Appendix G Updated Hydrology Assessment

Proposed Oxley Solar Farm, Armidale, New South Wales

Hydrological and Hydraulic Analysis

Project No. 1912
Date: 20 June 2022

Prepared for: NGH 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

Document and Distribution Status

Author(s)	Reviewer(s)	Signatures
Ashley Bond		

Revision No.	Status	Release Date	Document Distribution					
			Bridget Poulton (ngh)	Jane Blomfield (ngh)	Tammy Vesely (ngh)			
1	DRAFT	12/10/20	PDF					
2	FINAL	19/10/20		PDF				
3	AMENDED	24/10/20		PDF				
4	AMENDED	27/01/21		PDF				
5	AMENDED	20/06/22			PDF			

Distribution Types: F = Fax, H = Hard Copy, P = PDF, E = Other Electronic Document. Digits indicate number of copies.

TABLE OF CONTENTS

APPENDICES

APPENDIX A

Catchment Plan

APPENDIX B

ARR Hub Data

APPENDIX C

Rainfall Depths

APPENDIX D

Pre-burst Rainfall Depths

APPENDIX E

Flow Hydrographs

APPENDIX F

RFFE Method Results

APPENDIX G

Adopted Manning's Values

APPENDIX H

Flood Mapping

APPENDIX I

Stream Order

1.0 INTRODUCTION

Footprint (NSW) Pty. Ltd. (*Footprint*) has been engaged by NGH to undertake a hydrological and hydraulic analysis in support of a proposed solar farm located approximately 14km east of Armidale, NSW.

The purpose of the analysis is to define the flood behaviour, including depth of inundation and flood velocity over those parts of the Gara River and Commissioners Waters within the proposal area and the numerous ephemeral watercourses/overland flow paths that traverse the proposal area. 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.

1.1. Scope of Works

The scope of works for the project includes:

1. Review available background information including LiDAR data, topographic maps, proposed development plans.
2. Undertake hydrologic calculations to determine critical storm durations for the 5% AEP, 1% AEP and extreme rainfall events.
3. 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 both the pre development scenario and the 1% AEP event only for the 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.

2.0 PROPOSAL AREA

The Oxley Solar Farm proposal is to be situated over three land parcels located approximately 14km east of Armidale, New South Wales.

The proposal area occupies an area of approximately 1,048 hectares and includes Lot 5 DP253346, Lot 6 DP625427, Lots 1 and 2 DP1206469 and Lots 7003 and 7004 DP1060201, of which approximately 267 hectares would be developed for the solar farm and associated infrastructure (Development Footprint).

The location and extent of the proposal area in relation to Armidale is shown in Figure 1.

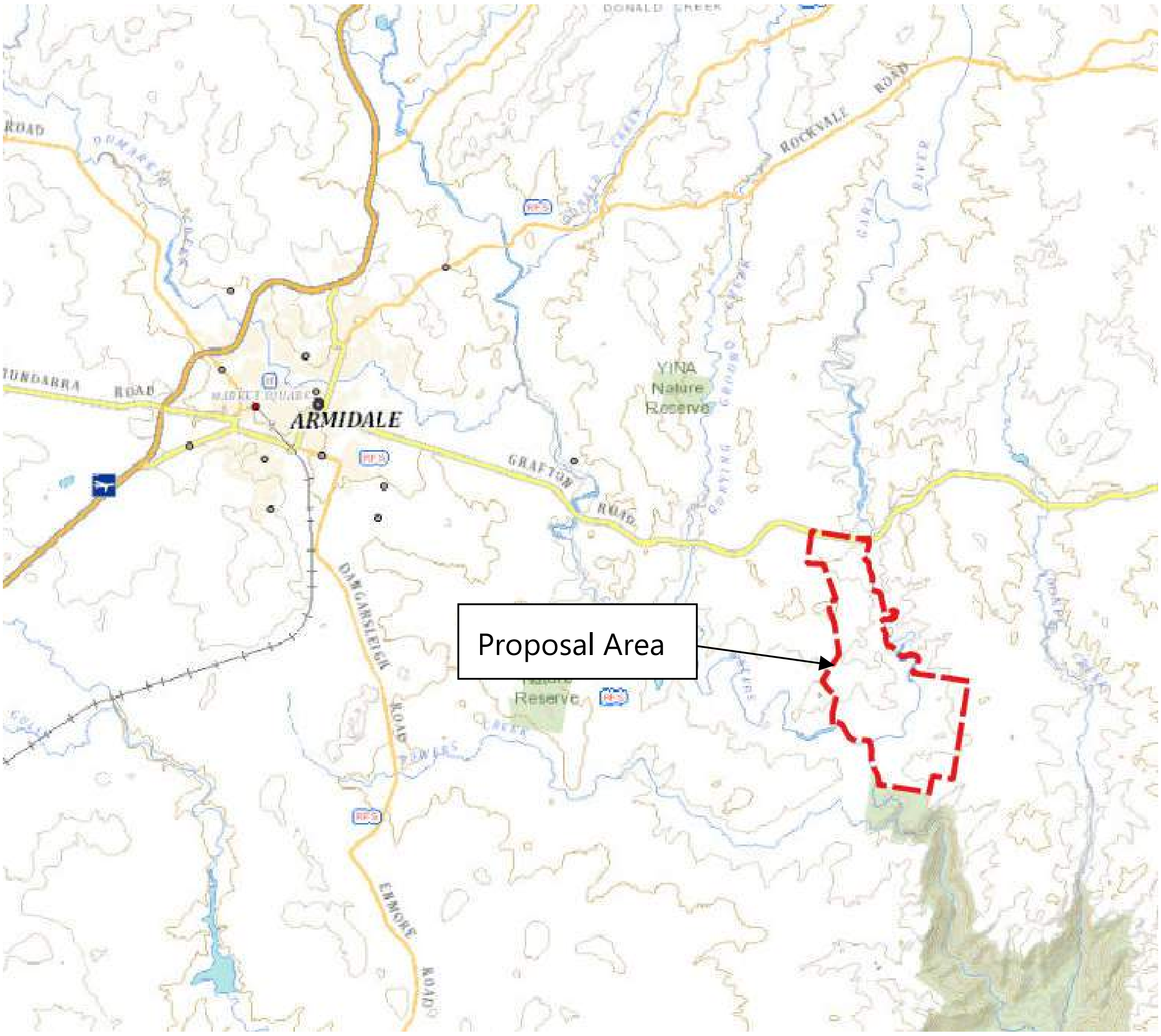


Figure 1: Location and Extent of Proposal Area

The proposal area is traversed by two major watercourses in the Gara River, which traverses the proposal area in a north-south direction, and Commissioners Waters, which traverses the proposal area in a west-east direction. These two watercourses meet on the western boundary in the southern portion of the proposal area before entering the Gara Gorge within the Oxley Wild Rivers National Park which abuts the southern boundary of the proposal areas shown in Figure 2. The proposal area also contains numerous other minor un-named tributaries of the above creeks, most of which are first or second order watercourses.

Except for the two primary watercourses all other watercourses within the proposal area would be described as ephemeral and would only contain flowing water during and shortly after rainfall events.

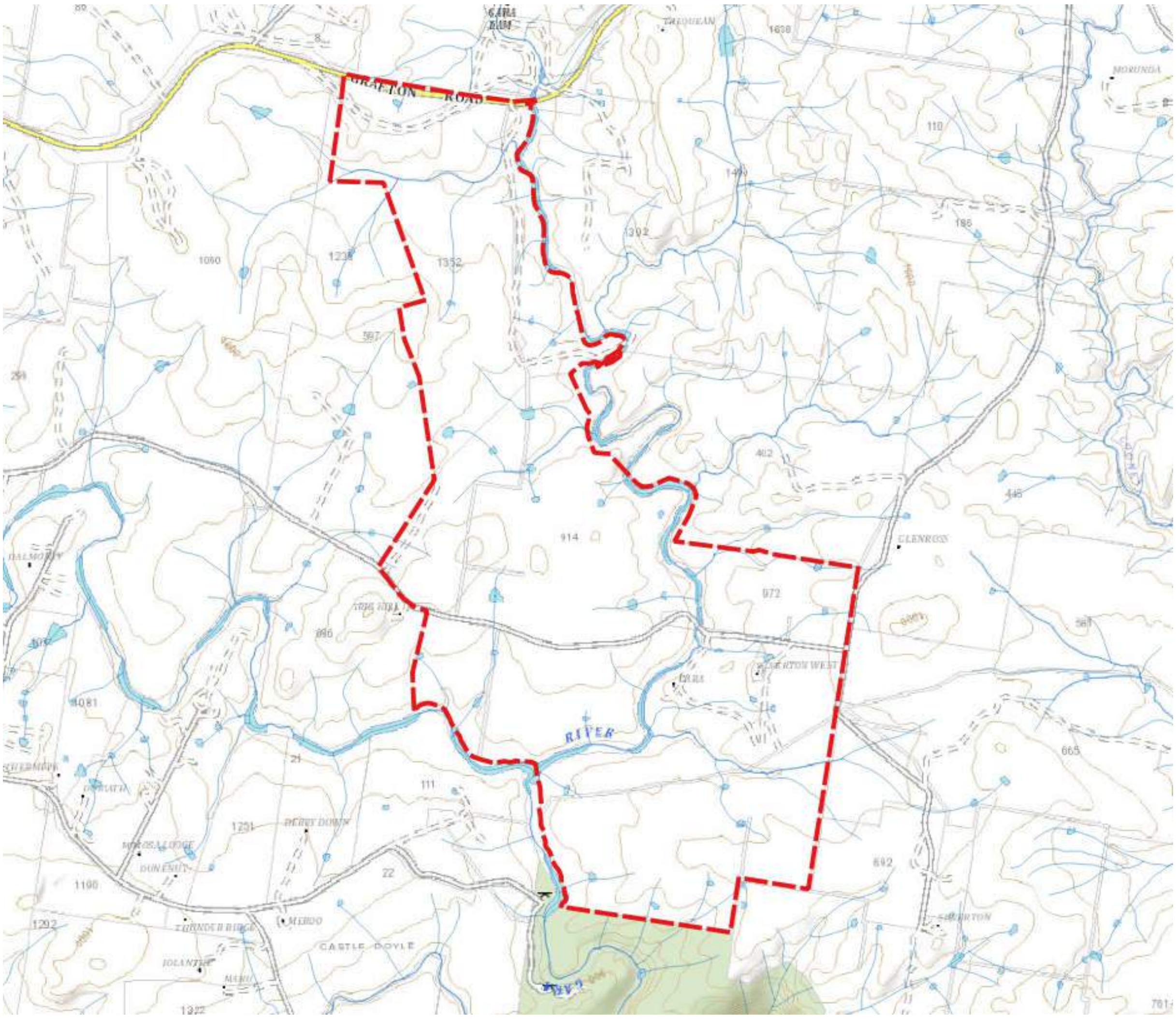


Figure 2: Watercourses within Proposal Area

The proposal area has been extensively cleared of woody vegetation and has been highly modified by historical farming practices as depicted in Figure 3.

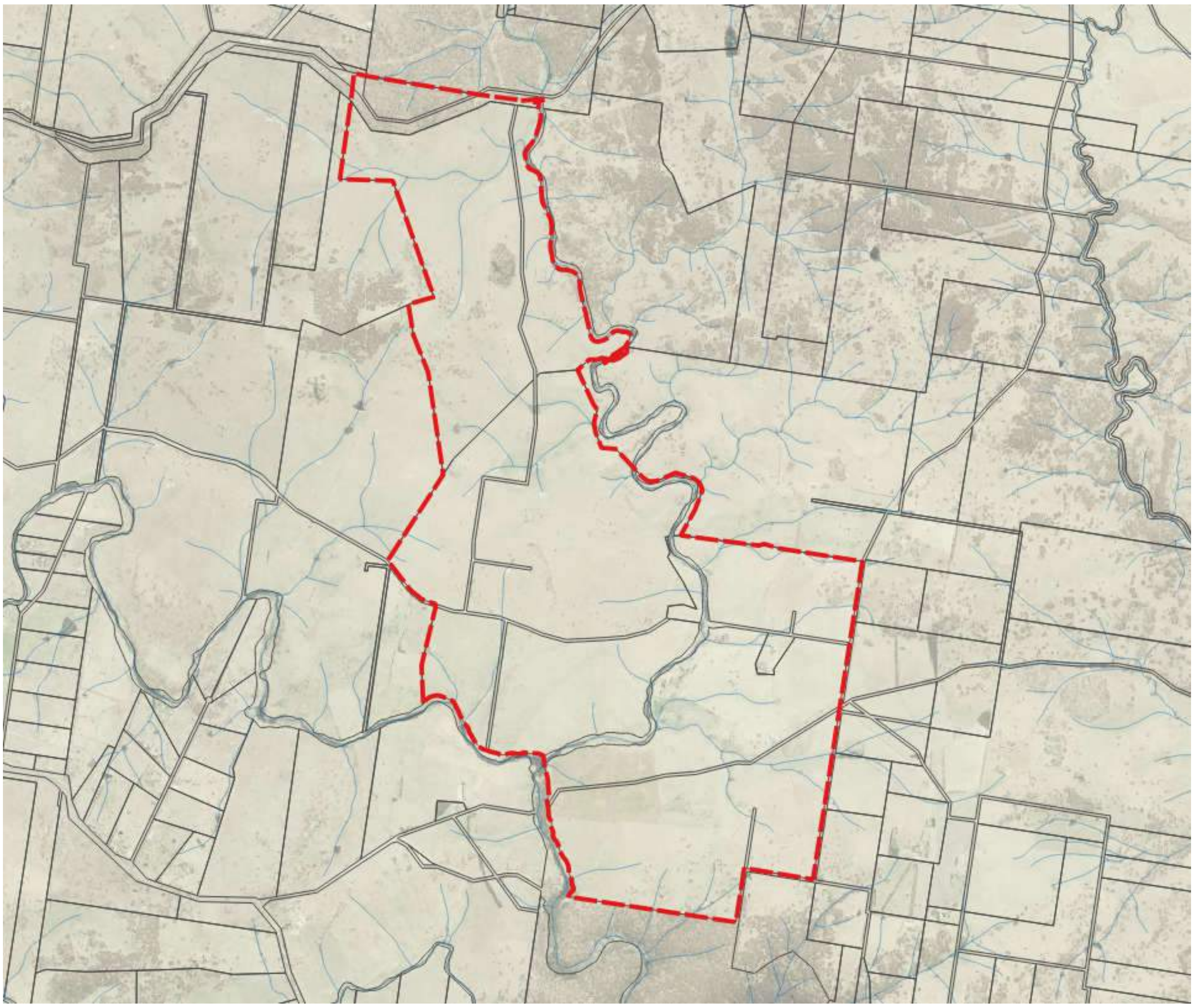


Figure 3: View of Proposal Area (outlined in red)

The proposal area typically falls from north to south with elevations ranging from about 1015m AHD to 905m AHD.

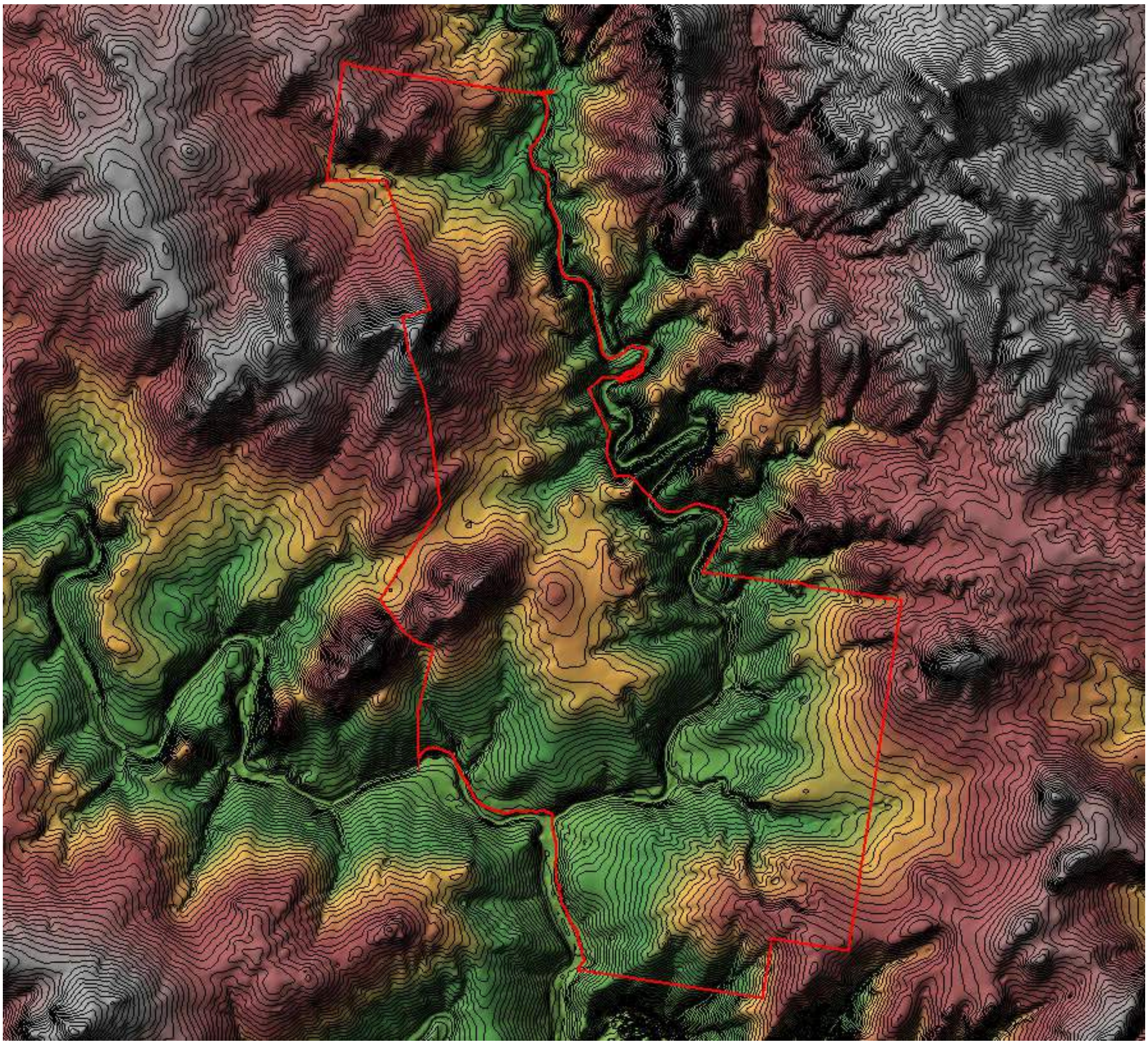


Figure 4: Terrain Analysis over Proposal Area (2m contour interval)

3.0 HYDROLOGICAL MODELLING

3.1. Purpose

Hydrological modelling was conducted to:

i. Determine peak inflow hydrographs for the Gara River and Commissioner Waters at the northern and western edges of the proposal area respectively, and
ii. determine the critical storm duration and median storm within the ensemble for the two-dimensional direct rainfall hydraulic model over the proposal area itself.

