WATER ASSESSMENT

West Wyalong Solar Farm

Prepared for:

Lightsource Development Services Australia Pty Ltd
Level 9, 401 Collins Street
MELBOURNE VIC 3000

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Lightsource Development Services Australia Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.18343.00300-Water Assessment-V1.0 181211	11 December 2018	Carrie Hartley, Peter Cupitt	Paul Delaney	Paul Delaney
610.18343.00300-Water Assessment-V2.0 20181220	20 December 2018	Peter Cupitt	Paul Delaney	Paul Delaney
610.18343.00300-Water Assessment-V2.1 20190109	9 January 2019	Peter Cupitt	Paul Delaney	Paul Delaney
610.18343.00300-Water Assessment-V2.1 20190109	21 January 2019	Peter Cupitt	Paul Delaney	Paul Delaney

EXECUTIVE SUMMARY

This assessment of hydrology, flooding and water resources for the proposed West Wyalong Solar Farm has been prepared to address the requirements of the project SEARs. The study has considered the present site land-use and existing environmental conditions.

Overall the nature of the proposal will have a very low impact on the environment and the existing behaviour of surface and ground waters. This is due to the absence of broad-scale reshaping of the landform or excavation, other than in relatively small areas associated with internal road access, site facilities and sub-stations. The same surface area of soils is available for infiltration of rainfall, and grass cover will be progressively established following construction and maintained during operation of the solar farm to distribute runoff from the solar panels and provide erosion protection.

The environmental impact of the project on flooding and water resources is considered to be low risk and readily manageable. **Table 1** below summarises the potential environmental impacts, the strategy for mitigation, and where this is detailed in the assessment.

Table 1 Summary and guide to potential impacts, mitigation, and where described

Potential Impact	Mitigation Strategy	Where detailed in Assessment
Flooding behaviour of the project site	The site contains one ephemeral drainage path parallel to the south eastern Site boundary. The topography of the surrounding catchment is such that runoff enters the Site on three sides and discharges only from the north eastern boundary. Flood modelling has identified that the six hour duration storm is critical up to the 1% AEP and the 4.5hr the critical for the 1 in 200 AEP. The site is very flat with typical slopes of 0.25%. There is a confluence of streams and overland flow paths approximately 2kms downstream of the Project Site, and the flooding conditions at this confluence provide the hydraulic boundary conditions for flooding across the Project Site.	**Section 7**
Flooding of project site – risk to property and life	The 1% AEP flood standard is the recommended minimum design standard with the 1 in 200 AEP recommended for projects with life expectancies extending beyond 50 years (ARR 2016). The latter is the recommended design standard for this site. Runoff moves very slowly and at shallow depths through the Site, with typical depths of 0.25m and velocities of 0.2 m/s. The maximum depth attained on site is 0.75m near the north eastern boundary and the velocity peaks at 0.5m/s over the road near the substation during the 1 in 200 AEP. The PV arrays will be pole mounted, and battery storage and substations will be designed to be elevated above the predicted 1 in 200 AEP flood levels, with appropriate freeboard. The flood hazard to persons within the Project Site is Very Low.	**Section 7**

EXECUTIVE SUMMARY

Potential Impact	Mitigation Strategy	Where detailed in Assessment
Changes to pattern of runoff and discharges from site	Modelling of site hydrology and hydraulics shows the project design has negligible effect to downstream flow conditions with a slight reduction in flood depths but a slight increase in velocity. This is likely to be a result of a slight increase in surface roughness associated with change in land-use. The PV arrays do not result in an increase in runoff since the same area of soil is available for infiltration, and vegetative groundcover will be maintained to distribute runoff.	**Section 7** **Section 6.1**
Environmental flows and annual yield of catchment	Other than maintaining the existing farm dams, no additional harvesting of surface water is proposed. There will be no change to low or environmental flows as a result of the project. The annual yield of runoff from the site catchments will be unchanged from the current rural activities.	**Section 6.1**
Construction phase water quality	Since the existing site is very flat there are very low rates of erosion and sediment transport from site. No broad scale earthworks or soil disturbance is proposed, and any localised soil disturbance will be progressively revegetated such that the total area of denuded soil is minimised. Sediment fences and contour bunds (very shallow bunds aligned across the slope to provide temporary pooling of runoff) will be used to mitigate the risk of sediment transport. Preparation of a Construction Environment Management Plan will include an Erosion and Sediment Control Plan, which will further detail requirements and procedures for erosion and sediment control, water quality monitoring, bunding of hydrocarbon storages, and spill response.	**Section 9.1**
Water management during operations	An Operational Environmental Management Plan will be prepared to detail requirements and procedures for • Monitoring and reporting on water quality. Water quality in farm dams will be monitored during initial stages of operation. • A procedure for erosion and sediment controls for ground disturbance activities; and • Requirements for storage and use of hydrocarbons and chemicals, and a spill response plan	**Section 9.2**

DOCUMENT REFERENCES

TABLES

FIGURES

1 Introduction

1.1 Purpose of this Document

This surface water assessment provides an environmental assessment of the surface and groundwater aspects of the West Wyalong Solar Project during the construction, operation and decommissioning phases of the project.

1.2 Project Description

The proposal is for a 90 MW AC solar farm located on a 560 Ha site located at 228-230 Blands Lane. The site is presently used for agriculture and is bounded to the north, south, east and west by flat, grassy rural landscapes.

The Project will include solar photovoltaic (PV) modules and single axis tracking system, inverter stations, a new substation, energy storage, grid connection, security perimeter fencing, designated buffer zones for confirmed environmentally and culturally sensitive areas, internal access roads, underground cabling and ancillary services including a Project site office.

The Project Site is located approximately 18 kilometres northeast of West Wyalong in NSW.

The proposed arrangement of infrastructure and facilities is shown on **Figure 1**.

1.3 Relevant Legislation

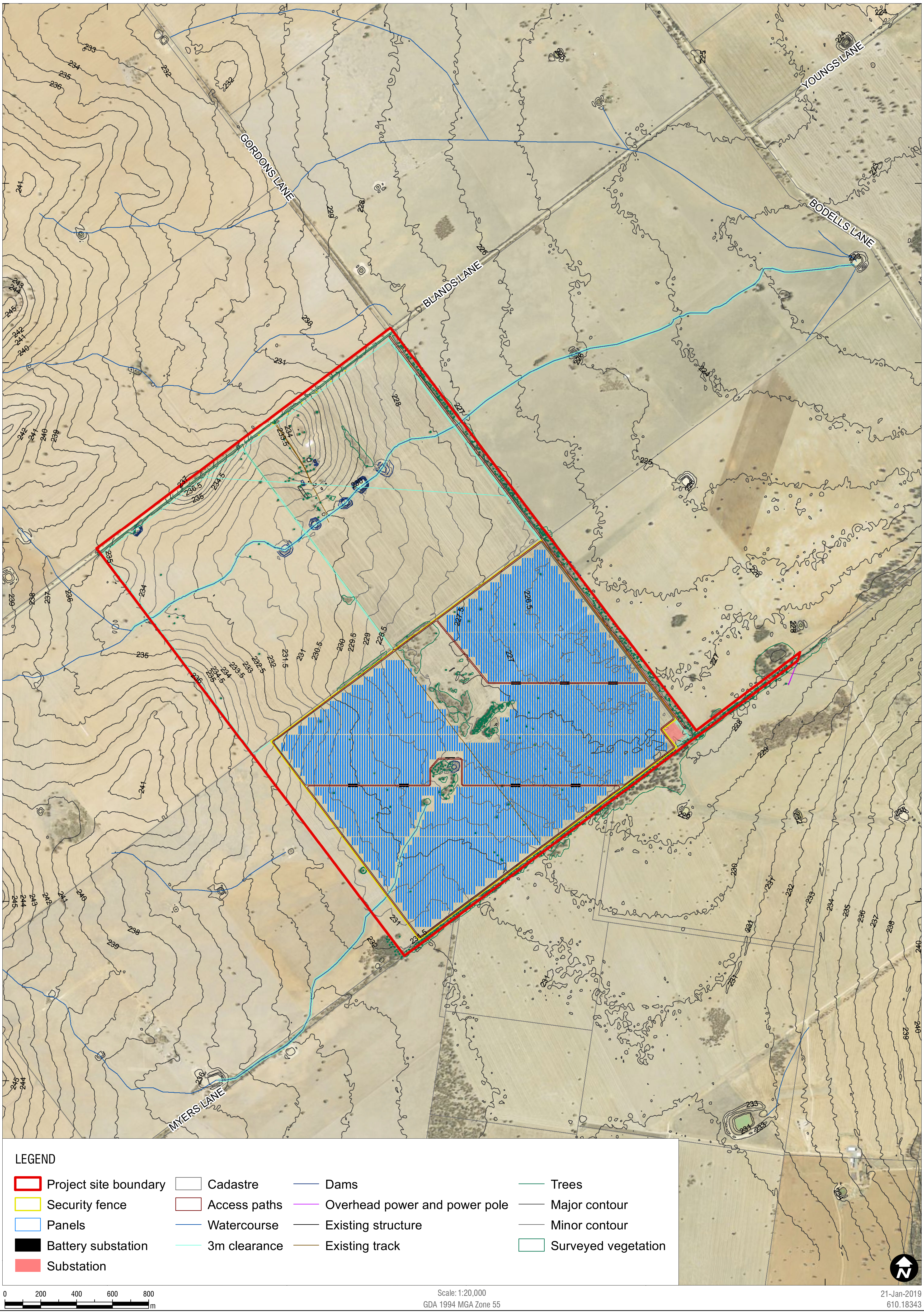
Federal legislation of relevance includes the Water Act 2007, which provides a legislative framework for management of water resources in the Murray-Darling Basin.

The NSW Water Management Act 2000 enables allocation of water for the environmental health of NSW's rivers and groundwater systems, while also providing licence holders with secure access to water and the opportunity to trade water. The NSW Murray and Lower Darling Regulated Rivers Water Sources – Water Sharing Plan 2016 includes the operational rules for allocating and trading water.

No change to water entitlements is proposed as part of the West Wyalong Solar Farm.

1.4 Assessment Methodology

This assessment has been prepared to address the requirements of the SEARs. The assessment was completed by desktop assessment to define existing conditions, an identification of potential impacts, and then identification of project features to mitigate and manage those impacts.



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Project Overview

FIGURE 1

2 Existing Water Environment and Site Soils

2.1 Site Topography and Drainage Patterns

The project Site is located within a predominantly agricultural area.

A LiDAR topographical survey across the project site was provided by T.J.Hinchcliffe & Associates. Contextual topography outside of the project site was obtained from the ELVIS Leica-Geosystems Airborne Digital Sensor supplied by NSW Spatial Survey.

The Site has a drainage path which dissects the site running almost parallel to the North western and South-eastern boundary. The watercourse is not incised into the landform, and forms a broad depression or swale generally less than 0.3m deep without clearly defined banks. Several broad and very shallow overland flow paths join the watercourse within the project site. The grade through this ephemeral watercourse is very gentle, with drainage slope of 0.32%.

