Appendix

E

E.7 | Water Resources Assessment

EMM creating opportunities | SPARK RENEWABLES

EMM
creating opportunities

Dinawan Wind Farm

Water Resources Assessment

Prepared for Spark Renewables Pty Limited

May 2024

Dinawan Wind Farm

Water Resources Assessment

Spark Renewables Pty Limited

E220305 RP1

May 2024

Version	Date	Prepared by	Reviewed by	Comments
V1	5 April 2024	Lachlan Hammersley	Nick Bartho	Draft for client review
V2	28 May 2024	Lachlan Hammersley	Nick Bartho	Final

Approved by

Nick Bartho
Associate Director, Water Resources Engineer
28 May 2024

Ground floor 20 Chandos Street
St Leonards NSW 2065
PO Box 21
St Leonards NSW 1590

Executive summary

ES1 Introduction

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Dinawan Wind Farm (the project). The project includes the installation, operation, maintenance and decommissioning of up to approximately 200 wind turbine generators (WTGs) and associated infrastructure. The project will have a generation capacity of up to approximately 1,200 megawatts (MW) (AC). The project is on the traditional lands of the Wiradjuri people and several smaller nations of the Murrumbidgee plains, about halfway between the towns of Coleambally and Jerilderie and lies within the Murrumbidgee and Edward River local government areas (LGAs) in New South Wales (NSW).

The project is State significant development (SSD) pursuant to schedule 1 of State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP). Accordingly, approval for the project is required under Part 4, Division 4.7 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and an environmental impact statement (EIS) is required to support this approval.

This water resources assessment (WRA) supports the EIS that has been prepared for the project and considers potential impacts to both surface water and groundwater. A land and rehabilitation assessment (EMM 2024b) (LRA) has also been prepared to support the EIS, and closely relates to this WRA in terms of assessing the potential for soil erosion and associated surface water quality impacts and describing proposed mitigation and management measures.

ES2 Existing environment

ES2.1 Site description

The project area is approximately 39,061 hectares (ha) and encompasses 349 land parcels. Within the project area, the development corridor is expected to be around 7,256 ha and development footprint of 1,339 ha. The majority of the land within the project area is privately owned and is currently used for sheep and cattle grazing. The surrounding land is also used for agriculture.

ES2.2 Surface water environment

North-east of the project area is the Coleambally Irrigation Area which is run by Coleambally Irrigation Co-operative Limited (CICL) and supplies irrigation and drainage services to nearly 500 farms. CICL's area of operations spans across over 400,000 ha including over 300,000 ha which is serviced by the Coleambally Outfall Drain. The water supply is from the regulated Murrumbidgee River and access to water is based on the Murrumbidgee Regulated River Water Sharing Plan 2016 (CICL 2021).

Elevation within the project area is approximately 110 m above sea level and is characterised by relatively flat terrain. There are eighteen first order watercourses, five second order watercourses and one third order watercourse mapped within the project area, all of which are ephemeral. The primary named watercourses which traverse the project area include (from east to west) Coleambally Irrigation Channel, Delta Creek and Coleambally Outfall Drain. Minor segments of Bublebundie and Blind creeks also traverse the north-west corner of the project area.

ES2.3 Groundwater environment

The project is within the Central Lachlan Fold Belt and the geology is mapped primarily as Cenozoic sedimentary units with overlying floodplain alluvium and aeolian sand plains. Local access to groundwater is via unconfined quaternary based porous aquifers in both shallow and deeper groundwater resources.

There are 226 registered bores within 5 km of the project area. Existing groundwater bores target a range of water bearing zones within both shallow and deep aquifers, with bore depths highly variable across all purposes and ranging from 9 to 363 m below ground level (mbgl).

Several terrestrial groundwater dependent ecosystems (GDEs) are mapped within the project area and specifically adjacent to the development footprint. GDEs typically follow watercourses and their associated riparian corridors.

ES3 Proposed water management approach

A conceptual approach to water management for the project has been developed to inform this WRA and broadly encompasses stormwater and flood management, erosion and sediment control, site water usage and sources of supply, wastewater management and treated effluent reuse. This will be subject to further development as part of detailed design.

During construction, non-potable water demand for the project is estimated at approximately 176 megalitres (ML) over a period of up to 60 months. This will be sourced primarily from existing extraction bores, located within the project area, external to the development corridor, owned by landholders associated to the project, where each bore has an associated water access license (WAL). Extracted groundwater will then be piped, conveyed via existing open irrigation channel or trucked within the project area as needed. Demand for groundwater will be minimised by opportunistic use of water from rainwater tanks collecting roof runoff, reuse of water captured by construction sediment basins and extraction from existing landholder dams in accordance with harvestable rights.

An additional potable water demand of 188 ML during construction is estimated to be required to support concrete batching activities and the construction workforce accommodation facility and site offices. Potable water volumes will be sourced primarily from a commercial water provider and trucked to site.

The estimated ongoing operational water usage for the project is 5 ML/year for ongoing maintenance, dust suppression, permanent site amenities and fire protection. This will be sourced primarily from groundwater, supplemented with other sources as required.

ES4 Residual impacts

Potential water related impacts were considered in terms of changes to:

- surface water quality, quantity, flooding, impacts to watercourses and riparian corridors, and impacts to irrigation infrastructure
- groundwater levels, quality and impacts to existing consumptive and environmental users.

Overall, potential surface water and groundwater impacts during both construction and operation are considered minor and manageable with the proposed water management and mitigation measures in place. Only minor and temporary potential impacts to groundwater receptors are expected from groundwater extraction.

ES5 Water licensing

Proposed surface water take will not require licensing under harvestable rights and excluded works provisions in the NSW *Water Management (General) Regulation 2018*.

Incidental groundwater inflows into excavations will be monitored, recorded and reported during construction, and a WAL and appropriate entitlement obtained in advance within the water year should the 3 ML per year licensing exemption threshold be exceeded.

Groundwater take via four existing landowner bores for water supply purposes during construction and operation is proposed. The bores will be a suitable water source for the project from a licensing perspective as there are existing WALs linked to water supply works approvals. Currently there are over 3,691 unit shares (i.e. ML/year) of water entitlement linked to the four existing bores, which far exceeds estimated demand. The approved use for the existing water supply works (bores) is irrigation, so a change in use/purpose will be required.

ES6 Management and mitigation

A summary of the proposed measures to manage and mitigate potential impacts to surface water and groundwater is provided in Chapter 9.

ES7 Conclusion

Overall, potential surface water and groundwater impacts during construction and operation are considered minor and can be adequately managed through the implementation of the proposed mitigation measures.

Abbreviations

Item	Definition
AC	alternating current
AEP	annual exceedance probability
AHD	Australian Height Datum
BESS	battery energy storage system
BGL	below ground level
BoM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
DC	direct current
DP	deposited plan
DPE	NSW Department of Planning and Environment
DPHI	NSW Department of Planning, Housing and Infrastructure (formerly DPE)
EC	electrical conductivity
EIS	Environmental Impact Statement
EMM	EMM Consulting Pty Limited
EnergyCo	Energy Corporation of NSW
EPA	NSW Environment Protection Authority
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
ESCP	Erosion and Sediment Control Plan
FMP	Flood Management Plan
GDE	groundwater dependent ecosystem
GW	gigawatt
ha	hectare
HEVAE	high-ecological value aquatic ecosystem
HSU	hydrostratigraphic unit
hydro line	terminology used in NSW watercourse mapping. The purpose of the NSW hydro line spatial data is to determine the Strahler stream order.
km	kilometre
kV	kilovolt
L/s	litres per second
LEP	Local Environmental Plan
LGA	local government area
LSC	land and soil capability

Item	Definition
m	metre
mm	millimetre
MDB	Murray Darling Basin
MHRDC	maximum harvestable right dam capacity
ML	megalitre
MW	megawatt
MWh	megawatt-hour
NSW	New South Wales
OEMP	Operational Environmental Management Plan
O&M	operations and maintenance
PESCP	Progressive Erosion and Sediment Control Plan
POEO Act	NSW *Protection of the Environment Operations Act 1997*
PMF	probable maximum flood
REZ	Renewable Energy Zone
RFOs	NSW River Flow Objectives
SDL	sustainable diversion limit
SEARs	Secretary's Environmental Assessment Requirements
SILO	Scientific Information for Land Owners
SSD	State significant development
SSI	State significant infrastructure
SWMP	Soil and Water Management Plan
WAL	water access licence
WM Act	NSW *Water Management Act 2000*
WM Regulation	NSW *Water Management (General) Regulation 2018*
WSP	water sharing plan
WRA	Water Resources Assessment
WTG	wind turbine generator
WQOs	NSW Water Quality Objectives

Glossary

- **Project area**: The land required for the project. The project area contains the entirety of all landholdings that overlap with the development corridor and is approximately 39,061 ha. The project area is the maximum area considered for the project based on the extent of land where Spark Renewables holds landholder agreements. The project area includes parts of Goolgumbla Road, Wilson Road, Fernbank Road, McLennons Bore Road and Kidman Way (including the road easement) and Coleambally Outfall Drain, where site access and/or electrical cabling may be required.
- **Development corridor**: The development corridor is the land within the project area where project components may be placed, providing the necessary flexibility for component placement during detailed design (i.e. micro-siting). The development corridor is wholly within the project area.
- **Development footprint**: The indicative extent of the project's ground disturbance area, including earthworks, associated with permanent infrastructure and temporary construction facilities. The development footprint will be within the development corridor; however, its exact location will be confirmed following detailed design.
- **Site access point**: The proposed locations where all construction and operation traffic will access the development footprint. Access across the development footprint will be possible via internal tracks.
- **Associated residence**: A dwelling whose owners have parts of their property included in a land agreement with Spark Renewables for the project (i.e. host landholder dwellings).
- **Non-associated residence**: A dwelling whose owners do not have parts of their property included in a land agreement with Spark Renewables for the project.

TABLE OF CONTENTS

Executive summary **ES.1**

Abbreviations **ES.4**

Glossary **ES.6**

1 Introduction **1**

1.1 Overview 1

1.2 Assessment approach and requirements 1

1.3 Structure of this report 4

1.4 Other relevant reports 5

1.5 Terminology 5

2 Project description and setting **6**

2.1 Project overview 6

2.2 Project area 6

2.3 Project staging 9

2.4 Water management infrastructure 9

2.5 Excavation requirements for foundations 10

2.6 Supporting infrastructure 10

3 Regulatory context **12**

3.1 NSW regulatory framework 12

3.2 Local planning instruments 14

3.3 Relevant guidelines 15

3.4 Water quality and river flow objectives 19

4 Existing environment **21**

4.1 Overview 21

4.2 Climate 21

4.3 Land use 22

4.4 Topography and landform 24

4.5 Hydrology 24

4.6 Soils 29

4.7 Geology 30

4.8 Hydrogeology 32

5 Proposed water management **38**

5.1 Overview 38
5.2 Preliminary design development 38
5.3 Proposed water management approach 38
5.4 Water demands, source of supply and wastewater management 42
6 Impact assessment 45
6.1 Overview 45
6.2 Surface water impacts 45
6.3 Groundwater impacts 55
6.4 Assessment against WQOs and RFOs 57
7 Water licensing 58
7.1 Overview 58
7.2 Surface water 58
7.3 Groundwater 58
8 Cumulative impacts 59
9 Management and mitigation measures 60
10 Conclusion 63
References 64

Attachments

Attachment A Flood study A.1
Attachment B Registered groundwater bores B.1

Tables

Table 1.1 SEARs relevant to surface water and groundwater 4
Table 3.1 Application of NSW Water Quality and River Flow Objectives 19
Table 4.1 Climate overview 21
Table 4.2 Mean daily flow for selected local streamflow monitoring sites 26
Table 4.3 Summary of flood mapping results in Appendix A 27
Table 4.4 Registered bores within the development corridor or development footprint 34
Table 5.1 Construction workforce accommodation facility water demand and wastewater load 43
Table 5.2 Construction offices water demand and wastewater load 43
Table 6.1 Areas of development corridor within or adjacent to VRZ 52
Table 6.2 Groundwater works proposed to be used by the project 56
Table 6.3 Groundwater allocation proposed to be used by the project 56
Table 6.4 Assessment against NSW Water Quality and River Flow Objectives 57
Table 9.1 Consolidated management and mitigation measures 60
Table B.1 Registered groundwater bores within the development corridor B.0

Table B.2 Registered telemetered groundwater bores nearby project area B.1

Figures

Figure 1.1 Regional context 2

Figure 1.2 Local context 3

Figure 2.1 Indicative project layout – Stage 1 East 7

Figure 2.2 Indicative project layout – Stage 2 West 8

Figure 3.1 Groundwater assessment considerations for SSD/SSI projects 17

Figure 4.1 Land use 23

Figure 4.2 Hydrologic context 25

Figure 4.3 Flood hazard vulnerability curves 28

Figure 4.4 Geologic context 31

Figure 4.5 Map of Murrumbidgee Alluvium Water Resource Plan area 32

Figure 4.6 North-south section through the Murrumbidgee Alluvium Water Resource Plan 33

Figure 4.7 Groundwater context 35

Figure 4.8 Historical telemetered groundwater level data surrounding the project (WaterNSW 2024) 36

Figure 6.1 Flooding context – Stage 1 East 49

Figure 6.2 Flooding context – Stage 2 West 50

Figure 6.3 Waterfront land and riparian corridors 54

Photographs

Photograph 5.1 Bridge crossings over Coleambally Outfall Drain 41

1 Introduction

1.1 Overview

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Dinawan Wind Farm (the project). The project includes the installation, operation, maintenance and decommissioning of up to approximately 200 wind turbine generators (WTGs) and associated infrastructure. The project is on the traditional lands of the Wiradjuri people and several smaller nations of the Murrumbidgee plains, about halfway between the towns of Coleambally and Jerilderie and lies within the Murrumbidgee and Edward River local government areas (LGAs) in New South Wales (NSW). The regional and local context of the project is shown in Figure 1.1 and Figure 1.2, respectively.

The project is part of the Dinawan Energy Hub, a hybrid wind, solar and battery storage hub. The project is within the South-West Renewable Energy Zone (REZ), a region selected by the NSW Government due to its significant potential for renewable energy infrastructure and regional development. The project will connect to the Dinawan Substation, which will be built by Transgrid as part of the Project EnergyConnect interconnector that will run between Robertstown in South Australia and Wagga Wagga in NSW. It is anticipated that the project will be constructed in two stages as indicated in Figure 1.2.

The main objective of the project is to generate renewable energy, consistent with NSW Government policy for development of infrastructure for renewable energy generation and storage. It will significantly contribute to the target of 3.98 gigawatts (GW) of generation planned in the South-West REZ. The project will have a generation capacity of up to approximately 1,200 megawatts (MW) (AC), equivalent to the needs of 700,000 NSW households per year. It will assist in meeting NSW and Australian Government emissions reduction targets and will abate approximately 3.2 million tonnes of greenhouse gases annually.

The project is State significant development (SSD) pursuant to schedule 1 of State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP). Accordingly, approval for the project is required under Part 4, Division 4.7 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

This water resources assessment (WRA) forms part of the environmental impact statement (EIS) for the project.

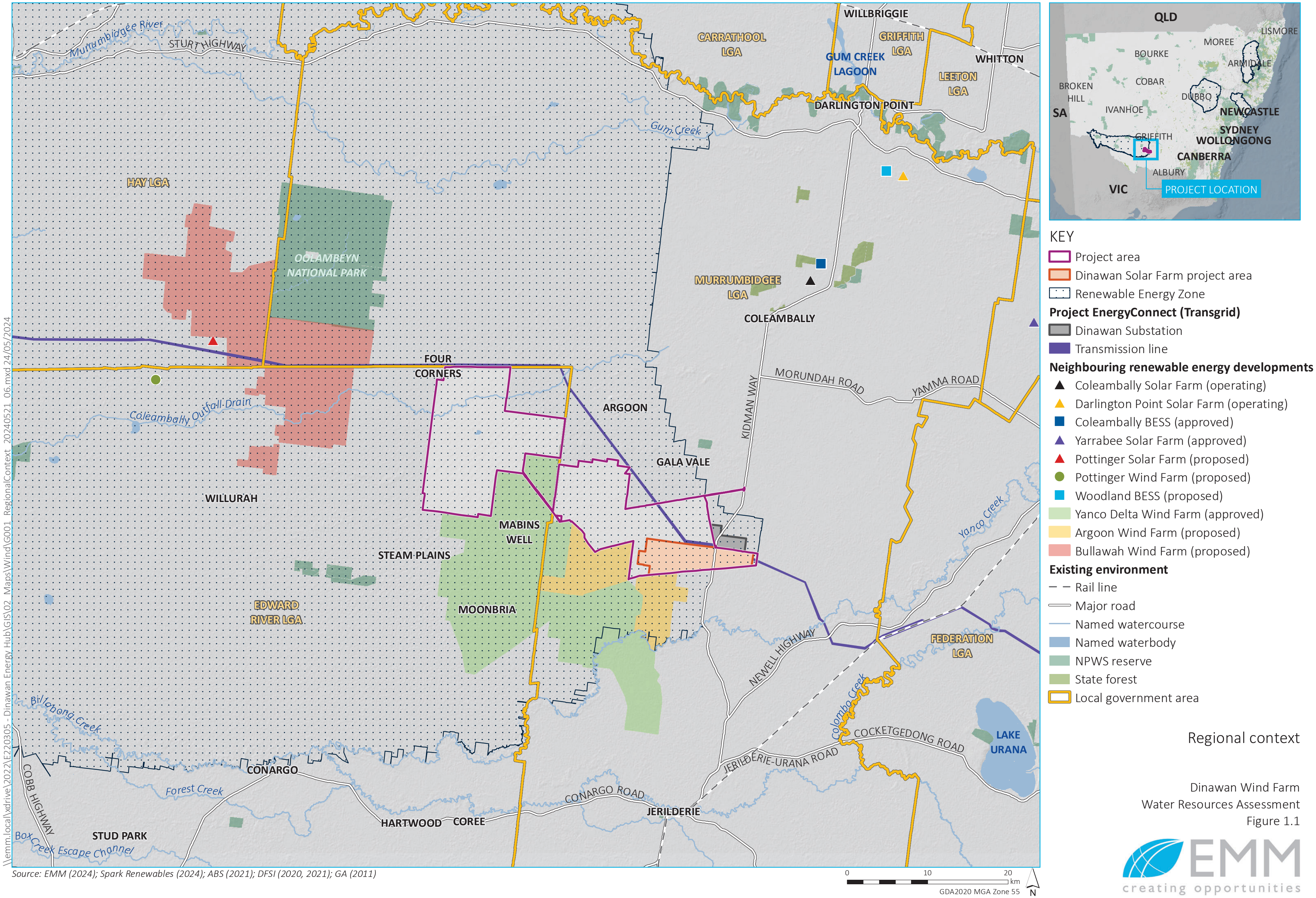
1.2 Assessment approach and requirements

1.2.1 Objectives

This WRA considers potential impacts to both surface water and groundwater in general accordance with the requirements of the NSW Department of Planning, Housing and Infrastructure (DPHI) (formally NSW Department of Planning and Environment (DPE)) and other government agencies, applicable legislation and industry guidance.

The key objectives of the WRA are to:

- describe the assessment requirements, regulatory framework and industry guidance relevant to the project
- describe and characterise the existing surface water and groundwater environment relevant to the project
- identify and assess potential water-related impacts of the project
- identify appropriate mitigation and management measures for the project.

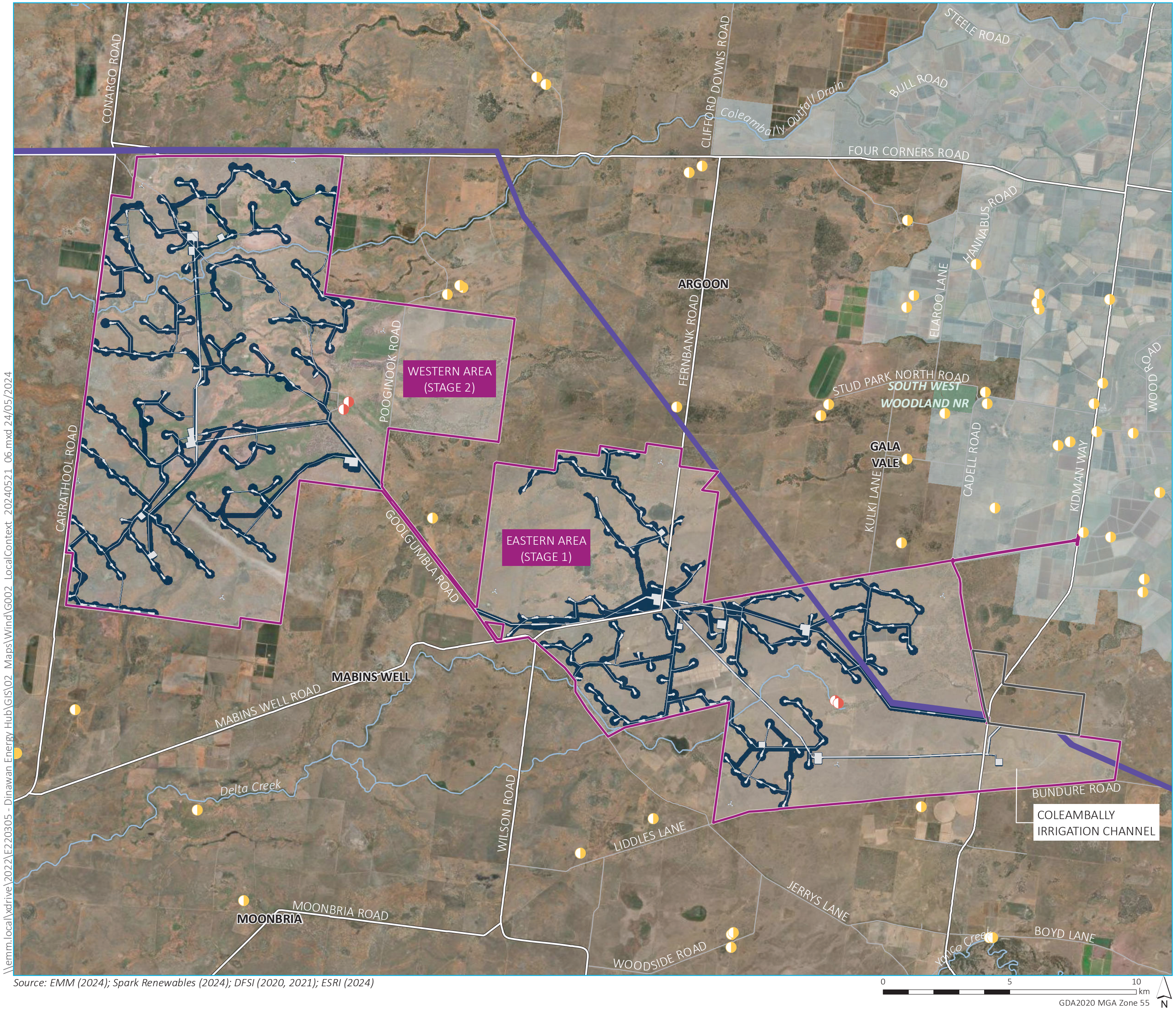


Source: EMM (2024); Spark Renewables (2024); ABS (2021); DFSI (2020, 2021); GA (2011)

Regional context

Dinawan Wind Farm
Water Resources Assessment
Figure 1.1

EMM creating opportunities



\\emm.local\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\G002_LocalContext_20240521_06.mxd 24/05/2024

Source: EMM (2024); Spark Renewables (2024); DFSI (2020, 2021); ESRI (2024)

KEY

- Project area
- Development corridor
- Development footprint

Project EnergyConnect (Transgrid)

- Dinawan Substation
- Transmission line

Residence

- Associated
- Non-associated

Existing environment

- Major road
- Minor road
- Watercourse (third order and higher)
- Coleambally irrigation area
- NPWS reserve

Local context

Dinawan Wind Farm
Water Resources Assessment
Figure 1.2

creating opportunities

1.2.2 Secretary's Environmental Assessment Requirements

This WRA has been prepared in accordance with the requirements of DPHI which were set out in the Planning Secretary's Environmental Assessment Requirements (SEARs) for the project, issued on 14 December 2022 and reissued on 22 August 2023 with additional requirements from the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW). The SEARs identify matters which must be addressed in the EIS. Table 1.1 lists individual requirements relevant to this WRA and where they have been addressed in this report.

Table 1.1 SEARs relevant to surface water and groundwater

Requirement	Section addressed
An assessment of the likely impacts of the development (including flooding and flood modelling) on surrounding watercourses (including their Strahler Stream order), irrigation and drainage channels, and groundwater resources and measures proposed to monitor, reduce and mitigate these impacts.	Impacts to surface water are described in Section 6.2. Impacts to groundwater are described in Section 6.3.
A site water balance for the development and details of water requirements and supply arrangements for construction and operation.	Site water balance is provided in Section 5.4. The preferred water supply for the project is described in Section 6.3.3.
Where the project involves works within 40 metres 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 *Guidelines for Controlled Activities on Waterfront Land* (2018) and (if necessary) *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (DPE, 2013); and *Guidelines for Fish Habitat Conservation & Management* (DPE, 2013).	Impacts to watercourses and riparian corridors are described in Section 6.2.4.
A description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with *Managing Urban Stormwater: Soils & Construction* (Landcom, 2004).	The proposed water management approach for the project, including an overview of proposed erosion and sediment control measures, is described in Section 5.3. Specific erosion and sediment control measures are described in the *Land and Rehabilitation Assessment* (LRA) (EMM 2023b).

Consultation letters with regulatory agencies and local government authorities were also received with the SEARs. Of these the Environment and Heritage group under the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) (formerly under DPE), included flood model requirements and considerations which have been addressed in Attachment A.

1.3 Structure of this report

This WRA is structured as follows:

- Chapter 2 describes the project.
- Chapter 3 identifies the applicable assessment requirements, regulatory framework and relevant guidelines.
- Chapter 4 characterises the existing surface water and groundwater environment.
- Chapter 5 presents the proposed water management approach for the project.

- Chapter 6 describes predicted impacts to surface water and groundwater resources.
- Chapter 7 presents water licencing considerations.
- Chapter 8 describes potential cumulative impacts of the project in conjunction with other significant projects.
- Chapter 9 presents a consolidated summary of proposed measures to manage and mitigate impacts to surface water and groundwater resources.
- Chapter 10 summarises the outcomes of the assessment.

The following attachments provide supporting details:

- Attachment A contains a baseline flood study for the project prepared by EMM (2023).
- Attachment B contains details of registered groundwater bores in the vicinity of the project.

1.4 Other relevant reports

A land and rehabilitation assessment (LRA) (EMM 2024) has also been prepared to support the EIS, and closely relates to this WRA in terms of assessing the potential for soil erosion and associated surface water quality impacts and describing proposed mitigation and management measures.

1.5 Terminology

A number of technical terms have been utilised throughout this report for the discussion of matters relating to water resources. These terms, along with typical project descriptions are explained in the abbreviations and glossary sections.

2 Project description and setting

2.1 Project overview

A full project description is provided in Chapter 3 of the EIS and an indicative project layout is shown in Figure 2.1 (Stage 1 East) and Figure 2.2 (Stage 2 West). The project will comprise the following key components:

- a network of approximately 200 (3 blade) WTGs across a western and eastern area
- electrical connection system, substations and control rooms
- electricity transmission line infrastructure connecting the project substations to the Dinawan Substation
- operations and maintenance (O&M) infrastructure, including site offices and amenities, buildings equipment and maintenance sheds and laydown, storage and parking areas
- temporary construction facilities including worker accommodation facility, construction compounds, site offices and amenities, concrete batching plants, construction materials storage (including stockpiles), laydown areas, temporary meteorological masts, borrow pits, water tanks and storage and parking areas
- other permanent infrastructure including hardstands, water tanks, permanent meteorological masts, new access tracks and upgrades to existing access tracks
- access points from the public road network and public road upgrades to facilitate the delivery of the WTG components.

2.2 Project area

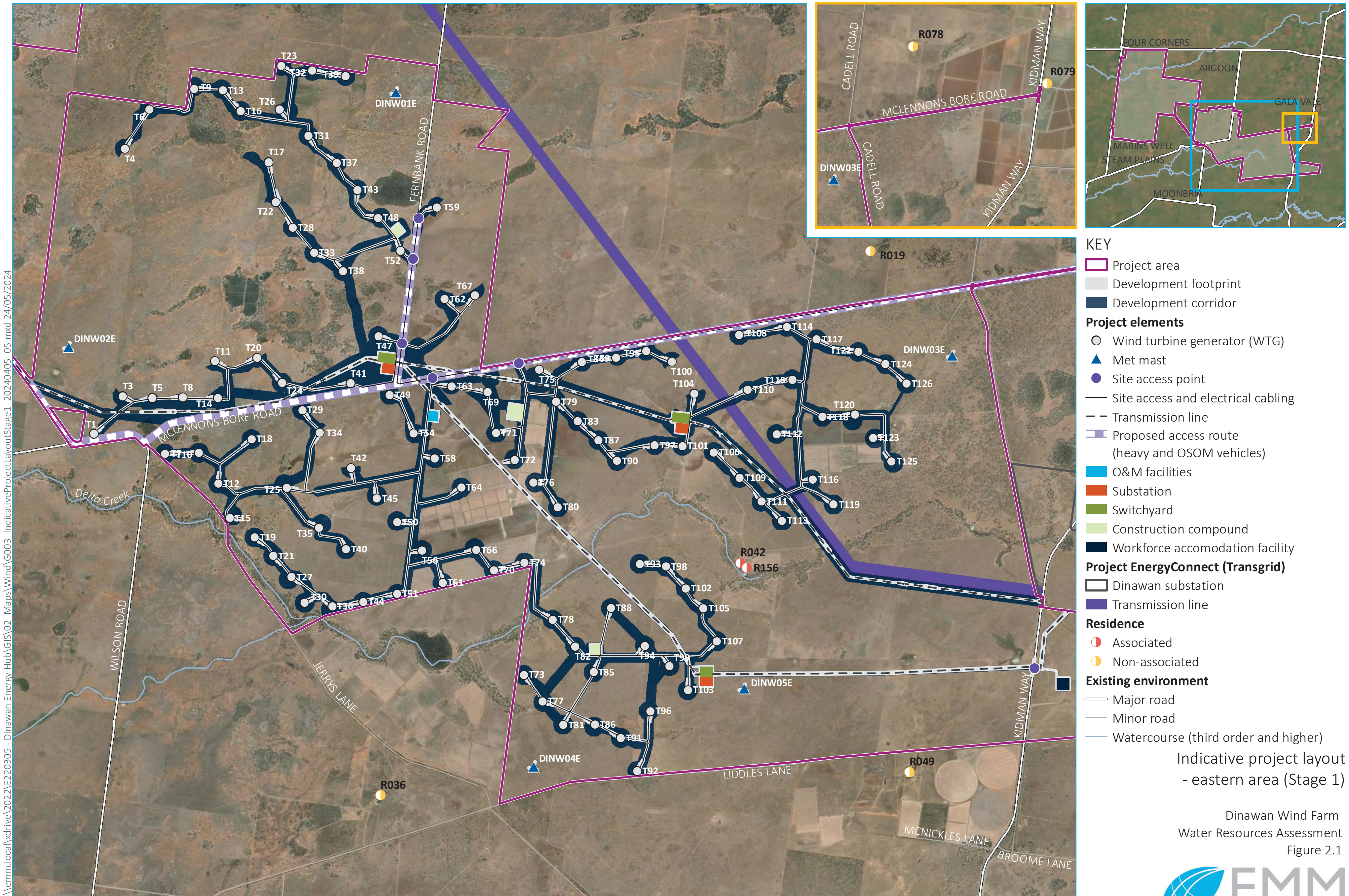
The project area is approximately 39,061 ha and encompasses 349 land parcels (Figure 2.1 and Figure 2.2). The majority of the land within the project area is privately owned, and can be considered as two distinct areas, namely the eastern wind area and the western wind area, aligned with anticipated project staging. The land within the project area is currently used for sheep and cattle grazing and some irrigated cropping.

Within the project area, the development corridor is approximately 7,256 ha (Figure 2.1 and Figure 2.2). The development corridor is the land within which the project components may be placed, providing the necessary flexibility for component placement during detailed design (i.e. micro-siting). The development corridor has been refined based on the results of environmental surveys, including biodiversity, Aboriginal cultural and historical heritage surveys, and with consideration of community and regulatory stakeholder feedback.

A development footprint has also been provided and is approximately 1,339 ha within the development corridor. This assessment assumes that the development footprint will be disturbed. As part of the detailed design, the development footprint may move within the development corridor, however, total direct surface disturbance is not anticipated to increase.

Direct impacts for public road upgrade works are required on Kidman Way, McLennons Bore Road, Wilson Road, Fernbank Road, and Goolgumbla Road (Figure 2.1 and Figure 2.2) and will facilitate access to the development footprint. From the site access points, private internal roads will be used to traverse the development corridor.

The preferred point of connection to Transgrid's network is via the Dinawan Substation (Figure 2.1), which forms part of Project EnergyConnect and will be constructed on land adjacent to the project area. An overhead transmission line will connect the project's on-site substations to the Dinawan Substation.



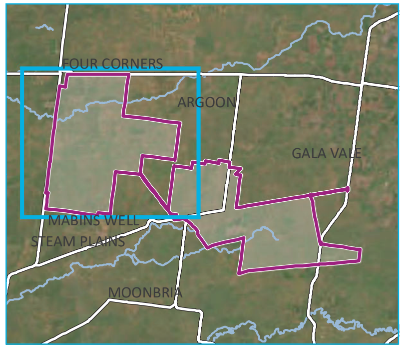
Indicative project layout
- eastern area (Stage 1)

Dinawan Wind Farm
Water Resources Assessment
Figure 2.1

Source: EMM (2024); Spark Renewables (2024); DFSI (2020, 2021); ESRI (2024)

\\emm.local\dfs\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\G003_IndicativeProjectLayoutStage1_20240405_05.mxd 24/05/2024

EMM
creating opportunities



KEY

- Project area
- Development footprint
- Development corridor

Project elements

- Wind turbine generator (WTG)
- Met mast
- Site access point
- Site access and electrical cabling
- Transmission line
- Proposed access route (heavy and OSOM vehicles)
- O&M facilities
- Substation
- Switchyard
- Construction compound
- Workforce accomodation facility

Project EnergyConnect (Transgrid)

- Transmission line

Residence

- Associated
- Non-associated

Existing environment

- Bridge
- Major road
- Minor road
- Watercourse (third order and higher)

Source: EMM (2024); Spark Renewables (2024); DFSI (2020, 2021); ESRI (2024)

0 2.5 5 km

GDA2020 MGA Zone 55

N

\\emm.local\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\G004_IndicativeProjectLayoutStage2_20240405_05.mxd 24/05/2024

Indicative project layout - western area (Stage 2)

Dinawan Wind Farm
Water Resources Assessment
Figure 2.2

EMM creating opportunities

2.3 Project staging

It is anticipated that the project will be constructed in two stages:

- Stage 1 will be the construction of the eastern wind area, including the associated public road upgrades, grid connection infrastructure and workforce accommodation facility. Stage 1 is within the Murrumbidgee LGA.
- Stage 2 will be the construction of the western wind area, including associated public road upgrades, grid connection infrastructure and workforce accommodation facility. Stage 2 is predominately within the Edward River LGA, with the exception of additional public road upgrades and grid connection infrastructure within Murrumbidgee LGA.

