Gunnedah Solar Project – Phase 2
Water Management Plan

September 14, 2020

Prepared for:

PCL Constructors Pacific Rim Pty Ltd.
Level 11
485 Bourke Street
Melbourne, VIC 3000

Prepared by:

Stantec Australia Pty Ltd.
Level 4, 99 Walker Street
North Sydney, NSW 2061

Revision	Description	Author		Quality Check		Independent Review	
0	Preliminary WMP	2020/07/22	DW	2020/07/27	BW	2020/07/27	PB
1	Preliminary WMP – Response to NSW DPIE Comments	2020/09/10	DW	2020/09/14	BW	2020/09/14	PB

David Williams – 2020/09/14

Prepared by ____
(signature)
David Williams, P.Eng. (Ontario, Canada)

Bedilu Wolelo – 2020/09/14

Reviewed by ____
(signature)
Bedilu Wolelo, Bsc(Civil), GradCert, MSc, MEngsc, MIEAust, CPEng, RPEQ, NER

Peter Bright – 2020/09/14

Approved by ____
(signature)
Peter Bright, Project Manager

Table of Contents

LIST OF APPENDICES

1.0 INTRODUCTION

Stantec Australia Pty Ltd (Stantec) has been retained by PCL Constructors Pacific Rim Pty Ltd. (PCL) to provide engineering services for the 147 MW Gunnedah Solar Project located at 765 Orange Grove Road, Gunnedah, New South Wales (NSW) (Site). The Site is located approximately 10 km north east of Gunnedah Township, 430 km north west of Sydney.

The approved Phase 1 of the Water Management Plan (Stantec, June 2020) documented stormwater management and erosion and sediment controls for the construction of the main access road, stretching from Orange Grove Road to the location of the substation.

This report documents Phase 2 of the Water Management Plan encompassing the remainder of the proposed works 3.24 and 4.24 of the project's Development Consent (Application Number SSD 8658). It is noted that Phase 2 of the Water Management Plan reflects the current grading design for the site with minor design changes anticipated for the site, however significant changes to flooding characteristics of the site and water management are not anticipated.

1.1 BACKGROUND INFORMATION

A list of resources referenced when completing this preliminary water management plan has been provided below for reference:

- *Gunnedah Solar Project – Early Works – Phase 1 Water Management Plan*, Stantec Consulting Ltd., June 2020
- *Gunnedah Solar Farm – Flood Risk Assessment*, Stantec Consulting Ltd, March 2020
- *Gunnedah Solar Farm Development Consent* – Independent Planning Commission of NSW, March 12, 2019
- *Australia Rainfall and Runoff (ARR)*, Geoscience Australia, 2019
- *Gunnedah Solar Farm Environmental Impact Statement*, Pitt & Sherry Pty Ltd., April 17, 2018
- *Guidelines for watercourse crossings on waterfront land*, NSW Department of Primary Industries – Office of Water, July 2012
- *Managing Urban Stormwater: Soils and Construction* – Landcom, 2004

In addition to the above noted reference documentation various communications with project team members from Stantec, PCL and Canadian Solar (CS) were considered.

2.0 EXISTING CONDITIONS

Under existing conditions the current land use of the site is primarily agricultural being used for row crops.

2.1 TOPOGRAPHY

The project area is relatively flat with ground slopes in the 0.1 to 0.5% range. Ground surface elevations range from 256 to 280 metres above sea level (masl).

2.2 EXISTING SITE HYDROLOGY

In general, runoff from the site drains as shallow overland flow towards the west. There are no significant natural drainage features across the site. The entire site is bound by irrigation channels which are approximately 5 m wide, 2-3 metres deep with a negligible longitudinal slope. During runoff events water is stored within these channels until they are pumped for irrigation or water infiltrates/evaporates. Anecdotal evidence from PCL suggests that irrigation channels infiltrate/evaporate within 3 days to a week of a rainfall event.

2.2.1 Flood Risk Assessment

An existing conditions flood risk assessment was completed by Pitt & Sherry Pty Ltd. (2018) and Stantec (2020) addressing requirements for regional and local flood modeling, respectively. These reports are available under separate cover. A summary of the local flood modeling is included in Section 6 of this report.

2.3 SOILS AND HYDROGEOLOGY

Site soils are described in the Environmental Impact Statement (EIS) as “deep alluvial brown clays, typically comprising clay loam toposoil’s (sic) over clay loam to medium clay soils” (pitt&sherry, 2018). The EIS suggests the erosion potential of the site as low to moderate hazard for rill and gully erosion

Groundwater depths range from 6.7 to 7.6 m below ground surface (bgs) in the area. The Site is not designated as groundwater vulnerable under the Gunnedah Local Environment Plan (LEP).

3.0 PROPOSED CONDITIONS

The Gunnedah Solar Project includes approximately 14 km of 4.5 to 6.5 m wide access roads, 45 inverter stations located on granular pads, one substation, a switching yard, laydown areas for construction and the ground mounted solar panels.

The design of the Gunnedah Solar Project employs a low-impact approach to site development. The grading plans appended, show that the proposed grades will match existing grades wherever possible; existing drainage patterns are preserved wherever possible; roads will typically be constructed at grade to maintain existing drainage patterns; and site excavation will be kept to a minimum in order to retain as much existing ground cover as possible.

Once panels and racking are in place, all accessible disturbed areas will be scarified to alleviate soil compaction prior to restoration seeding. The post-development hydrology will mimic a permanently grassed pasture, which represents an improved hydrologic condition over the existing agricultural land use.

It is understood that site inverter stations, switching station and other site infrastructure will be installed on piles such that the bottom floor elevation of the infrastructure is above the 1% AEP regional flood event.

Design of the substation pad in the southern portion of the site was completed by TransGrid. This area consists of substation infrastructure installed on a granular pad designed to raise floor elevations above the 1% AEP regional flood event.

3.1 GRADING AND DRAINAGE STRATEGY

The proposed grade of the access road generally matches existing conditions elevations on site. In areas where the access road crosses a topographical low the access road has been designed to meet the existing low point. Armouring will be provided in the form of a hardened surface and/or road sealer at road crossings where erosive velocities are exceeded for the proposed granular surface. Hardened surface / road sealer locations and extents will be confirmed prior to issuing drawings for construction.

Equalisation culverts have been provided in the existing site irrigation channels to provide a connection under the proposed access road. Culverts have been sized to fit within the base of the channel, without requiring over excavation of the side slopes. As the irrigation channels are used for storage of runoff and managed by a pump, conveyance of specific storm events is not required.

3.2 DROP-DOWN / FLOW THROUGH FENCING

Per the regional flood risk assessment, approximately 50% of the site perimeter fencing is required to be drop down fencing. A drawing of the proposed perimeter fence has been appended for reference, in which a flow through fence design has been selected instead of a drop-down fence. The flow through fence consists of a standard fence panel, with a pivot pin halfway up the fence. The bottom of the fence is secured using a 4 mm low tensile wire (designed by others) which will release following buildup of debris along the fence, allowing debris to flow under the fence during a high flow event. Following the event, the fence will fall back into place providing temporary security until a low tensile wire can be installed.

4.0 STORMWATER MANAGEMENT DESIGN

4.1 WATER QUANTITY CONTROLS

Grading design has been completed to mimic existing site drainage conditions. The increase in impervious coverage to downstream areas as a result of the installation of the proposed access road and substation infrastructure is minimal compared to the upstream drainage catchments. Therefore any increase in flows, and impact to downstream areas as a result of the access road construction is expected to be negligible (outlined in section 6.2.2).

It is noted that the site is bounded by existing irrigation channels, including a 5+ m wide irrigation channel on the adjacent property to the west running parallel to the main access road. It is anticipated that overland flows leaving the site will enter adjacent irrigation channels and redistribute throughout the channel prior to spilling and continuing downstream, similar to existing conditions.

4.1.1 Flow Through Fencing Monitoring Requirements

The primary concern for flooding impacts relate to the perimeter fencing and potential of increase in flooding due to blockage from flood debris. Following a significant rainfall event (> 25 mm in depth) or a Namoi River flood event (overtopping of Orange Grove Road in the vicinity of the site), the perimeter fence will be inspected (within 24-72 hours of the event) for damage, evidence of flow and debris along the fence and flow through fence activation (broken connectors). High water marks will be identified on interior solar panel racking and adjacent perimeter fence posts in locations identified on the attached figures. High water marks are to be measured as depth from ground surface. If it is noted that high water marks are different (> 200 mm) between external and adjacent internal features, further investigation into the performance of the drop-down/flow through fencing will be required.

Inspections shall be recorded within a log-book (including, date/depth of rainfall event, date of inspection, inspector name and high water mark measurements) and kept in the site operation and maintenance building. Log-books will be made available to local regulatory agencies upon request.

If regular monitoring concludes that the current fencing configuration requires improvement, the following mitigation measures may be considered:

- Install lower strength shear pins / connections (if debris build-up is identified on drop-down fencing panels and little evidence of flow through is identified)
- Increase percentage of flow though fencing panels along west and east edges of site
- Revise drop-down/flow fencing configuration

In addition to monitoring following significant rainfall events, regular monitoring of perimeter fencing should be completed to ensure shear pins / low-tensile wire connections are still intact and site security is maintained.

4.2 WATER QUALITY CONTROLS

As mentioned above the increase in impervious coverage to downstream areas as a result of the installation of the proposed access road is minimal compared to the upstream drainage catchments. In addition the remainder of the site will be converted from agricultural land with repeated disturbance to a permanently vegetated pasture improving the sites ability to prevent erosion and retain site soils in-situ.

Hardened surfaces and/or road sealing are proposed at access road low points / surface water crossings in order to mitigate erosion and transport of sediments downstream, while irrigation channels will have permanent rock check dams at regular intervals to promote sediment deposition.

No additional formal stormwater management water quality controls are recommended for the site.

4.3 LONG-TERM STORMWATER MANAGEMENT MONITORING PROGRAM

Implementation of a post-construction monitoring program provides the data necessary to assess that the stormwater management system is functioning as designed. The following objectives of the post-construction monitoring program should be assessed on a routine basis:

- Ensuring site vegetative cover is maintained and areas of exposed soil remediated
- Routine observations as to the presence of retained trash/debris that could be conveyed downstream and/or affect the conveyance capacity of the system and removal of same as needed
- Ensuring all surface water crossings are free of flow obstruction with armoring on access roads suitable for conveyance at low points
- Ensuring functioning condition of the on-site culverts
- Ensuring that the perimeter fence is functioning to allow the passage of floodwaters through the site
- Maintaining both the use and integrity of surrounding irrigation channels for stormwater storage

4.3.1 Visual Inspections

Site Vegetation

Regular inspections should be completed to identify areas of bare soil and/or the formation of erosive gullies. Remediative efforts would typically involve re-grading the area and/or re-vegetating with sod or appropriate seed mix, with fertilizer and water applied as necessary to ensure germination and stabilization

Vegetation management is not a strict requirement in that excess growth will serve to improve water quality treatment benefits. If the density of vegetation reaches a level where conveyance capacity is impacted, a cutting operation should be undertaken. A minimum vegetation height of 0.15 m should be maintained.

Drainage Swale Conveyance System

Routine observations of ditches for erosion and/or presence of trash/debris within the swale that could be conveyed downstream and/or effect the conveyance capacity of the system should be conducted.

Access Road Low-Points

Regular inspections of the low points should be conducted to assess the low point for erosion and/or potential flow blockages inhibiting smooth passage of water across the low point.

On-site Infrastructure

On-site culverts are used to convey stormwater under the site access roads. Routine inspections of the culverts should be conducted to ensure that the culverts can pass water per their design capacity. The inspector should be looking for flow obstructions and culvert damage which could impede the conveyance capacity of the culvert.

Site Perimeter Fencing

The perimeter fencing is designed to maintain existing floodwater drainage. Per Section 4.1.1 the perimeter fencing should be inspected to ensure the fence is capable of maintaining flow passage through the fence.

5.0 SEDIMENT AND EROSION CONTROL (SEC) MEASURES

The various construction activities required for construction include topsoil removal, minor area grading, placement of granular material, installation of piles, racking and panels and general construction traffic. If left unmitigated, these activities will result in impacts ranging form disturbance of at-surface soils to potential erosion and sediment transport to downstream locations.

Erosion control will be achieved primarily by:

- Managing disturbed soils using soil conservation practices to reduce runoff and sediment transport during construction;
- Constructing barriers to filter runoff

Erosion and sediment control measures (detailed on Drawing C-600) will be implemented prior to any grading or servicing works commencing, and include, but are not necessarily limited to, the following measures:

- Perimeter sediment fencing will be installed at the downstream side of the work limits
    - Where shallow topsoil depths prevent trenching in the filter fabric, 150 mm of clear stone or pea gravel will be used to provide contact between the fabric and ground surface.
- A construction entrance feature ("shaker") will be provided at the site entrance to minimize the offsite transport of sediment via construction vehicles.
- Orange Grove Road will be inspected for and cleaned daily of any sediment (if necessary) deposited by site construction traffic.
- Sediment and erosion control berms provided downstream of disturbed areas (as shown on drawings) to promote settling of any solids entrained in stormwater runoff
- Stabilise topsoil stockpiles expected to be left in place longer than 10 days with vegetative cover (i.e., hydroseeding) or a rolled erosion control product in the event of unfavourable growing conditions. Topsoil stockpiles are to be surrounded by sediment fence.
- No equipment will be permitted to enter any area beyond the proposed work limits during construction.
- Water or synthetic dust suppressants will be employed to manage wind erosion and reduce dust generated from unsealed roads, stockpiles or areas of disturbed soil.
    - Dust generating activities shall be limited during periods of high velocity wind, as determined by the Construction Manager
- Re-vegetate all disturbed areas where construction is not expected for 20 days with sufficient topsoil to support re-vegetation and hydro-seeding or other stabilising vegetation / erosion protection. If, given seasonal restriction or other revegetation limiting factors, the disturbed area should be stabilised against erosion impacts by non-vegetated means such as erosion control blankets.

- All materials and equipment used for site preparation and project construction should be operated and stored in a manner that prevents any deleterious substance (e.g., petroleum products, silt, etc.) from migrating to offsite receivers.
    - Refueling and maintenance of construction equipment should occur in designated areas, a minimum of 100 m from a water body.
- All spills must be reported to the appropriate regulatory authority(ies).
- In the event of inclement weather or unfavourable terrain for construction, construction best practices, such as temporary rig-mats may be used to prevent disruption of surface soils and vegetative cover by construction vehicles and equipment.
- Sediment and erosion control measures are to be cleaned out when sediment reaches 1/3 of the available storage capacity.
- In the event of large or back-to-back storm events where on-site irrigation channels begin to exceed 80% capacity, irrigation channels may be pumped to provide additional containment volume. Pumped water will be discharged through a filter sock a sediment trap located on a gently sloped, vegetated area (when possible) greater than 50 m from any waterbody or downstream property.
- Silt-soxx (or approved equivalent) will be installed downstream of all proposed culvert crossings to minimise transport of sediment downstream.
- Culvert crossings will be installed with a rip-rip apron upstream and downstream of culvert entrances and exits to mitigate erosion as a result of flow concentration.

5.1 CONSTRUCTION DEWATERING

Since no significant excavation is anticipated for the construction of the Gunnedah Solar Farm, construction activities are not expected to intercept the groundwater table. However, if necessary, any required dewatering operations will be completed such that discharge rates will not adversely impact flooding or erosion conditions upstream or downstream of the Site. To mitigate the risk of sediment migration to downstream areas, dewatering discharges may be treated with a variety of measures including, but not limited to, filter socks or sediment traps at the discretion of the contractor in consultation with the owner's engineer. Dewatering measures will be directed through the sediment control measures to a gently sloped, vegetated area (when possible) greater than 50 m from any waterbody or downstream property.

Although an exceedance isn't expected, should anticipated pumping rates exceed 3,000,000 L/water year (July 1 to June 30) a Water Access License will need to be obtained with sufficient entitlement to account for the total water take prior to the taking occurring.

5.2 PROJECT CONSTRUCTION WATER SUPPLY

Construction water requirements anticipated for the project include dust suppression and compaction. Water supply will be provided using on-site bores currently under agreement from the existing landowner.

The anticipated water consumption for the construction phase of the project is 240,000 L/day for a total of 30,240,000 L over the six (6) month construction timeline.

5.3 CONTINGENCY PLAN

The purpose of the contingency plan is to help minimize the risk or consequence of failure of the erosion and sediment control works. Failure could result from insufficient measures, lack of maintenance, or severe weather conditions. The contingency plan includes two areas of consideration: the procedures that will be followed where a failure has occurred; and the contingency measures that will be implemented where there is potential for failure.

The Contractor shall be responsible for following the contingency plan, and will prepare the following items:

- Workers shall be on call for emergency situations for all aspects of the emergency from design to construction of emergency sediment and erosion control measures. Any associated health and safety issues are the responsibility of the Contractor.
- Heavy duty silt fence, erosion control blankets, straw bales and stakes or silt-soxx, sandbags, appropriate sized rip-rap, and clean gravel fill shall be available on-site for emergency installation.
- Heavy equipment shall be on standby for emergency works.
- Fuel spill containment supplies and equipment shall be available on-site for emergency spills of deleterious substances.
- A contact list for any further required equipment or materials shall be prepared and made available for emergency use.

5.3.1 Contingency Measures in Case of Failure

In the event of a failure, the Contractor will cease all construction related work and focus on erosion and sediment control as required to effectively stabilise the site where a failure has occurred or is imminent.

If significant long-term damage to downstream fish habitat or property is suspected, the Environmental Monitor will immediately assess and document the situation and report the incident to the appropriate regulatory agencies The Contractor will develop a restoration plan in consultation with regulatory authorities. Development of the initial restoration plan will begin within 24 hours of the discovery of sediment discharge, and will be implemented as soon as possible, following consultation and approval. The plan will address:

- Removal and disposal of sediment from outside the work limits;
- Restoration of the affected area; and
- Restoration of any areas disturbed through deposition or removal.

5.3.2 Contingency Measures where there is a High Risk of Failure

Conditions that may potentially cause failures can be identified through two methods: monitoring of the erosion and sediment control measures, and weather forecasts that anticipate severe weather conditions.

