Flood Impact Assessment:
Jemalong Solar

Report Prepared for:

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1.0 FLOOD BEHAVIOUR

1.1. Existing knowledge

The development site is located on the Lachlan River floodplain, immediately downstream of the Jemalong Gap, a significant hydraulic control. A number of studies have been completed over the area to assist with planning for flood controls which have been implemented primarily to manage floodwaters for agriculture.

In 1978 the *Guidelines for Floodplain Development; Lachlan River Jemalong Gap to Condobolin (WRC, 1978),* hereon referred to the 1978 Guidelines, determined a flood planning level based on the 25 year ARI flood. These guidelines determined levee locations and heights and outlined proposed modifications to hydraulic control structures to better manage floodwaters for economic and environmental benefit.

From 2003 through to 2012 the floodplain risk management process (NSW Government, 2005) was followed and a flood study, floodplain risk management study and floodplain management plan were developed for this stretch of the Lachlan River

The flood studies undertaken make use of existing gauging data and use flood frequency analysis to estimate flood recurrence. The more recent significant events of 1952, 1974 and 1990 have been modelled as these historical events have influenced floodplain management and are recent enough to be understood by landholders.

The adopted 'design flood' for the current Floodplain Management Plan (FMP) (OEH, 2012) is the 1990 historical event and is identified as the 25 year ARI event. This adopted 'design flood' is very similar to the flood planning levels developed in the 1978 guidelines.

1.2. Flood behavior

Floods in this area are common, and cover a vast area of the floodplain for prolonged periods (DECCW, 2009). As mentioned, the Jemalong Gap, is a significant control with almost all floodwaters passing through this point. Downstream of the Jemalong Gap large flows in the Lachlan River spill onto the northern and southern floodplains. Generally the Lachlan River can be expected to convey approximately 15% of flood flows with the remainder split between the north and southern systems.

The proposed development is located in the southern system (Figure 1.1). Flows to the southern system enter at the 17 and 21 mile breakouts, downstream of the Jemalong Gap. The 21 mile breakout delivers floodwaters to the proposed development site.

The flows from these breakouts traverse an approximate 11km long corridor and merge downstream of the proposed development site at the Wilbertroy State Forest then move toward Lake Cowal, and re-join the Lachlan River further downstream.