The project's generation capacity and connection to the electricity grid is dependent on the outcomes of the South-West REZ Access Scheme and the construction of electricity grid infrastructure (including Dinawan Substation). For the purposes of this assessment, it has been assumed that the project will connect to Dinawan Substation and project infrastructure will be housed within the full extent of the development footprint (i.e. this assessment has assessed impacts associated with the construction and operation of both stages 1 and 2).

2.4 Water management infrastructure

2.4.1 Stormwater drainage

A stormwater drainage system will be required to manage runoff generated on the development footprint and surrounding area. This system will discharge as required to existing watercourses that traverse the project area. The drainage system will typically comprise a network of open drains to control and direct runoff toward receiving watercourses. Some limited sections of piped drainage, connecting to open drainage further downstream, are likely to be required for selected areas including the new substations.

Further details regarding stormwater drainage are provided in Section 5.3.

2.4.2 Watercourse crossings

The project will utilise existing watercourse crossings to support construction and operations. The indicative locations of watercourse crossings may change as part of detailed design.

Two existing bridges across the Coleambally Outfall Drain will be utilised for site access. Upgrade requirements (based on existing lane width or structural load constraints) for these bridge crossings are to be confirmed in detailed design. Upgrade of existing bridge or culvert structures will seek to maintain existing flow area and drainage function.

Electrical collection system infrastructure may need to cross the Coleambally Outfall Drain, tributaries of Delta Creek and other unnamed watercourses. Overhead and/or underground (installed by horizontal directional drilling) crossings may be used. Physical disturbance within the drain, waterfront land and associated riparian corridors will be avoided to the extent possible.

Further details regarding watercourse crossings are provided in Section 5.3.1iv.

2.4.3 Water supply and wastewater management

Water will be required to construct and operate the project. This will include water of a suitable quality for construction and O&M purposes as well as potable water for site offices and amenities and a temporary construction workforce accommodation facility. A wastewater management system will also be required to cater for these facilities.

Further details regarding water demands, sources of supply and wastewater management are provided in Section 5.4.

2.4.4 Decommissioning and rehabilitation

Once the project reaches the end of its operational life, a decision will be made to either decommission or re-power the facility, subject to approval requirements.

If the project is decommissioned, all aboveground project structures will be removed and the site rehabilitated generally to its pre-existing land use, as far as practicable. Project infrastructure will be managed in accordance with the waste management hierarchy and contemporary waste management legislation.

If re-powering is proposed, stakeholders will be consulted, and the required approvals sought.

2.5 Excavation requirements for foundations

Each WTG will have a foundation approximately 20 m wide, with a footprint of approximately 400 m^2 and to a depth of approximately 3–5 m below ground level (mbgl). The size, depth and type of each foundation will be determined as part of detailed design based on geotechnical conditions.

Topsoil and spoil from excavations will be stockpiled for reuse to backfill over the foundation and/or as part of vegetation rehabilitation around each WTG. Excess material will be utilised elsewhere within the development corridor (e.g. for access roads) or be exported off-site for beneficial reuse.

2.6 Supporting infrastructure

2.6.1 Concrete batching plants

Concrete will be used in the construction of the WTG foundations, as well as other infrastructure within the development corridor (including pads for collector substations and O&M facilities). Up to six concrete batching plants will be required within the development corridor and will be co-located with the footprints nominated for construction compounds. Only one concrete batching plant will be operating at any point in time with the infrastructure relocated between the six construction compounds. The water management aspects relating to the concrete batching plants will include:

- stockpile areas
- water tanks
- wastewater storage.

Water for concrete production will be transported via water trucks sourced externally or from groundwater bores (subject to water quality) and stored in temporary above ground tanks.

2.6.2 Temporary worker accommodation facility

A temporary worker accommodation facility for non-local construction employees may be established early in the construction of Stage 1 and/or Stage 2. Three potential locations for the temporary worker accommodation facility are proposed and include:

- one site for Stage 1 (east), which will be co-located with the temporary worker accommodation facility proposed as part of the Dinawan Solar Farm, should Dinawan Solar Farm be approved
- two sites for Stage 2 (west), however, only one site will be selected for the construction of the facility.

Only one worker accommodation facility will be in use at any one time. Each facility will accommodate up to 450 workers. It is expected that the majority (approximately 75%) of the project's peak construction workforce will stay at the accommodation facility.

In terms of water and wastewater demands, the facility will include:

- single rooms/quarters
- office buildings
- wet mess area
- laundry facilities
- toilet and shower facilities.

There is no existing water or sewerage services on-site. The accommodation facilities will require:

- Potable water, proposed to be delivered to the accommodation facility by truck weekly, and stored in tanks. Rainwater tank/s will be installed to capture water that can be used for non-potable functions such as toilet flushing, laundry, vehicle washing or landscape irrigation, to minimise demand for imported water.
- An on-site sewage treatment plant will be installed and will produce treated wastewater that can be used during the construction of the project. It may also be appropriate to use treated water to supplement rainwater captured for non-potable demands such as toilet flushing.

2.6.3 Permanent offices

In the context of water and wastewater demands, permanent supporting infrastructure required for operations will include a site office and O&M buildings (including offices and amenities) and water tanks.

Project operations will require up to 50 full-time employees.

On-site sewerage collection/treatment infrastructure will continue to be used during operations.

3 Regulatory context

3.1 NSW regulatory framework

3.1.1 *Protection of the Environment Operations Act 1997*

The NSW *Protection of the Environment Operations Act 1997* (POEO Act) establishes the NSW environmental regulatory framework and includes licensing requirements for certain activities.

Section 120 of the POEO Act prohibits the pollution of waters and creates a duty to notify the relevant authority of pollution incidents. The project will be managed to ensure pollution risks to soil, waterways and air quality are avoided or minimised. In the event of a pollution incident that causes or threatens material harm to the environment, the EPA would be notified.

Environment protection licences (EPLs) are administered by the EPA under the POEO Act. The project will be a scheduled activity pursuant to Schedule 1, clause 17 of the POEO Act and an EPL will, therefore, be required to operate the project. Typically, EPLs for wind farms are specific in regulating operational noise. However, the licence may also address other environmental issues during the construction phase, such as construction noise, dust and water quality.

The processing capacity of the proposed on-site sewage treatment plants will be below the threshold specified in Section 36 of Schedule 1 of the POEO Act and therefore an EPL will not be required for this part of the project.

3.1.2 *Water Management Act 2000*

The NSW *Water Management Act 2000* (WM Act) is the relevant statute for the regulation of water take from surface and groundwater water sources. The WM Act provides for water sharing between different water users, including environmental, basic landholder rights (i.e. domestic and stock, native title and harvestable rights) and existing water access holders and provides security for rights holders. The licensing provisions of the WM Act apply to those areas where a water sharing plan (WSP) has commenced.

i Water sharing plans

WSPs are statutory documents that apply to one or more water sources. They define the rules for sharing and managing water resources within water source areas. WSPs describe the basis for water sharing and document the water available and how it is shared between environmental, extractive and other uses. The WSPs outline the water available for extractive uses within different categories, such as basic landholder rights, local water utilities, irrigation and other commercial/industrial uses.

The following WSPs are relevant to the project:

- The *Water Sharing Plan for the Murrumbidgee Alluvial Groundwater Sources 2020* – the project area includes both the Lower Murrumbidgee Shallow and Deep groundwater sources.
  - The Lower Murrumbidgee Shallow Groundwater Source consists of all water contained within all unconsolidated alluvial sediments to a depth of 40 m or to the bottom of the Shepparton Formation, whichever is the deeper.
  - The Lower Murrumbidgee Deep Groundwater Source consists of all water contained within the Calivil Formation and Renmark Group unconsolidated alluvial sediments greater than a depth of 40 m.

- The *Water Sharing Plan for the Murrumbidgee Unregulated River Water Sources 2012* – the project area includes the Lower Billabong Anabranch Water Source and Murrumbidgee Western Water Sources. The sources are managed under the Unregulated Murrumbidgee Gogeldrie to Weimby Extraction Management Units.

- The *Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020* – the project area includes the buried Lachlan Fold Belt Murray Darling Basin groundwater source.

- The *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* – the project area includes the buried Oaklands Basin groundwater source.

ii Waterfront land

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of the riverbanks, lake shore or estuary mean high water mark and defines that a river includes:

> a stream of water, whether perennial or intermittent, flowing in a natural channel, or in a natural channel artificially improved, or in an artificial channel which has changed the course of the stream.

The project area includes watercourses that satisfy the above definition within the WM Act, as well as proposed works on waterfront land. Whilst some constructed irrigation channel reaches are included in the NSW *Water Management (General) Regulation 2018* (WM Regulation) Hydro Line spatial data mapping, it is noted that constructed irrigation channels do not meet the definition of a watercourse under the WM Act and therefore are also not associated with waterfront land.

Controlled activity approval (CAA) under Section 91 of the WM Act for certain activities in, on or under waterfront land does not apply to SSD. However, relevant guidance for controlled activities has been considered in the development of the project and assessment presented in this WRA (Section 3.3.1).

iii NSW Aquifer Interference Policy

Aquifer interference activities, which are those that take water incidentally to the primary purpose of the activity, are assessed against the requirements of the *NSW Aquifer Interference Policy* (DPI Water 2012) (AIP). The AIP clarifies the requirements for obtaining water licences for aquifer interference activities and defines considerations in assessing and providing advice on whether more than minimal impacts might occur to a key water-dependent asset.

The AIP defines the regime for protecting and managing the impacts of aquifer interference activities on NSW's water resources. The AIP requires consideration of the potential impacts of an aquifer interference activity in respect to the water table, water pressure and water quality. Proponents must estimate the water take (including incidental and indirect take) from each water source and connected water sources.

The WM Act (under Section 91) defines an 'aquifer interference activity' as an activity involving:

- penetration of an aquifer

- interference with water in an aquifer

- obstruction of the flow of water in an aquifer

- taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations, or

- disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed in the regulations.

The construction and operation of the project are not considered to be aquifer interference activities due to their minimal impact on groundwater, as detailed in Section 6.3.

Groundwater take via existing bores for construction water supply purposes is proposed. This does not constitute an aquifer interference activity as it is an approved works for the primary purpose of extracting groundwater.

iv Harvestable rights

Owners or occupiers of a landholding are entitled to collect a proportion of the runoff from their property in one or more dams located on a minor stream (defined as first or second order) or unmapped streams and use the water without the need for a licence or water supply work or water use approval.

The volume of water that can be captured and stored under harvestable rights is expressed as a maximum harvestable right dam capacity (MHRDC) for a landholding, which is a function of property size and location. In the central inland-draining catchment where the project is located, up to 10% of the average annual regional rainfall runoff may be captured and used for any purpose (i.e. there is no restriction on use).

If the total capacity of applicable dams on a landholding exceeds the MHRDC, a licence and water use approval is required to authorise the take and use of water for the volume in excess of the MHRDC. In addition, a water supply work approval is required for dams that exceed the MHRDC. Harvestable rights cannot be applied to runoff captured in storages located on or within 40 m of non-minor watercourses (defined as third order and above). Harvestable rights orders are published in the NSW Government Gazette and specify the rules relating to harvestable rights.

There are two non-minor watercourses that cross the development corridor. These watercourses are an upper tributary of Delta Creek and the Coleambally Outfall Drain. Dams cannot be constructed on these watercourses to capture runoff from properties. Elsewhere, runoff within properties can be captured from minor watercourses and water used up to the MHRDC. Where dams are to be constructed under the MHRDC, these will need to take into account existing dams within the landholdings of the project. Dams without a catchment (referred to as Turkeys Nest Dams), typically associated with the storage of water conveyed by irrigation channels, do not require licensing under harvestable rights.

3.1.3 Water resource plans

The project is within the Murray Darling Basin (MDB) and therefore is subject to water resource plans (WRPs), which have a primary role of ensuring that the sustainable diversion limits (SDLs) of water from the basin are not exceeded over time. The plans within the MDB have been established to complement and strengthen existing state water management arrangements. The plans cover compliance requirements, environmental water requirements, water quality and salinity objectives, acknowledgement of water for First Nations peoples and their uses, measuring and monitoring requirements and arrangements for extreme weather events.

For surface water resources, the project is within the Murrumbidgee Surface WRP area.

For groundwater resources, the project is within the Murrumbidgee Alluvium WRP area.

The project is consistent with the objectives of the WRPs in terms of establishing land uses that are compatible with the broader MDB framework. The project's demands on water resources are unlikely to place undue pressure on the established SDLs.

3.2 Local planning instruments

The project area is zoned RU1 Primary Production under the Jerilderie Local Environmental Plan 2012 (Jerilderie LEP), Murrumbidgee Local Environmental Plan 2013 (Murrumbidgee LEP) and Conargo Local Environmental Plan 2013 (Conargo LEP).

Within the Edward River LGA the project is located within the Conargo Local Environmental Plan (LEP) 2013 where no development control plan (DCP) is in place. Within the Murrumbidgee LGA, the project is located within the Jerilderie LEP 2012 and Jerilderie DCP 2012 guide planning decisions through zoning and development controls and, of relevance to this assessment, include considerations for flood risk management, groundwater management and wetland management. These local planning instruments have been considered in the preparation of this assessment.

The relevant flood planning objectives of the two LEP's (Clause 5.21) are:

- to minimise the flood risk to life and property associated with the use of land
- to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change
- to avoid adverse or cumulative impacts on flood behaviour and the environment
- to enable the safe occupation and efficient evacuation of people in the event of a flood.

These objectives have been considered as part of the assessment to minimise the project exposure to flood risk, including risk to life and project infrastructure, ensure compatibility of project infrastructure with flood behaviour, and to avoid significant impacts to flood behaviour. Flood-related impacts and risks are described in Section 6.2.3.

The project area, within the Jerilderie LEP, is partially located within the zone of groundwater vulnerability and therefore Clause 6.5 of the Jerilderie LEP has been considered, which includes the following objectives:

- maintain the hydrological function of the key groundwater systems
- protect vulnerable groundwater resources from depletion and contamination as a result of development.

Groundwater related impacts and risks are described in Section 6.3.

The development corridor and the proposed construction of transmission lines, within the Jerilderie LEP will result in interactions with areas of mapped wetlands. Therefore, Clause 6.7 of the Jerilderie LEP has been considered in the assessment, which includes the objective to ensure that wetlands are preserved and protected from the impacts of development. The project's impacts on biodiversity, including wetland habitat, have been assessed as part of the biodiversity development assessment report (BDAR) (Biosis 2024).

There were no mapped areas of vulnerability under the Conargo LEP within the project area.

3.3 Relevant guidelines

The following guidelines have been considered when preparing this assessment.

3.3.1 Guidelines for controlled activities on waterfront land

There are several guidelines in relation to works on waterfront land, as defined by the WM Act. These include:

- *Controlled activities – guidelines for riparian corridors on waterfront land* (DPE 2022a)
- *Controlled activities – guidelines for watercourse crossings on waterfront land* (DPE 2022b)
- *Controlled activities – guidelines for outlet structures on waterfront land* (DPE 2022c)
- *Controlled activities – guidelines for instream works on waterfront land* (DPE 2022d).

Whilst a CAA under Section 91 of the WM Act is not required for the project due to its SSD designation, relevant guidelines have been considered in the development of the project and assessment presented in this WRA. In particular these guidelines are relevant to the identification and management of riparian corridors and associated vegetated riparian zones, and placement of infrastructure (e.g. watercourse crossings and stormwater outlets) within and adjacent to waterfront land.

3.3.2 Guidelines relevant to fish passage and fish habitat conservation and management

NSW Department of Primary Industries (DPI) Fisheries provides a number of guidelines in relation to activities that may adversely impact on management of key fish habitat or more generally limit fish passage along watercourses. These include:

- *Policy and guidelines for fish habitat conservation and management – Update 2013* (DPI 2013)
- *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull, S. and Witheridge, G. 2003).

Whilst a permit under the NSW *Fisheries Management Act 1994* is not required for the project due to its SSD designation, relevant guidelines have been considered in the development of the project and assessment presented in this WRA. In particular these guidelines are relevant to consideration of appropriate riparian buffer distances for the purpose of key fish habitat conservation, as well as best practise guidance on minimising impacts to fish passage and general aquatic wildlife as a result of temporary and permanent waterway crossings that may be required for access purposes.

There is no mapping of key fish habitat within the project area; however, there are freshwater fish communities mapped within Coleambally Outfall Drain and Delta Creek.

3.3.3 Groundwater Assessment Toolbox for Major Projects in NSW

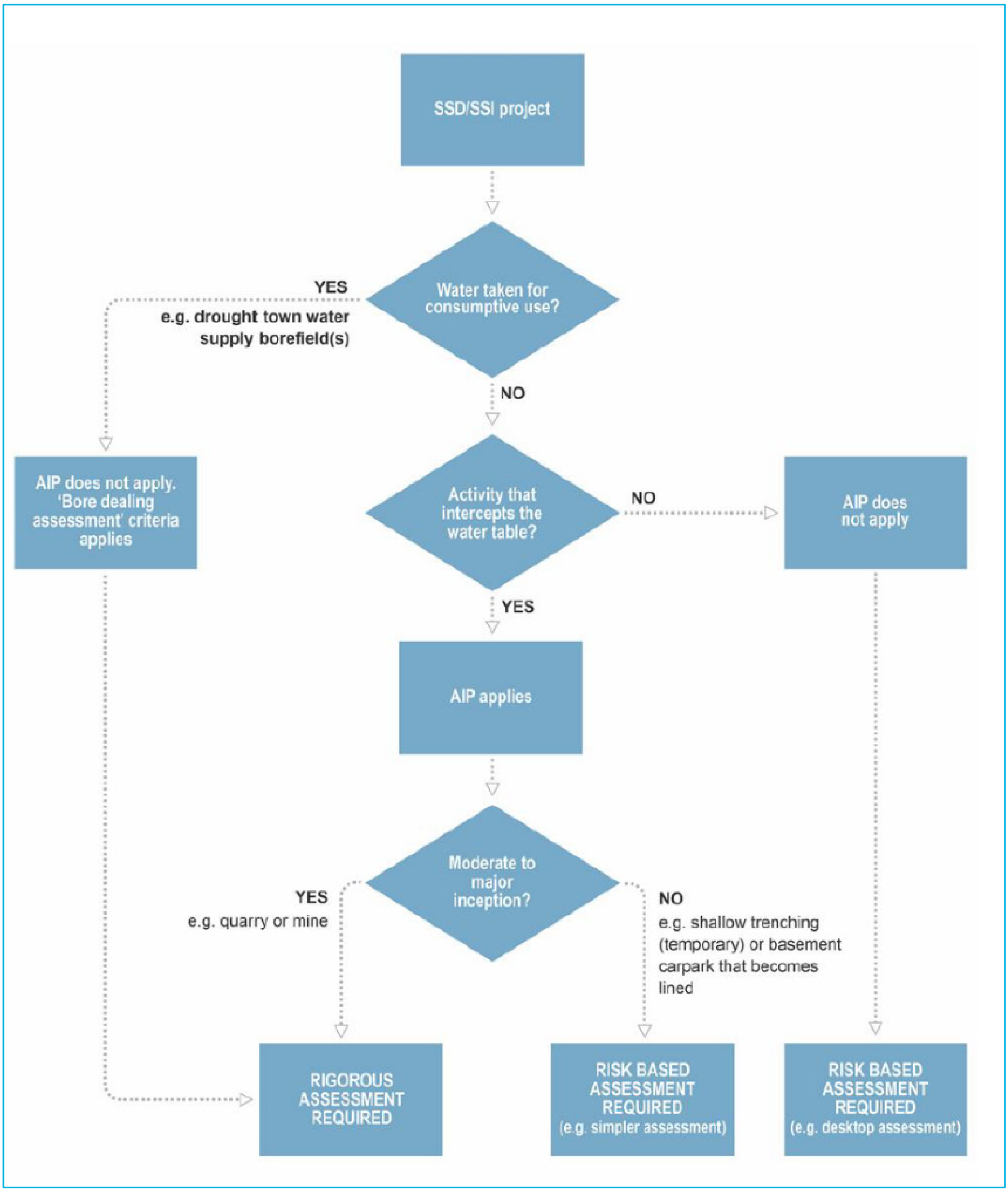
DPE Water (now NSW DCCEEW) developed a *Groundwater Assessment Toolbox for Major Projects in NSW* (DPE Water 2022a), which aims to create a collaborative, transparent and enabling environment for the preparation and review of groundwater assessments for major projects in NSW. The documents provide a framework to investigate, assess the impacts on, manage and monitor groundwater resources and their interaction with surface water resources within the footprint of a major project.

The Groundwater Assessment Toolbox is a complementary guidance document that comprises the following:

- *Guidelines for Groundwater Documentation for SSD/SSI projects* (DPE Water 2022b)
- *Minimum Groundwater Modelling Requirements for SSD/SSI Projects* (DPE Water 2022c)
- *Cumulative Groundwater Impact Assessment Approaches* (DPE Water 2022d).

These documents denote the role of the NSW Government in project assessment, and the continuation of guidance on and review of post-approvals monitoring and management plans, and compliance reporting.

DPE Water (2022b) provides high-level guidance on the assessment considerations for SSD/SSI projects, as shown in Figure 3.1. Based on this figure, and the interpretation that the construction and operation of the project does not constitute an aquifer interference activity, a desktop level risk-based assessment is appropriate for the project. This desktop assessment is presented in Section 6.3.



Source: DPE Water (2022b)

Figure 3.1 Groundwater assessment considerations for SSD/SSI projects

3.3.4 Risk assessment guidelines for groundwater dependent ecosystems

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov et al. 2012) (GDE Risk Assessment Guidelines) are the NSW requirements for assessment and management of GDEs under the WM Act. An ecosystem's dependence on groundwater can be variable, ranging from partial and infrequent dependence (i.e. seasonal or episodic (facultative)), to total continual dependence (entire/obligate).

The project has considered the presence of GDEs through a desktop-based assessment from public mapping and listing within relevant WSPs.

3.3.5 Erosion and sediment control guidelines

Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom 2004), Volume 2A (DECC 2008), and *Best Practice Erosion and Sediment Control* (IECA 2008) provides guidance on best practice erosion and sediment control methods. Strategies and measures outlined in these guidelines have been considered in the recommendation of mitigation measures for the project.

3.3.6 Bunding and spill management guidelines

The following NSW Government guidelines detail best practice storage, handling and spill management procedures for liquid chemicals:

- *Liquid Chemical Storage, Handling and Spill Management: Review of Best Practice Regulation* (DECC 2005)
- *Storing and Handling Liquids: Environmental Protection: Participant's Manual* (DECC 2007).

Strategies and measures outlined in these guidelines have been considered in the recommendation of mitigation measures for the project.

3.3.7 Flood estimation and flood risk management

i Flood Risk Management Manual

The *Flood Risk Management Manual* (DPE EES 2022) (FRMM) is the NSW Government's primary guideline relating to the management of flood liable land in accordance with the NSW Flood Prone Land Policy and the *Local Government Act 1993*. The FRMM and supporting toolkit updates the former *NSW Floodplain Development Manual* (DIPNR 2005) and previous technical guidelines.

The FRMM provides for the development and implementation of sustainable strategies for managing human occupation and use of the floodplain. It provides for evaluation of strategies and formulation of plans that achieve effective flood risk management outcomes accounting for social, economic, ecological and cultural factors, together with community aspirations for the use of flood prone land.

ii Australian Rainfall and Runoff

Australian Rainfall and Runoff (Ball et al. 2019) (ARR 2019) is a national guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. Methodologies in this guideline have been used in the development of flooding predictions for this project.

3.3.8 Wastewater management and reuse

The following guidelines and standards detail best practice on-site wastewater management and treated effluent reuse:

- *Onsite domestic wastewater management, Designing and Installing On-Site Wastewater Systems* (WaterNSW 2019)
- *AS/NZS 1547:2012 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012)
- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)* (Environment Protection and Heritage Council, National Resource Management Ministerial Council, and Australian Health Minister's Conference 2006).

Strategies and measures outlined in these references have been considered in the recommendation of mitigation measures for the project.

3.4 Water quality and river flow objectives

The NSW Water Quality Objectives (WQOs) are the agreed environmental values and long-term goals for surface waters within NSW. They set out the community's values and uses for our waterways as well as a range of water quality indicators to help assess whether the current condition of our waterways supports those values and uses.

The NSW River Flow Objectives (RFOs) are the agreed high-level goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human use.

The *NSW Water Quality and River Flow Objectives* (DECCW 2006) provides WQOs and RFOs for all catchments in NSW. The project and all potentially impacted receiving watercourses lie within the area classified as the Murrumbidgee River catchment and more broadly the Murray Darling River catchment. The watercourses relevant to the project are classified as both 'uncontrolled' and 'waterways affected by irrigation drainage'. This classification applies to:

- Streams, wetlands and natural lakes that are not classified in other categories where natural flow patterns are typical.
- Natural and semi-natural waterways whose flows are now dominated for substantial periods by irrigation drainage. Flow can be irregular and water quality is typically not comparable to nearby natural systems.

Table 3.1 summarises the WQOs and RFOs for waterways affected by irrigation drainage within the *Murrumbidgee River and Lake George* catchment and applicability to the project.

Table 3.1 Application of NSW Water Quality and River Flow Objectives

Environmental value	Objective	Application to the project
WQO		
Aquatic ecosystems	Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.	Several, smaller ephemeral streams are unlikely to support aquatic ecosystems. Two named watercourses in the project are tributaries of Delta Creek and then Coleambally Outfall Drain. The protection of potential aquatic ecosystems is the primary water quality objective to be met.

Table 3.1 Application of NSW Water Quality and River Flow Objectives

Environmental value	Objective	Application to the project
Visual amenity	Aesthetic qualities of waters.	There is landholder frontage to Delta Creek and the Coleambally Outfall Drain where aesthetic qualities of water are relevant.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock.	Some downstream users may use water from Delta Creek (when flowing) for stock. Water from the Coleambally Outfall Drain is utilised mainly for grazing land within and downstream of the project. A number of unnamed ephemeral watercourses flow through the project area.
Irrigation water supply	Protecting the quality of waters applied to crops and pasture.	Some downstream users may use water from Delta Creek (when flowing) for irrigation. The Coleambally Outfall Drain supplies water to opportunistic irrigation areas.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	It is unlikely that any downstream users extract water from Delta Creek or Coleambally Outfall Drain for homestead water supply.
RFO		
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems.	Stormwater discharges from the project will enter unnamed tributaries of Delta Creek and unnamed tributaries conveying water to the Coleambally Outfall Drain. The project, therefore, has potential to impact localised flow regimes; however, it is unlikely to influence regional flow patterns due to the scale of the proposed development footprint compared to contributing catchment. The natural flow regimes have potentially been modified by past land clearing, agriculture and irrigation schemes within the project area.
Mimic natural drying in temporary waterways	Mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways.	
Maintain natural flow variability	Maintain or mimic natural flow variability in all streams.	
Manage groundwater for ecosystems	Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.	Construction and operation of the project is not anticipated to materially impact groundwater.
Minimise effects of weirs and other structures	Minimise the impact of instream structures.	Existing watercourse crossings will be utilised for the project with upgrades required as necessary. Stormwater outlets will be required as part of the project. Proposed vehicle crossing structures required over existing irrigation infrastructure have not been considered in association with river flow objectives due to their commercial purpose.

4 Existing environment

4.1 Overview

This chapter describes the existing surface water and groundwater environment and related aspects of the project area and regional context as relevant to this WRA.

4.2 Climate

4.2.1 Current climate

Based on the Köppen classification system, the project area is classified as 'grassland – warm (persistently dry)', which is characterised by hot dry summers and cold winters. Maximum temperatures typically exceed 30°C during summer and fall to around 14°C during winter. Minimum temperatures are typically around 17°C during summer and below 4°C in winter. The project area receives approximately 390 millimetres (mm) of annual rainfall and annual potential evapotranspiration (PET) is in the order of 1,900–2,000 mm (BoM 2023). This results in generally low surface water availability and watercourse flow regimes that are typically ephemeral in nature.

Climate and rainfall information for the project has been collated from the SILO database. The SILO database contains Australian climate data from 1889 to the present, which is hosted by the Queensland Government Department of Environment and Science. SILO grid point data for rainfall, PET and temperature was downloaded for the grid point closest to the project location: latitude -35.05, longitude 145.75. SILO grid point data is constructed from observational data obtained from the Bureau of Meteorology (BoM) and other suppliers using mathematical interpolation techniques to construct spatial grids and infill gaps in time series datasets (Jeffrey et al. 2001). The annual climate statistics are displayed in Table 4.1.

Table 4.1 Climate overview

Parameter	Range	Time Period	Value
Mean monthly maximum temperature (°C)	Highest	January	32.5
	Mean	Annual	23.4
	Lowest	July	14.1
Mean minimum temperature (°C)	Highest	January	16.8
	Mean	Annual	9.8
	Lowest	July	3.3
Mean rainfall (mm)	Highest	February	77.3
	Mean	Annual	390
	Lowest	August	38.8

Source: SILO database

4.2.2 Future climate

AdaptNSW provides regional climate change snapshots for each region of NSW for the short term (to 2039) and long term (to 2079). The likely impacts of climate change during the 21st century in the Murrumbidgee region, where the project is located, are summarised here (OEH 2014):

- Temperature:
  - mean, maximum and minimum temperatures are projected to rise, with the greatest increases projected for spring and summer
  - the number of cold nights is projected to decrease
  - the number of hot days is projected to increase.
- Rainfall:
  - rainfall will continue to vary spatially, seasonally and from year-to-year
  - increased rainfall is predicted for summer and autumn
  - decreased rainfall is projected for spring.
- Increased number of fire weather days in summer and spring.

Additionally, extreme rain events in NSW are projected to become more intense (CSIRO and BoM 2021) based on predictions through the NSW and ACT Regional Climate Modelling project (NARCliM).

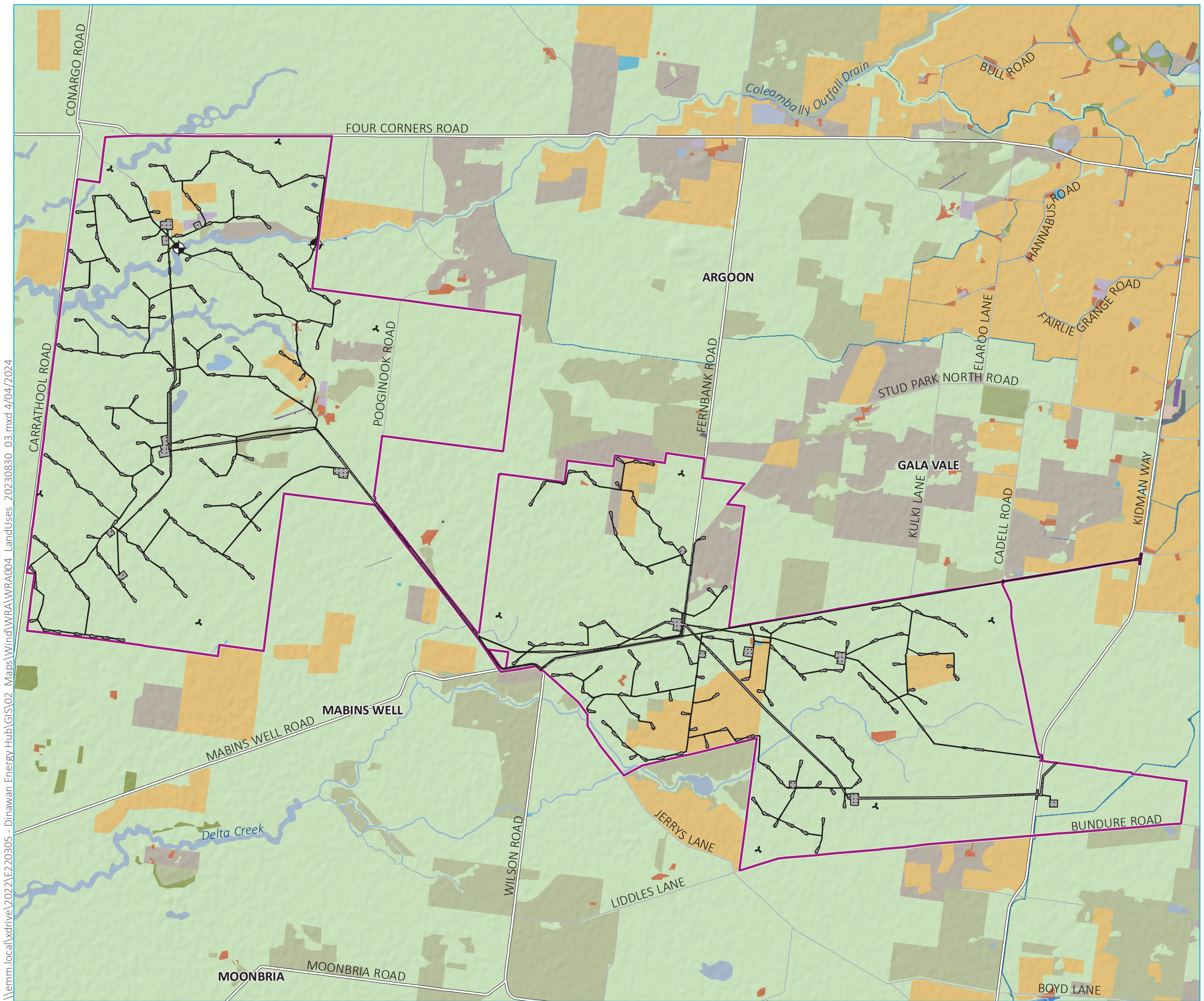
4.3 Land use

The project is situated in a relatively remote and sparsely populated part of south-west NSW. The nearest town to the project with a population of greater than 5,000 people is Griffith, approximately 100 km to the north. Land use within and around the project area (Figure 4.1) is dominated by agriculture, including grazing and cropping, based on land use mapping (NSW Landuse 2017 v1.2) (DPE 2020). As shown on Figure 4.1, the majority of the project area remains native vegetation used for grazing with smaller areas of irrigated and non-irrigated cropping, grazing irrigated and modified pastures and isolated residential and farm infrastructure.

Existing irrigation infrastructure within the project area includes several channel networks and associated dams, including the Coleambally Outfall Drain (Figure 1.2). The Coleambally Irrigation Channel is also included within the project area; however, it is not proposed to interact with the development corridor.

There are marsh/wetland areas scattered throughout the surrounding region as well as Oolambeyan National Park and South West Woodland Nature Reserve which are both nature conservation areas.

