Proposed Blind Creek Solar Farm, Lake George, New South Wales

Hydrological and Hydraulic Analysis

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Prepared for: Blind Creek Solar Farm Pty. Ltd.

Footprint (NSW) Pty Ltd
15 Meehan Drive
Kiama Downs, NSW 2533, Australia
ACN 131 571 929   ABN 44 131 571 929
Phone: 02 4237 6770
Mobile: 0430 421 661
Email: ashley@footprinteng.com.au

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1.0 EXECUTIVE SUMMARY

Footprint (NSW) Pty. Ltd. (*Footprint*) has been engaged by Blind Creek Solar Farm Pty. Ltd. to undertake a hydrological and hydraulic analysis in support of a proposed solar farm located approximately 8km north-east of Bungendore, NSW.

The project site occupies an area of approximately 1,225 hectares and is traversed by several ephemeral watercourses including Butmarro (Deep) Creek, Bridge Creek and Wrights Creek. The project site has been extensively cleared of woody vegetation and has been highly modified by historical farming practices.

The proposal involves the construction, operation and decommissioning of a ground mounted PV solar array and associated infrastructure. Of the 1,225 hectare project site approximately 680-700 hectares would be developed for the solar farm and associated infrastructure (i.e. the development footprint), including solar arrays, inverters and transformers, 330kV substation, energy storage devices and equipment, and associated building, tracks and fencing.

Hydrologic and hydraulic modelling were performed for the 5% AEP (Annual Exceedance Probability, 1% AEP and PMF (Probable Maximum Flood) events to determine existing flood behaviour on the site.

The modelling shows that for the 5% and 1% AEP events flooding within the project site is relatively shallow (less than 1m) and of low velocity (less than 1m/s) and is generally classified as a H1 or H2 hazard vulnerability, with some H3 hazard vulnerability. The exception to the above being flooding within Butmaroo and Bridge Creeks which reaches depth over 1m and velocities over 1m/s and high hazard levels (H5 and H6).

As expected, depths, velocities and hazard increase considerably over the project site in the PMF (extreme) event with the high hazard areas (H5 and H6) over Butmaroo Creek increasing in width to between approximately 700 to 1200m.

The hydraulic model was re-run for the 1% AEP event only by increasing the surface roughness within the development footprint to reflect the impact of the proposed development. It was found that the proposed development is unlikely to cause adverse impact on existing flood behaviour due to the proponent's design being sympathetic to flood behaviour and the careful siting of infrastructure commensurate with flood hazard.

This report makes recommendations with respect to management of the floodplain including locating critical infrastructure outside the floodplain, setting minimum elevations of infrastructure and solar array panels, the construction of fencing, roads and electrical infrastructure in the floodplain, and the provision of riparian corridors.

2.0 INTRODUCTION

Footprint (NSW) Pty. Ltd. (*Footprint*) has been engaged by Blind Creek Solar Farm Pty. Ltd. to undertake a hydrological and hydraulic analysis in support of a proposed solar farm located approximately 8km north-east of Bungendore, NSW.

The purpose of the analysis is to define the flood behaviour, including depth of inundation, flood velocity and flood hazard within the project site. The result of the analysis will be used to guide the design with respect to the extent and elevation of proposed solar array infrastructure and to determine the potential impact of this infrastructure on the existing flood behaviour.

2.1. Scope of Works

The scope of works for the project includes:

1. Undertake hydrologic modelling to determine peak flows arriving at the site from Butmaroo, Bridge and Wright's Creeks for the 5% Annual Exceedance Probability (AEP), 1% AEP and Probable Maximum Flood (PMF) storm events.
2. Undertake two-dimensional hydraulic modelling (using HEC-RAS) to determine the depth and extent of flooding over the proposal area for each of the above rainfall events for pre-development scenario.
3. Undertake two-dimensional hydraulic modelling (using HEC-RAS) to determine the impact of the proposed development for the 1% AEP post development scenario.
4. Preparation of a hydrological and hydraulic report, including flood mapping, defining the methodology and results of the above investigations, and providing any recommendations with respect to floodplain management.

3.0 PROJECT SITE

The proposed Blind Creek Solar Farm is located approximately 8km north-east of Bungendore, NSW on the eastern shores of Lake George.

The project site occupies an area of approximately 1,225 hectares and includes parts of Lots 1, 2, 3, 4 and 9 of DP237079, Lot E DP38379, Lot 2 DP 1154765 and Lot 1 DP1154765.

The location and extent of the project site in relation to Bungendore and Lake George is shown in Figure 1.

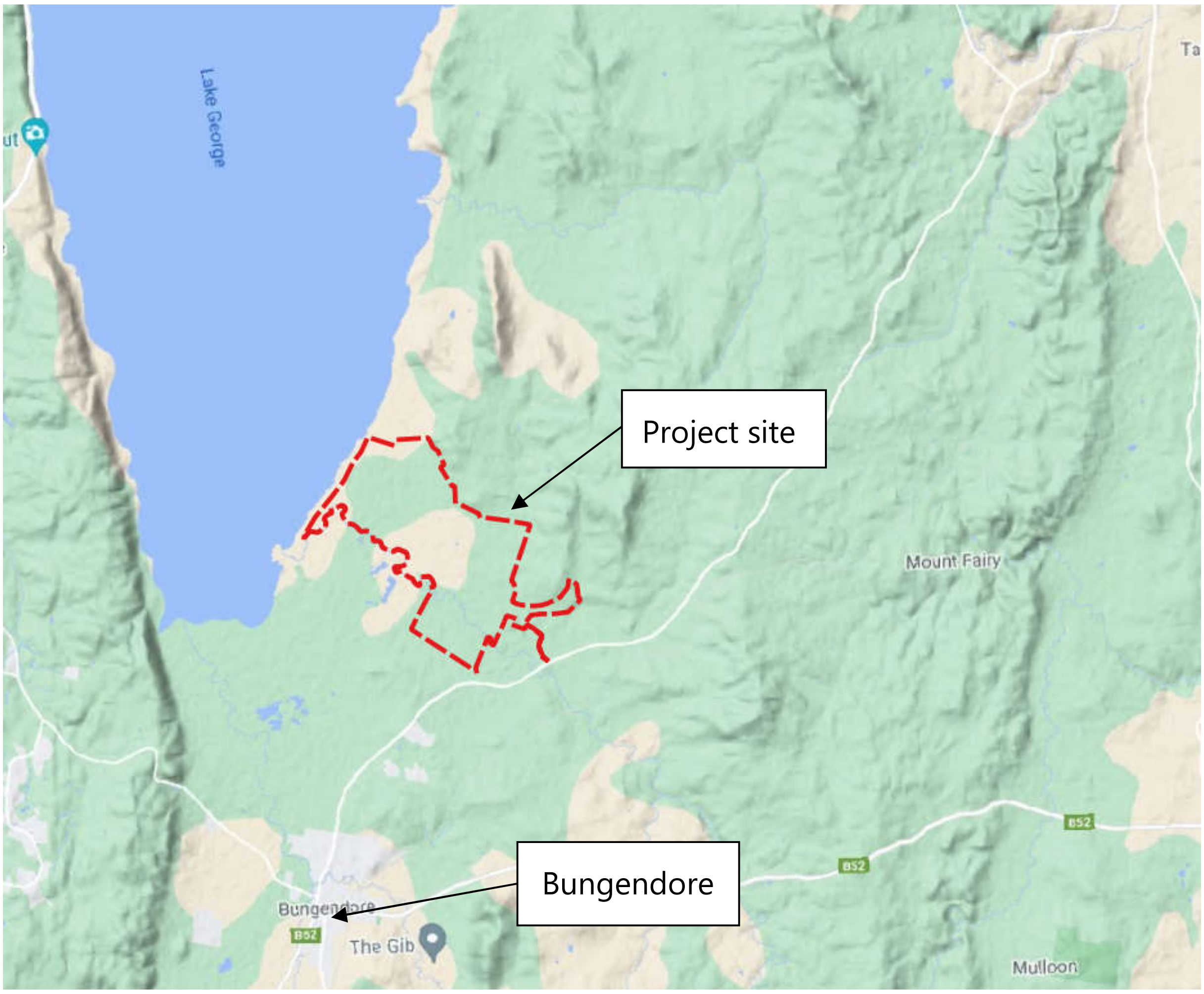

Figure 1: Location and Extent of Project site

Several watercourses traverse the project site including Butmarro (Deep) Creek, Bridge Creek and Wrights Creek. All three watercourses within the project site are ephemeral and would only contain flowing water during and shortly after rainfall events.

The project site has been extensively cleared of woody vegetation and has been highly modified by historical farming practices as shown in Figure 2.

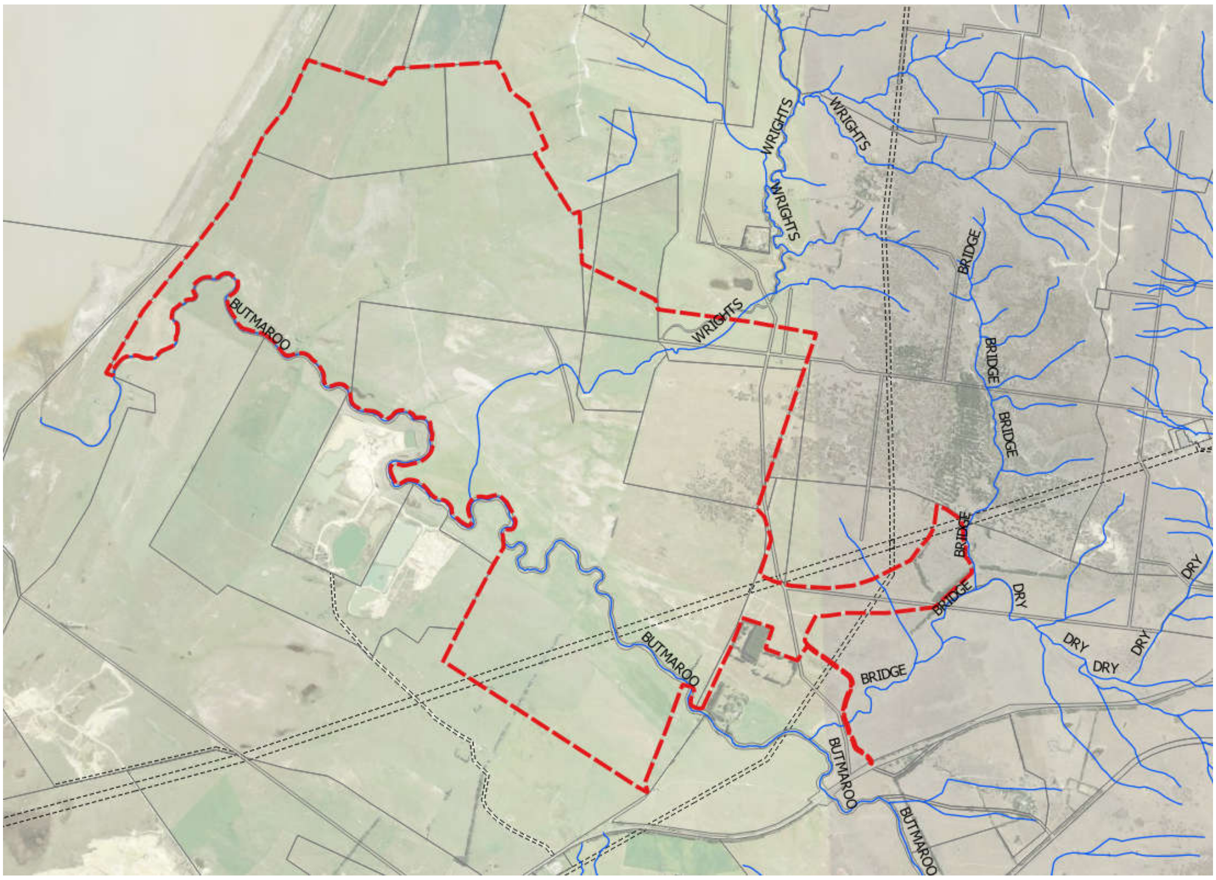

Figure 2: Aerial View of Project site (outlined in red)

The project site typically falls from east to west with elevations ranging from about 758m AHD to 675m AHD at the lake. On its northern flank the project site abuts a relatively steep terrain which rises to an elevation of about 900m AHD.

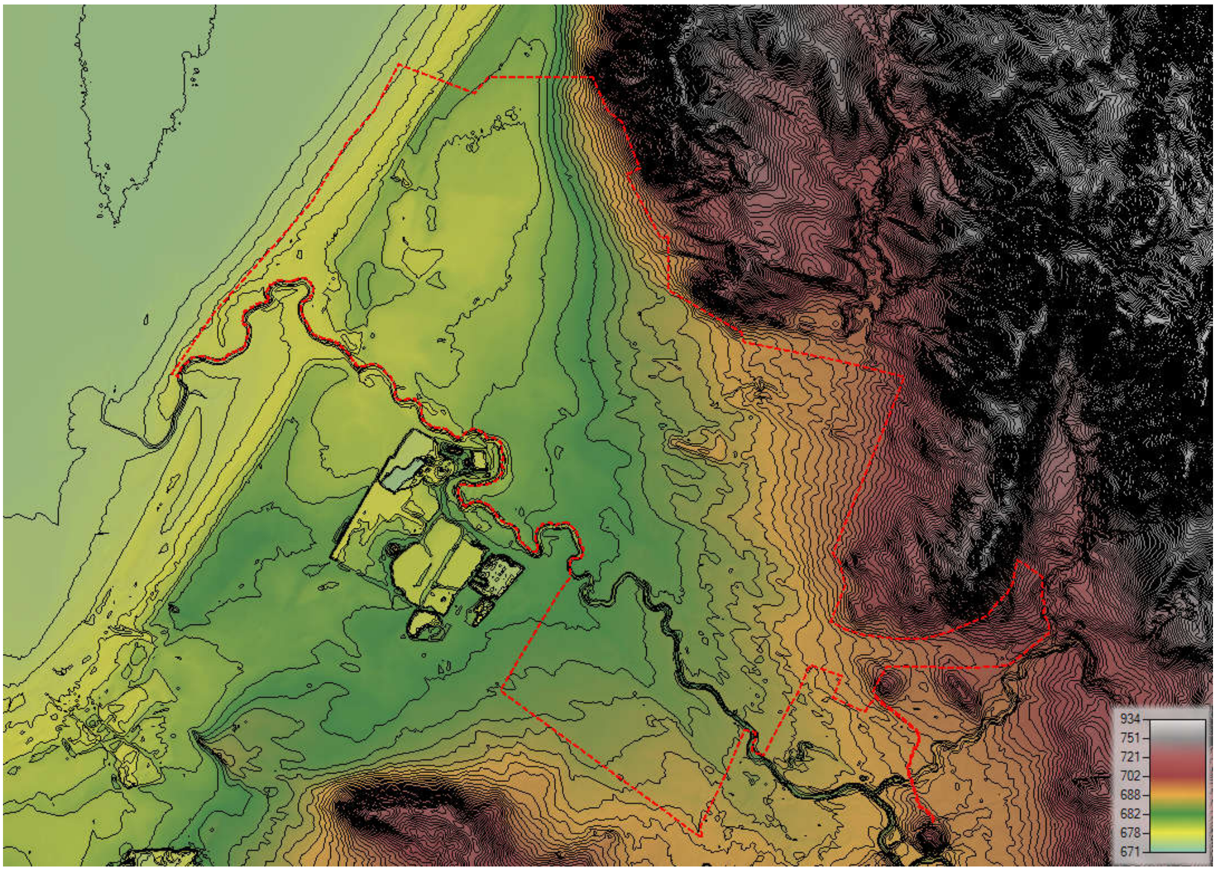

Figure 3: Terrain Analysis over Project site (1m contour interval)

4.0 HYDROLOGICAL MODELLING

4.1. Purpose

Hydrological modelling was conducted to:

i. Determine peak inflow hydrographs for the catchments of Butmaroo, Bridge and Wrights Creeks external to the project site, and
ii. determine the critical storm duration and median storm within the ensemble for the two-dimensional direct rainfall hydraulic model over the project site itself.

4.2. Model Adoption

Hydrological modelling was conducted in DRAINS using a RAFTS storage routing model.

Storage routing models can model larger catchments using a lumped approach by assuming heterogeneity within the sub-catchment to account for the storage and retardence of flows that occurs within the sub-catchment. Such models account for slope and roughness and use a loss model to produce a hydrograph at the sub-catchment outlet.

The RAFTS hydrological model was chosen because it is widely used and accepted across Australia within the industry and has been shown to be insensitive to initial conditions.

4.3. Catchment Areas

The total catchment area draining to Butmaroo Creek at Lake George, immediately downstream of the project site, was estimated to be approximately 16,570 hectares (165.7km^2) and was determined using 5m Digital Elevation Models (DEM) obtained through the Australian Foundation Spatial Data web portal.

The overall catchment was dissected into 18 sub-catchments using hydrologic analysis software package Catchment SIM and ranged in size from 267 to 2620 hectares, with an average size of approximately 920 hectares. Sub-catchment slopes were derived by CatchmentSIM using the above terrain data.

A catchment plan and summary of the sub-catchments is shown in Figure 1.1 in Appendix A.

4.4. Modelling Input Parameters

The parameters adopted for hydrological modelling are shown in Table 1.

Table 1: Hydrological Parameters Adopted

Parameter	Value Adopted	Justification/Source
Pervious Area Initial Loss (mm)	12.5	NSW FFA reconciled loss rate from reference gauge in the catchment (Butmaroo, STN 411003) as per ARR 2019 NSW Specific Data loss hierarchy level 4.
Pervious Area Continuing Loss (mm/h)	0.02	NSW FFA reconciled loss rate from reference gauge in the catchment (Butmaroo, STN 411003) as per ARR 2019 NSW Specific Data loss hierarchy level 4.
BX	1	RAFTS Default
Sub-catchment Area (ha)	Varies	As per Figure 1.1 in Appendix A
Impervious Area (%)	0	Based on aerial photography. It is acknowledged that some catchments may contain some small impervious areas (i.e. roads and roofs) these areas would not generally be directly connected to the receiving waters, but would rather be dispersed over pervious areas prior to receiving waters and therefore the effective impervious area would be zero, or very close to it.
Sub-catchment Slope (%)	Varies	Varies based on site topography. Refer to Figure 1.1 in Appendix A
Manning's n	Varies 0.035 – 0.10	Based on aerial photography and varies from 0.035 for rural pasture lands to 0.10 for heavily wooded areas. Refer to Figure 1.1 in Appendix A.

4.5. Rainfall Data

4.5.1. Design Rainfall

IFD design rainfall depth data and temporal patterns were derived in accordance with Australian Rainfall and Runoff (2019) using the Bureau of Meteorology's 2019 Rainfall IFD on-line Data System.

The temporal patterns for the Murray Basin region was used as these cover the subject site (latitude -35.258, longitude 149.522).

A copy of the rainfall depths for the range of storm durations used can be found in Appendix C.

Storm probabilities in ARR2019 are now classified in two ways: Very Frequent storms, quantified as 'Exceedances per Year' (EY), and both Frequent and Infrequent storms given as Annual Exceedance Probability (AEP). The 'very frequent' storms have only been used for the 1EY, 0.5EY and the 0.2EY as these are equivalent to the former classifications of 1 in 1 year, 1 in 2 year and 1 in 5 year storms respectively (ARR 2016 state that the 50% AEP and the 20% AEP do not correspond statistically to the 1 in 2 year and 1 in 5 year storms, but rather are equivalent to the 1 in 1.44 year and 1 in 4.48 year storms respectively).

4.5.2. Pre-Burst Rainfall

NSW transformation pre-burst rainfall depths derived from ARR 2019 data hub (refer Appendix B) were adopted in the model.

4.5.3. Probable Maximum Precipitation

The PMF is the response of the catchment to the probable maximum precipitation (PMP) and is the largest flood event that can reasonably be expected to occur at a location.

Estimates of PMP were made using the Generalised Short Duration Method (GSDM) presented in Bureau of Meteorology (2003) and are provided in Appendix E.

This method is appropriate for estimating extreme rainfall depths for catchments up to 1,000km^2 in area and storm durations up to 6 hours and is therefore considered appropriate for the subject catchment.

Due to the inability of DRAINS to model spatially variable rainfall no adjustment to the point values above where made. In this regard it is noted that the weighted average rainfall depth over the catchment is very close to the point values adopted and given the site in question is at the downstream end of the catchment the results yielded should be very similar to those where spatially distributed data has been used.

4.6. Flow Routing

The routing of flows through the catchment was undertaken by adopting an average link velocity of 3m/s, which is considered a typical value for watercourses in similar topography.

4.7. Results

The DRAINS model was run in 'standard' mode for storm durations ranging from 30 minutes to 24 hours for the 5% and 1% AEP events and 15 minutes to 6 hours for the PMF event.

The critical duration and median storm from the ensemble, where applicable, for the range of events modelled are shown in Table 2.

