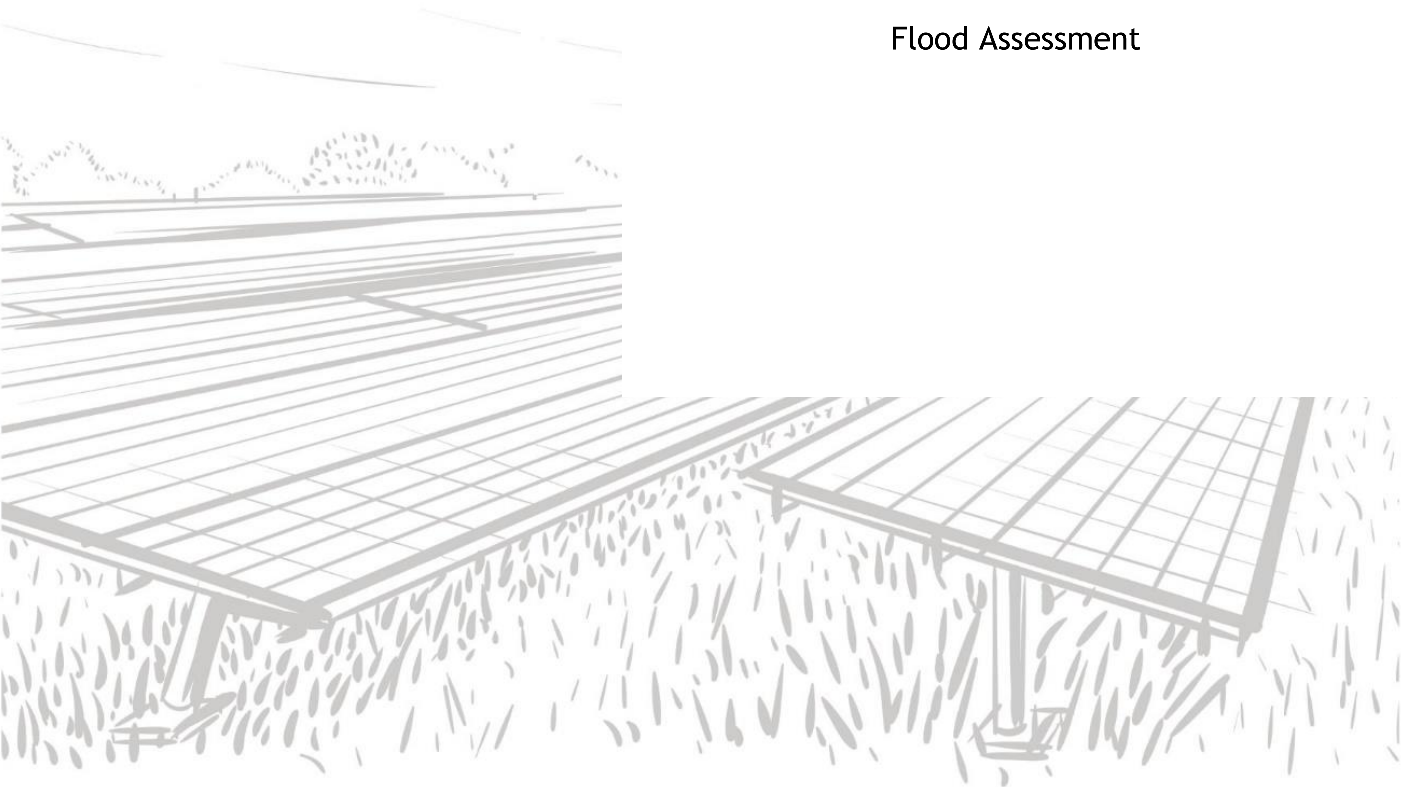
Appendix I

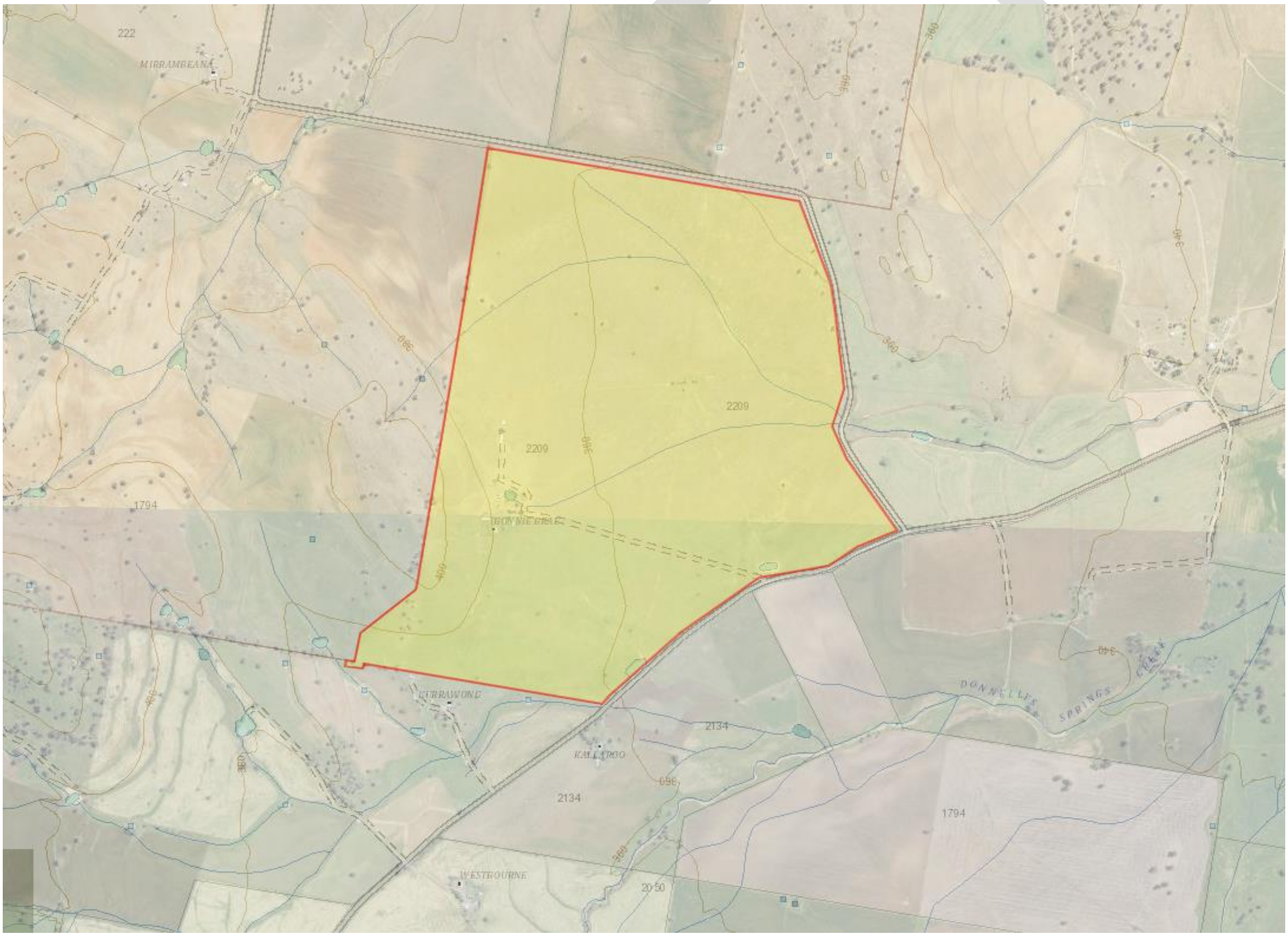
Flood Assessment



PROJECT.E

FLOOD ASSESSMENT - PROPOSED SOLAR FARM, 2209 SOLDIERS SETTLEMENT RD BECTIVE

FINAL



NOVEMBER 2019

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FLOOD ASSESSMENT -
PROPOSED SOLAR FARM, 2209 SOLDIERS SETTLEMENT RD BECTIVE

FINAL

NOVEMBER 2019

Project Flood Assessment - Proposed Solar Farm, 2209 Soldiers Settlement Rd Bective	**Project Number** **119064**
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FLOOD ASSESSMENT -
PROPOSED SOLAR FARM, 2209 SOLDIERS SETTLEMENT RD BECTIVE

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FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. Flood Study
- Determine the nature and extent of the flood problem.

2. Floodplain Risk Management Study
- Evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan
- Involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan
- Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

EXECUTIVE SUMMARY

WMAwater undertook an assessment of existing flood risk at 2209 Soldiers Settlement Road (the site). There is no existing Council Flood Study or Floodplain Risk Management Study/Plan that addresses floodplain management at the site.

WMAwater's assessment considered flood risk both from the Peel River and local watercourses within and around the site. It was concluded that the site is not at risk of flooding from the Peel River. However the site is large enough that runoff within the site can produce significant flow and flash flooding along the internal creeks. These internal watercourses are tributaries of Donnellys Springs Creek.

The flood risk was mapped for the 1% AEP event, under both existing site conditions and with the solar farm infrastructure. The assessment indicates that the proposed development will not produce adverse impacts on flood flows or levels beyond the site. The proposed development is generally compatible with the flood risk, although there are localised areas where the placement of solar panels is within the 1% AEP flood extents of the local watercourses. It is recommended that the design and placement of the affected solar panels in these locations be reconsidered as part of the detailed design of the proposed development. It may still be appropriate to place some panels in areas that are affected by either shallow or slow moving flow, but preferably not within "floodway" areas (see Figure 11).

The proposed development therefore would not significantly affect the existing SES community response planning. However the development is in an area where generally a high degree of self-sufficiency would be assumed for the local population, including:

- Sufficient supplies and tolerance for being isolated from urban areas for at least a day; and
- Reasonable awareness of the risks of driving through floodwaters.

Depending on the number of people required to operate the plant, their operational responsibilities within the site, and their shift movements, it may be necessary to including flooding as one of the risks considered under the site emergency response plan. This plan would need to provide training for operational personnel and visitors about flood risks, and provide direction about actions to take in case of flash flooding of creeks either within the site or on access roads to the site. Such information could be readily included in the broader emergency response plan prepared by the operator once the operational details of the site are known, and would need to be maintained by the site manager once the site becomes operational.

1. INTRODUCTION

Preparation of an Environmental Impact Statement (EIS) is being managed by PROJECT.e for a proposed solar electricity farm (the Tamworth Solar Farm). There is no existing information about flood risk at the site. PROJECT.e engaged WMAwater to assess the flood risk for the site, including preliminary modelling of flood behaviour, and to identify whether more detailed assessment will be required to satisfy planning approval requirements for the plant.

1.1. Scope of Work

The tasks documented in this assessment include:

<u>Data Collection and Review (Sections 2 and 3)</u>

- Review of site location with respect to watercourses and existing flood information for those watercourses;
- Acquisition of LiDAR aerial survey data and processing to produce a single topographic model of the study area.

<u>Peel River Flood Risk Assessment (Section 4)</u>

- Analysis of at-site Peel River flood risk through Flood Frequency Analysis of stream gauges.

<u>Local Creek Flood Risk Assessment (Section 5)</u>

- Preparation of new hydrologic and hydraulic models of the local creek catchments (Donnellys Springs Creek and an unnamed watercourse within the site);
- Modelling of the 1% AEP flood risk using rainfall-runoff techniques consistent with ARR 2019 (Reference 1), for both existing and proposed site conditions; and
- Mapping of flood depths, levels, hazard and flood function to enable planning assessment of whether the proposed solar farm development is consistent with the flood risk.

<u>Discussion of Emergency Management Considerations (Section 6)</u>

- Review of existing flood warning and flood emergency response information;
- Discussion of site-specific flood response considerations for operation of the proposed solar farm.

2. BACKGROUND

2.1. Site Characteristics

The location for the proposed solar power plant is at 2209 Soldier's Settlement Road, comprising Lot 186 DP755340 (the site, Figure 1). The site has an area of approximately 230 hectares and is located approximately 27 km west-north-west of Tamworth, at an elevation of between 350 m to 410 m above sea level. The existing land-use of the site is agricultural primary production, and is almost entirely cleared.

2.2. Waterways

The site is approximately 4 km from the Peel River at its closest point, as it runs east to west between Bective and Somerton (see Figure 2). This reach of the river is downstream of Tamworth. The Peel River system is regulated by Chaffey Dam which located in the upper catchment near the town of Woolomin, approximately 45 kilometres from Tamworth. Chaffey Dam was completed in 1979, with a capacity of approximately 62,000 ML and a contributing catchment area of 420 km^2.

The site is located close to the top of a hill, but encompasses a large enough catchment area to have developed internal ephemeral creek channels within the site, which are unnamed. The main creek branch within the site runs from the north-west corner at Warminster Road, and leaves the site near the midpoint of the eastern boundary. Another branch runs along the south-east boundary of the site roughly parallel to Soldiers Settlement Road. These site creeks flow into Donnellys Spring Creek, which has a total catchment area of approximately 2,235 ha where it meets Sandy Creek, approximately 1.3 km downstream (east) of the site, which in turn flows into the Peel River.

Soldiers Settlement Road borders the site to the south-east, and there are two existing farm dams that collect runoff along the ephemeral creek that runs roughly parallel to the road, through the site.

3. AVAILABLE DATA

3.1. Existing Flood Information

WMAwater was unable to find a previous Flood Study or Floodplain Risk Management Study/Plan that assessed flood risk at the site.

3.2. Peel River Stream Gauges

River level and flow for the Peel River was sourced from the Bureau of Meteorology's Water Data Online (Reference 2). Table 1 shows the details of the gauges used, with locations shown on Figure 2.

Table 1 Detail of river gauges on the Peel River

Site Number	Site Name	Record Start	Record End	Latitude	Longitude
419074	Peel River at Bective	29/10/1996	27/9/2019	−30.967	150.70314
419075	Peel River at Somerton	30/10/1996	14/03/2012	-30.94	150.65
419006	Peel River at Carroll Gap	26/02/1973	27/09/2019	-30.94	150.53

3.3. Design Rainfall Information

Intensity-Frequency-Duration (IFD) rainfall data was obtained from the Bureau of Meteorology (BoM). A summary of design rainfall depths at the site is provided in Table 2.

Table 2: Average design rainfall depths (mm)

Duration (minutes)	AEP				
	20%	10%	5%	2%	1%
20	22.1	26.4	30.7	36.6	41.2
25	24.3	29	33.7	40.2	45.3
30	26	31.1	36.1	43.1	48.6
45	29.9	35.7	41.5	49.4	55.7
60	32.7	38.9	45.2	53.8	60.7
90	36.8	43.7	50.6	60.1	67.6
120	39.9	47.3	54.7	64.8	72.8
180	44.9	52.9	61	72.1	80.8
270	50.6	59.5	68.4	80.6	90.3
360	55.3	64.9	74.5	87.8	98.3
540	62.8	73.8	84.8	99.9	112
720	68.9	81	93.3	110	124

3.4. Topographic Survey

Light Detection and Ranging (LiDAR) survey of the study area and its immediate surroundings was obtained from Elevation Information System (ELVIS, Reference 3). LiDAR is aerial survey data that provides a detailed topographic representation of the ground with a survey mark approximately every square metre.

There are two separate datasets that have a boundary that runs through the study area. The LiDAR in the northern part of the study area is from the “Manilla” region dataset collected in 2012. The southern part of the study area is covered by the “Tamworth” region dataset collected in 2016. For each of these regions, 5 m Digital Elevation Models (DEMs) were available for download from ELVIS. The levels along the edge where the datasets meet was compared and found to be reasonably consistent. The two datasets were combined into a single 5 m topographic grid.

The accuracy of the ground information obtained from LiDAR survey can be adversely affected by the nature and density of vegetation, the presence of steeply varying terrain, the vicinity of buildings and/or the presence of water. The accuracy of the ELVIS 1 m LiDAR data is typically ± 0.15 m for one standard deviation in the vertical direction and ± 0.5 m in the horizontal direction for clear terrain.