There are several proposed or approved renewable energy developments in the region, including wind farms, solar farms and battery energy storage systems (BESSs), as well as additional transmission infrastructure (refer to Figure 4.1).



Source: EMM (2024); DFSI (2020, 2021); GA (2011); DPIE (2020)

Land use

Dinawan Wind Farm
Water Resources Assessment
Figure 4.1

EMM
creating opportunities

4.4 Topography and landform

The topography of the project area and surrounds is characterised as relatively flat terrain. Natural ground elevations within the project area are on average 108 m Australian Height Datum (mAHD) and there is very little variation with a maximum elevation of 115 m AHD and an aspect from east to west. There are some minor drainage depressions that temporarily hold water during and following rainfall before eventually flowing in a south-westerly direction. Several minor topographic depressions on the floodplain hold water for longer, creating scattered swamp environments within the project area.

4.5 Hydrology

4.5.1 Overview

The hydrologic context for the project is shown in Figure 4.2 and key aspects are described in the following sections.

4.5.2 Catchment and watercourses

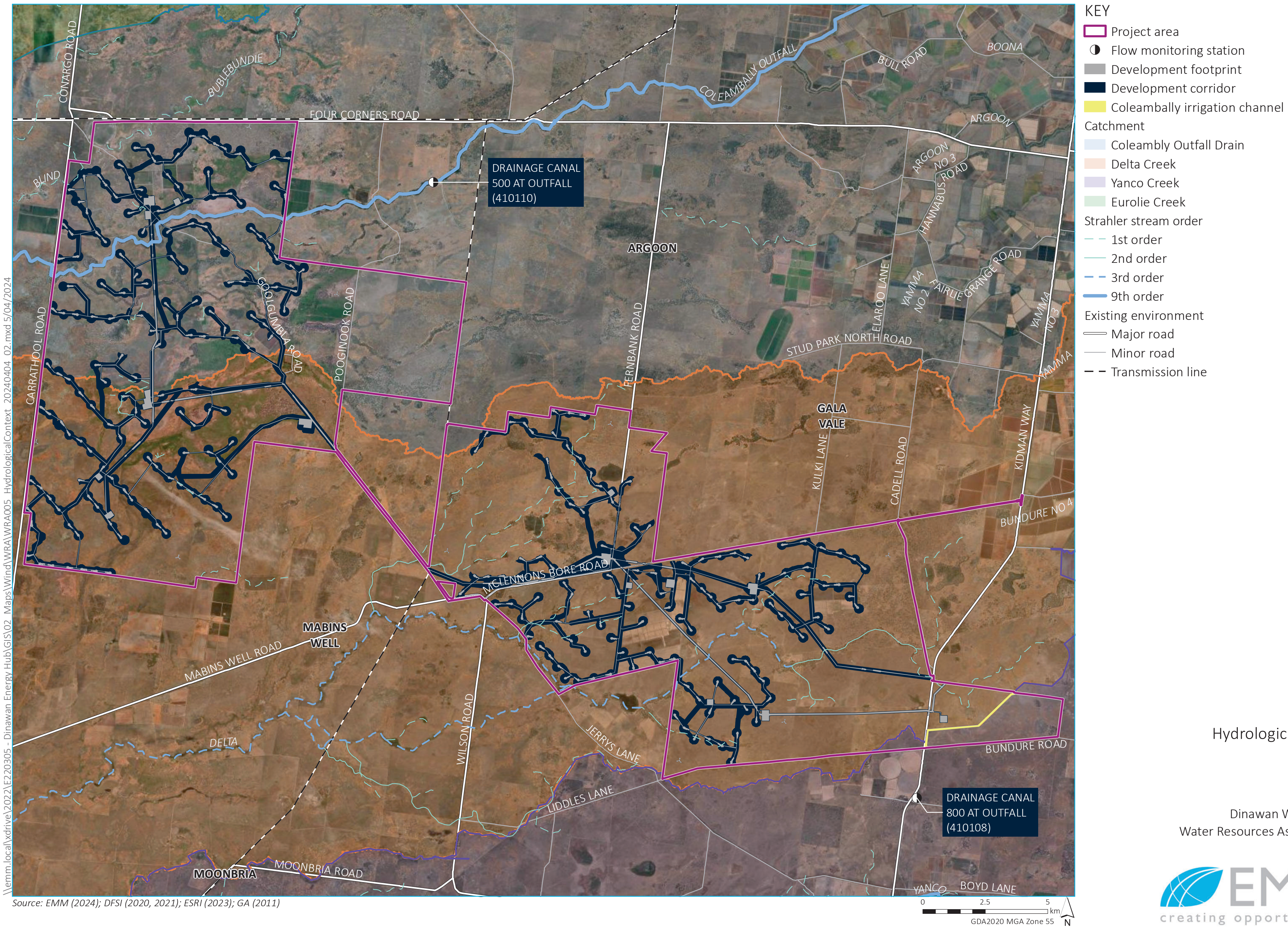
The project is within the lower Murrumbidgee River catchment in southern NSW which drains a total area of around 84,000 km^2. The Murrumbidgee River flows in a south-westerly direction from its headwaters in Kosciuszko National Park to the floodplains at the western end of the catchment where the project is situated.

The project is situated to the north of Yanco Creek, which has a regulated offtake from the Murrumbidgee River and flows generally south-west and ultimately to the Murray River via Billabong Creek, Edward River and Wakool River.

The project predominantly includes catchments draining to Delta Creek and the Coleambally Outfall Drain. The Coleambally Outfall Drain is the major outlet drainage channel for the Coleambally Irrigation Area and includes contributions from Bublebundie and Blind creeks. Delta Creek is a minor, ephemeral waterway which also drains in a south-westerly direction during significant rainfall, although does not connect to any downstream major channel unless the area is flooded.

The project area is largely flat with some minor drainage depressions that temporarily hold water during and following rainfall before eventually flowing in a south-westerly direction. Several minor topographic depressions on the floodplain hold water for longer, creating scattered swamp environments within the project area. There are several ephemeral first and second order watercourses mapped within the project area, all of which drain to Delta Creek.

Coleambally Irrigation Co-operative Limited (CICL) provides irrigation and drainage services to nearly 500 farms in the region within the Coleambally Irrigation Area, which is located to the north-east of the project area (Figure 1.2). CICL owns and operates a network of open earthen channels for this purpose. Regulated surface water supply for CICL is accessed from the Murrumbidgee River via Coleambally Canal just upstream of Gogeldrie Weir. The irrigation channel network in the vicinity of the project area is shown on Figure 4.2. Existing private irrigation infrastructure within the project area (i.e. not owned by CICL) is not identified on Figure 4.2.



Source: EMM (2024); DFSI (2020, 2021); ESRI (2023); GA (2011)

Hydrologic context

Dinawan Wind Farm
Water Resources Assessment
Figure 4.2

EMM
creating opportunities

4.5.3 Streamflow monitoring

There are approximately 100 active river gauges within the Murrumbidgee WRP area. Table 4.2 shows the mean daily flows over the past five years for selected locations close to the project area. This demonstrates:

- relatively higher flows in the Murrumbidgee River as the major watercourse in the region
- decreasing flows along Yanco Creek moving downstream as water is lost to evaporation and seepage and taken by consumptive and environmental users
- Coleambally Outfall Drain conveys an average flow of 57.3 ML/day upstream of the project (refer to Drainage Canal 500 at Outfall)
- reduced flow in Coleambally Outfall Drain at an average of approximately 36.7 ML/day downstream of the project (refer to Coleambally Outfall Drain at Near Bundy)
- relatively small returns back into Yanco Creek from irrigation system outfall drains.

Table 4.2 Mean daily flow for selected local streamflow monitoring sites

Gauge site	Latitude & Longitude	Mean daily flow (ML/d)	Period of record
Murrumbidgee River at Downstream Yanco Weir (410036)	-34.6953, 146.4007	9102.34	14/06/2018–14/06/2023
Yanco Creek at Offtake (410007)	-34.7061, 146.4094	1053.20	14/06/2018–14/06/2023
Yanco Creek at Yanco Bridge (410169)	-35.1484, 145.7731	475.68	14/06/2018–14/06/2023
Yanco Creek at Morundah (410015)	-34.9452, 146.2675	459.27	14/06/2018–14/06/2023
Yanco Creek at Wiraki (41000209)	-35.2949, 145.4917	416.54	14/06/2018–14/06/2023
Yanco Creek at Downstream Tarabah Weir (41000213)	-34.8859, 146.2771	207.74	14/06/2018–14/06/2023
Drainage Canal 800 at Outfall (410108)	-35.1037, 145.7833	40.65	14/06/2018–14/06/2023
Coleambally Outfall Drain at Near Bundy (410133)	-35.0341, 144.4564	36.67	14/06/2018–14/06/2023
Drainage Canal 500 at Outfall (410110)	-34.8787, 145.5744	57.31	14/06/2018–14/06/2023

Flow monitoring stations within the project area are shown in Figure 4.2.

4.5.4 Geomorphology

The NSW River Styles Database (DPIE 2020a) provides an overview of geomorphic watercourse character, behaviour, condition and recovery potential targeting third order and higher watercourses throughout NSW. Geomorphic characterisation is based on the River Styles Framework, developed by Macquarie University, which classifies watercourses based on measurable geomorphic attributes and qualities that include river type, fragility, sensitivity to disturbance, condition, rarity and recovery potential.

The relevant watercourses mapped by DPIE (2020a) for the project include Delta Creek, Coleambally Outfall Drain, and small segments of Bublebundie and Blind creeks. Whilst the DPIE information was completed in 2011 and is dated, it provides relevant context for understanding the nature and condition of the watercourse.

Delta Creek has been mapped as a discontinuous channel comprising of a fine-grained bed. The watercourse is in an unconfined valley setting. The condition is mapped as moderate and fragility is high. It has a moderate potential to recovery from impact.

Coleambally Outfall Drain has been mapped as a man-made structure comprising fine-grained bed. The watercourse has its margin controlled with earthen batters and bunding. The condition of the watercourse is mapped as poor but it has a low fragility. Due to its man-made nature, the watercourse is expected to provide limited environment value.

Bublebundie and Blind creeks are mapped as small segments within the north-west corner of the project area. Both watercourse segments are mapped similarly with their geomorphology described as valley fill. Both watercourses are highly fragile.

4.5.5 Flooding

i Overview

Existing flooding characteristics for the project area and surrounds have been established by flood modelling undertaken by EMM (2023) (Attachment A). The modelling was undertaken to define flooding conditions for the project area for both Dinawan Solar Farm and Dinawan Wind Farm. The approach to modelling adopted two-dimensional (2D) hydraulic modelling using the TUFLOW software, with local runoff generation based on a rain-on-grid approach and flood inputs from the Murrumbidgee River sourced from available studies. The work incorporates recent updates to design rainfall data and flood estimation techniques documented in ARR (Ball et al. 2019) and assesses flood behaviour for the 5%, 1% and 0.5% annual exceedance probability (AEP) events as well as the probable maximum flood (PMF).

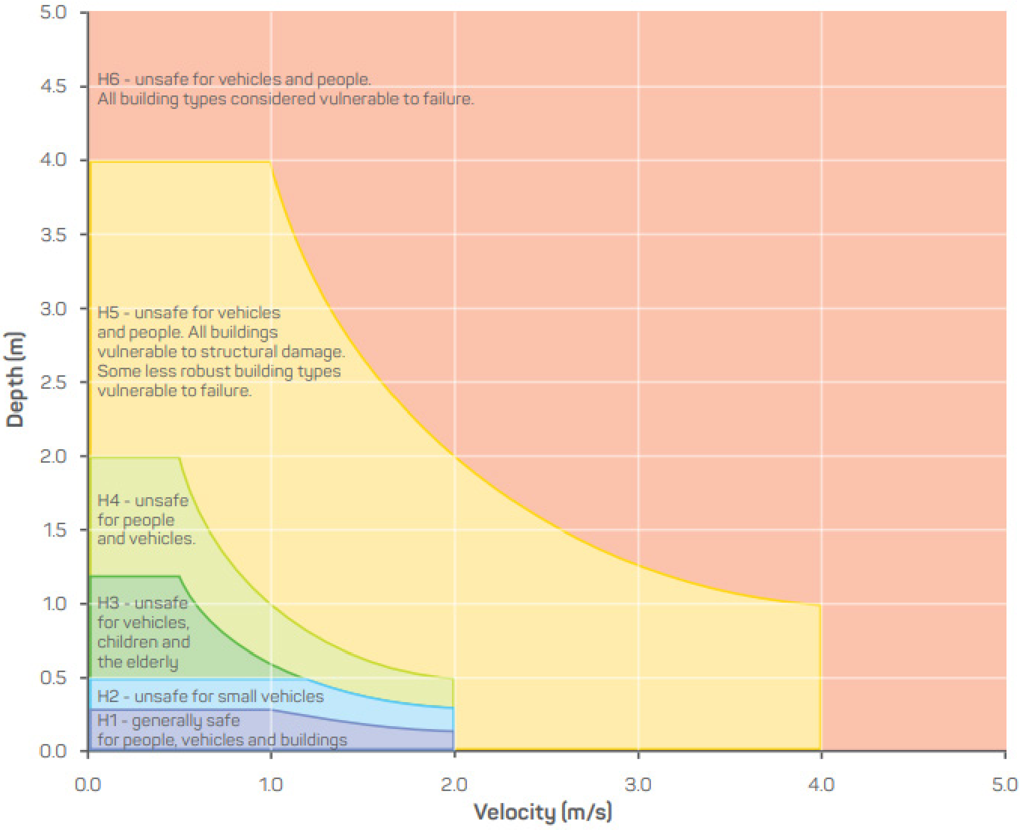
Flood mapping showing indicative extents, depths of inundation and flood hazard for all events assessed are presented in Attachment A with cross-references to the relevant figures outlined in Table 4.3.

Table 4.3 Summary of flood mapping results in Appendix A

Event	Peak flood extent and depth	Peak flood hazard
5% AEP	Figure A.1	Figure A.5
1% AEP	Figure A.2	Figure A.6
0.5% AEP	Figure A.3	Figure A.7
PMF	Figure A.4	Figure A.8

Existing flood extents and depths for the 1% AEP event are reproduced in this WRA on Figure 6.1 in Section 6.2.3.

The results of the modelling by EMM defines flood hazard in terms of vulnerability thresholds described in AEMI (2014), consistent with ARR (Ball et al. 2019). The adopted hazard curves and associated vulnerability thresholds are reproduced in Figure 4.3.



Source: AEMI (2014)

Figure 4.3 Flood hazard vulnerability curves

ii Existing flooding conditions

The project area is affected by two primary flooding mechanisms:

- Mainstream flooding sourced from the Murrumbidgee River to the north of the project area. This may occur as a result of heavy rainfall far upstream in the catchment or along river tributaries and not necessarily local to the project area.

- Local catchment flooding as a result of heavy rainfall in the vicinity of the project area.

The modelling results indicate flooding associated with local catchment flooding results in larger flood extents and depths compared to flooding that results from flows that break out of the Murrumbidgee River for all events assessed.

Flood extents within the project area generally follow the alignment of watercourses, irrigation canals and minor depressions for events up to 0.5% AEP. For the PMF event, more extensive inundation occurs over much of the landscape.

Depths of flooding and flood hazard are highly variable for all events depending on local hydraulic conditions.

4.5.6 Water quality

The Murrumbidgee WRP provides an insight into regional water quality. The water quality in the Murrumbidgee Water Resource Plan Area (WRPA) varies from poor to excellent. Water quality problems occurring within the catchment are mostly caused by a combination of alteration to natural flow regimes and land use change (DPE 2019).

There are no known water quality monitoring datasets available for the natural watercourses local to the project area. Areas subject to irrigation activities by CICL have water quality monitoring including of the Coleambally Outfall Drain both upstream and downstream of the project area. Monitoring of this watercourse includes specific monitoring for physiochemical, pesticides, and nutrients parameters. Data published publicly by CICL between 2019 and 2022 indicates that upstream of the project (sampling undertaken at flow gauging station 410110), water within Coleambally Outfall Drain is an ephemeral freshwater system with neutral pH and subject to elevated turbidity and total suspended solids, as well as elevated total nitrogen during flow events.

It is expected that Delta Creek and its tributaries are likely to exhibit relatively poor water quality relative to default guideline values, reflective of historical farming and land management practices in the area and substantial changes to natural flow regimes that have occurred over time.

4.5.7 Aquatic habitat

Within the project area Coleambally Outfall Drain is mapped as a 'poor' freshwater fish habitat (DPI 2023). The remainder of the project area has no watercourses mapped as freshwater fish habitats which is likely due to low stream order, ephemeral flow regimes and disturbed catchment areas.

Downstream (west) of the project area, the freshwater fish community status of Delta Creek is identified as 'poor' and to the south of the project area, Yanco Creek is mapped as 'very poor' fish habitat (DPI 2023).

4.6 Soils

This section provides a summary of the soils characterisation and related constraints which are described in detail in the LRA (EMM 2024).

The landscape of the Riverine Plains is composed from coalescing alluvial features and floodplain assemblages of fine-grained sands and upward fining clays. The majority of the development footprint is largely consistent with NSW mapping of the Australian Soil Classification (ASC) (Isbell 2021). The most common soil type associated with the development footprint is Vertosols, which comprise deep, cracking, sodic clays of alluvial origin. Other minor soil types may include Arenosols and Sodosols. These soil types vary from NSW mapping where changes to the ASC were superseded between 2016 and 2021 publications. Available soil profile information in eSPADE (OEH 2016) generally supports regional soil mapping.

Vertosols are clay soils with shrink swell properties that often exhibit cracking when dry and may have lenticular structural aggregates. Vertosols are typically highly productive and fertile soil types with high nutrient status and water holding capacity, with typically very slow infiltration when wet. Vertosols typically pose a moderate wind erosion hazard across fine-grained surfaces that have been disturbed, particularly when dry. Clay soils may be vulnerable to gully erosion when exposed to concentrated flows if underlain by sodic subsoils. Dispersion risk may be moderated by salinity in some areas. However, salt stores may generate potential salinity issues if not properly managed.

Sodosols are texture contrast soils with sodic subsoils which are not strongly acid and typically have low agricultural potential, poor permeability and high erodibility. These soil types are often dispersive and may be prone to gully and tunnel erosion. Careful management of these soils is required if ground disturbing activities are to be conducted.

Arenosols are soils with predominantly sandy field textures with no horizons observed to contain more than 15% clay content and no hard pans or underlying regolith. There is minimal pedologic development through the major part of the solum, but minimal development may be observed in the topsoil horizons. They occur extensively in arid, inland areas of eastern Australia and are closely associated with palaeochannel and palaeolacustrine borders of the Riverine Plains. As the Arenosols order includes soils with negligible development, many deep sandy soils previously described as Rudosols will now classify as Arenosols.

A lack of site-specific soil chemistry data results in uncertainty as to the exact hazards posed by the soils present on-site. Drying of the topsoils can make them vulnerable to wind erosion leading to scalding when underlain by sodic soils, especially on crests and upper slopes. Wind erosion can preferentially erode clay particles leading to a gradual reduction in water-holding capacity. Heavier, cracking soils are less prone to wind erosion, but they have poor trafficability when wet and are hardsetting. The loss of groundcover leads to thinning of topsoils and enhances the erosion hazard where gully erosion is present. Salinity is relatively fixed, but rising water tables (i.e. flooding) presents a risk of mobilising stored salts and a resulting salinity hazard.

Clay soils in the region are typically cracking and hardsetting at the surface. Topsoils are generally composed of clay loams with fine sandy texture and varies in structure from massive apedal to strong subangular (occasionally lenticular). Subsoils typically grade to medium clays with strong lenticular structure and are commonly mottled with few soft, calcareous segregations. They are slowly permeable and imperfectly drained, particularly when soil moisture is high causing the soil matrix to swell.

Sodic topsoils and subsoil have been detected (as discussed in the LRA) which may pose a dispersion hazard. Emerson aggregate testing suggests dispersion hazard may be mitigated by salinity and cation exchange potential in some areas, with overall dispersion risk remaining moderate (occasionally high).

Limited evidence of significant soil erosion was noted during the site inspection, with former farmed areas appearing relatively stable and generally good grass cover protecting the underlying soils from erosion. The inherent soil erosion hazard across the development footprint is considered generally low (based on methods outlined in Landcom (2004)) on the basis of generally flat terrain and low rainfall erosivity. The salinity often observed in subsoils may provide a chemical barrier to root penetration.

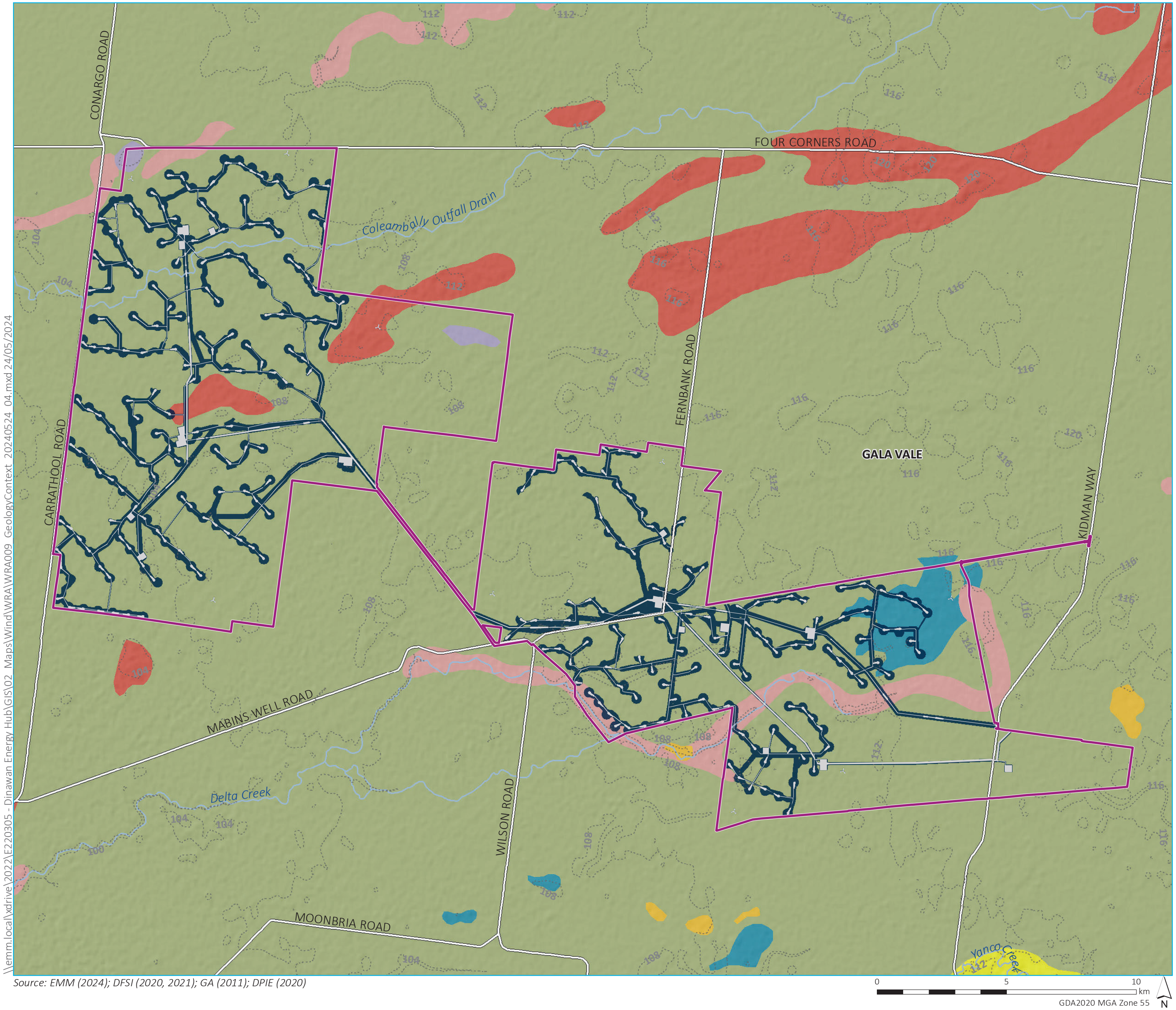
Acid sulfate soils (ASS) probability mapping has been completed along the NSW coast over 128 map sheets at 1:25,000 scale (Naylor et al. 1998). The desktop assessment identified that there are no ASS or potential ASS in the project area, in accordance with the *Guidelines for the Use of Acid Sulfate Soil Risk Maps* (Naylor et al. 1998). The NSW Acid Sulphate Risk Map (OEH 2018) indicates that the nearest site with a high probability of ASS is approximately 200 km south-east of the project area and as such the project area is at little risk from ASS.

4.7 Geology

The project area geology is described in the NSW Seamless Geology database, version 2.1 (May 2021). The project area is located on the Cenozoic Sedimentary Province with four sedimentary units in proximity to the project area. Alluvial floodplain deposits are the primary unit within the project area, with aeolian sand plains protruding into the north-east corner and an alluvial material strip that underlies the drainage paths into Delta Creek. Figure 4.4 shows the geologic context for the project area.

Groundwater bore installation logs indicate that between the surface and depths of 50 mbgl, the lithology of the project area typically consists of sands, clays and silts.

Underlying the alluvial material of the project area is expected to consist of claystones, mudstones and colluvial deposits, with the presence of thin coaly bands. Coaly bands were noted in groundwater bore installation logs at depths of 150 to 200 mbgl. Based on Tuckwell (1975), at further depths, the project area is likely underlaid by Permian geology consisting of clays, sandstones, claystones and shales with some coal bands.



KEY

- Project area
- Development corridor
- Development footprint

Existing environment

- Major road
- Topographic contour (4 m AHD interval)
- Watercourse (third order and higher)

Surface geology (250k)

- Aeolian sand plain
- Alluvial channel deposits - meander-plain facies
- Alluvial floodplain deposits
- Alluvium
- Claypan and lacustrine deposits
- Playa lake deposits
- Source-bordering dunes

Source: EMM (2024); DFSI (2020, 2021); GA (2011); DPIE (2020)

Geologic context

Dinawan Wind Farm
Water Resources Assessment
Figure 4.4

EMM
creating opportunities

\\emm.local\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\WRA\WRA009_GeologyContext_20240524_04.mxd 24/05/2024

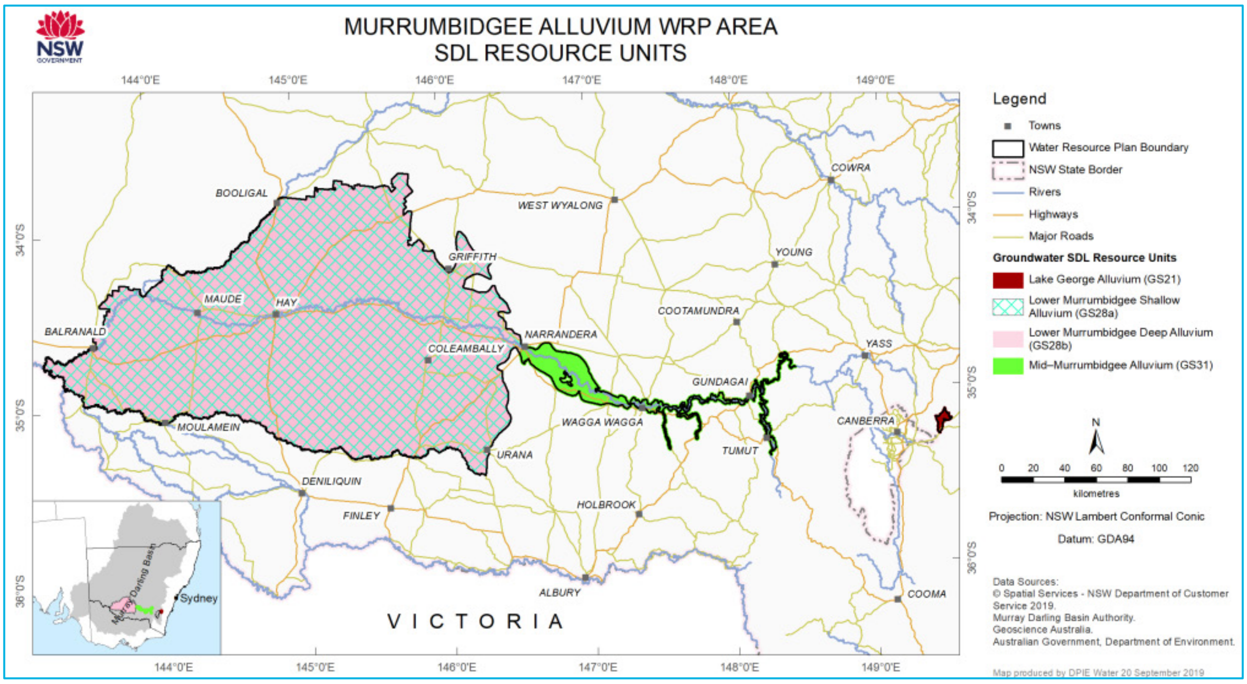
4.8 Hydrogeology

4.8.1 Overview

A review of existing hydrogeology studies was undertaken for the project. Existing studies associated with the adjacent Yanco Delta Wind Farm (Jacobs 2022) and Project EnergyConnect (WSP 2021) were reviewed along with data available through WaterNSW and various BoM datasets as described below.

4.8.2 Groundwater resources and consumptive use

Groundwater access within and local to the project area is via unconfined quaternary based porous aquifers either within shallow (associated with the Lower Murrumbidgee Shallow Alluvium Groundwater SDL resource unit) or deep groundwater resources (associated with the Lower Murrumbidgee Deep Alluvium Groundwater SDL resource unit), as described by the WRP (DPE 2022e) and shown in Figure 4.5.



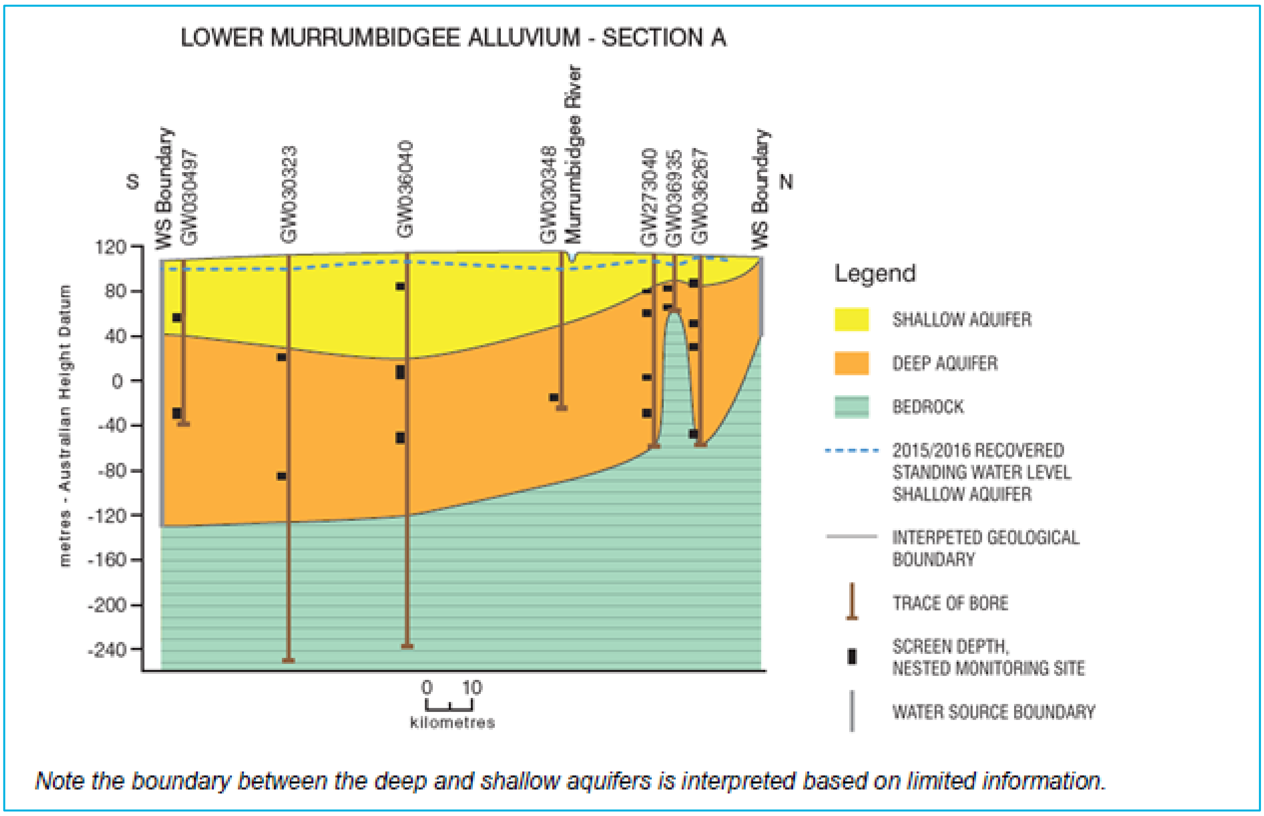
Source: DPE 2022e

Figure 4.5 Map of Murrumbidgee Alluvium Water Resource Plan area

Four key regional hydrostratigraphic units (HSUs) exist in order of depth below ground level:

- Quaternary Sediments – inconsistently present and typically associated with mapped watercourses.
- Upper Tertiary to Quaternary Aquifer – likely to be representative of the shallow aquifer described by the WRP.
- Upper Tertiary Fluvial Sediment Aquifer – likely to be more productive areas of the shallow aquifer systems.
- Lower Tertiary Aquifer – representative of the deeper groundwater source as described by the WRP.

A north-south section taken by DPE (2019) through the WRP area, and broadly representative of the project area, is shown in Figure 4.6 which illustrates the arrangement of shallow aquifers, deep aquifers and bedrock layers.



Source: DPE 2019

Figure 4.6 North-south section through the Murrumbidgee Alluvium Water Resource Plan

Groundwater bores within and surrounding the project area intercept a range of these HSUs; however, more productive units are within the Upper Tertiary Fluvial Sediment Aquifer and the Lower Tertiary Aquifer based on yield data from registered bores further described below.

i Registered users

Based on the BoM's National Groundwater Information System, a total of 226 registered groundwater bores are within a 5 km buffer of the project area. Groundwater bores in the vicinity of the project area are shown on Figure 4.7. Where recorded, registered bore depths range significantly from 9 to 363 mbgl. Groundwater bores have been constructed in the area since the early 1900s with the most recent bores installed in 2020. The existing registered uses of groundwater bores within the 5 km buffer include:

- exploration – 2 bores
- irrigation – 25 bores
- water supply – 24 bores
- monitoring – 118 bores
- stock and domestic – 40 bores
- unknown – 17 bores.

Of the licenced groundwater bores, the stock and domestic bores targeted 20 to 118 mbgl, exploration bores 70 to 120 mbgl, irrigation bores 68 to 242 mbgl and water supply bores 20 to 185 mbgl. Most of the monitoring bores are constructed less than 100 mbgl but several are built between 100 to 362 mbgl.

