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Bookaar Solar Farm
Flood Impact Assessment

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1 Introduction

1.1 Background

Bookaar Renewables Pty Ltd (the 'Proponent') is proposing to develop a renewable energy facility and associated works (the 'Proposal') on land at 520 Meningoort Road, Lots 51 & 52 and Res 1 on LP4677 and adjacent parts of Meningoort Road, Bookaar VIC 3260 (the 'Site'). The Site covers approximately 588ha. Of this, approximately 490ha is part of the 2024ha 'Meningoort' beef and sheep operation with the remaining 98ha forming part of a separate operation which is leased to a neighbouring farmer who is mainly using the area for dryland cropping.

A previous permit application for a solar farm was submitted to Corangamite Shire Council (Council) in July 2018 (the 'Previous Application'). On 4 September 2018, Council refused the application despite Council's Planning Officer recommendation for approval. An Application for Review under Section 77 of the *Planning and Environment Act 1987* was lodged with VACT. The Tribunal found against the Proponent, in part because of concerns raised by adjacent farmers pertaining to the potential for the solar farm to increase runoff onto their farms with a consequential increase in flood levels.

This report is prepared in response to the Tribunal's findings. It describes detailed flood modelling undertaken to assess the influence on hydrology and flooding of a newly designed solar farm (the 'Proposal'), that lies within the same Site boundary as the Previous Application. The assessment also considers the *Solar Energy Facilities Design and Development Guideline* (DELWP, August 2019) (the 'Guideline').

1.2 Scope of Works

The scope of works is:

- Describe the catchment and hydrological features of the Site;
- Prepare a flood model of the catchment to represent existing condition flooding for the 20% (1 in 5) AEP (annual exceedance probability) and the 1% (1 in 100) AEP events (the 'existing case model');
- Detail the nature of any hydrological constraints that the Proposal would be required to respond to;
- Modify the flood model to incorporate the Solar Farm and assess the 20% and 1% AEP events (the 'developed case model');
- Compare the flood levels from the developed and existing case models to understand the change in flood levels caused by the Solar Farm;
- If required, iterate the design to mitigate the off-site increases in flood level; and
- Prepare a report documenting the findings.

2 Existing Catchment and Site

The Site lies within the Blind Creek catchment which is itself a tributary of the Mt Emu Creek catchment. The catchment and the Site are shown on Figure 2-1. The Blind Creek catchment generally flows from north to south. During small rainfall events the runoff is collected in a series of mostly constructed drains through the catchment. In larger rainfall events the capacity of these drains can be exceeded resulting in the runoff collecting in natural lowlands, typically with poor drainage. The arrows in Figure 2-1 show generally the pattern of runoff in the catchment as is also evident from the topographical data in Figure 2-1.

The Site is located on the eastern slopes and lowlands of Mount Meningoort. Runoff from Mount Meningoort runs into the Site generally as shallow overland flow, although there are locations where it collects into small gullies or small constructed drains, the latter presumably constructed to assist in drainage of the paddocks. The lowlands are shown on some topographical maps as swamp, however an inspection of the Site revealed that there are no swamps but grassed paddocks that are currently used for grazing cattle.

The northern portion of the Site generally slopes to the east, except for the northern extremity which slopes to the north. Along the northern boundary of the Site is a drain which captures runoff from the Site and conveys it to the east. To the east of the Site it joins with a drain from the north and one form the east and turns to the south (the 'North South' drain). The North South drain travels under Meningoort Road and along the eastern boundary of the Site. The North South drain intercepts runoff from the northern and central portion of the Site taking the runoff to the south. The North South drain is shown in Photograph 1, which was taken at the location A shown on Figure 2-1. The fence line is on the left (eastern) side of the drain in this photograph. The Site boundary is on the right (western) side of the drain. Along this eastern boundary of the Site the fence line is on different sides of the North South drain as can be seen in the subsequent photographs. The fence line and its location with respect to the drain should not be confused with the site boundary. The site boundary is always on the western side of the North South drain.

At the location B shown on Figure 2-1, the North South drain bifurcates (see Photograph 2) with the larger drain cutting across the Site to the southwest (the 'East West' drain see Photograph 3) and exiting the Site along the western boundary. At the bifurcation, the North South drain becomes smaller and continues south (see Photograph 4) where it passes through the Site before exiting at the southern extremity of the Site.

There is an existing small farm dam on the eastern slope of the Site. This dam will be filled for the development of the Solar Farm.

Approximately 1.1 km to the east of the Site is Lake Bookaar which is listed as a permanent saline wetland in the Western District Lakes Ramsar Site. There is no hydrological connection between the Site and Lake Bookaar. Darlington Road runs along a ridge which is the catchment divide as shown in Figure 2-1. During large rainfall events such as the 1% AEP event, runoff from the Site will exceed the capacity of the North South drain along the site's eastern boundary and spill into the low-lying farmland between the Site and Darlington Road. This low-lying land also receives runoff from the catchment to the north with the volume of water from the north being significantly larger than the runoff volume from the Site. The flood modelling presented later in this report shows that the combined flow from the north and from the Site into this low-lying land is not sufficient to overtop Darlington Road, and hence there is no connectivity between the Site and Lake Bookaar. The analysis has also shown that there would be insufficient runoff in the catchment draining to Lake Bookaar to lift the levels sufficiently in Lake Bookaar to overtop Darlington Road. The proposed Solar Farm will not noticeably alter the volume of water infiltrating into the groundwater and hence it is not expected that the Solar Farm will impact on the groundwater table.

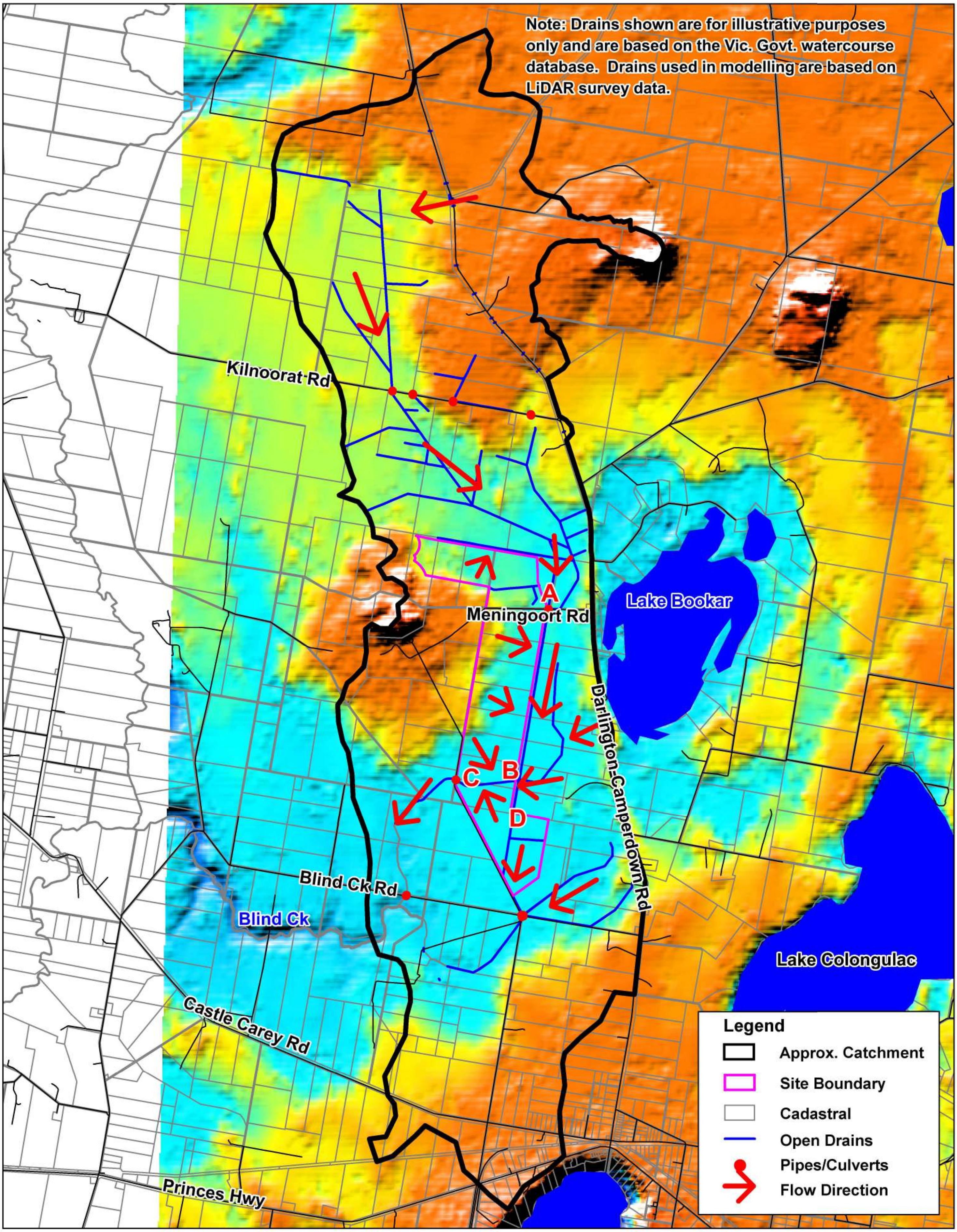
Photograph 1: Location A. Looking south along the North South drain adjacent to eastern boundary of the Site. The Site boundary is to the right (west) of this drain. Note the fence line is on the eastern side of the drain.

Photograph 2: Location B. Looking north. Point of channel bi-furcation of the North South drain. Note the fence line is on the western side of the drain.

Photograph 3: Location B. Looking south-west along the East West drain which crosses site to Location C.

Photograph 4: Location B. Looking south along the smaller section of the North East drain which continues south. Note the fence line is on the eastern side of the drain.

Photograph 3: Location C. Looking east from Meningoort Rd across the Site along the drain from Location B.



Title: Bookar Solar Farm
Site Locality and Catchment Plan

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Figure:	Rev:	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: DR	Level 1, Suite 101 26-30 Rokeby St Collingwood VIC 3066 T. (03) 9089 6700 www.VenantSolutions.com.au
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3 The Proposal

The Proposal involves the installation of a solar energy facility with a capacity of 200 MWac (282 MWdc). The Proposal includes the following elements (detailed in the plans in Appendix A):

- 'Array Areas', containing Photovoltaic (PV) panels mounted on a single axis tracking system with a maximum height of 4 m above natural ground at maximum tilt. The tracking system would be supported by piles driven into the ground. Row spacing (pile to pile) is either 12.75 m (south of the 220kV transmission line) or 13 m (north of the 220kV transmission line);
- 82 inverters located centrally throughout the Site in pairs at 41 locations across the Site (inverter stations). Inverter stations are located at least 171 m from the Site boundary;
- Below ground cabling connecting the PV panels between trackers and inverters;
- Below ground cabling connecting the inverters to the substation;
- An internal track network of all-weather gravel tracks (4 m), including a perimeter track which forms part of a 10 m wide defendable Asset Protection Zone (APZ) that surrounds the Site;
- Four (4) gated main site access points via Meningoort Road;
- Four (4) gated emergency access points along the western boundary of the Site;
- Eight dedicated water tanks for firefighting (maximum of 3.6m high), located adjacent to each access point;
- A perimeter security fence 2.5 m high (chain mesh);
- Perimeter vegetation screens (20 m wide with 4 rows of trees and maintained to a height of at least 4 m), planted on the outside of the security fencing;
- Agricultural style fencing 1.2 m high, around the perimeter of the vegetation screens and the perimeter of the existing vegetation on the Site's western boundary;
- A SCADA system that will gather, monitor and analyse data generated through operating the Proposal;
- On-demand, downward facing lighting (restricted to 4m in height); and
- Sensor triggered CCTV security cameras located around the perimeter of the Site and adjacent to key infrastructure.

