to achieve the principles outlined below. The ESCs are to be installed, managed and maintained in general accordance with the Blue Book Volume 1 (Landcom, 2004) and Volume 2C (DECC, 2008). This will be achieved using the following principles and strategies.

4.6.1.1 Principles of Site Management

- Clean water flows will be diverted around disturbed areas. Flows generated from runoff within the disturbed areas will have their water velocity minimised and any sediments captured before discharge from the Project Area.
- Stockpiles of erodible material that have the potential to cause environmental harm if displaced will be located away from concentrated surface flow and excessive up-slope stormwater surface flows.
- Sediment removed from any trapping device is to be disposed of in locations where further erosion and consequent pollution to downslope lands and watercourses will not occur.
- Temporary soil and water management structures are to be removed only after the Project Area is stabilised appropriately.
- Emergency spill kits are to be kept on site at all times. All workers are to be made aware of the location of the spill kits and trained in their use.
- Refuelling of plant and equipment is to be undertaken in an impervious bunded area located a minimum of 50 m from watercourses, see Figure 3.7.
- All fuels, chemicals and liquids will be stored in an impervious bunded area, a minimum of 50 m away from watercourses.
- Any concrete washout undertaken on site (during the construction phase) will be in a bunded area that is not on waterfront land (Stream Orders greater than 4) and at least ten metres from lower order streams mapped as having a Strahler Stream Orders greater than zero.

4.6.1.2 Erosion Sediment Controls strategy

The following ESC management strategies will be implemented within the Project Area.

- To minimise ground disturbance, construction and operational activities including vehicle and machinery movements, stockpiling, temporary vehicle parking and material laydown will be restricted to designated work areas. The disturbance boundary is to be clearly delineated with construction fencing or barrier tape
- Where possible, topsoil will be stripped and handled only when it is moist (not wet or dry) to avoid decline of soil structure
- Topsoil stockpiles will be stabilised with vegetation (seeded) if they are to be inactive for long periods
- Sediment traps should be located as close to the source of the sediment as practicable.

- Sediment control devices must be de-silted and made fully operational as soon as reasonable and practicable after a sediment-producing event. Sediment traps should be maintained to ensure that no more than 30% of their design capacity is lost to accumulated sediment.

As the Project Area is predominantly flat and the annual soil loss rate is very low, the Blue Book considers sediment basins as having limited practicality to drain and protect disconnected areas. The use of sediment basins will depend on the practicality of draining flat, disconnected and disturbed areas to a single sediment basin. The Blue Book suggests a contiguous disturbance area threshold of around two (2) ha. Other more effective sediment controls are possible, and they would protect receiving waters from sediment generated within the Project Area.

4.6.1.3 Drainage Controls

- All temporary drainage controls are to be designed to have non-erosive hydraulic capacity to convey runoff from a 10% AEP critical duration storm event
- Wherever reasonable and practicable, “clean” surface waters must be diverted away from sediment control devices and any untreated, sediment-laden waters
- All runoff from the works is to be passed through sediment controls
- Sediment controls will be inspected after significant rainfall events to ensure accumulation of material does not result in lost functionality.

5 EXISTING FLOOD BEHAVIOUR

5.1 MODELLING APPROACH

The purpose of the flood modelling was to assess the current climate flood behaviour within the Project Area to inform siting of flood vulnerable infrastructure and assessment of Project impacts. The 2023-03-AC version of the two-dimensional TUFLOW hydrodynamic model (BMT, 2018a) was used to simulate the flow behaviour in the vicinity of the Project Area for the 10% (1 in ten (10)), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) AEP flood events for the current climate records. The PMF was modelled to estimate extreme flood conditions.

There is no recorded water level data or anecdotal information available within the Project Area, and therefore model calibration was not possible.

Model topography was based on a five (5) metre Digital Elevation Model (DEM) available from the ELVIS (Elevation Information System) portal. The model grid size was 30 m. Used in combination with TUFLOW's sub-grid sampling (SGS) functionality, the 30 m model grid size provided adequate resolution to capture key drainage features and overland flow paths, while maintaining reasonable simulation times.

Inundation within the Project Area could occur, exclusively or as a combination of three (3) mechanisms:

- Site runoff: Short duration (< 60 minutes) intense rain falling directly on the Project Area
- Local catchment flooding: Medium duration (one (1) hour – six (6) hours) rain falling on land draining to the Project Area
- Regional flooding: Long duration (six (6) - 72 hours) arriving from rainfall falling on Murrumbidgee River Catchments upstream of the Project Area. For rare events, these flows could break out of the riverbank and flow into the Project Area via the Coleambally Outfall Drain and other floodplain flow paths.

A test model was developed to investigate the potential contribution of regional flooding caused by Murrumbidgee River breakouts draining to the Project Area. The test model included the Murrumbidgee River channel and southern floodplain. Estimated 0.5% AEP Murrumbidgee River flood flows from a previous study (BMT, 2018b) were applied to the Murrumbidgee River channel, with the model simulating breakouts and subsequent floodplain flow towards the Project Area. The test model results indicated that Murrumbidgee River breakout flows did not reach the Project Area.

Site runoff and local catchment flooding were modelled using a direct rainfall model to determine the extent of the surrounding floodplain that drains to the Project Area. The flat nature of the area precluded the use of a semi-distributed hydrologic model (URBS or RORB) from defining upstream catchments. The required extent of the hydraulic model domain was assessed by applying direct rainfall and assessing flow directions across the floodplain and interconnected watercourses. The hydraulic model domain was defined by the extent of rainfall that was assessed as likely to reach the Project Area. This ensured that model run times and file sizes provided optimal coverage of the local catchment flood behaviour.

The modelled flood events are indicative of conditions as outlined below:

- 10% AEP event – representative of a frequent-rare flood event
- 1% AEP event – representative of the principal flood planning event
- 0.5% and 0.2% AEP events – representative of a future climate's 1% AEP flood risk
- PMF – representative of the extreme flood event. This is based on the PMP estimate and does not have a design event probability.

5.2 DESIGN EVENTS

Design rainfall depth data, as well as design losses, and storm pre-burst details were obtained from ARR 2019 datahub, in accordance with the current ARR guidelines. Preliminary TUFLOW hydraulic model runs for a range of durations and temporal patterns were used to identify the critical storm duration for the Project Area, and relevant design storm temporal patterns. Design flows were estimated by applying design rainfall directly to the TUFLOW model grid. Details of the process and inputs are provided in the following sections.

Design event modelling results were post-processed to derive design flood parameters (e.g. peak flood depths and extents) for each AEP and design scenario. Existing and proposed developed conditions results were compared to determine the location and magnitude of predicted impacts.

5.2.1 Design Rainfall and Losses

Design rainfall depths were obtained from Design Rainfall Data System based on a single point location at the centroid of the Project Area. These depths are summarised in Table 5.1.

For the purpose of the local catchment investigation, no areal reduction factors were applied to the design rainfalls. This approach is considered conservative for the purpose of this study.

Estimation of initial and continuing loss rates is provided in ARR 2019 as accessed through the online datahub. The suggested probability neutral losses for initial losses were adopted. The adopted initial and continuing losses are provided in Table 5.2 and

Table 5.3. These losses are relevant to the pervious catchment areas noting that there is no significant proportion of impervious area within the modelled catchments.

Table 5.1 Design Rainfall Depths (mm) for Various Event Durations and AEPs

Duration (min)	10% AEP	1% AEP	0.5% AEP	0.2% AEP	PMP
60	27	43.6	48.9	55.9	150
90	30.9	50	56.1	64.1	180
120	33.9	54.9	61.5	70.4	200
180	38.4	62.1	69.7	79.8	250
270	43.4	69.9	78.5	90	280
360	47.3	75.8	85.2	97.8	310
540	53.3	84.6	95.3	109	350
720	57.9	91.4	103	118	380
1080	64.8	101	114	131	420
1440	69.9	109	122	140	460
1800	74	115	129	147	520
2160	77.2	120	134	153	550
2880	82.2	127	142	162	590
4320	88.6	137	152	173	-

5.2.2 ARR data hub

Recommended design rainfall parameters were based on ARR 2019 guidelines, available from the ARR datahub portal⁴. Key design rainfall parameters include:

- Initial and continuous loss rates;
- Design storm pre-burst depths;
- Areal reduction factors; and,
- Design storm temporal patterns.

5.2.3 Design rainfall losses and pre-burst rainfall

Storm initial loss (IL) and continuing loss (CL) method of accounting for rainfall losses was adopted based on ARR Data Hub recommendations. An initial loss (IL) and a continuing loss (CL) were adopted with median pre-burst depths obtained from the Data Hub used to adjust the initial loss with 1% AEP.

The IL and CL losses were derived by interpolating between rainfall losses adopted for infrequent events (up to 1% AEP) noting that:

- ILs for infrequent events were derived based on the Probability Neutral Burst ILs provided by ARR2019 datahub. This approach results in a unique Initial Loss for each duration;
- CLs for infrequent events were derived based on the suggested data hub and regional flood study CLs.

⁴ <https://data.arr-software.org/>

Table 5.2 provides the initial and continuing losses used for the 1% AEP event rainfall losses. Table 5.3 provides the Probability Neutral Burst Initial Loss values referred to by Table 5.2. As ARR 2019 datahub does not provide values beyond 1% AEP. The values were extrapolated and using the PMF value of zero as the limit.

Table 5.2 Losses Used in the Developed Hydraulic Model

Losses	Frequent and infrequent ($\leq 1\%$ AEP)	Rare ($> 1\%$ AEP)	PMF
IL (mm)	Probability Neutral Initial Loss	Probability Neutral Initial Loss interpolated	0
CL (mm/h)	2.5	1.5	1

Table 5.3 Probability Neutral Burst Initial Loss

Storm duration (min)	Probability Neutral Initial Loss (mm)	
	1% AEP	10% AEP
60	10.7	11.5
90	9.8	10.6
120	10.3	11.3
180	9.2	12.0
270	9.0	13.1
360	8.8	14.1
540	9.4	15.7
720	10.0	17.3
1080	11.4	19.3
1440	12.2	19.9
1800	14.6	20.9
2160	17.0	21.9
2880	14.1	23.5

Source: ARR2019 datahub

5.2.4 Temporal Patterns

Temporal patterns are the distribution of the total rainfall in different periods within a given duration. The suite of ten (10) temporal patterns appropriate to the Project Area were downloaded from ARR 2019 datahub and used to simulate the temporal distribution of rainfall depths during each storm duration modelled. The suite of temporal patterns has been applied to estimate the critical design event for flood estimation in accordance with ARR 2019 procedures.

5.2.5 Critical Storm Durations

A range of storm durations and temporal patterns were simulated using the TUFLOW model (using ARR 2019 inputs) to identify the critical storm duration and temporal pattern results providing the design peak discharges at the Project Area. The usage of a direct rainfall model resulted in numerous critical duration events at various locations within the Project Area. However, while different durations were identified based on various catchments sizes, they were of similar depths. As running numerous duration storms would ultimately produce similar depths, the overall critical duration event was selected on the basis of the storm duration that produced the greatest depth in the main flow path through the Project Area. This simplification may have the impact that shorter duration (intense) storms may result in slightly higher (~10mm) water levels in localised areas. This approach was considered appropriate given the broadscale nature of this assessment and is consistent with the approach adopted in nearby flood studies.

5.3 HYDRAULIC MODELLING

5.3.1 Topography and grid cell size

The five (5) m topographic data obtained from ELVIS database was adopted as the base model topography. A 30 m grid size resolution was adopted for hydraulic modelling. In combination with

TUFLOW's sub-grid sampling functionality, the 30 m cell size provides adequate resolution to capture key drainage features and overland flow paths, while maintaining reasonable simulation times.

5.3.2 Boundary conditions

Figure 5.1 shows the locations of rain on grid extent and outflow boundaries in the local catchment TUFLOW model. The model includes:

- Direct rainfall boundary covering the entire hydraulic model extent
- 21 discrete outflow boundaries.

Normal flow (HQ) type boundary conditions were implemented for the downstream model boundaries. The flows through the downstream boundaries are controlled by a normal depth rating curve. The downstream boundaries of the models were set well downstream of the Project Area to minimise influence on flood behaviour predicted near the Project Area. The downstream boundary conditions assumed a normal depth slope of 0.001 m/m, calculated from the river water surface slope. This normal depth slope is typical of the water surface slopes.

5.3.3 Hydraulic resistance

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance. Analysis of available aerial imagery showed that there are two (2) general land use classifications of relevance in the vicinity of the Project Area. Adopted Manning's 'n' values for each land use classification are listed in Table 5.4. The values adopted correspond to the values adopted in nearby flood studies.

Depth varying Manning's 'n' values were adopted as recommend by the TUFLOW manual for the direct rainfall (rain on grid) approach. Between flood depths of 50 mm and 100 mm, hydraulic roughness values are linearly interpolated by the TUFLOW software. The spatial discretisation of roughness values in the Project Area is shown in Figure 5.2

Table 5.4 Depth-Varying Manning's Roughness used in the Hydraulic Model

Land Use	Manning's 'n'	
	Depth < 50 mm	Depth > 100 mm
Active channel with light vegetation	0.080	0.035
Paved surface / hardstand	0.045	0.020
Water body/dam	0.020	0.020
Medium vegetation / rural res	0.060	0.060
Dense vegetation / residential	0.080	0.080
Exposed dirt/unsealed road	0.080	0.025

5.3.4 Hydraulic structures

No hydraulic structures were included in the model. At Clifford Down Road near the intersection of Four Corners Road and Fernbank Road, a minor modelling adjustment was used to enforce the creek channel in lieu of local culvert information. This enforcement is for model stability purposes only and does not impact on the Project Area which is located 34 kilometres further west.

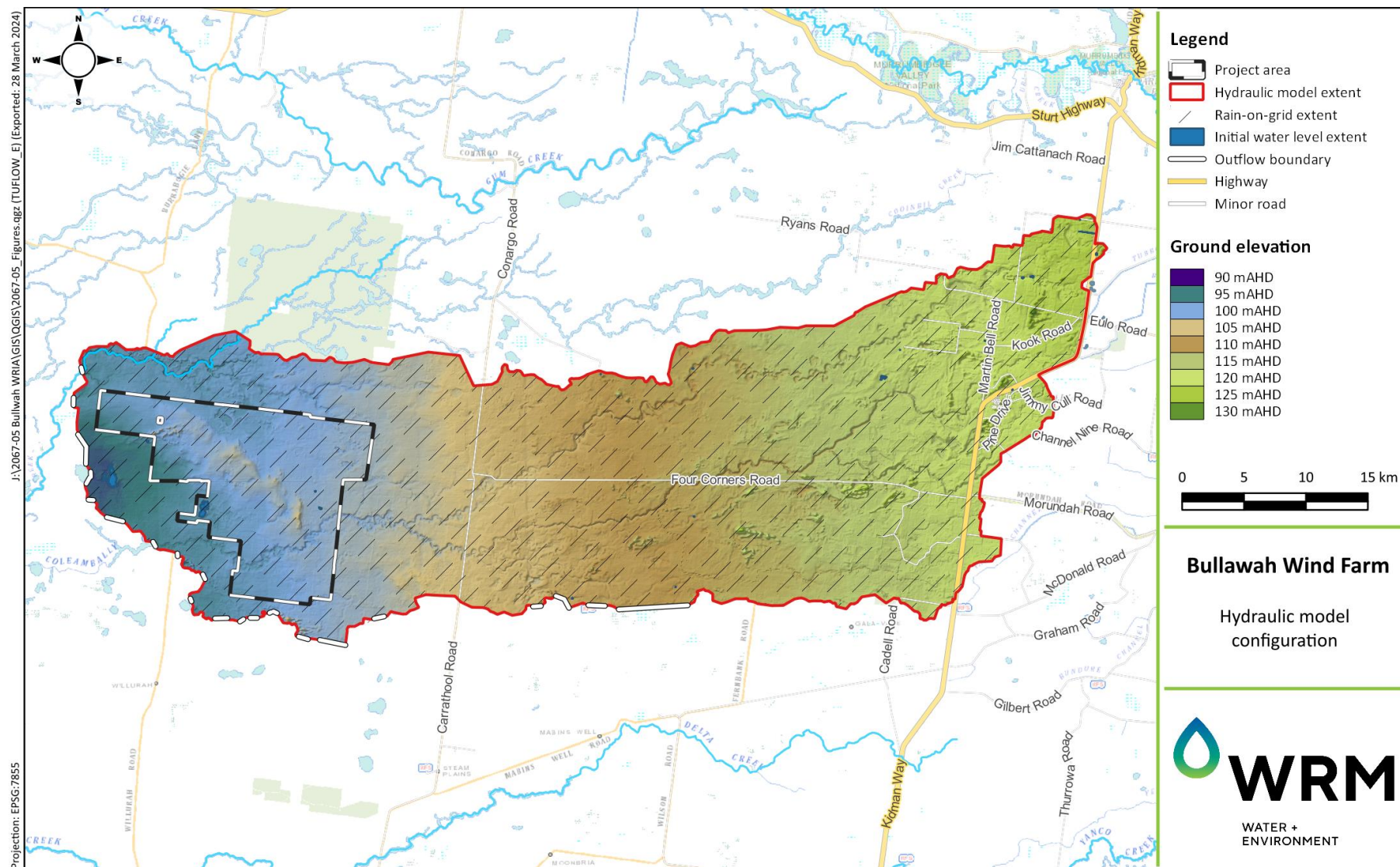


Figure 5.1 Hydraulic model configuration

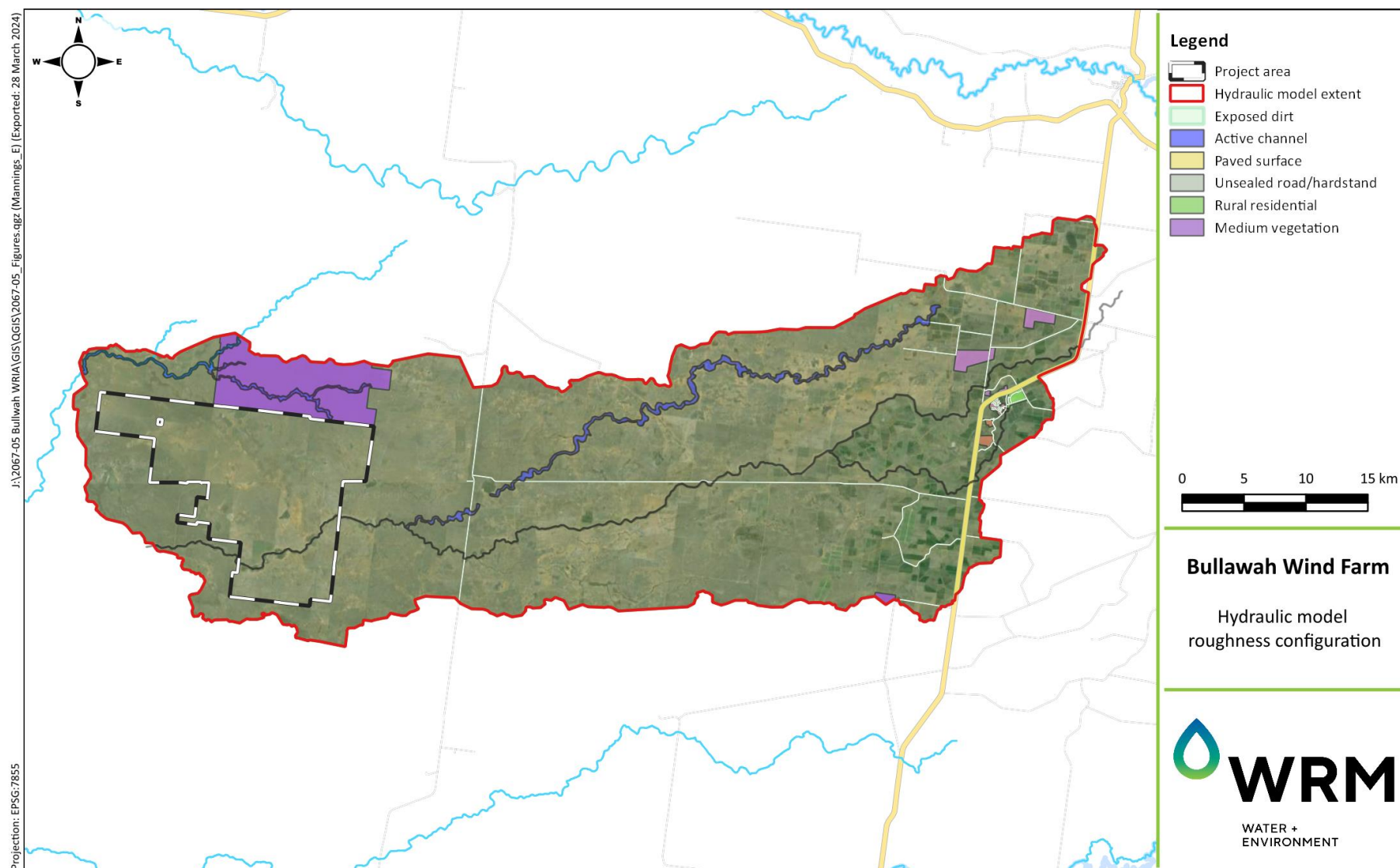


Figure 5.2 Hydraulic model roughness configuration

5.4 EXISTING FLOOD BEHAVIOUR

5.4.1 Overview

The flood model results provide the distribution of peak flood levels, depths, velocities and hazards across the Project Area for each modelled design magnitude flood event. Areas where the modelled flood depths are less than 50 mm have been filtered from the results. Note that this does not affect the hydraulic computations.

The suite of detailed flood mapping of the simulated depth, velocity and flood hazard distributions for all modelled events is provided in Appendix B. The figures show that the peak flood extent is largely confined to the watercourse alignments, with some moderate inundation beyond the channel corridors.

5.4.2 Flood Hazard

The flood hazard at the Project Area was assessed in accordance with ARR 2019. Flood hazard occurs due to the vulnerability of the public and assets interacting with floodwaters. ARR 2019 adopted the combined flood hazard classification based on research presented in the *Australian Disaster Resilience Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017). The flood hazard categories according to the AIDR definition are summarised in the Table 5.5 and flood hazard colour coded curves are shown in Figure 5.3. The flood hazard mapping is provided in Appendix B.

Table 5.5 Hazard Classification

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)	Description
H1	$D \cdot V \leq 0.3$	0.3	2.0	Generally safe for vehicles, people and buildings.
H2	$D \cdot V \leq 0.6$	0.5	2.0	Unsafe for small vehicles.
H3	$D \cdot V \leq 0.6$	1.2	2.0	Unsafe for vehicles, children, and the elderly.
H4	$D \cdot V \leq 1.0$	2.0	2.0	Unsafe for vehicles and people.
H5	$D \cdot V \leq 4.0$	4.0	4.0	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	$D \cdot V \geq 4.0$	-	-	Unsafe for vehicles and people. All building types considered vulnerable to failure.

Source: AIDR, 2017

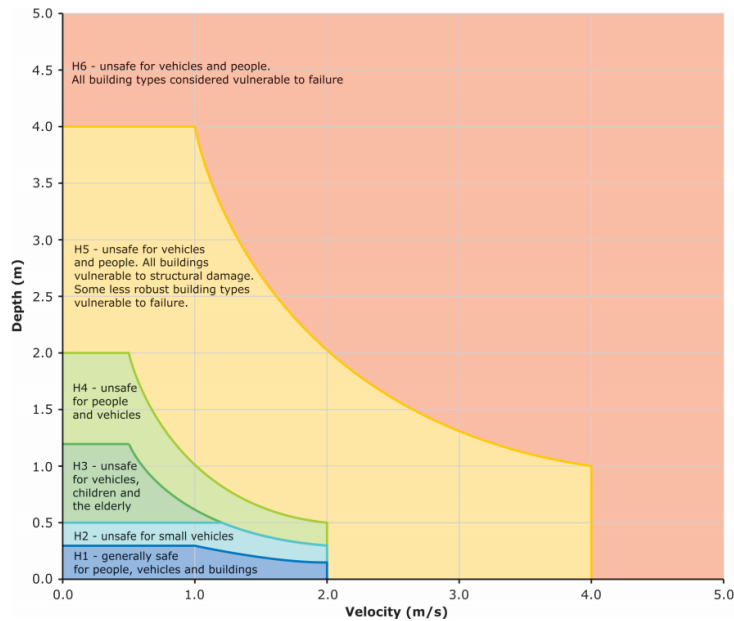


Figure 5.3 Combined Flood Hazard Curves

Source: Smith et al. 2014

5.4.3 Design Flood Events

The flood modelling results are discussed below, mapped results are available in Appendix B. The modelled flood behaviour within the hydraulic model's domain is shown in Figure 5.1. Summary observations about flood behaviour are as follows:

- **10% AEP:** Results show there is generally no widespread flooding within the Project Area, with active flow paths confined within the watercourses and local depressions. General overland flood flow depths outside of the main watercourse alignments are typically shallow at less than 0.1 m. The greatest depths within the watercourses within the Project Area are up to 0.8 m.
- **1% AEP:** The general flood inundation extents are increased from the 10% AEP event, with increasing depths and velocities associated with the higher flows. *This is the parameter adopted for planning purposes, and utilised here to derive all necessary mitigation measures. Based on the Project design utilised for this assessment the 1% AEP flood extents has minimal interaction with the Project disturbance area, and the hazard assessment has identified that the inundated areas of the Project Area are primarily classified as 'generally safe' (H1), with only isolated pockets of H2 and H3 hazard existing where water accumulates, refer Section 6.2 of this report.*
- **0.5% AEP and 0.2% AEP:** The flood depths are only marginally larger than those of more frequent conditions, with a median depth of 0.13 m and a peak depth of 1.7 m. Higher AEP events show similar results, indicating the inundation impact of climate change is not anticipated to be a significant issue for the Project.
- **PMF:** The PMF is the extreme upper limit of the design event window. The northeastern and southern extent of the Project Area is inundated and flood free access to the Project Area is not possible. Depths of flow within the Project Area are typically up to 1.0 m with a peak depth of 2.1 m. The mainstream flooding of the creeks within the Project Area has broken out of banks. *It is reiterated that the PMF defines the upper limit of flooding that could reasonably be expected to occur and is much rarer than the 1% AEP flood which is the parameter adopted for planning purposes, and utilised here to derive all necessary mitigation measures.*

6 ASSESSMENT OF POTENTIAL IMPACTS

The Project has the potential to impact receiving surface water and groundwater quality, flood regimes, soil resources, available water supply to existing users and aquatic habitat and GDEs. However, the potential impacts listed below would be contained to a small portion of the overall Project Area, and there are numerous mitigation measures possible that reduce the risk to an acceptable level. In the absence of appropriate controls and assuming the worst possible case, the potential impacts to surface water resources associated with the Project may include:

- degradation of downstream surface water quality (primarily during construction and decommissioning but also potentially during operation) due to:
 - elevated concentrations of sediment and nutrients bound to sediment in any runoff
 - elevated pH and fine sediment concentrations in runoff from mobile concrete batching plant areas
 - chemical spills/leaks entering streams (e.g. diesel fuel or hydraulic oils from mobile plant).
- increased erosion within watercourses due to:
 - damage to stream bed and bank from construction activities adjacent to and in-stream (e.g., stream crossings)
 - damage to riparian vegetation from construction activities on waterfront land
 - runoff being concentrated by impervious areas associated with the Project.
- potential for obstruction of fish passage associated with stream crossings
- potential for alteration of flood flows and levels due to infrastructure located in close proximity to streams
- loss of catchment yield during construction due to capture of water in sediment dams
- depressurisation of groundwater aquifers
- reduction in bore yields to existing groundwater source users due to Project water use
- degradation of groundwater quality due to chemical spills/leaks during construction.

This WRIA has considered and assessed each of these potential impacts and where there is the potential for impacts to occur, has identified appropriate management measures to mitigate these risks.

6.1 SOIL AND WATER QUALITY IMPACTS

Potential impacts relating to soil and water quality are proportional on land disturbance. Minimising total land disturbed significantly reduces the risk of the following impacts. The impacts listed here are intended to provide an exhaustive summary only. Inclusion within this list is not intended to indicate actual or likely outcomes as a result of this Project.

The Project Area was assessed through soil surveys and desktop studies, which has ensured a comprehensive understanding of the soil resources. Appendix C contains summary information from extensive evaluation of the current soils resources and their tolerance to the Project. Additionally, the Project has a strong commitment to minimal surface disturbance and a clear strategy to restore the land to its pre-disturbance agricultural capability and usage after the Project's completion.

6.1.1 Construction and Decommissioning

During construction and decommissioning of the Project, soils would be subject to disturbance, during the removal of vegetation, excavation works and stockpiling of materials, potentially leading to sediments and/or pollutants being entrained in rainfall runoff and entering local watercourses. Discharge of polluted rainfall runoff from the Project has the potential to result in the deterioration of EVs and WQOs, for example:

- Pollutants such as sediments, pH, oils/grease and other nutrients bound to sediment or dissolved form entering watercourses. The Project would aim as far as practicable to achieving the Murrumbidgee WQOs for protection of aquatic ecosystems
- Works within or near a watercourse are a risk to downstream water quality due to the disturbance of the streambed and the mobilisation of sediments and pollutants. Work occurring outside of watercourses may also indirectly mobilise sediment and pollutants via the action of wind then rainfall. Construction of the Project would not require controlled discharges to watercourses
- Mobilised high concentration nutrients (fertilisers) may trigger algal blooms that result in anoxic conditions within fish habitat. Mobilised heavy metals and contaminant concentration could result in degradation for aquatic habitats, irrigation and drinking water
- Soils within the Project Area may contain residual herbicides/pesticides from historical or present-day farming practices
- Loss of topsoil resources on the land and ongoing erosion reducing the area of usable land and/or damage to private property for involved landholders
- Water quality in farm dams is impacted and not suitable for stock watering, health or aquatic fauna and flora, as well as increased turbidity and decrease in water quality to downstream watercourses.

With the implementation of erosion and sediment control measures as well as appropriate measures to manage hazardous materials such as oils, fuels and other chemicals potential construction-related stormwater pollution impacts can be appropriately managed and are expected to be negligible.

During the construction phase, the construction of internal roads will require the establishment of new watercourse crossings. Provided watercourse crossings are designed and constructed in accordance with relevant guidelines and in consultation with DPI Fisheries, the Project watercourse crossings are not expected to result in any measurable impacts to stream health including water quality and fish passage.

With the implementation of measures outlined in Section 7, the potential water quality impacts would be adequately managed during the Project's construction and decommissioning phases.

6.1.2 Operation

During the operational phase the potential impacts on water quality relate to establishment of additional infrastructure, hardstands and roads. Due to the flat nature and broad distribution of infrastructure throughout the Project Area, the impacts of increased impervious areas are unlikely to be noticeable. An additional measure to be considered during detailed design phase, is the identification of gullies that are already eroding and locate within the Project's Disturbance Footprint. Where possible, the proposed works will rehabilitate these eroding gullies with a view to improving medium to long-term stormwater quality.

Other potential water quality impacts during the operational phase associated with the day-to-day activities during this phase would be limited to:

- Stormwater runoff from impervious surfaces resulting in localised erosion

- Accidental spills or discharge through use and storage of chemicals such as fuel.

The potential for ongoing erosion post construction is conserved to be low provided appropriate rehabilitation of disturbed areas is undertaken and any areas identified as exhibiting signs of erosion above expected background levels are addressed.

All hazardous materials and chemicals will be stored in accordance with relevant Australian standards and other state and local guidelines including the NSW EPA's *Storing and Handling Liquids: Environmental Protection – Participants Handbook*.

Based on the above, and with the implementation of management measures outlined in Section 7.0, water quality impacts during the operational phase are expected to be negligible.

6.2 FLOODING IMPACTS

6.2.1 Operation, Construction and Decommissioning

The 10 %, 1 %, 0.5 %, 0.2 % AEP and PMF events were assessed to quantify flood depth, velocity, and hazard levels. Modelling has shown the Project Area to be of low flood risk with minimal risk to changes in internal or external watercourse flows.

Travelling from Hay and entering the Project Area via Jerilderie Road is predicted to be a low flood risk. Just north of the Project Area, the Jerilderie Road crossing of Eurolie Creek is mapped as H2 “unsafe for small vehicles” during a 1% AEP flood event. Immediately prior reaching the Project Area along North Boundary Road is a shallow depression which is bisected a raised roadway. This depression, like many others in the area, will accumulate flood waters until they can discharge into the receiving watercourses.

The results of the 1% AEP flood hazard assessment have identified that the inundated areas of the Project Area are primarily classified as ‘generally safe’ (H1). Isolated pockets of H2 and H3 hazard exist where water accumulates. The peak modelled velocities were notably slow due to the flat topography.

Peak stormwater discharges within the Project Area may increase slightly through the creation of impervious areas, namely internal roads (constructed of road base or the like), temporary workers accommodation compound, and permanent ancillary infrastructure compounds (substations, switchyard, watercourse and O&M facilities). However, the potential impacts to drainage features and downstream watercourses are considered as imperceptible due to the relative size of the Project Area in relation to the size of the receiving catchments, and the distributed nature of minor impacts. The total new impervious area for the Project was estimated based on the Disturbance Footprint, and to be 238 ha within the 20,628 ha of Project Area, comprising:

- 129 ha of hardstand areas for 143 WTGs,
- 35 ha of permanent infrastructure (BESS, substations, switchyards).
- 17 ha of temporary infrastructure compounds.
- 58 ha internal road surface

The temporary infrastructure compounds would be reinstated as pervious area following the conclusion of the construction period. This total impervious area represents less than 1.2% of the total Project Area. Drainage from these impervious areas will not be directly connected, providing opportunity for distribution and infiltration of stormwater between the impervious area and receiving watercourses. Consequently, the hydrologic impacts of the Project at the catchment scale are likely to be undetectable.

Minimal changes to the land topography, impervious fraction and therefore runoff and groundwater infiltration are expected due to the nature and extent of proposed infrastructure. Subject to the

management and mitigation measures outlined in Section 7.0 being implemented the Project is unlikely to have any residual impacts on surface water. This will require the development of various of Management Plans developed prior to construction.

Access tracks and cable reticulation are the only works proposed within the watercourses and no other artificial structures are planned to be installed in the creeks within the Project Area. Design of watercourse crossings for access points and crossings within the Project Area will be undertaken at the detailed design phase. The crossing of the Coleambally Outfall drain will be designed in consideration of requirements of *Guidelines for Controlled Activities on Waterfront Land*, to reduce construction impacts to the riparian corridors of watercourses within the Project Area.

6.3 IMPACTS ON STREAM STABILITY, RIPARIAN HEALTH AND FISH PASSAGE

6.3.1 Construction, Operation and Decommissioning

As an SSD, the Project, if approved, will be exempt from the requirement to acquire CAAs for works on waterfront land (works within 40 m of the top of bank of a watercourse, i.e. > 4th order stream) under s.4.41(1)(g) of the *Environmental Planning and Assessment Act 1979*.

There are both ephemeral and perennial streams traversing the Project Area. While the Project design has aimed to avoid works close to or within waterways, watercourse crossings will be required for site access. Project watercourse crossings will be designed to minimise impacts on stream stability and fish passage and will be designed with reference to the following documents in addition to DPEs *Guidelines for Controlled Activities on Waterfront Land*:

- *Why Do Fish Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Department of Primary Industries (DPI) Fisheries, 2003).
- *Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management* (NSW DPI, 2013).

For works on waterfront land, the following measures will be incorporated into the design of the works and controls included in the Construction Soil and Water Management Plan (CSWMP):

- a site-specific ESCP will be prepared for all works on waterfront land;
- where practicable, infrastructure will be maintained outside of the vegetated riparian zone;
- utilise stream crossings for co-location of services to avoid the need to trench through stream beds wherever practicable;
- rehabilitate disturbed areas and provide scour protection to bed and banks as required to mitigate any areas with increased potential for erosion due to changes in flow regimes associated with Project infrastructure;
- where practicable, undertake works on waterfront land during periods of low rainfall erosivity from April to September when construction timing restrictions are recommended (refer to Table 3.1).

During detailed design, consultation will be undertaken with DPI Fisheries to determine if any of the proposed watercourse crossings require consideration of fish passage. For any crossings that do require consideration of fish passage, the relevant DPI Fisheries guidelines will be considered during the detailed design process.

6.4 IMPACTS ON WATER SUPPLY

6.4.1 Construction, Operation and Decommissioning

Water required for the Project is expected to be sourced primarily from:

- Existing groundwater bores within the Project Area (all phases).
- Commercial suppliers (potable water) via water trucks (all phases).

The maximum water demand will be during construction (refer Section 4.2). Reduced volumes of water are likely to be required during the decommissioning phase.

As surface water or groundwater used by the Project will be obtained from licensed sources under agreement with landholders and in accordance with the relevant water source WSP, no impacts to surface water or groundwater availability in the vicinity of the Project are anticipated.

Loss of catchment yield associated with containment of runoff from disturbed areas is expected to be negligible and will be temporary during the construction and decommissioning phases. As such, impacts on surface water availability to downstream water users are expected to be negligible.

6.5 GROUNDWATER QUALITY

6.5.1 Construction and Decommissioning

Generally, impacts to groundwater resources, including GDEs, are very unlikely given the groundwater table is not at risk of being intercepted during Project construction or decommissioning. Further, the anticipated depth to groundwater (i.e. at least 20 m BGL) within the Project Area means that in the unlikely event of any hydrocarbon/chemical spills they are unlikely to infiltrate to the groundwater table. Noting that appropriate spill management measures will be implemented during all phases of the Project.

Within the Project Area two (2) quarries (refer) will be used as borrow pits to source gravel on-site during construction. Of these, the southern quarry is an existing quarry which is proposed to be expanded as part of Project construction. The northern quarry will be a new quarry established specifically for the development. BWF has committed to not excavating more than 17 m BGL which provides at least three (3) m of cover to the regional groundwater table.

Should the final Project design identify that construction activities will result in the interception of the groundwater table, further assessment will be undertaken in accordance with the *NSW Aquifer Interference Policy* (NSW Government, 2012) and appropriate management measures be developed to mitigate any potential impacts.

During excavation from the borrow pits, the pit walls will be monitored for any seepage to indicate interception of any localised perched aquifers. Any incidental water take would be accounted for within existing WAL entitlements and reflected in an updated site water balance. During detailed design, a CSWMP will be developed for the borrow pits to ensure water balance within the pits are managed. The CSWMP will encompass the management of water quantity and quality requiring discharge from the pit.

6.5.2 Operation

There is limited scope and no conceivable mechanism for the Project to alter groundwater behaviour during operations. Project operation and maintenance is not anticipated to intersect the regional water table. Footing excavations (up to four (4) m in depth) are also unlikely to have lasting impact on groundwater level drawdown. Should localised perched aquifers be intercepted during construction, groundwater interactions are not anticipated to be significant enough to result in long term impacts, and any impacted aquifers are likely to recover by the time the Project reaches its operational phase. As such, no impacts to groundwater resources, registered bores or GDEs are expected during the operational phase of the Project.

6.6 CUMULATIVE IMPACTS

Related development, as outlined in the NSW Government State Significant Development Guidelines, refers to any existing or approved development that would be incorporated into, or operated in conjunction with the Project. Related development can also include development by a Proponent that is required for a Project; but is subject to a separate development approval process. At this stage, there are no existing or approved developments that would need to be incorporated into the assessment of the Project.

NSW Government – EnergyCo seeks to maximise opportunities created by the transformation of the NSW electricity system by coordinating investment in REZs across NSW. A REZ is the equivalent of modern-day power stations, combining new renewable energy infrastructure, including generators (such as solar and wind farms), storage (such as batteries and pumped hydro) and then high-voltage transmission infrastructure. Five dedicated REZs have already been identified in NSW.

The region is traversed by Project EnergyConnect, an interconnector being built by Transgrid and ElectraNet between Wagga Wagga in NSW and Robertstown in South Australia, with a connection to Red Cliffs in Victoria. Project EnergyConnect also involves an upgrade to the 330 kV transmission line between Wagga Wagga and Dinawan to 500 kV, which links to the eastern edge of the South-West REZ and south of the indicative Project location. The completion of Project EnergyConnect would support the South-West REZ and more broadly support the Project by unlocking additional transmission capacity, transporting electricity from the South-West REZ to homes and businesses across NSW. The South-West REZ would be further boosted by the construction of the Victoria-NSW Interconnector West, a 500kV interconnector proposed by TransGrid which is expected to be completed by 2031.

The Project is located wholly within the South-West REZ. Because of this, and the REZ benefits anticipated by NSW Government – EnergyCo, the South-West REZ has the potential to see strong interest for renewable energy development.

Based on information available within the public domain, specifically the NSW Government – Major Projects website, the following developments are identified in the vicinity of the Project:

- Pottinger Solar Farm (SSD-59254709)
- Pottinger Wind Farm (SSD-59235464)
- Dinawan Wind Farm (SSD-50725708)
- Dinawan Solar Farm (SSD-50725959)
- Argoon Wind Farm (SSD-64935522)
- Yanco Delta Wind Farm (SSD-41743746)
- The Plains Solar Farm (SSD-51219280)
- Romani Solar Farm (SSD-67105475)
- Tcherlery Wind Farm (SSD-59701722).

Based on the proximity of the above-mentioned developments to the Project, and the limited potential for interactions to occur with respect to water resources, cumulative impacts are considered highly unlikely to occur. Specifically:

- **Water Management (erosion and sedimentation):** given the Project will incorporate appropriate erosion and sediment control mitigation measures during construction and decommissioning phases, refer Section 7.0, cumulative impacts to receiving water quality are expected to be negligible, assuming other projects in the region do the same.

- **Flooding and Surface water:** the abovementioned projects exist within the Murrumbidgee basin, but few connected to Project's watercourses. Where projects are on interconnected watercourses to those of the Project, appropriate mitigation measures successfully incorporated into the Project (refer Section 7.0) and those at the abovementioned projects in the region will ensure that cumulative impacts on flood behaviour are imperceptible.
- **Water Management (demand, supply and balance):** Project water demands will be limited to relatively short periods of time with respect to the overall Project lifespan during both the construction and decommissioning phases. Additionally, it is noted that most, if not all, non-potable water demand can be met by on-site groundwater resources under existing licences (with agreement from the landholders). Water demands during the operational phase will be relatively small. Therefore, and with the successful implementation of mitigation measures (refer Section 7.0) cumulative impacts to surface water or groundwater availability are not anticipated.

It is noted that because of the development activity in the South West REZ the above list may not address all potential sites being privately developed and not yet in the public domain. Information pertaining to any developments not yet in the public domain is therefore unavailable and excluded for this study.

7 MITIGATION MEASURES

Table 7.1 lists the mitigation measures required to address any potential surface water impacts that are considered likely for the Project. Based on the assessment of water resource and flooding impacts in Section 6, the focus of the measures outlined below is ensuring downstream waterways are protected during construction (incl. decommissioning) and operational phases of the Project. The proposed erosion and sediment controls, as part of the broader management measures and strategies, are necessary to achieve this objective.

For the construction phase of the Project, measures are to be captured in the Construction Environment Management Plan (CEMP). This would include the preparation of a CSWMP and ESCP

For the operational phase of the Project, the measures outlined are to be documented in the Bush Fire Emergency Management and Operations Plan (BFEMOP) and in the Operational Environmental Management Plan (OEMP). These documents will be developed for the Project's operational phase. The OEMP will address potentially adverse impacts on the receiving environment surface water quality and flooding during the operational phase. The BFEMOP will outline the flood hazards, evacuation and warning procedures to ensure the safety of all onsite.

Table 7.1 Mitigation Measures relating to Water Resources

Potential Risk	Proposed Mitigation Measure	Project Phase
6.1 Soil and water quality	Maintaining the natural state of the drainage flow paths whenever possible. Internal access roads, where crossing watercourses, will be designed for 10% AEP design flow and may include compacted rock causeways to provide low maintenance access with limited impact on the watercourse or culvert structures	Detailed design & Construction
6.1 Soil and water quality	The design and construction of watercourse crossings should be generally in accordance with the <i>Guidelines for controlled activities on waterfront land – riparian corridors</i> , <i>Guidelines for watercourse crossings on waterfront land</i> and <i>Guidelines for laying pipes and cables in watercourses on waterfront land</i>	Detailed design & Construction
6.1 Soil and water quality	A CSWMP will be prepared to outline measures to manage soil and water impacts associated with the construction and decommissioning works.	Prior to construction
6.1 Soil and water quality	Creation of catch/diversion drains and sediment fences at the downstream boundary of construction activities where practicable to support containment of sediment-laden runoff.	Prior to construction
6.1 Soil and water quality	Erosion and sediment control measures will be implemented and maintained at all work sites in accordance with the principles and requirements in <i>Managing Urban Stormwater – Soils and Construction, Volume 1</i> and <i>Volume 2D</i> of Blue Book.	Prior to construction
6.1 Soil and water quality	Measures to minimise/manage erosion and sediment transport both within areas of disturbance and offsite including requirements for the preparation of ESCP for all progressive stages of construction.	Prior to construction
6.1 Soil and water quality	The best practice principles for stormwater and sediment control outlined in the <i>Managing Urban Stormwater</i> Blue Book guidelines will be incorporated into the design, construction and operation phases as part of a CSWMP and ESCP.	Construction & Operation

Potential Risk	Proposed Mitigation Measure	Project Phase
6.1 Soil and water quality	The battery storage compound will be constructed of road base (or the like). The peak velocities at the proposed location remain below 0.25 m/s and are not subject to erosive flows. The battery storage components will be aligned with local overland flow paths to prevent flows being redirected and concentrated.	Construction
6.1 Soil and water quality	Inspection and monitoring requirements including receiving water quality monitoring.	Construction
6.1 Soil and water quality	Maintenance of stormwater infrastructure including any stormwater treatment devices (e.g. bioretention basins and culverts (e.g. clearing debris).	Construction, Operation and Decommissioning
6.1 Soil and water quality	Maintenance of suitable ground cover and grassed table drains near access tracks to minimise the potential for erosion and export of sediment.	Construction and operation
6.2 Flooding	During construction design flood risk will be considered and include, as a minimum, a review of temporary infrastructure layouts and arrangements to a) avoid and/or minimise obstruction of overland flow paths, b) limit the extent of flow diversion, c) include stormwater management controls to avoid/minimise the impact of flooding, and d) consider measures to mitigate alterations to local runoff conditions due to on-site works and activities.	Construction
6.2 Flooding	During construction, design stockpiles would be located outside areas anticipated to flood and experience velocities above 0.5 m/s. Where reasonable/feasible located outside the mapped 10% AEP flood extents. Based on the Project design utilised for this assessment, this mitigation is achieved and will persist if any future design revisions occur.	Construction
6.2 Flooding	Temporary construction compounds and the temporary workforce accommodation camp would be maintained away (or above) areas anticipated to flood based to depths deeper than 250 mm during a 1% AEP flood event. Due to flat nature of the Project Area, shallow depths of water are extensive but setting infrastructure on stilts mitigates the limited drainage conveyance. Based on the Project design utilised for this assessment, this mitigation is achieved and will persist if any future design revisions occur.	Construction
6.2 Flooding	Flood emergency management measures for the construction phase would be prepared and included in applicable environmental and safety management documentation i.e. the CEMP, CSWMP and ESCP noted above, as relevant. As a minimum this would include identification of flood related risks and their management, and processes to monitor and communicate weather warnings. In this regard, construction staff will have access to the following facilities for early severe weather warnings: The Bureau of Meteorology's "MetEye" and The Bureau of Meteorology's "RSS feeds". Radio and Bureau of Meteorology information will be reviewed frequently for potential major storm events and to ensure on-site personnel and visitors are aware of potential flooding events and road closures.	Construction

Potential Risk	Proposed Mitigation Measure	Project Phase
6.2 Flooding	Flood emergency management measures for the operational phase would be prepared and included in applicable environmental and safety management documentation i.e. the BFEMOP and OEMP noted above, as relevant. In this regard, operations staff will have access to the following facilities for early severe weather warnings: The Bureau of Meteorology's "MetEye" and The Bureau of Meteorology's "RSS feeds". Radio and Bureau of Meteorology information will be reviewed frequently for potential major storm events and to ensure on-site personnel and visitors are aware of potential flooding events and road closures.	Operation
6.2 Flooding	Evacuation routes will be designed during the detailed design phase and will consider zones of flood hazard. These routes would be and included in applicable environmental and safety management documentation i.e. the BFEMOP and OEMP noted above, as relevant.	Detailed design
6.2 Flooding	Flood behaviour as a result of the Project would be confirmed during detailed design, inclusive of climate change. In this regard foundations for the WTGs and transmission lines, their footings are located away from areas of erosive behaviour such as flood depths of 0.3 m and flow velocities greater than 1.5 m/s. Detailed design of the Project will consider the results of the 1% AEP scenario. Based on the Project design utilised for this assessment, this mitigation is achieved and should persist if any future design revisions occur.	Detailed design
6.3 Stream stability, riparian health	Controls for receiving watercourses which may include designation of 'no go' zones for construction plant and equipment.	Prior to construction
6.3 Stream stability, riparian health and fish passage	Infrastructure with the potential to cause pollution to watercourses in the event of flooding, such as inverters, will be located with a minimum 300 mm freeboard above the 1% AEP flood level. Given the shallow depths across the Project Area, raising these small fill pads is highly unlikely to result in any adverse impacts offsite. Based on the Project design utilised for this assessment, this mitigation is achieved and should persist if any future design revisions occur.	Detailed design
6.3 Stream stability, riparian health and fish passage	No sensitive infrastructure (e.g., substations or battery storage) will be placed within 20 m of any Strahler 3 or above order streams. Sensitive infrastructure will be placed outside the 0.2% AEP flood extent with a minimum 500 mm freeboard to the 1% AEP flood level. Based on the Project design utilised for this assessment, this mitigation is achieved and should persist if any future design revisions occur.	Detailed design
6.4 Water supply	A water sourcing and monitoring strategy would be prepared to manage potential availability impacts on downstream water users and ensure compliance with legislation relating to water extraction.	Prior to construction

8 CONCLUSION

This WRIA has considered the potential impacts and appropriate measures to mitigate any potential impacts on water resources associated with the Project.

The Bullawah Wind Farm Project will have minimal impact on water resources as it involves limited ground disturbance, does not involve the storage or handling of large volumes of pollutants, and once constructed does not consume significant quantities of water.

Key potential issues relevant to the water resources impacts of the Project are summarised below:

- Potential impacts to surface water resources are primarily limited to the construction and decommissioning phases of the Project. These potential impacts can be mitigated to represent negligible risk as detailed in Section 7.
- The operational phase of the Project presents minimal risk provided that by the conclusion of the construction phase appropriate groundcover and drainage is established.
- The Project will not interact with the groundwater table and therefore, no impacts to groundwater resources or GDEs are expected.
- The Project Area does not contain any areas of major flood hazard.
- The large extent of the Project Area and distributed nature of minor impacts (if any) does not pose a risk to drainage features, downstream watercourses or receiving waters.

For these reasons, the key potential risks to surface water are only associated with the Project's construction. These risks can be adequately managed through the application of well-established construction environmental and safety management practices and appropriate design.