The contributing catchment area to the Project Site is 1674 Ha. Elevations across the Project Site vary from approximately 233.8m AHD in the west, to 226m AHD on the eastern boundary, indicating a maximum fall of around 8m over a distance of 2 km. Elevations undulate in the centre of the site, associated with areas of vegetation. The topography of the project Site, alignment of overland flow paths are shown in **Figure 2**

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Site Topography and Watercourses

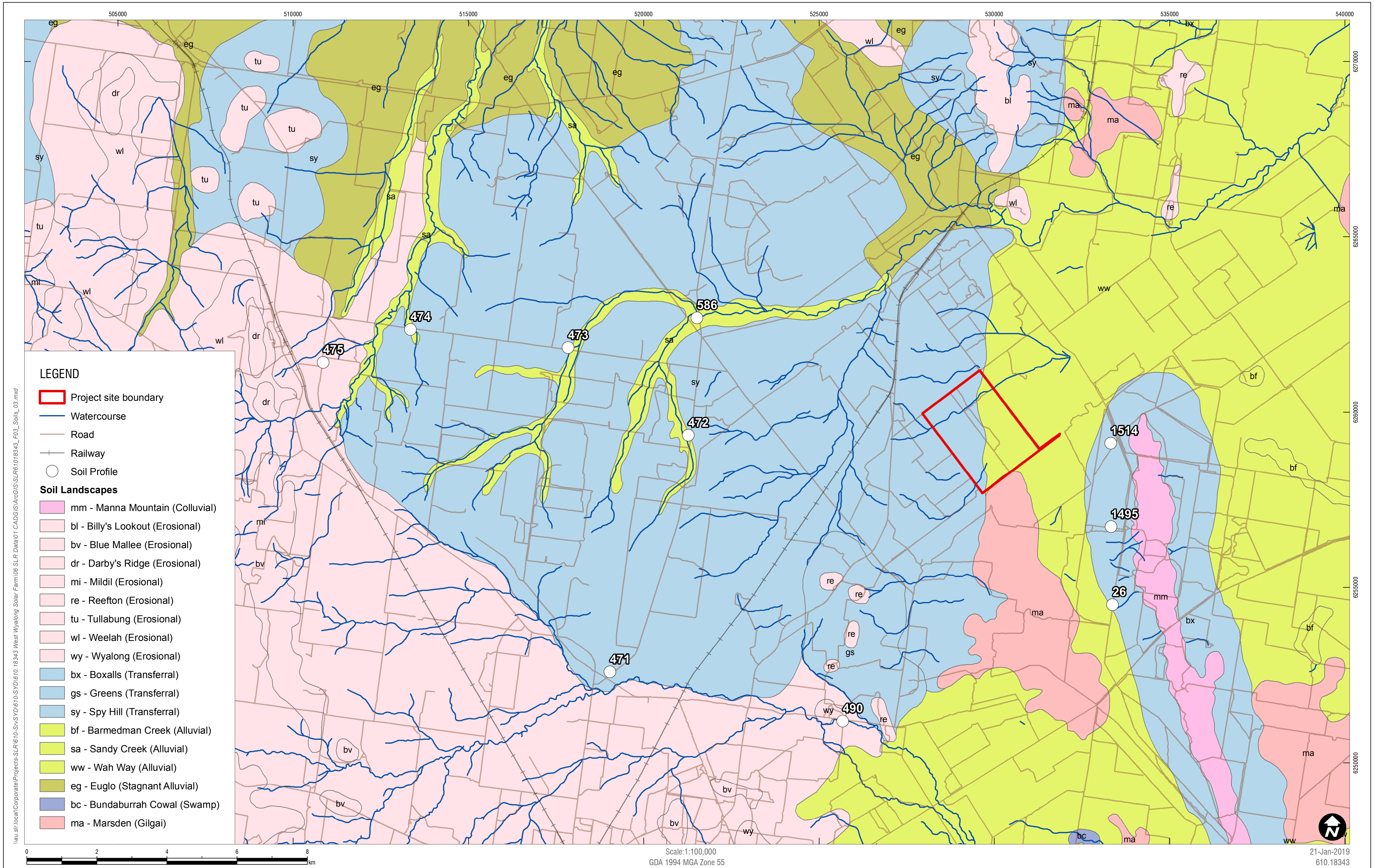
FIGURE 2

2.2 Site Soils

Information on site soils was obtained from the NSW Office of Environment and Heritage (OEH) website. Site soils are shown on **Figure 3**.

The soil landscape over the Site is comprised of two predominant soil types; Spy Hill (SY) and Wah Way (WW). The Spy Hill soils in the west of the site are moderately well drained earthy sands with a high run on and water erosion potential. The site lies within the lower slopes where soils are described as moderately deep (>60cm) dark reddish brown sandy clay loam with a moderate pH (6.0). Soils associated with drainage lines include the Yellow / Brown Solodic Soils comprising sandy loam underlain by sandy clay loam with a largely neutral pH (7.0).

The Wah Way soils in the east of the site include the poorly drained clays associated with the Wah Way alluvial plain. The red and brown clays are present to a depth greater than 150cm, with a neutral pH (7.0) found in the topsoil becoming more alkaline with depth (pH 8.0 - 9.0). The Wah Way soils have a low permeability, and during flood events water erosion potential can be high in areas of fast moving waters.



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Site Soils

FIGURE 3

2.2.1 Soil antecedent moisture

The antecedent moisture condition of soil before a storm has a significant bearing on the response of a catchment to rainfall. A saturated catchment will behave very differently to dry catchment particularly when sandy loams are involved as are experienced at this Site. ARR 2016 [ref 1] modelling practice requires the user to apply an average soil moisture condition at the commencement of a storm to eliminate such coincident probabilities.

The Bureau of Meteorology has developed continental scale mapping of the percentage of the available water content (AWC) in both the top soil and subsoil since 2005. The following graph summarises the average annual percentage of the AWC at the Site where the AWC can be expressed as the difference between the Field Capacity (FC) and the Wilting Point (WP).

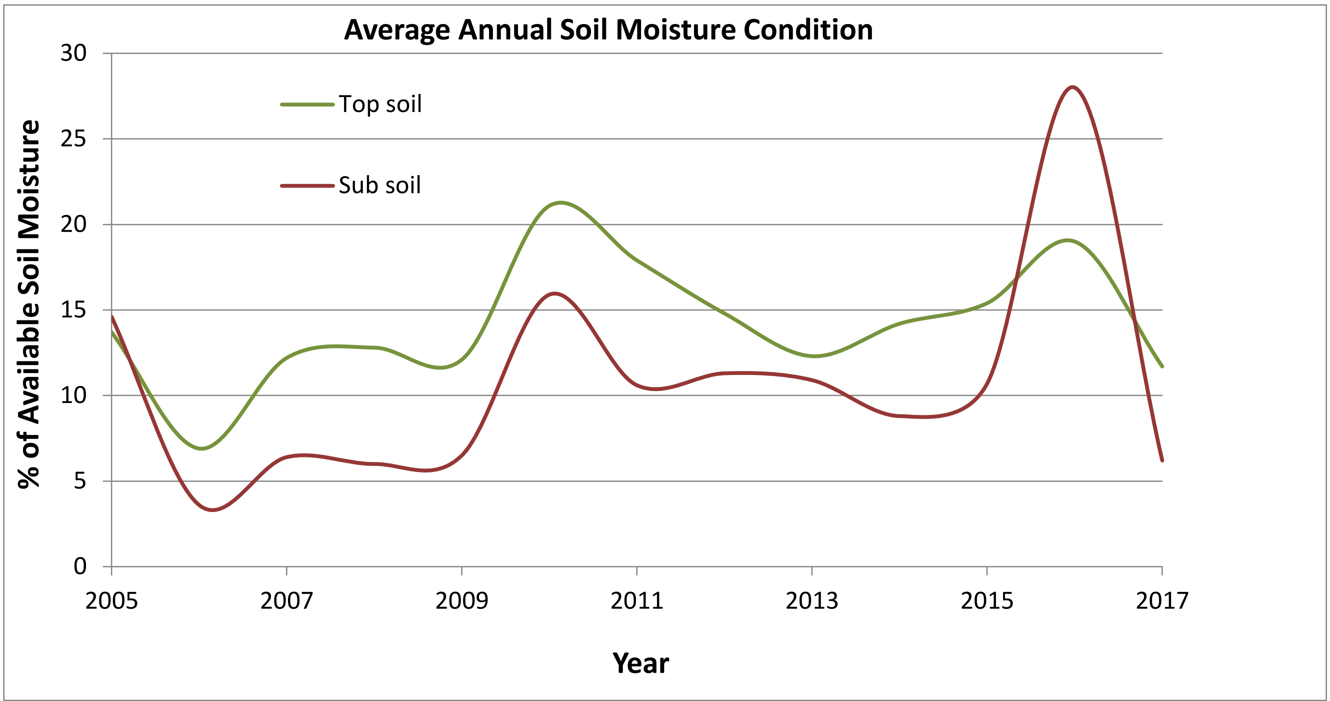


Figure 4 Average antecedent soil moisture condition at West Wyalong

The average percentage of available water content of the top soils for the past 13 years is 14.2% whereas the percentage of the sub soils is only 10.7%.

2.2.2 Horton's infiltration parameters applied in the model

According to the soil landscapes research conducted by OEH (**Figure 3**), eleven different soil types were identified within the contributing catchment to the Site. The following table summarises the soil parameters adopted in the Horton's infiltration model for each of the identified soils.

The Horton's infiltration model considers the hydraulic conductivity of both the top soil and subsoil with a decrease in infiltration rate over time in an exponential manner. It simulates an observed behaviour of a rapid infiltration rate at the onset of rainfall which decreases at an exponential rate as soil voids progressively fill. Rainfall excess only occurs if the applied rainfall rate exceeds the hydraulic conductivity. The antecedent moisture conditions are taken into consideration via the available water content store.

This approach is considerably more accurate than the traditional initial and continuing loss model which does not allow runoff to occur until the initial loss volume is exceeded. A constant continuing loss rate follows for the duration of the storm event.

Table 2 Horton's Loss Model Parameters

Soil Name	Profile	Average Depth (mm)	Hydraulic Conductivity (mm/h)	Available Water Content (mm)*
Marsden	topsoil	80	1	9
	subsoil	420	0.6	46
Spy Hill	topsoil	130	21.8	12
	subsoil	170	3	16
Wah Way	topsoil	150	2	20
	subsoil	1750	0.6	194
Sandy Creek	topsoil	100	21.8	10
	subsoil	500	3	48
Boxalls	topsoil	80	3	7
	subsoil	720	2	102
Euglo	topsoil	80	3	7
	subsoil	670	0.6	74
Billys Lookout	topsoil	160	59.8	10
(clayey sand)	subsoil	490	59.8	31
Manna Mountain	topsoil	100	21.8	10
	subsoil	200	21.8	20
Weelah	topsoil	100	3	9
	subsoil	350	3	33
Greens	topsoil	200	3	18
	subsoil	100	0.6	11
Reefton	topsoil	80	21.8	8
	subsoil	0	0	0

*Available Water Content = (Field Capacity – Wilting Point) x (100 – Average Moisture Content %)

2.3 Manning's roughness parameters

Roughness coefficients represent the resistance to flood flows in channels and flood plains. Refinement of Manning's roughness values is normally performed during calibration. As there are no recorded flood levels close to the Project Site, it was necessary to assign industry standard values of Manning's roughness for pre and post development scenarios.

The adjustment of the surface roughness following the installation of the arrays has abided by the guidelines in Arcement et al (1989). An increase in roughness of 0.012 has been applied to account for the resistance of the support poles and improved grass cover. The following values were applied in this project.

Table 3 Manning's 'n' values adopted in the model

Surface	Manning's n
Site pre-development (long grass)	0.035
Site post-development (long grass with array support posts)	0.047
Mature field crops	0.04
Scattered trees with grasslands	0.05
Perimeter tree lots	0.08
Forest on hill tops	0.10

2.4 Acid Sulfate Soils

The risk of encountering acid sulfate soils is very low since there are no known occurrences of acid sulphate soils within the site boundary, and also since the project will not involve any significant excavation other than shallow trenching for electrical cables. The NSW Government SEED database does not indicate the presence of any known risk of acid sulfate soils (database accessed 21 September 2018).