3.2. Model Adoption

Hydrological modelling was conducted using XP-RAFTS and was chosen because it is widely used and accepted across Australia within the industry and has been shown to be insensitive to initial conditions.

3.3. Catchment Areas

The total catchment area draining to the Oxley Wild River National Park at the southern extent of the proposal area is estimated to be approximately and was determined using 1 second Digital Elevation Models (DEM) covering the catchment area which was obtained through the Australian Foundation Spatial Data web portal. Of the 900km^2 the Gara River contributes approximately 430km^2, whilst Commissioners Waters contributed approximately 470km^2.

The overall catchment was dissected into 26 sub-catchments using hydrologic analysis software package Catchment SIM and ranged in size from approximately 5km^2 to 61km^2, with an average size of approximately 35km^2. 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.

3.4. 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)	15	Value obtained through ARR data hub (refer Appendix B)
Pervious Area Continuing Loss (mm/h)	1.7	40% of the value obtained through ARR data hub (refer Appendix B) in accordance with recommended NSW loss hierarchy (level 5)
BX	1	RAFTS Default
Sub-catchment Area (ha)	Varies	As per Figure 1.1 in Appendix A
Impervious Area (%)	Varies	As per Figure 1.1 in Appendix A
Sub-catchment Slope (%)	Varies	As per 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.

3.5. Rainfall Data

3.5.1. 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 East Coast South region was used as these cover the subject site (latitude -30.38, longitude 1501.724).

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).

The 0.05% AEP (2000yr ARI) was adopted for modelling of the extreme rainfall event.

3.5.2. Pre-Burst Rainfall

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

3.6. Flow Routing

The routing of flows through the catchment was undertaken by adopting an average link velocity of 2m/s, which is considered reasonable for a catchment of this nature.

3.7. Results

The XP-RAFTS hydrological model was run for storm durations ranging from 30 minutes to 12 hours using a one-minute time step and the results from the critical storm duration and median storm from the ensemble for the range of events modelled are shown in Table 2.

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	Node	Critical Duration	Peak Flow at Outlet (m^3/s)
5% AEP	1.08	9 hours	512
	2.05	6 hours	1016
1% AEP	1.08	9 hours	781
	2.05	6 hours	1453
0.05% AEP	1.08	9 hours	1257
	2.05	6 hours	2190

Flow hydrographs for each of the events are provided in Appendix E.

3.7.1. Comparison to Regional Flood Frequency Model

A comparison of 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 5, with a copy of the RFFE Model report contained in Appendix F.

The comparison shows that peak flows derived by the XP-RAFTS hydrological model are very close to the median discharge for the 5% AEP event but about 33% lower for the 1% AEP event compared to those estimated by the RFFE Model, but well within the confidence limits and are therefore considered reasonable for the purposes of this assessment.

Table 3: Comparison to RFFE Model

AEP	Peak Flow Rate (cumecs)			
	XP-RAFTS	Regional Flood Frequency Estimation Model		
		Discharge	Lower (5%)	Upper (95%)
5%	1,460	1,550	704	3,460
1%	2,104	3,190	1,290	7,920

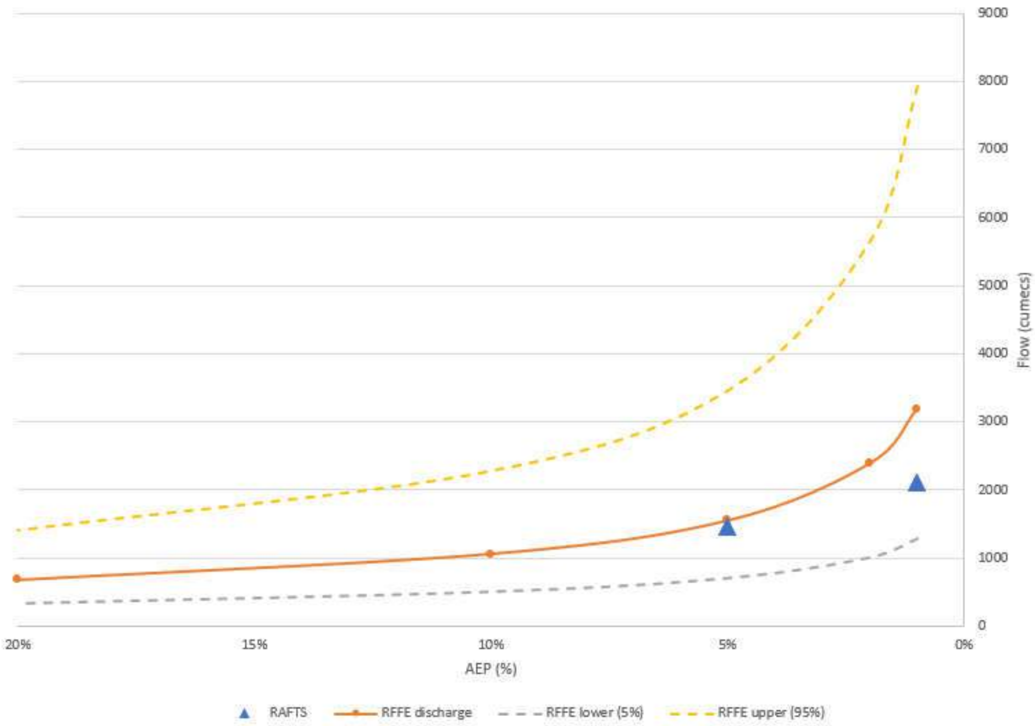
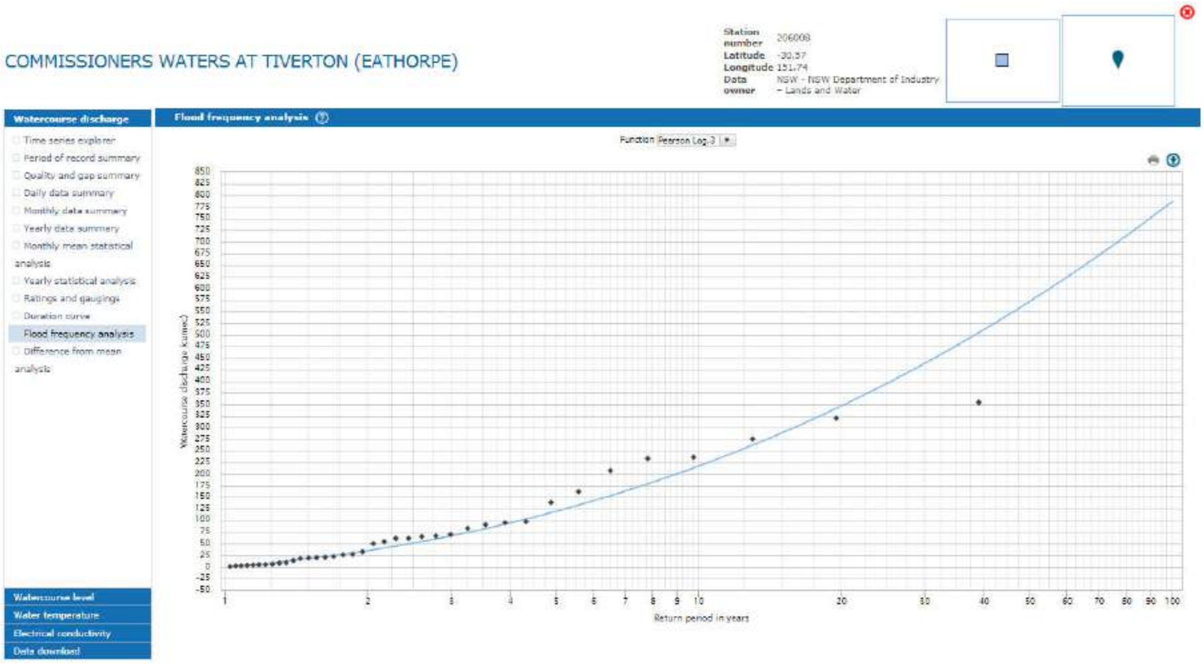


Figure 5: Comparison to RFFE Model

3.7.2. Comparison to Flow Gauge

NSW Department of Industry and Environment, through Water NSW, operate a water gauge (Station 206008) which includes depth measurement and discharge based on a cross section survey and rating table. The gauge is located on Commissioners Waters, downstream of Armidale and to the south of Waterfall Way, at latitude -30.57 and longitude 151.74. Depth data has been recorded since 1975.

A review of the flood frequency analysis at this gauge, using a Log Pearson method from the Bureau of meteorology Water Data Online website (http://www.bom.gov.au/waterdata/) shows a 5% AEP flow of approximately $345m^3/s$ and a 1% AEP flow of $790m^3/s$. The gauge location coincides approximately with the rainfall runoff model catchment node 2.04. The modelled 5% AEP flow at this point is $911m^3/s$ and the 1% AEP flow is $1266m^3/s$. suggesting that the model may be overestimating flows at this point, particularly for the more frequent events.



A separate RFFE model was obtained for the Commissioners Waters coinciding with the approximate location of the above gauge and the results estimate a 5% AEP flow of $581m^3/s$ and a 1% AEP flow of $1,190m^3/s$. The 1% AEP flow closely matching that predicted by the RAFTS Model.

Whilst it is acknowledged that there are some differences between the gauged and modelled flows the calibration of flow data against the gauged data is outside the scope for this project. The results of the modelling suggest that the model may be overestimating flows at this point, particularly for the more frequent events, however this is considered conservative as it will result in slightly higher flood levels at the proposal area downstream of this point.

4.0 HYDRAULIC MODELLING

Hydraulic modelling was conducted using an unsteady two-dimensional HEC-RAS model (Version 5.0.7).

4.1. Two-Dimensional Domain

A digital elevation model (DEM) covering the proposal area was established using a series of 2m gridded digital elevation models (Armidale201505.asc) sourced from www.elevation.fsdf.org.au.

A two-dimensional flow area (i.e. active cells) was defined over an area covering the proposal area as shown in Figure 2.1 in Appendix G.

The 2m DEM grid was imported into HEC-RAS and used as the basis for development of a 10m x 10m terrain model. The DEM grid was further refined where required by applying breaklines to enforce critical changes in geometry, such as at dam walls.

4.2. Manning's Roughness

Manning's roughness values adopted for the hydraulic modelling are shown in Figure 2.1 in Appendix G and were based on a desktop assessment using available aerial photography.

4.3. Inflow Boundary Conditions

4.3.1. Inflow Hydrographs

The hydrographs derived using XP-RAFTS were used to define the boundary conditions at the upstream edge of the two-dimensional flow area to represent inflows arriving from both the Gara River and Commissioners Waters for each of the modelled events.

Hydrographs for 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.

4.3.2. Direct Rainfall

Within the active domain (two-dimensional flow area) a direct rainfall boundary condition was adopted which applies precipitation directly to the surface of the grid to perform two-dimensional hydraulic calculations.

The current limitation of HEC-RAS 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 storm events shown in Table 2 were generated in Microsoft Excel by subtracting initial and continuing 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, 2-hour storm event is shown in Figure 6.

The critical storm duration and median storm from the ensemble used in the establishment of rainfall depths for the direct rainfall model for each storm event were established by interrogating the XP_RAFTS results for sub-catchment 1.09 which covers the proposal area.

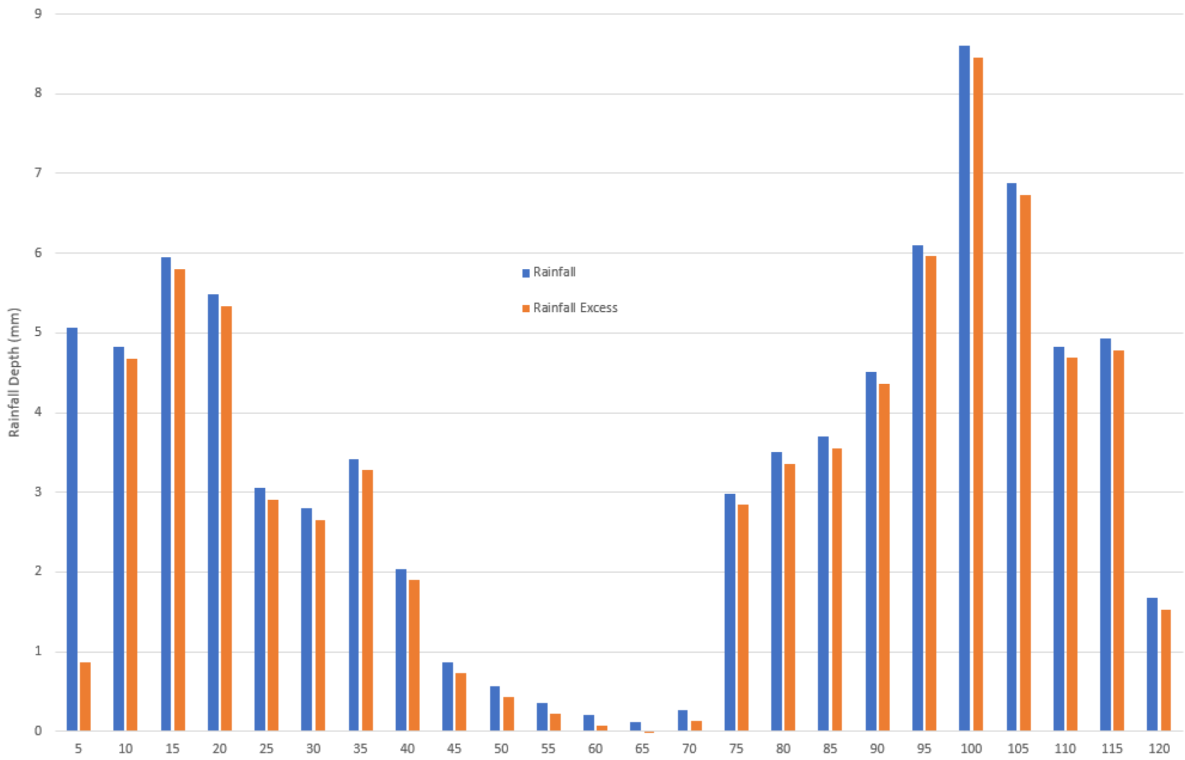


Figure 6: 1% AEP Hyetograph

4.3.3. Downstream Boundary Condition

Flows leaving the two-dimensional area were defined with a normal depth downstream boundary condition with a friction slope approximating the gradient of the land at the location of the boundary. The friction slope method uses the Manning's equation to compute a normal depth for each given flow, based on the cross section underneath the two-dimensional boundary condition line and is computed on a per cell basis.

4.4. 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 H 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 3.1	Maximum Flood Levels and Depths – 5% AEP
Figure 3.2	Maximum Flood Velocities – 5% AEP
Figure 3.3	Maximum Flood Hazard – 5% AEP
Figure 4.1	Maximum Flood Levels and Depths – 1% AEP
Figure 4.2	Maximum Flood Velocities – 1% AEP
Figure 4.3	Maximum Flood Hazard – 1% AEP
Figure 5.1	Maximum Flood Levels and Depths – PMF
Figure 5.2	Maximum Flood Velocities – PMF
Figure 5.3	Maximum Flood Hazard – PMF

4.5. Hazard Vulnerability

The flood hazard vulnerability over the proposal area was mapped in accordance with Table 6.7.4 of Australian Rainfall and Runoff (2019) and is shown in Figures 3.3, 4.3 and 5.3 in Appendix H for the 5%AEP, 1%AEP and PMF events respectively.

The mapping shows that flooding within the proposal area is primarily classified as a H1 hazard vulnerability in the 5% AEP and 1% AEP events, except for flooding within Gara River and Commissioners Waters which reaches H6 classification and flooding within some of the minor tributaries and existing farm dams where classification typically ranges from H1 to H4. As expected, hazard increases over the proposal area in the 0.05 AEP (extreme) event.