Substation Area (1.76 ha):

- Substation connecting the Proposal to the onsite 220KV transmission line, via two (2) new high voltage (HV) 220 kV transmission lines;
- A Control building (3 m high);
- Substation Operations and Maintenance building (up to 5 m high);
- A security fence (chain mesh) up to 2.5 m high, enclosing the Substation;
- A 10 m wide defendable APZ around the perimeter of the Substation; and
- Parking for 5 vehicles.

Battery Area (0.91 ha):

- A series of separate containerised battery units, connected by underground cables to the Substation (approximately 2.5 m high);
- A separate transformer adjacent to each battery; and
- A 10m defendable APZ around the perimeter of the Battery Area.

Operations Buildings Area (0.96 ha):

- A Site office building including amenities with a height of 3.6 m;
- A maintenance building and workshop with a height of 5 m;
- 3 Storage sheds with a height of 4.1 m;
- Car parking for twelve (12) vehicles;
- A septic tank and potable water tank;
- A defendable APZ of 20 m, which allows the area to function as the nominated 'Shelter in Place' location (see Bushfire Risk Assessment Report and Mitigation Plan).

Meningoort Road will require road improvements to facilitate site access, including the widening of the road surface and an upgrade of the intersection of Meningoort and Darlington-Camperdown Roads.

In addition to the key components outlined above, there will be a temporary construction compound (1.44 ha) to facilitate the construction phase of the Proposal. The construction compound would include:

- Temporary construction offices (up to 5 m high);
- Car and bus parking areas for construction vehicles (51 workers cars, 5 mini vans; and additional parking space provided for delivery vehicles and construction machinery);
- Staff amenity block including portable toilets, showers and a kitchen, designed for peak staff numbers during the construction period; and
- Laydown areas.

Once the Proposal is operational, the construction compound will be decommissioned and revegetated. Details of the Proposal are shown in plans in Appendix A.

Details of the Proposal that are of particular relevance to the flood risk assessment are the following components:

- Photovoltaic panels and supporting infrastructure (Array Areas);
- Inverter stations;
- Substation and Battery storage facility;
- Operation Buildings Area - site office, maintenance buildings, storage buildings, and workshop;
- Access roads, internal access tracks and firebreaks; and
- Security fencing and vegetation screening.

Table 3-1 provides the parameters of the Array Areas.

Table 3-1Configuration of the Array Areas

Parameter	measurement
Row spacing (distance pile to pile) (Array Areas north of 220KV Transmission Line)	13 m
Stow position panel to panel distance between rows (Array Areas north of 220KV Transmission Line)	9 m
Row spacing (distance pile to pile) (Array Areas south of 220KV Transmission Line)	12.75 m
Stow position panel to panel distance between rows (Array Areas south of 220KV Transmission Line)	8.75 m
Pile spacing along rows supporting tracker	8 m
Tracker length	55.8 m

Based on the parameters provided in Table 3-1, the coverage of the panels when in the stow position is approximately 30% of the Site by area.

In the fully extended (vertical) position the panels will have a minimum ground clearance of approximately 0.54 m, but during a flood the panels will go to the stow position which means ground clearance would be approximately 2.3m.

Pairs of inverters will be housed at inverter stations throughout the Site which will be 12.2 m long. The inverter stations will be positioned amongst the solar panels as shown on the Plan in Appendix A. Where the inverters are located in areas identified as flood prone, they will be elevated on footings 300mm above the flood level. Inverter Stations 1-2, 5-6, 9, 14, 16, 21-37 will all be elevated. The Plan also shows the proposed location and footprint areas of the substation, battery storage facility and operational buildings.

Access tracks will be required throughout the Site (Appendix A). The access tracks will be constructed at ground level to ensure they do not alter flows across the Site during flood events. Where tracks cross drainage lines, culverts have been designed to ensure that flows are maintained.

4 Flood Model Development and Impact Assessment

In response to the Tribunal's findings, a flood model was developed to determine the flood characteristics of the Site and surrounds under existing and developed case conditions. This model was developed based on industry best practice and guidance such as the principals outlined in Australian Rainfall and Runoff 2019 (ARR2019). The methodology and findings of this assessment are outlined below.

4.1 Existing Case Flood Model

As no existing flood model covers the Site, a new model was developed for the purposes of this assessment. The flood model covers the full catchment and extends beyond the Site to approximately 1.2 km downstream of Blind Creek Rd. The catchment extent (and model extent) was determined based on commercially available topographic information as well as an aerial survey (LiDAR) conducted as part of this study. The catchment is shown in Figure 4-1.

To determine the existing and developed case flooding conditions, a two-dimensional (2D) hydraulic model was developed using the TUFLOW flood modelling software package. The rain-on-grid feature was used to explicitly replicate the rainfall-runoff process within the model. A summary of the key model inputs and parameters are provided below with some features shown in Figure 4-1:

- Modelling undertaken on the latest version of TUFLOW HPC (2020-01-AB) (the most recent commercially available version of TUFLOW at the time of modelling);
- The model extent covered the full catchment upstream and downstream to ensure no boundary effects at the Site. The model covers a total area of approximately 67.5 km^2;
- The model was built on a 5 metre regular grid to allow for detailed modelling of the catchment and features. The Sub-Grid-Sampling feature was used to sub-sample at a 1 metre grid along each cell boundary to provide a superior result and ensure conveyance of the open channels were reliably represented in the model;
- Ground topography was based on available digital elevation data and included:
    - 30m gridded Geoscience Australia Shuttle Radar Topography Mission (SRTM);
    - 5m gridded 2007 South West Corangamite LiDAR; and
    - 1m gridded 2019 Site and surrounds aerial LiDAR survey captured by Photomapping.
- Open drains were reinforced within the model using the "z-shape gully" feature;
- Culverts and other drainage structures under roads and drains were field measured by Venant Solutions staff. These were then included as embedded 1D elements within the 2D model domain as appropriate;
- Manning's 'n' roughness layers were determined based on aerial photography of the catchment. These were applied as follows;
    - Unsealed dirt roads = 0.025;
    - Sealed roads = 0.020;

  - Maintained open drains = 0.040; and
  - For other surfaces (predominately farmland) a depth varying manning's 'n' roughness was applied whereby if depths are shallow, then a higher roughness of 0.100 is applied to a depth of 3cm, which linearly reduces to 0.050 at a depth of 10cm. In this way variable roughness losses associated with short vegetation have been considered within the model.

- Rainfall applied to the model was based on:
  - Design rainfall depths based on Bureau of Meteorology 2016 rainfall Intensity-Frequency-Duration curves. The 20% and 1% AEP depths were used;
  - The full ensemble of 10 rainfall temporal patterns were applied to the model to determine the median flood level. These were sourced from the ARR Datahub;
  - The standard rainfall duration events from 3 to 36 hours for the 1% AEP and 3 to 48 hours for the 20% AEP were simulated; and
  - Rainfall was applied directly to every grid cell within the model with the full loss and routing performed within the hydraulic model.

During a storm event not all of the rainfall is converted to runoff because a proportion of it will infiltrate into soil and a proportion will be trapped in small waterholes, divets etc and evaporate or slowly infiltrate. These are referred to as rainfall losses. In TUFLOW these losses can be represented by removing them directly from the rainfall or by using a soil infiltration model. The latter was adopted for this study. An initial loss and a continuing loss are applied. The initial loss is the amount of rainfall that is lost before any runoff commences and the continuing loss represents the ongoing infiltration through the event. The losses are an important parameter and so validation of the losses was undertaken as described in Section 4.2.

4.2 Model Validation

Due to the lack of stream gauge or historic information with which to calibrate the flood model, it was necessary to validate the model flows by comparing the peak flows from the flood model to regional peak flow estimate techniques. ARR2019 recommends that Regional Flood Frequency Estimation (RFFE) be undertaken to provide indicative peak flow rates for ungauged catchments for the purposes of validating flood models. The RFFE is based on research as part of ARR2019 and provides peak flood estimation based on the catchment size, location, and shape. The software uses this information and, based on relationships developed for neighbouring catchments, estimates the peak flow rates.

Loss rates were initially sourced from the ARR2019 Datahub. However, when applied to the TUFLOW model, the flows were significantly lower than the RFFE peak flow rates. Whilst this did not necessarily mean the flows from the TUFLOW model were low it indicated further consideration of the outcomes was required. Research was undertaken to source other flood studies done in the region to review losses adopted in these studies. Of particular interest were studies where calibration of the flood models was undertaken. Reports identified were the *Deans Creek and Barongarook Creek Flood Study* (BMT WBM, 2016), *Skipton Flood Investigation* (Water Technology, 2012) and *Wickliffe Flood Investigation* (Cardno 2012). In each case these models were developed for the local Councils and Catchment Management Authorities and included detailed hydrologic and hydraulic investigations including calibration of the models to historic flood events to better inform the design inputs.

In these studies the losses (particularly continuing losses) were substantially lower than those recommended from the regional datahub estimates. The adopted design losses for each of these studies is presented in Table 4-1. Where losses were varied based on AEP, the 1% AEP loss rates have been provided separately in the table. It is noted that in each of these studies the calibration losses tended to be lower than those finally adopted as part of the design hydrology. For consistency, the design storm losses rather than the calibration losses are reported. After some sensitivity testing and comparison to the RFFE peak flows the initial losses (23 mm) from the ARR2019 Datahub regionalised value was adopted, but a lower continuing losses of 1.5 mm/hr was adopted which is in line with the average losses adopted by these other studies.