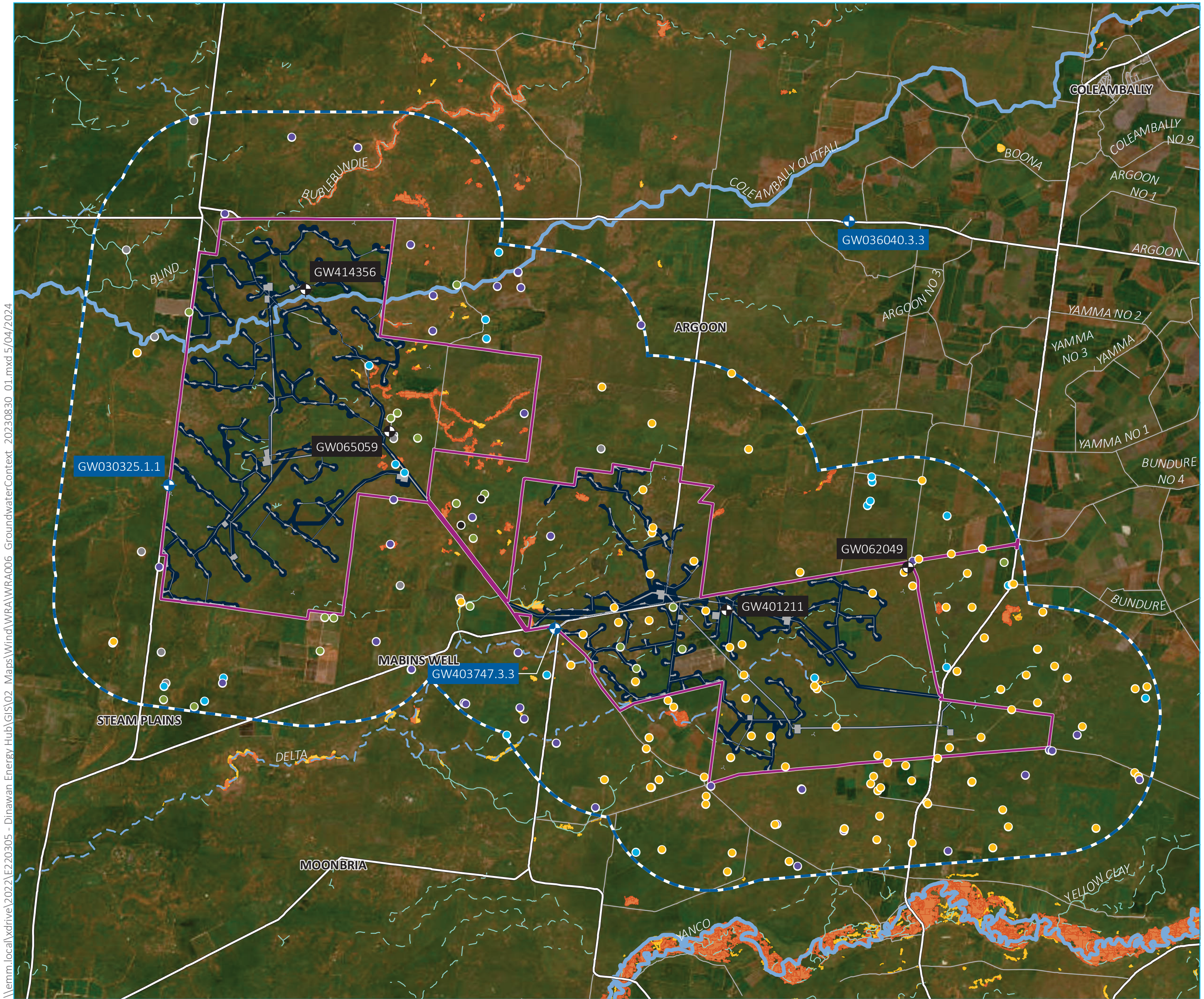
Data for groundwater bore installations have only typically occurred in more recent times (i.e. beyond 1990s). Many of the monitoring bores were installed prior to this time. Some stock and domestic and water supply bores were installed prior to the 1990s though the majority have been developed more recently. Most irrigation bores have been constructed between 1997 and 2020.

On review of the Australian Groundwater Insight data via the BoM, there is a significant intensity of licensed groundwater users in the region. Typically, groundwater users in the vicinity of the project area are licensed for between 1,000 and 15,000 ML/year.

A total of 13 registered groundwater bores are currently within the development corridor (Table 4.4) with three nominated as water supply, two nominated as supply for irrigation, and eight dedicated to monitoring. This number reduces to one monitoring bore when considering the development footprint.

Table 4.4 Registered bores within the development corridor or development footprint

Bore ID	Licensed use	Depth (mbgl)	Yield data (L/sec)	Salinity data (mg/L)	Location with respect to project
GW505524	Water supply	68	3	700	Within development corridor
GW401211	Water supply	185	NA	NA	Within development corridor
GW017769	Water supply	46.3	0.4	NA	Within development corridor
GW400978	Irrigation	176.83	250	NA	Within development corridor
GW500860	Irrigation	184	190	NA	Within development corridor
GW065217	Monitoring	56	0.6	501–1,000	Within development corridor
GW012554	Monitoring	25.3	NA	NA	Within development footprint
GW012862	Monitoring	35.1	NA	NA	Within development corridor
GW012860	Monitoring	39.3	NA	NA	Within development corridor
GW011038	Monitoring	54.3	0.88	NA	Within development corridor
GW017312	Monitoring	33.2	0.61	NA	Within development corridor
GW012892	Monitoring	27.4	NA	NA	Within development corridor
GW050184	Monitoring	77.7	NA	NA	Within development corridor



Source: EMM (2023); DFSI (2020, 2021); DPI (2013); ESRI (2022); GA (2011)

\\emm.local\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\WRA\WRA006_GroundwaterContext_20230830_01.mxd 5/04/2024

Groundwater context

Dinawan Wind Farm
Water Resources Assessment
Figure 4.7

creating opportunities

ii Groundwater levels

Several telemetered groundwater monitoring bores are in the vicinity of the project area (refer to Figure 4.8). These bores provide an indication to the water level of the productive groundwater source over time.

Figure 4.8 provides an overview of the groundwater level of the local groundwater environment between 2010 and 2024.

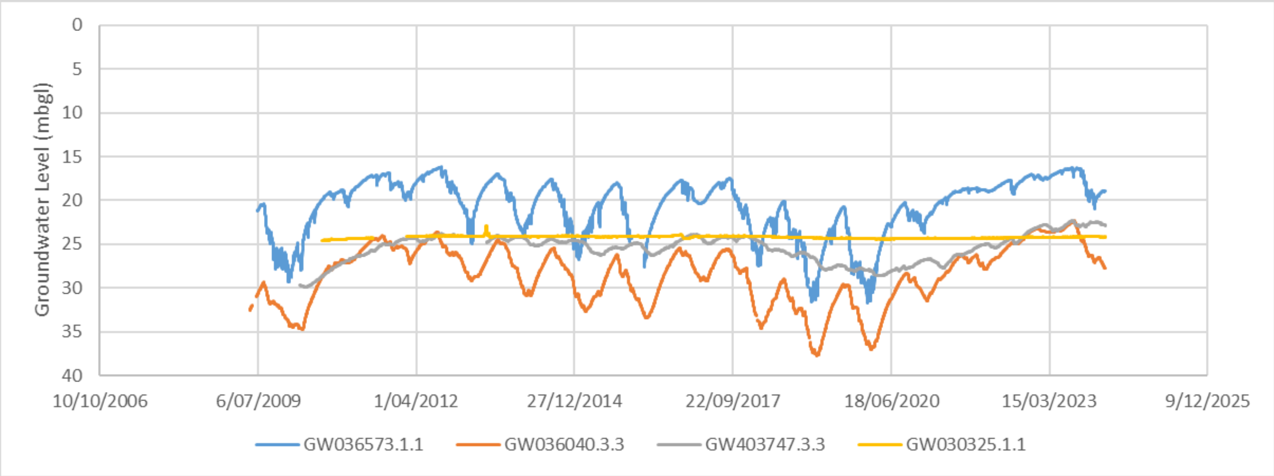


Figure 4.8 Historical telemetered groundwater level data surrounding the project (WaterNSW 2024)

Groundwater level, considered as a depth below ground level, has been considered in the evaluation of Figure 4.8, as there is minimal topographic relief between telemetered bores, and the data provides context with the potential risks of interactions due to the project. Generally, groundwater levels range from 15 to 40 mbgl. It should be noted that GW036573 and GW036040 are located nearby intensive irrigation districts which is likely the reason that there is a large seasonal variation in groundwater level observed at these bores. In contrast, GW403747 and GW030325 present a more stable groundwater level over time, as these bores are located at some distance from the irrigation districts.

Broad scale groundwater historical level trends, provided by Australian Groundwater Insight (BoM 2023b), indicate either a stable or reduction in groundwater levels recorded over 5, 10 and 20 year horizons for registered users in the vicinity of the project area. These results were similar for upper, middle and lower aquifers.

Further details on registered bores within the development corridor and bores with telemetry are provided in Attachment B.

iii Groundwater quality

Many of the registered bores where salinity has been measured indicate values less than 1,000 mg/L (approximately 1,500 µS/cm) and therefore relatively fresh water. This is supported by regional historical trend data available via Australian Groundwater Insight which indicates fresh to marginal within the upper, middle and lower aquifers. No change in this salinity trend has been noted in the last 20 years generally.

Groundwater use supports the generally good water quality with many registered water supply users present in the vicinity of the project area.

iv Groundwater yield

Of the yield information available from the data collected on registered bores in the vicinity of the project area, yield is observed to increase with depth. A review of registered bore constructions through WaterNSW shows that several bores constructed up to depths of 121 mbgl have achieved moderate yields up to 12.6 litres per second (L/s). This is in contrast to bores constructed between 121 to 185 mbgl that have produced significant yields of 157 to 304 L/s. It is noted whilst depth is a factor, spatial variability of the HSUs will also influence specific bore yields.

4.8.3 Surface and groundwater connectivity

The project area comprises isolated watercourses that are often dry and not supplied by the groundwater environment typically. This observation is supported by a recent study undertaken by Jacobs (2022). Groundwater monitoring data from continuous data recorded at selected groundwater sites further supports the presence of a regional groundwater table located well below the elevation of the surface water features of the project area.

DPE (2019) describes Yanco Creek and other anabranches and distributary channels of the Murrumbidgee River as losing systems (i.e. watercourses that lose water from the streambed or bank into the ground).

Considering the above observations and data, the likelihood is that surface water features are typically draining into the groundwater environment during wetter periods when flow does occur. Local groundwater systems are unlikely to reach an elevation near ground level where they would be able to discharge back into surface water features.

4.8.4 Potential groundwater dependent ecosystems

A range of terrestrial groundwater dependent ecosystems (GDEs) are mapped within the project area based on the *Groundwater Dependent Ecosystems Atlas* (BoM 2020). These comprise low to moderate potential for groundwater interactions. Associated plant community types include Weeping Myall open woodland, Curly Windmill Grass, Forb-rich Speargrass, Black Box and Cotton Bush open shrubland.

A review of the High-Ecological Value Aquatic Ecosystems (HEVAE) dataset (refer to Table 4.4) indicates that GDEs with medium to high value have been mapped within the project area; however, only a small number intersect the development corridor. The mapped GDEs intersecting the development corridor are typically associated with River Red Gum and shallow marsh wetland plant communities and are primarily around the corridor that connects the eastern and western parts of the project area (Figure 4.7).

5 Proposed water management

5.1 Overview

This chapter describes the proposed water management approach and estimated water demands for the project.

5.2 Preliminary design development

During preparation of the EIS, the development footprint has been refined to consider identified environmental constraints, outcomes of stakeholder engagement, community consultation and design of project infrastructure with the objective of developing an efficient project that avoids and minimises environmental impacts. From a water perspective this has included the following considerations:

- Limiting disturbance of existing minor watercourses and associated riparian corridors to the extent practicable with a preference for areas where there is:
  - limited ecological value
  - surface degradation due to existing land uses.
- Minimising the number of new watercourse crossings required through use of existing access tracks or roads where crossing structures already exist.
- Avoiding development and earthworks generally within flood prone areas (i.e. as defined by depths in excess of 0.5 m in the 1% AEP event) and locating sensitive infrastructure (e.g. substations) in appropriate locations compatible with flood risk and incorporating suitable mitigation measures.
- Avoiding disturbance of groundwater receptors (third-party users or GDEs).

Where future design refinements are necessary, adoption of low impact and impact avoidance principles will be considered.

5.3 Proposed water management approach

5.3.1 Construction

Prior to construction, a soil and water management plan (SWMP) will be developed as part of the overall construction environmental management plan (CEMP) or similar to address temporary and site-specific risks to surface water and groundwater during construction. Key principles and objectives for stormwater management, flood risk management, erosion and sediment control and watercourse crossings are described below.

i Stormwater management

The general approach to stormwater management will involve:

- Appropriate siting of proposed infrastructure within the development footprint, which will minimise disturbance to existing drainage lines and overland flow paths.
- Earthworks will aim to maintain the prevailing surface gradients and fall towards existing drainage lines, to minimise changes to existing flow paths.
- Minimisation of hardstand/impervious areas to reduce the additional volume of stormwater generated from within the development footprint.

- Provision of surface drainage infrastructure, comprising:
  - Diversion of upslope runoff around infrastructure.
  - Surface drainage measures as required to control runoff generated within the development footprint, minimise soil erosion potential and direct runoff towards receiving drainage lines. Sheet flow conditions will be maximised, and construction of diversion drains, channels and table drains to be minimised to the extent practicable.
  - Suitable treatments will be used to armour earthwork batters and site drainage as needed for scour protection and to achieve stable waterways where flow concentrations cannot be avoided.
  - Maintain existing flow paths where possible and minimise catchment diversions, with the objective of minimising changes to flow regimes in receiving watercourses.
- Specific stormwater management measures for the concrete batching plants during construction will include:
  - Diversion of clean runoff away from cement and concrete handling areas and stockpiles.
  - Maximising recycling of process wastewater, with dedicated storages for excess wastewater that will be manually emptied via vacuum truck and disposed of off-site.
  - Bunded areas for refuelling.
- Specific stormwater management measures for collector substations will include:
  - Diversion of clean runoff away from potentially oil-contaminated areas.
  - Bunding of potentially oil-contaminated areas.
  - Provision of stormwater treatment device(s) to remove oil/grease, hydrocarbons and sediment from runoff prior to discharge to the downstream drainage system.
- Prompt stabilisation of disturbed areas and progressive rehabilitation as early as practicable.
- Maintaining drainage, erosion and sediment control measures.
- Monitoring and adjustment protocols for drainage, erosion and sediment control practices to achieve the desired performance standard.
- Stormwater runoff from buildings will be captured in rainwater tanks for use on-site, to minimise demand for imported water.

These principles will be applied to the extent practicable as part of further design development.

In addition to the above, the SWMP will include measures to:

- implement procedures for hazardous material storage and spill management as defined in applicable guidelines (refer to Section 3.3.6)
- maintain spill kits on-site at all times during construction and operation

- consider weather preparedness and response planning
- identify requirements for monitoring and maintenance of water management and drainage systems.

ii Flood risk management

The general approach to flood risk management will involve the following:

- The collector substations will be raised above natural ground levels, if required, to achieve the desired level of flood immunity. It is anticipated that a minimum 1% AEP flood immunity will be provided, but this standard and an appropriate freeboard allowance will be determined during detailed design.
- Diverting local overland flow paths around infrastructure pads.
- Appropriate placement of temporary works, plant, materials and workforce facilities, that gives due consideration to overland flow paths and mainstream flood risk.
- Outside those areas requiring engineered drainage mitigation measures, finished ground levels are to be constructed at grade and not materially higher than existing levels in areas subject to flooding.
- Where watercourse crossings are required, they will consider appropriate watercourse crossing designs and construction methods that account for local hydraulic conditions, seek to minimise local flooding impacts, and are consistent with relevant guidelines.
- Development of a flood management plan (FMP), as part of the SWMP or standalone plan, to describe the required site management and protocols in the event of a flood event that could impact construction sites or access, including:
  - suitable early warning/prediction measures and communication protocols
  - site preparedness activities and procedures
  - triggers for closure, evacuation and recovery
  - emergency response and support.

These principles will be applied to the extent practicable as part of further design development.

iii Erosion and sediment control

Specific recommendations and proposed management measures for erosion and sediment control and stabilisation of disturbed surfaces during construction are contained in the LRA (EMM 2024) and will form part of the SWMP. The SWMP will be underpinned by progressive erosion and sediment control plans (PESCPs) for all discrete disturbance areas.

At the end of construction, areas no longer required to support operations will be rehabilitated. A principal aim of site rehabilitation will be to stabilise disturbed areas and minimise the potential for ongoing soil erosion and subsequent mobilisation/transport downstream of each site. Recommended rehabilitation principles and approaches are described in the LRA (EMM 2024).

iv Watercourse crossings

Existing watercourse crossings will be used to support construction and operation of the project to the extent practicable. The indicative locations of watercourse crossings may change as part of detailed design.

Two existing bridges cross the Coleambally Outfall Drain that traverses the western portion of the project area and will be utilised for access during construction and operations (Photograph 5.1).

Bridge crossing east ('3 – WEST' on Figure 6.3)

Bridge crossing west ('2 – WEST' on Figure 6.3)

Photograph 5.1 Bridge crossings over Coleambally Outfall Drain

During construction, oversize and/or overmass (OSOM) vehicles may require that these crossings are upgraded (either due to width or structural constraints). The project's requirement to include these upgrades will be confirmed in detailed design; however, it is expected that in any upgrade that may be required, that these bridge structures can be increased in width and/or structural load capacity. An upgraded bridge structure will fundamentally be of a similar form and drainage function as to what is existing (i.e. concrete box culverts spanning the width of the drain). The opportunity for fish passage will be not reduced in any upgrade requirements for bridge structures over the drain.

Many of the other watercourse crossings within the development corridor that will be utilised for access during construction and operations are also causeway crossings.

5.3.2 Operations

At the completion of construction, the SWMP and FMP will be updated to suitable operational versions forming part of an operational environmental management plan (OEMP) or similar to address ongoing site-specific risks to surface water and groundwater during operations.

In general terms, operations will require:

- rehabilitation of disturbed areas not used for operations
- ongoing maintenance of stabilised and vegetated surfaces, drainage and sediment and erosion control measures that will be retained for operations.

The general approach and key principles for stormwater management and flood risk management described above for construction will also apply to operations.

5.4 Water demands, source of supply and wastewater management

5.4.1 Construction

The estimated non-potable water demand for construction of the project is approximately 176 ML over the 60 month construction period. Most of this water will be required for dust suppression, with other uses including site amenities, fire protection and washing of construction equipment and plant.

During construction, water will be sourced from groundwater through existing landowner bores within the project area (Figure 4.7).

Water for construction purposes will also be opportunistically sourced from the following to minimise the need for imported water:

- use from existing dams where harvestable rights apply
- reuse from construction sediment basins
- wastewater from the concrete batching plants will be captured and recycled for concrete batching to the extent practicable, with any excess to be extracted via sucker truck and disposed of off-site at a licensed facility
- reuse from rainwater tanks collecting runoff from building roofs.

Groundwater supply impacts of this demand are further discussed in Section 6.3.3, with water licensing further discussed in Chapter 7.

5.4.2 Concrete batching

Concrete batching activities typically require good quality water. The quality of water from nearby groundwater bores may not be sufficient for use in concrete batching. For this reason, an allowance of 21 ML of potable water over the construction period has been considered for concrete batching activities. If the quality of groundwater is determined to meet the specifications for concrete production, then less potable water will be required, and it will be replaced with non-potable groundwater from nearby groundwater bores.

5.4.3 Accommodation facility and offices required for construction

i Water demand

The estimated water demand to support the construction workforce accommodation facility and construction offices for the project has been developed using typical guidance detailing applicable load rates for wastewater generation. The assumptions developed for the project's water demand estimate for the construction workforce accommodation facility and construction offices are provided in Table 5.1 (accommodation facility) and Table 5.2 (construction offices). In terms of wastewater loading, it is assumed that daily water demands will also inform typical wastewater loading.

Table 5.1 Construction workforce accommodation facility water demand and wastewater load

Aspect	Value	Details
Workforce numbers in accommodation	450 people	75% of the project's maximum workforce will use on-site accommodation
Assumed water demand and wastewater load	205 L/p/day	Including kitchen, laundry and accommodation amenities
Construction period	60 months	Stage 1 and 2
Total requirement	**166.1 ML (average 92.3. kL/day)**	Assumes residents remain 7 days per week

Table 5.2 Construction offices water demand and wastewater load

Aspect	Value	Details
Office workforce	10 people	Assumed allowance
Assumed office water demand and wastewater load	45 L/p/day	Including office kitchen, toilet, urinal and hand basin
Construction period	60 months	Stage 1 and 2
Total requirement	**702 kL (0.39 kL/day)**	Assumes workers present on-site 6 days per week

The total estimated water demand and wastewater load for the project from the construction workforce accommodation facility and offices has been estimated at approximately 167 ML over 60 months.

Water for the construction workforce accommodation facility and offices would be from potable sources, stored in dedicated water storage tanks located within the development footprint. Some non-potable water sources (such as groundwater bores) are appropriate to meet the demands of the facility (such as in toilets); however, this will be confirmed in the future stages of the project design. The potable water volumes for the project will be from existing approved potable water sources which will be trucked in via a commercial water provider.

Considering the potable water volume required for concrete batching activities, the total potable water demand for the project is estimated at 188 ML over 60 months.

ii Wastewater management

Wastewater management for the construction workforce accommodation facility and construction offices will be provided by an on-site treatment system. The system sizing will be based on refined versions of the estimates provided in Table 5.1 and Table 5.2 along with any other additional loads that may be determined during detailed design. The system will collect wastewater (blackwater and greywater) from kitchens, laundries, showers, toilets and basins for treatment and reuse on-site as a non-potable water.

The proposed treatment system will be a generally contained system and is anticipated to include mechanical screening, biological and chemical treatment, filtration and disinfection. The waste solids produced by the treatment system will be emptied by a licensed contractor and disposed of at a nearby council-operated wastewater treatment plant or other appropriately licensed facility.

Treated effluent suitable for reuse for construction purposes (anticipated to include dust suppression and earthworks conditioning) will be stored in sealed tanks or lined basins to avoid potential interaction with groundwater.

The on-site wastewater management and effluent reuse system is subject to further design development during detailed design and will:

- consider and confirm the most appropriate system for the project based on the preferred site layout, site conditions and constraints
- be designed, constructed, operated, maintained and decommissioned in accordance with best practise and relevant guidelines and standards (refer Section 3.3.8) and in consultation with Edward River and Murrumbidgee councils.

Following completion of construction activities, all temporary wastewater management infrastructure will be decommissioned and removed from the development footprint, and disturbed areas will be appropriately stabilised and rehabilitated.

5.4.4 Operations

The estimated ongoing operational water usage for the project is 5 ML/year, for in excess of 35 years. Water uses include permanent site amenities, fire protection and washing of equipment and plant.

During operations, water will continue to be sourced from groundwater sources via existing landowner bores; however, this will also be supplemented by other sources such as potable water trucked into site under commercial agreement and stored in tanks. Potable water will be used for specific purposes that require a higher standard of water.

It is expected that the project will be able to utilise the existing bores as a reliable ongoing source of water. An agreement between Spark Renewables and the landowner will be required.

Water will also be opportunistically sourced from rainwater tanks to minimise the need for imported water. Water may also be sourced opportunistically from existing landholder dams on minor streams, in accordance with harvestable rights.

Groundwater supply impacts of this demand are further discussed in Section 6.3.3, with water licensing further discussed in Chapter 7.

On-site treatment infrastructure will be used to treat sewage and will produce:

- treated effluent (i.e. water) suitable for reuse on-site, which will be stored in sealed tanks or lined basins
- waste solids, which will be emptied by a licensed contractor and disposed of at an appropriately licensed facility.

6 Impact assessment

6.1 Overview

Chapter 5 describes the proposed conceptual water management approach for the project. This chapter describes predicted residual impacts, on the basis that the proposed water management approach is implemented. Predicted impacts to water resources are assessed with respect to surface water and groundwater for construction and operation, in terms of:

- surface water quality and quantity
- flood risk
- watercourses and riparian corridors
- existing irrigation infrastructure
- groundwater levels and quality
- existing consumptive and environmental water use.

Water licencing is addressed in Chapter 7.

6.2 Surface water impacts

6.2.1 Water quality

i Construction

The primary risks to water quality during construction will occur as a result of:

- soil erosion and transport of sediment into receiving watercourses
- accidental spillage of fuel or other hazardous materials used to support construction activities
- poor or ineffective wastewater management practices
- entrainment of construction plant and/or materials in floodwaters.

If unmanaged, ground disturbance during earthworks and other site activities (e.g. material handling, installation of WTGs, new buildings, new substations, trenching for services and grading for new access roads) may lead to exposure of soils and potential erosion and mobilisation of sediment into receiving watercourses. The LRA has assessed this in detail and concludes that the key risks to the soil and land resources associated with the construction of the project, and accordingly risks to downstream water quality, can be effectively managed by proposed soil and water management measures. These measures are described in the LRA and summarised in Section 5.3 and will be further developed as part of detailed design and documented in the SWMP for the project.

Contamination of surface water as a result of accidental spillage of materials such as fuel, lubricants, herbicides and other chemicals used to support construction activities could also adversely impact water quality. Appropriate controls to effectively manage these activities, consistent with best practice and relevant guidelines, will also be incorporated in the SWMP.

Water quality could also be impacted during construction as a result of poor or ineffective wastewater management practices. This risk will be addressed by further design development to confirm an appropriate location and configuration for a temporary wastewater management system for the project based on site conditions and constraints, and to implement the system and on-site effluent reuse in accordance with best practise and relevant requirements, standards and guidelines. Direct discharge of wastewater or treated effluent to receiving watercourses will be avoided. The waste stream from the treatment plant will be collected and transported off-site to an appropriately licensed disposal facility. Appropriate protocols for wastewater management will be incorporated in the SWMP or similar.

In the event of flooding that impacts construction work sites or compounds, either as a result of mainstream flooding along watercourses or local overland flooding, there is potential for entrainment of sediment, vegetation, plant/equipment, hazardous substances/chemicals and other debris in floodwaters that is carried downstream. This risk can be adequately managed by suitable construction site planning that considers flood risk, avoids use of higher risk areas (i.e. subject to more frequent and/or severe flooding) and implements suitable controls for areas subject to lower risk (i.e. less frequent and/or less severe flooding). Appropriate protocols for minimising potential flood entrainment of materials will be incorporated in the SWMP (as described in Section 5.3).

Overall, potential impacts to water quality during construction are considered minor and manageable with proposed mitigation measures in place.

ii Operation

The primary risks to water quality during operation will occur as a result of:

- soil erosion and transport of sediment into receiving watercourses
- discharge of stormwater contaminated with hydrocarbons from the substation and switch yard sites
- accidental spillage of fuel or other hazardous materials used to support operational activities
- poor or ineffective wastewater management practices.

The key risk to water quality during operation will occur as a result of poor site stabilisation, poor reestablishment of ground cover revegetation, or instream erosion due to failed channel lining within engineered diversions. The occurrence of these risks will lead to ongoing exposure of soils and potential erosion and mobilisation of sediment into receiving watercourses. The LRA assesses this in detail and concludes that the key risks to the soil and land resources associated with the operation of the project, and risks to downstream water quality, can be effectively managed by proposed soil and water management and site rehabilitation measures. These measures are described in the LRA and will be further developed and documented in an operational SWMP or similar.

Potential discharge of stormwater contaminated with hydrocarbons from the substation and switch yard sites will be avoided by implementing suitable operational phase controls including separation of clean and oil-contaminated runoff, bunding of oil-contaminated areas and provision of treatment devices to remove oil/grease, hydrocarbons and sediment from runoff prior to discharge to the downstream drainage system.

Contamination of surface water as a result of accidental spillage of materials such as fuel, lubricants, herbicides and other chemicals used to support maintenance activities could also adversely impact water quality. Appropriate controls to effectively manage these activities, consistent with best practice and relevant guidelines, will also be incorporated in the operational SWMP.

On-site treatment infrastructure will be used to treat sewage and will produce:

- treated effluent (i.e. water) suitable for reuse on-site, which will be stored in sealed tanks or lined basins
- waste solids, which will be emptied by a licensed contractor and disposed of at an appropriately licensed facility.

Any hydrocarbons captured at the substation and switch yard sites will be collected and transported off-site for disposal at a suitable licensed facility.

Appropriate protocols for wastewater handling and transport will be incorporated in the operational SWMP.

Overall, potential impacts to water quality during operation are considered minor and manageable with proposed management measures in place.

6.2.2 Water quantity

i Construction

During construction, there is the potential for a temporary increase in site runoff as a result of clearing, earthworks, compaction of soils and installation of impervious surfaces, leading to additional runoff leaving the development footprint and impacting downstream properties and receptors.

However, potential construction phase impacts to site runoff volumes and rates are considered minor and manageable with implementation of temporary water and soil management measures that are described in Section 5.3.1. All temporary works will be designed to account for any short-term changes to catchment areas, runoff potential and flow paths that may be required during construction. Stormwater runoff from buildings will be captured in rainwater tanks for use on-site where practical to minimise demand for imported water, which will also assist in reducing minor increases in runoff from the development footprint.

ii Operation

The potential for surface water impacts downstream of the project associated with hydrologic changes due to increased runoff rates from proposed new impervious surfaces is considered negligible. Overall, the project is expected to result in no measurable net change to overall site runoff potential, provided stabilisation and revegetation recommendations identified in the LRA are implemented.

Where a concentration of runoff may occur due to the project, impacts of this discharge to the receiving environment are expected to be localised (e.g. culvert under an access track or clean water diversion bunding).

6.2.3 Flood risk and impacts

i Construction

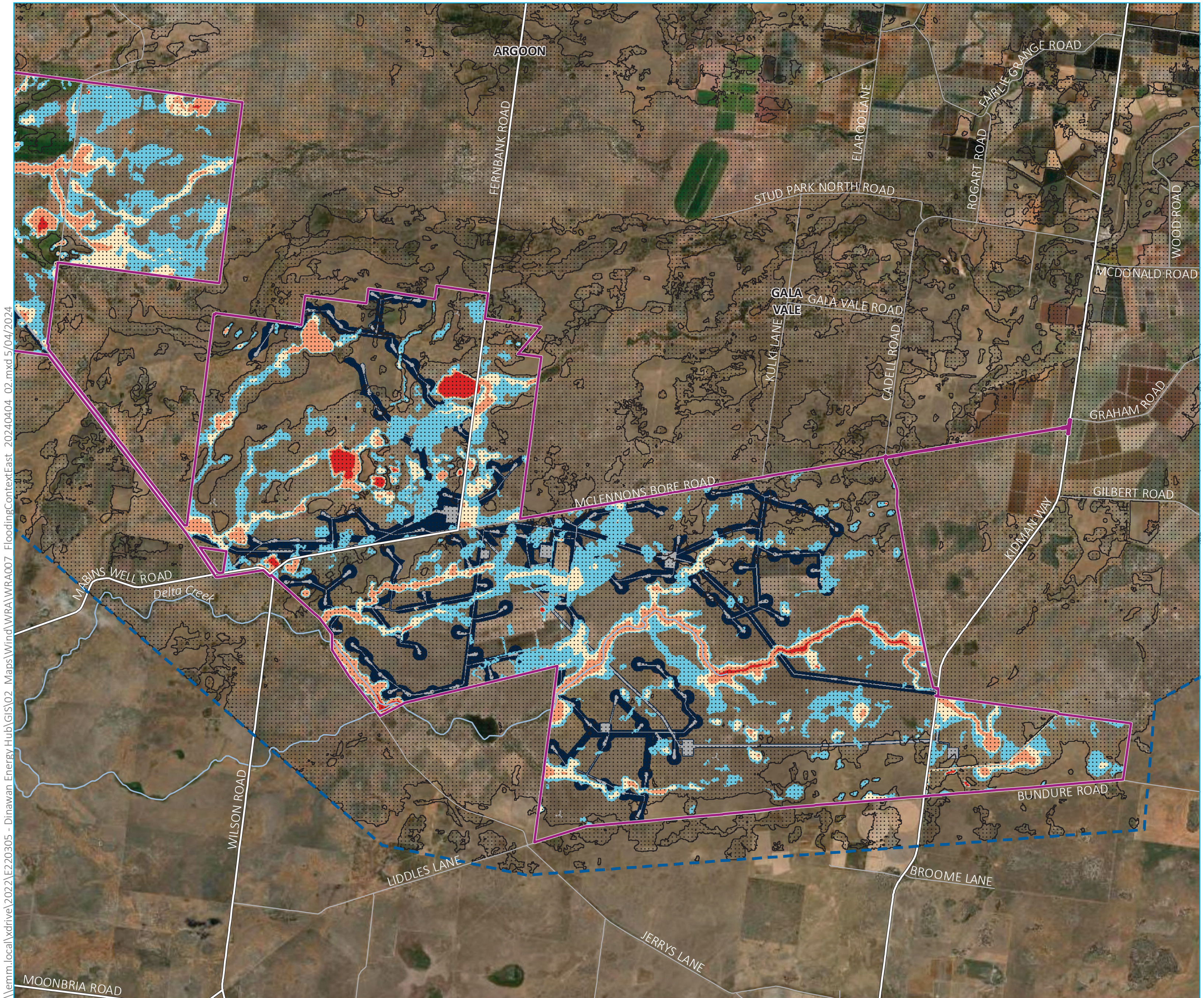
During construction, there is potential for inundation of site works, compounds, storage areas and plant/equipment if these are located within flood prone areas, which could lead to undesirable flooding impacts either off-site or within the project area. Flooding conditions may also present a safety hazard to construction workers.

Figure 6.1 and Figure 6.2 overlays the project area, development corridor and development footprint with modelled flooding conditions. Extents and depths of flooding are presented for the 1% AEP event, with the upper limiting flood extent (i.e. PMF event) also shown for context.

The figures demonstrate that the development footprint generally lies outside the 1% AEP flood extent following consideration of flooding constraints during preliminary design. A number of services and access corridors cross predicted flooding flow paths; however, flooding at these interactions is typically shallow (in the order of 0.1–0.3 m) and low hazard (H1, as described in Section 4.5.5). On this basis, there is low potential for adverse flooding impacts either within or downstream of the development footprint for events up to 1% AEP.

Residual flood risks can be adequately managed by suitable construction planning giving due consideration to flood risk, including for events larger than 1% AEP, which will occur as part of future detailed design. This will consider:

- appropriate placement of temporary works, plant, materials and workforce facilities
- development of appropriate watercourse crossing designs and construction methods that consider local hydraulic conditions, minimise local flooding impacts and are consistent with relevant guidelines
- development of a FMP or similar, to describe required site management and protocols in the event of flood events that could impact construction sites or access.



