Stormwater Assessment

Theodore Wind Farm

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ACRONYMS AND ABBREVIATIONS

Acronyms	**Description**
AEP	Annual Exceedance Probability
ANZECC	Australia and New Zealand Environment and Conservation Council
BESS	Battery Energy Storage System
BPESC	Best Practice Erosion and Sediment Control
CEMP	Construction Environment Management Plan
CESCP	Construction Erosion and Sediment Control Plan
DEM	Digital Elevation Model
DSDILGP	Department of State Development, Infrastructure, Local Government and Planning (now Department of Housing, Local Government, Planning and Public Works)
EPA	Environmental Protection Act 1994
EPP	Environmental Protection (Water and Wetland Biodiversity) Policy 2019
ERM	Environmental Resources Management Australia Pty Ltd
ESCP	Erosion and Sediment Control Plan
EV	Environmental Values
IECA	International Erosion Control Association
LGA	Local Government Area
PO	Performance Outcomes
QWQG	Queensland Water Quality Guidelines
RUSLE	Revised Universal Soil Loss Equation
SDAP	State Development Assessment Provisions
SPP	State Planning Policy
SWMP	Stormwater Management Plan
TED	Theodore Energy Development Pty Ltd
VMA	Vegetation Management Act 1999
WQG	Water Quality Guidelines
WQO	Water Quality Objectives

1. INTRODUCTION

Environmental Resources Management Australia Pty Ltd (ERM) has been engaged by Theodore Energy Development Pty Ltd (TED) (the Proponent) to develop an erosion risk assessment for the proposed Theodore Wind Farm (the Project), located approximately 22 kilometres (km) east of the township of Theodore and approximately 50 km south of Biloela in the Banana Shire Council local government area, Central Queensland as shown in Appendix A. The closest major town is Gladstone, 150 km north-east of the Project. TED is a wholly owned subsidiary of RWE Renewables Europe & Australia GmbH (RWE). A plan showing the Project development footprint and turbine locations is provided in Appendix B.

1.1 REGULATORY REQUIREMENTS

The stormwater assessment is compiled as part of meeting Performance Outcomes (PO) 7 and 8 of the State Development Assessment Provisions (SDAP), State Code 23: Wind farm development, version 3.0.

State Code 23 is currently under review, with new draft performance outcomes proposed. Where appropriate, additional assessment has been undertaken as part of this stormwater assessment to meet the intent of the draft update to State Code 23, in particular POs 6 – 8. The assessment considers the following elements that are drivers during Project development, which are:

- Stormwater quality;
- Flooding extents; and
- Erosion and Sediment Control.

The Project design has been refined through an interactive process, with considerations of environmental impacts, wind resource, construction feasibility and landowner requirements. The most recent Project disturbance footprint was determined through a number of preliminary impact assessments.

The assessment addresses and demonstrates the Project's compliance with the SDAP (QLD Government, 2017), State Code 23 performance outcomes concerning stormwater management:

- Performance Outcome (PO) 7 Water Quality;
  - Development maintains the water quality of receiving waters.
- Performance Outcome (PO) 8 Natural drainage patterns;
  - Development maintains the natural drainage patterns on the Project Area by protecting:
    - Bank stability by limiting bank erosion;
    - Water quality objectives by filtering sediments, nutrients and other pollutants;
    - Aquatic habitats; and
    - Terrestrial habitats.

The corresponding POs proposed in the intended draft State Code 23 update are;

- Draft PO7 Water Quality:

    - Development is constructed to maintain or improve the water quality of receiving waters and watercourses by;
        - Minimising erosion and run-off; and
        - Preserving the bank stability of affected watercourses and drainage lines.
- Draft PO8 Natural drainage patterns:
    - Development is stabilized following construction to ensure that erosion and run off to the surrounding landscape and watercourses is minimised to the greatest extent possible.

In addition to the water quality and drainage draft POs above, under the draft State Code 23 Planning Guidance, draft PO6 requires an erosion risk assessment, using the Revised Universal Soil Loss Equation (RUSLE). This stormwater assessment includes an erosion risk assessment using the RUSLE.

1.2 PROJECT DESCRIPTION

1.2.1 PROJECT AREA AND LOCATION

The Project involves the construction and operation of a large-scale wind farm (up to 170 turbines) approximately 50 km south of Biloela in the Banana Shire Council local government area, Central Queensland. The Study Area abuts the State Forest, Montour State Forest, and Trevethan State Forest, which are situated on the eastern, northern, and southern boundaries of the Study Area.

The Study Area is located within the Rural Zone of the Banana Shire Council, with the predominate land use being cattle grazing. The Study Area is 46,830 hectares (ha) in size, however the total development footprint for the Project is anticipated to be 19,32.2 ha.

1.2.2 PROJECT SPECIFICATION

The proposed development footprint of the Project is presented in Appendix B. The project is proposed to consist of the following infrastructure:

- Up to 170 Wind Turbine Generators (WTGs);
- WTG foundations and hardstand areas;
- Temporary infrastructure such as concrete batching plants, laydown areas, temporary construction offices, parking and accommodation camp, temporary fencing, and other standard construction ancillary works including local road upgrades to facilitate component delivery;
- Access tracks and electrical reticulation, including underground and overhead electrical works where necessary;
- Switching stations and substations, Battery Energy Storage Systems (BESS), Meteorological masts; and
- Operations and maintenance facilities, with a variety of associated project facilities and storage laydowns.

Notable roads within the vicinity of the Project include Crowsdale Camboon Road in the east, Defence Road in the west and Hamilton’s Road in the north-west. Smaller roads and tracks include Rockhampton Street and Park Street which adjoin the southern section of Crowsdale

Camboon Road, and several Queensland Parks and Wildlife Service owned unnamed tracks in the east.

1.3 WATERCOURSES AND TOPOGRAPHY

The most notable of the waterways within the proposed Study Area is Castle Creek, classified as Stream Order 5 under the Strahler system of stream order. Castle Creek intersects the Study Area in the north however, it does not intersect the development footprint. Other notable waterways include Oxtrack Creek, a Stream Order 4 waterway in the south of the Project, and several Stream Order 3 waterways situated throughout the Study Area (Boam Creek, South Creek, Keen Creek, and Six Mile Creek). Several other ephemeral Stream Order 1 and 2 tributaries of Castle Creek (and other surrounding waterways) flow through the Study Area. Mapping in Appendix C details the full extent of the watercourses within the Study Area.

Based on the topography and the Strahler system of stream order, Castle Creek flows east to west where it joins the nearby Dawson River approximately 30 km west of the Study Area just south of the township of Theodore. Dawson River is classified as a Stream Order 8 waterway.

2. APPROACH TO ADDRESSING PERFORMANCE OUTCOMES

2.1 DATA SOURCES

The stormwater assessment has been undertaken based on the following data:

- 5 m contour information obtained from ELVIS (ICSM, 2023) using the 1-arc second available digital elevation model (DEM) surface;
- Client provided Lidar of the project;
- Proposed development layout provided by the Proponent;
- Discussions with the proponent about the Project layout configuration; and
- Information obtained from Queensland Globe and QSpatial (QLD Government, 2023a).

2.2 STORMWATER QUANTITY AND QUALITY

2.2.1 PRE AND POST DEVELOPMENT CATCHMENTS

The total project disturbance footprint is anticipated to cover an estimated 1,932.2 ha, located within a Study Area approximately 46,830 ha in size. This represents a disturbance footprint of ~4% of the Study Area.

The Study Area is located across a range of terrains from generally low hilly country with long moderate gentle slopes, to small alluvial plains, moderate high hills with rounded crests and straight often gentle side slopes with narrow valley plains. A small portion of the Study Area is located within areas described as steep, hilly mountainous country.

Within the Study Area, soil types are described as shallow stony clay loams, black self-mulching cracking clays, siliceous sands, as well as some areas with hard pedal mottled-yellow duplex soils, hard pedal red duplex soils, and black smooth-ped earths. None of the soil types mapped within the project footprint are described as dispersive soils.

The predominant current land use type within the Study Area is grazing in improved pastures. The area is defined by sparsely scattered residential settlements, and reservoirs among grazing modified pastures, and cropping land.

Based on the disturbance footprint provided by the Proponent and presented in Appendix B, the post-development catchment is not considered to change significantly compared to the current catchment. The development will have a negligible impact on soil type and terrain. The project disturbance footprint of ~4% across the Study Area is predominantly associated with clearing areas for transmission lines and/or access tracks. A majority of the access tracks on the Study Area will not be sealed, however some tracks (in areas that may be steep or heavily trafficked) may be sealed, where possible, on-site access will be designed to utilise existing tracks where available. Therefore, the access tracks are not expected to have a considerable impact upon the amount of impervious area and the catchment response.

Any change to the amount of impervious area as a result of the project will be limited to the proposed foundations of turbines, and hardstanding areas associated with electrical substations, maintenance facilities and laydown areas. The total area of these footprints represents <4% of the total project boundary and are considered a negligible change to the total impervious area of the catchment. Even with sealed access tracks in some areas, the change in imperviousness is considered to be <5%.

Given such a negligible increase in the proportion of impervious land throughout the post-development landscape, it is anticipated that no significant changes to post-development peak flow rates will occur, and thus no specific mitigation measures will be required.

2.2.2 PROPOSED DESIGN

Given the negligible increase in impervious areas in the post development landscape, the post-development flow rates from the catchment are not expected to increase. As such, on-site detention system for the proposed development is unlikely to be required.

The proposed access tracks will be designed to minimise earthworks and maintain sheet flow conditions as far as practical, with access corridors designed to be as narrow as reasonably practical. Current designs indicate that table drains, or another drain topology as determined through detailed design will be fitted where needed.

The network of roads and the necessary drainage infrastructure associated with these has the potential to divert runoff from one part of a catchment to another as well as concentrate runoff in areas that previously only experienced broad sheet flow. Any drainage works constructed as part of the project will be carefully considered during detailed design to limit the concentration of runoff and prevent the diversion of runoff to other catchments where necessary.

2.2.3 FLOODING

The 1% annual exceedance probability (AEP) flood extent for Castle Creek and its tributaries has been obtained from Queensland Globe and QSpatial (refer to mapping in Appendix C). While the level of detail presented by this mapping is regional in nature, it provides an indicative understanding of the 1% AEP flood extent.

Based on a review of the mapping, none of the disturbance footprint is located within areas considered likely to be affected by a 1% AEP flood event. The mapping shows that flood extents to not intersect any of the project infrastructure or clearing areas. The proposed turbines, access tracks, substations, OM facility, alongside all other temporary infrastructure (such as the concrete batching plants and laydown areas) are all located outside of the 1% AEP flood area.

Based on this high-level review, and the project description provided. The proposed development is not considered likely to be significantly affected by flooding as a result of a 1%AEP storm event. It should be noted that minor flood impacts such as ponding of water and localised flooding may be possible during a 1%AEP flood event.