Table 4-1 Adopted Design Hydrologic Losses for Nearby Flood Studies

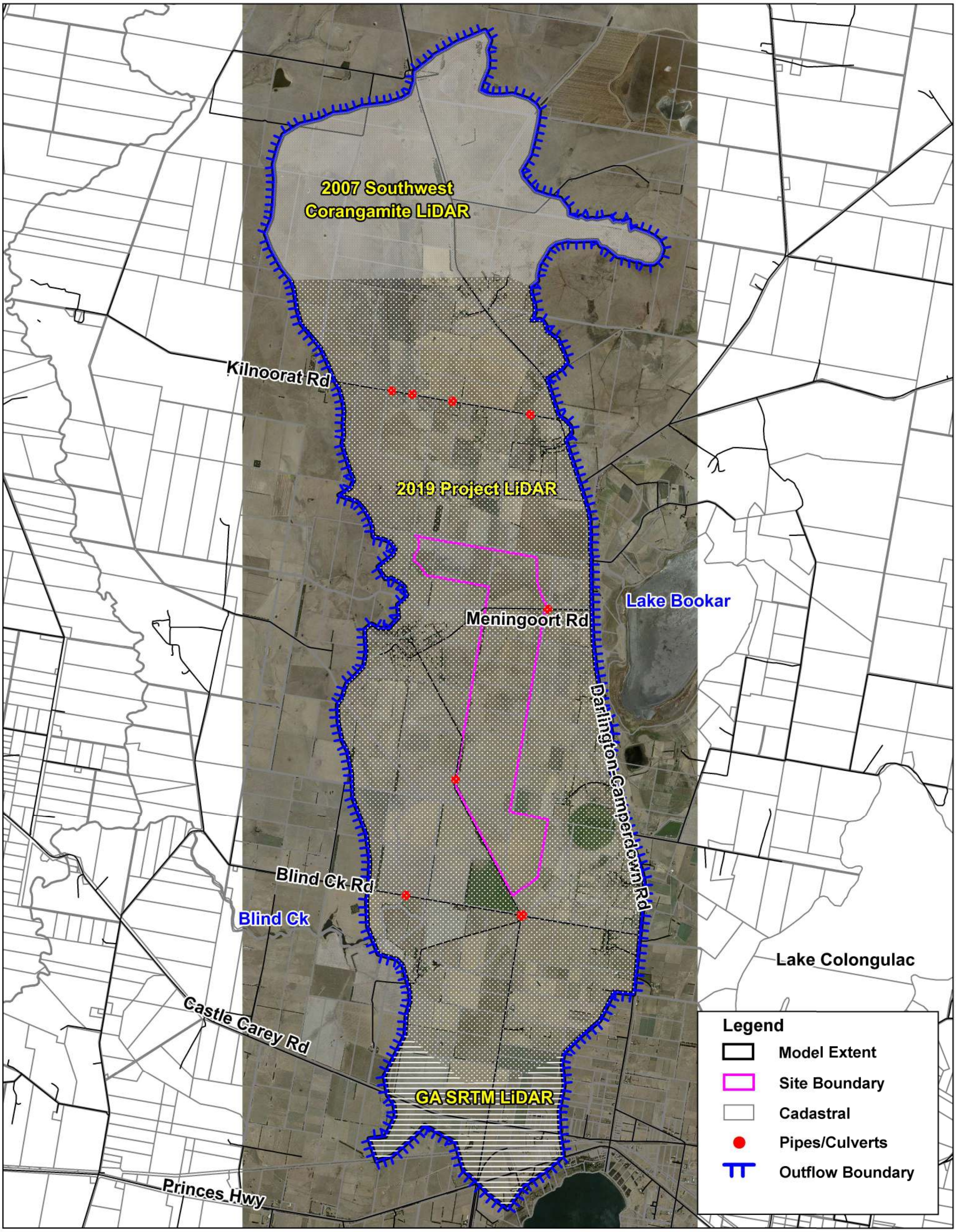
Study	Initial Loss (mm)	Continuing Loss (mm/h)
ARR Data Hub	23	4.6 mm/h
Wickliffe Flood Study (Cardno, 2012)	15 - 37 Varies based on AEP	1.7 - 3.7 (Varies based on AEP) **3 mm/h adopted for 1% AEP**
Skipton Flood Investigation (Water Technology, 2012)	14 - 16 Varies based on AEP	0.75 - 4.8 (Varies based on AEP) **1.45 mm/h adopted for 1% AEP**
Deans Creek and Barongarook Creek Regional Flood Mapping (BMT WBM, 2016)	25	**1.25 or 2.0 mm/h** Depending on catchment for all AEP
Adopted for Solar Farm	**23**	**1.5**

The RFFE is not applicable to areas with substantial floodplain storage and hence it was only possible to compare the flows from the RFFE in the upper catchment areas north of East Hill St. Three comparison sites were picked within the catchment as shown below in Figure 4-2. For each location, a peak flow estimation was determined and compared to the outputs from the flood model. The results of this are shown in below in Table 4-2.

As can be seen in Table 4-2 for each location the flood model peak flow and the RFFE estimation are consistent. Whilst there is some diversion, as would be expected, the model produces a runoff flow rate within the RFFE confidence limits. Therefore it is considered that the flood model is reliably replicating the natural rainfall-runoff flood mechanics and is suitable for this assessment.

Table 4-2 Flood Model Peak 1% AEP Flow Validation (m^3/s)

Location	RFFE Median 1% AEP Peak Flow	RFFE 1% AEP Confidence Limits	Flood Model median 1% AEP Peak Flow
Location 1	12.8	4.5 – 37.2	9.3
Location 2	3.2	1.1 – 9.3	4.7
Location 3	8.4	2.9 – 24.6	7.4



Title: Bookar Solar Farm
Existing Conditions TUFLOW Model Schematisation

Figure:	Rev:	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: DR
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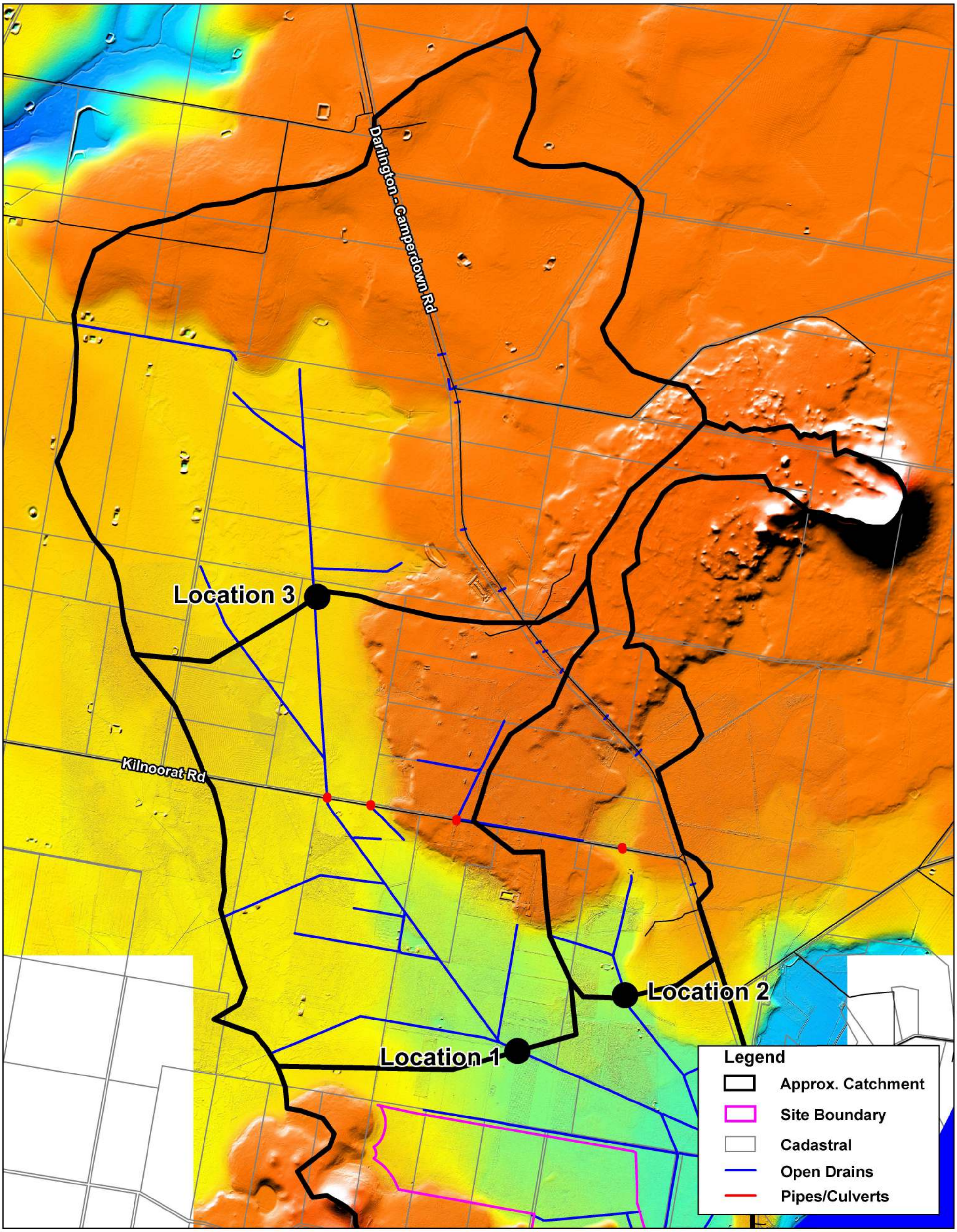

Title: 520 Meningoort Rd, Bookar
Model Validation Locations and Contributing Catchments

Figure: 4-2 | Rev: A | N | 0 0.5 1km Approx. Scale

This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.

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4.3 Existing Case Flood Behaviour

The flood depth and extent mapping for the existing conditions is shown in Figure 4-3 and Figure 4-4 for the 20% AEP and 1% AEP events respectively. Also shown on these figures are flood height contours. The depth of flooding is mapped in accordance with ranges shown on the legend, with the blue ranging from light to dark with increasing depth of flooding.

Because a rain-on-grid approach has been adopted for this assessment, the entire catchment is "wet" in the model and hence output from the model includes very shallow flow which is not considered flooding. For the purposes of this mapping, a mapping cut-off depth of 50 mm was adopted, i.e., an area is not shown as flooded on the maps if the depth is less than 50 mm. Applying the cut-off depth results in a patchy flood extent away from the main flow paths.

The more frequent 20% AEP flood extent shows very little flooding of greater than 50 mm both within the Site and external to the Site. By contrast the 1% AEP event shows widespread flooding of greater than 50 mm. The deepest flooding is shown to be to the north-east and south-east of the Site. On the Site the flooding is generally shallow being in the range 0.05 m to 0.2 m (50 mm to 200 mm).

The flow velocities across the Site are very low being in the range 0.1 m/s to 0.4 m/s. Visually these velocities would appear to be close to still up to very slow moving. Velocities this small will not cause erosion.

The flood mapping from the 1% AEP event was provided to the designers to inform the placement of the solar farm infrastructure.

Constraints were advised as follows and as shown on Figure 4-5:

- Along the East–West Drain, with the exception of culvert crossings, avoid placement of infrastructure (arrays, the inverters, substation, battery and other buildings);
    - This area included:
        - a 15 m corridor (7.5 m either side of the centreline of the drain) along the full length of the drain; and
        - a deeper and wider section at the western end of the drain at the Site boundary;
- About halfway along the western boundary, within an irregular shaped area of approximately 2 ha, avoid buildings and cut and fill (arrays acceptable).

In addition, it was advised that:

- All buildings, substation, and battery infrastructure be raised above the 1 % AEP flood level;
- Inverters be raised above the 1 % AEP flood level;
- The internal track network and upgrades to Meningoort Road be constructed to existing ground levels; and
- The Vegetation Screen could be located to the edge of the drain reserve on the eastern boundary, and to the edge of the minor drain on the northern boundary, noting that there is a 2.5m offset of the first row of trees within the screen (see Section 4.4)

As can be seen on Figure 4-5, constrained areas only cover a small portion of the Site and hence the majority of the Site was considered suitable for the placement of arrays and other infrastructure. In the description of the Site in Section 2, it was noted that there were a number of small gullies/drains traversing the Site. The modelling identified that the flooding in these areas would be shallow and hence placement of arrays across these small drains would not cause adverse impacts because they would not significantly block major flow paths.

The advice above was used by the designers in the preparation of the plans in Appendix A and the design presented in these plans was then incorporated into the developed case flood model as described in Section 4.4.

4.4 Developed Case Flood Model

The layout of the proposed Solar Farm is shown in in Appendix A. Details of the development are discussed in Section 3.