Table 2: Summary of Critical Durations and Storms

Event	**Critical Duration**	**Median Storm from Ensemble**	**Peak Flow at Outlet (m^3/s)**
5% AEP	6 hours	Storm 6	437
1% AEP	4.5 hours	Storm 7	619
PMF	3 hours	N/A	4,923

4.7.1. Comparison to Regional Flood Frequency Model

Peak flows for the 5% and 1% AEP events were compared to the peak flows obtained through the Regional Flood Frequency Estimation (RFFE) Model and the results are shown in Table 3 and Figure 4, with a copy of the RFFE Model report contained in Appendix F.

The comparison shows good correlation between the calculated and RFFE model values with calculated flows within 25% and 3% for the 5% AEP and 1% AEP events respectively and well within the RFFE model confidence limits. The results are therefore considered reasonable for the purposes of this assessment.

Table 3: Comparison to RFFE Model

AEP	Peak Flow Rate (cumecs)			
	DRAINS	Regional Flood Frequency Estimation Model		
		Discharge	Lower (5%)	Upper (95%)
5%	437	297	106	848
1%	619	577	197	1,730

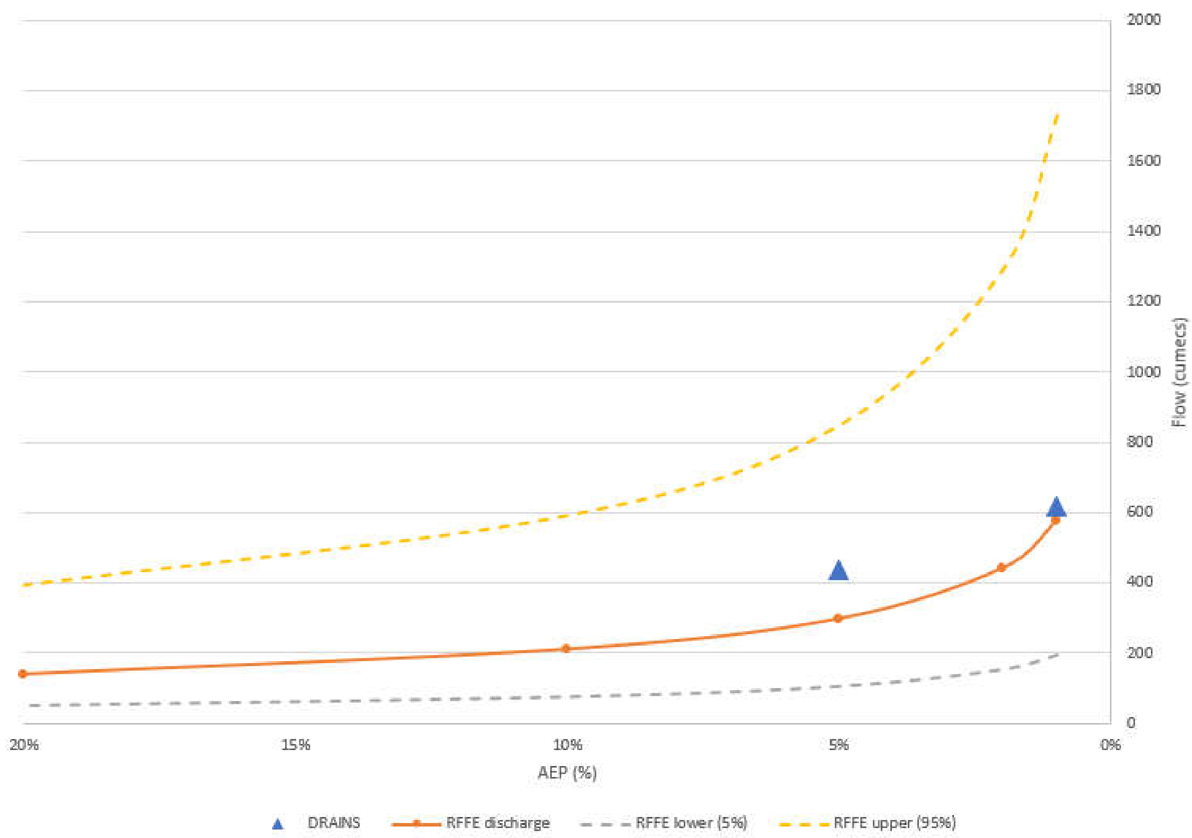

Figure 4: Comparison to RFFE Model

5.0 HYDRAULIC MODELLING

Hydraulic modelling was conducted using an unsteady direct rainfall two-dimensional HEC-RAS model (Version 5.0.7) over the lower reaches of the catchment with inflow hydrographs representing external flows from Butmaroo, Bridge and Wrights Creeks.

5.1. Two-Dimensional Domain

A digital elevation model (DEM) over the lower reaches of the catchment covering the project site was established using the Geoscience Australia 5m gridded digital elevation model derived from LiDAR sourced from www.elevation.fsdf.org.au.

A two-dimensional flow area (i.e. active cells) was defined over the project site to simulate the rainfall-runoff process. The extent of the two-dimensional flow area in relation to the project site is shown in Figure 4.

The 5m DEM grid was imported into HEC-RAS and used as the basis for development of a 5m x 5m terrain model. The DEM grid was further refined where required by applying breaklines to enforce critical changes in geometry, such as at dam walls.

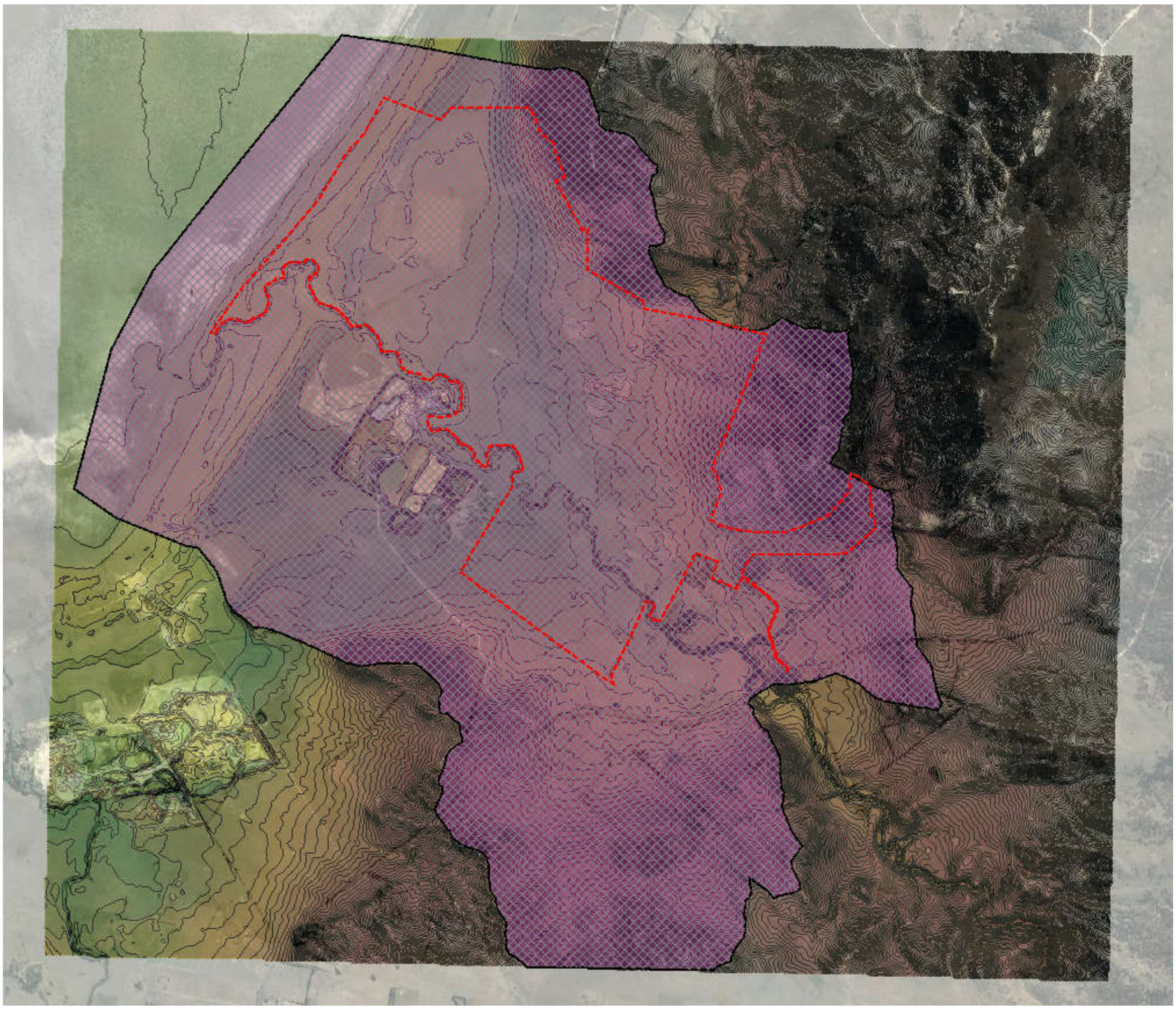

Figure 4: Two-Dimensional Flow Area (project site bound by red line)

5.2. Manning's Roughness

The entire active area was assigned a Manning's n value of 0.035 which is considered representative of a grazed floodplain lacking any significant vegetation.

5.3. Boundary Conditions

5.3.1. Inflow Boundary Conditions

The hydrographs derived using DRAINS were used to define the boundary conditions at the upstream edge of the two-dimensional flow area to represent inflows arriving from Butmaroo, Bridge, Dry and Wrights Creeks for each of the modelled events.

Hydrographs for each location and each event are contained in Appendix E.

The upstream boundary was extended along the upstream face of the two-dimensional domain across watercourses over enough length to enable the model to appropriately distribute the flow to the cells that are wet. At any given timestep, only a portion of the boundary condition line may be wet, thus only the cells in which the water surface elevation is higher than their outer boundary face terrain will receive water.

5.3.2. Direct Rainfall Boundary Condition

The direct rainfall boundary condition applies precipitation directly to the surface of the grid to perform two-dimensional hydraulic calculations.

The current limitation of HEC-RAS 5.0.7 means that precipitation can only be used to apply rainfall excess (rainfall minus losses due to interception/infiltration) directly to the two-dimensional grid.

Rainfall excess hyetographs for each of the critical duration median storm events shown in Table 2 were generated in Microsoft Excel by subtracting initial losses plus pre-burst rainfall (where applicable) from the design rainfall data starting from the beginning of the data set. An example of this for the 1% AEP, 4.5-hour storm event is shown in Figure 5.

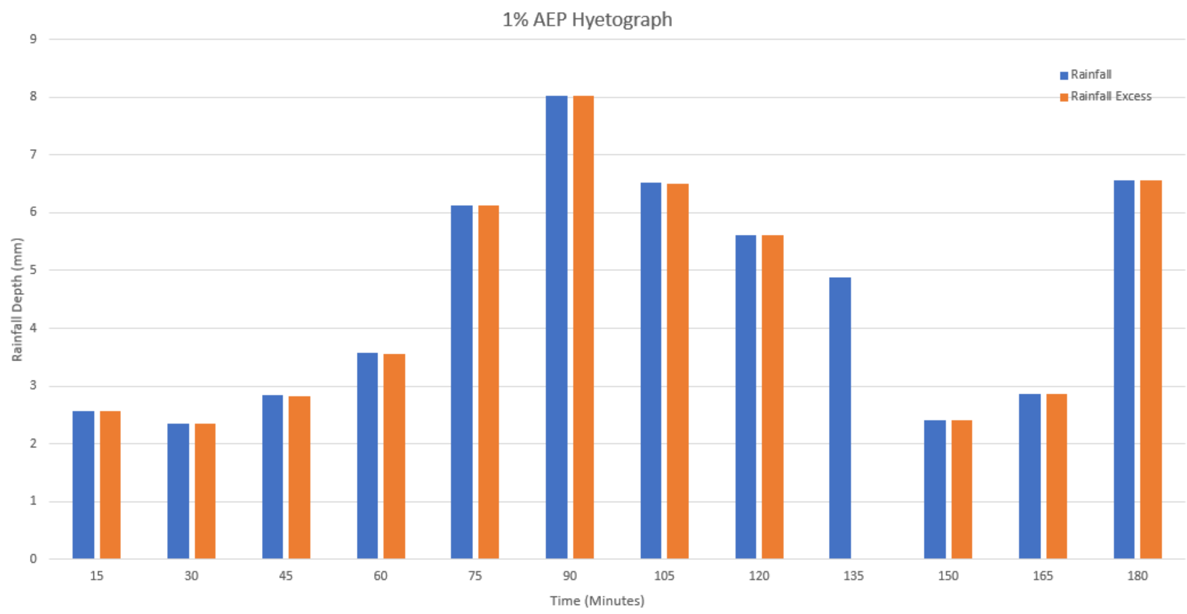

Figure 5: 1% AEP Hyetograph

5.3.3. Downstream Boundary Condition

Flows leaving the two-dimensional area were defined with a fixed water surface elevation of RL675m AHD which approximately corresponds to an approximate 20% AEP water level in Lake George (refer to Section 7.0).

5.4. Results

The HEC-RAS model was run in unsteady mode with variable timestep controlled by Courant conditions using the diffusion wave computational method. The results are provided in Appendix G and include the mapping shown in Table 4.

The results include the mapping of flood hazard vulnerability in accordance with Book 6, Chapter 7 of Australian Rainfall and Runoff (2019).

Table 4: Summary of Results

Figure	Description
Figure 2.1	Maximum Flood Levels and Depths – 5% AEP
Figure 2.2	Maximum Flood Velocities – 5% AEP
Figure 2.3	Maximum Flood Hazard – 5% AEP
Figure 3.1	Maximum Flood Levels and Depths – 1% AEP
Figure 3.2	Maximum Flood Velocities – 1% AEP
Figure 3.3	Maximum Flood Hazard – 1% AEP
Figure 4.1	Maximum Flood Levels and Depths – PMF
Figure 4.2	Maximum Flood Velocities – PMF
Figure 4.3	Maximum Flood Hazard – PMF

5.5. Hazard Vulnerability

The flood hazard vulnerability over the project site was mapped in accordance with Table 6.7.4 of Australian Rainfall and Runoff (2019) and is shown in Figures 2.3, 3.3 and 4.3 in Appendix G for the 5%AEP, 1%AEP and PMF events respectively.

The mapping shows that flooding within the project site is generally classified as a H1 or H2 hazard vulnerability in the 5% AEP and 1% AEP events, except for flooding within Butmaroo and Bridge Creeks which reach high hazard levels (H5 and H6). As expected, hazard increases considerably over the project site in the PMF (extreme) event with the high hazard areas (H5 and H6) over Butmaroo Creek increasing in width to between approximately 700 to 1200m.

Table 6.7.3 of Australian Rainfall and Runoff describes the hazard thresholds for community interaction with floodwaters and its' content to repeated in Table 5.

Table 5: Combined Hazard Curves – Vulnerability Thresholds (ARR 2019)

Hazard Vulnerability Classification	Description
H1	Generally Safe for vehicles, people and buildings
H2	Unsafe for small vehicles
H3	Unsafe for vehicles, children and the elderly
H4	Unsafe for vehicles and people
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

6.0 IMPACT OF PROPOSED WORKS

6.1. Proposal Description

The proposal involves the construction, operation and decommissioning of a ground mounted PV solar array and associated infrastructure. Of the 1,225 hectare project site approximately 680-700 hectares would be developed for the solar farm and associated infrastructure (i.e. the development footprint).

Key development and infrastructure components of the proposal include:

- Up to 850,000 PV solar modules mounted on a single axis tracking system.
- Up to 85 inverters and transformers, most likely containerised in modified shipping containers, together known as Power Conversion Units ('PCUs').
- Steel mounting frames with pile-driven foundations to hold the tracking system.
- An onsite 330kV substation containing up to four transformers and associated switchgear to facilitate connection to the national electricity grid. This will cut into the existing 330kV transmission line that passes through the site.
- Energy storage devices and equipment, including up to 300MW of lithium-ion batteries with inverters (PCUs). The batteries may be configured in either a DC-coupled format by distributing batteries through the site, or in an AC-coupled layout by placing all batteries in a purpose-built facility.
- Underground power cabling to connect solar modules, combiner boxes, PCUs and batteries.
- Underground auxiliary cabling for power supplies, data services and communications.
- Buildings to accommodate a site office, switchgear, protection and control facilities, maintenance facilities, storage and staff amenities.
- A communications tower for high reliability grid operations.
- Internal tracks for construction, operation, and maintenance activities.
- Internal fencing of paddocks to contain grazing livestock.
- External perimeter fencing.
- Paddock fencing.
- Native vegetation planting to provide visual screening for specific receivers if any are required.
- Two low-level crossings, over Wrights Creek (new) and Bridge Creek (upgrading existing crossing).

During the construction phase, temporary facilities would be established on the site. These may include:

- A construction laydown area with secure compound.
- Construction site offices and amenities.
- Car and bus parking areas for construction staff.

6.2. Hydraulic Modelling

An assessment of the impact of the proposed permanent infrastructure on flooding was undertaken by increasing the surface roughness over the proposed development footprint to account for solar array infrastructure and buildings.

Typical solar array modules consist of a frame supported by piers at a typical grid spacing of 5.75-7m. The addition of the solar arrays and their associated infrastructure will result in an increase in surface roughness over the site, from grazed/cropped pasture to a regular grid of steel piers.

The change in floodplain roughness associated with the proposed solar arrays was assessed using the Modified Cowan Method for Floodplain Roughness and is shown in Table 6. It should be noted that only n_3 (effect of obstructions) has been modified to represent the change in roughness associated with the solar array piers, all other variables remain at pre-development values and hence have remained at n_b, n_1 etc.

It demonstrates that the roughness is anticipated to slightly increase because of the proposed development.

Table 6: Modified Cowan Method for Estimation of Floodplain Roughness

Roughness Component	Existing (Grazed Pasture)	Proposed (Solar Array)
Floodplain Material (n_b)	n_b	n_b
Degree of Irregularity (n_1)	n_1	n_1
Variation in Floodplain Cross Section (n_2)	n_2	n_2
Effect of Obstructions (n_3)	0.000	0.003[1]
Amount of Vegetation (n_4)	n_4	n_4
Change in Roughness (n)	0.000	0.003

[1] Based on an obstruction of 2.5% of the available flow area (i.e. 150mm piers at 5-6m intervals)

The increase in roughness was applied to the pre-development roughness value specified in 5.2 over the extent of the proposed array inclusion zone (i.e. the maximum extent of the solar array footprint) increasing this roughness to 0.038.

The area nominated for the proposed substation, battery storage and O&M facilities, including parking areas was assigned a Manning's n value of 3 to reflect the impact of the proposed buildings and structures in these areas.

It should be noted that the proposed development would include a network of access roads and these would be constructed from gravel and within the floodplain itself would be constructed at or near the existing surface level so as not to result in adverse impact on flood behaviour.

In accordance with the Modified Cowan Method of Floodplain Roughness gravel has a similar floodplain roughness to that of the surrounding pre-development floodplain roughness. On this basis and considering the fact these tracks are likely to be less than 10m in width and therefore not well represented by the model, the marginal increase in floodplain roughness associated with the proposed road network has not been included in the post development model.

Two low-level crossing are proposed as part of the development: an upgrade to an existing low-level crossing on Bridge Creek and a new crossing on Wrights Creek. Both would be sized to preserve upstream and downstream flow connectivity during rain events and to overflow in time of flood. These crossings have not been included in the current model as they are minor in nature and are therefore unlikely to cause adverse flood impact. Once crossing designs are fully resolved during the detailed design process it is recommended that these structures be assessed to ensure any hydraulic impact is minimised.

Otherwise, any watercourse crossings on minor tributaries would utilise existing crossings where possible or be in the form of fords or bridges which minimise hydraulic impact (see Section 8.7). Once again, these structures are minor in nature and are unlikely to cause adverse flood impacts and have therefore not been included in the model.

The post development hydraulic model is therefore considered to be representative of the development as proposed and therefore reflective of the hydraulic impacts associated with the development.

The hydraulic model was re-run to assess the impact of an increase in surface roughness on flood behaviour for the 1% AEP event and the results in included in Figures 5.1, 5.2 and 5.3 in Appendix G.

The results in Figures 5.1, 5.2 and 5.3 demonstrate that there is not predicted to be a significant impact on flood behaviour for the 1% AEP event because of the proposed works, with flood level, depths, velocities and hazards remaining largely unchanged.

This is better demonstrated in Figures 6.1 and 6.2 which show the change in maximum flood level and peak velocity resulting from the proposed development. These figures show that the peak flood levels and velocities are anticipated to remain relatively unchanged across most of the floodplain, due primarily to most of the infrastructure being located outside high hazard areas of the floodplain. Some minor increases in flood levels of up to 50mm are shown to occur within the Butmaroo Creek northern overbank area and within the Wrights Creek floodplain however these changes are very localised and are largely contained within the project site. Some minor (up to 20mm) increases are anticipated within the adjacent quarry pits however these areas are already subject to flood depth in excess of 2m so this marginal increase should not create any adverse impact.