2.2.3.1 POTENTIAL FLOOD PROTECTION MEASURES

The disturbance footprint for the Project is well outside of the anticipated 1% AEP flood area. The 1%AEP flood area in concentrated around Castle Creek. As such, the WTG and associated infrastructure are unlikely to be affected by a 1% AEP flood event, however, there may be some localised flooding around larger infrastructure components. It would be prudent to include some potential flood mitigation measures in the detailed design phase in order to reduce the risk of impact from local creeks and streams. The following measures may be suitable to implement as a general protection against flood risk:

- Prepare staging of construction works to avoid or minimise obstruction of overland flow paths;

- Ensure footprint of the structures diverts overland flow around and away from key infrastructure;
- Where practical, reduce impervious surface area associated with component footprints. Consider the use of permeable pavement for example;
- Include a stormwater collection system and storage tanks near structures with roofs/guttering;
- Provide flood proofing to excavations at risk of flooding during construction, where feasible and reasonable, such as raised entry and/or pump out facilities to minimise ingress of floodwaters;
- Routine maintenance and removal of excess sediment and weed growth to maintain flood carrying capacity of drainage channels.

2.2.4 WATER QUALITY OBJECTIVES

The Project may impact on downstream water quality via two key mechanisms:

1. Increased concentrations of suspended solids, nutrients and metals associated with the erosion of disturbed areas.
2. Introduction of contaminants from chemicals and fuels used for the construction and maintenance of the wind farm.

All creeks within the Study Area are tributaries of the Dawson River, which forms part of the Lower Dawson River Sub-Basin waters. The Environmental Protection (Water) Policy 2019 (EPP 2019) specifies water quality objectives (WQOs) for the Lower Dawson River sub-basin to protect aquatic ecosystem environmental values (EVs) and human use EVs. Queensland Globe was used to identify that waters within the Study Area fall into the Lower Dawson River within the Dawson River sub-basin. The Dawson River sub-basin fresh waters WQOs are shown in Table 2-1.

2.2.5 MANAGEMENT AND MITIGATION MEASURES

To maintain compliance with the WQOs of the Dawson River Sub-basin during the construction phase, a Construction Environment Management Plan (CEMP) will be developed which provides additional detail regarding the storage and management of chemicals and potential contaminants. Details in the CEMP are to include storage and handling of chemicals used in the construction of the BESS, and wind farm turbines. Some of the measures to be captured in the detailed design and development of the CEMP can include:

- The BESS container units are to be designed with sufficient volume in the bottom of the containers to hold any leaks or spills of coolant that may occur. This should be considered a secondary containment system.
- Consider design measures incorporated into BESS benches to contain leaks or spills.
- The surface of the proposed BESS Area, or areas where batteries and chemicals are to be stored should be engineered to prevent seepage into the groundwater table, this may include a HDPE liner or impermeable clay layer to act as a barrier.
- The battery and chemical storage areas should be designed with appropriate bunding to capture any potential spills or leaks and enable clean up.

- Oil used for the operation of the transformers/substation will be either transported or stored within the development footprint. If stored on the development footprint it will be stored as per the relevant Australian Standard requirements.
- The location of storage sheds should be clearly identified in the projects CEMP, along with any construction vehicle parking. These should be away from sensitive areas.
- Construction Spill Management Protocols are to be implemented if any spills occur in the Study Area, in line with industry best practice.
- Based on currently available information water quality monitoring should be conducted to verify the current water quality at the Study Area. Dependent on the Project's design and management measures, ongoing monitoring may be required to enable early identification of potential unforeseen chemical spills/leaks.

TABLE 2-1 DAWSON RIVER SUB-BASIN: WATER QUALITY OBJECTIVES TO PROTECT AQUATIC ECOSYSTEM ENVIRONMENTAL VALUE UNDER BASEFLOW (AND,WHERE SPECIFIED, HIGH FLOW) CONDITIONS

Water area/type	Management intent /level of protection	Water Quality Objectives to Protect Aquatic Ecosystem EV[1-11]													
		Amm N (µg/L)	**Oxid N (µg/L)**	**Organic N (µg/L)**	**Total N (µg/L)**	**FRP (µg/L)**	**Total P (µg/L)**	**Chl-a (µg/L)**	**DO (% sat)**	**Turb (NTU)**	**SS (mg/L)**	**pH**	**EC baseflow (µS/cm)**	**EC high flow (µS/cm)**	**Sulfate (mg/L)**
Lower Dawson River Sub-basin waters	Aquatic ecosystem — moderately disturbed	<20[a]	<60[a]	<420[a]	<500[a]	<20[a]	<50[a]	<5[a]	85–110[a]	<50[a]	<10[b]	6.5–8.5[b]	<340[b]	<210[b]	<25[b]
		Macroinvertebrates[c]													
		– Taxa richness (composite): 12–21 – Taxa richness (edge habitat): 23–33 – PET taxa richness (composite): 2–5 – PET taxa richness (edge habitat): 2–5							– SIGNAL index (composite): 3.33–3.85 – SIGNAL index (edge habitat): 3.31–4.20 – % tolerant taxa (composite): 25–50% – % tolerant taxa (edge habitat): 44–56%						
For ALL fresh waters within this table	All	Toxicants in water and sediment as per AWQG: • Toxicants in water: refer to AWQG — 'water quality guidelines for toxicants' • Toxicants in sediments: refer to AWQG — 'sediment quality guidelines' Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.													

Notes:

a) The values for these indicators are based on the QWQG Central Coast regional water quality guidelines. For EC, the values are based on Appendix G of the QWQG.

b) The values for these indicators are based on sub-regional low flow water quality guidelines derived by the department as part of the process to establish EVs and WQOs in the Fitzroy Basin. Refer to 'sources' below for more details

c) The values for these macroinvertebrate biological indicators are based on the QWQG Central Coast regional water quality guidelines. They apply to support waters at a moderately disturbed level of protection. Values are provided for 20th and 80th percentiles. The median value of biological indicators at test sites is to be compared and assessed against these values. More details on indicators and derivation of values are in the QWQG. Refer to 'sources' below. Values are provided for two habitat types: edge (along the streambank) and composite (a mixture of all bed habitats). Taxa richness refers to the number of macroinvertebrate taxa collected in a sample. PET taxa richness refers to the total number of families from three orders of aquatic insects considered to be sensitive to changes in their environment (Plecoptera, Ephemeroptera, Trichoptera). SIGNAL index (stream invertebrate grade number – average level) gives an indication of water quality in the river from which the sample was collected, based on the sensitivity of taxa to water quality change. A higher number indicates greater sensitivity. The % tolerant taxa index was developed to assist in identifying taxa sensitivity to pollution. If a site is experiencing an impact from pollution it is expected that there would be a reduction in the percentage of sensitive taxa collected, and an increase in the percentage of tolerant taxa collected.

1. Oxidised N = NO2 + NO3. Units for nitrogen indicators are micrograms per litre (µg/L) N.

2. Units for phosphorus indicators are micrograms per litre (µg/L) P.

3. nd = no data, n/a = not applicable for this indicator and water type, ng = no guideline.

4. Dissolved oxygen (DO) objectives apply to daytime conditions. Lower values will occur at night in most waters. In estuaries, reductions should only be in the region of 10–15 per cent saturation below daytime values. In freshwaters, night-time reductions are more variable. Following significant rainfall events, reduced DO values may occur due to the influx of organic material. In estuaries post-event values as low as 40 per cent saturation may occur naturally for short periods but values well below this would indicate some anthropogenic effect. In freshwaters, post-event DO reductions are again more variable. In general, DO values consistently less than 50 per cent are likely to impact on the ongoing ability of fish to persist in a waterbody while short term DO values less than 30 per cent saturation are toxic to some fish species. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease.

5. DO values for fresh waters should only be applied to flowing waters. Stagnant pools in intermittent streams naturally experience values of DO below 50 per cent saturation.

6. Wallum/tannin-stained waters contain naturally high levels of humic acids (and have a characteristic brown ti-tree stain). In these types of waters, natural pH values may range from 3.6 to 6.

7. During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum/tannin waters) or exceed 9.

8. Nutrient objectives do not apply during high flow events. See QWQG Section 5 and Appendix D for more information on applying guidelines under high flow conditions.

9. During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (e.g. leaf litter) can result in increased organic N levels (generally in the range of 400 to 800µg/L). This may lead to total N values exceeding the WQOs. Provided that levels of inorganic N (i.e. NH_3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the WQOs, provided this is due to natural causes.

10. Conductivity, under natural conditions, is highly dependent on local geology and soil types. Where sufficient data were available, conductivity WQOs have been derived for different catchments in the Fitzroy and are shown in the table. In the absence of sub-regional conductivity WQOs, the QWQG (Appendix G) provides information on conductivity values in a set of 18 defined salinity zones throughout Queensland. For each zone, the QWQG provide a range of percentile values based on data from all the sites within that zone. This provides a useful first estimate of background conductivity within a zone. However, even within zones there is a degree of variation between streams and therefore the values for the zone would still need to be ground truthed against local values.

11. Temperature varies both daily and seasonally, it is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic WQOs for this indicator. The recommended approach is that local WQOs be developed. Thus, WQOs for potentially impacted streams should be based on measurements from nearby streams that have similar morphology and which are thought not to be impacted by anthropogenic thermal influences. From an ecological effects perspective, the most important aspects of temperature are the daily maximum temperature and the daily variation in temperature. Therefore measurements of temperature should be designed to collect information on these indicators of temperature and, similarly, local WQOs should be expressed in terms of these indicators. Clearly, there will be an annual cycle in the values of these indicators and therefore a full seasonal cycle of measurements is required to develop guideline values.

2.3 EROSION AND SEDIMENT MANAGEMENT

As erosion and sedimentation form the most significant potential contaminants during the development of the Project, the follow section outlines potential erosion risk, and mitigation measures to be adopted and outlined in the CEMP.

2.3.1 SOIL EROSION

Soil erosion is caused by wind, water or physical action displacing soil particles and resulting in movement from their previous location. Measures to mitigate or reduce erosion caused by water are discussed below. The most common forms of water erosion are:

- Splash erosion - spattering of soil particles cause by the impact of raindrops on soil.
- Sheet erosion - uniform removal of soil in thin layers from sloping land.
- Rill erosion - removal of soil by water concentrated in small but well-defined channels.
- Gully erosion - produces channels deeper and larger than rills (generally greater than 300 mm deep).

Excessive flow velocities can cause channel erosion, usually along the invert of the drain, which can then lead to bank slumping and widening of the channel. The flow velocity can be reduced by either:

- Reducing the bed slope.
- Reducing the depth of flow (increasing the width of the channel).
- Reducing the peak discharge (reducing catchment area).
- Increasing channel roughness.

If the channel slope, width or depth cannot be altered, then two erosion control options remain as follows:

- Reduce the flow velocity through the placement of rock check dams; or
- Increase the effective scour resistance in the channel through the placement of a channel liner such as rock.

Appropriate drainage will be identified at the detailed design stage by a RPEQ or similar.

