NGH Pty Ltd

Yarren Hut Solar Farm

Site Flood and Drainage Assessment

Final Report

April 2020

Cover photograph: View looking north across the access track entry point from the Mitchell Highway into the subject property.

Table of contents

Figure index

1. Introduction

BayWa r.e. Projects Australia Pty Ltd proposes to develop a solar farm at a site located 17 km north west of Nyngan, within the Bogan Shire Local Government Area (LGA) in central New South Wales.

The development proposal is for a 28 megawatt (MW) solar farm. The development will occupy around 92 hectares (ha) of rural land currently used for a mixture of cropping and grazing. The proposed solar farm infrastructure includes solar arrays, inverters, a substation / switchyard, site office, storage containers, water storage tanks, security fencing and cable connection to the adjoining Essential Energy network.

GHD was engaged by NGH Pty Ltd (NGH) to undertake an assessment of flooding and drainage impact issues associated with the proposed development.

The location of the solar farm site is shown on Figure 1.

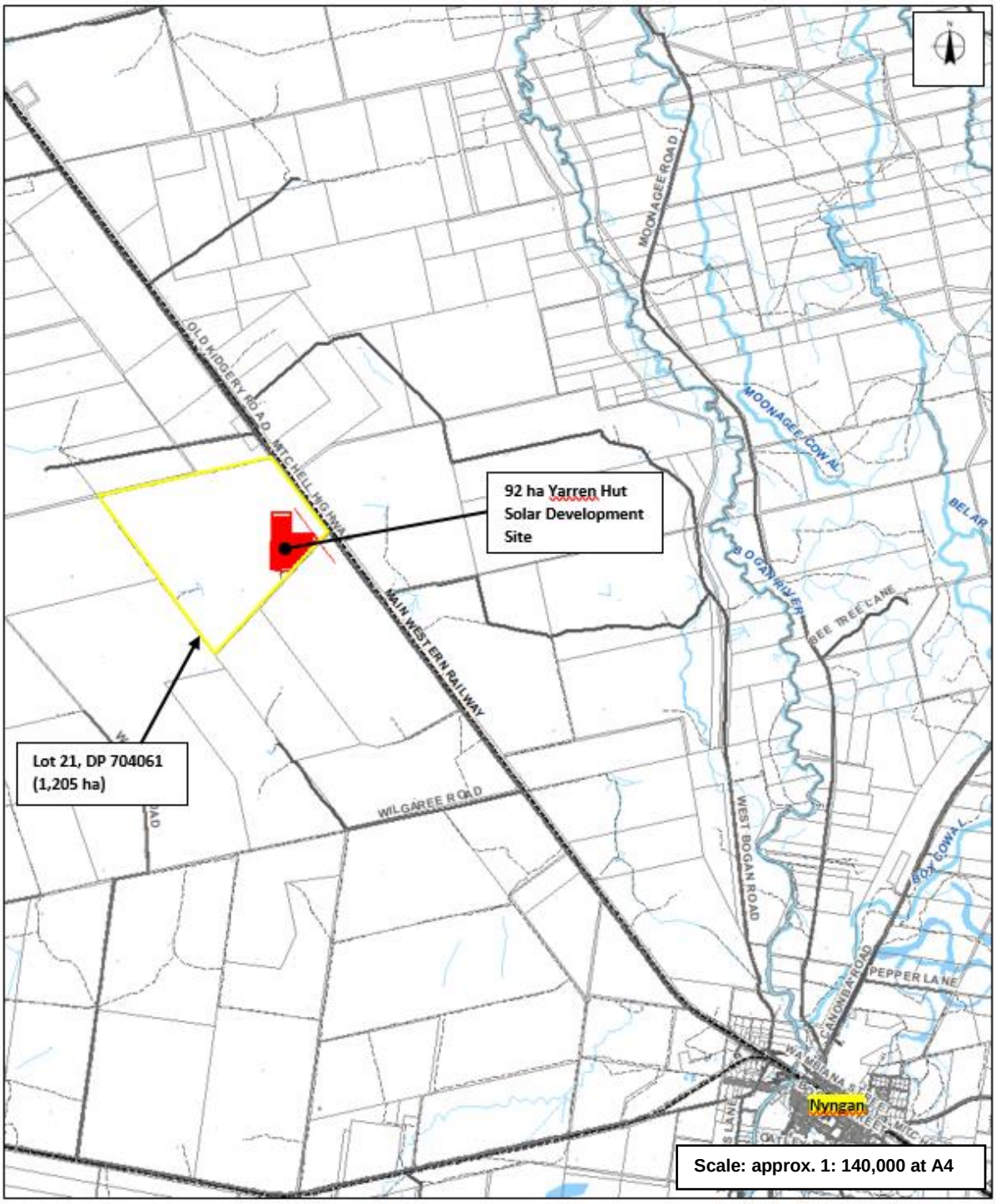


Figure 1 Locality Plan

2. Site and Development Description

2.1 Site Description

The solar farm site is located 250 m from the west side of the Mitchell Highway as shown on Figure 1.

The 92 ha solar farm site is located within the south eastern portion of a 1,205 ha rural property (Lot 21, DP 704061), which fronts onto the Mitchell Highway.