Table 6.7.3 of Australian Rainfall and Runoff (below) describes the hazard thresholds for community interaction with floodwaters.

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.

5.0 IMPACT OF PROPOSED WORKS

5.1. Proposal Description

The proposal would involve the construction of a ground-mounted photovoltaic (PV) solar fixed or tracking array generating around 215 MW AC of renewable energy. The power generated would be exported to the national electricity grid.

Key development and infrastructure components would include:

- Approximately 385,280 PV solar panels mounted on either fixed or tracking systems, both of which are considered feasible:
  - Fixed-tilted structures in a north orientation at an angle of 32 degrees or
  - East-west horizontal tracking systems.
- Approximately 43 Power Conversion Units (PCU) composed of two inverters, a transformer and associated control equipment to convert DC energy generated by the solar panels to 33kV AC energy.
- Steel mounting frames with driven or screwed pile foundations.
- An onsite 132kV outdoor substation containing two transformers and associated switchgear to facilitate connection to the national electricity grid via the existing 132kV transmission line onsite.
- Underground power cabling to connect solar panels, combiner boxes and PCUs.
- Underground auxiliary cabling for power supplies, data services and communications.
- Buildings to accommodate a site office, 33kV switchgear, protection and control facilities, maintenance facilities and staff amenities.
- About 2km of access track off Waterfalll Way to the site.
- Up to 50 kilometers of 7m wide internal gravel access tracks for construction, operation and maintenance activities.
- An energy storage facility with a capacity of up to 50 MWh and comprising of lithium-ion batteries with inverters.
- Perimeter security fencing up to 2.3m high with anti-climb topping.
- Native vegetation planting to provide visual screening for specific receivers, if any are required.

During the construction phase, temporary ancillary facilities would be established on the site and may include:

- Laydown areas.
- Construction site offices and amenities.
- Car and bus parking areas for construction staff.

In total, the construction phase of the proposal is expected to take approximately 12 to 18 months, and the facility would be expected to operate for around 30 years. At the end of its operational life, the facility would be decommissioned, or may be refurbished to continue operations.

5.2. 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 5-6m. 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 5. 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 which are variable across the site 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 5: 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 values shown in Figure 2.1 in Appendix F over the extent of the proposed solar array footprint.

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 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.

Furthermore, watercourse crossings have not been included in the model as fords or bridges, which minimise any hydraulic impact, have been recommended for minor tributaries (see Section 6.4), otherwise an existing crossing of the Gara River will be utilised.

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 6.1, 6.2 and 6.3 in Appendix H.

The results in Figures 6.1, 6.2 and 6.3 demonstrate that there is not predicted to be a significant impact on flood behaviour for the 1% AEP event as a result of the proposed works, with flood level, depths, velocities and hazards remaining largely unchanged.

This is better demonstrated in Figures 7.1 and 7.2 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 unchanged across most of the proposal area, due primarily to most of the infrastructure being located outside the floodplain. Some minor increases in flood levels and corresponding decreases in velocity are shown to occur with proposed laydown, parking and building areas, however these changes are very localised and are not anticipated to adversely impact on adjoining properties.

6.0 FLOOD MANAGEMENT RECOMMENDATIONS

6.1. 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.

6.2. Flood Management

Access to parts of the site may not be possible due to flooding within the Gara River which would likely render the existing crossing impassable during significant flood events and therefore it is recommended that:

i. Flood warning signs and flood level indicators should be placed on each approach to the existing crossing.
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"

It is noted that emergency access from both sides of the Gara River back to Waterfall Way is possible using Gara Road to the west and Gara Road and Silverton Road to the east.

6.3. 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 6.1 and 6.2 respectively in Appendix H.

6.4. Electrical Infrastructure

All electrical infrastructure, including power conversions stations and the proposed substation, 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.

6.5. 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 Gara River or Commissioners Waters should be avoided in preference to creating separate fenced compounds on either side of the creeks.

6.6. Watercourse Crossings

Watercourses on the subject site have been classified by the Strahler System in accordance with the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012) and are shown in Figure 8.1 in Appendix I. Any road crossings on watercourses within the subject site should be of the type defined in Table 2 of this same document (see extract below).

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, and, in the case of vehicular crossings should preferably consist of bed level crossings constructed flush with the bed of the watercourse on first and second order watercourses to minimise any hydraulic impact:

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)

6.7. Access Roads

Within the floodplain access roads should be constructed as close to natural ground levels as possible so as not to form an obstruction to floodwaters.

The surface treatment of roads should be designed giving regard to the velocity of floodwaters to minimise potential for scouring during flood events.

6.8. 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

7.0 SEAR'S COMPLIANCE

The Department of Planning and Environment issued environmental assessment requirements (SEARs) for the preparation of an Environmental Impact Assessment (EIS) for the proposed development on 02 August 2019, which included requirements from the Office of Environmental and Heritage (OEH) pertaining to flooding. Table 6 below demonstrates how this report addresses the OEH SEAR's requirements with respect to flooding.

Table 6: Assessment of Compliance with SEAR's

OEH Requirement	**Response**
13. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005), including:	
a. Flood Prone Land.	Flood Prone Land for the 5% AEP, 1% AEP and PMF have been defined over the proposal area as defined in Section 4.4 of this report.
b. Flood Planning Area, the area below the flood planning level.	Whilst an important tool in the management of flood risk the delineation of a flood planning areas is not considered relevant for the proposed development as the development does not comprise filling or habitable structures within the floodplain. Notwithstanding, Section 6.3 recommends setting proposal solar array panels a minimum of 500mm above the 1% AEP flood level.
c. Hydraulic Categorisation (floodways and flood storage areas).	Hydraulic categorisation is not considered relevant for the proposed development as they are a tool to assist in the preparation of appropriate floodplain risk management plans. The Floodplain Development Manual (2005) states that "they are not to be used for assessment of development proposals on an isolated or individual basis".

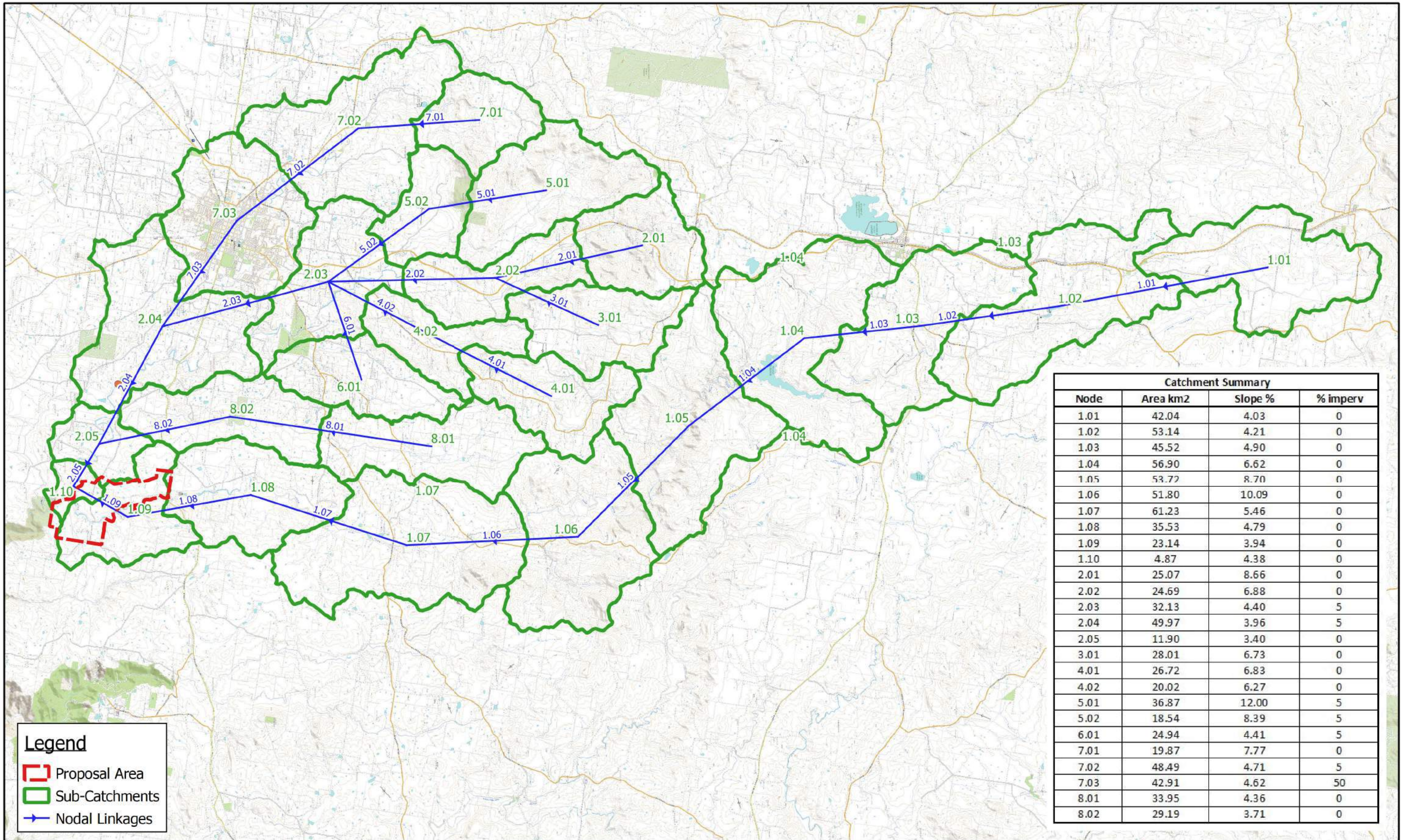
d. Flood Hazard.	Flood Hazard Categorisation for all design storm events modelled was undertaken in accordance with Table 6.7.4 of Australian Rainfall and Runoff (2019) and is included in Section 4.5 of this report.
14. The EIS must describe the flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% AEP, 1% AEP flood levels and the PMF, or equivalent extreme event.	The methodology and modelling undertaken in determining flood levels and velocities is described in details in Sections 3.0 and 5.0 of this report.
15. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios:	
a. Current flood behaviour for a range of design events as identified in 14 above. This includes the 0.5% and 0.2% year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	The impact of the proposed development on flood behaviour is described in detail in Section 5.0 of this report. Modelling for 1% AEP only was undertaken and shows minimal impact on existing flood behaviour. It is not considered necessary to model the 0.5% and 0.2% AEP events as proxies for assessing the sensitivity to an increase in rainfall intensity as the proposed development is relatively insensitive to flooding and will incorporate measures (such a solar array panels being a minimum of 500mm above the 1% AEP flood level) to minimise flood damages to proposed infrastructure.
16. Modelling in the EIS must consider and document:	
a. Existing Council flood studies in the area and examine consistency to the flood behaviour documented in these studies.	No existing studies are known to exist within proximity of the proposal area.
b. The impact on existing flood behaviour for a full range of flood events including up to the probably maximum flood, or equivalent extreme flood.	The impact on existing flood behaviour up to the 0.05% AEP (2,000 year ARI) event has been included in this assessment.

a. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazard categories and hydraulic categories	Section 5.0 of this report demonstrates that the impacts of the proposed development are very minor change in flood level and velocity within the proposal area. Importantly the modelling demonstrates that changes in peak flood levels are limited to within the proposal area and are therefore not anticipated to adversely affect adjoining properties
d. Relevant provision of the NSW Floodplain Development Manual 2005	This report is considered to address the relevant provisions of the NSW Floodplain Development Manual.
17. The EIS must assess the impact on the proposed development on flood behaviour including:	
a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure.	The post development modelling presented in Section 5.0 shows that the proposed development will have negligible impact on existing flood behaviour, and no change in flood behaviour on other properties, assets or infrastructure.
b. Consistency with Council Floodplain Risk Management Plans	No known Floodplain Risk Management Plan exists for the proposal area.
c. Consistency with any Rural Floodplain Management Plan	No known Rural Floodplain Management Plans exist for the proposal area.
d. Compatibility with the flood hazard of the land	The development is compatible with the flood hazard of the site as infrastructure proposed as part of the development is typically located on low flood hazard land.
e. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land.	The layout proposed infrastructure has been undertaken in consideration of flood risk with development located outside land subject to mainstream flooding and where located within the floodplain typically located on land with low associated flood risk.

f. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	The proposed development will not result in any change to the current flooding regime on the proposal area and beneficial inundation of the floodplain environment will continue to occur.
g. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Section 5.0 indicates that changes in peak velocity resulting from the proposed development are expected to be in the range of plus or minus 0.5m/s which will ensure the stability of the bed and banks of existing watercourses and minimise further erosion potential. Further Section 6.8 recommends that 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
h. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the NSW SES and Council.	No known community emergency management arrangement exists in proximity of the proposal area.
i. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the NSW SES and Council.	Recommendations regarding specific measures to manage the risk to life from flooding and evacuation are provided in Section 6.2 and include flood warning signs, and preparation of a Business Floodsafe Plan. Whilst not discussed with the NSW SES or Council they are considered standard flood management measures.
j. Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the NSW SES.	
k. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	The proposed development is not anticipated to have any adverse impact on the social and economic costs to the community because of flooding.

APPENDIX A

Catchment Plan



Catchment Summary			
Node	Area km2	Slope %	% imperv
1.01	42.04	4.03	0
1.02	53.14	4.21	0
1.03	45.52	4.90	0
1.04	56.90	6.62	0
1.05	53.72	8.70	0
1.06	51.80	10.09	0
1.07	61.23	5.46	0
1.08	35.53	4.79	0
1.09	23.14	3.94	0
1.10	4.87	4.38	0
2.01	25.07	8.66	0
2.02	24.69	6.88	0
2.03	32.13	4.40	5
2.04	49.97	3.96	5
2.05	11.90	3.40	0
3.01	28.01	6.73	0
4.01	26.72	6.83	0
4.02	20.02	6.27	0
5.01	36.87	12.00	5
5.02	18.54	8.39	5
6.01	24.94	4.41	5
7.01	19.87	7.77	0
7.02	48.49	4.71	5
7.03	42.91	4.62	50
8.01	33.95	4.36	0
8.02	29.19	3.71	0

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

2000 0 2000 4000 6000 m

Scale 1:170,000 at A3

OXLEY SOLAR FARM

FIGURE 1.1

CATCHMENT PLAN

Rev 2 - 24 OCTOBER 2020

APPENDIX B

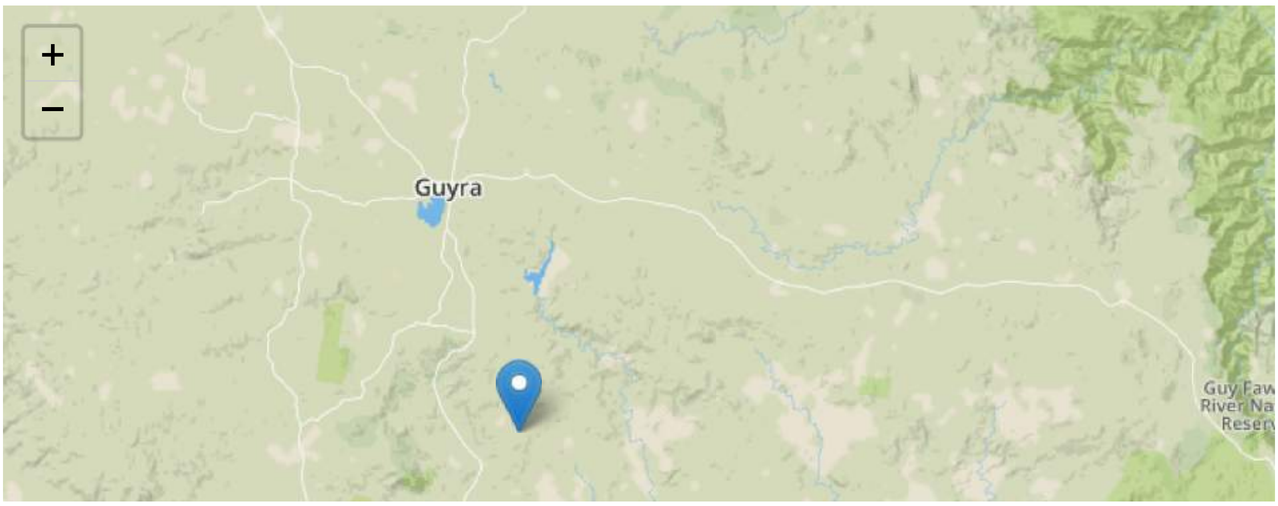
ARR Hub Data

ATTENTION: This site was updated recently, changing some of the functionality. Please see the changelog (./changelog) for further information

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	151.724
Latitude	-30.38
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	South East Coast (NSW)
River Number	6
River Name	Macleay River

Layer Info

Time Accessed	09 September 2020 12:22PM
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
East Coast North	0.327	0.241	0.448	0.36	0.00096	0.48	-0.21	0.012	-0.0013

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	09 September 2020 12:22PM
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	23453.0
Storm Initial Losses (mm)	15.0
Storm Continuing Losses (mm/h)	4.2

Layer Info

Time Accessed	09 September 2020 12:22PM
Version	2016_v1

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

code	ECsouth
Label	East Coast South

Layer Info

Time Accessed	09 September 2020 12:22PM
Version	2016_v2

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

code	ECsouth
arealabel	East Coast South

Layer Info

Time Accessed	09 September 2020 12:22PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-30.3798&longitude=151.7235&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	09 September 2020 12:22PM