5.3.2.1 High Risk Identified Through Monitoring

Where monitoring has identified a high potential for failure, steps shall be immediately taken to reduce the risk. These measures may include repair to existing measures, modification of existing measures, and the addition of new measures.

5.3.2.2 Severe Weather Anticipated

In cases where the weather forecast indicates that significant rainfall is expected within a 24-hour period, the Contractor shall immediately complete the following:

- Verify that all erosion and sediment control measures are secure and that there is no exposed soil that could erode and be deposited downstream;
- Verify that all other measures are in good working order;
- Monitor all measures during the rainfall event, and where a potential for failure is identified, take corrective measures.

If unforeseen events cause the strategies set out in the contingency plan to be insufficient or inappropriate to meet the objective of containing sediment within the work limits, the Contractor will respond in a timely manner with all reasonable measures consistent with safety, to prevent, counteract or remedy any negative effects on the natural environment or adjacent properties.

5.4 EROSION AND SEDIMENT CONTROL MONITORING PROGRAM

To ensure the effectiveness of the various erosion and sediment control measures, a routine program should be implemented which includes the inspection of the erosion and sediment controls weekly and after each rainfall event generating runoff, and immediate repair of any deficiencies. Non-urgent repairs (i.e., no immediate risk of sediment discharges to the downstream environment) will be completed within 48 hours of identifying the deficiency, or prior to the next anticipated rainfall event, whichever is less. This program will consist of the following activities:

- Visual inspection of the SEC measures to ensure discharged flows are generally free of sediment and turbidity;
- Inspection of vegetation protection, erosion control blankets and silt fencing to ensure that they are maintained in good repair;
- Removal of construction debris that may accumulate; and

- Implementation of remedial measures including erosion stabilization, repair of damaged measures and any other remediation where required.

If the monitoring program outlined above indicates a persistent problem, then the following steps should be undertaken to determine appropriate mitigative measures (if step 1 does not resolve the issue, proceed to step 2):

1. Analysis of the monitoring information and field visits as required, to determine the cause of the problem and develop a mitigation plan to address the issue in consultation with a qualified Environmental Monitor.
    a. Implement additional mitigation measures and monitor the results.
2. Convene a meeting with the appropriate review agencies.
    a. Develop a consensus on a proposed plan of action to resolve the problem in consultation with agency staff.
    b. Implement additional mitigation measures and monitor the results.

5.5 LONG TERM EROSION AND SEDIMENT CONTROL

Approximately one (1) year after completion of construction, a site inspection will be completed to ensure that long-term erosion control measures have been effective. Seeded or replanted areas will be inspected to ensure that vegetation measures were successful and reseeding or replanting will occur where necessary.

If erosion control measures are found to be less than fully effective during this survey, reseeding or replanting of problem areas will take place. Should there be residual effects noted during post-construction monitoring, advice on contingency measures will be sought and applied.

6.0 FLOODPLAIN MAPPING

Floodplain mapping was complete to address requirements outlined in the *Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019* (New South Wales, 2019) and the *Carroll to Boggabri Floodplain Management Plan* (NSW Department of Natural Resources, 2006). A detailed floodplain assessment is included in the *Gunnedah Solar Farm Hydrology Report* (Stantec, 2020).

6.1 SITE FLOODPLAIN CHARACTERISTICS

During major storm events Namoi River breaks bank and drains in a westerly direction across the access road. The site design was completed taking into account the requirements of the *Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019* to maintain flow characteristics during local and regional flood events. The vertical alignment was designed to blend with the existing ground form.

The vertical geometric alignments of the access roads follow the existing ground level. Cut was required at sections of the alignment and slight fill, not exceeding 0.5m was provided at sections of the road to maintain geometric design requirements.

Hardened surface is provided at sag points to allow runoff to drain across the road.

Equalisation culverts are provided at road crossings of existing irrigation channels, maintain connectivity.

6.2 FLOODPLAIN MANAGEMENT

The project site is located in the Upper Namoi Management Zone BL. The Zone BL management zone is important for the conveyance of floodwaters during large flood events. The *Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019* designates access road construction inside Zones BL and AID as flood works. Division 5 of the flood management plan provides rules for granting or amending flood works approvals in Upper Namoi Management Zones BL and AID. Floodplain modeling for the subject works was documented in the *Gunnedah Solar Farm Hydrology Report* (Stantec, 2020), attached.

6.2.1 Fish passage requirement

Inundation of the site occurs during the 10% AEP storm event. There is no defined watercourse along the road alignment and hence there is no permanent water feature along the access road alignment. Fish may cross the proposed road during this rare storm event. The hard pavement provided at the sag points and the road design will meet fish passage requirement as:

- The road is designed to follow the natural ground and minimises barrier to fish crossing
- The site a prime agricultural land that has a flat regular gradient of less than 0.5%, this has resulted in flow velocities less than 0.5m/sec during major regional storm events

- There is less turbulence created at downstream end of the access road as the difference in height above natural ground surface is limited. Turbulence to flow is limited and fish passage will be maintained

6.2.2 Flood characteristics

The proposed works vertical geometry undulates following the existing ground topography. Fill height is limited along the project to limit increase in flood level upstream and redistribution of flow on adjacent landholdings.

A flood model was completed to determine the impact of the proposed road on flow characteristics during the 1% AEP storm event generated from local catchments. The study has indicated that:

- The maximum reduction in depth of flow downstream of the site was 2 mm
  - This minor reduction, within the limits of accuracy of the hydraulic model
- The maximum increase in flood level downstream of the access road was 0.05m and the increase occurs at a ford crossing inside the project site limits
- The maximum increase in flood level upstream of the project was 90mm
  - The increase in flood level occurs inside project boundary.
- The difference in maximum flow velocity under proposed conditions 0.25m/sec.
  - The increase is within the limits acceptable by the upper Namoi Valley Flood Plain Management Plan.

The flood level difference maps were provided as appendix to the *Gunnedah Solar Farm Hydrology Report* (Stantec, 2020), attached. The flood study has indicated that the impacts are minor and that the impacts occur within the project limits. The study has indicated that there is no impact on adjacent landholding due to the construction of the proposed project.

6.2.3 Overall

The proposed site is designed taking into consideration the requirements of the *Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019*. There are no defined watercourses within the site. Runoff occurs as a sheet flow. With the site being flat (i.e., a grade less than 0.5%) maximum flow velocity across the site is less than 0.5m/sec. With the main access road, internal access road and minor grading design blending into the existing natural terrain, there was limited increase in flood levels upstream and limited/no increase in flow redistribution for downstream property.

The proposed site design was assessed against the requirements of the floodplain management plan for the upper Namoi River and it meets all the requirements.

7.0 CONCLUSION

Based on the findings of this report, the following recommendations are provided.

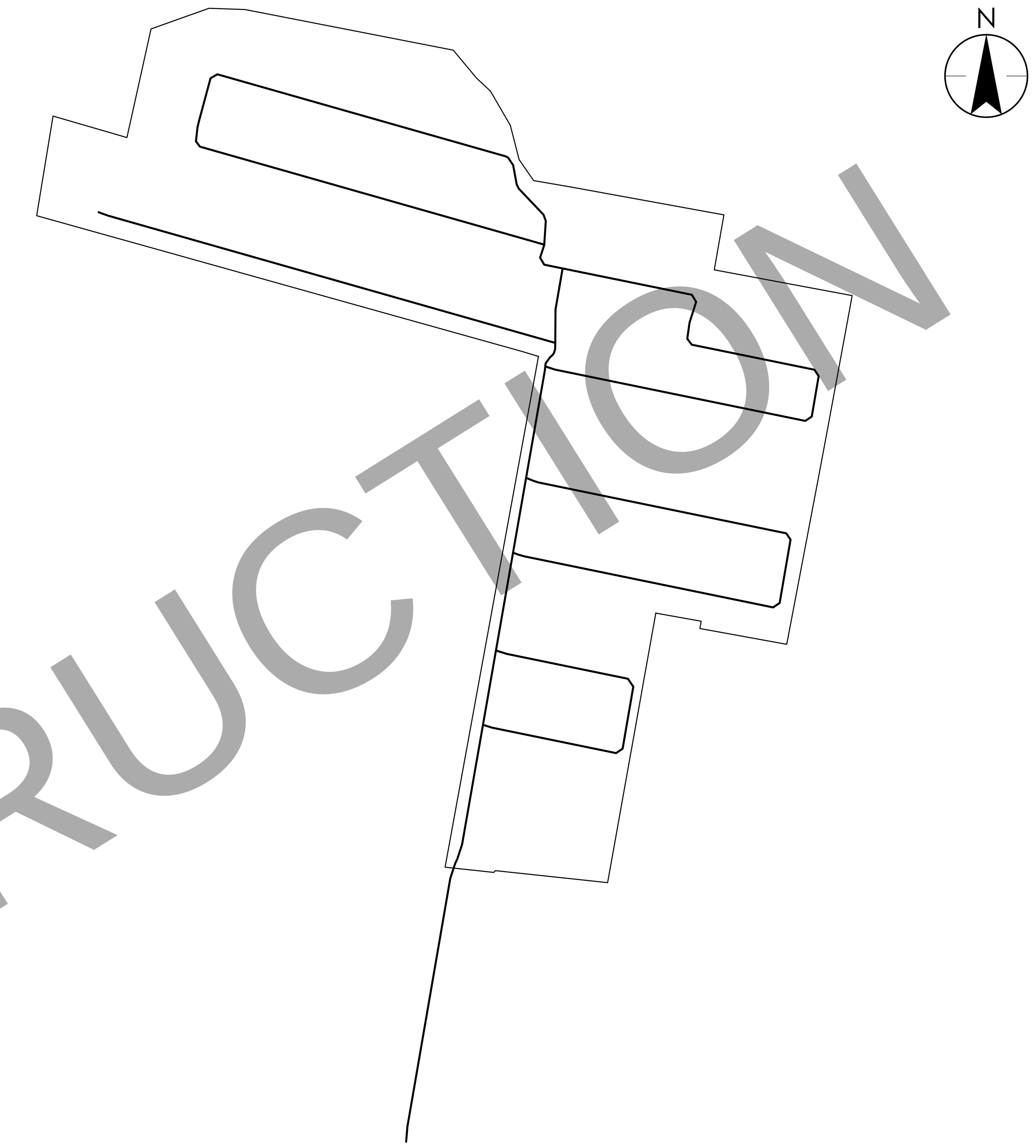
- The proposed stormwater management measures in this report shall be constructed as designed;
- The SEC measures documented herein shall be implemented during construction; and
- The monitoring and maintenance program (for both fencing and SEC) shall be carried out during and following construction;

DRAWINGS

Stantec

PCL

CONSTRUCTION LEADERS



DRAWING LIST

CIVIL

C010 SITE PLAN 1 TO 6
C050 EXISTING CONDITIONS, CLEARING, GRUBBING AND FENCING PLAN 1 TO 6
C200 PLAN & PROFILE, ENTRANCE & ACCESS ROAD 1 TO 16
C400 GRADING PLAN 1 TO 19
C500 NOTES AND DETAILS
C600 EROSION AND SEDIMENT CONTROL PLAN 1 TO 19

CANADIAN SOLAR AUSTRALIA
GUNNEDAH SOLAR PROJECT
147MW GROUND MOUNTED SOLAR FARM

GUNNEDAH, NEW SOUTH WALES, AUSTRALIA

APRIL, 2020
CIVIL PACKAGE
ISSUED FOR 30% REVIEW
Project Number: 3600727160

ORIGINAL SHEET - ISO A1
C:\Users\jchilds\Desktop\working Folder\3600727160 - Gunnedah Solar\design\drawing\civil\sheet_files\3600727160_C-CV.dwg
2020/07/26 11:37 PM By: Childs, Jason

INSPECTION FORMS

Stantec

RAINFALL EVENT MONITORING INSPECTION FORM

Project: GUNNEDAH SOLAR PROJECT

Project #: 3600727160

Inspection Date (m/d/y) ______________________________

Location: 765 Orange Grove Road, Gunnedah, NSW

Date of Rainfall Event (m/d/y) _________________________

Depth of Rainfall Event _____________________________________

HIGH WATER MARK OBSERVATIONS

Monitoring Location	External Measurement	Internal Measurement	High Water Difference	Monitoring Location	External Measurement	Internal Measurement	High Water Difference
1				17			
2				18			
3				19			
4				20			
5				21			
6				22			
7				23			
8				24			
9				25			
10				26			
11				27			
12				28			
13				29			
14				30			
15				31			
16							

*Measurements taken as depth from ground surface at panel racking or perimeter fence post, per monitoring location figure

Concerns/Comments:

____

____

____

____

PERIMETER FENCE OBSERVATIONS

Fence Condition (comment on evidence of flow and accumulated debris – markup attached map as necessary):

____

____

____

____

Fence connections (comment on location and condition of damaged or broken connectors – markup attached map as necessary):

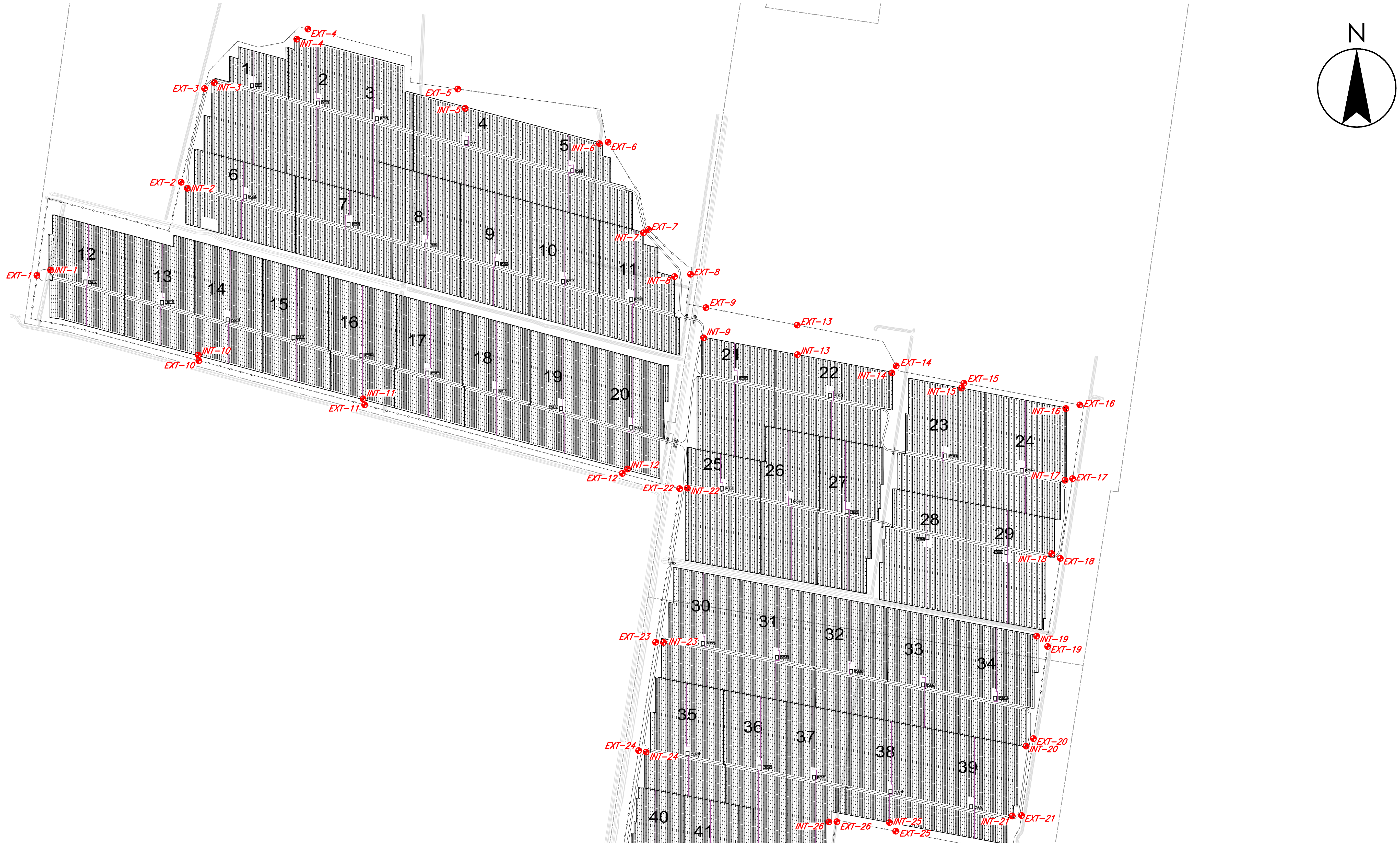
____

____

____

_____________________________ _____________________________________ _______________________

Print Name Signature (Inspector) Date



C:\Users\jchilds\Desktop\Working Folder\3600727160 - Gunnedah Solar\design\drawing\civil\sheet_files\3600727160_MONITOR_HWM_FIG.dwg
8/5/2020 9:49:15 AM By: Childs, Jason

Stantec

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo ON N2L 0A4
Tel: (519) 579-4410
www.stantec.com

LEGEND

EXT-24 MONITORING LOCATION

Client/Project

PCL CONSTRUCTION

GUNNEDAH SOLAR PROJECT

Project No.
3600727160

Title

HIGH WATER MARK MONITORING LOCATIONS

Revision	Date
0	2020.08.04
Reference Sheet	Figure No.
1	1

C:\Users\jchilds\Desktop\Working Folder\3600727160 - Gunnedah Solar\design\drawing\civil\sheet_files\3600727160_MONITOR_HWM_FIG.dwg
8/5/2020 9:51:54 AM By: Childs, Jason

Stantec

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo ON N2L 0A4
Tel: (519) 579-4410
www.stantec.com