Available terrain elevation data for the site and surrounds sourced for the assessment consists of:

- 5 metre grid LIDAR derived digital elevation model (DEM) NSW Government dataset. This data was acquired in 2015. The dataset has a vertical accuracy of 1 m.
- 30 m grid Shuttle Radar Topographic Mission (SRTM) derived DEM Australian Government dataset.

The 92 ha solar farm site consists of flat cleared terrain. The general direction of land fall is in a northerly direction. The indicative average land surface gradient on the site is 1 in 2,500. There is a fall of approximately 0.5 m from the southern most part of the site to the northern most part of the site (refer to Figure 2).

A private access track is aligned inside the southern boundary of the 1,205 ha property, providing access from the Mitchell Highway to the solar farm site (refer to Figure 3 – Photograph 1).

The site is currently used for cropping. A small number of scattered trees are present on the site.

There are no waterways present within the 92 ha site. The Bogan River is located 9 km to the east of the development site.

2.2 Development Description

The development proposal involves the construction of a ground mounted solar array which will generate around 28MW alternating current (AC) of renewable energy. The solar farm would connect via the substation / switchyard directly into the adjoining existing 66 kV power line transmission network.

The concept layout is shown on Figure 4. The layout features:

- Substation / switchyard and a small site office facility located in the south eastern corner of the site, adjacent to the access track connecting to the Mitchell Highway.
- Six inverter stations positioned within the solar array fields.
- Perimeter fence around the site.
- Internal access tracks providing vehicle access to the six inverter stations.
- 10 m wide asset protection zone inside the perimeter fencing.

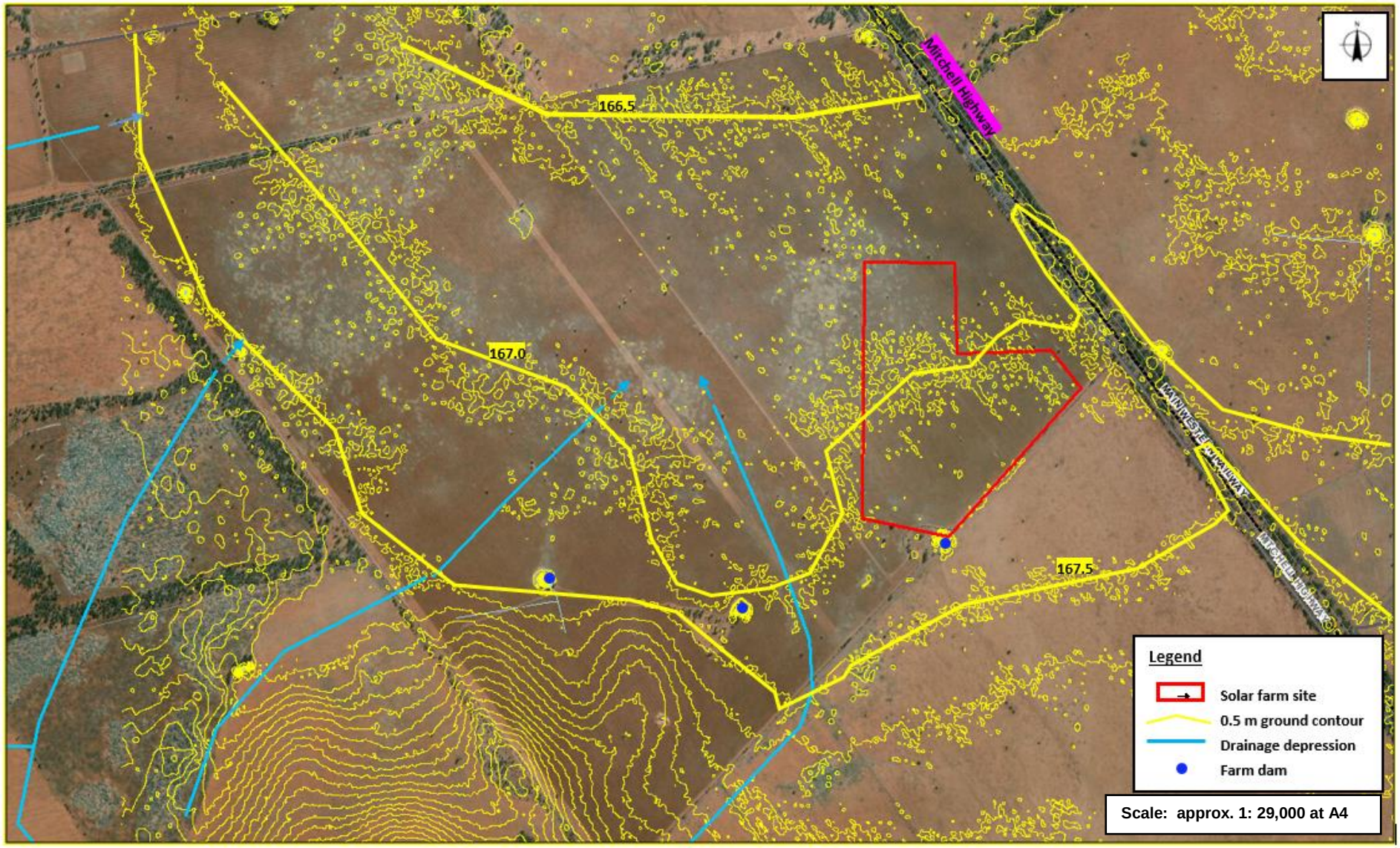


Figure 2 Local Area Topography

Photograph 1 - Access track entrance into the subject property from the Mitchell Highway