3 Climate Information

3.1 Rainfall and evaporation

The closest Bureau of Meteorology (BOM) station to the Project Site recording daily rainfall is Wyalong Airport Aws. This station is approximately 16.5km to the south west of the Project Site, and has 19 years of rainfall records. The BOM station at West Wyalong Post office provides historical data, recording the 100 years of rainfall data preceding the use of the station at Wyalong Airport. Rainfall for the project site is based on BOM data at the West Wyalong Airport station. **Table 4** shows the distances to, and lengths of data record at each of these stations.

Table 4 Rainfall stations within the surrounding area

Station	Station Number	Distance from Project (km)	Data available
West Wyalong Airport Aws	050017	17	1999-present day
West Wyalong Post Office	050044	16.5	1895-2002

Average annual rainfall at West Wyalong Airport Aws, is 453.8mm. There is not a substantial seasonal variance in rainfall during average years, with the driest months in January and April having 25-50% less rainfall than the wettest months from June to December. Average monthly and annual average rainfall depths are shown in **Table 5**.

Table 5 Average monthly rainfall depths at West Wyalong Airport Aws (Station 050017)

Month	Average Rainfall (mm)
January	27.7
February	43.9
March	32.8
April	18.8
May	31.0
June	44.2
July	42.1
August	36.3
September	37.7
October	43.7
November	45.5
December	53.6
Average Yearly Rainfall	**453.8**

There can be considerable fluctuation in the depth of rainfall from year to year. The lowest recorded annual rainfall was 122mm, and the highest annual rainfall was 895.6mm. In particular there are very high differences in summer rainfall between dry and wet years. For example, the 10th percentile rainfall in March is 1.2mm, while the 90th percentile rainfall is 78.0mm.

Rainfall statistics in **Table 6** show the mean and annual monthly rainfalls, as well as information for lowest, median and highest recorded months/years, and the 5th, 10th, 90th and 95th percentile months/years. Data accessed from the BOM website, 20th September 2018.

Table 6 Detailed Monthly and Annual Rainfall Depths

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	27.7	43.9	32.8	18.8	31.0	44.2	42.1	36.3	37.7	43.7	45.5	53.6	453.8
Lowest	1.0	0.0	0.0	0.0	1.2	1.8	6.0	8.4	0.6	0.4	2.4	3.4	122.4
5th %ile	6.6	2.5	0.2	1.9	1.4	5.8	8.9	9.0	4.0	1.1	5.6	4.7	212.7
10th %ile	7.8	5.8	1.2	2.4	1.6	10.1	18.5	10.1	8.9	8.4	6.6	12.2	277.7
Median	21.6	32.0	23.8	16.5	22.2	29.4	36.7	33.7	24.2	38.2	38.0	41.0	430.0
90th %ile	64.0	89.9	78.0	38.2	78.1	94.8	71.7	58.7	70.6	91.4	91.4	118.6	693.0
95th %ile	71.4	107.0	113.6	39.1	84.4	101.8	81.6	65.3	104.0	125.8	98.2	126.5	782.5
Highest	102.0	155.4	151.8	47.8	84.4	162.4	84.6	72.0	166.6	152.6	117.8	185.0	895.6

Intensity Frequency Duration (IFD) information for the site was sourced from the Bureau of Meteorology (BOM) website (2016 IFD data), accessed 21 September 2018. Rainfall depths (mm) for various AEP's and durations are shown in **Table 7** below.

Table 7 BOM 2016 Rainfall Depths – Frequent to Rare Storms

Duration	Annual Exceedance Probability (Average Recurrence Interval)		
	10% (1 in 10)	1% (1 in 100) AEP	1 in 200 AEP
30 min	25.2	40.4	53.5
1 hour	32.2	51.0	58.6
2 hour	40.1	63.0	72.5
3 hour	45.6	71.4	82.3
6 hour	56.7	89.1	103
12 hour	70.4	112	130
24 hour	86.2	139	160
48 hour	102	165	185
72 hour	110	177	198
96 hour	115	183	205
120 hour	118	187	209
144 hour	120	189	211
168 hour	122	190	212

3.2 Climate Change and Effect on Rainfall

There is now widespread acceptance that human activities are contributing to observed climate change. Climate change (warming) has the potential to increase the prevalence and severity of rainfall extremes, and needs to be considered in flood planning for long term projects. Climate Change in Australia state that for the Murray Basin region:

- There is very high confidence in continued substantial increases in projected mean, maximum and minimum temperatures, with a corresponding decline in mean annual rainfall depths;
- There is high confidence that there will be future increase in the intensity of extreme rainfall events.

In a warming climate, rainfall depths in extreme events are expected to increase mainly due to a warmer atmosphere being able to hold more moisture (Sherwood et al., 2010). Since the facility has a long design life, climate change may be significant.

Australian Rainfall and Runoff (ARR 2016) identifies two alternative methods to estimate the impact of climate change on rainfall depth. These are described below.

3.2.1 Simplified Method

The simplified method allows incorporating the effects of climate change in design rainfall and flood estimation, by modelling of the 0.5% (1 in 200) AEP in lieu of the 1% AEP event. For a 24 hour rainfall event this would represent an increase in rainfall of 15%.

3.2.2 Detailed Assessment

The second method involves a more detailed assessment of increased rainfall intensity based on predictive modelling of temperature increases sourced from the Climate Change in Australia website (https://www.climatechangeinaustralia.gov.au), and applying a 5% change in design rainfall per degree of global warming (Equation 1.6.1 of ARR 2016).

Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. A conservative high emission RCP 8.5 climate change scenario and intermediate scenario RCP4.5 have been considered for the year 2070. The climate change predictions are summarised in Table 8, and the outcomes summarised below for RCP 8.5 and RCP 4.5:

For RCP 8.5 there are 48 climate models - 67% predicted temperature increases in the Hotter interval (1.5°C to 3°C) while 33% predicted temperature increases in the Much Hotter interval (greater than 3°C).

For RCP 4.5 there are 46 climate models – 32% predicted temperature increases in the Warmer interval (0.5 to 1.5°C), 65% in the Hotter interval (1.5°C to 3°C), and 15% in the Much Hotter interval (greater than 3°C).

Table 8 Murray Basin Climate Futures – Summary of Data for Year 2070

RCP	No Models	Slightly Warmer >0.5	Warmer 0.5 to 1.5	Hotter 1.5 to 3.0	Much Hotter >3
RCP2.6	29	2	25	2	0
RCP4.5	46	1	15	30	7
RCP6.0	22	0	4	18	0
RCP8.5	8.5	0	0	32	16

Considering the range of outcomes from the climate change models, it is apparent that there is a high level of confidence that temperatures will increase, and for the more conservative higher RCP models (RCP 6.0 and RCP 8.5) it appears likely that the temperature increase will be within 1.5 to 3.0°C.

Based on this information, a conservative temperature increase for the project site of 2.5°C is considered suitable for estimating rainfall intensity increases, and using a rate of 5% per 1°C results in a 12.5% increase in rainfall intensity.

3.2.3 Adopted Climate Change Rainfall

The two methods of estimating increase in rainfall associated with climate change are compared in **Table 9**.

Table 9 Comparison of Climate Change Rainfall Increases

Duration	Rainfall Depth, 24 hour duration	Comment
2016 Rainfall – 1% AEP	139mm	Baseline
Method 1 - 2016 Rainfall for 0.5% AEP	160mm (+15%)	Adopted for sensitivity analysis
Method 2 - 2016 Rainfall for 1% AEP + 12.5% increase	156mm (+12.5%)	Similar to Method 1 for 0.5% AEP

Since the estimated increase in rainfall intensity due to climate change from Method 2 is very similar to the 0.5% AEP rainfall, the 0.5% AEP rainfall has been adopted to examine the effect of climate change on the project.

4 Water Quality

4.1 Existing Water Quality

No existing water quality data is available for the Project Site. Given the highly ephemeral nature of the project site channels, and the low impact of the proposal, it is intended for the proposal to include best practice water quality control measures, with an ongoing water quality monitoring regime to be assessed against the ANZG 2018 water quality criteria.

4.2 Water Quality and River Flow Objectives

The NSW Water Quality Objectives are the agreed environmental values and long-term goals for NSW's surface waters. Water Quality Objectives for most catchments in NSW are published on the Department of Environment Climate Change and Water website (http://www.environment.nsw.gov.au/ieo/).

The Project Site's contributing catchment is located between the catchments of Bland Creek to the south and Sandy Creek to the north. Both discharge into Lake Cowal, and are part of the catchment for the Lachlan River. Overbank flows from Sandy Creek during major flood events enter the catchment containing the Site. During major events a confluence of flows from the Site's catchment, overbank flows from Sandy Creek and runoff from the Boxalls Ridge discharge to Bland Creek and then into Lake Cowal. Lake Cowal is a significant wetland area and receives water from Bland Creek (uncontrolled) and the Lachlan (regulated).

The relevant agreed environmental values and river flow objectives for **Uncontrolled Streams** within the Lachlan River Catchment are detailed in **Table 10**. There are no irrigation water supplies, homestead water supplies, or drink water sources in the downstream vicinity of the Project Site.

Table 10 Environmental values and river flow objectives for Uncontrolled Streams **within the Lachlan River Catchment**

Water Quality Objectives	River Flow Objectives
Aquatic Ecosystems	Protect pools in dry times
Visual Amenity	Protect natural low flows
Livestock Water Supply	Manage groundwater for ecosystems
	Maintain wetland and floodplain inundation
	Minimise effects of weirs and other structures

River flow objectives suggest that the natural and existing regime of flows from the Project Site should be retained as far as practically compatible with other requirements, mimicking natural flow patterns as closely as possible. Additional damming or harvest of surface water on site should be minimised.

4.3 ANZG 2018 Default Water Quality Trigger Values

The Australian and New Zealand Water Quality Guidelines (ANZG 2018) advocate a risk based approach to water quality assessment and management. That is, the intensity of assessment of current water quality status or impacts on water quality should reflect the risk of impacts on the achievement/protection of the water quality objective.

For Protection of Aquatic Ecosystems in NSW, and for irrigation water used in primary production, the ANZG 2018 Guidelines refer back to the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) default trigger values for major physico-chemical stressors, which are used to assess whether the condition of an ambient water body supports the environmental values. These values, summarised in **Table 11**, provide typical values which if exceeded warrant investigation, and could adversely impact downstream environments and/or water uses.

With regards to the preservation of water quality for the purposes of livestock drinking water the revised guidelines will be published early in 2019 via the following weblink, (http://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance), and may need to be referenced in the OEMP.

Table 11 Trigger Values – Environment and Irrigation Water

Parameter	Default Trigger Value for NSW lowland rivers for aquatic ecosystems in slightly disturbed ecosystems
Total Phosphorous TP (mg/L)	0.05
Total Nitrogen TN (mg/L)	0.50
Ammonium NH_4^+ (mg/L)	0.02
Total Suspended Solids	50mg/L - Professional judgement
Turbidity (NTU)	6-50
Salinity	125-2200µS
pH	6.5 – 8.5

Parameter	Default Trigger Value for NSW lowland rivers for aquatic ecosystems in slightly disturbed ecosystems
Pesticides	Concentrations in discharge water should not exceed the crop injury threshold values in Table 4.2.12 of the ANZECC 2000 Guidelines
Heavy metals and metalloids	Concentrations in discharge water should not exceed the STV values in Table 4.2.10 of the ANZECC 2000 Guidelines
Thermotolerant coliforms (cfu/100mL)	<1000

4.4 Erosion and Sediment Control – Construction Phase

Construction activities which disturb the land surface typically increase the potential for erosion of soils during rainfall events and increase the risk of sediment-laden stormwater runoff discharging to the receiving environment. However, construction of the West Wyalong Solar Farm is expected to result in only minor ground disturbance, and a very low potential for erosion due to the following mitigating factors:

- Construction will proceed in two major stages, and within each stage the construction activities will be sequenced, such that the construction zone at any one time will be a small proportion of the overall site area;
- The solar farm will utilise the existing landform and no broad-scale re-contouring of the existing ground levels is proposed. Hence the existing vegetative cover and soil structure will be maintained intact across most of the project area;
- Substations and the pole mounted solar arrays will be supported on driven or screw piles, so that no excavation is required other than for electrical cabling
- Construction areas will be progressively revegetated as installation of solar array proceeds across the site.
- Gentle grades across the site are not conducive to erosion or sediment transport, since surface runoff can only move at very low velocities.