9 REFERENCES

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APPENDIX A SEARS AGENCY ADVICE TABLE

Table A.1 SEARs Agency Advice Table

DPE - Biodiversity and Conservation Division (BCD) and the NSW National Parks and Wildlife Service (NPWS)		
7	The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: a. Flood prone land. b. Flood planning area, the area below the flood planning level. c. Hydraulic categorisation (floodways and flood storage areas). d. Flood hazard.	Refer to Sections 5 and Section 6.2.
8	The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP flood levels and the probable maximum flood, or an equivalent extreme event.	Refer to Sections 5 and Section 6.2 and Appendix B
9	The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: a. Current flood behaviour for a range of design events as identified in 7 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Refer to Sections 5 and Section 6.2 and Appendix B
10	Modelling in the EIS must consider and document: a. Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies. b. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. c. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. d. Relevant provisions of the NSW Floodplain Development Manual 2005	Refer to Sections 5 and Section 6.2 and Appendix B

DPE - Biodiversity and Conservation Division (BCD) and the NSW National Parks and Wildlife Service (NPWS)

11	The EIS must assess the impacts on the proposed development on flood behaviour, including:	Refer to Sections 5 and Section 6.2 and Appendix B
	a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure.	
	b. Consistency with Council Floodplain Risk Management Plans.	
	c. Consistency with any Rural Floodplain Management Plans.	For 11g. refer to Section 6.3
	d. Compatibility with the flood hazard of the land.	
	e. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land.	
	f. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	
	g. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	
	h. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council.	
	i. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council.	
	j. Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES.	
	k. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	

DPE - Water

1	A detailed and consolidated site water balance	Refer to Sections 4.2, 4.3 and 4.4
2	Description of all works/activities that may intercept, extract, use, divert or receive surface water and/or groundwater. This includes the description of any development, activities or structures that will intercept, interfere with or remove groundwater, both temporary and permanent.	Refer to Section 4
3	Details of all water take for the life of the project and post closure where applicable. This is to include water taken directly and indirectly, and the relevant water source where water entitlements are required to account for the water take. If the water is to be taken from an alternative source confirmation should be provided by the supplier that the appropriate volumes can be obtained.	Refer to Section 4.3

DPE - Water

4	Details of Water Access Licences (WALs) held to account for any take of water where required, or demonstration that WALs can be obtained prior to take of water occurring. This should include an assessment of the current market depth where water entitlement is required to be purchased. Any exemptions or exclusions to requiring approvals or licenses under the Water Management Act 2000 should be detailed by the proponent	Refer to Section 4, 5 and 6
5	A description of groundwater conditions that provides an understanding of groundwater level across the site under a range of wet and dry conditions.	Refer to Section 4, 5 and 6
6	Assessment of impacts on surface and ground water sources (both quality and quantity) including flooding, related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, groundwater dependent ecosystems, and ground water levels; including measures proposed to reduce and mitigate these impacts	Refer to Section 4, 5 and 6
7	Proposed surface and groundwater monitoring activities and methodologies.	Refer to Section 4, 5 and 6
8	A description of the watercourses located within the vicinity of the development, including Strahler Stream Order as mapped by Spatial Services NSW, and appropriate riparian setbacks. Impact assessment of all works/activities located on waterfront land as defined by the Water Management Act 2000, including an assessment against the Guidelines for Controlled Activities.	Refer to Section 4, 5 and 6
9	A description of erosion and sediment control measures to mitigate any impacts	Refer to Section 4, 5 and 6
10	Identification and impact assessment of all works/activities located on waterfront land including an assessment against Guidelines for Guidelines for Controlled Activities on Waterfront Land (NOW 2012) Controlled Activities on Waterfront Land (NRAR 2018).	Refer to Section 4, 5 and 6
11	Assessment of project against relevant policies and guidelines	Refer to Section 4, 5 and 6

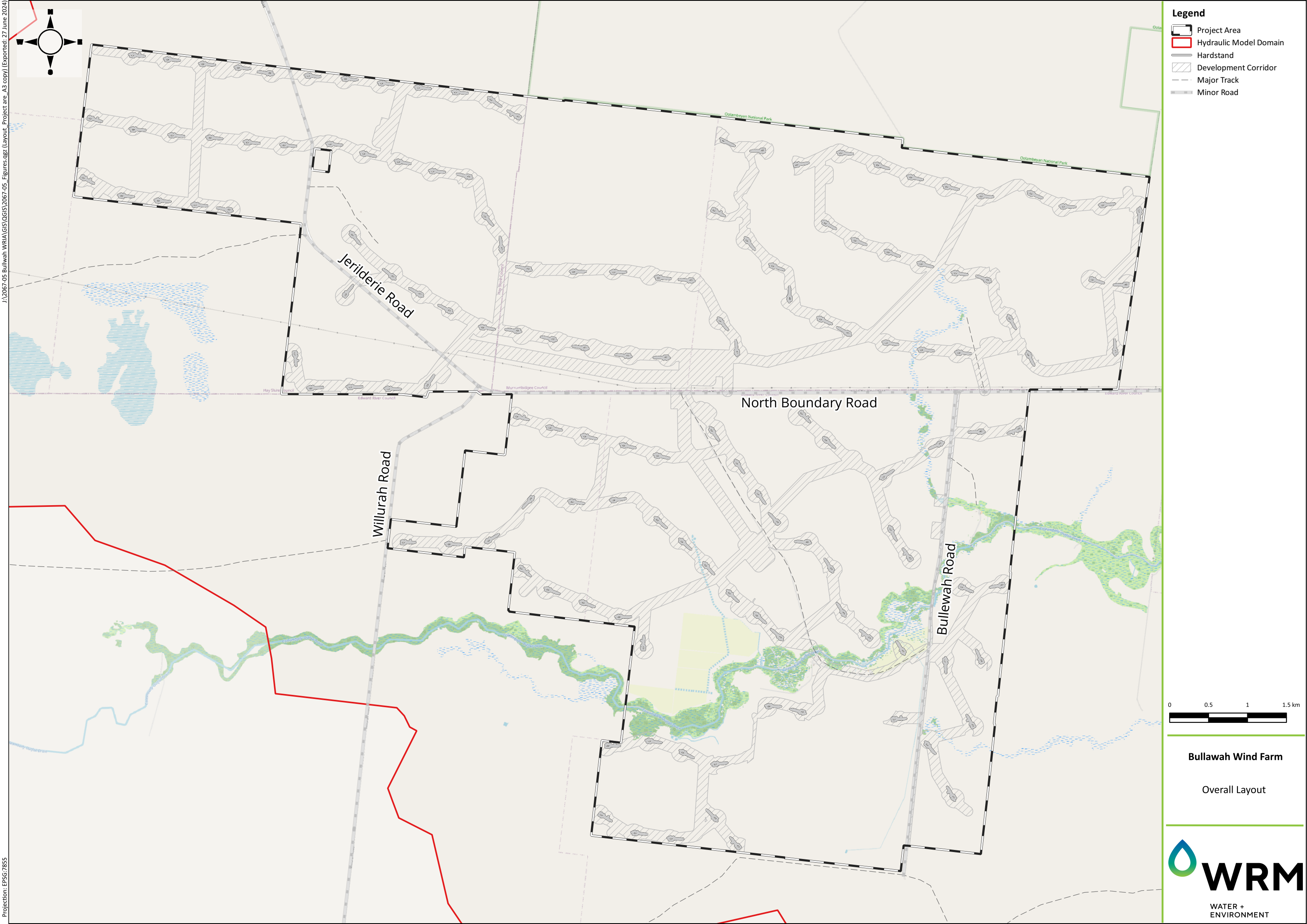
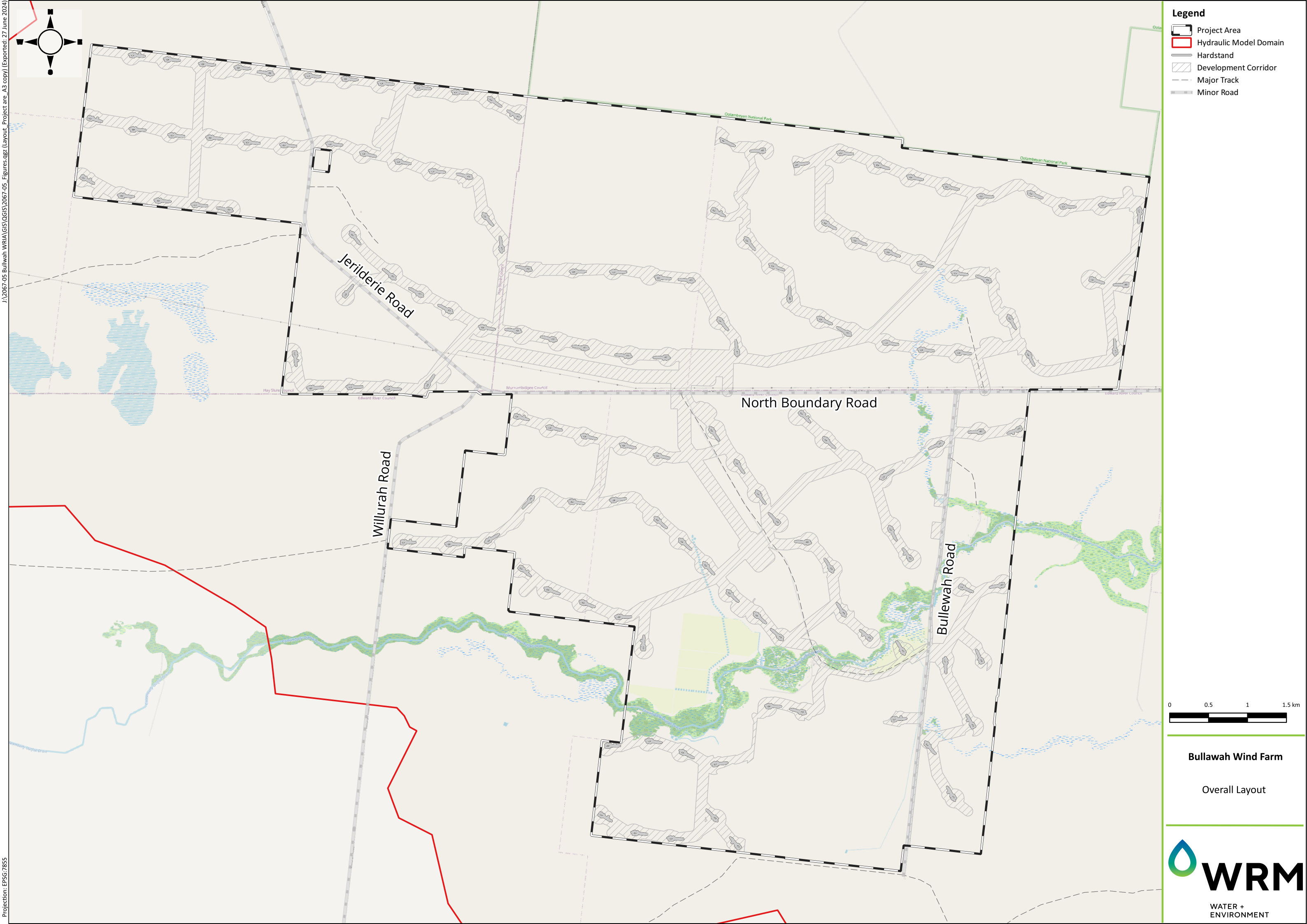
DPI - Fisheries

Watercourse crossings	The construction of watercourse crossings should be in accordance with DPI Fisheries Policy & Guideline document: Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013). Any temporary watercourse crossings must be removed immediately upon completion of the various stages of construction	Refer to Section 4, 5 and 6
Riparian buffer zones	The “degradation of native riparian vegetation” has been listed as a Key Threatening Process under the provisions of the Fisheries Management Act 1994. DPI Fisheries policy advocates the use of terrestrial buffer zones as per the Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013) in order to maintain the riparian buffer zone and limit disturbance and susceptibility to bed or bank erosion	Refer to Section 4, 5 and 6

The following agencies’ advice did not include any relevant requirements for this WRIA:

- Airservices
- DPE Agriculture
- CASA
- Crown Lands
- Edward River Council
- Environment Protection Authority
- Fire and Rescue NSW
- Hay Shire Council
- Heritage NSW
- Mining, Exploration & Geoscience
- Murrumbidgee Council
- Transport for NSW
- Rural Fire Service.

APPENDIX B FLOOD MAPPING



Legend

- Project Area
- Hydraulic Model Domain
- Hardstand
- Development Corridor
- Major Track
- Minor Road

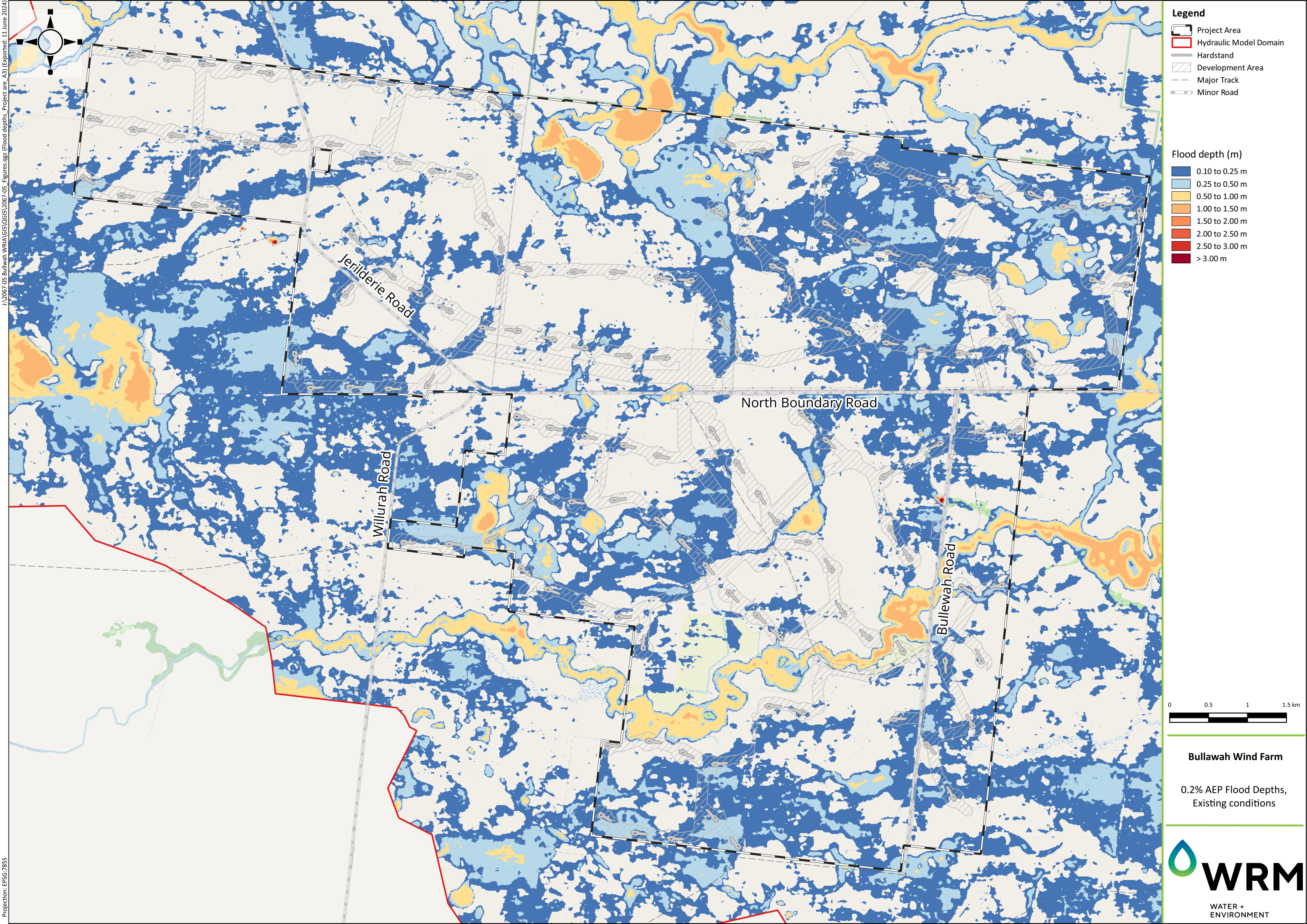


Bullawah Wind Farm

Overall Layout

WRM

WATER + ENVIRONMENT



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Legend

Project Area

Hydraulic Model Domain

Hardstand

Development Area

Major Track

Minor Road

Flood depth (m)

0.10 to 0.25 m

0.25 to 0.50 m

0.50 to 1.00 m

1.00 to 1.50 m

1.50 to 2.00 m

2.00 to 2.50 m

2.50 to 3.00 m

> 3.00 m

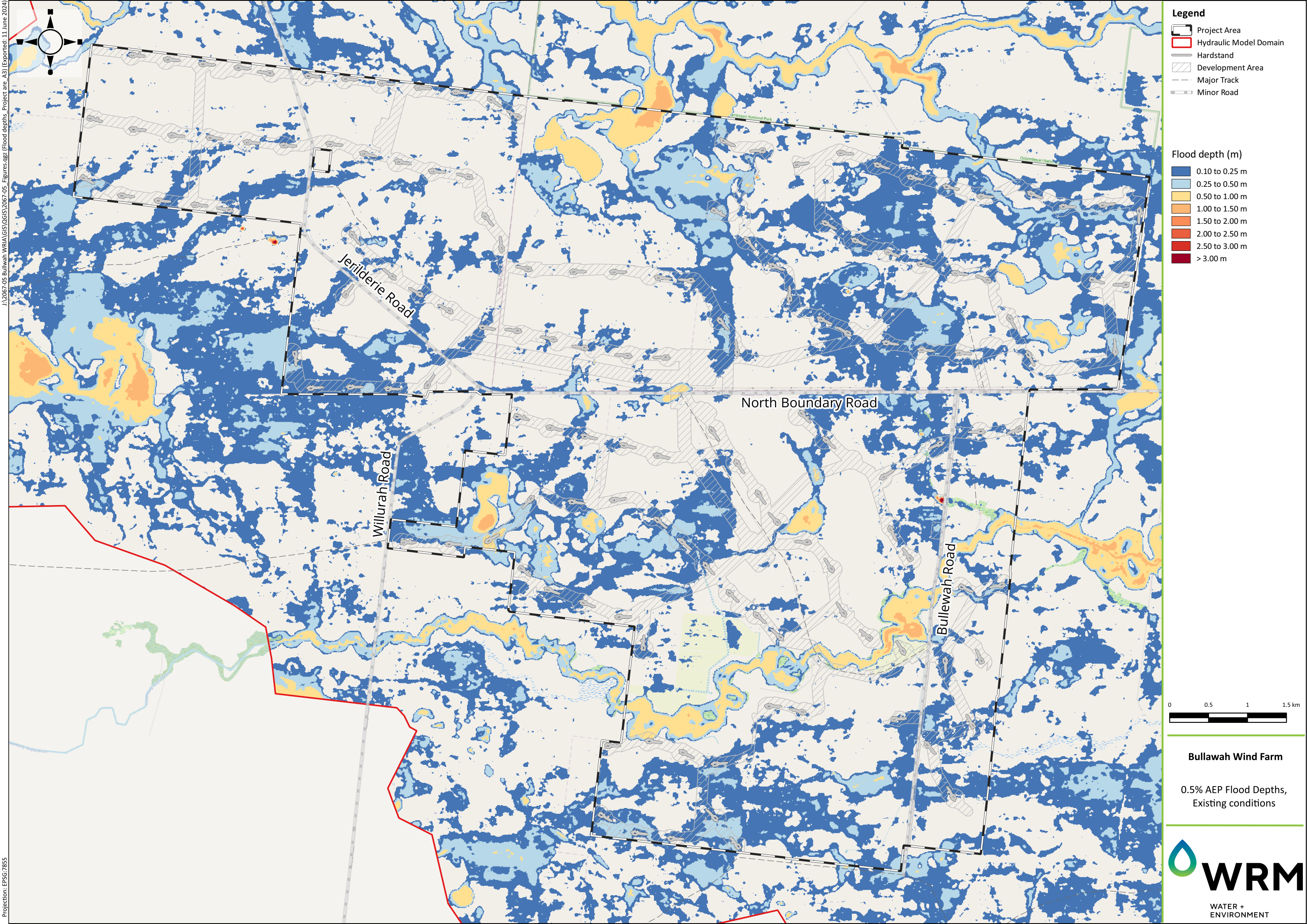


Bullawah Wind Farm

0.2% AEP Flood Depths,
Existing conditions

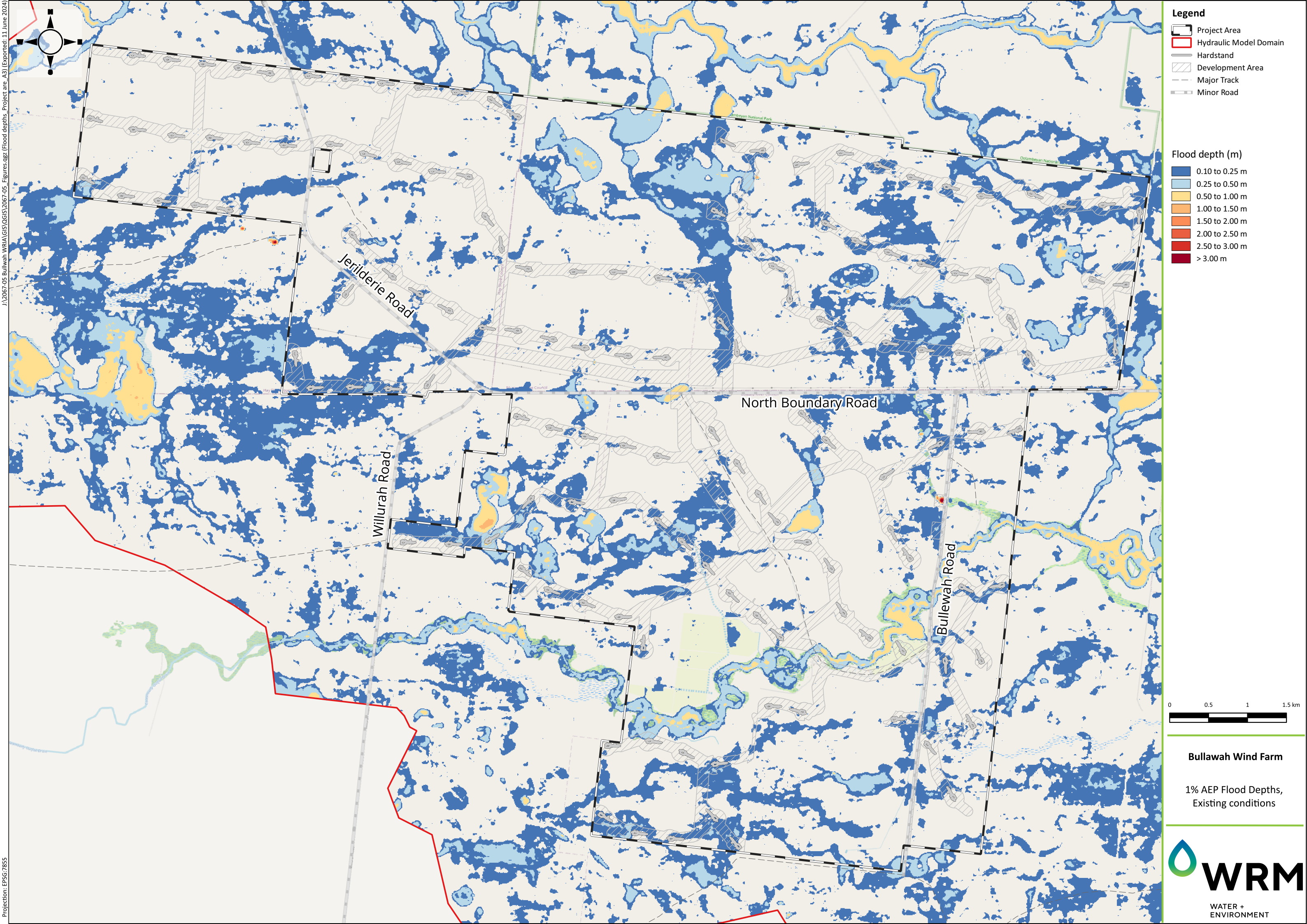
WRM

WATER +
ENVIRONMENT



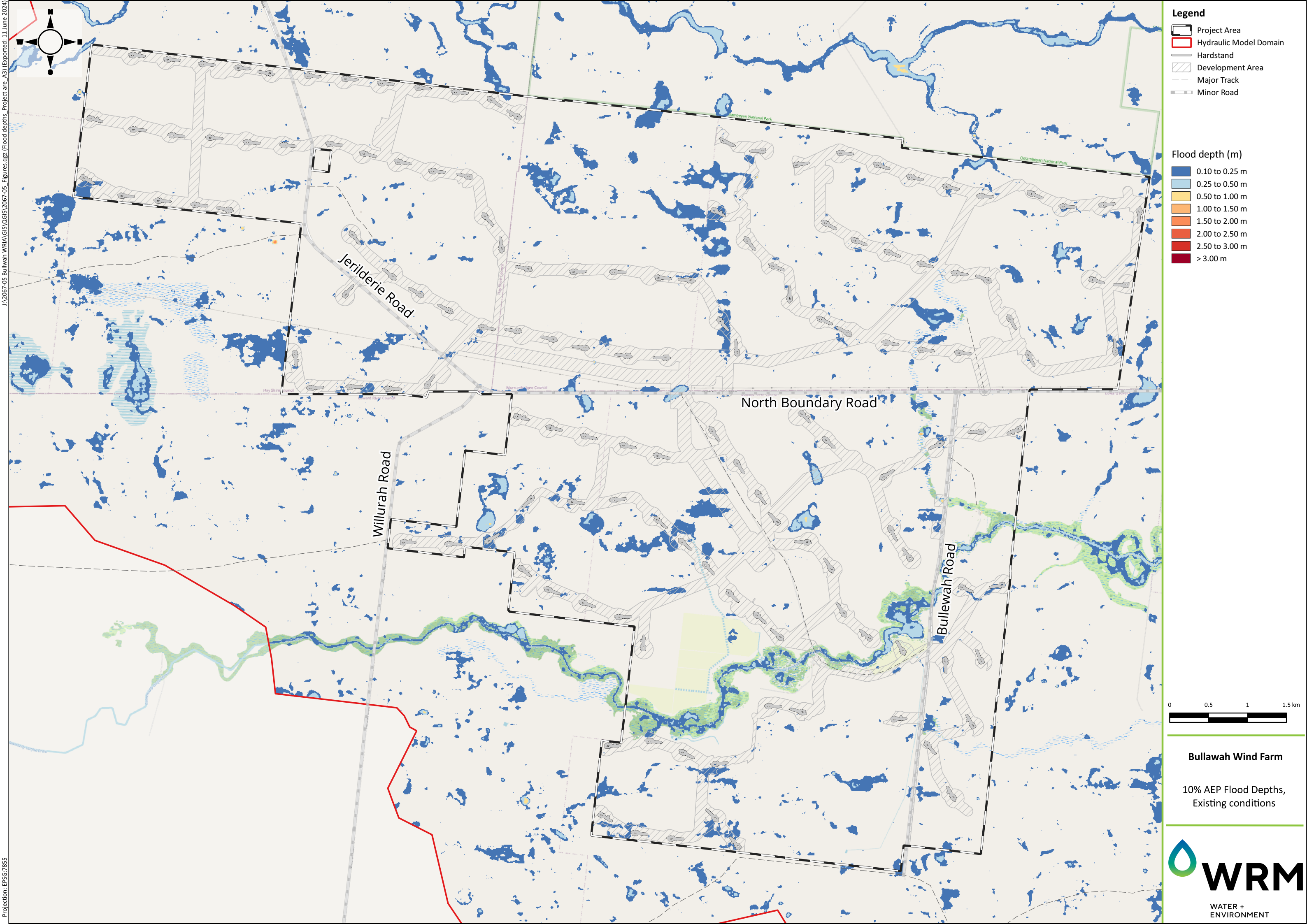
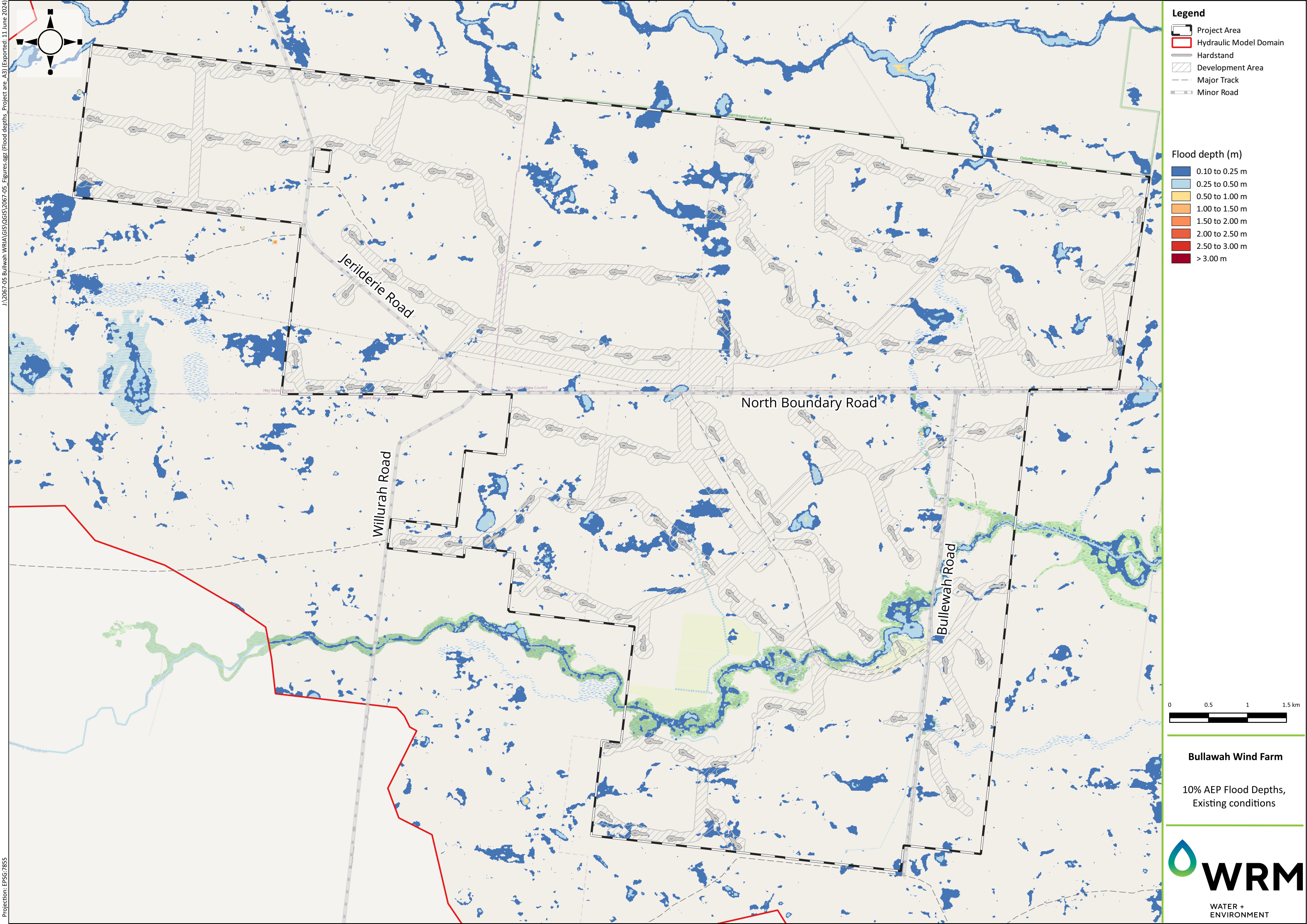
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Legend

- Project Area
- Hydraulic Model Domain
- Hardstand
- Development Area
- Major Track
- Minor Road

Flood depth (m)

- 0.10 to 0.25 m
- 0.25 to 0.50 m
- 0.50 to 1.00 m
- 1.00 to 1.50 m
- 1.50 to 2.00 m
- 2.00 to 2.50 m
- 2.50 to 3.00 m
- > 3.00 m

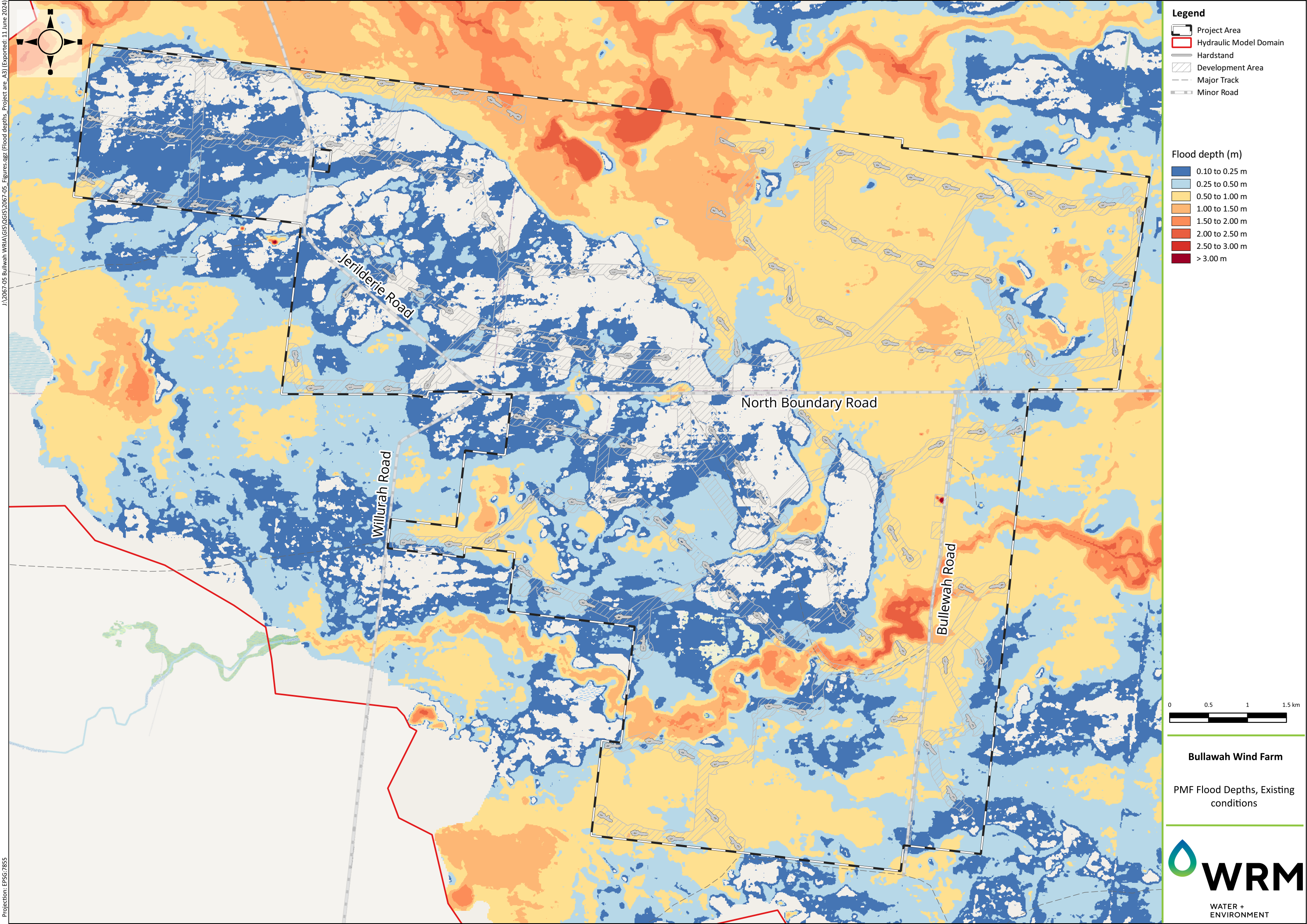


Bullawah Wind Farm

10% AEP Flood Depths,
Existing conditions

J:\2067-05 Bullwah WRIA\GIS\OGIS\2067-05 Figures.azp (Flood depths, Project are A3) (Exported: 11 June 2024)

Projection: EPSG:7855



J:\2067-05 Bullwah WRIA\GIS\OGIS\2067-05 Figures\agz Flood depths Project are A3\ Exported: 11 June 2021

Projection: EPSG:7855

- Legend**
- Project Area
 - Hydraulic Model Domain
 - Hardstand
 - Development Area
 - Major Track
 - Minor Road

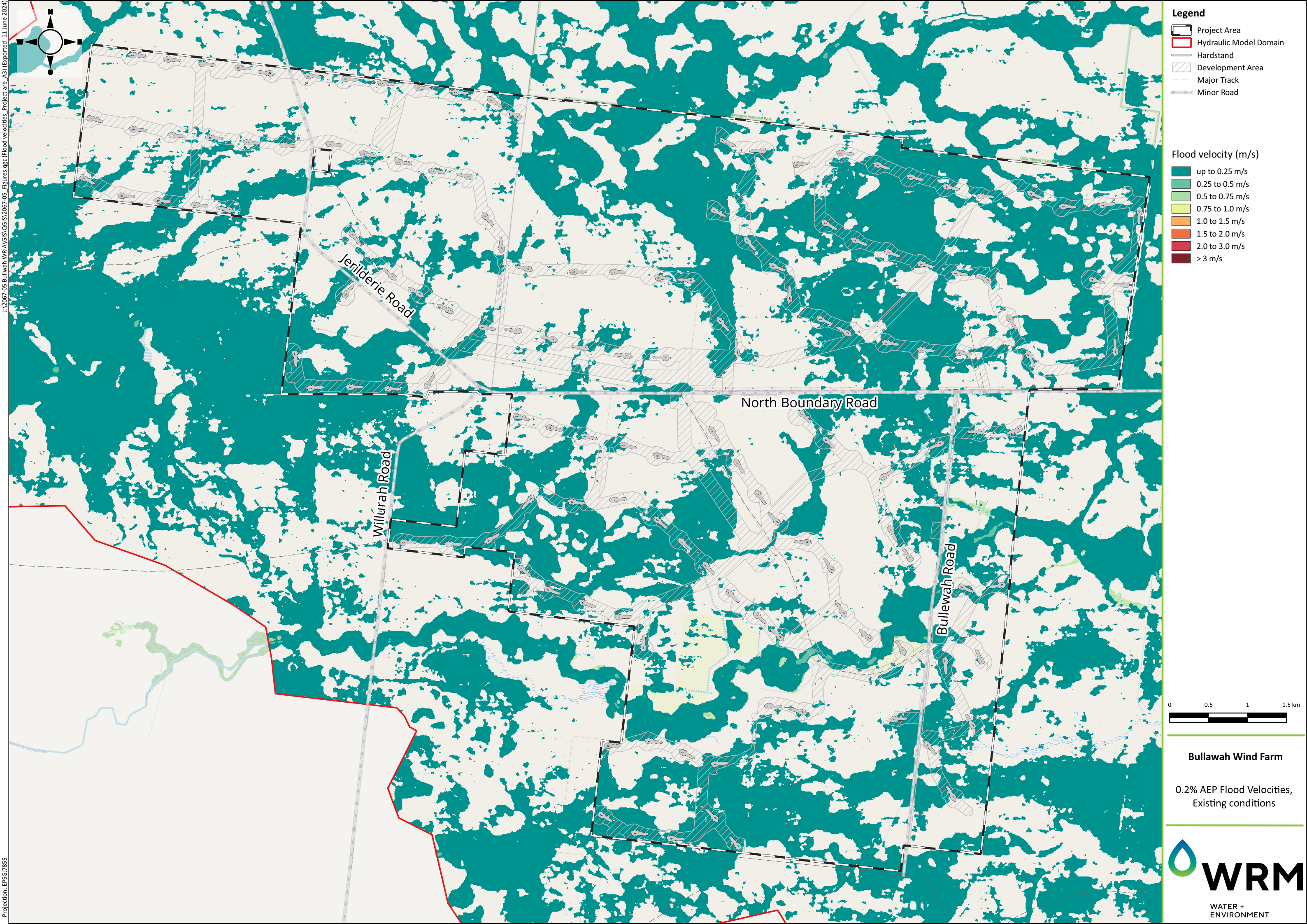
- Flood depth (m)**
- 0.10 to 0.25 m
 - 0.25 to 0.50 m
 - 0.50 to 1.00 m
 - 1.00 to 1.50 m
 - 1.50 to 2.00 m
 - 2.00 to 2.50 m
 - 2.50 to 3.00 m
 - > 3.00 m



Bullawah Wind Farm

PMF Flood Depths, Existing conditions





J:\2067-05 Bullawah WRIA\GIS\2067-05 Figures\agz Flood velocities Project are A3\ Exported: 11 June 2024

Projection: EPSG:7855

- Legend**
- Project Area
 - Hydraulic Model Domain
 - Hardstand
 - Development Area
 - Major Track
 - Minor Road

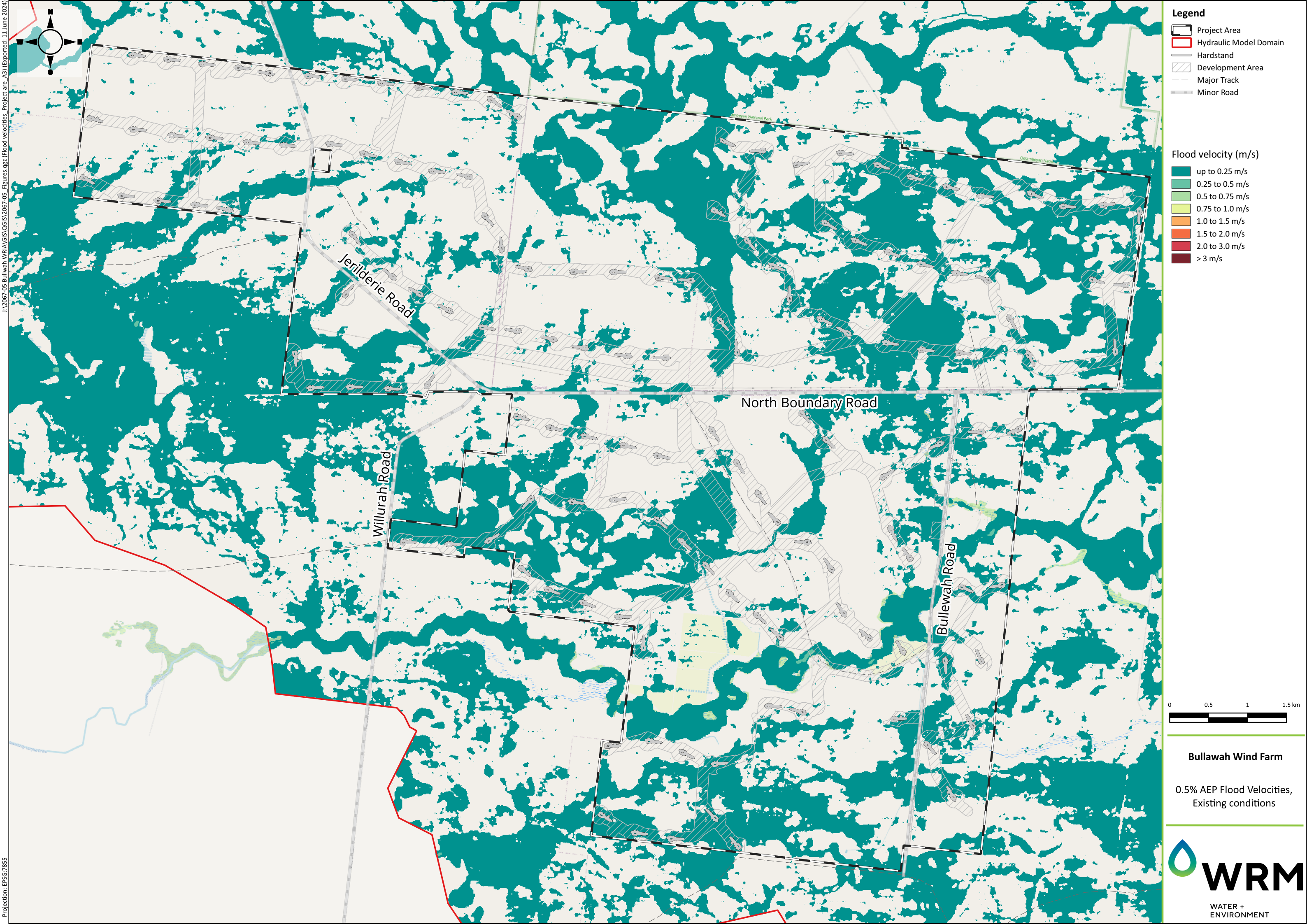
- Flood velocity (m/s)**
- up to 0.25 m/s
 - 0.25 to 0.5 m/s
 - 0.5 to 0.75 m/s
 - 0.75 to 1.0 m/s
 - 1.0 to 1.5 m/s
 - 1.5 to 2.0 m/s
 - 2.0 to 3.0 m/s
 - > 3 m/s



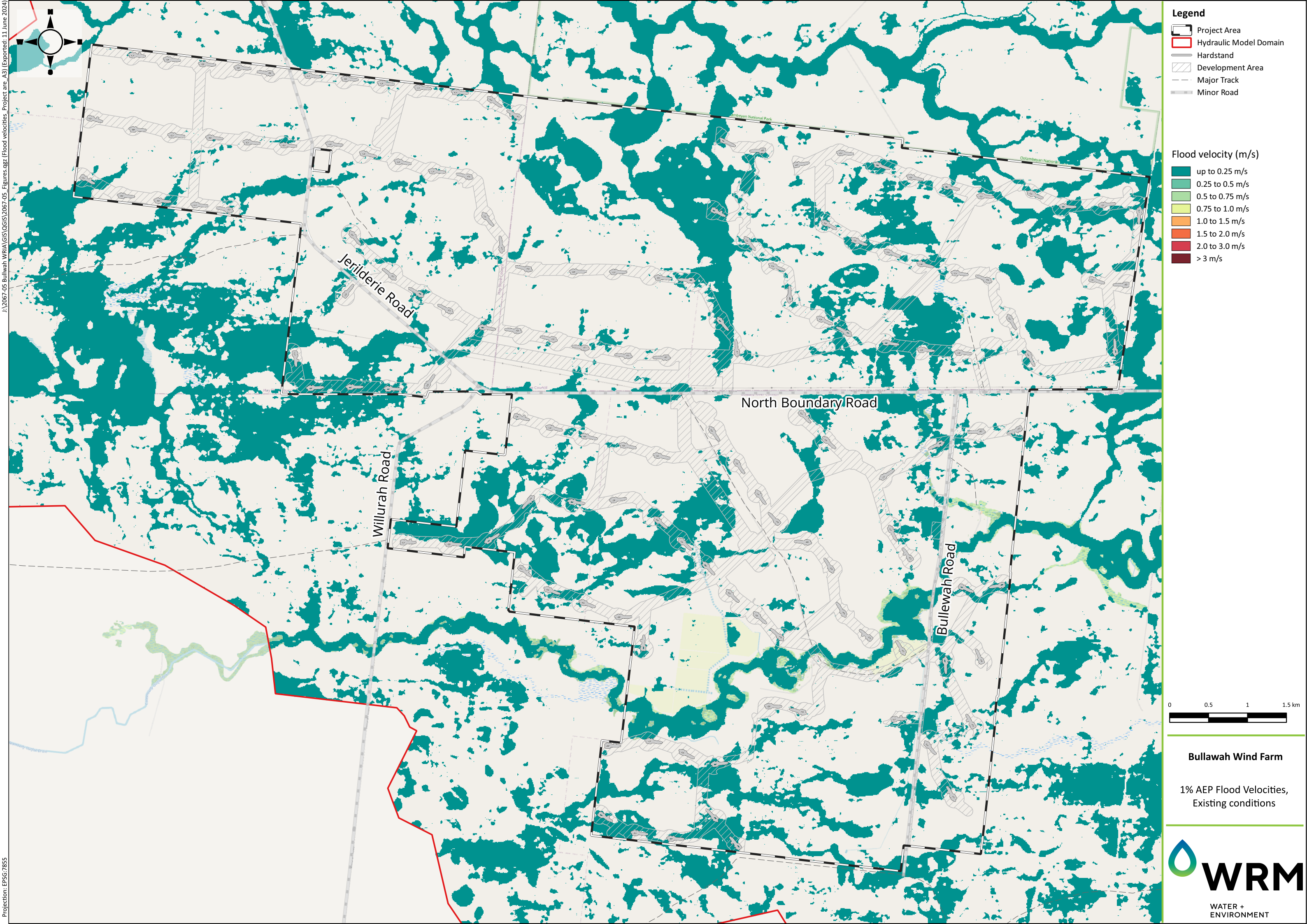
Bullawah Wind Farm

0.2% AEP Flood Velocities,
Existing conditions



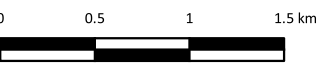


J:\2067-05 Bullawah WRIA\GIS\OGIS\2067-05 Figures\agz Flood velocities Project are A3\ Exported: 11 June 2023
Projection: EPSG:7855



- Legend**
- Project Area
 - Hydraulic Model Domain
 - Hardstand
 - Development Area
 - Major Track
 - Minor Road

- Flood velocity (m/s)**
- up to 0.25 m/s
 - 0.25 to 0.5 m/s
 - 0.5 to 0.75 m/s
 - 0.75 to 1.0 m/s
 - 1.0 to 1.5 m/s
 - 1.5 to 2.0 m/s
 - 2.0 to 3.0 m/s
 - > 3 m/s

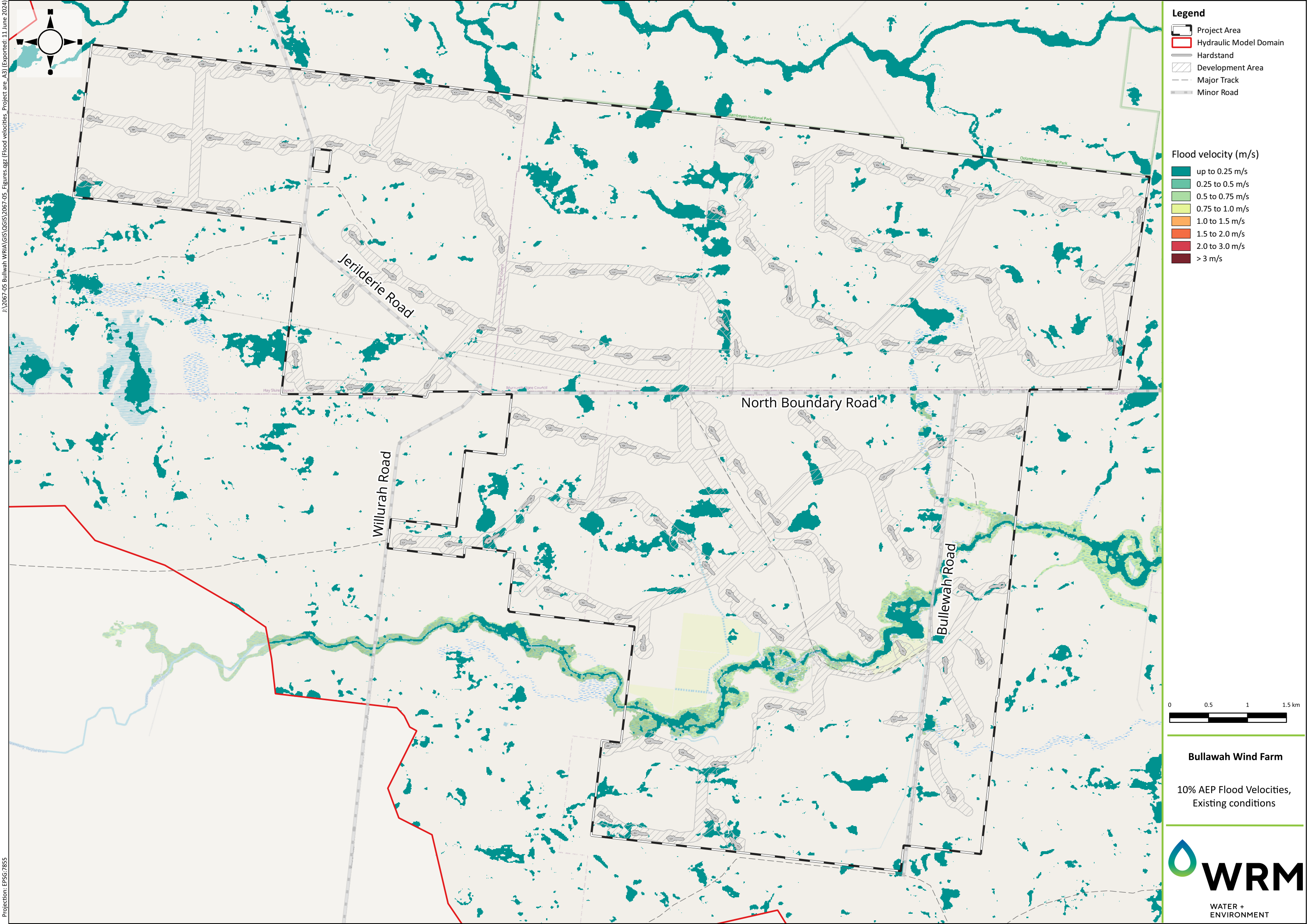
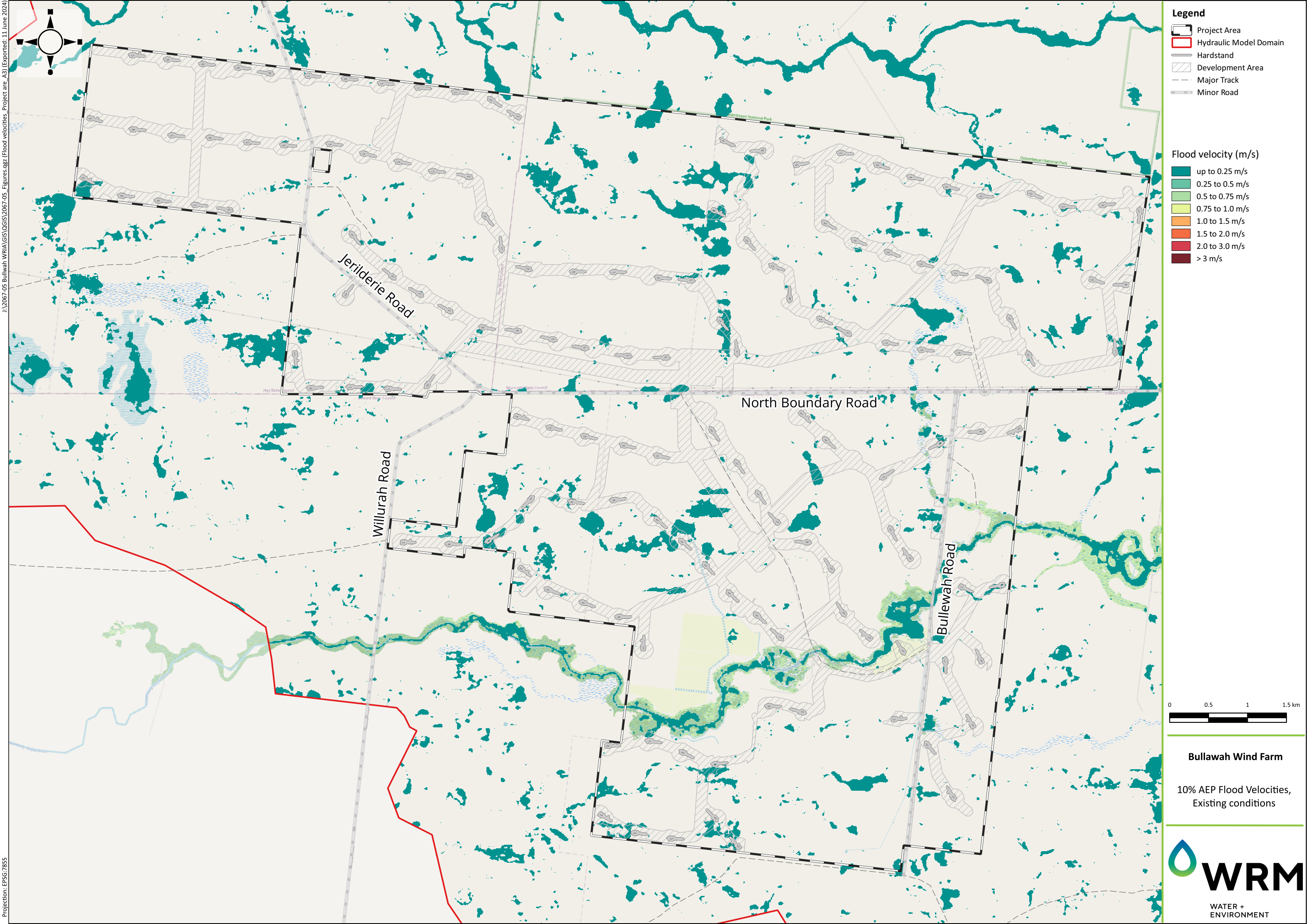


Bullawah Wind Farm

1% AEP Flood Velocities,
Existing conditions



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Projection: EPSG:7855



Legend

- Project Area
- Hydraulic Model Domain
- Hardstand
- Development Area
- Major Track
- Minor Road

Flood velocity (m/s)

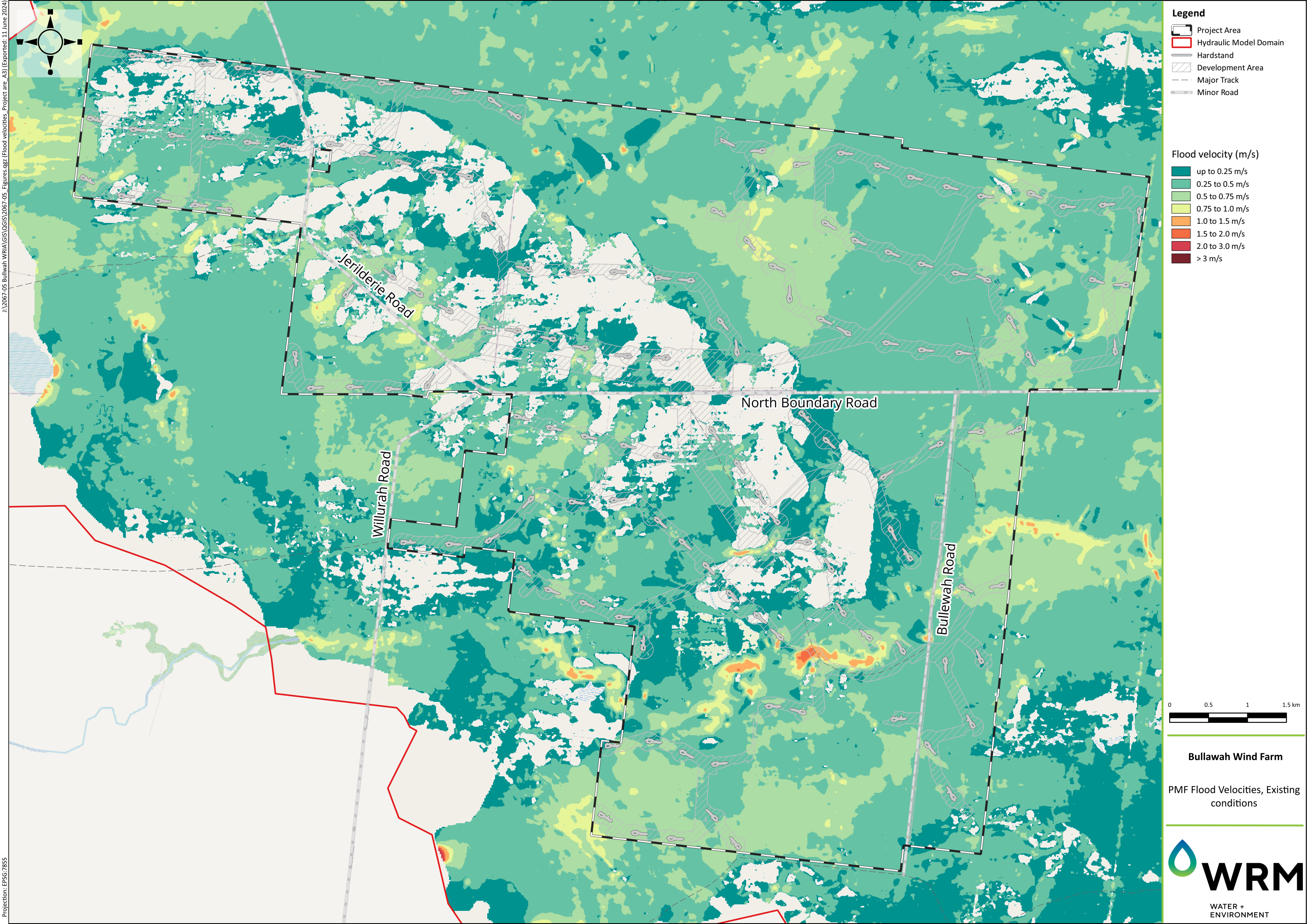
- up to 0.25 m/s
- 0.25 to 0.5 m/s
- 0.5 to 0.75 m/s
- 0.75 to 1.0 m/s
- 1.0 to 1.5 m/s
- 1.5 to 2.0 m/s
- 2.0 to 3.0 m/s
- > 3 m/s



Bullawah Wind Farm

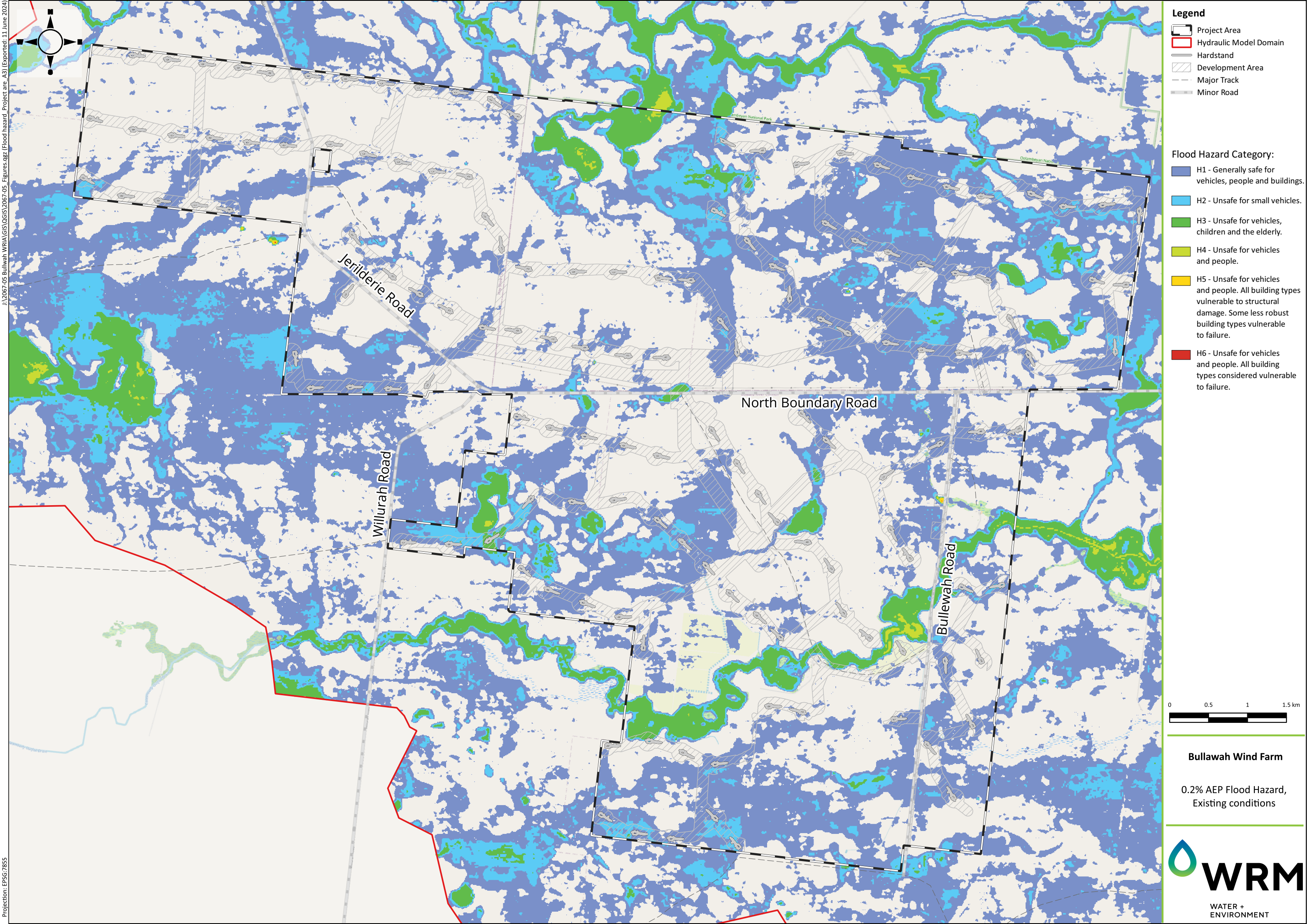
10% AEP Flood Velocities,
Existing conditions





J:\2067-05 Bullwah WRIA\GIS\OGIS\2067-05 Figures\agz Flood velocities Project are A3\ Exported: 11 June 2023

Projection: EPSG:7855



J:\2067-05 Bullawah WRIA\GIS\OGIS\2067-05 Figures\agz (Flood hazard, Project are A3) (Exported: 11 June 2023)

Projection: EPSG:7855

- Legend**
- Project Area
 - Hydraulic Model Domain
 - Hardstand
 - Development Area
 - Major Track
 - Minor Road

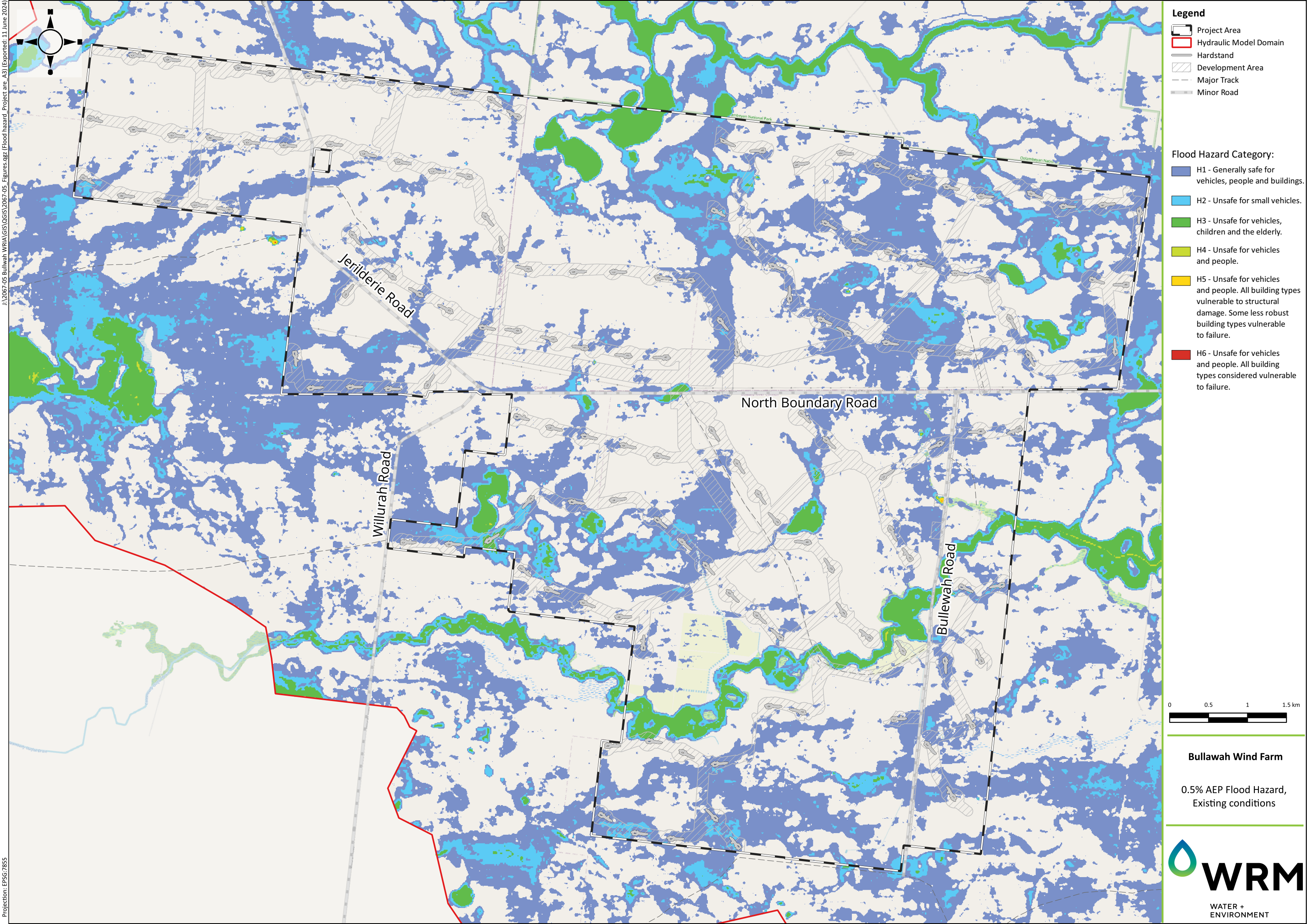
- Flood Hazard Category:**
- H1 - Generally safe for vehicles, people and buildings.
 - H2 - Unsafe for small vehicles.
 - H3 - Unsafe for vehicles, children and the elderly.
 - H4 - Unsafe for vehicles and people.
 - H5 - Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
 - H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.