The purpose of implementing erosion and sediment control measures is to assist in the management, reduction and mitigation of erosion and consequent transport of sediment to the receiving environment. As per IECA (2008), there are three cornerstones of erosional and sediment control as follows:

- Drainage control – prevention or reduction of soil erosion caused by the concentrated flow of water as well as appropriate management of water flows through the project.
- Erosion control – prevention or minimisation of soil erosion (from dispersive, nondispersive or competent material) caused by rain drop impact and exacerbated by overland flow on disturbed surfaces.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e., from up-slope erosion) or from windborne particles.

2.3.2 REFERENCE AND GUIDELINES

The IECA Best Practice Erosion and Sediment Control (2008) and the Queensland Government Department of Environment, Science, and Innovation 'Sediment and Erosion Control Guidelines (DES, 2019), are the two guiding documents used to develop the management measures outlined for the project. These guides should be used in developing the CEMP for the project and should be referred to in the detailed design stage.

Erosion and sediment control management measures applied during and after construction are to be in line with current best management practices applicable to the Project. Once the construction contractor has been selected, the Project will go through the detailed design phase which will include a detailed Erosion and Sediment Control Plan (ESCP). Once the ESCP is developed, measures will be implemented accordingly.

As per the Environmental Protection Act 1994 (EPA) (Queensland), all personnel must comply with the general environmental controls under Sections 319 and 320, provided as follows:

- Section 319 of the EPA states that all persons involved in the Project, from design to construction, are to act in accordance with the 'general environmental duty'. This requires all reasonable and practicable measures to be adopted to prevent or minimise environmental harm. Consequently, any erosion and sediment control devices proposed or implemented for the Project must represent current best management practices and all practical measures applicable to the project.
- Section 320 of the EPA, all personnel have a legally binding duty to notify their employer, their Local Regulatory Authority and Environmental Regulator (QLD) should they become aware of a potential or actual incident of environmental harm. The principal contractor should therefore be aware of their responsibility to ensure all persons on-site are aware of their environmental duties.

The following practices will be implemented (where practical):

- Maximising sheet flow and avoiding concentrated flow paths; and
- Use of vegetated swales and/or shallow bunds in place of bare earth table drains.

The detailed design phase will specify further detail regarding the extent, location, and application of these best practice management measures.

2.3.3 RESPONSIBILITY

In addition to the above, it is the responsibility of the principal contractor to put in place all the erosion and sediment control measures on-site until all disturbed areas are reinstated including the maintenance of the introduced measures. The principal contractor is, at all times, responsible for the erosion and sediment control measures to ensure minimal environmental harm and the compliance to Council's or the approving authority's standards.

2.4 EROSION RISK ASSESSMENT

The Department of Housing, Local Government, Planning and Public Works is currently reviewing how the planning framework regulates renewable energy development. This includes an ongoing review and consultation around the draft State Code 23: Wind farm development and the associated planning guidance.

The draft State Code 23 includes proposed performance outcomes requiring an erosion risk assessment (PO6) which should include the use of the Revised Universal Soil Loss Equation (RUSLE). The risk assessment should inform the project layout prior to lodgement of an application.

This report has been prepared to meet the requirements for an erosion risk assessment outlined in the draft State Code 23. The following erosion risk assessment has been undertaken using the RUSLE, the outputs of which are visualised in erosion risk mapping (Appendix D). This mapping has been prepared to inform the project layout.

2.4.1 REVISED UNIVERSAL SOIL LOSS EQUATION

The RUSLE is a method of predicting soil loss based on key data inputs (rainfall data, soil properties, digital elevation, and land use). The RUSLE quantifies average annual soil loss (A) using five factors; rainfall erosivity (R), soil erodibility (K), slope length (L) and slope steepness (S), cover management (C), and support practice (P). The RUSLE can be presented as follows:

$$\mathbf{A = R \times K \times L{\times}S \times C \times P}$$

- A is the mean annual soil loss (t $ha^{-1}yr^{-1}$)
- R is the rainfall erosivity
  - The R factor is an expression of energy and maximum intensity of rainfall averaged over long periods of time (more than 20 years) so as to accommodate discernible recurring rainfall patterns.
- K is the soil erodibility factor
  - The K factor is defined as the susceptibility of a soil to soil erosion. The K factor accounts for particle size, permeability, organic matter, and structure of the soil as the critical physiochemical properties which affect erodibility.
- L is the slope length factor
- S is the slope steepness factor
  - The landscape’s topography has a significant influence on the extent of soil erosion. The L and S factors expresses the effect slope length and gradient have on soil erosion.
- C is the cover management factor
  - The C factor considers the effect of vegetation and plant canopy cover.
- P is the support practice factor
  - P factor measures the combined effect of all support practices and management variables. It also represents structural methods for controlling erosion. These values are typically derived from satellite images, previous studies, or expert knowledge. Given the footprint will be cleared, a P factor of 1.3 has been used which means the surface condition will be compacted and smooth (default construction phase condition).

The RUSLE erosion risk assessment for the proposed development at Theodore Wind Farm was completed using a range of inputs including the Digital Atlas of Australian Soil in Queensland Globe, and spatial data available in the QSpatial catalogue. This initial assessment uses publicly available data, but the inputs to the RUSLE assessment can be refined and calibrated as project specific information becomes avaialble.

2.4.2 EROSION RISK CLASSIFICATION

The International Erosion Control Association (IECA) Best Practice Erosion and Sediment Control (BPESC) Book 1 provides guidance surrounding erosion risk classes, adopting classification developed by Morse and Rosewell (1996) to categorise annual soil loss rates into very low, to extremely high erosion risk. The risk categories and their corresponding soil loss rates are presented in Table 2-2.

TABLE 2-2 EROSION RISK CLASSES

Soil Loss Class	Mean Annual Soil Loss (t/ha/yr)	Erosion Risk
1	<150	Very Low
2	151 to 225	Low
3	226 to 350	Low - Moderate
4	351 to 500	Moderate
5	501 to 750	High
6	751 to 1500	Very High
7	>1500	Extremely High

Where possible, disturbance of land within an area prone to extremely high erosion risk should be avoided. Further guidance on how the erosion risk (soil loss) is calculated is detailed in the following section.

2.4.3 RUSLE ASSESSMENT RESULTS

The QSpatial catalogue provides proposed K, R, L and S factors across Queensland based on existing understanding of soil properties, statewide topographic mapping, and climatic data. The Project Area contains a range of topographical features which range from low to moderately hilly with small alluvial plains to steep mountainous country.

Using a geographic information system (ArcGIS), the various QSpatial inputs for the K, R, L, and S factors were overlayed. The C and P factors were determined based on project descriptions. These combined layers form a series of maps which present the results of the RUSLE assessment visually.

The results of the RUSLE erosion risk assessment are presented in Appendix D, with the intended location of wind farm turbines shown across the development footprint.

The percentage of the disturbance footprint area within each erosion risk was calculated from Appendix E and is shown in Table 2-3 below.

TABLE 2-3 EROSION RISK DISTURBANCE FOOTPRINT PERCENTAGE

Erosion Risk	Mean Annual Soil Loss (t/ha/yr)	Disturbance Footprint Percentage (%)
Very Low	< 150	37.90
Low	151 - 225	19.95
Low - Moderate	226 - 250	17.98
Moderate	351 - 500	13.31
High	501-750	5.75
Very High	751 - 1500	4.48
Extremely High	>1500	0.63

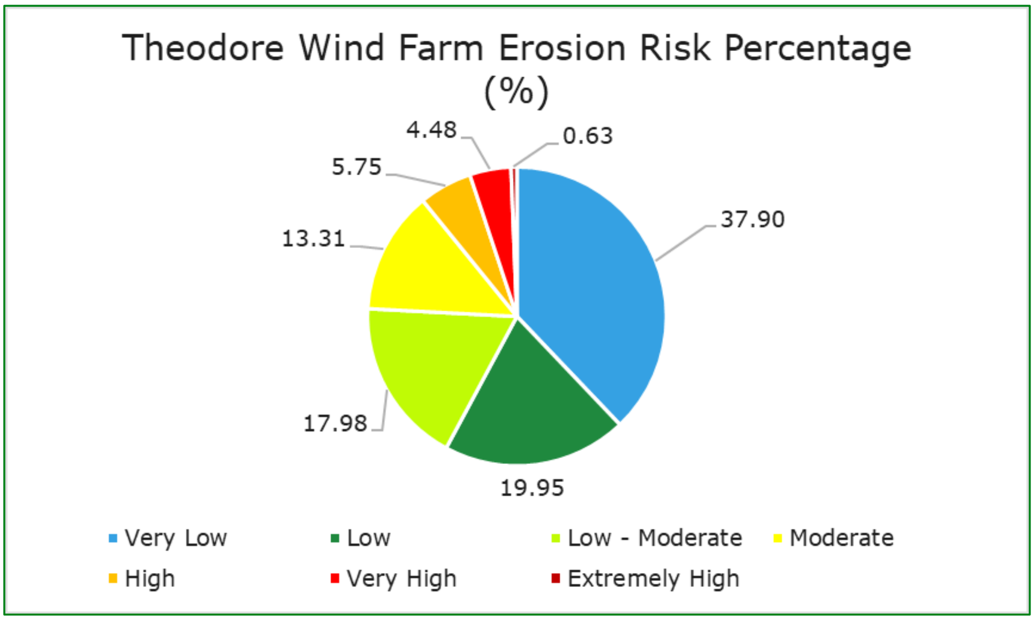

FIGURE 2-1 EROSION RISK PERCENTAGE

The findings of the RUSLE assessment indicate the following;

- Over half of the disturbance footprint (cumulatively 57.85%) is classified as very low to low erosion risk
- There is less than 1% of extremely high erosion risk within the disturbance footprint
- High to very high erosion risk occurs in 10.23% of the project footprint, driven by the hilly terrain of the region

The RUSLE disturbance footprint assessment map shows that approximately three quarters of the Projects disturbance footprint is considered to be very low to moderate erosion risk. Erosion and sedimentation in these areas will typically be manageable with basic or industry standard controls. Where there are areas of high or extremely high erosion risk, these tend to be located in areas with steep slopes. The turbine locations are typically away from steep slopes and therefore avoid extremely high erosion risk areas.

Overall, the erosion risk within the proposed disturbance footprint can be managed if the mitigation and control measures in Section 2.5 below are implemented and maintained. This mapping should be considered in the development of any roads or access tracks between the turbines, however current proposed infrastructure is mostly outside very high erosion risk areas, it’s overhead lines that cross over these sections within the footprint.

2.5 PROPOSED MITIGATION AND CONTROL MEASURES

2.5.1 GENERAL

This assessment has been carried out ahead of the detailed design of roads and access tracks. Based on the disturbance footprint provided, access roads have typically been placed in areas to try and avoid very high and extremely high erosion risk (though this is not always possible). It is noted however, that access tracks will likely be required to traverse hill slopes in some areas of the disturbance footprint.