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)	0.6 (0.023)	1.3 (0.034)	1.7 (0.038)	2.1 (0.040)	1.9 (0.031)	1.8 (0.025)
90 (1.5)	0.5 (0.017)	0.6 (0.015)	0.7 (0.014)	0.8 (0.014)	1.0 (0.015)	1.2 (0.015)
120 (2.0)	2.5 (0.079)	1.9 (0.044)	1.5 (0.029)	1.2 (0.019)	1.3 (0.018)	1.4 (0.017)
180 (3.0)	0.3 (0.009)	0.3 (0.007)	0.4 (0.007)	0.4 (0.006)	1.2 (0.016)	1.8 (0.021)
360 (6.0)	0.7 (0.016)	1.4 (0.024)	1.8 (0.028)	2.3 (0.030)	3.7 (0.041)	4.7 (0.046)
720 (12.0)	1.5 (0.029)	2.5 (0.038)	3.2 (0.041)	3.9 (0.043)	8.0 (0.075)	11.1 (0.092)
1080 (18.0)	0.0 (0.000)	0.3 (0.003)	0.4 (0.005)	0.6 (0.006)	11.5 (0.096)	19.7 (0.146)
1440 (24.0)	0.0 (0.000)	0.3 (0.004)	0.5 (0.005)	0.7 (0.006)	5.9 (0.045)	9.8 (0.067)
2160 (36.0)	0.0 (0.000)	0.1 (0.001)	0.1 (0.001)	0.2 (0.001)	2.8 (0.019)	4.7 (0.029)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.1 (0.001)	0.1 (0.001)	0.2 (0.002)	0.3 (0.002)
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	09 September 2020 12:22PM
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	09 September 2020 12:22PM
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)	0.2 (0.002)	0.2 (0.003)
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	09 September 2020 12:22PM
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)	12.0 (0.450)	12.1 (0.325)	12.1 (0.271)	12.1 (0.232)	14.6 (0.233)	16.4 (0.233)
90 (1.5)	8.7 (0.291)	10.4 (0.253)	11.5 (0.234)	12.6 (0.219)	10.9 (0.158)	9.6 (0.123)
120 (2.0)	16.6 (0.519)	15.5 (0.353)	14.7 (0.281)	14.0 (0.229)	13.3 (0.182)	12.8 (0.155)
180 (3.0)	10.0 (0.284)	10.9 (0.227)	11.4 (0.201)	12.0 (0.181)	17.3 (0.219)	21.3 (0.238)
360 (6.0)	13.9 (0.331)	18.8 (0.336)	22.0 (0.335)	25.2 (0.330)	30.4 (0.335)	34.3 (0.334)
720 (12.0)	14.2 (0.280)	17.6 (0.264)	19.9 (0.254)	22.0 (0.245)	39.8 (0.373)	53.1 (0.441)
1080 (18.0)	1.1 (0.020)	6.0 (0.080)	9.2 (0.105)	12.2 (0.122)	34.1 (0.285)	50.4 (0.375)
1440 (24.0)	2.3 (0.037)	5.6 (0.069)	7.8 (0.082)	9.9 (0.091)	22.4 (0.172)	31.8 (0.217)
2160 (36.0)	0.0 (0.000)	3.9 (0.042)	6.5 (0.060)	9.0 (0.072)	15.0 (0.101)	19.4 (0.118)
2880 (48.0)	0.0 (0.000)	4.4 (0.044)	7.4 (0.062)	10.2 (0.075)	10.4 (0.064)	10.5 (0.059)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.7 (0.004)	1.2 (0.006)

Layer Info

Time Accessed	09 September 2020 12:22PM
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)	34.3 (1.283)	30.0 (0.807)	27.1 (0.609)	24.4 (0.468)	45.3 (0.727)	61.0 (0.865)
90 (1.5)	24.5 (0.822)	31.4 (0.764)	36.0 (0.731)	40.4 (0.703)	38.1 (0.554)	36.3 (0.467)
120 (2.0)	34.3 (1.070)	44.3 (1.009)	50.9 (0.971)	57.2 (0.936)	57.4 (0.785)	57.4 (0.695)
180 (3.0)	28.5 (0.805)	29.1 (0.607)	29.5 (0.518)	29.9 (0.451)	84.4 (1.067)	125.3 (1.400)
360 (6.0)	52.7 (1.258)	63.1 (1.131)	70.0 (1.063)	76.7 (1.006)	92.1 (1.015)	103.8 (1.011)
720 (12.0)	30.6 (0.604)	43.1 (0.647)	51.4 (0.658)	59.3 (0.660)	78.1 (0.731)	92.2 (0.765)
1080 (18.0)	27.6 (0.484)	32.2 (0.431)	35.3 (0.403)	38.2 (0.380)	73.3 (0.614)	99.6 (0.741)
1440 (24.0)	19.4 (0.311)	25.5 (0.312)	29.6 (0.309)	33.5 (0.305)	57.8 (0.444)	76.0 (0.520)
2160 (36.0)	16.6 (0.234)	23.2 (0.250)	27.6 (0.254)	31.9 (0.256)	40.8 (0.277)	47.4 (0.287)
2880 (48.0)	4.7 (0.060)	11.5 (0.113)	16.1 (0.135)	20.4 (0.150)	32.2 (0.200)	41.1 (0.228)
4320 (72.0)	0.5 (0.006)	3.8 (0.033)	6.0 (0.045)	8.1 (0.053)	27.6 (0.153)	42.2 (0.210)

Layer Info

Time Accessed	09 September 2020 12:22PM
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	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Layer Info

Time Accessed	09 September 2020 12:22PM
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	20	10	5	2	1
60 (1.0)	9.6	7.7	8.0	7.7	7.7	3.8
90 (1.5)	10.6	8.3	8.3	8.4	8.0	5.6
120 (2.0)	8.9	7.2	7.8	7.8	7.8	4.4
180 (3.0)	10.6	8.5	8.8	8.4	7.8	4.0
360 (6.0)	9.4	7.3	7.6	7.0	7.2	2.4
720 (12.0)	9.7	7.5	7.7	6.6	6.5	1.7
1080 (18.0)	12.2	9.5	9.5	9.0	7.2	1.9
1440 (24.0)	12.7	10.0	10.1	9.8	7.9	2.7
2160 (36.0)	13.4	10.8	10.8	11.0	8.8	3.7
2880 (48.0)	15.3	11.8	12.2	12.4	9.9	6.5
4320 (72.0)	16.5	14.2	14.4	15.8	11.9	8.2

Layer Info

Time Accessed	09 September 2020 12:22PM

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/d47d8e16-ea89-41ac-a4be-ffa93e32e7b7.txt)

Download JSON (downloads/b5526f21-3ff8-4524-b89e-de5fa4b7ce6d.json)

Generating PDF... (downloads/aa4944ab-40bf-4518-b34b-209af21947bb.pdf)

APPENDIX C

Rainfall Depths

Location

Label: Oxley Solar Farm

Latitude: -30.3798 [Nearest grid cell: 30.3875 (S)]

Longitude:151.7235 [Nearest grid cell: 151.7125 (E)]

IFD Design Rainfall Depth (mm)

Issued: 12 October 2020

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	1.98	2.26	3.15	3.78	4.41	5.27	5.94
2 min	3.37	3.83	5.31	6.36	7.43	8.83	9.92
3 min	4.67	5.31	7.37	8.82	10.3	12.2	13.7
4 min	5.85	6.65	9.25	11.1	12.9	15.4	17.3
5 min	6.91	7.87	11.0	13.1	15.3	18.2	20.5
10 min	10.9	12.5	17.5	21.0	24.5	29.2	33.0
15 min	13.7	15.6	22.0	26.4	30.7	36.8	41.5
20 min	15.7	18.0	25.2	30.3	35.4	42.3	47.8
25 min	17.3	19.8	27.8	33.4	39.0	46.7	52.7
30 min	18.6	21.3	29.8	35.8	41.9	50.1	56.7
45 min	21.5	24.5	34.2	41.1	48.0	57.5	65.0
1 hour	23.5	26.7	37.2	44.6	52.1	62.4	70.5
1.5 hour	26.4	29.8	41.1	49.2	57.5	68.8	77.8
2 hour	28.5	32.1	43.9	52.4	61.1	73.1	82.7
3 hour	31.5	35.4	47.9	57.0	66.3	79.1	89.5
4.5 hour	35.0	39.0	52.3	61.9	71.8	85.6	96.8
6 hour	37.7	41.9	55.9	65.9	76.2	90.8	103
9 hour	42.1	46.7	61.7	72.5	83.6	99.4	112
12 hour	45.8	50.6	66.6	78.1	89.9	107	121
18 hour	51.7	57.1	74.9	87.6	101	119	134
24 hour	56.5	62.4	81.8	95.6	110	130	146
30 hour	60.5	66.9	87.8	103	118	139	156
36 hour	64.0	70.8	93.0	109	125	147	165
48 hour	69.8	77.3	102	119	136	161	180
72 hour	78.2	86.8	114	134	153	180	201
96 hour	84.0	93.3	123	143	164	192	214
120 hour	88.1	97.8	128	149	170	199	221

144 hour	91.1	101	132	153	173	202	224
168 hour	93.2	103	134	154	174	202	224

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 **12:58 on Monday 12 October 2020 (AEDT)**

APPENDIX D

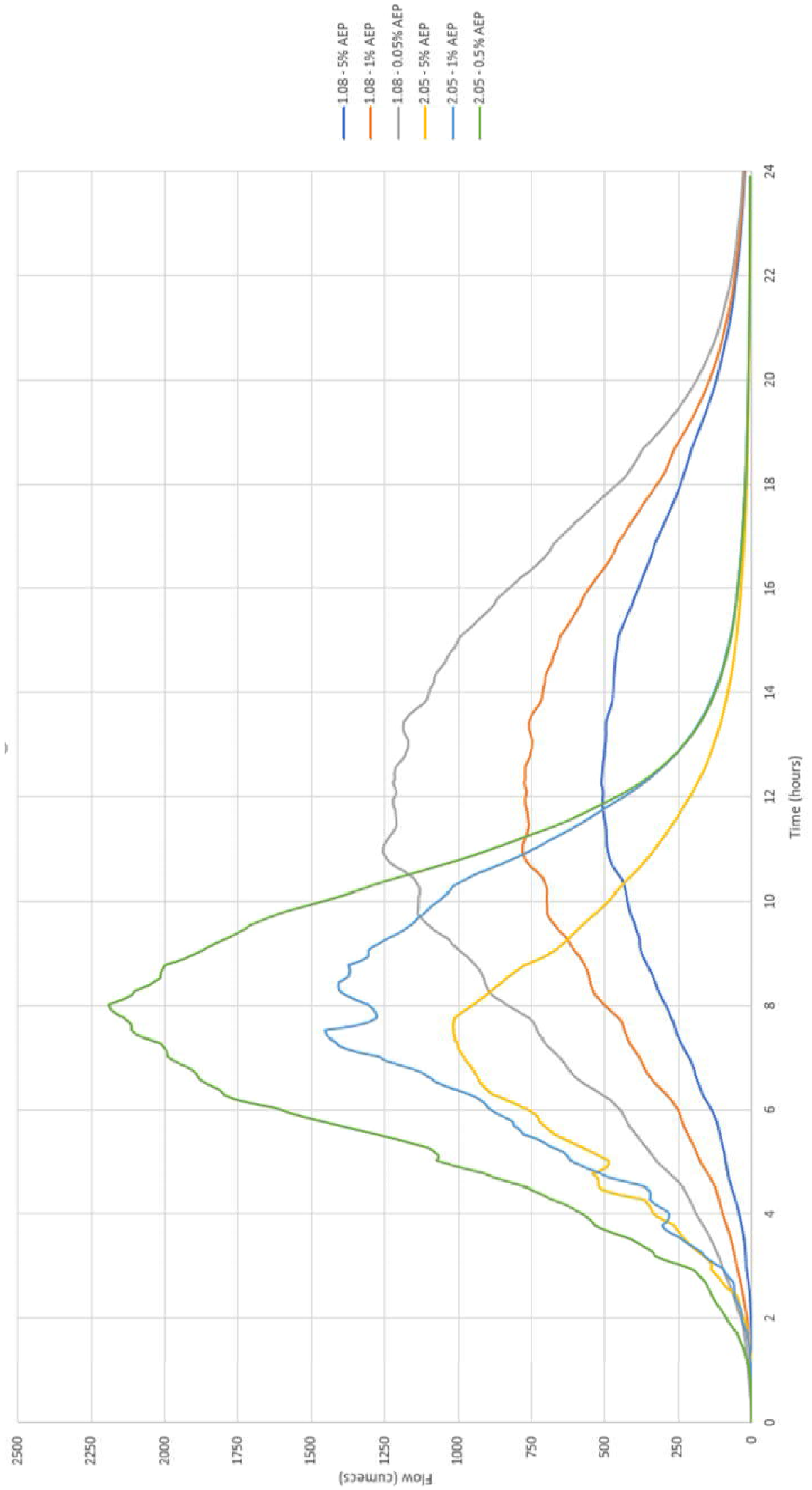
Pre-burst Rainfall Depths

Table E1: NSW Transformation Pre-Burst Rainfall Depths

Storm Duration		Pre-Burst Rainfall Depth (mm)	
		AEP (%)	
min	**hrs**	**5**	**1**
60	1	7.5	11.4
90	1.5	6.8	9.7
120	2	7.5	10.8
180	3	6.8	11.3
360	6	8.3	12.8
720	12	8.7	13.6
1080	18	6.3	13.3

APPENDIX E

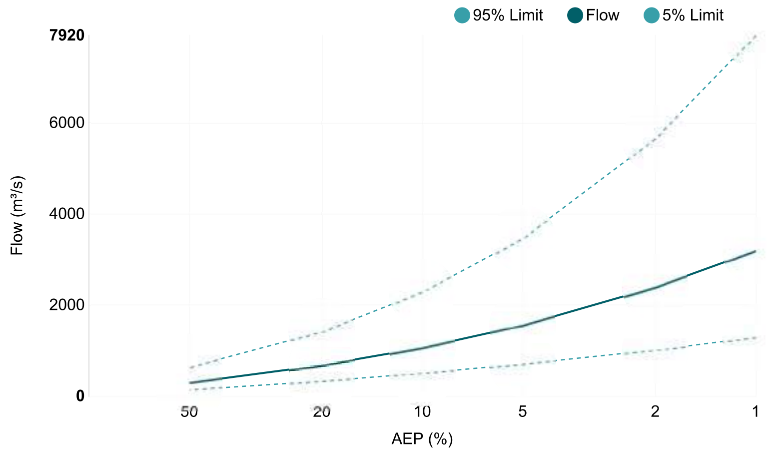
Flow Hydrographs


1.08 - 5% AEP
1.08 - 1% AEP
1.08 - 0.05% AEP
2.05 - 5% AEP
2.05 - 1% AEP
2.05 - 0.5% AEP
Flow (cumecs)
Time (hours)
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
0
2
4
6
8
10
12
14
16
18
20
22
24

APPENDIX F

RFFE Method Results

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	291	135	633
20	677	327	1410
10	1060	502	2280
5	1550	704	3460
2	2390	1010	5650
1	3190	1290	7920

Statistics

Variable	Value	Standard Dev
Mean	5.591	0.524
Standard Dev	0.995	0.201
Skew	0.101	0.028

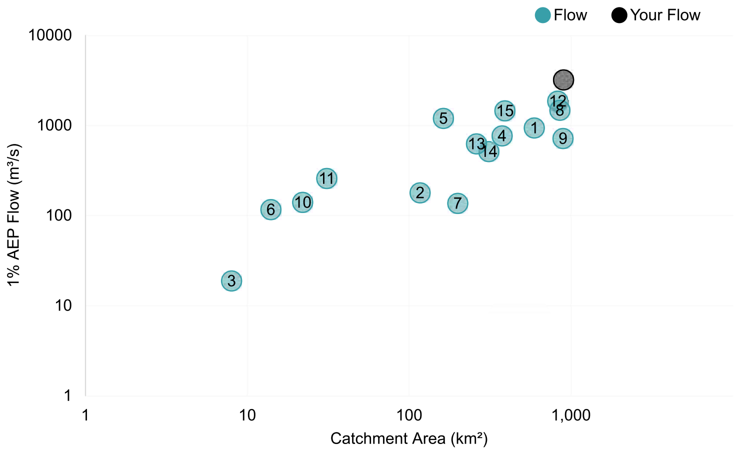
Note: These statistics come from the nearest gauged catchment. Details.

Correlation

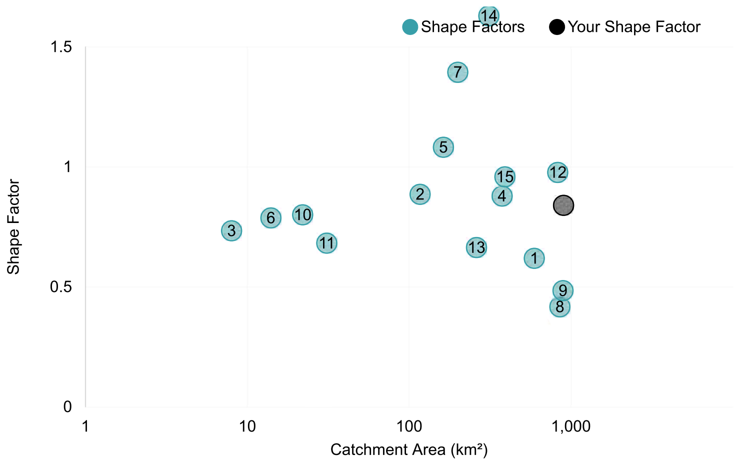
1.000		
-0.330	1.000	
0.170	-0.280	1.000

Note: These statistics are common to each region. Details.