Bullawah Wind Farm

0.2% AEP Flood Hazard,
Existing conditions





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Projection: EPSG:7855

- Legend**
- Project Area
 - Hydraulic Model Domain
 - Hardstand
 - Development Area
 - Major Track
 - Minor Road

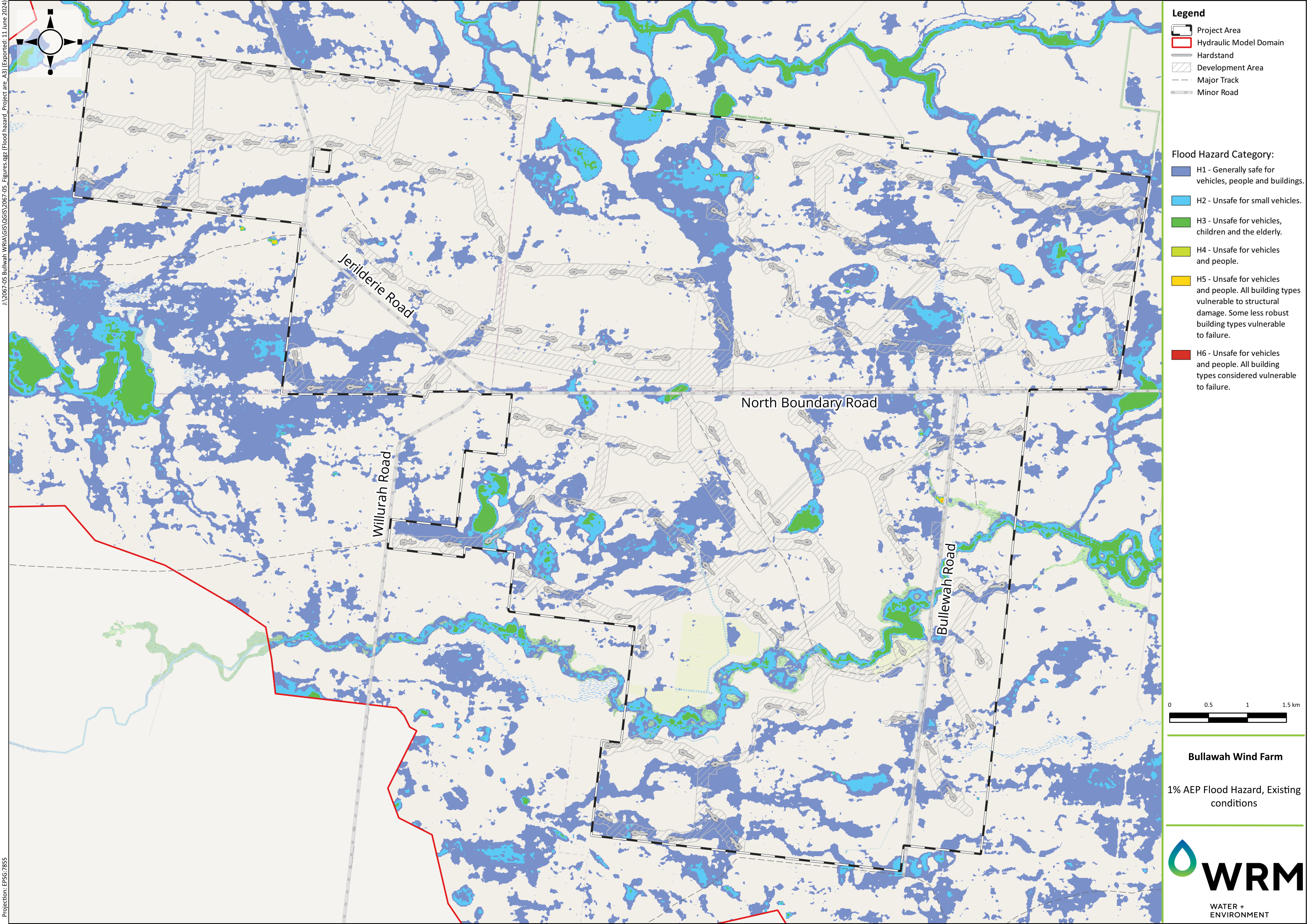
- Flood Hazard Category:**
- H1 - Generally safe for vehicles, people and buildings.
 - H2 - Unsafe for small vehicles.
 - H3 - Unsafe for vehicles, children and the elderly.
 - H4 - Unsafe for vehicles and people.
 - H5 - Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
 - H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.



Bullawah Wind Farm

0.5% AEP Flood Hazard,
Existing conditions





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Projection: EPSG:7855

- Legend**
- Project Area
 - Hydraulic Model Domain
 - Hardstand
 - Development Area
 - Major Track
 - Minor Road

