Golden Plains Wind Farm

WestWind Energy Pty Ltd

Hydrogeological desktop assessment

| Final

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D	18/05/17	Updated report to include larger area	EM	GH	GH

Contents

1. Introduction

1.1 Background

WestWind Energy Pty Ltd ('WestWind') has secured land at Barunah Park, 60 km north-west of Geelong. WestWind began wind monitoring in 2012 in order to prove the resource for a wind farm. The wind resource has been proven and WestWind are now looking to progress the project towards planning approval. The project is likely to consist of up to 235 wind turbines within the 3-5 MW class with an overall height of approximately 230 m from natural ground level to the blade tip.

In order to progress towards planning approval, Jacobs have been engaged by WestWind to undertake preliminary environmental assessments to understand the potential risk to environment of construction and operation of the proposed Golden Plains Wind Farm (referred to herein as the 'Wind Farm'). The outcomes of the assessments will be used to support the referrals and future planning permit applications under the *Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria, January 2016*.

1.2 Purpose of assessment

The purpose of the assessment provided in this report is to identify potential:

- Impacts to local or regional groundwater resulting from construction or operation of the project; and/or
- Development constraints that may be posed by groundwater.

1.3 Project information

Construction and operation information pertinent to the proposed Wind Farm provided by WestWind is summarised in Table 1-1 and the proposed site boundary has been included in Appendix A.

Specific to groundwater, the following construction and operation elements are important:

- Foundations for the wind turbines will reach to a maximum of 3.5mBNS[1] and will have a circular footprint of approximately 20-25 m diameter
- Trenching for the internal (power) collector network will be approximately 1mBNS

Table 1-1 Project information (WestWind, 2016)

Parameter	Details
Project name	Golden Plains Wind Farm
Location	Land to the south, south east and west of Rokewood and on land at Barunah Park approximately 60 kilometres north west of Geelong, Victoria
Client	WestWind Energy Pty Ltd (WestWind)
Proponent	WestWind Energy Pty Ltd (WestWind)
Wind turbine parameters	Capacity of wind individual wind turbines - 3-5 Megawatts (MW) Height of wind turbines – 230 m from the natural ground level to the tip.
Number of wind turbines	In the order of: • Up to 235 x 3-5 MW turbines
Wind turbine foundations	Expected to be concrete gravity foundations (depth approximately 3.5 meters, diameter 20-25 meters subject to geotech) or rock anchor foundations. (Subject to final geotechnical assessment).
Local government area	Golden Plains Shire

[1] mBNS: metres below natural surface

Parameter	Details
Catchment Management Authority	Corangamite
Land use	Agriculture – cropping and grazing
Proposed electricity connection point	A location within the site boundary (TBC) adjacent to the existing 500 kilovolt (kv) line

2. Site Setting

2.1 Geology

Both regionally (within the Otways Basin) and locally (the project site), geological mapping (Seamless Geology 2014 and GSV, 1996 and 1997) indicates that the surficial geology is dominated by two geological formations – lava flows and alluvial/colluvial deposits (Appendix B**Error! Reference source not found.**).

Lava flows: The predominant geological feature at the site (and in the wider region) is the Newer Volcanics (Qvn) geological unit, comprised of basalt, minor scoria and ash. Stony outcropping basalt was confirmed during a site visit on 2 August 2016 (Figure 2-1). The Newer Volcanics is a complex sequence of lava flows and associated volcanic material. Stony rise basalt is present in the east of the project site. The Newer Volcanics are also a locally important aquifer, albeit highly variable in quality and yield.

Alluvial/Colluvial deposits: In some of the watercourse and drainage lines, including the areas surrounding Mount Misery Creek and Kuruc A Ruc Creek, the Newer Volcanics is typically overlain by unnamed Quaternary alluvial flood plain deposit (Qa1). These unconsolidated sediments are comprised of silt, sand and gravel. During the drilling of monitoring bore 26662, 13 m of poorly sorted gravel sands and clays were intersected (Gill, 1989). In the north west of the project site incised colluvium (Nc1) is present; these sediments are similar to the alluvial deposits however they are generally poorly sorted and poorly rounded. Additionally, there are sparse areas across the site where the Newer Volcanics is overlain by unnamed (Qm1) swamp deposits of clay, silt, and sand. Alluvial and swamp sediments were deposited in shallow freshwater environments and so have a distribution that follows current and former rivers and lakes and colluvium was deposited at the base of a slopes.

Underlying the surficial geology but overlying the bedrock are marine sediments, predominantly marl, from the Heytesbury Group. Because of the relatively shallow depth of interest for the wind farm, these units are not relevant to this assessment. Regionally and locally, the underlying bedrock is comprised of the Ordovician sandstone, siltstone and shale, known as the Castlemaine Group. It is a hard, impermeable, cemented rock (SKM and GHD, 2009).Outside of the site to the east is the Yarrowee Fault. It is not expected to have any impact on the groundwater flow within the wind farm site.