Photograph 2 - View looking north west from the Mitchell Highway

Figure 3 Site Photogaphs

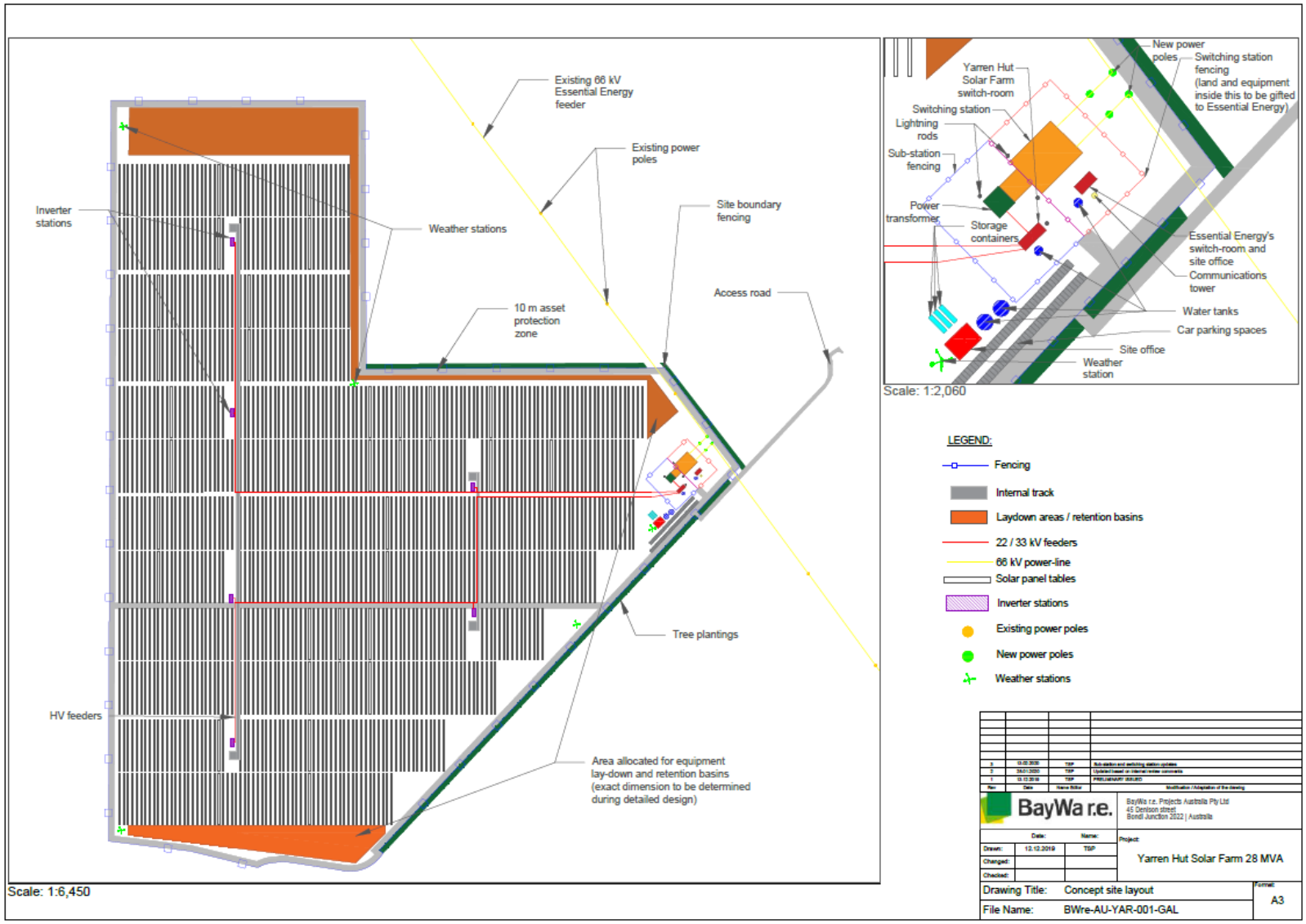


Figure 4 Development Concept Site Layout Plan

3. Flooding Assessment

3.1 Bogan River Floodplain

The Bogan River is located 9 km east of the solar farm development site (refer to Figure 5).

The Bogan River floodplain is a complex broad floodplain consisting of multiple waterways. The Bogan River is the western most of these waterways.

The terrain on the west side of the Bogan River rises on the approach to the solar site. The terrain on the east side of the Bogan River falls towards Belar Creek and Gunningbar Creek as shown on Figure 5.

Gunningbar Creek is an effluent waterway which transfers flood flows from the Macquarie River to the Bogan River.

In large Bogan River flood events, flooding is expected to extend across an extremely broad floodplain encompassing the Bogan River and extending eastwards for approximately 20 km.