KEY

- Project area
- Development footprint
- Development corridor
- PMF flood extent
- Model boundary

1% AEP flood depth (m)

- 0.1-0.3
- 0.3 - 0.5
- 0.5 - 1
- >1

Existing environment

- Major road
- Minor road
- Watercourse (third order and higher)

Source: EMM (2024); DFSI (2020, 2021); ESRI (2024); GA (2011)

0 2.5 5 km

GDA2020 MGA Zone 55

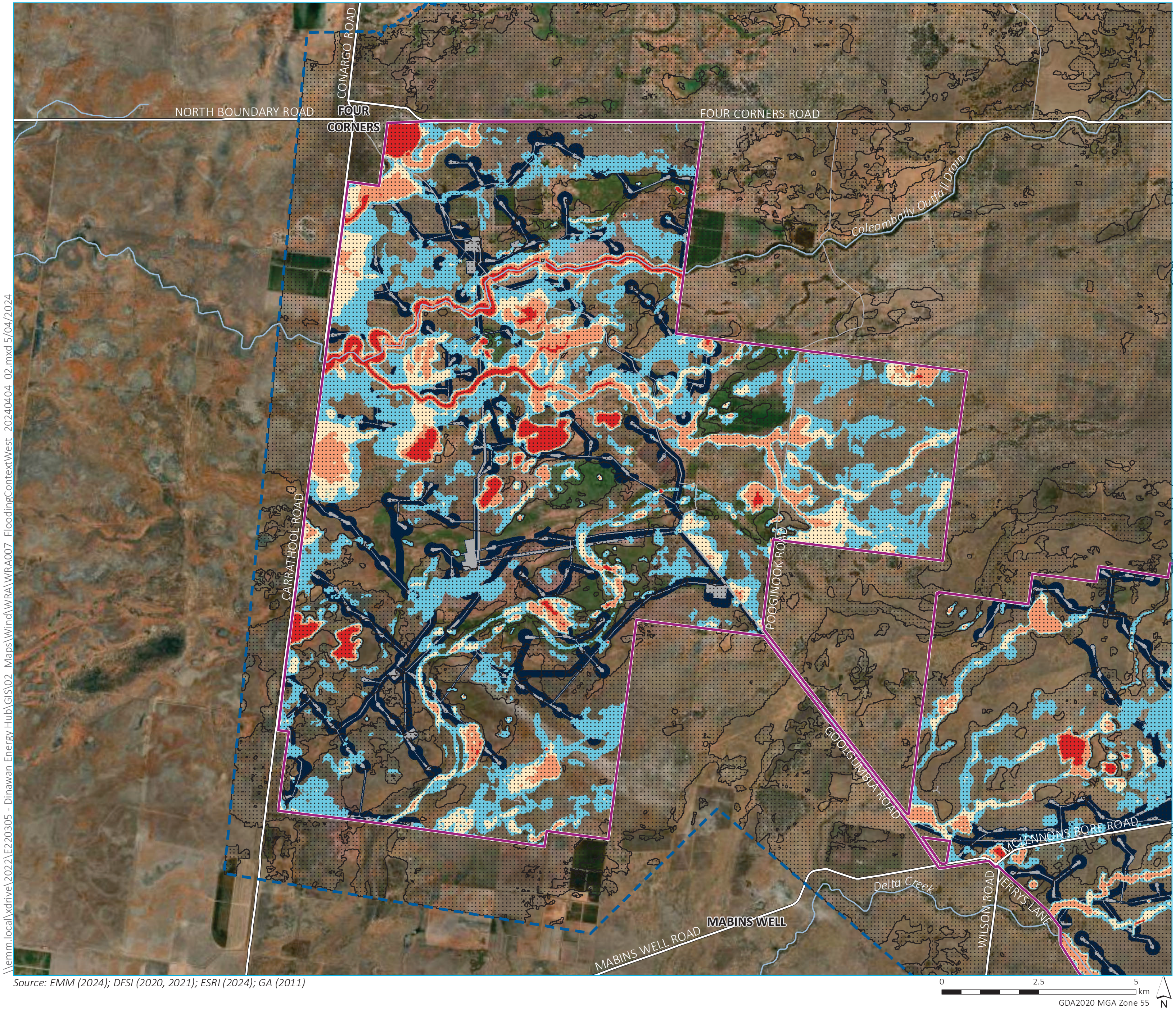
N

\\emm.local\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\WRA\WRA007_FloodingContextEast_20240404_02.mxd 5/04/2024

Flooding context – Stage 1 East

Dinawan Wind Farm
Water Resources Assessment
Figure 6.1

EMM
creating opportunities



\\emm.local\xdrive\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\Wind\WRA\WRA007_FloodingContextWest_20240404_02.mxd 5/04/2024

KEY
- Project area
- Development footprint
- Development corridor
- PMF flood extent
- Model boundary

1% AEP flood depth (m)
- 0.1-0.3
- 0.3 - 0.5
- 0.5 - 1
- >1

Existing environment
- Major road
- Minor road
- Watercourse (third order and higher)

Source: EMM (2024); DFSI (2020, 2021); ESRI (2024); GA (2011)

Flooding context – Stage 2 West

Dinawan Wind Farm
Water Resources Assessment
Figure 6.2

EMM
creating opportunities

ii Operation

During operation, there is the potential for inundation of permanent infrastructure if these areas are located within flood prone areas. This could also lead to undesirable flooding impacts either off-site or within the project area. Flooding conditions may also present a safety hazard for staff or visitors to the site.

Preliminary design has considered flooding constraints and makes appropriate responses in terms of avoiding works generally in areas impacted by significant flooding for events up to 1% AEP (Figure 6.1 and Figure 6.2). Sensitive infrastructure (including the collector substations) has been sited outside the mapped 1% AEP flood extent. Shallow inundation of the development corridor is expected to have negligible impact on broader flooding conditions and potential for adverse flooding impacts due to the minimal obstruction to floodwaters presented by most infrastructure proposed as part of the project. On this basis, there is low potential for adverse flooding impacts either within or downstream of the development footprint for events up to 1% AEP. However, due to the nature of drainage patterns within the project area, some mitigation measures are necessary in order to appropriately locate flood sensitive infrastructure.

Residual flood risks and the potential for adverse flooding impacts including for events larger than 1% AEP can be adequately managed through the implementation of the proposed water management approach provided in Section 5.3.

The development footprint has been selected considering the existing flooding constraints of the area. Therefore, the project is considered to be compatible with the flood hazard, in that the majority of the infrastructure areas are either free of flooding or subject to low flood hazard (H1) that is generally safe for people, vehicles and buildings for events up to and including the 1% AEP.

6.2.4 Watercourses and riparian corridors

i Watercourses

On the basis that significant changes to flow regimes and water quality will be avoided, the primary risk to watercourses during construction and operation relates to direct physical disturbance.

The number of required watercourse crossings has been minimised through the utilisation of the existing access roads and tracks of the existing agricultural operations. Where instream works are proposed (i.e. construction or upgrade of watercourse crossings), these works will be designed and constructed to consider local hydraulic conditions, minimise local flooding impacts, and will be consistent with relevant guidelines (specifically those outlined in Sections 3.3.1 and 3.3.2).

Where the project requires crossing of existing irrigation infrastructure, this has not been considered to be a watercourse crossing and not subject to relevant guidelines; however, any use of these structures will be undertaken in consultation with the infrastructure owner (i.e. CICL).

ii Riparian corridors

The outcomes of a detailed mapping exercise to assess the extent of waterfront land and associated vegetated riparian zones (VRZs) for all mapped watercourses within the development footprint is presented in Figure 6.3. This was determined in accordance with DPE (2022a) and included assessment of top of bank levels and channel widths based on available light detection and ranging (LiDAR) survey and supported by site observations.

It is expected that adverse impacts to riparian corridors will be avoided because where instream works (i.e. activities within the mapped corridor) are proposed, these works will be designed and constructed to consider local hydraulic conditions, minimise local flooding impacts, and will be consistent with relevant guidelines.

Several mapped watercourse reaches (excluding irrigation channels, shown in Figure 6.3) are proposed to have interactions with project components within the development corridor and development footprint. An interaction occurs where a project component crosses a mapped watercourse or riparian zone. Project components, primarily access tracks and electrical infrastructure, will cross watercourses or be developed within the riparian zone at approximately 29 locations. These include 25 first or second order watercourses and 4 higher order (third order or greater) watercourses. Many of the first and second order mapped watercourses have no definable bed or banks and/or negligible riparian zone and hence have not been considered further, as there will be negligible impacts from siting project components in these areas.

Ten locations were identified as needing further evaluation based on a combination of predicted flood extents (using 5% AEP flood model outputs) and stream order. The interaction between project components and predicted flood extents at these locations has the potential to result in localised changes in flow paths and instream velocity. The interaction between project components with select watercourses was evaluated against the specific project component and the condition of the watercourse. The identified watercourse interactions are considered in Table 6.1 and shown on Figure 6.3.

Table 6.1 Areas of development corridor within or adjacent to VRZ

Area	Interaction identifer[1]	Stream order	Project component	Condition assessment
Stage 1 East	1 – EAST	1st order	Transmission line	Modified and degraded riparian vegetation associated with historical land use practices.
	2 – EAST	2nd order	Transmission line	
	3 – EAST	1st order	WTG and associated infrastructure	
	4 – EAST	1st order	WTG and associated infrastructure	
	5 – EAST	1st order	WTG and associated infrastructure	
	6 – EAST	3rd order	Site access and electrical cabling	Partially within riparian zone; however, outside remnant vegetation.
	7 - EAST	3rd order	Transmission line	Modified and degraded riparian vegetation associated with historical land use practices
Stage 2 West	1 – WEST	2nd order	WTG and associated infrastructure	Modified and degraded riparian vegetation associated with historical land use practices.
	2 – WEST	Greater than 3rd order	Site access and electrical cabling	Coleambally Outfall Drain is a man-made structure. The watercourse has its margin controlled with earthen batters and bunding. Due to its man-made nature, the watercourse is expected to provide limited environment value.
	3 - WEST		Site access and electrical cabling	

Notes: 1. Interaction identifier aligns with labels shown on Figure 6.3.

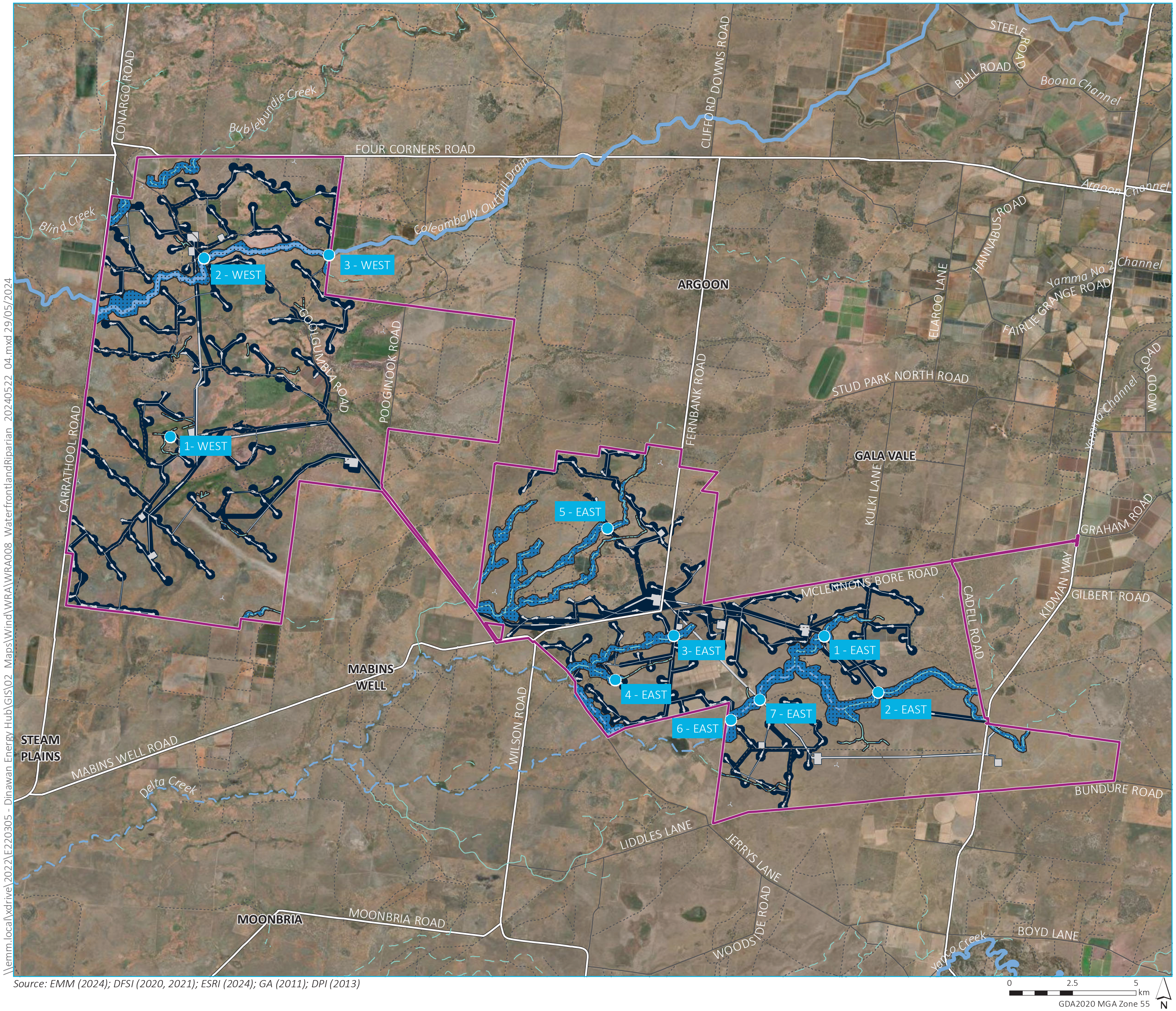
The placement of WTGs and ancillary infrastructure within third order and higher (i.e. non-minor) watercourses, and crossings of these watercourses for internal access tracks and electrical cabling, have been minimised to the extent practicable. Based on the evaluation of watercourse interactions in Table 6.1, project components are unlikely to create a significant impact on instream condition or riparian corridors at these locations.

During detailed design, micro-siting of project components within the development corridor that interact with watercourses will be in accordance with the fact sheet *Controlled activities – Guidelines for riparian corridors on waterfront land* (DPE 2022a). Project components can be located within the outer 50% vegetated riparian corridor, where the average width of the vegetated riparian zone can be achieved for each watercourse, and provided an equivalent area connected to each riparian corridor is offset. The project's potential use of the outer portion of the riparian corridor will be determined as required considering the detailed siting of project components within the development corridor.

6.2.5 Irrigation infrastructure

All existing irrigation infrastructure (e.g. channels and dams), located within the development corridor, will be considered further in infrastructure siting during detailed design.

Where the project is required to cross existing irrigation infrastructure, crossing options available include an overhead or underground (installed by horizontal directional drill methodology). Depending on the width of the crossing required, the preferred crossing method will be spanning the infrastructure overhead with an aerial crossing where spanning widths can be significant. Spark Renewables has had initial conversations with CICL to discuss crossing irrigation infrastructure, especially the two bridges (refer to 2-WEST and 3-WEST in Table 6.1 and Figure 6.3) located in the northern section of Stage 2.



Source: EMM (2024); DFSI (2020, 2021); ESRI (2024); GA (2011); DPI (2013)

Waterfront land and riparian zones

Dinawan Wind Farm
Water Resources Assessment
Figure 6.19

EMM creating opportunities

Spark Renewables will further consult with CICL regarding crossings of the irrigation infrastructure during detailed design and will agree designs, construction methods and timing prior to construction.

Where irrigation infrastructure (such as open channels and dams) is removed for the project, it would be reinstated at the completion of the project in consultation with the relevant landowner. Irrigation infrastructure located outside the development footprint (i.e. infrastructure associated with CICL) will be retained and no adverse impacts to operation or maintenance of this infrastructure are anticipated. Any necessary works within a nominated easement of the infrastructure will be undertaken in consultation with CICL as the asset owner.

6.3 Groundwater impacts

6.3.1 Groundwater levels

i Construction

The project will require excavation below existing surface levels to establish suitable foundation conditions for infrastructure, and for the installation of underground services. Excavations will be approximately 3 to 5 mbgl (to be determined in detailed design and based on geotechnical conditions). This depth of excavation is unlikely to interact with productive groundwater resources of the area. For comparison purposes, existing groundwater levels based on continuous datasets from registered irrigation bores in the vicinity of the project area are typically between approximately 15 to 40 mbgl (Figure 4.8).

Based on the data presented in Figure 4.8 and the evaluation of the water level within other registered bores within 5 km of the project area, groundwater is not expected to be intercepted by excavations. Any small incidental volumes collected will be recorded, managed and beneficially reused on-site.

Water use for construction from existing approved groundwater works are further discussed in Section 6.3.3. Groundwater licensing implications for the project are outlined in Section 7.3.

ii Operation

The introduction of impervious surfaces for selected site infrastructure will lead to a very small reduction in the infiltration of stormwater runoff to the underlying soils and recharge of groundwater. However, this will have a negligible impact on groundwater levels or availability to existing users (including GDEs) owing to the very small impacted area compared to the overall recharge area.

Water use for operations from existing approved groundwater works are further discussed in Section 6.3.3.

6.3.2 Groundwater quality

The primary risk to groundwater quality during construction and operations will occur as a result of accidental spillage of wastewater, fuel or other hazardous materials used to support site activities that may infiltrate through soils to groundwater.

Potential infiltration of treated wastewater to groundwater will be avoided by use of sealed storage tanks or lined basins for effluent storage prior to reuse or disposal off-site.

Appropriate controls to effectively manage these activities, consistent with best practice and relevant guidelines, will be incorporated in the SWMP or similar.

6.3.3 Groundwater supply

The project will use groundwater available from existing landowner bores to meet both construction and operational non-potable water demands. The details of the approved works are summarised in Table 6.2. Groundwater bore locations are shown on Figure 4.7.

Table 6.2 Groundwater works proposed to be used by the project

Works approval	Approval number	Documented works description	Location of works	Nominated works purpose	Licence expiry	Bore ID	Bore yield recorded at construction
Water supply works and water use	50CA503992	Extraction groundwater works 1 x bore (no size nominated)	Delta Park Lot 144 / DP756418	Irrigation	30/9/2029	GW401211	265 L/s
	50CA503997	Extraction groundwater works 1 x bore (408 mm)	Hawks Nest Lot 1 / DP593484	Irrigation	26/2/2031	GW062049	157 L/s
	50CA504004	Extraction groundwater works 3 x bores (457 mm, 130 mm and 460 mm)	Goolgumbla Merino Stud Lot 13 / DP756299 Lot 14 / DP756257	Irrigation, Stock and Domestic	14/5/2028	GW065059	227.5 L/s
						GW414356	160 L/s

The WALs and entitlements connected with the above works are summarised in Table 6.3.

Table 6.3 Groundwater allocation proposed to be used by the project

Nominated works approval	Water access licence number	Licence category	Water source	Entitlement (units)
50CA503992	11874	Aquifer	Lower Murrumbidgee Deep Groundwater Source	1,091
50CA503997	11876	Aquifer	Lower Murrumbidgee Deep Groundwater Source	743
50CA504004	11879	Aquifer	Lower Murrumbidgee Deep Groundwater Source	1,857

From Table 6.3, there is a total of 3,691 unit shares of water entitlement linked to four existing bores, under three water supply works and water use approvals (Table 6.2), within the project area that are proposed for construction and operations water supply. The predicted non-potable construction and operations usage volumes are 176 ML over 60 months and 5 ML/yr, respectively. Therefore, it is anticipated that there is sufficient access to groundwater to meet non-potable demands, and that the extraction volumes (and associated impacts) predicted for the project are consistent with the current approved use and entitlements linked to the bores. The risk to the groundwater environment from the proposed supply of water to the project is low and further assessment from the nominated bores has been determined not to be necessary. This determination is based on the fact that the likely demands for the project will fall within the available water entitlements and the documented individual groundwater yields of each of the individual bores.

The record of water taken (via metering and data logger installation) through the existing groundwater bores will be required by all users in accordance with the water supply works and licence conditions and the NSW Non-Urban Water Metering Policy (DPIE 2020b).

6.3.4 Impacts to existing groundwater users

The project construction activities are not anticipated to intersect the regional water table. Therefore, existing registered bores in the vicinity of the project will not be impacted. Similarly, the availability of groundwater to GDEs mapped in the vicinity of the project area is unlikely to be impacted.

6.4 Assessment against WQOs and RFOs

Table 6.4 assesses the performance of the proposed water management system against the WQOs and RFOs.

Table 6.4 Assessment against NSW Water Quality and River Flow Objectives

Environmental value	Objective	Potential impacts
WQO		
Aquatic ecosystems	Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.	No material impacts to water quality objectives are anticipated as the water quality of runoff leaving the project is expected to be similar to the water quality of the receiving environment during discharge.
Visual amenity	Aesthetic qualities of waters.	
Livestock water supply	Protecting water quality to maximise the production of healthy livestock.	
Irrigation water supply	Protecting the quality of waters applied to crops and pasture.	
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	
RFO		
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems.	No material impacts to river flow objectives are anticipated as the quantity and timing of runoff leaving the project is expected to be similar to that which currently occurs.
Mimic natural drying in temporary waterways	Mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways.	
Maintain natural flow variability	Maintain or mimic natural flow variability in all streams.	
Manage groundwater for ecosystems	Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.	No material impacts to groundwater are expected. Groundwater will form a source of non-potable water supply for the project; however, this is proposed to be temporary and consumed as part of an existing landowner entitlement linked to approved works.
Minimise effects of weirs and other structures	Minimise the impact of instream structures.	Watercourse crossings and instream works, where required, will be designed, and constructed to minimise potential impacts to watercourses and water quality.

7 Water licensing

7.1 Overview

This section sets out water licensing requirements for the project.

7.2 Surface water

Stormwater reuse is likely to be undertaken during construction, in line with best practice water management described in Chapter 5. This will include:

- harvesting and reuse of stormwater runoff from roof areas using rainwater tanks
- extraction and reuse of water from construction sediment basins.

These forms of water extraction (or water take) are defined as 'excluded works' under the WM Regulation and, therefore, licensing is not required.

It is proposed also to source water opportunistically during construction and operation from existing landholder dams in accordance with harvestable rights, in order to further minimise demand for imported water. Licensing of water will not be required provided the total volume of dams used for such purposes is within the MHRDC, and otherwise comply with the applicable harvestable rights order.

No other surface water take is proposed. Accordingly, the project is not expected to have any requirements for surface water licensing.

7.3 Groundwater

An exemption under the WM Regulation applies to the need for licensing of incidental groundwater take of 3 ML or less per year in any water source. This would apply to any groundwater entering excavations during construction. Regional groundwater within the project area is anticipated to be at least 20 to 30 mbgl. Given the depth of groundwater, it is expected that any incidental groundwater take will be under the 3 ML exemption and, therefore, will not require licensing.

Incidental groundwater inflows into excavations will be monitored, recorded and reported during construction in accordance with WM Regulation requirements and a WAL and appropriate entitlement obtained in advance within the water year should the 3 ML per year threshold be exceeded.

Groundwater take via bores for construction water supply purposes is proposed, as described in Section 5.4.1. Groundwater bores can provide a suitable water source for the project from a licensing perspective as there are existing linked WALs to water supply works approvals. However, the approved use for both water supply works (bores) is currently only for irrigation. A change in use/purpose to enable the addition of commercial (wind farm construction and operation) use for the water supply works approvals would need to be applied for before using these bores. The change in use/purpose is not expected to introduce any environmental risk due to the water historically used for irrigation within the region and the proposed use being subject to construction and operational environmental management plans, which will include appropriate water management requirements.

8 Cumulative impacts

Proposed, approved, under construction and operational renewable energy developments (known at the time of EIS preparation) within, and in the vicinity of, the South-West REZ have the potential to create a cumulative impact on water resources. There are 20 renewable energy generation projects at various stages (e.g. proposed, approved, operational) within 100 km of the project area, including a combination of solar farms, wind farms and BESSs.

Key cumulative impacts to water resources include potential changes to water quality and water use. With regards to water quality impacts, the project area and receiving environment is relatively disconnected to the regional surface water system. For this reason, other surrounding projects, proposed, approved or operational, are unlikely to share common receptors. Regardless, the potential impacts to water quality from the project are expected to be minor with the implementation of the recommended management and mitigation measures.

In regard to water use for the project, the proposed sources of non-potable groundwater are subject to existing approvals and involve the repurpose of existing allocation within the relevant water source. The project's non-potable usage of water will not be an introduced demand on the region and, therefore, will not create a cumulative impact. Other than non-potable supply of groundwater for the project, there are no other potential impacts to groundwater expected due to the project.

The supply of potable water to the project during construction is subject to the creation of new supply agreements from existing approved sources. Due to the uncertainty of timing for the construction of other renewable energy generation projects, the cumulative demand on these potable sources of water, whilst possible, is currently unknown and subject to consultation with suppliers.

9 Management and mitigation measures

A summary of the proposed measures to manage and mitigate potential impacts to surface water and groundwater is provided in Table 9.1.

Table 9.1 Consolidated management and mitigation measures

Reference	Management/mitigation measure	Timing
Stormwater management		
W1	Develop a SWMP to address temporary and site-specific risks to surface water and groundwater during construction. Key stormwater management principles will include: • Appropriate siting of proposed infrastructure within the development footprint, which will minimise disturbance to existing drainage lines and overland flow paths. • Earthworks will aim to maintain the prevailing surface gradients and fall towards existing drainage lines, to minimise changes to existing flow paths. • Provision of general surface drainage infrastructure comprising: – Diversion of upslope runoff around infrastructure. – Surface drainage measures as required to control runoff generated within the development footprint, minimise soil erosion potential and direct runoff towards receiving drainage lines. Sheet flow conditions will be maximised, and construction of diversion drains, channels and table drains to be minimised to the extent practicable. – Suitable treatments will be used to armour earthwork batters and site drainage as needed for scour protection and to achieve stable waterways where flow concentrations cannot be avoided. – Maintain existing flow paths where possible and minimise catchment diversions, with the objective of minimising changes to flow regimes in receiving watercourses. • Prompt stabilisation of disturbed areas and progressive rehabilitation as early as practicable. • Maintaining drainage, erosion and sediment control measures. • Monitoring and adjustment protocols for drainage, erosion and sediment control practices to achieve the desired performance standard. • Stormwater runoff from buildings will be captured in rainwater tanks for use on-site, to minimise demand for imported water. • Implement procedures for hazardous material storage and spill management as defined in applicable guidelines (Section 3.3.6). • Maintain spill kits on-site at all times during construction and operation. • Consider weather preparedness and response planning. • Identify requirements for monitoring and maintenance of water management and drainage systems.	Pre-construction
W2	Specific stormwater management measures for the substation and switchyard areas will include: • diversion of clean runoff away from potentially oil-contaminated areas • bunding of potentially oil-contaminated areas • provision of stormwater treatment device(s) to remove oil/grease, hydrocarbons and sediment from runoff prior to discharge to the downstream drainage system.	Pre-construction
W3	Specific stormwater management measures for the concrete batching plants during construction will include: • diversion of clean runoff away from cement and concrete handling areas and stockpiles • maximising recycling of process wastewater, with dedicated storages for excess wastewater that will be manually emptied via vacuum truck and disposed of off-site • bunded areas for refuelling.	Pre-construction

Table 9.1 Consolidated management and mitigation measures

Reference	Management/mitigation measure	Timing
W4	The SWMP will be updated to address ongoing site-specific risks to surface water and groundwater during operations. This will address: • rehabilitation of temporary works and construction disturbance areas not utilised for operations • continuation and maintenance of stabilised and vegetated surfaces, drainage and sediment and erosion control measures that will be retained for operations.	Operation
Erosion and sediment control		
W5	Implementation of erosion and sediment control measures and site rehabilitation and revegetation in accordance with best practice comprising *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom 2004) and *Volume 2A* (DECC 2008) and *Best Practice Erosion and Sediment Control* (IECA 2008). The LRA describes a range of proposed measures for adoption. Proposed measures will be considered further and formalised as part of detailed design and will form part of the SWMP.	Pre-construction
W6	PESCPs will be developed for all discrete disturbance areas.	Pre-construction
Flood risk management		
W7	Develop and implement an FMP to describe site management and protocols in the event of flood events that could impact construction sites or access, including: • suitable early warning/prediction measures and communication protocols • site preparedness activities and procedures • triggers for closure, evacuation and recovery • emergency response and support.	Pre-construction
W8	Construction site planning at detailed design stage to: • consider flood risk and adopt appropriate placement of temporary works, plant, materials and workforce facilities, that gives due consideration to overland flow paths and mainstream flood risk • ensure that temporary works minimise off-site flooding impacts as far as practical.	Pre-construction/ construction
W9	As per current project layout, design and construction of permanent works to: • Locate sensitive infrastructure (e.g. substations) on high ground above 1% AEP event flood levels (or other suitable level of flood immunity as may be determined during detailed design) and avoid or otherwise divert local overland flow paths around infrastructure. • Ensure finished ground levels are constructed at-grade and not materially higher than existing levels in areas subject to existing mainstream flooding, in order to minimise potential off-site flooding impacts as far as practical. Where a change in ground level is proposed in areas, as part of future design stages or refinements, assessment of the change should be quantified to confirm off-site flooding impacts do not occur. If changes in the project layout or changes in the landform are required and there is a risk of flooding, then the FMP should include remodelling to confirm the flood behaviour due to the project.	Pre-construction/ construction
W10	Update FMP to describe required site management and protocols in the event of flood events that could impact ongoing operations.	Operation
Watercourse crossings and stormwater outlets		
W11	Watercourse crossings and stormwater outlets to be designed and constructed to: • consider the appropriate level of serviceability and flood immunity required for the project • consider local hydraulic conditions and minimise scour potential • minimise local flooding impacts • be consistent with relevant guidelines outlined in this WRA.	Construction

Table 9.1 Consolidated management and mitigation measures

Reference	Management/mitigation measure	Timing
Interactions with existing irrigation infrastructure		
W12	Removal of private irrigation infrastructure within the development footprint to be confirmed with relevant landowners. If infrastructure is removed for the project this will be reinstated following the project, or as otherwise agreed with landowners.	Pre-construction/ construction/ rehabilitation
W13	Spark Renewables will continue to consult with CICL regarding cable crossings of irrigation infrastructure during detailed design and will agree designs, construction methods and timing prior to their implementation.	Pre-construction /construction
Water supply		
W14	All relevant water licensing and approvals will be obtained to support water supply arrangements for construction and operation.	Pre-construction/ construction/ operation
Wastewater management and effluent reuse		
W15	Temporary and permanent on-site wastewater management and effluent reuse systems will: • be appropriate for each site based on consideration of the project layout, site conditions and relevant environmental constraints (e.g. sensitive surface or groundwater water features) • be designed, constructed, operated, maintained and decommissioned in accordance with best practise and relevant guidelines and standards and in consultation with relevant Council.	Pre-construction/ construction/ operation

10 Conclusion

Potential water related impacts associated with the project were assessed, including impacts to:

- surface water quality, quantity, flooding and impacts to watercourses and riparian corridors
- groundwater levels, quality and impacts to existing groundwater users.

Overall, potential surface water and groundwater impacts during construction and operation are considered minor and can be adequately managed through the implementation of the recommended management and mitigation measures.

References

AEMI (2014), *Australian Emergency Management Handbook 7, Technical flood risk management guideline – flood hazard*, Australian Emergency Management Institute

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

Biosis (2024), *Dinawan Wind Farm Biodiversity Development Assessment Report*. Report prepared by Biosis for EMM.

BoM (2022a), *Climate statistics for Australian locations*. Bureau of Meteorology, Australian Government. Available: http://www.bom.gov.au/climate/data/index.shtml

BoM (2022b), *Groundwater Dependent Ecosystem Atlas*. Bureau of Meteorology, Australian Government. Available: http://www.bom.gov.au/water/groundwater/gde/

BoM (2023a), *Maps of average conditions*. Bureau of Meteorology, Australian Government. Available: http://www.bom.gov.au/climate/maps/averages/

BoM (2023b), *Australian Groundwater Insight*, Bureau of Meteorology, Australian Government. Available: http://www.bom.gov.au/water/groundwater/insight/#/overview/introduction

CICL (2022), *Brief overview of CICL*, Coleambally Irrigation Co-operative Limited. Available: Brief Overview — Coleambally Irrigation (colyirr.com.au)

CSIRO and BoM (2021), *New South Wales and ACT's Changing Climate*. Available: https://www.climatechangeinaustralia.gov.au/en/changing-climate/state-climate-statements/new-south-wales-act/ , CSIRO and Bureau of Meteorology, Australian Government

DIPNR (2005) *Floodplain Development Manual: the management of flood liable land*, Department of Infrastructure, Planning and Natural Resources, NSW Government

DPE (2019) *Murrumbidgee Alluvium Water Resource Plan, Resource Description, Appendix A*, September 2019, NSW Department of Planning and Environment

DPE (2020) *NSW Landuse 2017 mapping v1.2*, Department of Planning and Environment, Parramatta.