3.5. Proposed Development

PROJECT.e provided a preliminary plan of the proposed site layout, including the positions of buildings, proposed solar panel arrays, access driveways, and details of the typical mounting arrangement for the solar panels. The assumed layout is included in Appendix B.

WMAwater understands the plant would include hardstand areas with the following maximum dimensions:

- Substation – 60 m by 120 m
- Battery – 30 m by 50 m

The exact design of the solar panels is to be confirmed at a later stage. The panels are expected to be single-axis tracking mounted on booms that run north-south, supported by posts. The panels are expected to be at least 500 mm from the ground and this minimum height will only occur at sunrise and sunset when the panels are fully tilted. At other times the panels will be horizontal with a higher clearance above ground.

WMAwater understands that no net infill of soil is proposed for the development, and the proposed panels and hardstand area will generally be installed at the existing site levels.

3.6. Hydraulic Structures

WMAwater did not have access to detailed survey information about the locations or dimensions of cross-drainage culverts under roads, or other hydraulic controls in the vicinity of the site. The levels of road crests were estimated from the 5 m LiDAR DEMs.

4. PEEL RIVER FLOOD ASSESSMENT

4.1. Overview

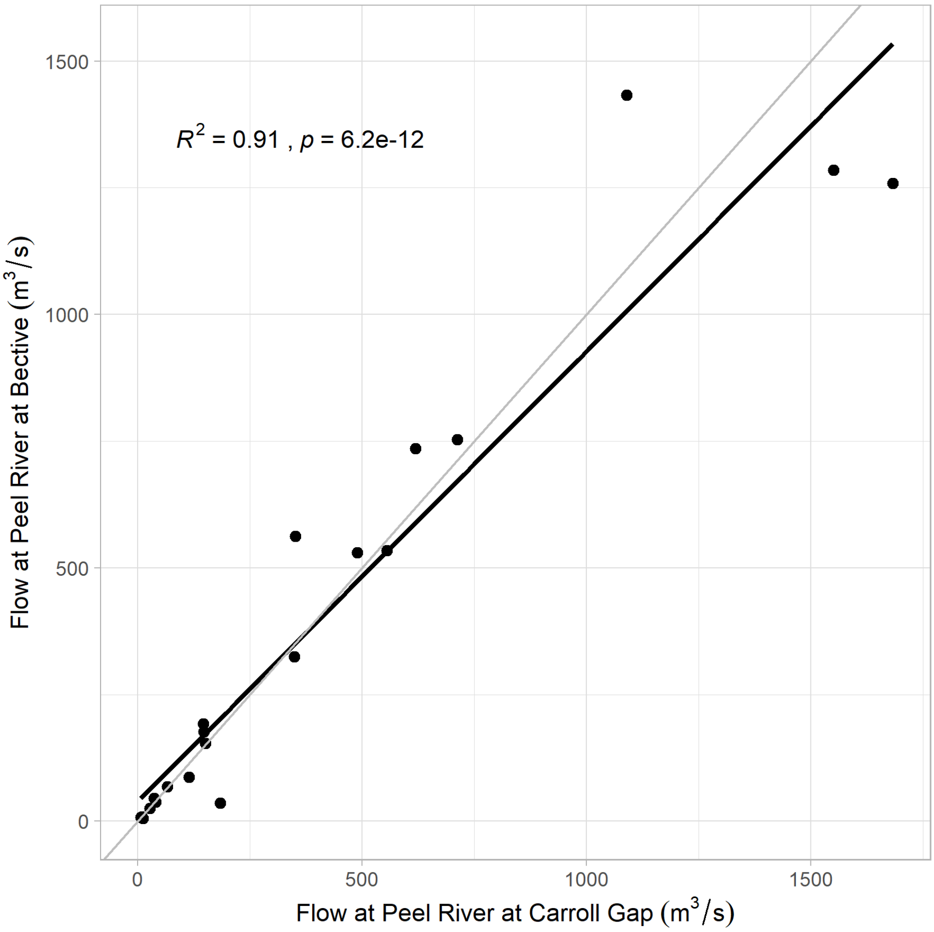
The objective of the Peel River component of the assessment was to understand whether the site is subject to flooding from the Peel River.

The solar farm site is located approximately 4 km as the crow flies from the Peel River, and approximately 7 km via local creek drainage lines. The lowest point of the site is approximately 40 m above the Peel River channel level. Therefore the main objective of the assessment was determine from available records whether flooding of the Peel River to sufficient depth to reach the site is feasible.

4.2. Method

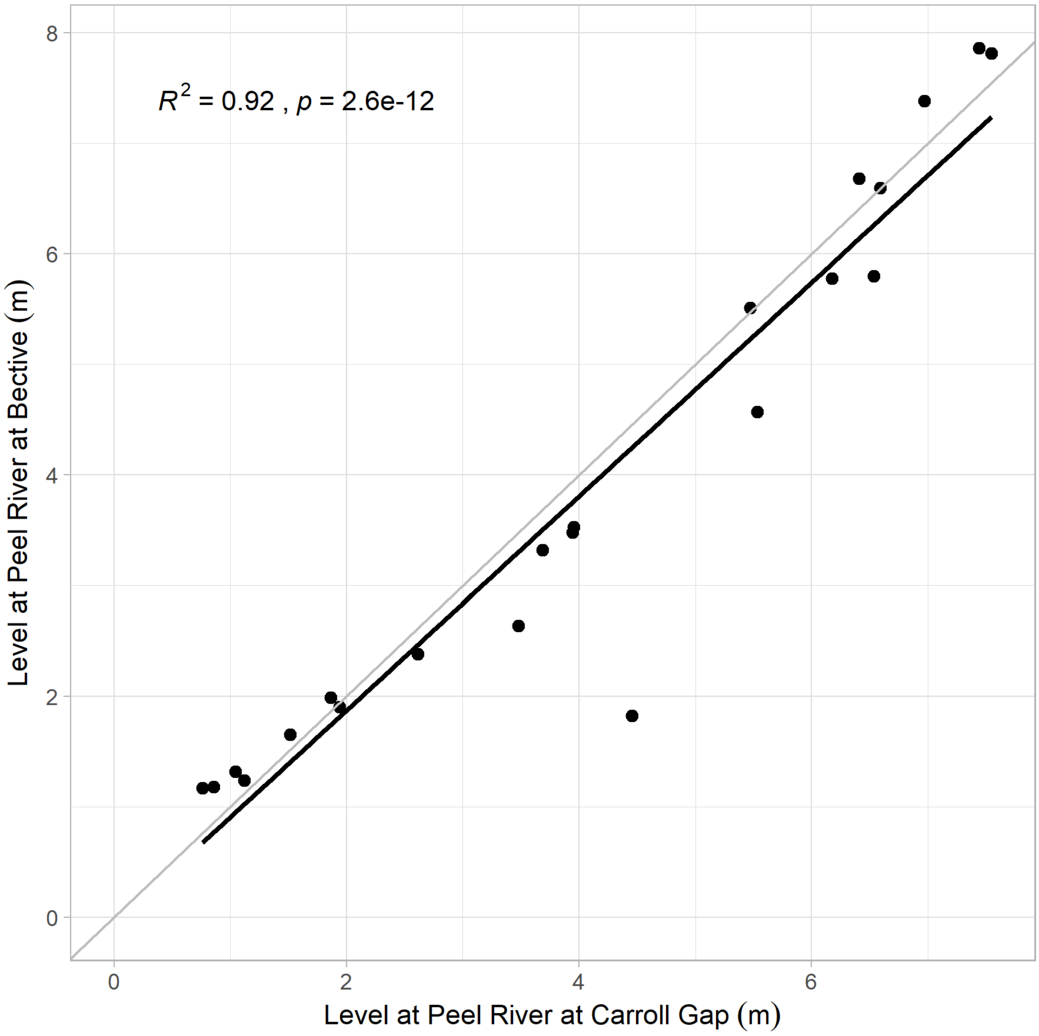
Historical records were analysed using Flood Frequency Analysis (FFA) of the nearby stream gauges. The record of the closest gauges on the Peel River (Peel River at Somerton and Bective) were both considered for the assessment. The Somerton gauge is located approximately 3.5 km downstream of where the runoff from the site enters the Peel River, and the Bective site is located a similar distance upstream.

Diagram 1: Flow Correlation between Peel River gauges at Bective and Carroll Gap



The gauges at Somerton and Bective have a record length of approximately 16 and 24 years of data respectively.. The gauge at Carroll Gap, further downstream along the Peel River, has a record length of approximately 45 years. A longer record improves the accuracy of the flood estimates from FFA. The flows for the Carroll Gap site were compared to those from the closer Somerton/Bective gauges during the period of overlap, and there was found to be a very close correlation in the recorded flows, with a R^2=0.91 correlation between data from Carrol Gap and Bective (see Diagram 1 and Diagram 2). This high degree of correlation indicates that the Carroll Gap records can be used to extend the local records for flow-based FFA.

Diagram 2: Water Level Correlation between Peel River gauges at Bective and Carroll Gap



The flood frequency analysis was undertaken on flow for the Peel River at Somerton gauge, and on level for the Peel River at Bective gauge. The flood frequency was fit using FLIKE (Reference 4) software. The method of fit was GEV with L2 moments for level, and LP3 with Bayesian inference for flow.

4.3. Results

The FFA for flood level at Bective shows that the 1% AEP flood level is significantly below the site.

A 1% AEP flood has a level of approximately 327.6 mAHD with a 90% confidence interval of between 325.8 mAHD to 329.6 mAHD (Diagram 3). This is at least 20 m below the site's lowest point (349.3mAHD). A flood frequency was also done on the flows at Peel River at Somerton which showed a 1% AEP flood flow of 3,500 m^3/s. The Peel River in this area is in a broad flood plain with no large constrictions between the gauge site and where the solar farm's runoff enters the river. Therefore, during floods there should not be any significant changes in flood depths between the Bective gauge (upstream of the site) and the Somerton gauge (downstream of the site) sites, so the property is significantly above the estimated 1% AEP flood of the Peel River.

Estimating the Probable Maximum Flood (PMF) was outside the scope of this assessment. However a rough assessment considering the Bective gauge rating curve (Diagram 4) and the waterway area in the Peel River cross section up to the elevation of the site indicates that there is floodplain capacity to pass orders of magnitude greater flow than the 1% AEP, and it is highly likely that the site is above the Peel River PMF level.

The SES Local Flood Plan (Reference 5) refers to a dam break assessment of Chaffey Dam that could potentially produce greater flows in the Peel River than a "natural" (i.e. without the presence of the dam) PMF level. The estimated dam-break flood wave depth is quoted as 11 m at Woolomin, just downstream of the dam wall, reducing to 3.5 m at Tamworth. This indicates that indicates that a depth of over 20 m at Bective, which is much further downstream than Tamworth, would not occur.

Based on the above considerations, the site is assessed to not be within the Peel River floodplain, even for extreme floods.

Diagram 3: Water Level Flood Frequency Analysis for Peel River at Bective Gauge

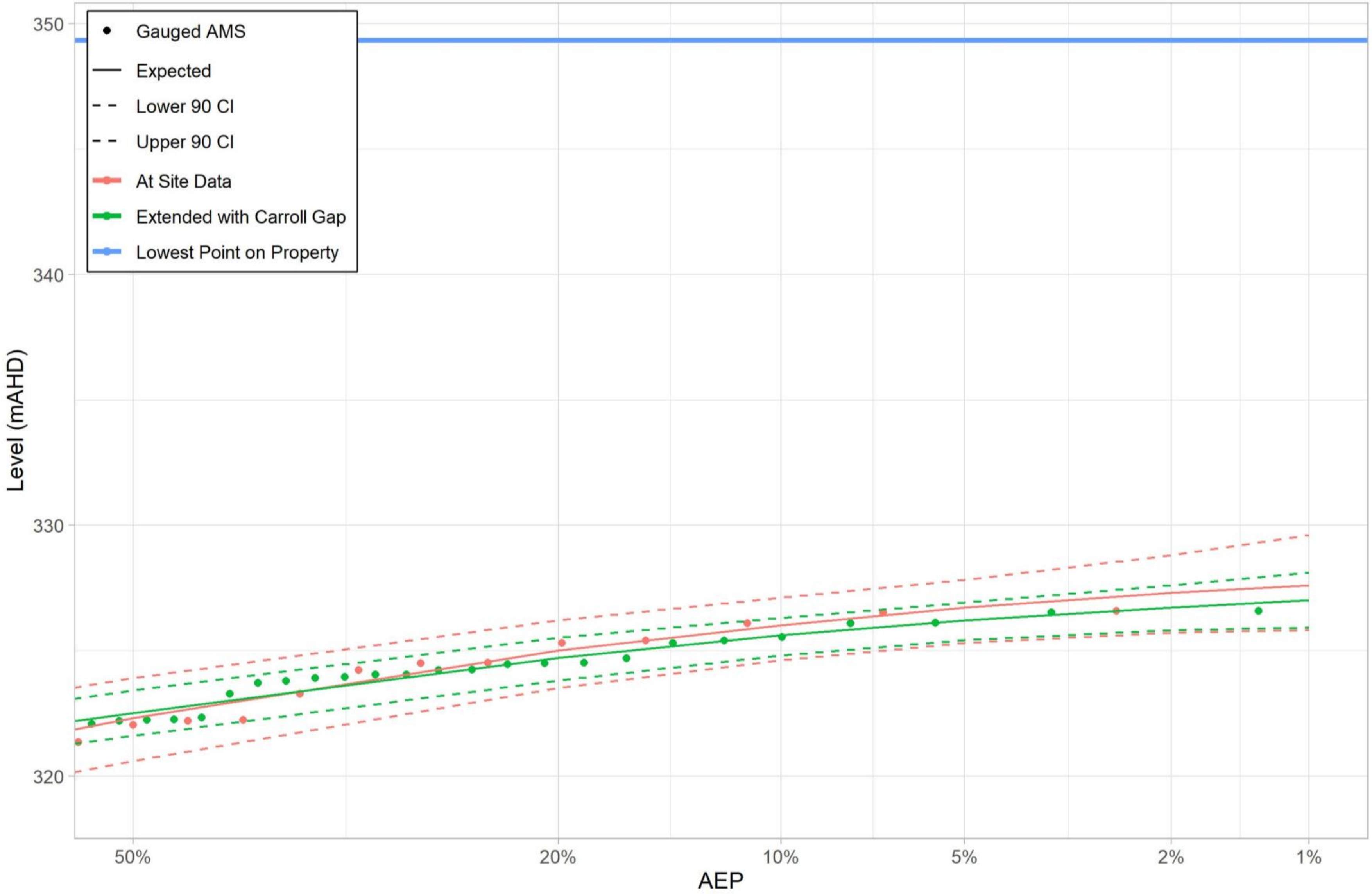
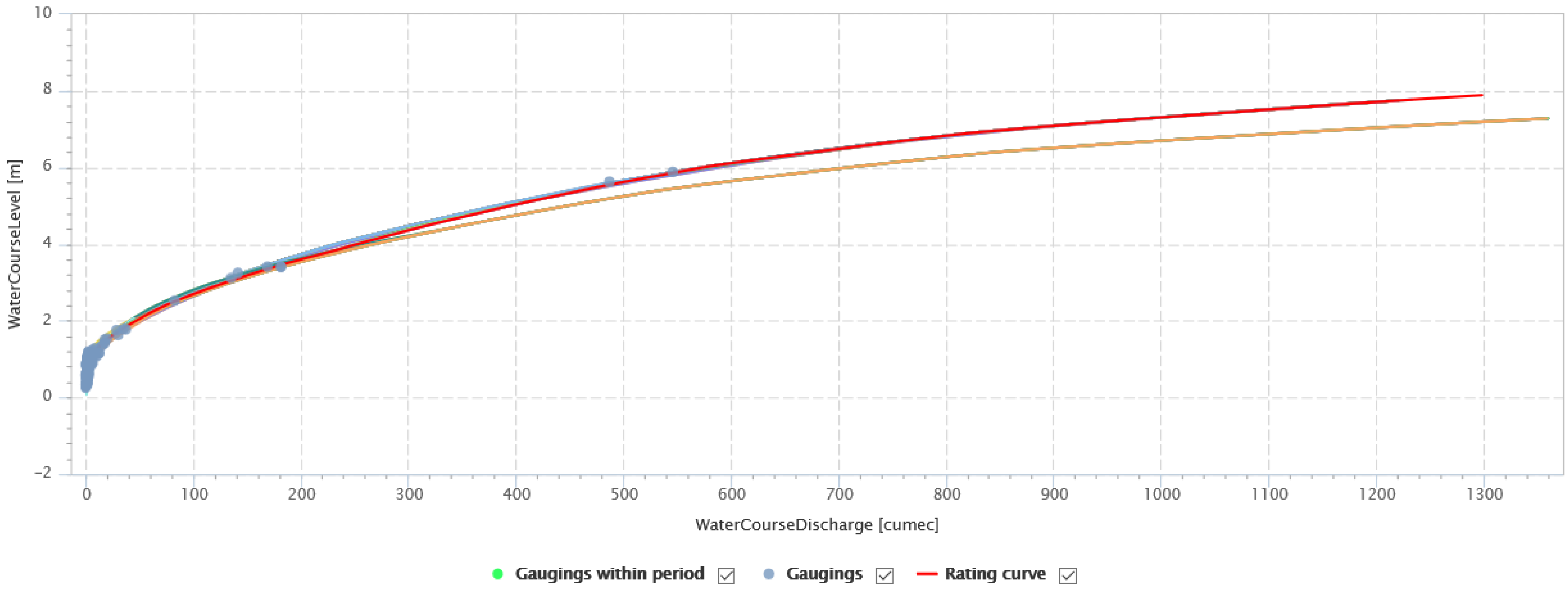