Figure 2-1 Photographs of the site showing outcropping basalt (site visit 2 August 2016). **Source: Jacobs**

2.2 Hydrogeology

2.2.1 Aquifer properties

The hydrogeology of the site can be characterised by three units.

- Regionally, the alluvial flood plain, swamp and colluvial deposits form a minor aquifer, where available. Locally, these deposits predominate in a portion of the site in the north west and to a small extent near drainage/watercourse lines in the east. Where these sediments overlie the Newer Volcanics, the deposits may contain the watertable. This unit would receive recharge from direct infiltration of rainfall.
- On both a regional and local scale, groundwater is present predominantly within the Newer Volcanics basalt, which forms the watertable aquifer across most of the area. Regionally, the aquifer can be up to 120 m thick, but it is mostly less than 70 m thick (Leonard, 1992). It is a fractured rock aquifer where groundwater yield is proportional to the size and interconnectivity of fractures. Regionally the Newer Volcanics can yield up to 60 L/s but typical yields are generally less than 1.5 L/s. The Newer Volcanics aquifer is predominantly used for stock watering with some irrigation and domestic use. Use of the aquifer is constrained by the generally low yield and high salinity (usually greater than 2000 mg/L TDS). Recharge to the aquifer is expected to be through direct infiltration from rainfall, or leakage from overlying alluvial units (where they are present). Within the study area are at least two eruption points (old volcanoes). Groundwater flow is often away from scoria cones associated with these eruption points and they may be areas of concentrated local recharge and possible better quality groundwater.
- The Castlemaine Group bedrock aquifer is a (typically) low yielding fractured rock aquifer that is relatively impermeable and unutilised aquifer in the local area. Regionally, this aquifer becomes more important in hydrogeological conceptualisation (for example, it provides the mineral springs at Daylesford) (SKM and GHD, 2009). Local recharge to this aquifer is likely to be through downwards leakage from overlying aquifers. Regionally, the bedrock aquifer would receive recharge from both downwards leakage from overlying aquifers and direct rainfall infiltration (where the unit outcrops).

Based on available hydrogeological information, the Newer Volanics basalt aquifer and alluvial/colluvial aquifers are the relevant aquifers for considering effects at the project site.

2.2.2 Groundwater level and flow

Within the project area, according to statewide database mapping (FUA, 2016), groundwater is expected to be predominantly within 5 m of natural surface or up to 10 m from natural surface along local ridgelines (Appendix C). The predicted shallower range (<5 mBNS) is likely to be associated with the western area of the project site and be associated with the presence of drainage lines and Creeks within the project site.

To confirm statewide mapping within the project site, three hydrographs have been produced using data from 1992 – 2015 from a local State Observation Bore Network (SOBN) and Dryland Salinity monitoring bores. The hydrograph (see Figure 2-2 and Figure 2-3) shows results consistent with the statewide mapping:

- Bore 110103 is located in the central eastern half of the project site and monitors the Newer Volcanics aquifer. Depth to groundwater has varied from 7.8-9.8 mBNS over the period of record, with a generally declining trend. This hydrograph is likely to be indicative of depth to groundwater along ridges on the project site.
- 26663 and 26662 are located north of the project boundary. Depth to groundwater has varied from 0.3 – 4.7 mBNS in 26663 and 1.1 - 5 mBNS in 26662. Bore 26662 and 26663 are screened in alluvial deposits (Gill. B, 1989); in 26663 this was based on drill depth and lithology encountered. This hydrograph is likely to be indicative of groundwater in alluvial sediments near watercourses.

Waterlogged soils and potential surface expressions of groundwater were observed during a site visit on 2 August 2016 (Figure 2-4). In addition, it should be noted that a network of pools (Lake Corangamite and Lake Colac) are present less than 10 km south of the project site area, which are likely to effect the elevation of groundwater in the general area. It is understood that groundwater flow within the Newer Volcanics is on a regional scale (Leonard, 1992). Groundwater is expected to be flowing in a southerly direction towards Lake

Corangamite and Lake Colac. The current layout map indicates the majority of turbines are located where groundwater is expected to be <5mBNS.

Eruption points are likely to be sources of recharge to the aquifer and may have shallow groundwater. Turbine locations on eruption points (such as those situated close to Gow Hill) should be evaluated to consider the effect on groundwater flow and the possible impact of the geology on footing design.