A site-specific erosion and sediment control plan (ESCP) will be required for each area disturbed. This should be referred to in the CEMP for the project. The development of the site-specific ESCP is to be in accordance with the State Planning Policy (SPP) (2017); Appendix 2 SPP. The design objectives are provided for construction and post-construction phases, covering the following issues:

- Drainage control;
- Erosion control;
- Sediment control;

The principal contractor will be responsible for the preparation and implementation of the ESCP, meeting the required minimum water quality objectives potentially represented by the Environmental Protection Policy (EPP) 2019 guidelines.

During the operational phase, sediment and erosion management and control measures will be governed by an operational Environment Management Plan. The CEMP should include details of the required control measures, engineering drawings (which will be be available at the detailed design phase), and ongoing maintenance measures and schedules.

The information in the following sections is provided to identify potential controls and procedures that could be adopted to mitigate erosion and sedimentation impacts. It is recommended these controls be incorporate into the CEMP and ESCP, with identification of who is responsible for the controls and procedures adopted to mitigate surface water impacts.

For erosion and sediment controls to be effective, the following fundamentals are required (IECA, 2008):

- Ensure ESC measures are designed and constructed effectively.
- Minimise the duration and extent of soil exposure.
- Promptly stabilise disturbed areas.
- Maximise sediment retention on the Project.
- Control water movement through the Project.
- Minimise soil erosion wherever possible rather than applying down slope sediment controls.
- Utilise existing topography and adopt construction practices that minimise soil erosion and sediment discharge from disturbed areas.
- Maintain ESC measures in proper working order at all times.
- Monitor the project and adjust ESC practices to maintain required performance standards.

Some erosion control measures that should be considered during the detailed planning phase include:

- Compost Blanket - Used during the revegetation of steep slopes either incorporating grasses or other plants. It is also particularly useful when the slope is too steep for the placement of topsoil, or when sufficient topsoil is absent from the slope.
- Gravelling – Used for protection of non-vegetated soils from raindrop impact erosion and also used to stabilise areas such as car parks and access roads.
- Revegetation – Used to provide stabilisation of soil, it can also be used to stabilise long-term stockpiles.
- Rock Mulching – Used for long term stabilization of non-vegetated banks and minor drainage channels.

Some flow velocity control structures that should be considered during the detailed planning phase include:

- Rock Check Dams – Used in drains with a depth exceeding 0.5 m and a gradient less than 10%, as well as minor sediment traps.
- Recessed Rock Check Dam – Used in wide, high velocity, shallow channels where sandbag check dams would likely wash away, recessed into the soil to maintain hydraulic capacity in the channel, and minor sediment traps.
- Sandbag Check Dam - Used in shallow drains with a depth less than 50 mm and gradient less than 10%, and minor sediment traps. These check dams are small and less likely to divert water out of the drain.
- Fibre Roll (Biodegradable logs) – Used in wide shallow drains where logs can be anchored down, they can also be used in locations where it is desirable to integrate into the vegetation, such as vegetated channels, and for minor sediment traps.
- Triangular Ditch Check - Used in drains with less than 10% gradient, minor sediment traps, and commonly used to stabilise newly formed table drains.

In addition to the general controls outlined above, Training is to be provided to relevant Project personnel, including relevant sub-contractors, on sound erosion and sediment control practices.

2.5.2 PRE-CONSTRUCTION PHASE

- The contractor is to establish a stabilised entry/exit point (rumble pad) for each area of the project with all-weather access to a sealed road. The stabilised entry and exit points will include a vehicle cleaning area (i.e. a shakedown device or wash facility) to mitigate the transportation of dust and dirt.
- Sediment fences are to be placed along the low side of the disturbance footprint where required to slow flows, reduce scour, and capture some sediment runoff. Soil testing should be undertaken (if required) to confirm the type of sediment fence most suitable for the disturbance footprint. This work should form part of the CEMP preparation and implementation by the contractor.
- Table drains or diversions (if required) should be located along the high side of each infrastructure area and the corresponding access track. This is to capture and minimise the flow of water across the disturbed areas.
- Areas for plant and construction material storage are to be designated along with associated diversion drains and spillage holding ponds.

- Construction compounds and temporary facilities are recommended to be located within areas of low erosion risk.
- Site personnel are to be educated to the sediment and erosion control measures implemented for the Project.

2.5.3 CONSTRUCTION PHASE

- The CEMP should include progressive stabilisation of exposed areas by the construction contractor to reduce erosion and sediment run-off.
- Construction activities are to be staged and confined to the necessary construction areas.
- Transport of any loads that are subject to loss through wind or spillage shall be covered or sealed to prevent entry of pollutants to stormwater system.
- Regular inspection and maintenance of sediment fences, sediment basins and other erosion control measures by the contractor. Following rainfall events sufficient to produce runoff, inspection of erosion control measures and removal of collected material should be undertaken. Replacement of any damaged equipment should be performed immediately.
- Adequate inspection and maintenance of controls in high erosion risk areas (Appendix D) by the contractor to ensure that the controls in these areas are operating effectively to manage the elevated risk of erosion that is present.

2.5.4 POST CONSTRUCTION PHASE

- The maintenance of erosion and sediment control devices should occur until stabilisation (revegetation) of disturbed areas has occurred to the satisfaction of the superintendent and principal contractor.
- All table drains (if implemented) are to be revegetated post construction.

2.5.5 PROTECTION ON SLOPES

This section highlights some practical measures to be included in the CEMP to manage erosion in extremely high risk areas associated with steep slopes in particular.

Noting that detailed roadway design is yet to be completed, which is likely to minimise ongoing extremely high erosion risk, the measures to be employed to manage erosion are focused on the construction phase. The measures proposed have been adopted from the IECA BPESC book. These are detailed below:

- Avoid disturbance (where practicable) during erosive periods of the year. Rainfall data for the region indicates a wet season from December to March, with a dry period from June to September.
- Where possible, construction should be phased to limit exposure to disturbance areas as far as practical.
- Use of mulch bunds on sloped areas to divert flows.
- Channels to be rock lined.
- In areas where the slope exceeds 1 in 10, implement hydraulically applied blankets such as bonded fiber matrix (BFM) or compost blankets to promote the establishment of a vegetative cover. BFM can also assist in reducing the effect of raindrop impact erosion.

It will be important to monitor the controls implemented to determine whether they are achieving the appropriate outcomes. Depending on the final disturbance footprint for the Project, sediment basins may be required if significant disturbance of high risk areas are planned. If necessary the following should be considered:

- Type B or D sediment basin (if disturbance is for less than 12 months).
- Type A sediment basin (if disturbance is in place for 12 months or more).

2.5.6 WATERWAY CROSSINGS

In general, most waterway crossings will have some influence on the conditions surrounding the crossing site. However, suitably designed and constructed waterway crossings consider the long-term stream dynamics at the crossing site to minimise potential impacts. The failure to do so, potentially risks long term physical damage to the surrounding waterway and potential damage to, and/or failure of the crossing structure. The potential impacts associated with waterway crossings are site-specific but, in general, may include:

- Increased sediment and nutrient loads due to altered roadside drainage arrangements.
- The disturbance and / or removal of riparian and in-stream vegetation.
- Prevention of fish passage/aquatic fauna through the crossing structure.
- The alteration of the stream’s natural flow pattern, both in-channel and floodplain flows, including:
  - The reduction in hydraulic capacity through the structure, (possible low flow damming effect and reduction in aquatic health).
  - The raising of water levels (an increased afflux or backwater effect) upstream of the crossing structure, potentially increasing the flooding upstream.
  - Increased hydraulic forces and hence erosion potential surrounding the crossing structure through the concentration of flows and poor design arrangements (concentration of flow).
  - A rise in water level on the upstream side of a crossing caused when the effective flow area at the crossing is less than the natural width of the stream (afflux).

Some waterway crossing types to be considered during the detailed planning phase include:

- Bridge;
- Box Culvert;
- Pipe Culvert (circular); and
- Bed Level Crossing / Causeway (i.e. a low-profile ford or bed level crossing that does not incorporate a culvert).

3. ADDRESSING PERFORMANCE OUTCOMES OF DSDILGP STATE CODE 23

3.1 COMMENTS ON PERFORMANCE OUTCOME PO6

The RUSLE disturbance footprint assessment map shows that approximately three quarters of the Project's disturbance footprint is at a very low erosion risk. Current proposed infrastructure is mostly outside very high erosion risk areas, it's overhead lines that cross over very high erosion risk sections within the disturbance footprint. The entire Project disturbance footprint is outside of 1% AEP flood extent, which also reduces the level of sediment being carried to receiving waterways. Overall, the erosion risk within the proposed disturbance footprint appears to be manageable.

3.2 COMMENTS ON PERFORMANCE OUTCOME PO7

The proposed Project layout consists of foundations for up to 170 wind turbines and ancillary infrastructure including, but not limited to, temporary infrastructure such as concrete batching plants, laydown areas, temporary construction offices, parking and accommodation camp, temporary fencing, and other standard construction ancillary works including local road upgrades to facilitate component delivery, access tracks and electrical reticulation, including underground and overhead electrical works where necessary, switching stations and substations, Battery Energy Storage Systems (BESS), Meteorological masts, operations and maintenance facilities, with a variety of associated Project facilities and storage laydowns. The Project results in a negligible increase in impervious surfaces in the post-development landscape, and the proposed development footprint indicates limited works near waterways (other than the construction of access tracks). Erosion risks are considered high in some parts of the disturbance footprint, these areas will need detailed construction erosion and sediment control plans (CESCPs).

Compliance with best management practices for stormwater (including appropriate design and implementation), will be sufficient to manage stormwater quality. It is considered unlikely that the quantity and quality of the stormwater leaving the disturbance footprint is to be of different quantity or quality to that observed prior to the Project. Based on this, the Project is compliant with PO7.

3.3 COMMENTS ON PERFORMANCE OUTCOME PO8

PO8 seeks to mitigate impacts on the natural drainage patterns of watercourses that flow through, and within the development footprint. The design of the Project minimises the disturbance of non-linear infrastructure on mapped watercourses. Access tracks and other linear infrastructure are proposed to intersect with some ephemeral Stream Order 1, 2, and 3 watercourses defined under the Vegetation Management Act 1999 (VMA).

An assessment was undertaken to determine the extent of disturbance upon watercourse crossings that is anticipated to occur where linear infrastructure intersects VMA Act defined watercourses. An evaluation of the proposed Project layout determined the occurrence of 60 potential watercourse crossings. Each watercourse crossing was assumed to have a nominal 50 m width of disturbance during construction. The Project has been designed to avoid impacts to mapped watercourses for all non-linear infrastructure. The access tracks associated with the

Project intersect 60 watercourses, (Stream Order 1, 2, 3 and 4), as defined under the Vegetation Management Act 1999.

For the assessment, the following impacts to regulated vegetation intersecting a watercourse are anticipated:

- 30.3 ha within stream orders 1 & 2
- 4.7 ha within stream orders 3 & 4

Detailed design will refine the corridor of disturbance across the disturbance footprint, ensuring potential impacts to the natural drainage patterns of watercourses are minimised. Impacts to the watercourses associated with the proposed development do not result in a significant residual impact, as per the Significant Residual Impact Guidelines (DSDIP, 2014).