DPE (2022a) *Controlled activities – guidelines for riparian corridors on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/173814 dated May 2022

DPE (2022b) *Controlled activities – guidelines for watercourse crossings on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/159001 dated May 2022

DPE (2022c) *Controlled activities – guidelines for outlet structures on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/159009 dated May 2022

DPE (2022d) *Controlled activities – guidelines for instream works on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/159006 dated May 2022

DPE (2022e) *Murrumbidgee Alluvium Water Resource Plan, GW9 Water Resource Plan area*, July 2022, NSW Department of Planning and Environment

DPE EES (2022) *Flood Risk Management Manual*, NSW Department of Planning and Environment (Environment, Energy and Science Division)

DPE Water (2022a) *Groundwater Assessment Toolbox for Major Projects in NSW*, NSW Department of Planning and Environment – Water group

DPE Water (2022b) *Guidelines for Groundwater Documentation for SSD/SSI projects*, Groundwater Assessment Toolbox for SSD/SSI, NSW Department of Planning and Environment – Water group

DPE Water (2022c) *Minimum Groundwater Modelling Requirements for SSD/SSI Projects*, Groundwater Assessment Toolbox for SSD/SSI, NSW Department of Planning and Environment – Water group

DPE Water (2022d) *Cumulative Groundwater Impact Assessment Approaches*, Groundwater Assessment Toolbox for SSD/SSI, NSW Department of Planning and Environment – Water group

DPE Water (2022e) *Spatial Layer of HEVAE Vegetation Groundwater Dependent Ecosystems Value in NSW*, Available: https://datasets.seed.nsw.gov.au/dataset/hevae-vegetation-groundwater-dependent-ecosystems-in-nsw

DPIE (2020a) *NSW River Styles database*, NSW Department of Planning, Industry and Environment. Available: https://www.industry.nsw.gov.au/water/science/surface-water/monitoring/river-health/river-styles

DPIE (2020b) *NSW Non-Urban Water Metering Policy*, NSW Department of Planning, Industry and Environment. Available: https://water.dpie.nsw.gov.au/__data/assets/pdf_file/0017/312335/nsw-non-urban-water-metering-policy.pdf

DPI (2013) *Policy and guidelines for fish habitat conservation and management – Update 2013*, NSW Department of Primary Industries

DPI (2023) *Fisheries NSW Spatial Data Portal*, NSW Department of Primary Industries. Available: https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal

DPI Water (2012) *NSW Aquifer Interference Policy*, NSW Government Policy for the licensing and assessment of aquifer interference activities, NSW Department of Primary Industries - Office of Water

EMM (2023) *Flood Study – Dinawan Energy Hub*, prepared for Spark Renewables

EMM (2024) *Land and Rehabilitation Assessment – Dinawan Wind Farm*, prepared for Spark Renewables

EPHC, NRMMC, AHMC (2006) *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*, National Resource Management Ministerial Council, Environment Protection and Heritage Council and Australian Health Minister's Conference

Fairfull, S. and Witheridge, G. (2003) *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*. NSW Fisheries, Cronulla

IECA (2008) *Best Practice Erosion and Sediment Control*, International Erosion Control Association, Australasian Chapter, Picton NSW

Isbell, R (2016) *The Australian soil classification, Australian Soil and Land Survey Handbooks Series*, 2nd Edition, CSIRO Publishing, Victoria

Jacobs (2022) *Technical Report – Surface Water Quality and Groundwater*, Virya Energy Yanco Delta Wind Farm, 3 June 2022

Jeffrey, S. J., Carter, J. O., Moodie, K. B. & Beswick, A. R., (2001) Using spatial interpolation to construct a comprehensive archive of Australian climate data. *Environmental Modelling and Software,* Volume Vol 16/4, pp. 309-330

Landcom (2004) *Managing urban stormwater: soils and construction. Vol. 1*, 4th edition, March 2004

OEH (2014) *Murray Murrumbidgee Climate change snapshot*. NSW Government Office of Environment & Heritage, Available: https://www.climatechange.environment.nsw.gov.au/sites/default/files/2021-06/Murray%20Murrumbidgee%20climate%20change%20snapshot.pdf

OEH (2016) *eSPADE NSW soil and land information database*, Version 2.0. NSW Department of Planning, Industry and Environment, Available: https://www.environment.nsw.gov.au/eSpade2Webapp

OEH (2017) *Australian soil classification (ASC) soil type map of NSW*, NSW Office of Environment and Heritage, Sydney

Serov P, Kuginis L, Williams J.P., May (2012) *Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework*, NSW Department of Primary Industries, Office of Water, Sydney

Standards Australia and Standards New Zealand (2012) *AS/NZS 1547:2012 On-site domestic wastewater management*,

Tuckwell, K.D. (1975) *Jerilderie 1:250,000 Geological Sheet*, 2nd Edition, Geological Survey NSW, Sydney

WaterNSW (2019) *Onsite domestic wastewater management, Designing and Installing On-Site Wastewater Systems, A WaterNSW Current Recommended Practice*, WaterNSW, November 2019

WaterNSW (2022) *NSW Water Register*, viewed June 2023, Available: https://waterregister.waternsw.com.au/water-register-frame

WaterNSW (2023) *Continuous water monitoring network, Groundwater (Telemetered data)*, viewed August 2023, Available: https://realtimedata.waternsw.com.au/water.stm

WSP (2021) *EnergyConnect (NSW-Eastern Section), Technical Paper 15 – Groundwater Impact Assessment*, prepared for Transgrid

Attachment A

Flood study

Dinawan Energy Hub

Flood study

Prepared for Spark Renewables Pty Limited

October 2023

Dinawan Energy Hub

Flood study

Spark Renewables Pty Limited

E220305 RP21

October 2023

Version	Date	Prepared by	Reviewed by	Comments
V1	18 September 2023	J O'Brien	N Bartho	Draft for client review
V2	31 October 2023	J O'Brien	N Bartho	Final

Approved by

Nick Bartho
Associate Director
26 October 2023

Level 3 175 Scott Street
Newcastle NSW 2300

TABLE OF CONTENTS

1	**Introduction**	**1**
1.1	Project overview	1
1.2	Project setting	1
1.3	Report purpose and structure	3
2	**Flooding mechanisms**	**4**
2.1	Overview	4
2.2	Murrumbidgee River flooding	4
2.3	Local tributary flooding	5
3	**Assessment methodology**	**6**
3.1	Overview	6
3.2	Available data	6
3.3	Relevant guidelines	6
3.4	Previous flood studies	7
3.5	Digital elevation model development	8
3.6	Modelling approach	8
3.7	Climate change	9
4	**Design rainfall data**	**10**
4.1	Overview	10
4.2	Design rainfall depths	10
4.3	Design storm data	12
5	**Hydraulic model development**	**14**
5.1	Overview	14
5.2	Model extent	14
5.3	Grid size	14
5.4	Model timestep	14
5.5	Hydraulic roughness	16
5.6	Hydraulic structures	16
5.7	Boundary conditions	17
6	**Model results**	**18**
6.1	Overview	18
6.2	Design flow validation	18
6.3	Model results	19

6.4 Discussion of results 20

6.5 Future model refinement 22

References 23

Abbreviations 24

Annexures

Annexure A Flood mapping A.1

Tables

Table 4.1 Probable maximum precipitation rainfall depths 12

Table 4.2 NSW hierarchical approach to the estimation of losses 13

Table 5.1 Manning's n values 16

Table 6.1 Local tributary design flow validation 18

Figures

Figure 1.1 Project investigation area and hydrological context 2

Figure 4.1 IFD curves for the project investigation area 11

Figure 5.1 Hydraulic model layout 15

Figure 5.2 Adopted design flood hydrographs for the Murrumbidgee River at Narrandera 17

Figure 6.1 Comparison of recorded and modelled Murrumbidgee River flows – March 2012 flood event 19

Figure 6.2 General flood hazard vulnerability curves (AIDR 2017) 20

Figure A.1 5% AEP flood extent and depth A.2

Figure A.2 1% AEP flood extent and depth A.3

Figure A.3 0.5% AEP flood extent and depth A.4

Figure A.4 PMF flood extent and depth A.5

Figure A.5 5% AEP flood hazard A.6

Figure A.6 1% AEP flood hazard A.7

Figure A.7 0.5% AEP flood hazard A.8

Figure A.8 PMF flood hazard A.9

1 Introduction

1.1 Project overview

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Dinawan Energy Hub, which comprises a hybrid wind and solar farm, battery energy storage system (BESS), and associated supporting infrastructure (the project). The project is on the traditional lands of the Wiradjuri people and several smaller nations of the Murrumbidgee plains, about halfway between the towns of Coleambally and Jerilderie and lies within the Murrumbidgee and Edward River local government areas (LGAs) in New South Wales (NSW).

The project is within the South-West Renewable Energy Zone (REZ) and would connect to the Dinawan Substation, which will be built by Transgrid as part of the Project EnergyConnect interconnector that will run between Robertstown in South Australia and Wagga Wagga in NSW.

The Dinawan Wind Farm and Dinawan Solar Farm will be delivered through two separate, but related, State Significant Development (SSD) applications to the NSW Department of Planning and Environment (DPE).

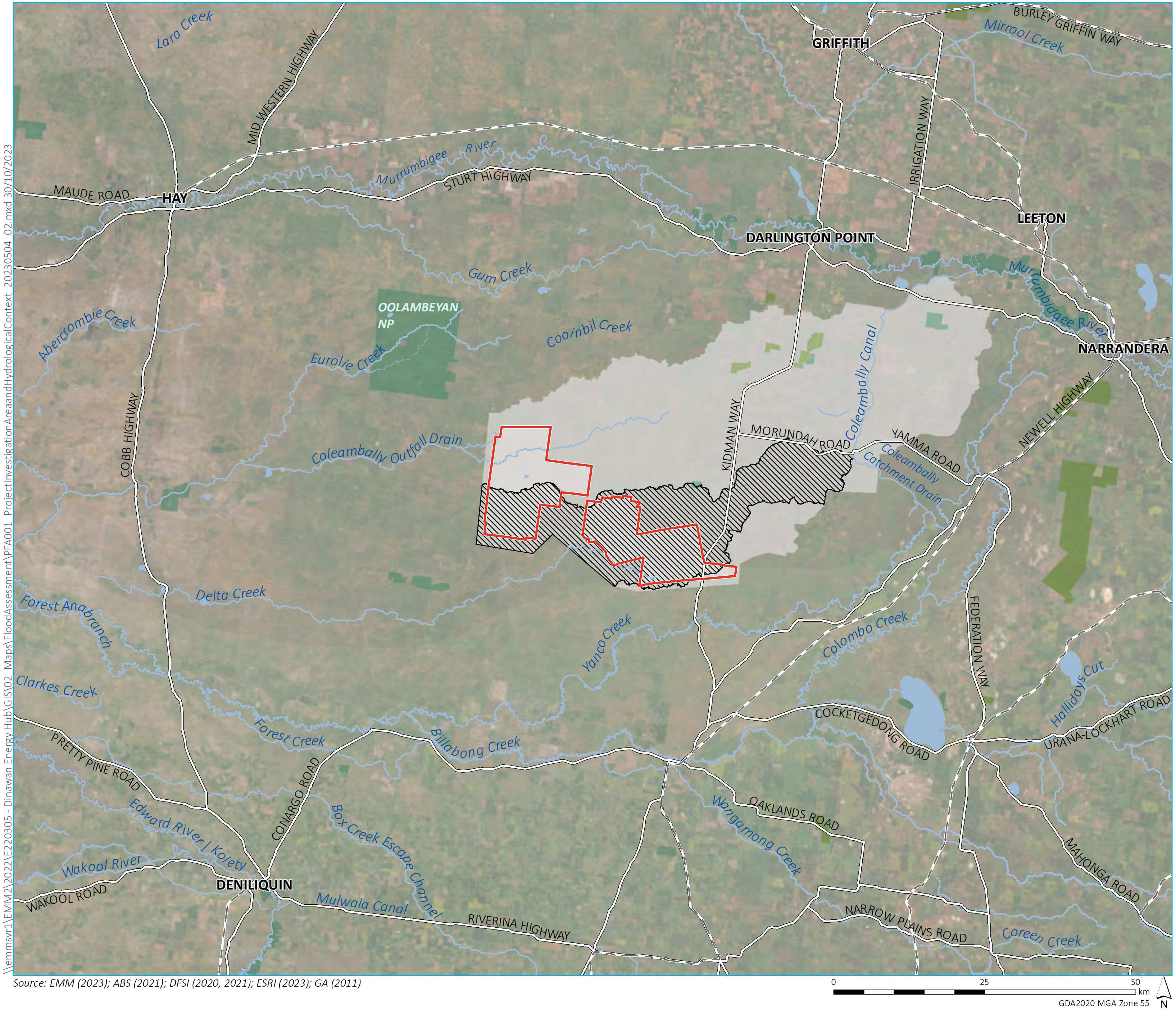
This report documents a flood study that has been undertaken to define existing flooding conditions relevant to both Dinawan Wind Farm and Dinawan Solar Farm. The project investigation area adopted for this flood study (refer to Figure 1.1) covers the land required for both Dinawan Solar Farm and Dinawan Wind Farm and is approximately 39,000 hectares (ha).

1.2 Project setting

The project is within the lower Murrumbidgee River catchment in southern NSW which drains a total area of around 84,000 square kilometres (km^2). The Murrumbidgee River flows in a south-westerly direction from its headwaters in Kosciuszko National Park to the floodplains at the western end of the catchment where the project is situated. Locally, the project is situated to the north of Yanco Creek, which has a regulated offtake from the Murrumbidgee River and flows generally south-west and ultimately to the Murray River via Billabong Creek, Edward River and Wakool River.

To the west of the project investigation area lies Coleambally Creek and Delta Creek. Coleambally Creek is a minor, ephemeral watercourse that forms part of the Coleambally Outfall Drain. This drain ultimately connects into Billabong Creek much further downstream. Delta Creek is a minor, ephemeral watercourse which also drains in a south-westerly direction during significant rainfall, although does not connect directly to any downstream watercourse.

The project investigation area is relatively flat with some minor drainage depressions that temporarily hold water during and following rainfall before eventually flowing in a south-westerly direction. Several minor topographic depressions on the floodplain hold water for longer, creating scattered wet environments within the project investigation area.



Source: EMM (2023); ABS (2021); DFSI (2020, 2021); ESRI (2023); GA (2011)

KEY
- Project investigation area
- Delta Creek catchment
- Extent of local catchment

Existing environment
- Rail line
- Major road
- Named watercourse
- Named waterbody
- NPWS reserve
- State forest

INSET KEY
- NPWS reserve
- State forest
- Murrumbidgee River catchment

Project investigation area and hydrological context

Dinawan Energy Hub
Flood Study
Figure 1.1

EMM creating opportunities

1.3 Report purpose and structure

This flood study was prepared to establish existing flood conditions across the project investigation area, understand broad flood-related risks and constraints for the project, and provide context for the assessment of potential flood impacts resulting from the project. It describes predicted flooding conditions for the project investigation area for the 5%, 1%, and 0.5% annual exceedance probability (AEP) flood events and for an extreme flood event approximating the probable maximum flood (PMF). Both mainstream flooding (from the Murrumbidgee River) and local tributary flooding are considered in this study.

This report is structured as follows:

- Chapter 2 describes the flooding mechanisms that affect the project investigation area.
- Chapter 3 describes the available data and assessment methodology used to characterise flooding.
- Chapter 4 presents design rainfall data for the project investigation area.
- Chapter 5 describes the hydraulic model used to characterise flooding within the project investigation area.
- Chapter 6 presents model results and describes existing flood conditions. This chapter also describes opportunities for further model refinement.

Flood mapping is presented in Annexure A.

2 Flooding mechanisms

2.1 Overview

Review of available information identified that the project investigation area will be affected by two primary flooding mechanisms:

- mainstream flooding sourced from the Murrumbidgee River to the north of the project investigation area
- local catchment flooding along several named and unnamed watercourses that traverse the project investigation area.

The following sections describe the above flooding mechanisms in the context of the project investigation area.

2.2 Murrumbidgee River flooding

The Murrumbidgee River flows from east to west approximately 50 kilometres (km) north of the project investigation area (refer to Figure 1.1). The Murrumbidgee River has a catchment area of 34,200 km^2 at the township of Narrandera, which is located 80 km north-east of the project investigation area (refer to Figure 1.1).

The Murrumbidgee River is a tributary to the Murray River and forms part of the broader Murray-Darling catchment. Land use within the catchment is primarily comprised of cleared agricultural land and remnant vegetation. Urban areas comprise only a very small portion of the catchment.

The Murrumbidgee River rises on the western slopes of the Great Dividing Range. The upper catchment between the Great Dividing Range and Narrandera is characterised by steep grades, a well-defined channel and a relatively confined floodplain. Downstream of Narrandera, the floodplain becomes broad and flat with numerous anabranches and flood runners (BMT WBM 2018).

During larger flood events, flows in the Murrumbidgee River break the banks or otherwise leave the river downstream of Narrandera and flow into Yanco Creek and other watercourses including Coleambally Canal. Floodwaters may also inundate the broader landscape as widespread overland flow. Floodwaters that leave the river generally follow the fall of the underlying terrain and flow in a south-westerly direction via watercourses and irrigation canals or become trapped in low points in the floodplain and are eventually lost to infiltration and evaporation.

Floodwaters that leave the Murrumbidgee River have the potential to affect the project investigation area via the following pathways:

- Yanco Creek which flows south-west about 8 km from the southern boundary of the project investigation area.
- Coleambally Outfall Drain which connects to the Coleambally Canal via a network of irrigation channels immediately west of the project investigation area.
- Overland flows that enter the project investigation area directly or via the numerous irrigation channels and minor watercourses that traverse the project investigation area.

Flood mapping presented as part of the *Yanco Delta Wind Farm: technical report – flooding and hydrology* (Jacobs 2022) indicates the project investigation area is unlikely to be impacted by flooding along Yanco Creek. This flooding mechanism is, however, considered as part of the current study.

2.3 Local tributary flooding

The project investigation area and local upstream catchment is relatively flat with elevations ranging from 105 to 135 m Australian Height Datum (AHD). Several topographic depressions exist within the project investigation area which are expected to hold water during and following intense rainfall events.

The local catchment area upstream of the project mainly consists of agricultural land that is intersected by a network of farm roads and irrigation canals. Several regional roads also traverse the local catchment including the Sturt Highway and Kidman Way. In some locations, the road and irrigation canal embankments act as a barrier to flood flows resulting in ponding and in some cases the redirection of flows upstream of these features.

The western section of the project investigation area is traversed by Coleambally Outfall Drain while the eastern section drains generally to Delta Creek. Several unnamed drainage lines also traverse the project investigation area. All local watercourses generally flow east to west across the project investigation area and ultimately discharge to the Murray River, approximately 150 to 200 km to the west.

Yanco Creek flows 8 km to the south of the project investigation area and is a major perennial tributary to the Murray River. Local tributary flooding within Yanco Creek is not anticipated to inundate the project investigation area.

3 Assessment methodology

3.1 Overview

The key focus of this flood study is to establish existing flood conditions across the project investigation area, understand broad flood-related risks and constraints for the project, and provide context for the assessment of potential flood impacts resulting from the project. An assessment methodology was developed to characterise mainstream and local tributary flooding based on available data, information contained in previous flood studies and relevant industry guidelines. This chapter describes the assessment methodology applied to this flood study.

3.2 Available data

The following data was used to inform the flood study:

- Design rainfall intensity and temporal pattern information obtained from the Bureau of Meteorology (BoM).
- Rainfall losses and temporal pattern information obtained from the Australian Rainfall and Runoff Data Hub (ARR Data Hub).
- Elevation data for the project investigation area including:
  - 1 m light detection and ranging (LiDAR) data obtained by Spark Renewables in August 2022.
  - 5 m digital elevation model (DEM) data obtained from the NSW Government Department of Finance, Services and Innovation (DFSI) – Spatial Services department (date unknown).
- Geographic information system (GIS) files showing the project investigation area.
- Digital photos of the project investigation area gathered during a site visit undertaken by EMM personnel in December 2022.

3.3 Relevant guidelines

Australian Rainfall and Runoff (ARR) is a national guideline document, data source and software suite that can be used for the estimation of design flood characteristics in Australia. The key objective of ARR is to provide the best available information on design flood estimation in a manner suitable for use by Australian practitioners. Ultimately the outcomes aim to support provision of reliable and robust estimates of flood risk, support risk mitigation and community resilience.

A major revision to ARR was released in 2016 followed by a major update in 2019 (Ball, et al. 2019) (ARR 2019). ARR 2019 is the 4th edition of ARR and represents industry best practice. It is published and supported by the Commonwealth of Australia and is publically available online and free of charge via the ARR Data Hub (http://data.arr-software.org/).

This flood study was carried out in accordance with guidance in ARR 2019 (Ball, et al. 2019), using associated datasets where available, and industry standard software packages.

3.4 Previous flood studies

3.4.1 Yanco Delta Wind Farm: technical report – flooding and hydrology (Jacobs 2022)

The Yanco Delta Wind Farm is immediately south and west of the project investigation area. *Yanco Delta Wind Farm: technical report – flooding and hydrology* (Jacobs 2022) assesses flooding impacts and risk associated with the construction and operation of the Yanco Delta Wind Farm. The report establishes existing flooding conditions for the 1% AEP and PMF events.

The Jacobs (2022) assessment modelled an area of 16,000 km^2 to simulate local tributary flooding as well as flooding associated with the Murrumbidgee River. Local tributary flooding was modelled using a rain on grid approach while flows in the Murrumbidgee River were adopted from *Review of the Narrandera Floodplain Risk Management Study and Plan* (the Narrandera FRMSP) (Lyall & Associates 2019).

The project investigation area is expected to be impacted by similar flooding mechanisms to the Yanco Delta Wind Farm site. Rainfall losses and hydraulic roughness (Manning's n) values from Jacobs (2022) were considered when assigning model parameters for this current flood assessment.

3.4.2 Narrandera Floodplain Risk Management Study and Plan (Lyall & Associates 2019)

The *Narrandera Floodplain Risk Management Study and Plan* (FRMSP) (Lyall & Associates 2019) characterises flooding within the urban parts of Narrandera and considers both main river flooding from the Murrumbidgee River and local overland flows. Flooding associated with the Murrumbidgee River was adopted from the *Narrandera Flood Study Review and Levee Options Assessment* (the Narrandera flood study) (Lyall & Associates 2015) hydraulic model outputs while a new hydraulic model was developed as part of the Narrandera FRMSP to assess overland flows.

The Narrandera flood study (Lyall & Associates 2015) provides peak discharges and design hydrographs for a range of flood events between 5% and 0.2% AEP. Design event peak discharges were based on a flood frequency analysis (FFA) of data from 1892 to 2012 (121 years) at the Murrumbidgee River at Narrandera (410005) stream gauge. Inflow hydrographs were developed by applying the FFA peak discharges to a typical flood hydrograph profile. An extreme flood approximating the PMF was also defined by multiplying the 1% AEP hydrograph by a factor of three.

The design hydrographs developed for the Narrandera flood study (Lyall & Associates 2015) and subsequently used in the Narrandera FRMSP (Lyall & Associates 2019) and *Yanco Delta Wind Farm: technical report – flooding and hydrology* (Jacobs 2022) have also been applied to simulate Murrumbidgee River flooding in this assessment (refer to Section 5.7.2). Rainfall losses and hydraulic roughness (Manning's n) values from the Narrandera FRMSP were considered when assigning model parameters for this current flood assessment.

3.4.3 Murrumbidgee River at Darlington Point and Environs Flood Study (BMT WBM 2018)

The *Murrumbidgee River at Darlington Point and Environs Flood Study* (BMT WBM 2018) characterises flooding within the urban parts of Darlington Point and considers both main river flooding from the Murrumbidgee River and local overland flows. The study developed and calibrated hydraulic models to simulate flood behaviour for a range of design events ranging from the 20% AEP to an extreme flood approximating the PMF. A similar approach was applied for developing and modelling design flood events as the Narrandera flood study and Narrandera FRMSP.

Rainfall losses and hydraulic roughness (Manning's n) values from the *Murrumbidgee River at Darlington Point and Environs Flood Study* (BMT WBM 2018) were considered when assigning model parameters for this current flood assessment.

3.5 Digital elevation model development

Hydraulic modelling of flood flows requires accurate topographic data; the more accurate the data, the better flow paths and conveyance volumes are represented within the model. However, it is rare to have fine resolution topographic data available over large areas since this type of data is expensive to collect and often is collected for specific projects. It is more common to have multiple datasets, each with different properties (e.g. spatial resolution, datum, extent). Therefore, it is important to combine/process the topographic data that is available, with the aims of:

- preferentially using good quality higher resolution data where it exists and where it is most important (e.g. infrastructure or narrow flow paths)
- creating smooth transitions between datasets to prevent abrupt changes in height or slope at the transition, which can interrupt flow paths within the model.

Topographic data for the project investigation area was provided as 1 m LIDAR data by Spark Renewables while a 5 m DEM was obtained from DFSI for the broader catchment area. The two topographic datasets were merged to form one DEM using a process based on Gallant (2019) which established a method to adjust a shuttle radar topography mission derived hydrological DEM to match finer LiDAR data, remove abrupt steps at the boundary and ensure the combined data is suitable for hydraulic modelling.

The 1 m LIDAR data was preferentially used where available (i.e. within the project investigation area). All other areas of the hydraulic model domain were modelled using the 5 m DEM data.

3.6 Modelling approach

The modelling approach aims to assess flooding across the project investigation area resulting from both the Murrumbidgee River and local tributaries. The following modelling approach was applied to establish existing flooding conditions:

1. Review of available data and previous flood studies for completeness and reliability. The available data and previous studies were used to inform modelling methodologies and assumptions.
2. Obtain design rainfall data for the local catchment area to be applied directly to the hydraulic model as rain-on-grid. A rain-on-grid approach was applied to assess local tributary flooding due to the poorly defined catchment boundaries resulting from the relatively flat terrain and network of interconnected irrigation channels upstream of the project investigation area.
3. Develop Murrumbidgee River inflow hydrographs for the range of design flood events to be investigated. Design hydrographs were developed using the peak flow rates presented in the Narrandera flood study (Lyall & Associates 2015). The inflow hydrograph for an extreme flood approximating the PMF was estimated as three times the magnitude of the 1% AEP flood event.
4. Develop a two-dimensional (2D) hydraulic model covering the local catchment area and portion of the Murrumbidgee River that is predicted to breakout and potentially flow into the project investigation area during main river flooding events. The hydraulic model was established using the TUFLOW software. The TUFLOW model was used to establish flooding conditions for the 5%, 1%, and 0.5% AEP events as well as an extreme flood approximating the PMF.

The design rainfall data applied to the local catchment area as rain-on-grid is provided in Chapter 4. The TUFLOW model is described in Chapter 5.

Validation of local tributary flooding was undertaken against the ARR (2016) Regional Flood Frequency Estimation (RFFE) model. Validation of flows within the Murrumbidgee River was undertaken by comparing the conveyance of flood flows between Narrandera and Darlington Point for the March 2012 flood event.

3.7 Climate change

ARR 2019 presents a decision tree for selecting an appropriate method for considering the effects of climate change within flood studies with regards to the planning horizon, risks, and associated consequences of climate change on projects.

The ARR Data Hub provides estimated increases in rainfall intensity for the project investigation area of between 7% and 12% by 2060, considering the planned operating life of 25–35 years. The 0.5% AEP storm intensity is approximately 12% higher than the 1% AEP storm intensity, which means the current climate 0.5% AEP flood results can be taken as approximately equivalent to the future climate 1% AEP flood results and provide a good understanding of how climate change may impact the project.

ARR 2019 does not recommend any changes to probable maximum precipitation (PMP) estimates to account for climate change.

4 Design rainfall data

4.1 Overview

This chapter describes design rainfall data for the project investigation area including rainfall depths, rainfall losses and temporal patterns. The design storms established in this chapter were applied to the TUFLOW hydraulic model (refer to Chapter 5) as direct rainfall to simulate flooding from the local catchment area. The information contained in this chapter has been sourced from the BoM and ARR Data Hub.

4.2 Design rainfall depths

4.2.1 General storm events

Design rainfall depths were obtained for the project investigation area from the BoM Design Rainfall Data System (2016) (Bureau of Meteorology 2016). Design rainfall depths are presented as intensity frequency duration (IFD) data which describe the relationship between rainfall intensity, storm frequency and storm duration and form the basis of design storms used for modelling purposes.

Review of the IFD data indicates there is a rainfall gradient from east to west across the local catchment area. Rainfall intensities are approximately 5–10% higher in the western portion of the catchment for the storm frequency and durations of interest. The minor rainfall gradient between east and west has effectively been averaged by applying IFD data at the local catchment centroid to develop design rainfall inputs for this assessment.

IFD curves for the local catchment centroid are shown in Figure 4.1.

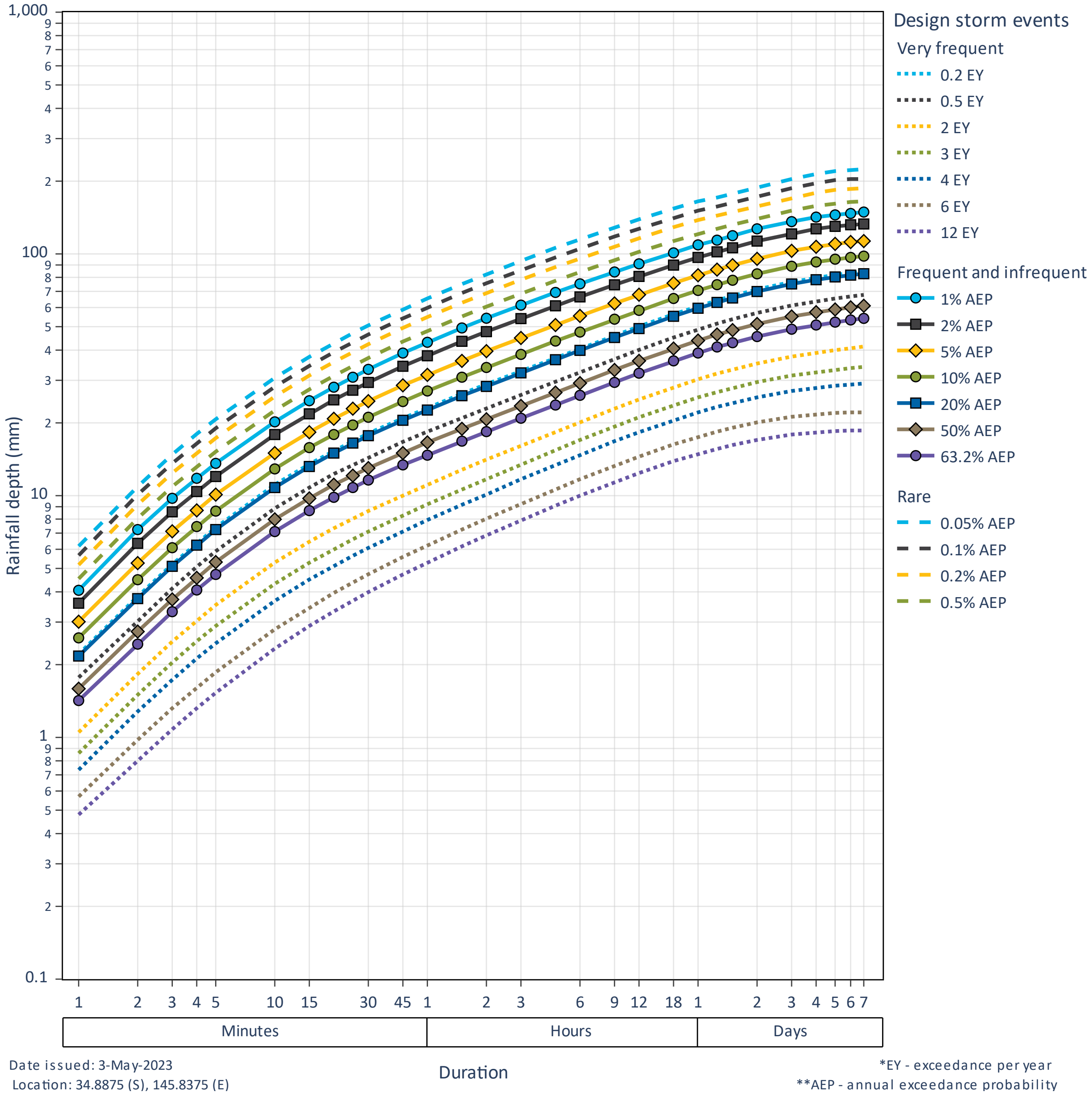


Figure 4.1 IFD curves for the project investigation area

4.2.2 Probable maximum precipitation

PMP depths represent the upper limit of possible rainfall and are used to determine flood characteristics for the PMF. The Generalised Southeast Australia Method (GSAM) (BoM 2006) was used to develop PMP estimates as the total local catchment area is greater than 1,000 km^2. The local catchment area is in the GSAM Inland Zone and adjustment factors were estimated using spatial parameters provided by BoM (BoM 2006). PMP estimates were developed for storm durations ranging from 24 to 96 hours and are shown in Table 4.1.

Table 4.1 Probable maximum precipitation rainfall depths

	Storm duration				
	24 hour	36 hour	48 hour	72 hour	96 hour
PMP depth (mm)	430	480	510	530	540

4.3 Design storm data

4.3.1 Areal reduction factors

When catchments are sufficiently large, design rainfall intensities at a given point are not representative of the areal average rainfall intensity across the catchment because larger catchments are less likely than smaller catchments to experience high intensity storms simultaneously over the whole of the catchment area (Ball, et al. 2019). Areal reduction factors (ARFs) are provided via the ARR Data Hub and represent the ratio between the design values of areal average rainfall and point rainfall, computed for the same duration and AEP.

ARFs were applied to the design rainfall data based on the total local catchment area of 2,593 km^2 and data obtained from the ARR data hub. The ARF values ranged from 0.84 for the 0.5% AEP, 24-hour storm duration to 0.92 for the 5% AEP, 168-hour storm duration.

No reduction factors were applied to the PMP estimates.

4.3.2 Rainfall temporal patterns

Rainfall temporal patterns describe how rainfall is distributed over the duration of a storm and can significantly affect estimated peak flow.

The recommended ARR 2019 ensemble approach to applying temporal patterns was utilised to simulate rainfall over the local catchment area. The ensemble approach to flood modelling applies a suite of ten temporal patterns for each storm duration. Areal temporal patterns were implemented as the local catchment area is greater than 75 km^2.

ARR 2019 describes temporal pattern regions across Australia and provides temporal patterns for each region. Temporal patterns were obtained from ARR Data Hub for the project investigation area catchment, which is in the Murray Basin temporal pattern region.

Temporal patterns for the PMP storm event were developed using the methodology recommended for the GSAM.

4.3.3 Rainfall losses

ARR 2019 recommends the initial loss–continuing loss model whereby rainfall loss mechanisms are lumped together as:

- Initial loss – occurs at the beginning of a storm before any runoff is generated. The first rain falling on a catchment wets the vegetation, fills depressions and infiltrates into the soil (i.e. before the soil surface is saturated).
- Continuing loss – is applied for the remainder of the storm. Once parts of the catchment become saturated runoff begins, though some rain continues to be lost to infiltration and evaporation.

ARR 2019 provides default rainfall loss values for catchments across Australia. A 2019 review of ARR design inputs for NSW identified that default ARR data hub losses were not fit-for-purpose for NSW catchments and should only be used where better information was not available (Podger 2019). The review established a hierarchical approach to the estimation of losses (1 = most preferred, 5 = least preferred), which is reproduced in Table 4.2.

Table 4.2 NSW hierarchical approach to the estimation of losses

Approach	Description	Project investigation area catchment
1	Use the average of calibration losses from the actual study on the catchment if available.	No recent calibrated flood studies are available in the vicinity of the project investigation area or local catchment area. The existing flood studies referenced in Section 3.4 all applied the default losses from the ARR Data Hub when modelling local catchment rainfall.
2	Use the average calibration losses from other studies in the catchment, if available and appropriate for the study.	
3	Use the average calibration losses from other studies in the similar adjacent catchments, if available and appropriate for the study.	
4	Use the NSW FFA-reconciled losses available through the ARR Data Hub. These losses may be used within the catchment in which they were derived or similar adjacent catchments with appropriate scrutiny. This is used with the unmodified ARR Data Hub initial losses[1] which requires the application of additional scrutiny.	The nearest NSW-FFA reconciled losses are for the Kyeamba Creek catchment (streamflow gauge 410048), which is approximately 160 km south-east of the project investigation area and has an initial loss of 50 mm and continuing loss of 1.6 mm/hour. The NSW-FFA reconciled loss approach is not considered appropriate for the project investigation area due to the distance between sites.
5	Use default ARR data hub continuing losses with a multiplication factor of 0.4. This is used with the unmodified ARR Data Hub initial losses[1] which requires the application of additional scrutiny.	Initial loss = 26.0 mm Continuing loss = 0.0 mm/hour

Notes: 1. Where good local initial loss data is not available (Case 4 and 5), the probability neutral burst initial loss values available through the ARR Data Hub should be used in all instances unless a detailed Monte Carlo assessment of pre-burst rainfall depth and rainfall losses has been carried out.