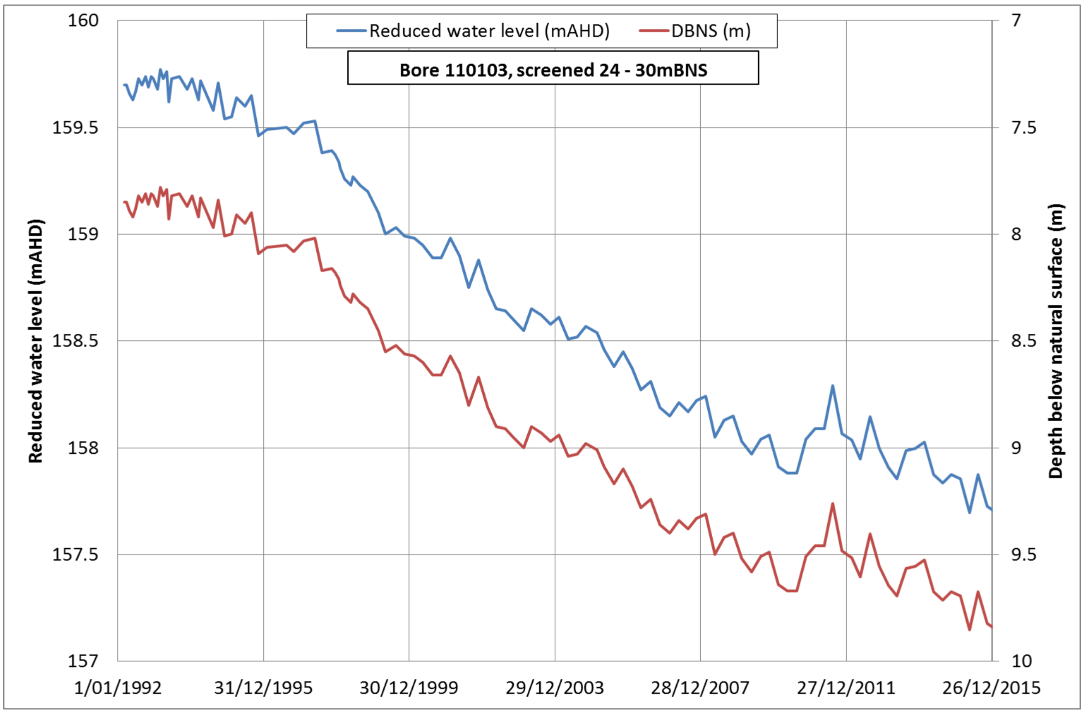

Figure 2-2 Hydrograph for 110103 (data derived from FUA, 2016)

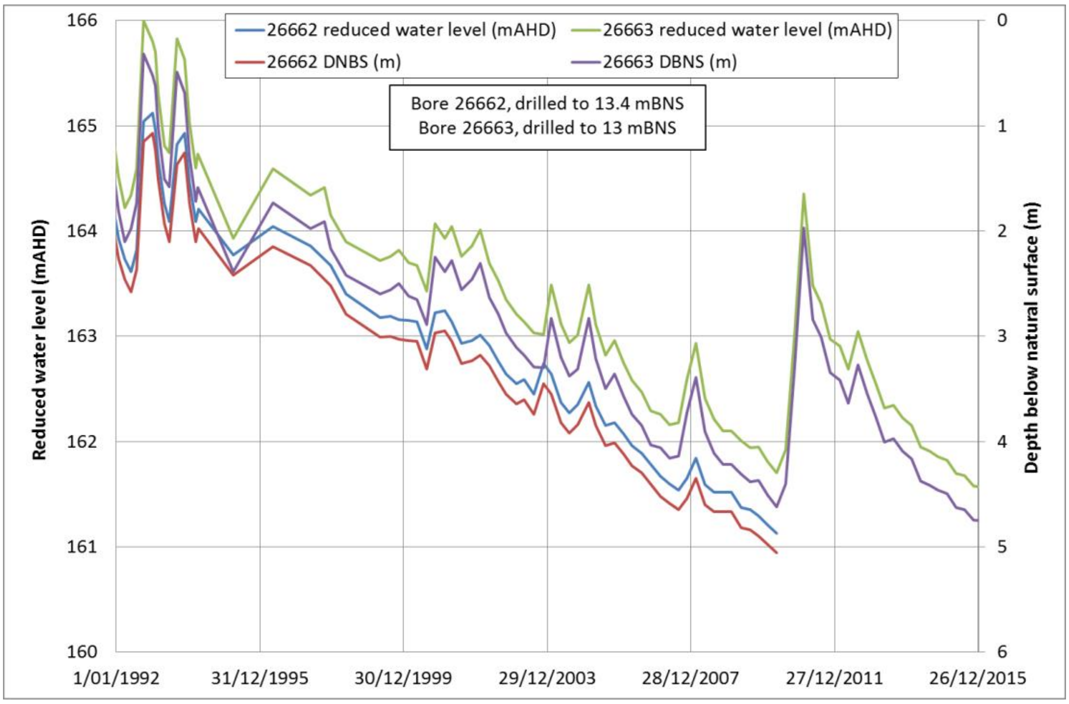

Figure 2-3 Hydrographs for 26662 and 26663 (data derived from FUA, 2016)