It is also noted that the site presently has a rural land-use, and that the level of soil disturbance for installation of solar arrays may actually be less than that associated with broad-acre agriculture.

With the implementation of standard erosion and sediment control measures in accordance with Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition (Landcom 2004) the potential environmental impact is considered very low and manageable.

A site wide Erosion and Sediment Control Plan (ESCP) will be prepared as part of the Construction Environmental Management Plan (CEMP) for the Project. The ESCP will be prepared in accordance with Landcom (2004), known as 'the Blue Book', and Volume 2A Installation of Services (DECC 2008a). Mitigation measures and site management practices will include:

- Staging of construction works and progressive revegetation to limit the disturbed area
- Early establishment of site access tracks to minimise disturbance of site soils by construction vehicles
- Progressive revegetation of disturbed areas
- Reseeding of soils beneath the lower edge of PV panels, to ensure the early establishment of vegetative ground cover, and limit the potential for soil erosion from panel runoff
- Stabilisation of table drains alongside access tracks using vegetation, and rock check dams

- Installation of sediment fences for any earthworks in proximity to site overland flow paths
- Installation of localised sediment controls such as sediment fencing, straw bales, and sediment sumps at any site areas involving earthworks greater than 1,000m^2 in area. Ssediment controls may also include a series of temporary swales constructed across the contour, to provide erosion and sediment control
- Install a shaker pad at the site exit to reduce mud or clay on vehicle wheels being tracked onto external roads
- Appropriate site storage of hydrocarbons within bunded areas, and documented spill response procedures
- Inspection of ESC measures following heavy rainfall
- Water quality monitoring and reporting requirements
- Providing an appropriate level of resourcing for environmental management and monitoring.

4.5 Erosion and Sediment Controls – Operational Phase

- Soil disturbance during operation of the solar farm would be minimal and limited to maintenance activities, which will involve very small localised disturbance areas on an infrequent basis. Water quality impacts from these minor disturbances is unlikely to have any significant impact on overall site water quality. For sites in proximity (less than 200m) to site overland flow paths or the site boundary, erosion and sediment control measures will be implemented to minimise the potential for sediment export. These measures would be developed on a case by case basis in accordance with the Landcom (2004) guidelines, and are likely to include measures such as sediment fencing, sediment traps, and progressive stabilisation with vegetation.
- Concentrated runoff from the surface of solar panels falling onto the ground has some potential to cause localised erosion below the solar array modules. Cook and McCuen's (2013) study of solar farms indicates that the potential for localised erosion can be effectively mitigated by the establishment and maintenance of thick groundcover vegetation beneath the panels. The rates of erosion during the period when vegetation is being established will be closely monitored during the initial stages of the development, and if warranted, jute mesh will be used to cover and protect these small areas from erosion during the establishment of grass cover.
- During operation the panels would constantly change orientation, with runoff being distributed in the area around each panel, and not drained permanently to a single place on the ground. Measures to manage any bare areas and erosion that develop beneath the solar arrays over time would be included in a groundcover management plan for implementation during ongoing operation of the proposal.
- The existing farm dam will be maintained, and will provide a location for collection of samples for monitoring surface water quality from the Project.
- Access tracks across the site will be unsealed, and there is potential for dust creation, mainly when tracks are traversed by site vehicles. Dusts deposited on the ground can be easily washed away during rainfall, increasing the turbidity and sediment loads in downstream waterbodies. The solar farm will have a strong interest in reducing dust, which can reduce the efficiency of PV arrays. Dust will be reduced by a range of mitigation measures including watering to suppress dust when required on dry windy days, the application of binders to road surfaces to reduce dust, limiting vehicle speeds, and reducing vehicle movements.

- Herbicides may be used on site to control vegetation growth around the base of PV arrays. Spillage of herbicides has potential to contaminate site soils and/or result in the migration of contamination into downstream watercourses. All herbicides used on site will be used in accordance with best practice, and stored in bunded containers in accordance with Australian Standards.

4.6 Storage and Use of Hydrocarbons and Chemicals

The storage and use of hydrocarbon fuels and other chemicals on site present a potential risk if spilled substances contaminate site soils or are mobilised and spread to the downstream receiving environment. Chemicals used onsite during both the construction and operational phases may include fuels, lubricants and (minimally) herbicides.

Accidental spill or discharge of hydrocarbons, such as fuels and oils in vehicles and/or earthmoving equipment, has potential to contaminate downstream waterbodies or groundwater. The risk of hydrocarbon contamination will be mitigated by:

- Storage of chemicals in accordance with Australian Standards
- Storage of hydrocarbon fuels within bunded storage areas
- Bunding of substations or other infrastructure that utilises oil
- Minimise usage of herbicides, and avoid spraying when rain is predicted
- A Spill Response Plan, including emergency response and EPA notification procedures

Requirements for the storage and use of hydrocarbon fuels and other chemicals on site will be documented in both the Construction and Operational Management Plans.

Overall, with the implementation of suitable controls these risks are low and considered readily manageable.

5 Groundwater impacts

5.1 Groundwater Dependent Ecosystems (GDEs)

Groundwater is important in sustaining Groundwater Dependent Ecosystems (GDEs), including aquatic and terrestial ecosystems such as springs, wetlands, rivers and forests. GDEs can include aquatic ecosystems which rely on the surface expression of groundwater, and terrestial ecosytsems which rely on the subsurface presence of groundwater.

The Groundwater Dependent Ecosystems Atlas (BOM, 2017) indicates that there are no Terrestial GDEs within the proposal area, as shown on **Figure 5.**

5.2 Groundwater Vulnerability

The Project Site is located within an area mapped as having groundwater vulnerability under the Bland LEP, indicating areas in which the hydrological functions of groundwater systems should be maintained to protect vulnerable groundwater resources from depletion and contamination as a result of development. The Bland LEP Clause 6.6 – Groundwater Vulnerability states that:

"Before determining a development application for development on land to which this clause applies, the consent authority must consider the following:

(a) whether or not the development (including any on-site storage or disposal of solid or liquid waste and chemicals) is likely to cause any groundwater contamination or have any adverse effect on groundwater dependent ecosystems, and

(b) the cumulative impact (including the impact on nearby groundwater extraction for potable water supply or stock water supply) of the development and any other existing development on groundwater."

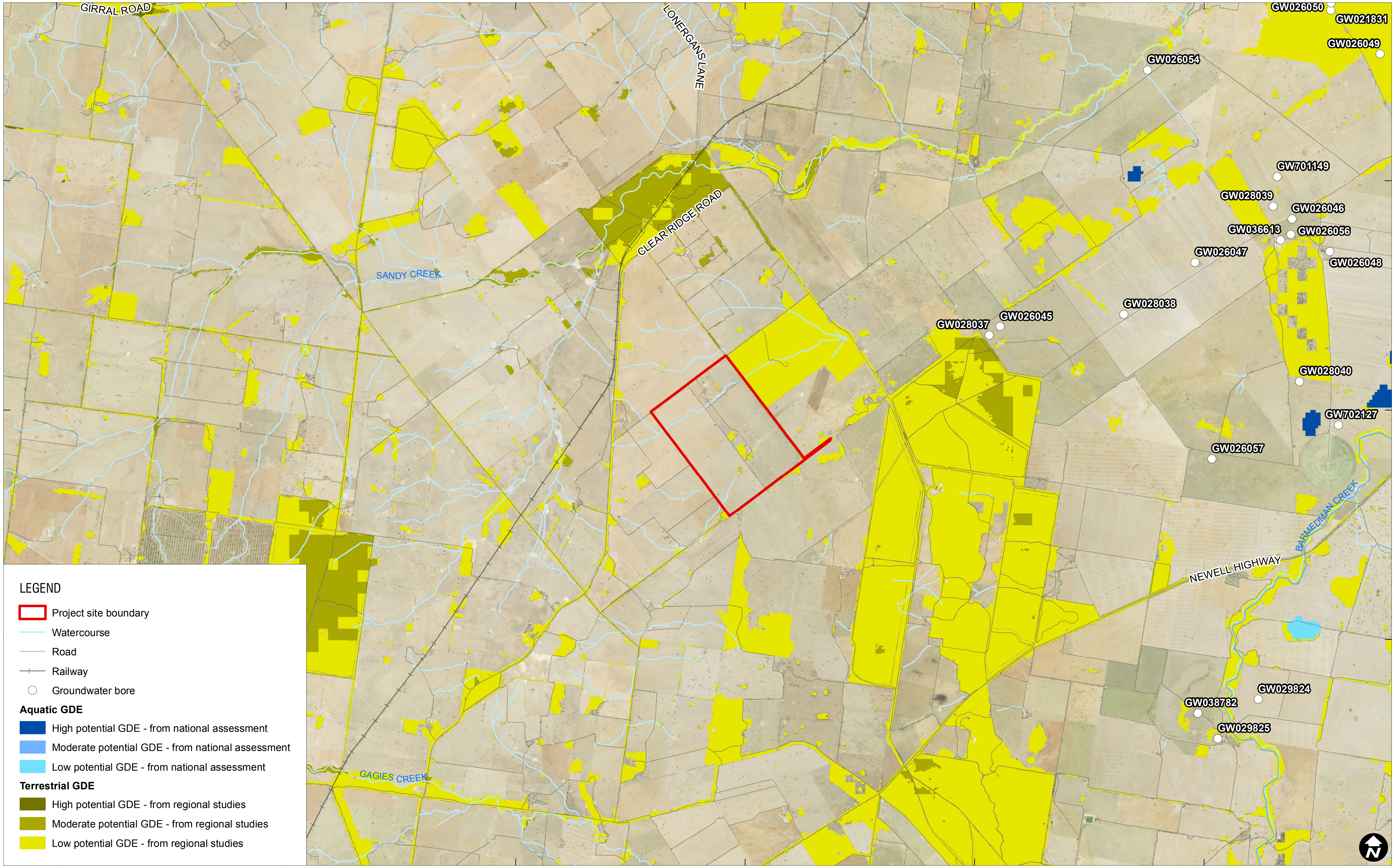
5.3 Existing Water Users

The site has no licenced groundwater bores.

5.4 Impact Assessment

The Project is not likely to have any impact on groundwater resources or GDE's. Impacts to groundwater during construction and operation of the solar farm are unlikely to occur due to:

- The pattern of surface drainage and associated groundwater recharge will remain unchanged;
- Soil infiltration across the broader surface of the site will be unchanged, as discussed in Section **6.1** of this report, and therefore the rates of groundwater recharge will be unaffected;
- The Project does not include any excavation with potential to interact with groundwater; and,
- No solar arrays or other infrastructure are proposed at or close to the locations of GDE's within the site



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Groundwater

FIGURE 5

6 Rainfall infiltration, harvesting and catchment yield

6.1 Rainfall Infiltration and Catchment Yield

Mean Annual Runoff (MAR) for the project site is 434 ML, based on a Project Site area of 560ha, with the average annual rainfall of 453.8mm, and a very low volumetric runoff coefficient of 0.013. This is based on the WaterNSW Harvestable Rights Calculator.