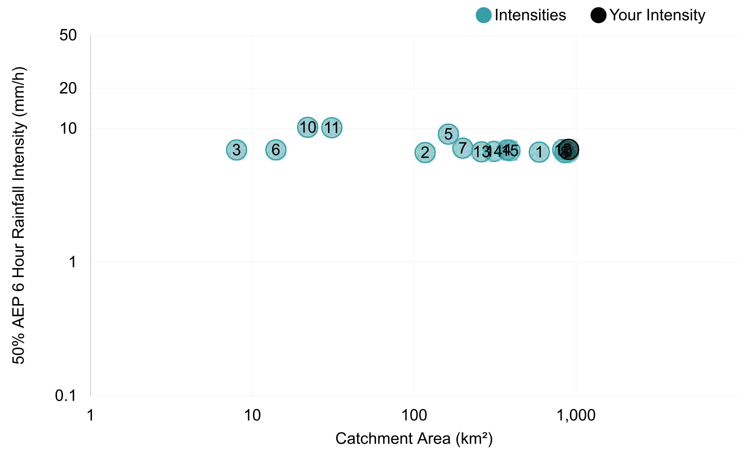
1% AEP Flow vs Catchment Area



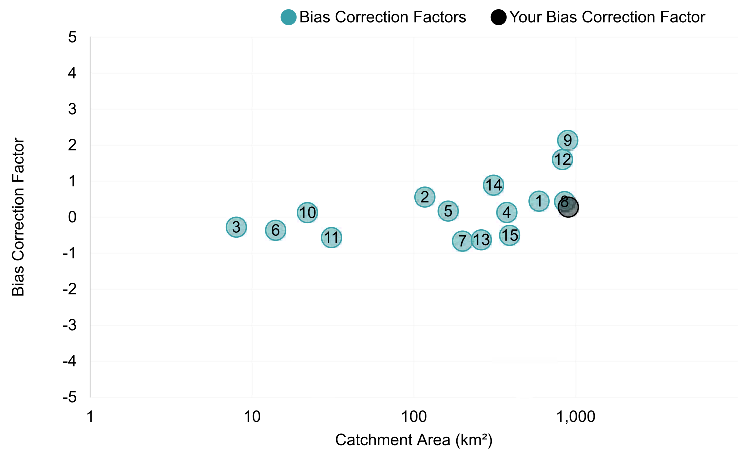
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



Download

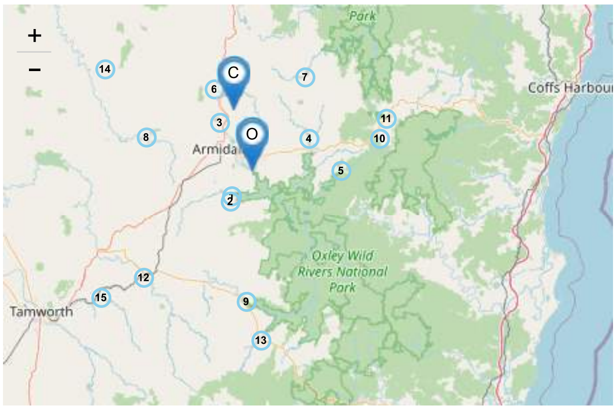
TXT Nearby JSON

Input Data

Date/Time	2020-09-09 12:11

Input Data

Catchment Name	Oxley Solar Farm
Latitude (Outlet)	-30.5972
Longitude (Outlet)	151.7988
Latitude (Centroid)	-30.3798
Longitude (Centroid)	151.7235
Catchment Area (km^2)	901.0
Distance to Nearest Gauged Catchment (km)	12.53
50% AEP 6 Hour Rainfall Intensity (mm/h)	6.988602
2% AEP 6 Hour Rainfall Intensity (mm/h)	15.11331
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.84
Interpolation Method	Natural Neighbour
Bias Correction Value	0.28



Leaflet (http://leafletjs.com) | © OpenStreetMap (http://osm.org/copyright) contributors

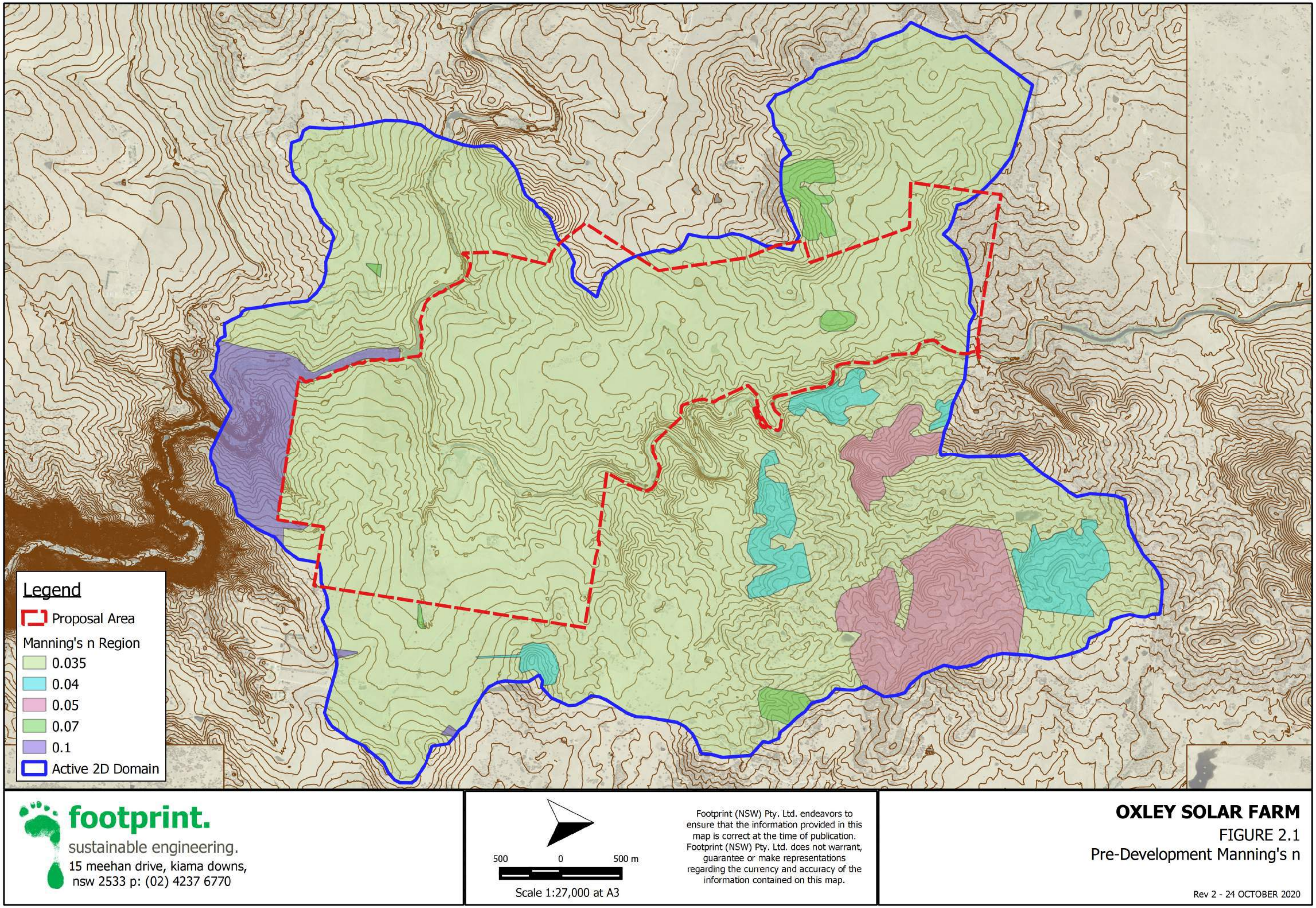
Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (http://arr.ga.gov.au/revision-projects/project-list/projects/project-5) on the ARR website. Send any questions regarding the method or project here (mailto:admin@arr-software.org).

ENGINEERS AUSTRALIA (http://www.engineersaustralia.org.au)

WESTERN SYDNEY UNIVERSITY (http://www.uws.edu.au)

APPENDIX G

Adopted Manning's Values



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

OXLEY SOLAR FARM

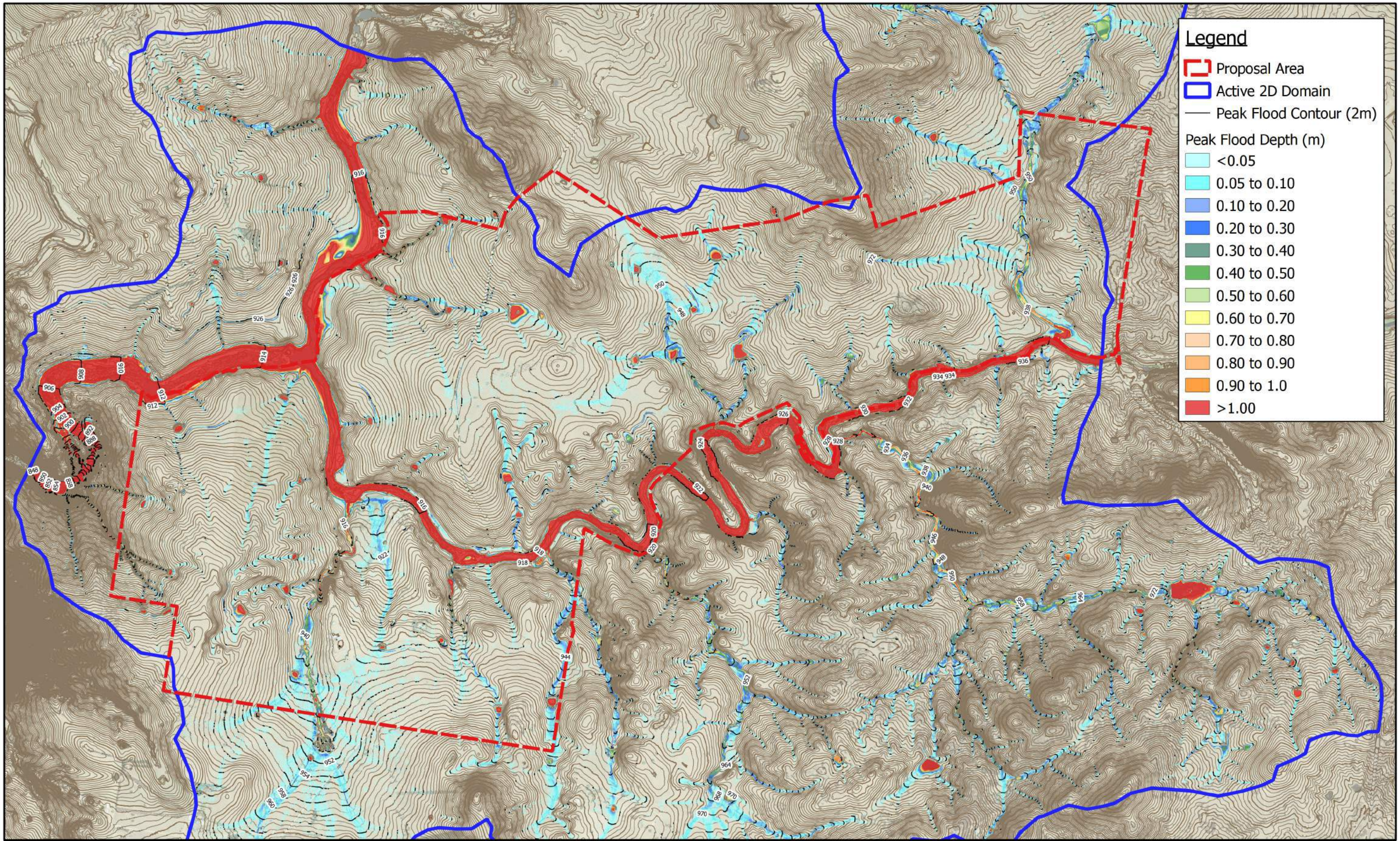
FIGURE 2.1

Pre-Development Manning's n

Rev 2 - 24 OCTOBER 2020

APPENDIX H

Flood Mapping

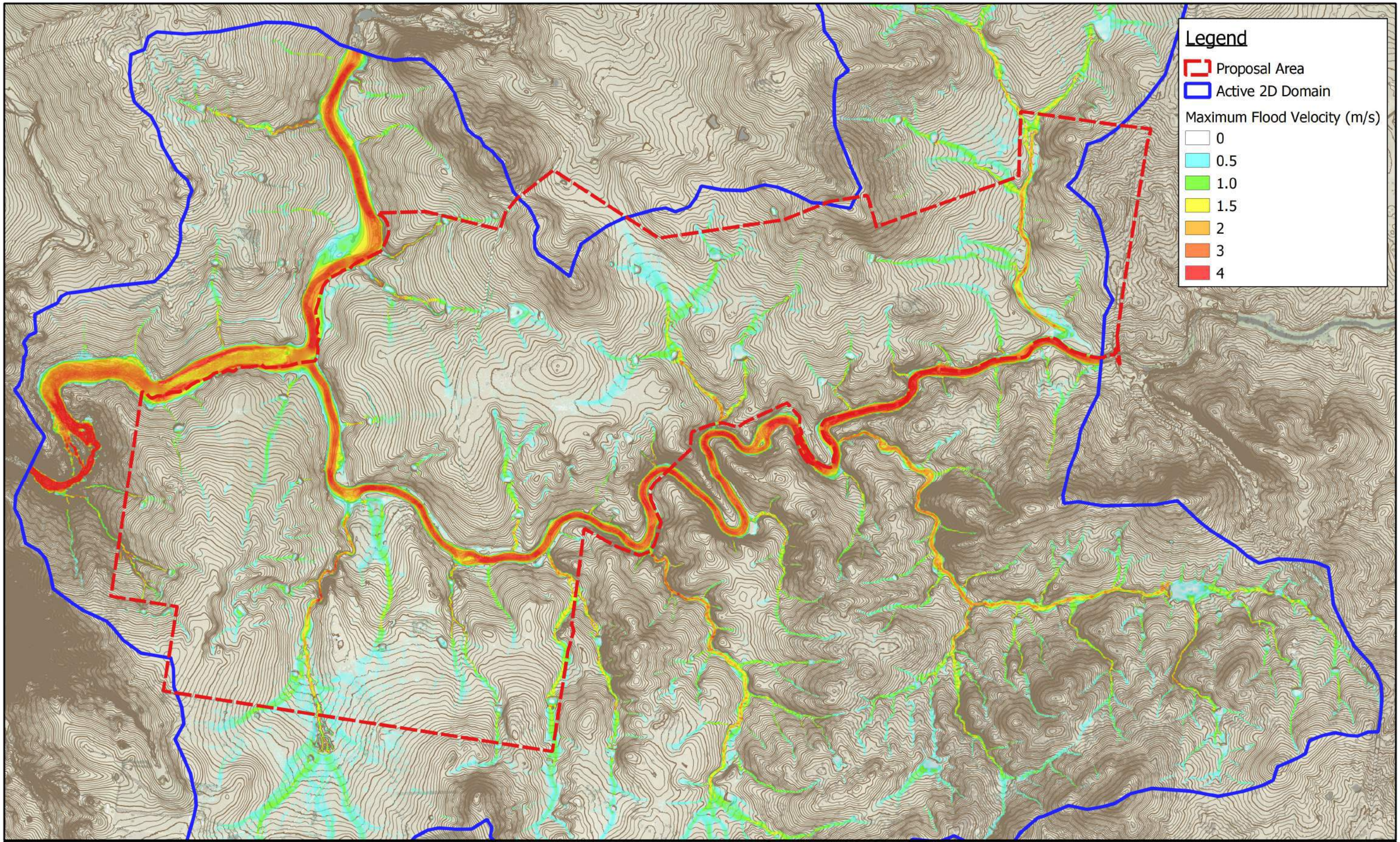


footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

400 0 400 m
Scale 1:20,000 at A3

OXLEY SOLAR FARM
FIGURE 3.1
MAXIMUM FLOOD LEVELS AND DEPTHS
PRE-DEVELOPMENT 5% AEP

Rev 2 - 24 OCTOBER 2020



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

400 0 400 m

Scale 1:20,000 at A3

Footprint (NSW) Pty. Ltd. endeavors to ensure that the information provided in this map is correct at the time of publication. Footprint (NSW) Pty. Ltd. does not warrant, guarantee or make representations regarding the currency and accuracy of the information contained on this map.