The report 'Bogan River at Nyngan Flood Study' (WRM Water & Environment, 2014) documents an assessment of Bogan River flooding conditions at Nyngan. The report includes hydraulic modelling and flood mapping for Nyngan and the immediate surrounding area. The 2014 study hydraulic modelling and mapping extends approximately 7 km downstream of Nyngan (i.e. terminates upstream of the solar development site).

A terrain cross section extending from the proposed solar development site across the intervening area to the Bogan River and the floodplain further east is shown on Figure 5. Large Bogan River floods (e.g. 1%, 0.5% and 0.2% AEP events) are expected to be confined to east of the Mitchell Highway opposite the solar development site, given the elevation differences and the broad size of the floodplain to the east of the Bogan River.

It is possible that flooding from the Bogan River floodplain may impact on the development site in a Probable Maximum Flood (PMF). A PMF has a very low probability of occurrence and most forms of non-critical infrastructure development including a solar farm facility are not required to be free from PMF flooding.

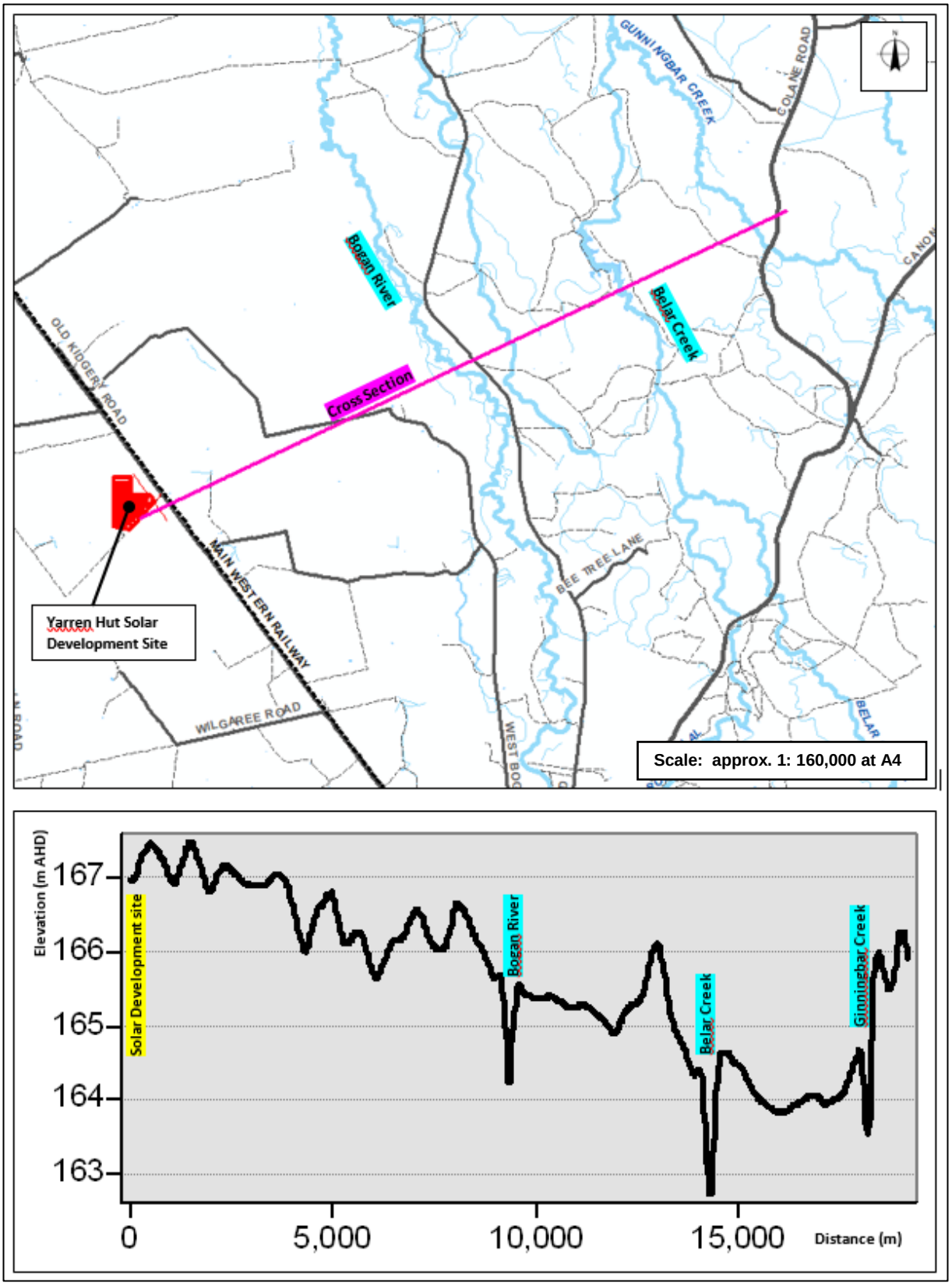


Figure 5 Terrain Cross Section – Bogan River Floodplain

3.2 Local Runoff Flooding

Based on a review of the available terrain elevation data, the indicative location of local runoff catchment boundaries and drainage line depressions in the vicinity of the development site is shown on Figure 6.

