APPENDIX J WALLA WALLA FLOOD STUDY

NGH Environmental

Walla Walla Solar Farm - Site Flood Assessment

Final Report

October 2019

Cover photograph: Benambra Road looking east across Back Creek.

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1. Introduction

FRV Services Australia (FRV) proposes to develop a solar farm on a 605 hectare site located 4 km north east of Walla Walla. GHD was engaged by NGH Environmental to undertake an assessment of existing flooding conditions and risks associated with the proposed development.

The location of the assessment property is shown on Figure 1. There are two waterways aligned through the site as shown. The waterway entering at the eastern boundary of the assessment site is Back Creek. The waterway entering at the southern boundary of the assessment site is Middle Creek.

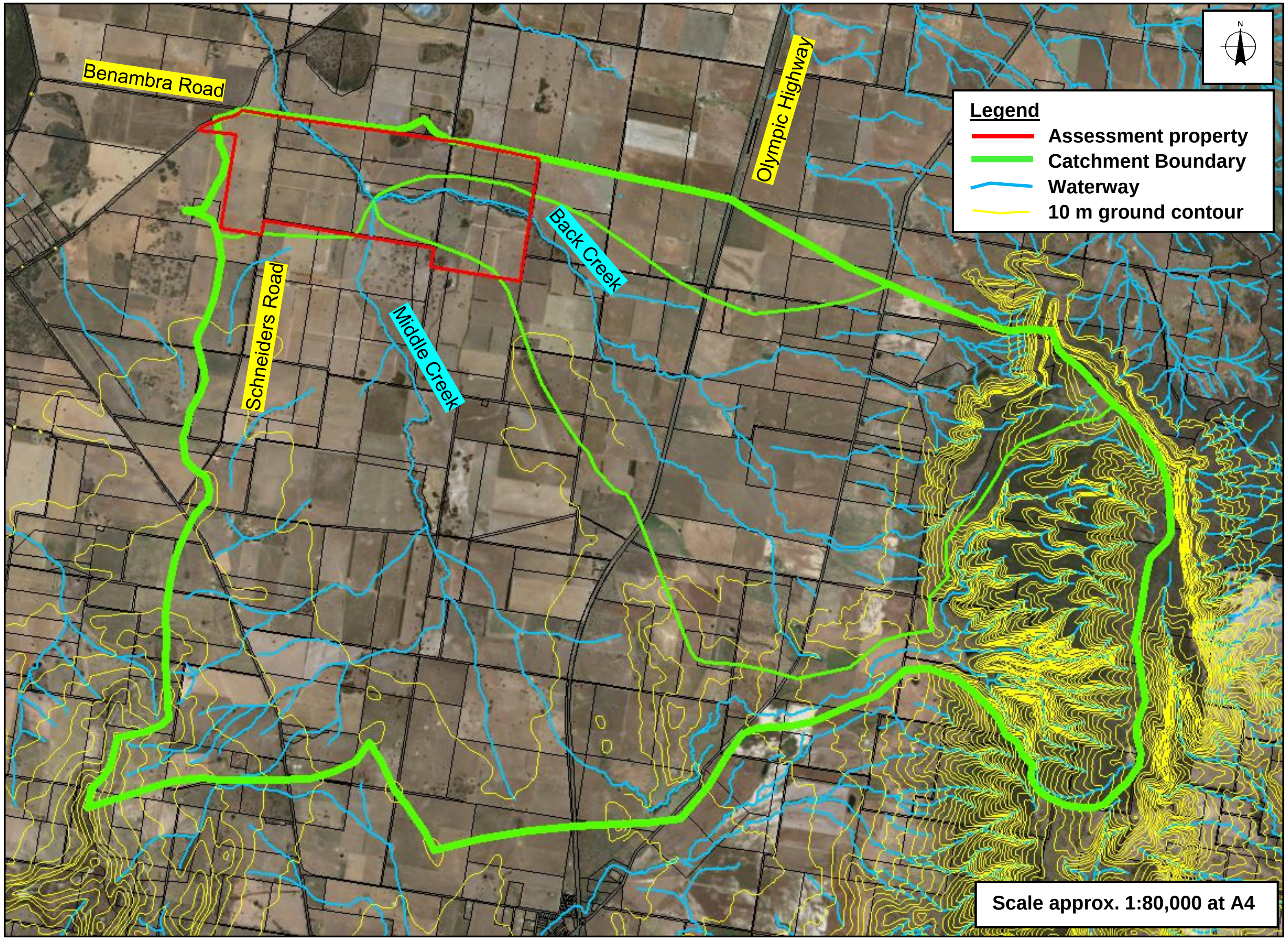


Figure 1 Locality Plan / Catchment Plan

2. Site and Development Description

2.1 Site Description

The 605 hectares assessment site is located on the south side of Benambra Road as shown on Figure 2. The western boundary of the assessment property is located 500 m west of Schneiders Road. The eastern and southern boundaries adjoin rural land use properties.

The whole of the assessment site is currently a rural land use property. There are no buildings located on the property.

An incised channel is present along the Back Creek route (refer to Photographs 1 and 2 in Figure 3). The creek corridor is covered with native trees. No formal waterway structures are present along the Back Creek route within the assessment site. An informal existing access crossing is present due south of Weeamera Road.

Benambra Road is only marginally raised at Back Creek (refer to Figure 4 – Photograph 3). The roadway culvert structure present is a low flow culvert capacity structure only. The road will overtop during minor flood events.

The Middle Creek waterway route is characteristic of a broad depression (refer to Photograph 4 in Figure 4). There is no incised channel present. The depression is covered by pasture with no tree cover.