The proposal will not alter the existing runoff characteristics of the site. While the proposal involves constructing solar arrays with impervious surfaces, runoff volumes will not be increased, because rainwater will drain to the ground underneath the arrays, be dispersed by vegetation maintained below the panels, and infiltrate into the existing soils which will provide the same overall soil surface area available for rainfall infiltration. Overland flows will follow flow paths to those currently present on the site. This is supported by the study by Cook and McCuen (2013) into the impact of solar farms on hydrology, which found that a solar farm with pole mounted PV arrays would not have a significant impact on the surface water run-off rate, or volume. This study found that underlying groundcover was the primary determinant of run-off rate.

No change to the annual runoff generated by the site is expected, because by retaining good grass cover across the site, run-off water from PV arrays would be absorbed into the ground similarly to current conditions.

No additional dams are proposed on site as part of this Project. The existing farm dams will be retained.

7 Hydrology and Flood Behaviour

7.1 Existing

The existing runoff characteristics of the proposal site will be maintained throughout the construction and operation of the proposal. As described in section 6.1, while the proposal involves constructing solar arrays with impervious surfaces, these would not increase runoff, since the same area of soil is still available for infiltration below the solar panels, and a good vegetation cover will be maintained to spread flows. Hence the proposal will not result in any significant changes to the existing pattern or amounts of site run-off.

7.2 Hydrology and Flooding Methodology

There are no existing flood studies which cover the Project Site.

Assessment of the flow of surface water across the Project Site has been carried out in accordance with Chapter 6, Book 1 of the online version of the Australian Rainfall and Runoff 2016 (ARR 2016) guideline.

Hydrological and hydraulic modelling has been carried out using the XP-SWMM 1D/2D software to estimate the peak flows and flood behaviour for the existing and developed site scenarios.

7.3 Critical Duration Storms

In November 2016 the Institution of Engineers introduced a revised protocol for hydrological assessment of catchments. The former procedure required the hydrologist to determine the storm duration which generates the greatest peak flow downstream of the catchment by simulating a common rainfall temporal pattern (percentage rainfall fallen over time) for each duration storm.

The revised procedure now requires 10 different temporal patterns to be tested for each duration and each magnitude storm. The maximum of the means of each 10 temporal patterns (referred to as an ensemble) is considered the critical duration storm for the catchment.

The following graphs shows the range of peak flows immediately downstream of the Site for 200 storms simulated for each of the 10%, 1% and 1 in 200 AEP magnitude storms to determine the critical duration storm.

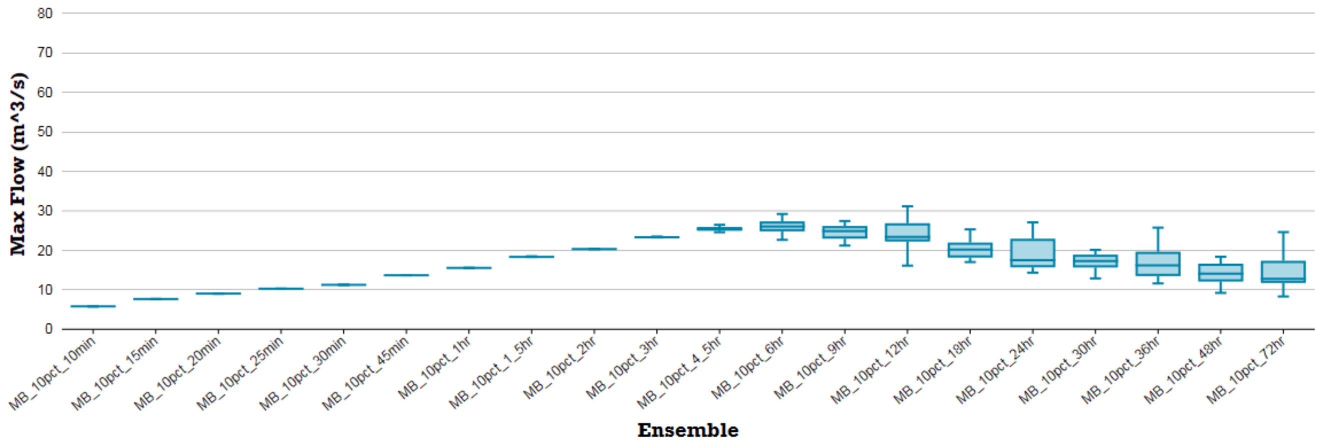


Figure 6 10% AEP storm event peak flow ranges for each ensemble of temporal patterns

➔ The 6 hour, temporal pattern No.3 is the critical 10% AEP storm for the catchment

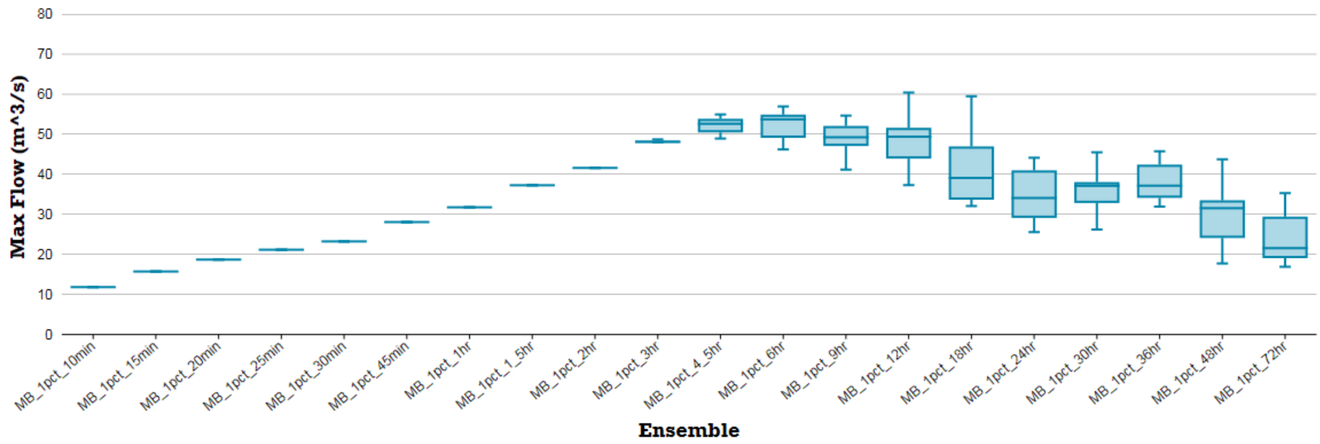


Figure 7 1% AEP storm event peak flow ranges for each ensemble of temporal patterns

➔ The 6 hour, temporal pattern No.9 is the critical 1% AEP storm for the catchment

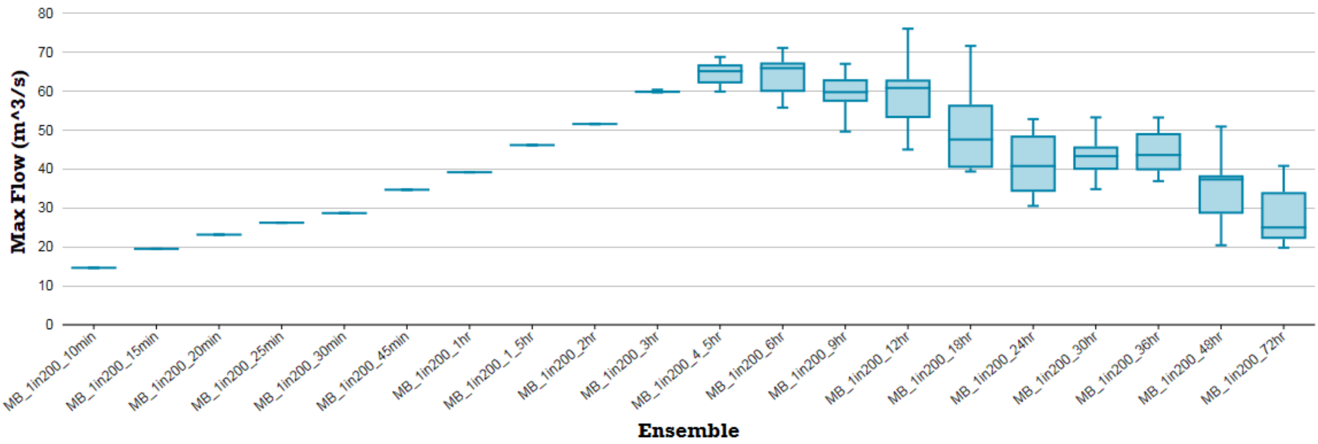


Figure 8 1 in 200 AEP storm event peak flow ranges for each ensemble of temporal patterns

➔ The 4.5hour, temporal pattern No.7 is the critical 1 in 200 AEP storm for the catchment

Table 12 Critical duration storms

Magnitude Storm	Critical Duration
10% AEP	6 hours
1% AEP	6 hours
1 in 200 AEP	4.5 hours

7.4 Proposed Drainage Structures and Obstructions to Flow

Overland flow pathways will be maintained in their natural state and locations. Site access tracks will have a table drain on the upslope side that will convey runoff towards the nearest overland flow path. The flood modelling has assumed that the site access tracks may be elevated slightly above the existing terrain, by a maximum of 100mm, and graded to follow the existing terrain. Shallow table drains may be constructed to follow the grades of the existing ground alongside the roads. Some localised ponding is likely to occur in the very flat table drains following heavy rainfall. Where access roads cross the overland flow path, a cattle grid crossing or at grade causeway will be used to convey runoff across the road.

The existing dam will be retained and has been included in the flood modelling.

PV arrays will not obstruct flood flows. All PV arrays will be mounted on poles. When orientated in a vertical position the bottom edge will be approximately 430mm above the ground. In areas where flood modelling shows inundation depths exceed this level then the affected arrays may be designed with appropriate level of water proofing or placed on higher poles.