Upon review of Queensland Globe data, all infrastructure within the disturbance footprint is located outside of the 1% AEP flood extent.

Stormwater management measures outlined in Section 2.2 are to be implemented to ensure the protection of water quality objectives, and the performance objectives defined in PO8.

Site-specific ESCPs will be developed and implemented for each area of disturbance by the construction contractor to suit the detailed design of the Project and the proposed construction method and schedule. The ESCP will be prepared in accordance with the IECA and Department of Environment, Science and Innovation Guidelines. Clearing of vegetation is subject to the design layout of the proposed development. Future site-specific appropriate measures are expected to be included for protection of bank stability, water quality and habitat through suitable stormwater management and ESCP measures where vegetation clearing within drainage features is required.

Based on this assessment, the Project is compliant with PO8.

4. CONCLUSION

This report presents a stormwater assessment for the proposed Theodore Wind Farm, located approximately 50 km south of Biloela in the Banana Shire Council local government area, Central Queensland. The document addresses the Department of Housing, Local Government, Planning and Public Works State Code 23 for wind farm development, specifically the proposed Performance Outcomes PO7 and PO8, relating to water quality and nature drainage patterns. The report also addresses PO6 of the draft State Code 23, currently under consideration, which requires an erosion risk assessment.

The Project has the potential to impact stormwater discharged to local waterways in the vicinity of the Study Area. Any significant changes in the amount of imperviousness within the catchment could increase peak discharge. Based on a review of the project description, and the disturbance footprint, the overall change in imperviousness across the catchment is considered to be negligible, with some small, temporary changes in flows during the construction phase. The Project is not expected to cause any nuisance or impacts to the downstream waterways or nearby property owners.

The result of the erosion risk assessment shows a majority of the Study Area is located within areas classified as low to moderate soil erosion risk. Erosion and sediment generated as a result of project disturbance within these areas is considered to be manageable with typical construction ESC controls. Best practice erosion sediment control management strategies should be employed, particularly in areas of moderate to high erosion risk. The disturbance footprint shows turbine footprints near some of the extremely high erosion risk areas. Any disturbance of soils in extreme or high erosion risk areas will require additional scrutiny (refer to section 2.5.5 for typical measures to be considered) and should be specifically identified in the Project CEMP. Controls to be put in place should extend beyond the WTG footprints and include access roads on steep slopes.

Where disturbance of extremely high erosion risk areas is unavoidable, this report provides some recommended actions to be implemented to help manage erosion risk. These measures should be incorporated into the CEMP for the project. Overall, based on the results of this erosion risk assessment, there are no unacceptable risks posed by the Project, and the proposed turbine locations.

5. REFERENCES

Department of Infrastructure, Local Government and Planning (DILGP) 2017. State Planning Policy – July 2017

Intergovernmental Committee on Surveying and Mapping (ICSM), 2021, Elevation and Depth (ELVIS) – Foundation Spatial Data. Website.

International Erosion Control Association (IECA), 2008. Best Practice Erosion and Sediment Control (BPESC). Picton, NSW.

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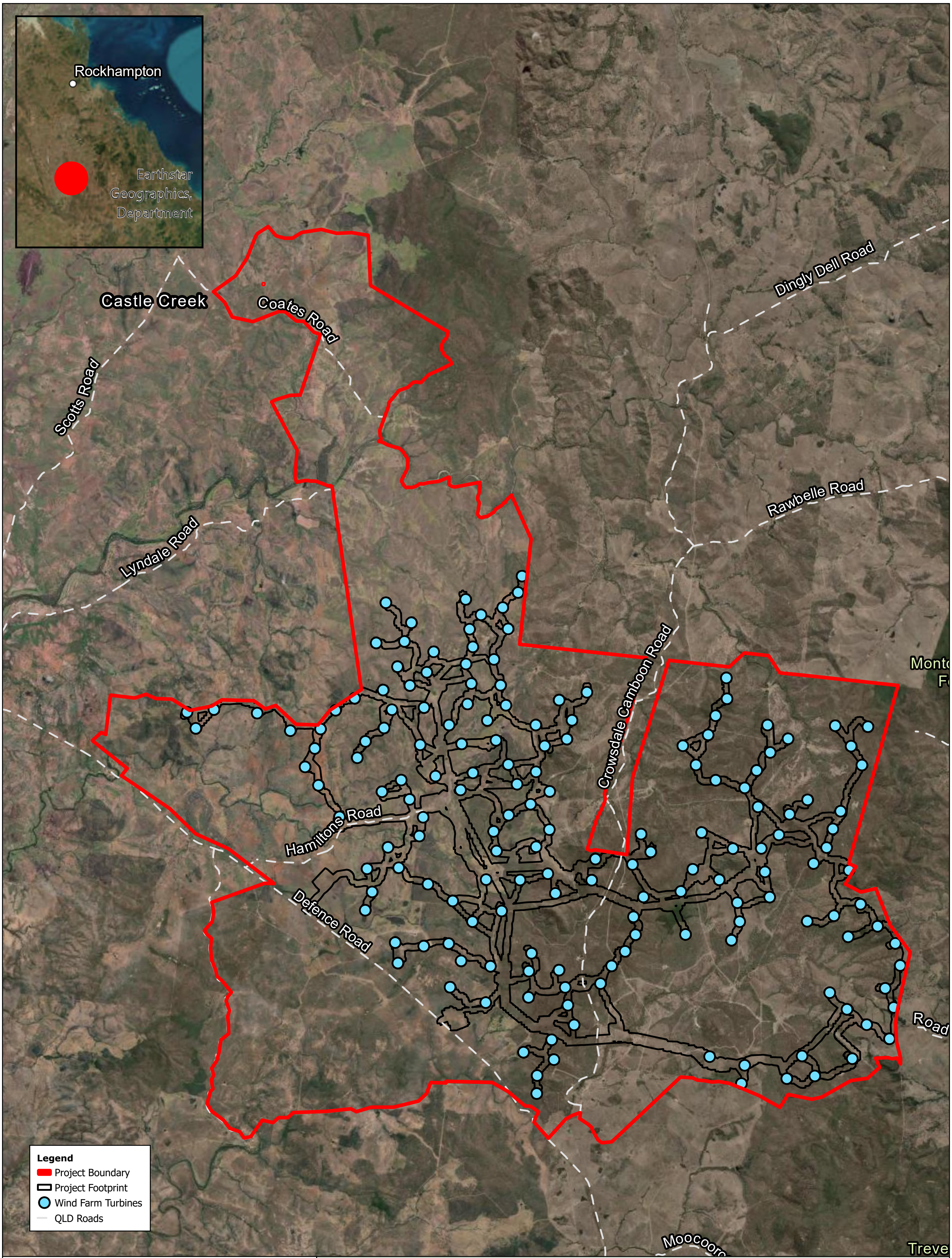
Queensland State Government, 2023b. Environmental Protection Act 1994.

Queensland State Government, 2023c. State Code 23: Wind Farm Development, Version 3.0. Department of State Development, Infrastructure, Local Government and Planning

Queensland State Government, 2023d. Draft State Code 23: Wind Farm Development, Version 3.1. Department of State Development, Infrastructure, Local Government and Planning

Thapa, P, 2020. Spatial estimation of soil erosion using RUSLE modelling: a case study of Dolakha district, Nepal.