Figure 2-4 Photographs of the site showing waterlogged areas and a creek, likely to influence groundwater elevation or be a surface expression of groundwater. **Source: Jacobs**

2.2.3 Groundwater quality

As stated in section 2.2.1, regional salinity of the Newer Volcanics is generally upwards of 2,000 mg/L TDS. Statewide mapping (FUA, 2016) indicates that watertable salinity of the site ranges between 3,500 – 13,000 mg/L TDS (Appendix D). Available electrical conductivity data from local bores (data collected from the Victorian water database: DELWP, 2016) indicates that salinity within the project area (in the Newer Volcanics) ranges from 3,180-8,736 mg/L TDS, generally within the expected range derived from statewide mapping. Bore 56267 that intersects alluvium recorded a concentration of total dissolved solids of 10,104 mg/L.

2.2.4 Groundwater use

Existing users

Bore data within 2 km of the approximate site boundaries was obtained from the Victorian water database (DELWP, 2016). A summary of existing users is summarised by use type Table 2-1. These bores and bores outside the 2 km zone have been plotted on the depth to water table map (Appendix C).

Table 2-1 Summary of local bore users in within 2 km of the site boundary

Use type	Number of bores
Stock and domestic	24
Investigation, observation	20
Irrigation	1
Unknown or listed as 'non-groundwater'	123

Groundwater dependent ecosystems (GDEs)

Information on known GDEs within and in vicinity of the project site was collected from the National GDE Atlas (Bureau of Meteorology, 2016) and is presented in Appendix E. Several potential GDEs have been identified within the project site, as summarised in Table 2-2.

Table 2-2 Summary of GDEs within the project site (Bureau of Meteorology, 2016)

Potential for groundwater interaction	GDEs
High	• Mount Misery, Kur A Ruc Creek, Ferrers Creek and Mia Mia Creek, that run north-south through the project site • Floodplain riparian woodland associated with Ferrers Creek along the western side of the project site • Deep marches/wetlands in the southern section of the site
Moderate	• Deep marshes in the southern section of the site • Grassy woodlands in the south-east section and western of the site • Riparian woodlands near Mount Misery Creek and Kur A Ruc Creek.

South of the site is Lake Weering and Cundare Pool, saline wetlands that rely on the surface expression of groundwater and have been classed as connected with groundwater in the Newer Volcanics.

3. Impacts Assessment

3.1 Construction

From the project information provided (Section 1.3) it is understood that foundations for the wind turbines will sit at a maximum of 3.5 mBNS and will have a 20 – 25 m circular diameter foundation. Available hydrogeological information has indicated the potential for shallow (<5 mBNS) groundwater occurrence across much of site. As such, if foundation depths are designed to 3.5 mBNS, then there is the potential (risk) that groundwater will be encountered.

Available construction information suggests that manual excavation or blasting may be the preferred excavation method for construction. If so, then the impact of groundwater on construction is that site dewatering may be required. This could be in the form of sump-pumps within the excavation or dewatering using constructed wells outside the excavation zone. Dewatering can have temporary impacts to local water level and as a result has a risk of impacting local users and groundwater dependent ecosystems. These risks will require assessment prior to undertaking dewatering activities and construction works.

Given the proposed depths, it is likely that only the bottom of the footings may encounter groundwater. Local and short term dewatering would only be required. Given the likely duration of any dewatering and the generally shallow nature of any drawdown the impacts are expected to be very localised and are expected to be minor. Where groundwater is very close to the surface and there is a GDE in close proximity, further assessment of individual sites may be required. It is recommended that the final sites be assessed (using a desktop assessment) when the design is finalised. Construction during summer, when groundwater is typically at a low ebb, would minimise the impact.

3.2 Design and operation

As discussed above, there is potential that the foundations of the wind turbines will be constructed below the watertable. As such, the impact on groundwater quality on concrete or steel structures (depending on construction material choice) will need to be assessed. Groundwater, particularly saline groundwater, can have corrosive or aggressive properties that could affect concrete and steel structures.

Groundwater inflow to excavations may be higher on scoria cones and as such, siting of final turbine locations should avoid these areas, where practical. Low lying areas and drainage lines should also be avoided for final location siting.