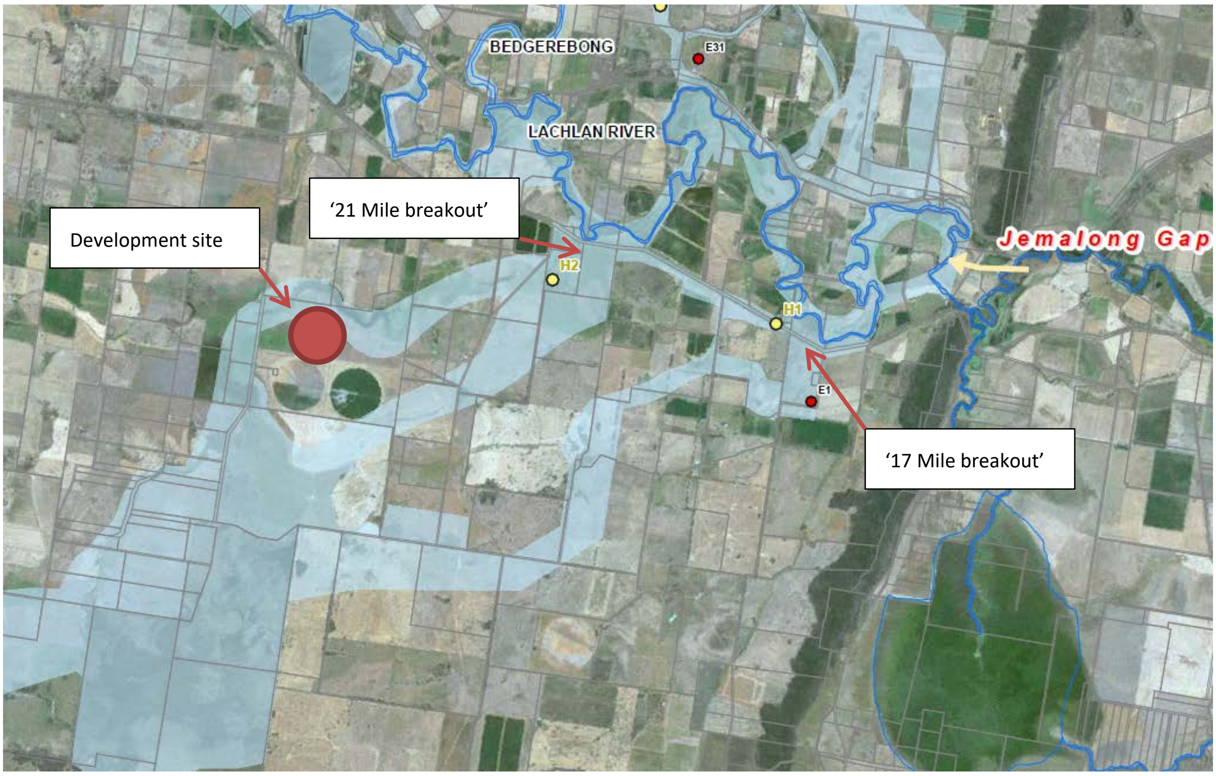

Figure 1.1 Development location in relation to design flood extents (approx.)

The area immediately downstream of the Jemalog Gap is particularly sensitive to hydraulic modifications. This part of the floodplain determines how flows are distributed to the northern floodplain, southern floodplain and the Lachlan River. This part of the floodplain (Zones A and B) have the highest level of control on in-stream works, discussed further below. The development site is located around the boundary between zone A and zone B. Refer Figure 1.2

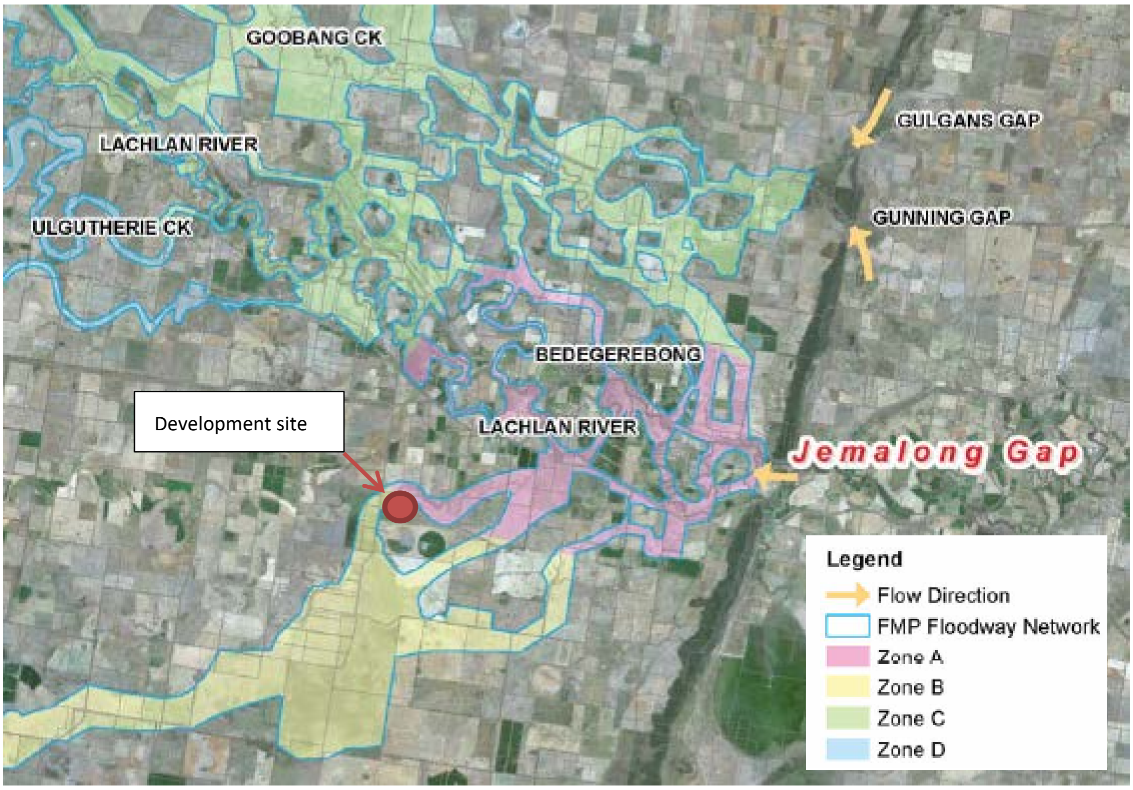

Figure 1.2 Floodway network and zones for management

1.3. Floodplain planning controls

The 1978 Guidelines established a feasible floodway network for this area of the floodplain. As mentioned, these guidelines included modifications to existing flood controls and the addition of new controls to improve floodway hydraulics for both economic and environmental objectives.