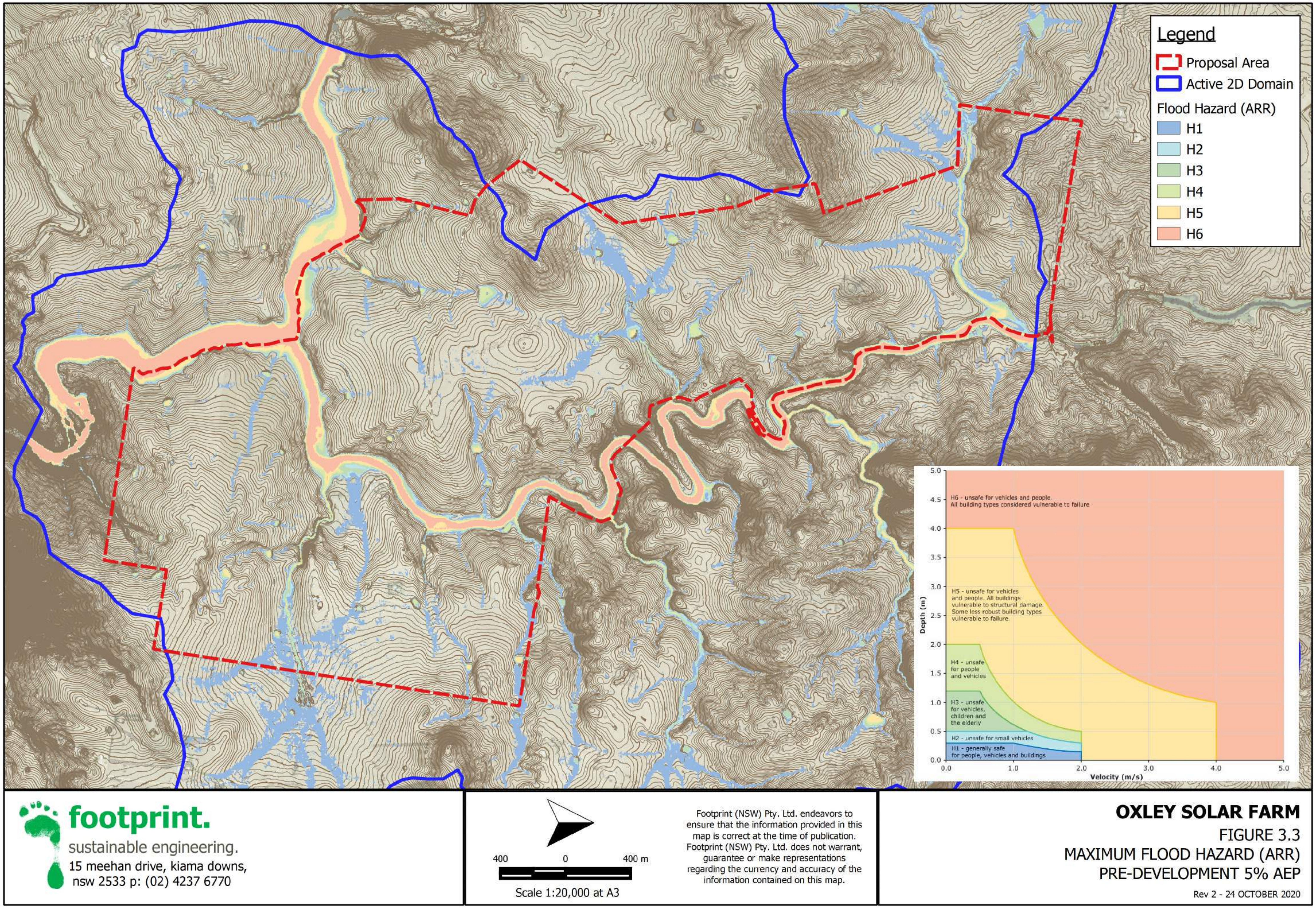
OXLEY SOLAR FARM

FIGURE 3.2

MAXIMUM FLOOD VELOCITY

PRE-DEVELOPMENT 5% AEP

Rev 2 - 24 OCTOBER 2020



footprint.
sustainable engineering.

15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

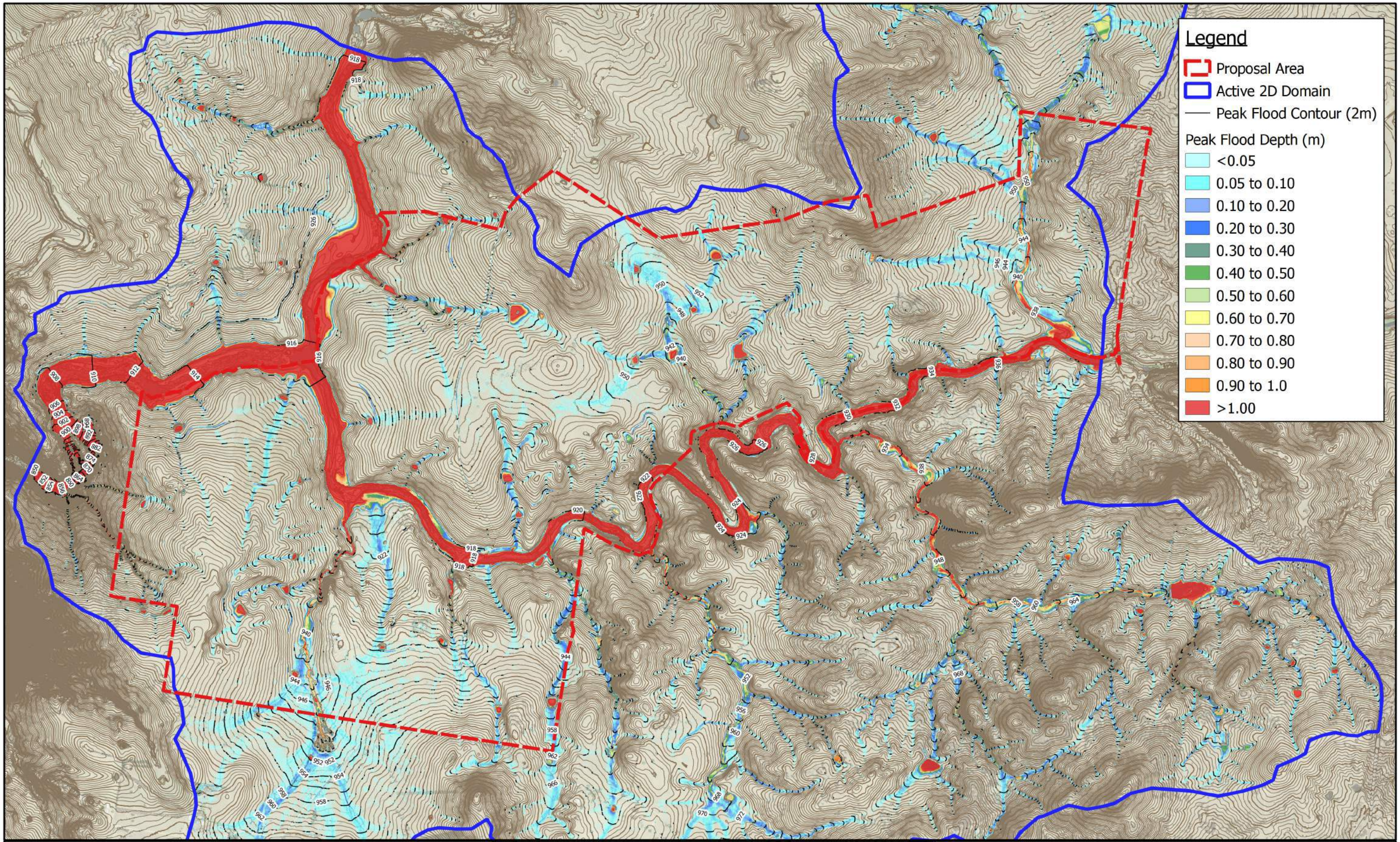
OXLEY SOLAR FARM

FIGURE 3.3

MAXIMUM FLOOD HAZARD (ARR)

PRE-DEVELOPMENT 5% AEP

Rev 2 - 24 OCTOBER 2020



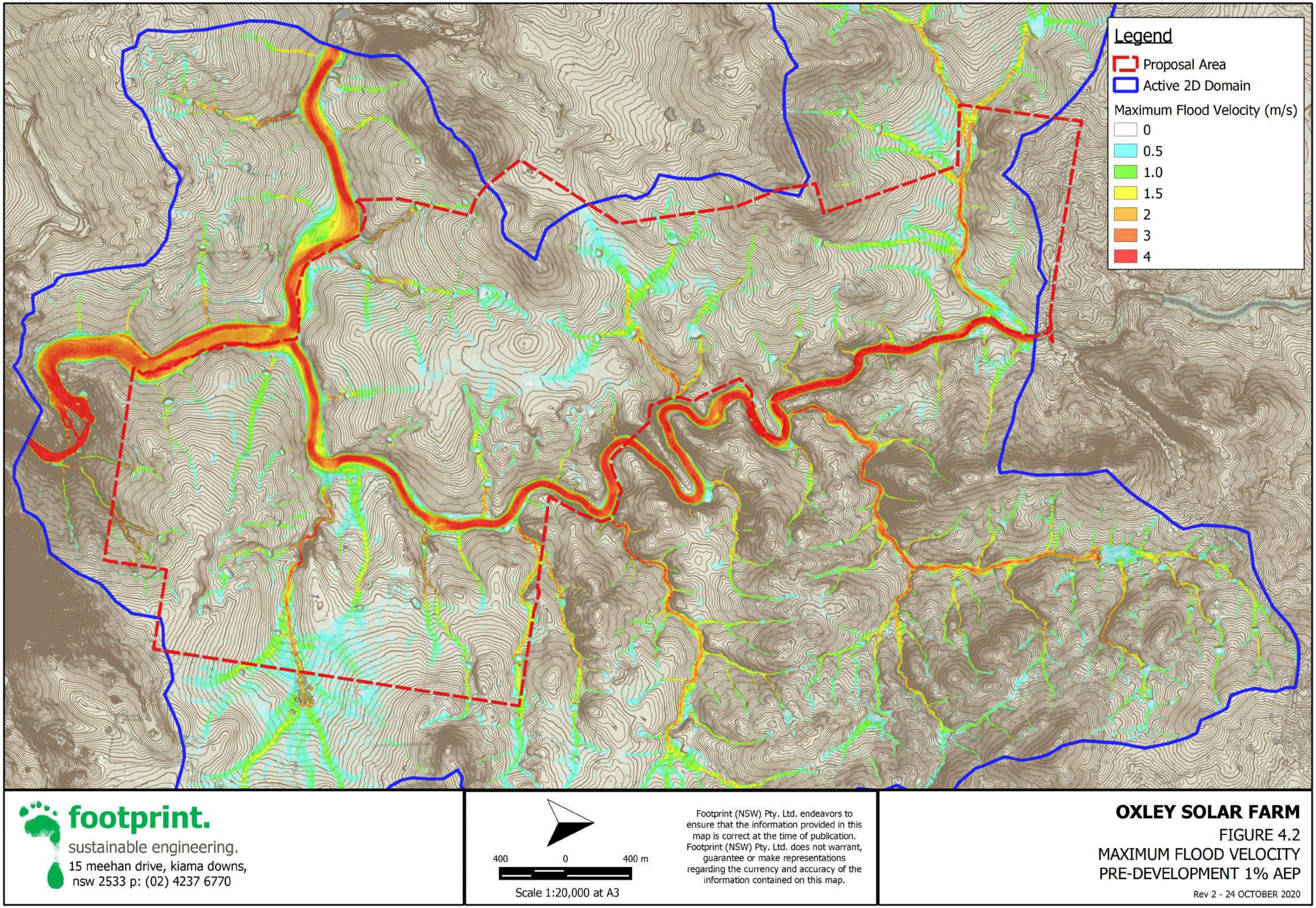
footprint.
sustainable engineering.
15 meehan drive, kiama downs, nsw 2533 p: (02) 4237 6770

OXLEY SOLAR FARM

FIGURE 4.1

MAXIMUM FLOOD LEVELS AND DEPTHS PRE-DEVELOPMENT 1% AEP

Rev 2 - 24 OCTOBER 2020

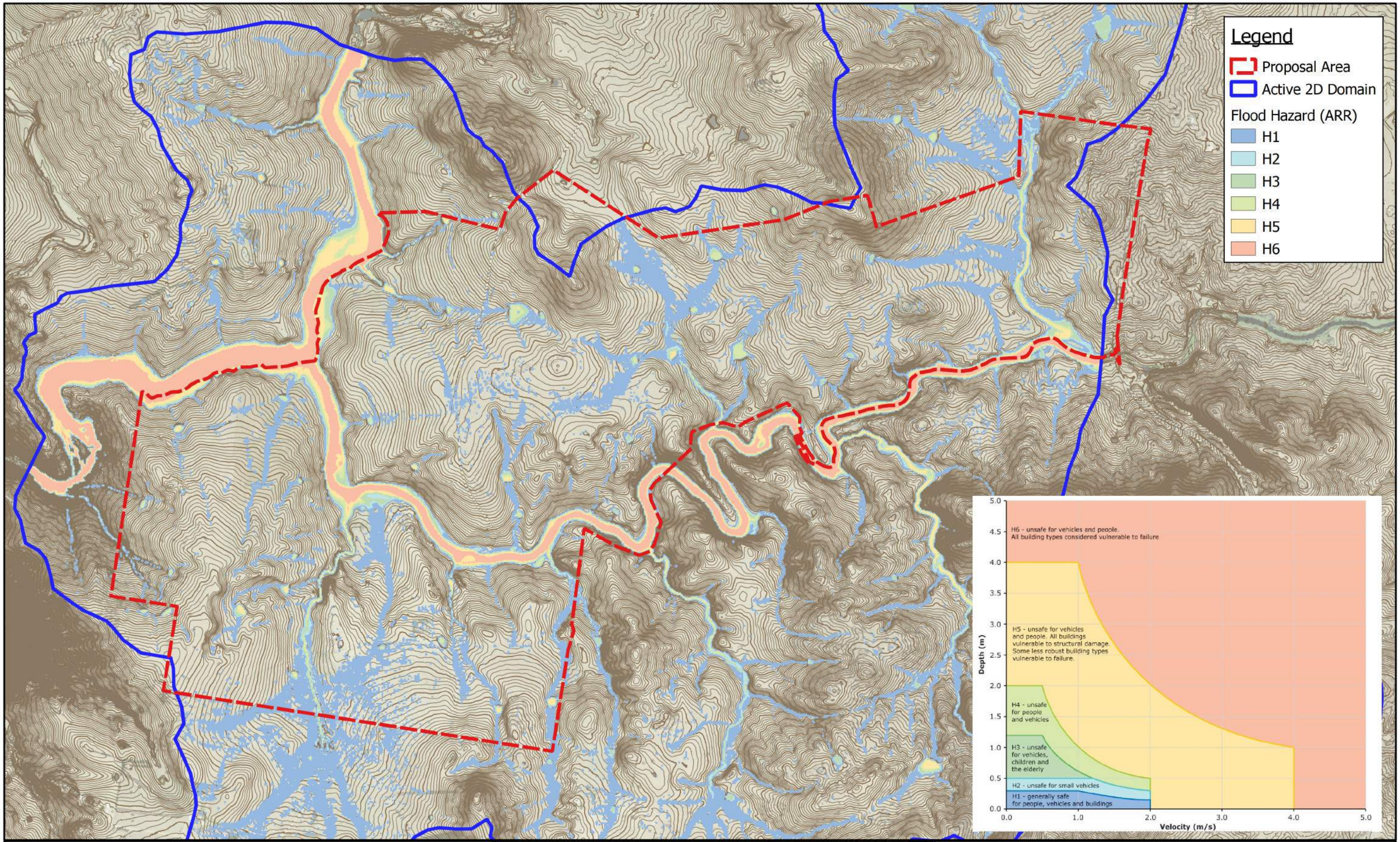


footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

OXLEY SOLAR FARM

FIGURE 4.2
MAXIMUM FLOOD VELOCITY
PRE-DEVELOPMENT 1% AEP

Rev 2 - 24 OCTOBER 2020



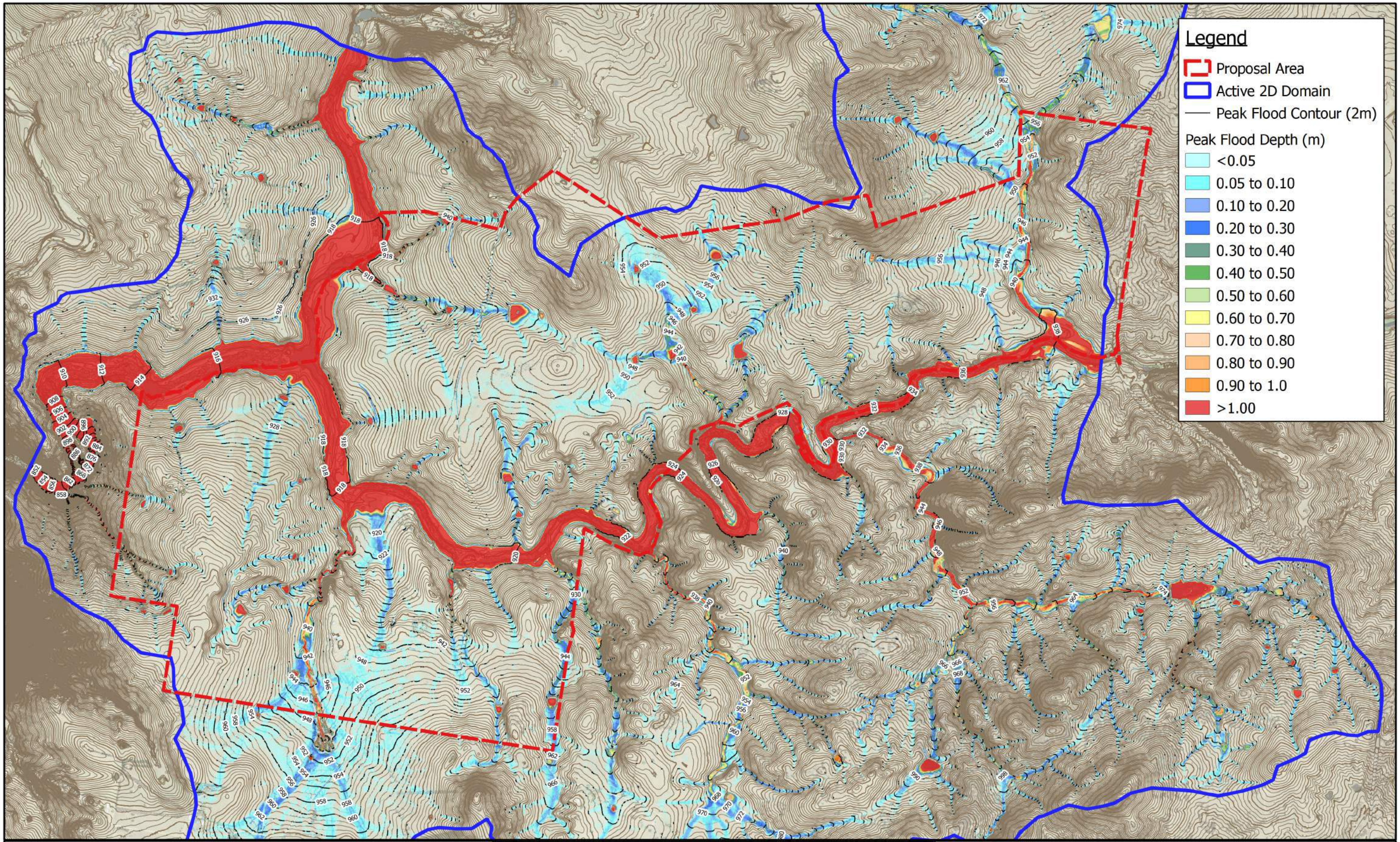
footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