Local runoff catchments encompass an area extending approximately 12 km west of the solar site. These catchment drain in a generally north-easterly direction as shown on Figure 6.

Within the local runoff catchment area shown on Figure 6, the land gradients typically vary from 1 to 5%. The foot of the undulating catchment is located more than 1 km west of the development site as per the ground surface contours shown on Figures 2 and 4.

In the immediate vicinity of the solar farm site, the terrain generally falls in a northwards direction. The average grade is 1 in 2,500 (refer to Figure 2).

The terrain in close proximity to the development site is such that incised waterways have not formed. Runoff is conveyed within broad depressions. The most significant depressions are aligned to the north of the solar farm site as shown on Figure 6. These depressions drain towards the Mitchell Highway, 2 to 3 km to the north of the development.

Any local runoff flooding from the catchment areas on the west side of the Mitchell Highway is expected to be relatively shallow (generally less than 0.3 m deep) and slow moving (generally less than 0.5 m/s) given the terrain conditions. The absence of any incised waterways in the vicinity of the development site is due to these benign hydraulic conditions.

3.3 Rural Drainage

A farm dam is located adjacent to the southern most corner of the solar farm (refer to Figure 2). The dam receives inflows from small local runoff open drains. The available terrain data indicates that overflows from this farm dam will discharge westwards approximately parallel with the solar development site perimeter boundary in the direction of two further farm dams located on the 1,205 ha property.

A roadside drain is present down the western side of the Mitchell Highway. A roadside drain culvert is present under the access road leading into the development site as shown on Figure 3 (Photograph 1).

The flat terrain conditions in the vicinity of the development site are such that some residual pondage is expected following significant rainfall events. Local soil conditions will determine how long any residual pondage remains.

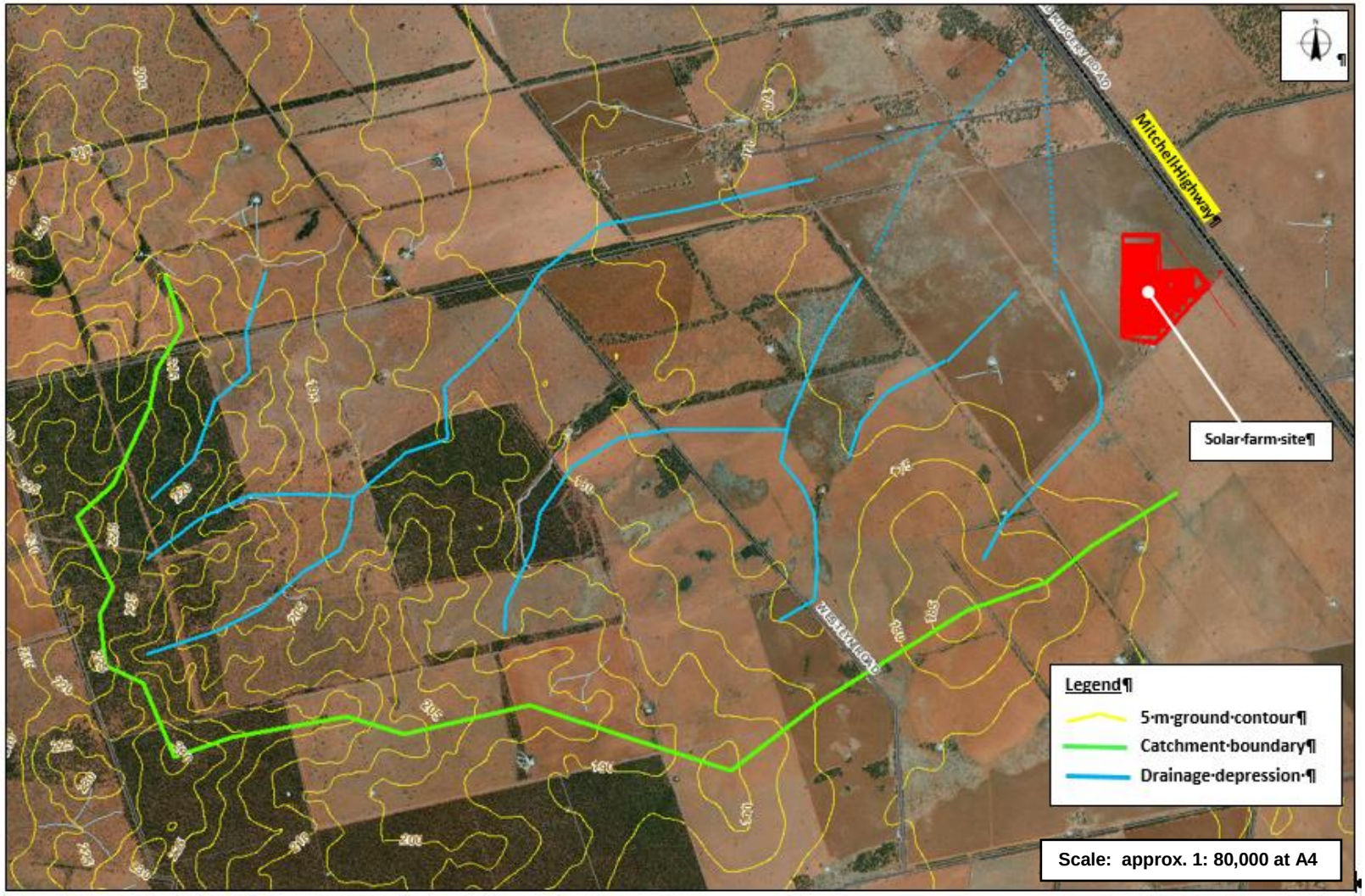


Figure 6 Local Catchment Plan

4. Impacts of Flooding on the Development

4.1 Development Overview

The detailed design of the solar farm infrastructure has not yet been undertaken. Aspects of the current concept layout may therefore change (e.g. in response to authority approval conditions).