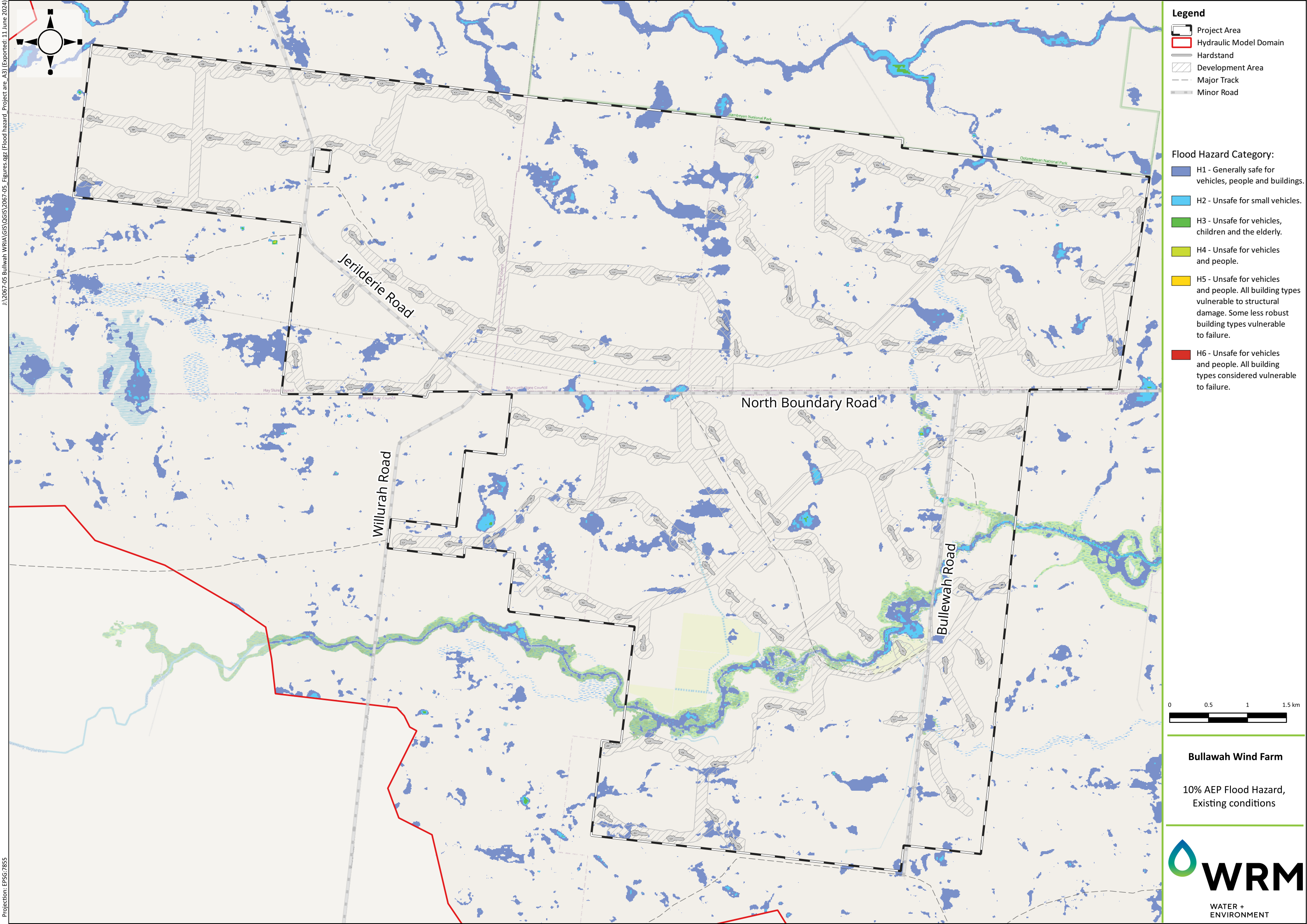
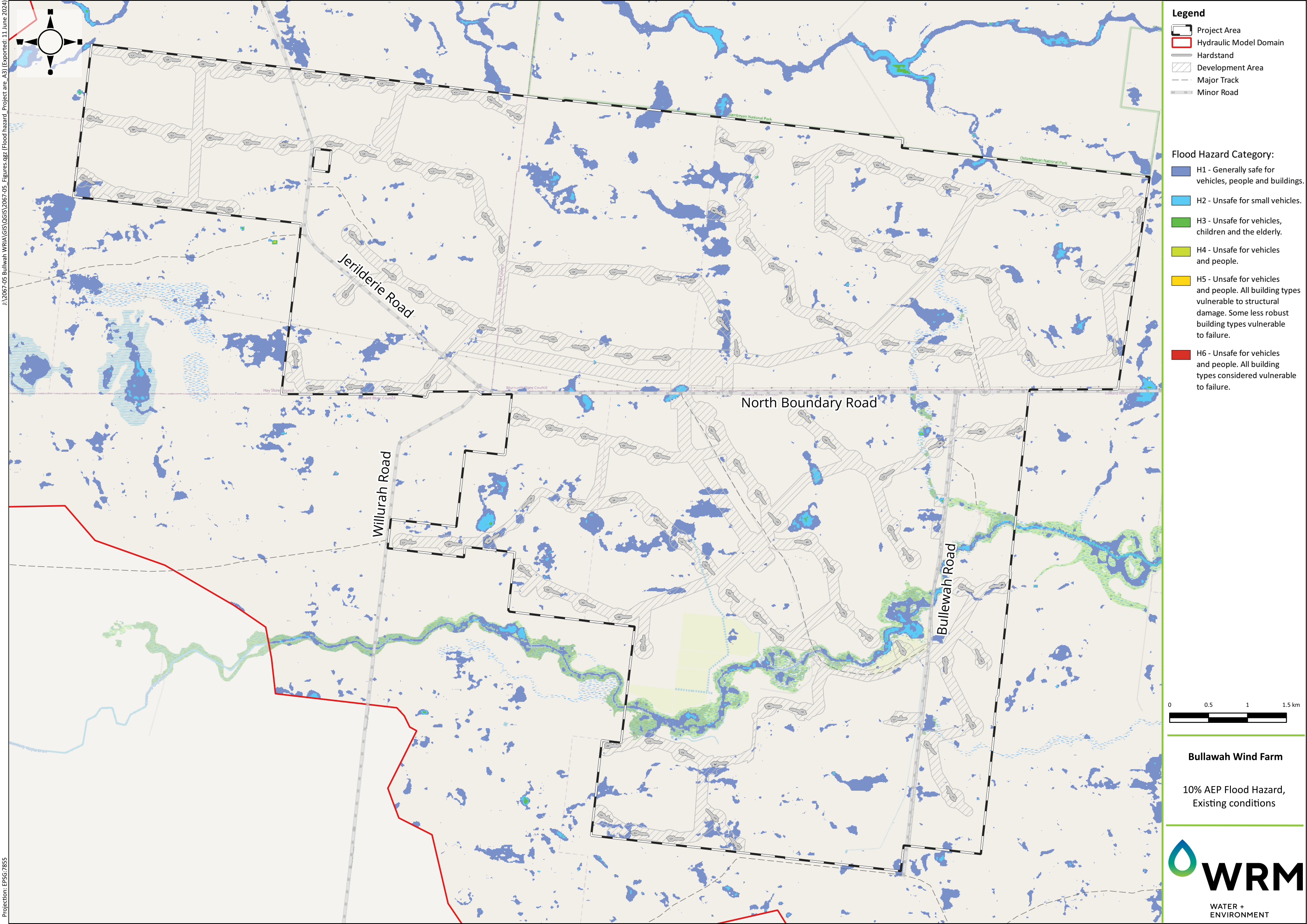
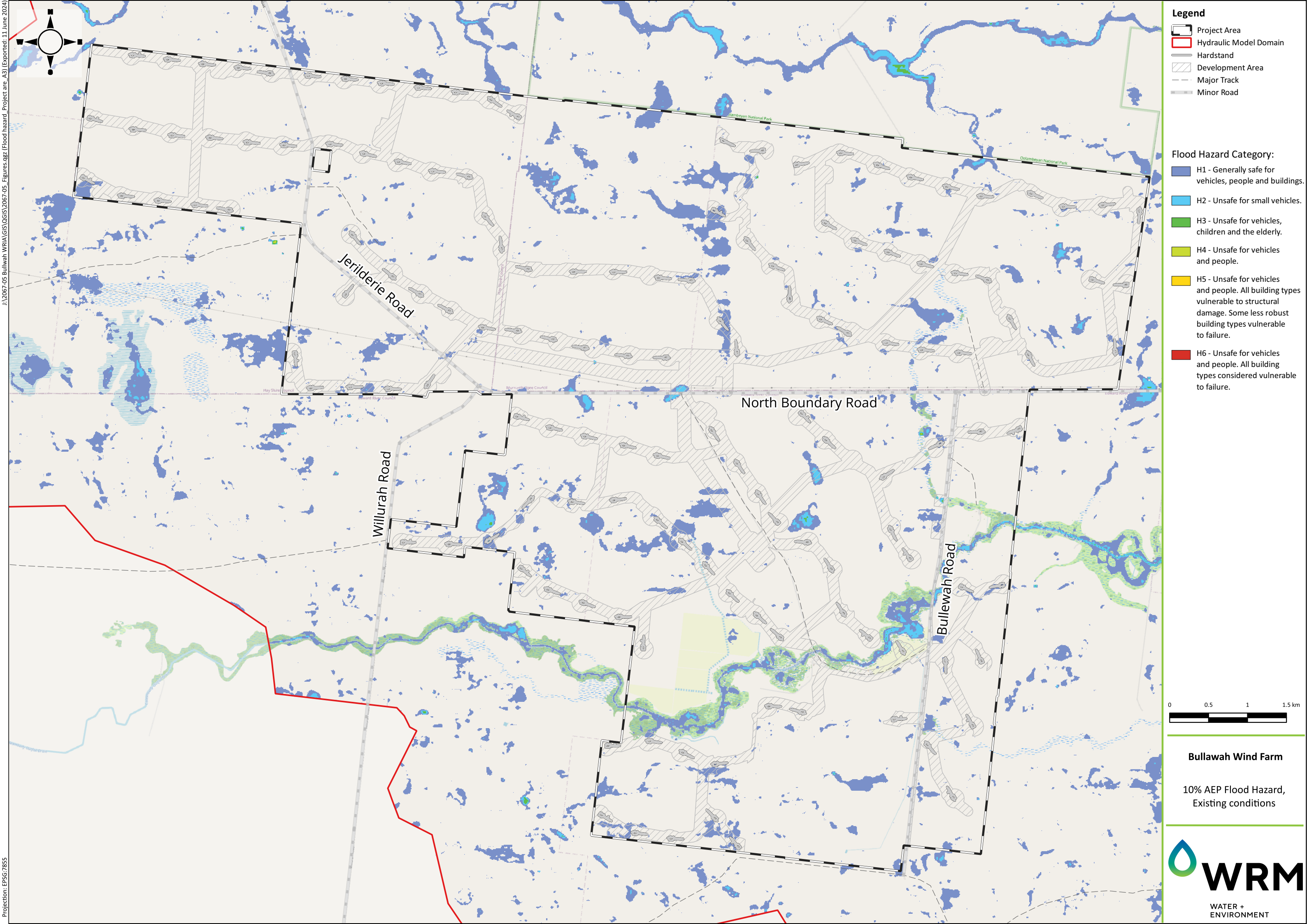
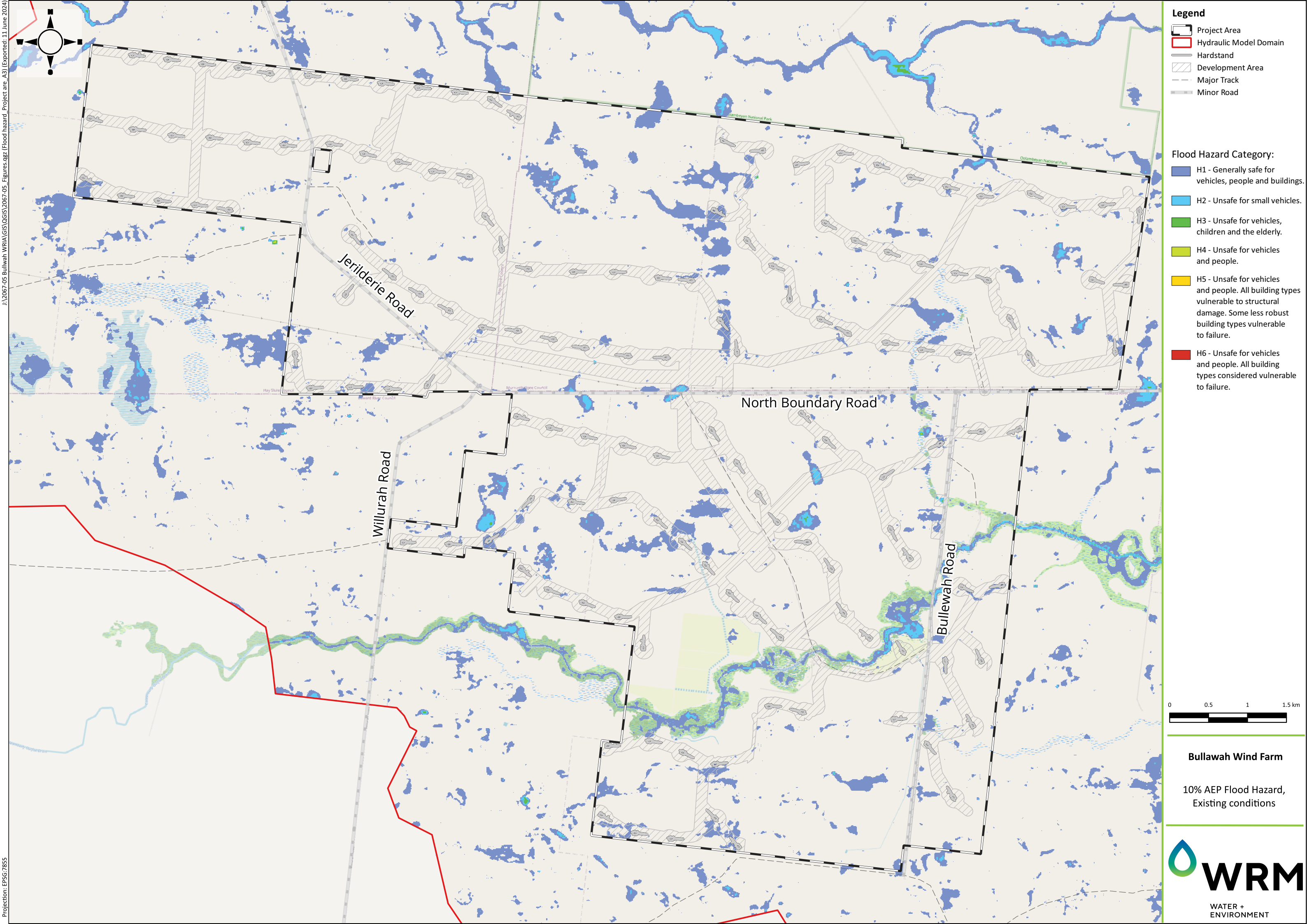
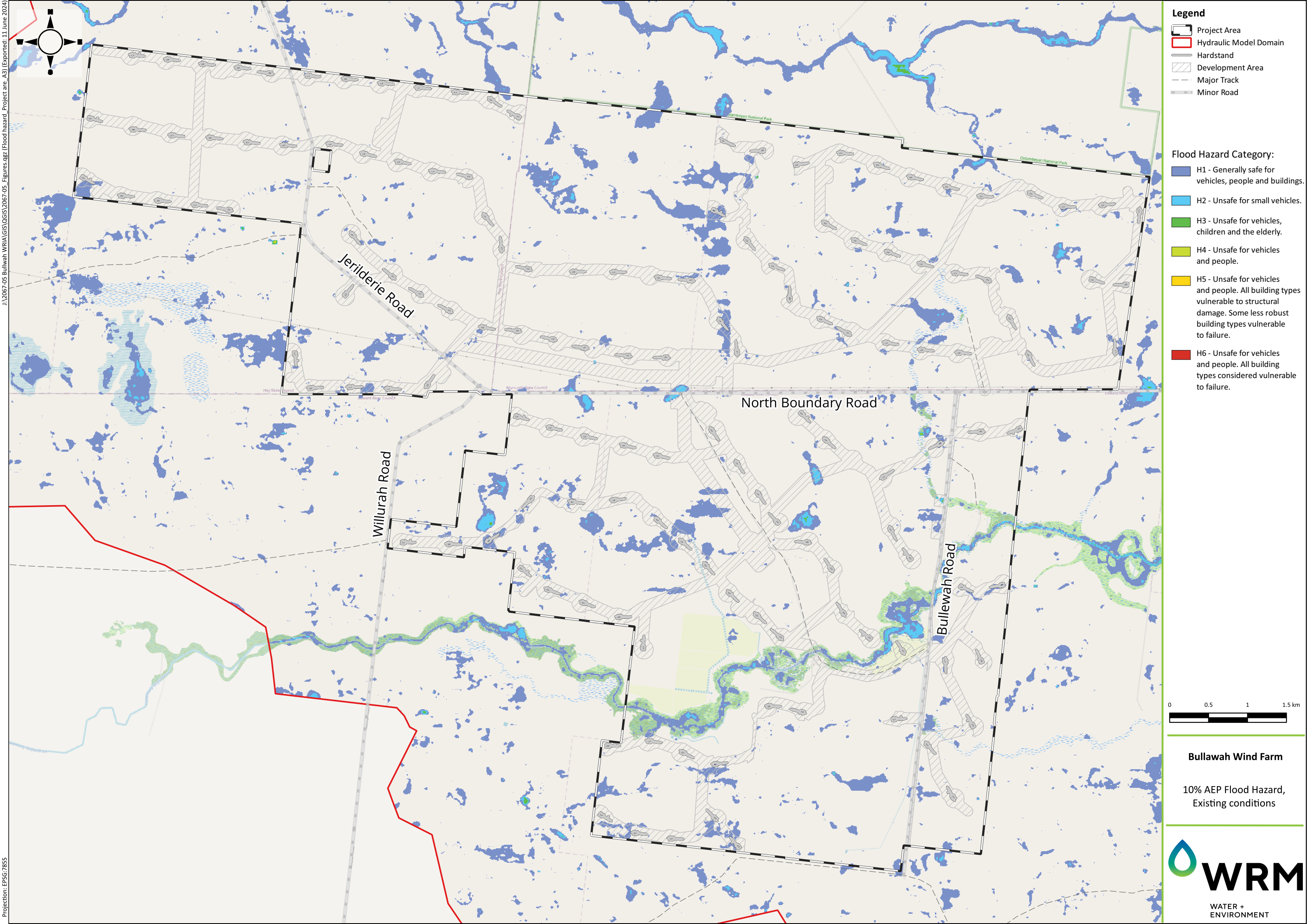
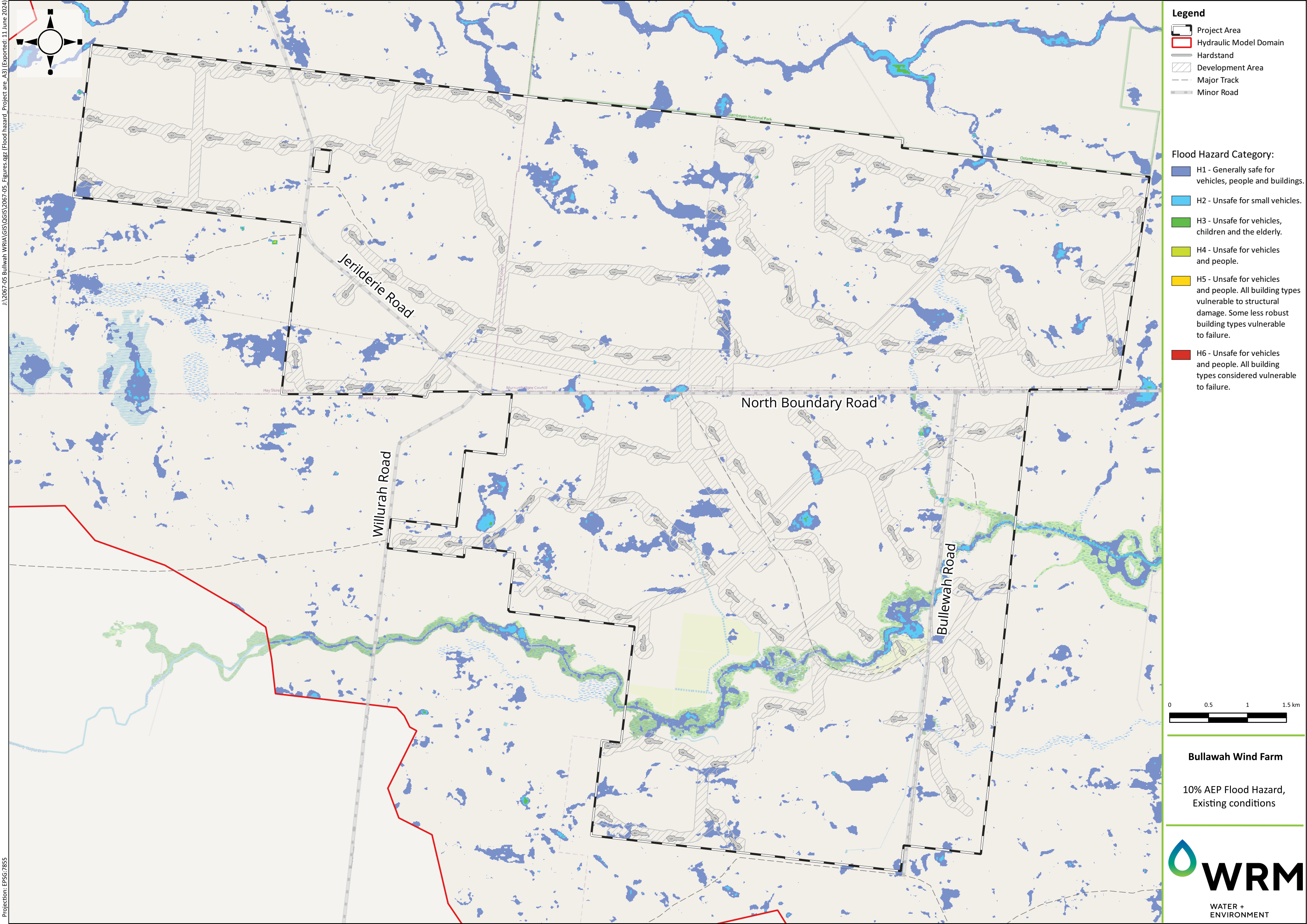
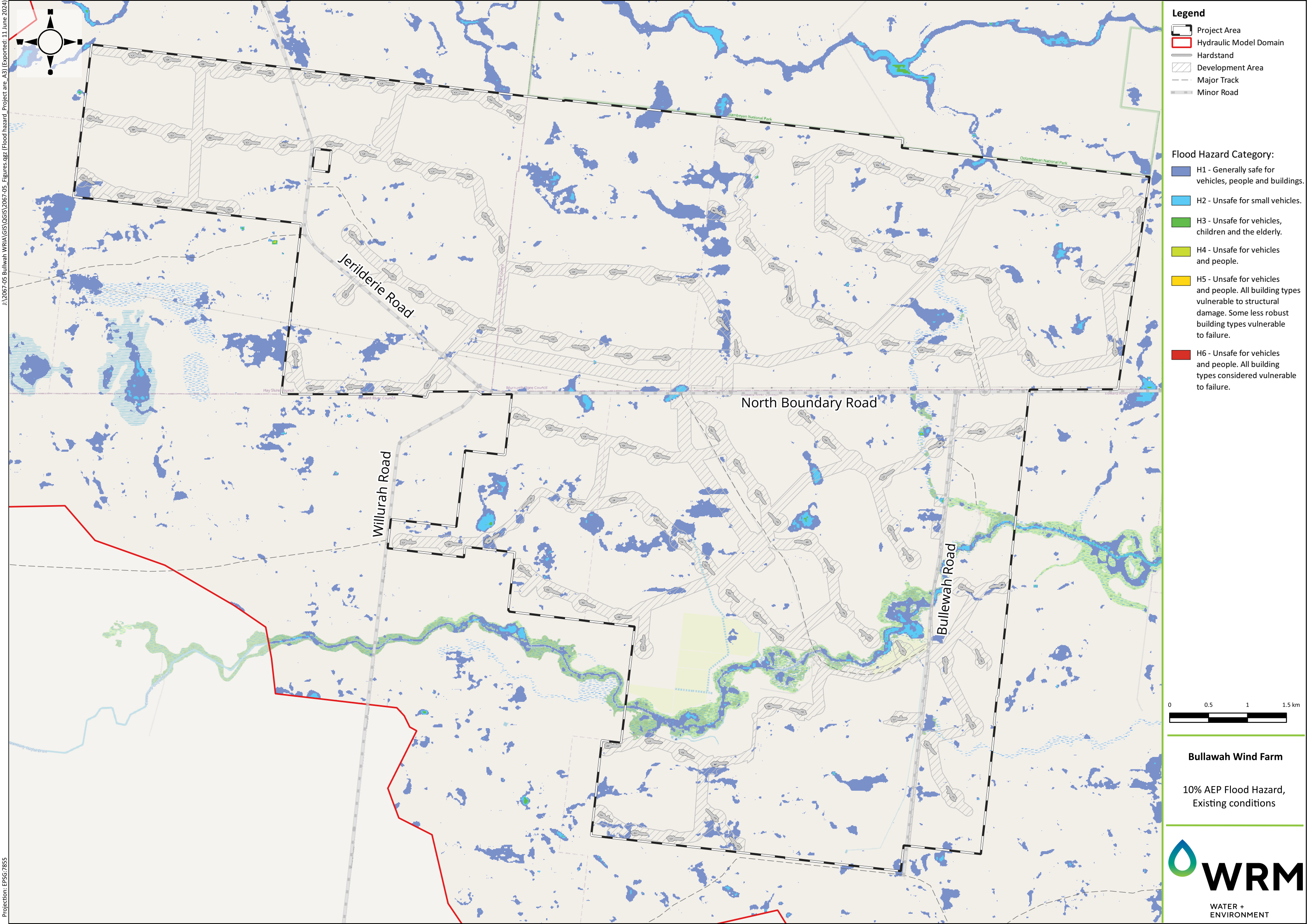
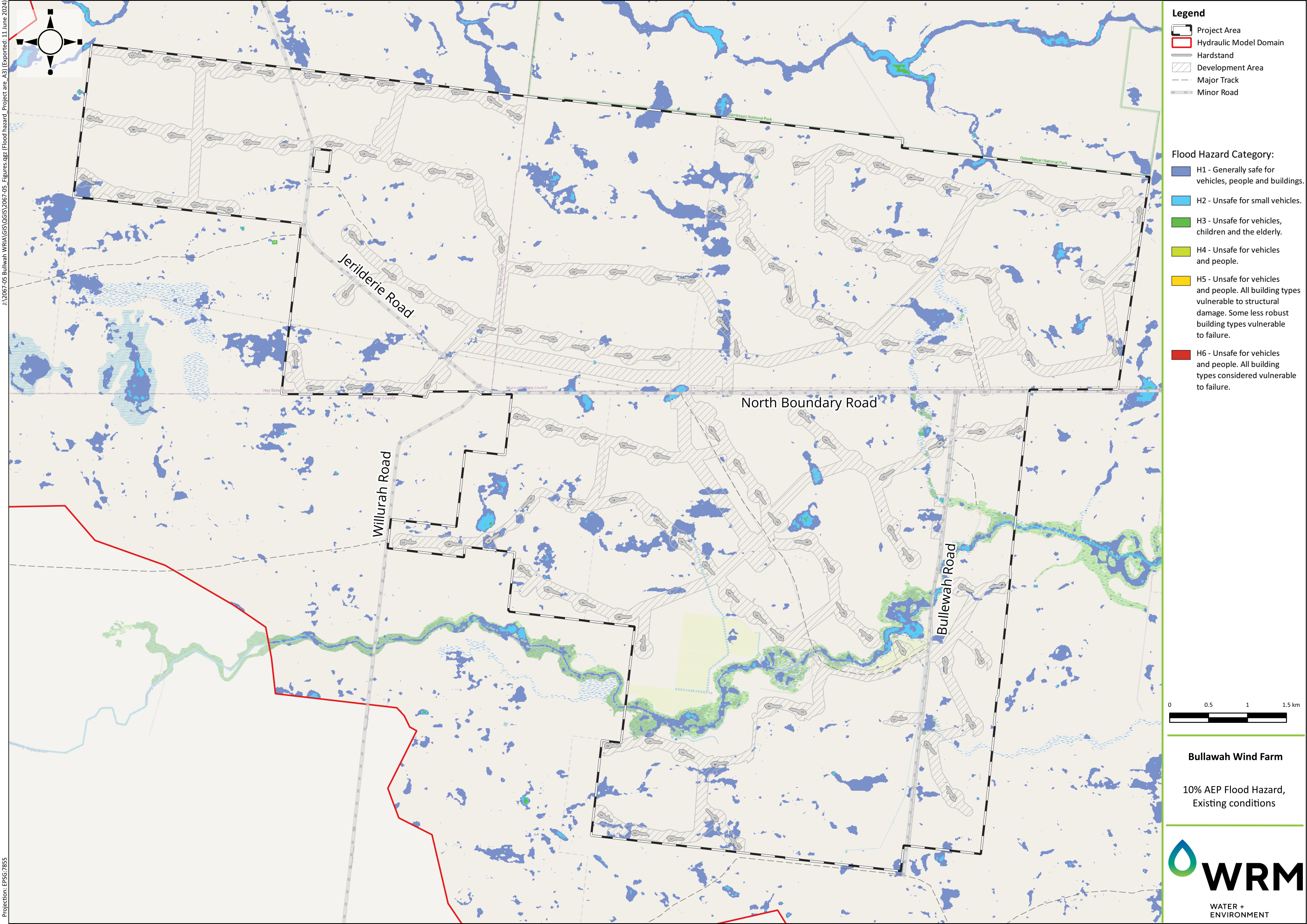
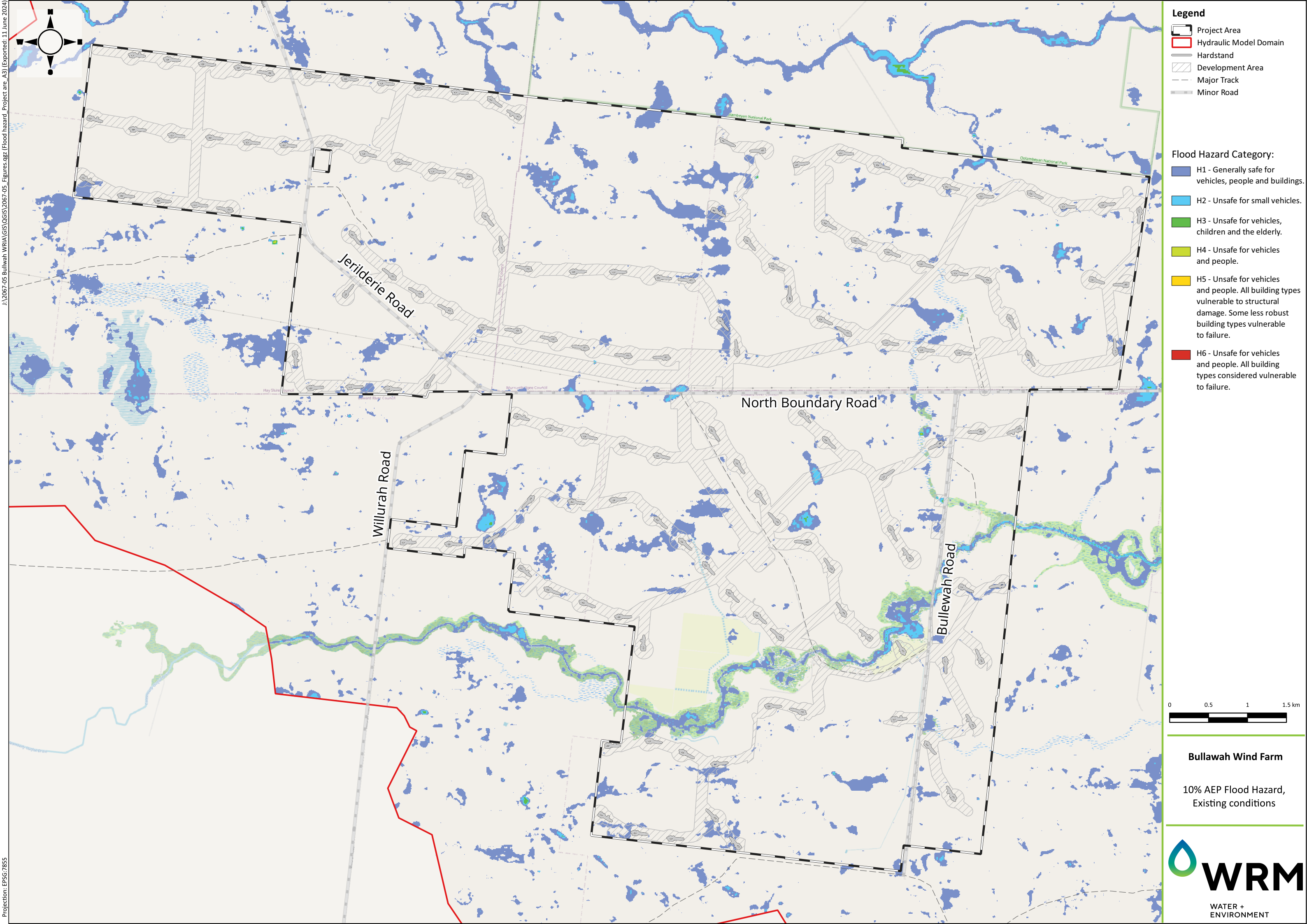
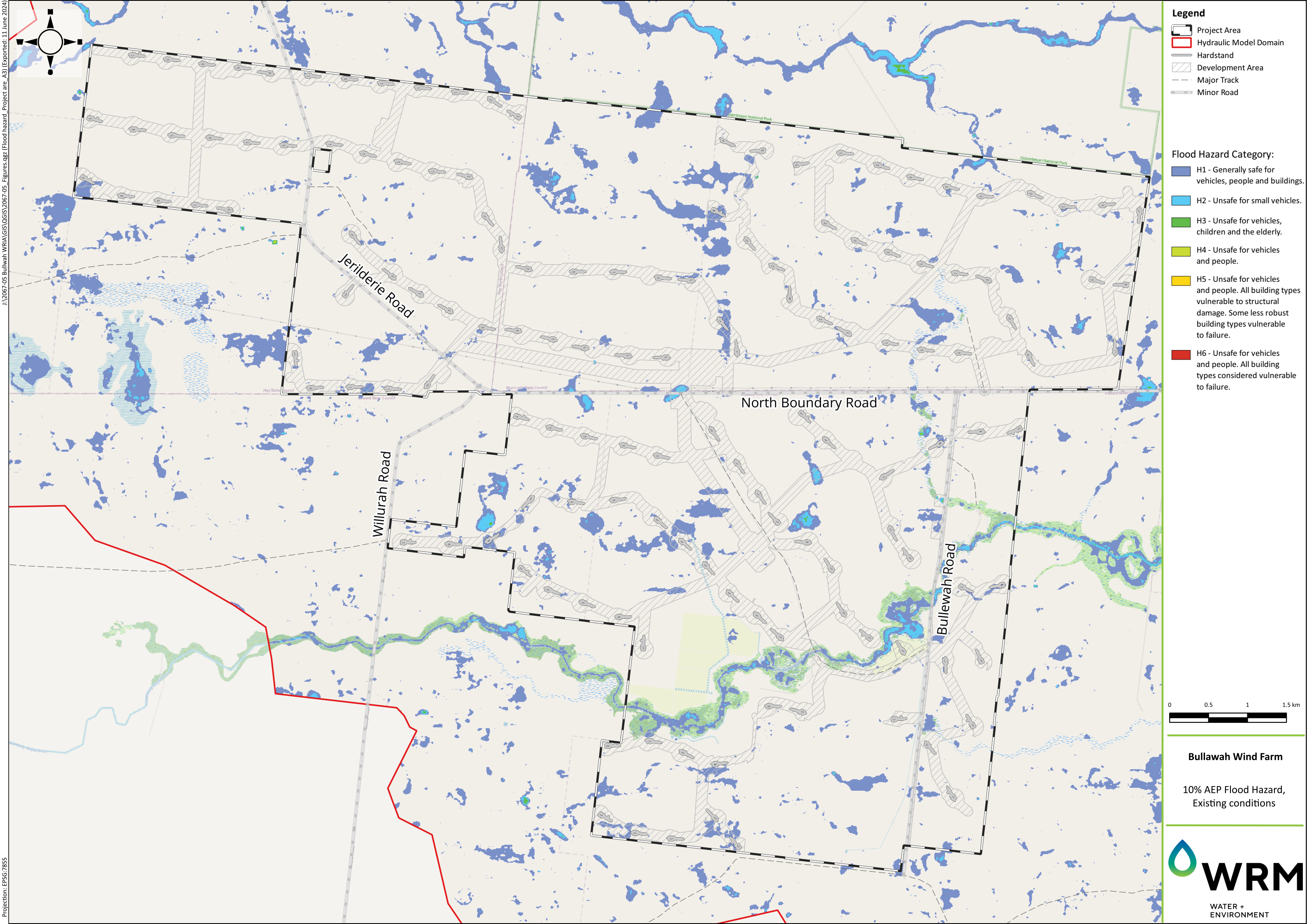
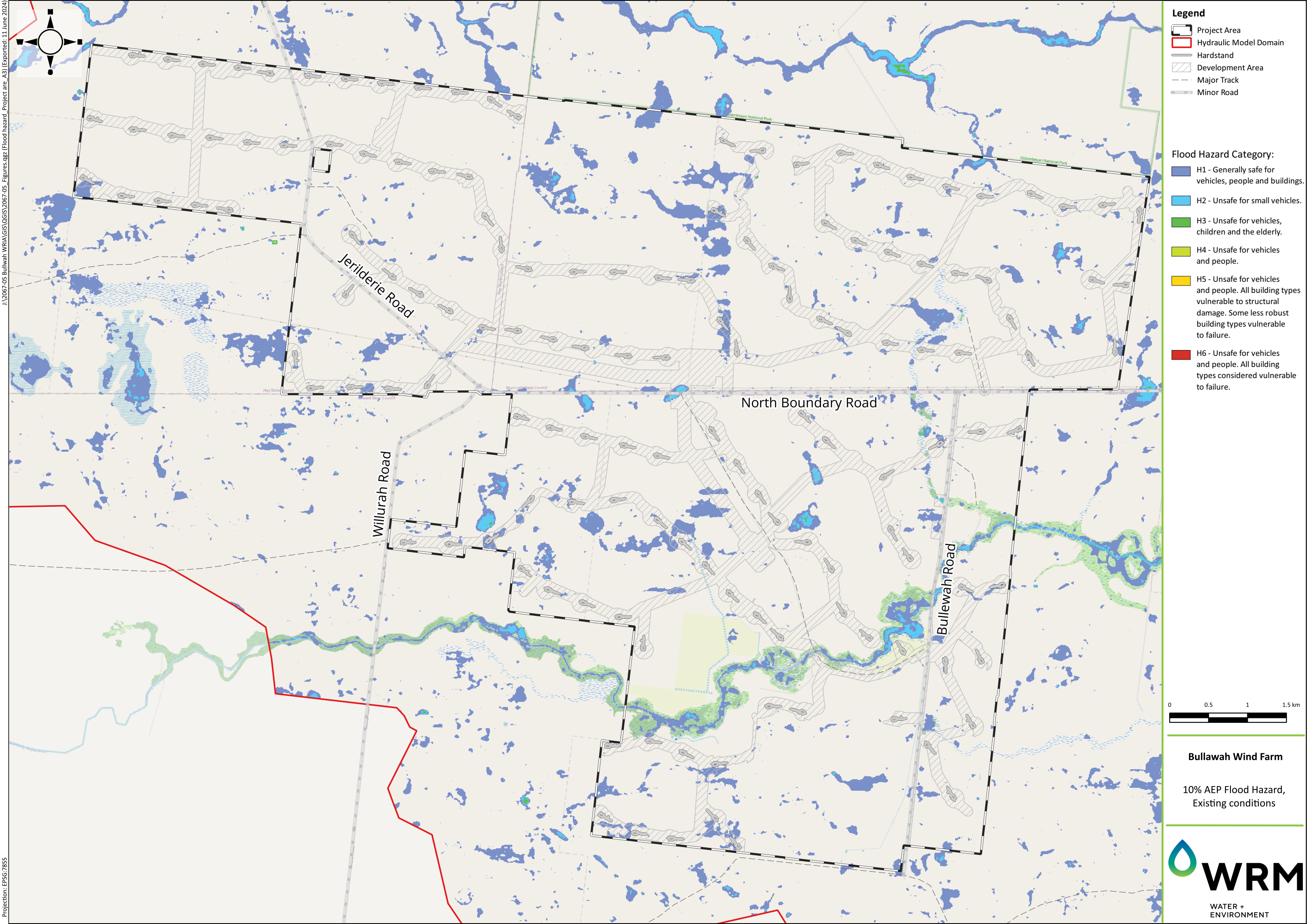
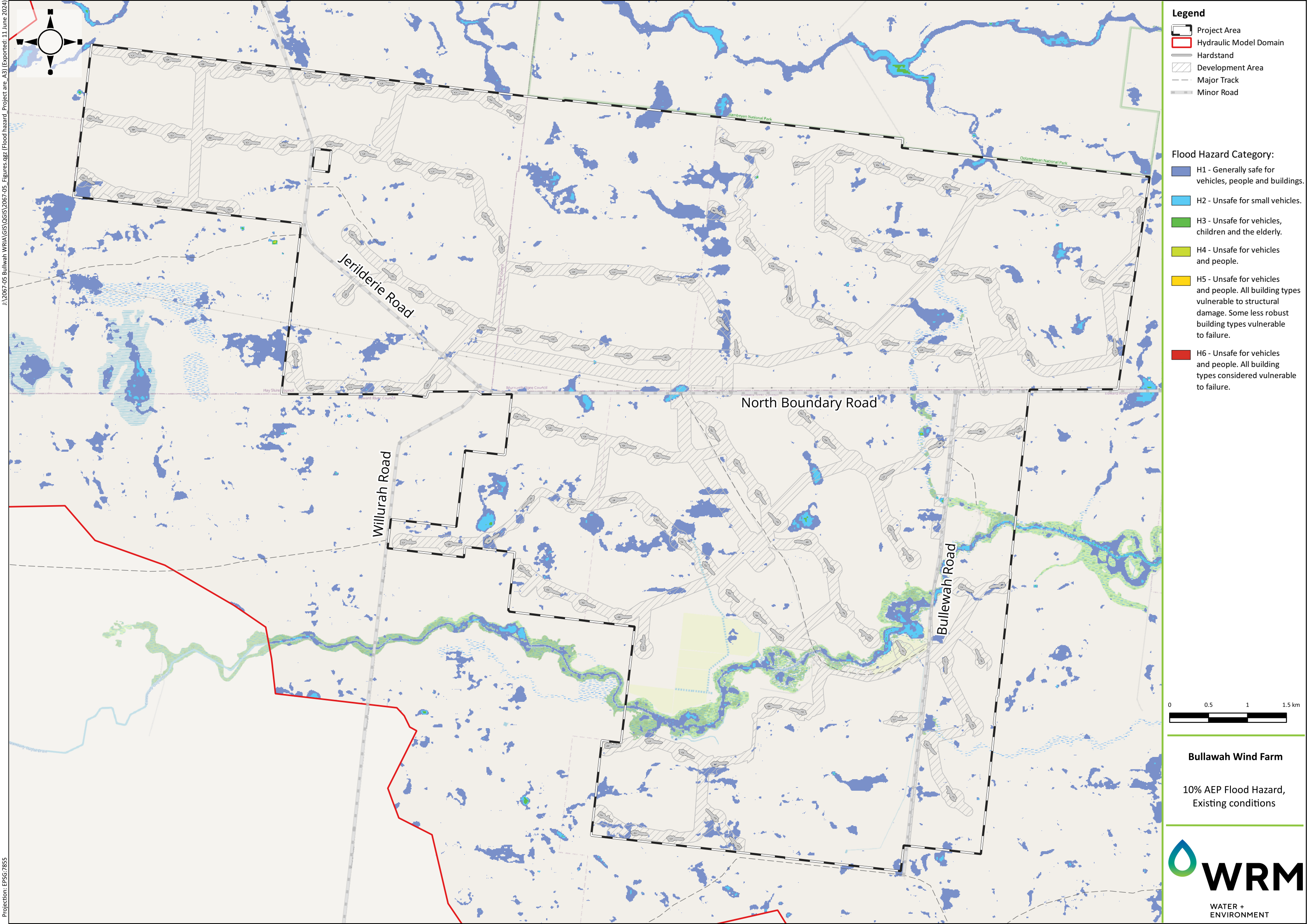
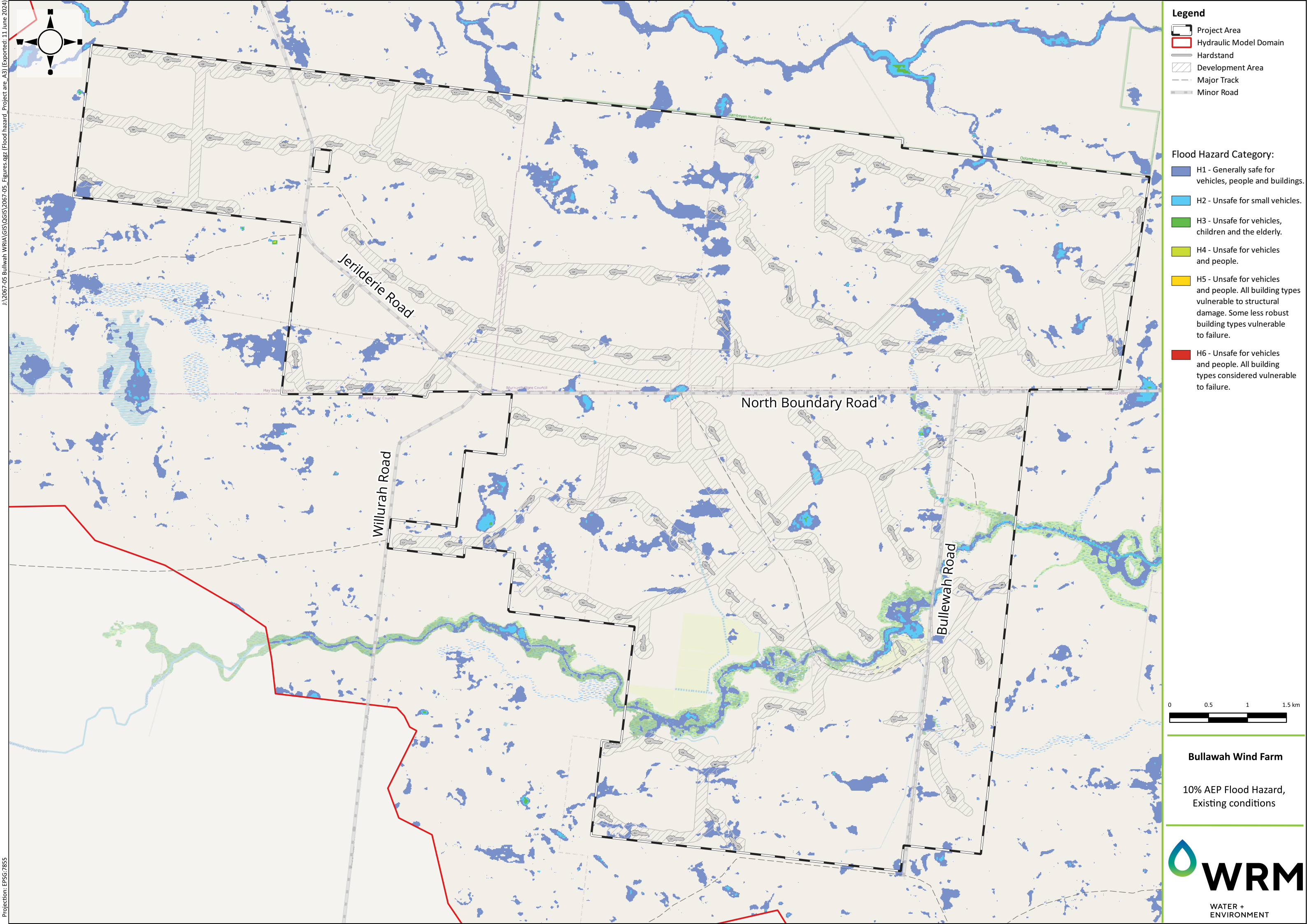
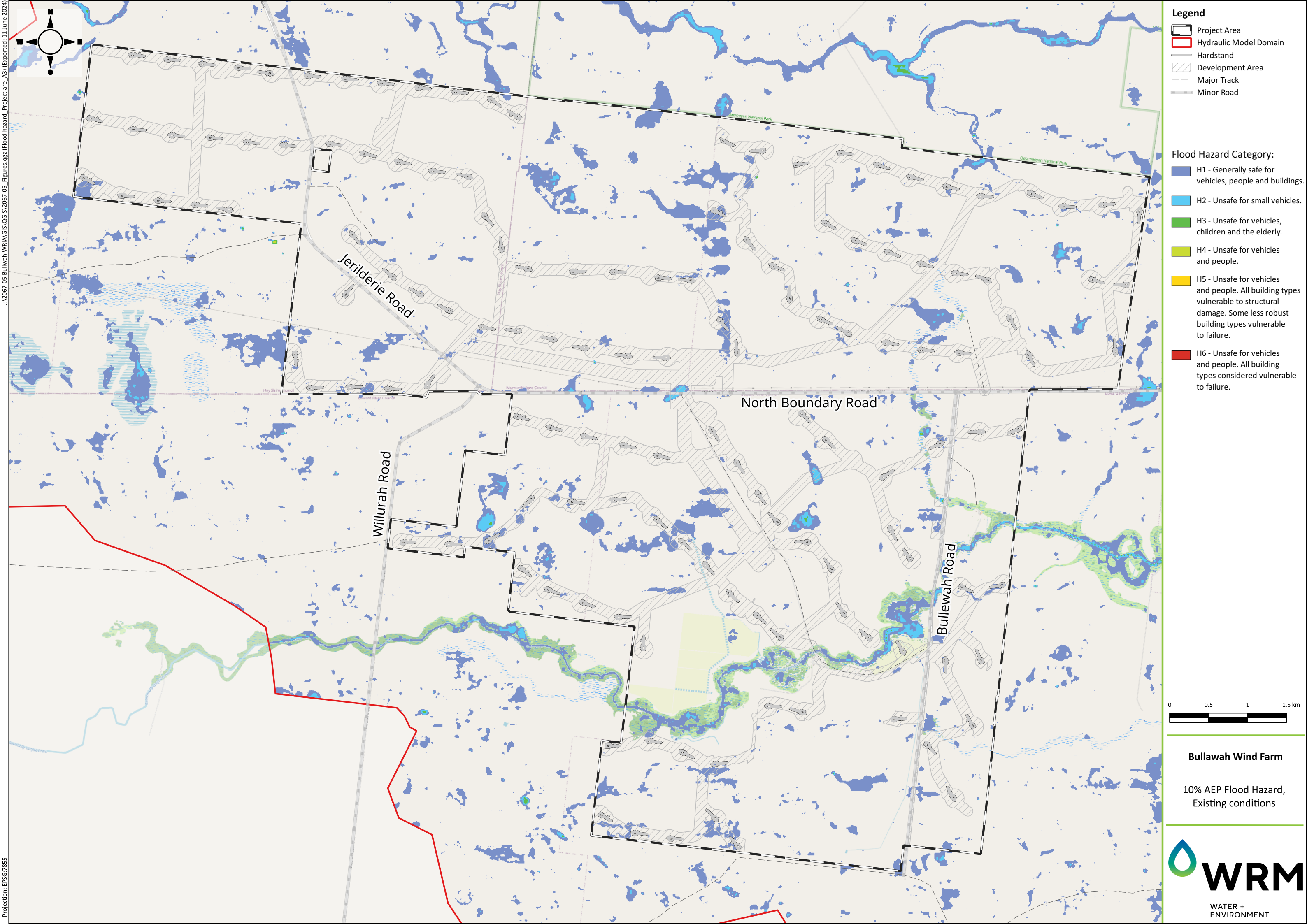
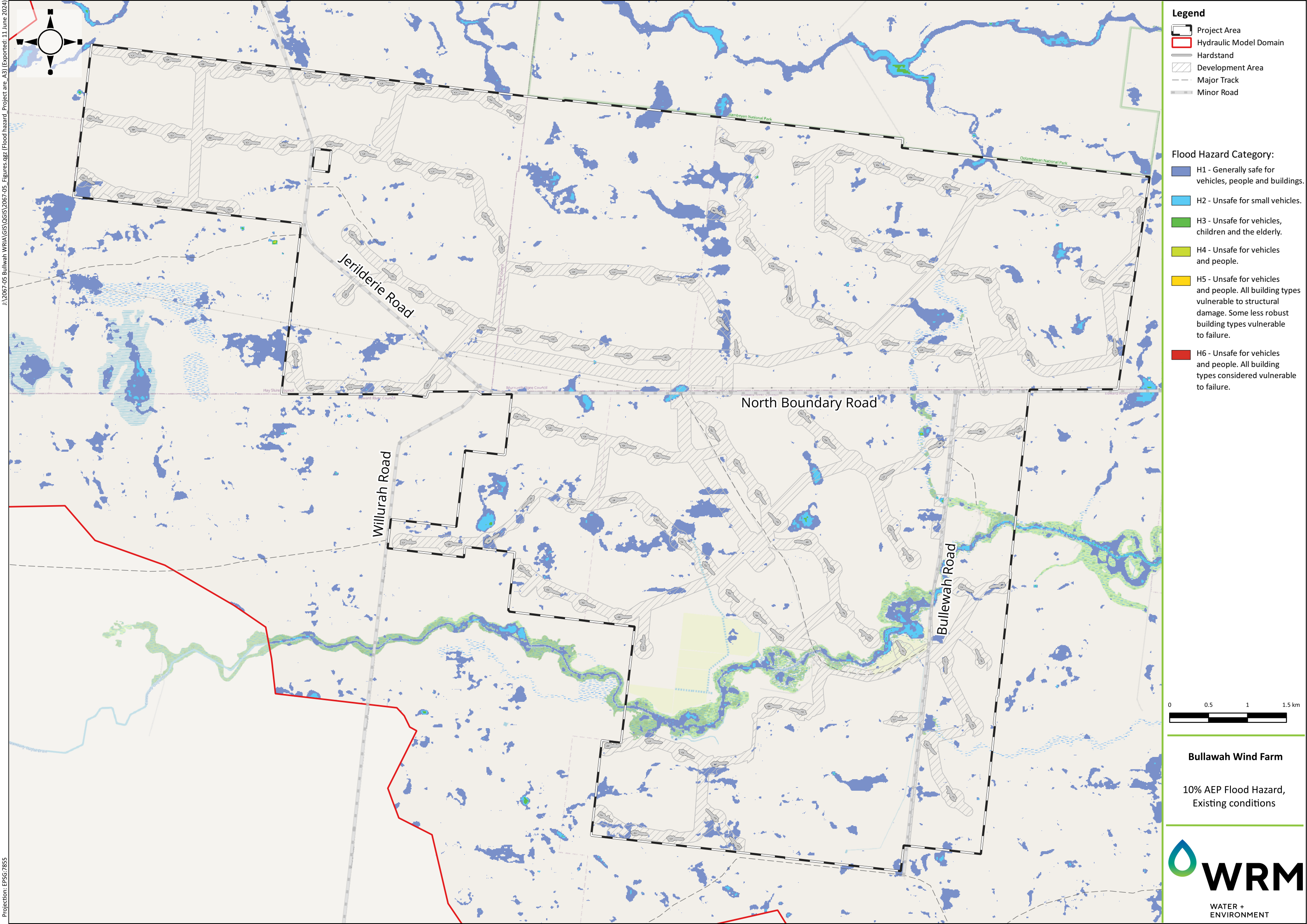
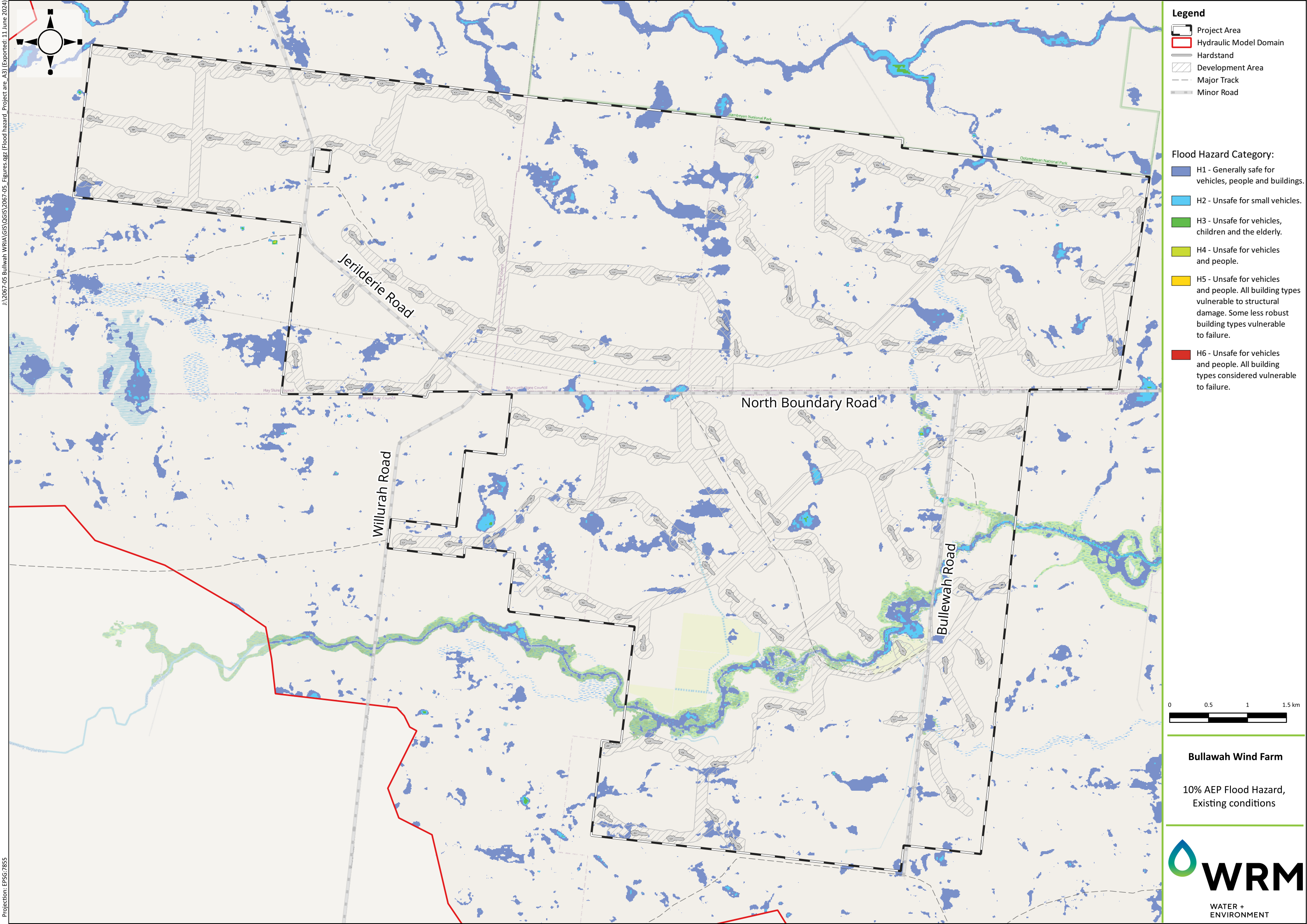
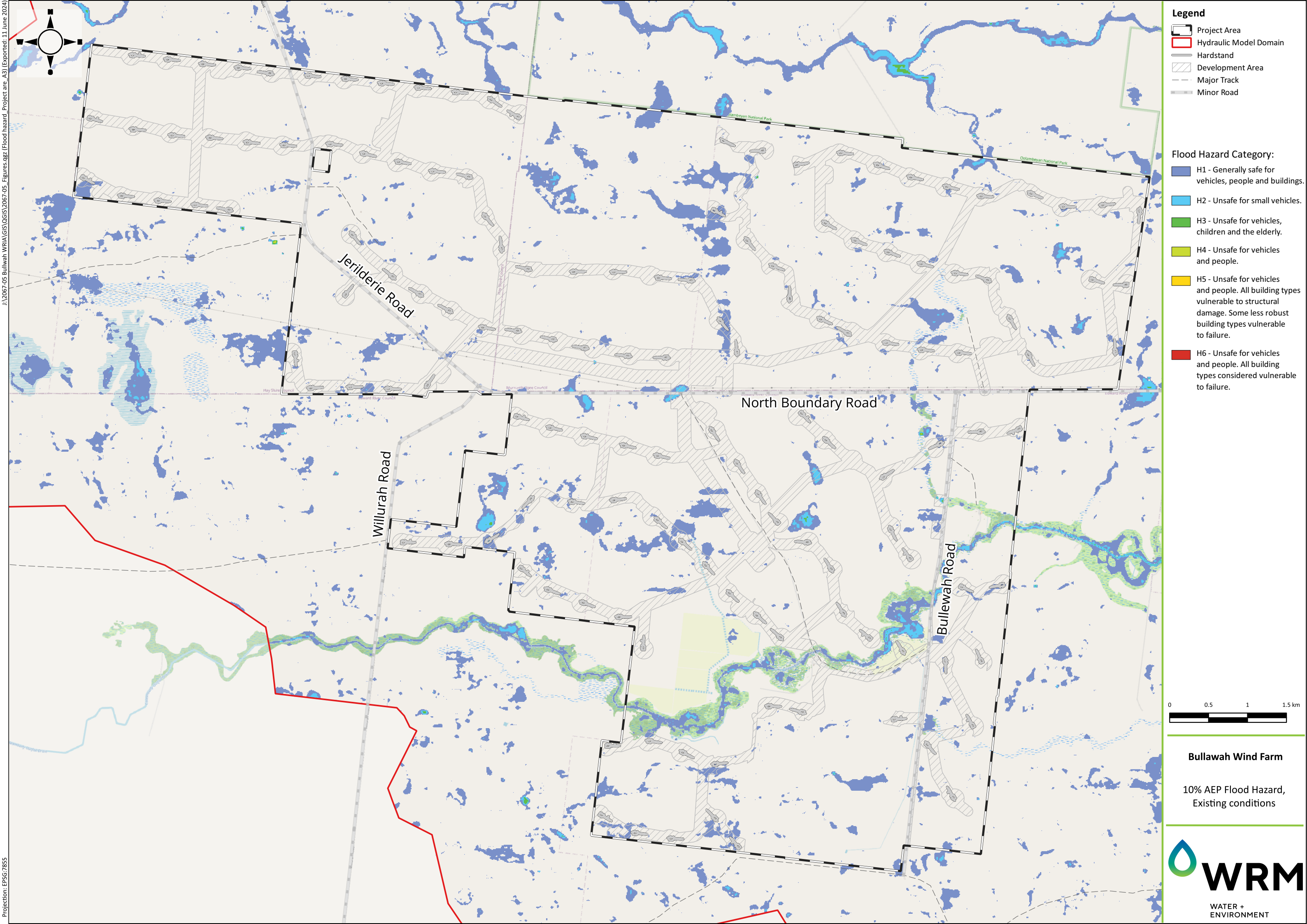
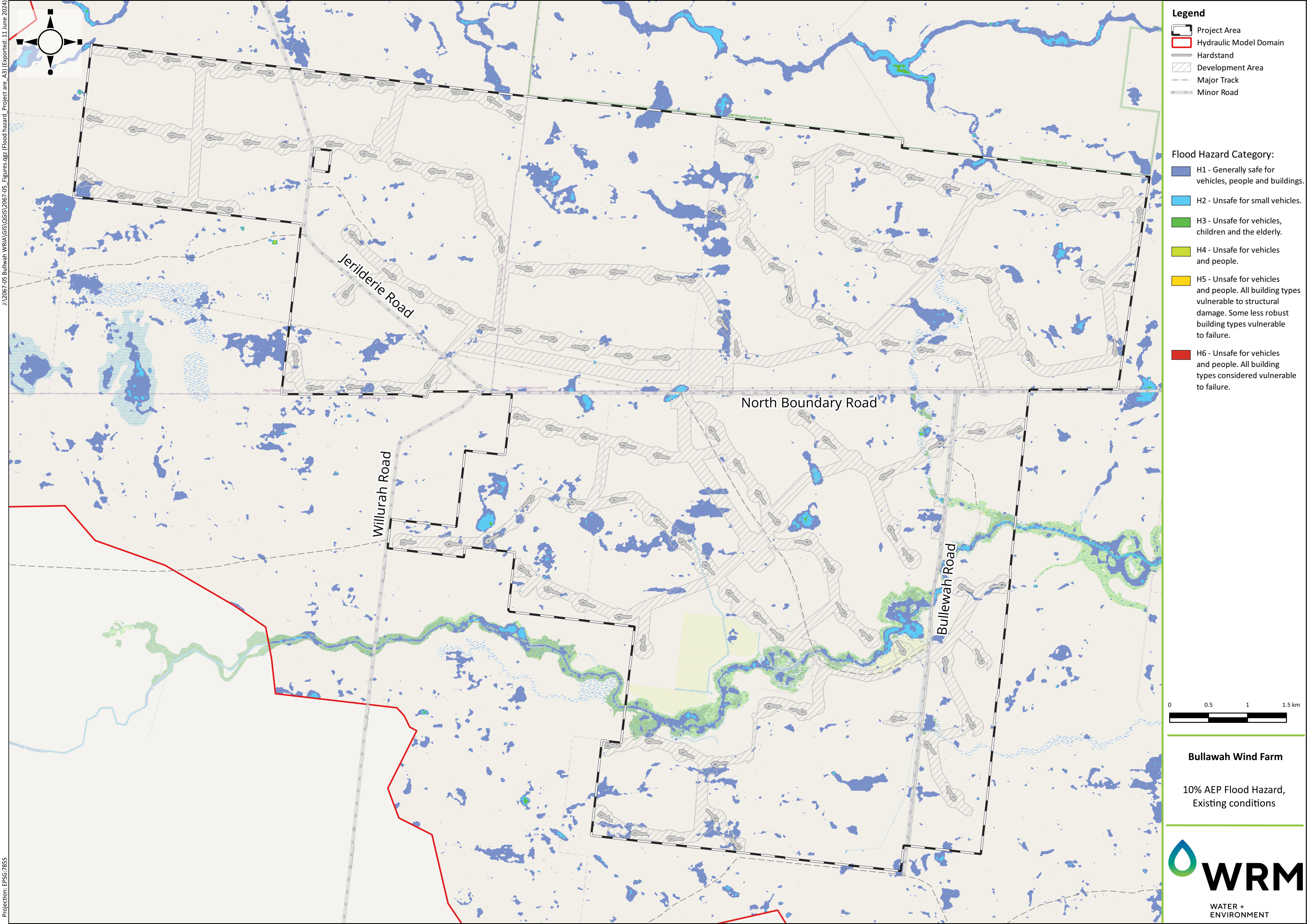
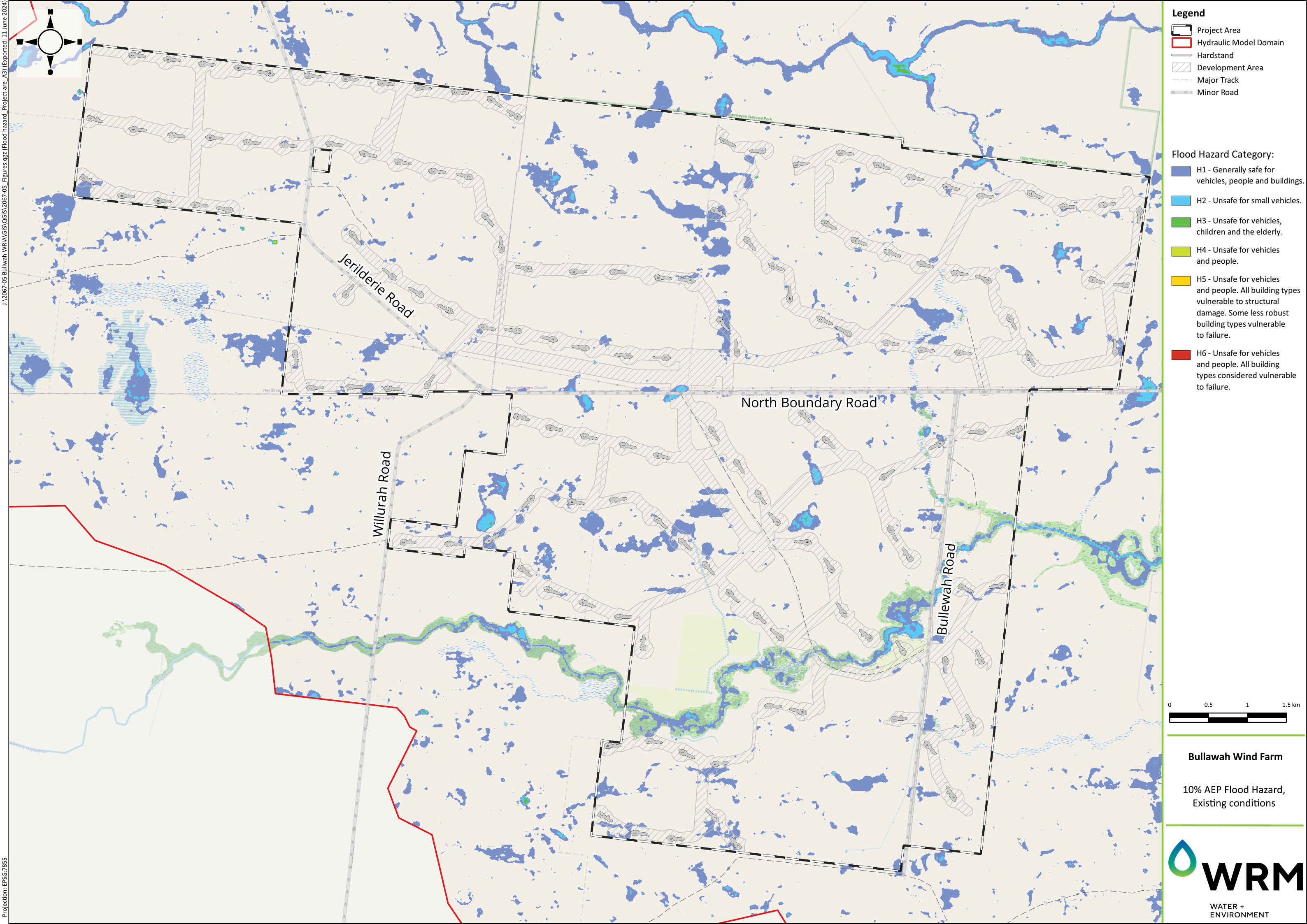
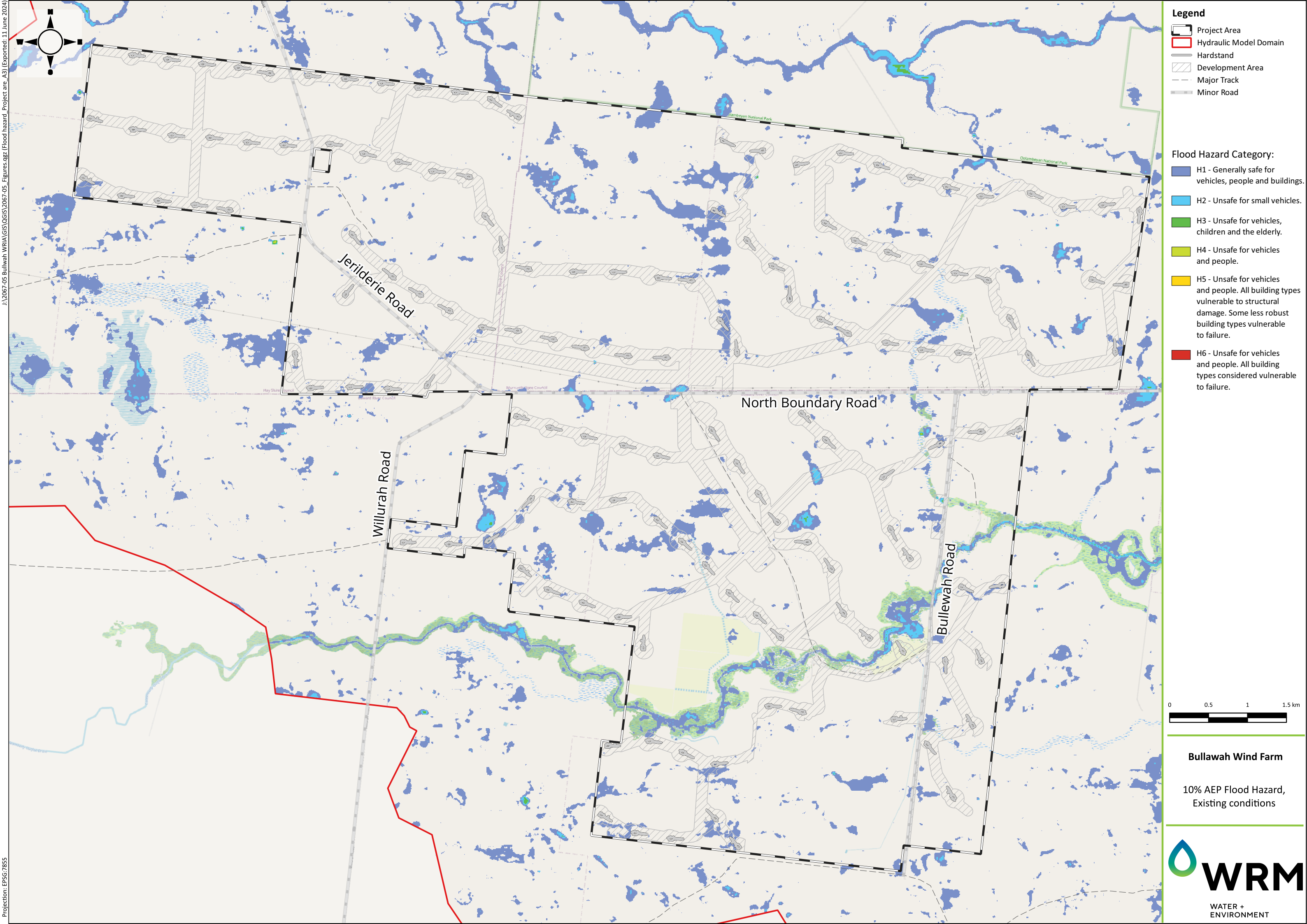
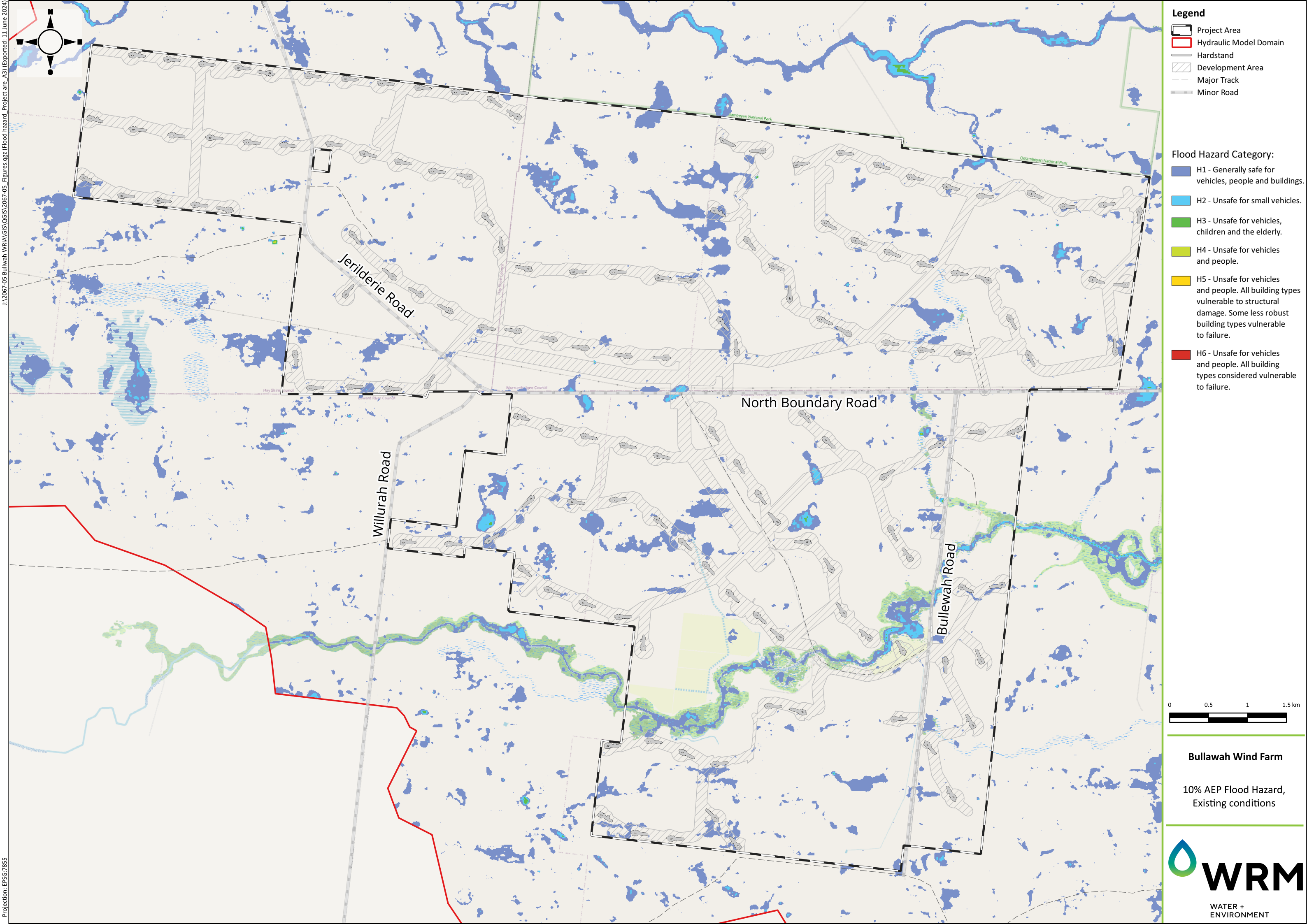
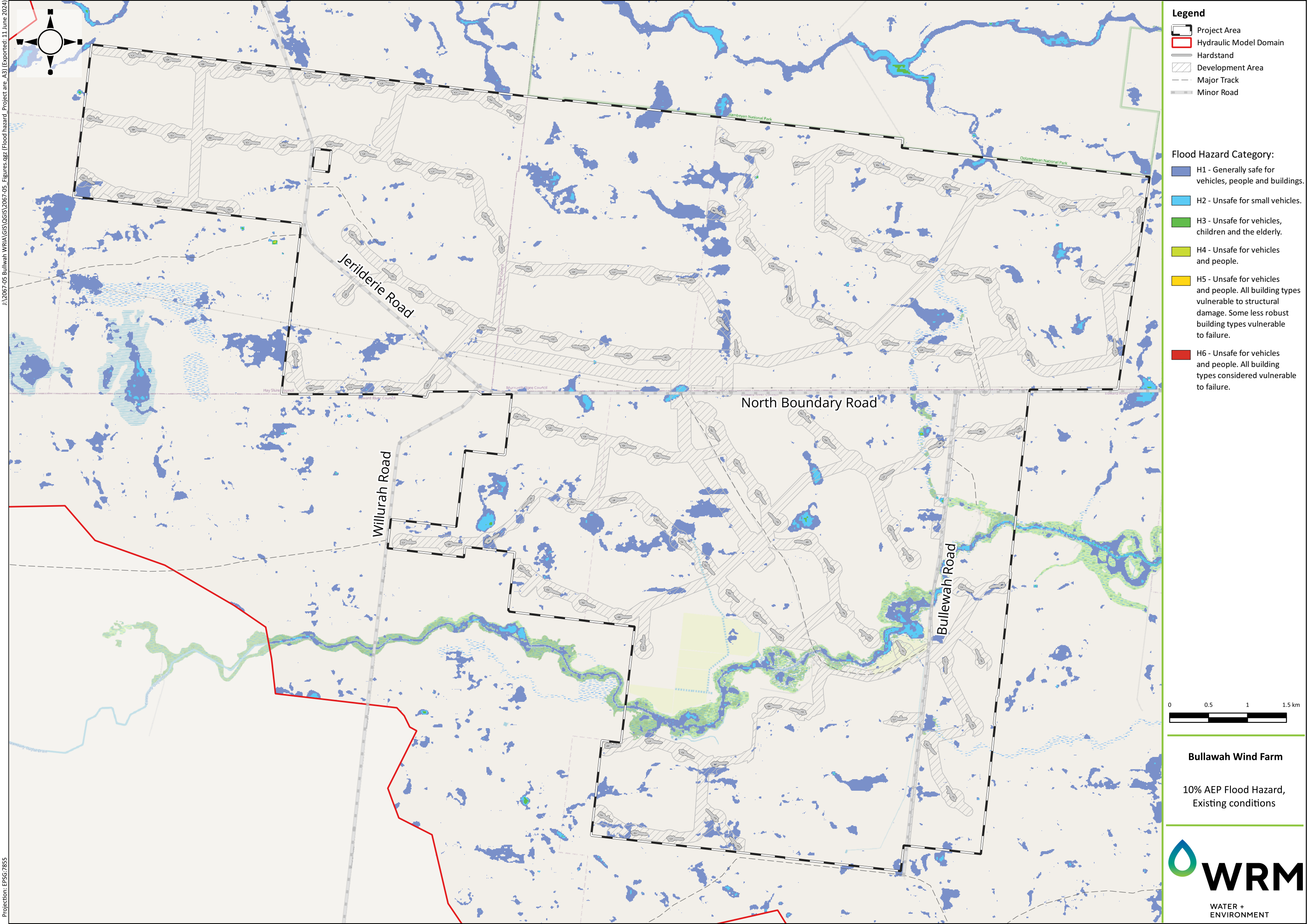