LEGEND

EXT–24 — MONITORING LOCATION

Client/Project

PCL CONSTRUCTION

GUNNEDAH SOLAR PROJECT

Project No.
3600727160

Title

HIGH WATER MARK MONITORING LOCATIONS

Revision	Date
0	2020.08.04
Reference Sheet	**Figure No.**
2	2

Stantec

GUNNEDAH SOLAR PROJECT – SEC Inspection and Monitoring Checklist

Project: GUNNEDAH SOLAR PROJECT

Project #: 3600727160

Inspection Date (m/d/y) ______________________________

Location: 765 Orange Grove Road, Gunnedah, NSW

STORMWATER MANAGEMENT

Any obstructions or pieces of debris in the graded drainage swales?	Y / N
Is there on-site water ponding?	Y / N
Anticipated conveyance issues at surface water crossings on access road low points?	Y / N
Obstructions to or damage of on-site culverts inhibiting conveyance capacity?	Y / N
Evidence of poor flow passage through the perimeter fence?	Y / N
Missing or inoperable connections at locations of the flow through fence?	Y / N
Any drainage intrusions mitigating overland flow to surrounding irrigation channel?	Y / N
Any indication of downstream conveyance capacity issues?	Y / N

Concerns/Comments (use site map to identify specific areas of concern):

____

____

____

____

EROSION AND SEDIMENT CONTROL

Are there areas of exposed soil (no vegetation)?	Y / N
Are there significant shaded areas lacking vegetation growth under the panels?	Y / N
Are there signs of overland erosion/rilling?	Y / N
Evidence of erosion on granular pad and road infrastructure?	Y / N
Erosion in the on-site diversion swales?	Y / N
Scour and erosion at the culverts located on-site?	Y / N
Evidence of erosion or sediment build-up at entrances and exits of culverts?	Y / N
Access road low point armoring showing signs of sour/erosion?	Y / N
Evidence of silt fence damage / repairs required?	Y / N
Evidence of sediment deposition downstream of the site?	Y / N
Do sediment accumulations exceed 1/3 of the capacity of any sediment storage areas?	Y / N

Concerns/Comments (use site map to identify specific areas of concern):

____

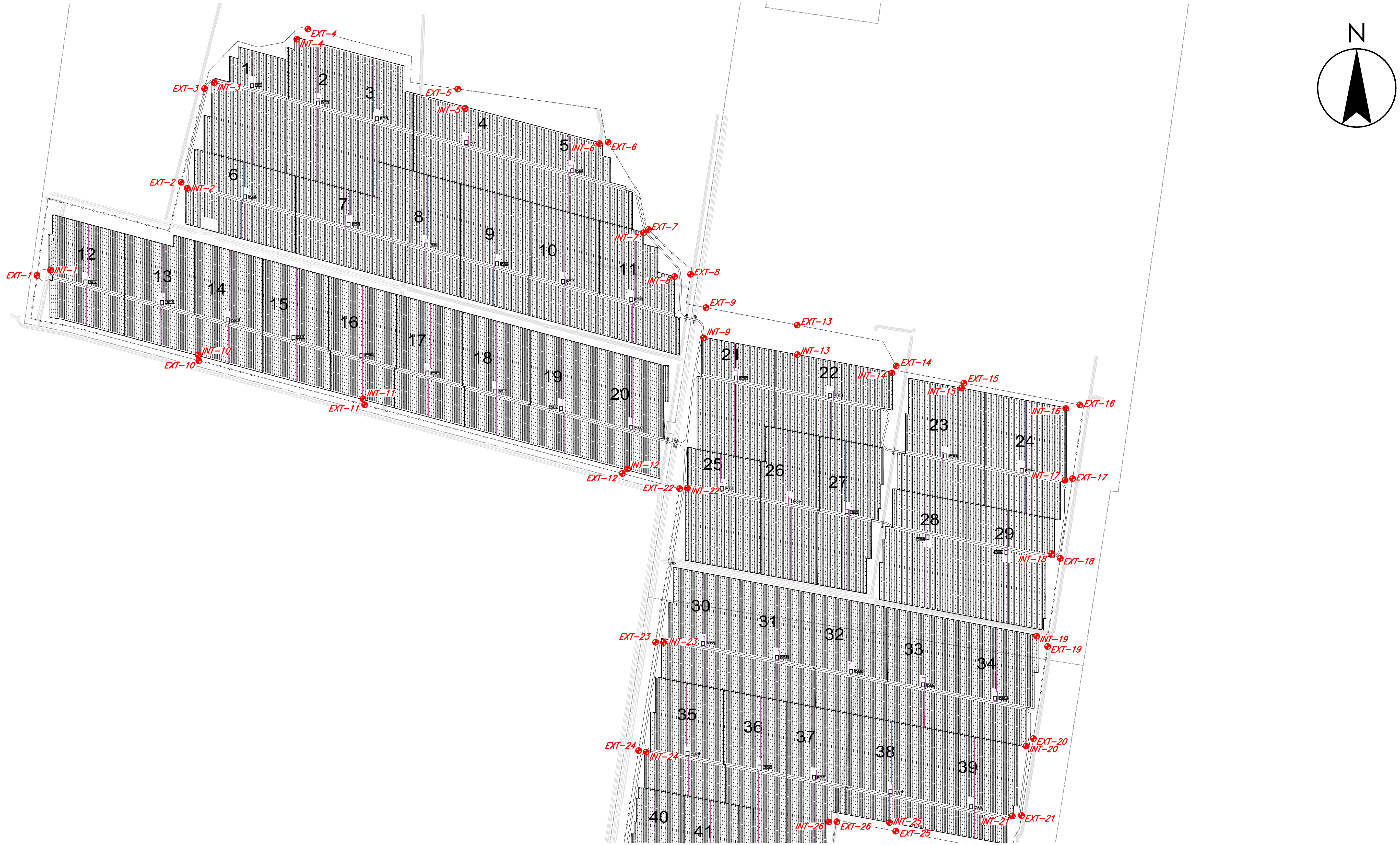
____

____

____

______________________ ______________________ ______________________

Print Name | Signature (Inspector) | Date



C:\Users\jchilds\Desktop\Working Folder\3600727160 - Gunnedah Solar\design\drawing\civil\sheet_files\3600727160_MONITOR_HWM_FIG.dwg
8/5/2020 9:49:15 AM By: Childs, Jason

Stantec

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo ON N2L 0A4
Tel: (519) 579-4410
www.stantec.com

LEGEND

EXT-24 MONITORING LOCATION

Client/Project

PCL CONSTRUCTION

GUNNEDAH SOLAR PROJECT

Project No.
3600727160

Title

HIGH WATER MARK MONITORING LOCATIONS

Revision	Date
0	2020.08.04
Reference Sheet	**Figure No.**
1	1

Stantec

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo ON N2L 0A4
Tel: (519) 579-4410
www.stantec.com

LEGEND

EXT-24 MONITORING LOCATION

Client/Project

PCL CONSTRUCTION

GUNNEDAH SOLAR PROJECT

Project No.
3600727160

Title

HIGH WATER MARK MONITORING LOCATIONS

Revision	Date
0	2020.08.04
Reference Sheet	Figure No.
2	2

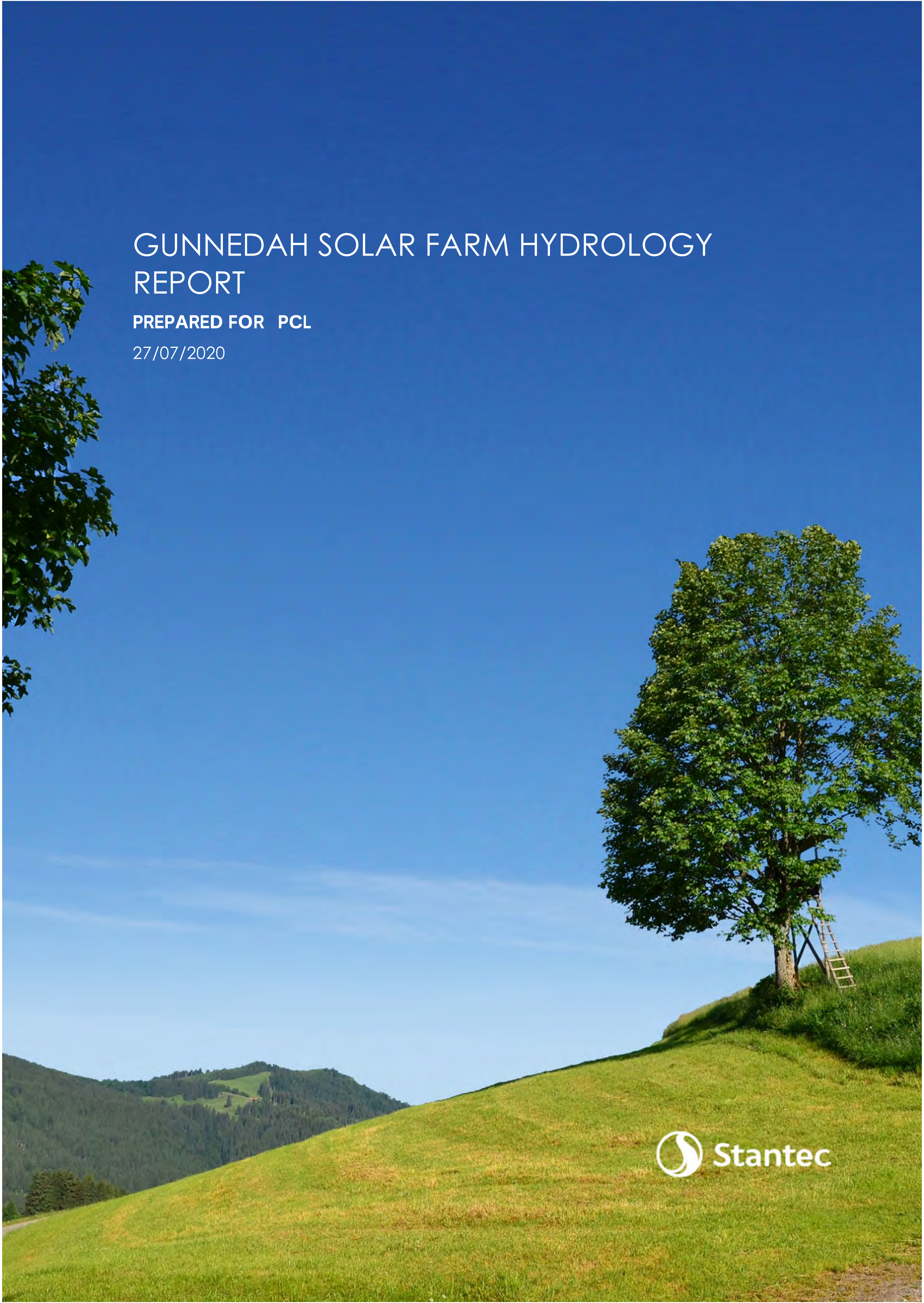
C:\Users\jchilds\Desktop\Working Folder\3600727160 - Gunnedah Solar\design\drawing\civil\sheet_files\3600727160_MONITOR_HWM_FIG.dwg
8/5/2020 9:51:54 AM By: Childs, Jason

GUNNEDAH SOLAR FARM HYDROLOGY REPORT

GUNNEDAH SOLAR FARM HYDROLOGY REPORT

PREPARED FOR PCL

27/07/2020



Stantec

QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Darren Schreiber	Dave Williams

PREPARED BY		
Bedilu Wolelo	…………………………………………	……/……/……
CHECKED BY		
	…………………………………………	……/……/……
REVIEWED BY		
Darren Schreiber	…………………………………………	……/……/……
APPROVED FOR ISSUE BY		
Peter Bright	…………………………………………	……/……/……

SYDNEY
Level 4, 99 Walker Street, NORTH SYDNEY, NSW 2060
TEL +61 2 9493 9700, FAX +61 2 9493 9799

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
01	06/03/2020	Issued for Review	B. Wolelo	N. Keenan	D. Schreiber	P. Bright
02	18/03/2020	Issued for Client Review	B. Wolelo	D. Williams	D. Schreiber	P. Bright
03	25/05/2020	reissued to support water management plan for access road construction	B. Wolelo	D. Williams	D. Schreiber	P. Bright
04	27/07/2020	Re issued to support water management plan for conceptual grading	B. Wolelo	D. Williams	D. Schreiber	P. Bright

Abbreviations

Terms, abbreviations and acronyms	Meaning
12d	12d Model Civil Engineering Design and Surveying software package
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AGRD	Austroads Guide to Road Design
ALS	Aerial laser survey
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
CBFMP	Carroll to Boggabri Floodplain Management Plan
DTM	Digital Terrain Model
GIS	Geographic Information System
IFD	Intensity Frequency Duration
Lidar	Light Detection and Ranging
LOF	Local Overland Flow
NSW	New South Wales
RFFE	Regional Flood Frequency Estimation Model
Tuflow	Tuflow Software Package
UNVFMP	Upper Namoi Valley Flood Management Plan
XpRafts	Xprafts software package

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1. Introduction

1.1 Purpose

This Hydrology report is prepared to document depth of inundation, flood levels, hazard and flow velocity generated while design storm occurs in the locality of the proposed Gunnedah Solar Farm (GSF) project site. A separate report that documents flow behaviour across the project site during regional flooding has been prepared by Pitt & Sherry Group. The report will inform the panel block layout plan, proposed landform design and risk of flooding during the construction and operation sitewide. The hydraulic modelling was conducted using Tuflow 1d/2d software package applying rainfall on grid hydrology. The modelling was undertaken in accordance with ARR2019. This report was updated to include finding from the post access construction modelling conducted to support water management plan during the construction of the access road and in accordance with the internal road and panel block provided during preliminary design development.

This hydrology Report summarises the processes and procedures followed, and assumptions taken while conducting the hydrological and hydraulic assessment during the following scenarios:

- Existing catchments in a pre-development condition and
- Post the construction of the access road connecting the project site with Orange Grove Road, internal roads and panel block layout provided during the preliminary design development stage.

1.2 References

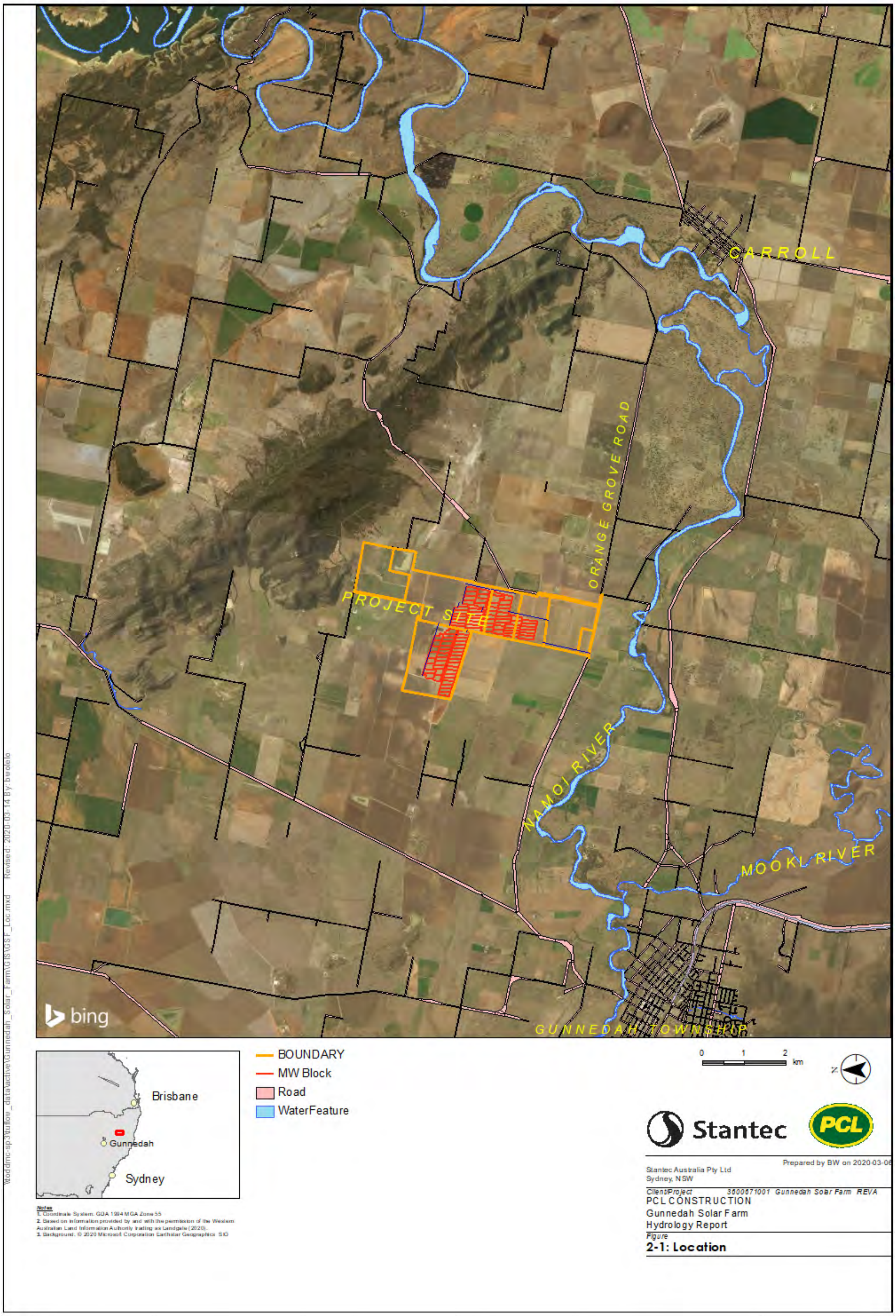
This item lists the reference documents including reports on previous investigations, studies, consultations and data gathering processes. This includes data utilised for hydrological and hydraulic modelling.