Small woodlands and scattered trees are present over the remainder of the site.

The eastern half of the assessment site falls in a generally westerly direction (refer to ground surface contours in Figure 2). The western half of the site falls towards the Back Creek crossing of Benambra Road, located 200 m west of Schneiders Road.

The highest parts of the assessment site are located in the south west corner (up to 218 m AHD) and the south east corner (up to 231 m AHD). Ground surface elevations along the Benambra Road frontage vary from 205 to 216 m AHD.

Back Creek crosses under a decommissioned railway line (Corowa-Culcairn Railway) approximately 900 m downstream of the assessment site (i.e. downstream of Benambra Road). The railway line embankment remains intact with a large 50 m overall span bridge structure present at Back Creek. Back Creek flows into the Billabong Creek 8 km downstream of the assessment site.

2.2 Development Description

The proposal involves the construction of a ground mounted solar array which would generate around 300 MW AC of renewable energy. The solar farm would connect via the substation and transmission line directly into the TransGrid 330 kV transmission network which passes through the property.

The preliminary development proposal layout is provided in Appendix A.

The layout features:

- Substation located in the north western corner of the site
- Solar panel fields
- Inverter stations for controlling the solar panels in their vicinity
- Network of vehicle access roads

Those parts of the site which are not proposed to be developed include the Back Creek waterway corridor and a number of woodland areas.

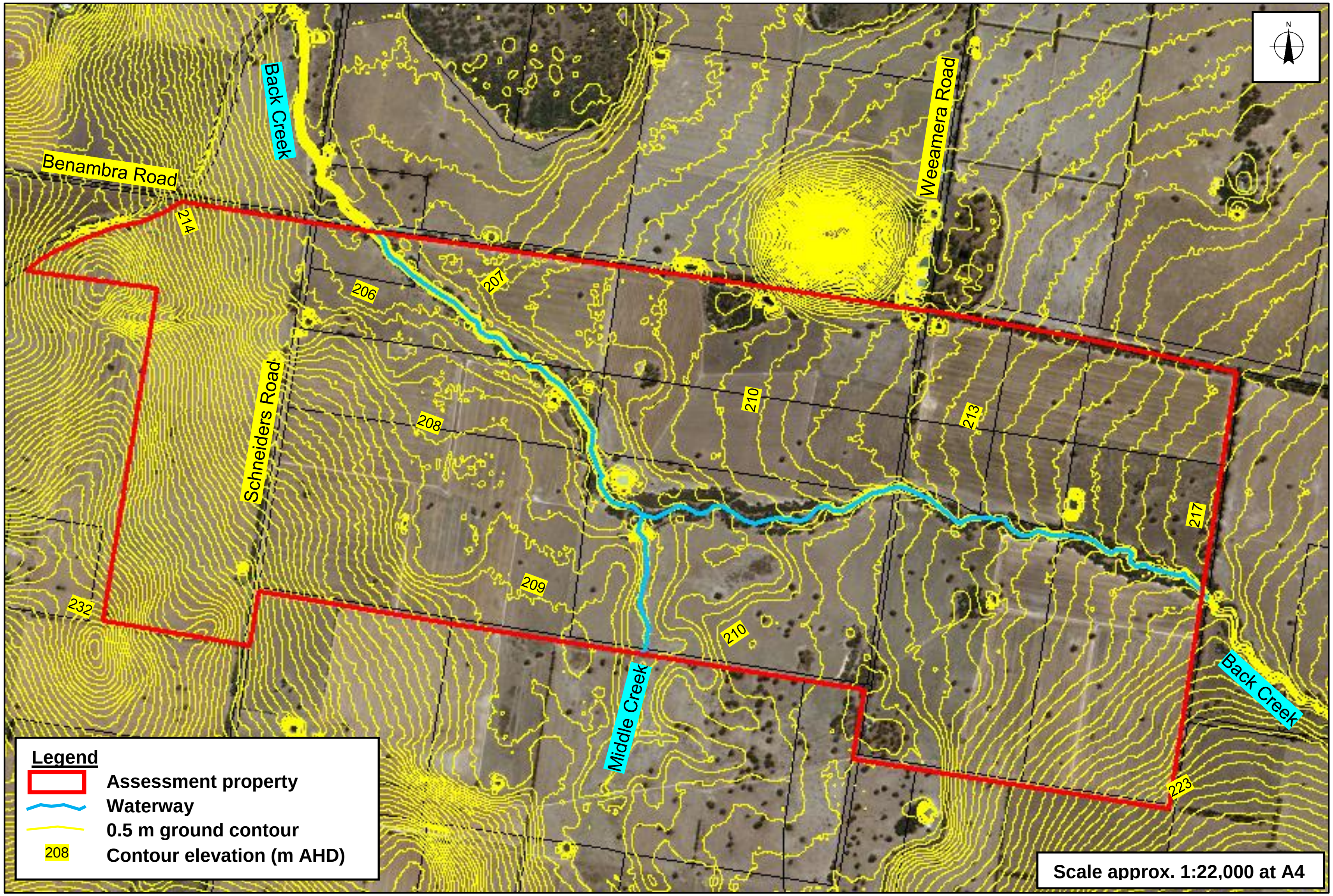
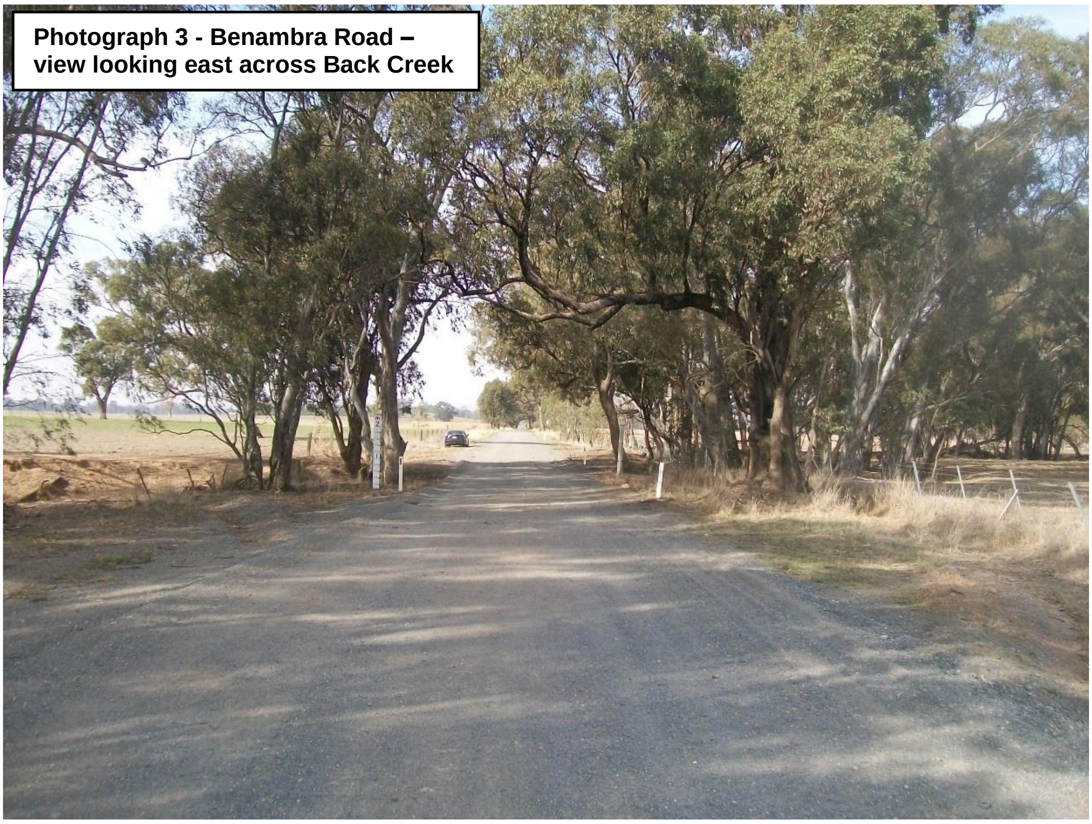


