Appendix E: Flood modelling report

alluvium

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Sandigo Solar Farm Flood Modelling

Northern Area Assessment

February 2018

ACCENT ENVIRONMENTAL

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1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) has been commissioned by Accent Environmental to develop a response to the flooding section of an Environmental Impact Study (EIS). The EIS is required as a part of ESCO Pacific's planned solar farm at Sandigo, on the Sturt Highway between Narrandera and Wagga Wagga, NSW (Figure 1).

The initial area comprises approximately 231 ha located at the northern end of the total site being assessed as part of the EIS (Figure 3). ESCO Pacific may expand the solar farm to include the remaining 377 ha to the south end of the total site at a later date. This expansion and the close proximity of the two northern and southern ends of the total site resulted in both sites being included in this project.

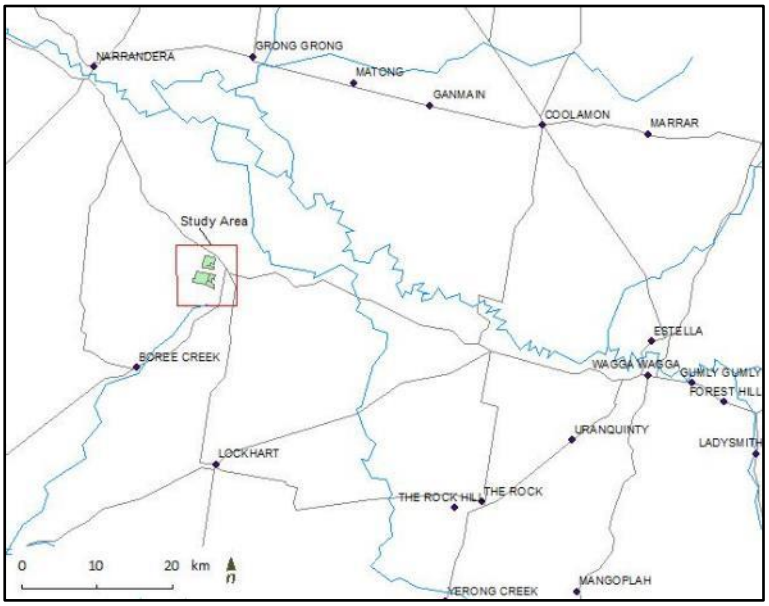

Figure 1: *Locality Plan of the proposed Study Area.*

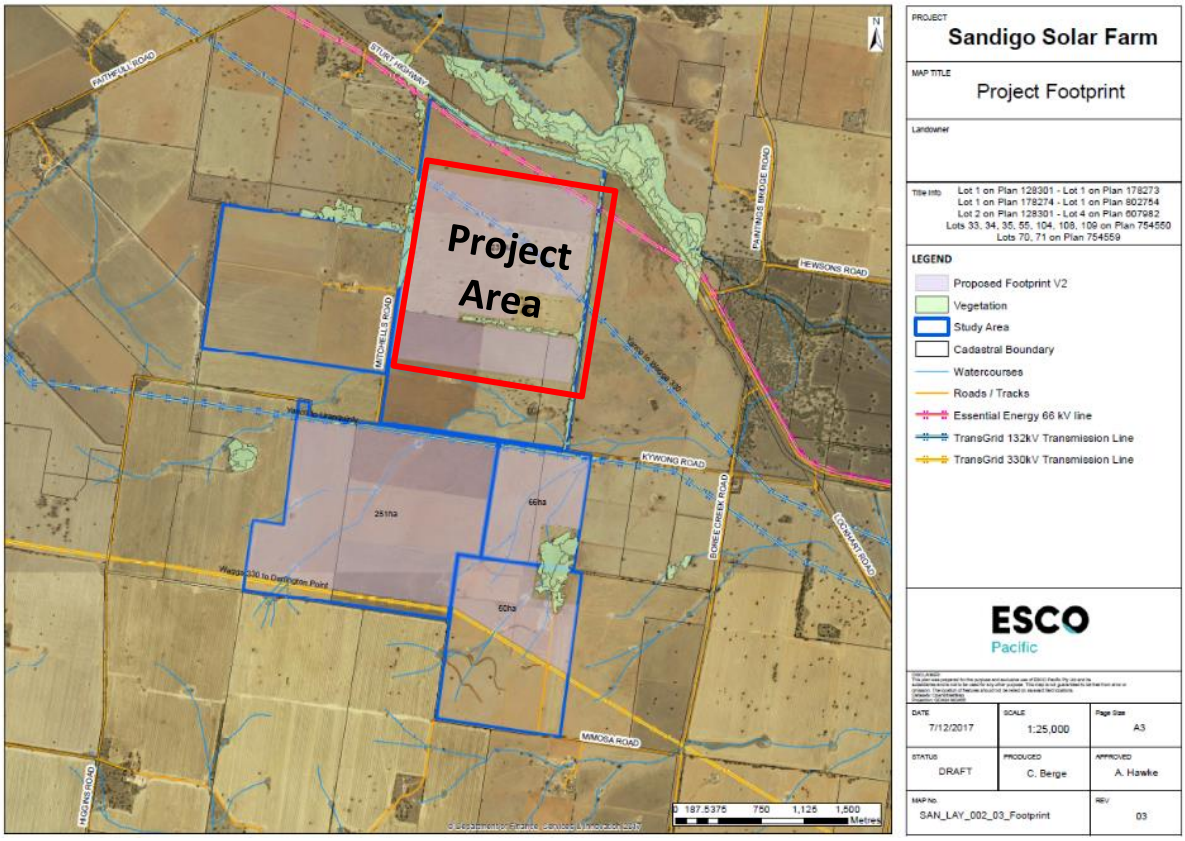

Figure 2: *Proposed ESCO Pacific Solar Farm – total "Study Area" footprint (Note: layout is conceptual in nature)*

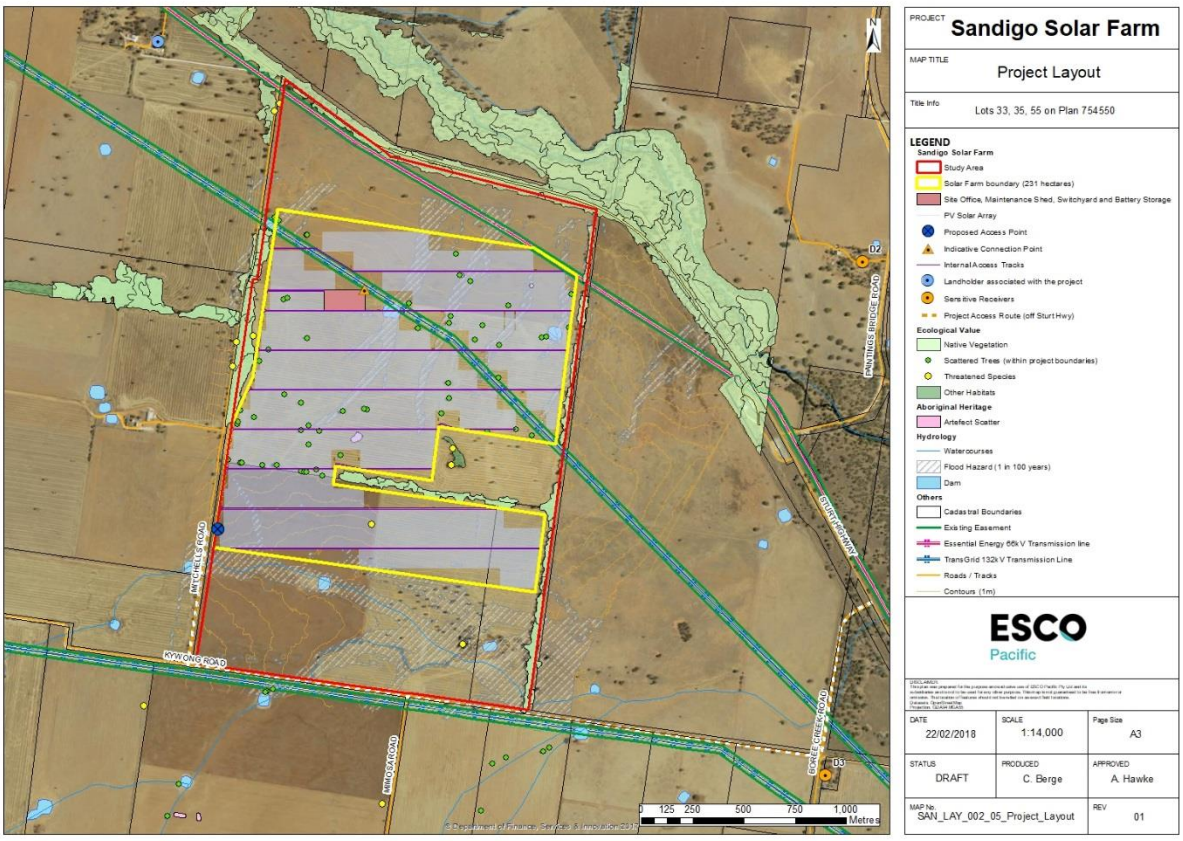

Figure 3: *Proposed ESCO Pacific Solar Farm – "Project Area" (Note: layout is conceptual in nature)*

2 Flood Modelling

2.1 Overview

The NSW Office of Environment and Heritage (OEH) has requested a Flood Study to assess several criteria in relation to Project Area. Specific responses to those criteria are included in Section 5 below which are underpinned by the findings of this assessment. As per discussions between ESCO Pacific and OEH on 23 January 2018, OEH approved a lower level of flood assessment for two key reasons:

1. the Study Area is located in low flood hazard areas (elevated well above the Murrumbidgee River Floodplain and subjected to mainly overland flows)
2. the low flood impact nature of the Project Area and associated infrastructure.