To implement the solar farm into the hydraulic model, the following inputs were added to the existing model (refer Figure 4-5):

- Solar arrays:
    - A key aspect of the assessment was representing the solar panels in the model, particularly how they might influence the infiltration of rainfall into the soil and hence alter the runoff from the site. The panels are impervious, but they are elevated approximately 2.2 m above the ground. Therefore, the ground under the panel will remain pervious but will not receive direct rainfall when the panels are in the stow position. Rainfall falling onto the panels will runoff the panels into the 8.75 m or 9 m gap (depending on which side of the transmission lines they lie) between the panel rows and would then flow in the direction of the ground slope, including back under the panels where the runoff can infiltrate into the soil;
    - It is proposed to ensure that the solar array area is vegetated with grass which will be managed through a maintenance program to be no more than about 100 mm during the annual Fire Danger Period. In the context of modelling infiltration and runoff from the Site over these grassed areas, this is similar to the existing Site;
    - For the existing conditions assessment, the rainfall was distributed evenly across the site. Recognising that the solar panels would concentrate the rainfall into the 8.75 m or 9 m gap between the panel rows, the application of the rainfall in the model was concentrated into these gaps. To be clear, the amount of rainfall was not reduced, rather the same rainfall was applied over a smaller area. In the model rainfall boundary, this was done by applying no rainfall to the areas covered by the panels (assumed in the stowed position), and by increasing the rainfall to the remaining areas by 30%;
- Inverters were input using layered flow constriction shapes with either zero or 100 percent blockage depending on whether the inverter base will be on grade (100%) or raised (0%). The footprint of the inverters was assumed to be impervious with the infiltration (rainfall) losses set to IL = 1 mm and CL = 0 mm/h. A Manning's 'n' of 0.02 was applied;

- The operations building, substation area, battery area and temporary construction area were input using a finished surface level digital elevation model (DEM) supplied by LD Eng Pty Ltd on 25 June 2020. These areas were assumed to be impervious with infiltration losses set to IL = 1 mm and CL = 0 mm/h and a Manning's 'n' of 0.02 was applied. Apart from these areas and the filling of the farm dam, there are no other changes to the finished surface levels across the Site;
- Internal access roads will be constructed to follow existing surface topography, but were assumed to be impervious and the infiltration losses set to IL = 1 mm and CL = 0 mm/h and a Manning's 'n' of 0.025 (unsealed road) was applied;
- The perimeter security (chain wire) fence was assumed to be 70 percent blocked with debris;
- Planting of the vegetation screening will result in mounding approximately 400 mm above the natural surface which would fully block much of the overland flow which is typically up to 200 mm deep in the 1% AEP flood event. After discussions with the Proponent, it was agreed that between the trees the mounds would be removed such that there is a maximum of 50 percent blockage. A schematic of the mounding is shown in Figure 4-6;
- Culvert crossings were added at locations where proposed internal tracks will cross existing drains. The sizing of these were iterated in the flood model to ensure sufficient capacity so as not to cause off-site impacts. The location and size of these culverts are shown on Figure 4-5; and
- It is proposed to bury cabling and hence this aspect was not included in the model.

The operations building, substation area, battery area, inverters and pads, internal access roads and fire tracks add 18.8 ha of impervious area to the Site which is about 3.2 % of the full area of the Site. This does not include the impervious panel area which was modelled as described earlier.

The access along Meningoort Road will be upgraded. The design of this upgrade was discussed in detail with traffic and civil engineers to ensure that the upgrade would not impact on flooding. Key requirements and design outcomes were:

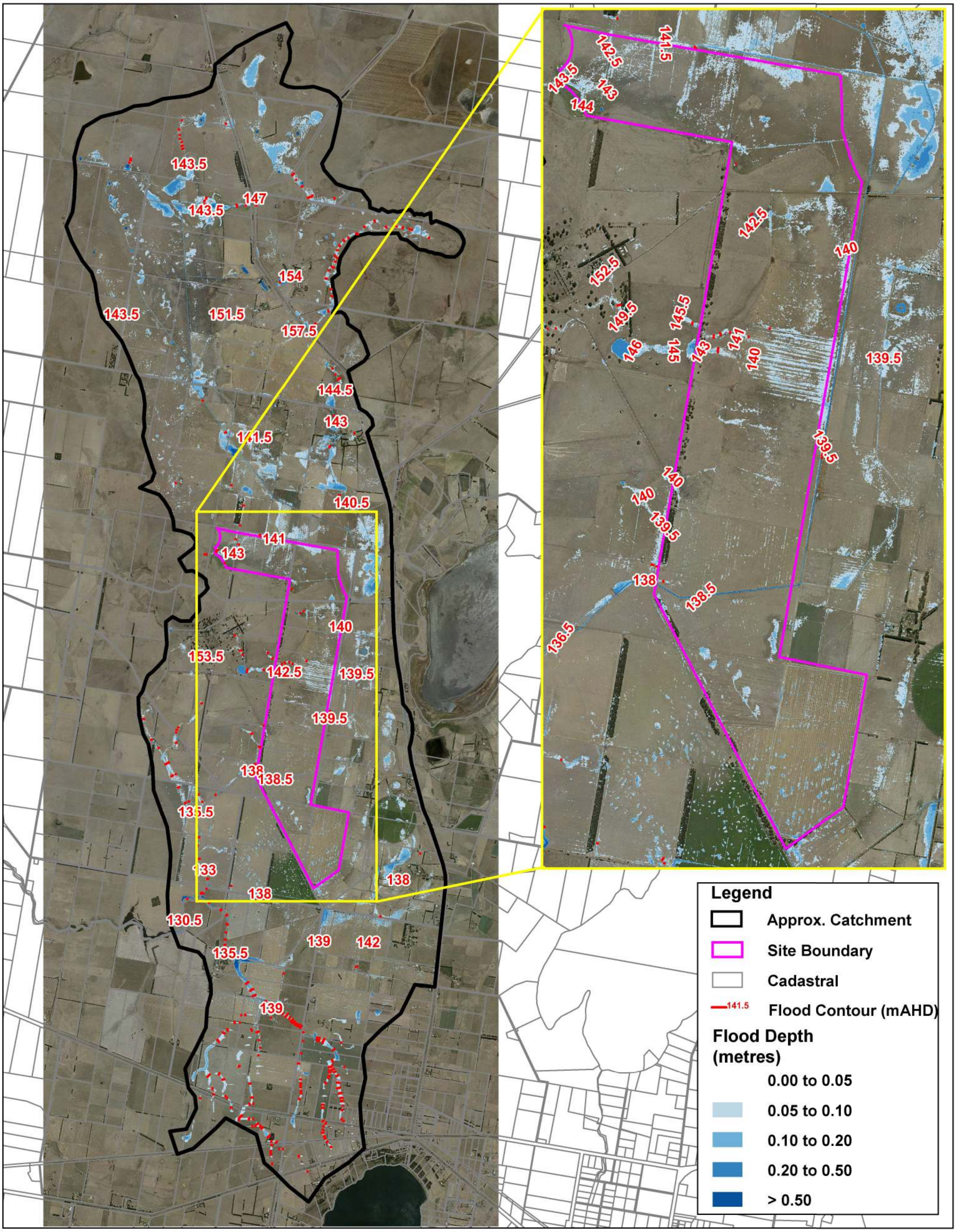
- Road Level:
    - The existing case modelling shows that the existing road is above the 20% AEP flood level but would be overtopped in a 1% AEP event by water from the north in a regional (Blind Creek) flood event;
    - If the road is raised it would have the potential to impede this flow from the north and potentially increase the flood level on the land to the north. Therefore, the road should remain at its existing level so as to not impede flow from the north, or alternatively if it is raised it would be necessary to increase the size of the existing culverts under the road;
    - The design outcome is to retain the existing grade of the road, noting that there may be some minor changes required to provide a smooth longitudinal profile. Therefore for the purposes of this current modelling assessment, the road upgrade in the model (developed case) was assumed to be at the same level as the existing road; and

    - At the detailed design stage a 3 dimensional (3D) earthworks model of the upgrade will be developed. As a matter of course the flood model would be updated with this 3D earthworks model to check for any impacts and the design iterated as required to mitigate the impacts. Given the road will be kept at the same level as existing, it is expected that iterations to the design, if any, would be minimal;

- Road Widening:
    - If the widened road encroaches on existing table drains, the table drains should also be widened to maintain at least the same flow capacity as the existing drain;
        - The road design by LDEng (Drawing set 131500 RD01 to RD05) shows that the road can be widened without encroaching on the existing swale drains;
    - Widening of the road will result in a small increase in the impervious area. This is represented in the developed case flood model.

As noted in Section 4.1, the existing case modelling involved assessing a large range of durations and ten temporal patterns for each duration. Then, based on the existing conditions assessment, the durations and temporal patterns critical to the Site and surrounds were identified and these were run for the developed case. The durations identified as critical for each AEP were:

- 20% AEP—4.5 hours, 9 hours, 12 hours, 18 hours, 30 hours, 48 hours; and
- 1% AEP—3 hours, 4.5 hours, 9 hours, 12 hours, 24 hours.



Title:
Bookar Solar Farm
Existing 20% AEP Flood Depth and Height Contours

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Figure:	Rev:				By:
4-3	A	N	0 1 2km Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: DR Date: Aug 2020

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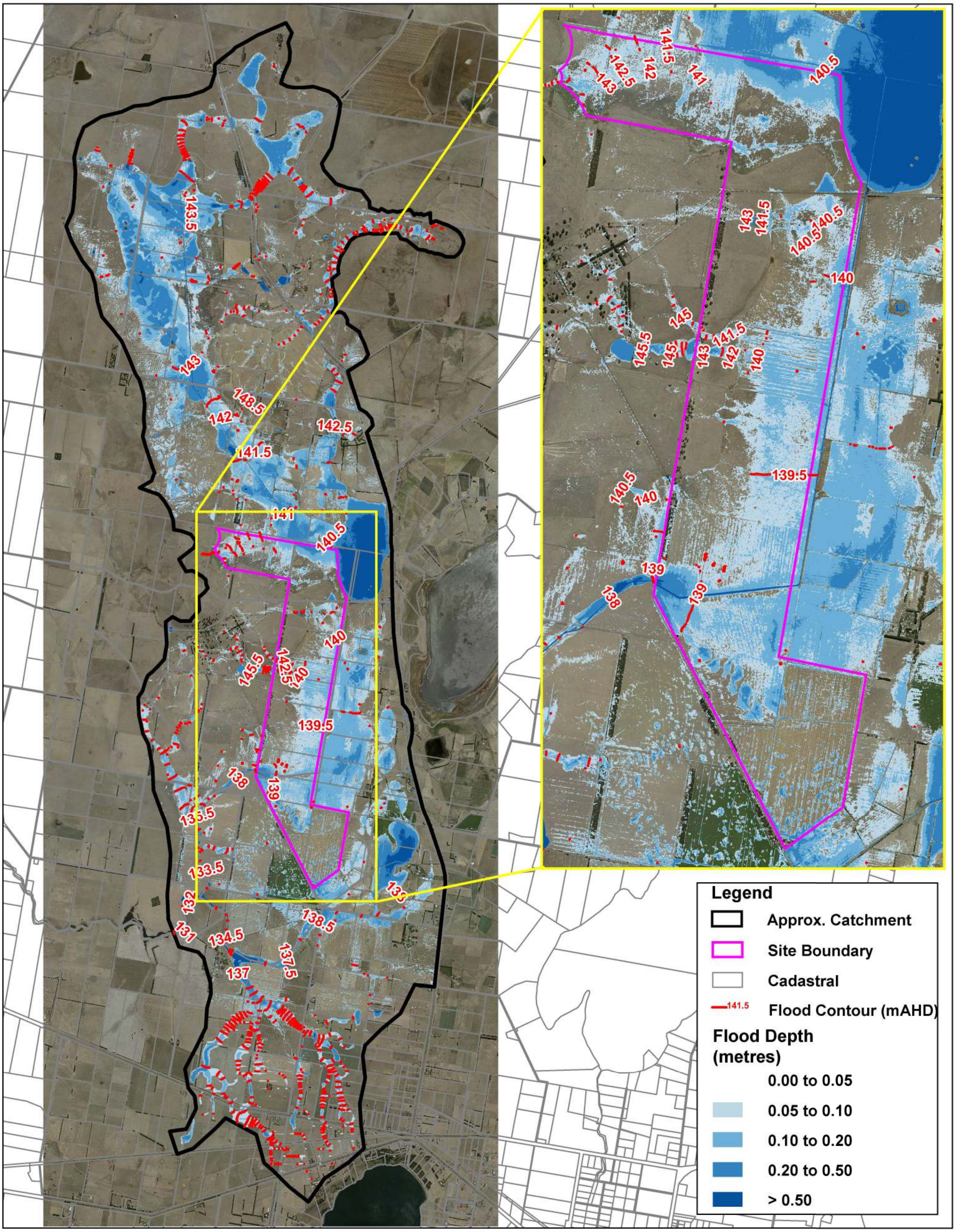