APPENDIX A PROJECT LOCATION



Coordinate System: GDA2020 MGA Zone 56

Date: 26/07/2024

Created By: FB

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F1 Project Location

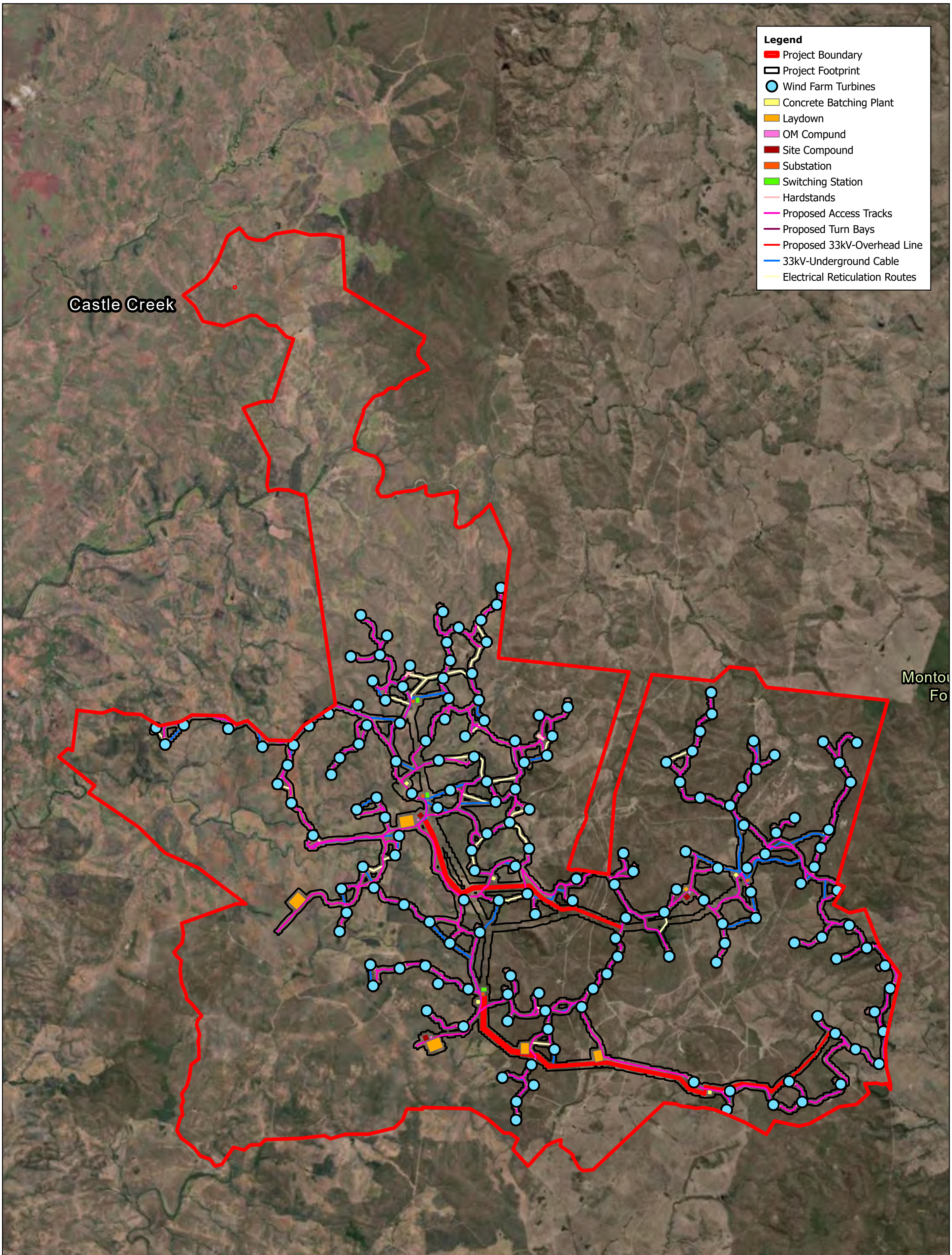
Theodore Wind Farm

Theodore Energy Development Pty Ltd

ERM

Theodore_Wind_Farm.mxd

APPENDIX B PROJECT FOOTPRINT



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Created By: FB

Drawing Size: A4

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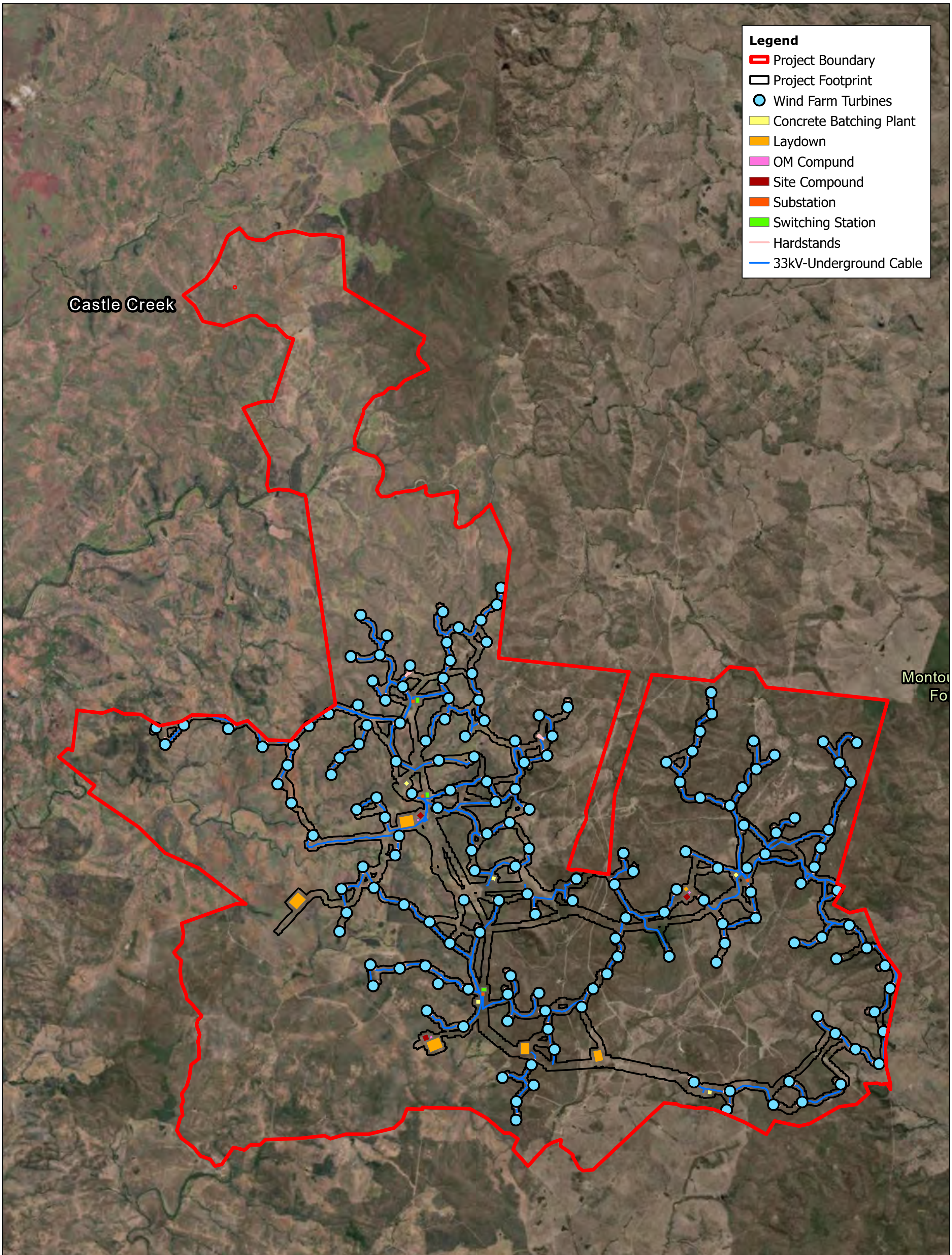
F2 Project Footprint - All Infrastructure

Theodore Wind Farm

Theodore Energy Development Pty Ltd

Theodore_Wind_Farm_R1.mxd



Coordinate System:
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Date: 08/08/2024

Created By: FB

Drawing Size: A4

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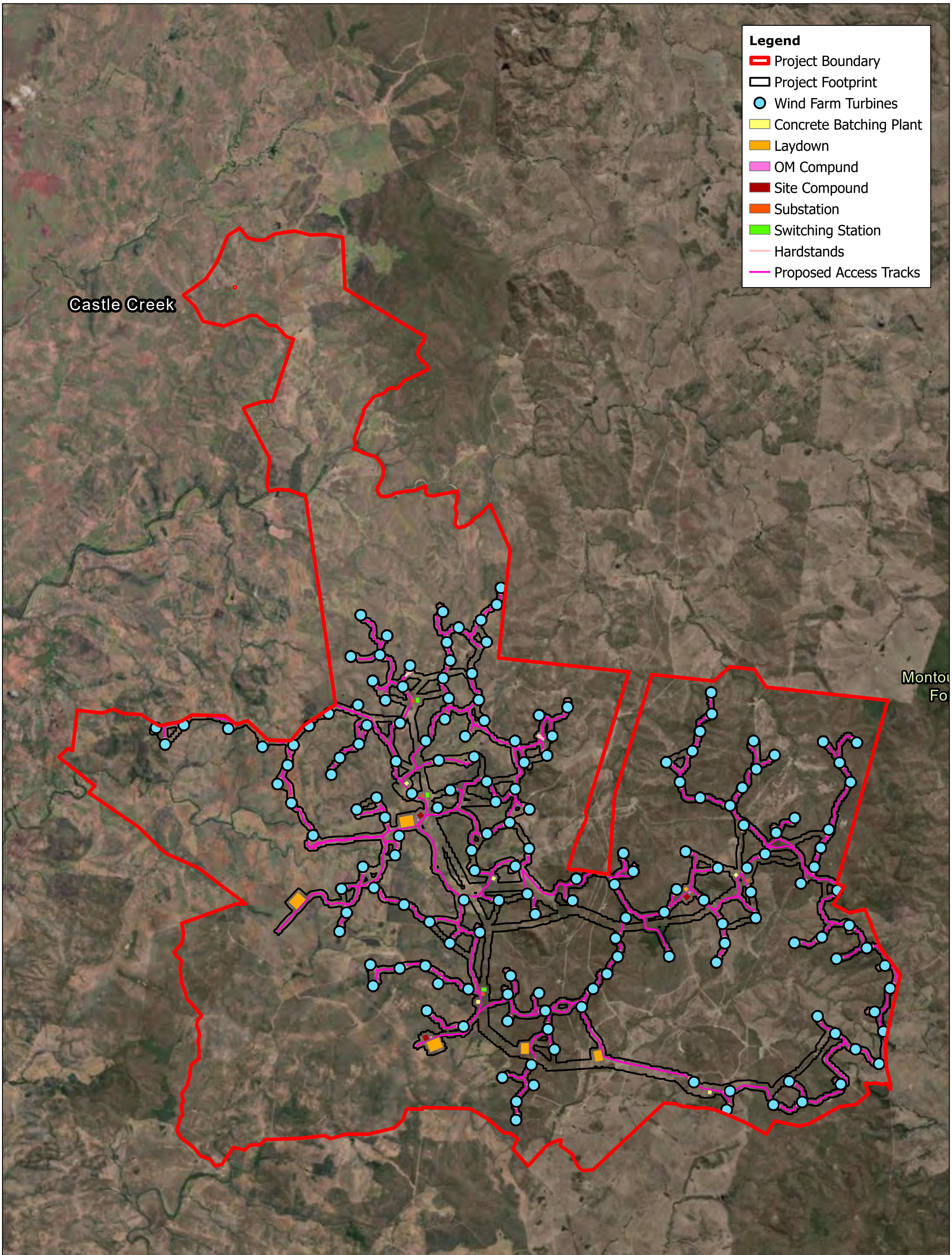
F2 Project Footprint - All Infrastructure

Theodore Wind Farm

Theodore Energy Development Pty Ltd

Theodore_Wind_Farm_R1.mxd



Coordinate System:
GDA2020 MGA Zone 56

Date: 08/08/2024

Created By: FB

Drawing Size: A4

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1:180,000

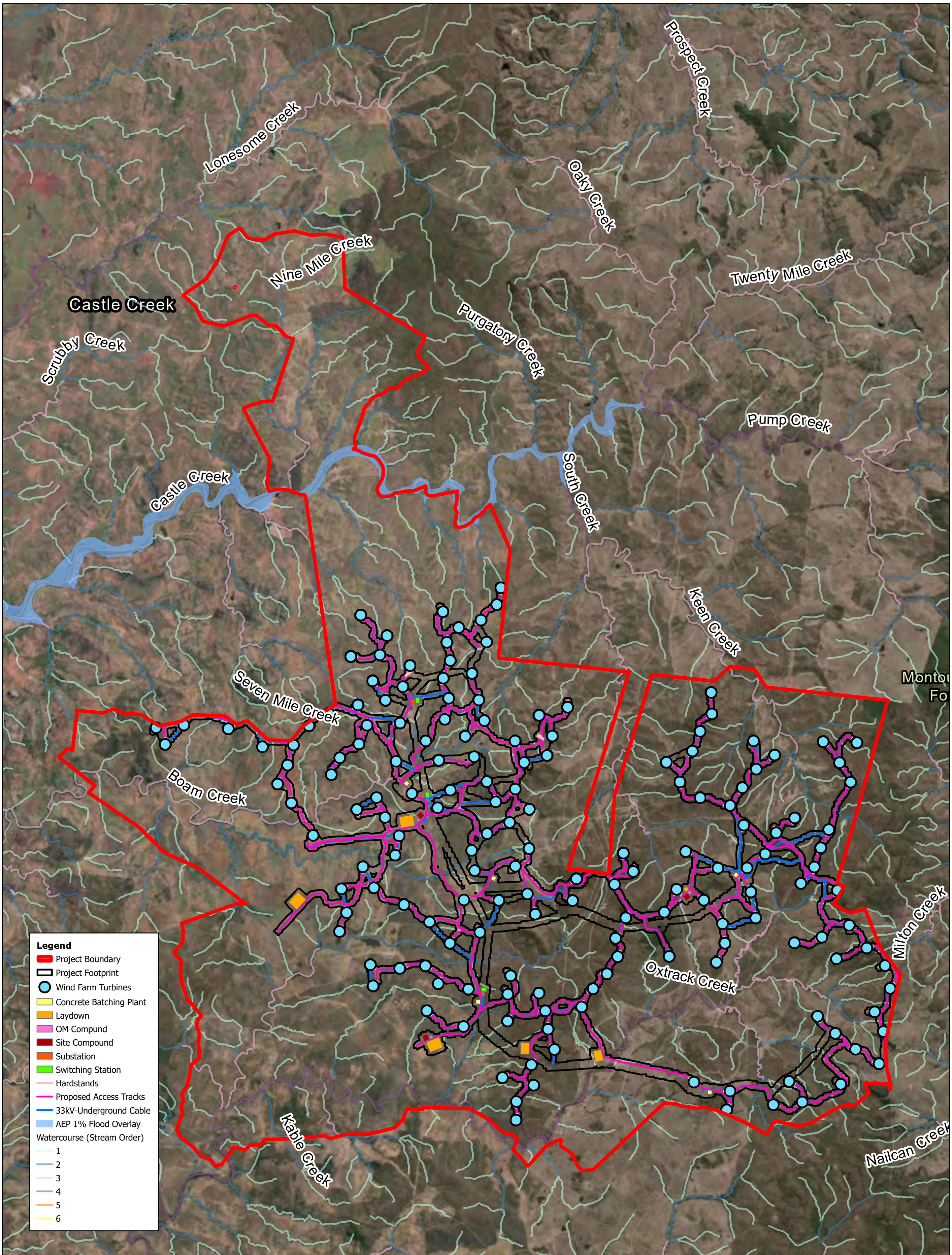
F2 Project Footprint - All Infrastructure