400 0 400 m
Scale 1:20,000 at A3

OXLEY SOLAR FARM

FIGURE 4.3
MAXIMUM FLOOD HAZARD (ARR)
PRE-DEVELOPMENT 1% AEP

Rev 2 - 24 OCTOBER 2020



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

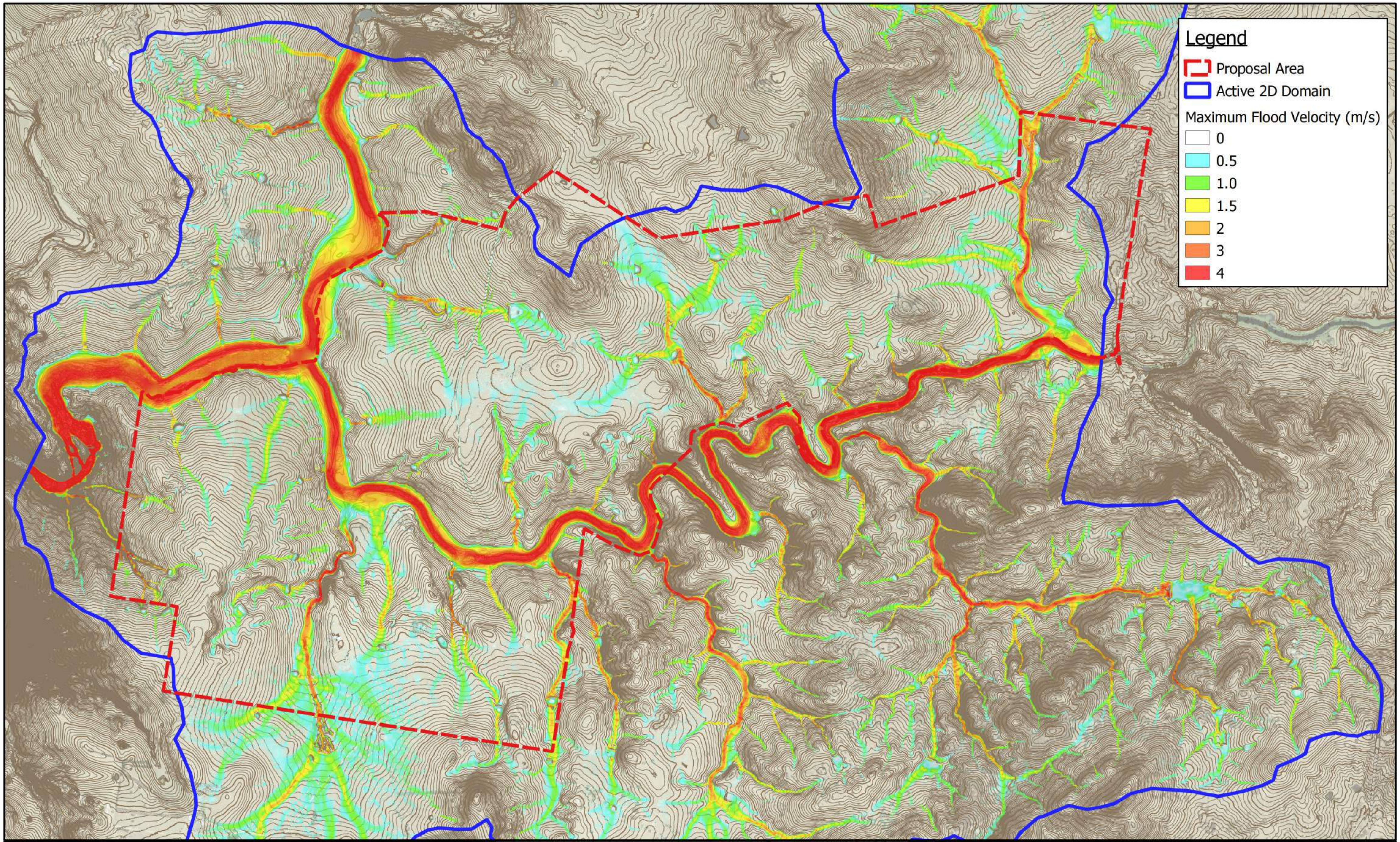
OXLEY SOLAR FARM

FIGURE 5.1

MAXIMUM FLOOD LEVELS AND DEPTHS

PRE-DEVELOPMENT 0.05% AEP

Rev 2 - 24 OCTOBER 2020



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

400 0 400 m

Scale 1:20,000 at A3

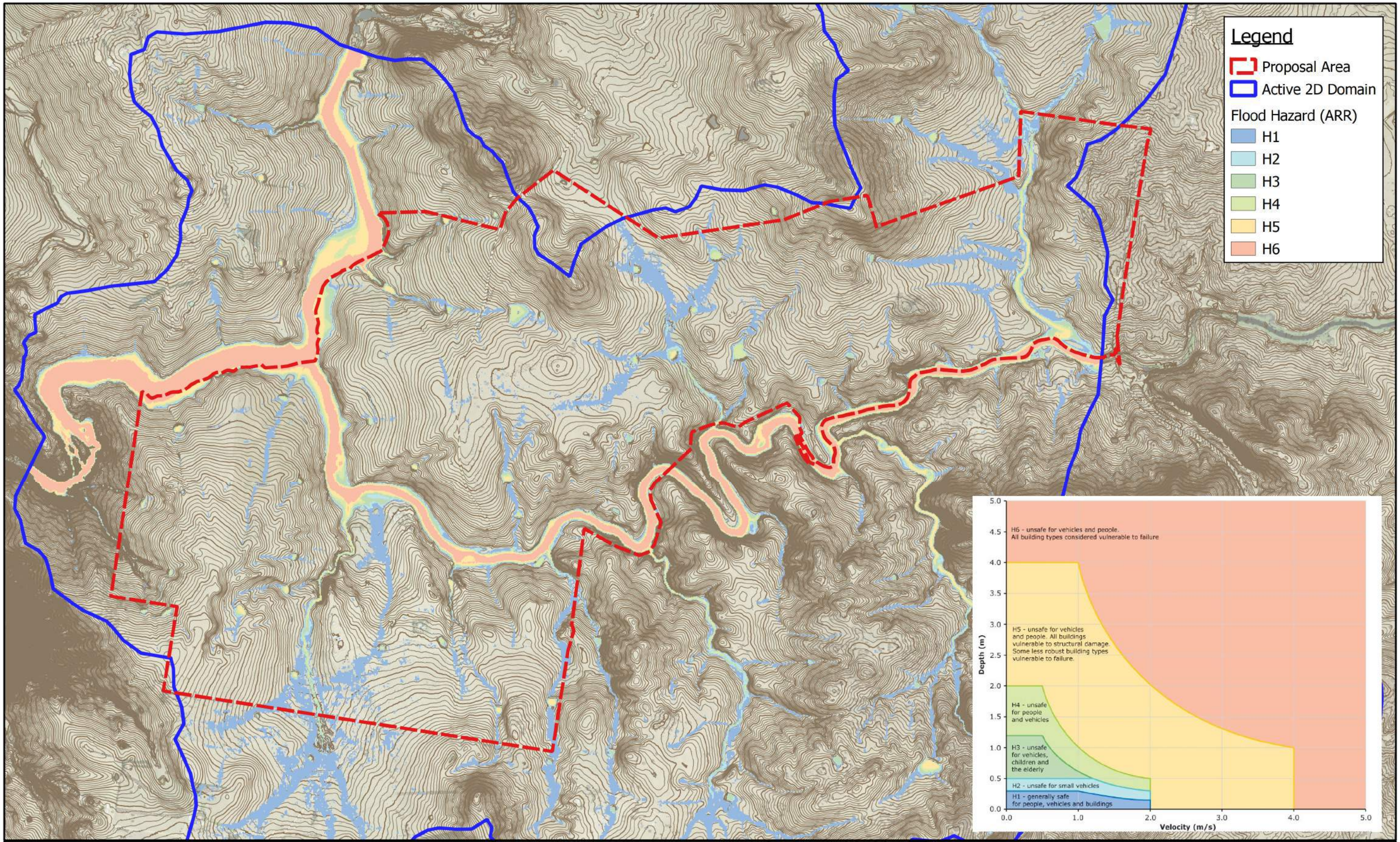
OXLEY SOLAR FARM

FIGURE 5.2

MAXIMUM FLOOD VELOCITY

PRE-DEVELOPMENT 0.05% AEP

Rev 2 - 24 OCTOBER 2020



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

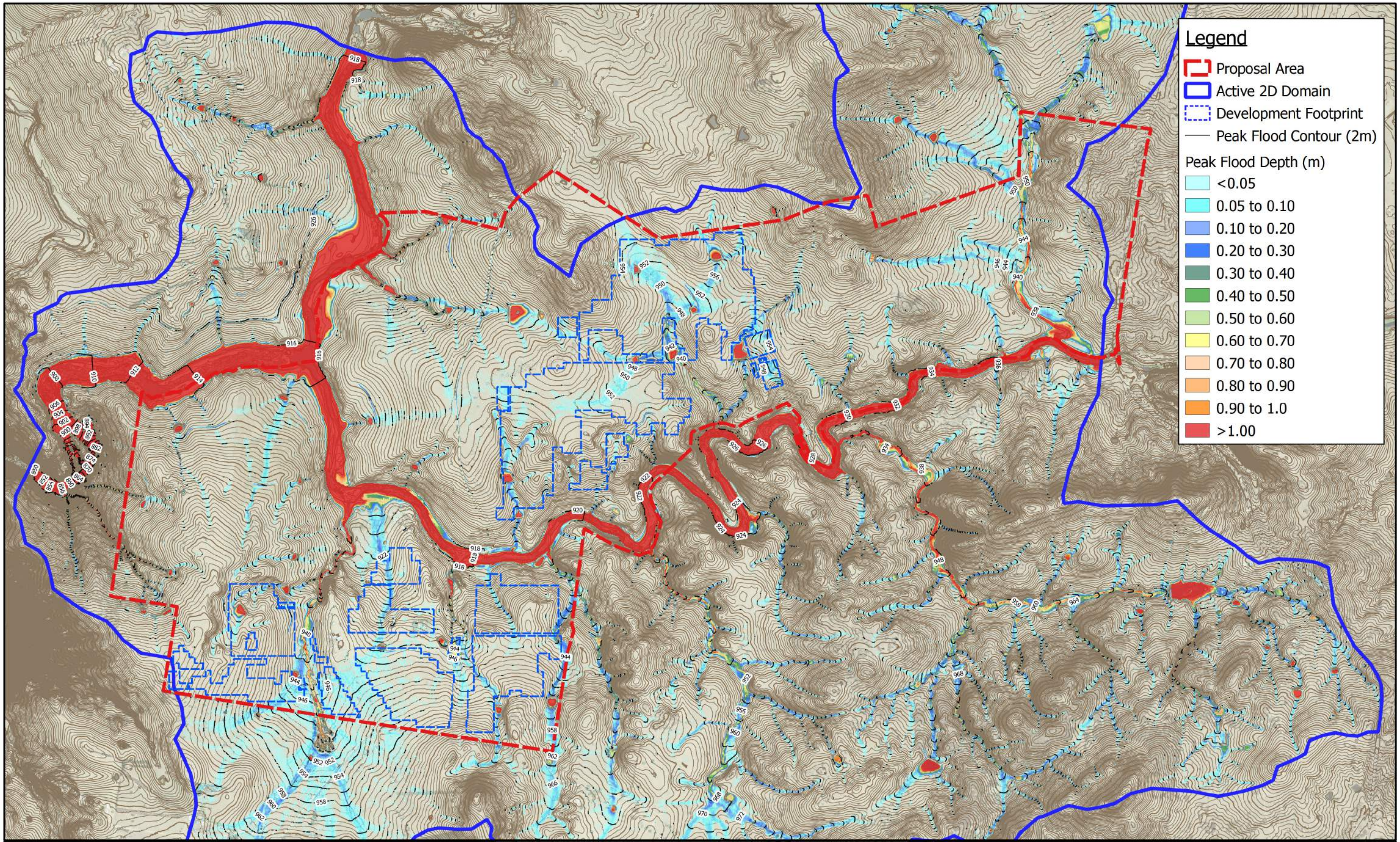
OXLEY SOLAR FARM

FIGURE 5.3

MAXIMUM FLOOD HAZARD (ARR)

PRE-DEVELOPMENT 0.05% AEP

Rev 2 - 24 OCTOBER 2020



footprint.
sustainable engineering.

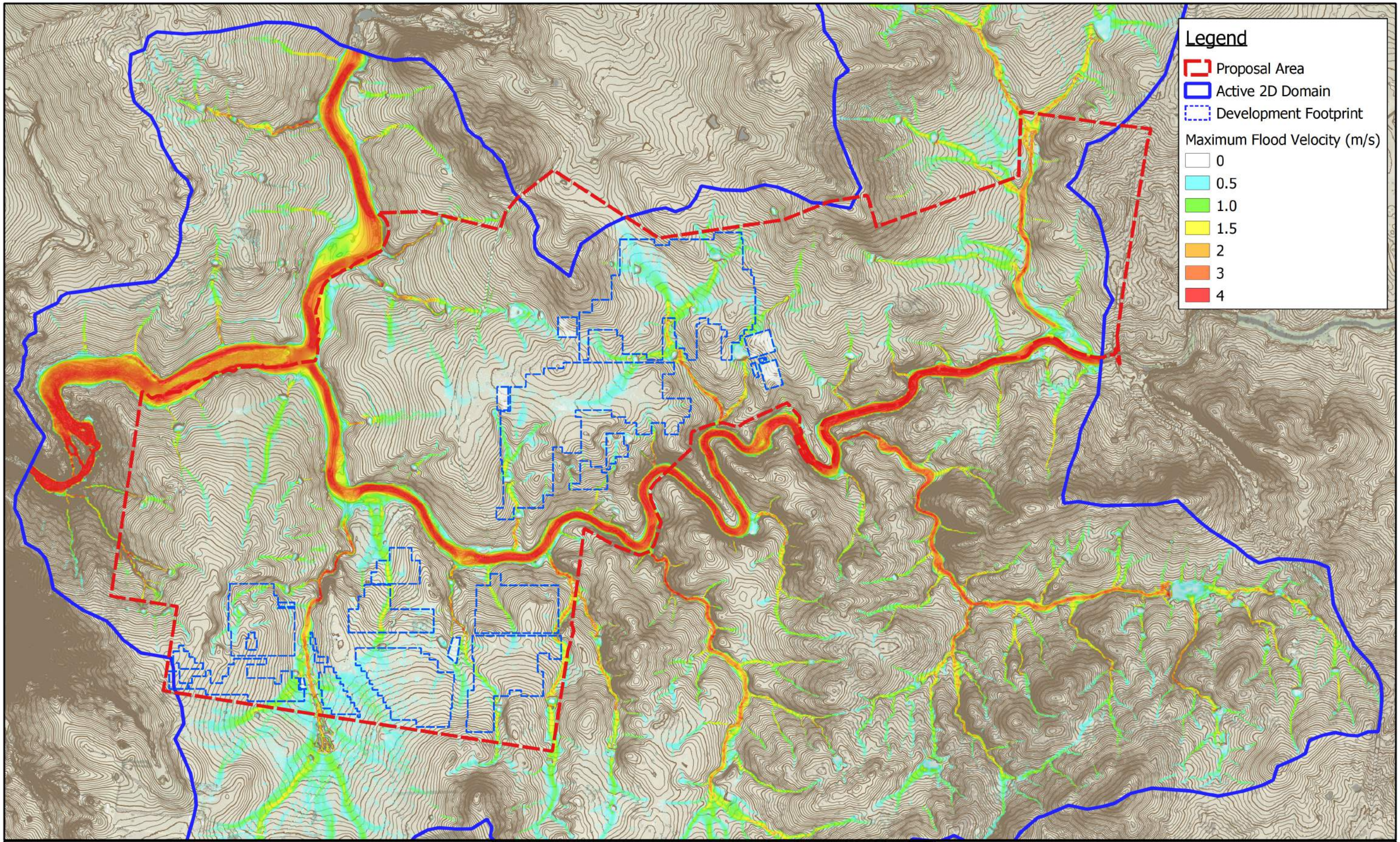
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