Further, velocities over the project site are shown to be contained in the range of plus or minus 0.25m/s when compared to pre-development velocities and therefore should not result in any adverse impact to the stability of the bed and banks of existing waterways or contribute to degradation of the land by erosive flood forces.

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7.0 LAKE GEORGE FLOODING

The project abuts Lake George and it is appropriate to investigate its likely high water mark. According to Short et al[1], "water levels respond rapidly to changes in decadal climate fluctuations—primarily rainfall and evaporation". The lake has no outlet and is instead finely balanced between these competing forces and often dries completely.

Fortunately, a reasonable record of lake depths has been recorded, by numerous parties, in the period 1885-2019, and recently collated in Short et al. Prior to official records commencing in 1885, anecdotal records were collected from the recollections of local residents but Short reports that it is "unknown how accurate these measurements are but is likely to be on the order of up to a metre, and probably even more uncertain for the earlier periods". This pre 1885 data is therefore not included in this analysis.

The highest lake level recorded in the 134-year period of recordings was 677.38m AHD in 1956, in a period when record keeping is believed to be reasonably accurate (this corresponds to a lake depth of 4.58m). This is therefore adopted as the approximately 1% AEP level. The data, presented as annual exceedance probability, is presented in Figure 6.

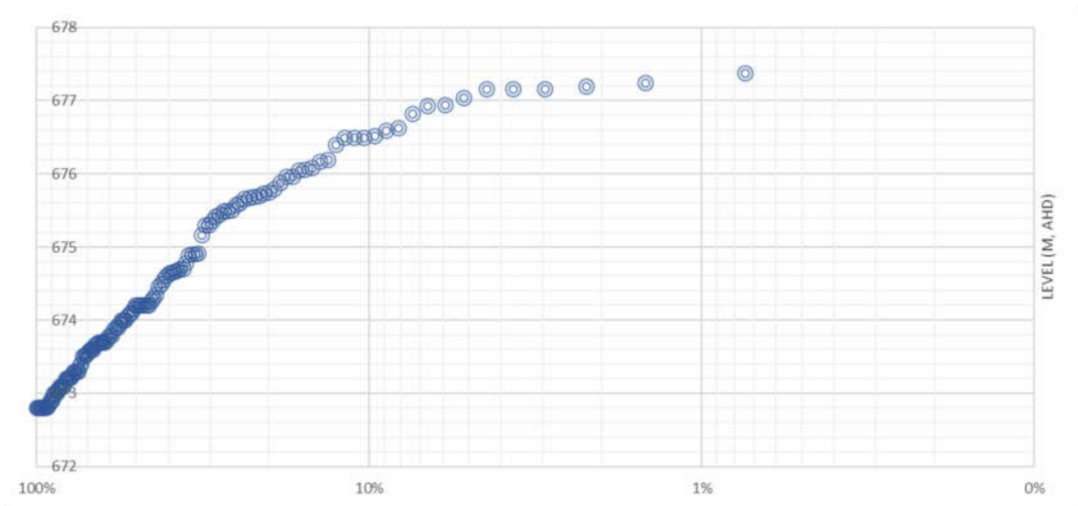


Figure 6: Lake George Levels AEP (based on 185-2019 Measured Data (source: MA Short et al)

The proposed development has a minimum height of 679.5m AHD (approximately), which provides a margin over the likely highest levels in Lake George.

[1] MA Short, RS Norman, B Pillans, P De Deckker, R Usback, BN Opdyke, TR Ransley, S Gray & DC McPhail – Two Centuries of Water-Level Records at Lake George, NSW, Australian Journal of Earth Sciences, September 2020.

8.0 FLOOD MANAGEMENT RECOMMENDATIONS

8.1. Buildings and Structures

All buildings and structures (including solar arrays) associated with the proposal should be located outside high hazard areas (H5 and above) where they may be vulnerable to structural damage and have significant impact on flood behaviour.

The finished floor level of all buildings should be a minimum of 500mm above the 1% AEP flood level, whilst critical infrastructure such as the electrical substation, control room and battery storage areas (i.e. BESS infrastructure) should be a minimum of 500mm above the PMF flood level in the adjacent Bridge Creek.

8.2. Flood Management

For proposed crossing structures over any watercourses that will likely be rendered impassable during significant flood events it is recommended that:

i. Flood warning signs and flood level indicators should be placed on each approach to the proposed crossings.
ii. A Business Floodsafe Plan be prepared for the development to ensure the safety of employees during flood events in general accordance with the NSW SES "Business Floodsafe Toolkit and Plan"

8.3. Solar Array Field

For fixed solar panel modules, the mounting height of the module frames should be designed such that the lower edge of the frame is clear of the predicted 1% AEP flood level plus 500mm freeboard so as not to impact on existing flood behaviour and to prevent the infrastructure from being damaged from flooding.

For solar tracking modules, the tracking axis should be located above the 1% AEP flood level plus 500mm freeboard, and the modules rotated to the horizontal during significant flood events to provide maximum clearance to the predicted flood level.

Where located in the floodplain the solar array mounting piers should be designed to withstand the forces of floodwater (including any potential debris loading) up to the 1% AEP flood event, giving regard to the depth and velocity of floodwaters. Post development 1% AEP flood levels and velocities are included in Figures 5.1 and 5.2 respectively in Appendix G.

8.4. Electrical Infrastructure

All electrical infrastructure, including power conversions units (inverters), should be located above the 1% AEP flood level plus appropriate freeboard (min 500mm).

Where electrical cabling is required to be constructed below the 1% AEP flood level it should be capable of continuous submergence in water.

8.5. Perimeter Fencing

Wherever possible security fencing within the floodplain should be avoided or minimised. Where required security fencing should be constructed in a manner which does not adversely affect the flow of floodwater and should be designed to withstand the forces of floodwater or collapse in a controlled manner to prevent impediment to floodwater.

Any fencing across Butmaroo, Bridge and Wrights Creeks should be avoided in preference to creating separate fenced compounds on either side of the creeks.

8.6. Riparian Corridors

All proposed infrastructure associated with the proposed development should be setback from existing watercourses at the recommended riparian corridor widths specified in Table 1 of the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012) as provided below. In accordance with the guidelines the width of the VRZ should be measured from the top of the highest bank on both sides of the watercourse.

Table 1. Recommended riparian corridor (RC) widths

Watercourse type	**VRZ width** (each side of watercourse)	**Total RC width**
1st order	10 metres	20 m + channel width
2nd order	20 metres	40 m + channel width
3rd order	30 metres	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 metres	80 m + channel width

According to the guide, non-riparian corridor works, and activities can be authorised within the outer riparian corridor, so long as the average width of the vegetated riparian zone can be achieved over the length of the watercourse within the development footprint. That is, were appropriate 50 percent of the outer vegetated riparian zone width may be used for non-riparian uses including asset protection zones, recreational areas, roads, development lots and infrastructure. However, an equivalent area connected to the riparian corridor must be offset on the site and the inner 50 percent of the vegetated riparian zone must be fully protected and vegetated with native endemic riparian plant species. For further information refer to the guidline.

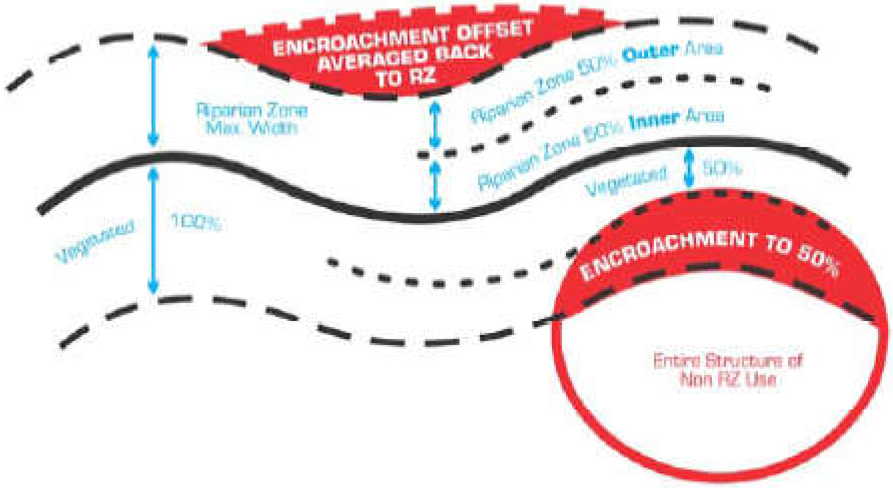


Figure 7: Riparian Corridor Averaging Rule

8.7. Watercourse Crossings

Any road crossing of existing watercourses associated with the proposed development should be of the type defined in Table 2 of the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012) as provided below.

Based on a preliminary assessment under the Strahler System defined in the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012) all three watercourses of the subject site would be classified as having a stream order of four or greater.

Table 2. Riparian corridor matrix

Stream order	Vegetated Riparian Zone (VRZ)	RC off-setting for non RC uses	Cycleways and paths	Detention basins		Stormwater outlet structures and essential services	Stream realignment	Road crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1st	10m	•	•	•	•	•	•	•		
2nd	20m	•	•	•	•	•		•		
3rd	30m	•	•	•		•			•	•
4th +	40m	•	•	•		•			•	•

Any proposed crossings (vehicular or service) of existing watercourses on the subject site should be designed in accordance with the following guidelines:

i. Guidelines for Watercourse Crossings on Waterfront land (NSW DPI, 2012)
ii. Guidelines for Laying Pipes and Cable in Watercourses on Waterfront Land (NSW DPI, 2012)

8.8. Access Roads

Within the floodplain access roads should be constructed as close to natural ground levels as possible and preferably parallel to the direction of flow so as to limit the potential for channelling and concentration of flood flows along road corridors, unless otherwise supported by modelling to demonstrate no adverse flooding impact or increased scour potential during the detailed design phase.

The surface treatment of roads should be designed giving regard to the velocity of floodwaters to minimise potential for scouring during flood events, which could include the use of stabilised gravels or grassed surfaces for roads within the floodplain.

8.9. Erosion Management

Any areas of existing erosion within the proposed development footprint should be appropriately treated prior to the erection of solar array modules to ensure their ongoing stability.

For further information refer to Saving Soil: A Landowners Guide to Preventing and Repairing Soil Erosion, NSW DPI (2009) available at https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

9.0 DEVELOPMENT OVER MAPPED WATERCOURSES

The development proposes the erection of solar panel infrastructure over the mapped watercourse of Wrights Creek which is classified as a fourth order stream under the Strahler System.

Although Wrights Creek has been mapped (NSW Hydroline Dataset) as a tributary of Butmaroo Creek with a confluence within the project site, ground truthing shows that there is no direct discharge into Butmaroo Creek via a defined watercourse as suggested.

Rather, Wrights Creek discharges out of the more mountainous area to the north of the project site where flows are channelised and where the watercourse exhibits the typical features of a watercourse (i.e. defined bed and banks) onto the floodplain of Butmarooo Creek and Lake George. When reaching the floodplain near the northern boundary of the project site flows typically make their way to either Butmaroo Creek or the existing ephemeral wetland in the north-eastern corner of the project site in a dispersed fashion. The phenomenon can be seen by studying the flood depth and velocity maps in Appendix G which clearly show no predominate flow path where flow depths and velocities are significantly higher than the remainder of the floodplain. This is further demonstrated in Figure 8 which superimposes velocity vectors on an extract of the pre-development 1% AEP flood velocity map.

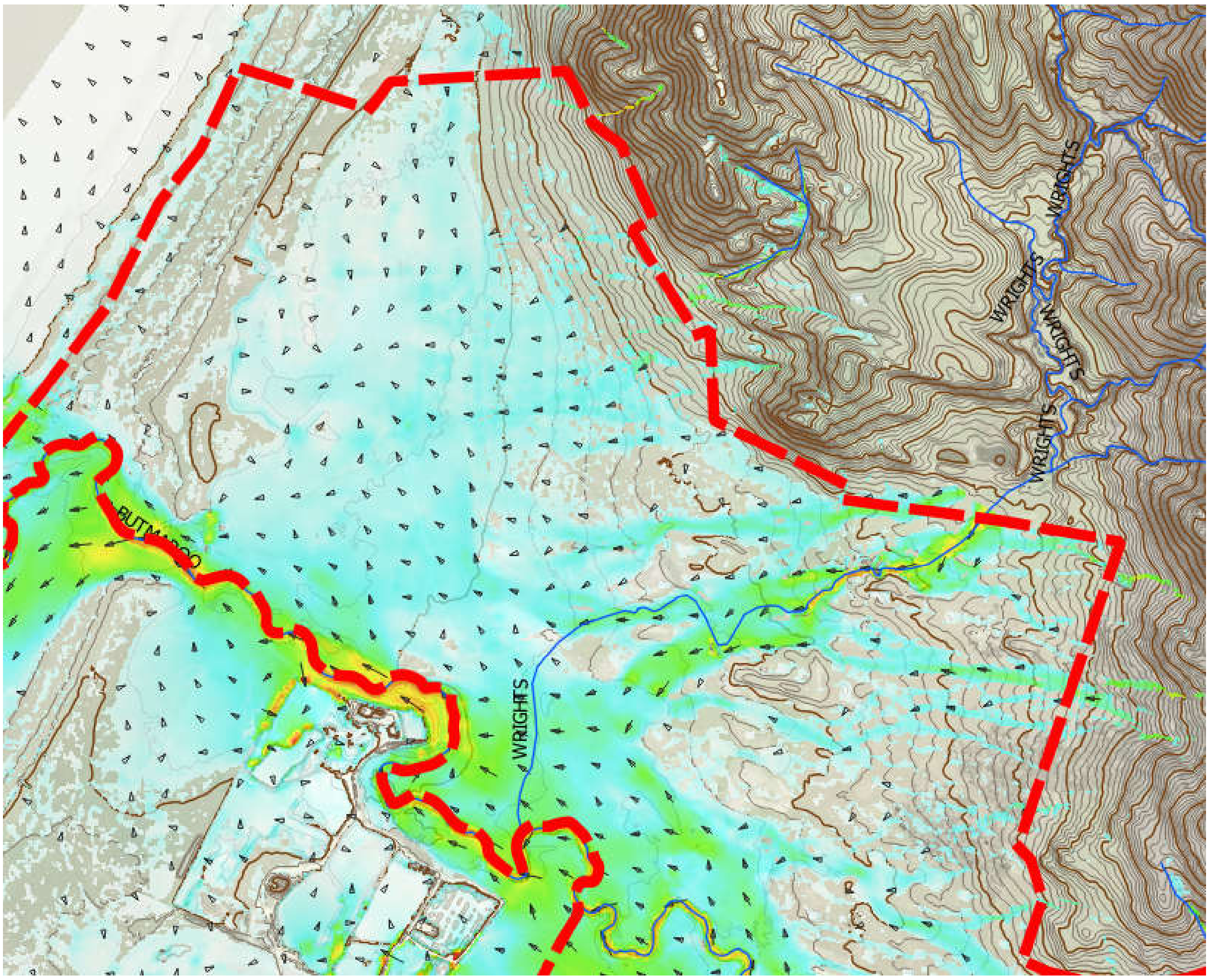


Figure 8: Extract from Pre-Development 1% AEP Flood Velocity Map showing Velocity Vectors (note erroneous mapping of the watercourse)

A desktop assessment and on-site verification of Wrights Creek in proximity of the project site was undertaken by the proponent and the results of this assessment and verification process has revealed that:

1. Isolated channels occur in three locations as shown in Figure 9. Historical aerial photography (1959) shows these channels were present at that time.
2. These channels are well vegetated and relatively stable which is also evidenced by the fact that there have been no significant changes since 1959.
3. No other areas within the floodplain within the vicinity of the mapped watercourse exhibited the typical attributes of a watercourse (i.e. defined bed and banks).

Channels A and B are located within the project site and their presence is well reflected in the flood mapping which shows these areas subject to greater flood depth and velocities that the surrounding floodplain areas. Channel C is located just north of the project site.

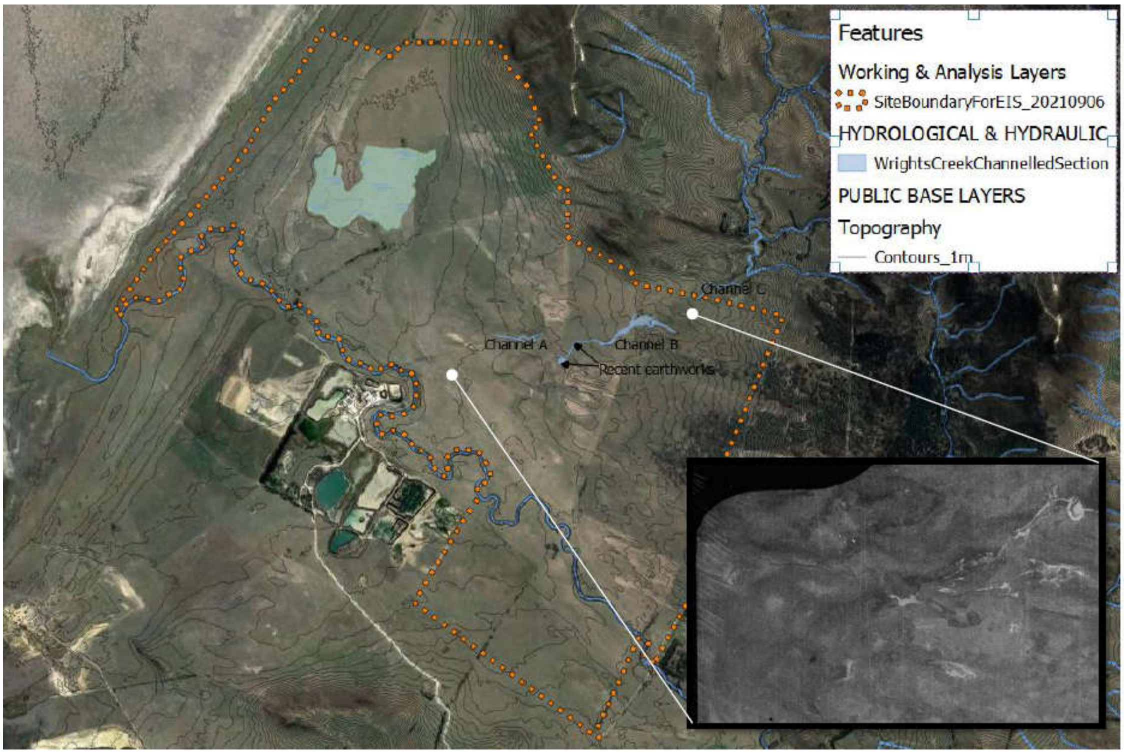


Figure 9: Channelised Sections of Wrights Creek within Project site (1959 image inset showing these channels to be present at that time)

Panoramic photographs of the floodplain were taken by the proponent on 12 September 2021 after a prolonged wet period where Wrights Creek was discharging onto the floodplain.

The panoramic photographs are provided in Appendix H and clearly demonstrate the distinct lack of a watercourse across the floodplain linking Wrights Creek to Butmaroo Creek.

The proposal has responded to the existing channels identified along Wrights Creek (Channels A and B) by excluding these areas from the array inclusion zone. Elsewhere solar array infrastructure is proposed over the line of the mapped watercourse and post development modelling has shown that the erection of solar panel infrastructure over these areas will have a negligible impact on flood behaviour and will therefore not impact the stability of the existing watercourse or contribute to degradation of the floodplain by erosive flood forces (principally Figures 6.1 and 6.2 in Appendix G).

From a biodiversity perspective ngh consulting (project biodiversity consultant) have provided the following comments in relation to the proposed development over Wrights Creek:

The longitudinal connectivity between upstream and downstream habitats of Wrights Creek and Butmaroo Creek only occurs intermittently following heavy rains and/or flooding.

The aquatic ecology and aquatic fauna within these systems is adapted to the seasonal flow regime of Wrights Creek. The proposed design will not change the overland flow patterns of Wrights Creek and would not impede longitudinal connectivity, as such any aquatic fauna present within these systems would be able to migrate upstream from Buttmaroo Creek when Wrights Creek is in flow or flood.