OEH suggested using the September 1974 flood as the 1% [1:100] AEP design flood in this case, since recent flood studies consider it very close to this in terms of peak discharge in the Murrumbidgee River floodplain at both Wagga Wagga and Narrandera.

The assessment aims to address the regional riverine flooding from Sandy Creek (Figure 14), but also localised internal flooding which originates from rainfall over the proposed Project Area and its headwaters accounting for the significant runoff above and through the Project Area.

The proposed Project Area plus the upstream catchment has a total area of over 18 sq.km (1,800 ha) which is substantial from a flooding perspective. The level of assessment for the methodology takes a minimalist approach to the flood study, as it is believed the Project Area is of low risk (both its own internal infrastructure and impacts to neighbouring property). This status is due to the Project Area's generally high elevation (Figure 4), and the nature of the assets (panels mounted on posts above ground).

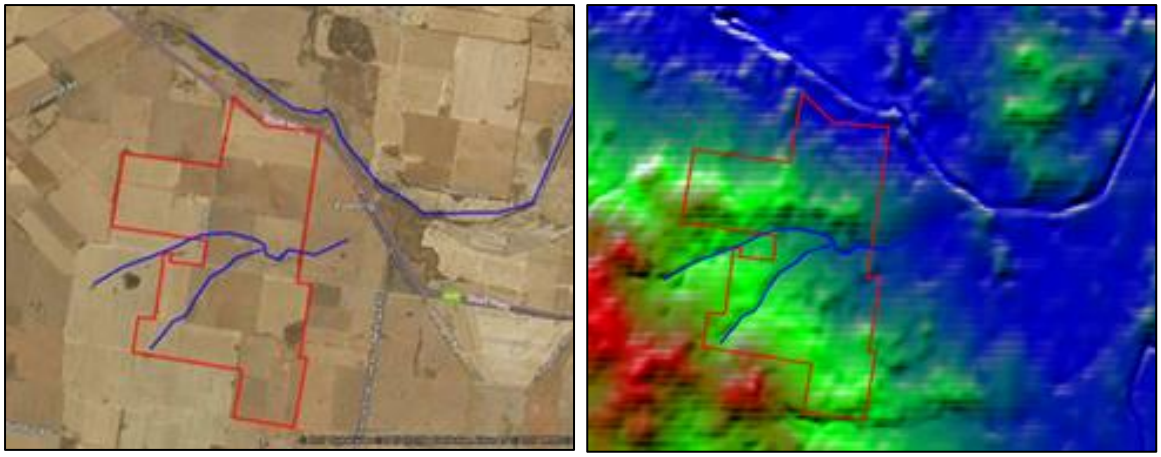

Figure 4: *(LEFT) Aerial with the extents of the Study Area (red). (RIGHT) Digital Elevation Model (red = high; blue = low)*

The following events were simulated in the assessment:

- 10% [1:10] AEP: to plan road and drainage / cross drainage infrastructure for the Project Area
- 1% [1:100] AEP: to determine flood immune locations and levels for main buildings such as the Operation and Maintenance (O&M) Building and other medium risk infrastructure
- 0.2% [1:500] AEP: to determine flood immune locations and levels for high risk infrastructure such as the Project Area switch yard.

2.2 Survey & Digital Elevation Model

In January 2018 a detailed drone survey was captured for the Project Area (Figure 5). The data was very fine resolution with points, on average, captured at 200 mm intervals. To represent the remaining catchment area, upstream of the Project Area, the 2018 ALS dataset was supplemented by the SRTM shuttle data captured in 2011. The two datasets were combined by stamping the recent 2018 Lidar on to the 2011 SRTM shuttle data and resampled to form a 5 m resolution Digital Elevation Model (DEM). This DEM formed the basis of the localised stormwater flood modelling and the positioning of flood extents from regional riverine flooding. A GIS algorithm was then used to trace the DEM boundaries, and high points to low points, in order to form sub-catchment boundaries (see indicative flow lines along gullies (Figure 6 and Figure 7). The main Study Area catchment high point is RL 198 m AHD, and Sturt Highway at Project Area RL 154 to 155 m AHD.

Figure 5: *Drone survey extents provided by ESCO Pacific shown in red*

Figure 6: *Combined DEM and streamlines over the Study Area*

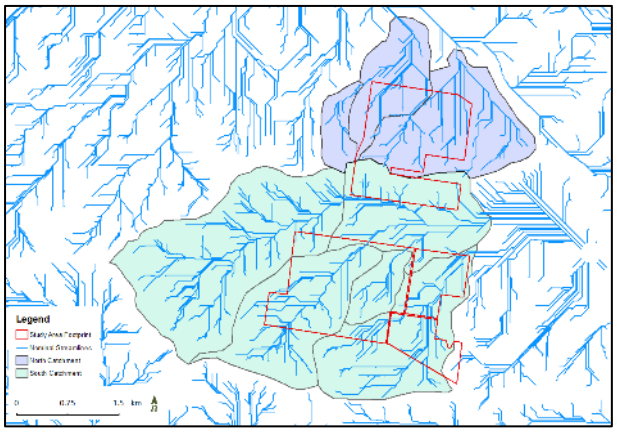

Figure 7: *Combined Subcatchments and streamlines over the Study Area*

2.3 Localised Stormwater Flooding

Hydraulic Model Build

The flood model was built using the TUFLOW software. The Direct Rainfall Approach was employed for the flood modelling where a rainfall hyetograph is applied to every model cell within the catchment contributing to drainage through the Study Area. Given the flat nature of the terrain, a 5 m DEM resolution was considered adequate for the purposes of the 2D flood model and flood maps. In general, the SRTM data had a higher elevation than the recent ALS data (2018), which led to a step in the terrain at the interface of the two datasets, causing floodwater to become trapped at the downstream boundary of the Project Area. The downstream model boundary was therefore adjusted to the downstream extent of the new drone DEM to ensure the model adequately drained creating more realistic flow paths at the downstream extent of the Project Area (Figure 8).

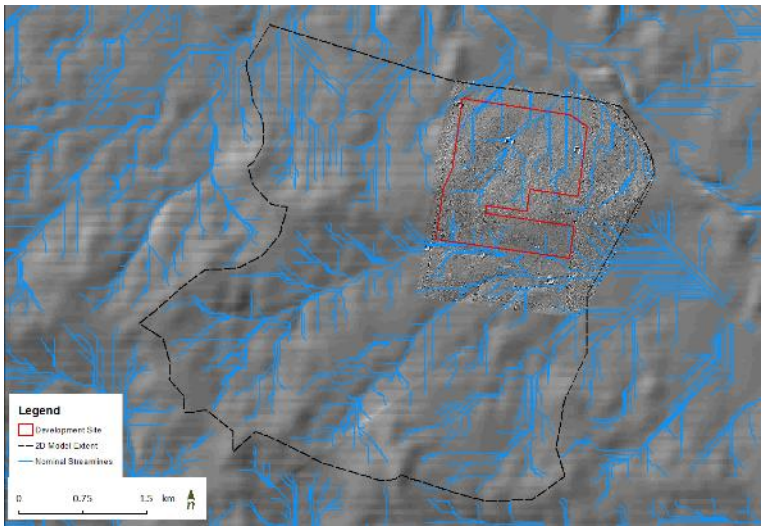

Figure 8: *Extent of the 2D TUFLOW model with nominal streamlines*

Hydrological Simulation

Rainstorms were applied to the model for the 0.2% [1:500] AEP, 1% [1:100] AEP and 10% [1:10] AEP events for the 60-minute, 120-minute and 180-minute storm durations. The 60-minute storm was found to be the critical duration event, which is quite common for small sized catchments utilising temporal pattern data sets from Australian Rainfall and Runoff (1987). A Manning's n roughness coefficient of 0.03 was initially assumed for the catchment.