Figure 2 Local Features Plan

Photograph 1 - Back Creek – view looking upstream of Benambra Road

Photograph 2 - Back Creek – view looking downstream from the development properties eastern boundary

Figure 3 Photographs 1 and 2



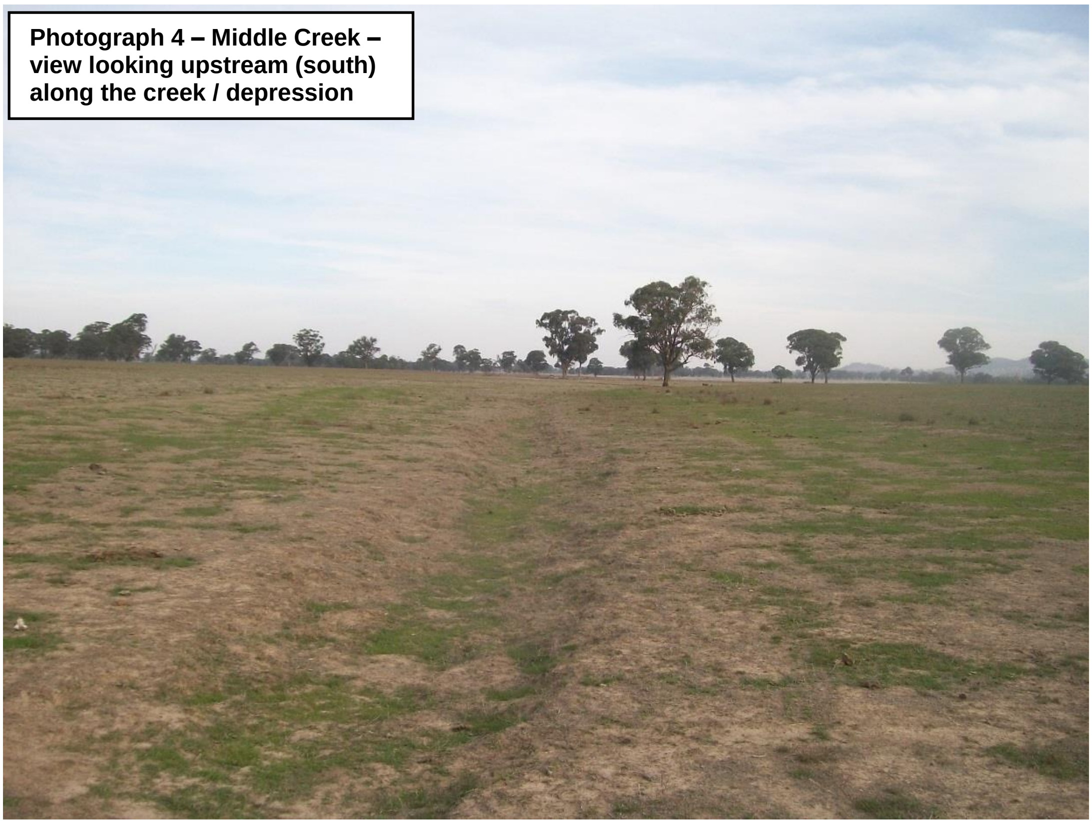


Figure 4 Photographs 3 and 4

3. Hydrology

3.1 Catchment Description

The Back Creek catchment draining to Benambra Road is shown on Figure 1.