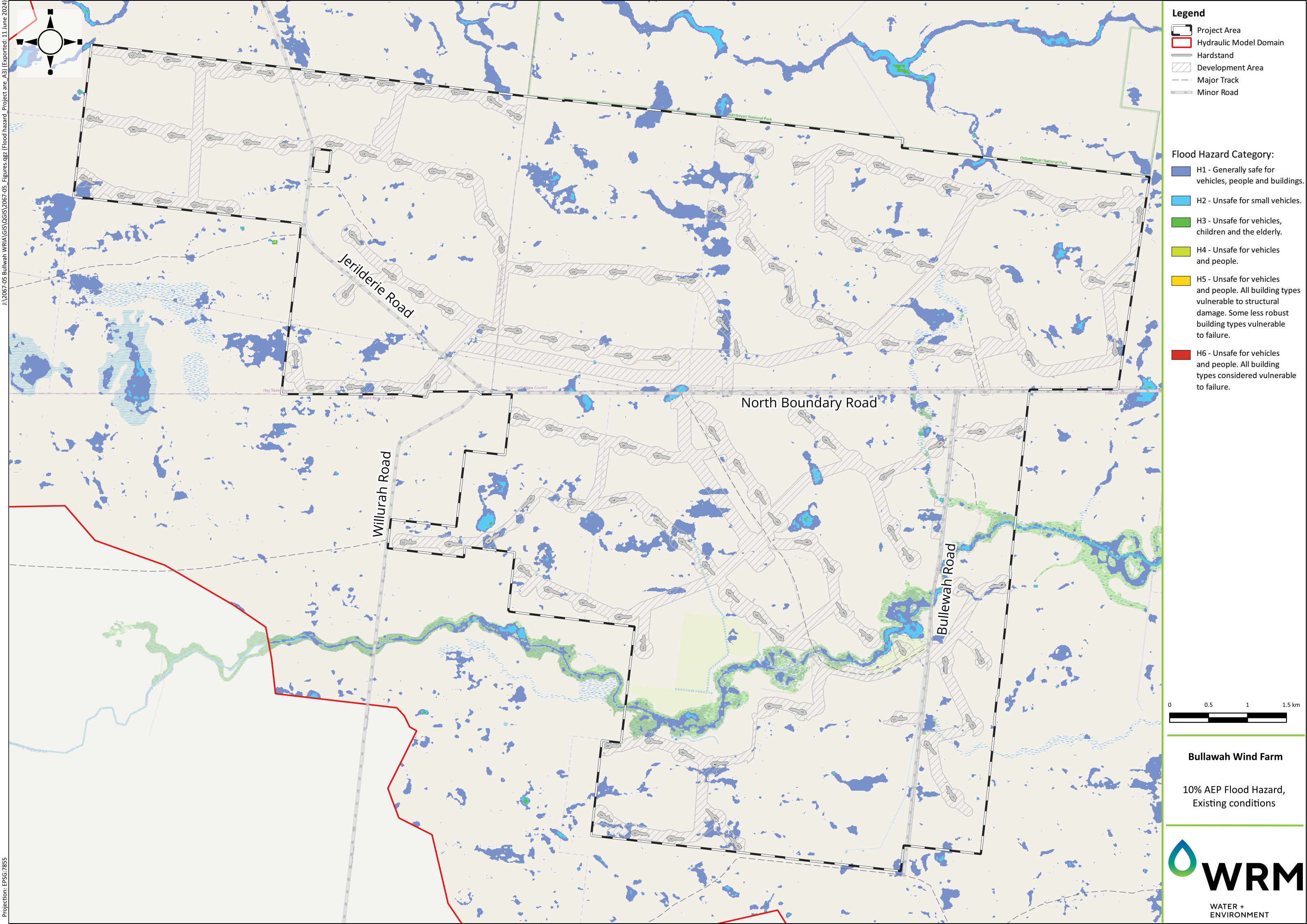
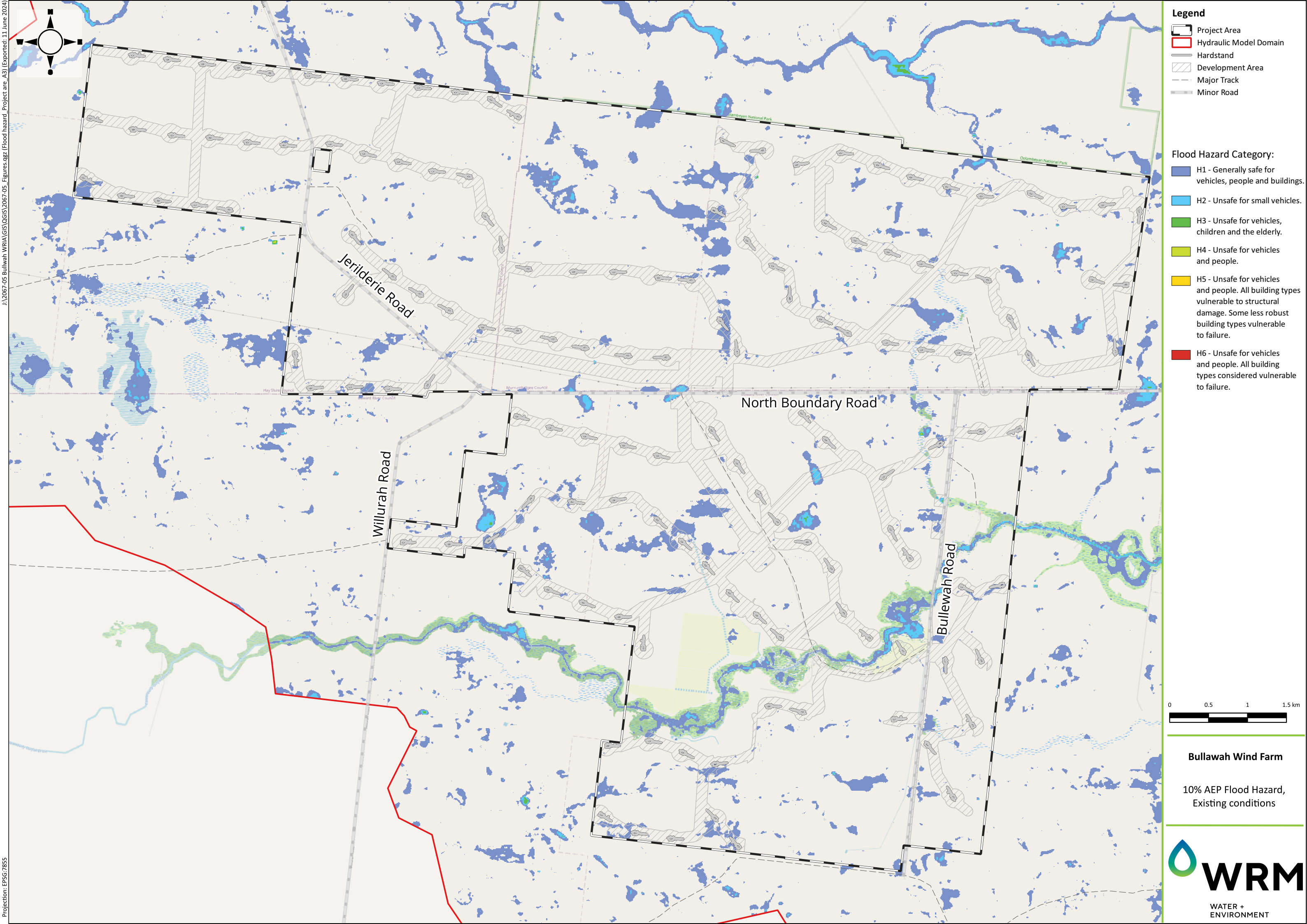
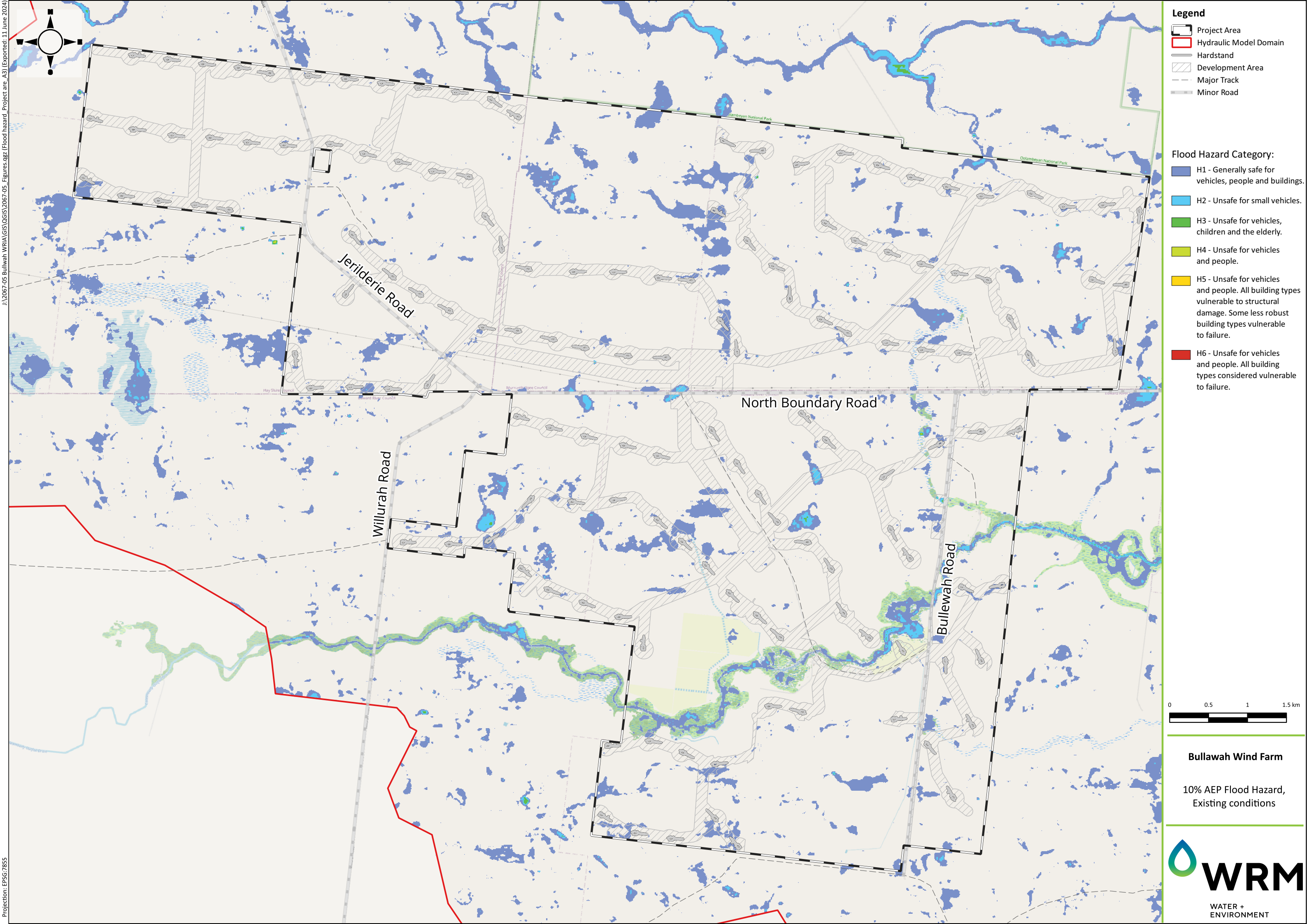
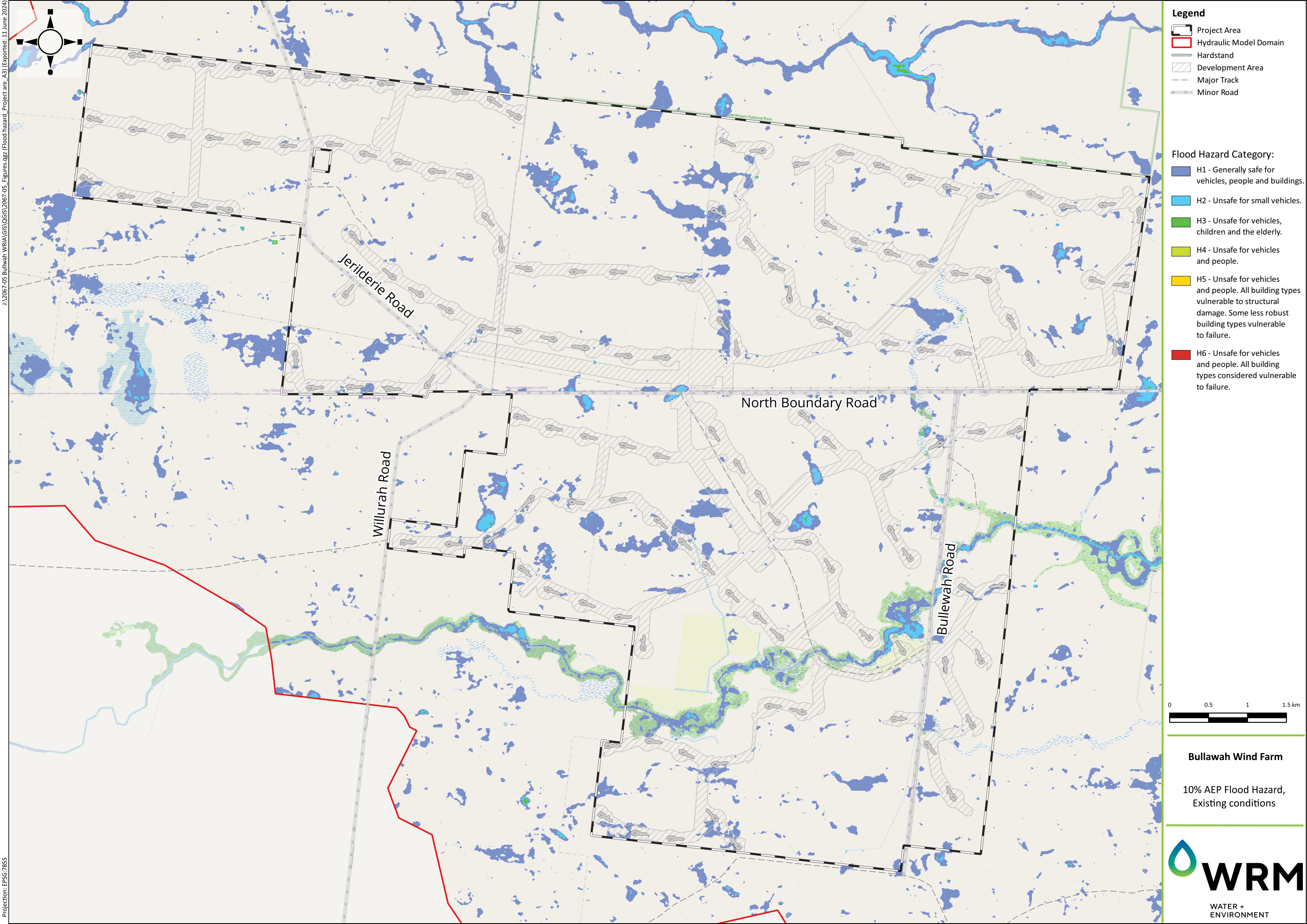
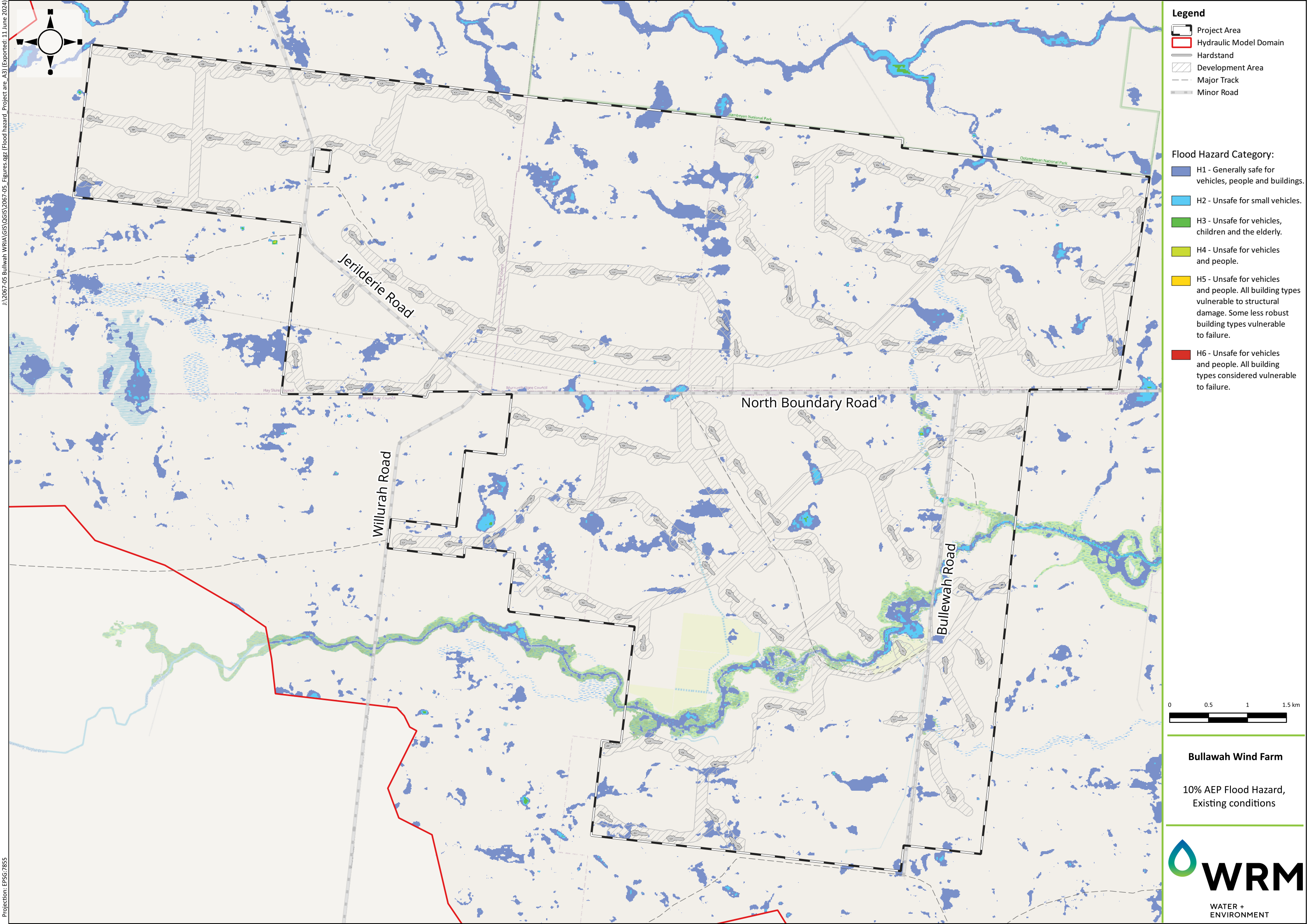
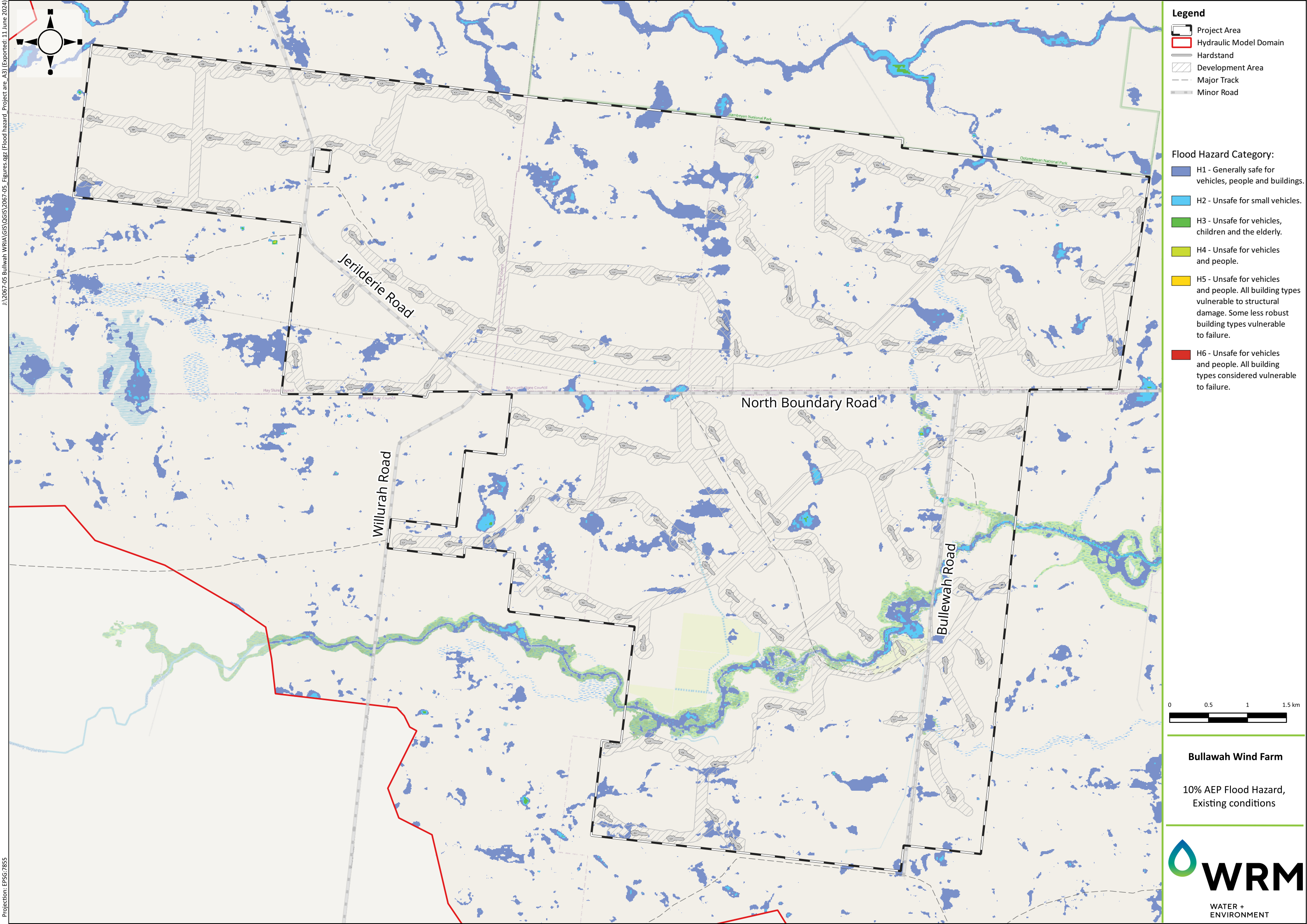
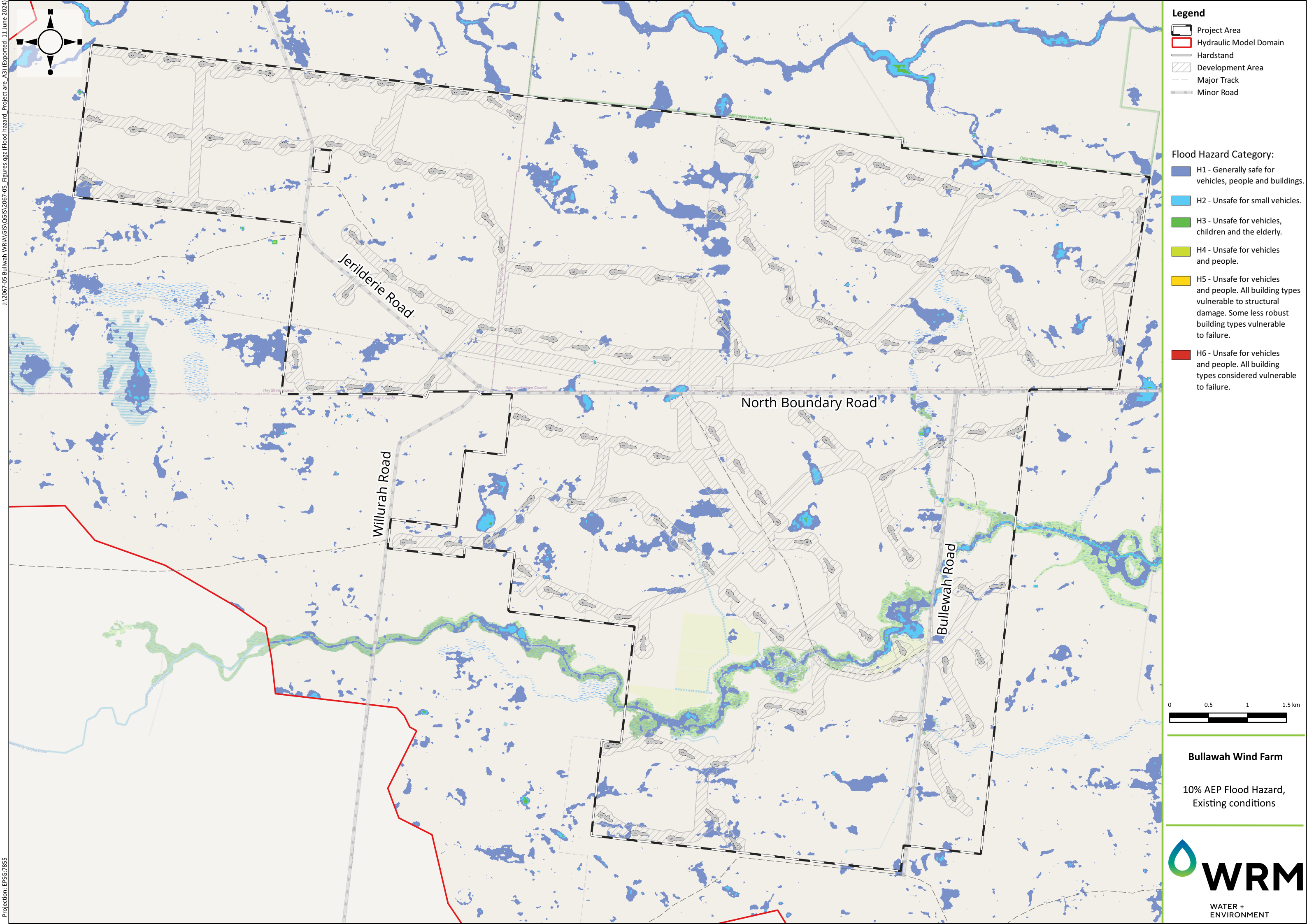
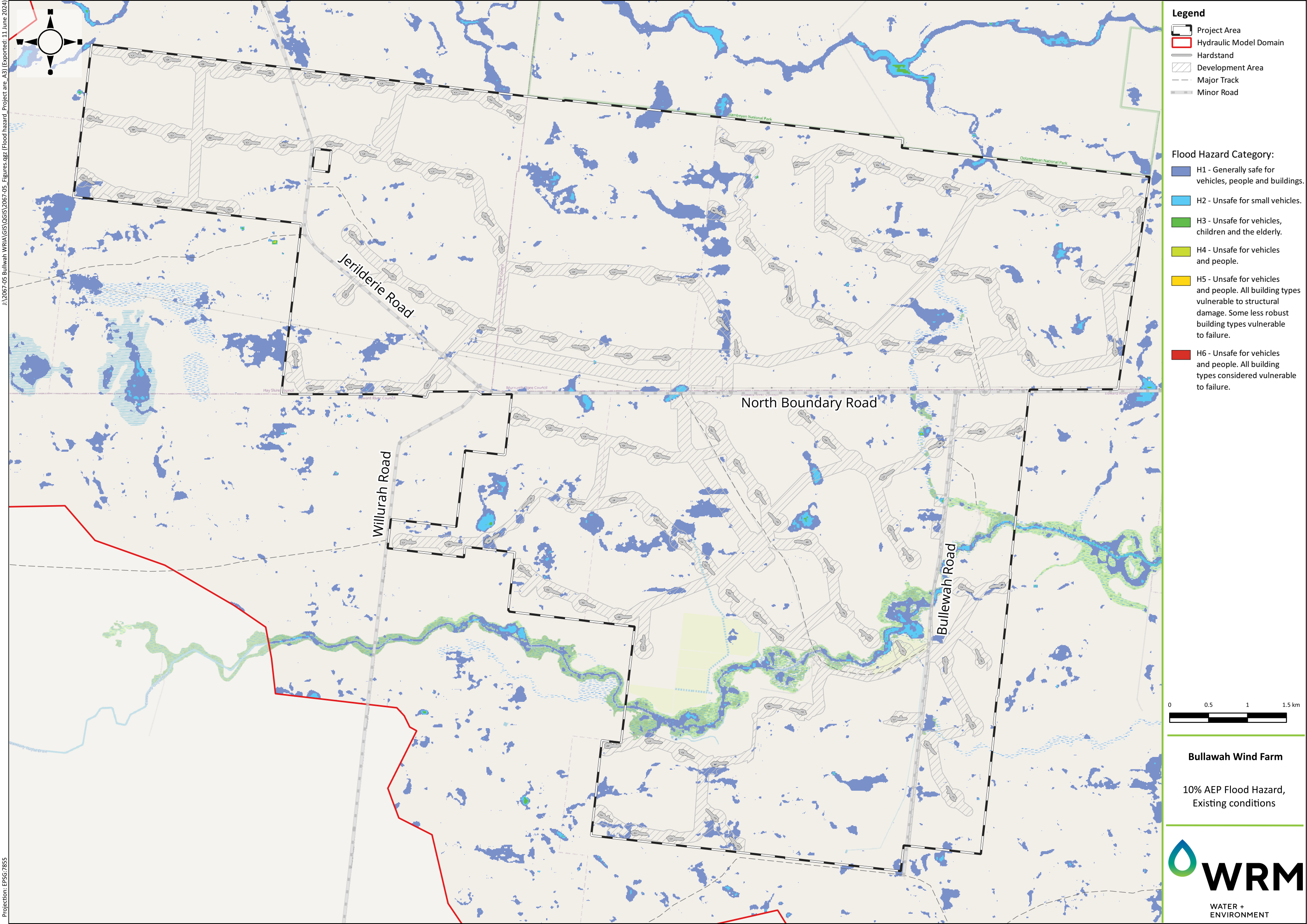
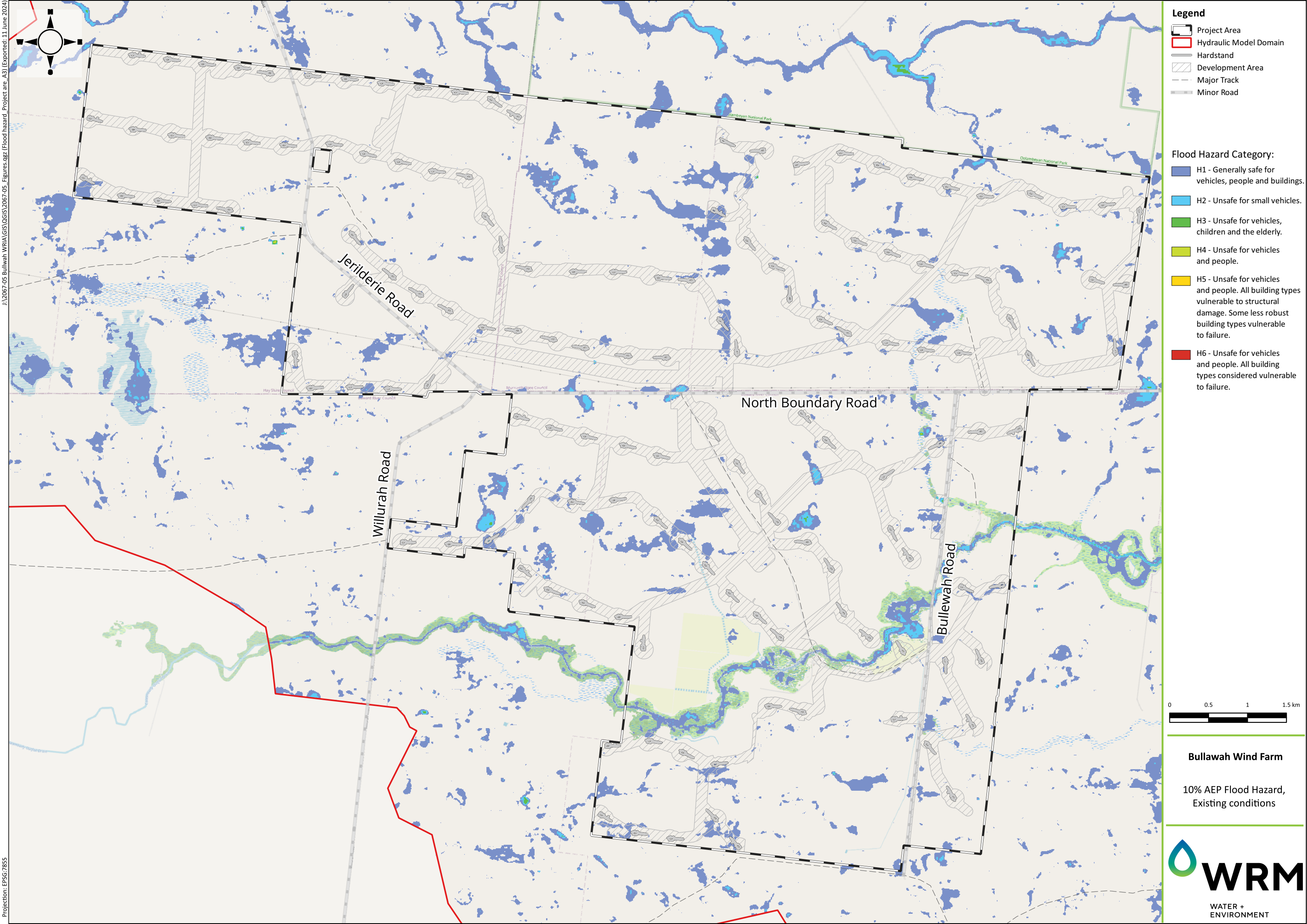
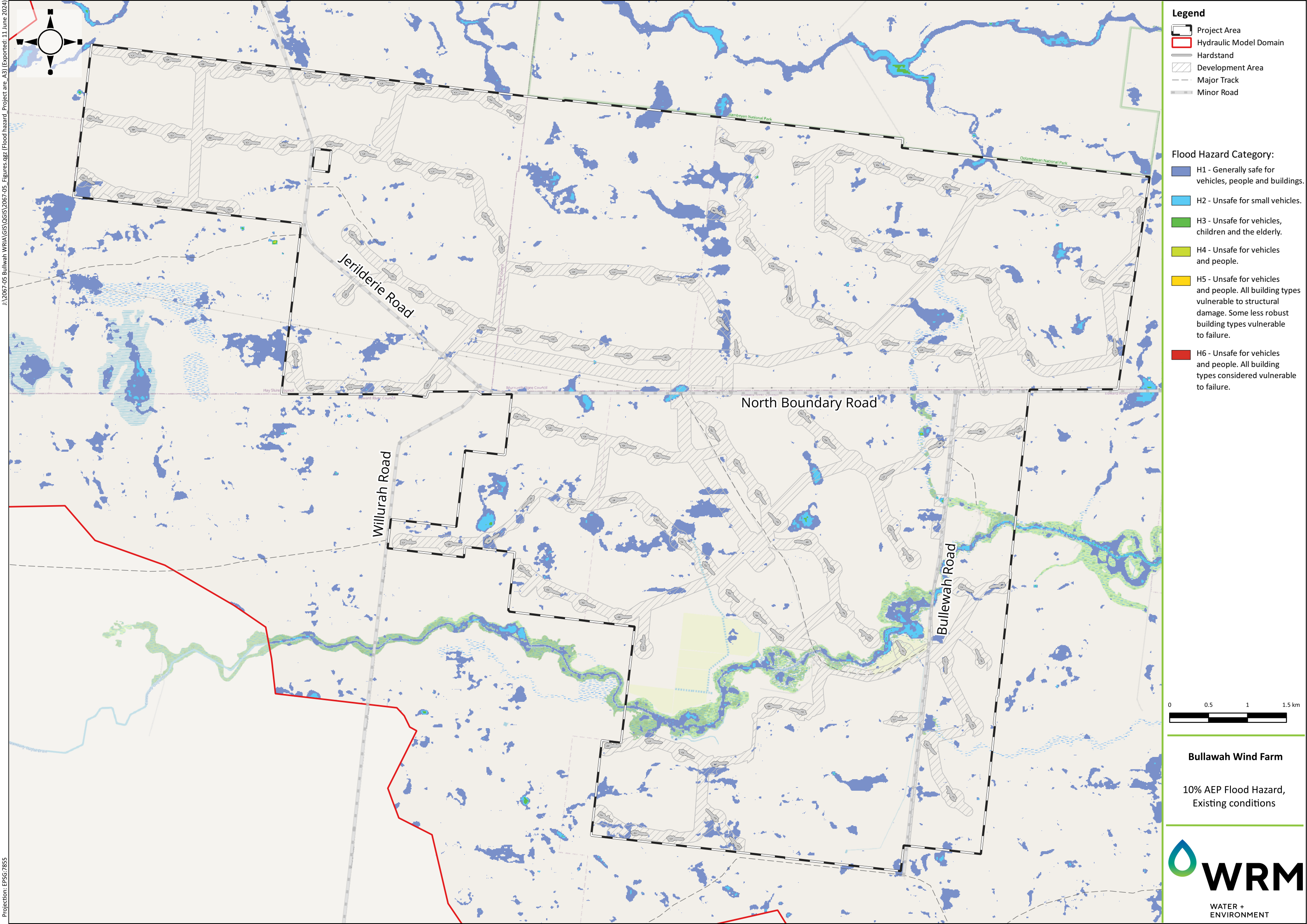
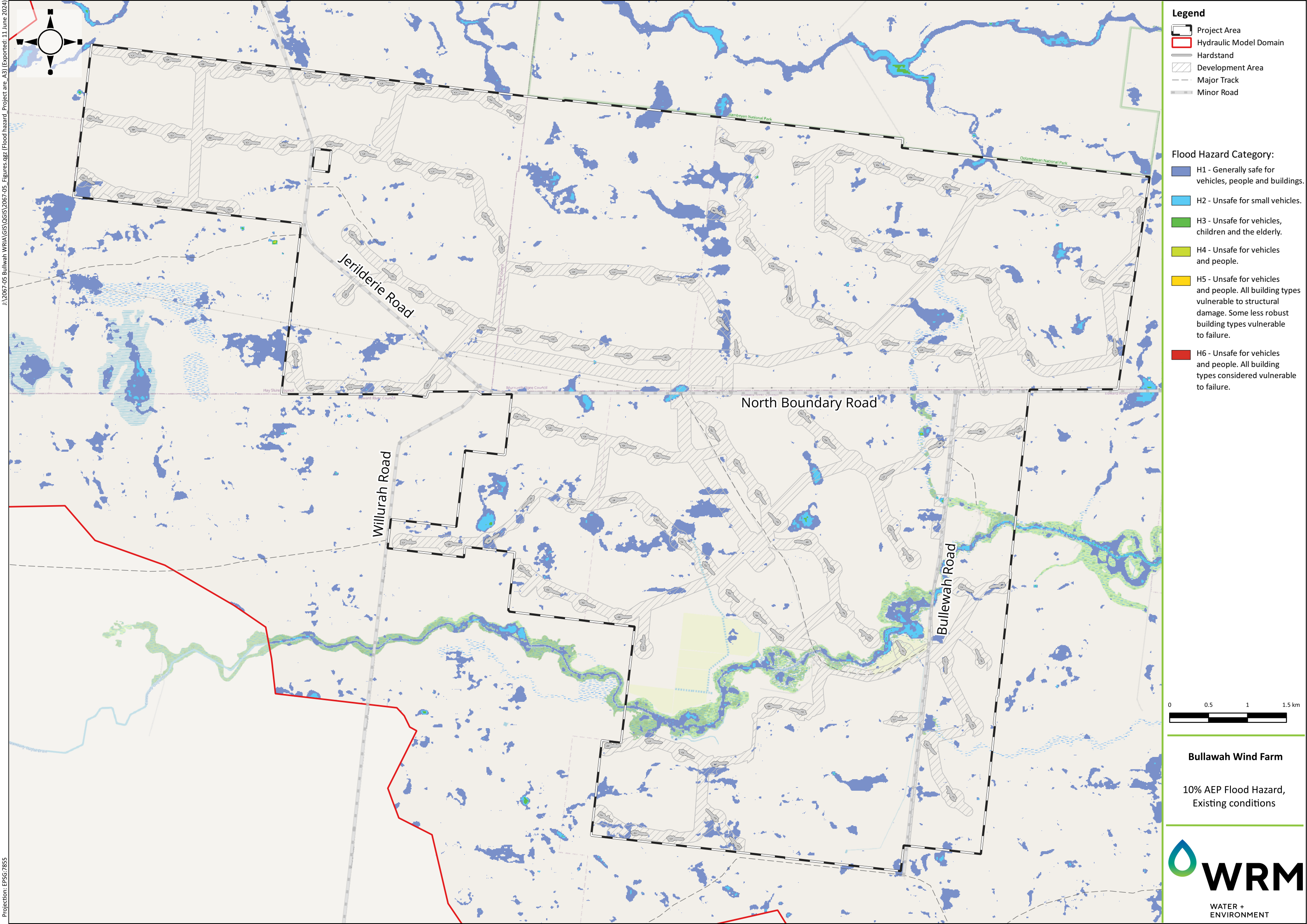
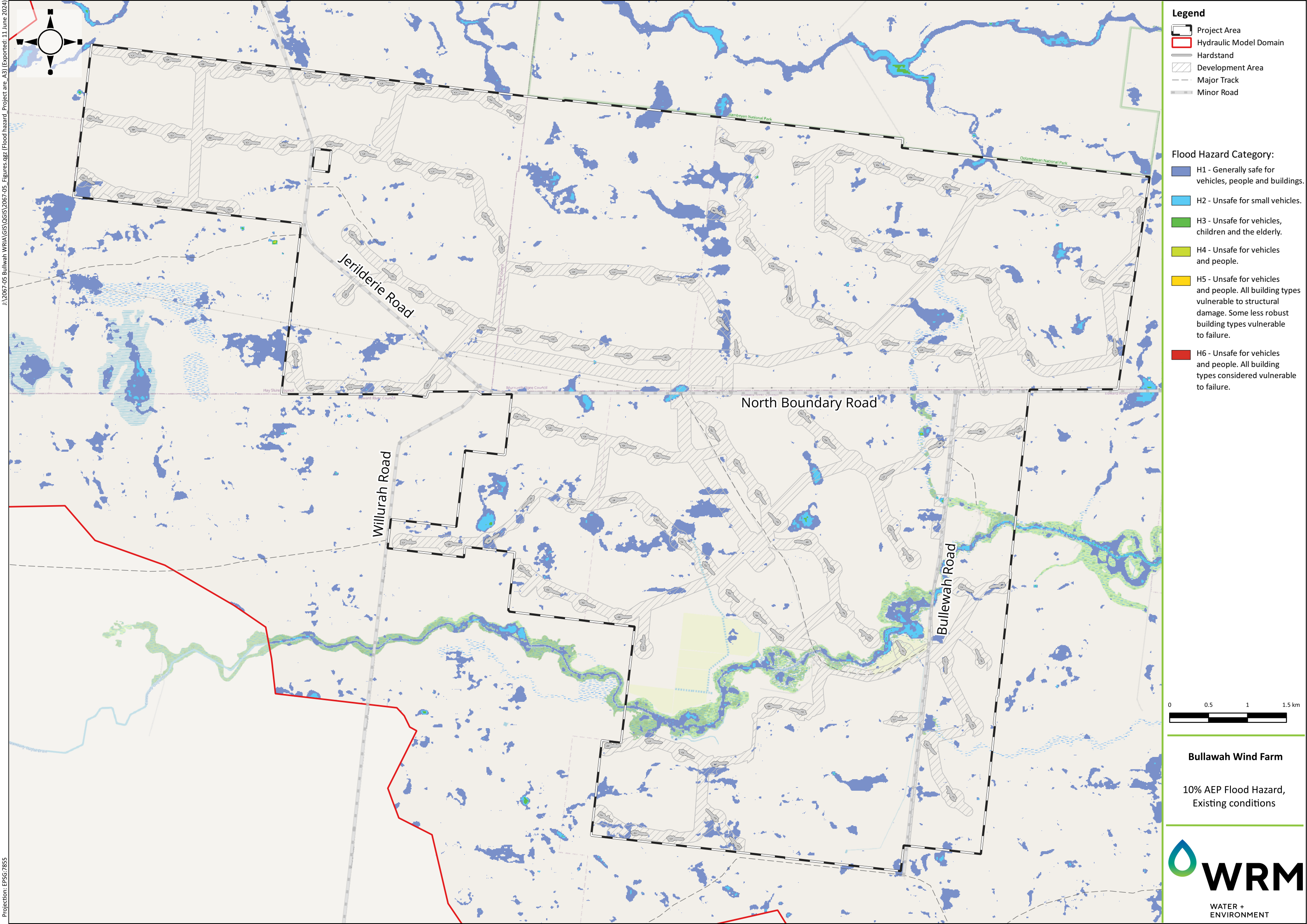
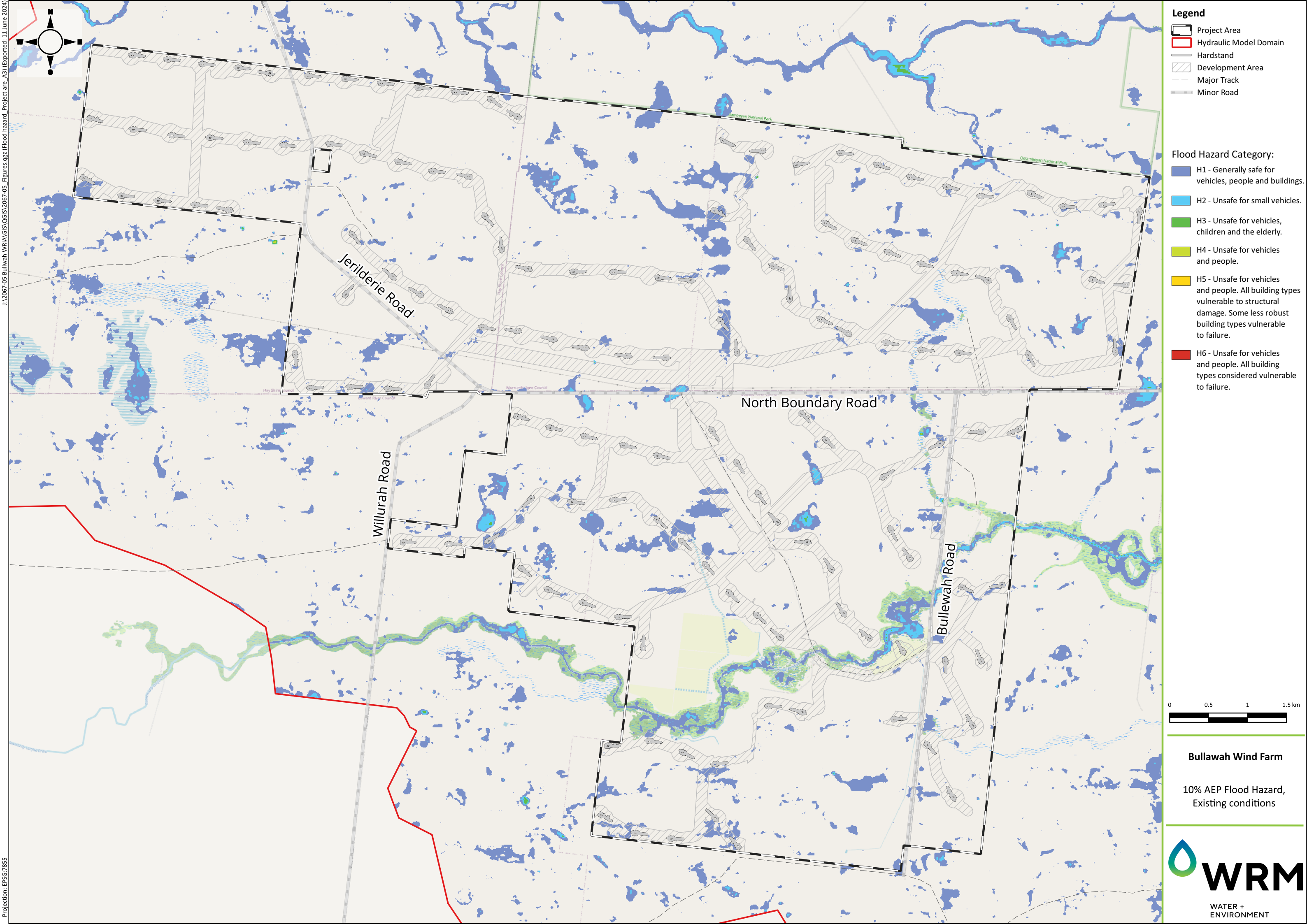
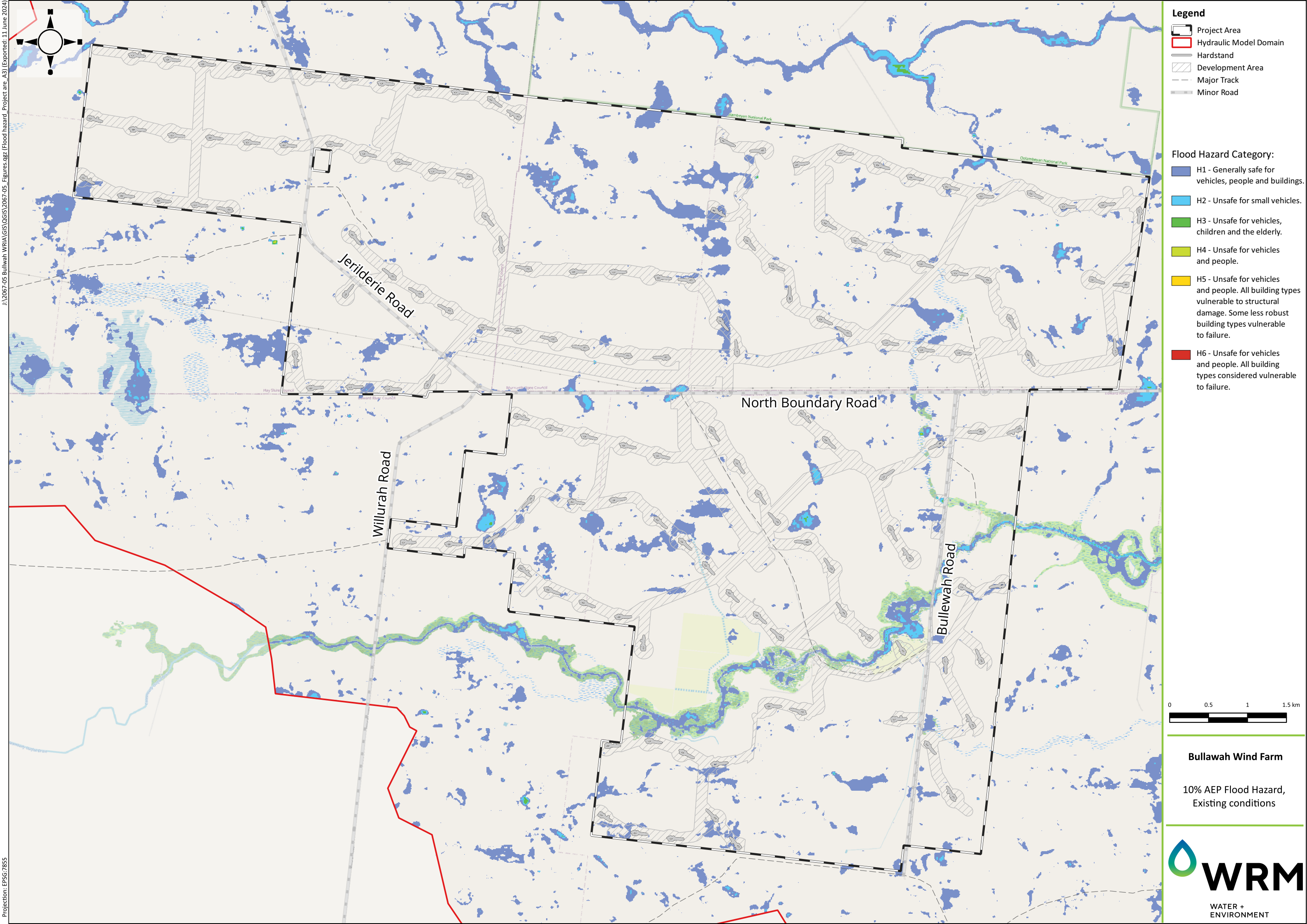
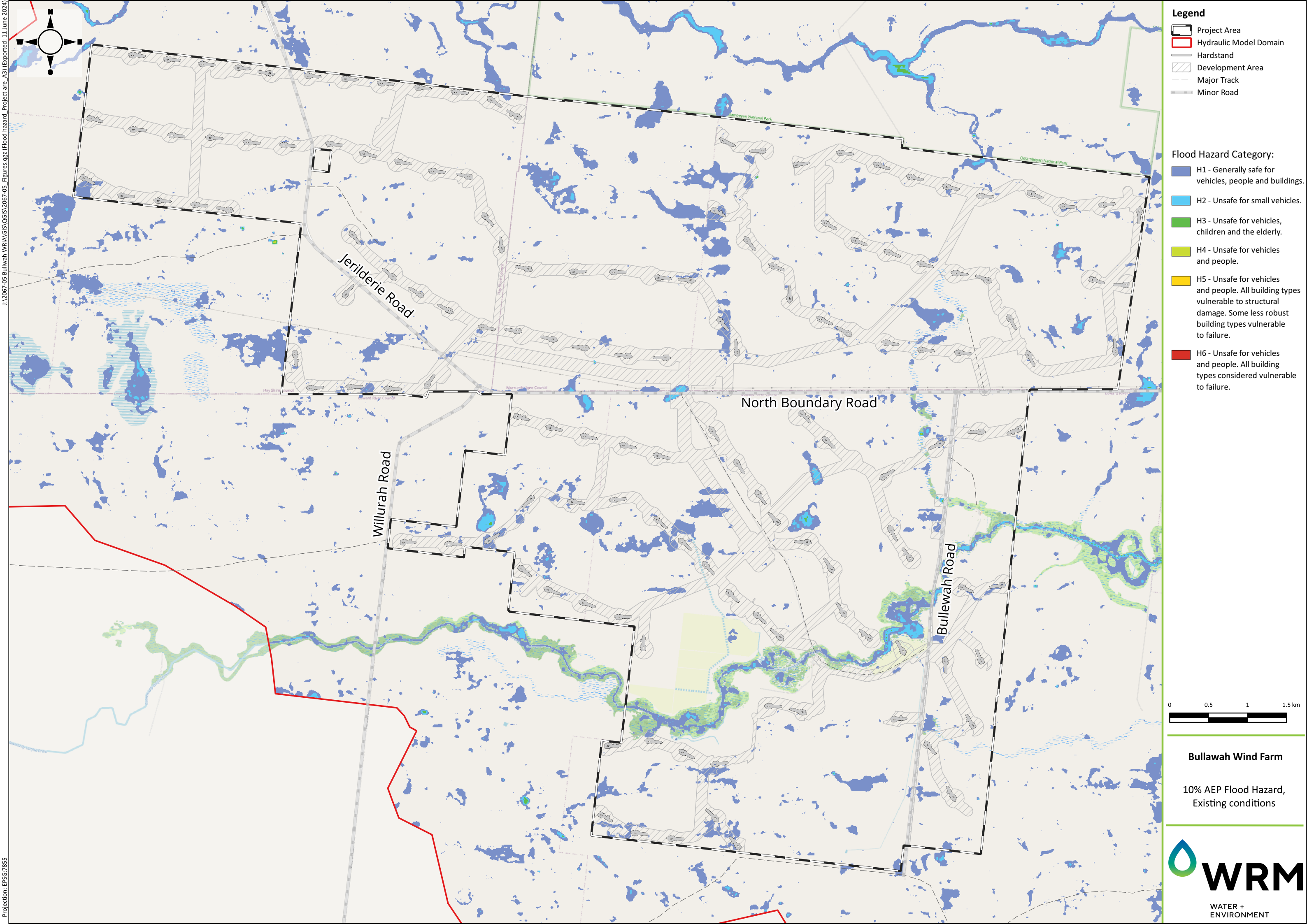
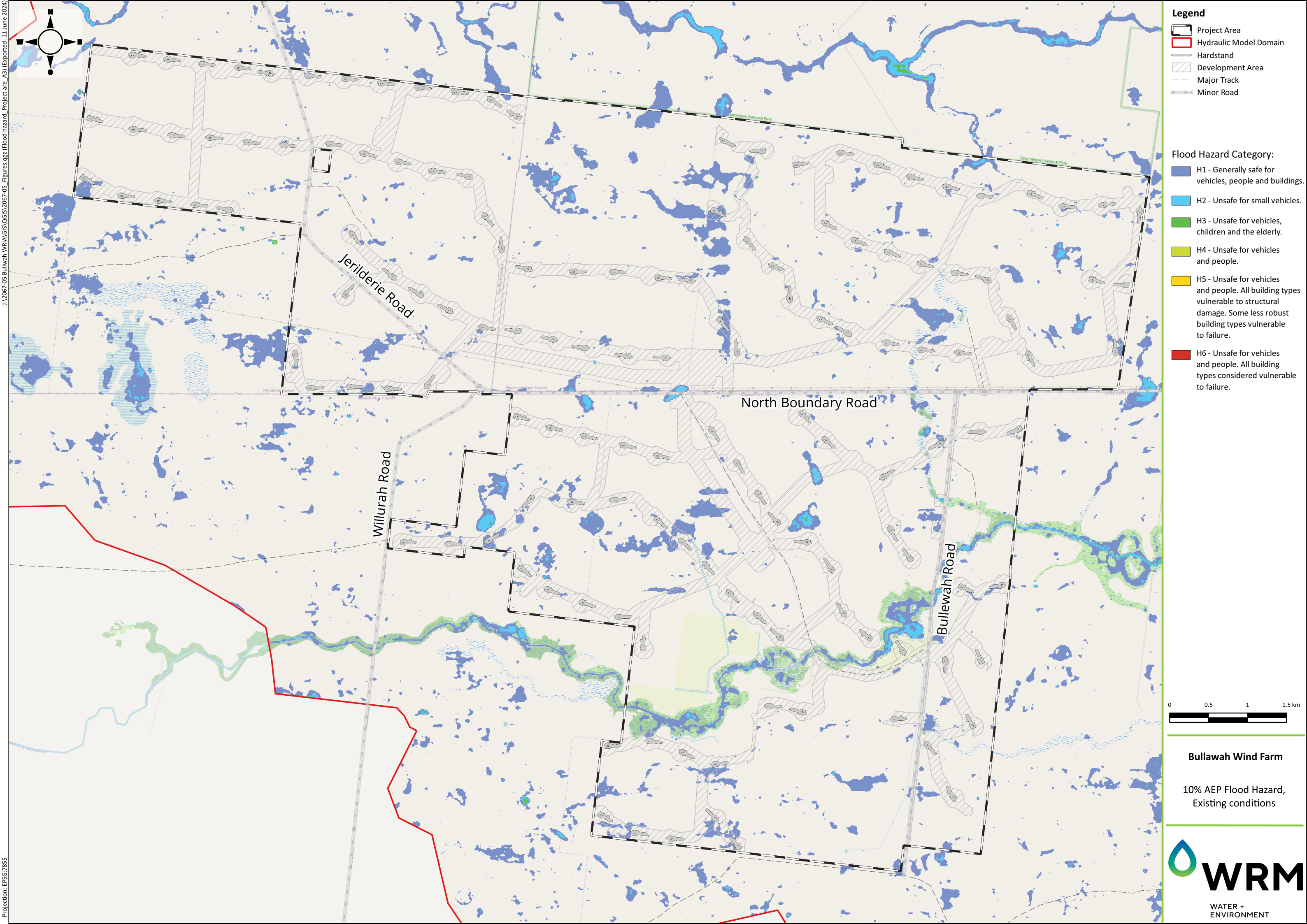
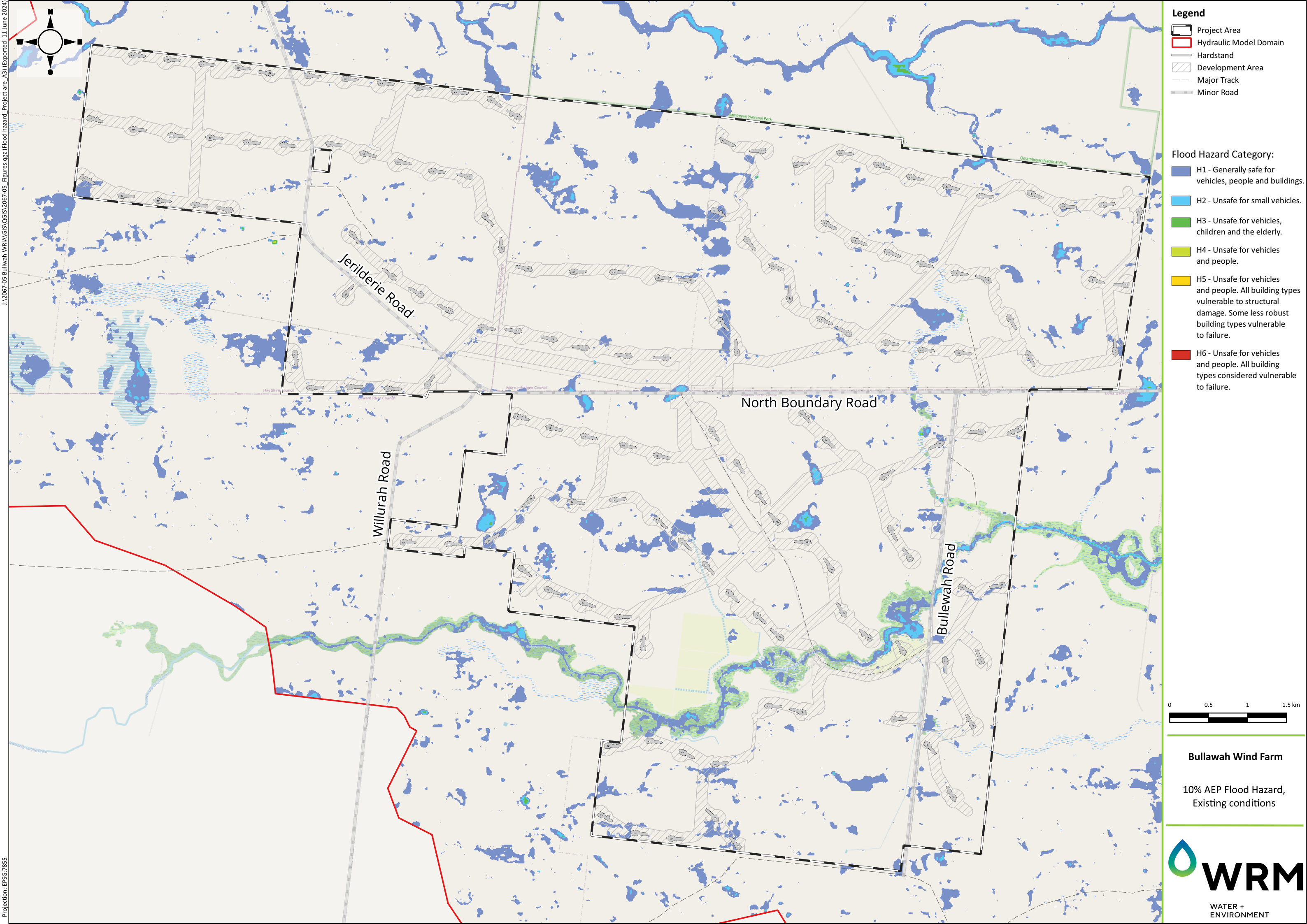
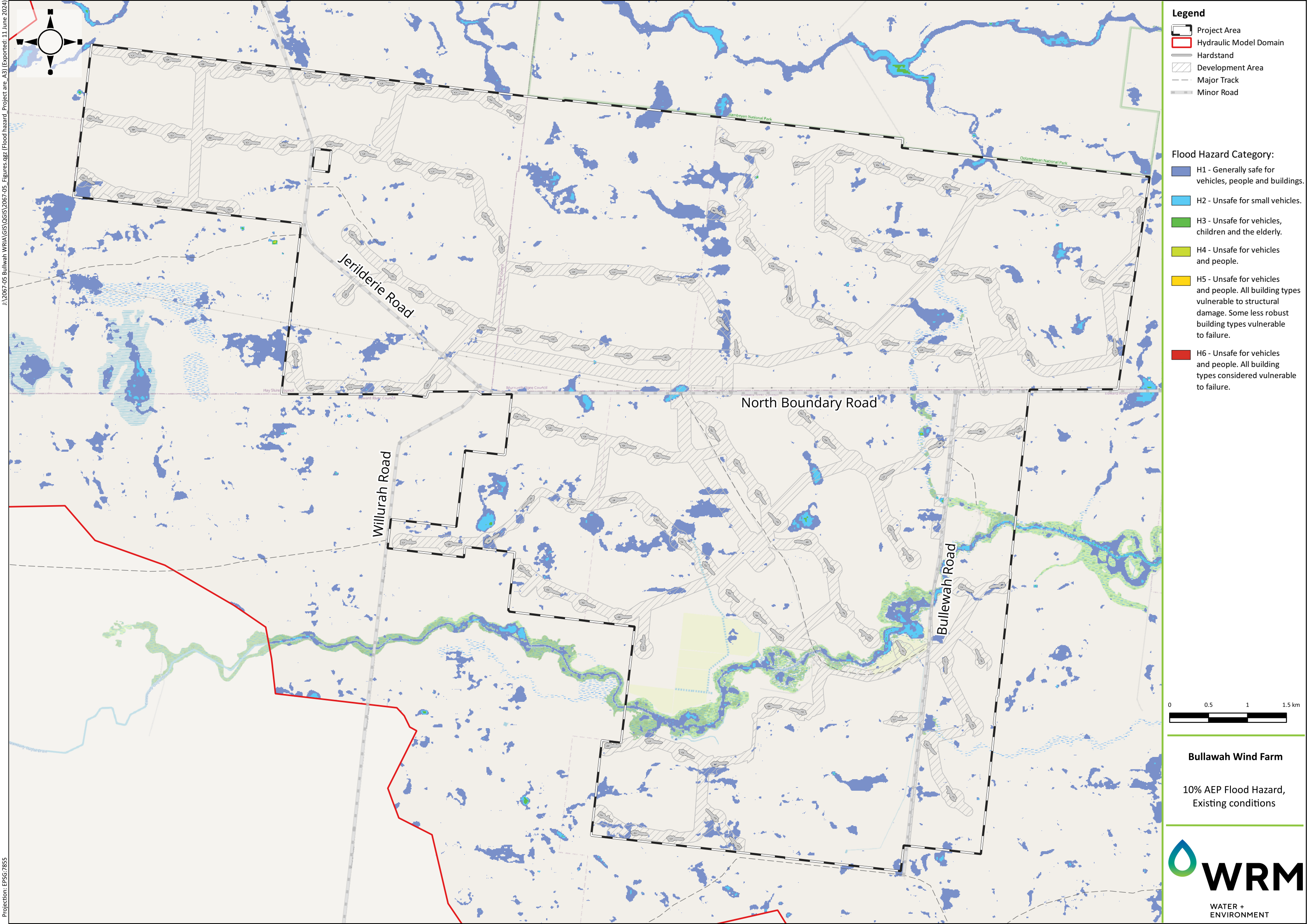
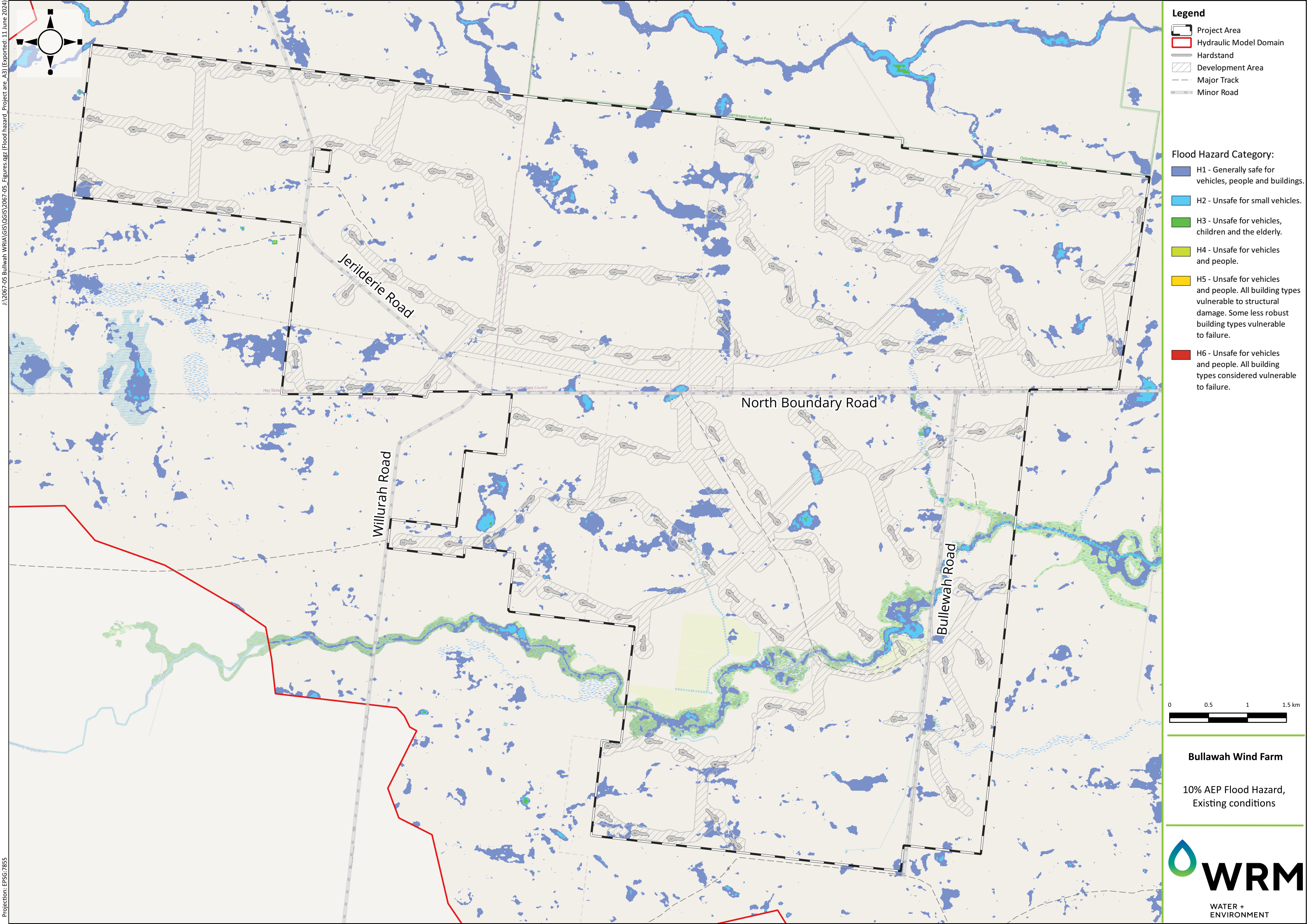
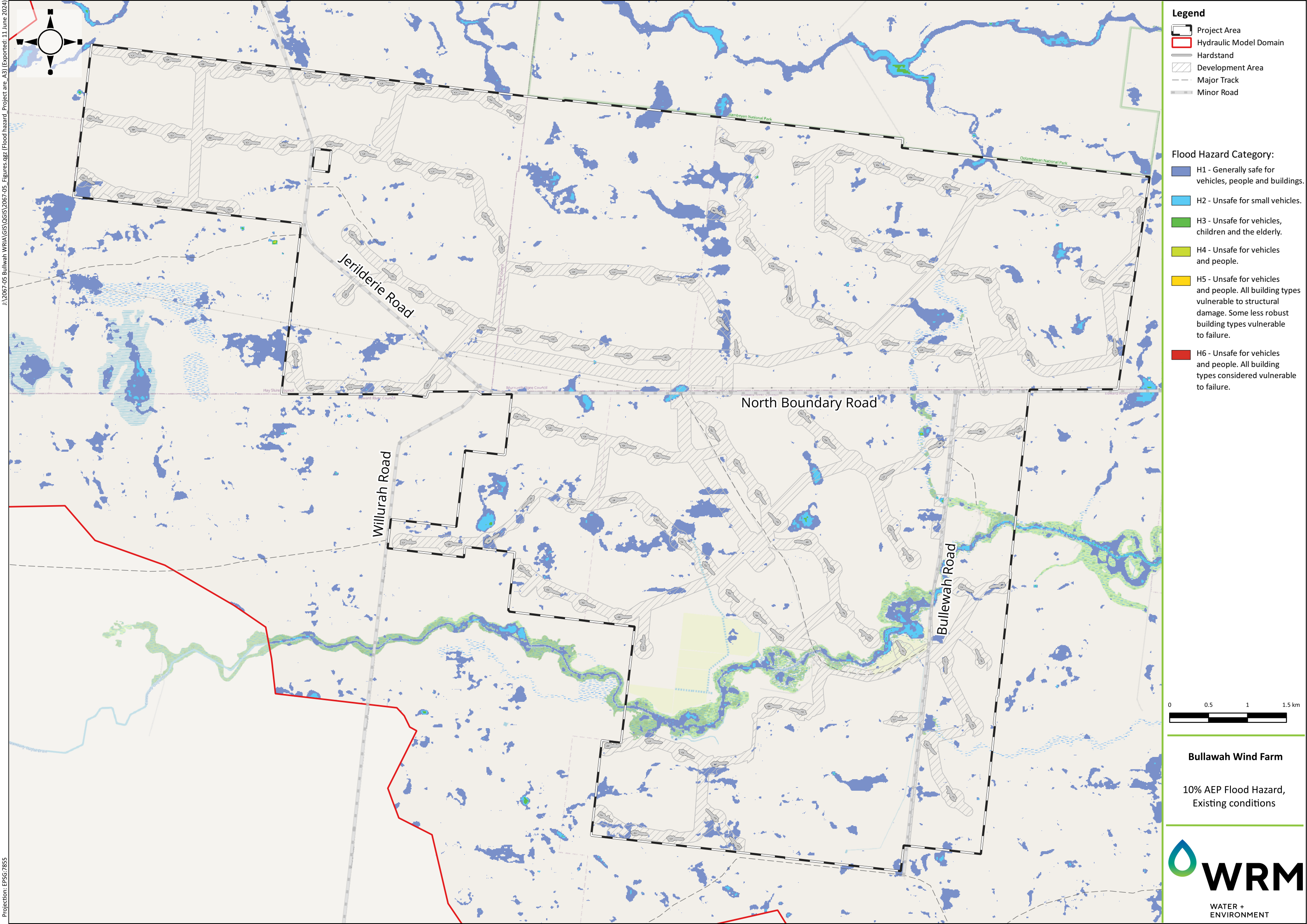
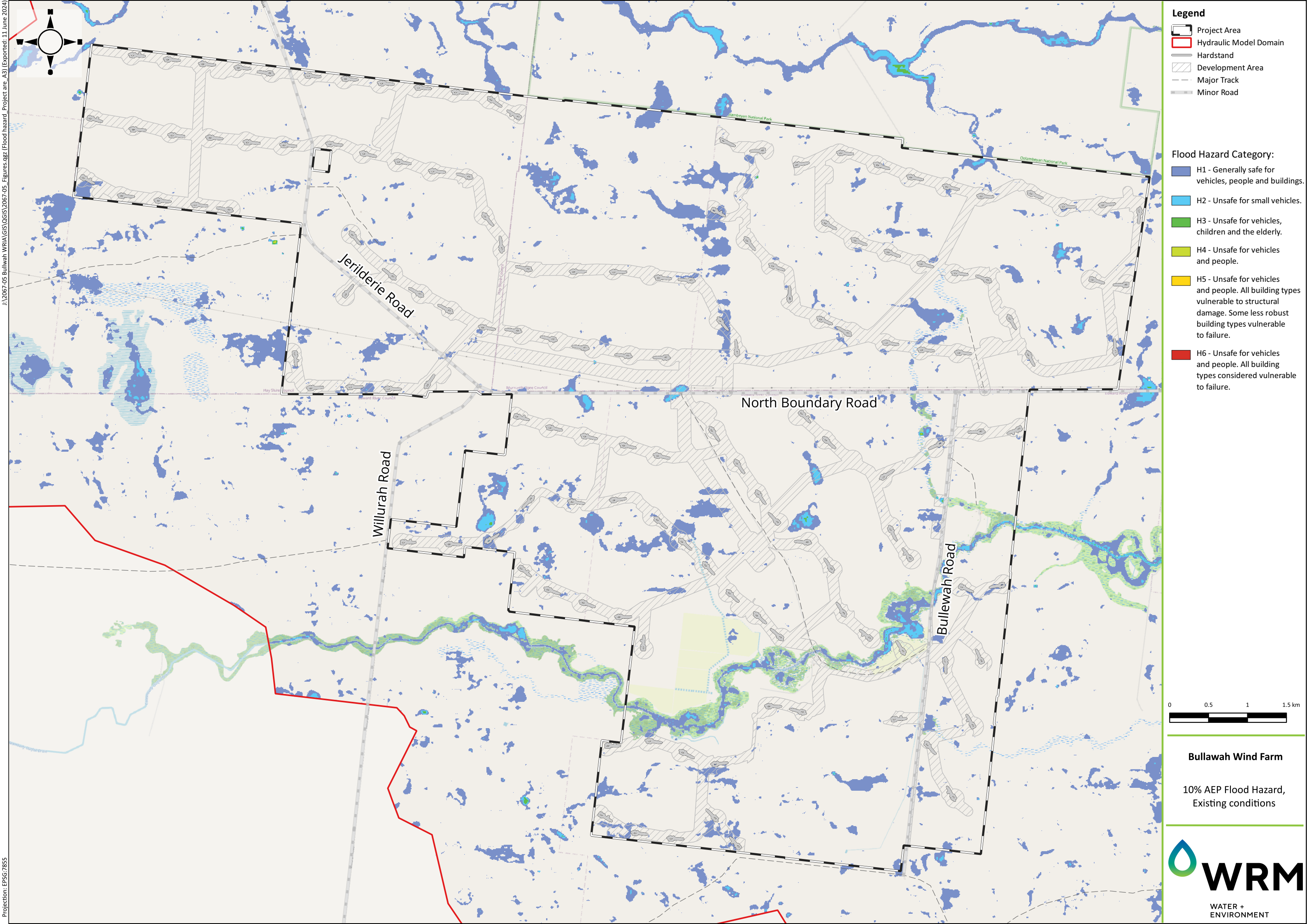