Discharge estimates in the TUFLOW model were measured in the main stream to the south of the Project Area, immediately upstream (west) and downstream (east) of the lot boundary (Figure 9). To assist validating the model, the Regional Flood Frequency Estimation Model (RFFEM, 2016) was used to determine the upper limit discharges for the same measurement locations. Flood discharge estimates are given in Table 1, and the raw outputs from the RFFEM are given in Attachment B. The final roughness coefficient adopted was 0.07. It is noted that the RFFEM does have significant confidence limits and should be considered as a guide only. At detailed design, it is recommended the TUFLOW model be appropriately calibrated using a more rigorous methodology such as a fully dynamic hydrological model.

Table 1: Discharge Estimates

Flood AEP	Lower Catchment 10% [1:10]	Lower Catchment 1% [1:100]	Upper Catchment 10% [1:10]	Upper Catchment 1% [1:100]	Units (%) [1:year]
Subcatchment Area	10.09	10.09	4.86	4.86	(km^2)
RFFEM Upper Discharge	22.9	57.3	15.8	39.2	m^3/s
TUFLOW DRM Discharge	14.2	41.2	16.7	28.2	m^3/s

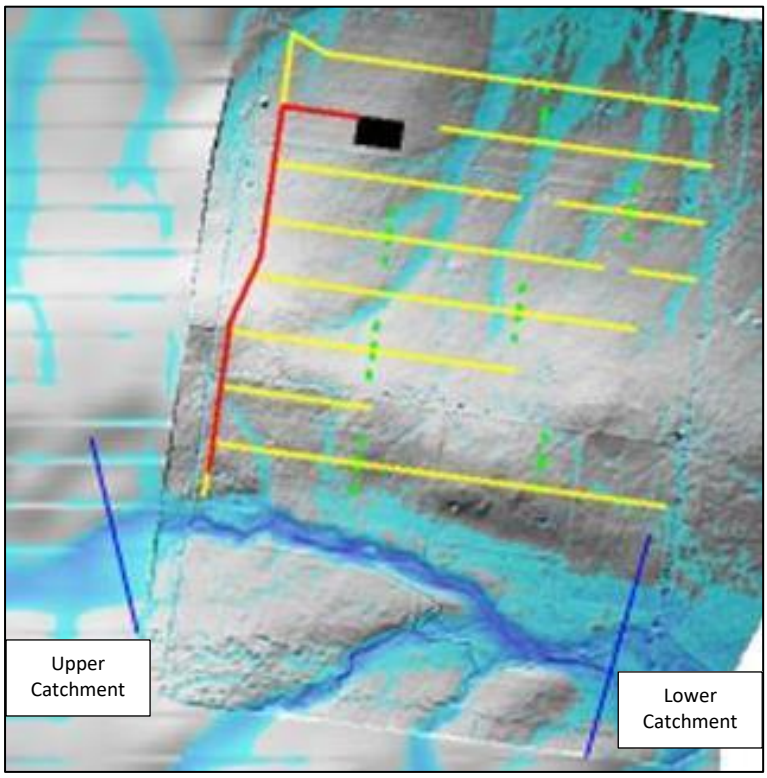

Figure 9: *Discharge Measurement Locations (Note: layout is conceptual in nature)*

Local Flood and Hazard Mapping Results

Detailed maps of flood inundation and flood hazard are given in Attachment A.

An investigation of the flooding hazard was achieved by multiplying the maximum flood depths and velocities of the 100-year ARI event (1% AEP), yielding Figure 10. Of note is that based on the categories of flood risk given by Table 2 the majority of the Project Area flood risk is nil with the exception of the northern most extent which is a low risk area.

Table 2: Low Hazard Evacuation Routes (Scenic Rim Regional Council, 2017)

Criteria	Degree of Flood Hazard			
	Low	Medium	High	Extreme
Wading ability	If necessary children and the elderly could wade. (Generally, safe wading velocity depth product is less than 0.25).	Fit adults can wade. (Generally, safe wading velocity depth product is less than 0.4).	Fit adults would have difficulty wading. (Generally, where wading velocity depth product is less than 0.6.)	Wading is not an option.
Evacuation distances	<200 metres	200-400 metres	400-600 metres	>600 metres
Maximum Flood Depths	<0.3 metres	<0.6 metres	<1.2 metres	>1.2 metres
Maximum Flood Velocity	<0.4 metres per second	<0.8 metres per second	<1.5 metres per second	>1.5 metres per second
Typical means of egress	Sedan	Sedan early, but 4WD or trucks later.	4WD or trucks only in early stages, boats or helicopters	Large trucks, boats or helicopters.

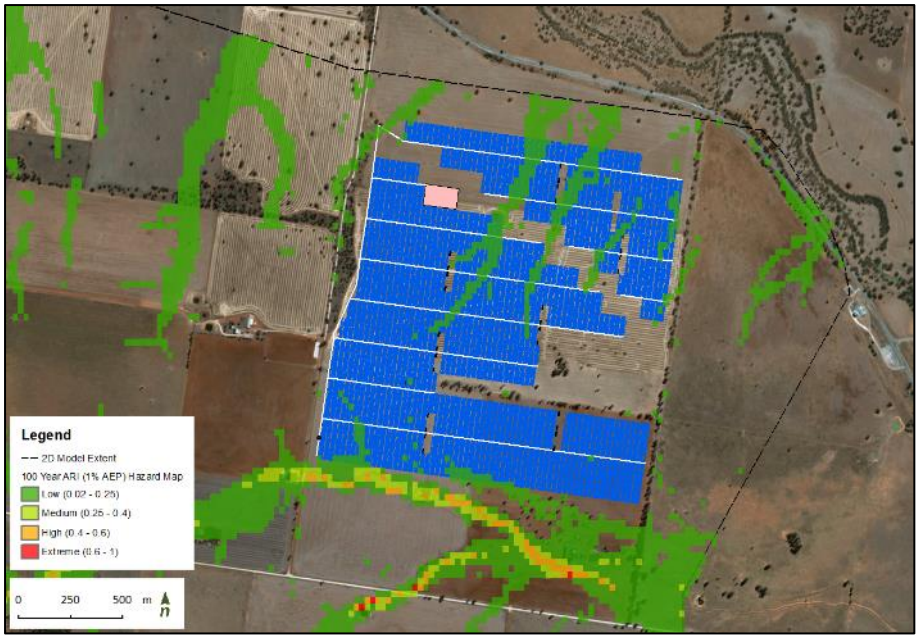

Figure 10: *Hazard mapping (D x V product) of the Project Area for the 1% [1:100 ARI] AEP. (Note: layout is conceptual in nature)*

Please note: the results of the hydraulic model outside of the drone survey should be considered as a guide only and should not be used for planning and engineering purposes. This area covers the portion of the model run on the 25m SRTM data and is indicative only.

2.4 Regional Riverine Flooding

Riverine flooding which occurs external to the Project Area has been identified as a potential risk from Sandy Creek. In October 2015 the Narrandera Shire Council undertook a flood study review and assessment of levee options for the Narrandera Township and surrounds (Narrandera Council, 2015). The flood levels used for this assessment have been sourced and extrapolated from the 2015 study as follows:

1. In considering the Narrandera 2015 flood study, Volume 2, Figure 4.6 September 1974 Flood, the flood contour at the Project Area reads RL 155 m AHD, which is in agreement with the flood extent in the geo-referenced image (Figure 11) when compared with the recent 2018 Lidar data.
2. When comparing the 1974 discharge at Narrandera Township (3,078 m^3/s, Volume 1 Flood Report Table 2.1 Historic Flood Data), this correlates almost exactly with the 1% [1:100] design event peak discharge as shown in Table 2.2 of the report (3,107 m^3/s for Parameter Set 2 used to calibrate the 1974 flood).
3. When considering the Extreme Flood levels at the downstream end of Sandy Creek (narrow channel) and Murrumbidgee River (wide open floodplain) the Probable Maximum Flood (PMF) level is approximately 1.5 m higher than the 1% [1:100] AEP 1974 event (compare Figure 12 with Figure 13). This equates to an indicative PMF level at the Project Area of RL 156.5 m AHD.
4. The position of the 1% [1:100] AEP and PMF contours in context with the Project Area are shown in Figure 14.