Diagram 4: Rating Curve for Peel River at Bective Gauge



5. LOCAL CATCHMENT FLOOD ASSESSMENT

5.1. Overview

Although the site is close to the top of a hill, it is large enough that runoff within the site can produce significant flow and flash flooding along the internal creeks. Furthermore, Donnellys Springs Creek has a relatively large local catchment area of 2,235 ha, so it was necessary to determine whether flooding in this creek or other nearby creeks could potentially affect the site.

Given there are no stream gauges for these local watercourses that provide a record of flood levels, the appropriate methodology to estimate the local catchment flood risk is rainfall-runoff modelling using design rainfalls from the BoM, and typical regional modelling parameters. Australian Rainfall and Runoff (ARR) 2019 (Reference 1) guidelines for design flood modelling were adopted for this study, including the use of ARR 2019 design rainfall information, ensemble temporal patterns, and rainfall loss assumptions. A summary of the data hub information at the catchment centroid is presented in Appendix A.

WMAwater developed a simple hydrologic model using the Watershed Bounded Network Model (WBNM) software for the local catchment to determine the critical duration – this process was undertaken for the Donnellys Springs Creek catchment and the unnamed local creek catchment within the site.

WMAwater also developed a 2D TUFLOW hydraulic model using “rainfall on grid” developed of the local catchments to determine flood depths, velocities, extents, etc. through and around the site.

The flow response at the catchment outlet was compared between the hydrologic and hydraulic models, and catchment parameters were adjusted to produce a reasonable match between these two models as a form of validation.

Details of the model setup and results for the local creek catchments are discussed below.

5.2. Hydrologic Model

A WBNM model of the Donnellys Springs Creek catchment was prepared, with subcatchments delineated as shown in Figure 3. It can be seen that the site occupies most of a subcatchment that flows into Donnellys Springs Creek downstream of the site, approximately 1.7 km downstream of the eastern site boundary. The purpose of this model was to estimate the catchment critical duration and validate the flow estimates obtained from the TUFLOW hydraulic model.

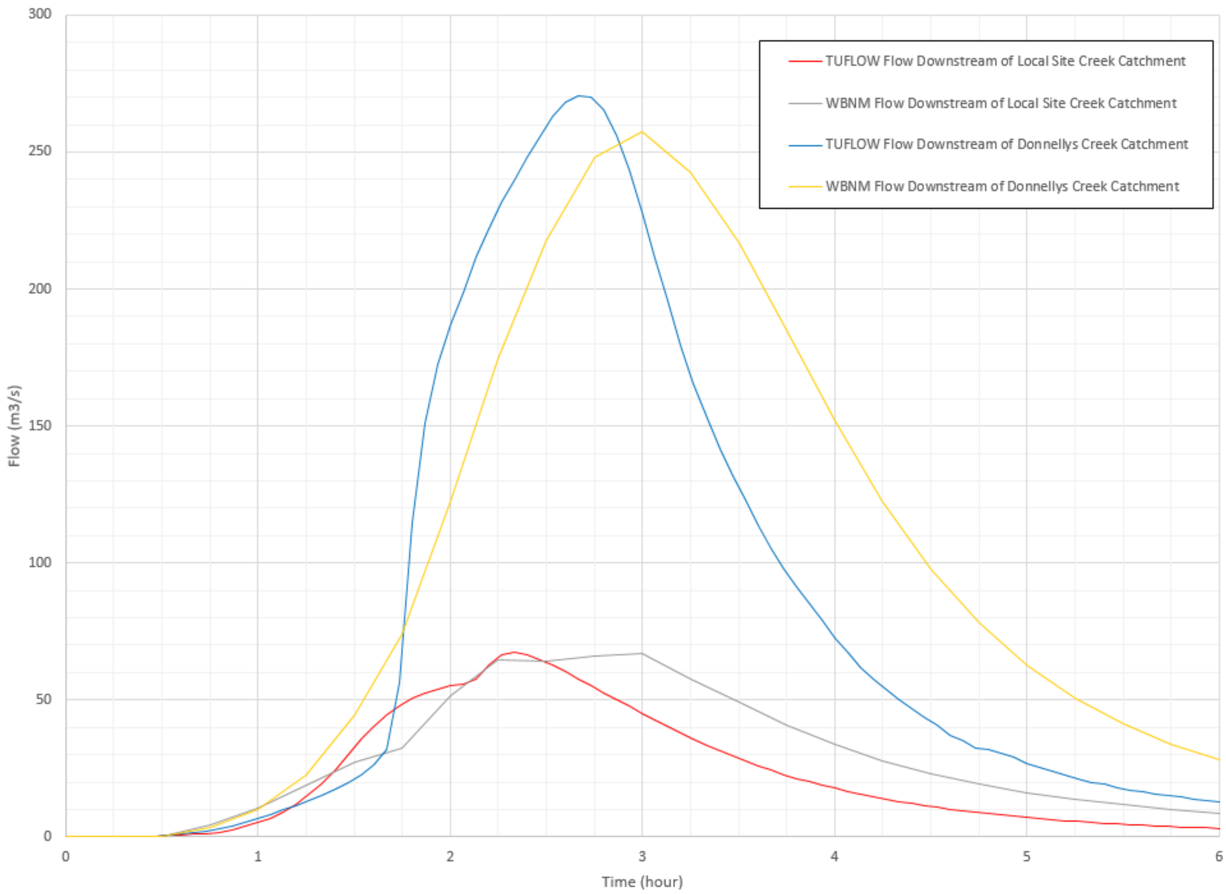
5.3. Hydraulic Model

A 2D TUFLOW hydraulic model was established covering the extent shown in Figure 4. The model comprised a 5 m orthogonal computational grid using the TUFLOW HPC finite volume solver, version 2018-03-AD.

The ground elevations for the hydraulic model were sampled from the 5 m LiDAR DEMs (Section 3.4). No details of road crest breaklines or cross-drainage culverts were included in the model. There are no significant hydraulic structures within the site, so the omission of these structures only affects the distribution of flows outside the site, and is not a significant concern for the purposes of this high level assessment.
Surface friction in the hydraulic model was represented using Mannings "n" roughness, with typical values based on experience with similar land use areas. The assumed roughness values are mapped on Figure 5.

The TUFLOW model covers the entire local creek catchment area covering the site as well as Donnellys Springs Creek. A "rainfall on grid" boundary condition approach was used where the design rainfalls are introduced to every cell in the hydraulic domain. Therefore the flows derived from the hydrologic model discussed above are not used directly as inflows to the hydraulic model. Rather the hydraulic model reproduces the hydrologic model calculations but also provides details about depths and velocities of flow across the model domain. The flows at the downstream catchment outlet obtained from each of the two modelling approaches were compared and the WBNM catchment lag parameter adjusted to produce a reasonable match. Diagram 5 shows a comparison of the flow hydrograph validation comparison.

Diagram 5: Hydrologic/Hydraulic Model Flow Validation Comparison



The model was run for both existing and proposed site conditions. The proposed development scenario was based on the drawing provided by PROJECT.e (Appendix B). The roughness values and loss rates were modified to reflect the proposed hardstand areas. The proposed solar panel mounting posts were represented by assumed a 10% blockage of the flow path area covered by the panels. The 10% parameter is a conservative value given that the structural form of the posts themselves is much less of the flow area than this – however it may represent debris that is mobilised in the flow being caught around the posts. Site boundary fences were assumed to be blocked by 40% to account for the obstruction of the fence and debris build-up along the fence line from overland flows. Effective design of the fences with rising bars for debris capture could minimise the effect of blockage on flow behaviour.

These blockage estimates only have a very localised effect on flow behaviour and the outcomes of the assessment are not likely to be significantly affected by the assumed blockage parameters. The real blockage risk is likely to be lower than what has been assessed, and this would not materially change the results provided in this assessment.

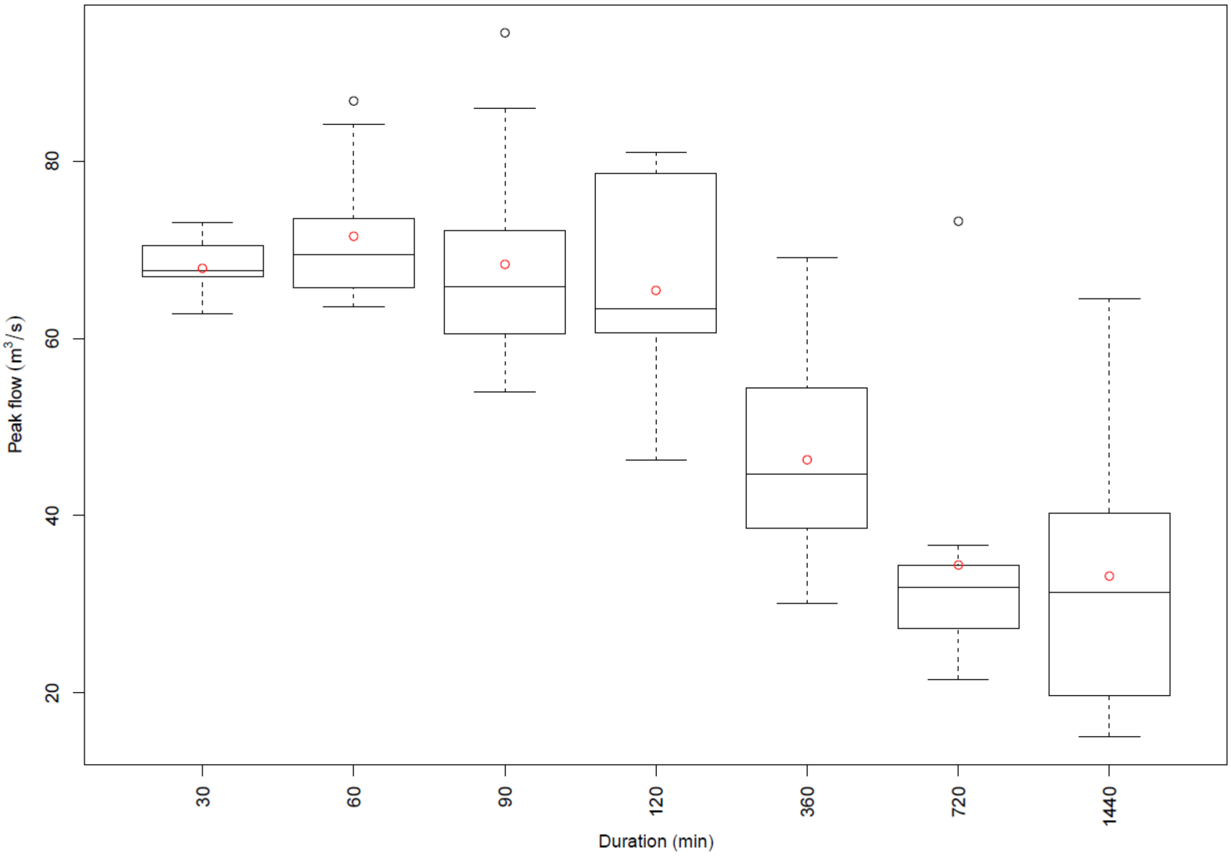
The proposed development modifications included in the model are mapped on Figure 6

5.4. Critical Storm Duration

There are a wide variety of temporal patterns possible for rainfall events of similar magnitude. This variation in temporal pattern can result in significant effects on the estimated peak flow. As such, the recommended methodology is to consider an ensemble of design rainfall events and determine the median catchment response from this ensemble. The validated hydrologic model was run for ten ensemble temporal patterns over a range of durations as recommended in ARR2019. The critical storm duration for each catchment was determined based on the duration with the highest mean flow response for the ensemble of temporal patterns.

Diagram 6 shows the flows for the local creek catchment within the site, with flow measured at the downstream boundary of the site. The box and whisker plots show the range of flow responses for different temporal patterns, with outliers represented as black dots. The red dot represents the median catchment response for the duration.

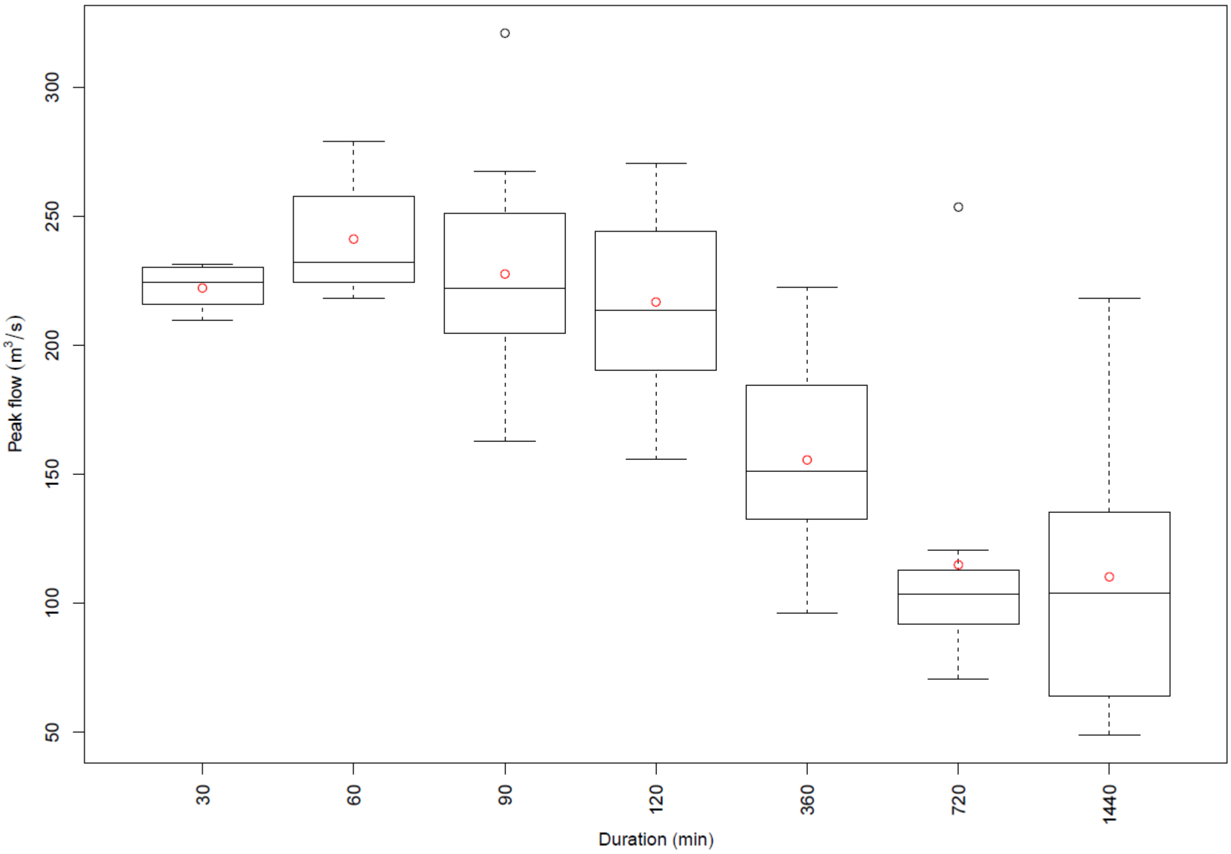
Diagram 6: Critical Duration Box-Plot – 1% AEP Local Site Creek Catchment



Based on Diagram 6, the 60 minute storm was adopted as the critical design event for the local creek catchment.