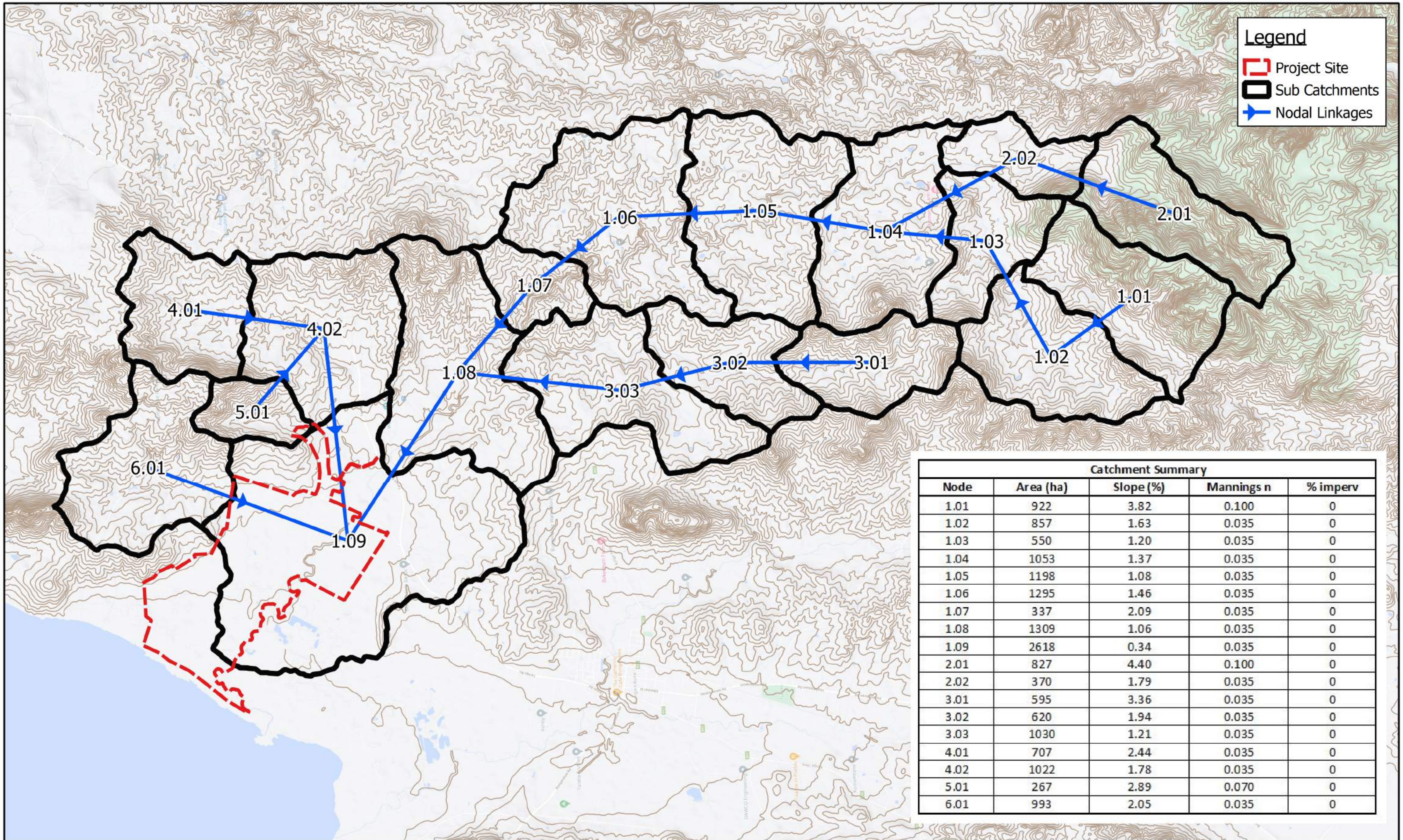
The riparian vegetation along Wrights Creek has been modified by agricultural practices and mostly comprises of grasses. The riparian vegetation along Buttmarro Creek has been influenced by the long-term agriculture activities and comprises mostly of bushes, shrubs and grasses. There is currently limited lateral connectivity between the riparian habitats of the creeks, however the vegetation does provide a variety of habitat types for aquatic species. The riparian vegetation also provides bank stabilisation and erosion control, and helps to minimise sedimentation. The project would not change the riparian habitat or structure of Buttmaroo Creek. The vegetation along the alignment of Wrights Creek would be modified by the project. Currently the site is heavily grazed, however grazing pressure will decrease once the project is operational. As such, lateral connectivity between riparian corridors will not be fragmented or degraded by the project once operational.

Finally, no barriers or instream works are proposed within Wrights Creek during construction, and none are proposed in the design. As such longitudinal connectivity of Wrights Creek would not be impacted by the proposal.

Figure 10: Example of current vegetation within Wrights Creek (North-east corner in the vicinity of Channel B)

APPENDIX A

Catchment Plan



Catchment Summary				
Node	Area (ha)	Slope (%)	Mannings n	% imperv
1.01	922	3.82	0.100	0
1.02	857	1.63	0.035	0
1.03	550	1.20	0.035	0
1.04	1053	1.37	0.035	0
1.05	1198	1.08	0.035	0
1.06	1295	1.46	0.035	0
1.07	337	2.09	0.035	0
1.08	1309	1.06	0.035	0
1.09	2618	0.34	0.035	0
2.01	827	4.40	0.100	0
2.02	370	1.79	0.035	0
3.01	595	3.36	0.035	0
3.02	620	1.94	0.035	0
3.03	1030	1.21	0.035	0
4.01	707	2.44	0.035	0
4.02	1022	1.78	0.035	0
5.01	267	2.89	0.070	0
6.01	993	2.05	0.035	0

footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

BLIND CREEK SOLAR FARM

FIGURE 1.1
CATCHMENT PLAN

Rev 3 - 22 November 2021

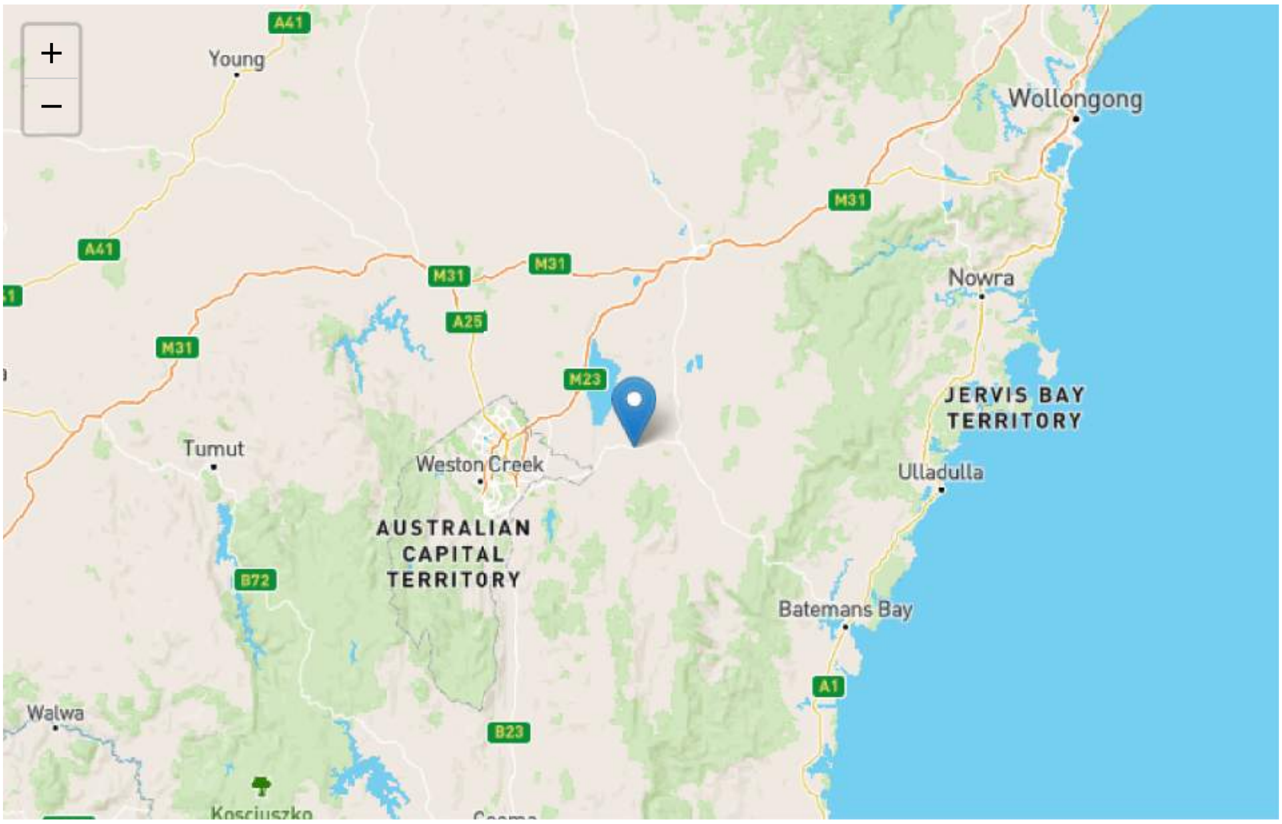
APPENDIX B

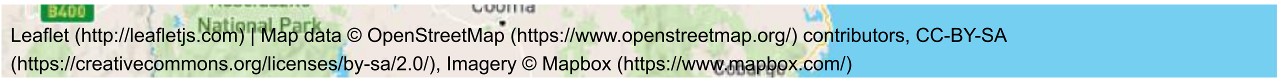
ARR Hub Data

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	149.522
Latitude	-35.258
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show





Data

River Region

Division	Murray-Darling Basin
River Number	12
River Name	Murrumbidgee River

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} + eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
SE Coast	0.06	0.361	0.0	0.317	8.11e-05	0.651	0.0	0.0	0.0

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	21694.0
Storm Initial Losses (mm)	23.0
Storm Continuing Losses (mm/h)	4.1

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/MB.zip)

code	MB
Label	Murray Basin

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_MB.zip)

code	MB
arealabel	Murray Basin

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-35.25787&longitude=149.52243&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	06 December 2020 03:33PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	1.3 (0.067)	0.8 (0.029)	0.4 (0.012)	0.0 (0.001)	0.1 (0.003)	0.2 (0.005)
90 (1.5)	2.9 (0.125)	1.9 (0.062)	1.2 (0.034)	0.6 (0.014)	0.7 (0.015)	0.8 (0.015)
120 (2.0)	1.5 (0.059)	1.1 (0.034)	0.9 (0.023)	0.7 (0.015)	0.4 (0.008)	0.2 (0.003)
180 (3.0)	2.8 (0.097)	2.1 (0.056)	1.6 (0.038)	1.2 (0.024)	0.6 (0.010)	0.1 (0.001)
360 (6.0)	0.8 (0.022)	0.5 (0.010)	0.3 (0.005)	0.1 (0.001)	0.7 (0.010)	1.2 (0.014)
720 (12.0)	0.3 (0.008)	2.6 (0.044)	4.2 (0.058)	5.6 (0.067)	8.8 (0.087)	11.1 (0.096)
1080 (18.0)	0.0 (0.000)	1.8 (0.026)	3.0 (0.036)	4.2 (0.042)	8.8 (0.072)	12.2 (0.088)
1440 (24.0)	0.0 (0.000)	0.5 (0.006)	0.8 (0.008)	1.1 (0.009)	4.6 (0.033)	7.2 (0.045)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.8 (0.005)	1.4 (0.008)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.000)	0.1 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.2 (0.002)	0.4 (0.003)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	11.4 (0.572)	8.0 (0.298)	5.7 (0.181)	3.5 (0.096)	8.6 (0.205)	12.4 (0.267)
90 (1.5)	11.7 (0.515)	12.1 (0.400)	12.3 (0.348)	12.5 (0.310)	14.1 (0.301)	15.4 (0.295)
120 (2.0)	12.5 (0.500)	13.6 (0.413)	14.3 (0.373)	15.0 (0.343)	13.2 (0.259)	11.8 (0.209)
180 (3.0)	13.3 (0.468)	13.4 (0.361)	13.5 (0.311)	13.5 (0.274)	12.7 (0.218)	12.0 (0.185)
360 (6.0)	10.6 (0.295)	12.9 (0.276)	14.4 (0.264)	15.9 (0.253)	23.0 (0.307)	28.4 (0.334)
720 (12.0)	9.1 (0.201)	14.3 (0.239)	17.7 (0.249)	21.0 (0.252)	38.2 (0.378)	51.0 (0.440)
1080 (18.0)	6.4 (0.122)	9.9 (0.141)	12.2 (0.145)	14.4 (0.145)	29.0 (0.239)	39.9 (0.285)
1440 (24.0)	0.5 (0.008)	4.8 (0.062)	7.7 (0.082)	10.5 (0.093)	20.2 (0.147)	27.4 (0.173)
2160 (36.0)	0.0 (0.000)	2.3 (0.025)	3.8 (0.035)	5.3 (0.040)	11.2 (0.069)	15.7 (0.084)
2880 (48.0)	0.0 (0.001)	1.1 (0.011)	1.8 (0.015)	2.4 (0.017)	4.7 (0.026)	6.4 (0.031)
4320 (72.0)	0.0 (0.000)	0.2 (0.002)	0.4 (0.003)	0.6 (0.003)	0.7 (0.003)	0.7 (0.003)

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	21.0 (1.050)	19.3 (0.723)	18.2 (0.581)	17.2 (0.478)	19.9 (0.474)	21.9 (0.470)
90 (1.5)	25.9 (1.136)	28.0 (0.928)	29.4 (0.835)	30.8 (0.765)	31.7 (0.675)	32.3 (0.620)
120 (2.0)	26.2 (1.051)	29.1 (0.884)	30.9 (0.807)	32.7 (0.748)	43.4 (0.851)	51.5 (0.907)
180 (3.0)	30.1 (1.060)	29.0 (0.781)	28.3 (0.653)	27.6 (0.558)	32.4 (0.559)	36.0 (0.556)
360 (6.0)	29.3 (0.819)	33.0 (0.709)	35.5 (0.651)	37.9 (0.602)	51.5 (0.687)	61.6 (0.727)
720 (12.0)	24.1 (0.532)	35.3 (0.589)	42.7 (0.600)	49.8 (0.597)	76.4 (0.756)	96.4 (0.832)
1080 (18.0)	23.3 (0.447)	27.3 (0.391)	30.0 (0.358)	32.6 (0.328)	57.8 (0.476)	76.7 (0.549)
1440 (24.0)	14.1 (0.246)	19.7 (0.253)	23.3 (0.248)	26.9 (0.239)	43.2 (0.314)	55.4 (0.349)
2160 (36.0)	11.9 (0.182)	13.1 (0.145)	13.9 (0.126)	14.7 (0.111)	27.4 (0.169)	36.9 (0.197)
2880 (48.0)	7.7 (0.109)	11.9 (0.120)	14.7 (0.120)	17.4 (0.118)	25.1 (0.140)	30.9 (0.150)
4320 (72.0)	3.1 (0.040)	7.2 (0.064)	9.8 (0.071)	12.4 (0.074)	20.2 (0.100)	26.1 (0.114)

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.816 (4.1%)**	0.726 (3.6%)	**0.934 (4.7%)**
2040	**1.046 (5.2%)**	1.015 (5.1%)	**1.305 (6.6%)**
2050	**1.260 (6.3%)**	1.277 (6.4%)	**1.737 (8.8%)**
2060	**1.450 (7.3%)**	1.520 (7.7%)	**2.214 (11.4%)**
2070	**1.609 (8.2%)**	1.753 (8.9%)	**2.722 (14.2%)**
2080	**1.728 (8.8%)**	1.985 (10.2%)	**3.246 (17.2%)**
2090	**1.798 (9.2%)**	2.226 (11.5%)	**3.772 (20.2%)**

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	**50.0**	**20.0**	**10.0**	**5.0**	**2.0**	**1.0**
60 (1.0)	17.3	10.6	10.2	10.9	9.9	8.2
90 (1.5)	16.1	9.7	8.8	9.1	8.4	6.7
120 (2.0)	16.3	10.0	9.0	9.2	7.9	7.2
180 (3.0)	15.3	10.2	9.4	10.4	9.3	7.6
360 (6.0)	16.2	11.4	10.8	11.0	10.4	6.5
720 (12.0)	17.0	11.7	11.7	10.8	9.9	4.1
1080 (18.0)	18.2	13.6	14.3	13.5	12.2	5.1
1440 (24.0)	20.5	16.1	16.7	16.8	13.4	5.9
2160 (36.0)	21.6	18.4	19.0	21.7	16.8	9.5
2880 (48.0)	22.5	19.2	19.5	23.0	18.2	11.1
4320 (72.0)	23.7	21.0	20.9	25.1	19.3	11.7

Layer Info

Time Accessed	06 December 2020 03:33PM
Version	2018_v1

Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Download TXT (downloads/202e887a-abbe-4347-ac71-54968f24b934.txt)

Download JSON (downloads/72c7b415-346f-4ccc-aab3-81927f0158b4.json)

Generating PDF... (downloads/8cd83207-73a1-4a6b-a995-6cf98c86e2f2.pdf)

APPENDIX C

Design Rainfall Depths

Australian Government
Bureau of Meteorology

Location

Label: Blind Creek Solar Farm

Latitude: -35.2579 [Nearest grid cell: 35.2625 (S)]

Longitude: 149.5224 [Nearest grid cell: 149.5125 (E)]

IFD Design Rainfall Depth (mm)

Issued: 16 January 2021

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.63	1.83	2.48	2.93	3.38	3.99	4.47
2 min	2.76	3.08	4.09	4.77	5.40	6.19	6.78
3 min	3.77	4.22	5.62	6.57	7.48	8.63	9.52
4 min	4.67	5.23	7.00	8.21	9.39	10.9	12.1
5 min	5.45	6.12	8.23	9.68	11.1	13.0	14.5
10 min	8.35	9.41	12.8	15.2	17.6	20.8	23.4
15 min	10.3	11.6	15.8	18.8	21.7	25.8	29.0
20 min	11.7	13.2	18.0	21.4	24.7	29.3	32.9
25 min	12.9	14.5	19.8	23.4	27.0	31.9	35.8
30 min	13.9	15.6	21.2	25.0	28.9	34.0	38.0
45 min	16.1	18.1	24.4	28.7	33.0	38.6	43.0
1 hour	17.8	20.0	26.7	31.3	35.9	41.9	46.6
1.5 hour	20.4	22.8	30.2	35.3	40.3	46.9	52.1
2 hour	22.5	25.0	32.9	38.3	43.7	51.0	56.7
3 hour	25.7	28.4	37.2	43.3	49.5	58.0	64.8
4.5 hour	29.5	32.5	42.3	49.4	56.7	67.0	75.3
6 hour	32.5	35.8	46.6	54.6	63.0	75.0	84.8
9 hour	37.3	41.1	53.9	63.5	73.9	89.0	101
12 hour	41.2	45.4	59.9	71.2	83.4	101	116
18 hour	47.1	52.1	69.9	83.9	99.3	121	140
24 hour	51.6	57.4	77.9	94.3	112	138	159
30 hour	55.2	61.6	84.5	103	123	151	174
36 hour	58.1	65.1	90.2	110	133	162	187
48 hour	62.7	70.6	99.2	122	147	180	206
72 hour	68.8	78.0	111	138	166	201	229
96 hour	72.7	82.8	118	146	177	213	241
120 hour	75.6	86.0	123	151	182	219	248

144 hour	77.8	88.3	125	153	185	223	253
168 hour	79.7	90.1	126	154	185	224	256

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

This page was created at **16:40 on Saturday 16 January 2021 (AEDT)**

APPENDIX D

Pre-Burst Rainfall Depths

Table E1: NSW Transformation Pre-Burst Rainfall Depths

Storm Duration		Pre-Burst Rainfall Depth (mm)	
		AEP (%)	
min	hrs	5	1
60	1	11.9	14.6
90	1.5	13.7	16.1
120	2	13.6	15.6
180	3	12.4	15.2
270	4.5	12.1*	15.8*
360	6	11.8	16.3
540	9	11.9*	17.5*
720	12	12.0	18.7
1080	18	9.3	17.7
1440	24	6.0	16.9

* Denotes linearly interpolated value

APPENDIX E

PMP Calculations

GSDM Calculation Sheet

Location Information				
Catchment	Blind Creek Solar	Area (km2)	165.7	
State	NSW	Duration Limit (hrs)	6	
Latitude	-35.258	Longitude	149.522	
Proportion of Area Considered:				
Smooth S= (0.0 - 1.0)	0	Rough R= (0.0-1.0)	1	
Elevation Adjustment Factor (EAF)				
Mean Elevation (m AHD)			810	
Adjustment for Eelvation (-0.05 per 300m above 1500m)			0	
EAF = (0.85-1.00)			1	
Moisture Adjustment Factor (MAF)				
MAF = (0.40 - 1.00)			0.65	
PMP Values				
Duarion (hrs)	Initial Depth - Smooth	Initial Depth - Rough	PMP Estimate	Rounded PMP Estimate (nearest 10mm)
0.25		165	107	110
0.50		230	150	150
0.75		290	189	190
1.0		355	231	230
1.5		460	299	300
2.0		530	345	340
2.5		600	390	390
3.0		650	423	420
4.0		730	475	470
5.0		800	520	520
6.0		850	553	550