1. A300 – Civil Engineering and construction requirements - Australia
2. Aerial Imagery, obtained from Bing Maps
3. Topographical Terrain Model Survey, undertaken by Land Survey
4. Topographical Digital Terrain Model, obtained from Airbus Website
5. 1987 & 2016 IFD data obtained from the Bureau of Meteorology Web Site
6. 2016 Ensemble temporal pattern data from Bureau of Meteorology Web Site
7. ARR Datahub, publications and guidelines
8. Australian Rainfall and Runoff (ARR), Geoscience Australia, 2019
9. Drains Utility Spreadsheet
10. Gunnedah Solar Farm – Flood impact Assessment Rev 5 by Pitt & Sherry Group
11. Aerial laser survey (ALS) data, Obtained from Pitt & Sherry Hydraulic model file
12. Gunnedah Solar Farm Development Consent – Independent Planning Commission of NSW,
13. Flood Management Plan for the Upper Namoi Valley Floodplain, NSW Government, June 2019
14. Upper Namoi Valley Floodplain Management Plan – Management Zone BL – rules and assessment criteria, NSW Government, June 2019 (UNVFMP)
15. *Carroll to Boggabri Floodplain Management Plan*, NSW Government, September 2006 (CBFMP)

2. Project Definition

2.1 Location

The GSF will be installed at 765 Orange Grove Road Gunnedah, approximately 10km north east of Gunnedah township. Gunnedah township is located 430km north west of Sydney. It is proposed to provide site access road from Orange Grove Road located east of the site. There were recorded incidences of flood waters overtopping Namoi River banks located east of Orange Grove Road and inundating the project site. The site is currently used for agriculture. Irrigation channels traverse the project site. The terrain of the site is flat. There are no distinct gullies inside the project site. Site location is shown in Figure 2-1.



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 2-1: Location

3. Flooding & Drainage design Criteria

A generic civil design specification A300 was provided at an earlier stage of design development. The project site is located at the banks of Namoi River. The Namoi River Breaks banks during storm events including and larger than the 10% AEP storm event. It was required to amend the design criteria to take into consideration the impacts of:

- Site flat topography and flood affectation of the site by local and regional flooding;
- Existing regional flood extent and AEP of the Namoi River Breaking bank,
- conditions set in the Gunnedah Solar Farm Development Consent;
- conditions set in the floodplain management plan for the Upper Namoi Valley floodplain; 2019 and
- the solar farm operational requirements.

The revised flooding and drainage design criteria for various project infrastructure requirements are set in Table 3-1.

Table 3-1 GSF Civil Design Criteria

Asset	Criteria	Limit	Reference	Storm type governing Design Element
Road Side Swale	minimum Vertical gradient	0.10%	A300	Local Overland Flooding
Culverts	minimum culvert diameter	450mm	A300 & Standard Pipe Size in Australia	Local Overland Flooding
Ditches	Design AEP	10%AEP Freeboard:150mm	A300	Local Overland Flooding
Ditches	Design AEP	1% AEP no overtopping	A300	Local Overland Flooding
	Flooding Risk	Minimize Risk to life and property	EIS section 4.5.7	Local Overland Flooding & Regional Fluvial Flooding
	Maximum flood depth difference post construction	100mm	CBFMP	Local Overland Flooding & Regional Fluvial Flooding
	Maximum height of civil/structural works arresting floodwaters	only 10% of the length of proposed sctructure could exeed 0.5m above existing ground level	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
Floodways	capacity	no reduction	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
	Flow Velocity	< 50% increase	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
	Flow Velocity	< 0.5m/sec	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
Adjacent Land holding	drainage pattern	No change	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
Access Road	Floodway	allowed to overtop through floodway	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
Internal Roads	Floodway	allowed to overtop through floodway	UNVFMP / CBFMP	Local Overland Flooding & Regional Fluvial Flooding
Invertor Station	Design AEP	1% AEP + 300 Freeboard	GSF Operational Requirement	Regional Fluvial Flooding
Switch Yard	Design AEP	1% AEP + 300 Freeboard	GSF Operational Requirement	Regional Fluvial Flooding

4. Hydrology

Rainfall on grid hydrology was utilised to determine flow behaviour across the project site. The hydrological model development process involved collecting rainfall depth and temporal pattern data from the Bureau of Meteorology website and collecting loss parameters from ARR Datahub. The temporal patterns that resulted in maximum intensity following initial losses were selected to be routed through the hydraulic model.

4.1 Data Collection

Data utilised for the hydrological modelling purposes was collected from the following sources:

- Areal Imagery by Bing Maps
- Digital Terrain model from Airbus website
- Areal Laser Survey data utilised in Pitt & Sherry Regional flood model
- Unmanned Aerial vehicle (UAV) survey undertaken by Land Survey
- 2016 IFD data from the Bureau of Meteorology website
- 2016 Ensemble temporal pattern data for the Bureau of Meteorology website
- Catchment loss parameters obtained from ARR Datahub website

4.2 Terrain

A digital terrain model of the existing scenario model was developed from ground survey data utilised in the Pitt & Sherry hydraulic model, data obtained from Airbus website and UAV survey data undertaken across the project site by Land survey and follow up update of the site survey. During the proposed scenario modelling the preliminary design layout and earthworks were superimposed on top of the existing scenario ground model. Runoff collected from the hills located north of the project site are collected in farm dams provided at the bottom of the hills. The locality downstream of the dams is uniformly graded flat terrain. The elevation of the project site varies from 256m AHD to 279.7m AHD. Majority of the project site has a longitudinal less than 0.5%. Runoff in the flat section drains as sheet flow across the project site. Irrigation channels traverse the site. The Irrigation channels are up to 1m deep. A berm is provided upstream of the irrigation channels.

4.3 Rainfall Data

Rainfall data was collected from the Bureau of Meteorology (BoM) website for Station number 055023 Gunnedah (Pool) Station. The data indicates that the mean annual rainfall for the locality is 615.7mm. Precipitation occurs at the site throughout the year. However, majority of the rainfall occurs between the months of October and March. The data could assist in selecting suitable period to undertake the construction works on site. Statistical summary of rainfall at the locality is provided in Figure 4-1.

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	70.6	66.1	48.9	36.6	42	44	41.5	40.9	40.2	54.2	61.4	69.6	615.7

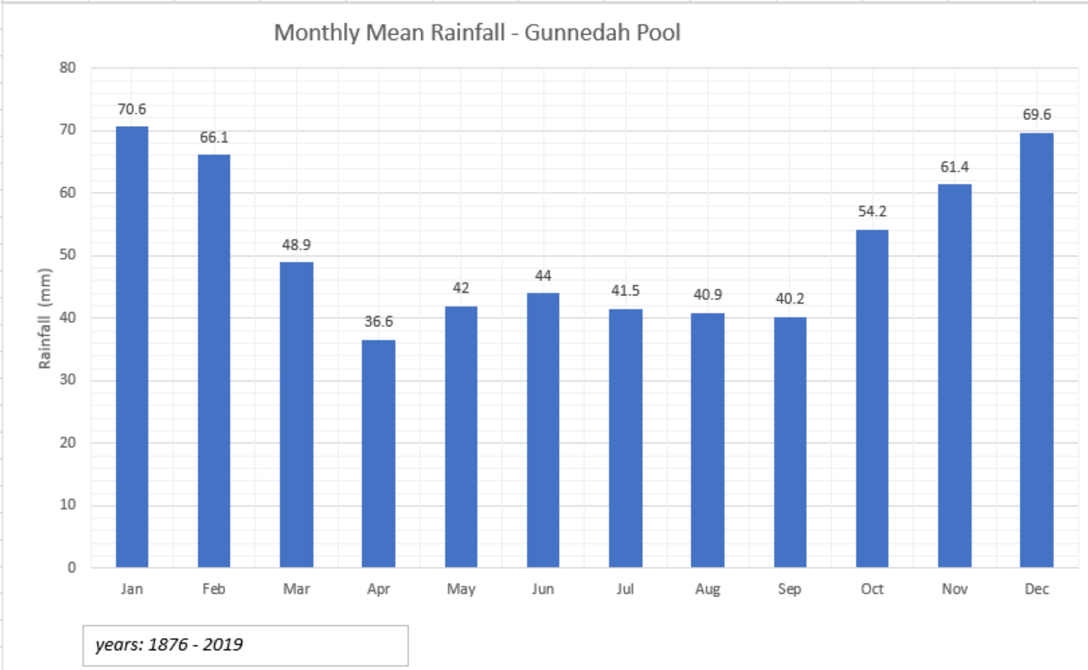


Figure 4-1: Mean Monthly Rainfall at Gunnedah Pool Station

4.4 Temperature

Temperature data collected at station number 056037 (Gunnedah Pool) in Gunnedah indicates that the mean maximum temperature varies between 21 and 41^{0}c. The mean minimum temperature varies between 11 and 29^{0}c.

The minimum temperature occurs in the winter month of July and the maximum temperature occurs in the summer month of January. Mean, lowest and highest monthly temperature data is shown in Figure 4-2.

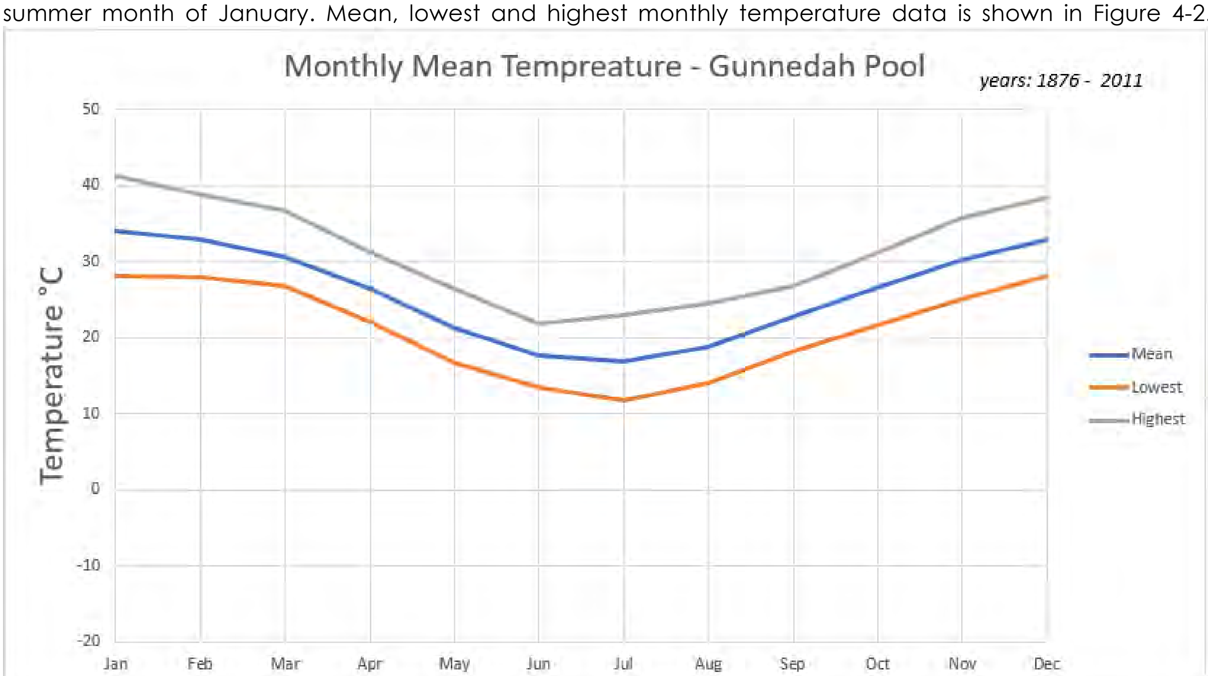


Figure 4-2: Mean Monthly Temperature at Gunnedah Pool

4.5 IFD and Temporal Pattern

The 2016 IFD data was obtained from the Bureau of Meteorology site. The IFD depth and intensity for the project site is shown in Figure 4-3. Tabular form of the data is provided in Appendix F. The 2016 ensemble temporal data for the site was obtained from ARR Datahub website. Datahub prescribes that the east coast south temporal pattern be applied for the site.

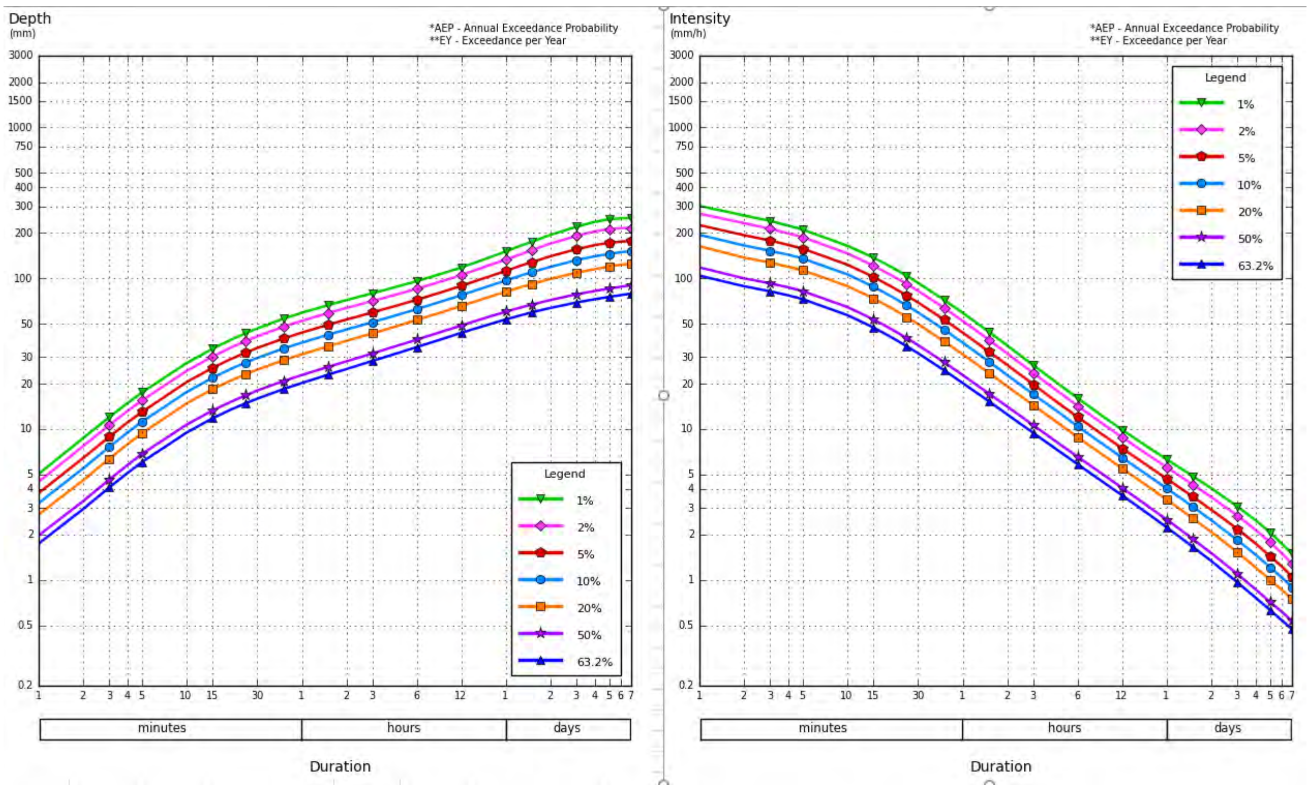


Figure 4-3: IFD Depth and Intensity data

4.5.1 Loss Parameters

Initial and continuing loss parameters were selected in accordance with the approaches prescribed in ARR 2019. Literature review has not identified a study conducted in the catchment that determined calibrated initial loss in the locality of the catchment. Where good initial loss figures are not available OEH has prescribed that hierarchical approach be utilised to determine preferred loss parameter. The catchments fits in hierarchy number five where it is preferred to utilise probability neutral initial loss figures provided in ARR Datahub. Accordingly, probability neutral burst initial figures shown in Table 4-2 where utilised while conducting the hydrological modelling.

Table 4-1 Site initial and continuing loss figures (Obtained from ARR Data hub)

ID	2264.0
Storm Initial Losses (mm)	53.0
Storm Continuing Losses (mm/h)	0.2

Table 4-2 Site Probability Neutral Burst Initial Loss (Obtained from ARR Data Hub)

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	22.8	26.0	21.2	21.0	21.0	20.7
90 (1.5)	25.8	27.3	22.8	22.9	22.2	21.2
120 (2.0)	28.1	24.5	21.1	21.2	21.9	21.0
180 (3.0)	31.6	24.7	21.7	21.6	21.6	19.8
360 (6.0)	39.0	25.9	22.8	21.9	20.0	16.9
720 (12.0)	47.0	31.6	28.2	27.6	21.8	15.9
1080 (18.0)	49.0	35.0	31.2	29.5	21.9	13.5
1440 (24.0)	50.3	37.5	35.0	34.2	26.3	17.4
2160 (36.0)	49.5	37.7	35.6	36.0	31.6	23.7
2880 (48.0)	53.5	43.4	42.3	43.2	40.2	32.2
4320 (72.0)	54.0	45.5	46.3	47.8	45.2	36.0

4.5.2 Storm Events and Temporal Patterns and Loss parameters

The initial loss for the site as obtained from ARR Data Hub is 53mm. If we use this in the study no runoff will be generated for design storms ranging from 5 minutes to 1hr. The 1hr storm depth is 59mm. FFA conducted for a site inside the Namoi River Catchment and far from the site under consideration indicates that the initial loss figure of 49mm.

As there is no source of good initial loss data, for the locality, which makes it fall in category 5 of the ARR NSW specific guide. The NSW guide specifies that a probability neutral burst initial loss values available on ARR datahub be utilised in all instances. Accordingly, the probability neutral burst initial loss figures shown in Table 4-2 were utilised in the study.

Storm events with durations less than and including 1hr duration would not provide significant flooding as a significant part of the rainfall will be lost as an initial loss. Storm events with durations of 90, 120, 180, 270 and 360 minutes were run through the hydraulic model to determine flood characteristics across the project site.

The temporal patterns that generate worst scenario flooding at the site were tested. The test has indicated that the depth of flooding across the project site during local storm events was less than 100mm for the 75% of the site and is less than 0.5m near the bunds provided on the upstream side of the irrigation channels. The site is flat agricultural land. Flow across the site occurs as a sheet flow. The depth of water in these areas is controlled only by the bunds provided upstream of the irrigation channels. The median storm as directed by ARR will produce much less inundation than the worst case scenarios. Storms that generated worst inundation at the site for each storm duration were considered for hydraulic run.