Diagram 7 shows the flows for the Donnellys Spring Creek catchment, with flow measured at the confluence downstream of the site where the unnamed creek through the site joins Donnellys Spring Creek. Based on Diagram 7, the 60 minute storm was adopted as the critical design event for the Donnellys Spring Creek catchment.

Diagram 7: Critical Duration Box-Plot – 1% AEP Donnellys Springs Creek Catchment



For the design flood mapping presented in this study, a single representative 60 minute design storm was adopted, using temporal pattern ID TP2183 from the ARR2019 Data-hub.

5.5. Design Rainfall Losses and Pre-Burst Rainfall

NSW State Government guidance for ARR2019 implementation (Reference 6) was followed to select appropriate losses for used in design flood modelling. The ARR Data-hub probability neutral burst initial loss values and continuing loss values, in conjunction with probability neutral pre-burst rainfalls were applied for the design flood modelling.

Assumed rainfall losses were 13.9 mm for the burst initial loss, and 0.5 mm/hour for continuing loss. Probability neutral burst initial loss values are dependent on the AEP and duration of the design event. Zero losses were applied to impervious surfaces.

5.6. Hydraulic Model Results

5.6.1. Existing Conditions

Figure 7 shows 1% AEP peak flood levels and depths in and around the site for existing conditions.

5.6.2. Impacts of Proposed Development Scenario

The proposed development scenario includes changes to the site from the proposed development resulting from increased hardstand area and the obstruction to flow from solar panel mounting posts and fences.

Figure 8 shows 1% AEP changes in peak flood levels and flows resulting from the proposed development compared to the existing conditions. The results indicate there would not be a significant change in flood behaviour downstream caused by the proposed development.

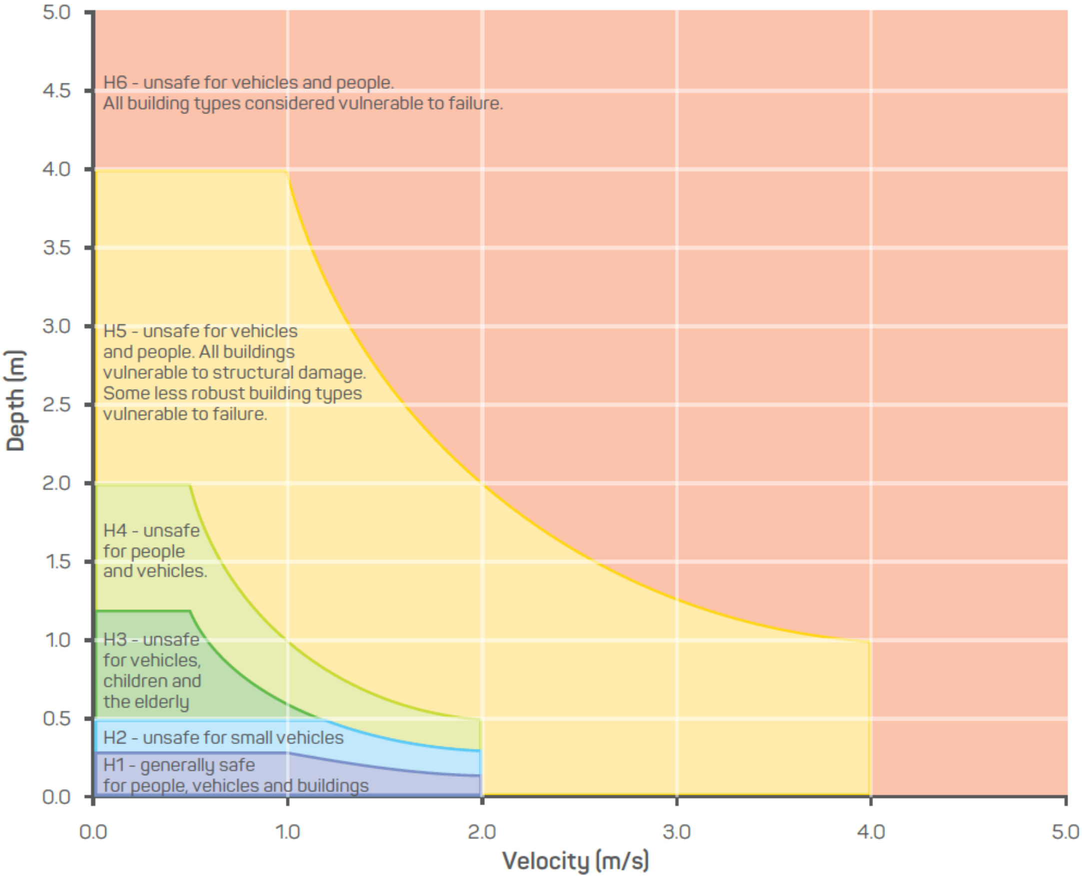
Figure 9 shows the proposed development 1% peak flood depths with the proposed solar panel locations overlaid on the map. Near the eastern corner of the site, and along the south eastern boundary near Soldiers Settlement road, the extents of the 1% AEP flood event will inundate the footings of some of the solar panels (to shallow depth less than 0.5 m), but would not reach the solar panels themselves even when they are fully tilted.

5.7. Hazard Categorisation

Hydraulic hazard is a measure of potential risk to life and property damage from flood. Hydraulic hazard is typically determined by considering the depth and velocity of floodwaters. In recent years, there have been a number of developments in the classification of hazards. Research has been undertaken to assess the hazard to people, vehicles and buildings based on flood depth, velocity and velocity depth product.

The Australian Disaster Resilience Handbook Collection deals with floods in Handbook 7 (Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia). The supporting guideline 7-3 (Reference 8) contains information relating to the categorisation of flood hazard. A summary of this categorisation is provided in Diagram 8.

Diagram 8: General flood hazard vulnerability curves (ADR)



This classification provides a more detailed distinction and practical application of hazard categories, identifying the following 6 classes of hazard:

- H1 – No constraints, generally safe for vehicles, people and buildings;
- H2 – Unsafe for small vehicles;
- H3 – Unsafe for all vehicles, children and the elderly;
- H4 – Unsafe for all people and all vehicles;
- H5 – Unsafe for all people and all vehicles. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure. Buildings require special engineering design and construction; and
- H6 – Unsafe for all people and all vehicles. All building types considered vulnerable to failure.

Figure 10 shows the ADR hazard classifications for the 1% AEP flood modelling, with the proposed development footprint overlaid within the site. This indicates that the proposed infrastructure for the site would generally only be affected by H1 category flows, except for some localised areas of H2 category flow along the internal site watercourses.

5.8. Flood Function Categorisation

Identification of flood function involves mapping the floodplain to indicate which areas are most important for the conveyance of floodwaters, and the temporary storage of floodwaters. This can help in planning decisions about which parts of the floodplain are suitable for development, and which areas need to be left as-is to ensure that flooding impacts are not worsened compared to existing conditions.

The 2005 NSW Government's Floodplain Development Manual (Reference 7) defines three hydraulic categories which can be applied to different areas of the floodplain depending on the flood function:

- Floodways;
- Flood Storage; and
- Flood Fringe.

Floodways are areas of the floodplain where a significant discharge of water occurs during flood events and by definition, if blocked would have a significant effect on flood levels and/or distribution of flood flow. Flood storages are important areas for the temporary storage of floodwaters and if filled would result in an increase in nearby flood levels and the peak discharge downstream may increase due to the loss of flood attenuation. The remainder of the floodplain is defined as flood fringe.

There is no quantitative definition of these three categories or accepted approach to differentiate between the various classifications. The delineation of these areas is somewhat subjective depending on knowledge of an area and flood behaviour, hydraulic modelling and previous experience in categorising flood function. A number of approaches are available, such as the method defined by *Howells et al* (Reference 9), rely on combinations of velocity and depth criteria to define the floodway.

For this study, hydraulic categories were defined by the following criteria using the 1% AEP flood modelling:

- Floodway is defined as areas where:
    - the peak value of velocity multiplied by depth (V x D) > 0.25 m^2/s, **AND** peak velocity > 0.25 m/s, **OR**
    - peak velocity > 1.0 m/s **AND** peak depth > 0.1 m, **OR**
    - defined channels (from bank to bank) on creeks or tributary flow paths.

The remainder of the floodplain is either Flood Storage or Flood Fringe,

- Flood Storage comprises areas outside the floodway where peak depth > 0.2 m, and
- Flood Fringe comprises areas outside the Floodway where peak depth ≤ 0.2 m.

Figure 11 shows the flood function categorisation for the 1% AEP modelling. These results indicate that some of the proposed solar panel locations would be within floodway or flood storage areas. While they will not affect the flow behaviour beyond the site (as demonstrated in Section 5.6.2), it may be necessary to relocate these panels to avoid potential soil erosion around the solar panel mounting posts during times of significant flow.

6. EMERGENCY RESPONSE MANAGEMENT

6.1. Existing Flood Warnings and Response

6.1.1. Bureau of Meteorology flood warning

The Bureau of Meteorology issues quantitative flood warnings for specified forecast locations including expected flood class (major, moderate, minor) and timing of flooding. The Bureau does not cover quantitative flash-flood warnings, defined as rain-to-flood times of less than six hours. While there would be warnings issued for Peel River flooding, which is relevant to the site with regards to access to supplies and facilities in nearby towns. The area around the site is subject to flash-flooding and, as such, The Bureau does not issue quantitative warnings of river level heights for the study area.

6.1.2. Bureau of Meteorology severe weather warnings

The Bureau of Meteorology issues severe weather warnings whenever severe weather is occurring in an area or expected to develop or move into an area. This includes very heavy rain that may lead to flash flooding. The warnings describe the area under threat and the expected hazards. Warnings are issued with varying lead-times, depending on the weather situation, and can be from one hour to 24 hours or more. The Bureau also issues severe thunderstorm warnings that include thunderstorms producing heavy rainfall which may cause flash flooding.

6.1.3. SES warnings and response

The SES is the legislated Combat Agency for floods and is responsible for the control of flood operations. This includes the coordination of other agencies and organisations for flood management tasks. The NSW SES Tamworth Regional Local Controller is responsible for dealing with floods as detailed in the State Flood Plan.

Actions, responsibilities and flood intelligence for the region where the site is located are detailed in the Tamworth Regional Local Flood Plan (Reference 5). This plan is focussed on areas at risk from major riverine flooding and does not make specific reference to the rural communities outside Somerton and Bective where the site is located.

6.1.4. Flood intelligence

The SES does not have any formal flood intelligence for the roads or local creeks in the vicinity of the site. The work undertaken in this assessment is the only available flood modelling for these creeks.

6.1.5. Response

Response is via community volunteers, coordinated by SES. Response operations are outlined in the Tamworth Regional Local Flood Plan (Reference 5). Of relevance to the study, the start of response operations will begin:

- On receipt of a Bureau of Meteorology Flood Watch or Severe Weather Warning.
- When other evidence leads to an expectation of flooding within the council area.

Given the lack of flood intelligence available to the SES for the local creeks around the site, the SES unlikely to deploy resources to the area during a flash flood, or order any evacuations, unless called to respond to a specific incident.

6.2. Overview of Recommended Site Response Strategy

It will not be possible in real time during a flood to understand what the peak of the flood will be for this site. This is because:

- the time between the rainfall occurring and flooding occurring is short (generally less than an hour, and possibly as short as 15 minutes for local flash flooding on-site),
- the location of the most intense rainfall bursts for flood-producing storms in small catchments such as this cannot be predicted accurately ahead of time; and
- as a result of the above, there are no formal flood warning systems in place for the catchment.

There will likely be very little warning of flooding, apart from very heavy local rainfall. General warnings about severe storms will be available for the Sydney Metropolitan region provided by the Bureau of Meteorology (BoM) but these will not provide specific information for this site. Cessnock Council may in the future develop flood warning systems for nearby catchments or larger creeks, but these will only provide a general indication of potential flood risk for the catchments and creeks affecting the site.

Small vehicles can become unstable and vulnerable to stall at depths of only 0.2 m to 0.3 m. Advice from the SES is that nobody should drive through any depth of floodwater, because of the difficulty for the driver to accurately gauge the depth of water, to accurately follow the path of the road, and because conditions underneath the water may have changed (such as failure of the pavement or a pothole).

The proposed development therefore would not significantly affect the existing SES community response planning. However the development is in an area where generally a high degree of self-sufficiency would be assumed for the local population, including:

- Sufficient supplies and tolerance for being isolated from urban areas for at least a day; and
- Reasonable awareness of the risks of driving through floodwaters.

Depending on the number of people required to operate the plant, their operational responsibilities within the site, and their shift movements, it may be necessary to including flooding as one of the risks considered under the site emergency response plan. This plan would provide training for operational personnel and visitors about flood risks, and provide direction about actions to take in case of flash flooding of creeks either within the site or on access roads to the site.

7. CONCLUSIONS

7.1. Summary and Recommendations

WMAwater undertook an assessment of existing flood risk at 2209 Soldiers Settlement Road (the site). There is no existing Council Flood Study or Floodplain Risk Management Study/Plan that addresses floodplain management at the site.

WMAwater's assessment considered flood risk both from the Peel River and local watercourses within and around the site. It was concluded that the site is not at risk of flooding from the Peel River. However the site is large enough that runoff within the site can produce significant flow and flash flooding along the internal creeks. These internal watercourses are tributaries of Donnellys Springs Creek.

The flood risk was mapped for the 1% AEP event, under both existing site conditions and with the solar farm infrastructure. The assessment indicates that the proposed development will not produce adverse impacts on flood flows or levels beyond the site. The proposed development is generally compatible with the flood risk, although there are localised areas where the placement of solar panels is within the 1% AEP flood extents of the local watercourses. It is recommended that the design and placement of the affected solar panels in these locations be reconsidered as part of the detailed design of the proposed development. It may still be appropriate to place some panels in areas that are affected by either shallow or slow moving flow, but preferably not within "floodway" areas (see Figure 11).

The proposed development therefore would not significantly affect the existing SES community response planning. However the development is in an area where generally a high degree of self-sufficiency would be assumed for the local population, including:

- Sufficient supplies and tolerance for being isolated from urban areas for at least a day; and
- Reasonable awareness of the risks of driving through floodwaters.

Depending on the number of people required to operate the plant, their operational responsibilities within the site, and their shift movements, it may be necessary to including flooding as one of the risks considered under the site emergency response plan. This plan would provide training for operational personnel and visitors about flood risks, and provide direction about actions to take in case of flash flooding of creeks either within the site or on access roads to the site. Such information could be readily included in the broader emergency response plan prepared by the operator once the operational details of the site are known, and would need to be maintained by the site manager once the site becomes operational.