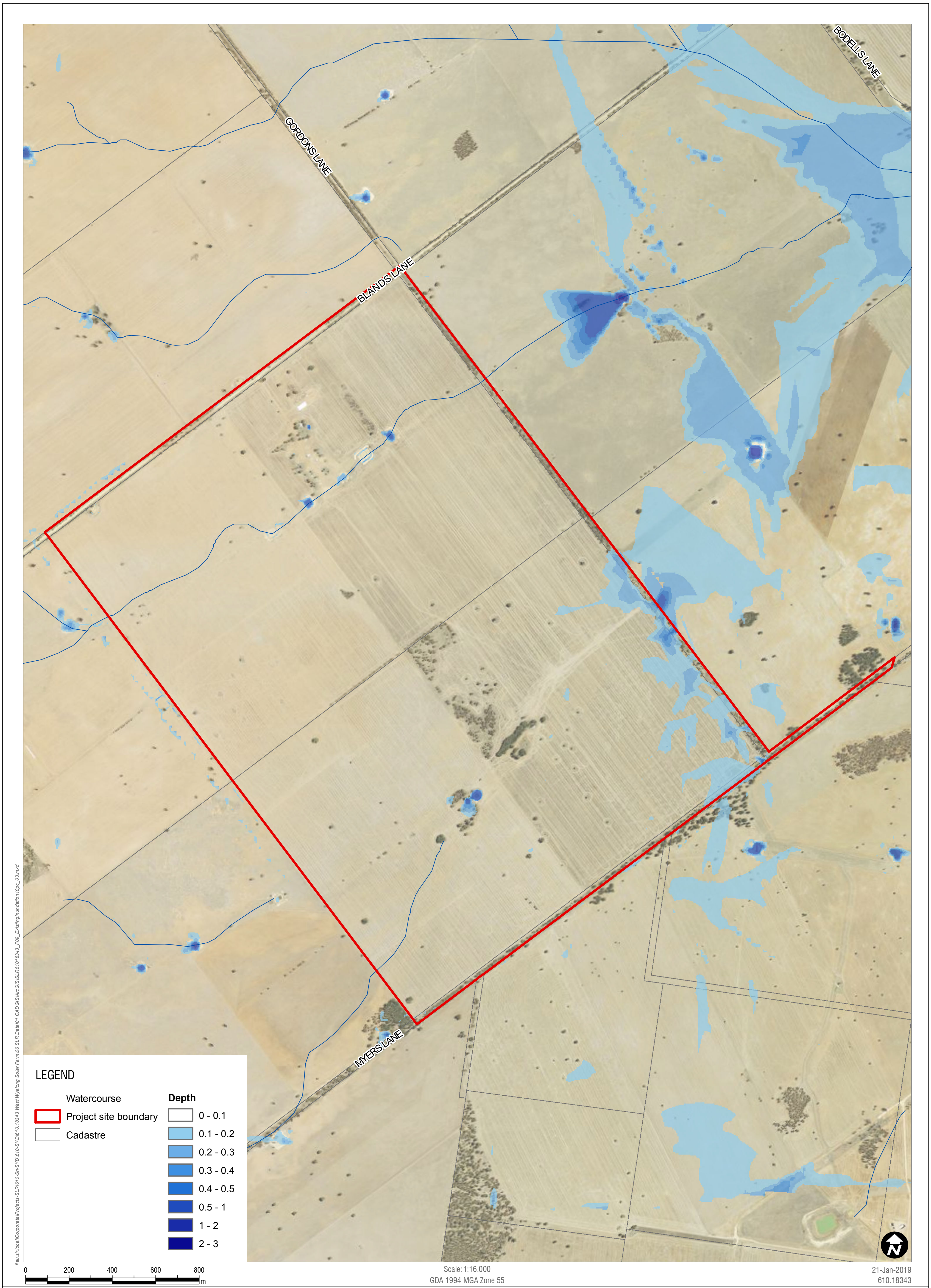
7.5 Site Inundation, Discharges, Flood Levels and Velocities

The topography is such that discharge from the Project Site only occurs along the eastern boundary. There is one dominant drainage path through the Project Site recognised as a drainage corridor by the Office of Water. The inundation within the Site generally follows this corridor however during major events a drainage path to the north surcharges as does a drainage path to the south and a major portion of the flow combines with flow passing through the Project Site.

7.5.1 Site Inundation Pre and Post Development

Site inundation has been simulated pre and post development for the 10%, 1% and 1 in 200 AEP flood events using SWMM-XP two dimensional software. The flat slopes and dendritic nature of the drainage paths necessitates two dimensional analysis.

Average annual antecedent soil moisture conditions were assumed at the commencement of all storms. Free discharge conditions were achieved by modelling two dimensional behaviour from the upstream ridgeline to a distance of 5.3kms downstream of the Project Site.



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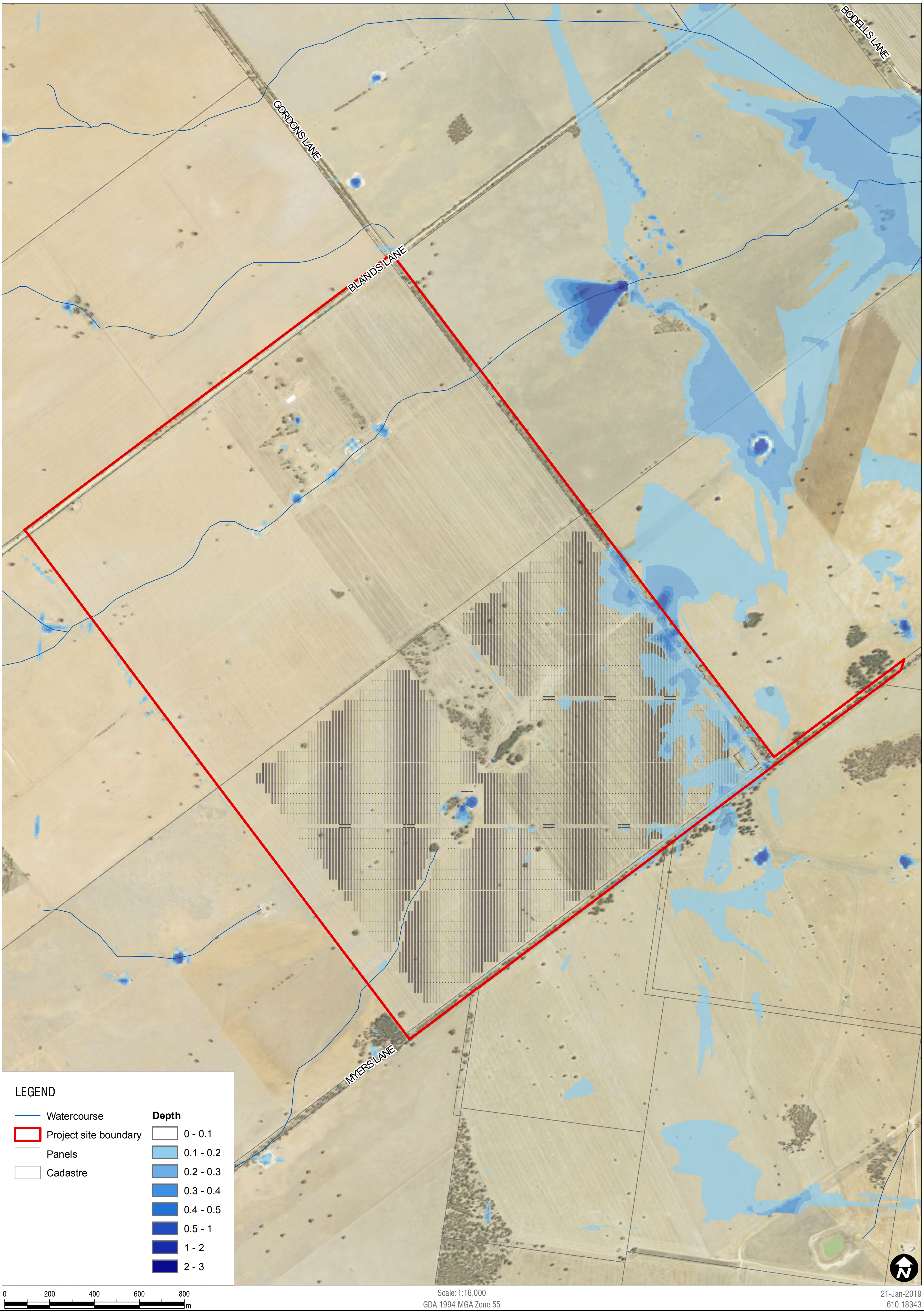
Existing inundation during a 10% AEP flood

FIGURE 9



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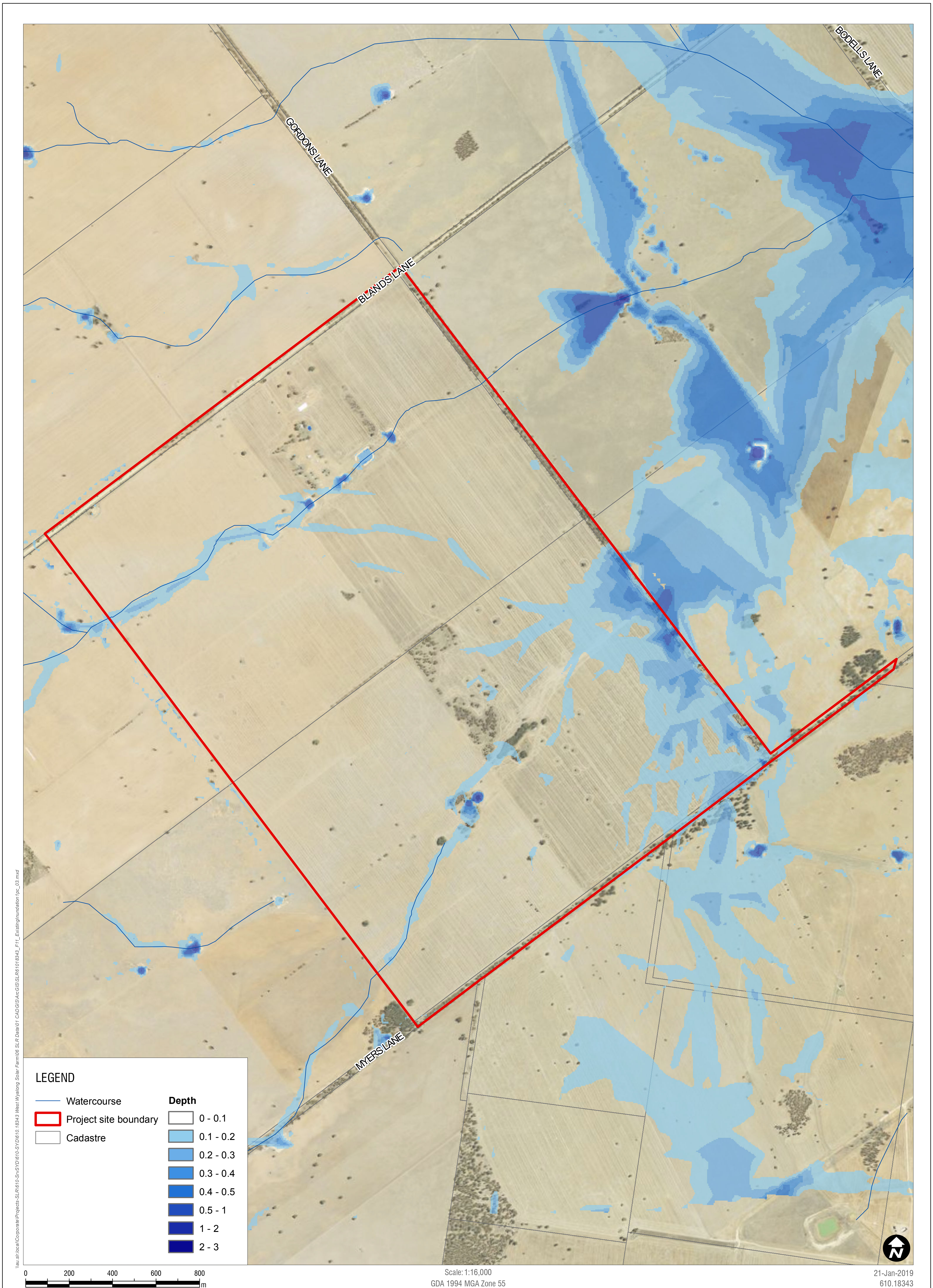
Post development inundation during a 10% AEP flood