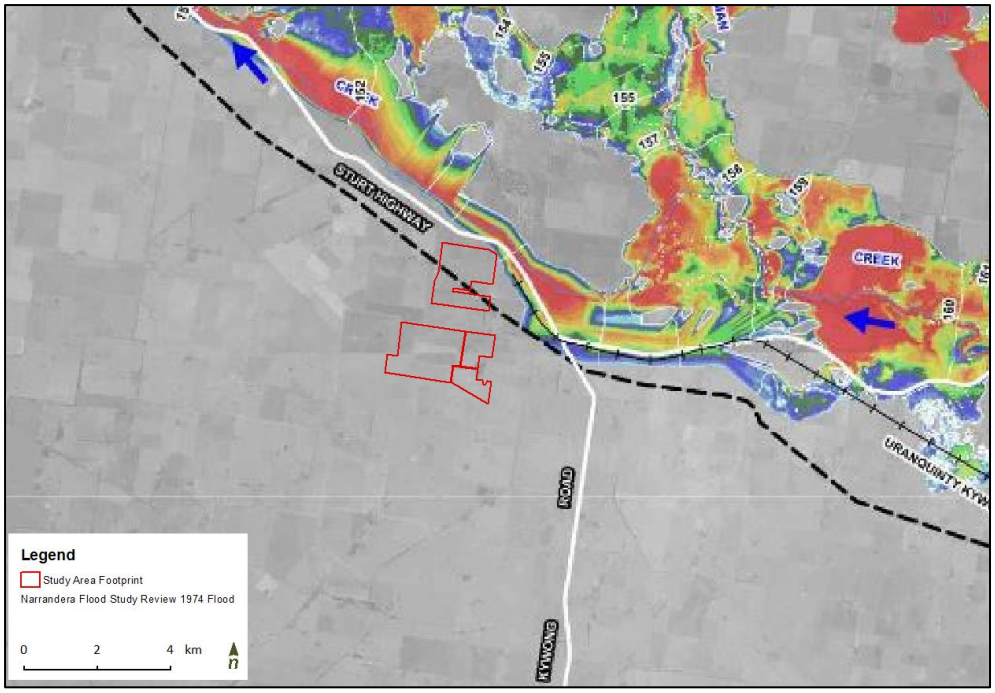

Figure 11: *Sandigo Study Area and 1974 1% AEP [1:100 ARI] Flood (Sourced from Narrandera Shire Council, 2015b)*

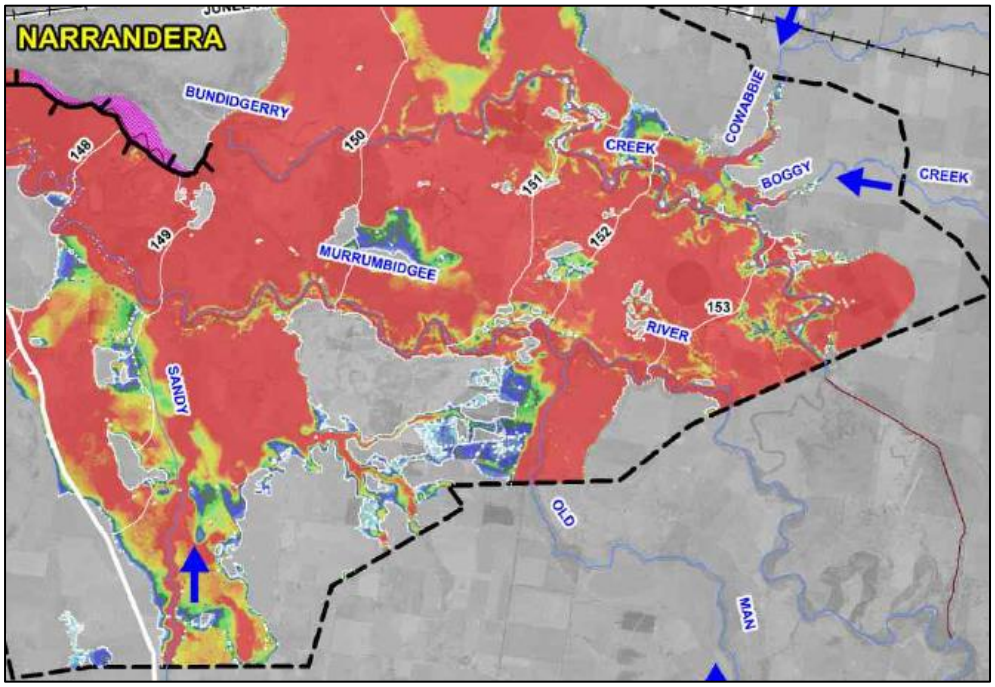

Figure 12: *Narrandera 1% AEP [1:100 ARI] Flood Extent (Sourced from Narrandera Shire Council, 2015b)*

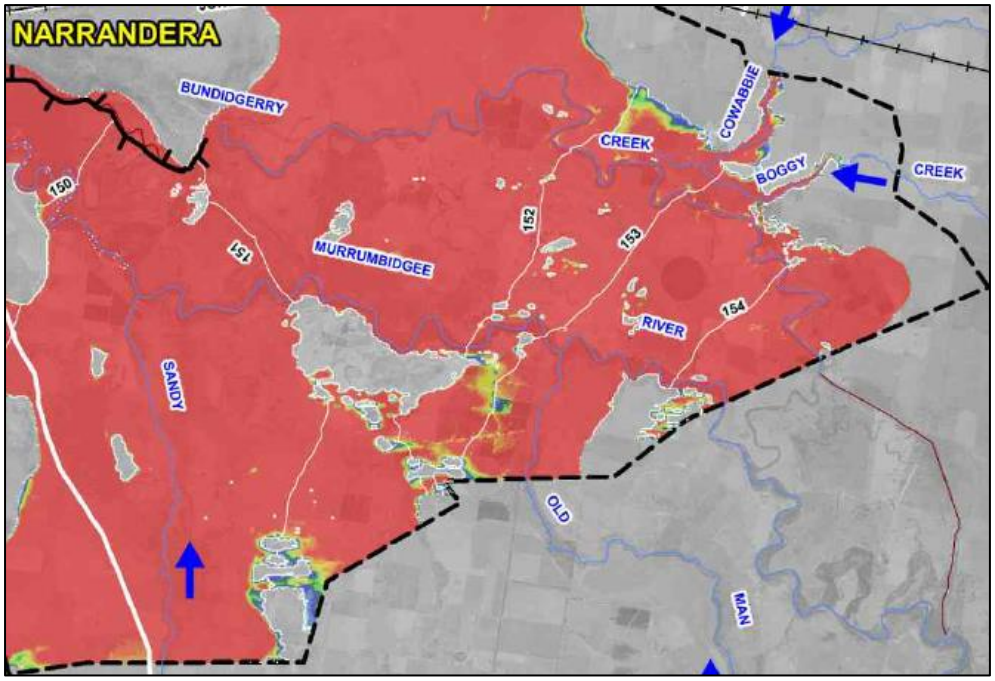

Figure 13: *Narrandera Extreme [PMF] AEP Flood Extent*

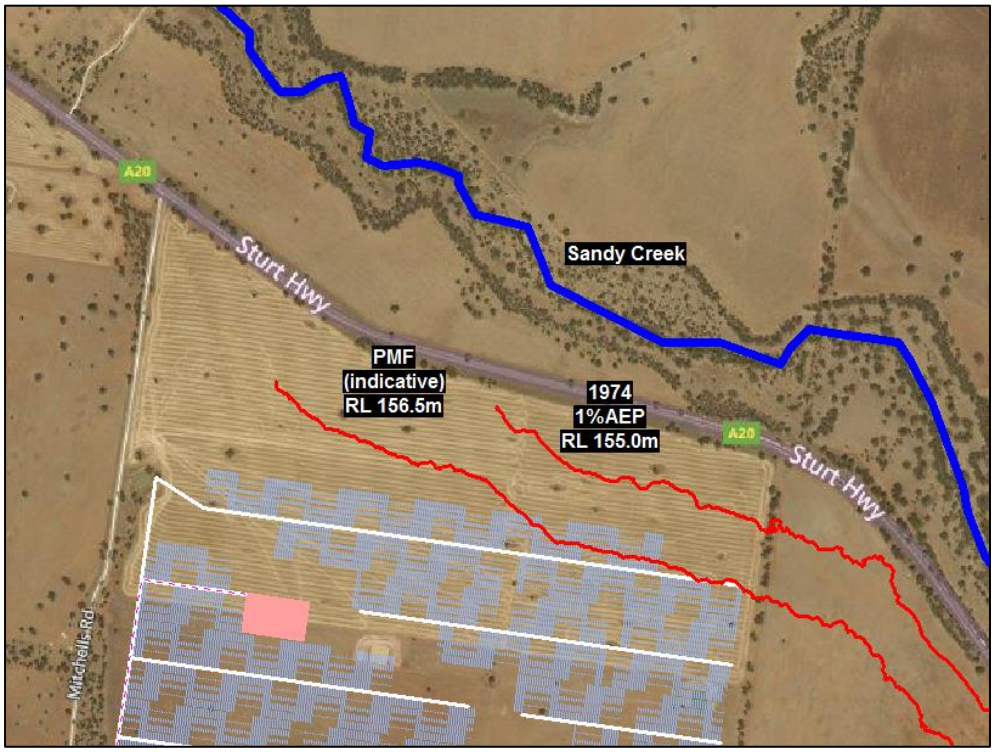

Figure 14: *Project Area and Riverine Flood Contours with internal roads (white) and indicative panels (blue). (Note: layout is conceptual in nature)*

Please note: the results of the hydraulic model outside of the drone survey should be considered as a guide only and should not be used for planning and engineering purposes. This area covers the portion of the model run on the 25m SRTM data and is indicative only.