The catchment extends into a hill range, 6 km east of the Olympic Highway. The upper catchment area drains westwards crossing the Olympic Highway and the adjoining Melbourne-Sydney Railway at multiple culvert structures.

The terrain west of the Olympic Highway is flatter, generally draining northwards towards the assessment property.

The majority of the Back Creek catchment has been predominantly cleared for agriculture, with the exception of the steeper hillside areas located in the upper catchment.

The west side catchment boundary of the Back Creek / Middle Creek catchment abuts the Petries Creek catchment which drains into the Walla Walla township and ultimately Gum Swamp on the north side of Walla Walla.

3.2 Design Flow Estimates

Design flow estimates for Back Creek and Middle Creek were estimated using a simplified approach as described below.

Design flow estimates for the adjoining Petries Creek catchment at Walla Walla are documented in the Walla Walla Flood Study report (GHD, 2017). The Walla Walla Flood Study estimates are based on Regional Flood Frequency Estimation (RFFE) derived estimates, which are consistent with design flow estimates used for other nearby town flood studies at Jindera and Henty.

The adopted 5% and 1% annual exceedance probability (AEP) design flow estimates for the flood assessment are given in Table 1. They are consistent with the estimates derived for the adjoining Walla Walla Flood Study after adjusting for the differences in catchment area.

The Probable Maximum Flood (PMF) estimates given in Table 1 coincide with approximately 12 times the 1% AEP design flow. This is consistent with typical PMF to 1% AEP flow ratios for catchments of this size.

3.3 Adjustments to Back Creek flows upstream of Middle Creek

The eastern most part of the catchment is a relatively steep hillside area (refer to Figure 1). Most of this hillside area drains into the Middle Creek subcatchment. It is possible however that in large flood events, overflows from the Middle Creek subcatchment spill into the Back Creek catchment.

Modelling of flooding conditions within the upper catchment hillside area was outside the scope of this assessment. It was however assumed for the purpose of this assessment that the uppermost portion of the Middle Creek catchment spills into the Back Creek catchment.

The Back Creek design flow estimates were subsequently adjusted upwards to reflect this assumption (refer to Table 1). The Middle Creek design flow estimates were retained without adjustment.

Table 1 Design Flows

Location	Catchment Area (km^2)	Peak Design Flow (m^3/s)		
		5% AEP	1% AEP	PMF
Middle Creek at Back Creek junction	57.7	52	87	1,000
Back Creek upstream of Middle Creek junction – no overflows from Middle Creek	27.6	32	53	600
Back Creek upstream of Middle Creek junction – overflows from Middle Creek	40.0 (adjusted – see Note 1)	41	69	800
Back Creek at Benambra Road	93.8	75	125	1,500

Note on Table 1:

1. The adjusted catchment area is based on the assumption that there are significant overflows from the Middle Creek catchment into the Back Creek catchment within the upper catchment hillside area east of the Olympic Highway (refer to catchment plan in Figure 1).

4. Hydraulics

4.1 Terrain Data

LiDAR terrain elevation data was available for the assessment site and surrounding area. The LiDAR dataset details are as follows:

- Data acquired in 2014
- Source data processed to a 5 m digital elevation model (DEM)
- Vertical accuracy +/- 0.9 m (95% confidence interval)

The above LiDAR dataset overlaps with a 2013 LiDAR dataset, which was obtained for use as part of the Walla Walla Flood Study (GHD, 2017). The 2013 dataset has a vertical accuracy of 0.3 m (95% confidence interval).

A comparison of the 2014 LiDAR dataset with the 2013 dataset showed generally good agreement. The accuracy of the 2014 LiDAR data is however not compatible with what should be used for determining flood levels to be used for the setting of minimum floor levels for development which is sensitive to flooding (e.g. during the detailed design phase of this project).

4.2 Hydraulic Model

The HEC-RAS hydraulic model was used to simulate flooding conditions within Back Creek and Middle Creek. The modelling was undertaken as follows:

- Cross sections extracted at intervals from the 5 m grid LiDAR dataset. Cross sections were orientated perpendicular to predominant flow direction.
- Mannings roughness values assigned based on observed and expected typical conditions. Main channel roughness of 0.06 adopted for Back Creek channel and woodland corridor. Mannings roughness of 0.04 adopted elsewhere.
- Steady state flow inputs as per Table 1.

The resultant modelled flood extents are shown on Figure 5. The reliability of the flood extents is limited by the accuracy of the terrain data set used for the modelling.

4.3 Description of Flooding Conditions

4.3.1 5% AEP Flood

The 5% AEP flood extent results in the inundation of 15% of the development property (refer to Figure 5). The width of the 5% AEP flood extent generally varies from 120 m to 250 m as shown on Figure 5, with the exception of the area to the east of the Middle Creek / Back Creek junction where broader inundation is present.

Velocities and flood depths will be highest within the incised Back Creek channel. The 20% AEP flood depth typically varies from 1.0 to 3.0 m within the incised channel. The average in-channel velocity typically varies from 0.5 to 1.5 m/s.

The overbank 5% AEP flood depth is generally less than 0.5 m. Average overbank velocities are generally expected to be in the vicinity of 0.5 to 1.0 m/s.

Although an incised waterway is not present along the Middle Creek route, it is still a high conveyance zone. In a 5% AEP event, the modelled flood depth in the base of the Middle Creek depression is typically 1.0 to 1.3 m. Average velocities are in the vicinity of 0.5 m/s.