Title:
Bookar Solar Farm
Existing 1% AEP Flood Depth and Height Contours

Figure:	Rev:			By: DR
4-4	A	N, 0 1 2km, Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	Date: Aug 2020

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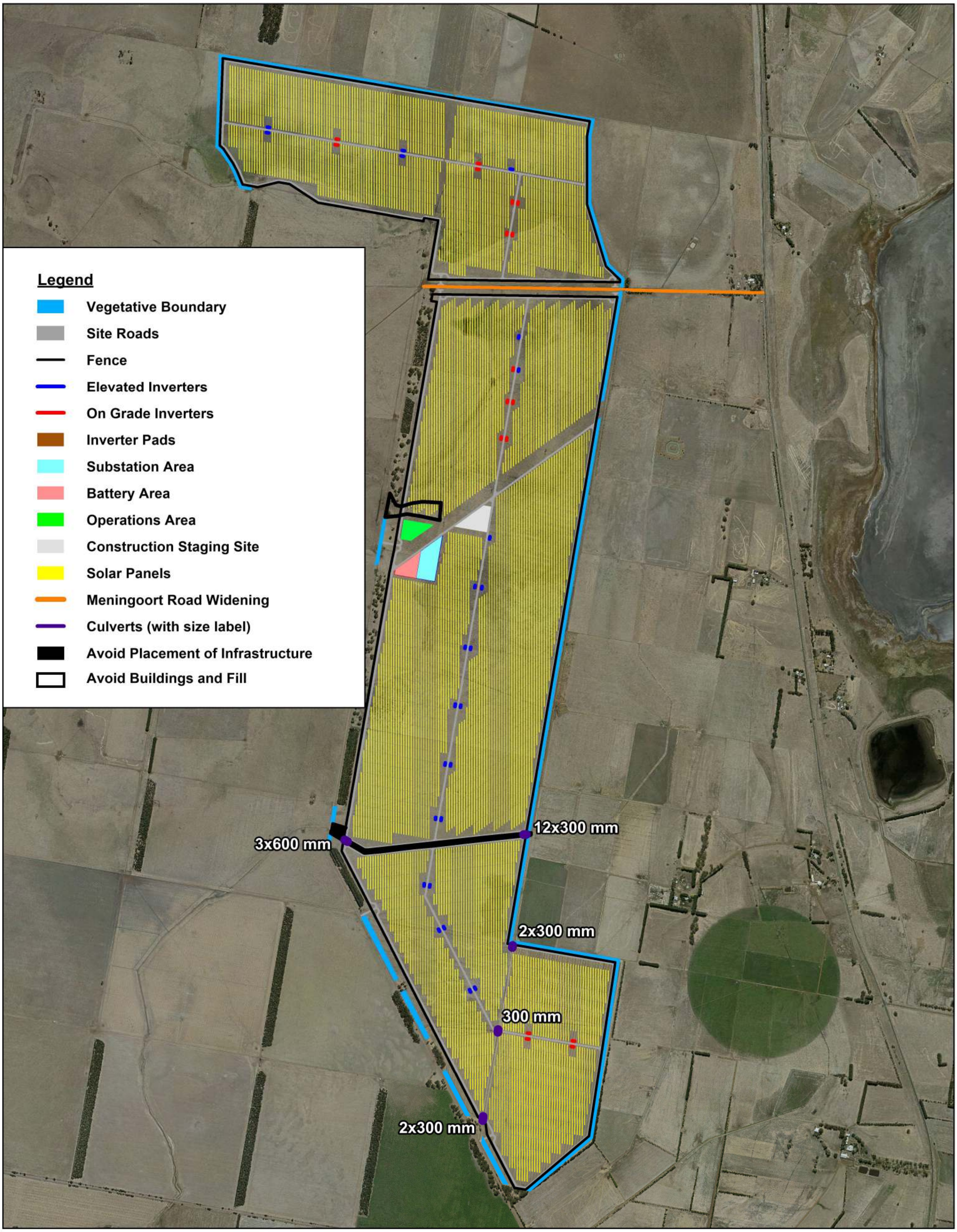

Title: Bookar Solar Farm
Site Elements for Developed Case

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Figure: 4-5
Rev: C

N
0 0.5 1km
Approx. Scale

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Date: Oct 2020

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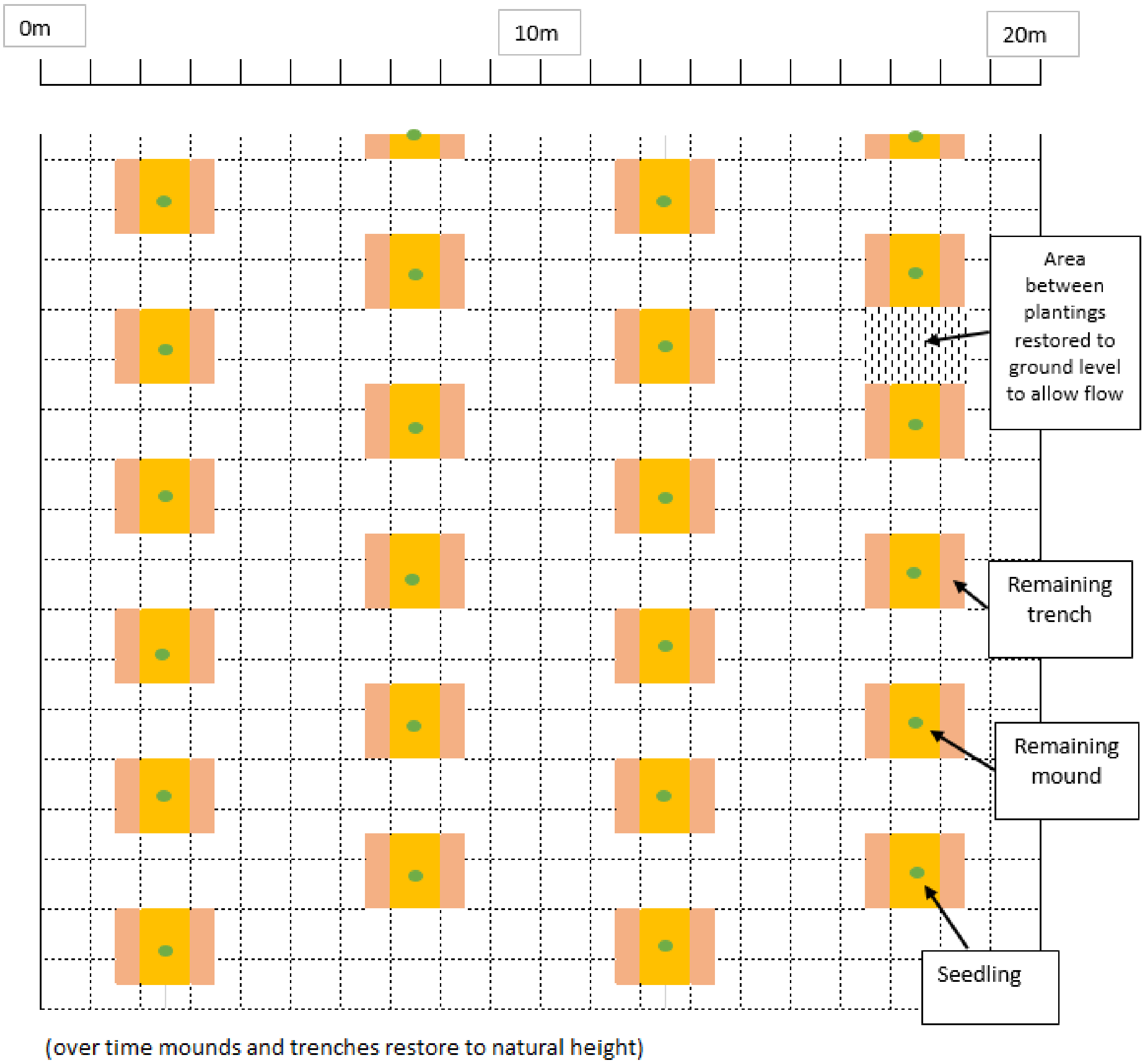

Figure 4-6 Vegetated Screen Mound Spacing

4.5 Flood Impact Assessment

The flood impact assessment considers:

- Change in peak flood level;
- Change in peak flow velocity; and
- Flow off-site onto adjoining properties.

The Proposal could potentially increase flood levels on nearby properties by increasing the amount of runoff onto the properties or by blocking overland flow paths resulting in backup of water on the neighbouring land. To investigate this, the peak flood surface is generated for both the existing and developed case model runs. The existing case flood surface is subtracted from the developed case flood surface to generate the change in flood levels caused by the Proposal.

The change in peak flood levels are mapped in Figure 4-7 and Figure 4-8 for the 20% AEP and 1% AEP events respectively. In these figures the change in flood level is mapped in ranges in accordance with the colours shown in the legend. The yellow colour represents flooded land where the Proposal does not change (increase or decrease) the flood level by more than a ± 0.01 m (10 mm) modelling tolerance; in this assessment land is considered flooded where the depth is more than 50 mm as noted earlier. The green shades represent flooded land where the Proposal would decrease flood levels, and the brown/red shades represent flooded land where the Proposal would increase flood levels.

The change in flood levels assumes that the drains along the northern and eastern boundaries are not allowed to become overgrown with vegetation, e.g., grass and weeds. The modelling assumed that the vegetation will be similar to that shown in the photographs in Section 2.

As noted earlier, there is very little flooding in the 20% AEP and the Proposal does not change (increase or decrease) the existing levels (Figure 4-7). In the 1% AEP event there are no areas where the introduction of the Proposal including the upgrade to Meningoort Rd, results in an increase in flood level outside the Site (Figure 4-8). There are areas to the south and southeast of the Site where the modelling indicates there would be small decreases in the range 0.05 m to 0.1 m (50 mm to 100 mm) in the 1% AEP event. These small decreases are caused by a slight reduction in the flow off the Site caused by the perimeter fence and the vegetation screen partially blocking the flow.

The change in peak flood velocity is mapped in Figure 4-9 and Figure 4-10 for the 20% AEP and 1% AEP events respectively. Like the change in flood level mapping, the change in velocity is mapped in ranges in accordance with the legend. The yellow colour represents flooded land where the Proposal does not change (increase or decrease) the flood level by more than ± 0.1 m/s. There are no locations off-site where the changes in velocity are outside this range, and hence it is concluded that the Proposal will not increase the flood velocity on other properties.

On the Site there is no significant increase in velocity and hence the velocities with the Proposal constructed will be very low (0.1 m/s to 0.4 m/s) as reported for the existing Site in Section 4.3. Velocities this low will not cause erosion.

The 1% AEP flow rate off the Site onto adjoining properties was assessed along the three boundaries shown in Figure 4-11 where the flow direction is predominantly leaving the Site onto adjoining properties. The 1% AEP flow rate at each of these boundaries is plotted as a timeseries in Figure

4-12, Figure 4-13 and Figure 4-14. In these figures a positive flow is flow leaving the site and a negative flow is flow coming on to the Site. The scenarios are plotted on these figures:

1. Existing conditions (blue line);
2. The Proposal with the perimeter fence (70% blocked with debris) and the vegetated screening in place (brown line); and
3. The Proposal without the perimeter fence blocked with debris or vegetated screening (grey line).