Given the relatively small scale of the footings (20-25 m circular diameter) it is considered highly unlikely that the wind farm development would have any regional scale impact to groundwater (in terms of flow, quality etc.). At the very local scale (< 100 m) the footings may cause local alteration to the groundwater flow system if they intersect the watertable. Minor re-direction of groundwater around the footings may occur, with local changes in groundwater level. This has the potential to affect GDEs if present within 100 m of turbines and should be evaluated prior to final design.

Project information provided has not suggested groundwater is required for operation of the Wind Farm and hence there is currently no impact expected in terms of operation.

4. Conclusions and Recommendations

4.1 Conclusion

A desktop assessment of hydrogeological information pertaining to the Golden Plains Wind Farm has been completed. Available information has indicated that

- The majority of the site is predominantly directly underlain by the Newer Volcanics basalt which hosts the watertable. However, the watertable may be present in alluvial and colluvial deposits in the northern area of the site and near Mount Misey and Kuruc A Ruc Creek;
- Groundwater is expected to be shallow; predominantly less than 5mBNS and up to 10mBNS in some areas of the project site. Shallower groundwater is expected in the western area of the site and near watercourse/drainage lines. Groundwater flow is likely to be the in a southerly direction towards Lake Corangamite and Lake Colac;
- Groundwater quality in terms of salinity at the project site is expected to range between 3,500 – 13,000 mg/L TDS; and
- Turbine sites that are close to GDEs (closer than 100 m) should be evaluated for impact on groundwater flow and potential to affect groundwater flow patterns during and post construction.

Final siting of turbine locations should avoid scoria cones, low lying areas, drainage lines (where practical) and if possible, maintain a distance of 100 m from GDEs. Available information on proposed excavation levels indicates there is a potential for groundwater to be intersected during construction, which may require dewatering to manage. Depending on excavation methods and depth of groundwater encountered at the time of construction, dewatering may be in the form of sump-pumps within the excavation itself or via constructed wells outside of the excavation. If groundwater is encountered, the impact of the quality of the water in terms of materials selection (steel and concrete) should be assessed prior to detailed design. Project information provided has not suggested groundwater is required for operation of the Wind Farm and hence there is currently no impact expected in terms of operation.

4.2 Recommendations

Based on available depth to watertable mapping (Appendix C) and the current site boundary, it is likely that groundwater will be intercepted during construction at most turbine sites. Final siting of turbines should consider impact of local geological and hydrogeological conditions to final design and constructability. Conversely, final siting should also consider impact to local groundwater conditions and groundwater dependent ecosystems.

To confirm the local hydrogeological conditions (and the presence of groundwater) and inform detailed design, a field investigation is recommended. This could consist of shallow monitoring wells installed across the site, targeting the maximum invert level (it is unlikely that a well is required at each turbine site). These wells could be 'slug tested' to confirm hydraulic conductivity and inform inflow volumes during construction. Water quality samples could be collected to determine groundwater corrosion effects. Using data from the field investigation, a dewatering impact assessment may be required to assess the impacts of dewatering/construction on local GDEs. Disposal location of discharged groundwater during dewatering activities will require consideration and approvals may be required (i.e. to discharge to Creek or sewer).