The solar array fields occupy the majority of the development site. Solar panels are typically mounted on either individual vertical pole supports (i.e. one pole support for each panel) or alternatively multiple panels can be attached to a single horizontal frame support which in turn is attached to vertical pole supports at either end.

The panels typically have the ability to rotate according to a movement pattern which maximises the solar capture efficiency of the panel. This may include being able to rotate to a horizontal position relative to the ground surface below.

The elevation of solar panels above the ground surface on pole supports means that solar panels can be positioned within areas which experience broad, shallow, low velocity flooding. Floodwater can pass below the elevated panels, with pole supports structurally strong enough to withstand any debris impact loads, whilst also being sparse enough to not significantly obstruct floodwater.

The development components of a solar farm which are most sensitive to flooding impacts consist of the:

- Inverter stations
- Substation / switchyard
- Office / storage buildings

The above flood sensitive components would be positioned and / or designed to minimise their flood risk (e.g. by positioning them on a part of the development site which floods less frequently and less severely, and / or by elevating them above the ground level).

The inverter stations need to be positioned within the solar panel fields. The flood risk to the inverter stations can be reduced by having the inverters elevated above ground level.

4.2 Flood Mitigation Design Measures

The available ground survey elevation data indicates that the surface water flooding risk across the development site is low and quite uniform across the site. Riverine flooding is not expected to be impacting on the site. Local runoff flooding in the form of shallow slow moving inundation will occur in significant rainfall runoff events. The depth of local runoff flooding is unlikely to exceed 0.3 m and a velocity of 0.5 m/s.

To mitigate the risk of flood sensitive components of the development being subject to flood damage, the following mitigation measures are proposed:

- Inverter stations:
    - Floor level of the inverter stations are to be elevated a minimum of 0.5 m above the surrounding ground surface level.
    - Inverter stations are to be aligned such that their longer side is positioned in the north-south direction to minimise the potential for them to obstruct flow.
- Substation / switchyard and site office:
    - The floor level of any flood sensitive facility buildings are to be elevated a minimum of 0.5 m above the surrounding ground surface level.
- Solar array fields
    - The solar panels should be designed such that the whole of the panels are able to be elevated a minimum of 0.5 m above the ground surface level below (i.e. minimum height difference between the ground surface and the lowest part of the solar panel).

The above measures will result in a very low risk of flood damage to the solar farm facility for events up to and including a 1% AEP flood.

4.3 Potential Risk to Life, Health and Safety

The proposed developed is expected to pose an extremely low risk in relation to the safety of persons who may be prese nt on the site during flooding.

The reasons for this are as follows:

- The expected benign nature of flooding conditions on the site. Flooding depths due to any local runoff flooding are not expected to exceed 0.3 m. Velocities are not expected to exceed more than 0.5 m/s.
- The nature of the proposed development is such that no persons will be occupying the site, except when carrying out maintenance and any other temporary work related activities. There are no habitable buildings proposed for the site.
- The expected limited need for actions to minimise property flood damage (i.e. there is no need for persons to be on-site during flooding).

5. Impacts of the Development on Flooding

5.1 Potential Causes

Development on a floodplain can lead to changes in flooding conditions as a result of the following causes:

- Raised ground levels obstructing flow (i.e. land filling associated with the development).
- Structures obstructing flow (e.g. buildings, roadway embankments, fences).

The above obstructions can lead to floodwater being redirected, thereby exacerbating flooding where the additional flow is diverted to. It can also lead to higher flood levels and velocities due to floodwater banking up behind obstructions.

Higher flood levels and velocities are of particular concern where they occur on adjoining properties. In these circumstances, development has effectively increased the flood risk of the adjoining property.

5.2 Nearest Flood Sensitive Development

There is no existing flood sensitive development (e.g. dwellings or rural shedding) within a 4 km radius of the proposed development.

The closest existing flood sensitive development is a dwelling and shedding located approximately 5 km north west of the solar development site. There is also a house and shedding located 7 km south west, a house and shedding 6 km south east, and a house and shedding located 7 km north east.

5.3 Development Components

5.3.1 Substation/ Switchyard and Site Office

The concept layout (refer to Figure 4) includes an access road and car parking area in the vicinity of the substation / switchyard and the site office compound.

To limit any potential obstruction of surface flows, the following design constraints are nominated:

- Filling in this area is to be limited to elevating any flood sensitive components above the ground surface as described in the preceding Section 4.2 (i.e. substation / switchyard, site office).
- Access road and car parking bays are to be elevated no more than 0.10 m above the existing ground surface level.