4.3.2 1% AEP Flooding

The 1% AEP flood results in the inundation of 31% of the development site (refer to Figure 5).

The 1% AEP flood levels are typically 0.2 to 0.3 m higher in comparison to the 5% AEP flood levels. Velocities will also be slightly higher.

The 1% AEP extent is generally relatively well confined, with the exception of the Back Creek south bank area upstream of the Middle Creek junction. Broad inundation on the south side of Back Creek upstream of the Middle Creek junction occurs in a 1% AEP flood as shown on Figure 5. The 1% AEP flood depths for this area and the other areas outside the 5% AEP extent will typically not be more than 0.3 m, although there will be some localised areas where the flood depth is greater than 0.3 m.

4.3.3 PMF

The PMF results in the inundation of 72% of the development site (refer to Figure 5). PMF flood levels are up to 2 m above the 1% AEP flood levels.

The PMF extent is what can be expected in the most extreme flood event possible. The probability of the PMF occurring is extremely small.

4.3.4 General Flooding Conditions

Given the catchment size, the time interval between the commencement of the flood inducing rainfall and the peak of the flood is typically expected to be in the vicinity of 1 to 6 hours. Higher intensity rainfall will result in a shorter response time whilst rainfall spread over a longer period will increase the available warning time.

The duration of extensive out of channel flooding is not expected to typically exceed 3 to 12 hours. There may however be flood events when flows in the creek channel remain high for extended periods exceeding 12 hours, including overflows across Benambra Road.

Benambra Road is not expected to be trafficable in a 5% AEP event. The threshold for Benambra Road overflows is expected to be less than the 20% AEP event.

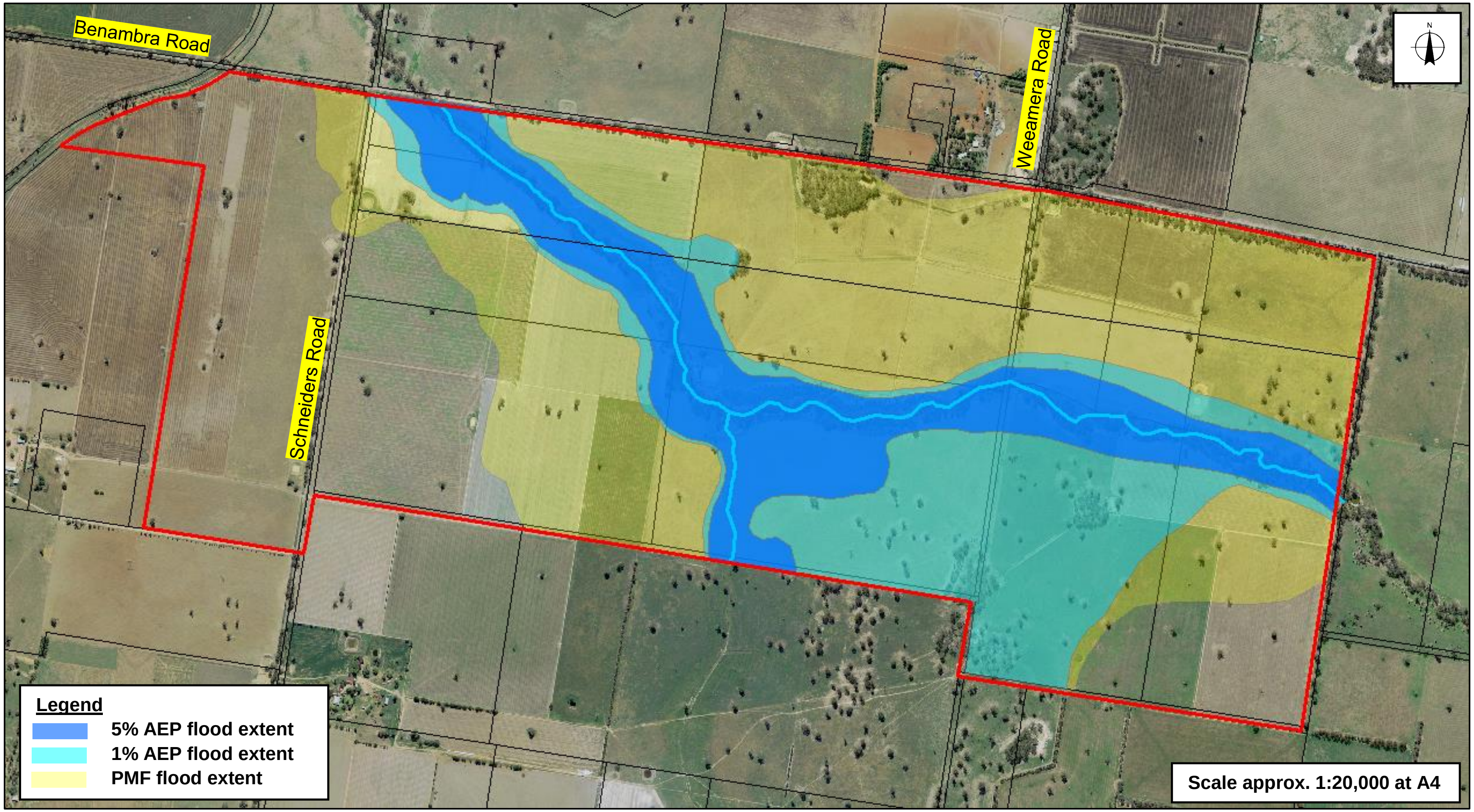


Figure 5 Flood Extent Plan

5. Potential Impacts of Flooding on the Development

5.1 Development Description

The development proposal layout plan is provided in Appendix A.