Selection of storms that generate worst scenario flood characteristics was selected based on the following rational:

- Intensity of rainfall is directly correlated to generation of runoff
- No runoff being generated from site prior to rainfall depth in excess of initial loss occurs
- Back loaded storms with intense rainfall occurring at a duration following rainfall in excess of initial loss

Based on the analysis provided above, the following storm durations, associated temporal patterns and loss figures were run through the hydraulic model

Table 4-3 AEP, Storm Duration, Temporal Patterns and initial loss figures

AEP	Storm duration	Temporal pattern	loss (mm)
1%AEP	90	TP10	21.2
1%AEP	120	TP07	21
1%AEP	120	TP09	21
1%AEP	180	TP02	19.8
1%AEP	270	TP10	18.3
1%AEP	360	TP05	16.9

4.6 Hydrological and Hydraulic Modelling in Tuflow

A 2d–hydrodynamic model was developed using Tuflow software package to determine flood level, flow depth, flow velocity and hazard mapping across the project during the existing scenario. Tuflow solves depth averaged free surface flow in 1d channels or over a 2d regular grid with square cells. A hydrograph generated in other hydrological modelling packages could be applied as a boundary conduction or Tuflow can route rainfall excess across the 1d/2d model domain.

There are no significant drainage features obstructing flow at the project site. 2d hydrodynamic model could provide sufficient information on flooding across the site. Accordingly, rainfall on grid methodology was used while undertaking the flood modelling. The flood modelling process included developing existing surface digital terrain model, determining rainfall and outlet boundary conditions, determining the manning's roughness of the existing ground, preparing the Tuflow control files, debugging the model, preparing the result files and preparing the flood characteristics maps.

4.6.1 2d Model Bathymetry

Accuracy of the 2d hydraulic model result is influenced by the accuracy of model bathymetry. Model bathymetry was developed from unmanned Aerial vehicle (UAV) survey undertaken by Land Survey in the locality of the project and merged aerial survey data utilised in the Pitt & Sherry model to develop a regional flood model. Airbus DTM data was utilised in localities that were not covered by both survey data discussed. A model cell size of 2m is adopted for the study. This resolution is sufficient to determine flood characteristic across the site for the modelled events. Model domain and DTM data utilised in the study is shown in Figure 4-4.

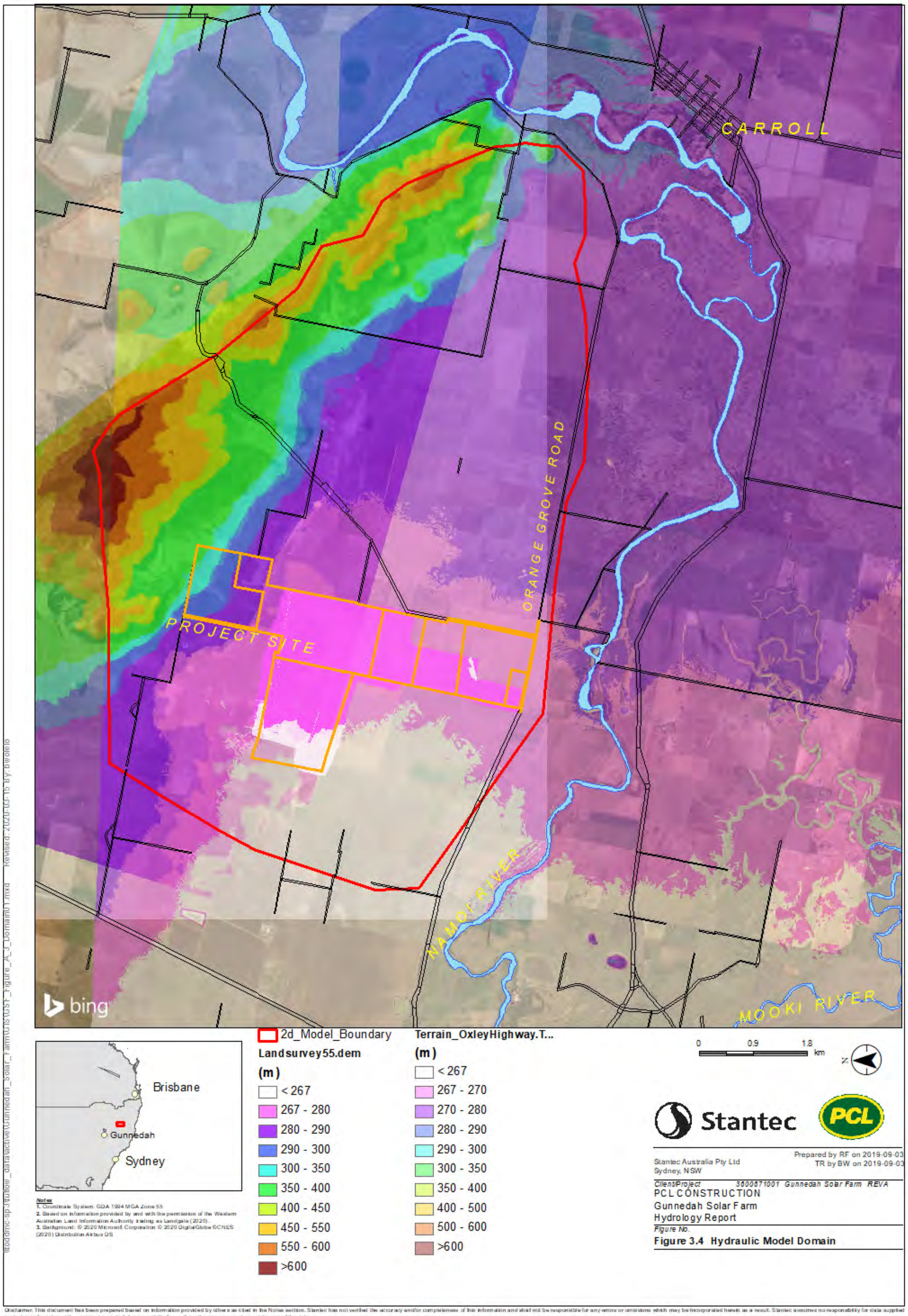


Figure 4-4: Hydraulic Model Domain

4.6.2 2d model boundary Conditions

Rainfall in excess of initial and continued loss in each cell is routed through the hydraulic model towards catchment outlet. Storm events that generate intense rainfall, post the initial losses, cause maximum flood depth, flow velocity and hazard. As the initial losses for the locality are high, an insignificant amount of runoff is generated during short duration storms including the 1% AEP, 20minute storm. The study has reduced the number of hydraulic model runs by systematically reviewing the temporal patterns and selecting storm durations and temporal patterns that have the potential to generate maximum flood characteristics. Temporal distribution patterns and storm durations that generated maximum flood characteristics during the 1% AEP storm events for storm durations ranging from 30 minutes to 270 minutes are provided in Appendix E. The temporal patterns that were selected to be routed through the hydraulic model are highlighted in yellow. The rainfall depth data is stored in the boundary condition database file and was applied across the 2d rainfall boundary layer. 2d downstream condition layers were digitised in GIS and normal depth boundary condition was applied at local catchment downstream outlet locations.

4.6.3 Model data

2d model extent, 2d rainfall layer, 2d boundary and 2d land use (material type) was digitised using the ArcGIS software package. Aerial imagery obtained from Bing Maps was utilised to digitise ground cover that exists within the model domain. The hydraulic roughness figures utilised for the respective ground cover inside the model domain is provided in Table 4-4. The land use map is

Table 4-4 Adopted Manning's n values

Land use (Ground Cover)	Manning's n
Dense Vegetation	0.1
Farm/Pasture	0.045

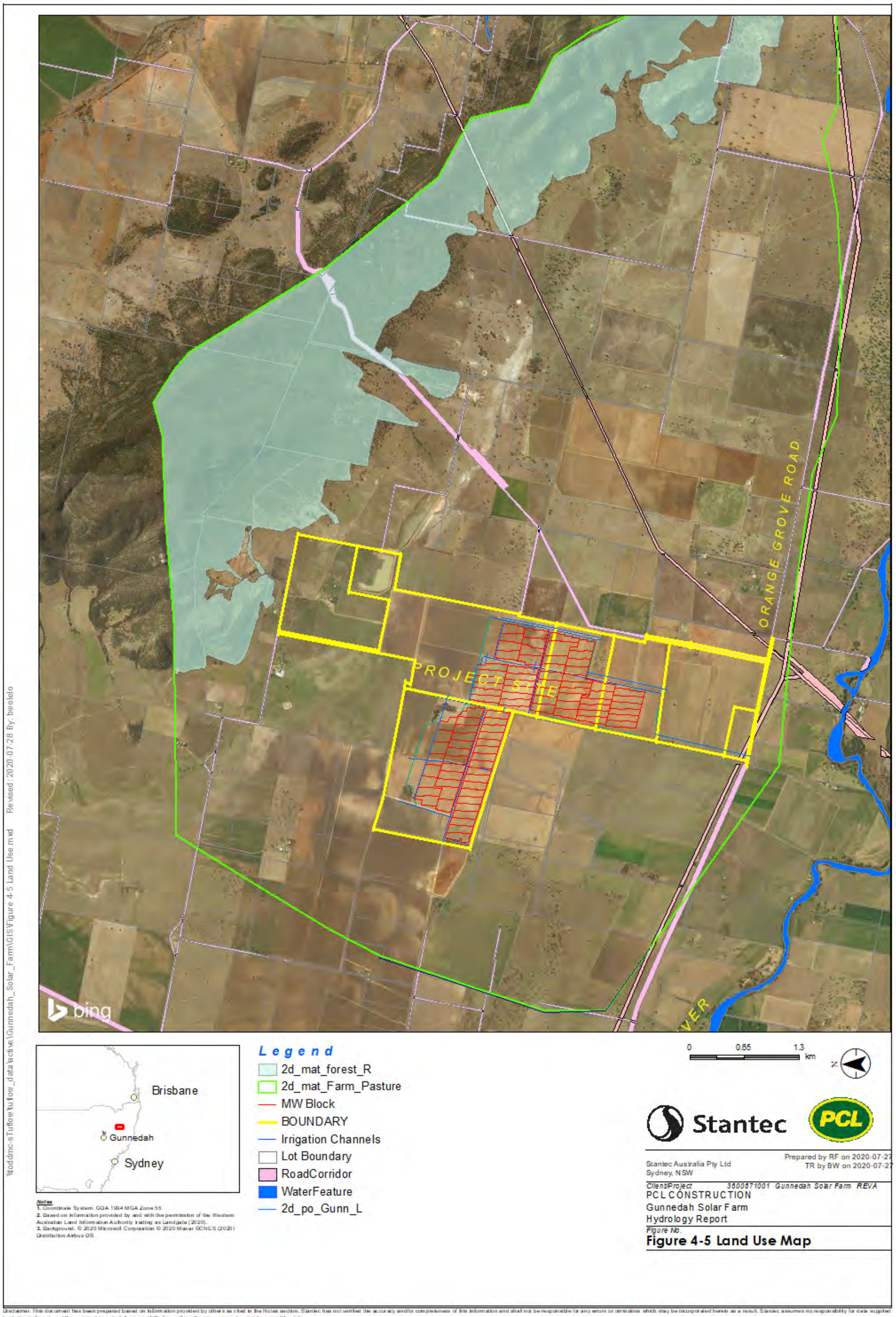


Figure 4-5: Land Use Map

4.6.4 Existing Scenario Tuflow Model Results

Existing scenario Tuflow model run was conducted to determine extent of flooding, flood level, depth of flow, flow velocity and flooding hazard across the project site. Flow hydrographs were also extracted at key locations to assist with sizing of drainage structures at road crossings.

4.6.4.1 Flood Depth

The gradient of the site is flat. There are no natural drainage features that direct runoff through the site. runoff from external catchment enters the project site as a sheet flow. Runoff at the site occurs as a sheet flow and runoff from the site and upstream catchments drains away from the site as a sheet flow.

Irrigation channels traverse the project site. Bunds are provided upstream of the irrigation channels. These bunds block the sheet flow from entering the Irrigation Channels. During major storm events, runoff ponds upstream of the bunds and overtops these bunds to eventually drain towards the irrigation channels. Runoff draining towards the irrigation channel ponds in these channels and once the capacity is exceeded, it overtops the channels and drains towards downstream project boundary. Sheet flow depth is minor. Flow depth in excess of 50mm is observed only behind the bunds and inside the irrigation channels during major storm events in the local catchment. Map Showing depth of flooding generated from the 1% AEP storm event occurring across the model boundary from local catchments is shown in Appendix A.1. The map in Appendix A.2 Shows data presented in Appendix A.1 in the project locality.

4.6.4.2 Velocity

Map showing maximum flow velocity across the project site is provided in Appendix B.1. The mapping shows that maximum velocity across the site is less than 0.5m/sec.

4.6.4.3 Hazard

Depth of flow, velocity of flow or product of velocity and depth of flow could provide flooding hazard across a floodplain. MBRC hazard category pallets are utilised to generate hazard category at the project site. MBRC hazard category description is provided in Appendix C.2. Depth of flow at the site is less than 0.5m and velocity of flow is less than 0.5m/sec. Majority of the site is covered under category H1. The irrigation channels and localities abutting the irrigation channel are categorised as H2. This indicates that there is no significant hazard across the project site during major storm event in the local catchment.

4.6.5 Proposed Scenario Tuflow Model Results

Proposed Scenario Tuflow model run was conducted to determine extent of flooding, flood level, depth of flow, flow velocity and flooding hazard across the project site post installation of the solar farm.

4.6.5.1 Flood Depth

The installation of the proposed solar farm involved minimal amount of regrading works. it is proposed to drive piles and install the solar arrays. It is also proposed to install the invertor stations on piles to ensure that the infrastructure is above the regional flood level. The vertical geometry of the proposed access road and internal roads follows the existing terrain pattern and is provided to not to interfere with flow behaviour in the floodplain.

The existing irrigation channels were maintained post construction and the bunds placed upstream of the irrigation channel were not altered. The proposed scenario digital terrain model was superimposed on the existing ground DTM and has been utilised as bathymetry for the proposed scenario flood model.

The model of the proposed scenario has indicated that ponding not exceeding 0.5m was observed upstream of the existing bunds provided upstream of the irrigation channels. Runoff through the project site occurs as a sheet flow. Depth of inundation during the 1% AEP storm event is less than 50mm at approximately more than 50% of the project site area.

4.6.5.2 Velocity

Map showing maximum flow velocity across the project site is provided in Appendix B. The mapping shows that maximum velocity across the site post the installation of the solar farm is less than 0.5m/sec.

4.6.5.3 Hazard

Depth of flow, velocity of flow or product of velocity and depth of flow could provide flooding hazard across a floodplain. MBRC hazard category pallets are utilised to generate hazard category at the project site. MBRC hazard category description is provided in Appendix C.2. Depth of flow at the site is less than 0.5m and velocity of flow is less than 0.5m/sec. Majority of the site is covered under category H1. In category H1 area parked cars could not be buoyed by flood waters and moving cars could easily navigate through during local storm events. Localities abutting the irrigation channel which could pond up to a depth of 0.5m are categorised as H2. Category H2 covers less than 10% of the site area. Heavy vehicles could be parked or would be able to navigate through these areas.

4.6.6 Impacts of the proposed works

The proposed installation of the solar farm will minimise works that would interfere with the natural floodwater movement in the vicinity of the project area. This is inline with the requirements of the UNVFMP. The Development consent requires that impacts to adjacent land holdings be minimised. The modelling of the hydraulic modelling, post processing and mapping of flood characteristics has indicated that the proposed works have minimal impact on adjacent land holdings.

The modelling, post processing and mapping has indicated that:

- Maximum afflux of 2mm was observed outside the project boundary. This is within the limits of accuracy of the hydraulic modelling software package
- The modelling has indicated that a maximum flow velocity of 0.5m/sec could be observed inside and outside the project boundary. In some localities a maximum flow velocity increase of 0.25m/sec is predicted. Maximum flow of 0.5m/sec estimate included 0.25m/sec increase inside the model boundary. The UNVFRM allows an increase of velocity by up to 50% and the increase is within the limits acceptable by the UNVFRM.
- Difference mapping of hazard category has indicated that there is no change for this parameter post installation of the solar farm

5. Access Road Model

As part of the access road water management plan, it was required to identify impacts of the proposed road on flood characteristics in the locality of the project.

A proposed scenario modelling was conducted to determine the flood levels, flow velocity, depth of flow and flow hazard post construction of the road. It was also required to understand the impacts of the proposed works.

The proposed road terrain model was included in the Tuflow model geometry control file and model run was conducted for the 1% AEP storm event. Post processing was conducted in ArcGIS to determine the flood level and maximum velocity difference across the model domain.

The modelling has indicated that:

- The increase in flood level upstream and downstream of the proposed road was minor and it occurred inside the project boundary. The maximum level increase was estimated at 100mm.
- The increase in velocity was minor. The maximum change in velocity post the construction of the proposed road was 0.05m/sec and this increase occurs inside the proposed road corridor.

The road design blends well with the existing terrain and has minor to no impact on holding downstream of the proposed road.

6. Regional Flooding

The project site is located adjacent the Namoi River. Data obtained from New South Wales Water website indicates that the catchment of Namoi River at Gunnedah (stream gauging station # 419001) is approximately 17. 100 sq.km. This station is located approximately 10km downstream of the project site. The river breaks banks and flows through the site during major storm events. Flooding occurring at the project site due to major storms occurring in the entire 17,100 sq. km is referred as the regional flooding. The regional flood modelling was conducted by Pitt & Sherry Group. Depth of flooding during the 1% AEP regional flooding event is shown in Appendix B.

The regional flooding produces worst case flow characteristics at the project site and should be utilised to determine finished floor level for essential services site wide. The impact of constructing access road and earthworks on the regional flood characteristics should be tested in the regional model.

Fencing arrangements were tested in the regional model and to ensure EIS requirements are met. Pitt & Sherry Group has proposed a preferred fencing arrangements. It is proposed that the recommendation made by the group be utilised while installing perimeter fence around the site.