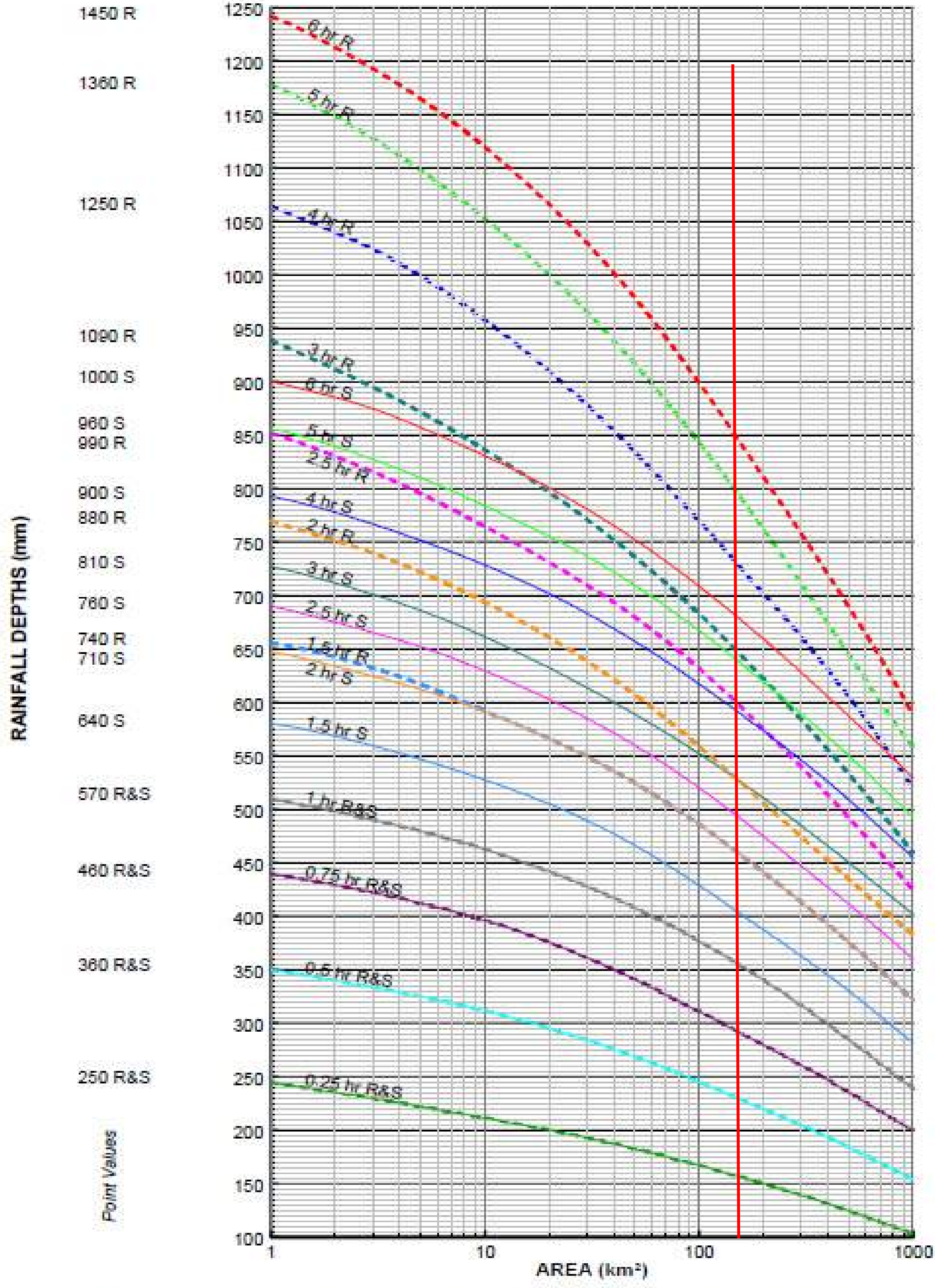
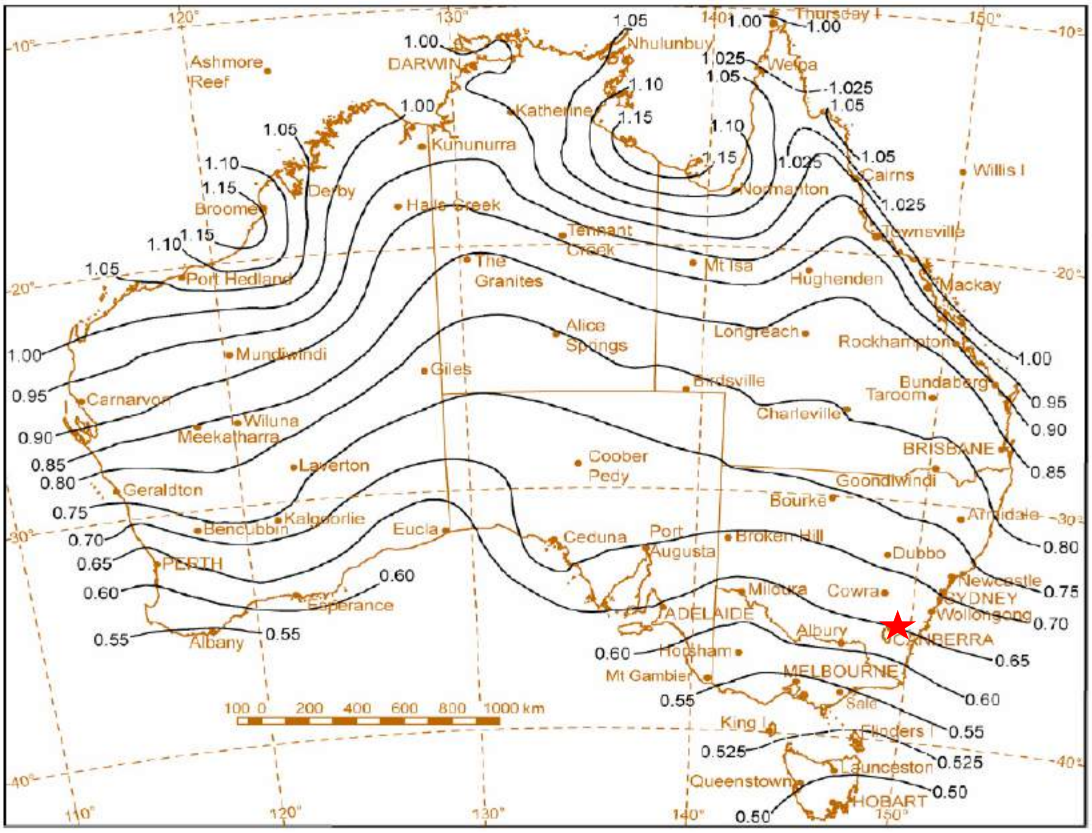
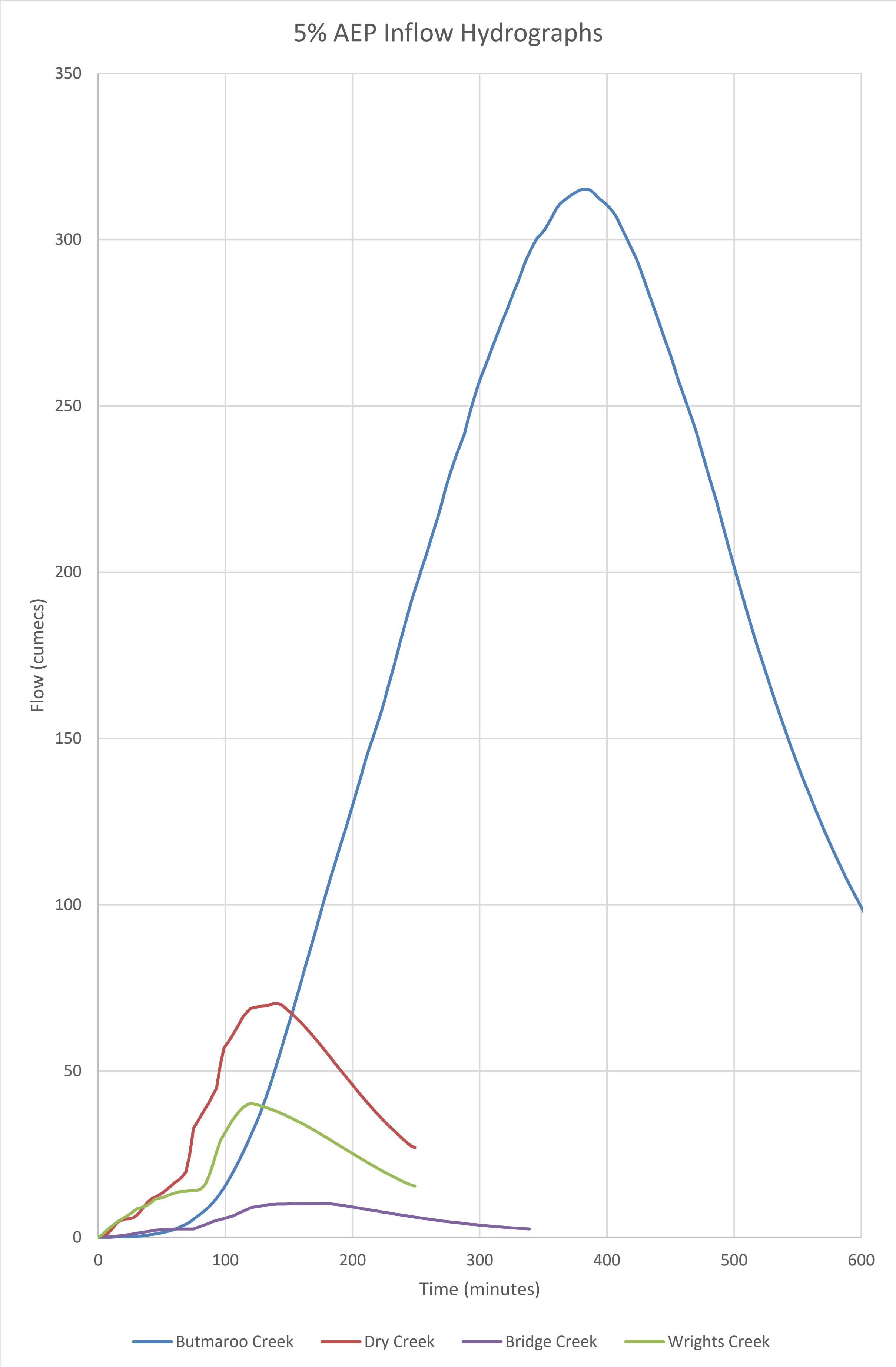


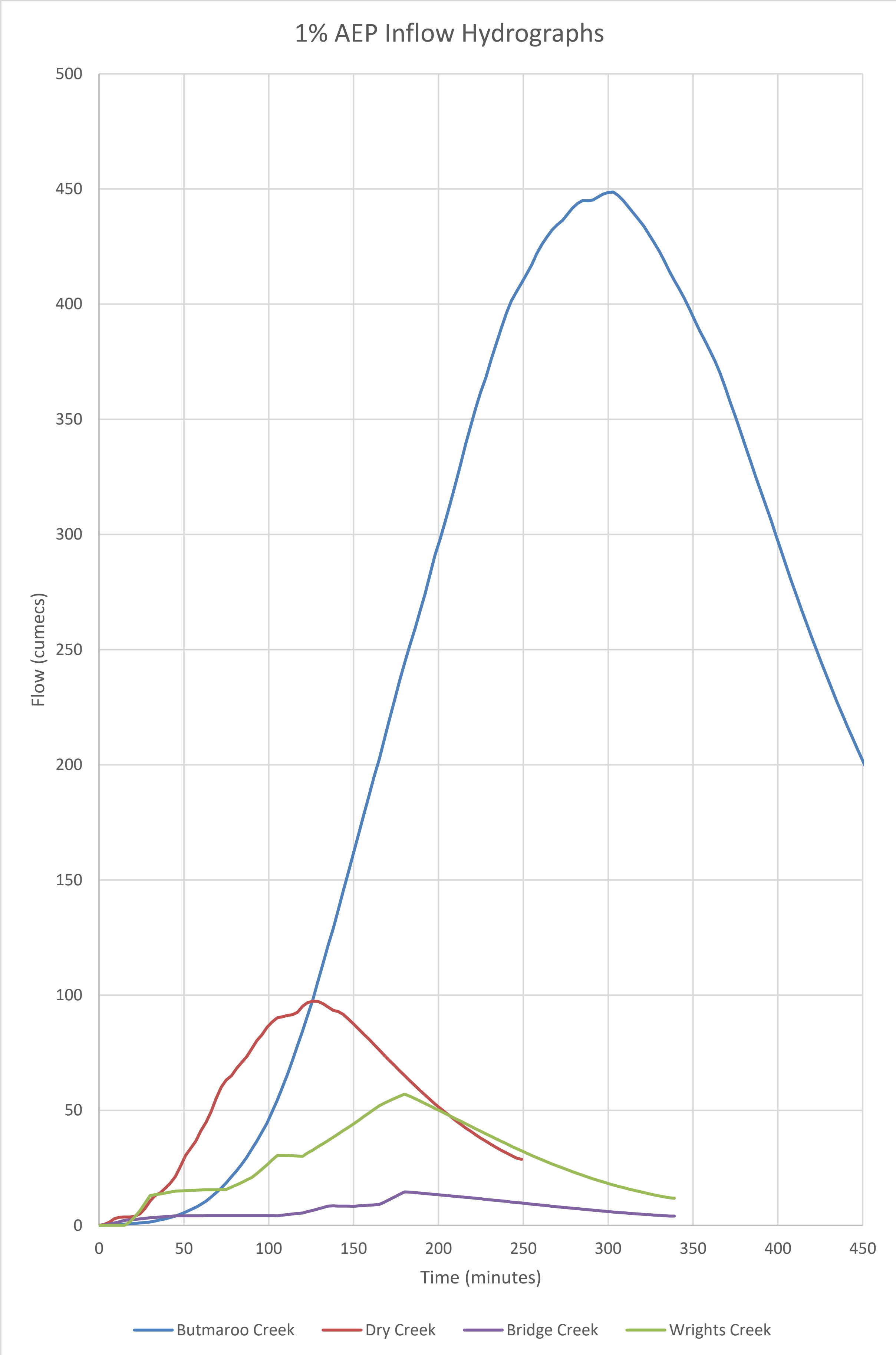
Figure 4: **Depth-Duration-Area Curves of Short Duration Rainfall**



APPENDIX F

Inflow Hydrographs


5% AEP Inflow Hydrographs
350
300
250
200
150
100
50
0
Flow (cumecs)
0
100
200
300
400
500
600
Time (minutes)
Butmaroo Creek
Dry Creek
Bridge Creek
Wrights Creek


1% AEP Inflow Hydrographs
Flow (cumecs)
500
450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
400
450
Time (minutes)
Butmaroo Creek
Dry Creek
Bridge Creek
Wrights Creek

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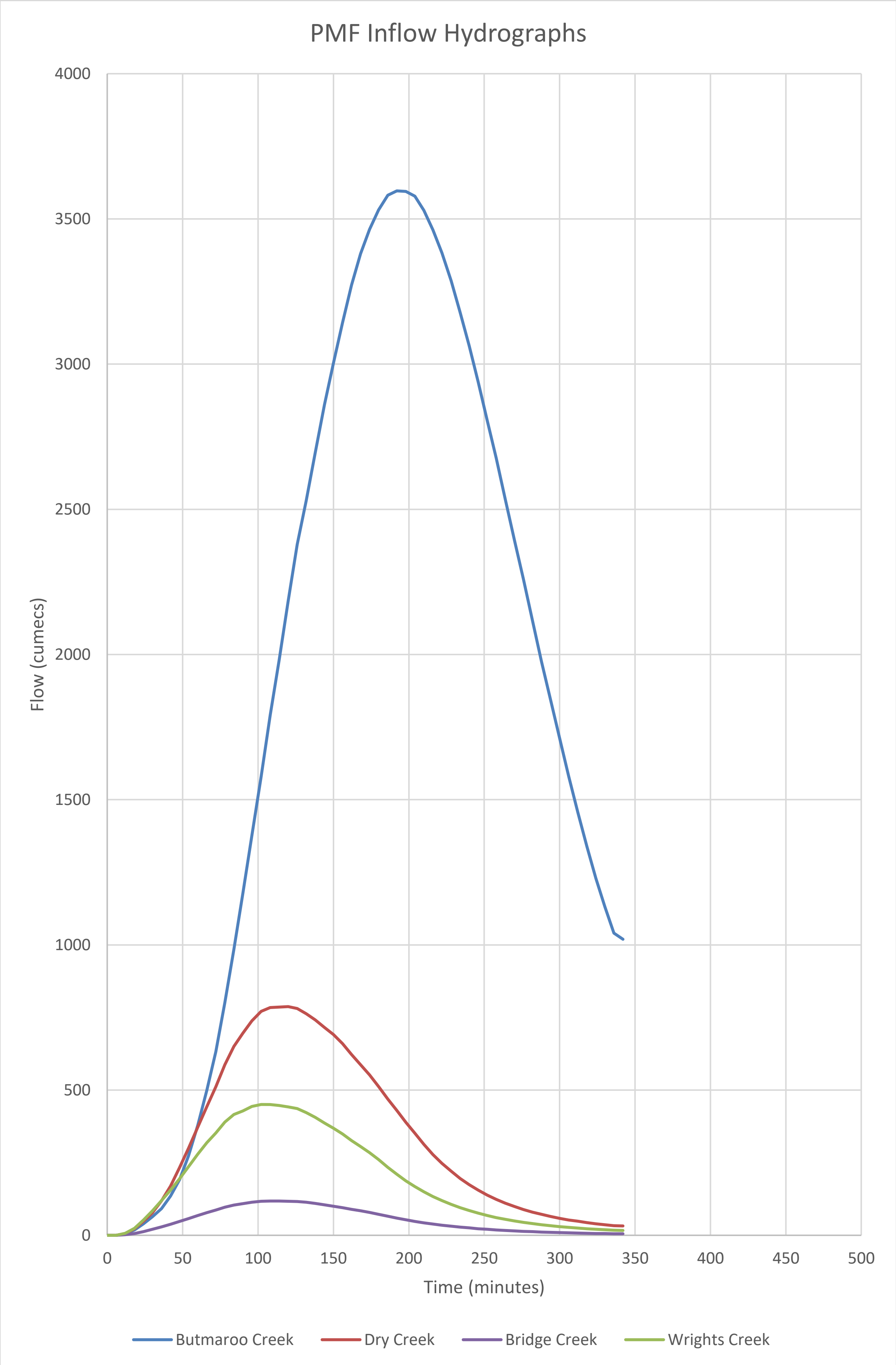

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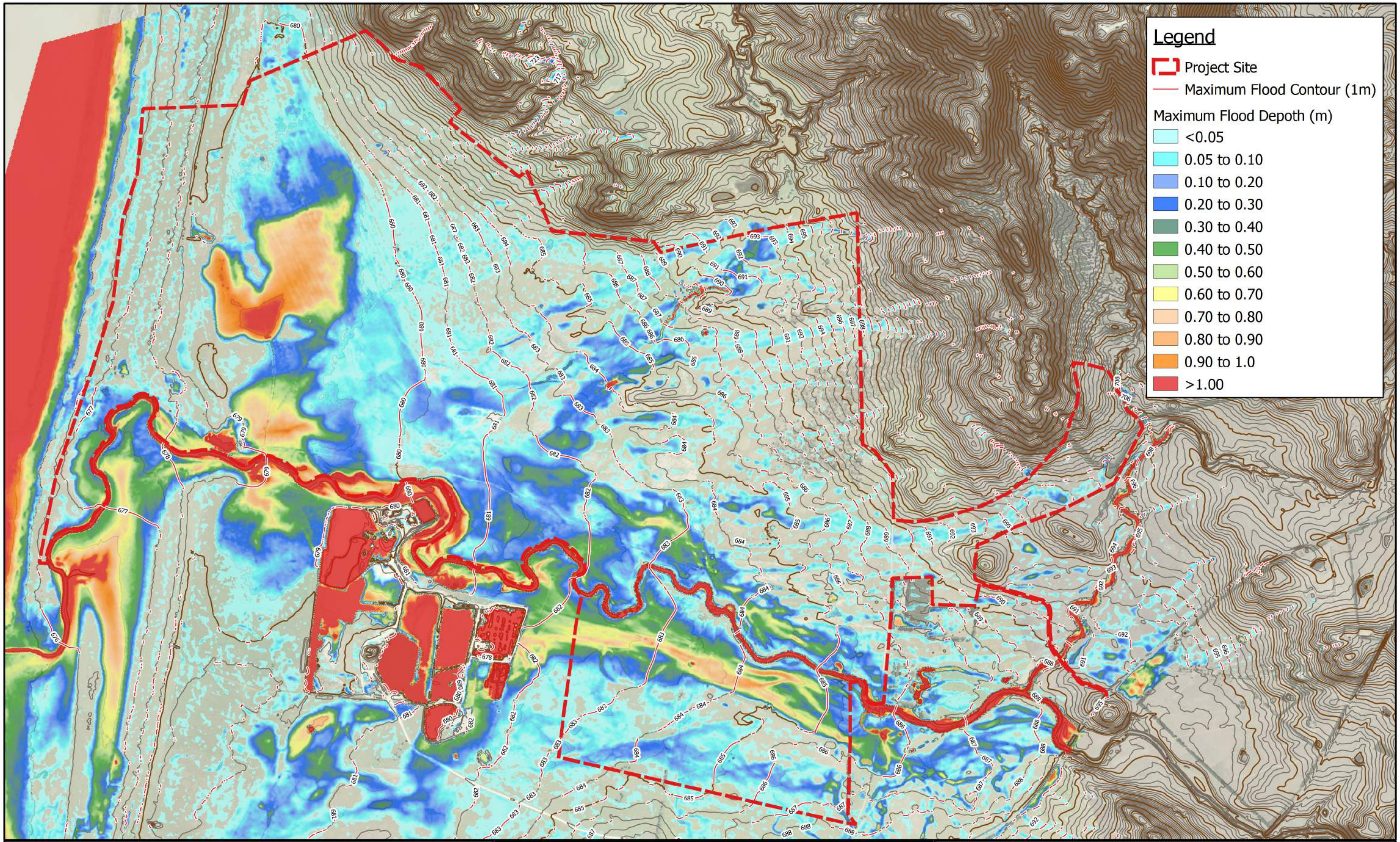
APPENDIX G