5. References

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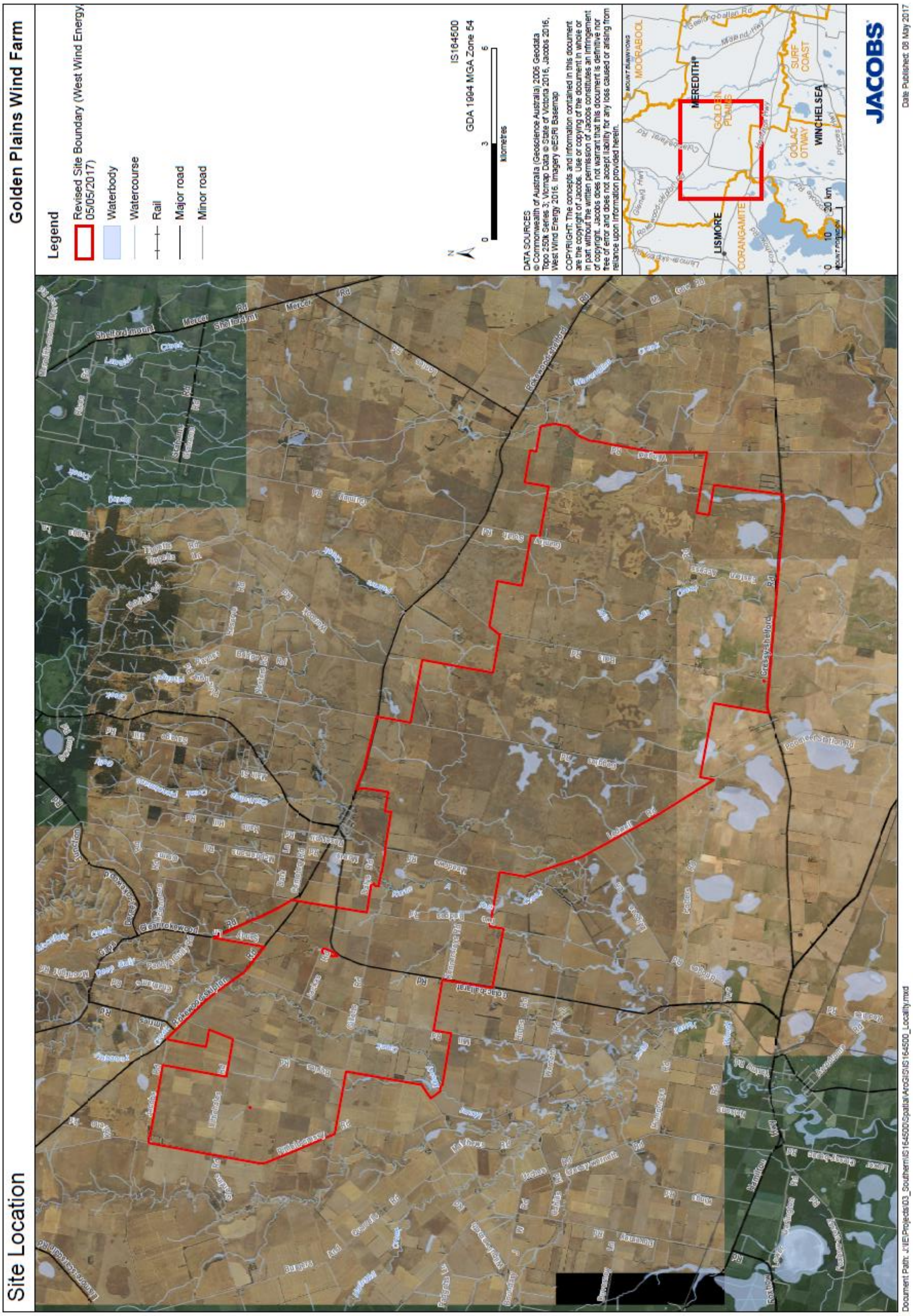