FIGURE 10



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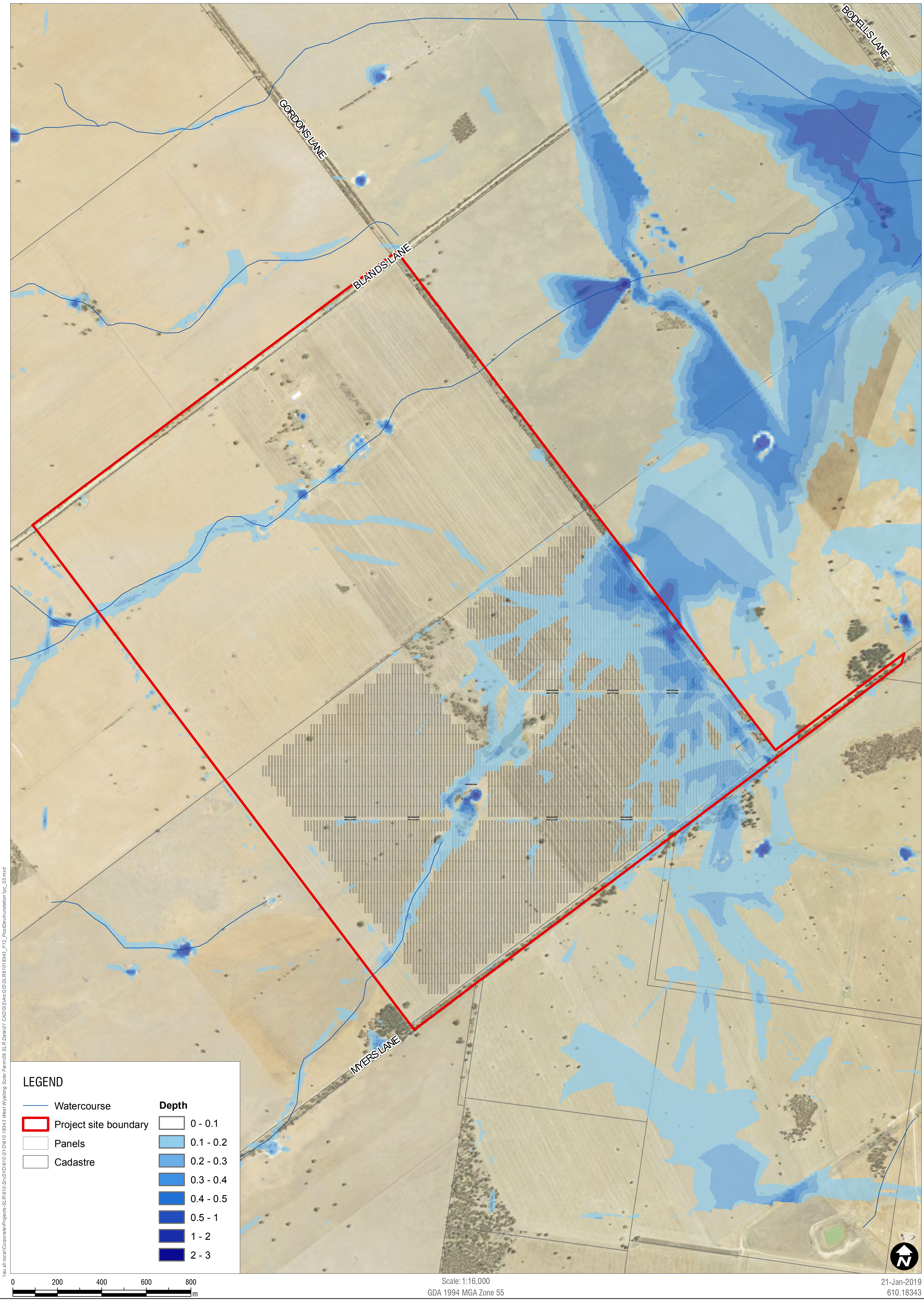
Existing inundation during a 1% AEP flood

FIGURE 11



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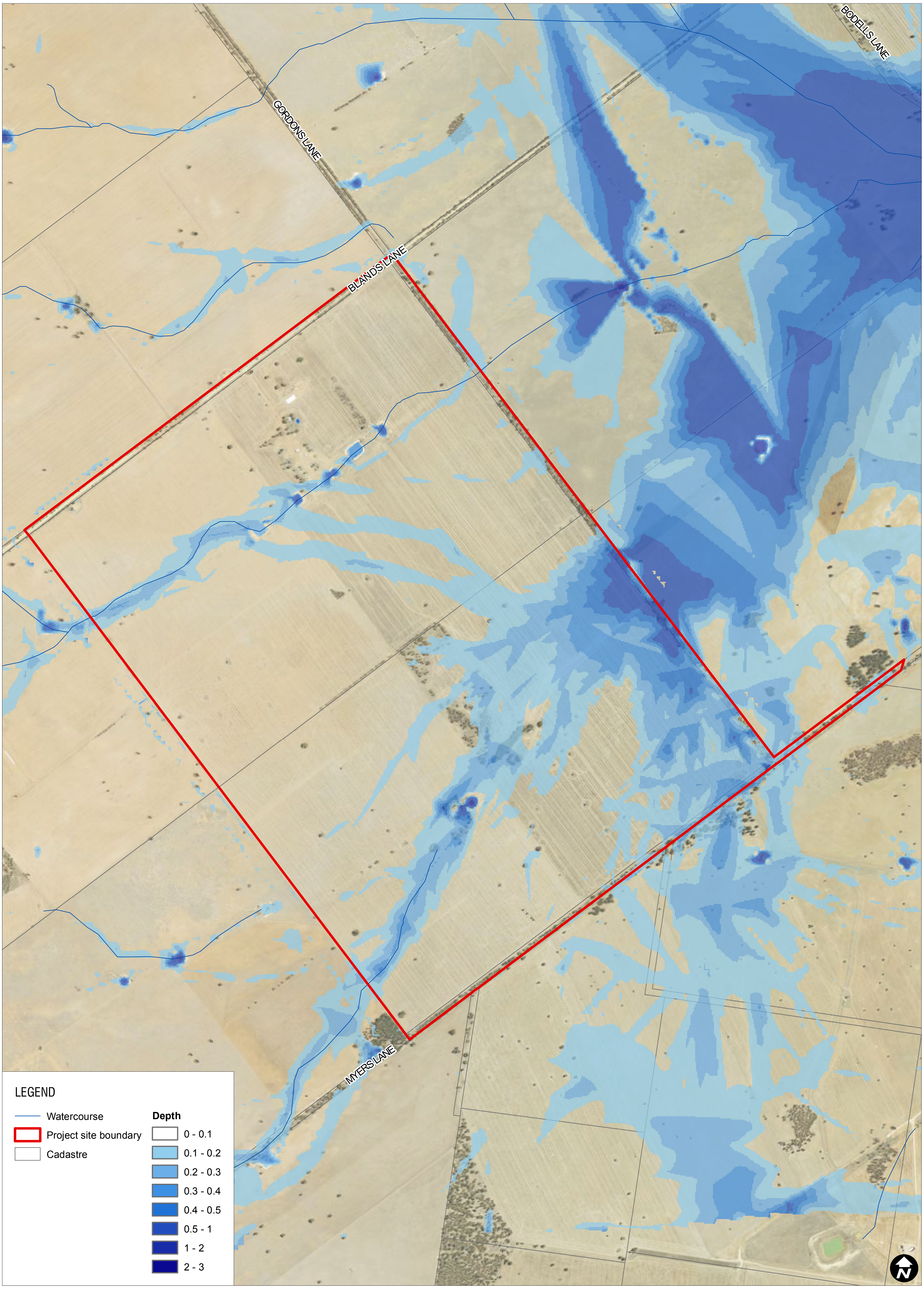
Post development inundation during a 1% AEP flood

FIGURE 12



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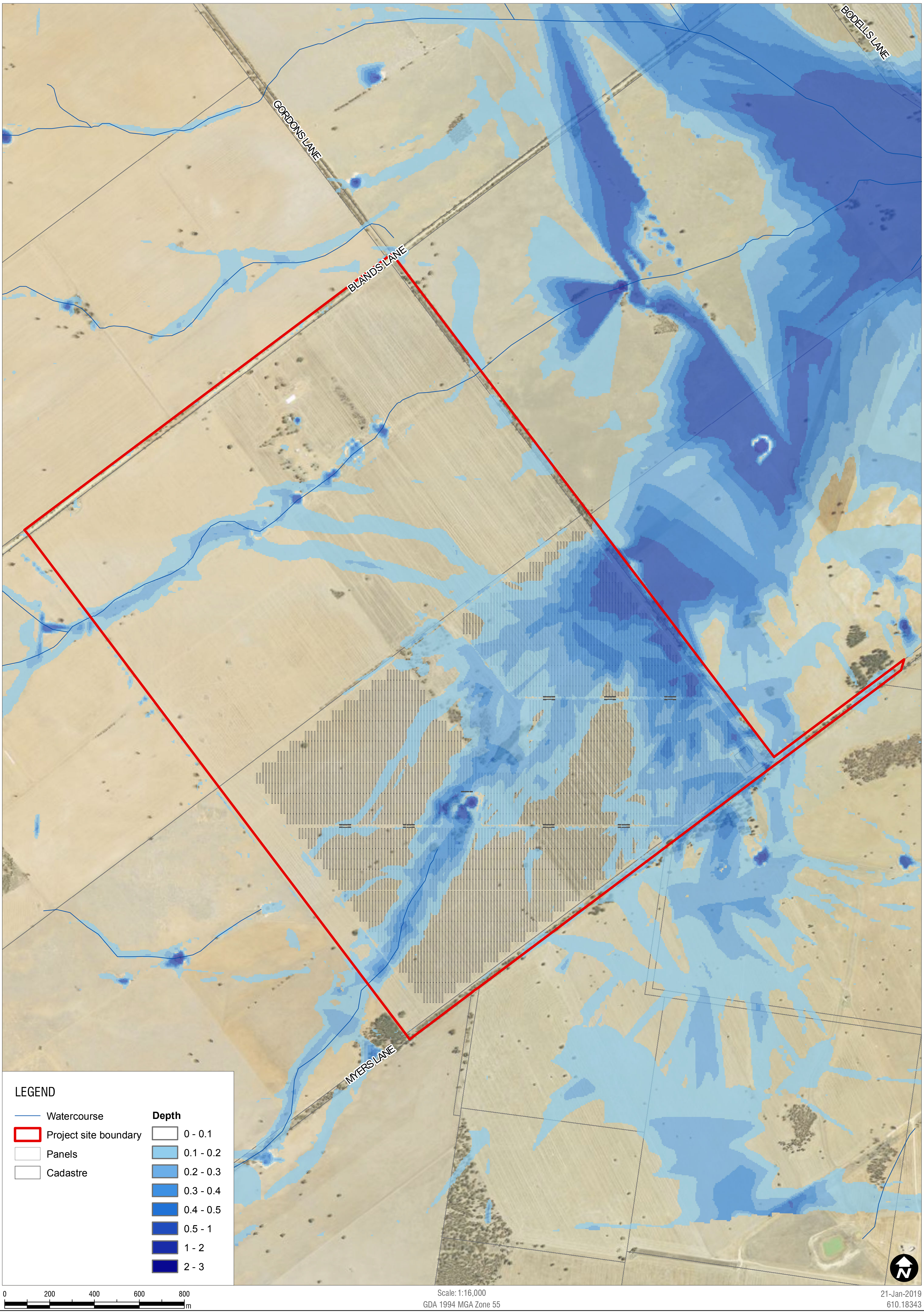
Existing inundation during a 1 in 200 AEP flood

FIGURE 13



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Post development inundation during a 1 in 200 AEP flood

FIGURE 14

7.5.2 Pre and Post Development Flows Downstream of Site

As discharge from the eastern boundary of the Project Site occurs in multiple locations, it was necessary to apply a flow trace vector across the complete eastern boundary. This vector sums all flow rates as it crosses the vector at any point in time.

The following table summarises the calculated peak flows for the existing and developed scenarios downstream of the Site (approximately 240m downstream from the Project Site boundary);

Table 13 Change in Peak Flow from the Site

AEP	Peak flow (m^3/s) for existing site	Peak flow (m^3/s) for developed site	Change (%)
10% AEP	12.4	12.4	0.0%
1% AEP	47.0	47.0	0.0%
1 in 200 AEP	135	135	0.0%

- ➔ The solar farm development does not change the flowrate downstream of the Site

7.5.3 Pre and Post Development Depths Downstream of Site

To compare the flood level pre and post development, a coordinated recorder was assigned central to the drainage path in an identical position for all flood simulations. The same critical duration and temporal pattern storms were simulated pre and post development for each magnitude storm. **Table 14** below summarises the effect of the solar farm development.