3 Flood Impacts due to the Project Area

Generally, there are two potential impacts the Project Area could have on flooding and runoff external to the Project Area.

- Impacts on riverine flood levels due to the Project Area obstructing flow
- Impacts on flood levels due the Project Area producing extra runoff.

3.1 Regional Riverine Flooding

As can be seen in Figure 14, the footprint of the Project Area is outside of the 1% AEP flood extent, and just on the verge of the PMF flood extent. At these outer limits of flooding, flood waters and the associated floodplain will be acting as both “minor conveyance” and also “minor storage” as per the NSW Floodplain Development Manual (NSW, 2005). As the Project Area has little or no intrusion into the 1% and PMF flood extents, and as the infrastructure (mostly vertical poles spaced at significant distances) will generate little or no afflux within slow moving flood waters, the potential of the Project Area to obstruct riverine flood flow is nil.

3.2 Localised Stormwater Flooding

In terms of the Project Area and associated panels generating additional local stormwater runoff a literature review was initially conducted on this topic and a number of references sourced and reviewed. The references and their summaries are as follows:

AECOM, 2012. County of San Diego. Preliminary Hydrology and Drainage Study for Tierra Del Sol Solar Farm.

- Potential for 5% increase in runoff discharges due to impervious areas.
- To be mitigated by infiltration trenches.

Cook and McCuen, 2013. Journal of Hydrologic Engineering, ASCE. Hydrologic Response of Solar Farms.

- The solar panels themselves do not have a significant effect on catchment runoff.
- If the runoff characteristics of the final ground cover under the panels is increased (increased impervious area or decreased roughness) then runoff may increase significantly.

Water Solutions, 2017. Lower Wonga Solar Q1 Renewable Energy Generation Facility Flood Study.

- There are no expected changes to the runoff volumes, peaks, or times to peak for flood events in the catchment due to all the additional surface area of solar panels provided the surface coverage is maintained.
- Considered that a healthy cover of vegetation will ensure similar levels of infiltration as currently experienced at the Project Area.

It may be concluded that so long as the Project Area vegetation conditions are maintained to pre-developed conditions, and that impervious areas are not increased substantially, additional runoff from the Project Area is unlikely to occur. Small increases in imperviousness are unlikely to increase peaks due to hydrograph timing effects.

4 Flood Emergency Management

4.1 Severe Weather Warnings

The Bureau of Meteorology has a range of severe weather warning systems appropriate for use in the operation of the sports complex. It is recommended that operations staff have access to the following facilities for early severe weather warnings:

- The "**BOM Weather**" application provides severe weather warnings, summaries listed by State, and live updates. Other information provided by the application such as radar and forecasts is also useful.
- The BOM "**RSS feeds**" (Really Simple Syndication) is an information system which provides the latest weather information and may be issued any time. RSS feeds has a Land Warning feed for NSW, which can provide up-to-date information as soon as it becomes available to desktop and mobile devices. See: http://www.bom.gov.au/rss/

During heavy weather warnings, ABC Radio announce information on flood affected areas and road closures. Radio and BOM information should be reviewed frequently for potential major flooding and road closures.

4.2 River Flood Levels

The recent Narrandera (2015) flood study was reviewed to determine likely river level response times during large regional or riverine flood events. Volume 2 Figure 5.1 showed various historic and design flood hydrographs at Narrandera Township, and in general it was found that at least a 24-hour period was needed for floods to reach their peak (Figure 15). This timeframe provides additional time when combined with the early warnings available from the BOM above.

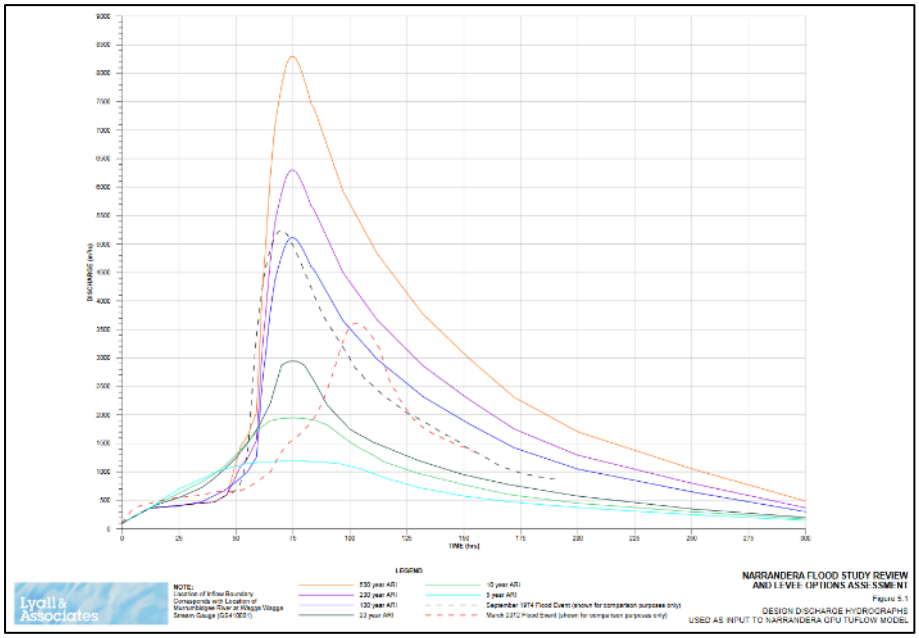

Figure 15: *Flood study hydrographs (Sourced from Narrandera Shire Council, 2015b).*

4.3 Notification of Staff at Risk from flooding

Facility members and visitors can be notified of potential flooding, road and facility closure via several mechanisms:

1. Staff severe weather applications (above)
2. "Group Text" (message) notification via mobile phone, sent to all members;
3. Group email;
4. Individual telephone notifications.

4.4 Evacuation Route

Prior to significant flood events it is likely the main evacuation route will be along the Sturt Highway to either the Narrandera or Wagga Wagga Townships. Although the Sturt Highway will be cut-off during large floods, warning times will be sufficient so that staff may evacuate the Project Area. It is noted that it is not necessary for staff to remain at the Project Area O&M facility during severe flood events.

4.5 Consultation

Local Government

As the Project Area is largely free from regional riverine flooding, and as flood warning times are significant, consultation has presently not been undertaken directly with Council officers or staff. Staff are not required to be present at the Project Area O&M facility during large flood events.

A review was undertaken of Council's recent investigation for Narrandera Township and flood protection options (Narrandera, 2015). Infrastructure identified as requiring flood protection and flood mitigation measures (mostly levee banks) focused on the Narrandera Township and immediate surrounds. The Sandigo area to the east of Narrandera was not included in the requirements for flood mitigation.

State Emergency Services (SES)

As noted above the Project Area is largely free from regional riverine flooding, and as flood warning times are significant, consultation has presently not been undertaken directly with the State Emergency Service (SES). The assessment confirms that early flood warning, evacuation time, and flood evacuation routes are realistically achievable for the Project Area, without placing additional burden on SES staff.

4.6 Flood Emergency Management Procedures

At this point in time, it is not considered warranted to produce detailed Emergency Management Procedures for flood emergency. However, it is proposed that detailed Emergency Management procedures be developed in due course, covering but not limited to the following.

Roles and Responsibilities

It is noted that further details and specific procedures need to be developed for the Project Area, and this report clearly lays the foundation for these procedures and demonstrates that flood warning and evacuation of the Project Area is realistically achievable. The initial requirement for the procedures will need to identify roles and responsibilities:

1. Who has legal responsibility for the maintenance and implementation of the Flood Emergency Management Plan;
2. the specific roles and responsibilities of the business owner or facility manager;
3. Whether there are Flood Duty Officers on-site and their roles and responsibilities;
4. Roles and responsibilities of all facility users including public and members.