The layout features:

- Substation building located in the north western corner of the site.
- 72 inverter stations (inverter stations) for controlling the solar panels in their vicinity
- Approximately 900,000 solar panels occupying the majority of the site with the exception of the development exclusion zones

The development components likely to be most sensitive to flooding impacts are expected to be the buildings and equipment associated with the substation facility.

The inverter stations are also expected to be sensitive to flooding impacts. Approximately 72 inverter stations are expected to be scattered across the site. The footprint dimensions of the inverter stations are expected to be approximately 3 m x 12 m. The inverter units would be constructed on concrete footings generally 0.3 m above ground level.

The 2 x 1 m solar panels are expected to be attached to a horizontal steel frame member (rack) which is supported by steel pole (pile) mounts. Row lengths will depend on the detailed design but could be up to 100m. The space between the rows is expected to vary between 8 m and 14 m.

The panels are able to pivot to maximise their efficiency as the sun moves across the sky. The panels can also be pivoted to a horizontal position during a flood event to minimise the risk of the panels being submerged in floodwater and subject to possible debris impacts. The panels even in a vertical position are well clear of the ground meaning that even without pivoting to the horizontal position, the panels should generally be elevated well above the floodwater height.

5.2 Flood Based Development Controls

The following approach is nominated for limiting potential flooding impacts on the development:

- Item 1 - Substation zone should be located in a portion of the site, which has very limited flood risk.
- Item 2 – Inverter stations should where possible be located on land which is located outside the higher conveyance areas.
- Item 3 - Solar panel mounts and panel elevations should be designed to minimise flood damage.
- Item 4 - Development should comply with the minimum setback distances from waterways.

5.3 Development Impacts

5.3.1 Substation

The development layout (refer to Appendix A) positions the substation in the north western corner of the site. This is the highest portion of the site, which adjoins road frontage (Benambra Road).

The substation footprint is located wholly outside the PMF extent.

Given the above, the risk of Back Creek flooding impacting on the substation is extremely low.

Consideration should be given to elevating the floor level of any substation facility buildings above the ground level (say by 0.3 m) to minimise the risk of any local runoff flooding.

5.3.2 Inverter Stations

The following flood based controls are nominated for the power stations:

- Floor level of the inverter stations should be elevated above the 1% AEP flood levels with an appropriate freeboard added.
- Inverter stations should preferable be located wholly outside or close to the outer edge of the 5% AEP flood extent (i.e. outside the more frequently flooded, higher conveyance, higher hazard flood areas).

The hydraulic modelling undertaken as part of the current assessment is simplified one dimensional modelling using the HEC-RAS model. The modelling has been undertaken using a low accuracy specification DEM dataset.

For the purpose of detailed design of the power stations (i.e. identification of floor elevation heights) it is desirable that 1% AEP flood levels at the location of each of the power stations is identified. The minimum power station design floor height would then coincide with the 1% AEP flood level plus an appropriate freeboard allowance.

Hydraulic conditions on the site are complex. This warrants the use of a two dimensional hydraulic model (e.g. TUFLOW or similar) for the purpose of identifying 1% AEP flood levels for the setting of inverter station floor levels at the time of detailed design. The hydraulic modelling should also be undertaken with a higher accuracy DEM terrain dataset than is currently available.

The current assessment hydraulic modelling indicates that the depth of 1% AEP flooding outside the 5% AEP flood extent will generally not exceed 0.3 m. A 1% AEP flood depth of 0.3 m and an applied freeboard of 0.3 m would position the floor level of an inverter station 0.6 m above the ground surface.

5.3.3 Solar Panel Fields

To minimise the potential for floodwater to impact on the solar panels, the detailed design approach adopted should aim to position the solar panels, when in a horizontal pivoted position, an appropriate freeboard amount above the 1% AEP flood levels to minimise the risk of floodwater damaging the panels.

To this end, the bottom side of the horizontal frame support member should be designed to be elevated above the 1% AEP flood level plus an appropriate freeboard allowance.

Outside the 5% AEP flood extent, the base of the horizontal support frame and / or solar panels will need to be elevated typically no more than 0.6 m above the ground assuming that a freeboard of say 0.3 m is applied.

5.3.4 Perimeter Fencing

Where perimeter fencing around the outside of the development side crosses the waterways at Back Creek and Middle Creek, the fencing will need to be designed to not excessively capture debris carried by floodwater. Excessive debris capture will lead to higher forces on the fence and likely resulting damage.

Where the perimeter fencing crosses the proposed 5% AEP flood extent zone, it is proposed that the lower portions of the fence will consist of a hinged type flood gate arrangement. The flood gates will be free to pivot outwards in the downstream direction and allow debris to pass downstream underneath the flood gate, thereby minimising the risk of debris becoming trapped and obstructing floodwater.

5.4 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 present on the site during flooding.

The reasons for this are as follows:

- 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. no need for persons to be on-site during flooding), assuming that the solar panels are able to be pivoted to a horizontal position remotely.

6. Impact of the Development on Flooding

6.1 Potential Causes

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

- Raising of ground levels (i.e. filling associated with the development, including building pads and raised access tracks).
- Structures obstructing flow (e.g. buildings, bridges / culvert crossings, pole mounts in the case of solar fields, fences).

The above 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.

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.

6.2 Proposed Development Issues

6.2.1 Substation

The largest potential obstruction to flow on the finished development site will be the substation facility buildings.

The substation has been located wholly outside the flood affected area. There is therefore no risk that the substation will result in impacts on flooding conditions.

6.2.2 Power Stations

There are 72 proposed inverter stations located on the site (refer to the development layout plan in Appendix A). The preliminary design footprint for each power station is 18 m^2 (6 m x 3 m).