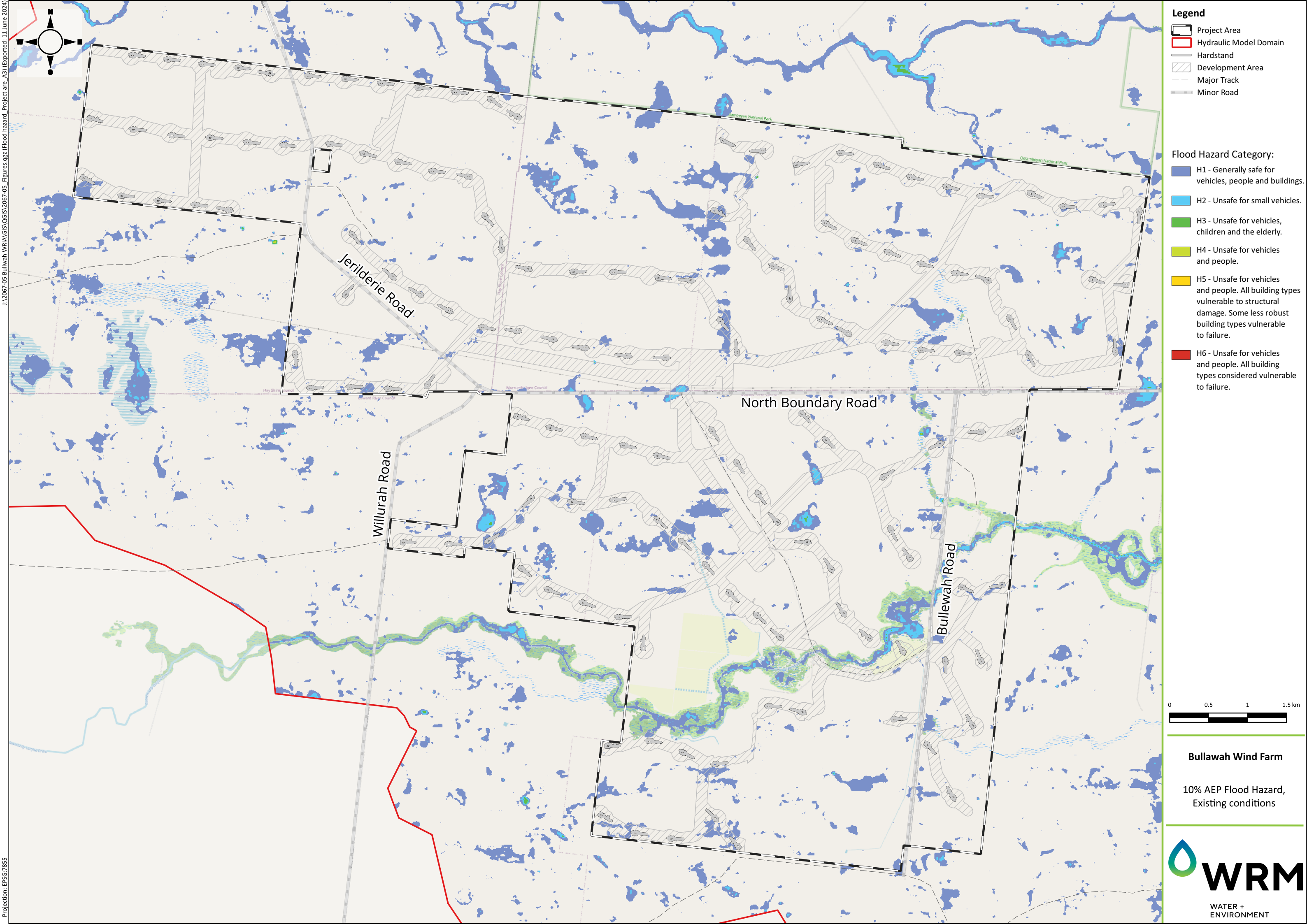
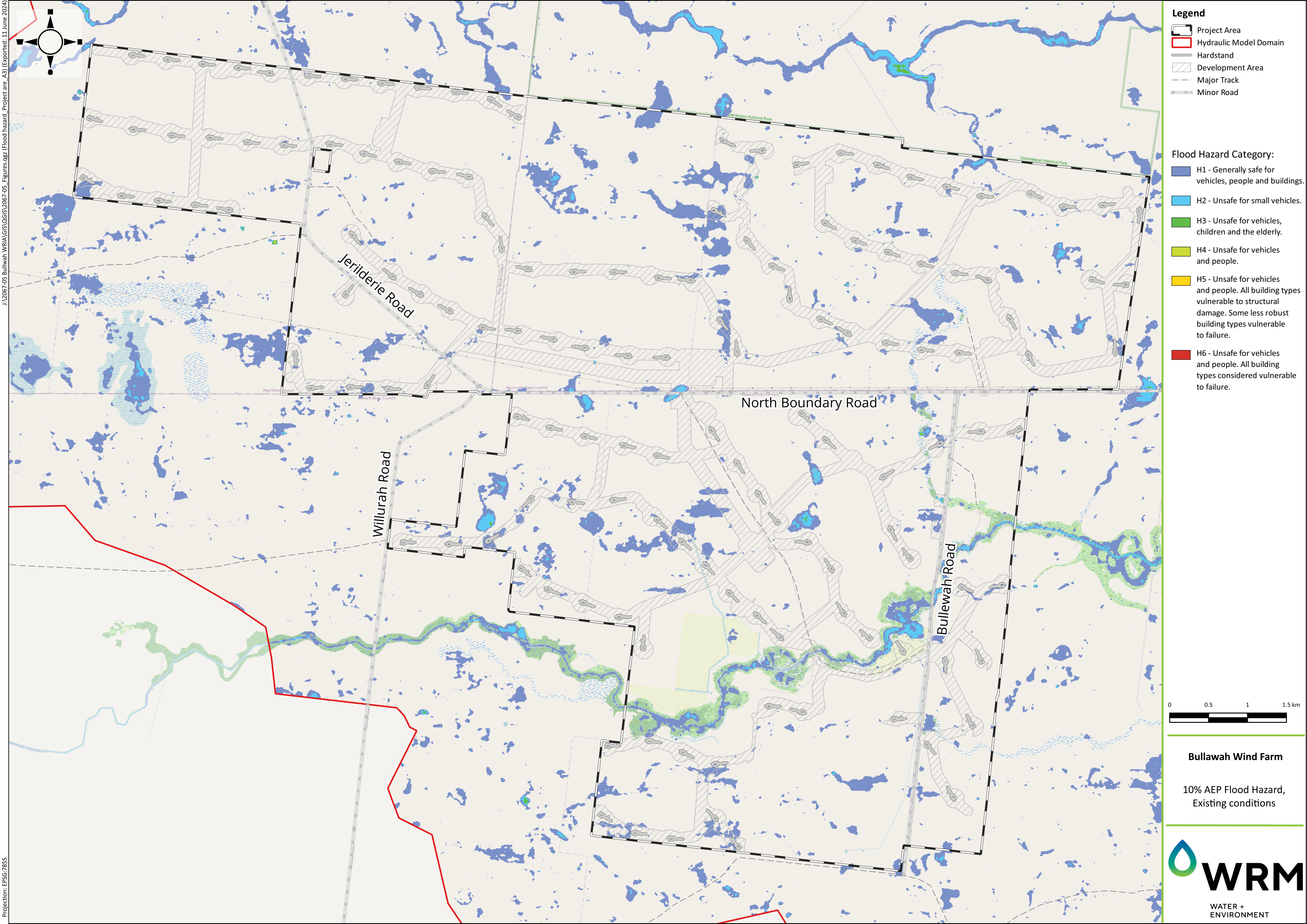
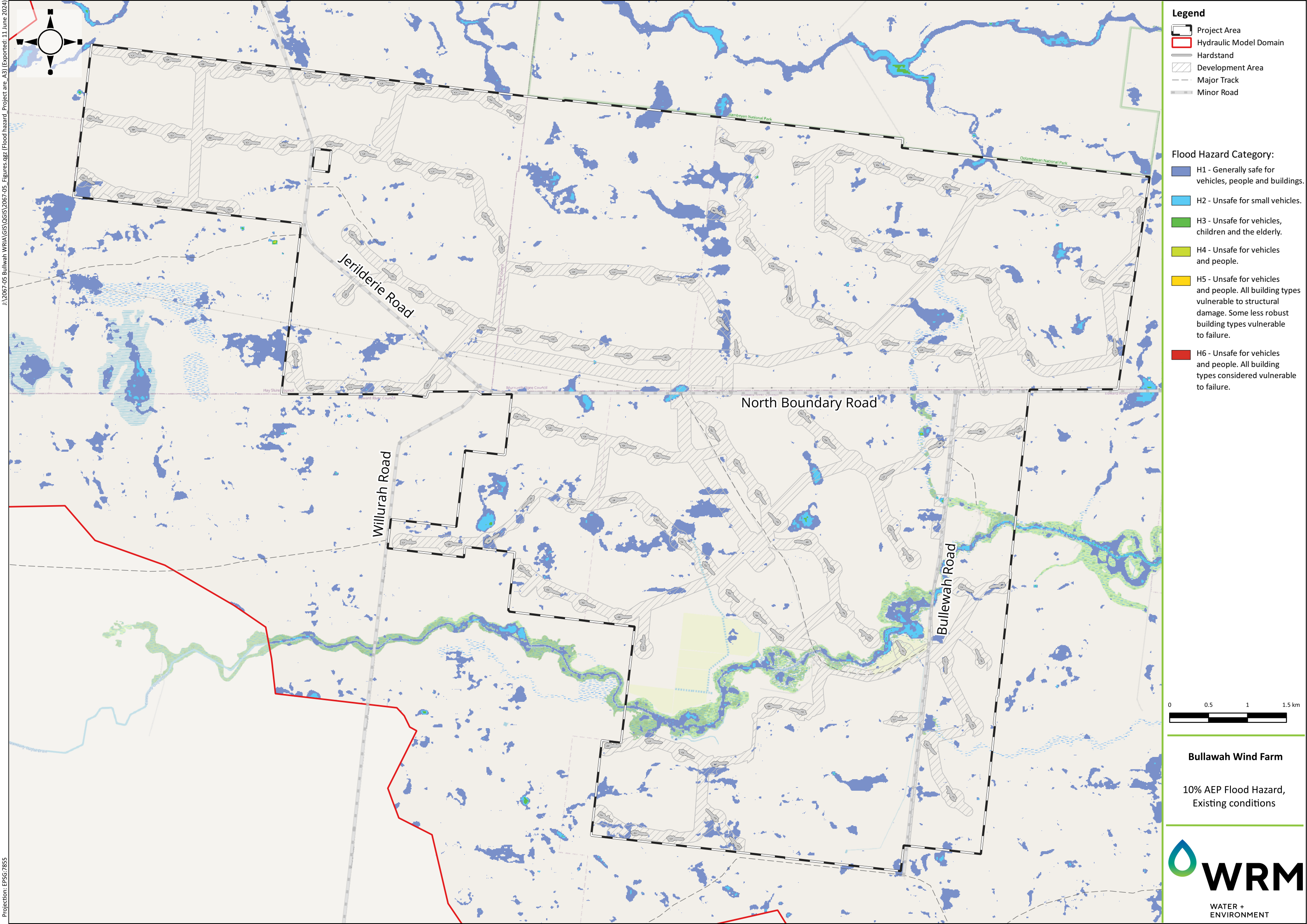
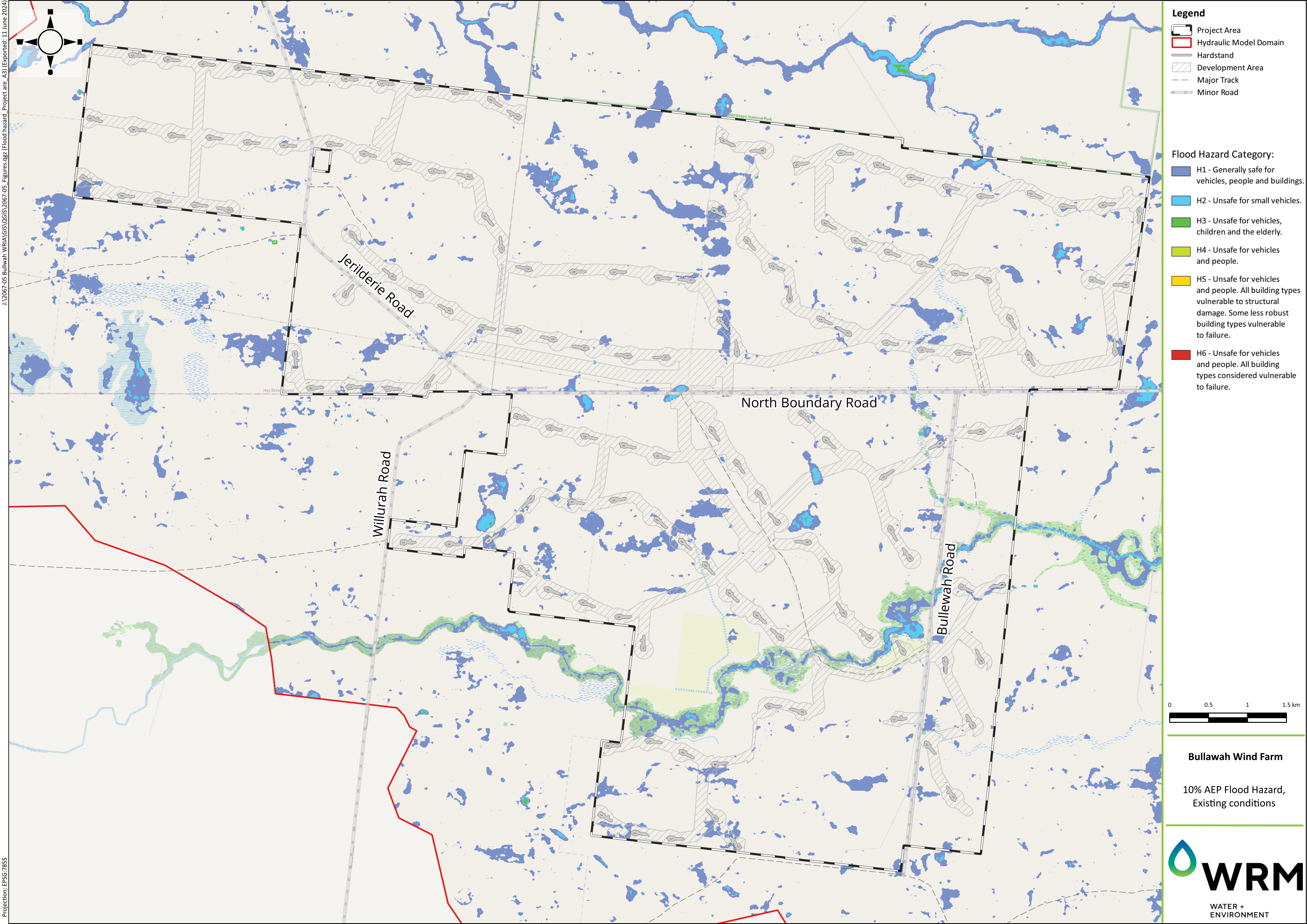
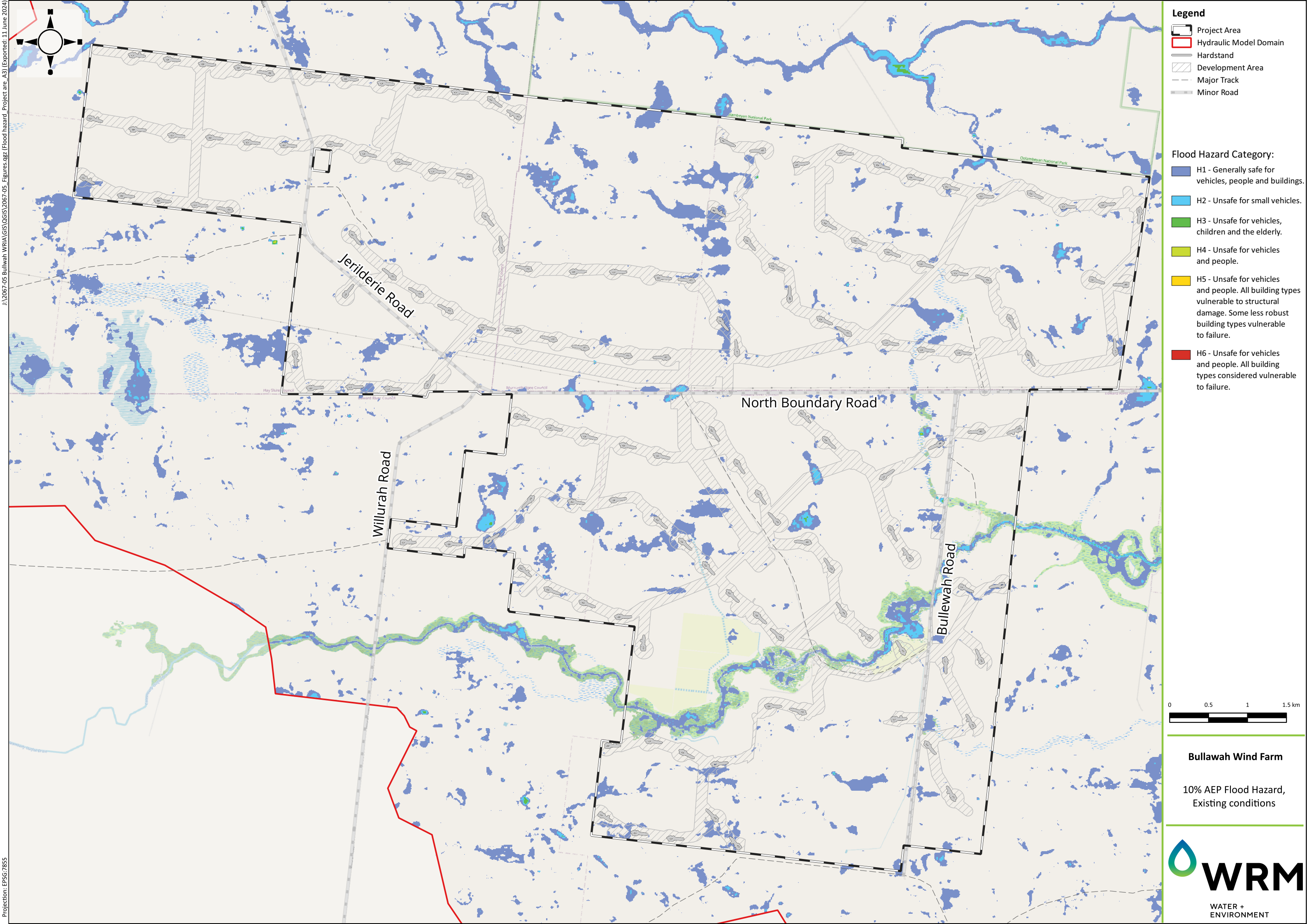
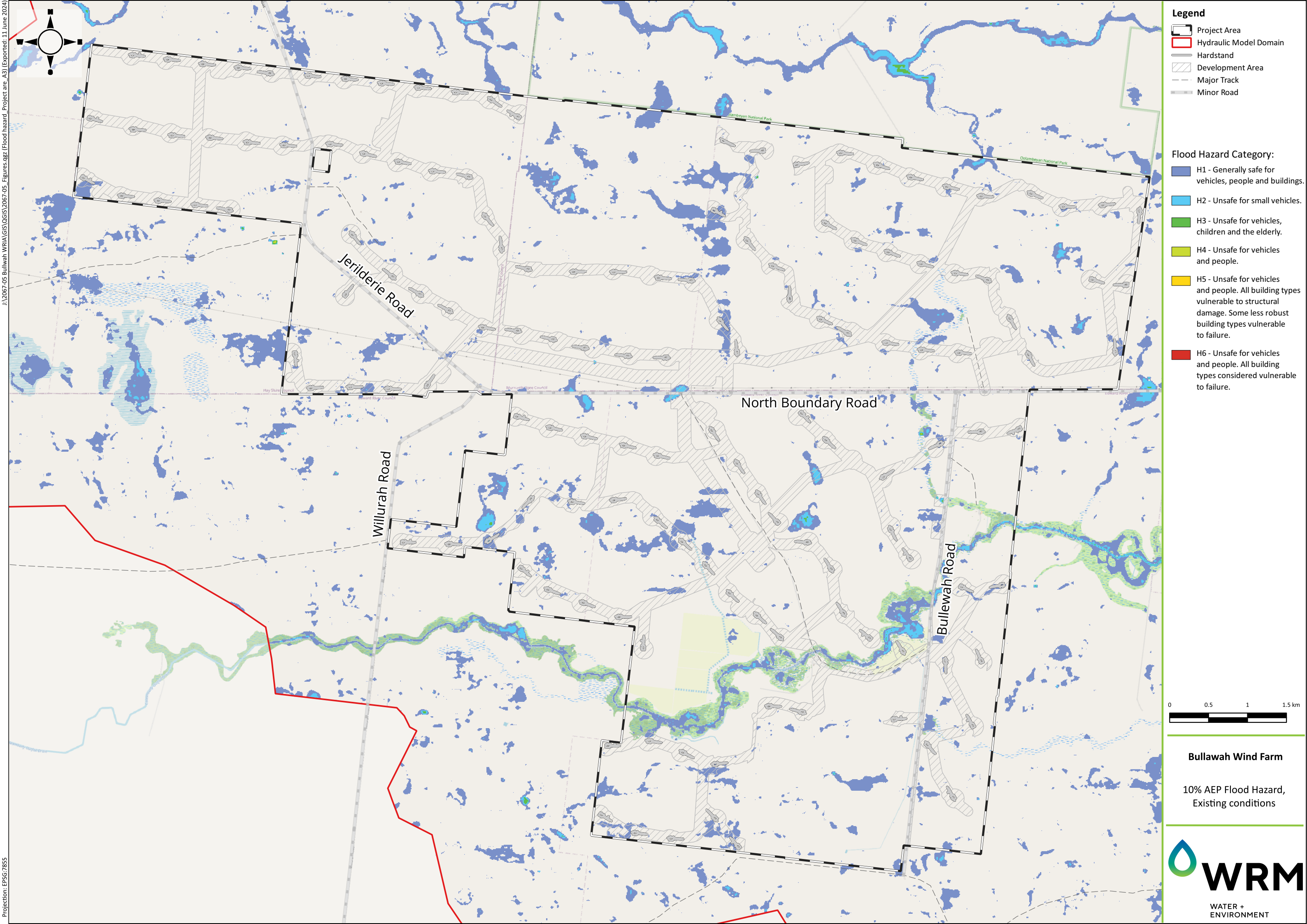
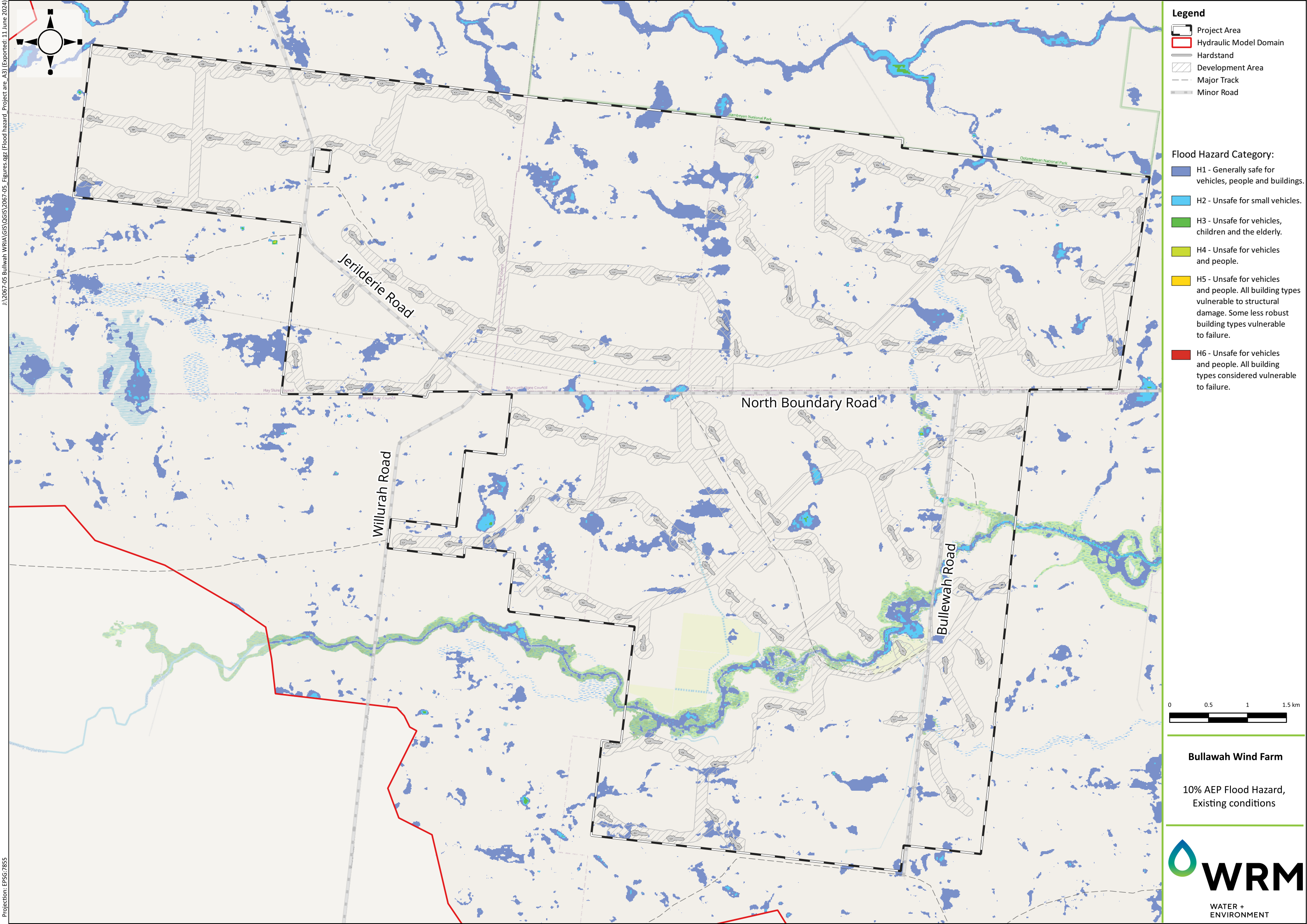
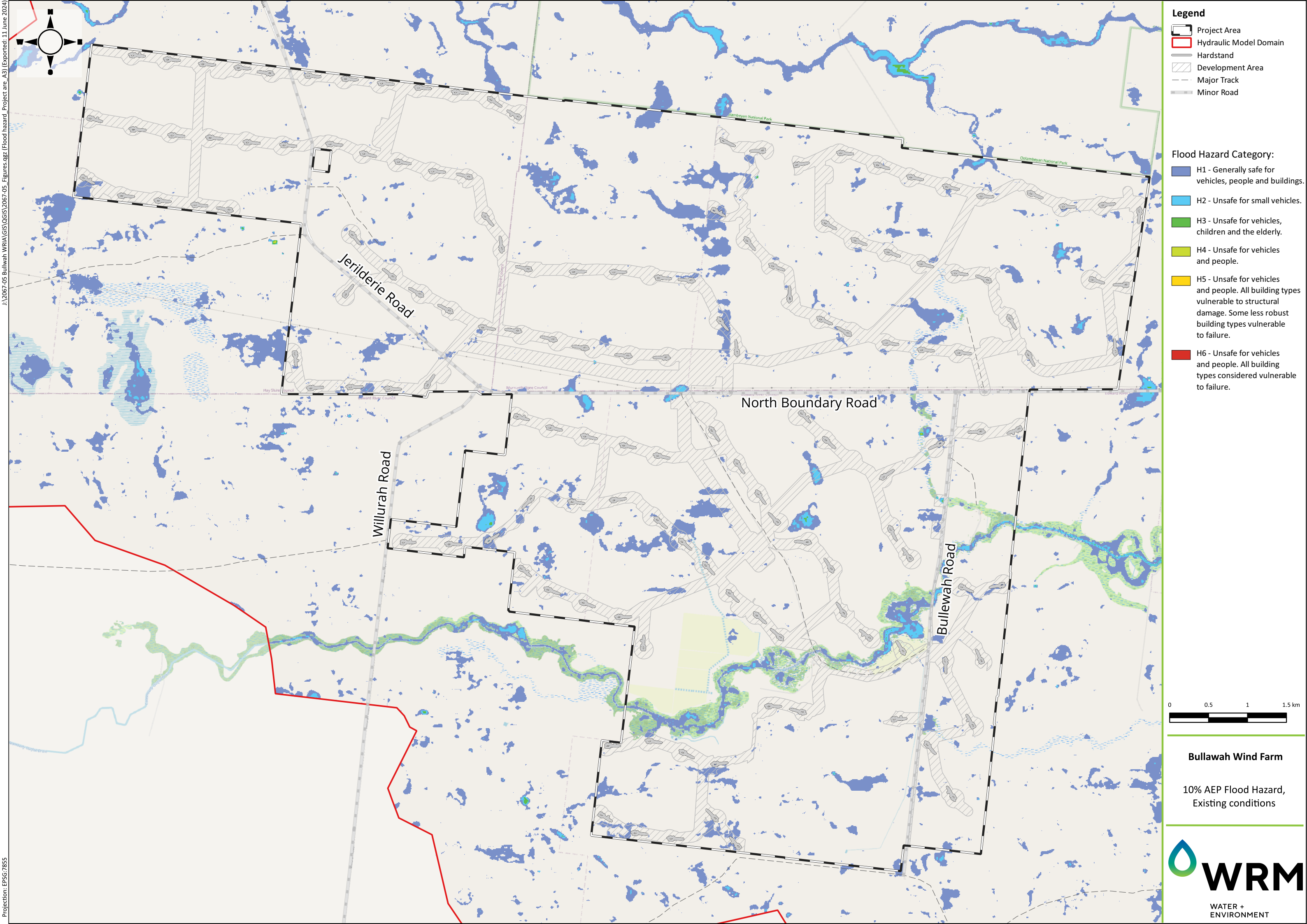
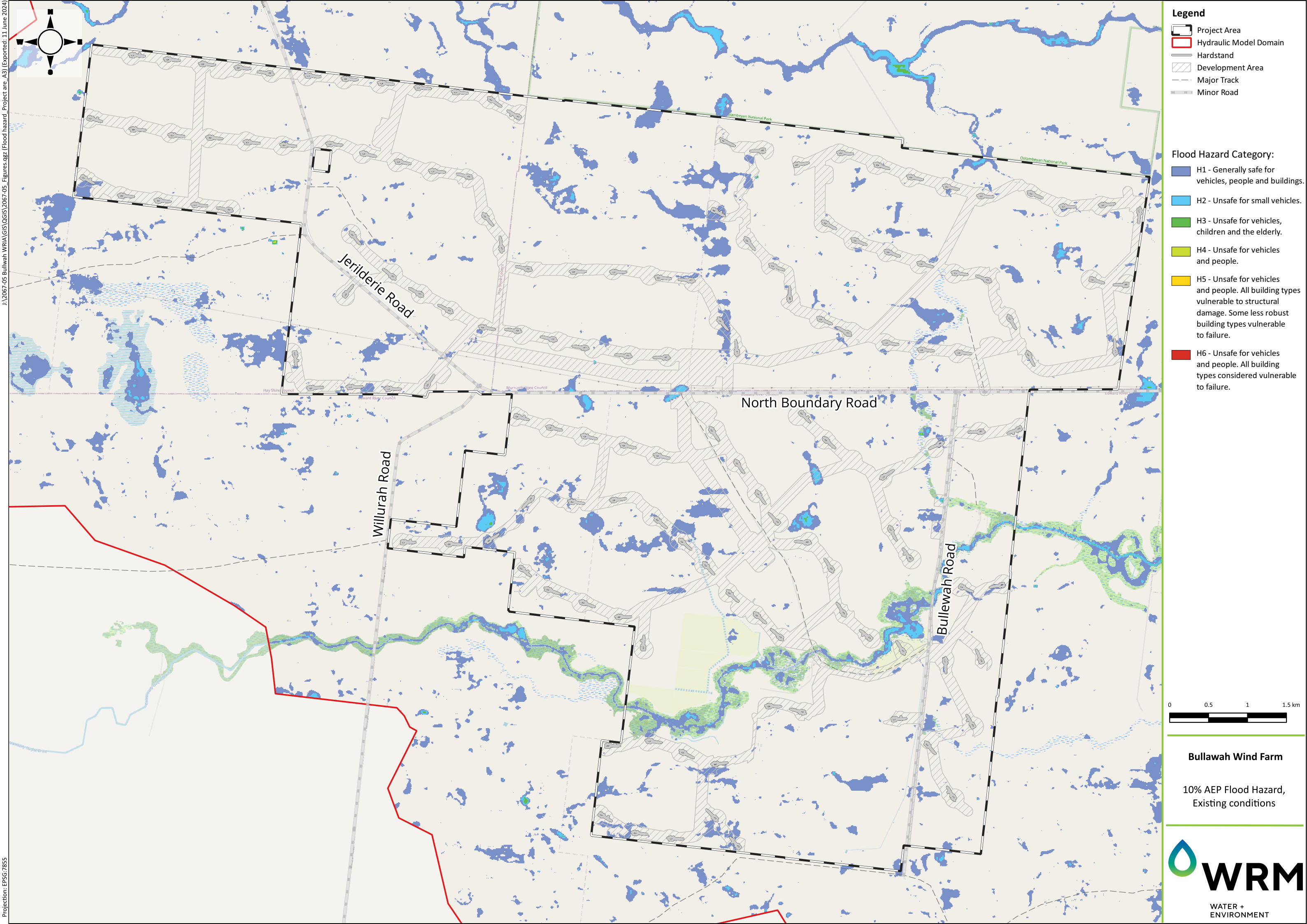
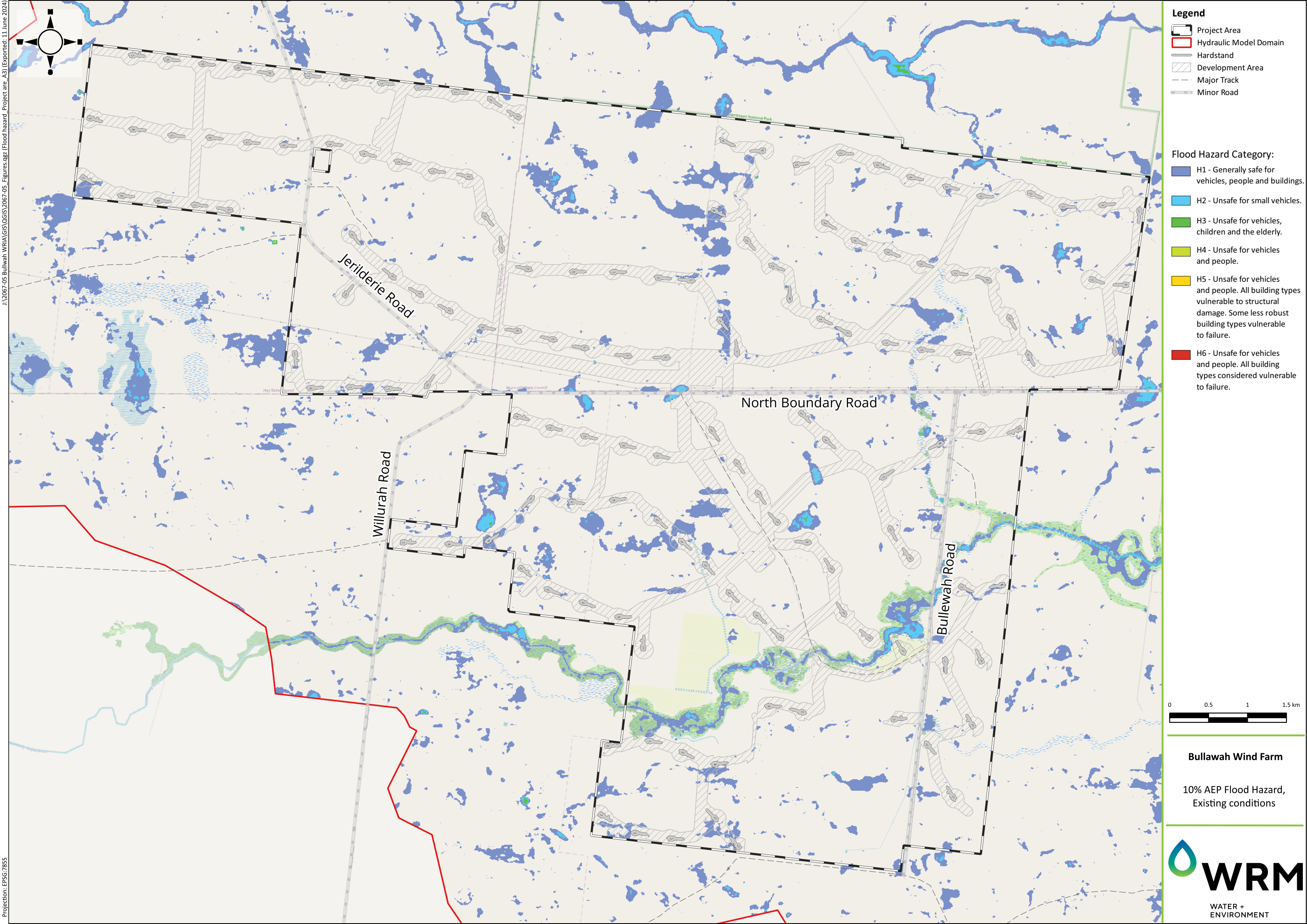
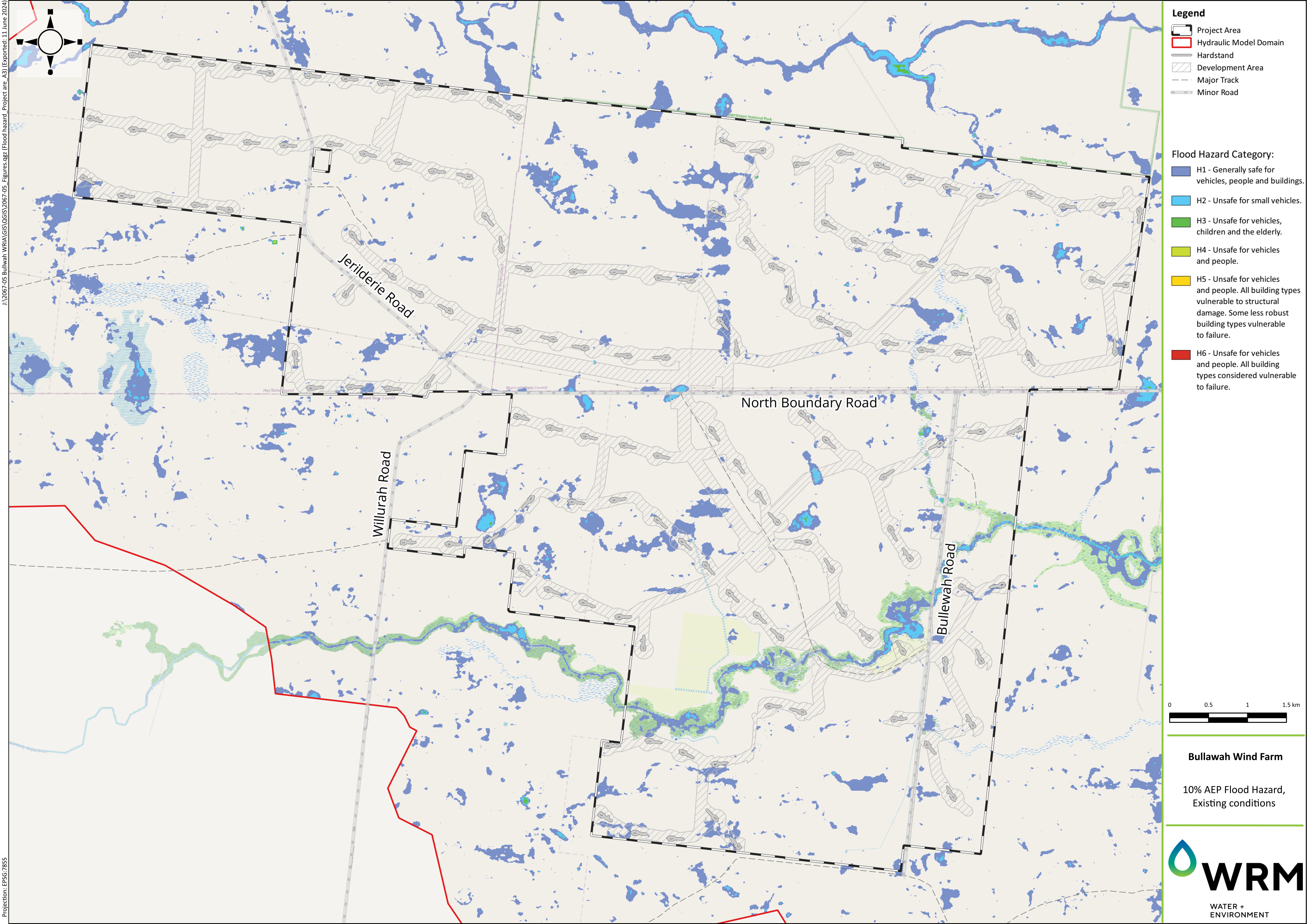
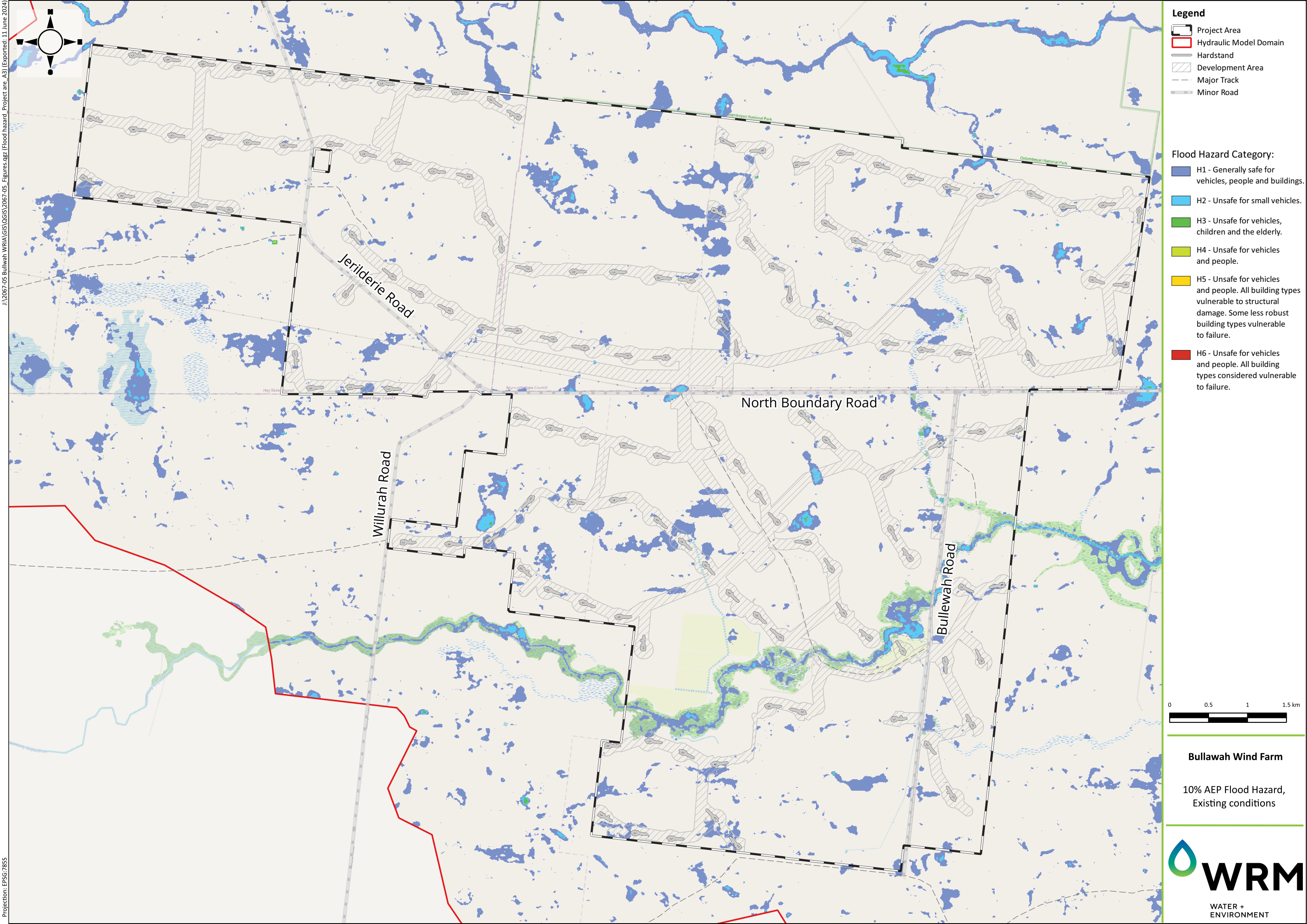
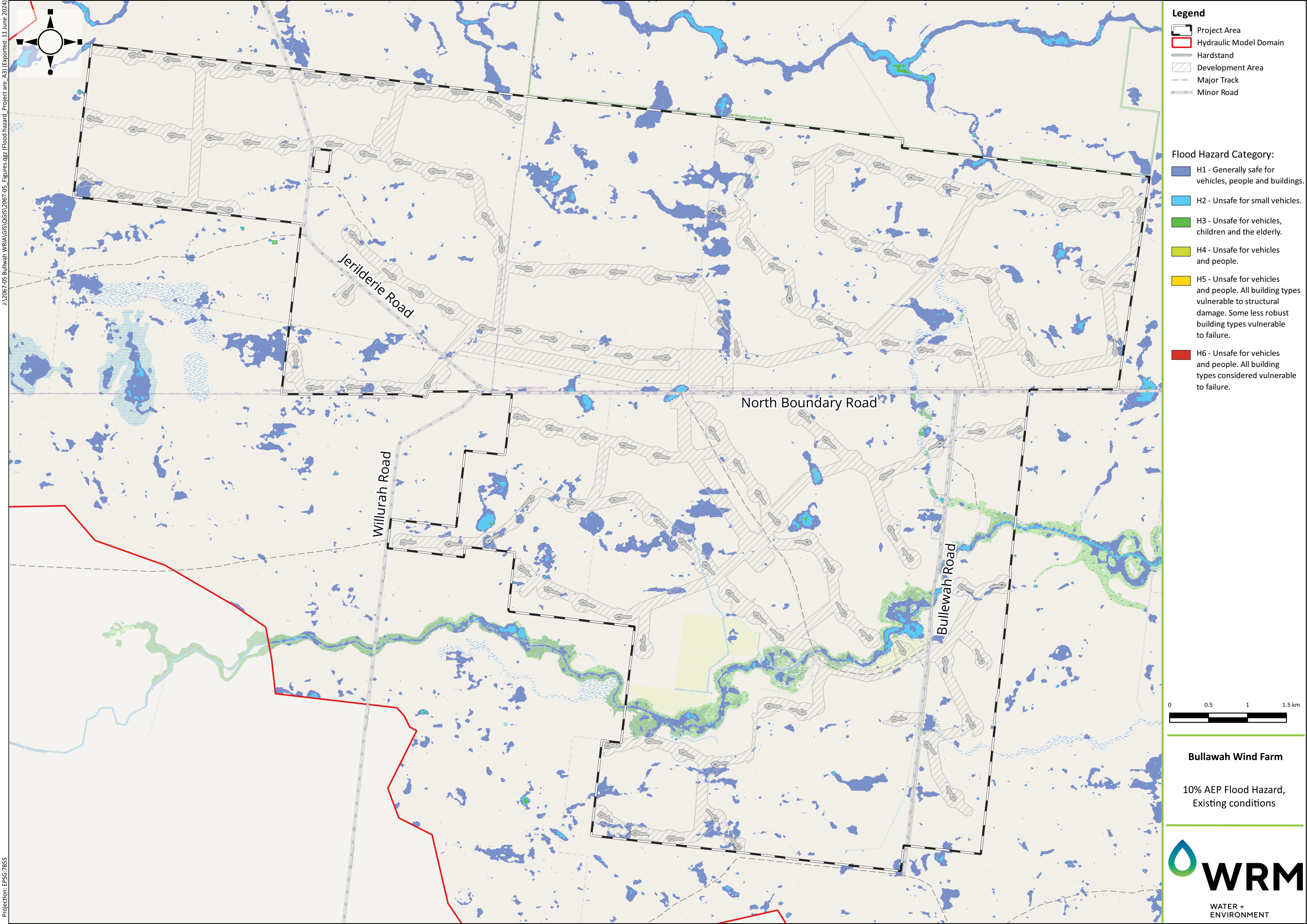
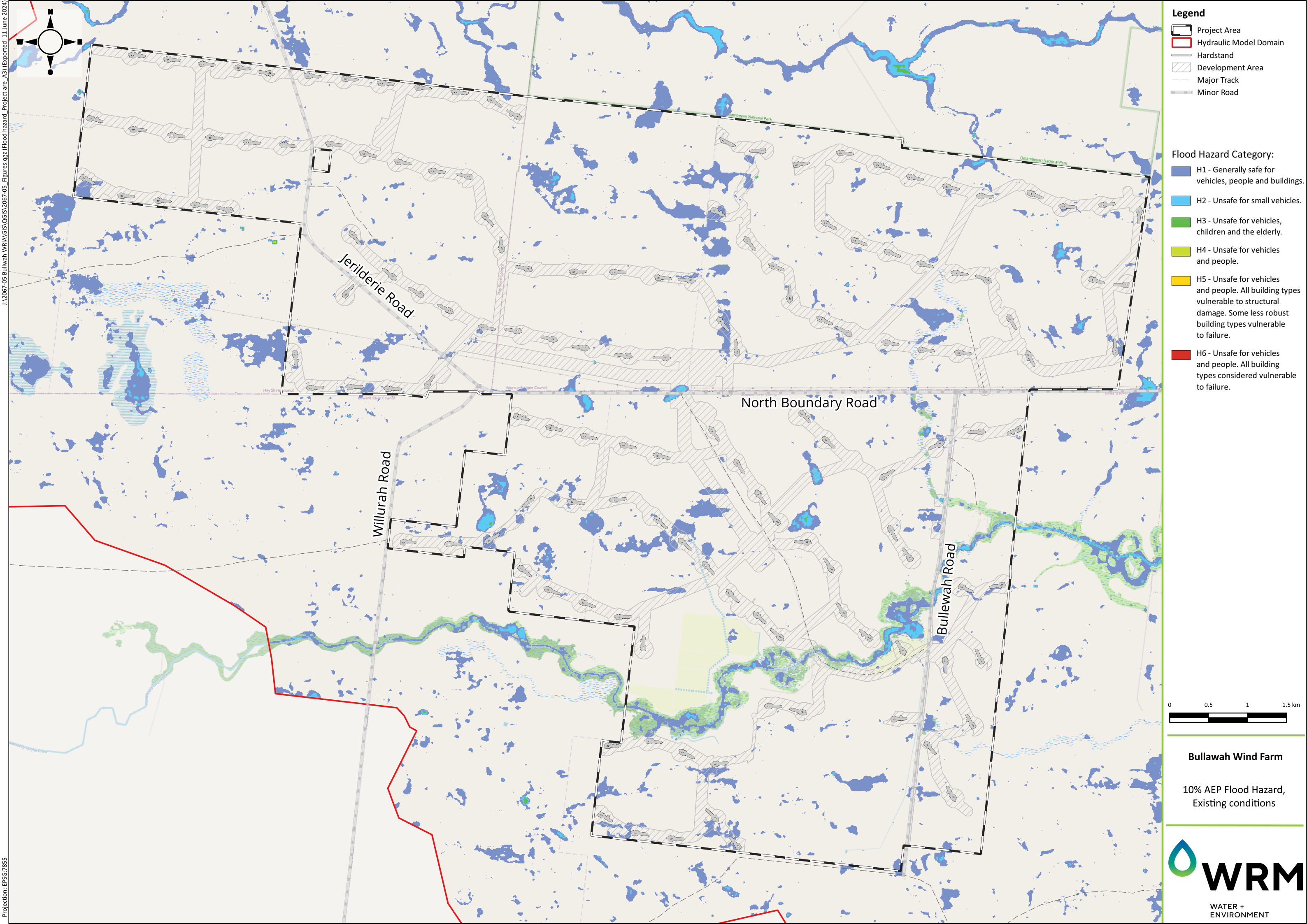
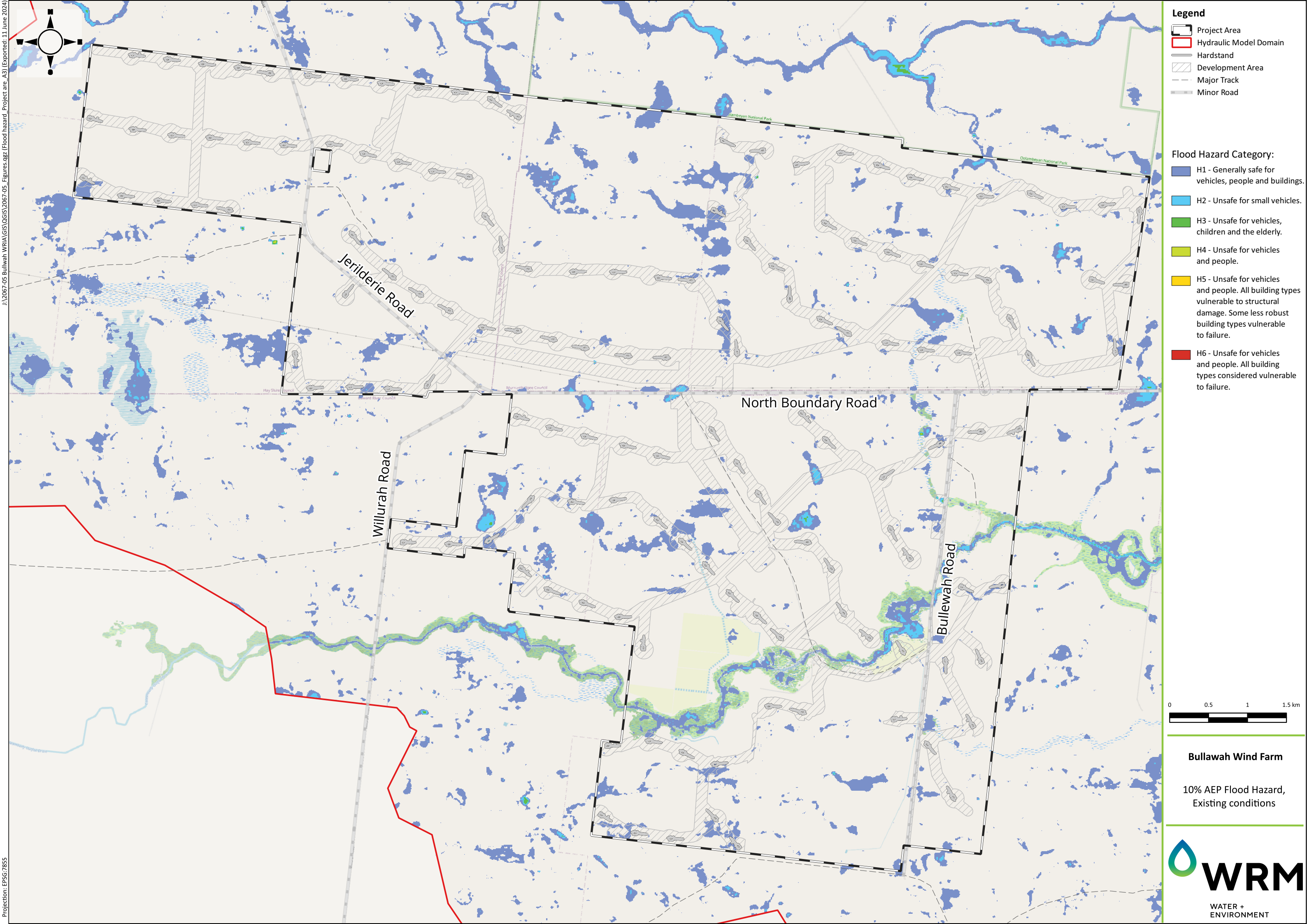
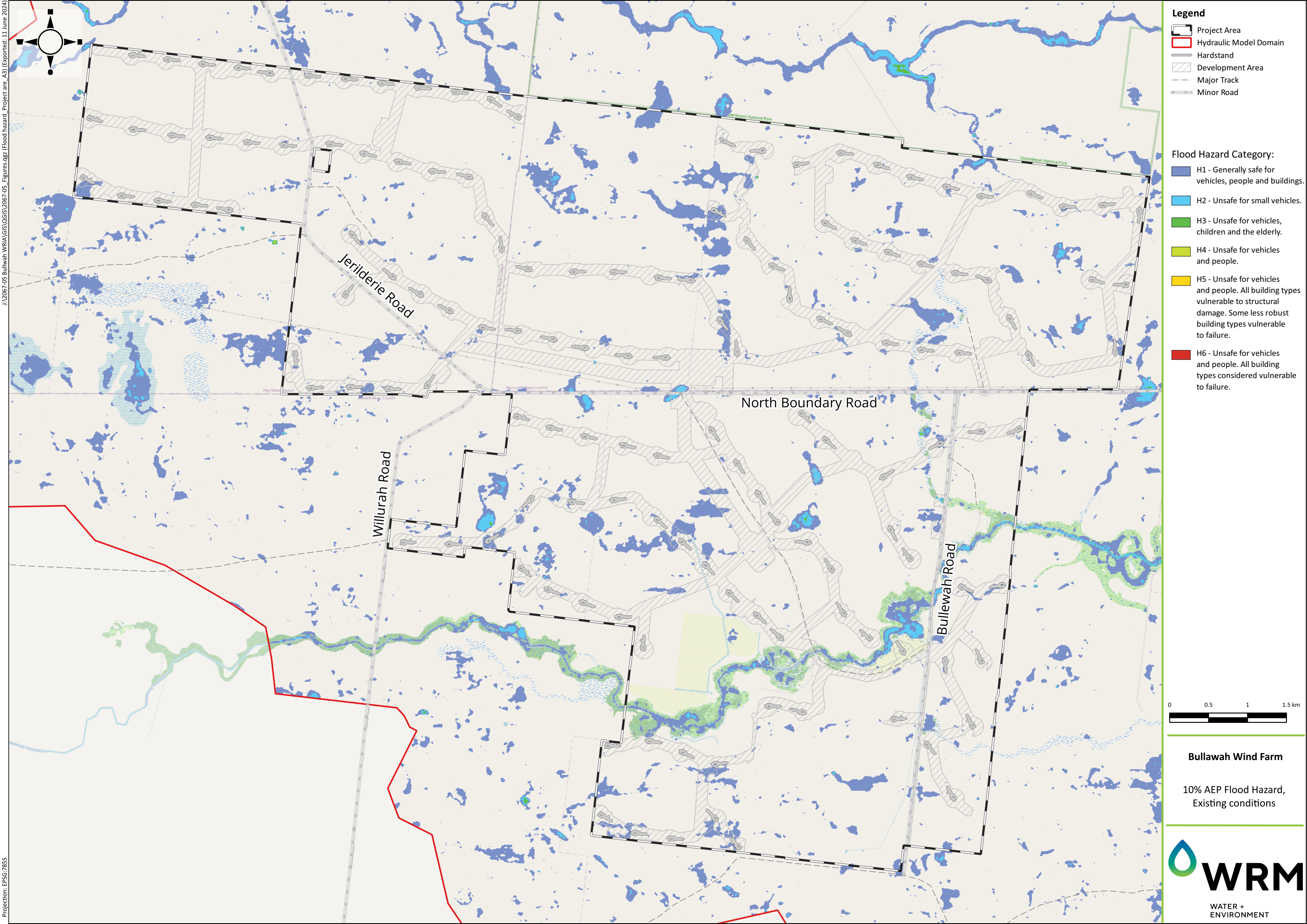
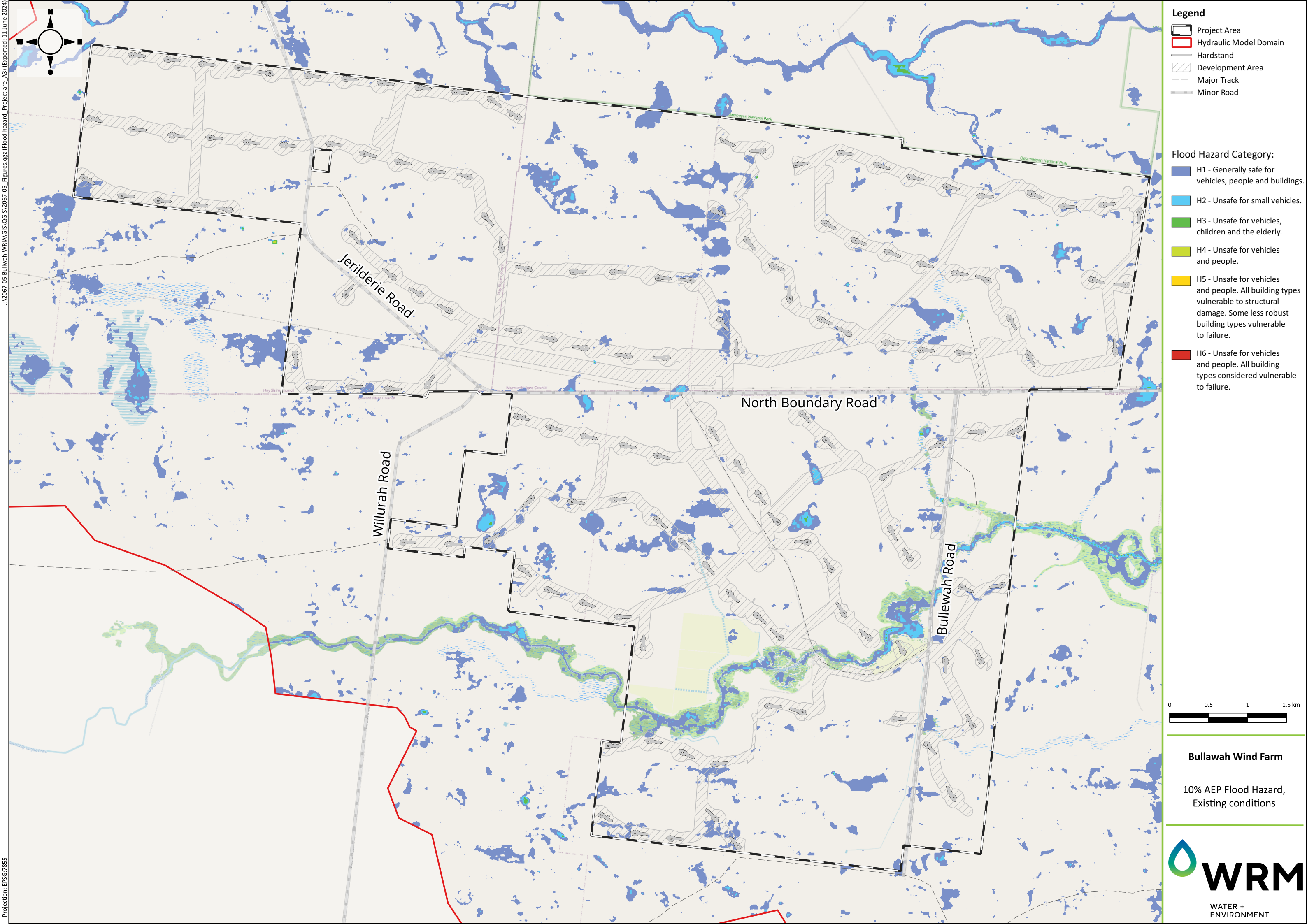
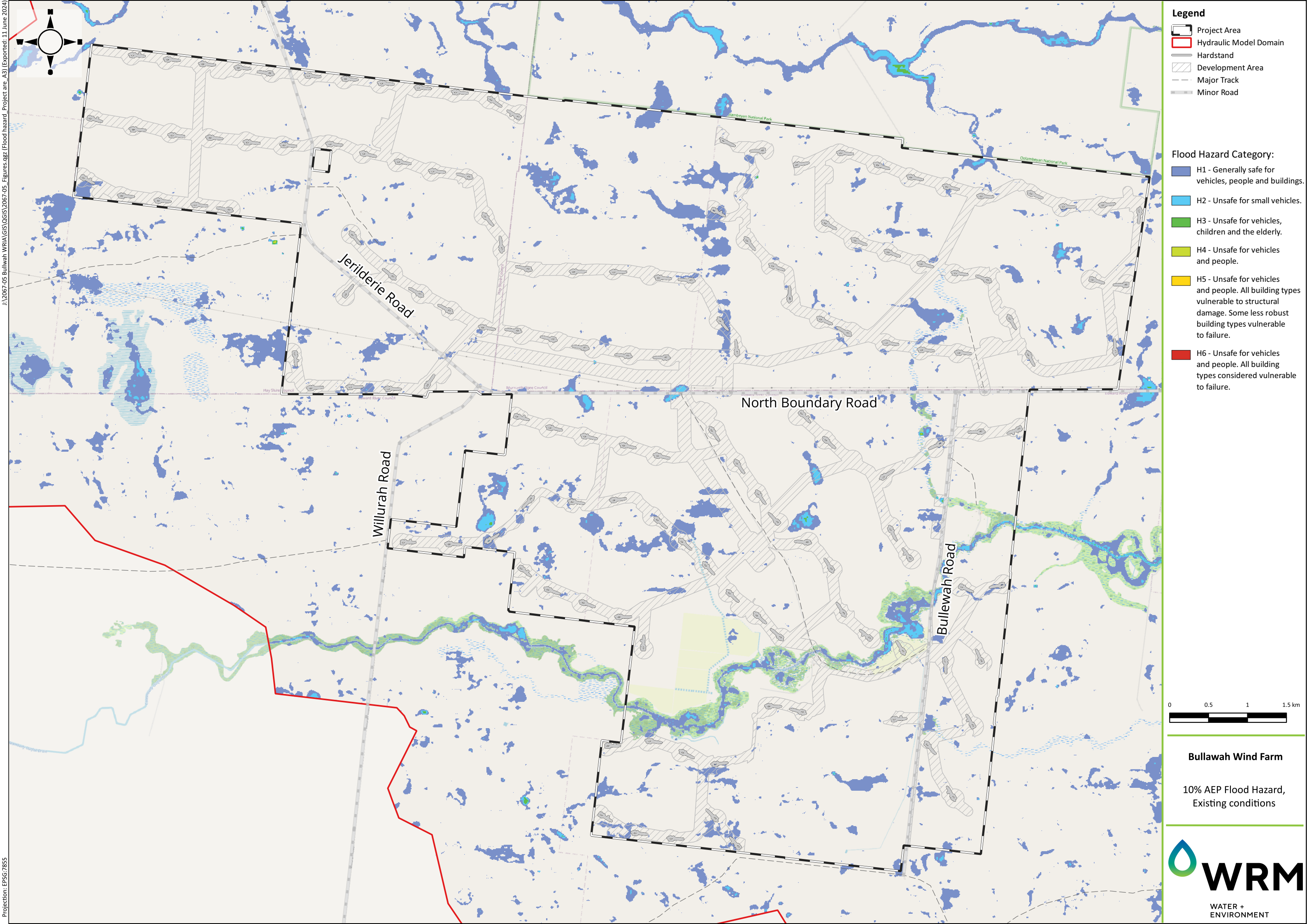
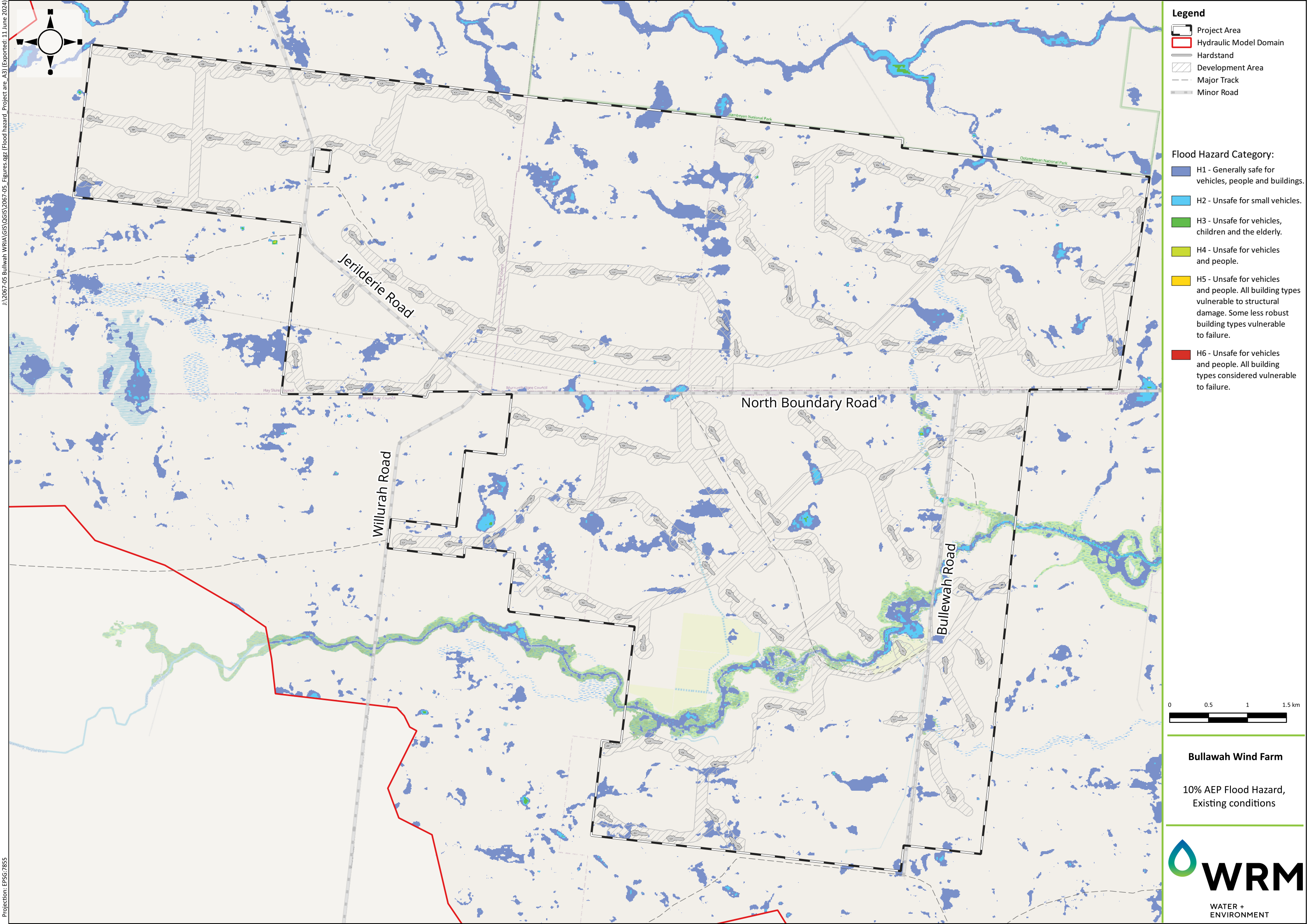
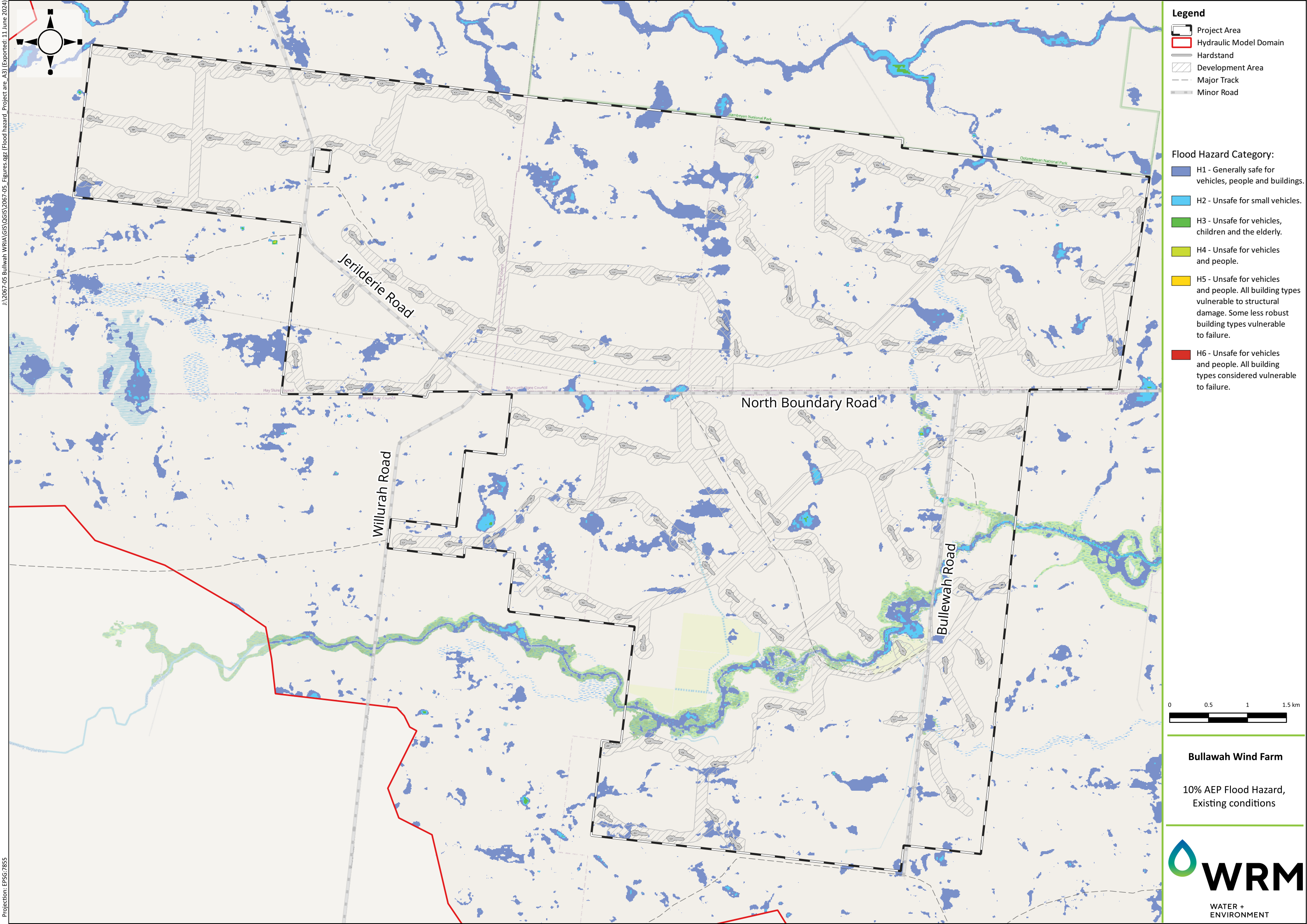
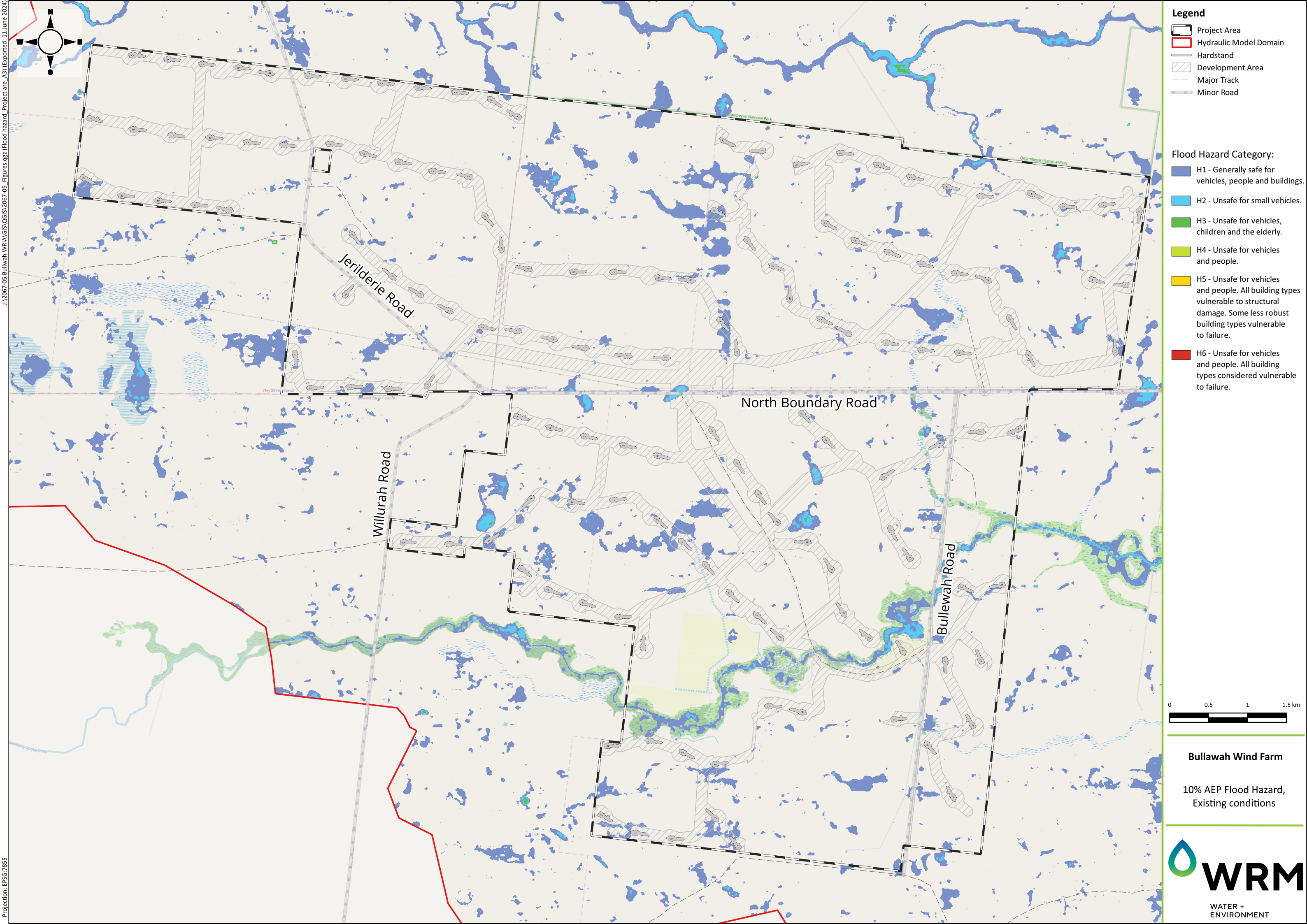
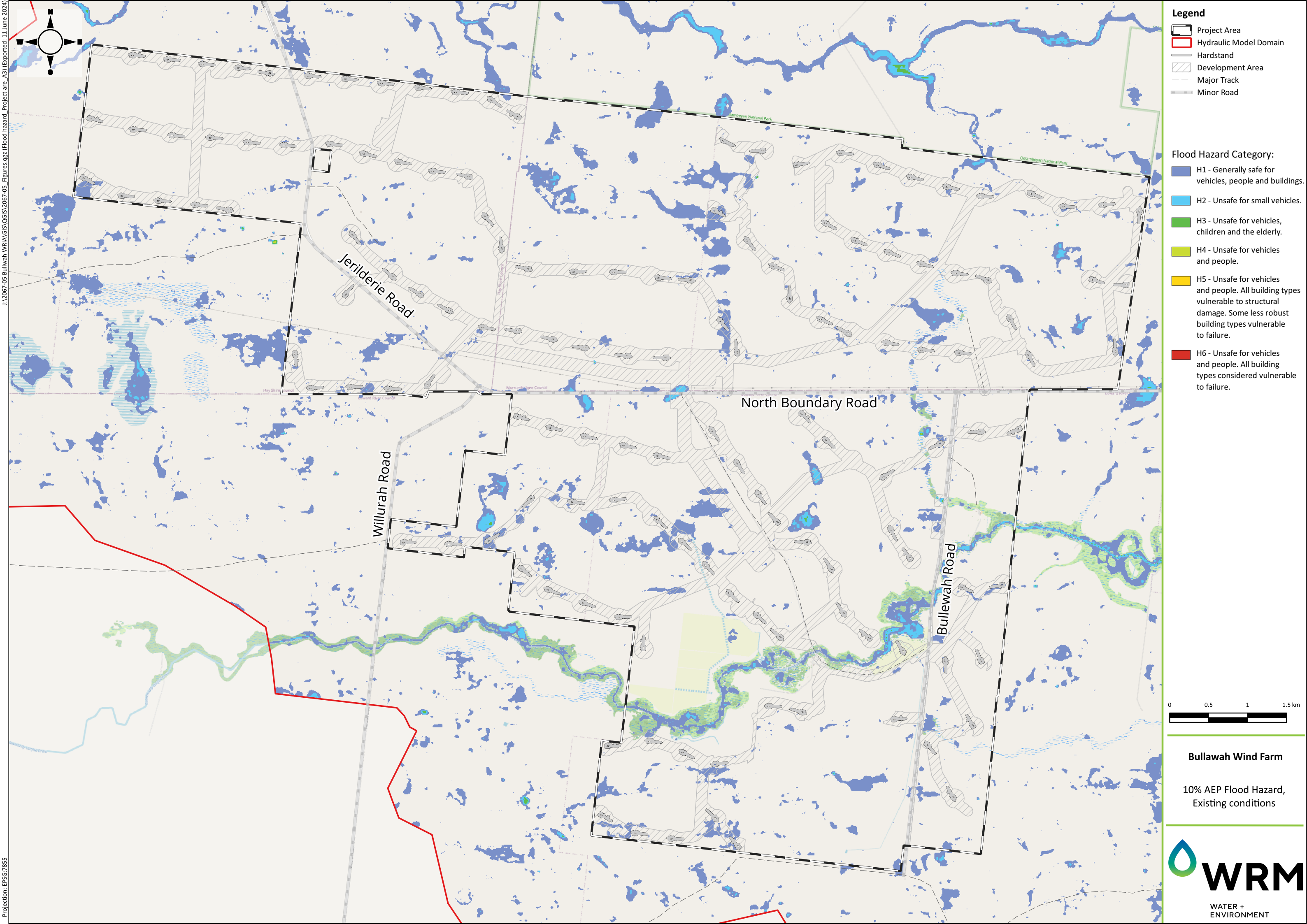