Hierarchy approach five is applicable to this flood study. Hence, probability neutral burst initial losses (PNBIL) and a continuing loss of 0.0 mm/hour were applied to estimate rainfall losses for this flood assessment.

PNBIL are initial losses that have been adjusted to account for pre-burst rainfall depths. PNBIL for the local catchment area were extracted from the ARR Data Hub. PNBIL values ranged between 11.9 mm and 24.6 mm for the 5% and 1% AEP storm events.

No initial or continuing losses were applied to the 0.5% AEP and PMP rainfall data.

5 Hydraulic model development

5.1 Overview

A TUFLOW model (version 2023-03-AA) was developed to characterise existing flood conditions across the project investigation area. TUFLOW is a 2D numerical simulation free-surface water flow modelling tool for rivers, floodplains, estuaries, coastlines, and urban environments commonly used within Australia for assessing drainage and flooding. Roads, channels, culverts, and embankments can be included in TUFLOW models, and comparisons made between pre- and post-development flood behaviour.

This chapter describes the development of the TUFLOW model. Results are presented in Chapter 6.

5.2 Model extent

The TUFLOW model domain has an area of 5,000 km^2 and extends from the project investigation area to the Murrumbidgee River to the north-east (refer to Figure 5.1). The model domain also includes the section of Yanco Creek that flows south of the project investigation area. The model domain extends several kilometres downstream of the project, so that downstream hydraulic conditions do not influence flood results within the project investigation area.

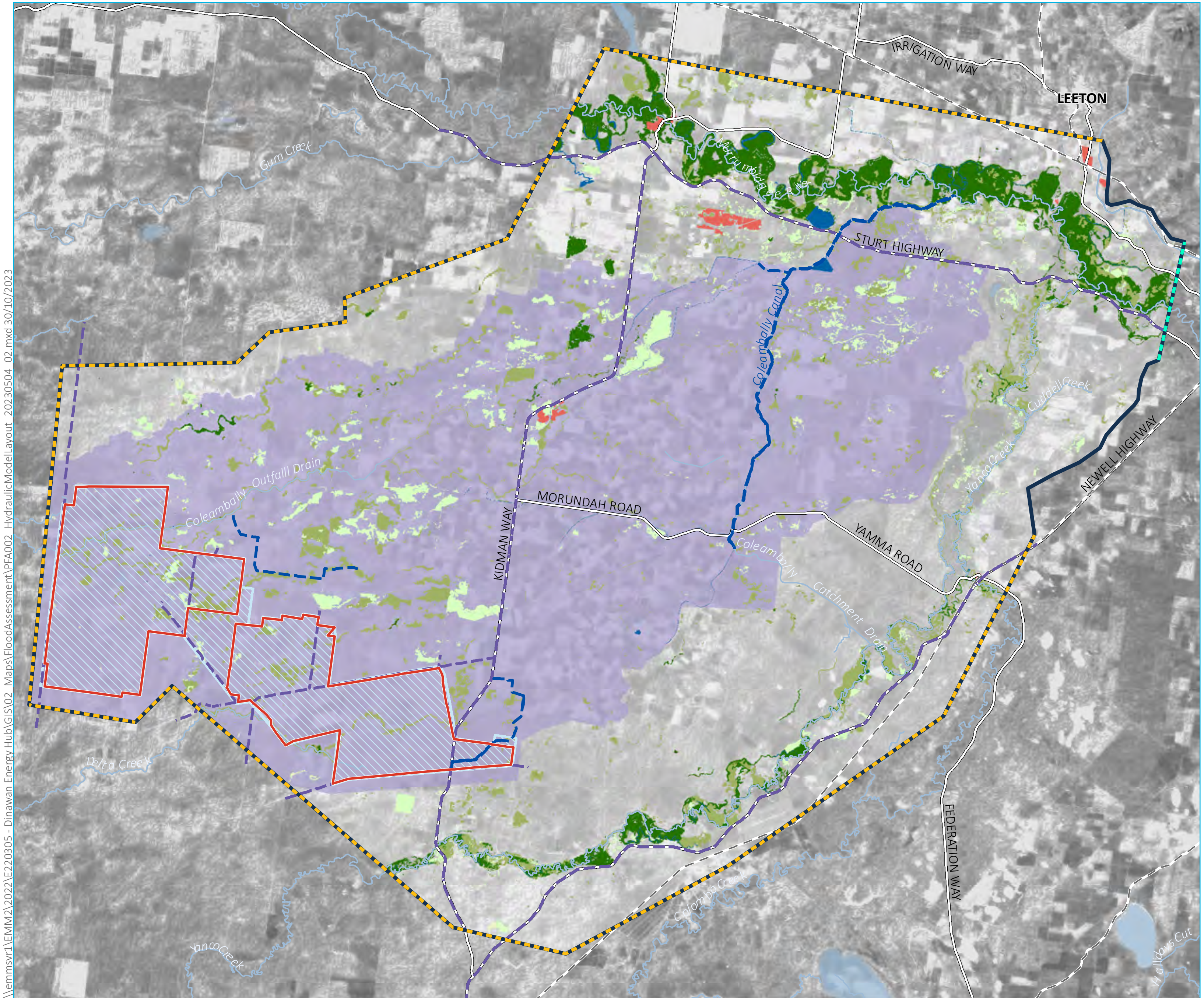
5.3 Grid size

The DEM described in Section 3.5 was used to inform grid resolution across the model domain, which is represented entirely in 2D using a grid size of 30 m.

Sub-grid sampling (SGS) was used to increase the resolution of sampling the underlying DEMs and enable sub-grid scale features to be adequately represented in the model without excessively long model run times. A SGS distance of 5 m was applied to the model.

5.4 Model timestep

Due to the large model extent and relatively small grid size, the 2D heavily parallelised compute (HPC) TUFLOW solver was used to reduce run times. TUFLOW HPC uses an adaptive timestep approach to maintain unconditional stability during simulations. Timesteps are automatically adjusted during the simulation to maintain stability, based a range of criterion (BMT 2018). Timesteps during model runs were typically in the order of 3.5 seconds.



KEY
- Project investigation area
- Inflow boundary
- Outflow boundary

Hydraulic model layout
- TUFLOW model boundary
- Breakline for irrigation canal embankment
- Breakline for road embankment
- Area of 1m LiDAR data
- Rain on grid applied

Land use (for hydraulic roughness mapping)
- Water
- Dense vegetation and riparian zone
- Medium density vegetation
- Light vegetation
- Urban areas (balance of model domain is pasture/crop area)

Existing environment
- Rail line
- Major road
- Named watercourse
- Named waterbody

Source: EMM (2023); DFSI (2020, 2021)

0 10 20 km
GDA2020 MGA Zone 55
N

Hydraulic model layout

Dinawan Energy Hub
Flood Study
Figure 5.1

EMM creating opportunities

\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA002_HydraulicModelLayout_20230504_02.mxd 30/10/2023

5.5 Hydraulic roughness

Manning's n values representing hydraulic roughness were selected based on inspection of aerial imagery, site observations and from values adopted in previous flood studies (refer to Section 3.4). The local catchment area was observed to primarily comprise of pasture and crops while medium to dense vegetation was observed along the Murrumbidgee River and other watercourses.

The Manning's n values applied to the hydraulic model are provided in Table 5.1 and shown in Figure 5.1. The adopted Manning's n values are compared to those applied to the previous studies and the ranges published in ARR 2019 for further context.

Table 5.1 Manning's n values

Land use	Recommended range (ARR 2019)	Existing studies range	Adopted Manning's n value
Waterbodies	0.02–0.04	0.015–0.05	0.03
Urban areas	0.1–0.2	0.05–0.06	0.06[1]
Pasture/crop [2]	0.025–0.045	0.04–0.05	0.04
Light vegetation	0.03–0.05	0.04–0.06	0.04
Medium density vegetation	0.05–0.07	0.06–0.08	0.07
Dense vegetation/riparian zone	0.07–0.12	0.08–0.12	0.10

Notes: 1. Urbans areas typically comprise of scattered housing and grassed/vegetated area. Hence, a lower Manning's n value has been adopted compared to the recommended ARR 2019 range.

2. Default land use within model domain – not shown on Figure 5.1.

5.6 Hydraulic structures

The Sturt Highway runs to the south of the Murrumbidgee River in an east to west orientation. It is constructed on a raised embankment and acts as a control on overflows from the Murrumbidgee River. The model domain is traversed by several other roads including Kidman Way. Roads with the potential to cause a barrier to overland flow and flooding were modelled in TUFLOW using 2D break lines with embankment elevations based on 1 m LiDAR data within the project investigation area and 5 m DEM data outside the project investigation area.

Similarly, irrigation channels that include embankments adjacent to the channel were modelled using 2D break lines based on the underlying DEM. Irrigation channel embankments were only included in the model if they were expected to materially influence flood behaviour (i.e. blocked or diverted flows). The locations of the irrigation channel embankments and road 2D break lines included in the TUFLOW model are shown in Figure 5.1.

Key waterway crossings such as bridges and culverts were left as open channels within the 2D domain to allow flows to pass through road embankments unimpeded.

5.7 Boundary conditions

5.7.1 Murrumbidgee River inflows

An inflow boundary was applied to the Murrumbidgee River immediately downstream of Narrandera (refer to Figure 5.1). Peak flow rates for the 5%, 1%, 0.5% AEP and extreme flood events were obtained from Narrandera flood study (Lyall & Associates 2015). As a hydrologic model was not developed for the Murrumbidgee River, design hydrographs were developed using the peak flow rates and typical hydrograph shapes from observed flood events.

The extreme flood event inflow for the Murrumbidgee River was estimated as three times the 1% AEP flood event as is consistent with other studies in the area (Lyall & Associates 2015, BMT WBM 2018). The design hydrographs applied to the Murrumbidgee River inflow boundary are shown in Figure 5.2.

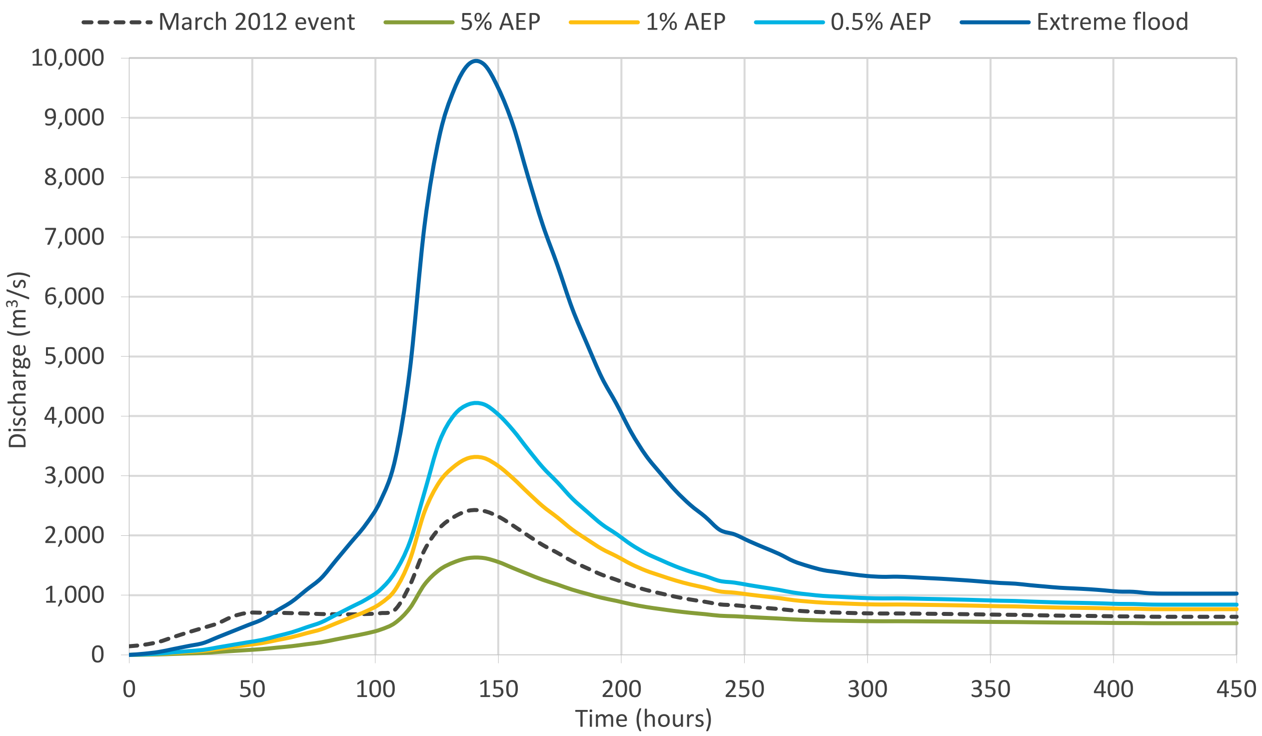


Figure 5.2 Adopted design flood hydrographs for the Murrumbidgee River at Narrandera

5.7.2 Local catchment inflows

Inflows from rainfall runoff on the local catchment area were modelled as rainfall hyetographs applied directly to the TUFLOW model domain. The catchment area modelled using the rain-on-grid approach is shown in Figure 5.1.

5.7.3 Downstream boundaries

Stage-discharge boundary conditions were applied at all downstream model boundaries. A water surface slope of 1% was assumed. The downstream boundary was set far enough downstream so that downstream conditions would not influence results within the project investigation area.

6 Model results

6.1 Overview

The hydraulic model described in Chapter 5 was used to establish existing flood characteristics in terms of flood extent, depth and hazard across the project investigation area. This chapter describes the critical storm duration for key areas of interest, the process of validating design flow estimates, presents and discusses the TUFLOW model results, and identifies opportunities for future model refinement.

Flood mapping is provided in Annexure A, which includes figures showing indicative flood extent, depth and hazard for the 5%, 1%, 0.5% AEP and PMF events.

6.2 Design flow validation

6.2.1 Local tributary flooding

To improve confidence in the TUFLOW design flow estimates, the design flows were validated against the Regional Flood Frequency Estimation (RFFE) Model. Peak flow estimates from the TUFLOW hydraulic model are compared to the RFFE Model estimates for the Delta Creek catchment in Table 6.1.

Table 6.1 Local tributary design flow validation

Design event	TUFLOW model peak flow estimates (m^3/s)	RFFE Model peak flow estimates (m^3/s)		
		Design estimate	Lower confidence limit	Upper confidence limit
5% AEP	57	177	54	793
1% AEP	96	302	90	1,040

The results presented in Table 6.1 show the peak flows estimated by the TUFLOW model are within the lower and upper confidence limits of the RFFE Model estimates, and similar to the lower confidence limit values. The relatively low peak flow estimates generated from the TUFLOW model can be attributed to the flat terrain, the presence of embankments and irrigation canals that act to redirect flows away from drainage outlets, and the substantial number of drainage sinks which trap rainfall and runoff within the landscape.

The RFFE Model estimates are based on streamflow gauging data from catchments that are located remote from the project, typically have steeper and more hydraulically efficient watercourse channels, and generally receive greater rainfall intensity and depths. For these reasons it is expected that the RFFE Model would tend to overestimate runoff response for catchments local to the project.

6.2.2 Murrumbidgee River flooding

The hydraulic model capability to represent flow conveyance within the Murrumbidgee River was assessed by simulating the 2012 Murrumbidgee River flood event. The discharge hydrograph recorded at the Narrandera (410005) stream gauge during the March 2012 event was applied to the upstream Murrumbidgee River inflow boundary (refer to Section 5.7.1). The simulated flows were then compared to the recorded flows at the Darlington Point (410021) stream gauge approximately 50 km downstream of the model inflow boundary. A comparison between the recorded and modelled flows is provided in Figure 6.1.

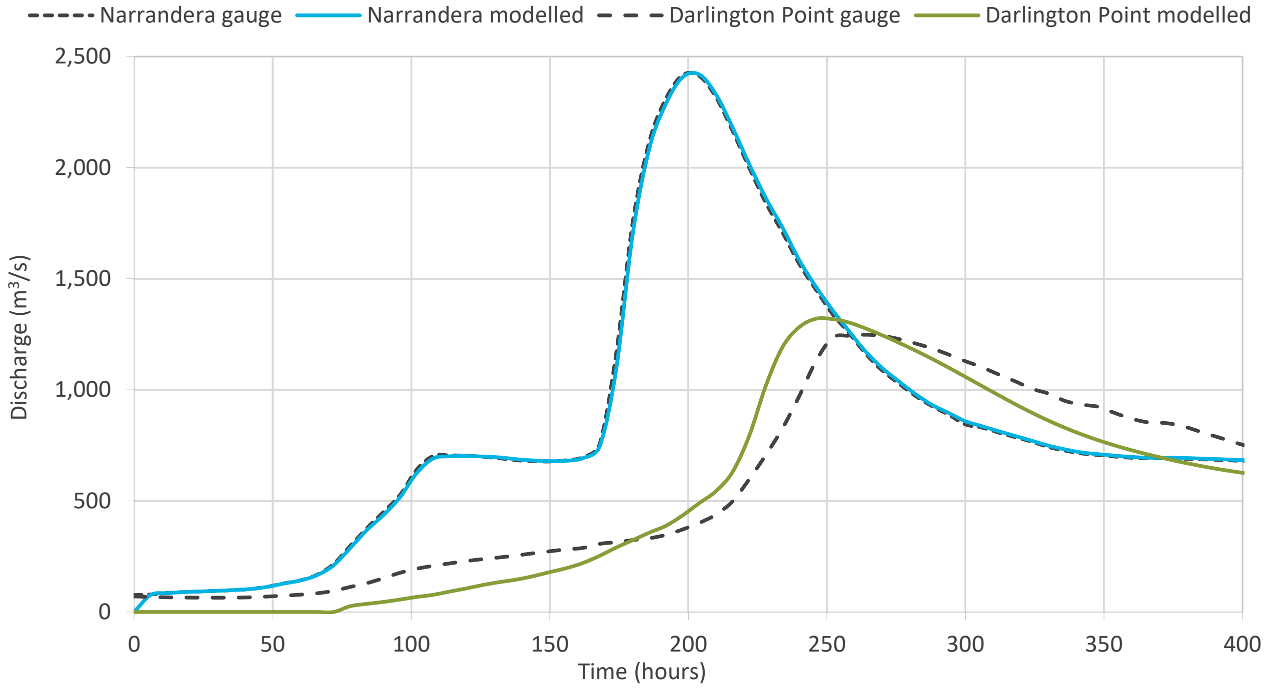


Figure 6.1 Comparison of recorded and modelled Murrumbidgee River flows – March 2012 flood event

Figure 6.1 indicates there is a reasonable match between the recorded and modelled flows at the Darlington Point gauge with modelled peak discharge occurring 18 hours earlier and 5% larger than the recorded peak discharge. The TUFLOW model is adequately representing Murrumbidgee River flow conveyance for the purposes of this assessment.

6.3 Model results

TUFLOW model results showing the 5% AEP, 1% AEP, 0.5% AEP and PMF flood extent, depth and hazard are provided in Annexure A.

The flood maps in Annexure A were generated using the following steps:

1. Calculate the average value resulting from all 10 temporal patterns to determine the critical flow conditions for each storm duration.
2. Envelope the maximum value from each critical storm duration to determine the critical storm flow conditions for each AEP.
3. Apply a filter so that critical storm flow conditions are only shown if the flood depth is greater than 0.1 m or the product of flood depth and velocity is greater than 0.05 m^2/s. This removes the shallow, slow moving sheet flow which is not considered representative of significant overland or mainstream flooding.
4. Apply a filter that removes all isolated areas of flooding with a surface area less than 1 ha. This eliminates small areas of ponding that occur due to minor depressions in the underlying DEM filling with water because of the rain-on-grid modelling approach. The depressions may be real or a result of discrepancies in the LiDAR data used to generate the DEM. Regardless, these small, ponded areas are expected to provide a low level of flood risk.

Figure 6.2 shows the general flood hazard vulnerability curves from the Australian Disaster Resilience Handbook (AIDR 2017) and describes the hazard categories which are produced as results from the model.

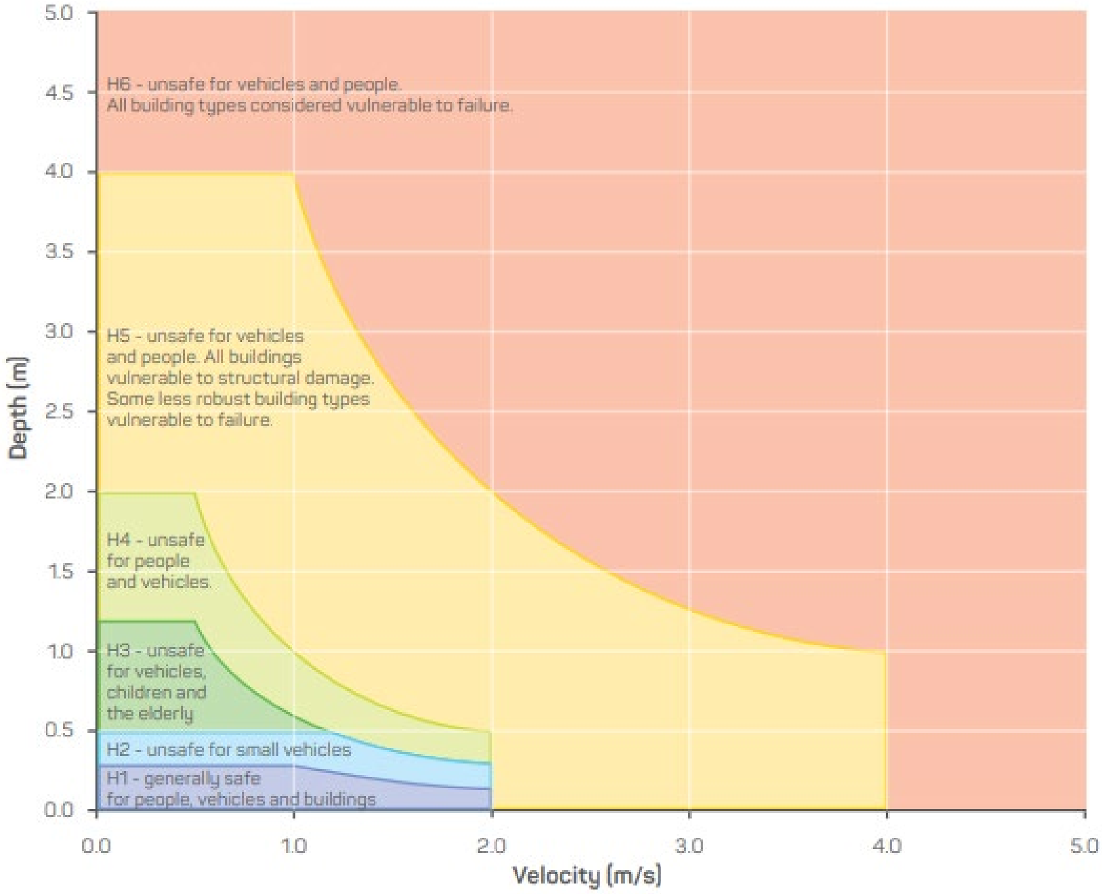


Figure 6.2 General flood hazard vulnerability curves (AIDR 2017)

Key results for each flood event modelled are described in the section below.

6.4 Discussion of results

The modelling results indicate flooding associated with local catchment rainfall and runoff results in larger flood extents and depths compared to flooding that results from flows that break out of the Murrumbidgee River for all events modelled.

The following provides a summary of the key model results for each event:

- 5% AEP event:
  - Flooding from the Murrumbidgee River is primarily diverted to the east of the project investigation area by the Coleambally Canal embankments and channel before discharging to Yanco Creek. A portion of the flows break out of the Coleambally Canal and into the Coleambally Outfall Drain which traverses the north-west section of the project investigation area. These flows are primarily confined within the Coleambally Outfall Drain channel.
  - Local tributary flooding is primarily contained within the watercourse channels and irrigation canals that traverse the project investigation area. Isolated ponding occurs across the project investigation area due to overland flows becoming trapped behind existing road embankments or in low points (drainage sinks) in the landscape.

  - Most of the project infrastructure is likely to be unaffected by flooding associated with the Murrumbidgee River and local tributary flows. Significant flooding in the 5% AEP event generally follows the alignment of watercourses, irrigation canals and minor topographic depressions. The Dinawan Solar Farm development footprint generally lies outside the 5% AEP flood extent. Wind turbine generator (WTG) locations associated with the Dinawan Wind Farm generally avoid flood prone areas, with a small number of WTGs likely to experience flood depths of up to about 0.4 m.

  - Flood hazard is highly variable, and generally reaches H3 within and immediately adjacent to watercourses and irrigation canals, with lower hazard H1 and H2 categories typically applying to broader overland flows.

- 1% AEP event:

  - Larger volumes of Murrumbidgee River floodwaters break out of the Coleambally Canal and flow west across the project investigation area. Floodwaters commence draining via Delta Creek and shallow (less than 0.1 m) overbank flows occur along Coleambally Outfall Drain. Substantial ponding is experienced upstream of Carrathool Road due to the overbank flows.

  - Local tributary flooding is primarily contained within the watercourse channels and irrigation canals that traverse the project investigation area. Overland flows are generally shallow (less than 0.1 m) across most of the project investigation area. Ponding is more substantial than experienced for the 5% AEP event, particularly upstream of existing road alignments.

  - Most of the project infrastructure is likely to be unaffected by flooding associated with the Murrumbidgee River and local tributary flows. The Dinawan Solar Farm development footprint generally lies outside the 1% AEP flood extent. WTG locations generally avoid flood prone areas, with a small number of WTGs likely to experience flood depths of up to 0.5 m.

  - Flood hazard is highly variable, and is generally in the H3 to H4 category range within and immediately adjacent to watercourses and irrigation canals, with lower hazard H1 and H2 categories typically applying to broader overland flows.

- 0.5% AEP event:

  - Flooding from the Murrumbidgee River is similar to what is experienced in the 1% AEP event. Flows in Delta Creek remain within the watercourse channel. Overbank flows associated with Coleambally Outfall Drain are more widespread and deeper but still generally less than 0.25 m.

  - Local tributary flooding is primarily contained within the watercourse channels and irrigation canals; however, more substantial overbank flooding is observed. Both overbank and overland flows are generally shallow (less than 0.25 m) across most of the project investigation area.

  - Most of the project infrastructure is likely to be unaffected by flooding associated with the Murrumbidgee River and local tributary flows. The Dinawan Solar Farm development footprint generally lies outside the 0.5% AEP flood extent, with encroachments typically small and shallow (less than 0.1 m deep) in nature. WTG locations generally avoid flood prone areas, with a small number of WTGs likely to experience flood depths of up to 0.6 m.

  - Flood hazard is highly variable, and is generally in the H3 to H4 category range within and immediately adjacent to watercourses and irrigation canals, with lower hazard H1 and H2 categories typically applying to broader overland flows.

- PMF event:
  - Widespread flooding occurs from the Murrumbidgee River with most of the western portion of the project investigation area experiencing inundation. Overbank flows are experienced from both the Coleambally Outfall Drain and Delta Creek. Substantial flooding also occurs along an unnamed drainage line that traverses the project investigation area to the south of Coleambally Outfall Drain. Overbank flows of greater than 0.5 m are experienced in the west of the project investigation area while overbank flows are generally less than 0.25 m in the east.
  - Local tributary flooding results in widespread overbank and overland flows at depths greater than 0.1 m across most of the project investigation area.
  - Most of the project infrastructure is likely to experience some degree of flood inundation. Flood depths across the Dinawan Solar Farm development footprint are generally less than 0.25 m, up to a maximum of about 0.5 m in a small number of locations. WTG locations experience flood depths up to 1.2 m.
  - Flood hazard is highly variable, and generally reaches H4 within and immediately adjacent to watercourses and irrigation canals with some isolated areas of H5, with lower hazard H1 to H3 categories typically applying to broader overland flows.

6.5 Future model refinement

Whilst suitable to inform understanding of flood-related risks and constraints for the project and to provide context for the assessment of potential flood impacts resulting from the project, it is recommended that model refinement is undertaken prior to use of the model results to inform infrastructure design, such as setting pad or building floor levels to achieve desired flood immunity levels.

This should include:

- Sensitivity analysis of the study area hydrology, particularly rainfall loss parameter selection and the potential influence of evaporation on ponded areas during longer duration storm events.
- Sensitivity analysis of the TUFLOW model grid size in the vicinity of the project investigation area.
- Consideration of the need to include additional definition of existing embankment levels and/or drainage infrastructure in the vicinity of the project investigation area.

References

AIDR. 2017. *Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia.* Australian Institute for Disaster Resilience, on behalf of the Australian Government Attorney-General's Department.

Ball, J, M Babister, R Nathan, W Weeks, E Weinmann, M Retallick, and I Testoni, . 2019. *Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia.*

BMT. 2018. "TUFLOW Classic/HPC User Manual: Build 2018-03-AD." https://www.tuflow.com/Download/TUFLOW/Releases/2018-03/TUFLOW%20Manual.2018-03.pdf.

BMT WBM. 2018. *Murrumbidgee River at Darlington Point and Environs Flood Study.* Prepared for Murrumbidgee Council by BMT WBM Pty Ltd.

BoM. 2006. *Guidebook to the Estimation of Probably Maximum Precipitation: Generalised Southeast Australia Method.* Bureau of Meteorology.

Bureau of Meteorology. 2016. *Deaign Rainfall Data System (2016).* Retrieved March 2023, from Water information: http://www.bom.gov.au/water/designRainfalls/revised-ifd/.

—. 2016. *Design Rainfall Data System (2016).* Accessed January 2022. http://www.bom.gov.au/water/designRainfalls/revised-ifd.

—. 2016. *Design Rainfall Data System (2016).* Accessed 2023. http://www.bom.gov.au/water/designRainfalls/revised-ifd.

Gallant, John. 2019. "Merging lidar with coarser DEMs for hydrodynamic modelling over large areas." *23rd International Congress on Modelling and Simulation.* Canberra. 1161-1166. Accessed September 27, 2021. https://mssanz.org.au/modsim2019/K24/gallant.pdf.

Jacobs. 2022. *Yanco Delta Wind Farm: Technical Report - Flooding and hydrology.* Prepared for Virya Energy by Jacobs.

Lyall & Associates. 2015. *Narrandera Flood Study Review and Levee Options Assessment Volume 1 - Report.* Prepared for Narrandera Shire Council by Lyall & Associates.

Lyall & Associates. 2019. *Review of the Narrandera Floodplain Risk Management Study and Plan.* Prepared by Lyall & Associates for Narrandera Shire Council.

Podger, S., Babister, M., Trim, A., Retallick, M., & Adam, M. 2019. "Review of ARR Design Inputs for NSW - Final Report." Edited by NSW Government Office of Environment and Heritage. https://data.arr-software.org/static/pdf/nsw_losses_report.pdf.

TUFLOW. 2020. 3 May. https://www.tuflow.com/Download/Presentations/2019/2019_11_RCEM_SGS_Poster.pdf.