Appendices

Appendix A Depth of Flooding

Figure Appendix A. 1 Existing scenario Local overland Flow depth model wide during the 1% AEP Storm event

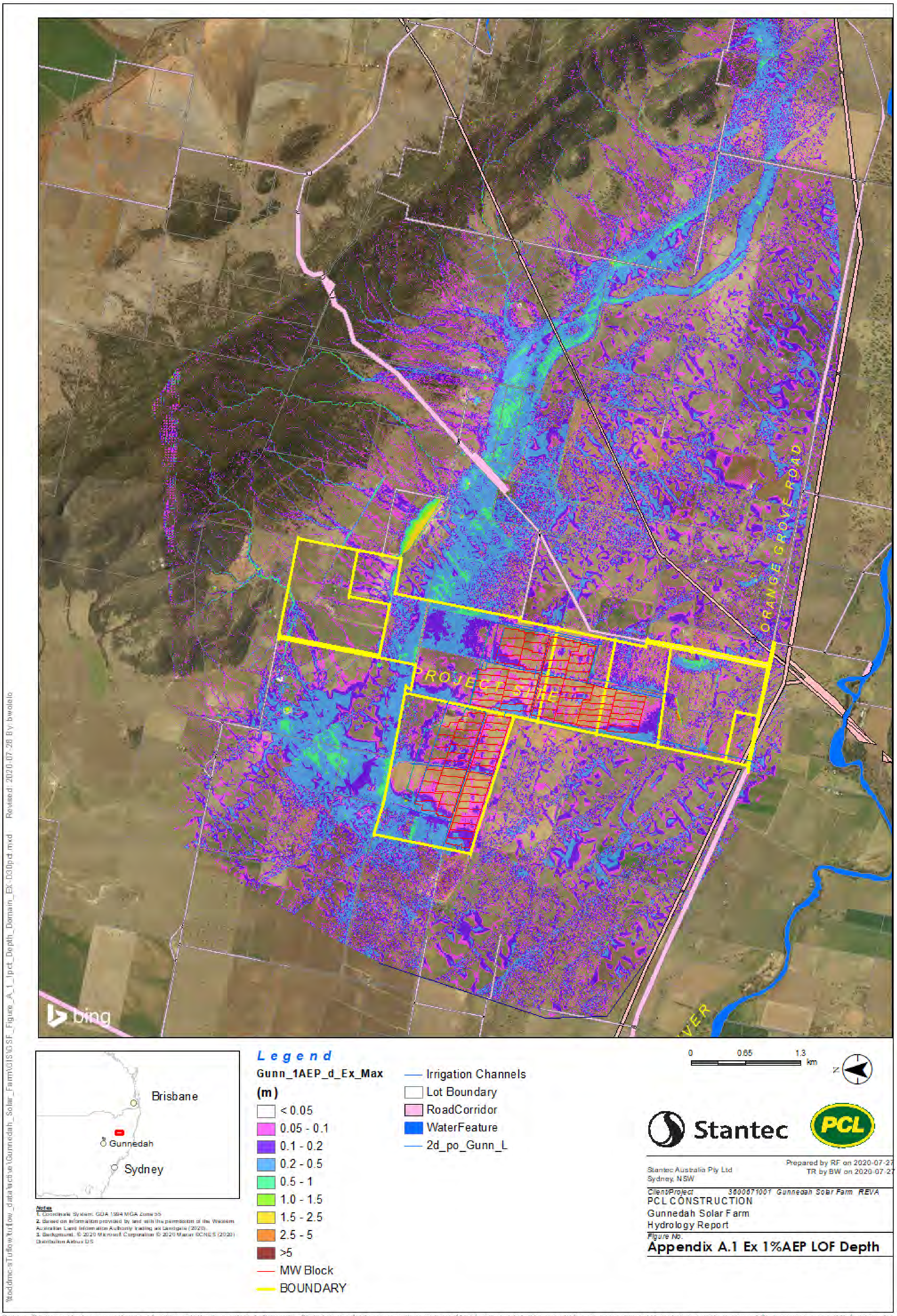
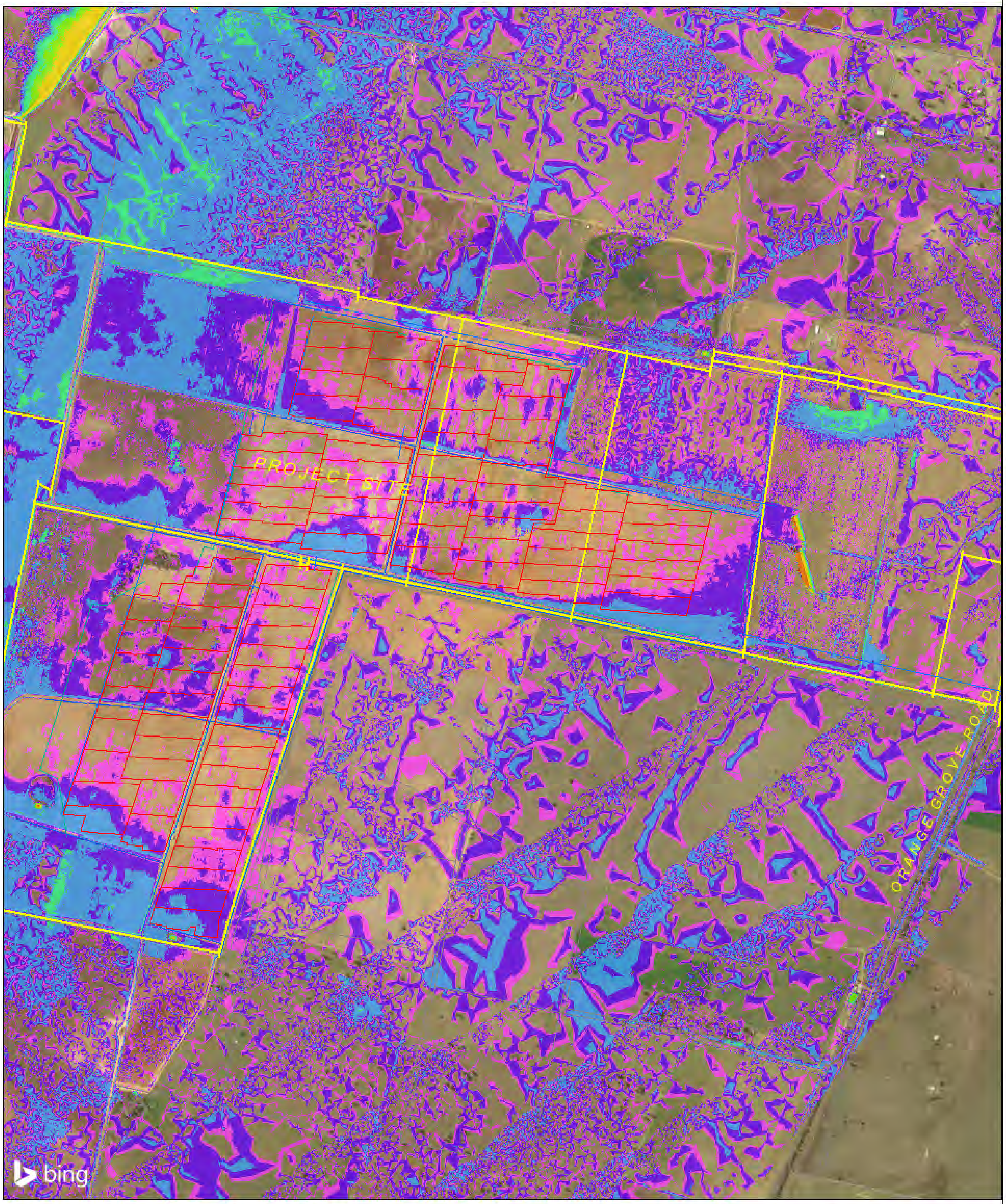


Figure Appendix A 2 Existing scenario Local overland Flow depth across project site during the 1% AEP Storm event



Notes
1. Coordinate System: GDA 1994 MGA Zone 55
2. Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2020).
3. Background: © 2020 Microsoft Corporation © 2020 Maxar ©CNES (2020) Distribution Airbus DS

Legend

Gunn_1AEP_d_Ex_Max (m)

- < 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- >5
- MW Block
- BOUNDARY
- Irrigation Channels
- Lot Boundary
- RoadCorridor
- WaterFeature
- 2d_po_Gunn_L

Stantec Australia Pty Ltd
Sydney, NSW

Prepared by RF on 2020-07-27
TR by BW on 2020-07-27

Client/Project 3600671001 Gunnedah Solar Farm REVA
PCL CONSTRUCTION
Gunnedah Solar Farm
Hydrology Report

Figure No.
Appendix A.2 Ex 1%AEP LOF Depth

Figure Appendix A. 3 Proposed scenario Local overland Flow depth model wide during the 1% AEP Storm event

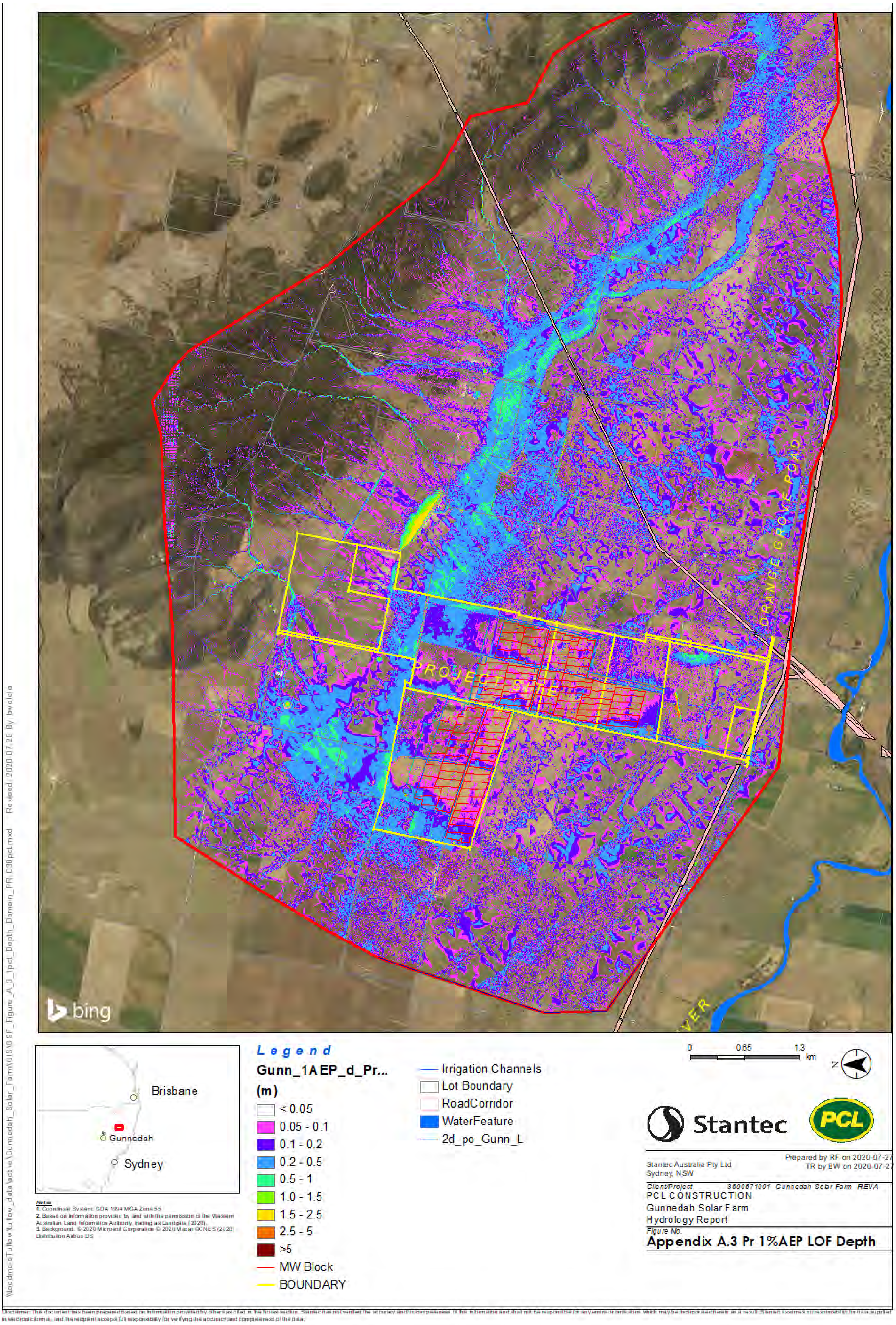
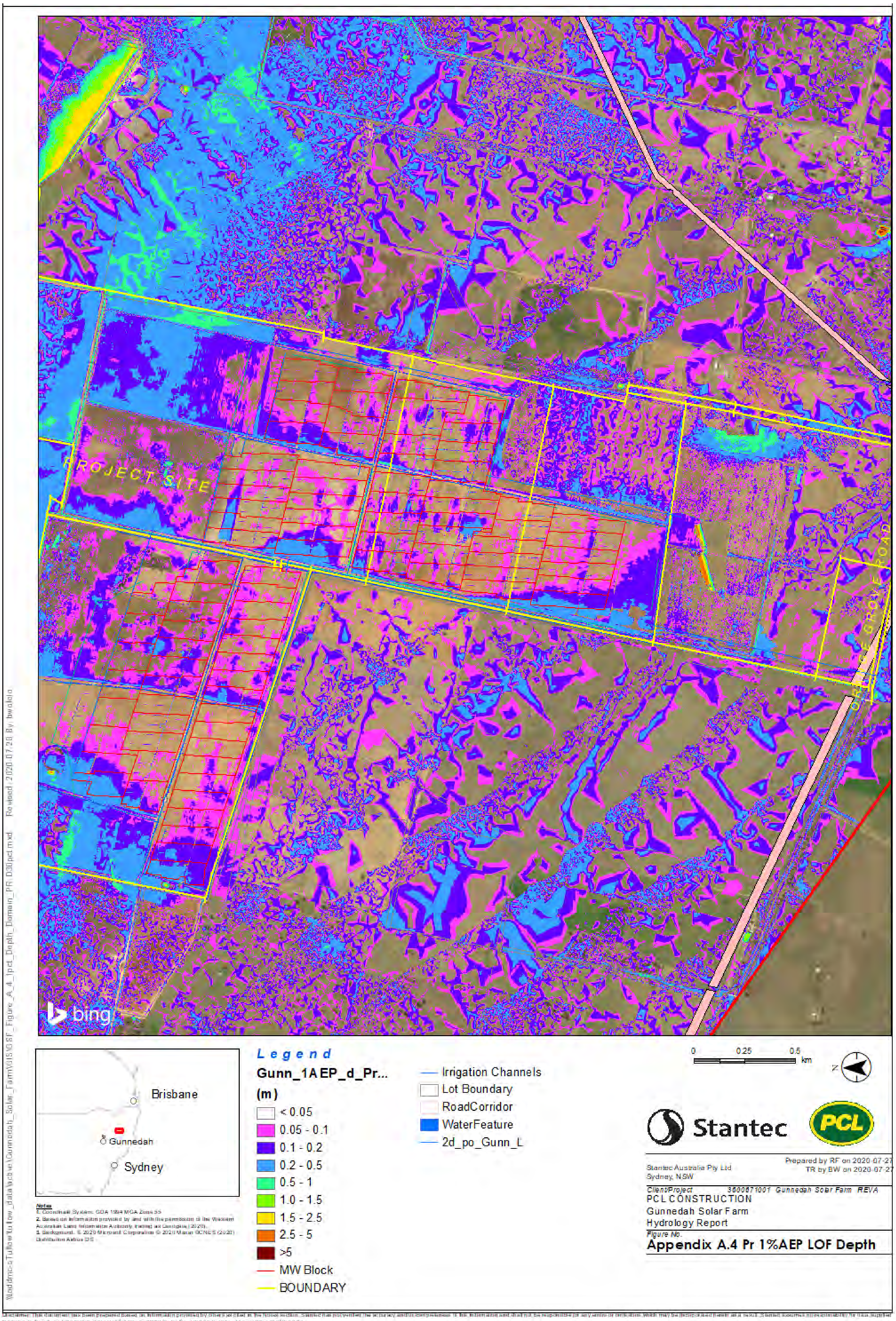
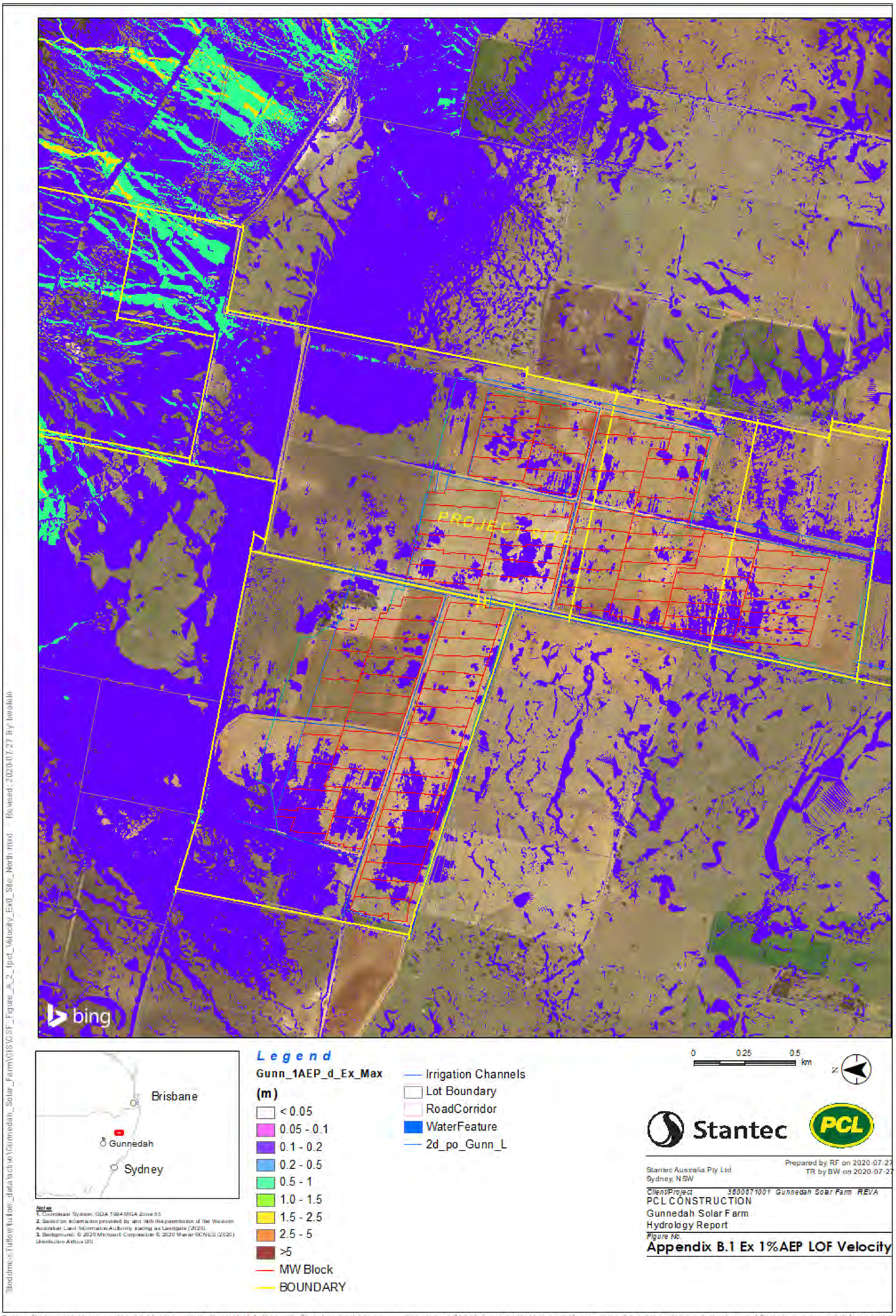