8. REFERENCES

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9. GLOSSARY AND TERMINOLOGY

9.1. LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ALS	Airborne Laser Scanning
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DRM	Direct Rainfall Method
DEM	Digital Elevation Model
IFD	Intensity, Frequency and Duration (Rainfall)
mAHD	meters above Australian Height Datum
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
SRMT	Shuttle Radar Mission Topography
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)

9.2. TERMINOLOGY OF FLOOD RISK

Australian Rainfall and Runoff (ARR, editors Ball et al, 2016) recommends terminology that is not misleading to the public and stakeholders. Therefore the use of terms such as "recurrence interval" and "return period" are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2016 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% or 1 in 100 AEP event (sometimes referred to as a 100 year ARI), has a 1% chance of being equalled or exceeded in any year. ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table below describes how they are subtly different.

For events more frequent than 50% AEP, expressing frequency in terms of Annual Exceedance Probability is not meaningful and misleading particularly in areas with strong seasonality. Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6 month Average Recurrence Interval where there is no seasonality, or an event that is likely to occur twice in one year.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore an AEP is not assigned to the PMF.

This report has adopted the approach recommended by ARR and uses % AEP for all events of 50% AEP or rarer and EY for all events more frequent than this.

9.3. GLOSSARY OF TERMS

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
DRAINS	Stormwater Drainage System design and analysis program.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.

flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.

	existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
LiDAR	Surveying method that measures distances via laser.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	

	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:
	$ the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
	
	$ water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
	
	$ major overland flow paths through developed areas outside of defined drainage reserves; and/or
	
	$ the potential to affect a number of buildings along the major flow path.

mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).

RAFTS	Runoff routing model for hydrologic and hydraulic analysis of storm water drainage and conveyance systems.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RORB	General runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
SOBEK	Integrated 1D/2D modelling suite for flood modelling, flood forecasting and optimisation of drainage systems.
stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
TUFLOW	One-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model).
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.

Figures

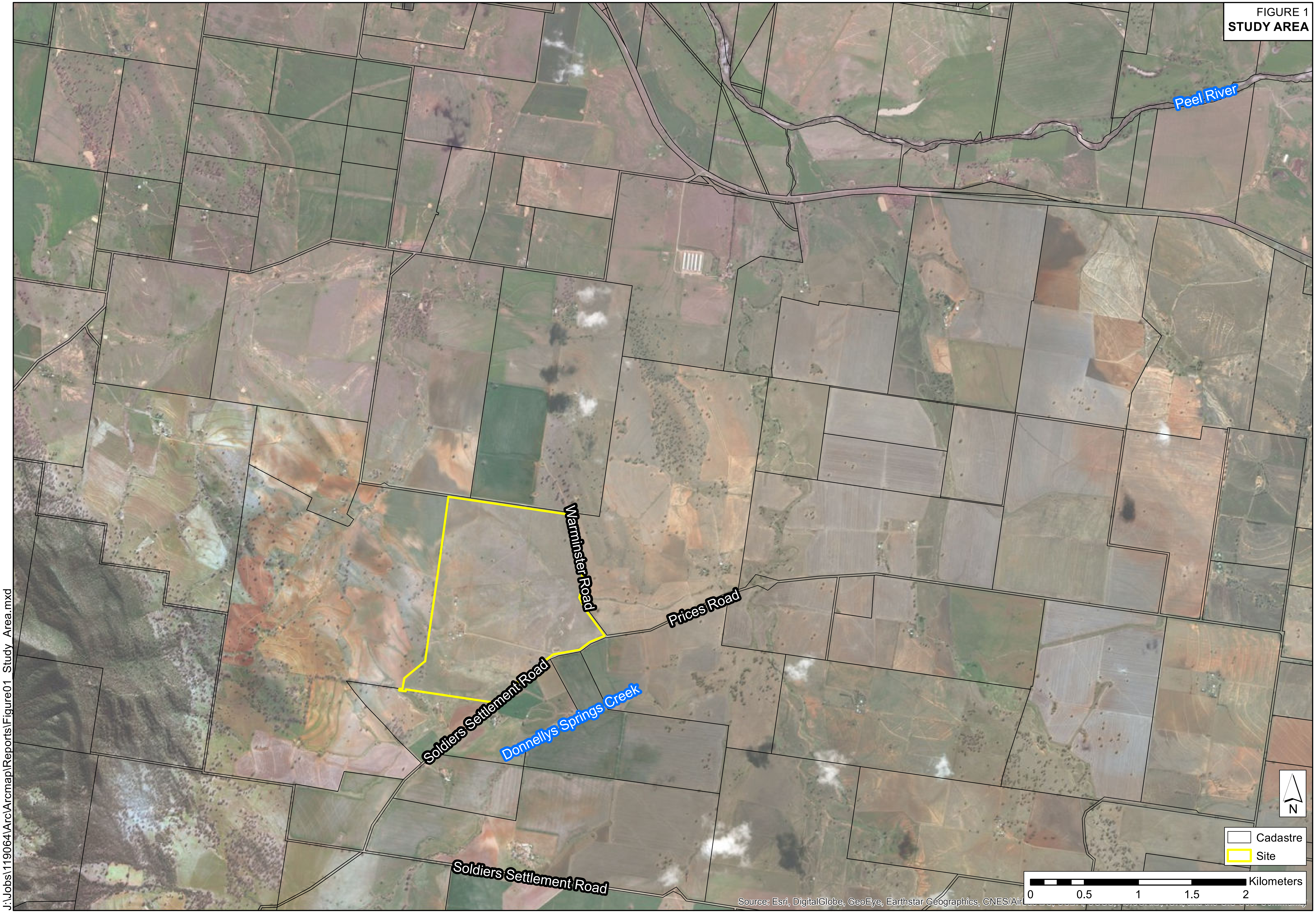

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FIGURE 2
STREAM GAUGE LOCATIONS

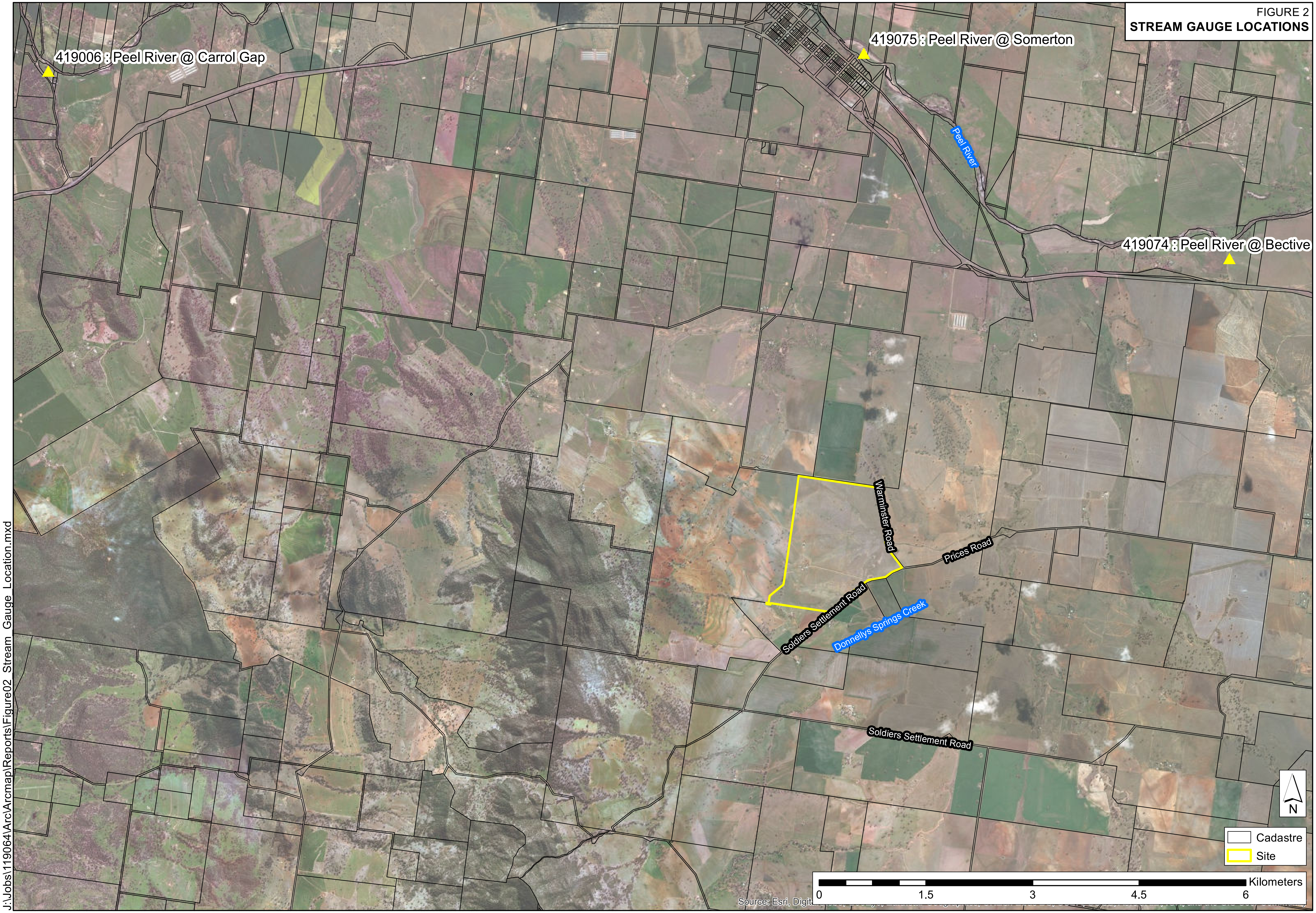

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FIGURE 3
WBNM MODEL LAYOUT

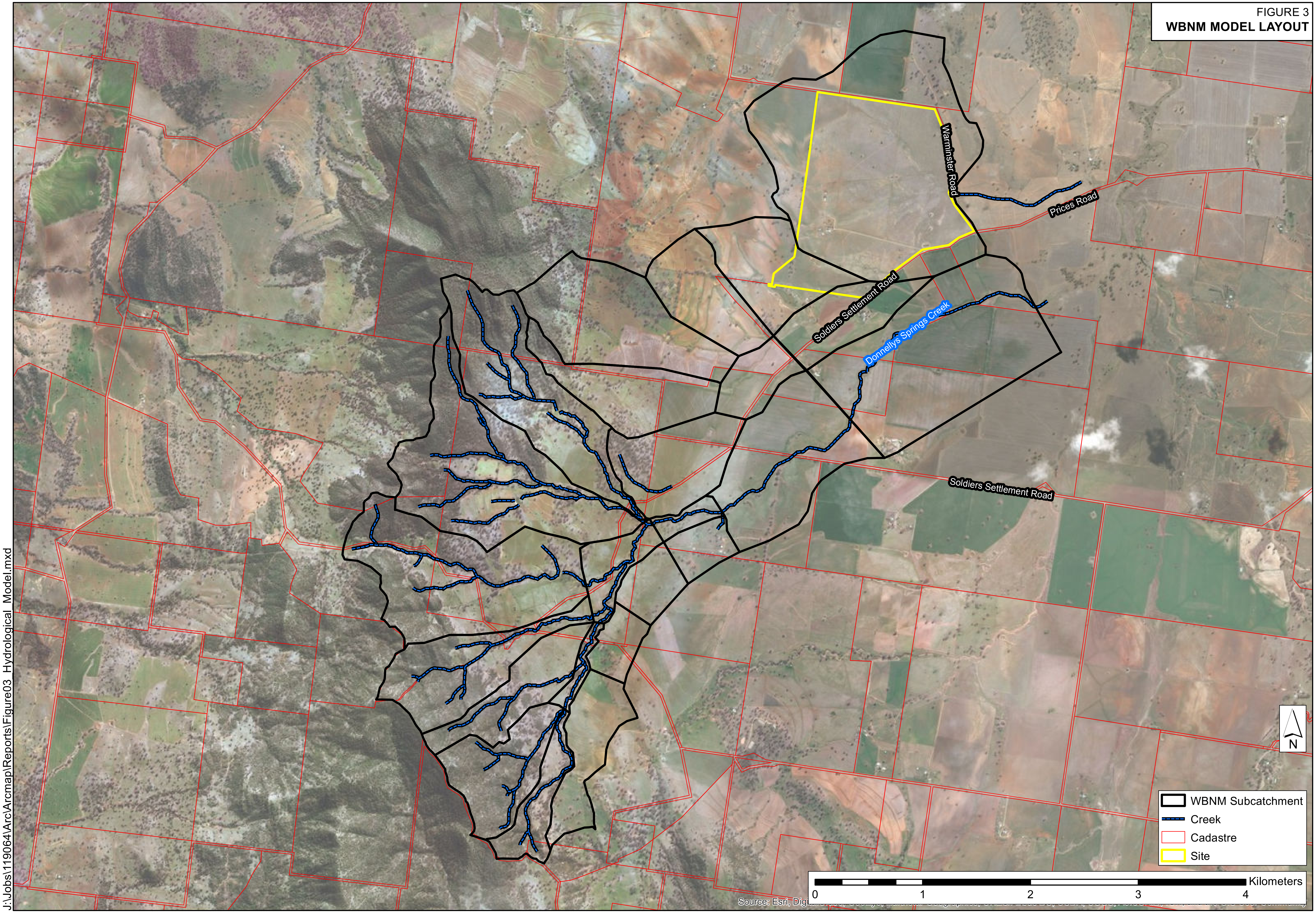

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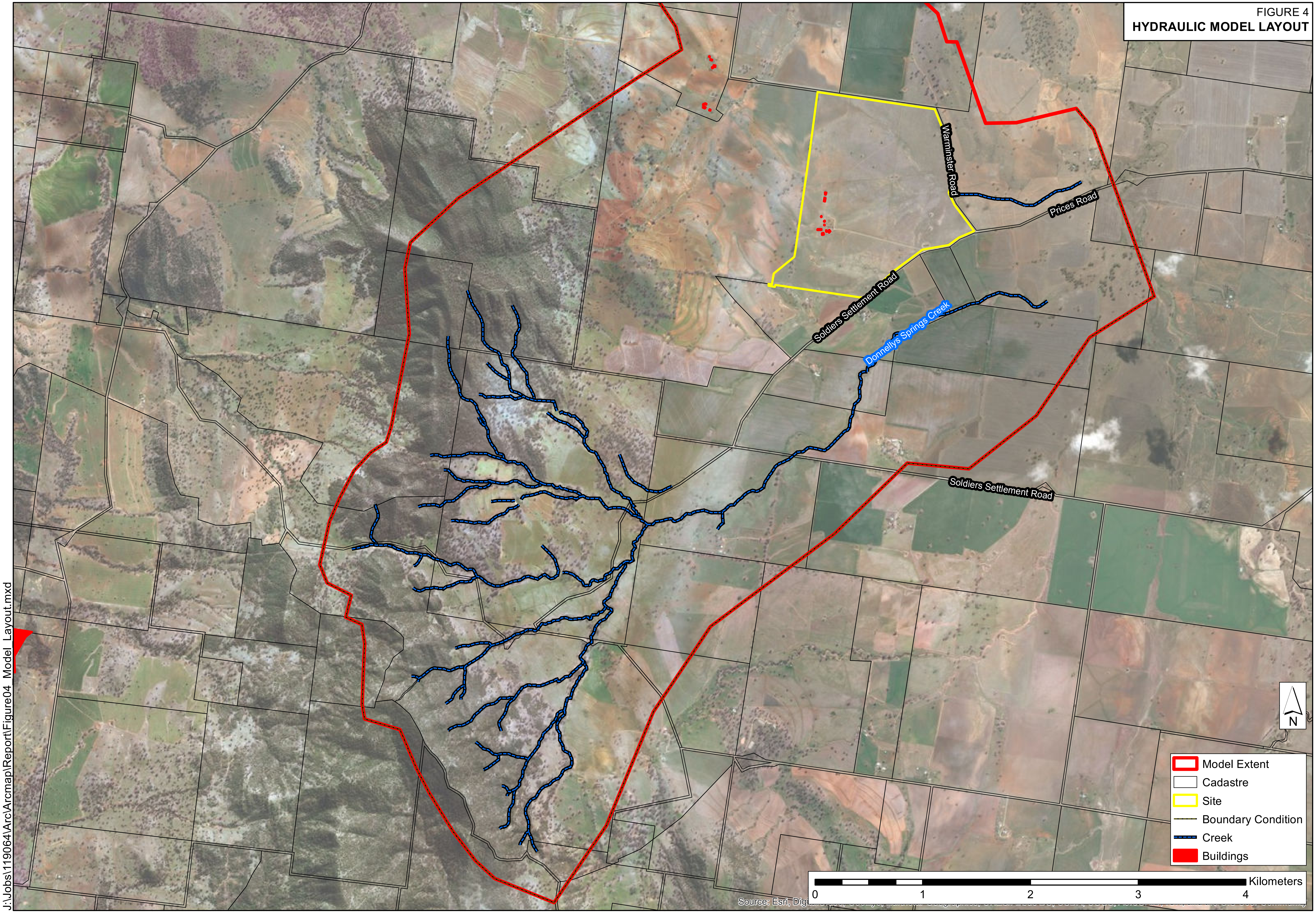
FIGURE 4
HYDRAULIC MODEL LAYOUT