The more recent flood studies, floodplain risk management plans and flood management plans have further refined the 'floodway network' from the 1978 Guidelines. These studies have included further adjustments to maintain flow distribution and ensure the sustainable and equitable use of floodplain resources (OEH, 2012). Examples of modifications include removal of obstruction and reinstatement of natural flow regimes where feasible.

Modifications in and around floodways in the western rural areas of NSW is managed through Part 8 of the Water Act 1912. The Water Act 1912 requires that all flood control works within a designated floodplain need to be assessed for approval. The designated floodplain is defined by the green line and shaded area as shown in Figure 1.3. Works that are managed through the Water Management Act 1912 are known as 'controlled works', which are generally earthworks, embankments or levees or other works that are likely to affect the flow of water that are also declared to be a 'controlled work'. It is assumed that this project, given its location within the designated floodplain would be considered a 'controlled work'. More specifically, the following definition from the FMP (OEH, 2012) best describes the proposed works:

> *Any work that is situated, or proposed to be constructed on land that is, or forms part of, the bank of a river or lake, or, is within a designated floodplain, and is declared to be a 'controlled work',*

Figure 1.3 Designated floodplain (development site shown in red)

Controlled works within the floodplain are either considered complying, or non-complying works under the Water Act 2012. The definition of 'complying' generally refers to where the NSW Office of Water (NOW) are satisfied that the work complies with the floodplain management plan for the area in which the work is situated or proposed to be constructed.

In this case no works are proposed within the floodway, although works are proposed on the broader designated floodplain. In this particular case the Floodplain Management Plan (OEH, 2012) notes:

> *Development outside of the limits of the FMP floodway network would not generally cause a significant redistribution of design flood flows or a significant increase in flood levels. However, while applications for flood control works in this area will generally be assessed as complying works, the assessment may need to take into account any potential increase in flood hazard or flood damage under flood conditions larger than the design flood. Adverse impacts could result, for example, if extensive works proposed near to the floodway network are substantially higher than the corresponding design level of the floodway network.*
>
> *Assessment of the flood hazard will be largely qualitative, taking into consideration existing works, the extent of proposed works, and the potential for localised impacts on neighbouring unprotected properties. Such an assessment would not need to go into the details required for works within the floodway, unless the impact on overall flood behaviour could be significant and therefore far-reaching.*

The key consideration for this development proposal is whether the possible;

'*impact on overall flood behaviour could be significant and therefore far-reaching.'*

As outlined previously, the floodway network has been divided into four zones based on the hydraulic impact of works within the floodway (non-complying works). The proposed development is located adjacent to zone A and zone B. In general works within the floodway of these areas would not be approved. No works within these areas are proposed.

2.0 FLOOD IMPACT ASSESSMENT

2.1. Development in relation to floodway

Potential flood impacts are caused by modifications to the landscape within the floodplain. The proposed development consists of the following infrastructure located beyond the floodway, and within the designated floodplain; including:

- 89 modules, each comprising a heliostat field and a receiving tower
- two thermal storage tanks
- a condenser
- a shed containing electricity generator and turbines
- a 66kV transformer station and switchgear
- a control and administration building
- internal unsealed access tracks and parking to allow for site maintenance
- three 6800 square metre evaporation ponds NEED DETAILS
- flood levy earthworks NEED DETAILS
- perimeter security fencing.

The 89 heliostat fields are spread out over the western portion of the property, taking up an area of about 50 Ha. The remaining power generation infrastructure, including generators, turbines, transformers, condenser and administration buildings are located close to the centre of the site.

The heliostats consist of a steel support pole with the heliostat on top. The reflective surfaces are all set on the same horizontal plane.

Figure 2.1 shows the layout of the proposed development in relation to the 1978 Guideline levees and the FMP approved levee locations. The proposed development is located beyond both the existing levee location which approximately follows the 1978 Guideline levee locations and the FMP approved location.

No modifications within the floodway are proposed, and no modifications to existing levees are required for the proposal. If necessary, a new levee could be constructed following the alignment outlined in the FMP where it differs from the 1978 Guidelines to the north of the site.

Figure 2.1 Development extents and 1978 Guideline Levees (purple) and FMP approved levee (red)

2.2. Flood conditions

Flood information in the area of the development is taken from the MIKE11 results in appendix F of the Floodplain Management Study (DECWW, 2009). This area of the model is the flood path S21 MileB2, cross sections 2375 to 5549 (Appendix A).