Theodore Wind Farm

Theodore Energy Development Pty Ltd

Theodore_Wind_Farm_R1.mxd

APPENDIX C FLOOD EXTENT & WATERWAYS



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Date: 08/08/2024
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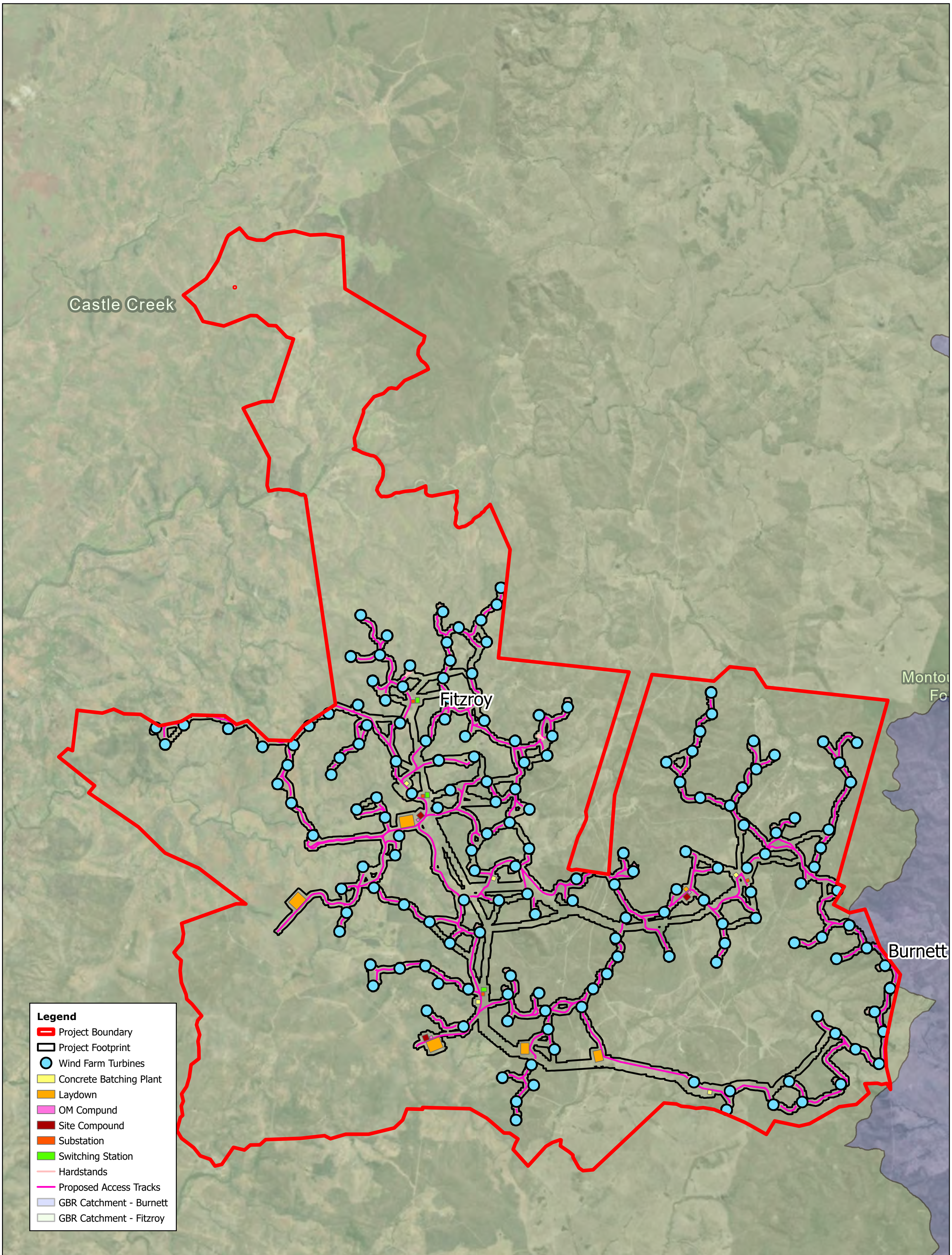
F2 Flood Extent

Theodore Wind Farm

Theodore Energy Development Pty Ltd

Theodore_Wind_Farm_R1.mxd



F3-1 Great Barrier Reef Drainage Basin Catchments

Theodore Wind Farm

Theodore Energy Development Pty Ltd

Coordinate System: GDA2020 MGA Zone 56

Date: 08/08/2024

Created By: FB

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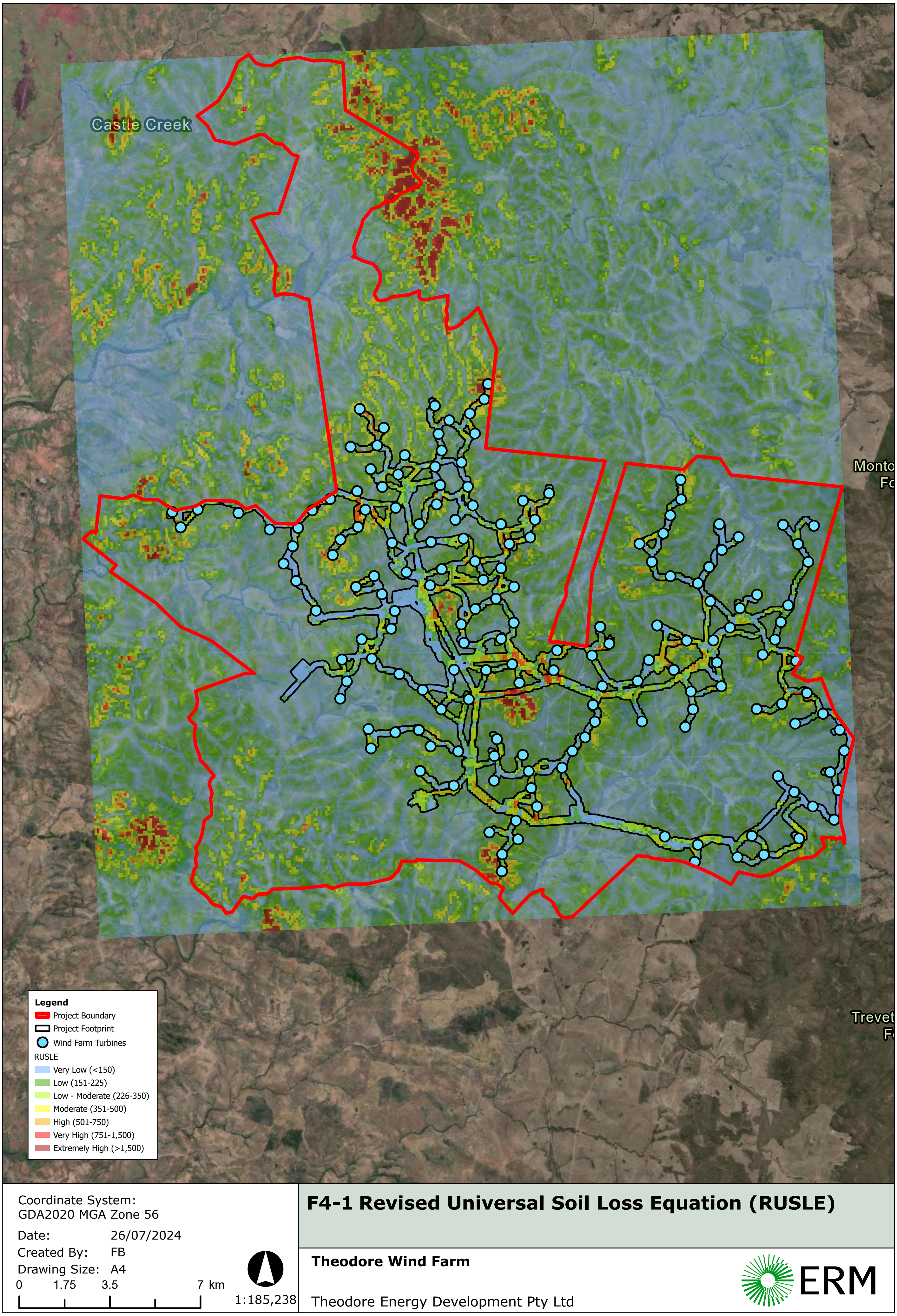
Theodore_Wind_Farm_R1.mxd

APPENDIX D RUSLE EROSION RISK



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Date: 26/07/2024

Created By: FB

Drawing Size: A4

F4-1 Revised Universal Soil Loss Equation (RUSLE)

