Flood Impact Assessment
Dungog DBESS

G8 Energy

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ABBREVIATIONS

Abbreviation	Abbreviated term
AEP	Annual Exceedance Probability
ARF	Areal Reduction Factor
AHD	Australian Height Datum
ARR	Australian Rainfall and Runoff
ARI	Average Recurrence Interval
BOM	Bureau of Meteorology
DCCEEW	Department of Climate Change, Energy, The Environment and Water
DEM	Digital Elevation Model
DFE	Defined Flood Event
EAF	Elevation Adjustment Factor
FFL	Finished Floor Level
FIA	Flood Impact Assessment
FPA	Flood Planning Area
FPL	Flood Planning Level
GSDM	Generalised Short-Duration Method
IFD	Intensity–Frequency–Duration
LGA	Local Government Area
MAF	Moisture Adjustment Factor
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
WBNM	Watershed Bounded Network Model

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EXECUTIVE SUMMARY

Premise has been commissioned by G8 Energy to accompany a Development Application (DA) for the proposed Dungog Distribution Battery Energy Storage System (DBESS), located at Lot 2 DP 211171 & Lot 30 DP 1113705, 2243 Stroud Hill Road, Alison within the Dungog Local Government Area (LGA).

As part of the DA, a flood impact assessment was undertaken in accordance with the Flood Risk Management Guideline LU01 and other relevant technical references to assess potential flood risks associated with the proposed development. The proposed development comprises the installation of a 5 MW Battery Energy Storage System (BESS) and associated infrastructure, including modular units, access driveway, and security fencing, within the southern portion of the site adjacent to the existing Dungog Zone Substation.

The detailed hydrologic and hydraulic modelling assessment was carried out using data sourced from the Australian Rainfall and Runoff (ARR) Data Hub, Bureau of Meteorology (BoM), and LiDAR elevation data. The model simulated flood conditions for the 10%, 1% Annual Exceedance Probability (AEP), and Probable Maximum Flood (PMF) events.

Key findings from the assessment

- The development footprint is located outside the Flood Planning Area (FPA) for the 1% AEP event (Defined Flood Event).
- The maximum flood level at the proposed BESS footprint during the 1% AEP event is 71.5 m AHD. A Flood Planning Level (FPL) of 72.0 m AHD is recommended, incorporating a 500 mm freeboard to safeguard electrical equipment.
- Flood hazard and velocities at the site are classified as low, indicating minimal risk to the proposed infrastructure.
- A minor spill flow path from a nearby farm dam crosses Stroud Hill Road near the proposed access road. Appropriate drainage and erosion control measures should be included at the detailed design stage.
- Under the PMF event, flood depths exceeding 2.0 metres may occur across parts of the site. Accordingly, emergency response and evacuation procedures are recommended for such extreme events.

Overall, the results indicate that the proposed Dungog DBESS development is suitable from a flood risk perspective, subject to the implementation of the recommended flood planning levels, drainage design, and operational management measures.

1. INTRODCUTION

1.1 Project Area

The project area (refer to Figure 1) is located at Lot 2 DP 211171 & Lot 30 DP 1113705, 2243 Stroud Hill Road, Alison. Alison (Dungog) is a semi-rural locality within the Dungog Local Government Area (LGA). The site lies approximately 660 metres north of Dungog village and about 75 kilometres west of Forster. It is bounded by Stroud Hill Road and North Coast Railway line, and rural properties. The site is located within the RU1 – Primary Production zone under Clause 2.1 of the Dungog Local Environmental Plan 2014 (LEP).

As shown in **Figure 1**, the proposed development footprint occupies approximately 5% of the total project area and is situated in the southern portion of the site, adjacent to the Dungog Zone Substation. Lot 2 is otherwise undeveloped.