Procedures for Before, During and After a Flood

Flood emergency management procedures and training will be a crucial for staff and management working at the facility, but also a formalised induction will be required for new members. The development of future WHS Procedures (recommended to be undertaken by a WHS specialist), Staff Training and Inductions should include at a minimum but not be limited to:

1). At all times

1. Annual testing (e.g., drills) of FEMP procedures, including annual review and update;
2. Adequate resourcing of the FEMP, including designated trained flood duty officers;
3. Staff and club member induction accreditation;
4. Monitoring of weather conditions and warnings, weather forecasts;
5. Create and annually update the emergency contact list;
6. Ensure all equipment and resources to implement the FEMP are available and in working order.

2). When a flood is likely

1. The FEMP manager monitors the official warnings, selected response triggers and warning system;
2. Facility occupants are notified of the possibility of flooding and reminded of actions and procedures should an emergency response be required;
3. If early evacuation is the selected response action, the selected means of transport is provided, and evacuation occurs before cut off time;
4. If sheltering in place is the selected response action stocking or food and medications is undertaken by occupants according to the maximum possible duration of isolation;
5. Other resources are brought in as required by the FEMP;
6. Movable objects are secured, and chemicals lifted above PMF level;
7. Outdoor activities are suspended;
8. Safety equipment is checked.

3). During a Flood

1. The FEMP manager monitors the official warnings, response triggers and warning system;
2. Evacuations cease, and no one leaves the premises until all clear is given by emergency services;
3. Members who are not on the premises at the time are notified not to try and reach the premise;
4. FEMP manager provides regular updates on the situation to members.

4). After a Flood

1. Check the building structural integrity before evacuees can return to the premises (a qualified structural engineer may be required);
2. Check the safety and function of services before evacuees can return to the premises;
3. Organise a safe clean-up;
4. Review the FEMP to account for lessons learnt.

5 NSW OEH Flood Assessment Criteria

Criteria	Response
9. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: 1. Flood prone land (ie, any land below the PMF) 2. Flood planning area, the area below the flood planning level (ie, Designated Flood Level incorporating asset risk) 3. Hydraulic categorisation (floodways and flood storage areas)	a). Probably Maximum Flood (PMF) plotted in Figure 14. Only very small fraction of Project Area floodable in PMF. Project Area potentially not considered flood-liable or flood-prone from a pragmatic point of view (ie, no impact on emergency management, placement of infrastructure, or impacts external to Project Area). b). 1% [1:100] AEP RL 155m AHD. PMF level approximately RL 156.5m AHD. The switchyard component of the Project Area will be flood-free from the 0.2% [1:500] AEP. This is currently elevated at RL 162-164m AHD, 5m higher than needed. The Operations & Maintenance (O&M) building to be flood free in 1% [1:100] AEP. Current building RL 162-164m AHD, 7m higher than needed. Sturt Highway elevation at Project Area varies between RL 154m abd 155m AHD. c). Over the majority of the Project Area, NIL flooding. Both “minor floodway” and “minor storage” just within the tip of the Project Area.
10. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP flood levels and the probably maximum flood, or an equivalent extreme event.	Refer to recent flood study completed by Narrandera Council (2015). Narrandera Flood Study Review and Levee Options Assessment. Volume 1 Report. Volume 2 Figures. Narrandera Shire Council, October 2015. Substantially calibrated 2-dimensional hydraulic model (TUFLOW) and rainfall-runoff hydrological (Rafts) model.
11. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: 1. Current flood behaviour for a range of design events as identified in 10 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Project Area likely to have little no impact on flooding, as: Footprint located slightly on flood fringe where velocity is low. Does not included any infilling or depletion of flood storage. The Project Area should not produce additional runoff, provided developed case vegetation and land cover provides similar levels of infiltration and retardance.

12. Modelling in the EIS must consider and document: 1. The impact on existing flood behaviour for a full range of flood events including up to probably maximum flood. 2. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. 3. Relevant provisions of the NSW Floodplain Development Manual 2005.	Project Area likely to have little no impact on flooding, as: Footprint located slightly on flood fringe where velocity is low. Does not included any infilling or depletion of flood storage. The Project Area should not produce additional runoff, provided developed case vegetation and land cover provides similar levels of infiltration and retardance.
13. The EIS must assess the impacts on the proposed development on flood behaviour, including: 1. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. 2. Consistency with Council Floodplain Risk Management Plans. 3. Consistency with any Rural Floodplain Management Plans. 4. Compatibility with flood hazard of the land. 5. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. 6. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. 7. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. 8. Any impacts the development may have upon existing community emergency management arrangements for flooding.	a). No impact on adjacent properties for reasons discussed in 11. and 12. above. b). and c). Council's reports reviewed for Narrandera Township and surrounds. Project Area located outside areas of flood mitigation or levee works. Project Area has excellent level of flood immunity, and staff are not required onsite during flood events. Significant flood warning is available. Potential for significant conflict with existing floodplain management plans is considered low. Project Area is mostly floor-free from riverine or floodplain inundation. d). Project Area mostly unmanned, flood free and low hazard. Thus, Project Area considered compatible. e). Project Area will have no infilling or impact on flow characteristics. Therefore, the Project Area is considered compatible with hydraulic functions. f). Project Area will have no infilling or impact on flow characteristics. Therefore the Project Area is considered to maintain any beneficial inundation. g). The Project Area is located outside zones which include riparian vegetation, riverbanks or water courses. Normal measures will be undertaken at construction to mitigate erosion and sedimentation though an erosion and sediment control plan.

These matters are to be discussed with the SES and Council. 9. Whether the proposal incorporates specific measures to manage risk to life from flooding. These matters are to be discussed with the SES and Council. 10. Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. 11. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	h). The Project Area is not expected to have any impact on existing community emergency management arrangements and is not expected to place any burden on Council or SES staff. Consultation with Council and SES not considered to be warranted at this point. i). Normal emergency management procedures are to be employed with respect to flooding. Flood warning times are reasonable, and staff are not required to be onsite during flood conditions. Consultation with Council and SES not considered to be warranted at this point. j). Flood warning times are reasonable, and staff are not required to be onsite during flood conditions. The Project Area is mostly flood free even during extreme events. Consultation with Council and SES not considered to be warranted at this point. However, consultation will be undertaken at the time of developing internal WH&S policy and plans. k). The Projec Area is generally flood free, and not expected to sustain flood damages during major flooding. Power cuts during flooding possible due to interruption to external power infrastructure such as transmission lines.

6 Conclusions & Recommendations

1. This investigation has been undertaken in order to support an EIS for the initial Project Area precinct of the Sandigo Solar Farm, having a total precinct area of 231 ha. The NSW Office of Environment and Heritage (OEH) has requested a Flood Study to assess several criteria pertaining to flood immunity, floodplain impacts, safety and emergency management. Response is made to individual criteria in Section 5, being underpinned by the main body of this assessment.

2. Local catchment (stormwater runoff or overland flow) flood modelling was undertaken for the Project Area in order to provide guidance on the planning of internal infrastructure and to assess the external impacts of the site development. Regional riverine flood information was also extrapolated and applied to the Project Area based on the recently completed Narrandera Flood Study (2015).

3. Flood emergency management was investigated in detail, including such elements as severe weather warnings and river flood levels (early warning), notification of staff, communication protocols and sources of up to date information, evacuation, and emergency management procedures.

4. In responding to specific OEH Flood Assessment Criteria in Section 5, the following conclusions were made in general:

    a) Flood prone areas have been mapped, appropriate flood planning levels identified, and hydraulic categories on the floodplain identified. Medium to high risk infrastructure in the Project Area has a high level of flood immunity well above designated flood levels. Over the majority of the Project Area there is NIL riverine flooding, and only a very small portion north (adjacent to the Sturt Highway) experienced minor inundation during the PMF.

    b) Project Area will have no impact on flooding, as the footprint is only located slightly on the flood fringe where velocity is low. The Project Area earthworks do not include any infilling or depletion of floodplain storage. The Project Area should not produce increased runoff, provided developed case vegetation and land cover provides similar levels of infiltration and retardance.

    c) The Project Area is not expected to have any impact on existing community emergency management arrangements and is not expected to place any burden on Council or SES staff. Consultation with Council and SES was not considered to be warranted at this point in the assessment, however will be undertaken on development of internal WH&S procedures at a later date. Normal emergency management procedures are to be employed with respect to flooding. Flood warning times are reasonable, and staff are not required to be onsite during flood conditions.

    d) The Project Area is generally flood free, and not expected to sustain flood damages during major flooding. Power cuts during flooding possible due to interruption to external power infrastructure such as transmission lines. Social and economic consequences due to the impact of flooding on the Project Area are expected to be negligible.