Theodore Wind Farm

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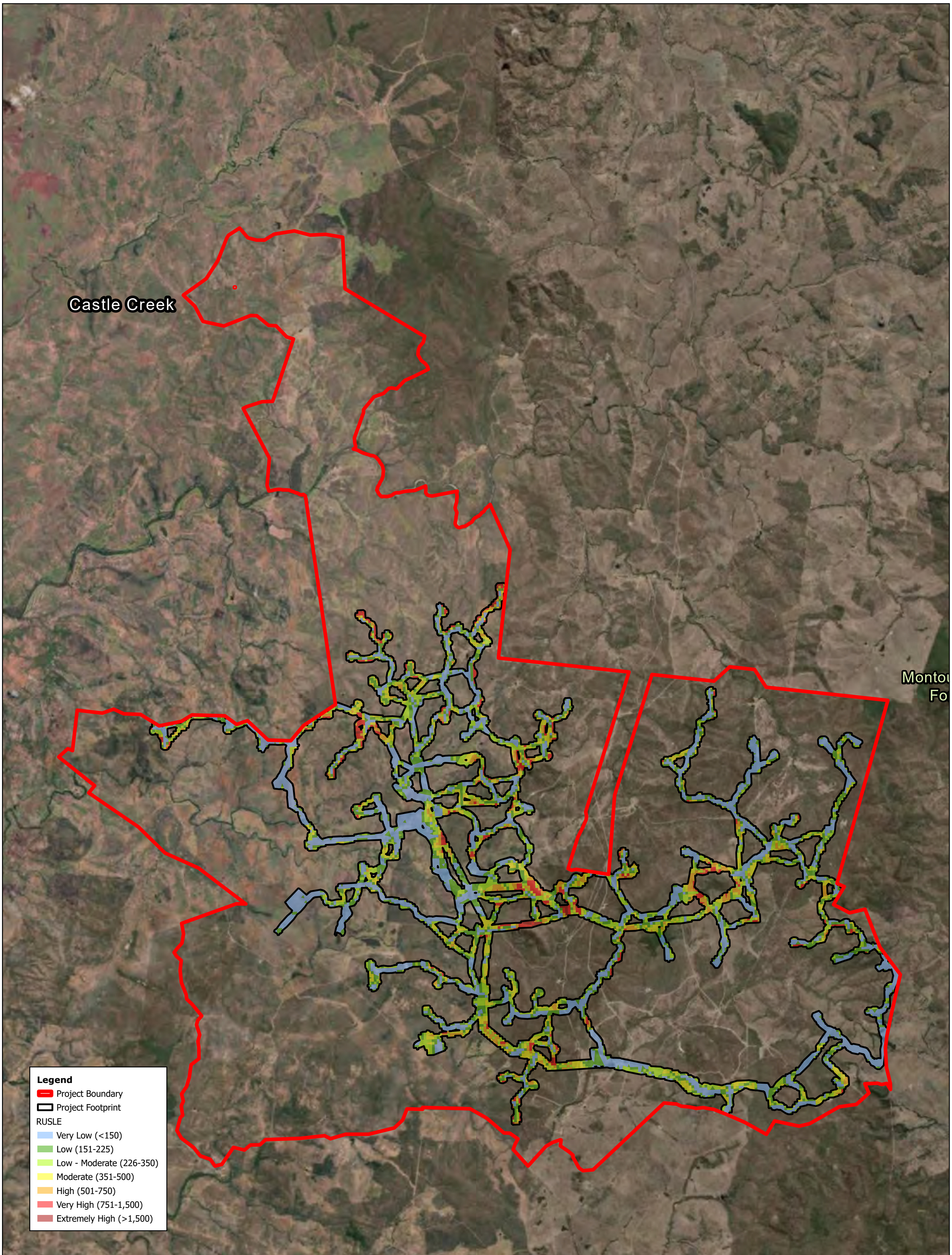
Theodore_Wind_Farm.mxd

APPENDIX E RUSLE DISTURBANCE FOOTPRINT ASSESSMENT



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Date: 08/08/2024

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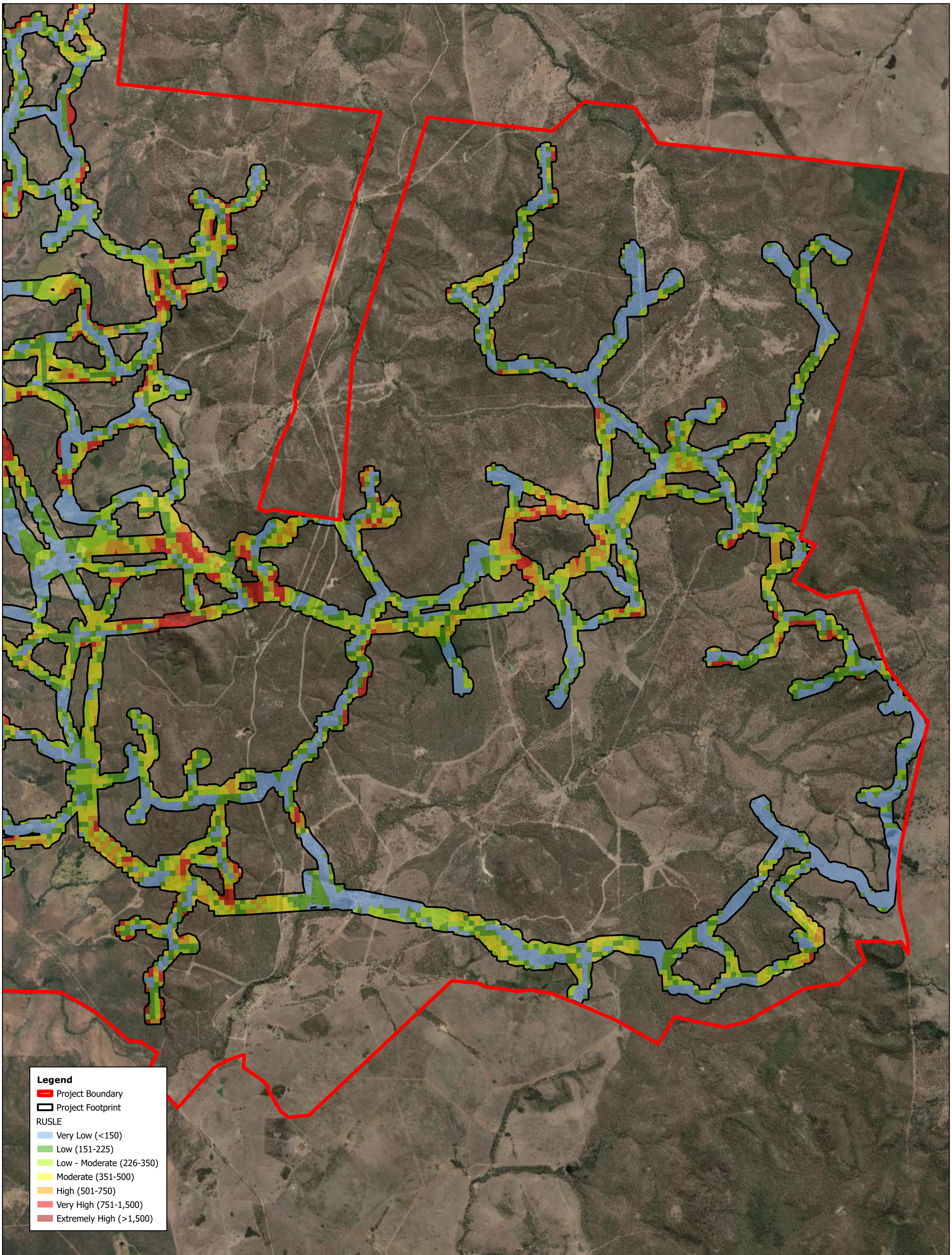
F4-1 Revised Universal Soil Loss Equation (RUSLE) - Disturbance Footprint

Theodore Wind Farm

Theodore Energy Development Pty Ltd

Theodore_Wind_Farm_R1.mxd



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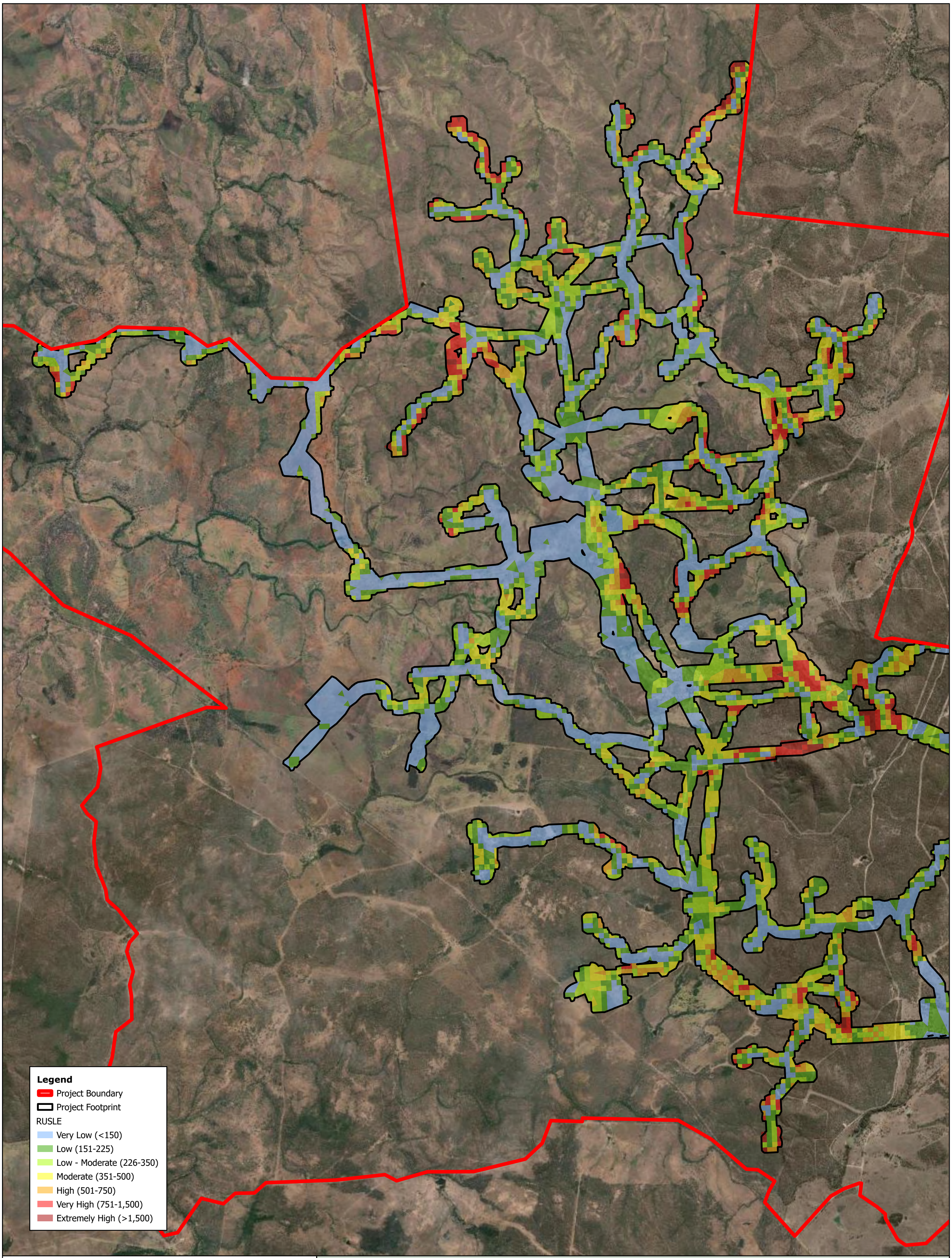
F4-1 Revised Universal Soil Loss Equation (RUSLE) - Disturbance Footprint

Theodore Wind Farm

Theodore Energy Development Pty Ltd

ERM

Theodore_Wind_Farm.mxd



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Date: 26/07/2024

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Drawing Size: A4

F4-1 Revised Universal Soil Loss Equation (RUSLE) - Disturbance Footprint

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