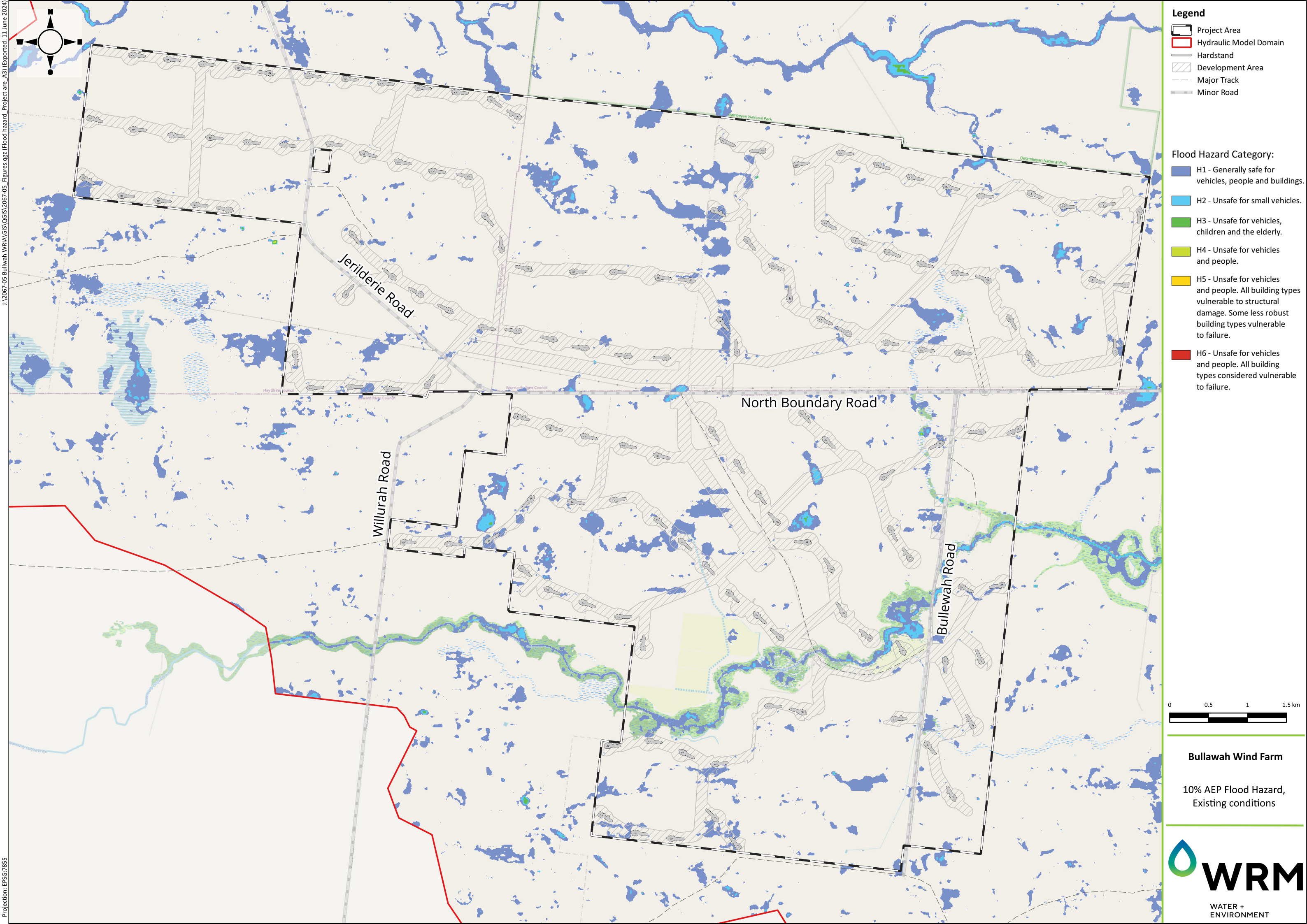
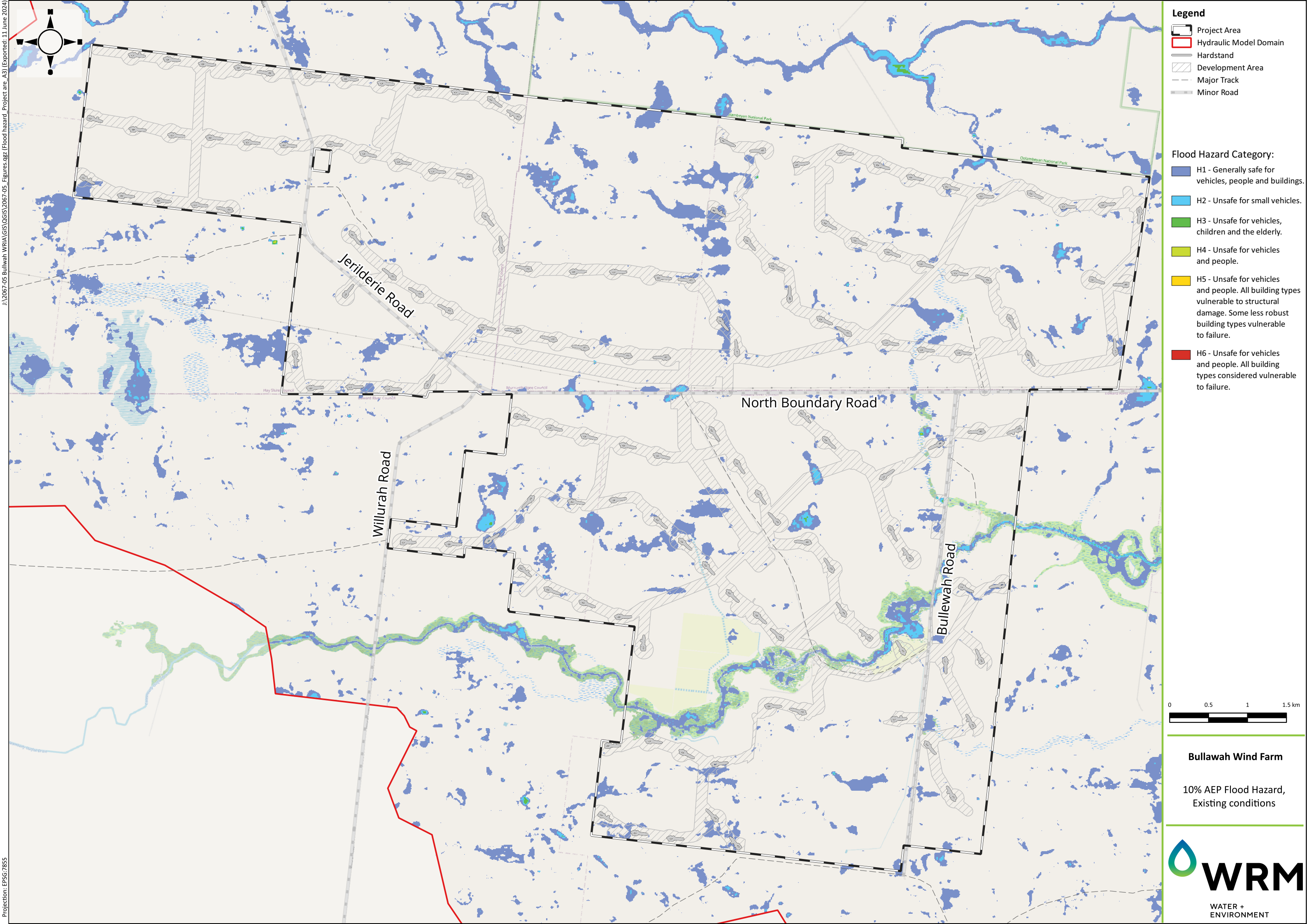
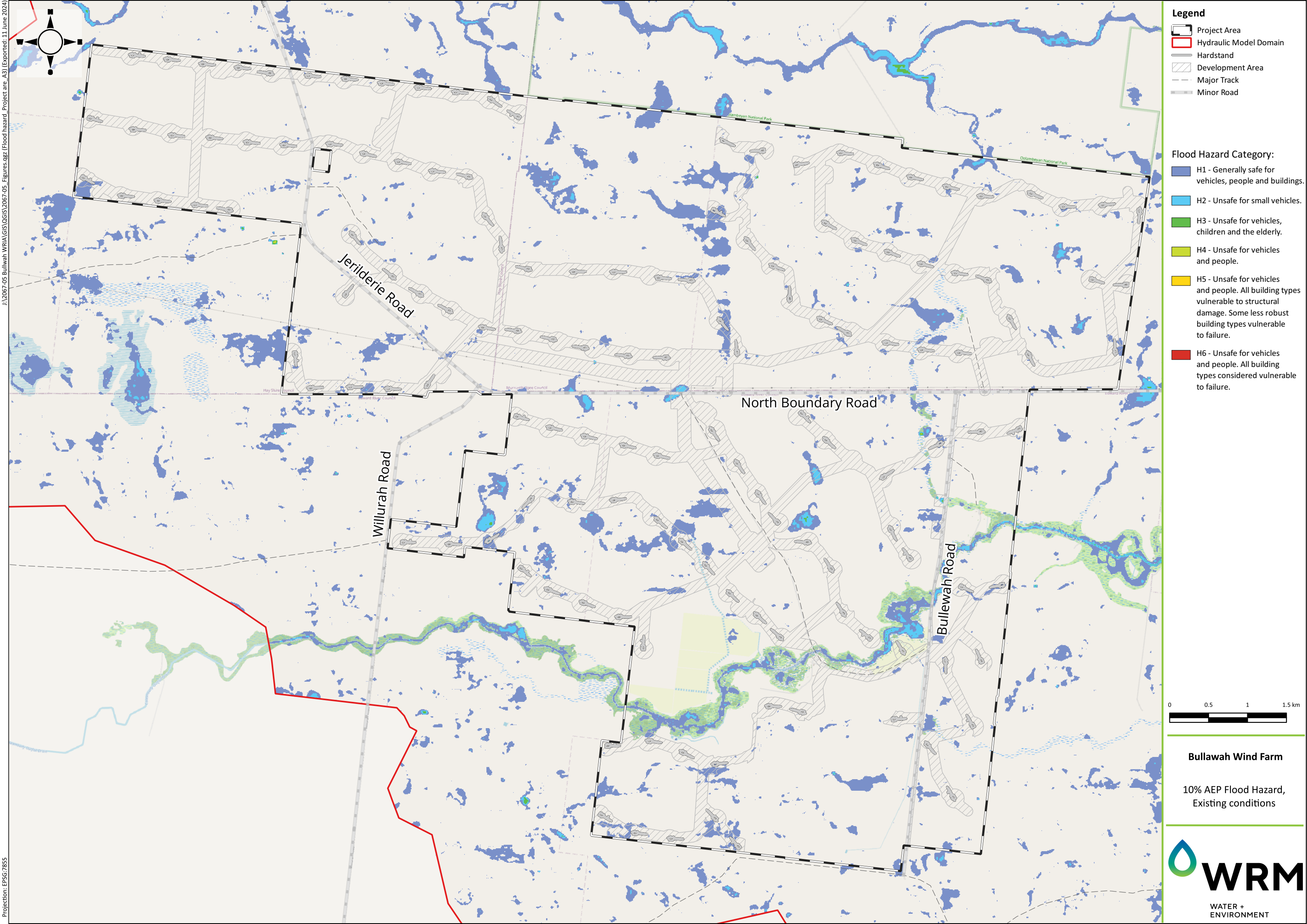
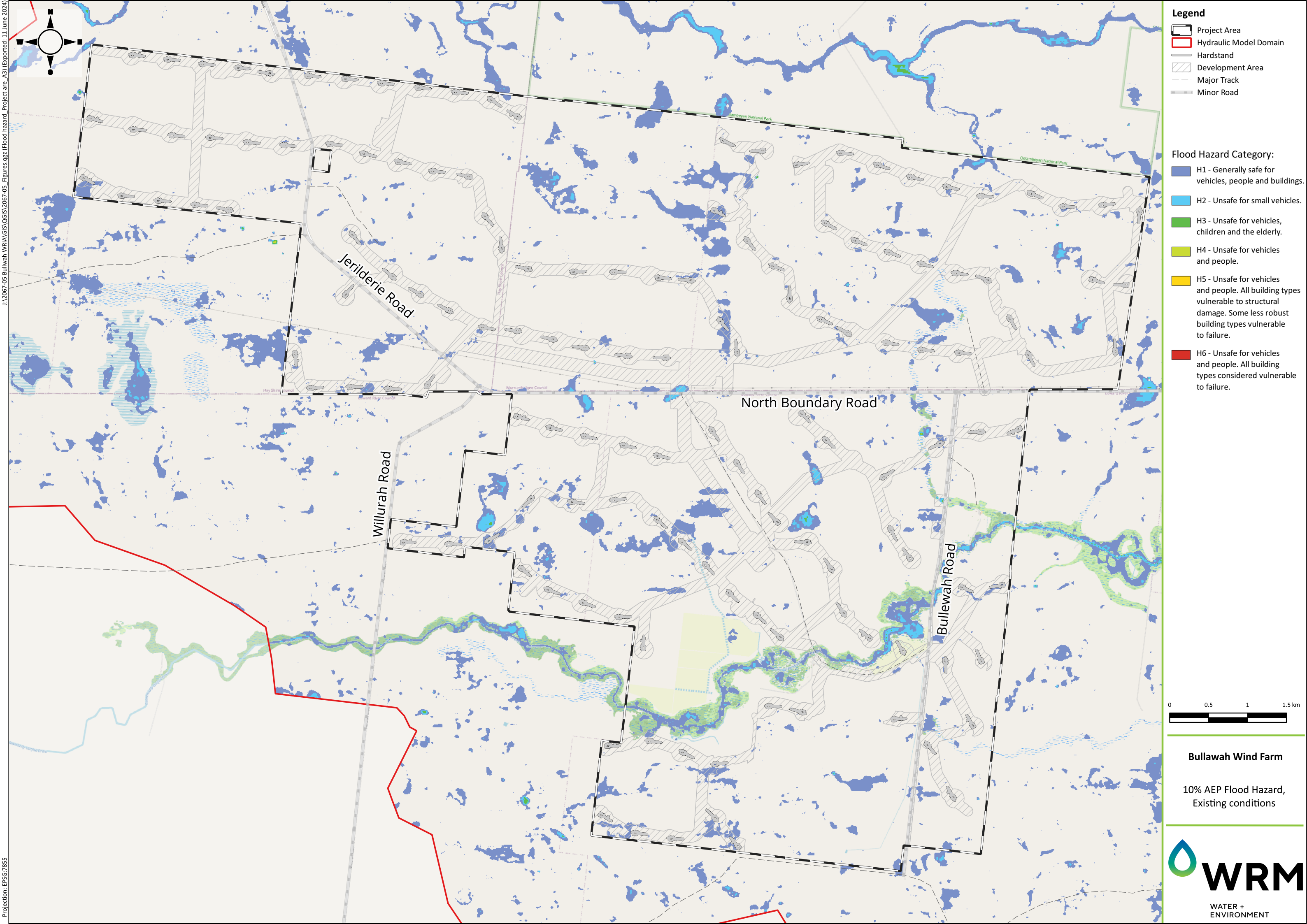
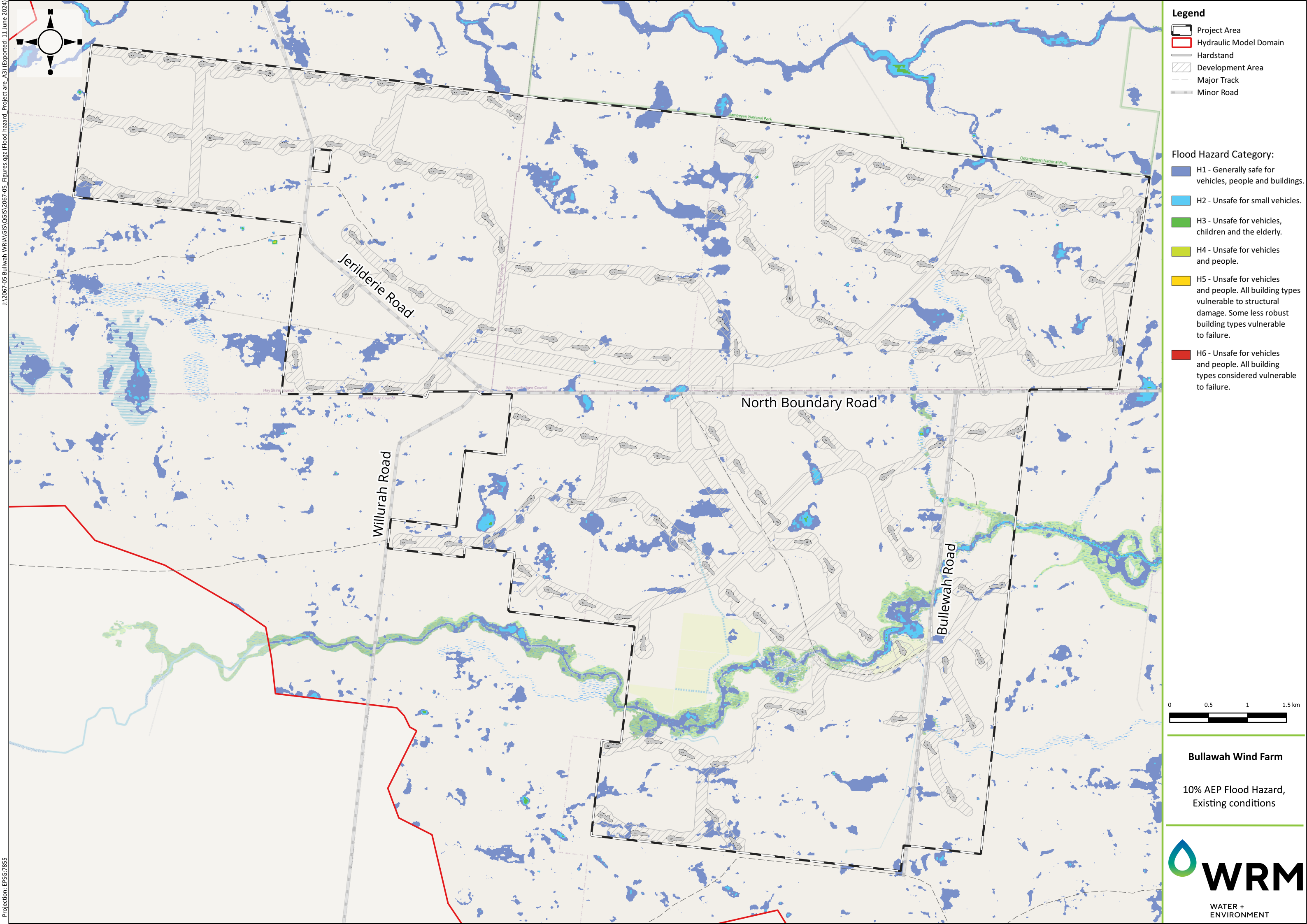
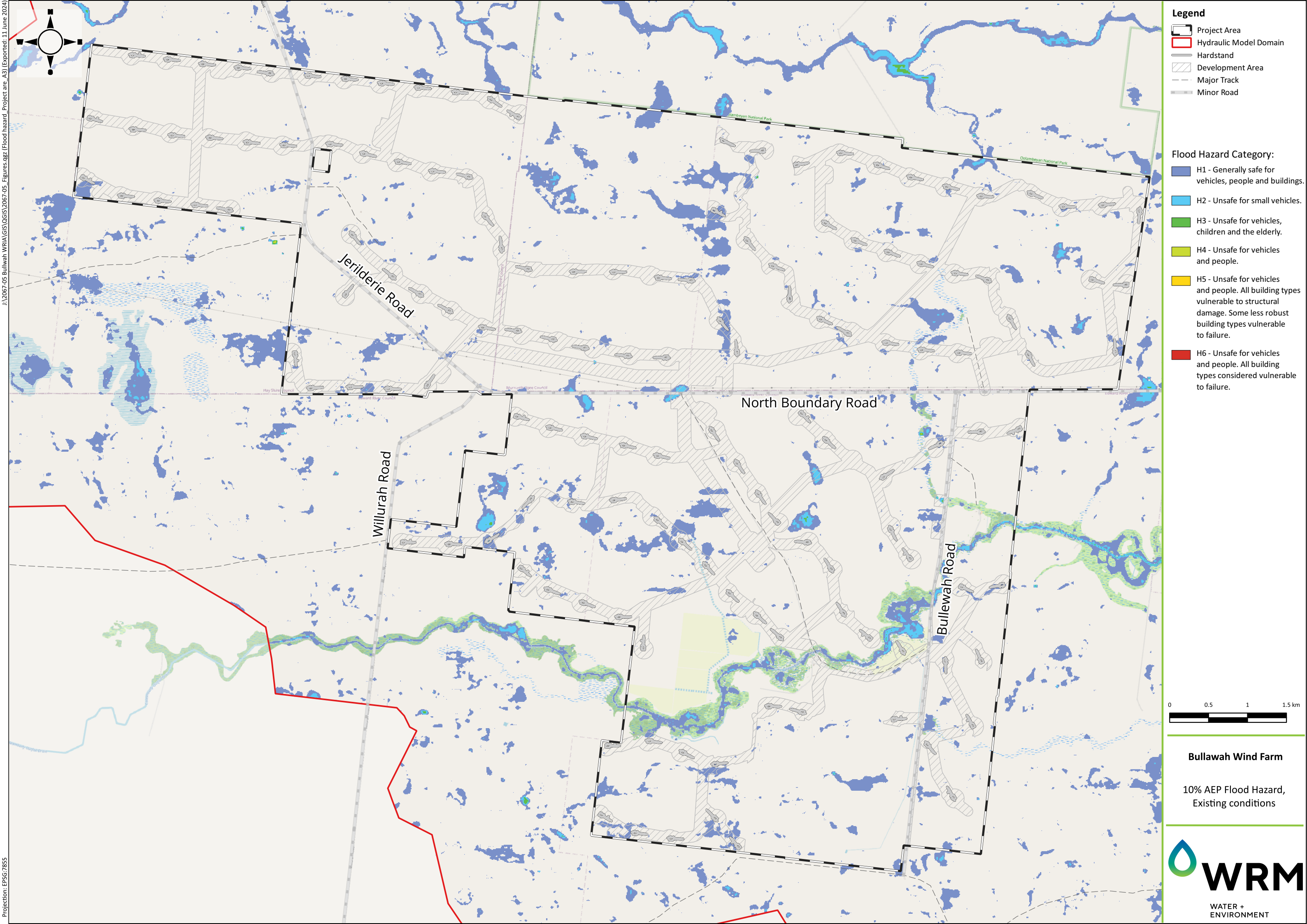
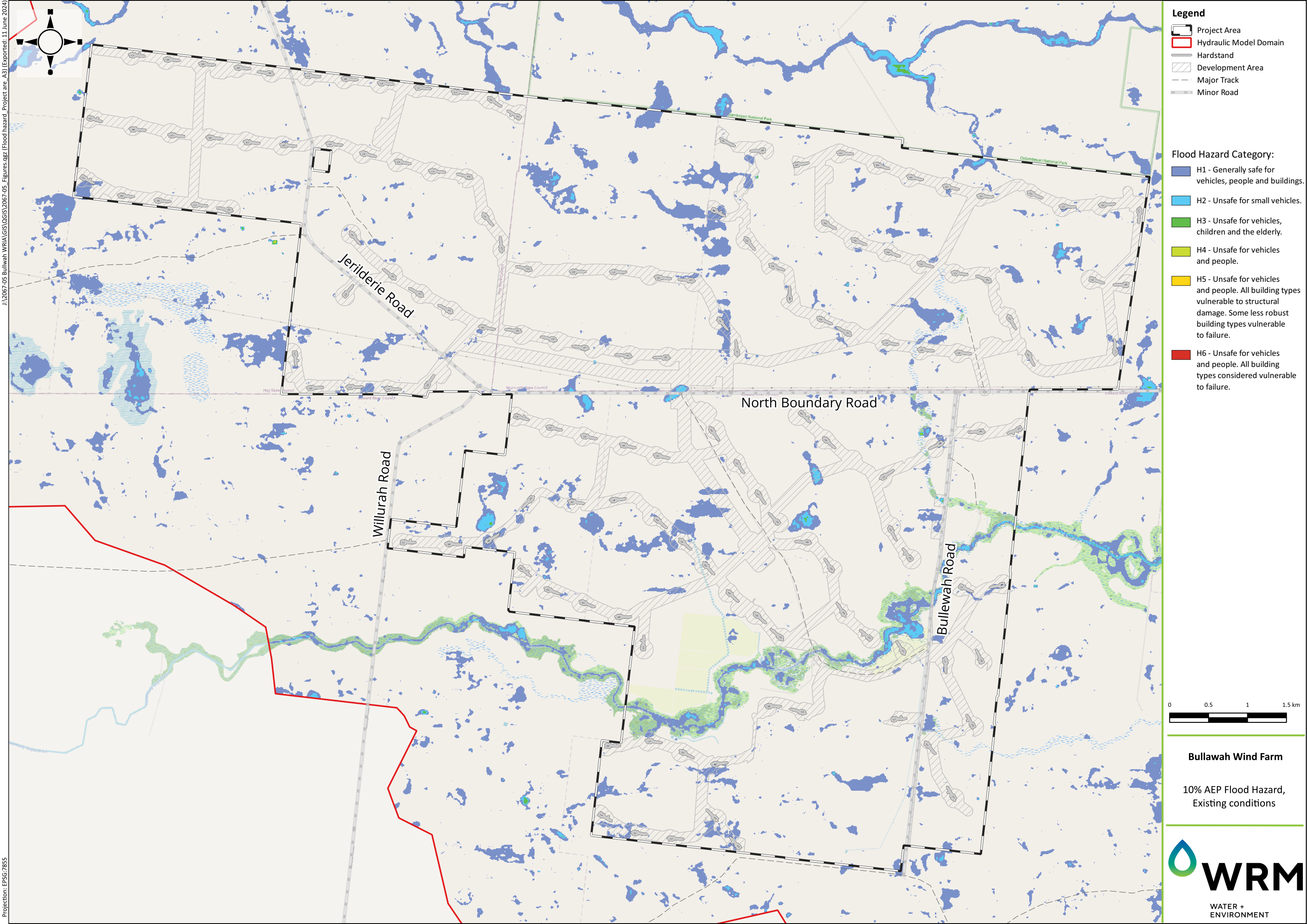
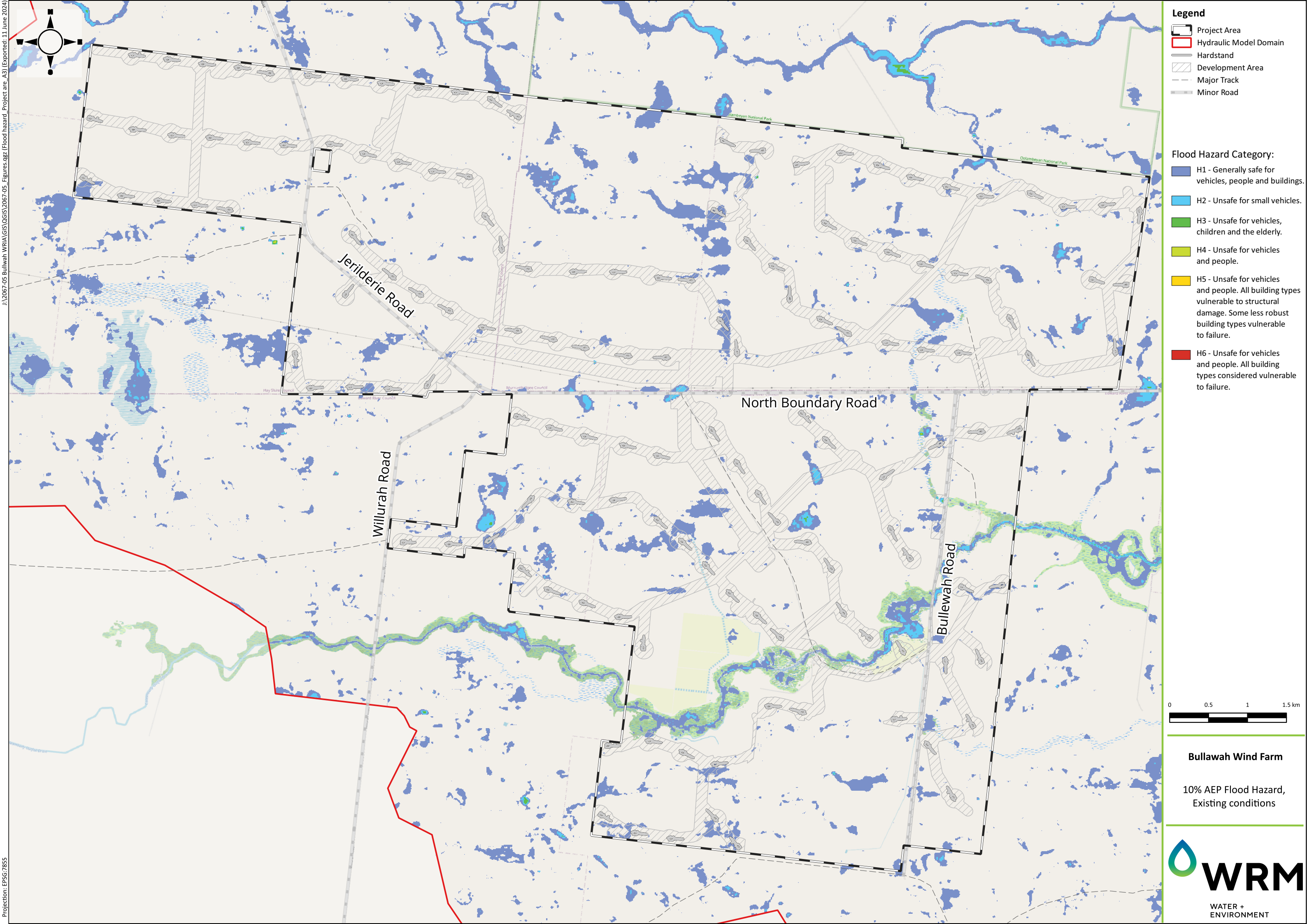
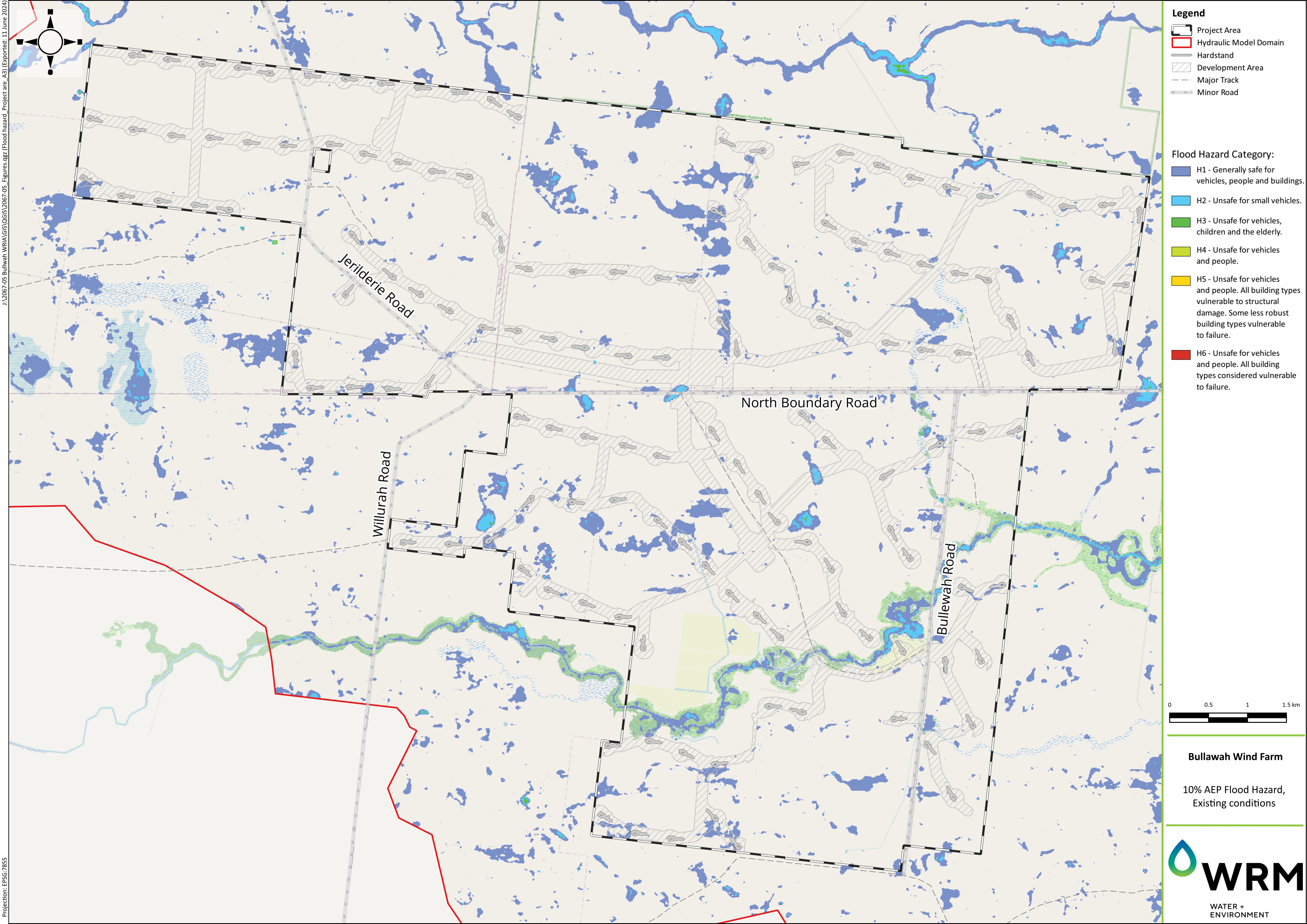
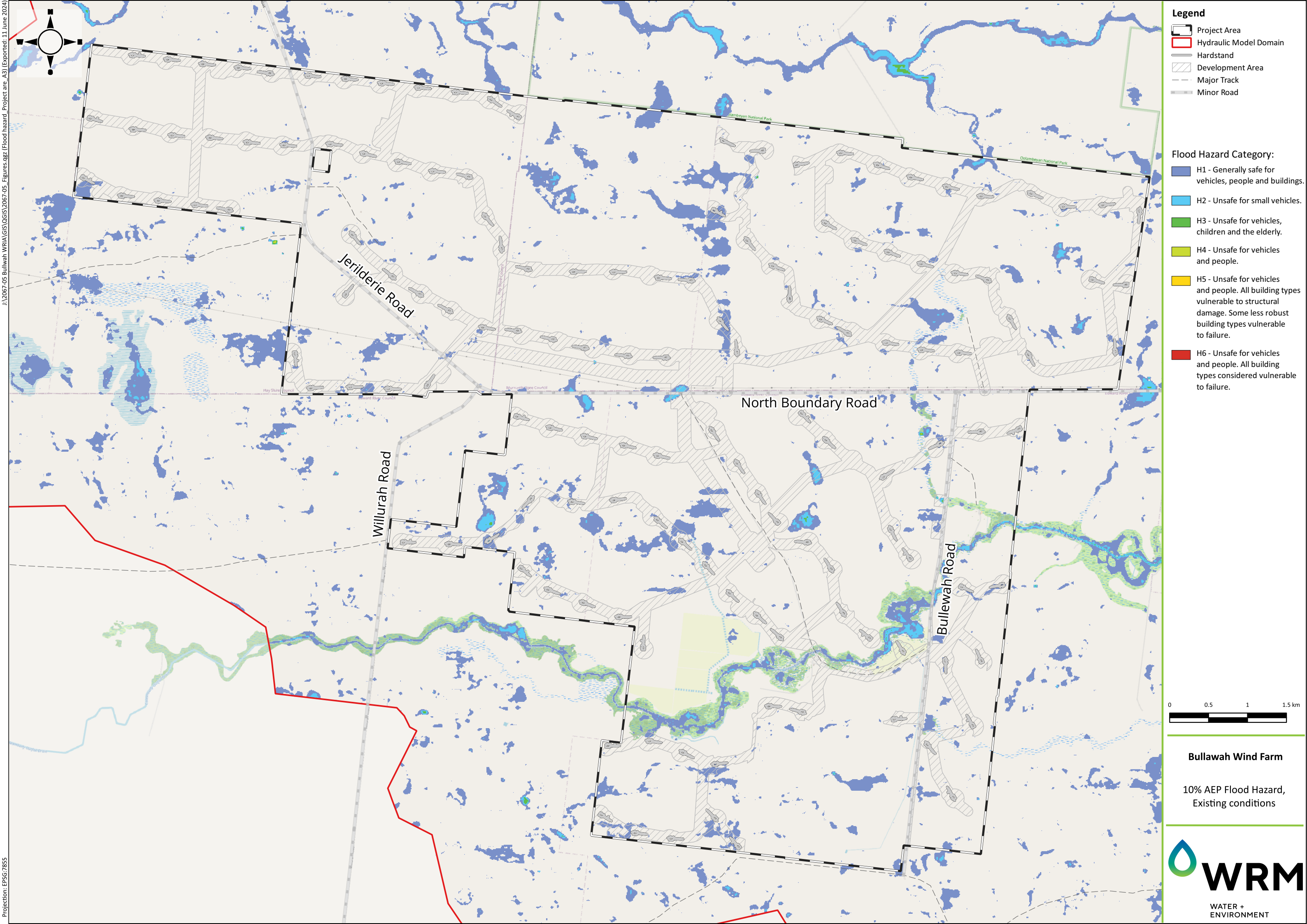
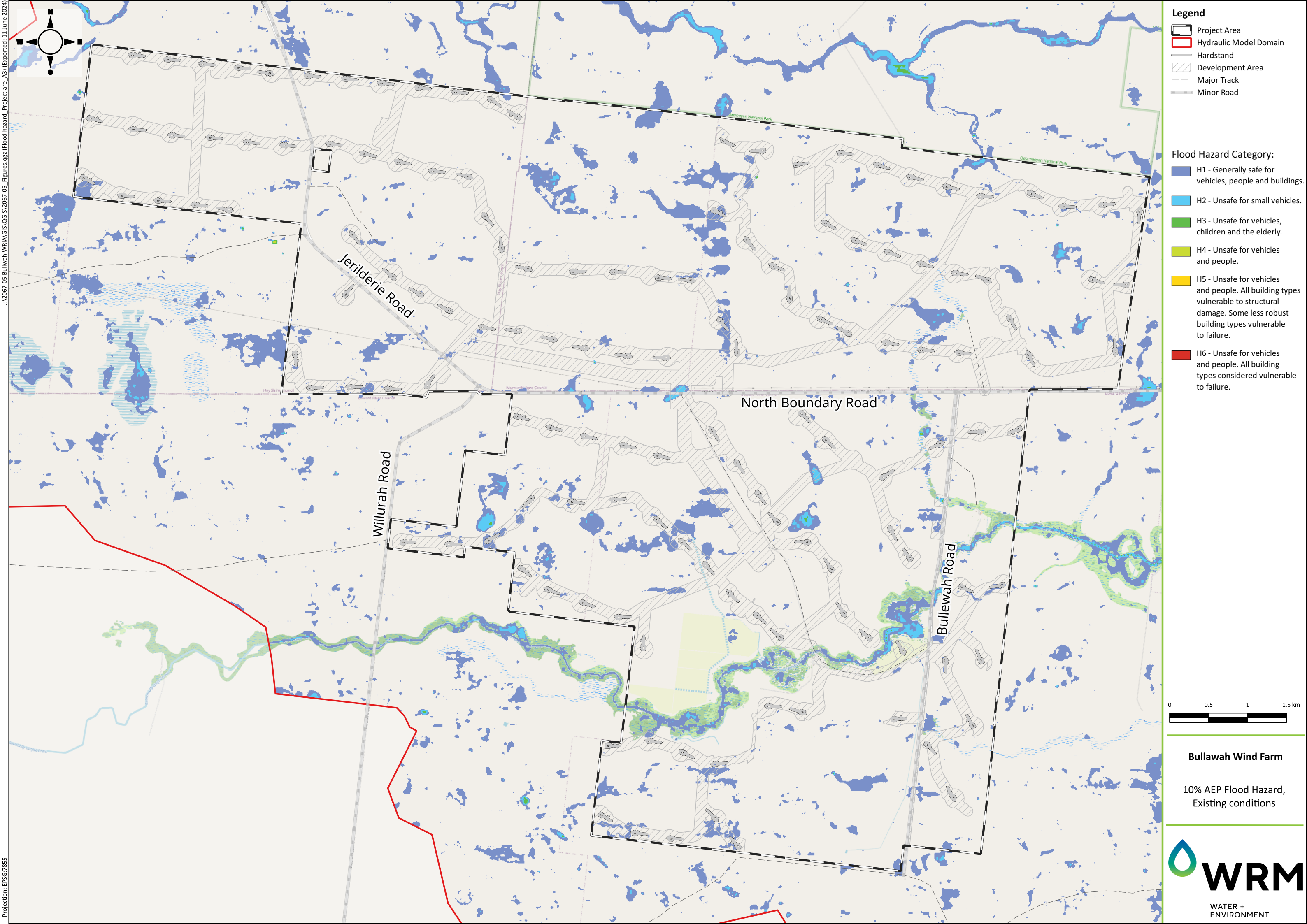
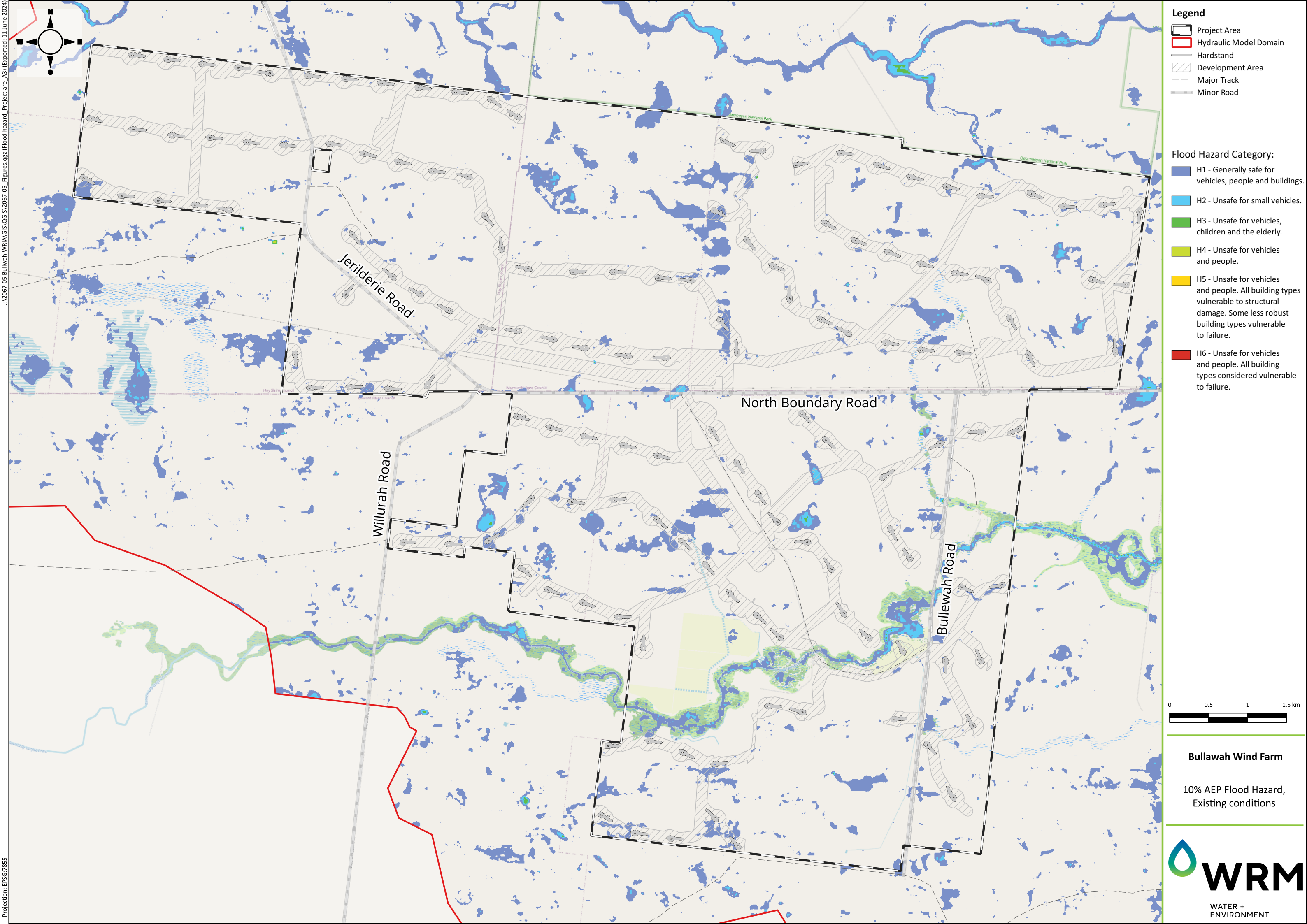
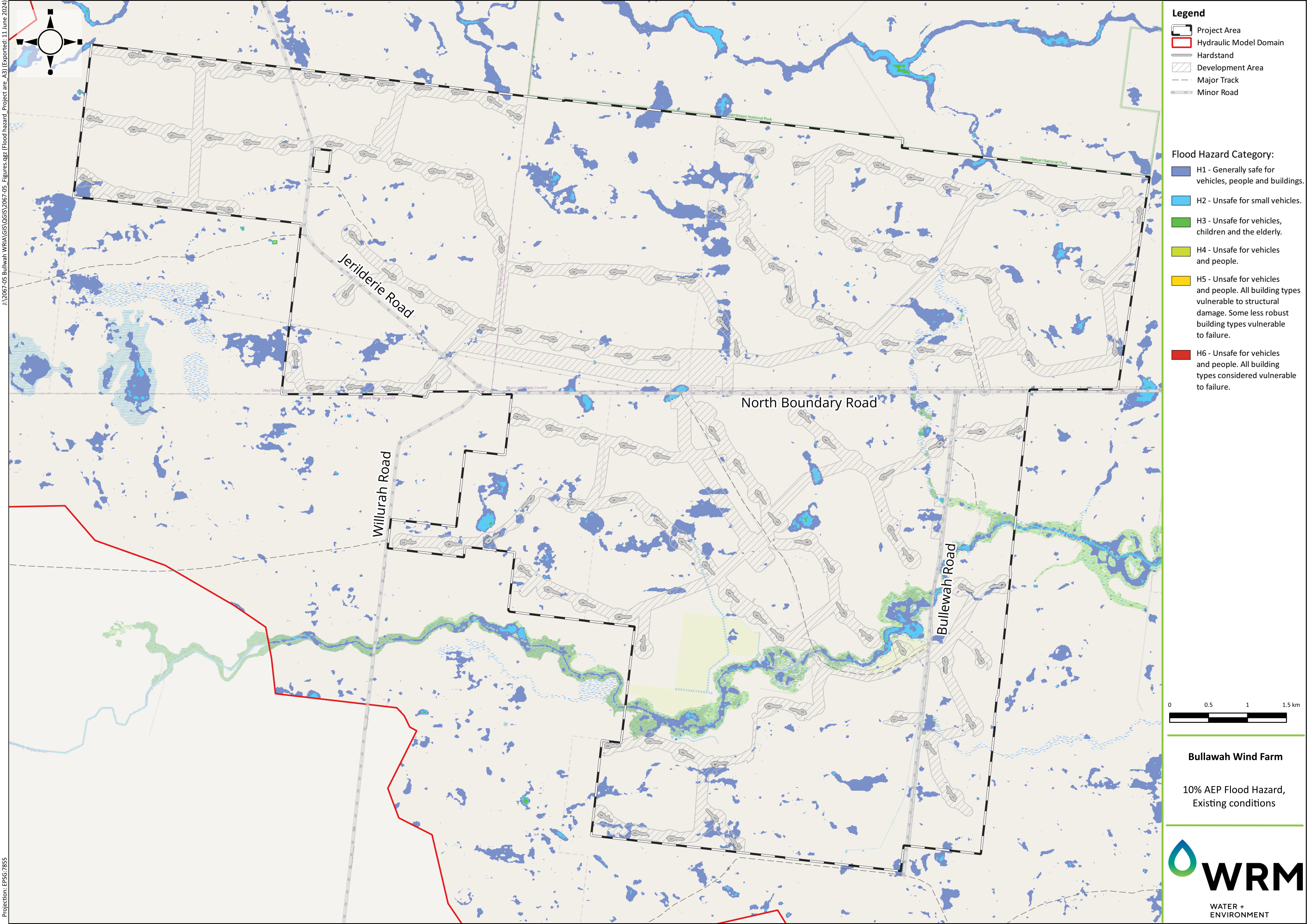
- Flood Hazard Category:**
- H1 - Generally safe for vehicles, people and buildings.
 - H2 - Unsafe for small vehicles.
 - H3 - Unsafe for vehicles, children and the elderly.
 - H4 - Unsafe for vehicles and people.
 - H5 - Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
 - H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