Figure Appendix A 4 Proposed scenario Local overland Flow depth across project site during the 1% AEP Storm event



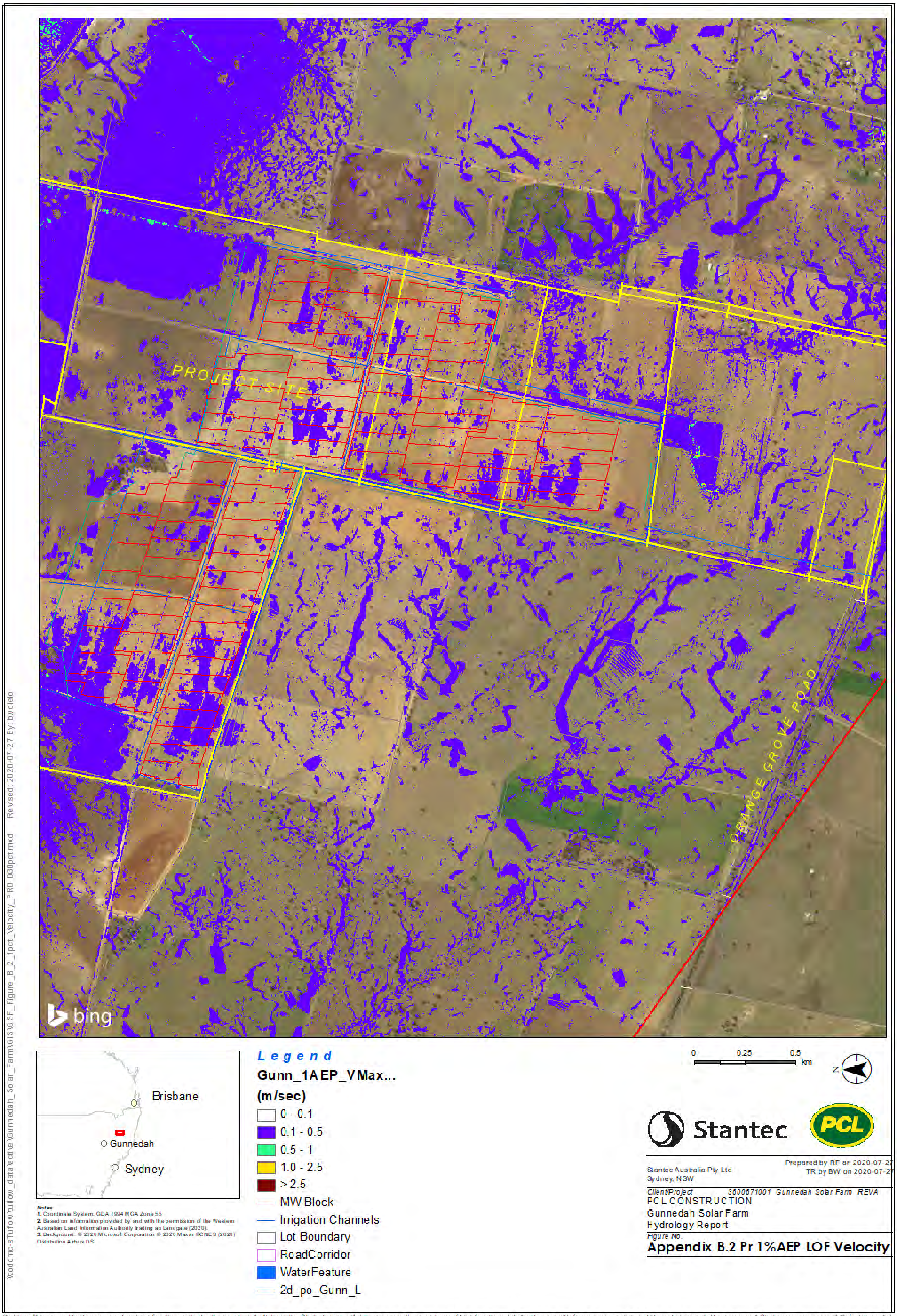
Appendix B Flow velocity

Figure Appendix B 1 Existing Scenario Local overland Flow Velocity project site wide during the 1% AEP Storm event



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

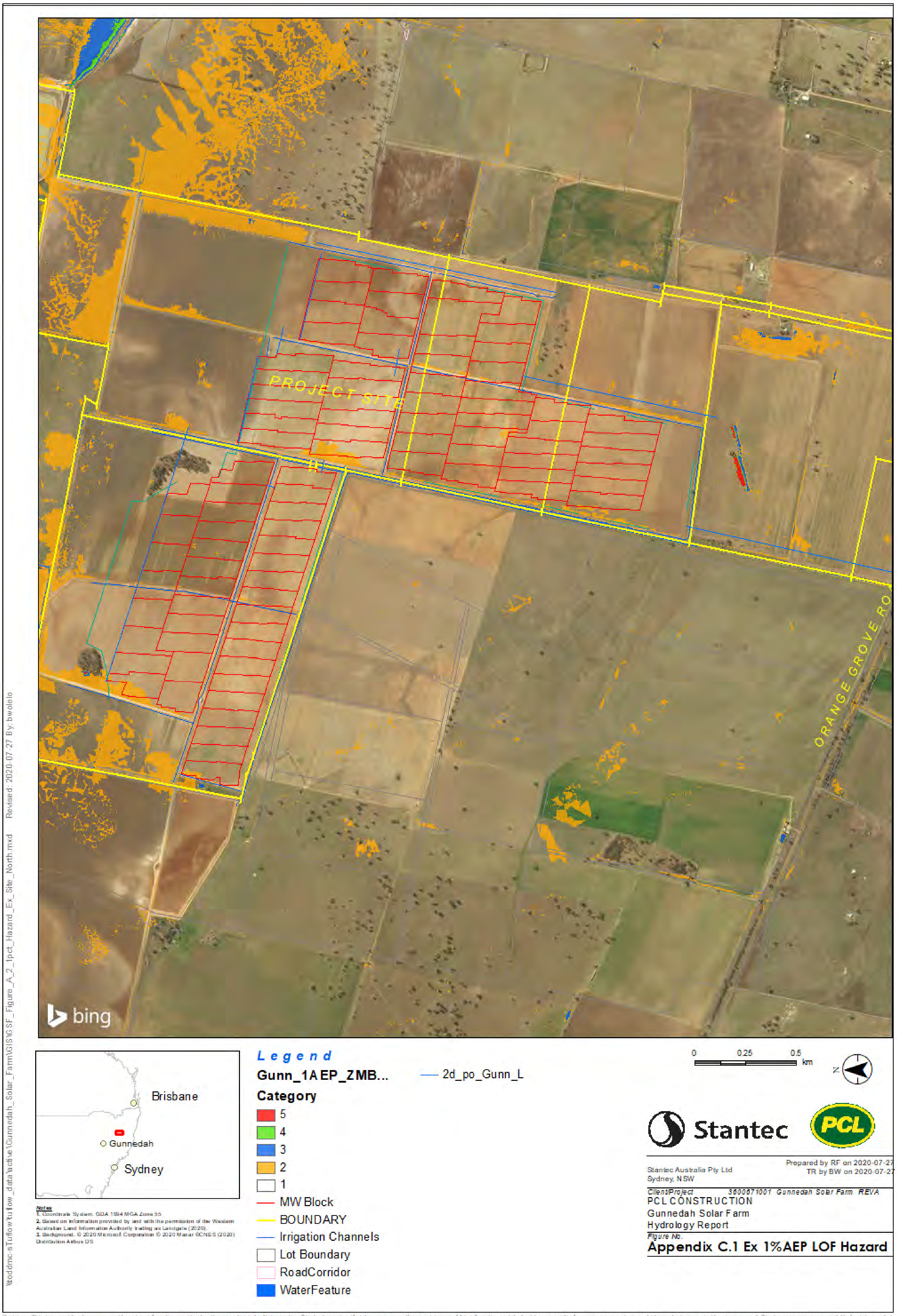
Figure Appendix B 2 Proposed Scenario Local overland Flow Velocity project site wide during the 1% AEP Storm event



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Appendix C Flood Hazard

Figure Appendix C 1 Existing Scenario Local overland Flow project site wide Hazard during the 1% AEP Storm event



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure Appendix C 2 Proposed Scenario Local overland Flow project site wide Hazard during the 1% AEP Storm event

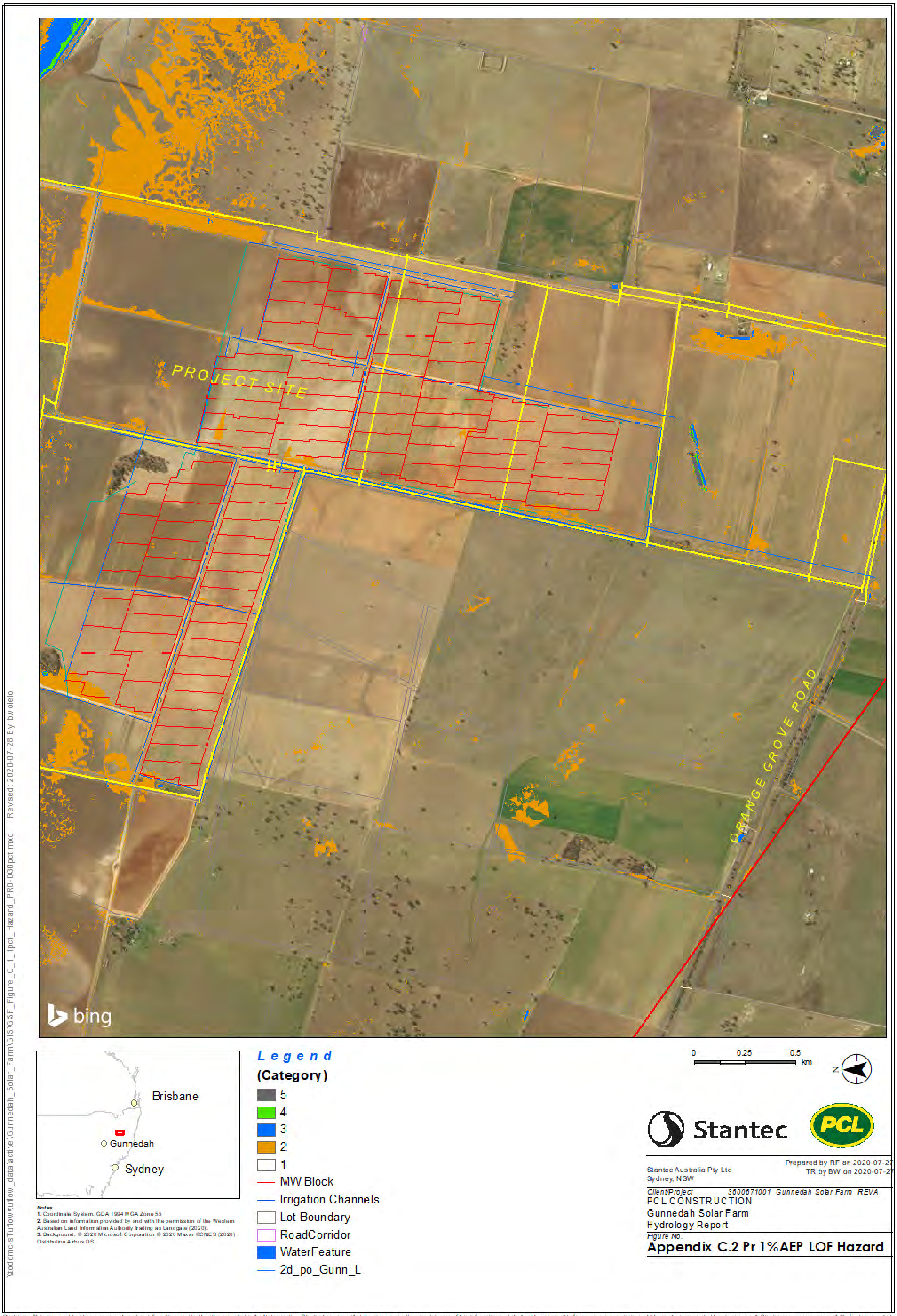
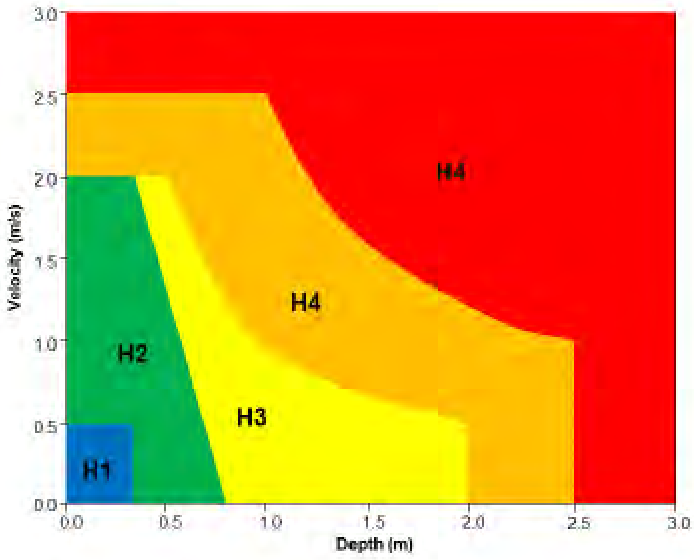
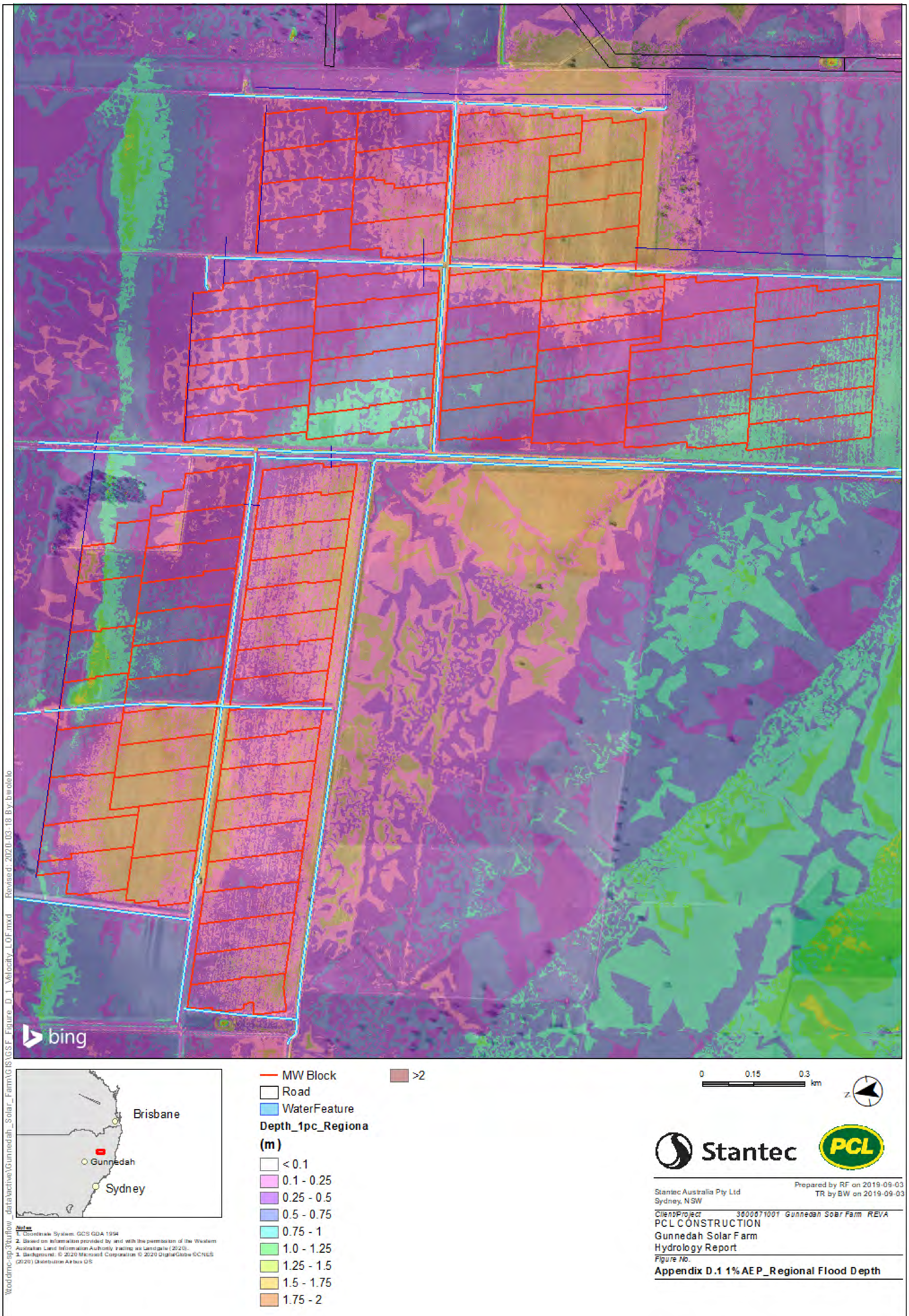