Inverter stations located within the 1% AEP flood extent will lead to a localised increase in flood level due to floodwater being obstructed by the power station pad / footing. The invert station pads are proposed to be elevated at the 1% AEP flood level plus an appropriate freeboard.

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

- Inverter stations will be predominantly located outside the 5% AEP inundation extent zone.
- Any localised increases in flood level are expected to largely dissipate within the development property.
- There is no existing flood sensitive development within the adjoining properties in close proximity to either Back Creek or Middle Creek.

6.2.3 Solar Panels

The design intent of the solar panels and their supports will be to minimise the potential for floodwater obstruction (refer to Section 5.3.3). This will be achieved by:

- Positioned of the solar panel fields predominantly outside the 5% AEP flood extent
- Ensuring that the horizontal support frame members and the solar panels themselves are elevated above the 1% AEP flood level when in a horizontal pivoted position
- The low density of the 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.

6.2.4 Fencing

All fencing crossing the 5% AEP flood inundation extent should be designed with the objective of minimising the extent to which the fencing traps debris and obstructs floodwater. This is particularly important for the boundary perimeter fencing, where obstructions will affect the adjoining property.

An appropriate fence design will be identified during detailed design. This is likely to be in the form of the lower portion of the fence line consisting of a hinged flood gate, designed to open outwards in the downstream direction during a flood thereby allowing debris to pass through below the hinged flood gate.

The impacts of site fencing on flooding can therefore be adequately minimised providing an appropriate fence design is adopted.

6.2.5 Access Roads

The proposed alignment of the internal access roads is shown on the development layout plan included in Appendix A.

The following controls are nominated for the access roads:

- Access roads located within the 1% AEP inundation extents should not be raised more than 100 mm above the adjoining ground surface level.
- Access roads located within 100 metres of the upstream property boundaries (Back Creek – eastern boundary, Middle Creek – southern boundary) should not be raised more than 60 mm above the existing ground surface.

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

The preliminary access road design arrangement has the outer surface of the access roads positioned at existing ground level, with 3% camber to the road centreline. Based on this arrangement, the crown of the access road will be typically 0.06 m above the existing ground level.

The development layout plan does shows one crossing of the Back Creek waterway and one crossing of the Middle Creek waterway. The detailed design arrangements for these two crossings should demonstrate that the two crossings are not likely to excessively obstruct floodwater.

A ford type crossing will achieve this and will be suited for the Middle Creek crossing, where no incised channel is present. Either a ford type crossing, or a low flow culvert structure, or a modified form of the existing informal structure will be best suited for the Back Creek crossing.

6.3 Impacts of Development on Floodplain Environmental Values

The development layout (refer to Appendix A) includes a development corridor buffer zone extending over and either side of the length of Back Creek. This development buffer zone encompasses the woodlands on either side of Back Creek. The development is not therefore expected to impact on the floodplain environmental values (e.g. woodland native trees) within the Back Creek corridor.

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

7. Summary and Conclusions

Flooding from Back Creek and Middle Creek affects parts of the development site.

The extent of 5% and 1% AEP flooding from the two creeks is shown on Figure 5. The 5% AEP flood inundates 15% of the development site. The 1% AEP flood extent inundates 31% of the development site.

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

- Development will be largely excluded from within the 5% AEP flood extent.
- The development infrastructure most sensitive to flooding impacts will be positioned outside the 1% AEP flood event or above the 1% AEP flood level.

The flood risk posed to life, health and safety from the 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 flood event with pivoting of the solar panels to a horizontal position expected to be initiated remotely.

The risk posed by the 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 substation facilities, the 72 inverter stations and height limited access tracks.
- The solar panels when a horizontal pivoted position and the supporting horizontal racks (if applicable) are wholly elevated above the 1% AEP flood level.
- Site fencing within the 5% AEP extent is designed to minimise the potential for debris blockage.

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

- The Back Creek corridor including the adjoining woodland on either side of the creek is wholly positioned outside the development area and will not therefore be affected.
- Existing site drainage characteristics will be largely retained, given the absence of land filling with the exception of the substation, power stations and access tracks.

In summary, the key findings of this assessment are:

- The proposed development activity appears compatible with the identified flood risk for the site.
- The development is not expected to cause adverse impacts on flooding conditions on the surrounding rural land use properties.

This assessment has been completed to provide input into the planning approval process and the design of the preliminary layout. It is recommended that two dimensional hydraulic modelling be undertaken at the time of detailed design for the purpose of identifying 1% AEP flood levels for the setting of minimum floor heights for flood sensitive components of the development. The hydraulic modelling during detailed design should be undertaken with a higher accuracy acquired DEM terrain dataset than is currently available.