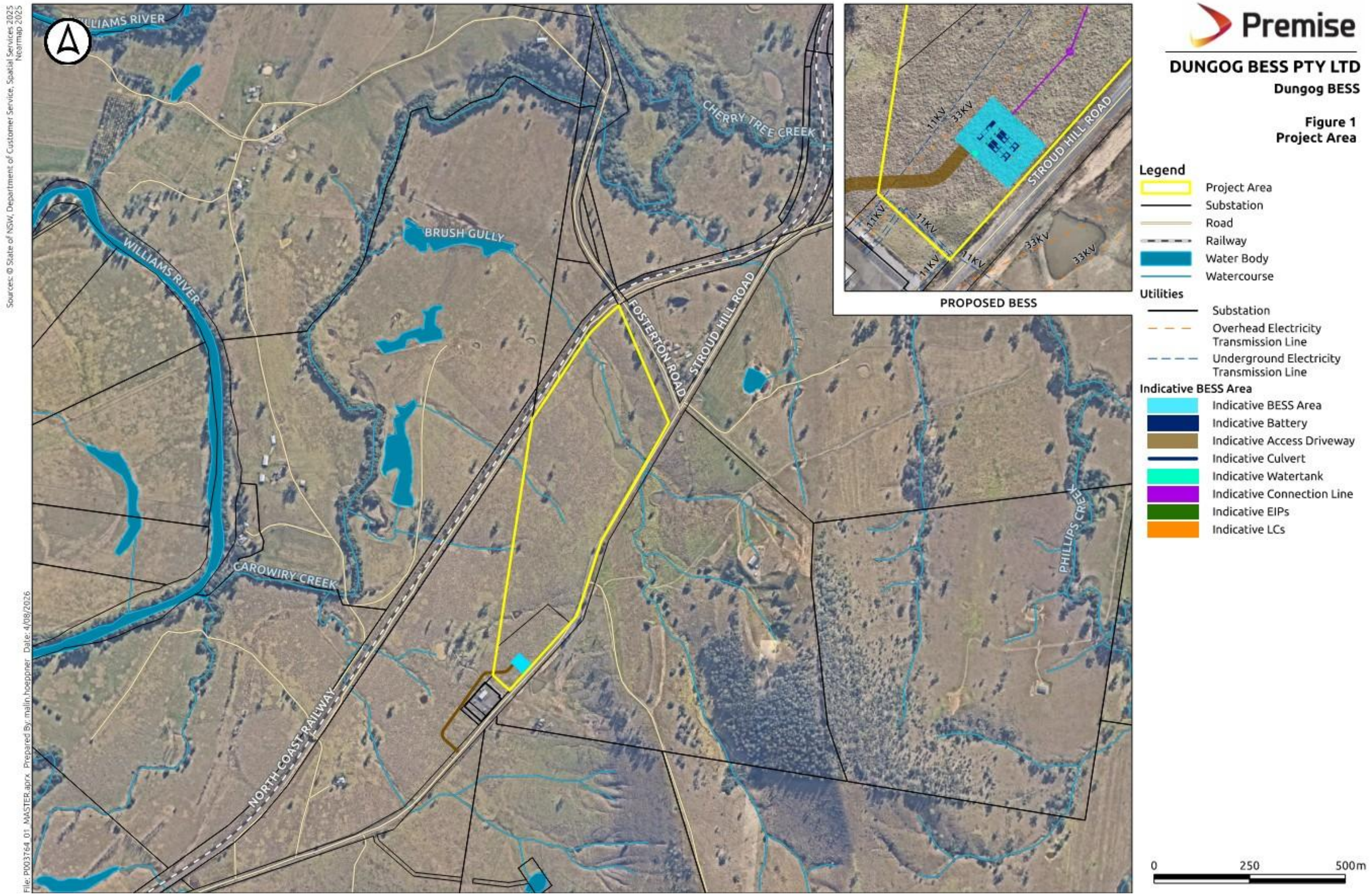
Several drainage lines traverse the northern section of the site, flowing toward Carowiry Creek, which ultimately discharges into the Williams River, a tributary of the Hunter River. However, no drainage lines intersect the proposed development footprint.

1.2 Proposed Development

G8 Energy is proposing to develop a 5 MW Distribution Battery Energy Storage System (BESS). The proposed development will include the following key components:

- Road-base gravel access driveway
- Four (4) BESS modular units
- One (1) Power Conversion System (PCS) modular unit
- Four (4) EIP units
- Two (2) LC units
- Perimeter high-security (Man-proof) fencing

Figure 1 – Project Area Map



2. FLOOD IMPACT ASSESSMENT FRAMEWORK

2.1 Data Collection and Review

The following data and information were collected, reviewed, and used in the assessment:

- Hydrological data from Australian Rainfall and Runoff (ARR) data hub.
- Intensity–Frequency–Duration (IFD) design rainfall data from Bureau of Meteorology (BoM).
- 5m Aerial LiDAR sourced from Geosciences Australia (Elvis Elevation and Depth Data).
- Land use data from Department of Climate Change, Energy, the Environment and Water (DCCEEW) of New South Wales.
- Satellite images from Google Earth and aerial imagery by NSW Spatial Services Six Maps.