As discussed, flood frequency analysis of gauged events was used to estimate flood frequency, and the 1952, 1974 and 1990 events were modelled as part of the Flood Management Study process. Both the 1974 and 1990 events have similar return intervals based on gauged data, of 30 years (3% AEP) and 25 years (4% AEP) respectively. The 1952 flood is estimated to be around a 200 year ARI event (0.5% AEP), although the available gauge data gives a 90% confidence interval for this estimate of quite a wide range from a 40 year to 1440 year recurrence interval.

2.3. Changes to the floodplain – surface roughness

As mentioned the development is located outside of the floodway network (Figure 2.1), however events greater than the 4% AEP (1990) event would overflow onto the floodplain and the proposed development may impact on these flood flows.

The addition of the solar arrays and their associated infrastructure, particularly the fields of heliostats will change the surface roughness over the site, from existing managed pasture to a large area of steel poles, at approximately ?m spacing. For the purpose of this assessment we assume that the heliostat panels themselves are above the flood surface.

Flow behaviour (being a function of flow area, wetted perimeter and surface roughness) may change as a result of modification surface roughness and could subsequently impact flood levels and distribution over the landscape.

Existing pasture has a Mannings roughness of approximately 0.035-0.045, whilst the solar array may have a Mannings roughness of around 0.05 or greater, assuming roughness caused by the support poles. An example of an equivalent scenario where surface roughness has already been estimated is shown in Figure 2.2 below. This shows grass and trees at approximately 8m spacing and no ground cover. The addition of the heliostat poles is not dissimilar in terms of roughness to a tree plantation with very limited undergrowth.

Figure 2.2 Roughness example similar to that of the proposed heliostat field poles. Mannings roughness = 0.05. (BCC, 2003)

2.4. Impact assessment methodology

The FMP states that "*Development outside of the limits of the FMP floodway network would not generally cause a significant redistribution of design flood flows or a significant increase in flood levels"* and that works beyond the floodway would *generally* be considered complying works. However in some cases impacts could be significant.

Given the extents of the works this issue of significance needs to be addressed. In this case adjustments to the existing hydraulic model are used to assess whether the impact is significant, or not, and therefore whether the works are considered ''complying' in relation to the Floodplain Management Plan.

To investigate the impact of surface roughness changes over the area, a HECR RAS model was created using cross section information from the MIKE11 model. Cross sections from the S21Mile branch, from chainage CH849 to CH7617 were used as these are located adjacent to the proposed development area (refer to Appendix A).

In order to assess the impact of the development over the floodplain, surface roughness in the model was adjusted from pasture; a Manning's roughness of 0.045, to 0.08 to represent the heliostat field. A Manning's roughness of 0.08 is a conservative estimation of the solar array field impact given the discussion above and the anticipated similar roughness characteristics to that of Figure 2.2.

Two approaches were modelled to understand the likely flood impacts of the proposed development:

Approach 1.

Roughness was increased from the approved levee location into the floodplain to the edge of the current modelled extent, for CH 3275 to CH 5102 (chainages at or adjacent to the proposed development). This extends outside of the actual development footprint in some areas. For this approach the model extents (i.e. chainage cross sections) do not extend over the entire development site. Refer to Appendix A showing the overlay of these two areas.

Approach 2

Select model cross sections were extended over the development area maintaining the existing level at the end of the section (no survey data is available), and roughness adjusted over the footprint of the development area for CH 3275 to CH 5102. Refer to Appendix A showing the overlay of these two areas.

2.5. Development impact - quantitative assessment

The HEC RAS model created for this assessment estimates flood levels at less than the Mike11 model for the 0.5% AEP (1952) event. This is the result of removing walls in the Mike11 model that artificially confine the 0.5% AEP event to within the levee bounds. This was done to ensure that flows for the 0.5% AEP event spread out over the floodplain, as would occur in reality. A table of comparison is contained in Appendix B.

For Approach 1 which uses the existing model sections, the impact of roughness change to the area beyond the approved levees, from CH 3275 to CH 5102 was an increase to the 0.5% AEP flood level by a maximum of 2 cm, with the impact dissipated upstream by CH 3275.

For Approach 2 which extended existing sections to cover the proposed development extent, the impact of roughness change to the area beyond the approved levees, from CH 3275 to CH 5102 was an increases flood levels by a maximum of 3cm with the impact dissipated by CH 1689.

The small change in flood level reported from both Approach 1 and Approach 2 suggests that changes to roughness (as a result of the proposed development) is not sufficient enough to create a significant change in flood level to the overall flood extents.

In addition there is no impact of the development on the 4% AEP event (1990) as this event is confined by the approved levee structures.