Table 14 Change in Peak Flood Level (m AHD) in the drainage path

AEP	Peak flood level for existing site	Peak flood level developed site	Change (m)
10% AEP	226.18	226.18	0.00
1% AEP	226.31	226.31	0.00
1 in 200 AEP	226.50	226.49	-0.01

The flooding analysis indicates that there is no increase in flooding levels due to development of the solar farm. In a 1 in 200 year AEP event, the flood levels actually marginally reduce.

7.5.4 Pre and Post Development Velocities Downstream of Site

To compare the velocity in the drainage path pre and post development, a coordinated recorder was assigned central to the drainage path in an identical position for all flood simulations. The same critical duration and temporal pattern storms were simulated pre and post development for each magnitude storm. The following tables summarise the effect of the solar farm development.

Table 15 Change in Peak Velocity downstream of the Project Site

AEP	Peak velocity (m/s) for existing site	Peak velocity (m/s) for developed site	Change (%)
10% AEP	0.14	0.14	0%
1% AEP	0.26	0.27	+4%
1 in 200 AEP	0.44	0.45	+2%

- ➔ The solar farm development will marginally increase the flow velocity in the drainage path downstream of the site.

7.6 Risk to Loss of Life

ARR 2016 assign flood hazard to the product of velocity and depth. A value of $0.4m^2/s$ and below is considered low hazard. There are no locations within the Project Site where the hazard rating exceeds this value.

7.7 Risk to Property

Where PV arrays are located within overland flow pathways, their height above ground may be increased if warranted by the predicted flow depth, to reduce the risk of damage to arrays.

Other project infrastructure such as storage batteries and substations will be provided with appropriate levels of flood immunity in accordance with relevant standards.

The following figure identifies the location of the batteries, substation and the zones of maximum inundation depth on the Project Site.

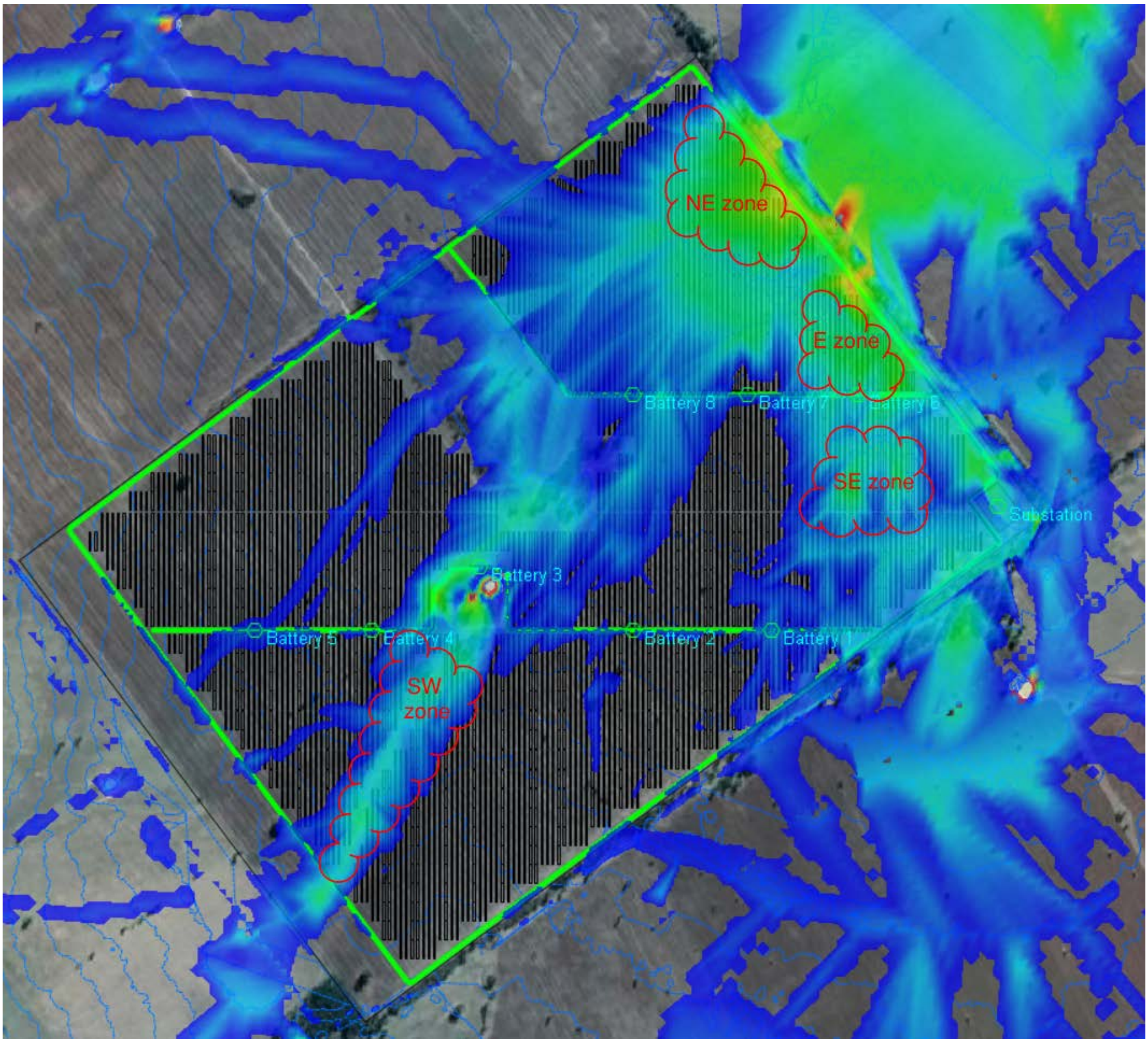

Figure 15 Reference location of assets during the 1 in 200 AEP flood inundation

7.7.1 Solar Arrays

The greatest flood depth is experienced at the exit to the Project Site along the North Eastern boundary. With reference to Figure 15, the following table summarises the maximum flood depth attained within the four zones.

Table 16 Flood inundation maximum depth attained under solar panels

Storm Magnitude	North eastern zone	Eastern zone	South Eastern zone	South Western zone
10 % AEP	0.32	0.37	0.22	0
1 % AEP	0.53	0.55	0.36	0.21
1 in 200 AEP	0.75	0.74	0.49	0.37

➔ The maximum flood depth attained during the 1 in 200 AEP is approximately 0.75m. This level would require the arrays within the north eastern portion of the Project Site to be designed appropriately to withstand the inundation without damage.

7.7.2 Substation and battery sites

The following table summarises inundation expected at the substation and the battery cells sites. Appropriate freeboard should be applied to these values to account for accuracy of flood modelling, construction tolerances, and potential wind or vehicle generated wave heights.

Table 17 Magnitude of inundation of batteries and substation

Infrastructure Reference	Ground level (m AHD)	1% AEP Peak flood level (m AHD)	1% AEP Peak flood depth (m)	1 in 200 AEP Peak flood level (m AHD)	1 in 200 AEP Peak flood depth (m)
Substation	227.31	227.67	0.36	227.76	0.45
Battery 1	228.23	228.28	0.05	228.32	0.09
Battery 2	228.77	228.77	0	228.78	0.01
Battery 3	228.50	228.66	0.16	228.85	0.35
Battery 4	229.38	229.50	0.12	229.51	0.13
Battery 5	230.20	230.22	0.02	230.23	0.03
Battery 6	226.80	226.93	0.13	227.05	0.25
Battery 7	227.12	227.12	0	227.16	0.04
Battery 8	227.34	227.35	0.01	227.39	0.05

➔ Flood modelling estimates the depth of inundation of the substation during the 1 in 200 AEP is 0.45m. Appropriate freeboard should be applied to the infrastructure above this level.

8 Water Supply

8.1 Construction Phase

Non-potable water demand will be very minor as the construction of solar PV farms is not water intensive. Water will be used for dust suppression along site access tracks during dry and/or windy weather conditions. Options for non-potable water supply being considered include:

- Drawing water from existing farm dams
- Trucking water in
- Harvesting of site surface water (within harvestable rights)

Non-potable water use during construction would be mainly for dust suppression on unsealed roads and watering to re-establish vegetation on disturbed areas. Based on a staged construction of 50ha per month, with up to 10% disturbance by area, and a dust suppression/watering application depth of 5mm per day, then the daily demand for construction water may be up to 250m3/day during dry weather, but would be significantly less during wet weather. Total water use during construction is expected to be in the order of 75ML per year, which may be sourced from the existing site dams (within the limitations of harvestable rights) plus water transported to site by tanker.

Wastewater during construction will be captured and removed from site for off-site treatment. Grey water from activities like showering may be discharged to a tank and recycled for dust suppression.

Potable water may be transported to site in water trucks and stored in temporary water tanks for use by the construction work force. The provision of potable water, grey water and wastewater infrastructure would be confirmed during the detailed design phase of the project.

8.2 Operational Phase

During operation of the solar facility water will be utilised for the following purposes:

- Potable water for site offices
- Cleaning of PV arrays
- Dust suppression on site access roads
- Topping up a fire fighting water tank

Demands for non-potable water may be met by several methods which are under consideration, including:

- Small domestic scale water tanks collecting roof water at site facilities
- Collection of surface water within harvestable rights
- Supplementary water as required via water trucked to site.

Potable water will be trucked into site to refill domestic scale water tanks at the site facilities.

The proposal includes a static 45,000L water tank for fire-fighting purposes. This water would only be used for firefighting and not for potable water supply nor for general non-potable site water use. The tank levels would be topped up as required from non-potable water supply sources as outlines above.

Toilet facilities will involve waterless toilets which are emptied annually, or other similar system in accordance with the requirements of Bland Shire Council. The provision of potable water, grey water and wastewater infrastructure would be confirmed during the detailed design phase of the Project. Water use approval is not required for State Significant Developments under section 89J (1)(g) of the EP&A Act.

Operational water demands for solar farms are not significant. Total water demand for the site is likely to be less than 25ML per annum, or significantly less than the Harvestable Right of the site (estimated at 43ML). However, the demand would vary significantly with weather conditions, and during long periods of dry weather when site dams may be dry, make-up water will need to be imported to site.

9 Monitoring, Licensing and Reporting

9.1 Construction Environment Management Plan (CEMP)

A CEMP will be prepared during the detailed design phase of the project, and will outline the environmental measures, monitoring and reporting required to ensure satisfactory environmental performance. Minimum requirements for inclusion within the CEMP include:

- Water quality monitoring during the construction phase, will be carried out as described below for the OEMP.
- An Erosion and Sediment Control Plan (ESCP) for construction activities that is consistent with the measures outlined in this EIS.

9.2 Operational Environment Management Plan (OEMP)

An OEMP will be prepared during the detailed design phase of the project, and will outline the environmental measures, monitoring and reporting required to ensure satisfactory environmental performance.

With regard to water quality monitoring, the default water quality triggers from ANZG 2018 will be used as an initial baseline for water quality trigger values. These trigger values are considered to be conservative, and water management that achieves these outcomes is considered to pose a low risk to the downstream environment and downstream water users. However, since there is no site specific baseline of water quality data, an adaptive approach is recommended, to enable the management regime to change as appropriate should unforeseen water quality issues become evident. The proposed mechanism for identifying changes is a bi-annual review of water quality.

Minimum requirements for inclusion within the OEMP include:

- Development of a suitable strategy for monitoring and reporting on water quality;
- A procedure for erosion and sediment controls for ground disturbance activities; and
- Requirements for storage and use of hydrocarbons and chemicals, and a spill response plan.

10 References

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