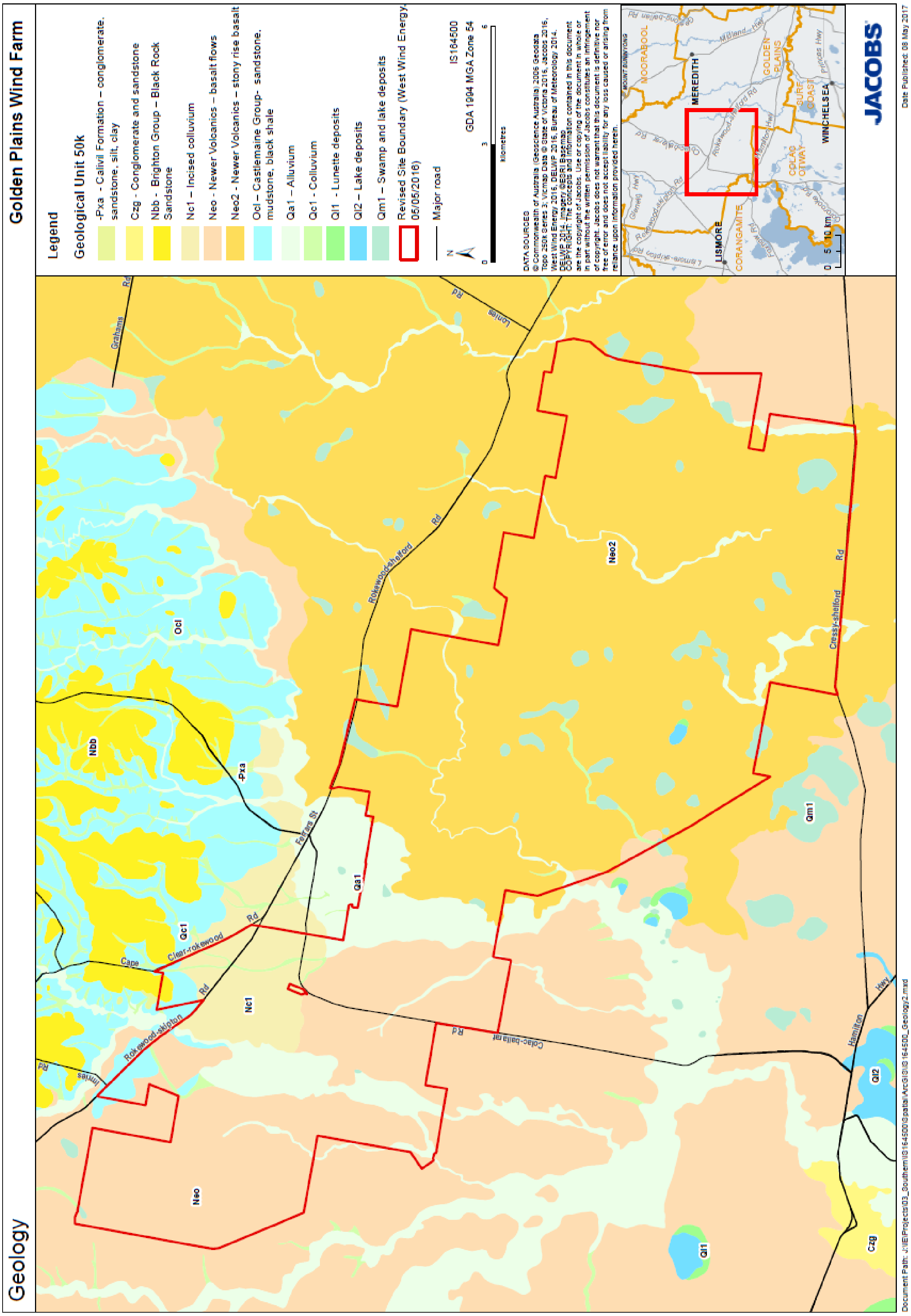
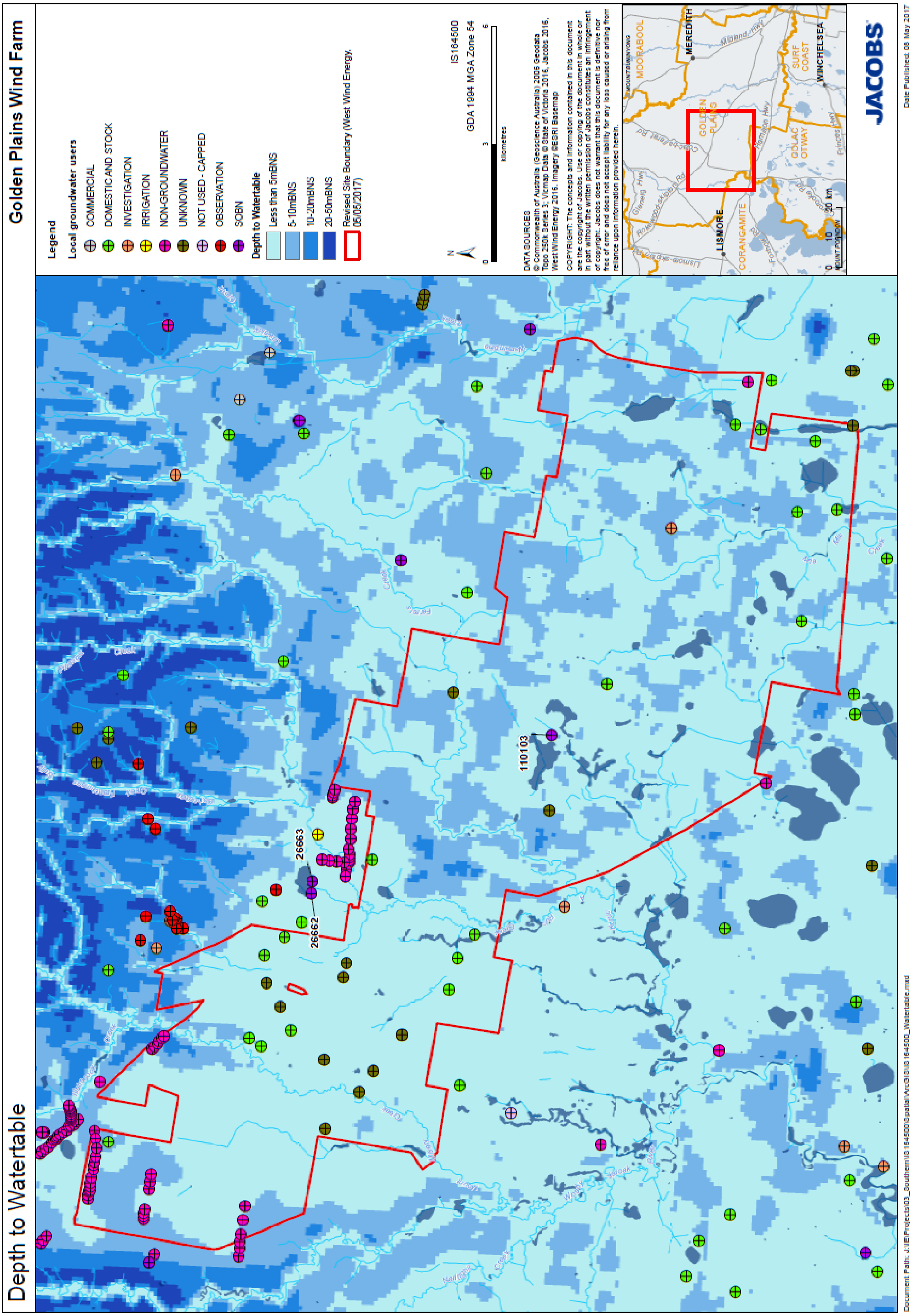
Appendix A. Map: Site location map