5.3.2 Inverters

As previously described in Section 4.2, the inverters are to be elevated a minimum of 0.5 m above the adjoining ground level to minimise the risk of flooding impacting on the inverters.

The impacts of the inverter stations on flooding conditions are expected to be minimal for the following reasons:

- The expected benign nature of flooding conditions on the site (i.e. flood depths less than 0.3 m, velocities less than 0.5 m/s).

- Inverter stations to be aligned such that their longer side is positioned in the north-south direction, parallel with the direction of flood flows in order to minimise the obstruction of surface flows.
- Any localised increases in flood level associated with the inverters obstructing surface flows are expected to dissipate within the development property.
- There is no existing flood sensitive development located inside a 4 km radius of the development property.

5.3.3 Solar Panels

The design intent of the solar panels and their supports will be to minimise the potential for floodwater obstruction (refer to Section 4.2). This will be achieved by:

- Ensuring that the whole of the solar panels are able to be elevated a minimum of 0.5 m above the ground surface (i.e. height difference between the ground surface and the lowest part of the solar panel).
- Maintaining a relatively low density of vertical member pile supports.

Given the above design approach, the solar panels and their support frames are expected to pose a very limited risk in relation to altering off-site flooding conditions.

5.3.4 Fencing

The site is located in an area where flooding conditions are expected to be limited to local runoff flooding with very limited concentration of runoff.

The fencing route around the perimeter of the 92 hectares development site is not known to cross any significant overland flow paths.

Given the above, the use of a cyclone type security mesh fence around the perimeter of the development site is not expected to lead to excessive impacts on the shallow sheet surface flow generated in local runoff events.

5.3.5 Internal Access Tracks

The proposed alignment of the internal access tracks is shown on the development concept layout plan (refer to Figure 4).

To avoid the potential for the internal access tracks to obstruct surface flows, potentially leading to an increase in flooding on any adjoining properties, it is proposed that the internal access tracks be limited in height to no more than 100 mm above the adjoining ground surface level.

Compliance with the above will ensure that the access roads do not lead to the excessive obstruction of floodwater.

5.4 Impacts of Development on Floodplain Environmental Values

The development site is not located on a designated floodplain. The Bogan River floodplain is located to the east of the Mitchell Highway, a considerable distance from the development. There are no waterways or wetlands located on the development site. The development site has been predominantly cleared for agriculture.

Given the above, the development is not expected to impact on floodplain environmental values.

The environmental assessment of the development site is being undertaken by NGH.

6. Response to SEARs

6.1 DPIE Issue of SEARs

A list of Standard Environmental Assessment Requirements (SEARs) for the development was issued by the Department of Planning Industry & Environment (DPIE) on the 6 February 2020.

A response to the SEARs relevant to this flooding and drainage (surface water) assessment is provided as follows.

6.2 Flooding based SEARs

SEARs Items 14 to 22 are flooding based requirements.

Items 14, 15 and 16. The assessment site is not located on a designated floodplain. Given this, SEARs items 14 to 16 are not therefore seen to be applicable.

It is not expected that the development site will be affected by flooding in a Bogan River 1%, 0.5% or 0.2% AEP flood as outlined in Section 3.1 of this report. It is possible that the development site may be affected by flooding in a Bogan River PMF. A PMF has an extremely low probability of occurrence (less than 1 in 10,000 in any given year). If the site is affected by Bogan River flooding in a PMF, this is not seen to have any implications given the nature of the development proposal (i.e. there are no habitable buildings proposed for the site and no permanent staff presence).

Item 18. The report 'Bogan River at Nyngan Flood Study' was completed in 2014 for the Bogan Shire Council. The report does not however include hydraulic modelling or flood mapping extending more than 7 km downstream of Nyngan and is therefore of limited use in defining flooding conditions within the Bogan River floodplain opposite the development site. The report documents that the April 1990 Bogan River flood was the highest recorded flood at Nyngan, with an estimated equivalent exceedance probability of in excess of 1% AEP.

Items 19 and 20. The expected impact of the development on flooding behaviour is described in Section 5 of this report.

Item 22 a. Refer to Section 5 of this report in relation to the expected impacts of the development on flooding conditions.

Item 22 b and c. There are no known Council or rural floodplain management plans for the area encompassing the development site.

Item 22 d and e. Flooding conditions at the site generated from local runoff are expected to be characteristic of a low hazard hydraulic area. The development proposed (large scale solar) is compatible with low hazard type hydraulic conditions (refer to Section 4 of this report).

Item 22 f and g. The development is not expected to lead to adverse environmental impacts on flood dependent ecosystems (refer to Section 5.4). The environmental site assessment is being undertaken by NGH.

Item 22 h, i and j. The development is not expected to have any implications in relation to community emergency management arrangements for flooding (refer to Section 4 of this report for further details). The only persons on site will be those attending to periodic maintenance which will not require a permanent presence. No on-site flood response actions in the event of local runoff flooding are envisaged.

Item 22 k. No social or economic costs to the community are expected as a consequence of flooding.

6.3 Water and Soils based SEARs

SEARs Items 10 to 13 are water and soils based requirements. Comments on the surface water related items are as follows.