5. RECOMMENDATION: In summary, the findings of this Flood Study demonstrate that the Project Area solar development should meet OEH's recommended policies and assessment criteria, as impacts on the surrounding floodplain are considered to be negligible or NIL. Furthermore, risk to human life and infrastructure is considered to be low during large floods, and no additional burden is placed on Council or State Emergency Services staff. It is recommended that the findings of this report be provided to NSW OEH in support of the Project Area solar development.

6. With respect to flooding, construction of the facilities (O&M Building, Switchyard and Battery Storage Area) could be positioned anywhere along the transmission line provided they are located outside of overland flood zones. If located within flood zones, facilities should be suitably designed to address for example (but not limited to) flood immunity, erosion, structural, and safety issues. At some

locations staff will need to cross one or more overland flow paths when vacating the site. Vehicle crossings will need to be provided to allow safe entry and egress, and also be designed to appropriate standards and safety criteria.

7 References

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http://www.narrandera.nsw.gov.au/cp_content/resources/Flood_Study_Part_1.pdf
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http://www.scenicrim.qld.gov.au/documents/44179689/44249160/Certified%20Temporary%20Local%20Planning%20Instrument%20adopted%206%20November%202017.pdf

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Attachment A
Flood Modelling Extent Mapping

Please note: the results of the hydraulic model outside of the drone survey should be considered as a guide only and should not be used for planning and engineering purposes. This area covers the portion of the model run on the 25m SRTM data and is indicative only.

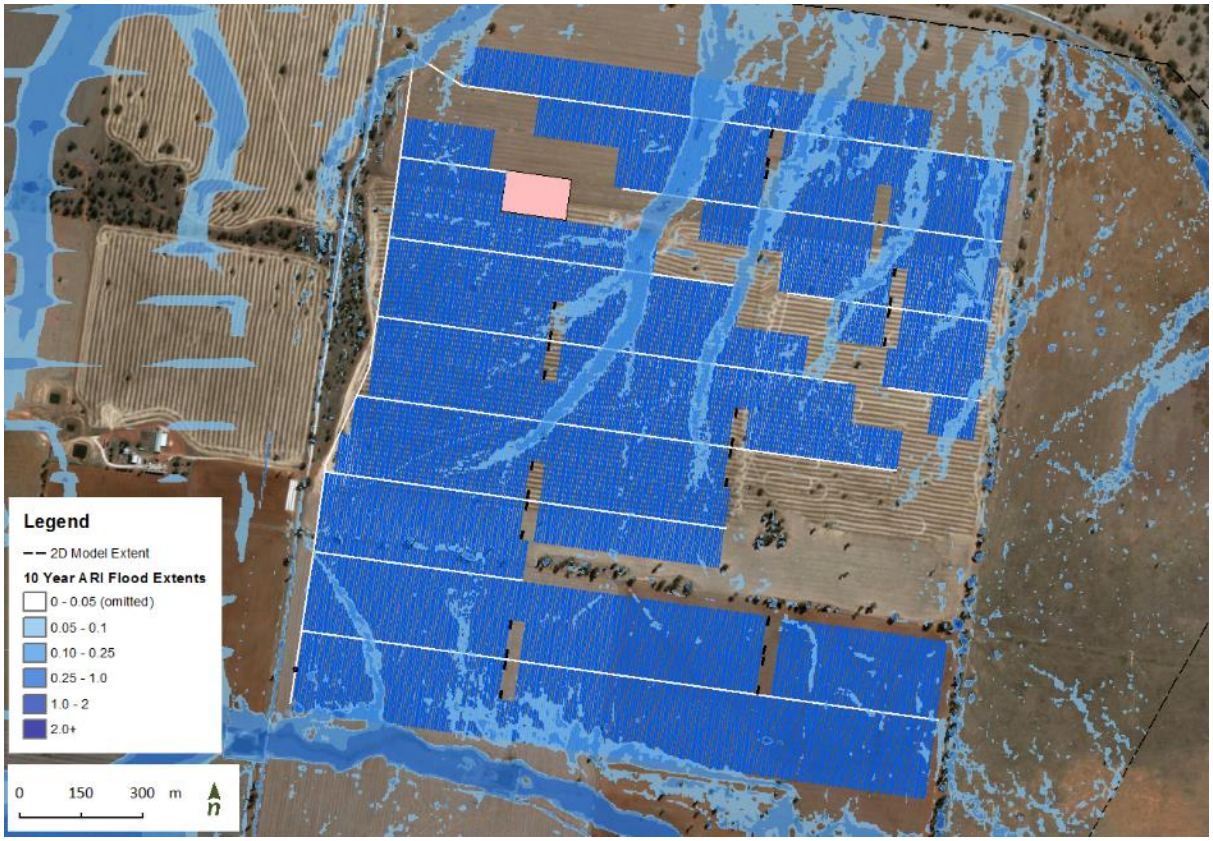


Figure 16: *10 AEP (10 year ARI) Flood Inundation Project Area (Note: layout is conceptual in nature)*

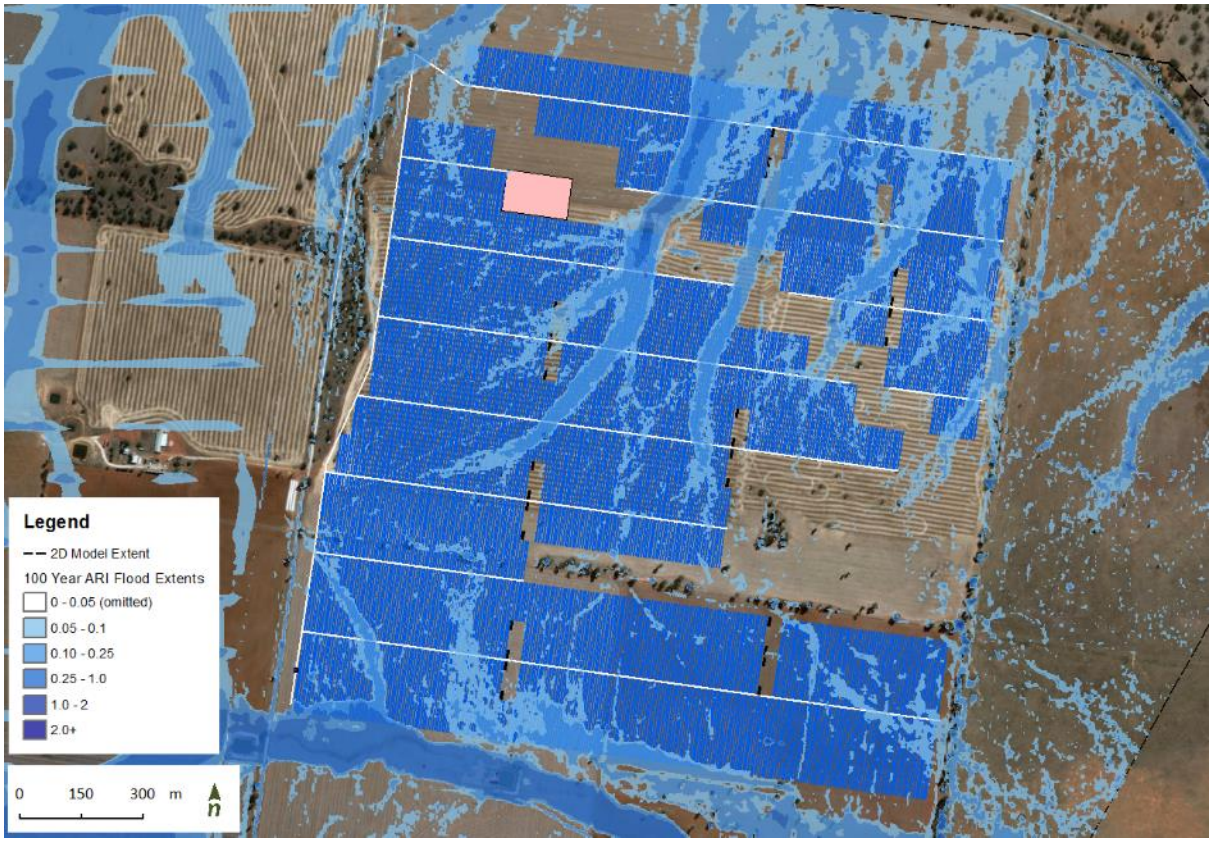


Figure 17: *1% AEP (100 year ARI) Flood Inundation Project Area (Note: layout is conceptual in nature)*