2.6. Events outside of those included in the FMP

The assessment criteria provided by the assessment agencies suggest a review of impacts for the full range of potential flood events up to and including the Probable Maximum Flood (PMF). The existing flood investigations cover the 1990 (4%), 1974 (3%) and 1952 (0.5%) events were estimated through a combination of flood frequency analysis, runoff routing Actual events were used as these are relevant to landowners experiences in the area.

Estimation of flood flows outside of those considered in the Floodplain Management Study (DECCW, 2009) would require modelling of the entire system to determine flow distribution into the development area which would be considerable work, particularly when considered against the amount of disturbance in the floodplain.

An assessment of the available modelled events is considered sufficient to garner an understanding of the flood impacts associated with development at the site.

3.0 EIS ASSESSMENT CRITERIA AND RECOMMENDATIONS

Assessment criteria	Comment and recommendation
An assessment of any proposed modification to surface water management including modelling of redistribution of waters and an assessment of the impact on neighbouring properties and the associated watercourse and floodplain including a review of the proposed levees in accordance with the requirements of the *Lachlan River Jemalong Gap to Condoblin Floodplain Management Plan, 2012).*	The development is located outside of the approved floodway, therefore has no impact on floodway flows, which are flows up to approximately the 4% AEP event. For the 0.5% AEP event, which extends beyond the floodway into the floodplain, the assumed surface roughness change associated with the development has a minor impact on flood heights of up to 2 cm to 3cm in the vicinity of the site. This is not considered significant and therefore the works would be considered 'complying' as defined in the Floodplain Management Plan. No levee additions or modifications are proposed as part of the development. If requested the proponent may relocate the levee location to the north to align with the Floodplain Management Plan (OEH, 2012). If this occurs the available floodway will be increased, improving flood conveyance.
An appropriate assessment of potential flooding impacts undertaken generally in accordance with the principles, processes and guidelines as outlined in the NSW Government *Floodplain Development Manual, 2005.* The study shall consider a full range of potential flood events up to and including the Probable Maximum Flood (PMF) and any local floodplain management processes.	No modelling or assessments of events outside of those provided in the Floodplain Management Study (DECWW, 2009) and Floodplain Management Plan (OEH, 2012) have been undertaken. The range of events used in the FMP (4%, 3% and 0.5% AEP) is used to assess flood impacts over a range of recurrence intervals. There are no impacts from the development up to the 4% AEP design event which is confined to the floodway. For events up to the 0.5% AEP event there is a minor impact on flood levels of up to 3cm, this is not considered significant. The proponent should consider the level of flood protection required for infrastructure proposed on the site to appropriately manage flood risk. This may include: • Raising infrastructure above a selected flood level • Flood proofing infrastructure below the 0.5% AEP flood level It is recommended that the base of the heliostat panel is set at or above the 0.5% AEP event flood level as recorded in the floodplain management study (DECWW, 2009).

REFERENCES

Brisbane City Council 2009, *Natural Channel Design Guidelines*

Department of Environment and Climate Change 2009, *Lachlan River Jemalong Gap to Condobolin Floodplain Risk Management Study*

Parsons Brinkerhoff 2004, *Lachlan River (Jemalong Gap to Condobolin), Lachlan, NSW, Rural Flood Study.*
Water Resoutces Commission 1978, *Guidelines for Floodplain Development; Lachlan River Jemalong Gap to Condobolin*

Office of Environment and Heritage 2012, *Laxchlan River, Jemalong Gap to Condoboli, Floodplain Management Plan.*

APPENDIX A – DEVELOPMENT FOOTPRINT AND MODEL SECTIONS

APPENDIX B

Approach 1

River Sta	Flood levels for 1952 event (0.5% AEP) (mAHD)		
	Existing roughness	Modified roughness	Difference (m)
-849	216.55	216.55	0
-1689	216.53	216.54	0.01
-2597	216.52	216.53	0.01
-3275	216.34	216.36	0.02
-3743	216.2	216.22	0.02
-4018	216.13	216.14	0.01
-4550	215.89	215.91	0.02
-5102	215.68	215.68	0
-5311	215.62	215.62	0
-5549	214.96	214.96	0
-5738	214.97	214.97	0
-5989	214.82	214.82	0
-6359	214.97	214.97	0
-6802	214.96	214.96	0
-7617	214.94	214.94	0

Approach 2

	Flood levels for 1952 event (0.5% AEP) (mAHD)		
River Sta	Existing roughness	Modified roughness	Difference (m)
-849	216.55	216.55	0
-1689	216.48	216.5	0.02
-2597	216.47	216.49	0.02
-3275	216.33	216.36	0.03
-5102	215.03	215.03	0
-6802	214.96	214.96	0
-7617	214.94	214.94	0