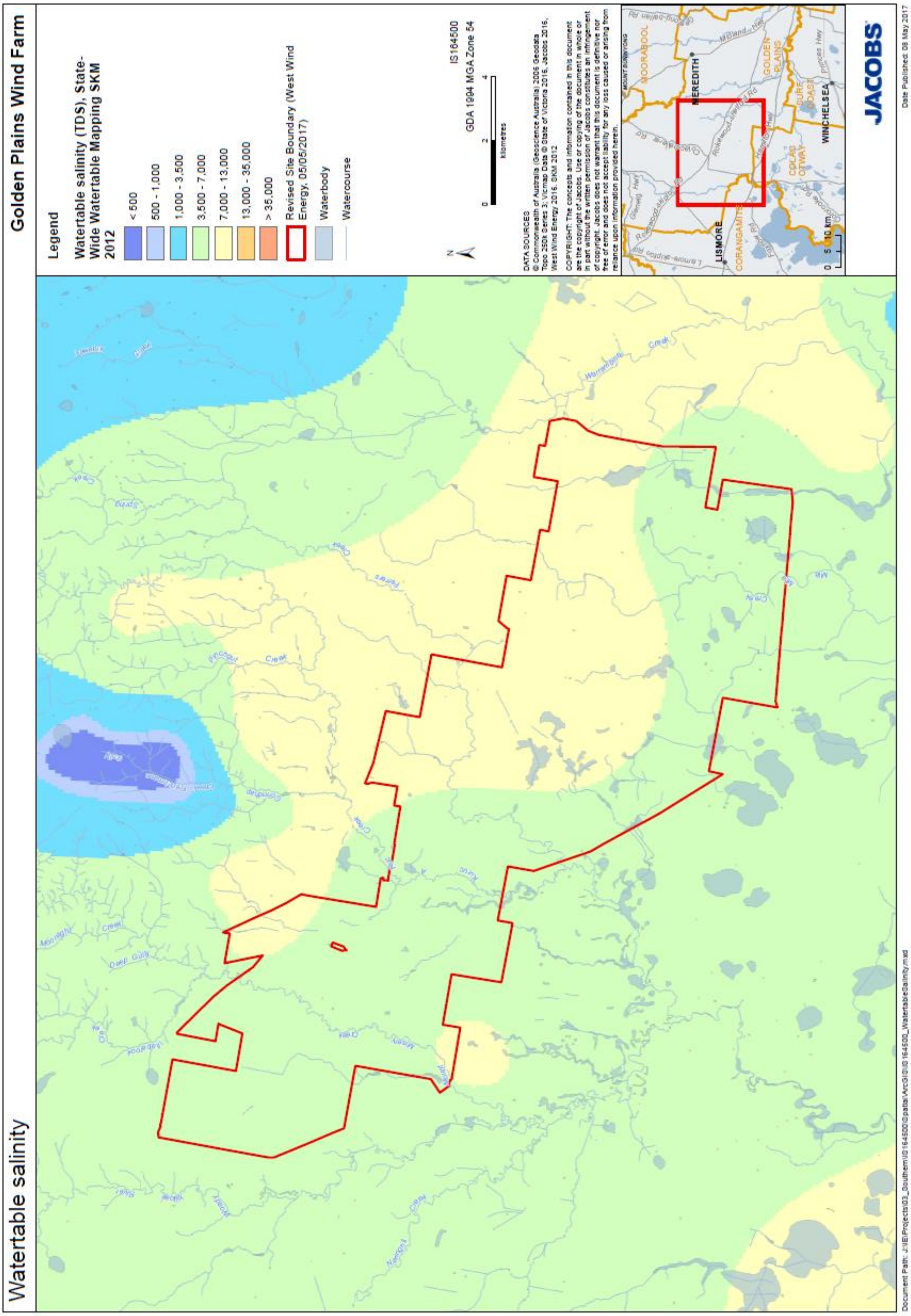
Appendix B. Map: Geology



Appendix C. Map: Depth to watertable and groundwater users



Appendix D. Map: Watertable salinity



Appendix E. Map: Groundwater Dependent Ecosystems