Flood Mapping



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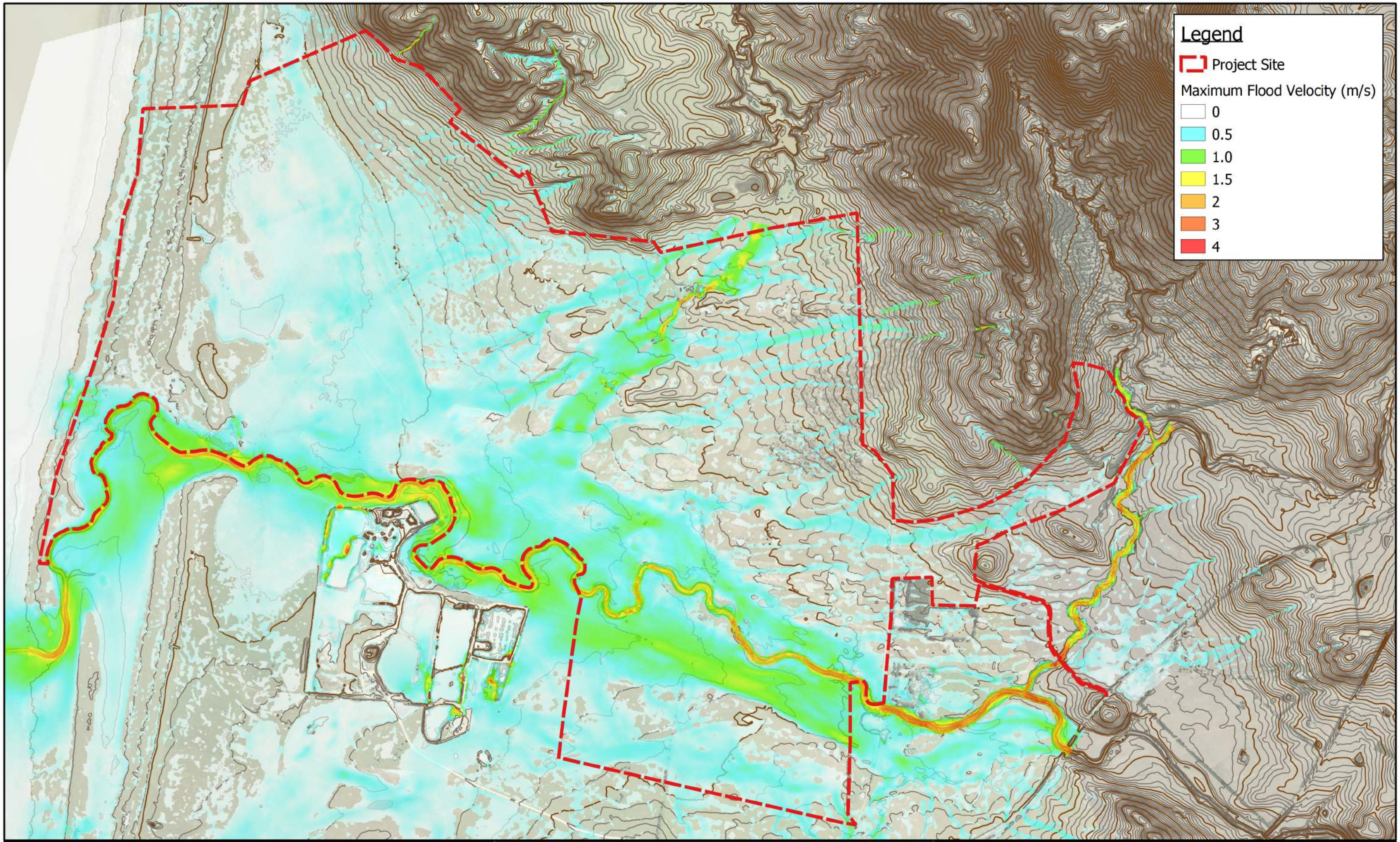
BLIND CREEK SOLAR FARM

FIGURE 2.1

PRE-DEVELOPMENT 5% AEP MAXIMUM FLOOD LEVELS AND DEPTHS

Rev 3 - 22 November 2021



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300 0 300 600 m

Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 2.2

PRE-DEVELOPMENT 5% AEP MAXIMUM FLOOD VELOCITY

Rev 3 - 22 November 2021

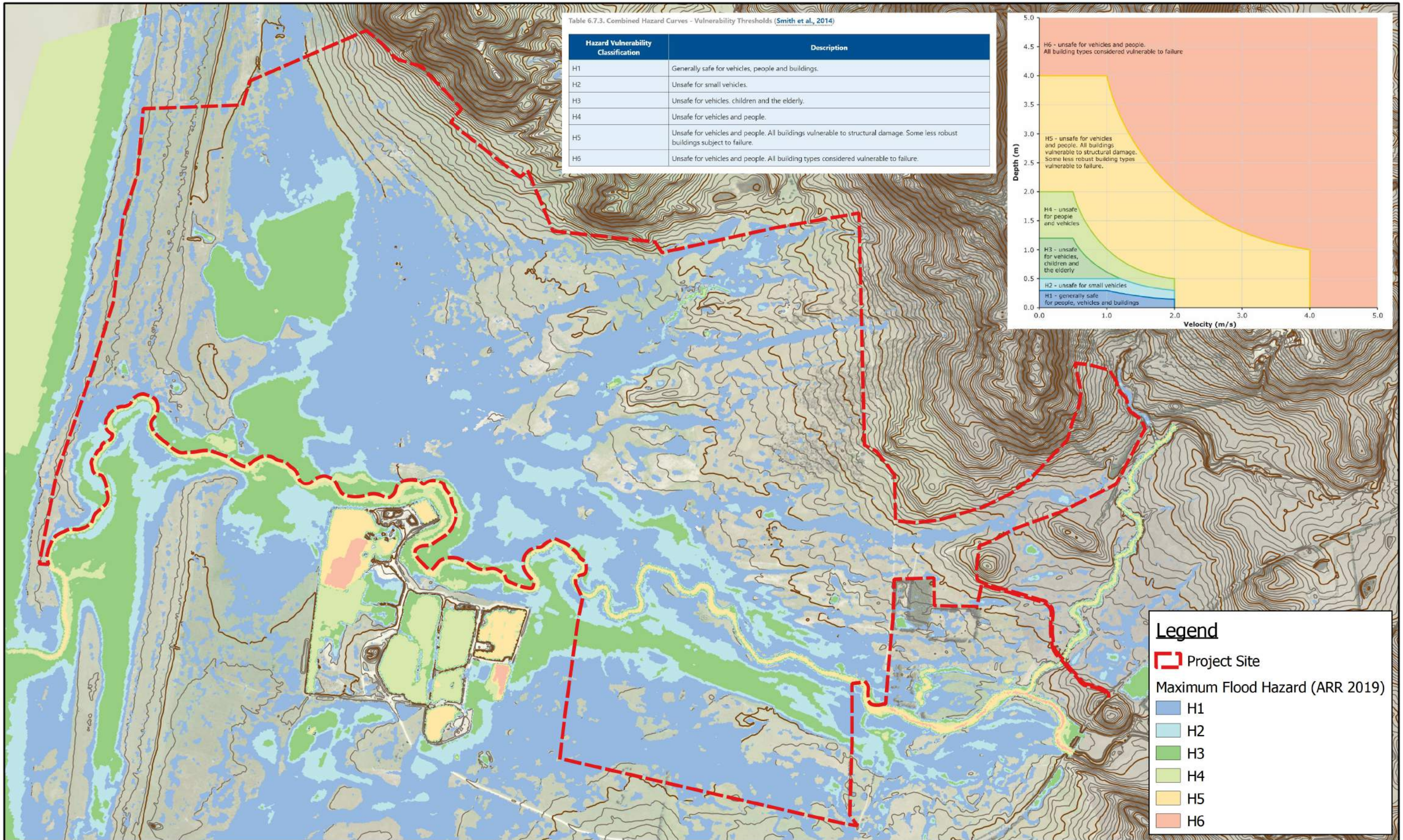

Table 6.7.3. Combined Hazard Curves - Vulnerability Thresholds (Smith et al., 2014)

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles. children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

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Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 2.3
PRE-DEVELOPMENT 5% AEP MAXIMUM FLOOD HAZARD (ARR 2019)

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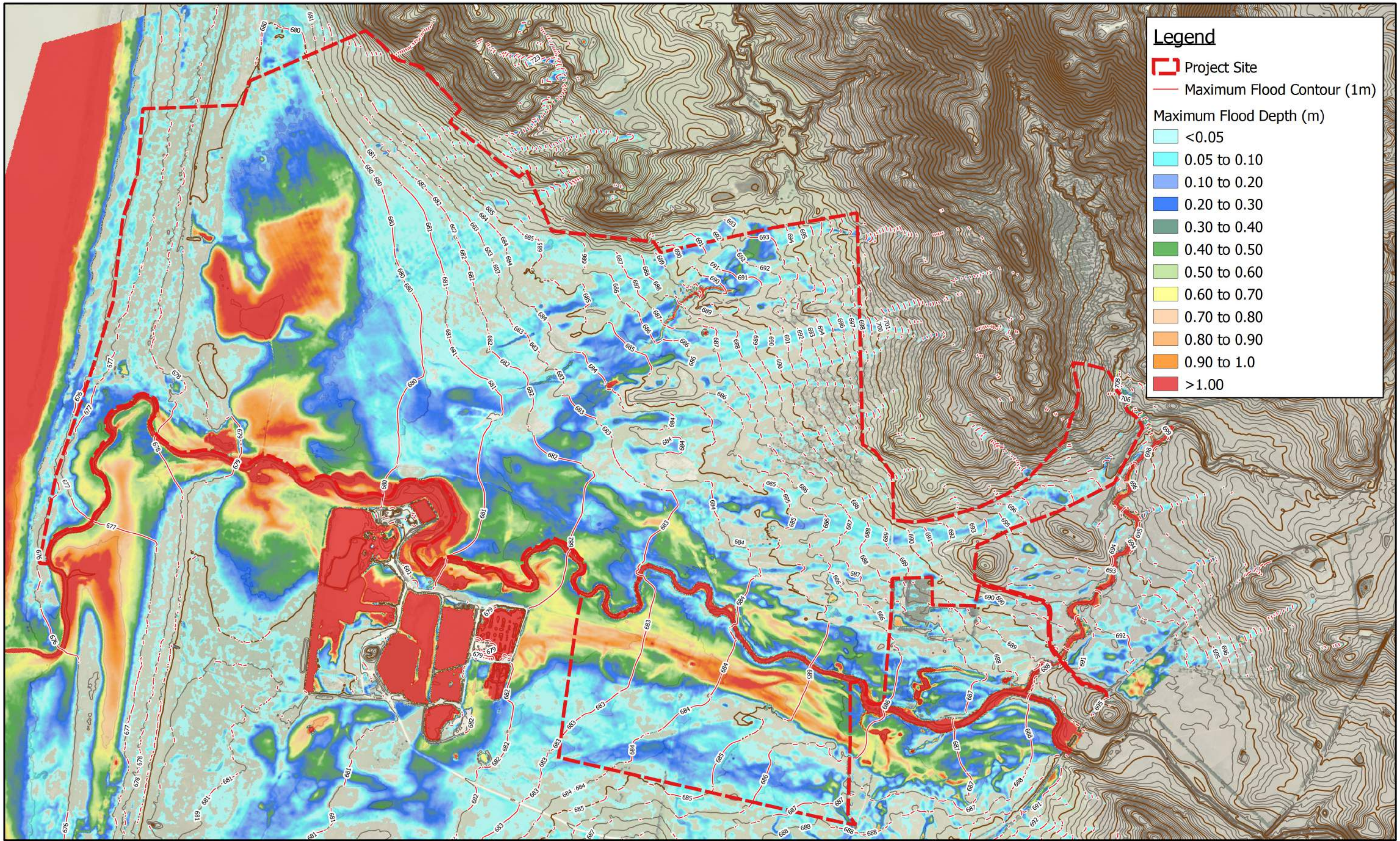

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BLIND CREEK SOLAR FARM

FIGURE 3.1

PRE-DEVELOPMENT 1% AEP MAXIMUM FLOOD LEVELS AND DEPTHS

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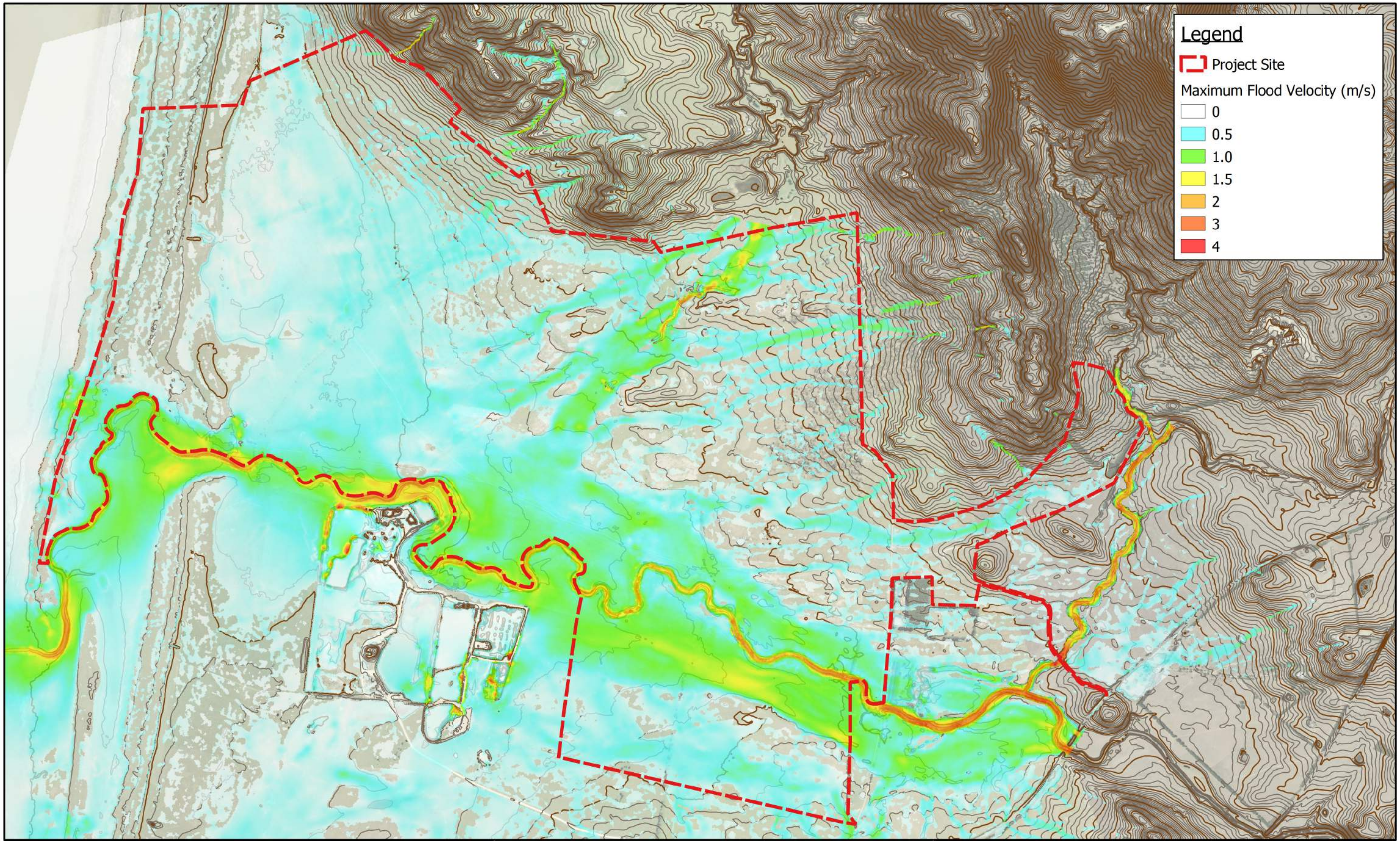

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300 0 300 600 m

Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 3.2

PRE-DEVELOPMENT 1% AEP MAXIMUM FLOOD VELOCITY

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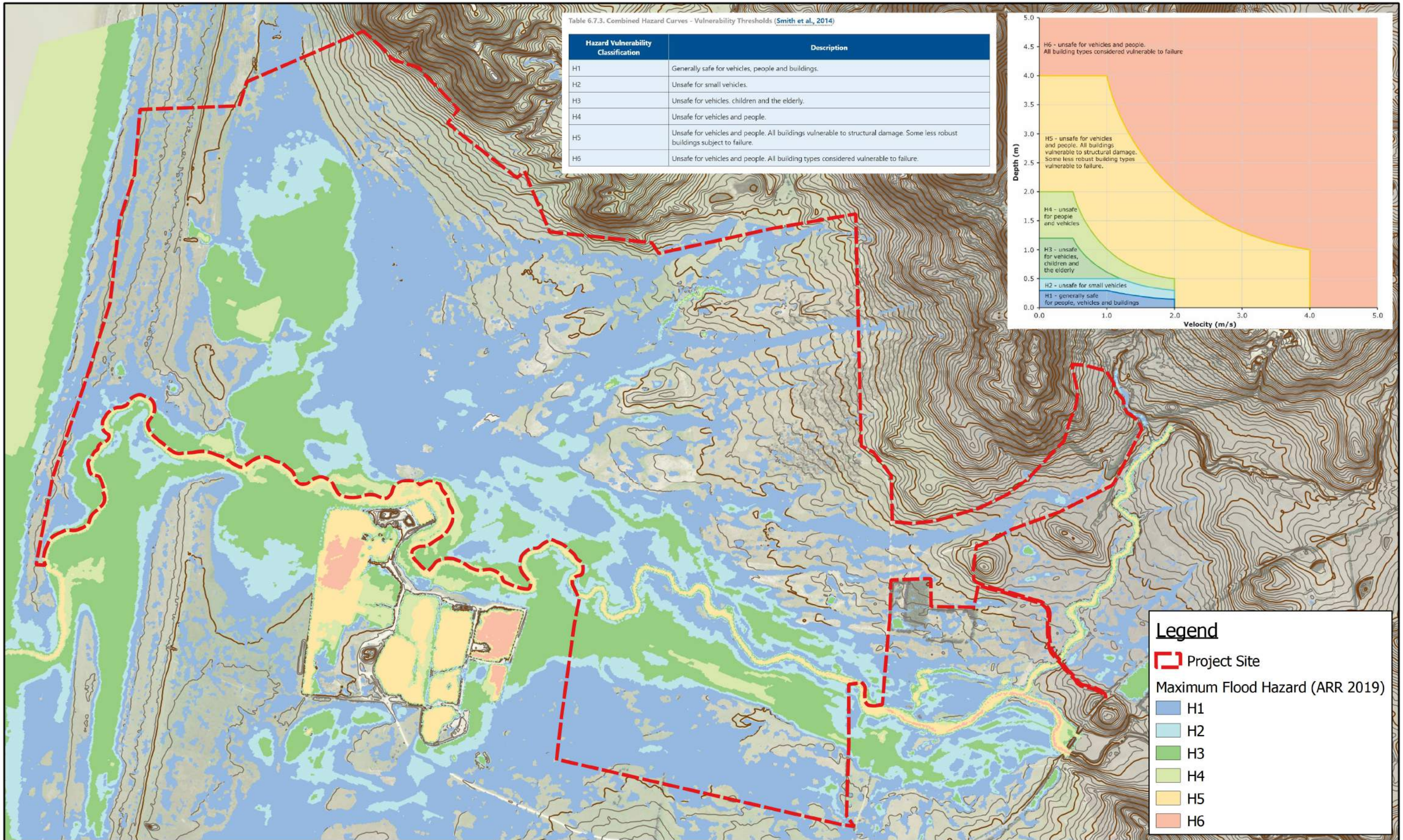

Table 6.7.3. Combined Hazard Curves - Vulnerability Thresholds (Smith et al., 2014)

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H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