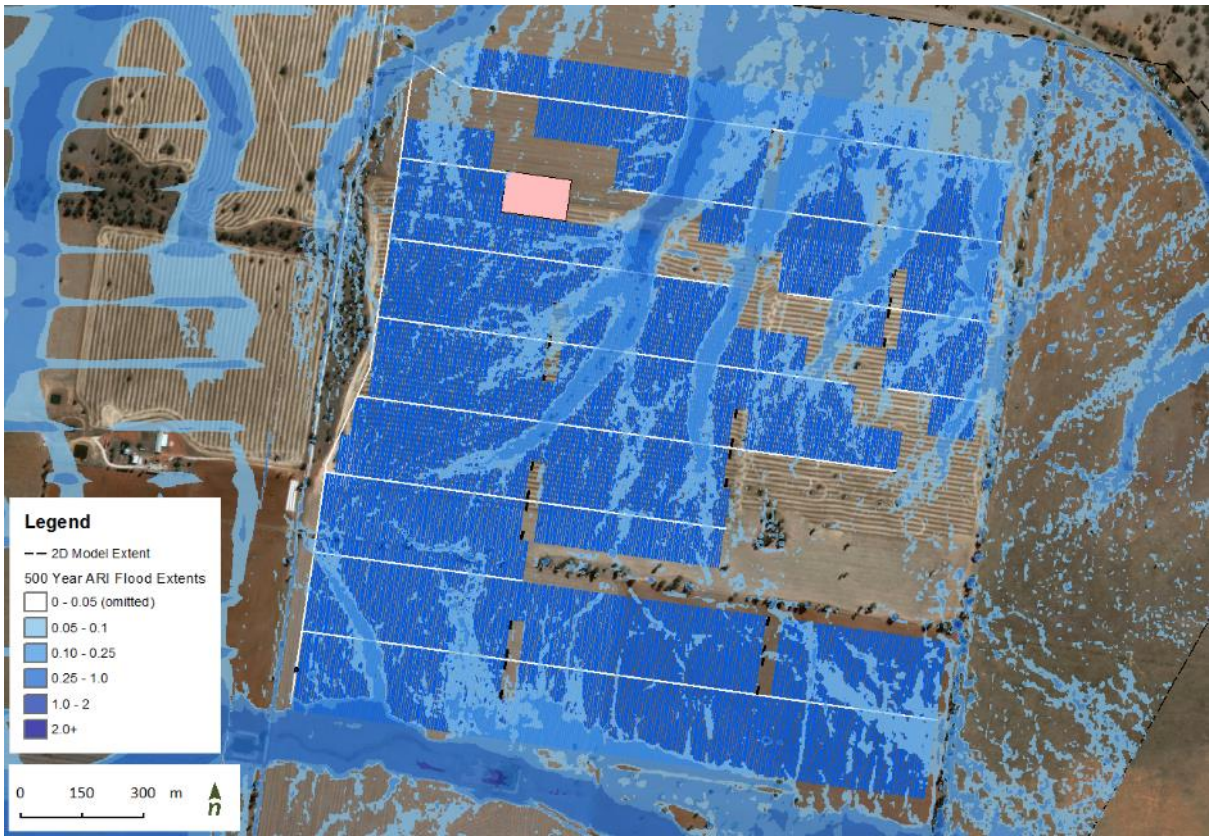


Figure 18: *0.2% AEP (500 year ARI) Flood Inundation Project Area (Note: layout is conceptual in nature)*

Figure 19: *10% AEP (10 year ARI) Flood Hazard Study Area (Note: layout is conceptual in nature)*

Figure 20: *1% AEP (100 year ARI) Flood Hazard Study Area (Note: layout is conceptual in nature)*

Figure 21: *0.2% AEP (500 year ARI) Flood Hazard Study Area (Note: layout is conceptual in nature)*

Attachment B
Regional Flood Frequency Estimation Model Results

Results | Regional Flood Frequency Estimation Model

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	2.82	0.980	8.19
20	5.65	2.04	16.0
10	8.15	2.95	22.9
5	11.1	4.02	31.6
2	15.6	5.60	44.5
1	19.8	7.01	57.3

Statistics

Variable	Value	Standard Dev
Mean	1.429	0.652
Standard Dev	0.784	0.131
Skew	0.087	0.026

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

Correlation		
1.000		
-0.330	1.000	
0.170	-0.280	1.000

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

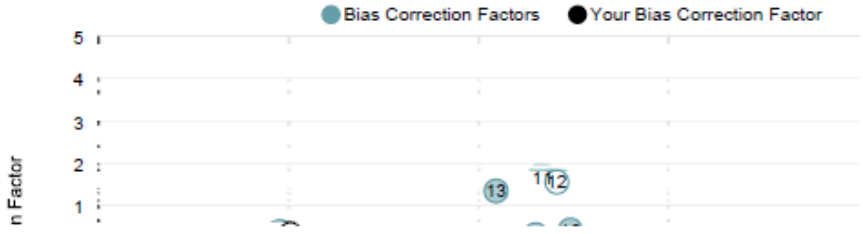
1% AEP Flow vs Catchment Area

Shape Factor vs Catchment Area

Note: This region does not use shape factors

Intensity vs Catchment Area

Bias Correction Factor vs Catchment Area



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TXT PDF Nearby JSON

Input Data

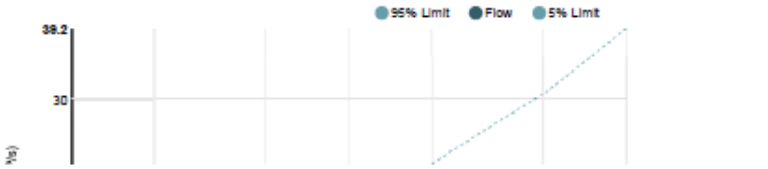
Date/Time	2018-02-13 10:26
Catchment Name	Lower Catchment
Latitude (Outlet)	-34.991146
Longitude (Outlet)	146.7229842
Latitude (Centroid)	-34.9985094
Longitude (Centroid)	146.6961973
Catchment Area (km²)	10.09
Distance to Nearest Gauged Catchment (km)	75.27
50% AEP 6 Hour Rainfall Intensity (mm/h)	5.064616
2% AEP 6 Hour Rainfall Intensity (mm/h)	11.387254
Rainfall Intensity Source (User/Auto)	Auto
Region	Fringe - East Coast & Arid and Semi-arid
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.81
Interpolation Method	Natural Neighbour
Bias Correction Value	0.362

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

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

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

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m³/s)	Lower Confidence Limit (5%) (m³/s)	Upper Confidence Limit (95%) (m³/s)
50	2.00	0.700	5.73
20	3.97	1.45	11.1
10	5.70	2.10	15.8
5	7.76	2.84	21.7
2	10.8	3.94	30.6
1	13.7	4.92	39.2

Statistics

Variable	Value	Standard Dev
Mean	1.118	0.652
Standard Dev	0.784	0.131
Skew	0.087	0.026

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

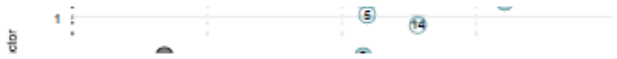
Correlation		
1.000		
-0.330	1.000	
0.170	-0.260	1.000

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

1% AEP Flow vs Catchment Area

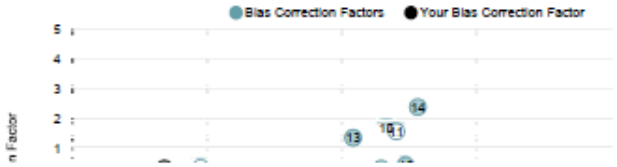
Shape Factor vs Catchment Area

Note: This region does not use shape factors



Intensity vs Catchment Area

Bias Correction Factor vs Catchment Area



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Input Data

Date/Time	2018-02-13 10:21
Catchment Name	Sandigo Upper
Latitude (Outlet)	-34.9887982
Longitude (Outlet)	146.7036763
Latitude (Centroid)	-34.9969555
Longitude (Centroid)	146.6866048
Catchment Area (km^2)	4.86
Distance to Nearest Gauged Catchment (km)	77.03
50% AEP 6 Hour Rainfall Intensity (mm/h)	5.064616
2% AEP 6 Hour Rainfall Intensity (mm/h)	11.387254
Rainfall Intensity Source (User/Auto)	Auto
Region	Fringe - East Coast & Arid and Semi-arid
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.82
Interpolation Method	Natural Neighbour
Bias Correction Value	0.362

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

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

(http://www.uws.edu.au)