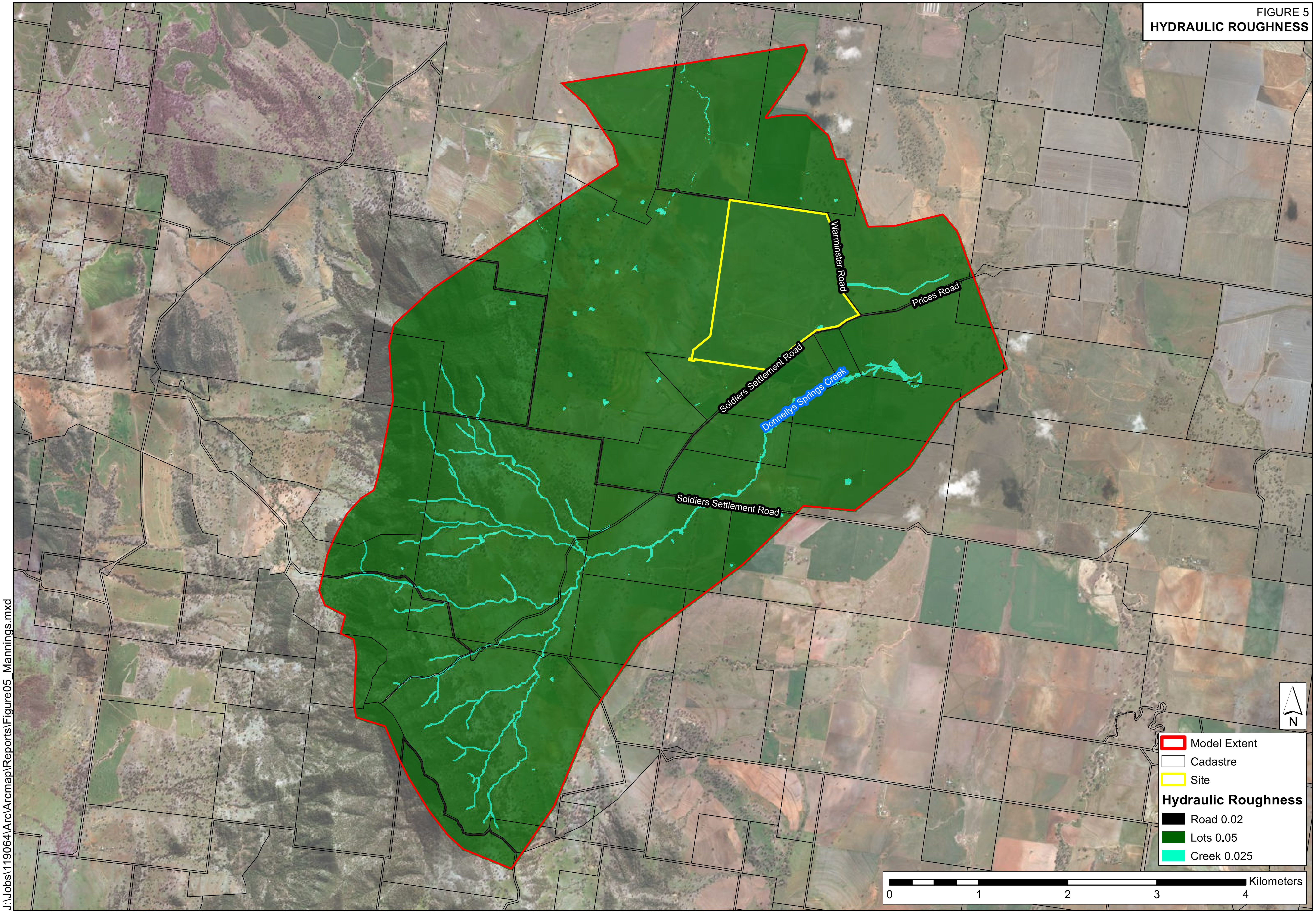


FIGURE 5
HYDRAULIC ROUGHNESS
Warminster Road
Prices Road
Soldiers Settlement Road
Donnellys Springs Creek
Soldiers Settlement Road
N
Model Extent
Cadastre
Site
Hydraulic Roughness
Road 0.02
Lots 0.05
Creek 0.025
0
1
2
3
4
Kilometers
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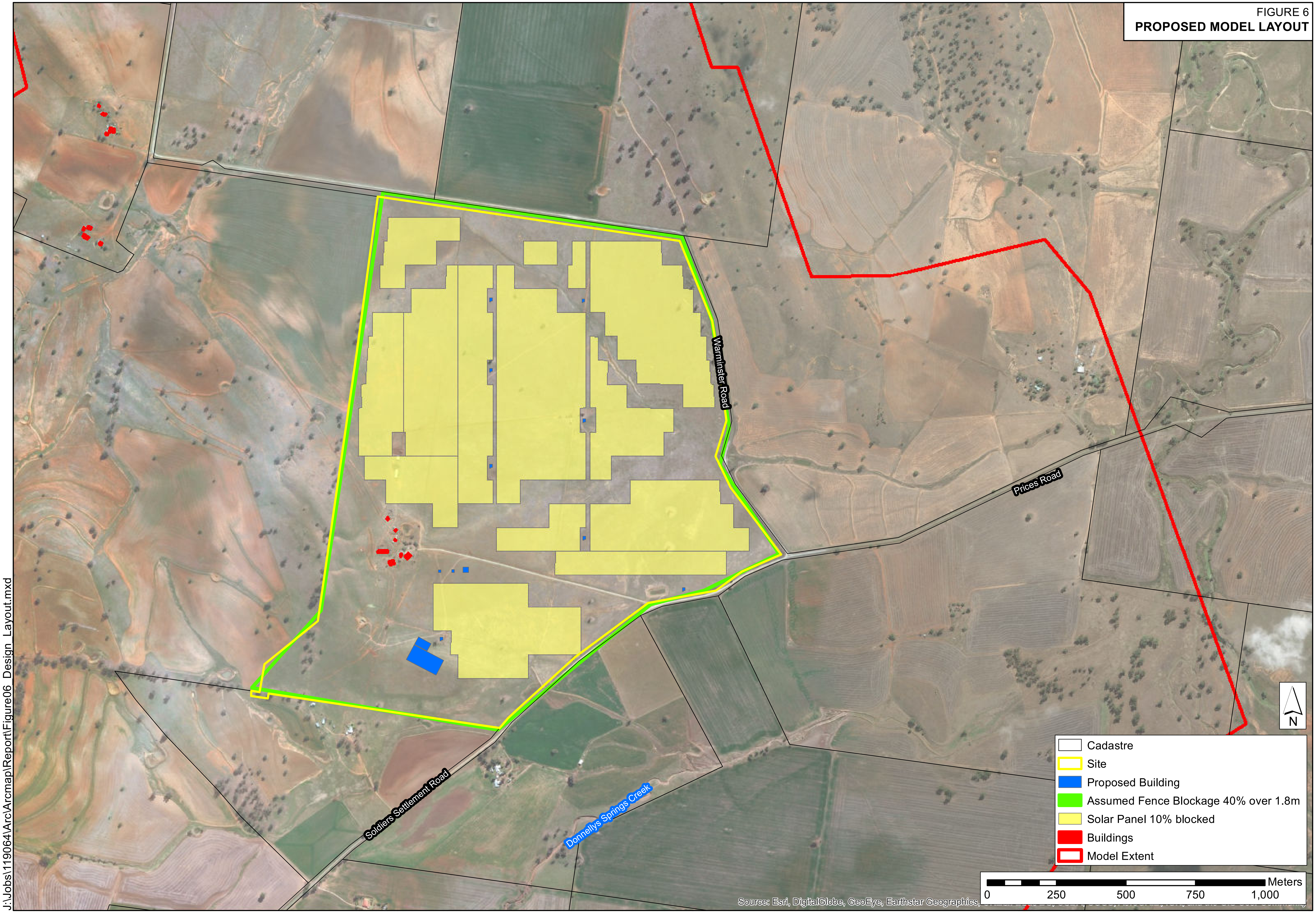
FIGURE 6
PROPOSED MODEL LAYOUT



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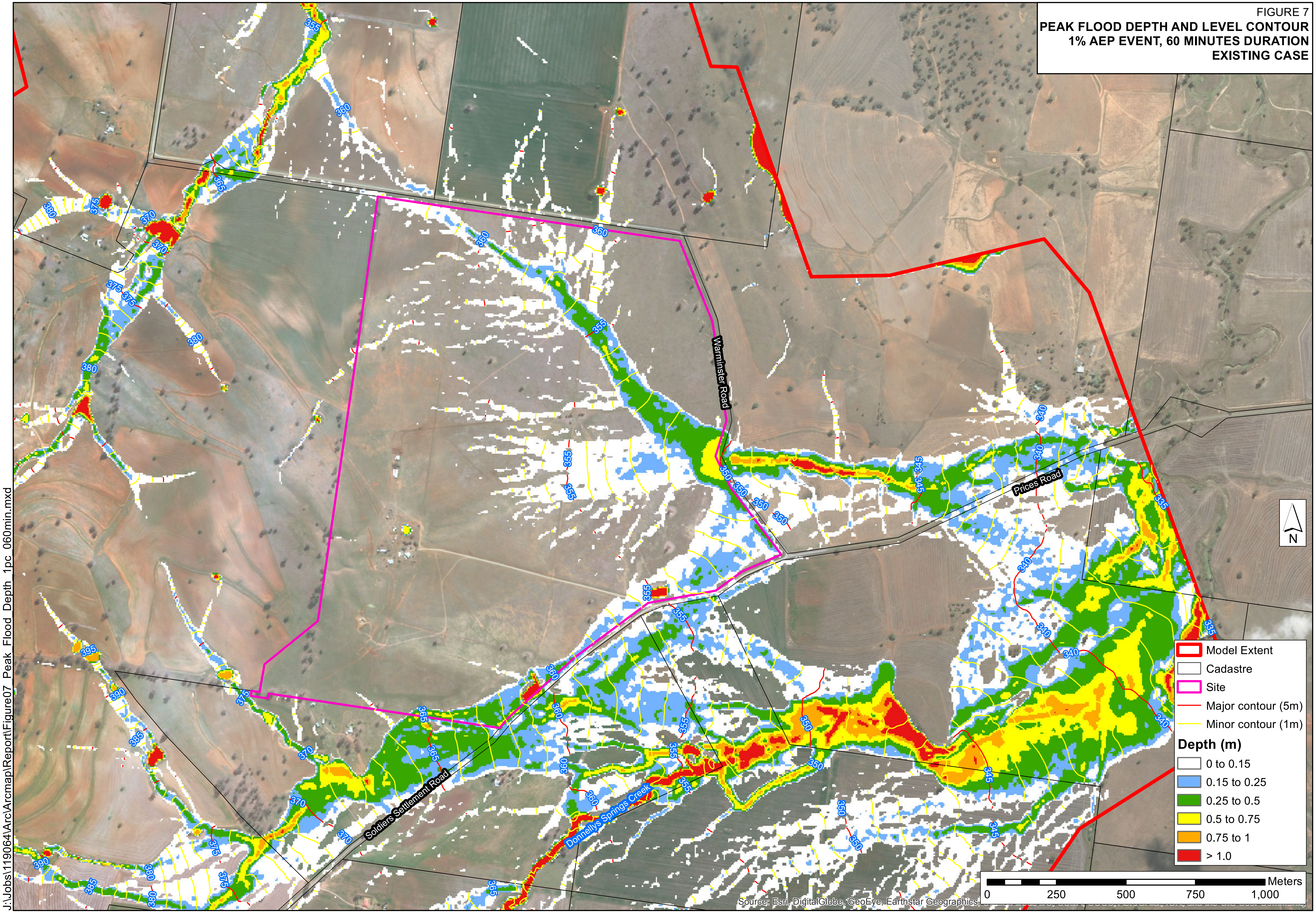

FIGURE 7
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1% AEP EVENT, 60 MINUTES DURATION
EXISTING CASE
Warminster Road
Prices Road
Soldiers Settlement Road
Donnellys Springs Creek
Model Extent
Cadastre
Site
Major contour (5m)
Minor contour (1m)
Depth (m)
0 to 0.15
0.15 to 0.25
0.25 to 0.5
0.5 to 0.75
0.75 to 1
> 1.0
N
Meters
0
250
500
750
1,000
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics
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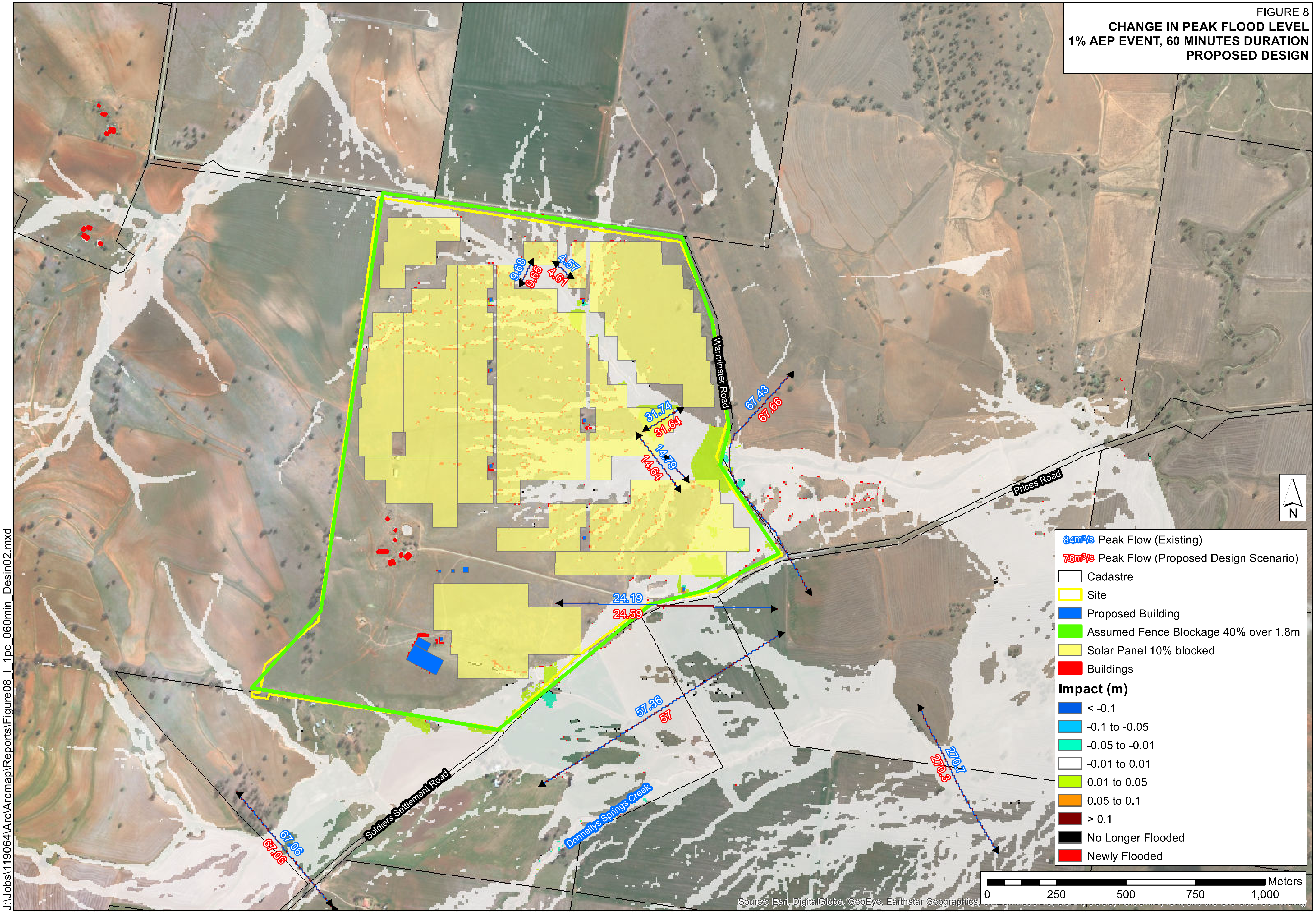