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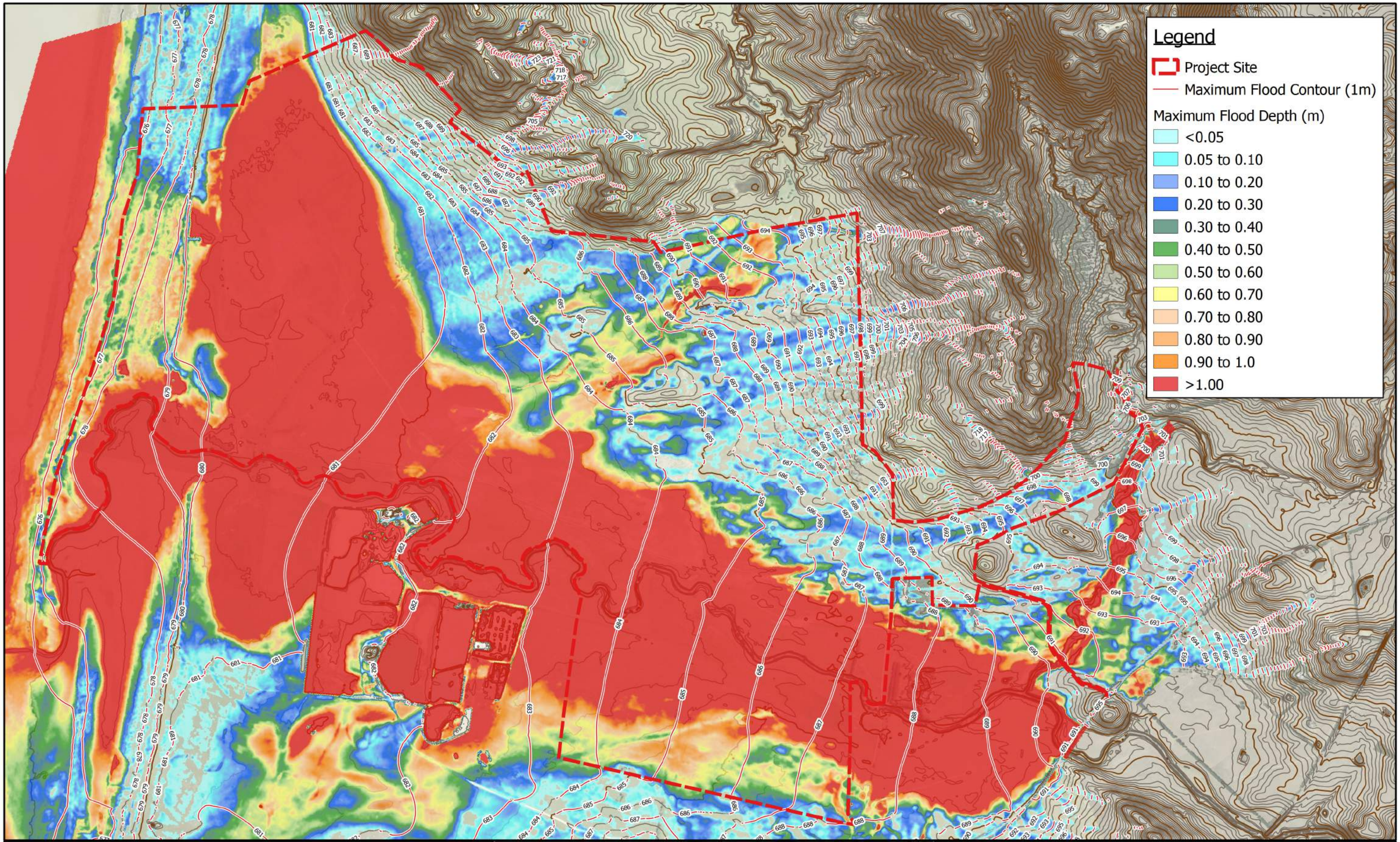
BLIND CREEK SOLAR FARM

FIGURE 3.3
PRE-DEVELOPMENT 1% AEP MAXIMUM FLOOD HAZARD (ARR 2019)

Rev 3 - 22 November 2021



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Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 4.1

PRE-DEVELOPMENT PMF MAXIMUM FLOOD LEVELS AND DEPTHS

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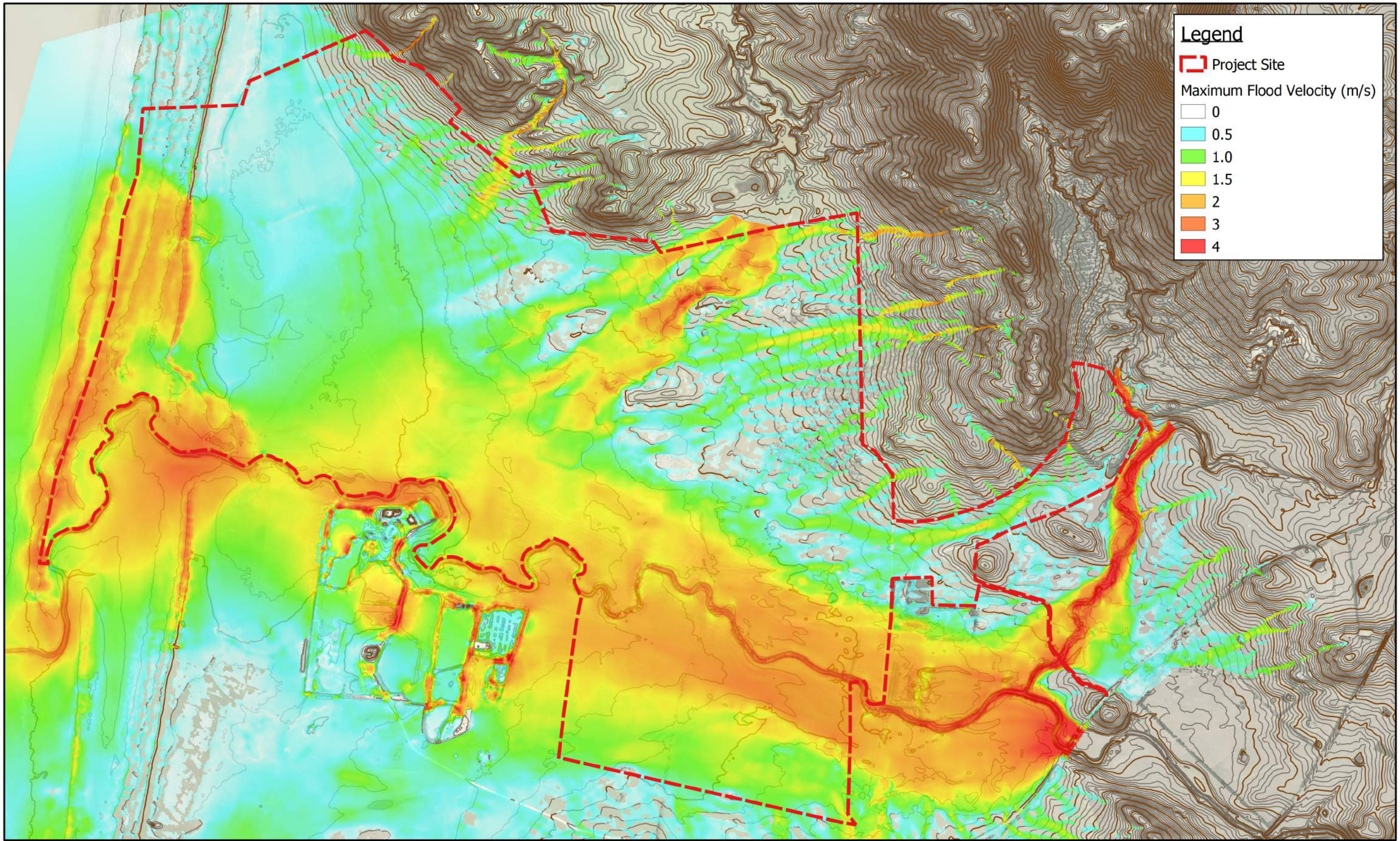

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Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 4.2

PRE-DEVELOPMENT PMF MAXIMUM FLOOD VELOCITY

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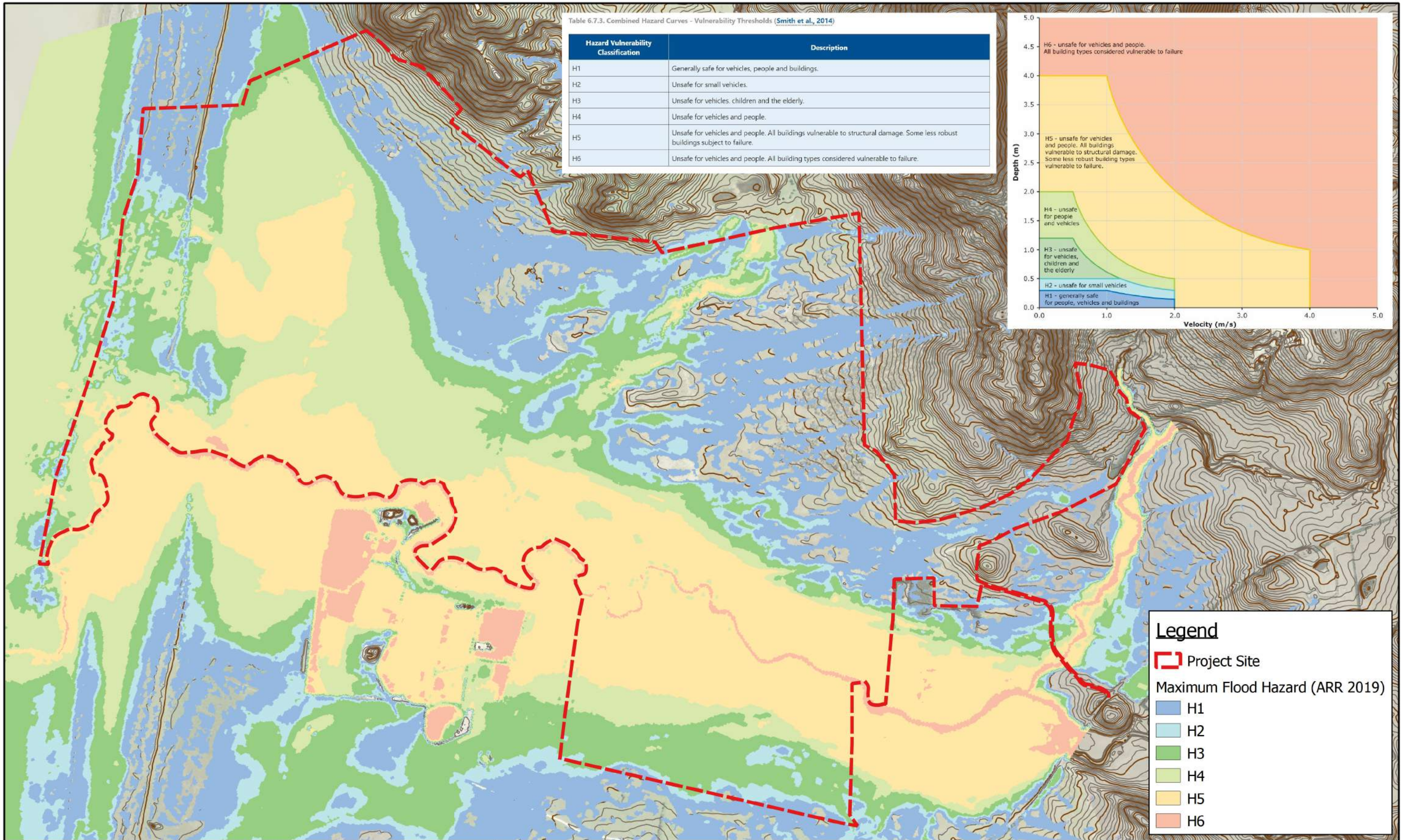

Table 6.7.3. Combined Hazard Curves - Vulnerability Thresholds (Smith et al., 2014)

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
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H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

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BLIND CREEK SOLAR FARM

FIGURE 4.3
PRE-DEVELOPMENT PMF MAXIMUM FLOOD HAZARD (ARR 2019)

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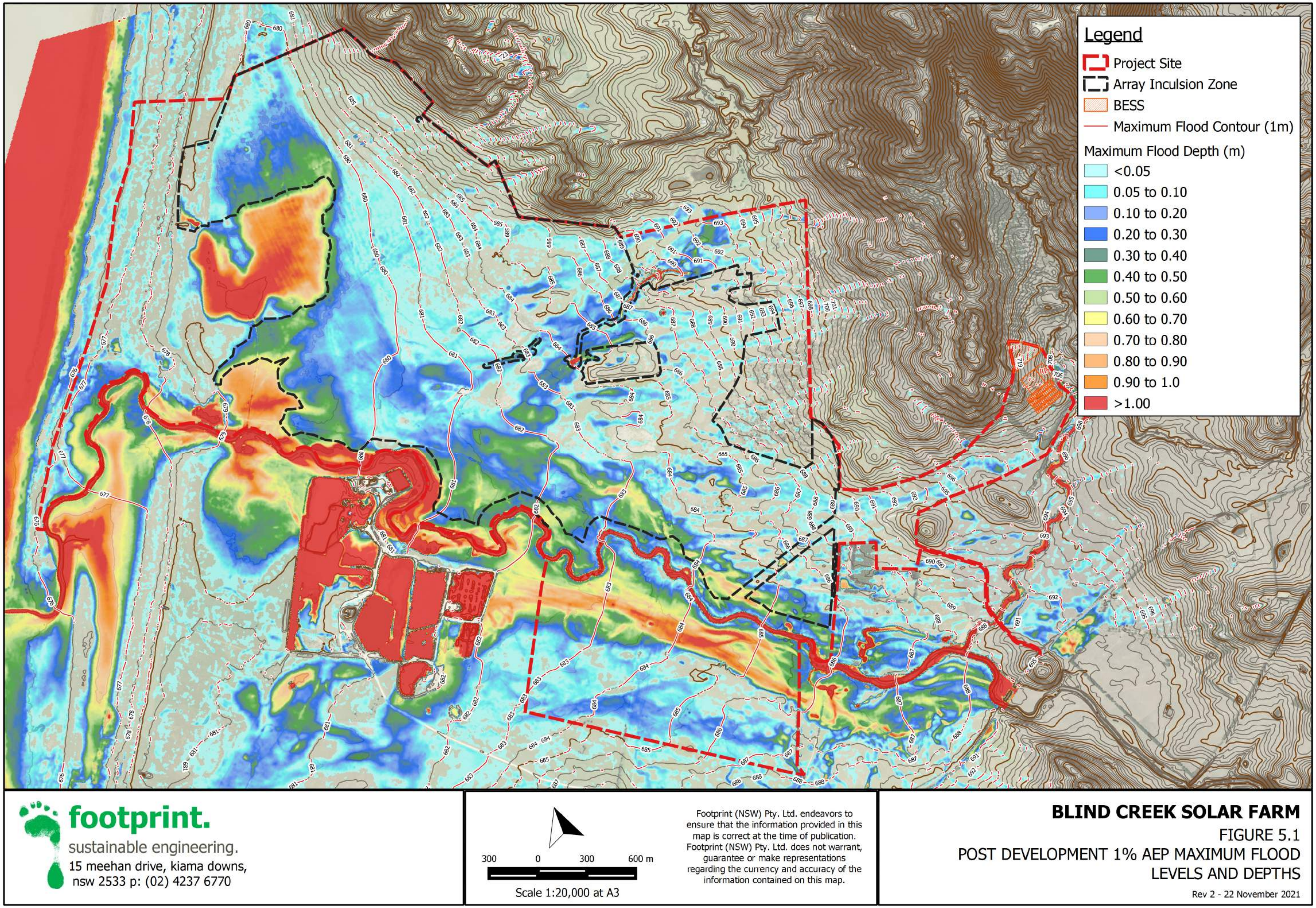

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BLIND CREEK SOLAR FARM

FIGURE 5.1

POST DEVELOPMENT 1% AEP MAXIMUM FLOOD LEVELS AND DEPTHS

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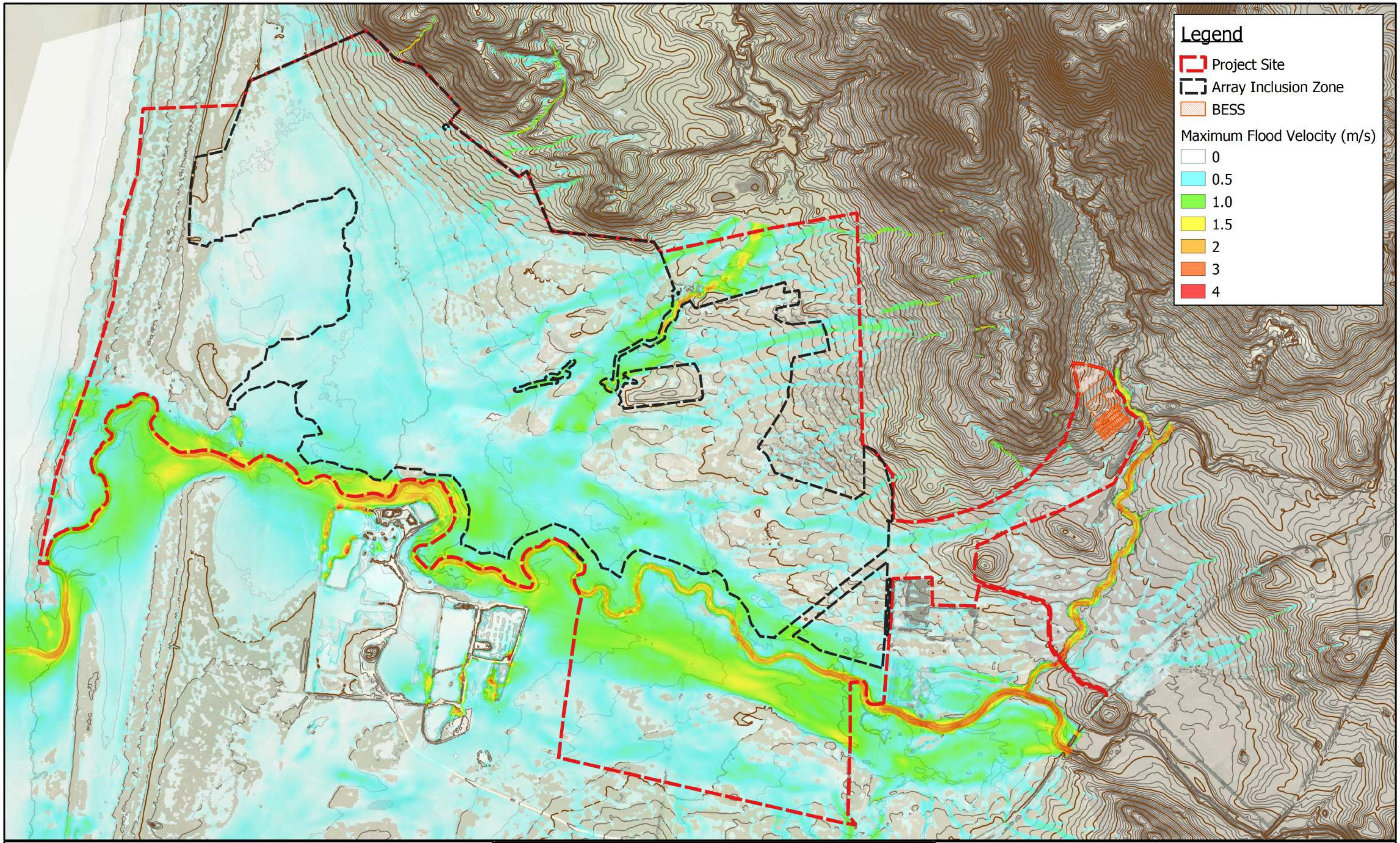

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sustainable engineering.
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300 0 300 600 m
Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 5.2