OXLEY SOLAR FARM

FIGURE 6.1

MAXIMUM FLOOD LEVELS AND DEPTHS
POST DEVELOPMENT 1% AEP

Rev 4 - 14 June 2022

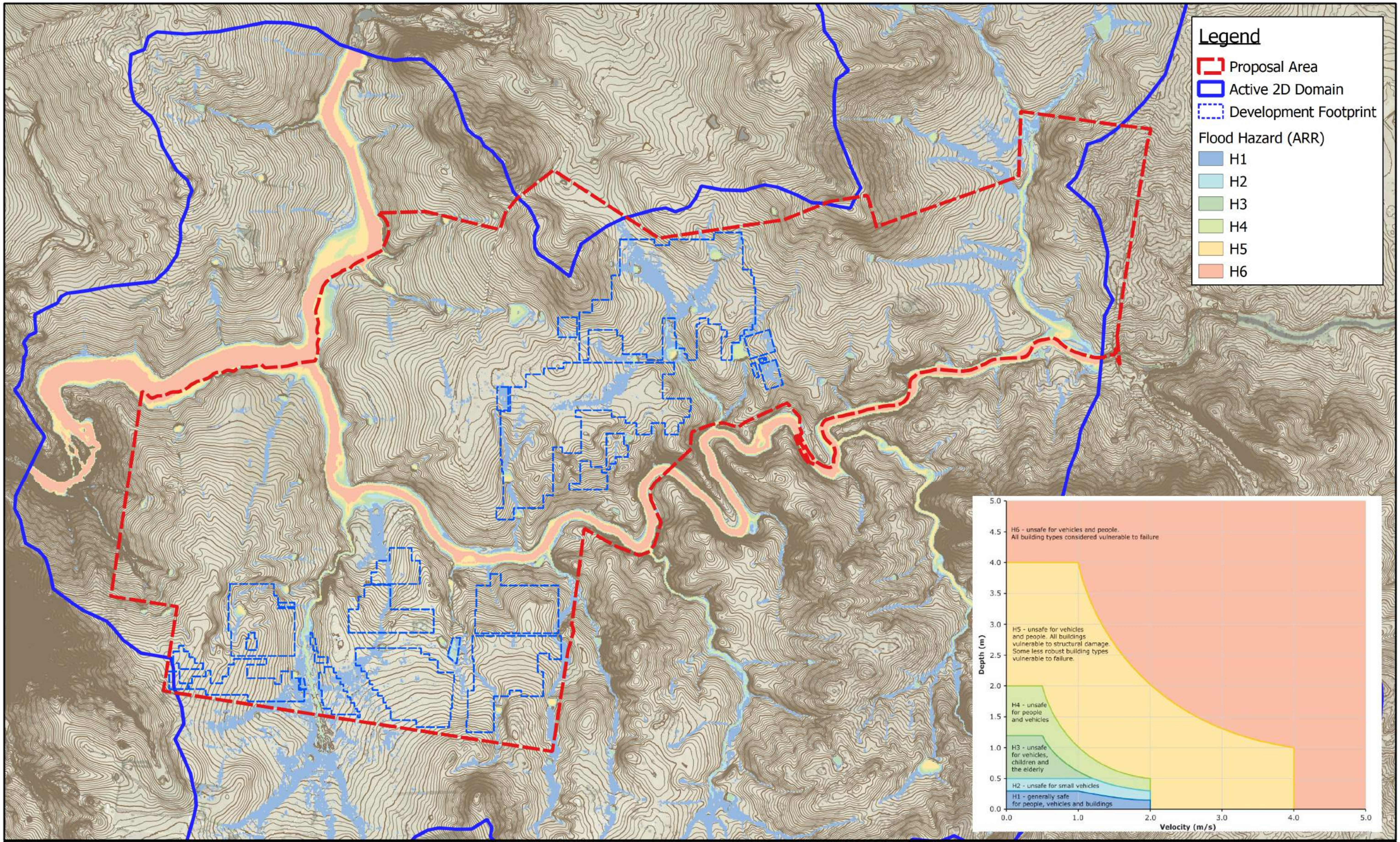


footprint.
sustainable engineering.
15 meehan drive, kiama downs, nsw 2533 p: (02) 4237 6770

400 0 400 m
Scale 1:20,000 at A3

OXLEY SOLAR FARM
FIGURE 6.2
MAXIMUM FLOOD VELOCITY
POST DEVELOPMENT 1% AEP

Rev 4 - 14 June 2022



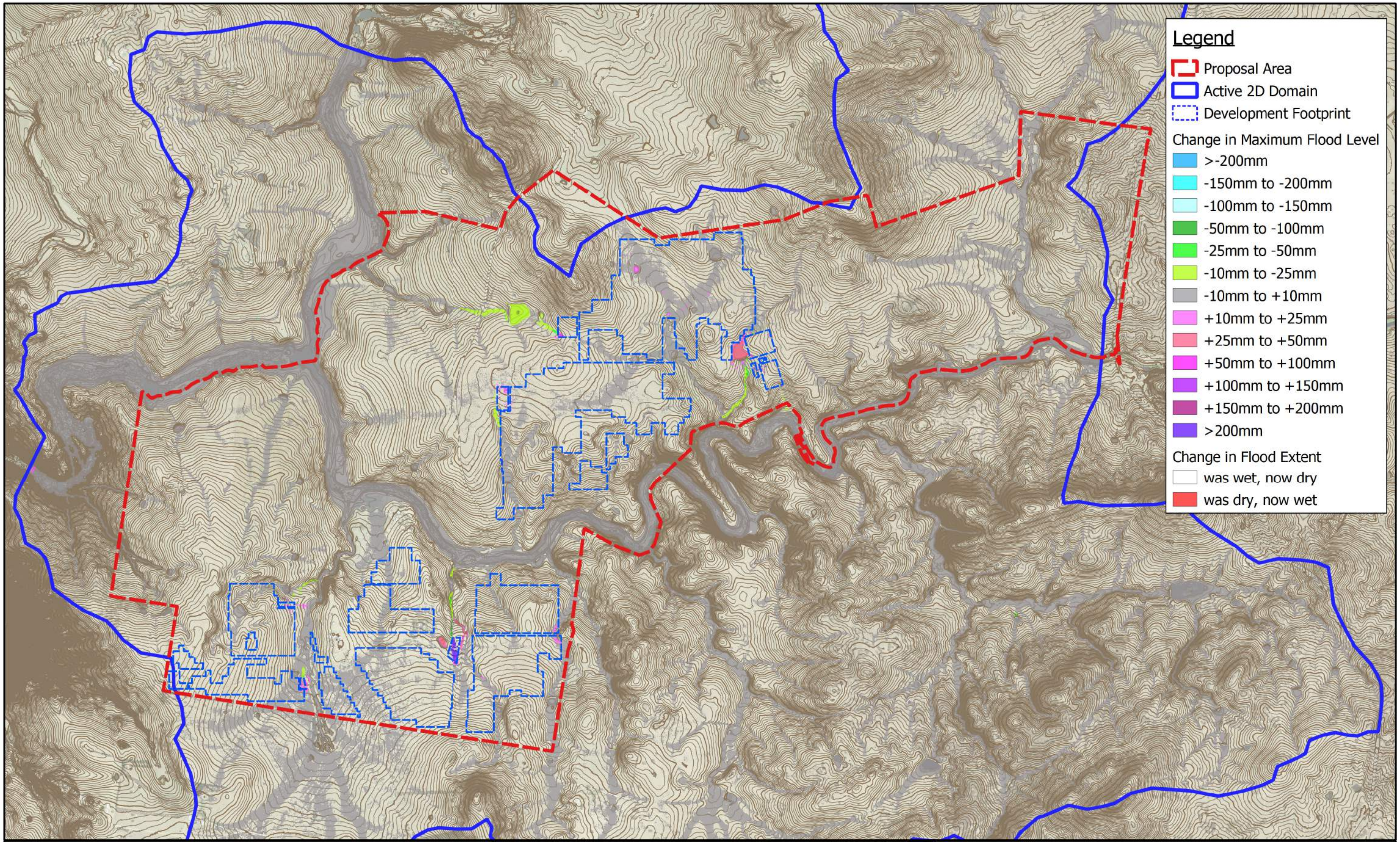
footprint.
sustainable engineering.

15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

OXLEY SOLAR FARM

FIGURE 6.3
MAXIMUM FLOOD HAZARD (ARR)
POST DEVELOPMENT 1% AEP

Rev 4 - 14 June 2022

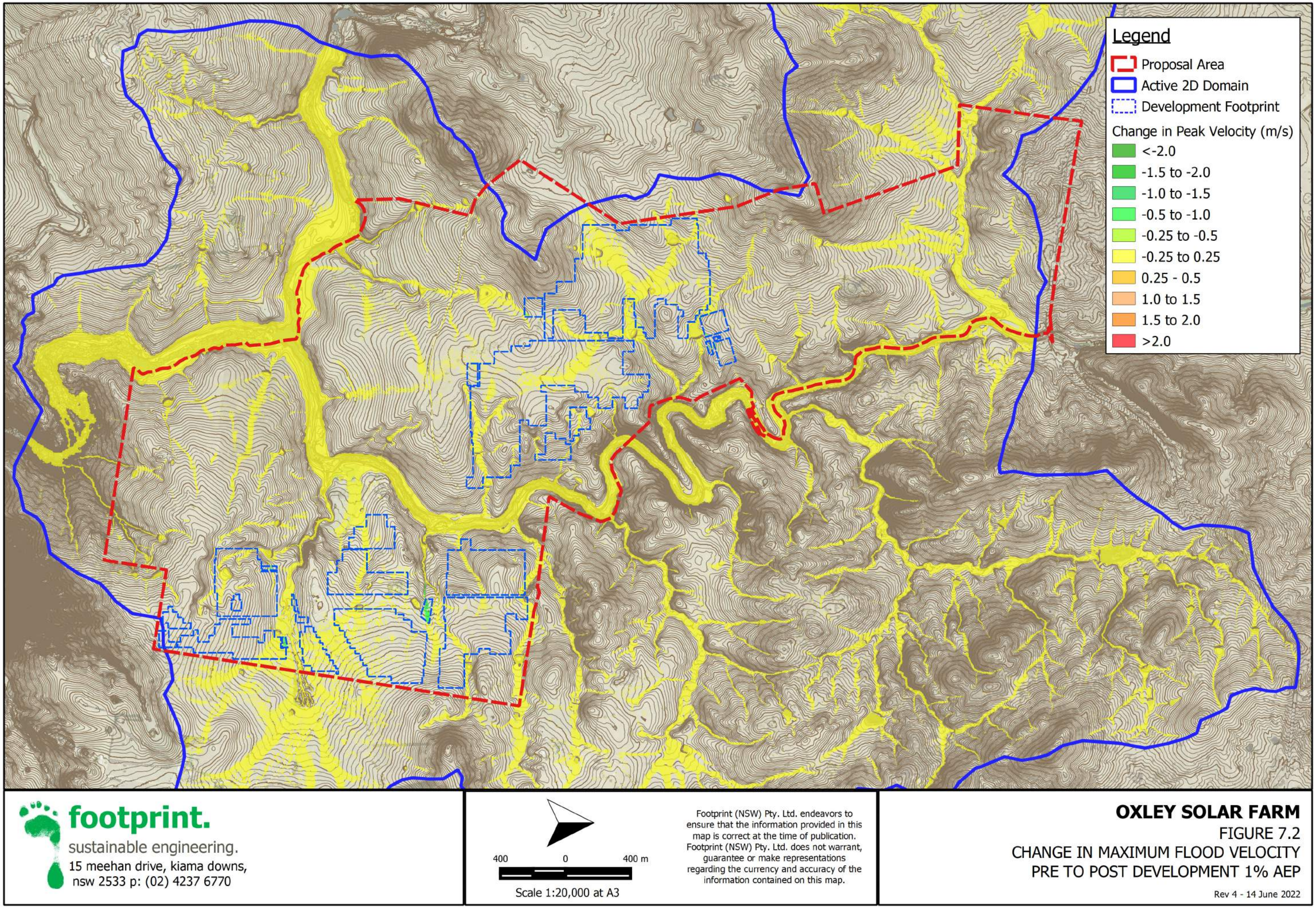


footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

OXLEY SOLAR FARM

FIGURE 7.1
CHANGE IN MAXIMUM FLOOD LEVEL
PRE TO POST DEVELOPMENT 1% AEP

Rev 4 - 14 June 2022



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

OXLEY SOLAR FARM

FIGURE 7.2

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

Rev 4 - 14 June 2022

APPENDIX I

Stream Order

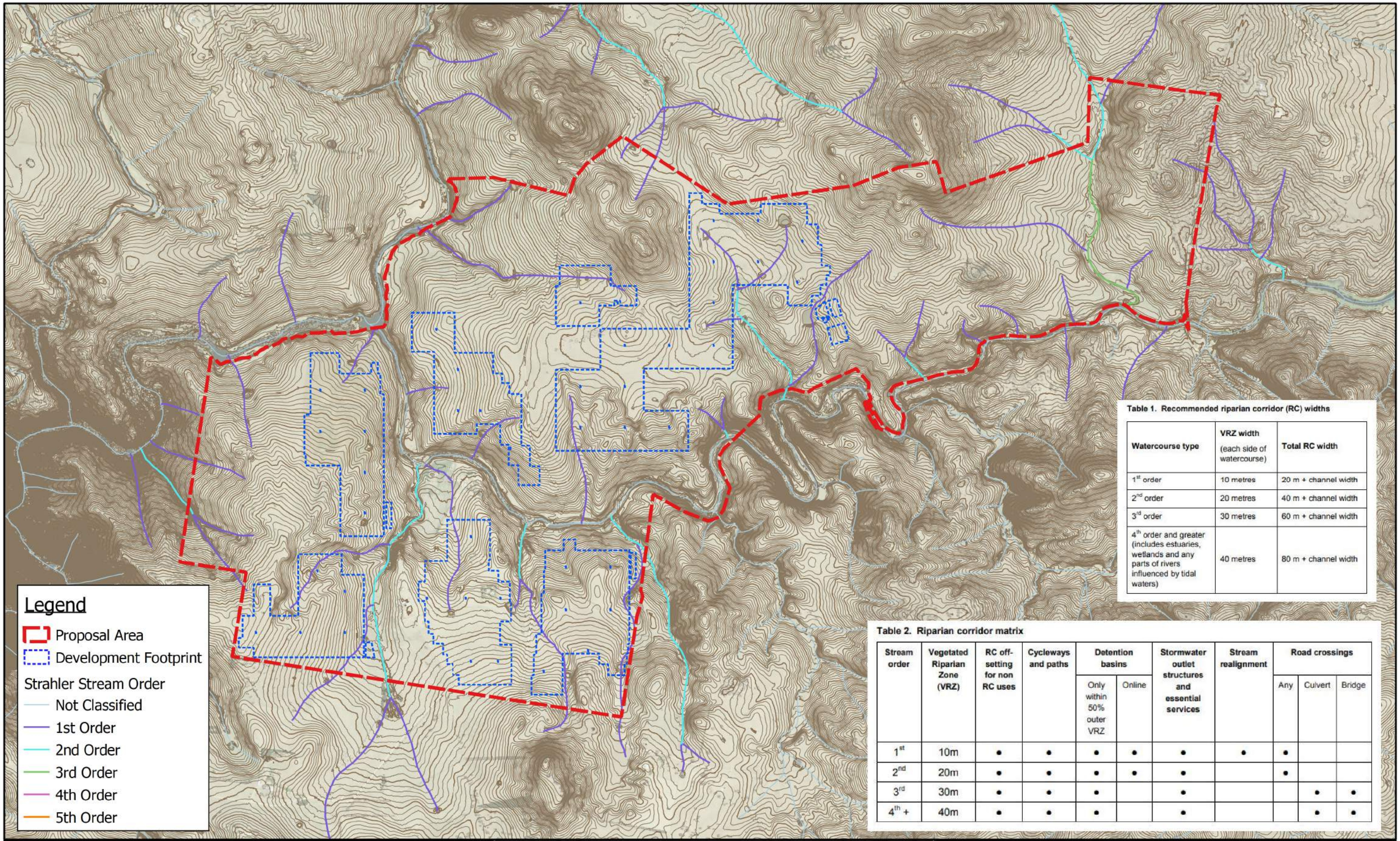


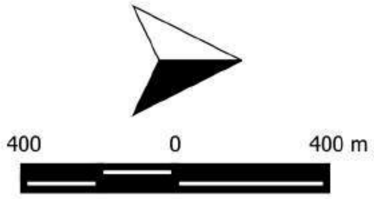
Table 1. Recommended riparian corridor (RC) widths

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

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	•	•	•		•			•	•

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



Scale 1:20,000 at A3

OXLEY SOLAR FARM

FIGURE 8.1

STREAM CLASSIFICATION

Rev 3 - 27 JANUARY 2021