FIGURE 8
CHANGE IN PEAK FLOOD LEVEL
1% AEP EVENT, 60 MINUTES DURATION
PROPOSED DESIGN

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FIGURE 9
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1% AEP EVENT, 60 MINUTES DURATION
PROPOSED DESIGN

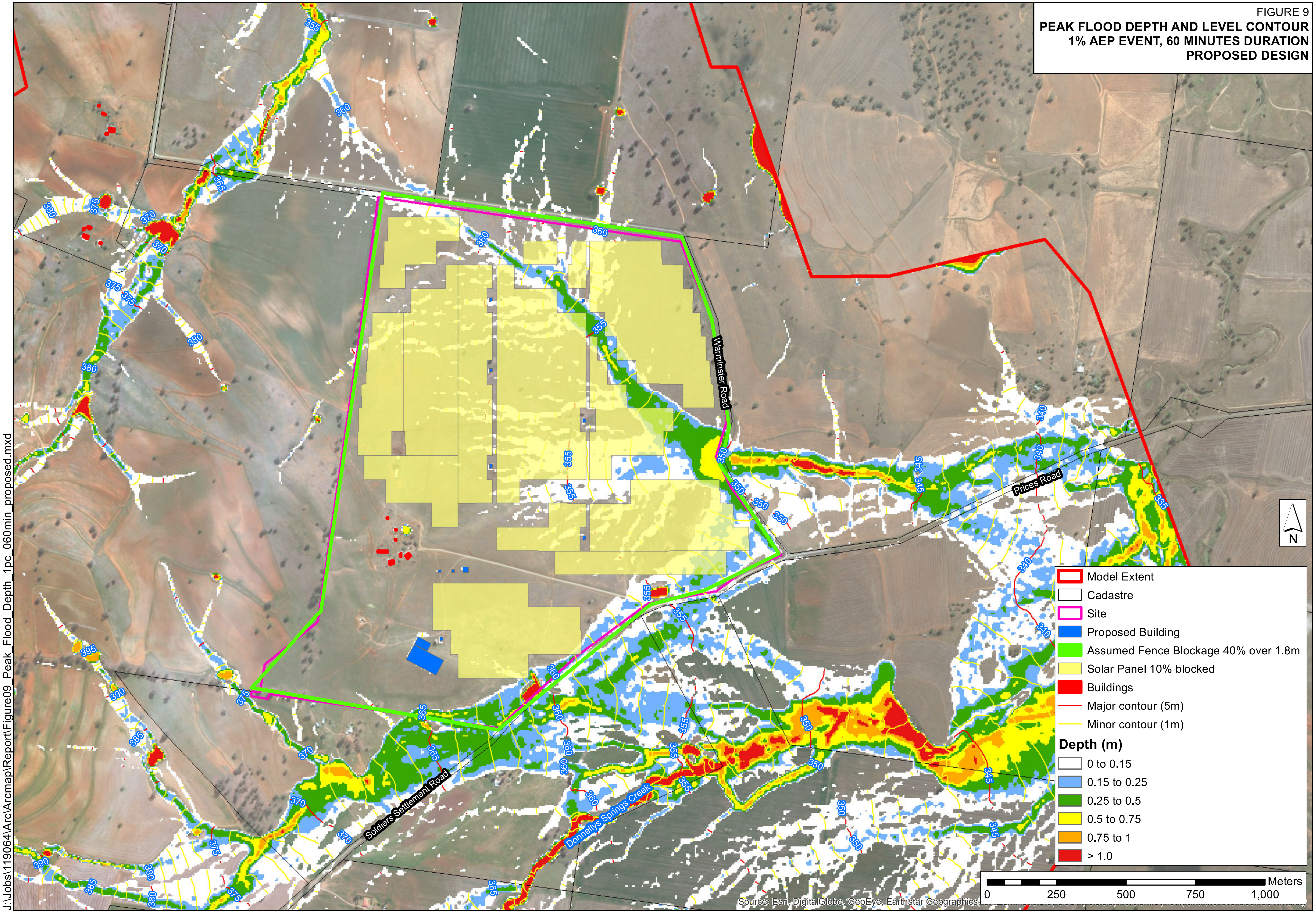

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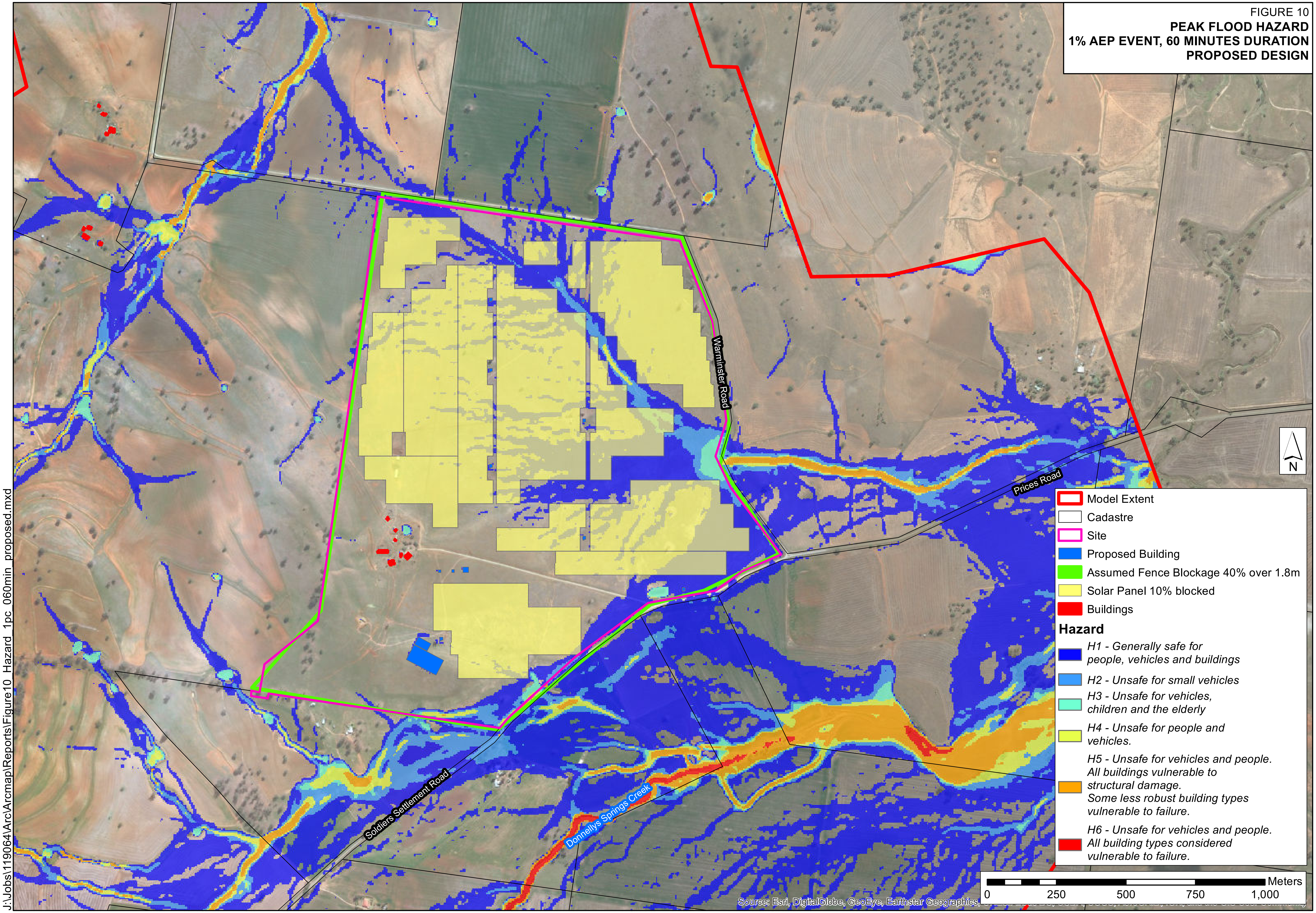
FIGURE 10
PEAK FLOOD HAZARD
1% AEP EVENT, 60 MINUTES DURATION
PROPOSED DESIGN



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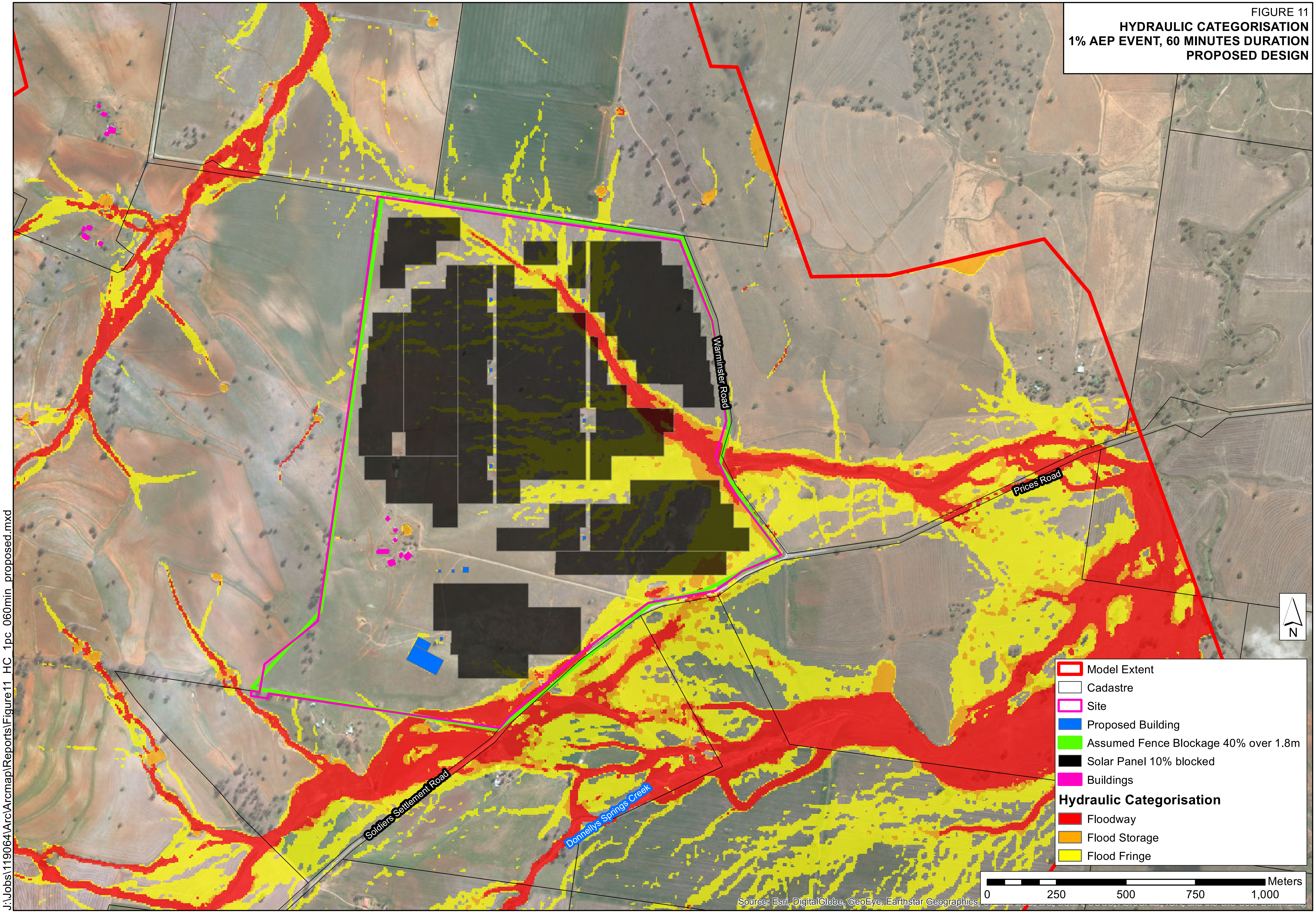

FIGURE 11
HYDRAULIC CATEGORISATION
1% AEP EVENT, 60 MINUTES DURATION
PROPOSED DESIGN

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APPENDIX A. ARR Data-hub Metadata

Appendix A

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	150.647
Latitude	-31.005
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	20
River Name	Namoi River

Layer Info

Time Accessed	30 September 2019 03:11PM
Version	2016_v1

ARF Parameters

A R F = M i n { 1 , [1 – a (A r e a b – c log 10 D u r a t i o n) D u r a t i o n – d + e A r e a f D u r a t i o n g (0.3 + log 10 A E P) + h 10 i A r e a D u r a t i o n 1440 (0.3 + log 10 A E P)] }

Zone	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Semi-arid Inland QLD	0.159	0.283	0.25	0.308	7.3e-07	1.0	0.039	0.0	0.0

Short Duration ARF

A R F = M i n [1 , 1 – 0.287 (A r e a 0.265 – 0.439 log 10 (D u r a t i o n)) . D u r a t i o n – 0.36 + 2.26 x 10 – 3 x A r e a 0.226 . D u r a t i o n 0.125 (0.3 + log 10 (A E P)) + 0.0141 x A r e a 0.213 x 10 – 0.021 (D u r a t i o n – 180) 2 1440 (0.3 + log 10 (A E P))]

Layer Info

Time Accessed	30 September 2019 03:11PM
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	8732.0
Storm Initial Losses (mm)	38.0
Storm Continuing Losses (mm/h)	0.5

Layer Info

Time Accessed	30 September 2019 03:11PM
Version	2016_v1

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

code	CS
Label	Central Slopes

Layer Info

Time Accessed	30 September 2019 03:11PM
Version	2016_v2

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

code	CS
arealabel	Central Slopes

Layer Info

Time Accessed	30 September 2019 03:11PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-31.005&longitude=150.647&sdmin=true&sdhr=true&sdday=true& to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	30 September 2019 03:11PM