POST DEVELOPMENT 1% AEP MAXIMUM FLOOD VELOCITY

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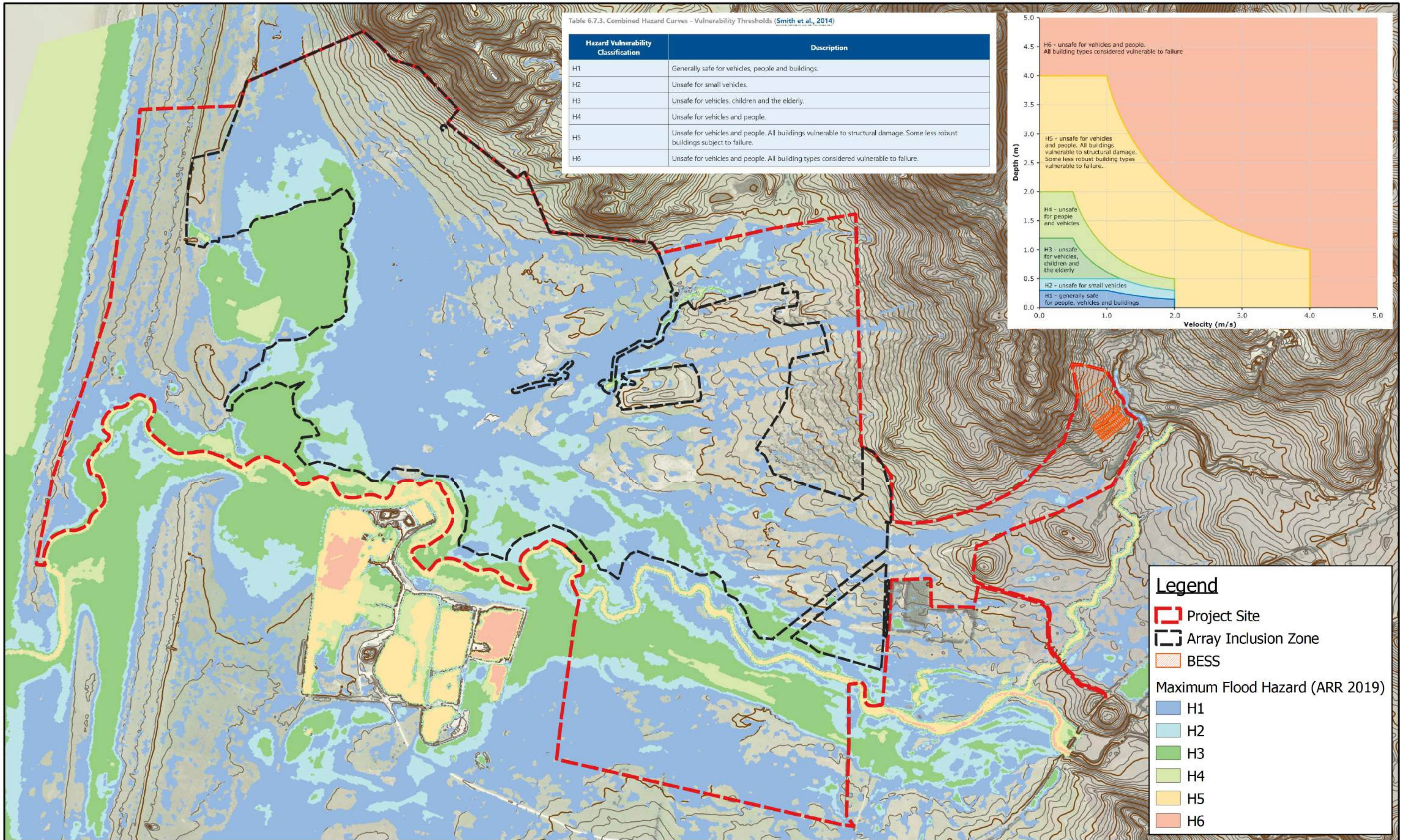

Table 6.7.3. Combined Hazard Curves - Vulnerability Thresholds (Smith et al., 2014)

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H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

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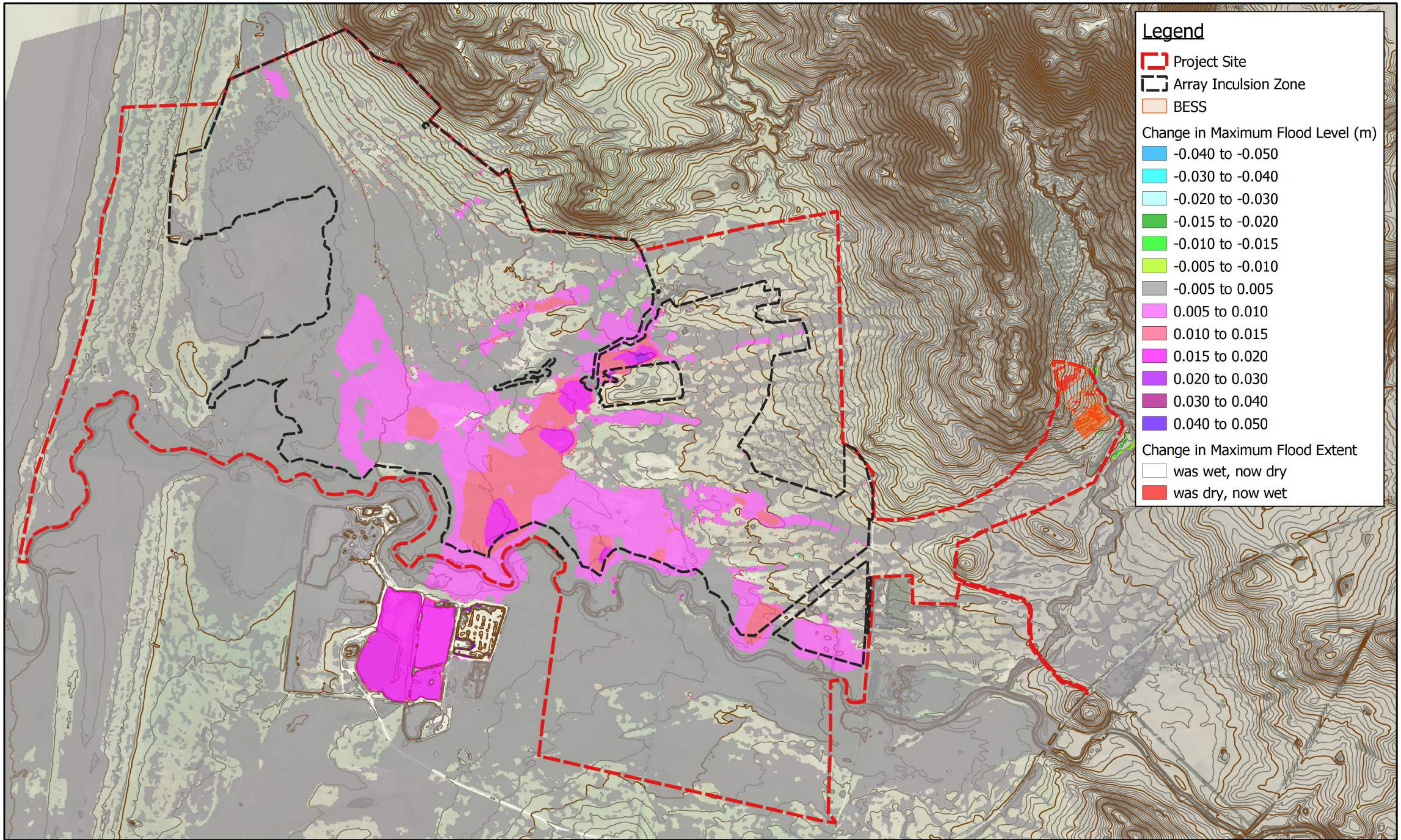
300 0 300 600 m

Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

FIGURE 5.3
POST DEVELOPMENT 1% AEP MAXIMUM FLOOD HAZARD (ARR 2019)

Rev 2 - 22 November 2021



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BLIND CREEK SOLAR FARM

FIGURE 6.1
CHANGE IN MAXIMUM FLOOD LEVEL
PRE TO POST DEVELOPMENT 1% AEP

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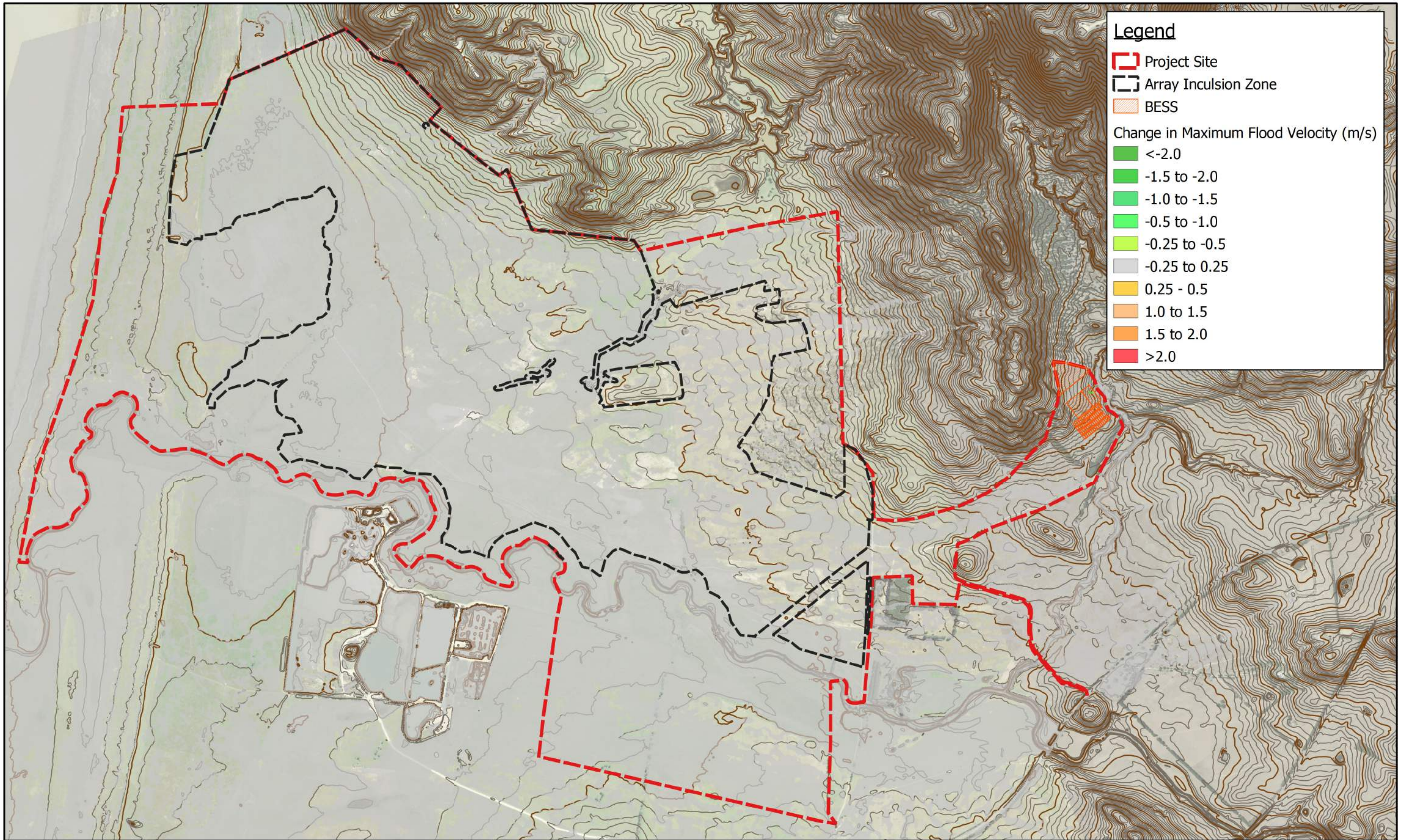

footprint.
sustainable engineering.
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300 0 300 600 m

Scale 1:20,000 at A3

BLIND CREEK SOLAR FARM

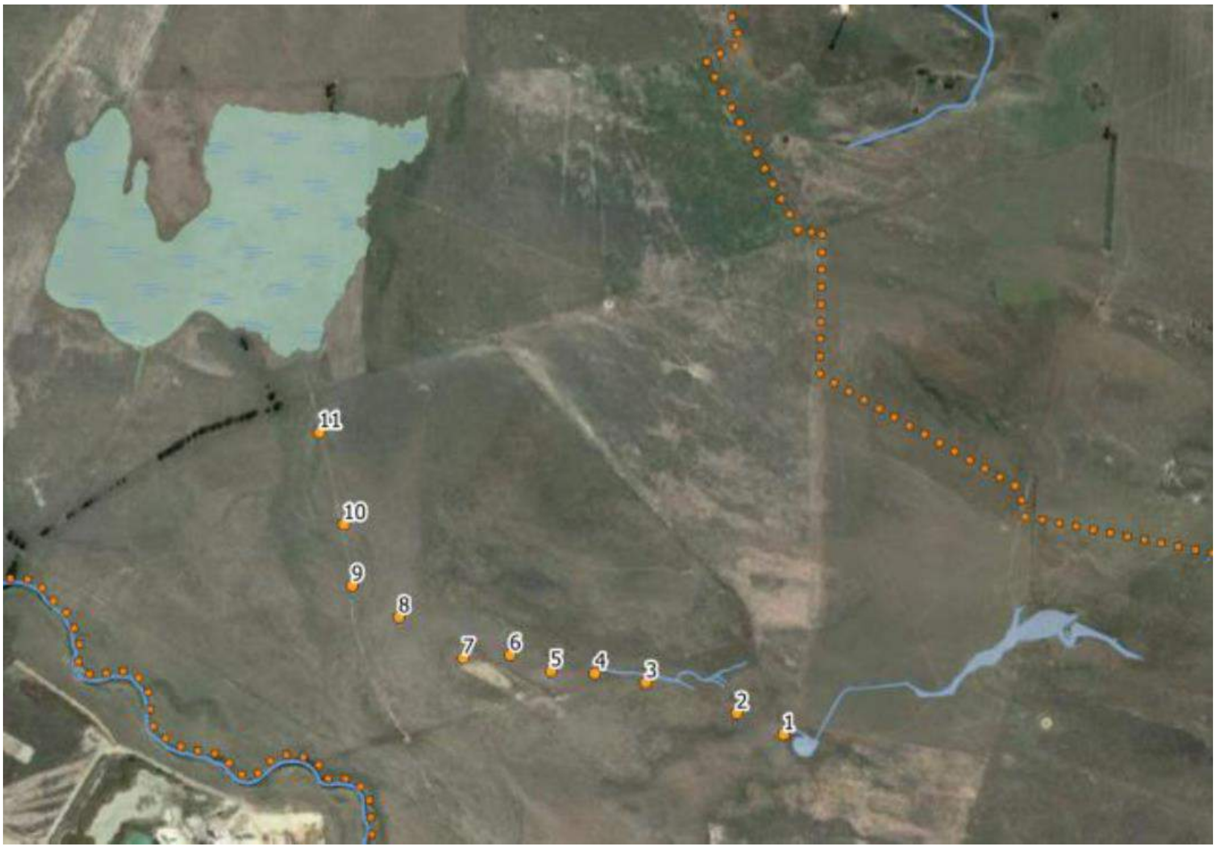
FIGURE 6.2

CHANGE IN MAXIMUM FLOOD VELOCITY PRE TO POST DEVELOPMENT 1% AEP

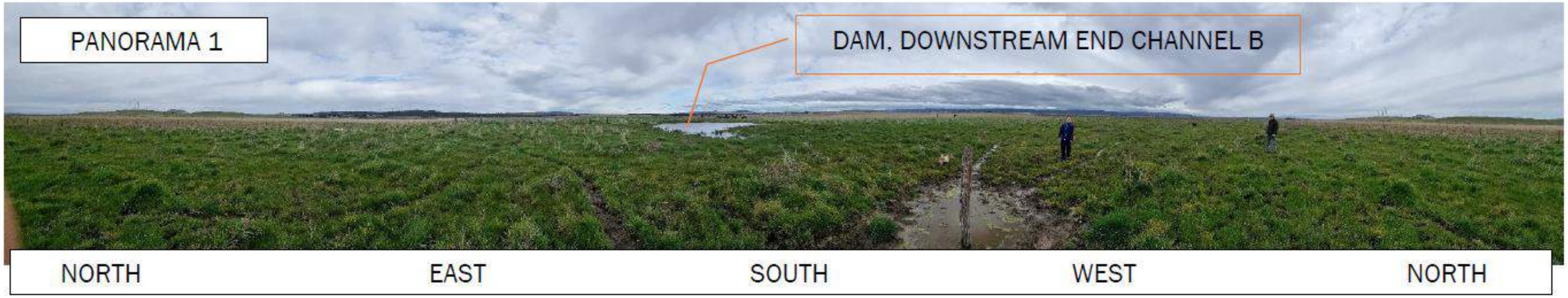
Rev 2 - 22 November 2021

APPENDIX H

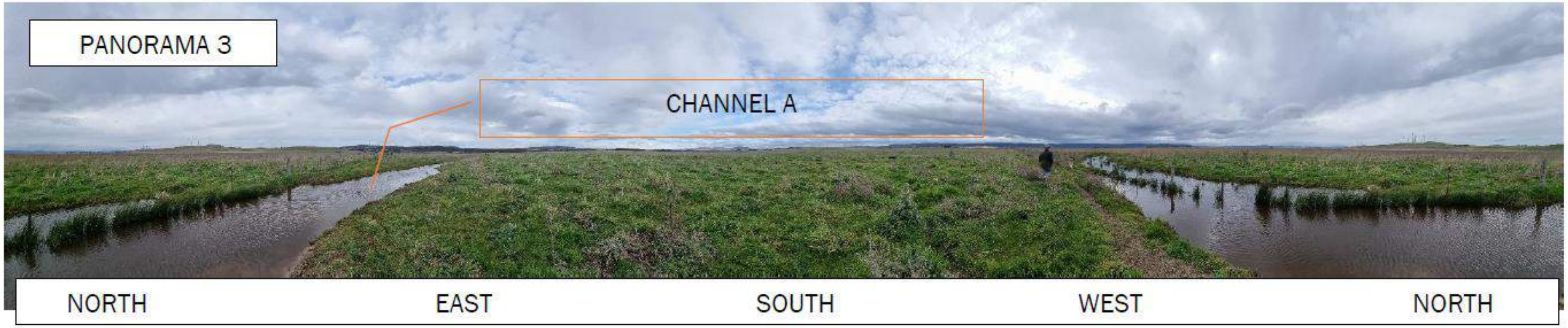
Wrights Creek Panoramic Photographs

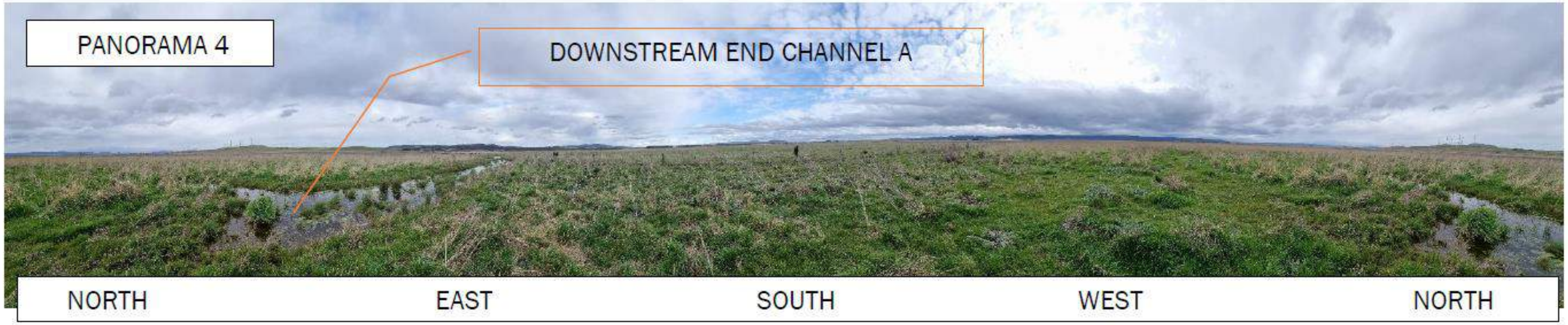


Panoramic Photograph Locations


PANORAMA 1
DAM, DOWNSTREAM END CHANNEL B
NORTH
EAST
SOUTH
WEST
NORTH

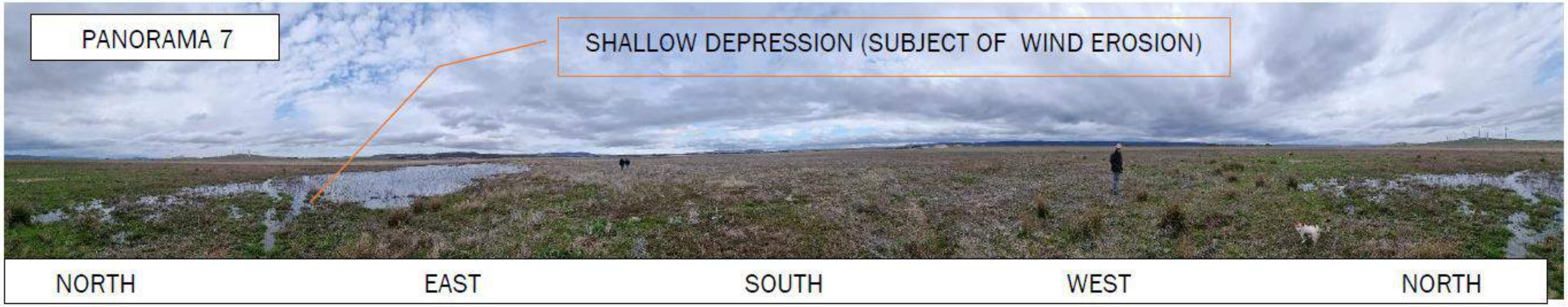

PANORAMA 2
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 3
CHANNEL A
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 4
DOWNSTREAM END CHANNEL A
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 5
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 6
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 7
SHALLOW DEPRESSION (SUBJECT OF WIND EROSION)
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 8
NORTH
EAST
SOUTH
WEST
NORTH


PANORAMA 9
SEEPAGE ALONG TRACK
NORTH
EAST
SOUTH
WEST
NORTH