Item 10 b and c. There are no rivers, streams, wetlands or estuaries in the vicinity of the development site.

Item 11. The development is not expected to affect any water resource. Runoff from the development site will continue to drain northwards as it does under existing conditions with little or no concentration of runoff, consistent with existing surface runoff conditions. There is no harvesting of runoff proposed by the development. Runoff from the development site will ultimately discharge to the Bogan River, approximately 15 km north east of the development site.

Items 12 and 13. The intent of the site management surface drainage measures is to avoid concentration of surface runoff. Under existing conditions, local runoff within the 92 ha site discharges northwards as shallow sheet flow. There is very little concentration of runoff.

No incised open drains or internal access track culverts are proposed as part of the site works within the solar panel fields. The intention is for the natural drainage characteristics to be largely retained, with any local runoff free to discharge over the pervious ground surface below the elevated solar panels.

All of the development site surface will remain pervious with the exception of the inverters and the buildings / structures located within the site office and substation / switchyard compound area. This equates to more than 99% of the site remaining in a pervious condition. Rainfall running off the solar panels will fall onto the pervious ground surface below and be free to infiltrate.

The internal access tracks are to be raised only marginally above the ground surface (no more than 100 mm) to avoid the excessive obstruction, concentration and diversion of local runoff.

Stormwater and wastewater management infrastructure will be provided for servicing the site office and substation / switchyard area. Details of these will be provided as part of the detailed design and are likely to include an appropriate wastewater management system for the site office, and a retention basin / sedimentation basin for surface runoff from the site office / substation area. The development layout includes an area set aside on the north side of the site office / substation for a retention basin.

Given the above proposed conditions, the quantity and quality of runoff discharging from the site is expected to be similar to that present under existing conditions.

7. Summary and Conclusions

The Yarren Hut solar development site is located as shown on Figure 1. The concept layout plan is shown on Figure 4.

There are no waterways located within or in close proximity to the 92 hectares development site. Under existing conditions, surface runoff from the development site and immediate surrounds drains in a generally northwards direction with little concentration of runoff. The terrain falls at an indicative grade of 0.04% to the north (refer to Figure 2).

The site is not located on a designated floodplain. The Bogan River is located 9 km to the east of the development site (refer to Figure 5). Flooding from the Bogan River is not expected to impact on the development site with the possible exception of an extreme event (e.g. Probable Maximum Flood (PMF)). A PMF has an extremely low probability of occurrence (less than 1 in 10,000 in any given year). This risk of a PMF occurring during the design life of a solar farm is extremely low and not sufficient to warrant any specific planning related development constraints or controls for this type of development.

An assessment of terrain data in the vicinity of the development site indicates that runoff from local catchment areas to the west of the development site will drain via broad shallow depressions in a generally north east direction, predominantly bypassing the development site to the north (refer to Figure 6) . Local runoff flooding is expected to be shallow (depth less than 0.3 m) and relatively slow moving (velocities less than 0.5 m/s) based on the terrain conditions.

The property damage flood risk posed to the solar farm development is assessed to be very low for the following reasons:

- Riverine flooding is not expected to impact on the development site with the possible exception of a Bogan River extreme event.
- Local runoff flooding is expected to be relatively benign and not sufficiently severe to cause any significant damage to the solar farm facility provided that flood sensitive components of the development are elevated a minimum of 0.5 m above the ground surface level.

The flood risk posed to life, health and safety from the solar farm development is assessed to be extremely low. The reasons for this are:

- No permanent occupants / residents on site (no habitable dwellings).
- No need for persons to be on the site during a local runoff flood event (i.e. no need for on-site actions to minimise flooding impacts).
- The benign nature of flooding conditions (i.e. shallow local runoff flooding only).

The risk posed by the solar farm development in relation to the potential for the development to adversely affect offsite flooding conditions can be adequately mitigated provided that:

- Site filling is limited to that associated with the site office, substation / switchyard facilities, the six inverter stations and height limited internal access tracks.
- The whole of the solar panels are elevated a minimum of 0.5 m above the ground surface level (i.e. panels elevated above the water surface).

The risk posed by the development to flood dependent environmental values is assessed to be low. The reasons for this are:

- There are no flood dependent ecosystems located within or adjoining the development site.
- Existing site drainage characteristics will be largely retained, given that greater than 99% of the site will remain in a pervious condition and surface runoff will continue to discharge from the site with minimal concentration.

8. References

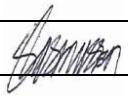
WRM Water & Environment Pty Ltd (September 2014). *Bogan River at Nyngan Flood Study*. Prepared for Bogan Shire Council.

GHD

Suite 5, 105 Hume Street
Wodonga VIC 3690
T: 61 2 6043 8700 F: 61 2 6043 8711 E: abxmail@ghd.com

12527990-78901-1/https://projectsportal.ghd.com/sites/pp17_05/nyngansolarfarmsitef/ProjectDocs/12527990-REP_YarenHutSolarFarm_FloodReport.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	T Clark	J Ellwood		S Rasmussen		3/4/2020
0	T Clark	J Ellwood		S Rasmussen		6/4/2020

www.ghd.com