The last scenario is a worst-case scenario. The blocked fence and vegetated screening could potentially slow up water leaving the Site and hence it was removed to test a worst case.

At each boundary, the Proposal case flows (scenarios 2 and 3) are slightly lower than the existing case, i.e., with the Proposal the flow rate leaving the Site marginally reduces in the 1% AEP event. The presence or otherwise of the fence blockage and the vegetated screening did not significantly influence the flow leaving the Site; in Figure 4-12 and Figure 4-13 the difference in flow rates between the two scenarios is so small that the brown line mostly plots over the blue line.

In Figure 4-14, which shows the flows across Eastern Boundary 2, existing condition flows leaving the Site appear to be significantly larger than those with the Proposal. However, the flows are small compared with the other boundaries and a different scale is used on the graph. On the Northern Boundary the flow leaving the Site peaks at about 11 hours, but quickly reverses and for most of the time the flow is entering the Site along this boundary (negative flow). This occurs because the runoff from the site leaves the Site ahead of the arrival of the flooding from the larger catchment to the north which flows onto the Site.

The very small reductions in flow leaving the Site with the Proposal is evident in plots for this assessment and is consistent with change in flood level and velocity plots which show no significant change between the existing conditions and the developed case.

4.6 Mitigation Strategies

Through the design iteration process a number of mitigation strategies were implemented as follows:

- Areas were identified to avoid infrastructure as detailed in Section 4.4 including a 15 m wide zone around the East West drain;
- The size of the culverts was selected and tested in the model to ensure they did not adversely block flows and cause an increase in flood levels off-site;
- The mounding associated with the planting of vegetated screening will be required to have at least a 50% opening as described in Section 4.4 to ensure that runoff is not diverted and concentrated onto neighbouring properties;
- The Site access along Meningoort Road will be kept at the existing road level; and
- Internal access tracks will be kept at ground level.

Whilst not a mitigation strategy incorporated into the design, in selecting the modelling parameters it was assumed that the drains along the northern and eastern boundaries and the East West drain are not allowed to become overgrown with vegetation, e.g., grass and weeds. The parameters were adopted on the assumption that a maintenance plan would maintain the vegetation similar to that shown in the photographs in Section 2. The Proposal will not materially change the hydrology of the Site and associated runoff patterns. Some low lying areas of the Site currently pool water during winter/spring. This will continue with the Proposal in place but will not require the development of a drainage plan as the arrays and associated infrastructure have been designed to be compatible with the depth of water expected in a 1% AEP event.

Balustrade fences where water is flowing onto the Site was considered, however a chain-wire security fence 70% blocked with debris did not result in off-site impacts and hence it was concluded that balustrade fencing is not required. Regardless of the assumption in the modelling, the Site maintenance strategy should include removing debris from fences.

The modelling showed that there are no adverse impacts on neighbouring properties and hence no further mitigation strategies are required to manage off-site impacts.

4.7 Guideline Considerations

The Guideline makes recommendations pertaining to flooding. These are discussed in Table 4-3.

Table 4-3 Guideline Recommendations and Reponses

Guideline Recommendation	Response
A proponent should avoid siting a solar energy facility within an identified floodplain to a major river system and a mapped wetland area, to avoid unnecessary risk to the facility and its associated infrastructure and the consequential need for flood attenuation measures such as flood levies and barriers.	The Site is not an identified floodplain to a major river system nor a mapped wetland.
A solar energy facility can occupy a large site, and earthworks to grade or level a site can change the overland flow of water, which can change natural and constructed drainage patterns. This can increase the risk from future flood events on the site and neighbouring land.	Earthworks on the Site are minimal with the majority of the Site unmodified. Flood modelling has been undertaken which demonstrates no changes to flood levels and velocity on the Site and neighbouring land, and no increase in flow onto neighbouring land. Therefore there is no increase in risk on the site and neighbouring land.

Guideline Recommendation	Response
A solar energy facility should not increase flood risks on the site or in the immediate area. Flood risks (unlike most other natural hazards) are predictable in terms of their location, depth and extent. This means a proponent can implement measures to reduce flood damage, including: • minimising grading or levelling of the site, to avoid changes to overland water flow and discharge patterns • avoiding locations within the immediate floodplain or a watercourse or river system • elevating structures above the floodplain as recommended by the relevant	The Site is not located in the floodplain to a major river system. The flood modelling shows that part of the Site is flooded to shallow depths during a 1% AEP storm event in the broader Blind Creek catchment. Solar panels are not located in the East West drain. The operations building, substation area, battery area and construction compound are sited on elevated and levelled fill platforms above the 1% AEP flood level. The location of these structures is not within the Blind Creek floodplain, but higher up on Mount Meningoort and hence the flooding at this location is overland flow runoff from Mount Meningoort. Some arrays and inverters are located in the areas of shallow depth flooding during a 1% AEP event, however the arrays and inverters are elevated so as not to be damaged. Earthworks has been minimised. Flood modelling has been undertaken which demonstrates minimal change in overland water flow and discharge patterns with the result that there is no increase in flood risk on the Site or on neighbouring land

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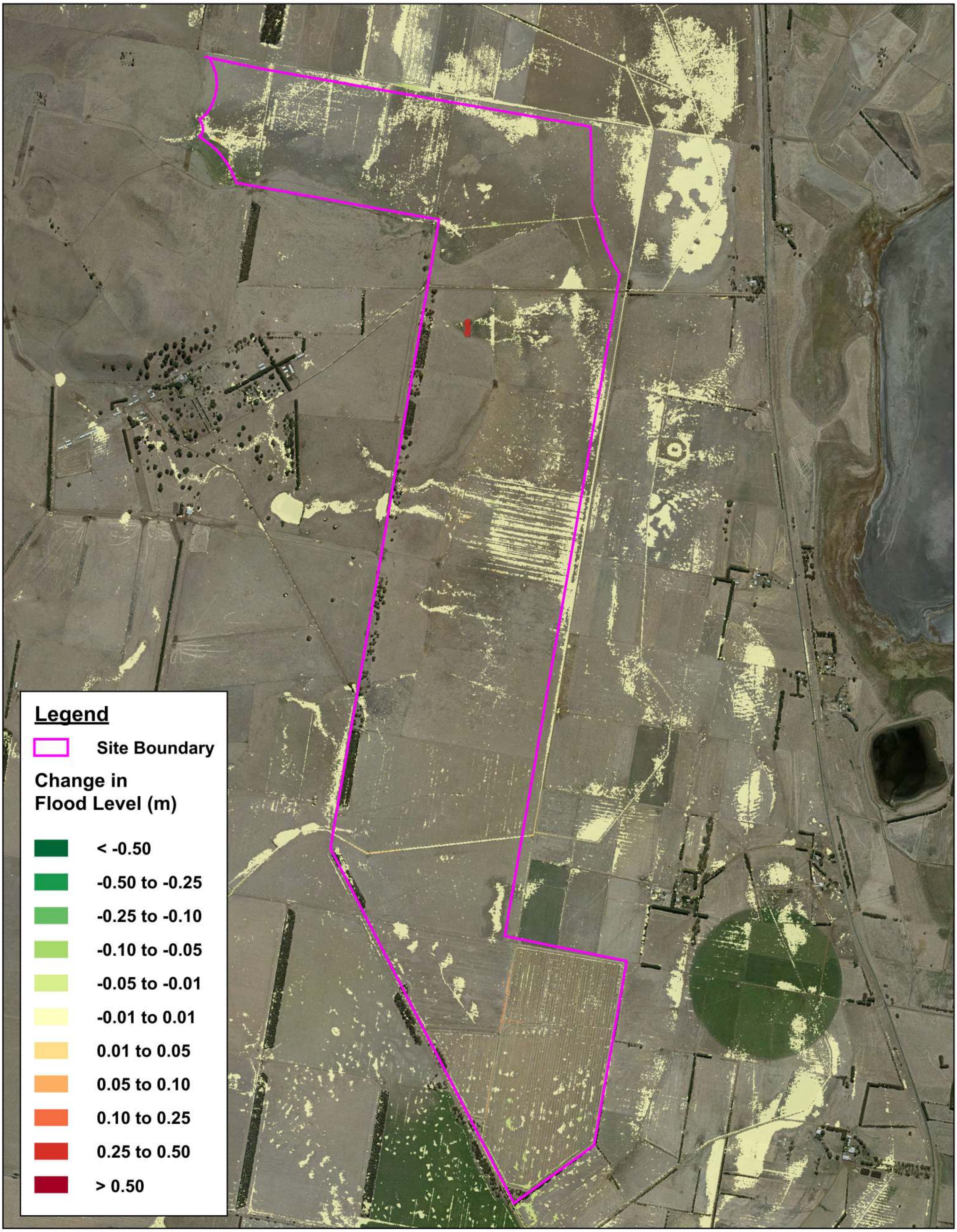

Title: Bookar Solar Farm
20% AEP Change in Flood Level

Figure:	Rev:	Scale	Disclaimer	
4-7	A	N; 0 – 0.5 – 1km; Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LC Date: Oct 2020

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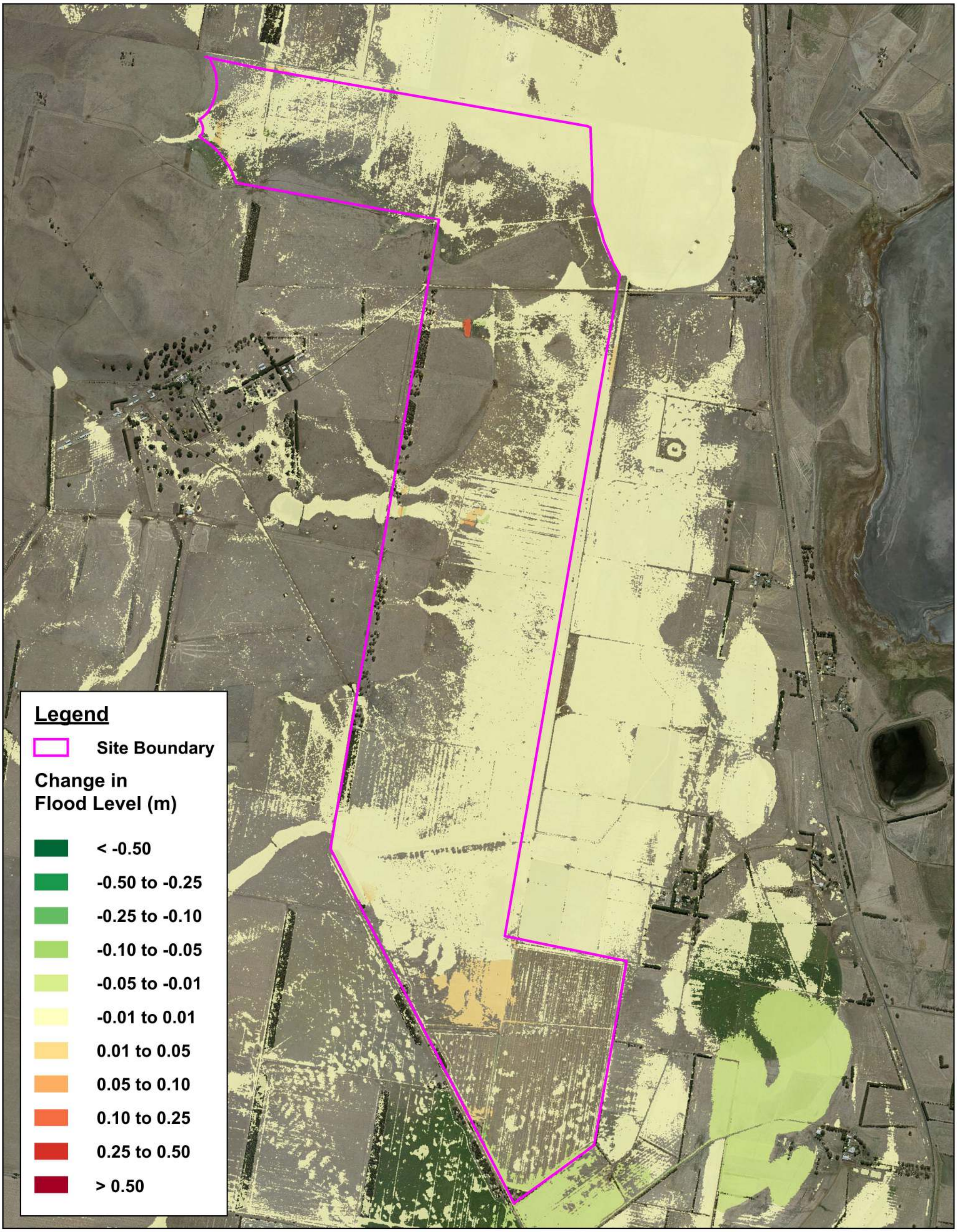