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)	0.9 (0.037)	0.9 (0.028)	1.0 (0.025)	1.0 (0.022)	1.1 (0.021)	1.3 (0.021)
90 (1.5)	0.7 (0.025)	0.8 (0.022)	0.9 (0.021)	1.0 (0.020)	0.8 (0.014)	0.7 (0.010)
120 (2.0)	2.0 (0.068)	2.3 (0.058)	2.5 (0.053)	2.7 (0.049)	1.6 (0.025)	0.8 (0.011)
180 (3.0)	0.4 (0.013)	0.5 (0.012)	0.6 (0.011)	0.7 (0.011)	1.1 (0.015)	1.4 (0.018)
360 (6.0)	0.9 (0.021)	1.1 (0.019)	1.2 (0.019)	1.3 (0.018)	3.4 (0.038)	4.9 (0.050)
720 (12.0)	0.8 (0.016)	0.9 (0.013)	0.9 (0.011)	0.9 (0.010)	6.9 (0.063)	11.4 (0.092)
1080 (18.0)	0.0 (0.000)	0.4 (0.005)	0.6 (0.006)	0.8 (0.008)	10.6 (0.084)	18.0 (0.126)
1440 (24.0)	0.0 (0.000)	0.3 (0.003)	0.5 (0.005)	0.6 (0.005)	8.5 (0.060)	14.4 (0.090)
2160 (36.0)	0.0 (0.000)	0.5 (0.006)	0.9 (0.008)	1.2 (0.009)	4.9 (0.030)	7.7 (0.041)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.2 (0.001)	0.4 (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	30 September 2019 03:11PM
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	30 September 2019 03:11PM
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 (0.001)	0.1 (0.001)	0.1 (0.002)	0.0 (0.001)	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)	0.3 (0.003)	0.6 (0.004)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.6 (0.004)	1.0 (0.006)
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	30 September 2019 03:11PM
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)	9.1 (0.380)	8.1 (0.249)	7.5 (0.192)	6.9 (0.152)	11.0 (0.204)	14.1 (0.232)
90 (1.5)	7.2 (0.265)	9.0 (0.245)	10.2 (0.234)	11.4 (0.225)	9.5 (0.158)	8.0 (0.119)
120 (2.0)	17.3 (0.584)	16.6 (0.417)	16.2 (0.343)	15.8 (0.289)	17.0 (0.263)	17.9 (0.246)
180 (3.0)	11.2 (0.335)	11.5 (0.256)	11.7 (0.221)	11.9 (0.195)	15.9 (0.220)	18.9 (0.234)
360 (6.0)	14.8 (0.357)	16.1 (0.291)	16.9 (0.261)	17.7 (0.238)	26.4 (0.301)	32.9 (0.335)
720 (12.0)	15.4 (0.299)	15.5 (0.224)	15.5 (0.191)	15.5 (0.166)	35.1 (0.319)	49.8 (0.403)
1080 (18.0)	3.1 (0.053)	9.8 (0.125)	14.2 (0.153)	18.5 (0.172)	36.3 (0.285)	49.6 (0.346)
1440 (24.0)	2.9 (0.046)	9.0 (0.105)	13.0 (0.128)	16.9 (0.142)	30.0 (0.212)	39.8 (0.249)
2160 (36.0)	0.0 (0.001)	7.2 (0.075)	12.0 (0.104)	16.5 (0.122)	24.0 (0.147)	29.5 (0.159)
2880 (48.0)	0.0 (0.000)	3.3 (0.032)	5.5 (0.044)	7.6 (0.051)	11.5 (0.064)	14.4 (0.070)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	3.4 (0.017)	5.9 (0.026)

Layer Info

Time Accessed	30 September 2019 03:11PM
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)	27.5 (1.145)	25.8 (0.790)	24.8 (0.636)	23.7 (0.525)	37.0 (0.687)	46.9 (0.774)
90 (1.5)	36.9 (1.358)	34.4 (0.935)	32.8 (0.751)	31.2 (0.617)	31.1 (0.517)	31.0 (0.458)
120 (2.0)	45.6 (1.539)	45.2 (1.132)	45.0 (0.951)	44.8 (0.818)	52.4 (0.809)	58.2 (0.799)
180 (3.0)	38.9 (1.164)	34.8 (0.776)	32.1 (0.607)	29.5 (0.484)	60.4 (0.837)	83.5 (1.032)
360 (6.0)	38.9 (0.937)	42.6 (0.770)	45.0 (0.694)	47.4 (0.636)	69.5 (0.792)	86.1 (0.876)
720 (12.0)	31.6 (0.613)	40.2 (0.584)	45.9 (0.566)	51.3 (0.550)	76.8 (0.698)	96.0 (0.777)
1080 (18.0)	23.1 (0.396)	33.4 (0.427)	40.3 (0.435)	46.9 (0.437)	69.9 (0.549)	87.1 (0.608)
1440 (24.0)	19.7 (0.312)	32.1 (0.375)	40.2 (0.396)	48.1 (0.406)	69.4 (0.491)	85.4 (0.535)
2160 (36.0)	17.4 (0.248)	24.5 (0.256)	29.3 (0.255)	33.8 (0.250)	48.4 (0.297)	59.3 (0.320)
2880 (48.0)	6.1 (0.082)	13.6 (0.132)	18.5 (0.149)	23.3 (0.157)	39.1 (0.218)	50.9 (0.248)
4320 (72.0)	0.0 (0.000)	4.5 (0.040)	7.4 (0.054)	10.3 (0.063)	24.9 (0.124)	35.9 (0.155)

Layer Info

Time Accessed	30 September 2019 03:11PM
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	**0.972 (4.9%)**	0.847 (4.2%)	**1.052 (5.3%)**
2040	**1.225 (6.2%)**	1.127 (5.7%)	**1.495 (7.6%)**
2050	**1.452 (7.3%)**	1.406 (7.1%)	**1.971 (10.1%)**
2060	**1.653 (8.4%)**	1.685 (8.6%)	**2.480 (12.9%)**
2070	**1.827 (9.3%)**	1.963 (10.1%)	**3.023 (15.9%)**
2080	**1.974 (10.1%)**	2.241 (11.6%)	**3.599 (19.2%)**
2090	**2.095 (10.8%)**	2.518 (13.1%)	**4.208 (22.8%)**

Layer Info

Time Accessed	30 September 2019 03:11PM
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)	23.9	18.3	16.7	16.8	15.7	13.9
90 (1.5)	27.1	17.6	16.4	17.0	17.0	15.6
120 (2.0)	27.8	15.0	14.3	15.2	15.3	12.4
180 (3.0)	29.9	18.0	17.2	18.3	15.6	12.3
360 (6.0)	28.9	18.6	17.0	17.7	14.5	9.9
720 (12.0)	29.4	21.2	19.4	19.8	15.3	9.2
1080 (18.0)	32.8	24.4	22.1	22.3	16.7	7.6
1440 (24.0)	33.6	25.6	23.7	24.3	19.4	10.5
2160 (36.0)	34.8	27.5	27.0	27.7	23.3	15.6
2880 (48.0)	37.2	30.7	30.6	33.0	29.4	18.4
4320 (72.0)	39.5	33.2	35.5	38.9	33.6	22.2

Layer Info

Time Accessed	30 September 2019 03:11PM
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/adf123f6-2448-4723-8621-32d5d66bbfc3.txt)

Download JSON (downloads/36089f34-d7f9-4f20-aa37-104869e8324a.json)

Download PDF ()

APPENDIX B. Indicative Proposed Site Layout

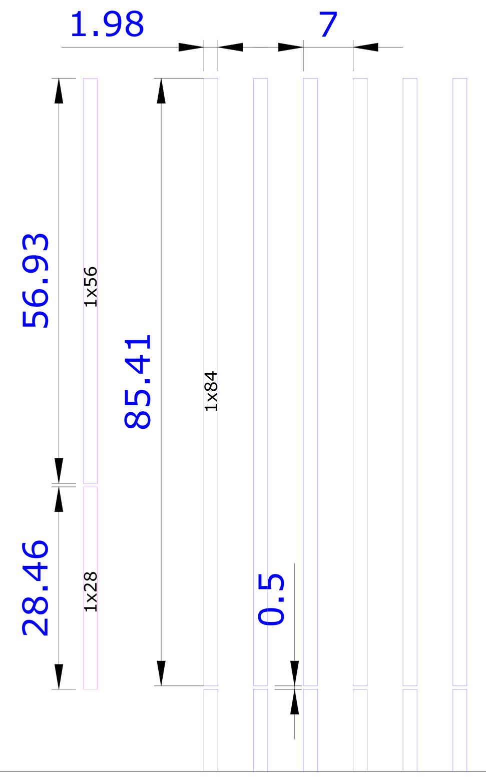
Appendix B

PRELIMINARY LAYOUT DATA (BIFACIAL MODULES (395 Wp)

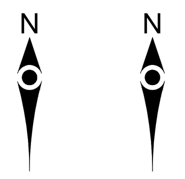
- SOLAR PLANT DC POWER: **254.19MW DC**
- SOLAR PLANT AC POWER: **236.43MW**

- 10 CABINS FOR 40 INVERTERS(1637 kVA @ 25°C)
- 2705 PANELS (1X84,1X56 & 1X28 MODULES IN PORTRAIT ORIENTATION: 0° - TILT FROM HORIZONTAL: '+/-60° E/W
- 194208 MODULES (BIFACIAL MODULES (395 WP))
- GCR-3.54
-

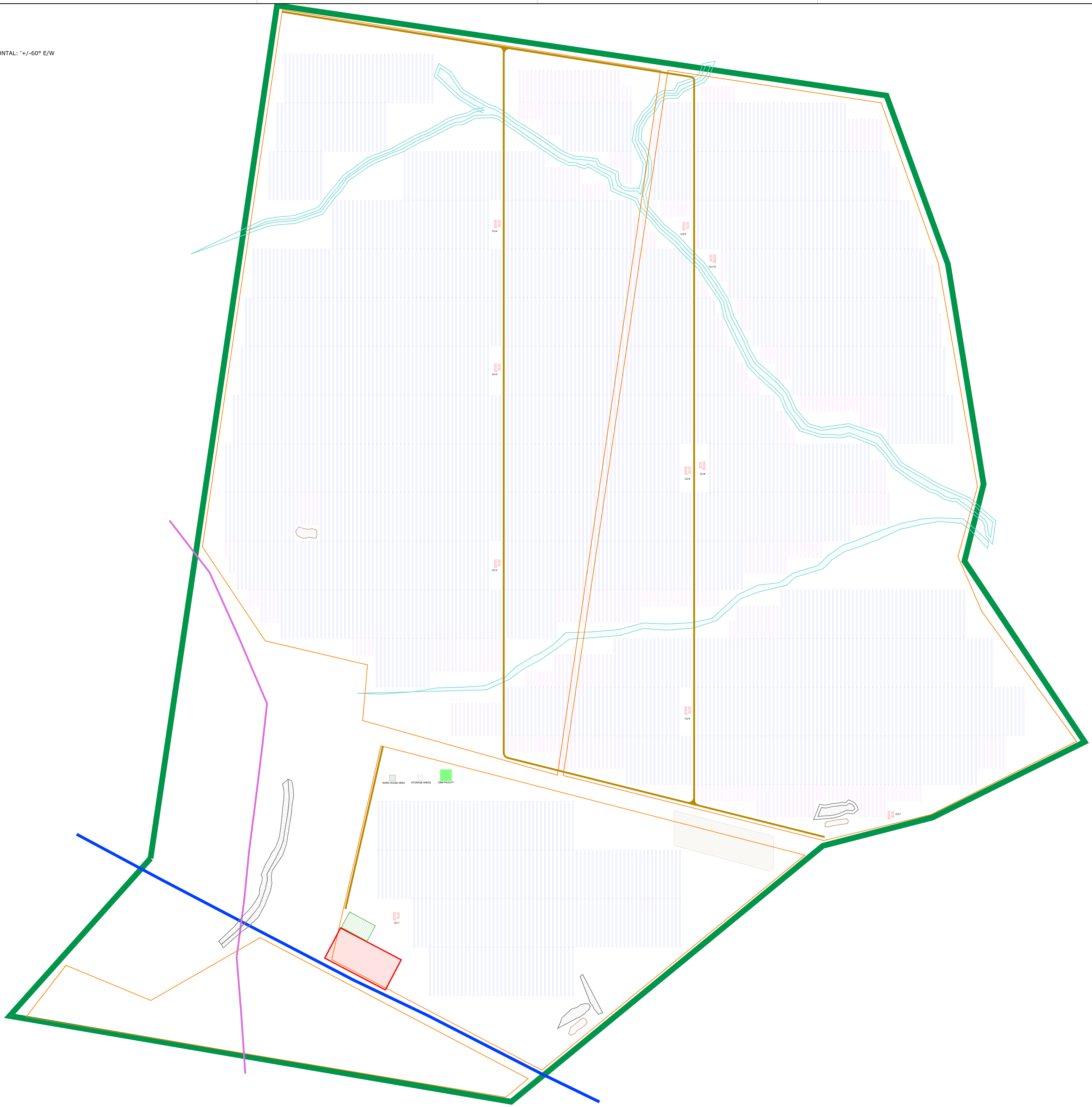
PANELS (DIMENSIONS)



Conversion Units	# of Panels			# of Modules (395 Wp)	# of Strings	# of Inverter (1637 kVA @ 25°C)	AC Power	DC Power
	1x28	1x56	1x84					
1	0	0	232	19488	696	4	6.55	7.70
2	10	31	208	19488	696	4	6.55	7.70
3	0	0	232	19488	696	4	6.55	7.70
4	0	0	232	19488	696	4	6.55	7.70
5	50	83	160	19488	696	4	6.55	7.70
6	0	0	232	19488	696	4	6.55	7.70
7	20	23	210	19488	696	4	6.55	7.70
8	44	47	186	19488	696	4	6.55	7.70
9	30	48	190	19152	684	4	6.55	7.57
10	9	18	217	19152	684	4	6.55	7.57
Total	**303**	**252**	**2150**	**194208**	**6936**	**40**	**65.48**	**76.71**



Geographic
(-xx°)



Legend:

- Project Boundary
- Solar Area (195.08ha)
- Substation
- Inverters cabin
- Solar panels
- Internal path
- Fence
- BESS
- Transmission Line 11kV
- Transmission Line 132kV
- Construction Laydown Area
- Waste Area
- Storage areas
- O&M Facility
- Drainage
- Dam
- Barrier

Projection & Datum : UTM WGS84 56 South

REV. / *REV.*	DATA / *DATE*	DESCRIZIONE / *DESCRIPTION*	PREPARATO / *PREPARED*	CONTROLLATO / *CHECKED*	APPROVATO / *APPROVED*
1	25/07/2019	S/S, BESS,Laydwon Area Relocated	Gopi		
0	30/05/2019	Bifacial Module (395 W) on Horizontal Trackers Preliminary Layout	Gopi		

VALIDO PER IMPIANTI / *ISSUED FOR PLANT*

PROGETTO / *PROJECT:* **Tamworth Australia**

REV. 00 - EMISSIONE / *REV. 00 - ISSUED*

DATA / *DATE*	PREPARATO / *PREPARED*	CONTROLLATO / *CHECKED*	APPROVATO / *APPROVED*

NOME FILE / *FILE NAME:*

FORMATO / *FORMAT:*

SCALA / *SCALE:* **NTS**

CLASSIFF. / *CLASSIFICATION*

Rif. ARCHIVIO / *ARCHIVE ID*

SCALA PLOT / *PLOT SCALE*

TAVOLA / *SHEET:* di / of

enel Green Power

TITOLO / *TITLE:* **Bifacial Module (380 W) on Horizontal trackers Preliminary Layout**

LINGUE DISPONIBILI / *AVAILABLE LANGUAGES:*

Area / *Area*

Unità / *Unit*

CODICE / *CODE*

TIPO / *TYPE*	EMITTENTE / *ISSUER*	PAESE / *COUNTRY*	TEC. / *TEC.*	ARGOMENTO / *AREA*	IMPIANTO / *PLANT*	SISTEMA / *SYSTEM*	PROGRESSIVO / *PROGRESSIVE*	REVISIONE / *REVISION*