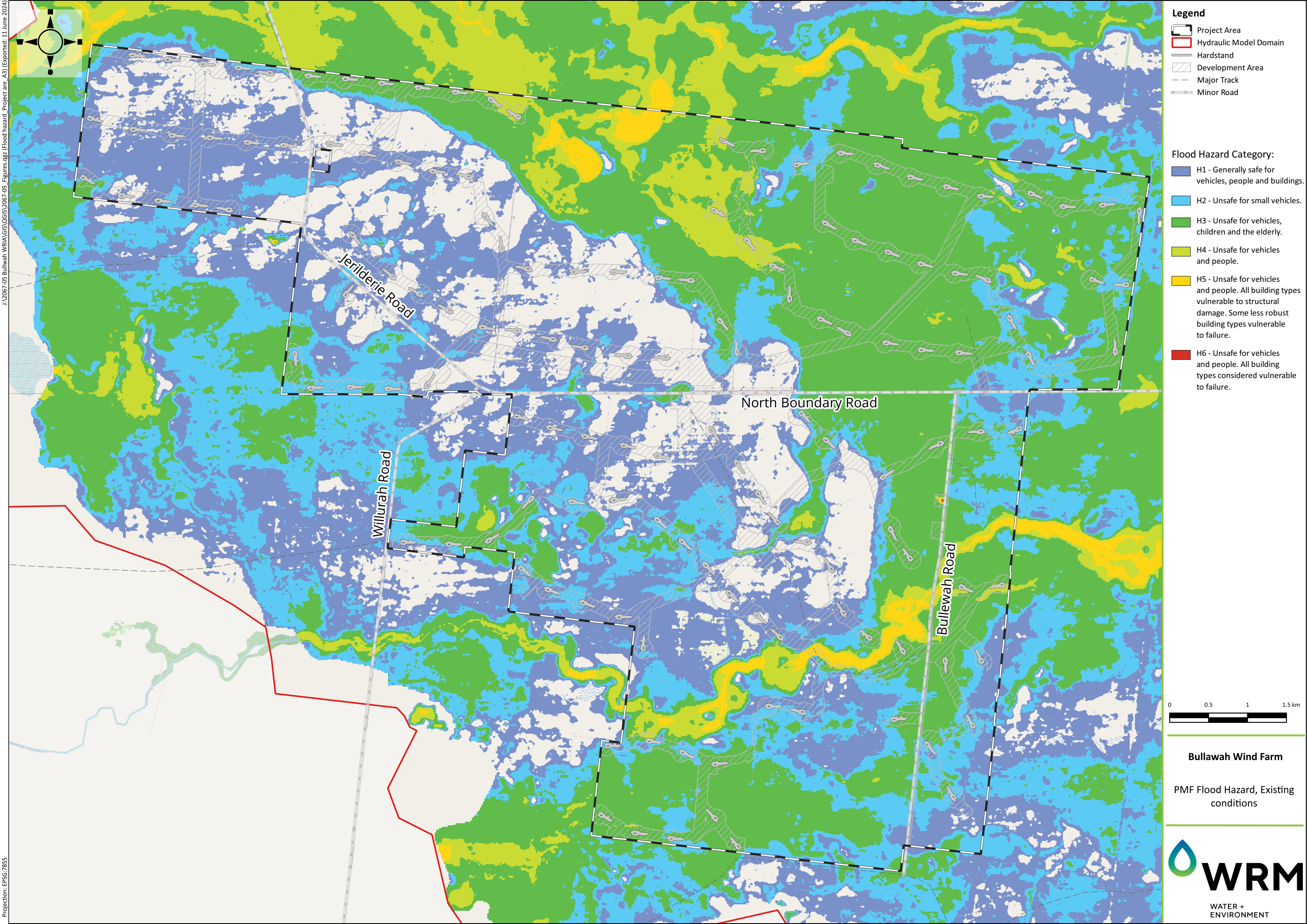


Bullawah Wind Farm

1% AEP Flood Hazard, Existing conditions







J:\2067-05 Bullwah WMA\GIS\OGIS\2067-05 Figures\agz Flood hazard Project are A3\ Exported: 11 June 2023

Projection: EPSG:7855

APPENDIX C SOIL PROFILE DESCRIPTIONS

Site Description – Site 1				
Site Reference	1	ASC Name	Epihypersodic-Endocalcareous Epipedal Brown Vertosol (ERRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 327764
Surface Condition	Cracked	Permeability	High	Y: 6148633

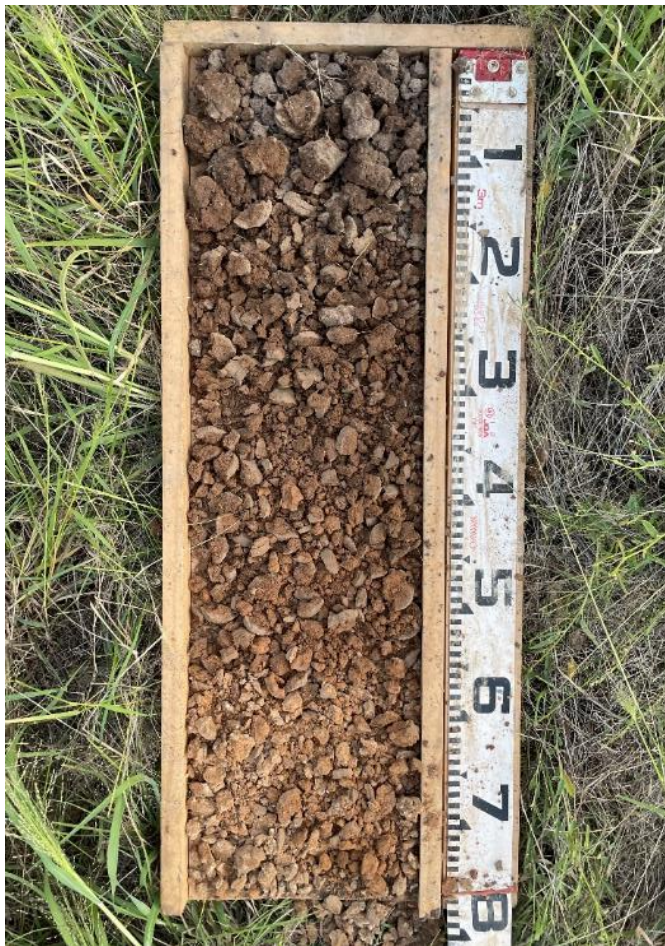


Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with strong pedality, rough fabric and strong consistence. Moderately alkaline pH, non-saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.55	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, moderately saline and strongly sodic. Moderately drained. Gradual boundary.				
B22	0.55 +	Brown (Munsell 7.5YR 4/3) Silty Clay with weak pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	0.8	Non-saline	8.0	Moderately Alkaline	14.6	Strongly Sodic
0.20 – 0.30	5.1	Moderately saline	8.5	Strongly Alkaline	28.5	Strongly Sodic
0.50 – 0.60	56.3	Extremely saline	7.9	Moderately Alkaline	18.8	Strongly Sodic

Site Description – Site 2				
Site Reference	2	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 325125
Surface Condition	Cracked	Permeability	High	Y: 6149069



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Common roots and well drained. Gradual boundary.
B21	0.20 – 0.60	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.60 +	Dark brown (Munsell 7.5YR 3/4) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. Trace roots and moderately drained.

Site Description – Site 3				
Site Reference	3	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 325947
Surface Condition	Cracked	Permeability	High	Y: 6147334



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.45	Brown (Munsell 7.5YR 5/4) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.45 +	Yellowish brown (Munsell 10YR 5/4) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 4				
Site Reference	4	ASC Name	Epihypersodic-Endocalcareous Epipedal Brown Vertosol (ERRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 325185
Surface Condition	Cracked	Permeability	High	Y: 6146031



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.10	Yellowish brown (Munsell 10YR 5/4) Heavy Clay with strong pedality, rough fabric and strong consistence. Mildly alkaline pH, non-saline and sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.10 – 0.40	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, moderately saline and strongly sodic. No coarse fragments. Common roots and moderately drained. Gradual boundary.				
B22	0.40 +	Yellowish brown (Munsell 10YR 5/4) Light Medium Clay with weak pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained. 15% calcium carbonate nodules.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	0.7	Non-saline	7.4	Mildly Alkaline	10.9	Sodic
0.20 – 0.30	5.2	Moderately saline	8.5	Strongly Alkaline	30.2	Strongly Sodic
0.50 – 0.60	45.6	Extremely saline	8.2	Moderately Alkaline	20.4	Strongly Sodic

Site Description – Site 5				
Site Reference	5	ASC Name	Epipedal Brown Vertosol	
Average Slope	1%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 327924
Surface Condition	Cracked	Permeability	High	Y: 6145726



Plate 1 – Soil Profile

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.20 – 0.50	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.50 +	Very dark greyish brown (Munsell 10YR 3/2) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.



Plate 2 – Landscape



Plate 3 – Surface



Site Description – Site 6				
Site Reference	6	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 329138
Surface Condition	Cracked	Permeability	High	Y: 6146959



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 - 0.15	Brown (Munsell 10YR 4/3) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 - 0.45	Brown (Munsell 10YR 4/3) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.45 +	Strong brown (Munsell 7.5YR 5/8) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. Trace roots and moderately drained.



Site Description – Site 7				
Site Reference	7	ASC Name	Epihypersodic Epipedal Red Vertosol (ESRY)	
Average Slope	1%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 331235
Surface Condition	Cracked	Permeability	High	Y: 6147415



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.20	Dark reddish brown (Munsell 5YR 3/4) Heavy Clay with strong pedality, rough fabric and strong consistence. Strongly alkaline pH, non-saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.20 – 0.45	Reddish brown (Munsell 5YR 4/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Gradual boundary.				
B22	0.45 +	Reddish brown (Munsell 5YR 4/4) Silty Clay with weak pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	1.0	Non-saline	8.5	Strongly Alkaline	14.2	Strongly Sodic
0.20 – 0.30	9.2	Highly saline	8.8	Strongly Alkaline	29.7	Strongly Sodic
0.50 – 0.60	38.5	Extremely saline	8.4	Moderately Alkaline	30.1	Strongly Sodic

Site Description – Site 8				
Site Reference	8	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 332679
Surface Condition	Cracked	Permeability	High	Y: 6148148



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.55	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.55 +	Dark brown (Munsell 7.5YR 3/4) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.



Site Description – Site 9				
Site Reference	9	ASC Name	Sodic Hypocalcic Brown Dermosol (BEOMY)	
Average Slope	1%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Well	X: 332172
Surface Condition	Cracked	Permeability	High	Y: 6146502



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Dark reddish brown (Munsell 5YR 3/4) Medium Clay with moderate pedality, rough fabric and weak consistence. Strongly pH, non-saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.50	Strong brown (Munsell 7.5YR 5/8) Clay Loam with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. Few roots and well drained. Gradual boundary.				
B22	0.50 +	Strong brown (Munsell 7.5YR 4/6) Clay Loam with weak pedality, sandy fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. No roots and well drained. 15% calcium carbonate nodules.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	1.6	Non-saline	8.6	Strongly Alkaline	16.1	Strongly Sodic
0.30 – 0.40	11.3	Highly saline	8.9	Strongly Alkaline	18.4	Strongly Sodic
0.60 – 0.70	13.2	Highly saline	8.6	Strongly Alkaline	16.4	Strongly Sodic

Site Description – Site 10				
Site Reference	10	ASC Name	Hypocalcic Red Dermosol	
Average Slope	1%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Well	X: 330555
Surface Condition	Cracked	Permeability	High	Y: 6145185



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark reddish brown (Munsell 5YR 3/4) Heavy Clay with strong pedality, sandy fabric and weak consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.60	Reddish brown (Munsell 5YR 5/4) Light Clay with weak pedality, sandy fabric and moderate consistence. No coarse fragments. Few roots and well drained. Gradual boundary.
B22	0.60 +	Strong brown (Munsell 7.5YR 4/6) Clay Loam with weak pedality, sandy fabric and moderate consistence. No coarse fragments. No roots and well drained. 10% calcium carbonate nodules.

Site Description – Site 11				
Site Reference	11	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 332690
Surface Condition	Cracked	Permeability	High	Y: 6142879



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Brown (Munsell 10YR 5/3) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.40	Brown (Munsell 7.5YR 4/3) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.40 +	Strong brown (Munsell 7.5YR 4/6) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.



Site Description – Site 12				
Site Reference	12	ASC Name	Salic Epipedal Brown Vertisol (ERRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 331245
Surface Condition	Cracked	Permeability	High	Y: 6142016



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. Mildly alkaline pH, slightly saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.60	Brown (Munsell 10YR 5/3) Silty Clay with strong pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Gradual boundary.				
B22	0.60 +	Brown (Munsell 10YR 5/3) Heavy Clay with weak pedality, rough fabric and moderate consistence. Moderately alkaline pH, highly saline and strongly sodic. No coarse fragments. No roots and moderately drained. 2% calcium carbonate nodules.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	3.3	Slightly saline	7.7	Mildly Alkaline	20.8	Strongly Sodic
0.30 – 0.40	31.3	Extremely saline	8.3	Moderately Alkaline	33.2	Strongly Sodic
0.60 – 0.70	13.0	Highly saline	8.3	Moderately Alkaline	35.1	Strongly Sodic

Site Description – Site 13				
Site Reference	13	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 329155
Surface Condition	Cracked	Permeability	High	Y: 6142210



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Dark grey (Munsell 10YR 4/1) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.20 – 0.50	Brown (Munsell 10YR 5/3) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. 10% faint grey mottling. Gradual boundary.
B22	0.50 +	Dark yellowish brown (Munsell 10YR 3/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 14				
Site Reference	14	ASC Name	Sodic Eutrophic Red Dermosol (BE00Y)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 331577
Surface Condition	Cracked	Permeability	High	Y: 6138596



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.10	Yellowish red (Munsell 5YR 4/6) Heavy Clay with strong pedality, rough fabric and strong consistence. Moderately alkaline pH, non-saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.10 – 0.30	Yellowish red (Munsell 5YR 4/6) Medium Clay with strong pedality, rough fabric and moderate consistence. Strongly alkaline pH, moderately saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Abrupt boundary.				
B22	0.30 +	Strong brown (Munsell 7.5YR 5/6) Loam with weak pedality, rough fabric and moderate consistence. Strongly alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	1.1	Non-saline	8.3	Moderately Alkaline	18.7	Strongly Sodic
0.20 – 0.30	6.5	Moderately saline	8.8	Strongly Alkaline	33.6	Strongly Sodic
0.50 – 0.60	17.1	Extremely saline	8.6	Strongly Alkaline	38.0	Strongly Sodic

Site Description – Site 15				
Site Reference	15	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 335943
Surface Condition	Cracked	Permeability	High	Y: 6132628



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.20 – 0.50	Greyish brown (Munsell 10YR 5/2) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.50 +	Greyish brown (Munsell 10YR 5/2) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 16				
Site Reference	16	ASC Name	Epihypersodic Epipedal Brown Vertosol (ESRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 338132
Surface Condition	Cracked	Permeability	High	Y: 6134170



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Brown (Munsell 10YR 5/3) Heavy Clay with strong pedality, rough fabric and strong consistence. Moderately alkaline pH, non-saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.40	Brown (Munsell 7.5YR 4/4) Silty Clay with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Gradual boundary.				
B22	0.40 +	Brown (Munsell 10YR 4/3) Silty Clay Loam with weak pedality, rough fabric and moderate consistence. Strongly alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1:5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	1.8	Non-saline	8.3	Moderately Alkaline	21.4	Strongly Sodic
0.30 – 0.40	15.0	Highly saline	8.5	Strongly Alkaline	36.6	Strongly Sodic
0.60 – 0.70	17.9	Extremely saline	8.6	Strongly Alkaline	37.4	Strongly Sodic

Site Description – Site 17				
Site Reference	17	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 338566
Surface Condition	Cracked	Permeability	High	Y: 6132435



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.50	Strong brown (Munsell 7.5YR 4/6) Medium Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.50 +	Brown (Munsell 7.5YR 5/4) Silty Clay Loam with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 18				
Site Reference	18	ASC Name	Eutrophic Red Dermosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 339364
Surface Condition	Cracked	Permeability	High	Y: 6136801

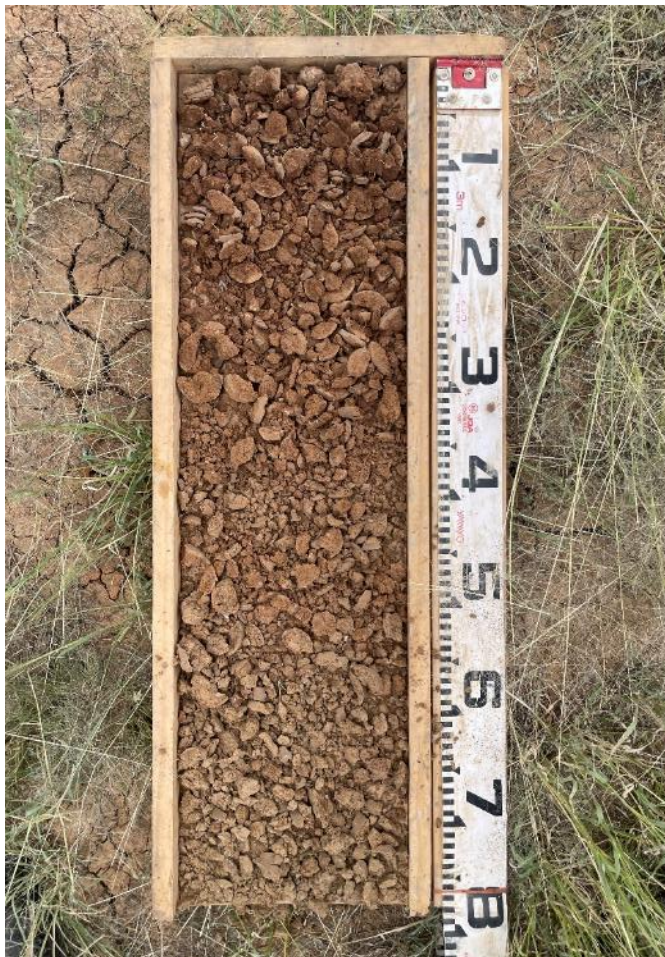


Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Yellowish red (Munsell 5YR 4/6) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.50	Yellowish red (Munsell 5YR 4/6) Light Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.50 +	Brown (Munsell 10YR 4/3) Clay Loam with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 19				
Site Reference	19	ASC Name	Sodic Eutrophic Red Dermosol (BE00Y)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 339297
Surface Condition	Cracked	Permeability	High	Y: 6139139



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Yellowish red (Munsell 5YR 4/6) Heavy Clay with strong pedality, rough fabric and strong consistence. Moderately alkaline pH, slightly saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.45	Yellowish red (Munsell 5YR 4/6) Heavy Clay with strong pedality, rough fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Abrupt boundary.				
B22	0.45 +	Strong brown (Munsell 7.5YR 5/6) Silty Clay Loam with weak pedality, rough fabric and moderate consistence. Strongly alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	2.9	Slightly saline	8.3	Moderately Alkaline	22.0	Strongly Sodic
0.20 – 0.30	8.7	Highly saline	8.5	Strongly Alkaline	33.9	Strongly Sodic
0.50 – 0.60	26.7	Extremely saline	8.5	Strongly Alkaline	28.3	Strongly Sodic

Site Description – Site 20				
Site Reference	20	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 336865
Surface Condition	Cracked	Permeability	High	Y: 6139206



Plate 1 – Soil Profile

Horizon	Depth (m)	Description
A1	0.00 - 0.10	Grey (Munsell 10YR 5/1) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 - 0.45	Dark grey (Munsell 10YR 4/1) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.45 +	Dark grey (Munsell 10YR 4/1) Clay Loam with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Plate 3 – Surface



Plate 2 – Landscape



Site Description – Site 21				
Site Reference	21	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 336424
Surface Condition	Cracked	Permeability	High	Y: 6137019



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 - 0.20	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.20 - 0.50	Brown (Munsell 7.5YR5/4) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.50 +	Dark yellowish brown (Munsell 5/8) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.



Site Description – Site 22				
Site Reference	22	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 334015
Surface Condition	Cracked	Permeability	High	Y: 6137721



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.20 – 0.60	Dark brown (Munsell 7.5YR 3/4) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. 10% faint grey mottling. Gradual boundary.
B22	0.60 +	Brown (Munsell 10YR 4/3) Clay Loam with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.



Site Description – Site 23				
Site Reference	23	ASC Name	Hypocalcic Red Dermosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 335327
Surface Condition	Cracked	Permeability	High	Y: 6141017



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.40	Yellowish red (Munsell 5YR 4/6) Light Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Clear boundary.
B22	0.40 +	Strong brown (Munsell 7.5YR 5/6) Silty Clay Loam with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.

Site Description – Site 24				
Site Reference	24	ASC Name	Sodic Eutrophic Brown Dermosol (BE00Y)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 335229
Surface Condition	Firm	Permeability	High	Y: 6144394



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.20	Brown (Munsell 7.5YR 4/4) Heavy Clay with strong pedality, rough fabric and strong consistence. Mildly alkaline pH, moderately saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.20 – 0.60	Brown (Munsell 7.5YR 4/4) Silty Clay with moderate pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. Common roots and moderately drained. Gradual boundary.				
B22	0.60 +	Yellowish brown (Munsell 10YR 5/4) Clay Loam with weak pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	4.4	Moderately saline	7.6	Mildly Alkaline	20.7	Strongly Sodic
0.30 – 0.40	18.4	Extremely saline	8.2	Moderately Alkaline	28.0	Strongly Sodic
0.60 – 0.70	21.2	Extremely saline	8.3	Moderately Alkaline	30.9	Strongly Sodic

Site Description – Site 25				
Site Reference	25	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 338087
Surface Condition	Cracked	Permeability	High	Y: 6147243



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.45	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Gradual boundary.
B22	0.45 +	Grey (Munsell 10YR 5/1) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.



Site Description – Site 26				
Site Reference	26	ASC Name	Epihypersodic Epipedal Grey Vertosol (ERRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 337555
Surface Condition	Cracked	Permeability	High	Y: 6144243



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.10	Brown (Munsell 7.5YR 4/2) Medium Clay with strong pedality, rough fabric and strong consistence. Mildly alkaline pH, non-saline and sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.10 – 0.45	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and moderate consistence. Strongly alkaline pH, moderately saline and strongly sodic. No coarse fragments. Common roots and moderately drained. Gradual boundary.				
B22	0.45 +	Yellowish brown (Munsell 10YR 5/4) Light Medium Clay with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	0.9	Non-saline	7.6	Mildly Alkaline	11.2	Sodic
0.30 – 0.40	5.4	Moderately saline	8.5	Strongly Alkaline	27.6	Strongly Sodic
0.60 – 0.70	15.8	Highly saline	8.6	Strongly Alkaline	31.8	Strongly Sodic

Site Description – Site 27				
Site Reference	27	ASC Name	Eutrophic Red Dermosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 337505
Surface Condition	Cracked	Permeability	High	Y: 6142303



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.25	Dark reddish brown (Munsell 2.5YR 3/3) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.25 – 0.60	Yellowish red (Munsell 5YR 4/6) Light Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.60 +	Yellowish red (Munsell 5YR 4/6) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 28				
Site Reference	28	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 340369
Surface Condition	Cracked	Permeability	High	Y: 6143440



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.45	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.45 +	Greyish brown (Munsell 10YR 5/2) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.



Site Description – Site 29				
Site Reference	29	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 340341
Surface Condition	Cracked	Permeability	High	Y: 6146455



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.50	Strong brown (Munsell 7.5YR 4/6) Medium Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.50 +	Light brown (Munsell 7.5YR 6/4) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.

Site Description – Site 30				
Site Reference	30	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 341697
Surface Condition	Cracked	Permeability	High	Y: 6144809



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.50	Greyish brown (Munsell 10YR 5/2) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary. 10% faint grey mottling.
B22	0.50 +	Strong brown (Munsell 7.5YR 4/6) Silty Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 31				
Site Reference	31	ASC Name	Epihypersodic Epipedal Brown Vertosol (ERRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 343089
Surface Condition	Cracked	Permeability	High	Y: 6144321



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Reddish brown (Munsell 5YR 4/3) Heavy Clay with strong pedality, rough fabric and strong consistence. Moderately alkaline pH, non-saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.50	Brown (Munsell 7.5YR 4/3) Heavy Clay with strong pedality, rough fabric and moderate consistence. Strongly alkaline pH, extremely saline and strongly sodic. No coarse fragments. Common roots and moderately drained. Gradual boundary.				
B22	0.50 +	Yellowish brown (Munsell 10YR 5/4) Light Medium Clay with weak pedality, rough fabric and moderate consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained. 10% faint orange mottles.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	1.7	Non-saline	8.3	Moderately Alkaline	15.6	Strongly Sodic
0.30 – 0.40	36.4	Extremely saline	8.5	Strongly Alkaline	29.5	Strongly Sodic
0.60 – 0.70	28.0	Extremely saline	8.2	Moderately Alkaline	21.6	Strongly Sodic

Site Description – Site 32				
Site Reference	32	ASC Name	Epipedal Red Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 343684
Surface Condition	Cracked	Permeability	High	Y: 6145979



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark reddish brown (Munsell 2.5YR 3/3) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.50	Yellowish red (Munsell 5YR 4/6) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.50 +	Yellowish brown (Munsell 10YR 5/4) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 15% calcium carbonate nodules.

Site Description – Site 33				
Site Reference	33	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 346951
Surface Condition	Cracked	Permeability	High	Y: 6145647

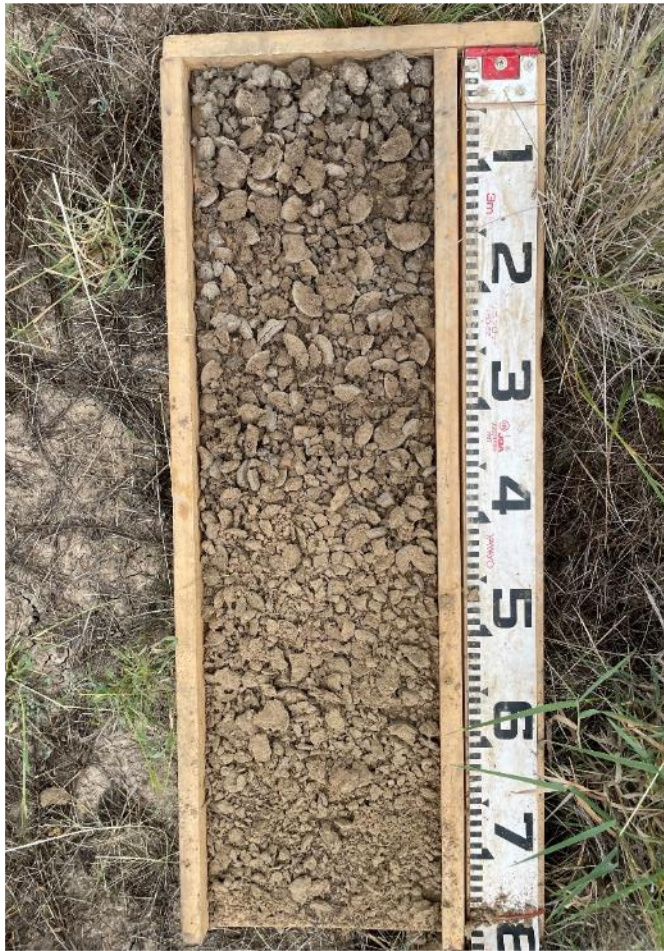


Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 - 0.10	Greyish brown (Munsell 10YR 5/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 - 0.40	Strong brown (Munsell 7.5YR 4/6) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.40 +	Strong brown (Munsell 7.5YR 4/6) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.

Site Description – Site 34				
Site Reference	34	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 346475
Surface Condition	Cracked	Permeability	High	Y: 6142726



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Dark brown (Munsell 10YR 3/3) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.50	Strong brown (Munsell 7.5YR 4/6) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.50 +	Light yellowish brown (Munsell 10YR 6/4) Light Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 35				
Site Reference	35	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 343844
Surface Condition	Cracked	Permeability	High	Y: 6142807



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 - 0.10	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 - 0.40	Greyish brown (Munsell 10YR 5/2) Heavy Clay with strong pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary. 10% faint grey mottling.
B22	0.40 +	Brown (Munsell 10YR 5/3) Medium Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.



Site Description – Site 36				
Site Reference	36	ASC Name	Epihypersodic Epipedal Brown Vertosol (ERRY)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 344429
Surface Condition	Cracked	Permeability	High	Y: 6141117



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.15	Dark brown (Munsell 7.5YR 3/2) Heavy Clay with strong pedality, rough fabric and strong consistence. Mildly alkaline pH, slightly saline and sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.15 – 0.50	Brown (Munsell 7.5YR 4/2) Heavy Clay with moderate pedality, rough fabric and moderate consistence. Moderately alkaline pH, moderately saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Gradual boundary.				
B22	0.50 +	Brown (Munsell 10YR 4/3) Heavy Clay with weak pedality, rough fabric and moderate consistence. Mildly alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	4.0	Slightly saline	7.5	Mildly Alkaline	14.0	Sodic
0.30 – 0.40	6.8	Moderately saline	8.1	Moderately Alkaline	26.5	Strongly Sodic
0.60 – 0.70	16.6	Extremely saline	7.8	Mildly Alkaline	31.7	Strongly Sodic



Site Description – Site 37				
Site Reference	37	ASC Name	Epihypersodic Epipedal Red Vertosol (ERRY)	
Average Slope	1%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 340563
Surface Condition	Cracked	Permeability	High	Y: 6140740



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.20	Dark reddish brown (Munsell 2.5YR 3/3) Heavy Clay with moderate pedality, sandy fabric and weak consistence. Moderately alkaline pH, slightly saline and strongly sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.20 – 0.55	Yellowish red (Munsell 5YR 4/6) Heavy Clay with weak pedality, sandy fabric and weak consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. Few roots and moderately drained. Clear boundary.				
B22	0.55 +	Strong brown (Munsell 7.5YR 4/6) Light Clay with weak pedality, sandy fabric and weak consistence. Moderately alkaline pH, extremely saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	4.0	Slightly saline	7.9	Moderately Alkaline	20.4	Strongly Sodic
0.30 – 0.40	15.1	Highly saline	8.4	Strongly Alkaline	29.0	Strongly Sodic
0.60 – 0.70	20.7	Extremely saline	8.3	Moderately Alkaline	21.5	Strongly Sodic

Site Description – Site 38				
Site Reference	38	ASC Name	Hypocalcic Brown Dermosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 342838
Surface Condition	Firm	Permeability	High	Y: 6139497



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.10	Brown (Munsell 7.5YR 4/2) Medium Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 – 0.45	Brown (Munsell 10YR5/4) Medium Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. Clear boundary.
B22	0.45 +	Yellowish brown (Munsell 10YR 3/2) Silty Clay Loam with weak pedality, rough fabric and weak consistence. No coarse fragments. No roots and moderately drained. 10% calcium carbonate nodules.

Site Description – Site 39				
Site Reference	39	ASC Name	Epipedal Grey Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 344045
Surface Condition	Cracked	Permeability	High	Y: 6137831



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.20	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.20 – 0.50	Greyish brown (Munsell 10YR 5/2) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. 10% faint brown mottling. Clear boundary.
B22	0.50 +	Dark yellowish brown (Munsell 10YR 4/4) Light Clay with weak pedality, rough fabric and weak consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 40				
Site Reference	40	ASC Name	Epipedal Brown Vertosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 342666
Surface Condition	Cracked	Permeability	High	Y: 6136466



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 – 0.15	Brown (Munsell 7.5YR 4/3) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.15 – 0.55	Strong brown (Munsell 10YR 5/6) Heavy Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Common roots and moderately drained. Gradual boundary.
B22	0.55 +	Dark yellowish brown (Munsell 10YR 4/6) Medium Clay with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained.

Site Description – Site 41				
Site Reference	41	ASC Name	Sodic Eutrophic Brown Dermosol (BE00Y)	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 343354
Surface Condition	Cracked	Permeability	High	Y: 6133137



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description				
A1	0.00 – 0.10	Brown (Munsell 7.5YR 4/3) Heavy Clay with strong pedality, rough fabric and strong consistence. Strongly alkaline pH, non-saline and sodic. No coarse fragments. Many roots and well drained. Gradual boundary.				
B21	0.10 – 0.50	Brown (Munsell 7.5YR 4/3) Heavy Clay with moderate pedality, rough fabric and moderate consistence. Strongly alkaline pH, moderately saline and strongly sodic. No coarse fragments. Common roots and moderately drained. Clear boundary.				
B22	0.50 +	Reddish yellow (Munsell 7.5YR 7/6) Clay Loam with weak pedality, rough fabric and moderate consistence. Strongly alkaline pH, highly saline and strongly sodic. No coarse fragments. No roots and moderately drained.				
Sample Depth	ECe		pH _(1-5water)		ESP	
	dS/m	Rating	Value	Rating	Value	Rating
0.00 – 0.10	0.9	Non-saline	8.5	Strongly Alkaline	13.8	Sodic
0.30 – 0.40	6.3	Moderately saline	8.8	Strongly Alkaline	28.9	Strongly Sodic
0.60 – 0.70	13.1	Highly saline	8.6	Strongly Alkaline	30.0	Strongly Sodic

Site Description – Site 42				
Site Reference	42	ASC Name	Hypocalcic Brown Dermosol	
Average Slope	0%	Land Use	Grazing	Coordinates
Landform Pattern	Plain	Soil Fertility	Moderately High	MGA 55
Landform Element	Flat	Drainage	Moderate	X: 341829
Surface Condition	Cracked	Permeability	High	Y: 6135044



Plate 1 – Soil Profile



Plate 2 – Landscape



Plate 3 – Surface

Horizon	Depth (m)	Description
A1	0.00 - 0.10	Dark greyish brown (Munsell 10YR 4/2) Heavy Clay with strong pedality, rough fabric and strong consistence. No coarse fragments. Many roots and well drained. Gradual boundary.
B21	0.10 - 0.40	Brown (Munsell 10YR 5/3) Medium Clay with moderate pedality, rough fabric and moderate consistence. No coarse fragments. Few roots and moderately drained. 10% faint grey mottling. Gradual boundary.
B22	0.40 +	Pale brown (Munsell 10YR 6/3) Clay Loam with weak pedality, rough fabric and moderate consistence. No coarse fragments. No roots and moderately drained. 15% calcium carbonate nodules.





Level 1, 369 Ann Street Brisbane
PO Box 10703 Brisbane Adelaide Street Qld 4000
07 3225 0200

Level 5, 93 Mitchell Street Darwin
GPO Box 43348 Casuarina NT 0811
08 8911 0060

wrm@wrmwater.com.au
wrmwater.com.au

ABN 96 107 404 544