Title: Bookar Solar Farm
1% AEP Change in Flood Level

Figure:	Rev:			By: LC
4-8	A		This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	Date: Oct 2020

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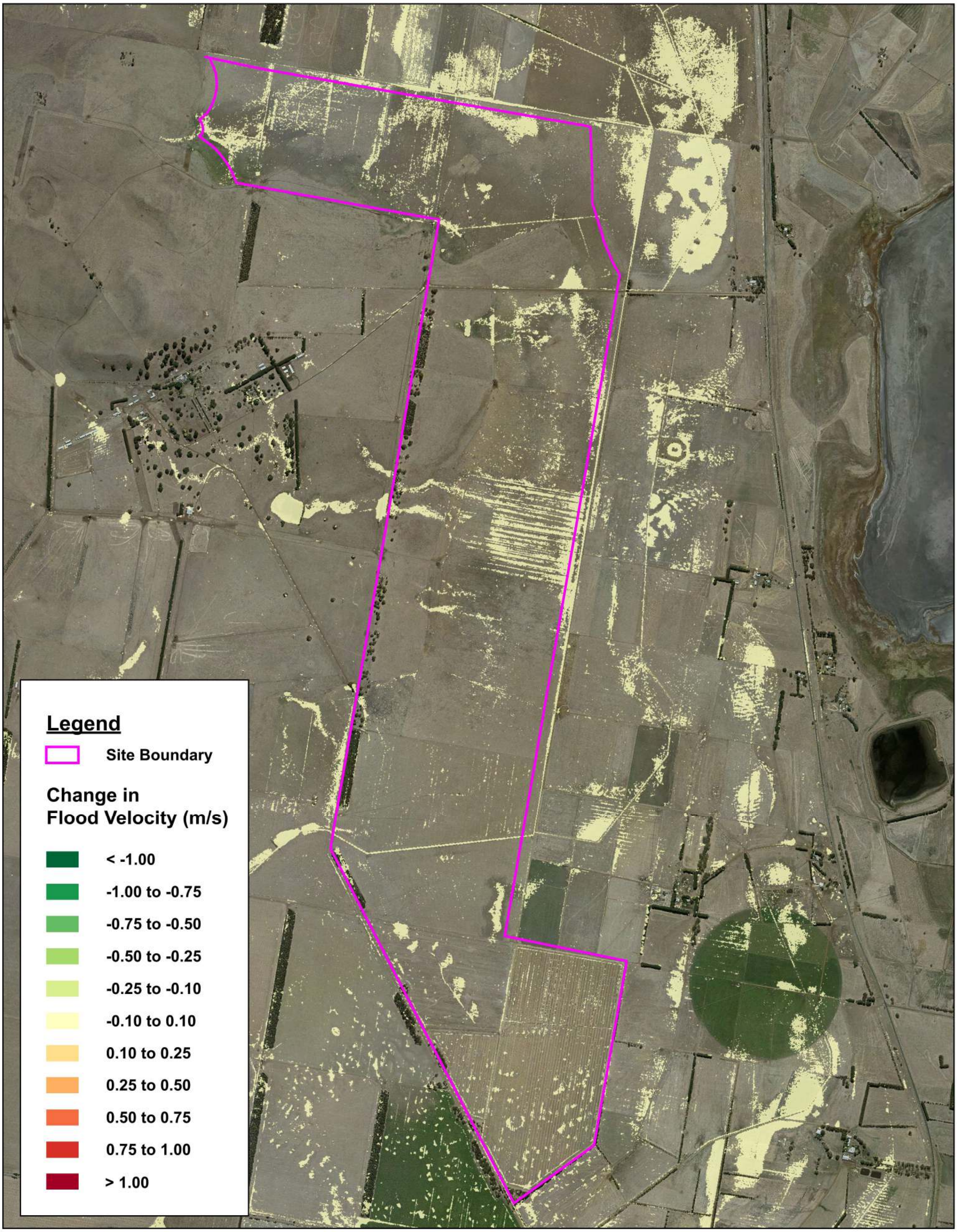

Title: Bookar Solar Farm
20% AEP Change in Flood Velocity

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Figure:	Rev:	Scale	Disclaimer	By / Date
4-9	A	N 0 0.5 1km Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LC Date: Oct 2020

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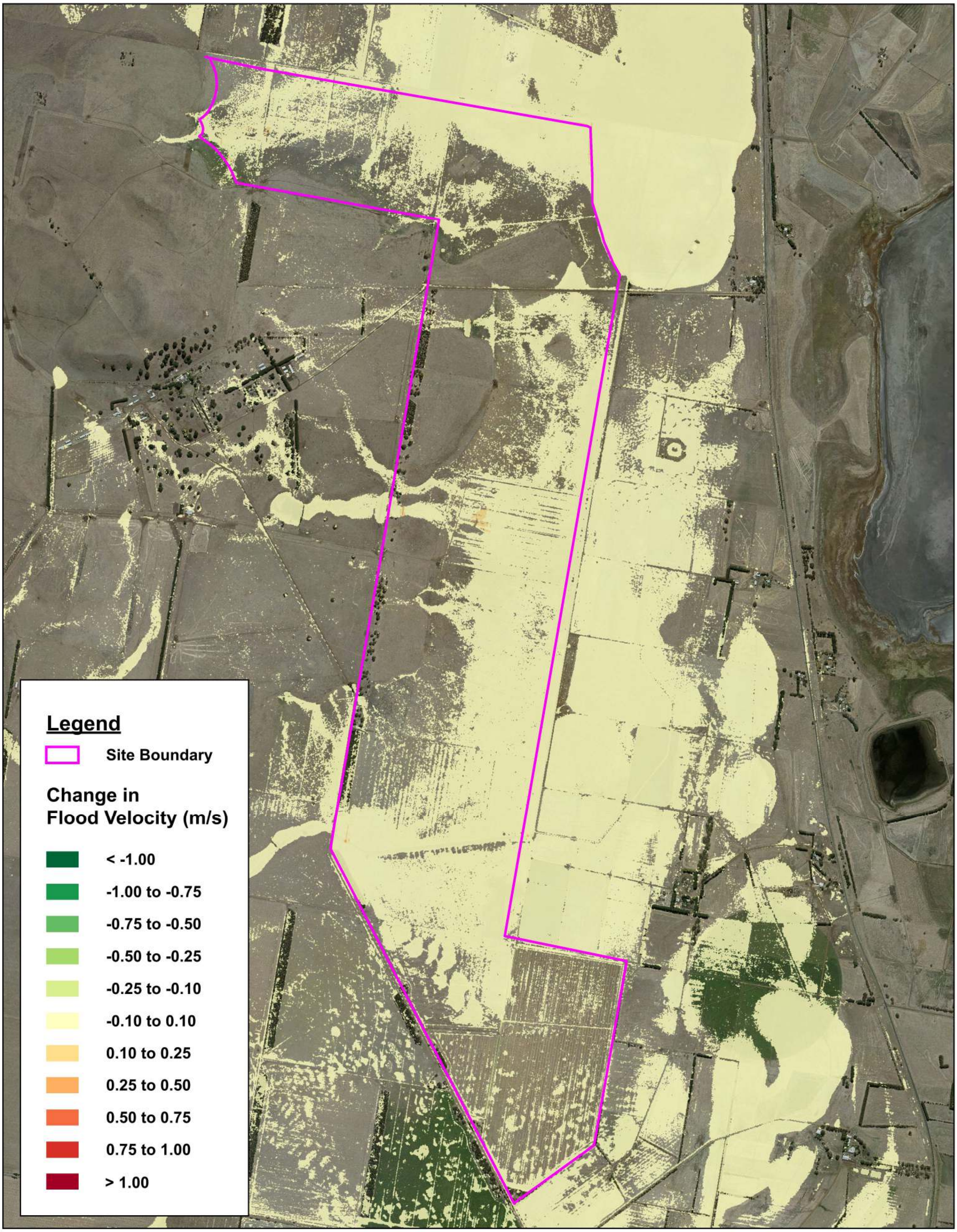

Title: **Bookar Solar Farm**
1% AEP Change in Flood Velocity

Figure:	Rev:	Scale	Notes	
4-10	A	N 0 0.5 1km Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LC Date: Oct 2020

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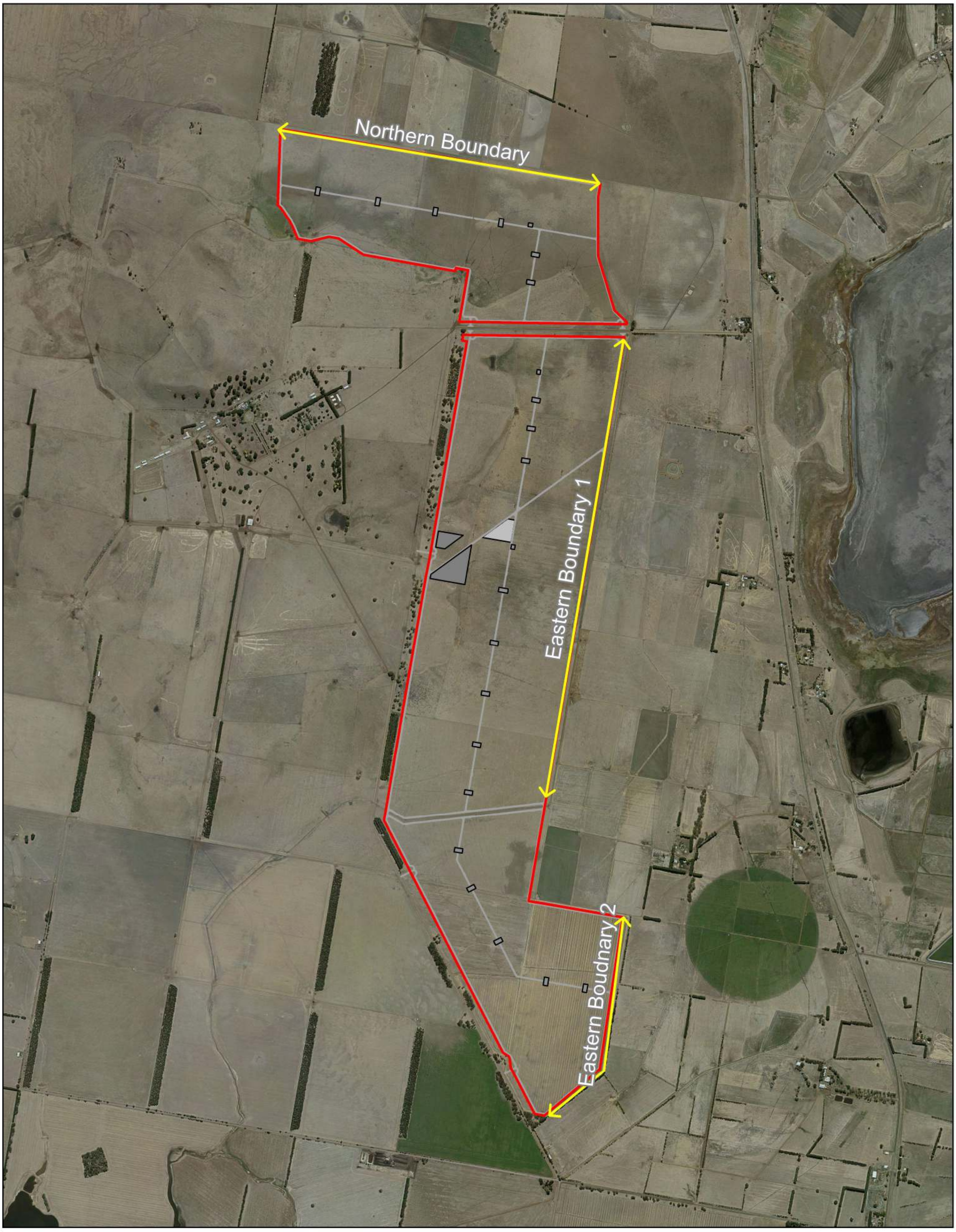