Figure Appendix C 3 MBRC Hazard Category (adopted from BMTWBM 2018)

Flag	Map Output Hazard Type	Supported Formats	Description
ZMBRC	ZMBRC	All formats	Flood hazard output used by Moreton Bay Regional Council. Where: V > 2.5 or D > 2.5 or V*D > 2.5: Category 5 (H5) V > 2.0 or D > 2.0 or V*D > 1.0: Category 4 (H4) V > 3.2 - 4D: Category 3 (H3) V > 0.5 or D > 0.3: Category 2 (H2) Otherwise Category 1 (H1) Dry points are assigned Category 0  H1: Hydraulically suitable for parked or moving cars. H2: Hydraulically suitable for parked or moving heavy vehicles and wading by able-bodied adults. H3: Hydraulically suitable for light construction (e.g. Timber frame and brick veneer). H4: Hydraulically suitable for heavy construction (e.g. steel frame and reinforced concrete). H5: Generally unsuitable

Appendix D Regional Flooding

Figure Appendix D 1 Depth of Flooding during the 1% AEP Regional Storm Event



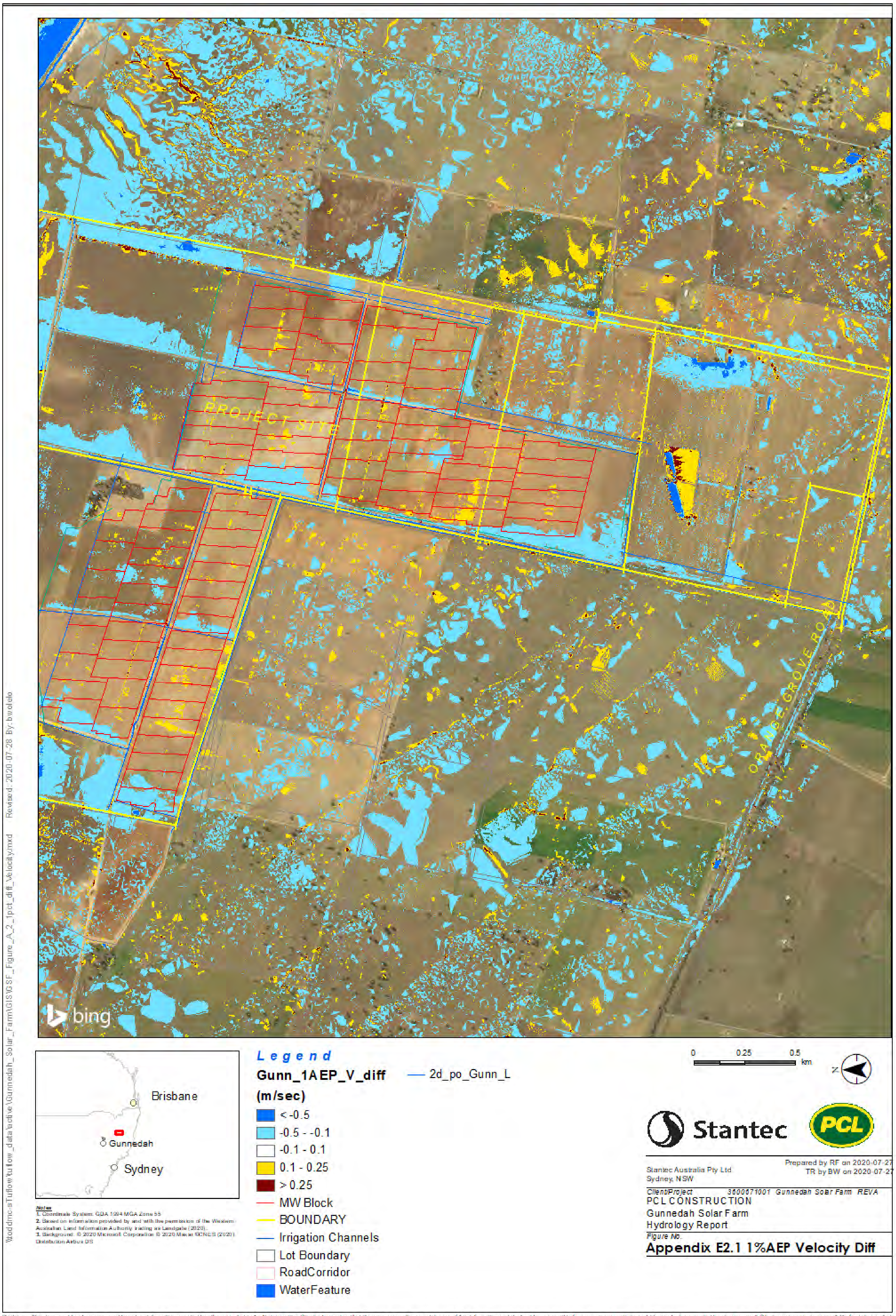
Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Appendix E Depth of Flooding Difference Post Construction of Access Road

Figure Appendix E 1 Afflux project site wide during the 1% AEP Storm event

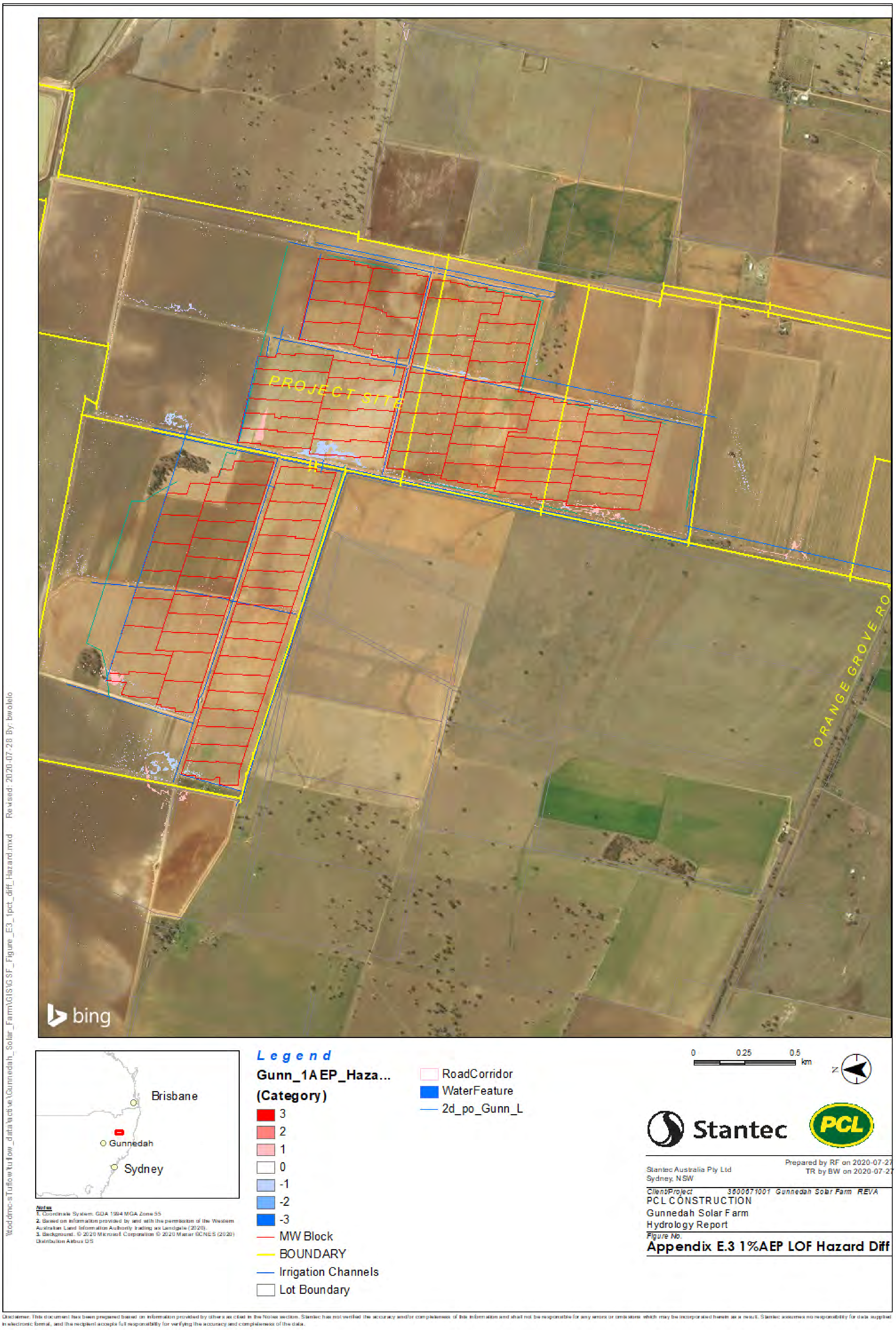
Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure Appendix E 2 Velocity Difference project site wide during the 1% AEP Storm event



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure Appendix E 3 Afflux project site wide during the 1% AEP Storm event



Appendix F Design Rainfall Depth and Site IFD

Appendix F Table 1 1% AEP 30minute rainfall Patterns

1% AEP, 90 Minute (1.5 Hour) Rainfall Patterns										
	Duration (minutes)		90			Original Depth (mm)	66.30			
						Climate Adjusted Depth (mm)	66.30		Intensity (mm/h)	44.20
Time	**Depth** (mm) **for Pattern:**									
(minutes)	1	2	3	4	5	6	7	8	9	10
0										
5	2.82	4.79	2.96	1.72	6.68	5.68	2.19	3.45	1.28	2.43
10	5.66	2.51	5.14	2.86	3.73	14.22	2.65	3.45	5.54	4.12
15	8.33	1.14	7.57	2.19	4.16	5.64	1.47	4.61	4.63	3.56
20	7.23	1.37	9.02	2.25	2.78	7.04	0.86	2.88	3.95	1.31
25	6.76	4.55	5.52	6.24	3.14	5.34	1.37	3.46	0.69	2.43
30	3.77	6.84	3.95	9.64	8.08	2.77	4.00	4.04	0.27	1.50
35	5.81	8.66	3.27	5.68	6.16	1.23	5.84	4.04	1.49	3.18
40	3.45	6.84	2.18	9.47	2.13	0.21	4.16	2.31	4.89	2.06
45	2.67	2.73	0.67	2.52	2.13	0.06	3.38	2.88	1.44	0.75
50	3.61	3.19	0.62	5.53	5.26	0.06	3.98	4.04	0.25	0.75
55	4.40	5.01	1.44	5.53	3.20	0.50	6.29	5.77	0.25	0.75
60	2.35	3.19	3.74	3.10	4.83	1.06	5.73	4.61	6.29	0.93
65	1.88	3.19	4.55	2.23	3.21	1.17	6.84	5.19	7.58	0.56
70	2.20	4.55	3.80	2.23	3.24	3.60	5.04	4.04	2.83	7.86
75	1.73	3.65	3.26	1.61	2.99	3.60	2.39	3.46	4.52	11.05
80	1.41	2.05	3.74	1.19	2.68	3.60	4.69	3.75	3.53	9.74
85	0.63	0.68	2.29	1.45	0.48	6.44	3.30	1.44	10.26	7.31
90	1.57	1.37	2.57	0.84	1.43	4.08	2.11	2.88	6.64	5.99
Check	66.30	66.30	66.30	66.30	66.30	66.30	66.30	66.30	66.30	66.30

Appendix F Table 2 Adopted 1% AEP 3 hour rainfall Pattern

1% AEP, 180 Minute (3 Hour) Rainfall Patterns										
	Duration (minutes)		180			Original Depth (mm)	79.50			
						Climate Adjusted Depth (mm)	79.50		Intensity (mm/h)	26.50
Time	**Depth** (mm) **for Pattern:**									
(minutes)	1	2	3	4	5	6	7	8	9	10
0										
15	3.92	16.77	2.27	2.02	11.68	6.34	9.51	13.87	2.92	3.02
30	13.75	3.59	2.21	9.29	10.02	5.28	7.36	12.00	9.60	4.68
45	4.71	1.91	6.65	7.47	16.28	7.39	9.09	12.51	5.26	4.34
60	7.26	0.02	1.26	8.07	10.53	5.72	11.50	11.30	7.78	5.76
75	14.25	0.02	1.50	8.47	11.21	2.02	9.46	7.37	7.76	4.79
90	6.03	0.02	3.82	18.36	6.11	6.33	5.41	3.60	2.78	7.04
105	4.89	0.02	12.09	10.29	2.38	14.07	9.91	1.03	10.14	13.00
120	5.75	6.82	14.64	3.83	0.08	13.72	5.41	0.52	10.81	4.45
135	5.80	10.29	10.96	0.20	1.26	1.58	4.51	6.17	5.63	9.99
150	3.66	8.09	10.20	1.42	2.08	5.10	4.21	3.77	5.90	4.52
165	4.74	15.82	8.23	4.04	7.47	7.39	2.10	1.72	2.40	4.80
180	4.76	16.11	5.66	6.05	0.41	4.57	1.05	5.65	8.52	13.11
Check	79.50	79.50	79.50	79.50	79.50	79.50	79.50	79.50	79.50	79.50
Sum										

Appendix F Table 3 Adopted 1% AEP 4.5 hour rainfall Pattern

1% AEP, 270 Minute (4.5 Hour) Rainfall Patterns										
	Duration (minutes)		270		Original Depth (mm)		88.50			
					Climate Adjusted Depth (mm)		88.50	Intensity (mm/h)		19.67
Time	**Depth (mm) for Pattern:**									
(minutes)	1	2	3	4	5	6	7	8	9	10
0										
15	5.51	1.50	4.88	1.65	18.30	11.55	0.05	6.88	2.54	2.14
30	1.33	1.78	8.87	2.82	14.18	13.56	0.05	8.83	10.02	6.50
45	3.09	5.66	16.39	3.11	3.91	8.17	8.19	3.30	4.73	1.73
60	4.03	5.24	2.51	3.46	8.97	2.79	13.44	6.80	3.31	13.70
75	4.52	6.48	2.18	3.28	1.50	5.58	7.20	1.42	6.37	6.05
90	11.30	3.00	3.03	4.24	2.96	4.19	17.29	2.08	5.58	2.52
105	8.82	7.13	7.13	2.66	0.61	6.38	7.68	4.06	3.61	0.36
120	3.58	10.31	4.71	4.12	0.00	7.18	4.81	5.89	4.04	0.58
135	2.35	11.63	5.57	3.82	0.23	4.19	0.48	6.96	3.01	0.09
150	4.55	5.33	3.94	5.06	0.00	2.99	0.70	6.50	2.93	0.03
165	1.51	4.36	1.50	4.22	0.00	2.59	0.26	5.61	7.09	2.14
180	6.48	4.04	5.96	6.19	5.15	3.19	0.96	6.02	15.90	5.43
195	2.48	7.85	7.65	11.43	7.41	2.19	3.36	6.55	6.93	3.81
210	0.68	4.48	0.93	3.91	11.05	1.80	9.12	6.60	1.78	10.82
225	0.45	4.90	4.85	8.79	9.12	2.59	1.92	2.87	0.91	9.80
240	13.20	2.42	4.24	3.98	1.12	3.39	0.96	2.60	0.73	13.97
255	10.75	1.33	2.42	4.22	1.49	2.99	7.20	2.51	0.72	8.30
270	3.86	1.06	1.76	11.53	2.50	3.19	4.81	3.01	8.29	0.51
Check Sum	88.50	88.50	88.50	88.50	88.50	88.50	88.50	88.50	88.50	88.50

Appendix F Table 4 Gunnedah Site IFD Data

	Annual Exceedance Probability (AEP)						
Duration	63.20%	50%	20%	10%	5%	2%	1%
1 min	104	118	163	194	225	268	302
2 min	88.5	99.8	137	165	193	232	261
3 min	81.9	92.5	127	152	178	213	240
4 min	76.9	86.9	119	143	166	198	223
5 min	72.6	82.1	113	135	157	187	210
10 min	56.9	64.4	88.7	106	123	146	164
15 min	47.1	53.3	73.5	87.7	102	121	137
20 min	40.4	45.7	63.1	75.3	87.5	104	118
25 min	35.5	40.2	55.4	66.2	77	91.9	104
30 min	31.8	36	49.6	59.2	69	82.4	93.1
45 min	24.5	27.7	38.1	45.6	53.1	63.5	71.8
1 hour	20.2	22.8	31.3	37.4	43.6	52.2	59
1.5 hour	15.3	17.2	23.6	28.1	32.7	39.1	44.2
2 hour	12.5	14.1	19.2	22.8	26.6	31.7	35.8
3 hour	9.42	10.6	14.4	17	19.8	23.5	26.5
4.5 hour	7.11	7.97	10.8	12.8	14.7	17.5	19.7
6 hour	5.83	6.54	8.81	10.4	12	14.2	16
9 hour	4.41	4.95	6.66	7.85	9.05	10.7	12
12 hour	3.62	4.06	5.47	6.45	7.43	8.78	9.86
18 hour	2.73	3.06	4.14	4.9	5.66	6.71	7.55
24 hour	2.22	2.5	3.4	4.03	4.67	5.56	6.28
30 hour	1.89	2.13	2.9	3.46	4.02	4.81	5.45
36 hour	1.65	1.86	2.55	3.05	3.55	4.27	4.86
48 hour	1.33	1.5	2.07	2.48	2.91	3.53	4.04
72 hour	0.96	1.09	1.52	1.83	2.17	2.66	3.06
96 hour	0.757	0.859	1.2	1.46	1.73	2.13	2.47
120 hour	0.627	0.712	0.998	1.21	1.43	1.77	2.05
144 hour	0.537	0.61	0.854	1.03	1.22	1.49	1.73
168 hour	0.471	0.535	0.746	0.897	1.05	1.28	1.49

Sydney

Level 4, 99 Walker Street,
NORTH SYDNEY, NSW 2060
Tel +61 2 9493 9700
Fax +61 2 9493 9799

Please visit **www.stantec.com** to learn more about how Stantec design with community in mind.

Stantec