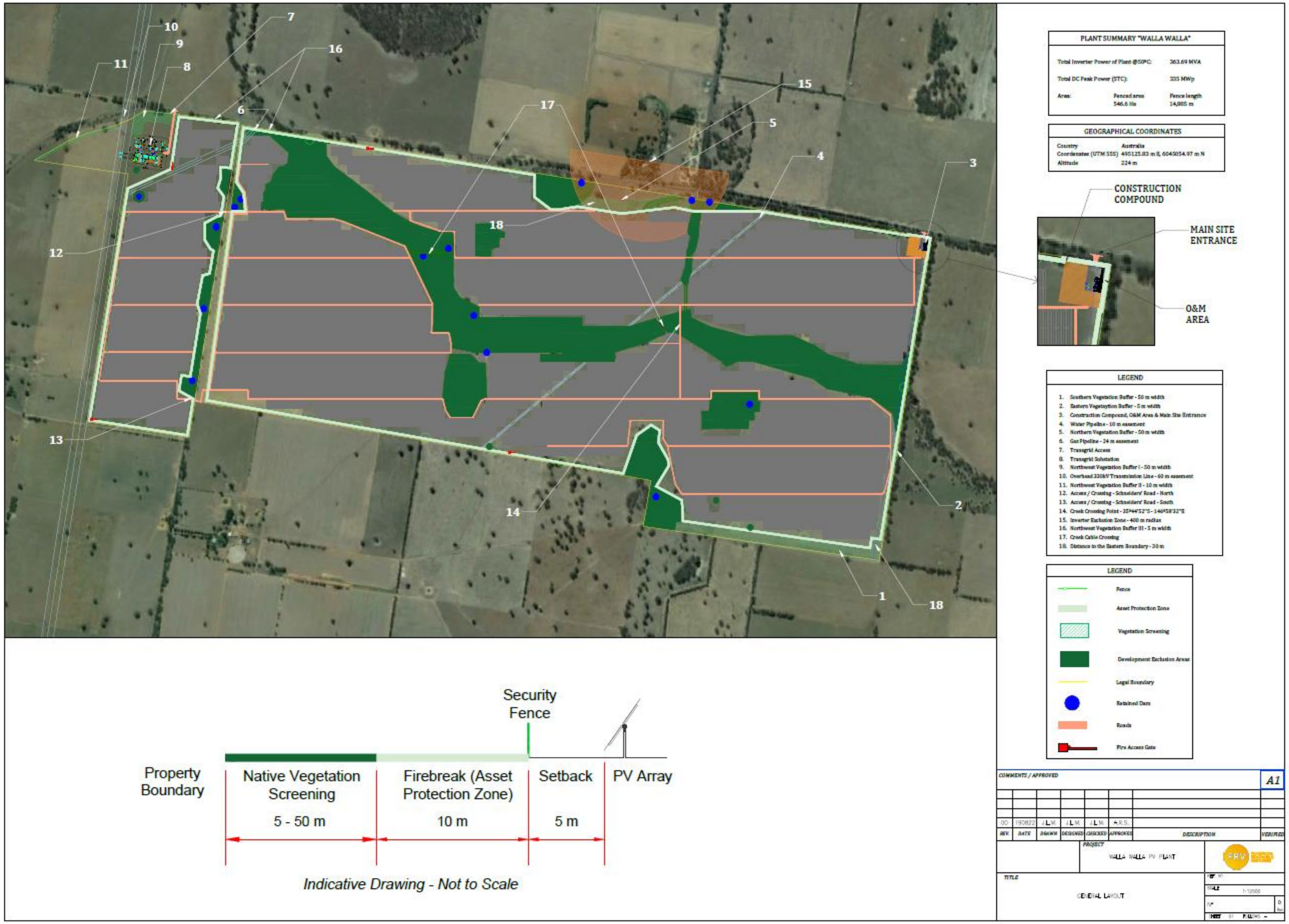
8. References

GHD Pty Ltd (February 2017). *Walla Walla Flood Study, Floodplain Risk Management Study and Plan – Flood Study Final Report*. Prepared for Greater Hume Shire Council.

Appendices

Appendix A – Development Layout Plan

Walla Walla PV Plant – General Layout


PLANT SUMMARY "WALLA WALLA"
Total Inverter Power of Plant @50ºC: 363.69 MVA
Total DC Peak Power (STC): 335 MWp
Area: Fenced area 546.6 Ha Fence length 14,005 m
GEOGRAPHICAL COORDINATES
Country Australia
Coordenates (UTM 55S) 495125.83 m E, 6045054.97 m N
Altitude 224 m
CONSTRUCTION COMPOUND
MAIN SITE ENTRANCE
O&M AREA
LEGEND
1. Southern Vegetation Buffer - 50 m width
2. Eastern Vegetaytion Buffer - 5 m width
3. Construction Compound, O&M Area & Main Site Entrance
4. Water Pipeline - 10 m easement
5. Northern Vegetation Buffer - 50 m width
6. Gas Pipeline - 24 m easement
7. Transgrid Access
8. Transgrid Substation
9. Northwest Vegetation Buffer I - 50 m width
10. Overhead 330kV Transmission Line - 60 m easement
11. Northwest Vegetation Buffer II - 10 m width
12. Access / Crossing - Schneiders' Road - North
13. Access / Crossing - Schneiders' Road - South
14. Creek Crossing Point - 35º44'52"S - 146º58'32"E
15. Inverter Exclusion Zone - 400 m radius
16. Northwest Vegetation Buffer III - 5 m width
17. Creek Cable Crossing
18. Distance to the Eastern Boundary - 30 m
LEGEND
Fence
Asset Protection Zone
Vegetation Screening
Development Exclusion Areas
Legal Boundary
Retained Dam
Roads
Fire Access Gate
COMMENTS / APPROVED
A1
REV DATE DRAWN DESIGNED CHECKED APPROVED DESCRIPTION VERIFIED
PROJECT
WALLA WALLA PV PLANT
TITLE
GENERAL LAYOUT
Security Fence
Property Boundary
Native Vegetation Screening
5 - 50 m
Firebreak (Asset Protection Zone)
10 m
Setback
5 m
PV Array
Indicative Drawing - Not to Scale

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3137251-94971/https://projects.ghd.com/oc/Victoria3/wallawallasolardevel/Delivery/Documents/3137251-REP-WallaSolarSiteFloodAssessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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1	T Clark	J Ellwood	John Ellwood	J Ellwood	John Ellwood	15/10/2019

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