Title:
Bookar Solar Farm
Flow Over Boundary Locations

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Figure:	Rev:	Scale	Notes	By / Date
4-11	A	N; 0 0.5 1km; Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LC; Date: Oct 2020

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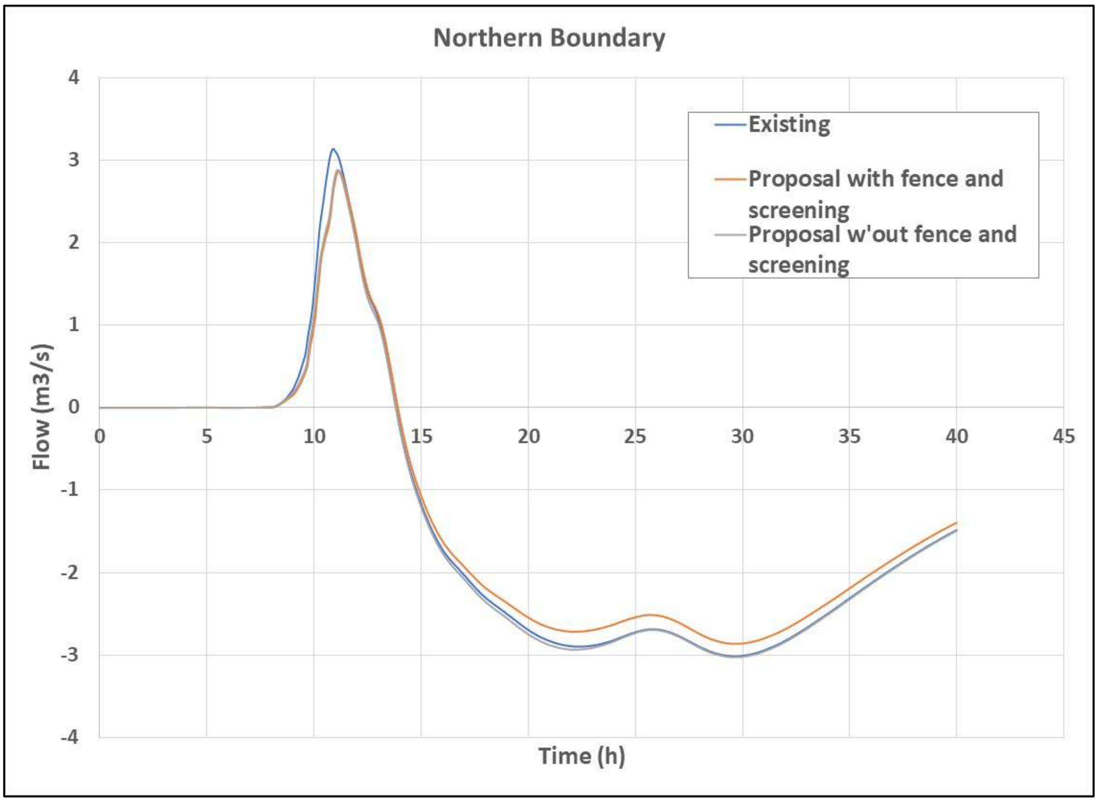

Figure 4-12 1% AEP Flow Crossing Site Boundary – Northern Boundary

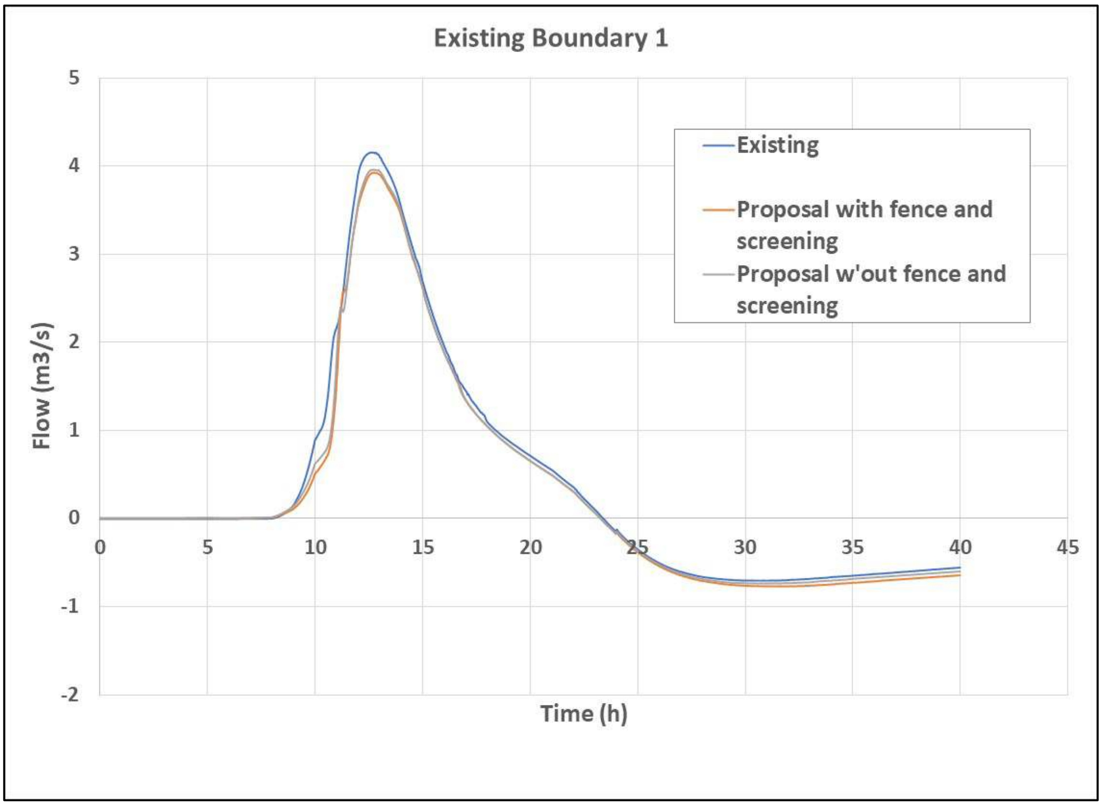

Figure 4-13 1% AEP Flow Crossing Site Boundary – Eastern Boundary 1

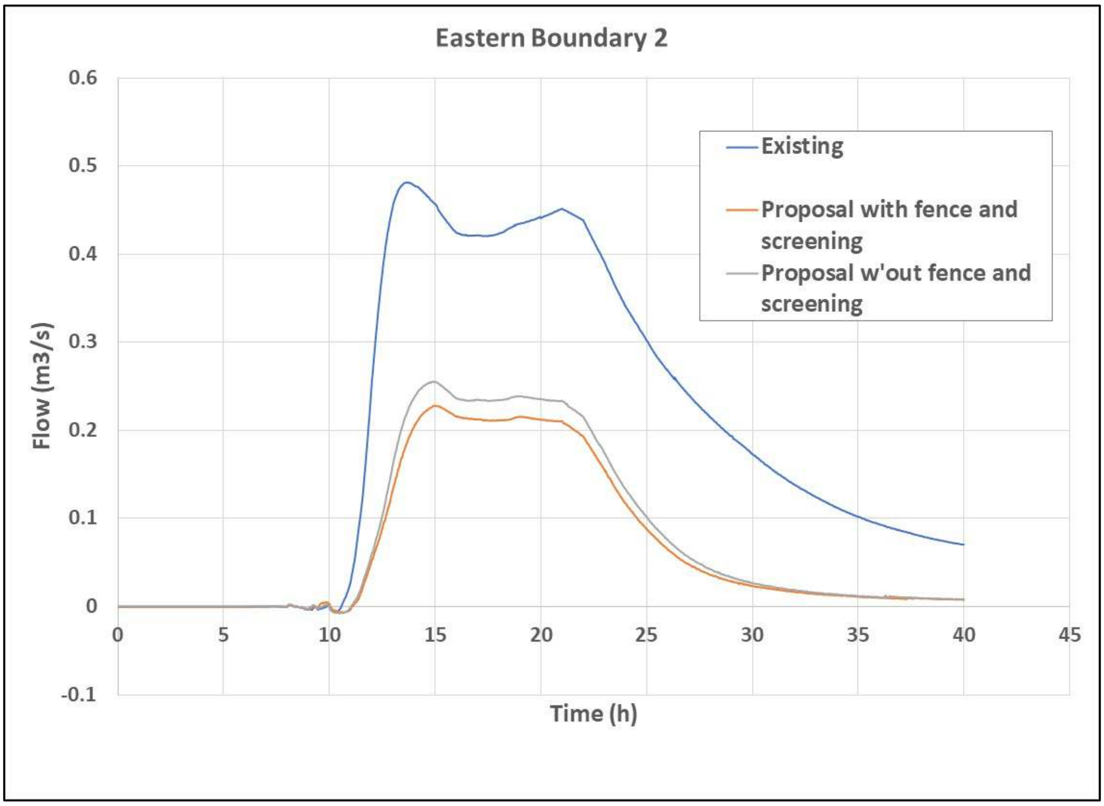

Figure 4-14 1% AEP Flow Crossing Site Boundary – Eastern Boundary 2

5 Summary

Flood modelling of the Blind Creek catchment has been undertaken to assess the potential for the Proposal to adversely impact on surrounding properties. A TUFLOW flood model was developed of the entire catchment using the rain-on-grid approach to represent the hydrological process within the catchment. This model was developed based on industry best practice and guidance such as the principals outlined in Australian Rainfall and Runoff 2019.

Existing and developed conditions (with Solar Farm) were assessed using the 20% AEP and 1% AEP design flood events. The developed case model incorporated all features of the Solar Farm that could potentially alter the hydrological and hydraulic processes, including a process to represent the solar panels intercepting rainfall and concentrating the runoff into the 8.75 or 9 m gap between panels. The assessment found that there was no increase in flood levels or velocities on neighbouring land and that there would be no increase in the flow rate onto adjoining land.

6 References

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