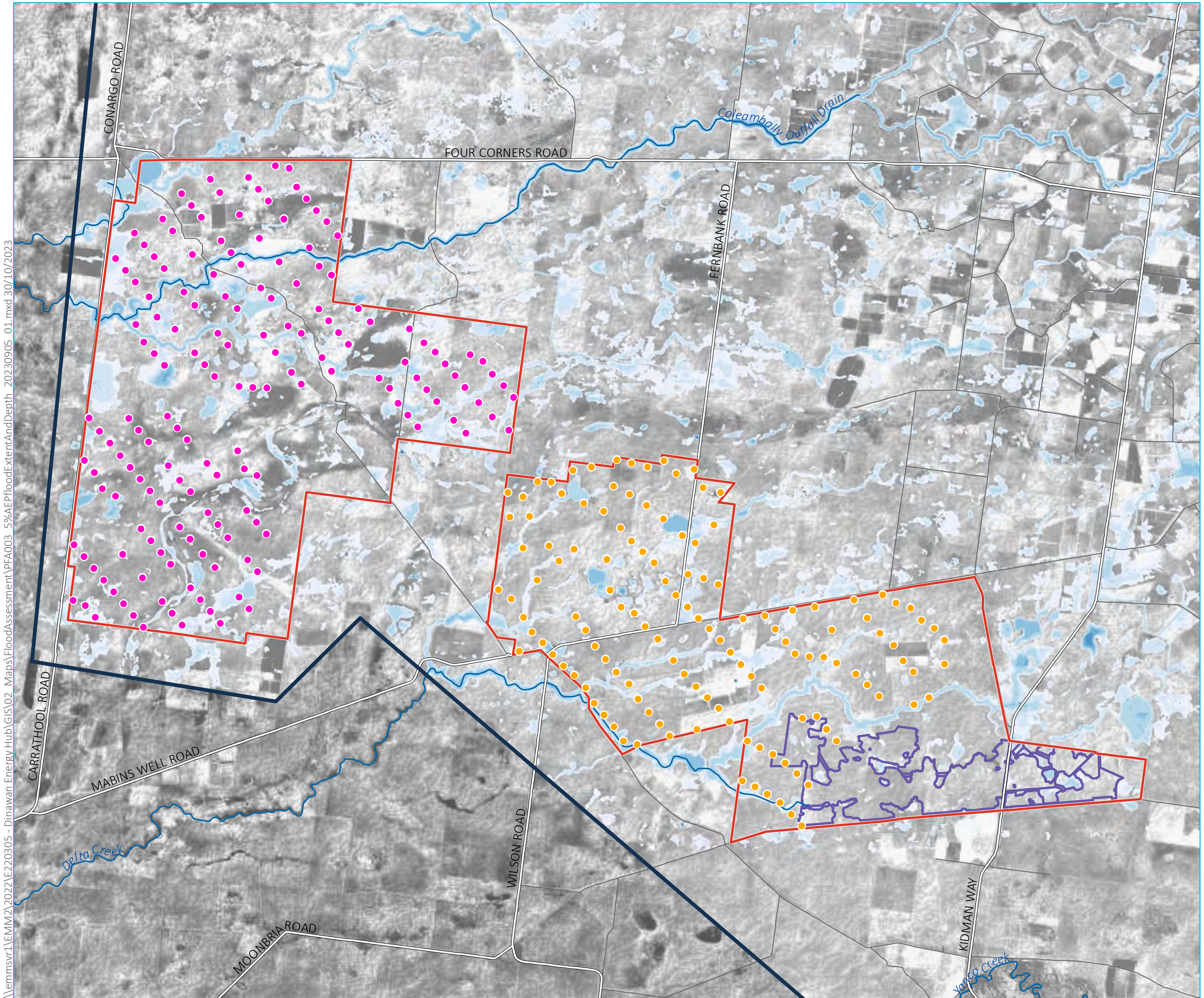
Abbreviations

Abbreviation	Meaning
2D	two-dimensional
AEP	annual exceedance probability
AHD	Australian Height Datum
ARF	areal reduction factor
BESS	battery energy storage system
BoM	Bureau of Meteorology
DEM	digital elevation model
DFSI	Department of Finance, Services and Innovation
DPE	Department of Planning and Environment
FFA	flood frequency analysis
GIS	geographic information system
GSAM	Generalised Southeast Australia Method
ha	hectare
HPC	heavily parallelised compute
IFD	Intensity Frequency Duration
km	kilometre
km^2	square kilometre
LGA	local government area
LiDAR	light detection and ranging
m	metre
NSW	New South Wales
PMF	probable maximum flood
PMP	probable maximum precipitation
REZ	Renewable Energy Zone
RFFE	Regional Flood Frequency Estimation
SSD	State Significant Development
SGS	sub-grid sampling
WTG	wind turbine generator

Annexure A

Flood mapping

EMM
creating opportunities



KEY

- Project investigation area
- TUFLOW model boundary
- Dinawan Solar Farm development footprint
- Wind turbine generator (East)
- Wind turbine generator (West)

Existing environment

- Major road
- Minor road
- Named watercourse

5% AEP flood depth (m)

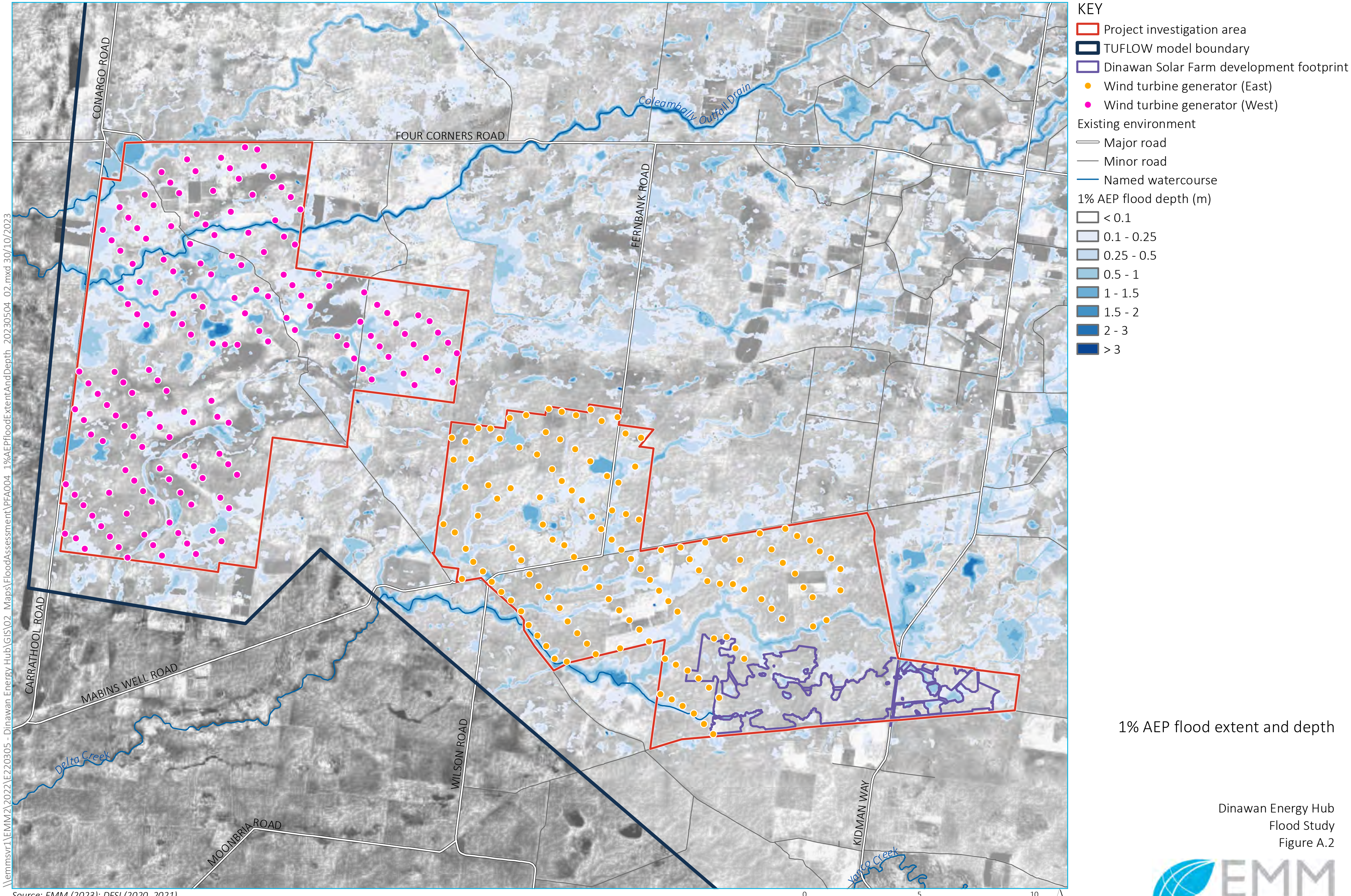
- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

5% AEP flood extent and depth

Dinawan Energy Hub
Flood Study
Figure A.1

Source: EMM (2023); DFSI (2020, 2021)

\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA003_5%AEPfloodExtentAndDepth_20230905_01.mxd 30/10/2023



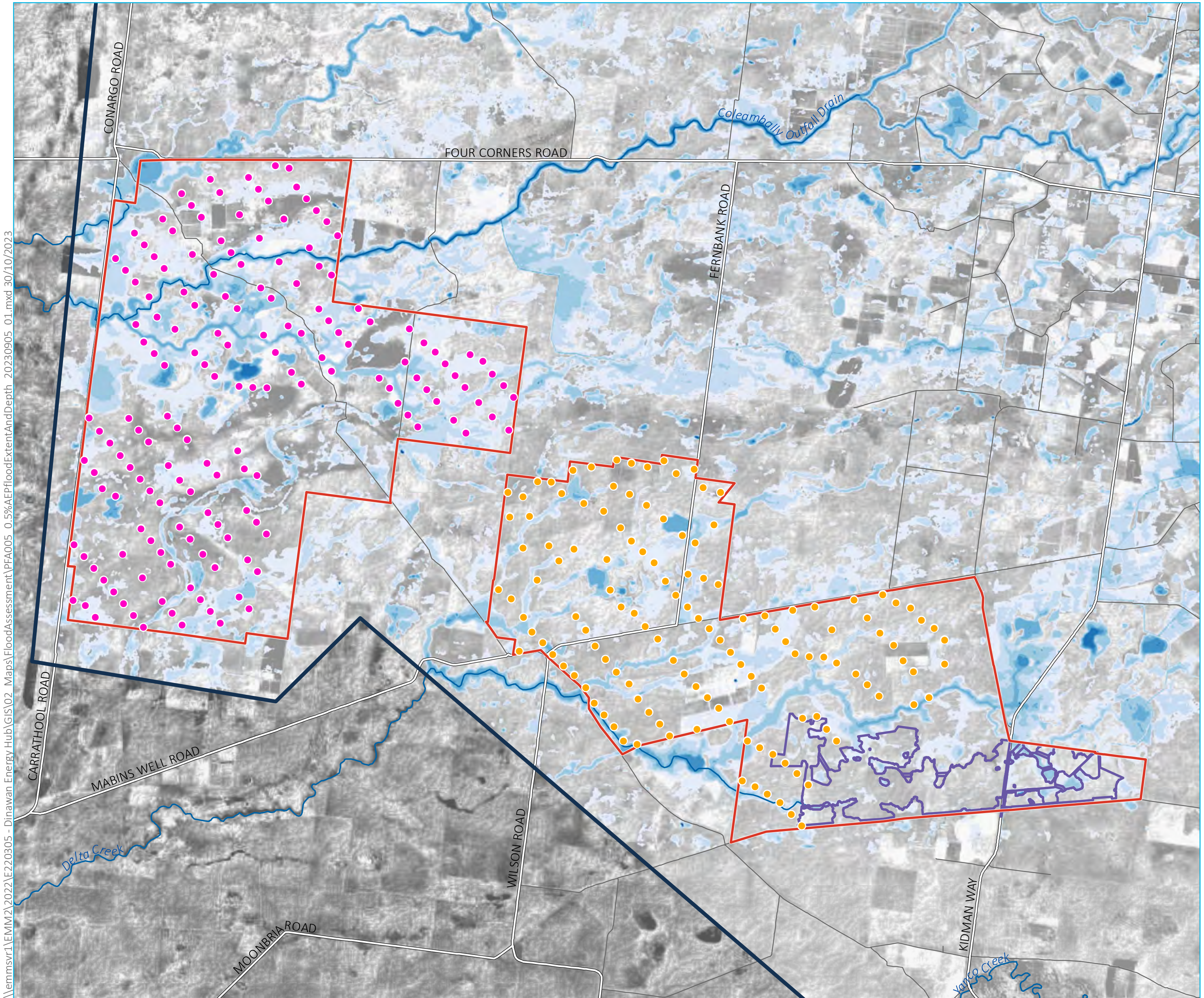
\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA004_1%AEPfloodExtentAndDepth_20230504_02.mxd 30/10/2023

Source: EMM (2023); DFSI (2020, 2021)

1% AEP flood extent and depth

Dinawan Energy Hub
Flood Study
Figure A.2

EMM
creating opportunities



KEY

- Project investigation area
- TUFLOW model boundary
- Dinawan Solar Farm development footprint
- Wind turbine generator (East)
- Wind turbine generator (West)

Existing environment

- Major road
- Minor road
- Named watercourse

0.5% AEP flood depth (m)

- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

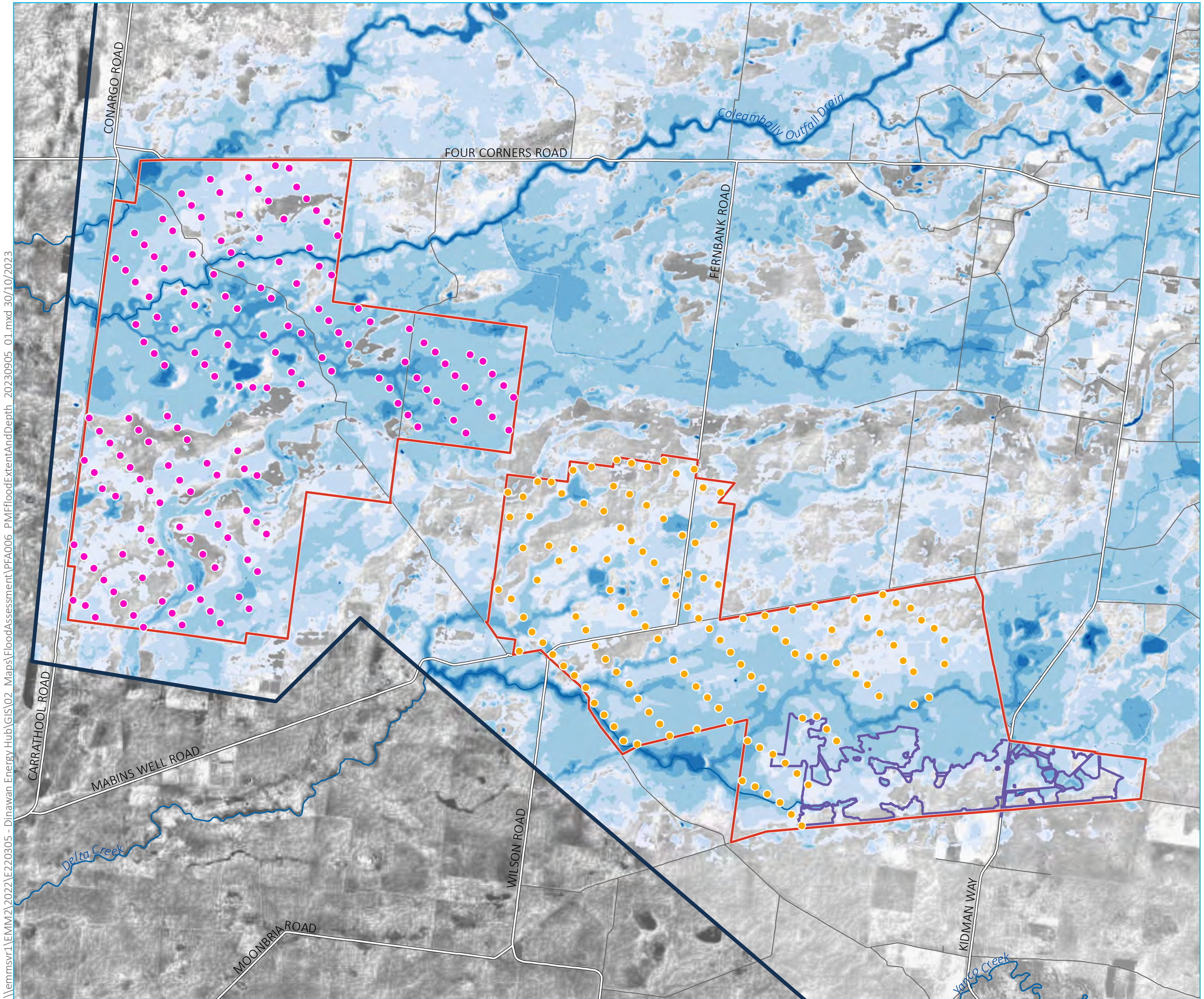
Source: EMM (2023); DFSI (2020, 2021)

\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA005_0.5%AEPfloodExtentAndDepth_20230905_01.mxd 30/10/2023

0.5% AEP flood extent and depth

Dinawan Energy Hub
Flood Study
Figure A.3

creating opportunities



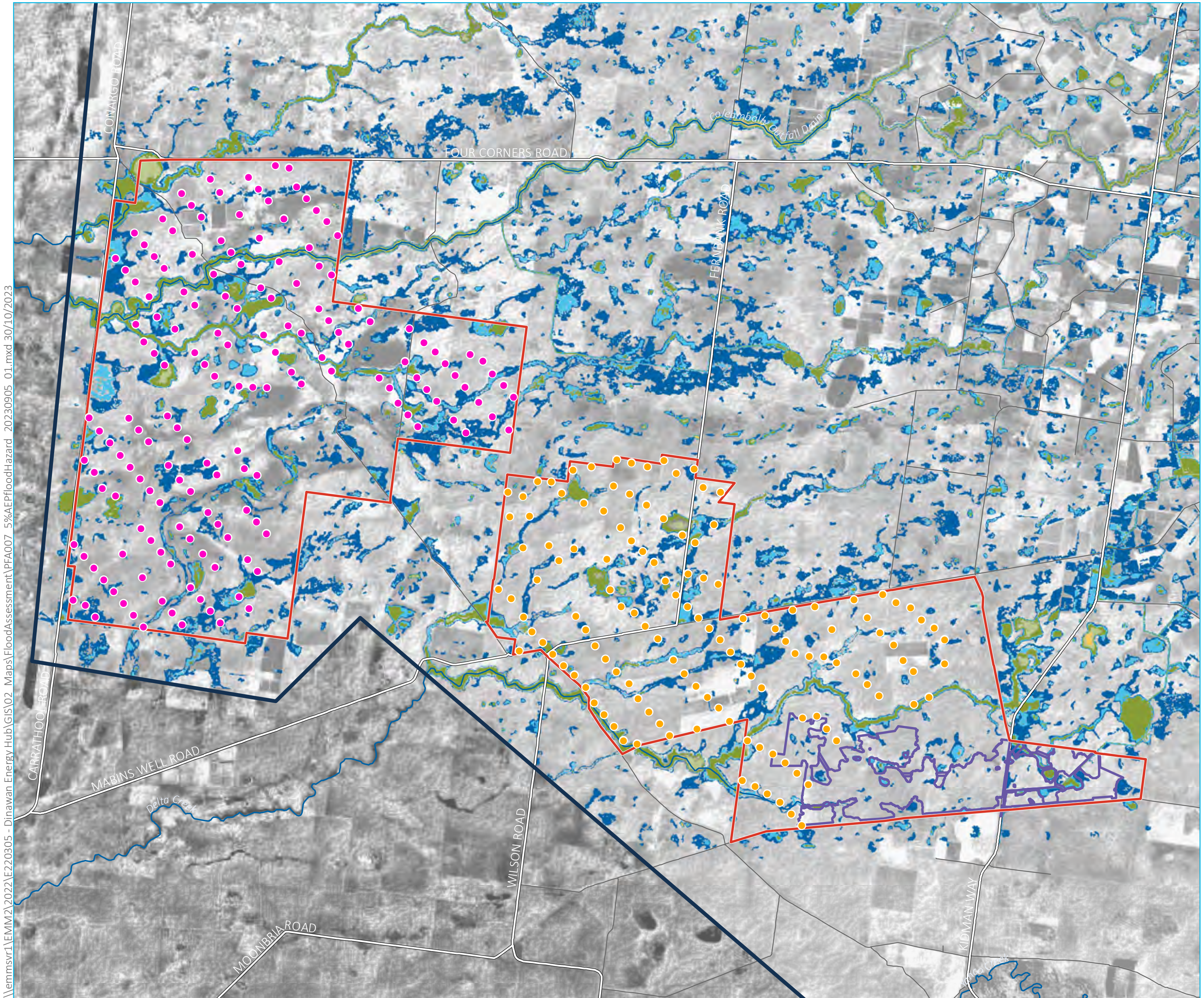
Source: EMM (2023); DFSI (2020, 2021)

\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA006_PMFfloodExtentAndDepth_20230905_01.mxd 30/10/2023

PMF flood extent and depth

Dinawan Energy Hub
Flood Study
Figure A.4

EMM creating opportunities



KEY

- Project investigation area
- TUFLOW model boundary
- Dinawan Solar Farm development footprint
- Wind turbine generator (East)
- Wind turbine generator (West)

Existing environment

- Major road
- Minor road
- Named watercourse

Peak flood hazard - 5% AEP

- H1
- H2
- H3
- H4
- H5
- H6

5% AEP flood hazard

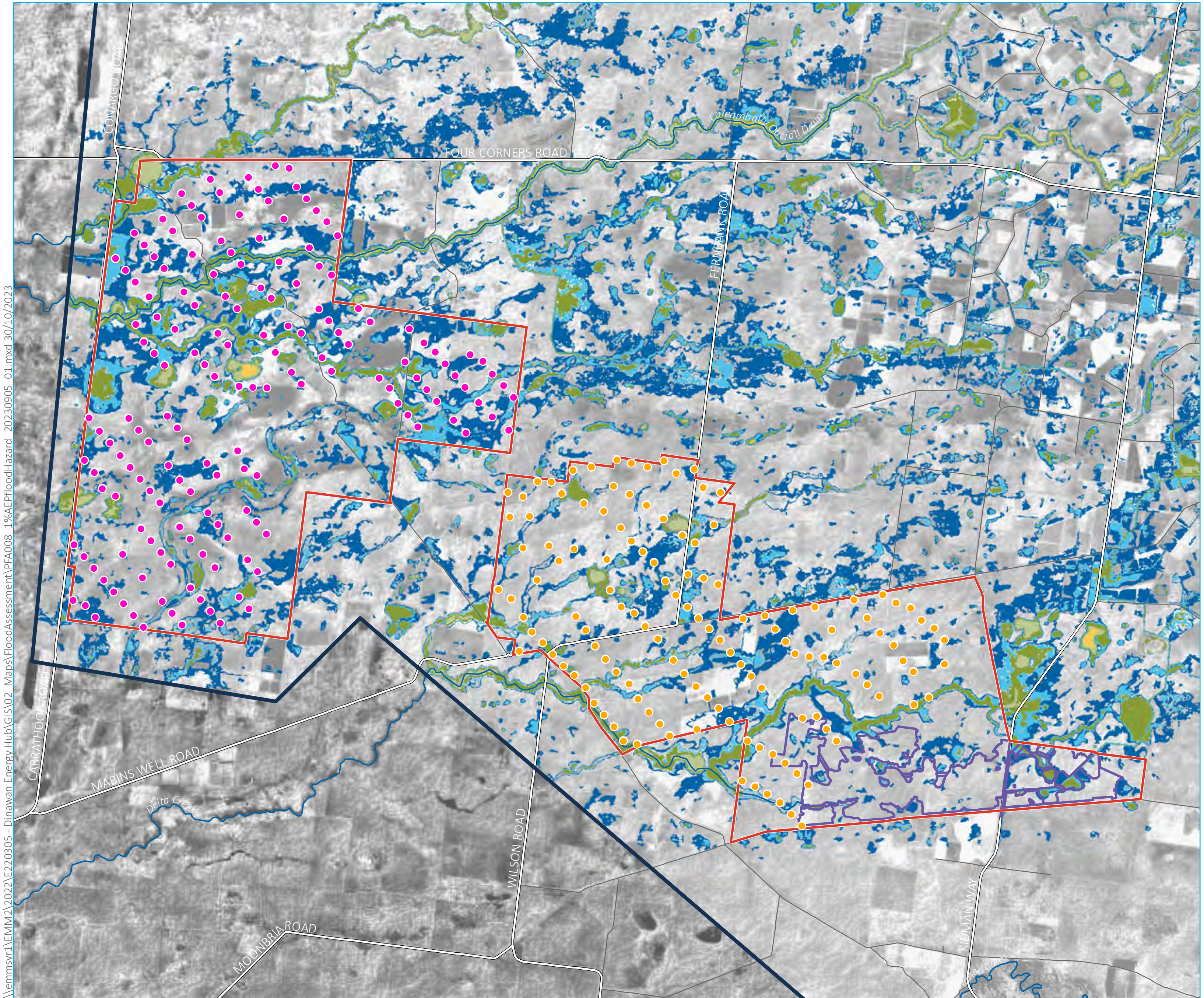
Dinawan Energy Hub
Flood Study
Figure A.5

Source: EMM (2023); DFSI (2020, 2021)

0 5 10 km
GDA2020 MGA Zone 55
N

\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA007_5%AEPfloodHazard_20230905_01.mxd 30/10/2023

EMM creating opportunities



KEY

- Project investigation area
- TUFLOW model boundary
- Dinawan Solar Farm development footprint
- Wind turbine generator (East)
- Wind turbine generator (West)

Existing environment

- Major road
- Minor road
- Named watercourse

Peak flood hazard - 1% AEP

- H1
- H2
- H3
- H4
- H5
- H6

Source: EMM (2023); DFSI (2020, 2021)

0 5 10 km

GDA2020 MGA Zone 55

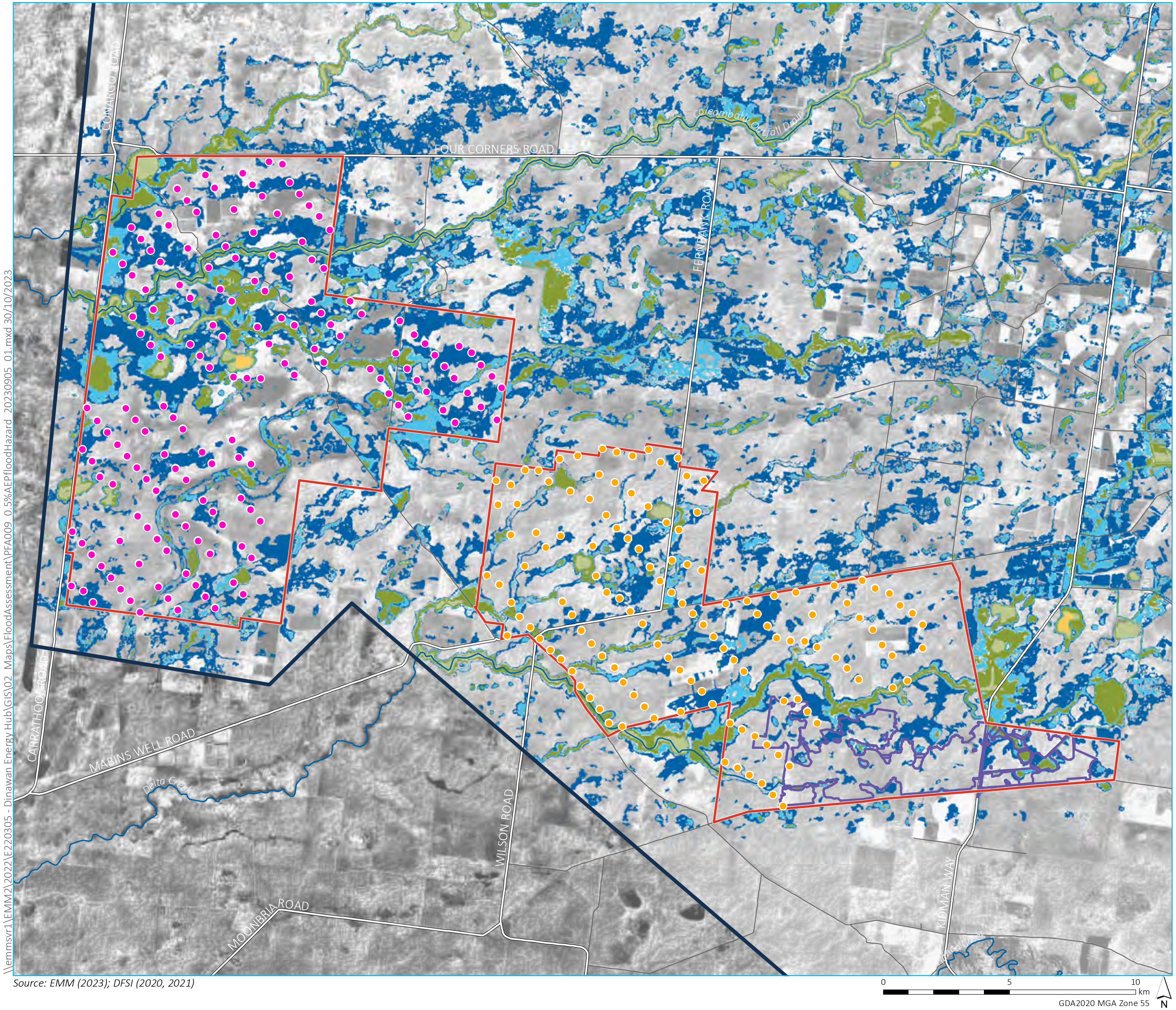
N

1% AEP flood hazard

Dinawan Energy Hub
Flood Study
Figure A.6

EMM creating opportunities

\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA008_1%AEPfloodHazard_20230905_01.mxd 30/10/2023



\\emmsvr1\EMM2\2022\E220305 - Dinawan Energy Hub\GIS\02_Maps\FloodAssessment\PFA009_0.5%AEPfloodHazard_20230905_01.mxd 30/10/2023

Source: EMM (2023); DFSI (2020, 2021)

KEY

- Project investigation area
- TUFLOW model boundary
- Dinawan Solar Farm development footprint
- Wind turbine generator (East)
- Wind turbine generator (West)

Existing environment

- Major road
- Minor road
- Named watercourse

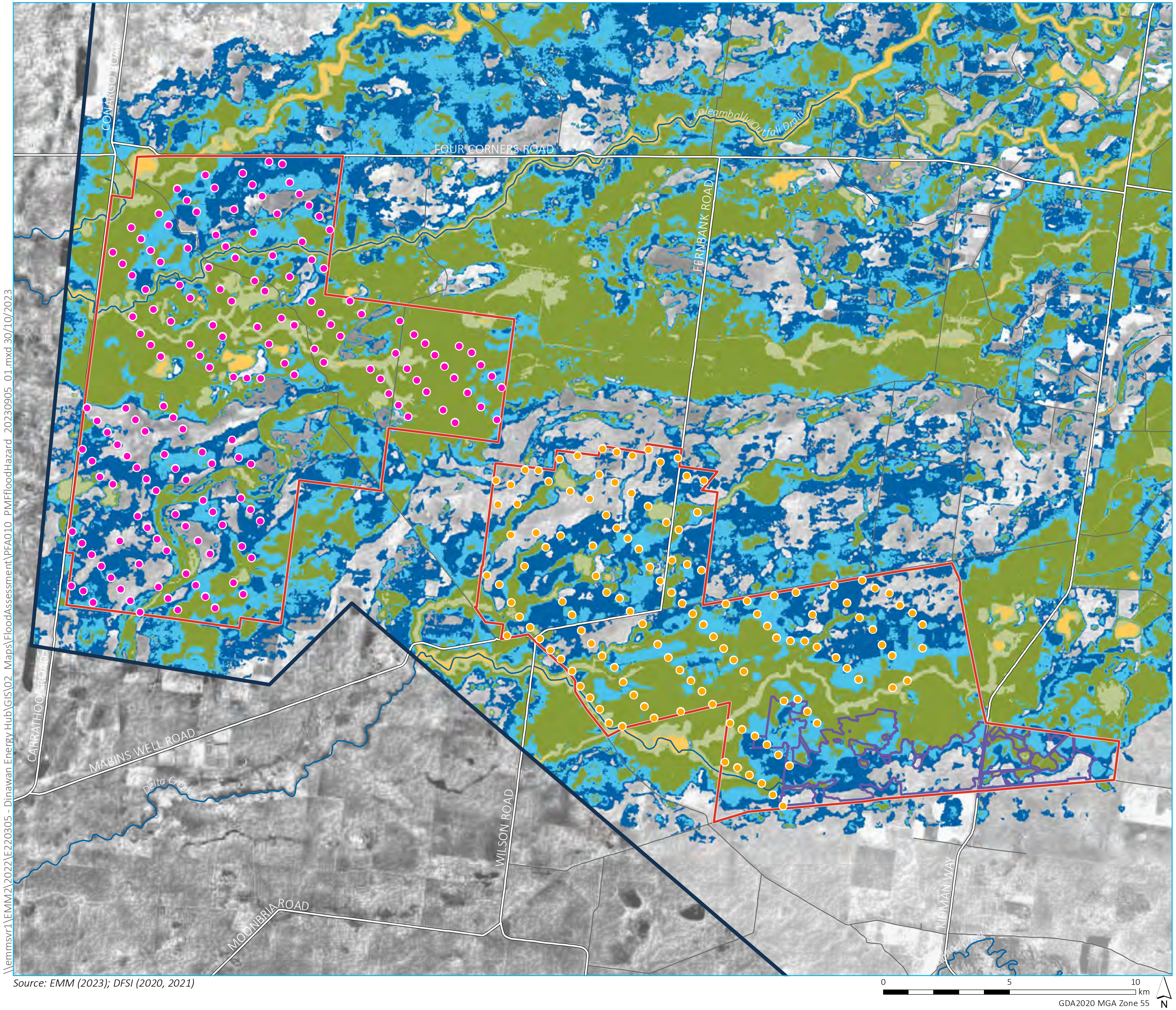
Peak flood hazard - 0.5% AEP

- H1
- H2
- H3
- H4
- H5
- H6

0.5% AEP flood hazard

Dinawan Energy Hub
Flood Study
Figure A.7

EMM
creating opportunities



KEY

- Project investigation area
- TUFLOW model boundary
- Dinawan Solar Farm development footprint
- Wind turbine generator (East)
- Wind turbine generator (West)

Existing environment

- Major road
- Minor road
- Named watercourse

PMF flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Source: EMM (2023); DFSI (2020, 2021)

PMF flood hazard

Dinawan Energy Hub
Flood Study
Figure A.8

creating opportunities

Australia

SYDNEY
Ground floor, 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3, 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1, 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Level 2, Suite 2.04
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4, 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
188 Normanby Road
Southbank VIC 3006

PERTH
Level 9, Suite 9.02
109 St Georges Terrace
Perth WA 6831

Canada

TORONTO
2345 Yonge Street, Suite 300
Toronto ON M4P 2E5

VANCOUVER
60 W 6th Ave Suite 200
Vancouver BC V5Y 1K1

linkedin.com/company/emm-consulting-pty-limited

emmconsulting.com.au

Attachment B

Registered groundwater bores

EMM
creating opportunities

B.1 Registered groundwater bores

Table B.1 Registered groundwater bores within the development corridor

State bore ID	Bore depth (mbgl)	Drilled depth (mbgl)	Status	Drilled date	Type	Easting	Northing	Ref elev (mAHD)	Type class
GW505524	68	68	USE	3/07/2008 0:00	HUSE	363046	6135083	0	Water Supply
GW401211	185	185	USE	25/03/1997 0:00	HUSE	379718	6123643	111.98	Water Supply
GW017769	46.3	46.3	UNK	1/10/1959 0:00	HUSE	364692	6130067	0	Water Supply
GW400978	176.83	182.88	UNK	1/11/1998 0:00	IRAG	375515	6120925	0	Irrigation
GW500860	184	193	UNK	1/12/2000 0:00	IRAG	374774	6121946	0	Irrigation
GW065217	56	0	FUN	6/10/1988 0:00	MON	376246	6127274	111.06	Monitoring
GW012554	25.3	0	FUN	1/01/1956 0:00	MON	380543	6120613	111.76	Monitoring
GW012862	35.1	0	FUN	1/01/1956 0:00	MON	373042	6122514	109.2	Monitoring
GW012860	39.3	0	FUN	1/01/1956 0:00	MON	378755	6123609	111.54	Monitoring
GW011038	54.3	54.3	FUN	1/11/1954 0:00	MON	379873	6121915	111.7	Monitoring
GW017312	33.2	33.2	FUN	1/03/1958 0:00	MON	373043	6122505	109.2	Monitoring
GW012892	27.4	0	FUN	1/01/1956 0:00	MON	386551	6124449	114.03	Monitoring
GW050184	77.7	77.7	FUN	1/12/1979 0:00	MON	374493	6123755	109.96	Monitoring

Table B.2 Registered telemetered groundwater bores nearby project area

State bore ID	Bore depth (mbgl)	Drilled depth (mbgl)	Status	Monitoring Commencement	Type	Easting	Northing	Ref Elev (mAHD)	Type class
GW030325	115.5	120.3	FUN	2010	MON	353692	6129481	104	Monitoring
GW036040	348	248	FUN	2009	MON	385455.3	6141799.7	114.85	Monitoring
GW036573	110	110	FUN	2009	MON	408023	6127476	123.2	Monitoring
GW403747	229	229	FUN	2010	MON	371707	6122789	107.94	Monitoring

Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Level 2 Suite 2.04
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
Suite 8.03 Level 8 454 Collins Street
Melbourne VIC 3000
T 03 9993 1900

PERTH
Level 3 111 St Georges Terrace
Perth WA 6000

Canada

TORONTO
2345 Younge Street Suite 300
Toronto ON M4P 2E5

VANCOUVER
60 W 6th Ave Suite 200
Vancouver BC V5Y 1K1

linkedin.com/company/emm-consulting-pty-limited

emmconsulting.com.au