2.2 Methodology

The key procedures adopted in the flood impact assessment are summarised below.

- Collection and review of relevant hydrological data.
- Development of a 5 m resolution Digital Elevation Model (DEM)
- Delineation of the upstream catchment.
- Development of a hydrologic model using Drains software and conducting simulations to identify the critical storm durations and temporal patterns of design storm events.
- Preparation of design rainfall inputs for the 10% AEP ,1% AEP and PMF storm events, based on the identified critical duration and temporal patterns.
- Setup of a TUFLOW hydraulic model with an appropriately defined model domain.
- Simulation of flood characteristics for the design events under existing conditions using the hydraulic model.
- Preparation of flood maps, definition of flood risk areas, and assessment of the potential impacts of the proposed development on flood behaviour.

2.3 Relevant Guidelines

Relevant guidelines and reference used in this assessment are:

- Flood Impact and Risk Assessment: Flood Risk Management Guideline LU01, Department of Planning and Environment (2022).
- The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method (GSDM), Bureau of Meteorology.
- Dungog Local Environmental Plan (LEP) 2014
- Considering Flooding in Land Use Planning: Guidance and Statutory Requirements, Department of Planning, Industry and Environment – Planning Circular PS 21-006

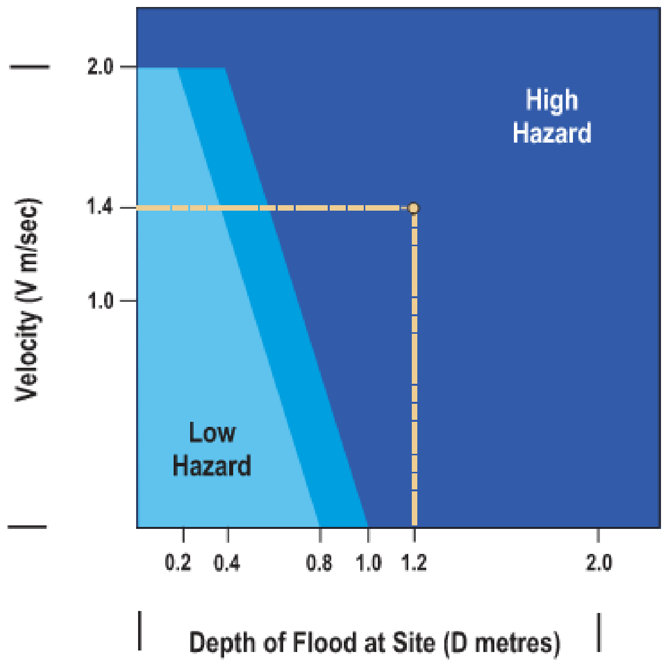
> Flood Risk Management Manual: The policy and manual for the management of flood liable land

Based on this guideline, the following key design parameters have been adopted for flood planning:

- Defined Flood Event (DFE): The flood event selected as a general standard for the management of flooding to development.
  - 1% AEP event was selected as the DFE for this assessment
- Flood Planning Area (FPA): The area of land below the FPL
- Flood Planning Level (FPL) The combination of the flood event from the DFE and the freeboard selected for FRM purposes
  - When defining the FPL a 500mm freeboard was considered
- Flood Risk Management (FRM): The management of flood risk to communities
  - Floodplain Development Manual, the management of flood liable land

As per the guideline, the provisional hydraulic hazard categories were defined according to classification provided in **Figure 2.**

Figure 2 – Provisional Hydraulic Hazard Categories



3. HYDROLOGIC ASSESSMENT

3.1 Data from ARR Data Hub

Primary data and information obtained from the ARR Data Hub are provided in **Table 1**.

Table 1 – Summary of Data obtained from ARR Data Hub

Data	Value
Latitude	-32.387969
Longitude	151.778947
River Region	Hunter River
Initial Losses (IL)	22.0 mm
Continuing Losses (CL)	3.3 mm/hr*
Temporal Patterns	East Coast South
Preburst Depths and Ratios	Median

* Default ARR data hub continuing losses was used with a multiplication factor of 0.4 as per ARR recommendation

3.2 Catchment Delineation

The project area is located within the downstream portion of the Carowiry Creek catchment. To assess the site's hydrological context, the entire Carowiry Creek catchment was delineated up to its confluence with the Williams River. The total catchment area is approximately 8,060 hectares. The extent of the catchment and the position of the project area within it are shown in **Figure 3**.

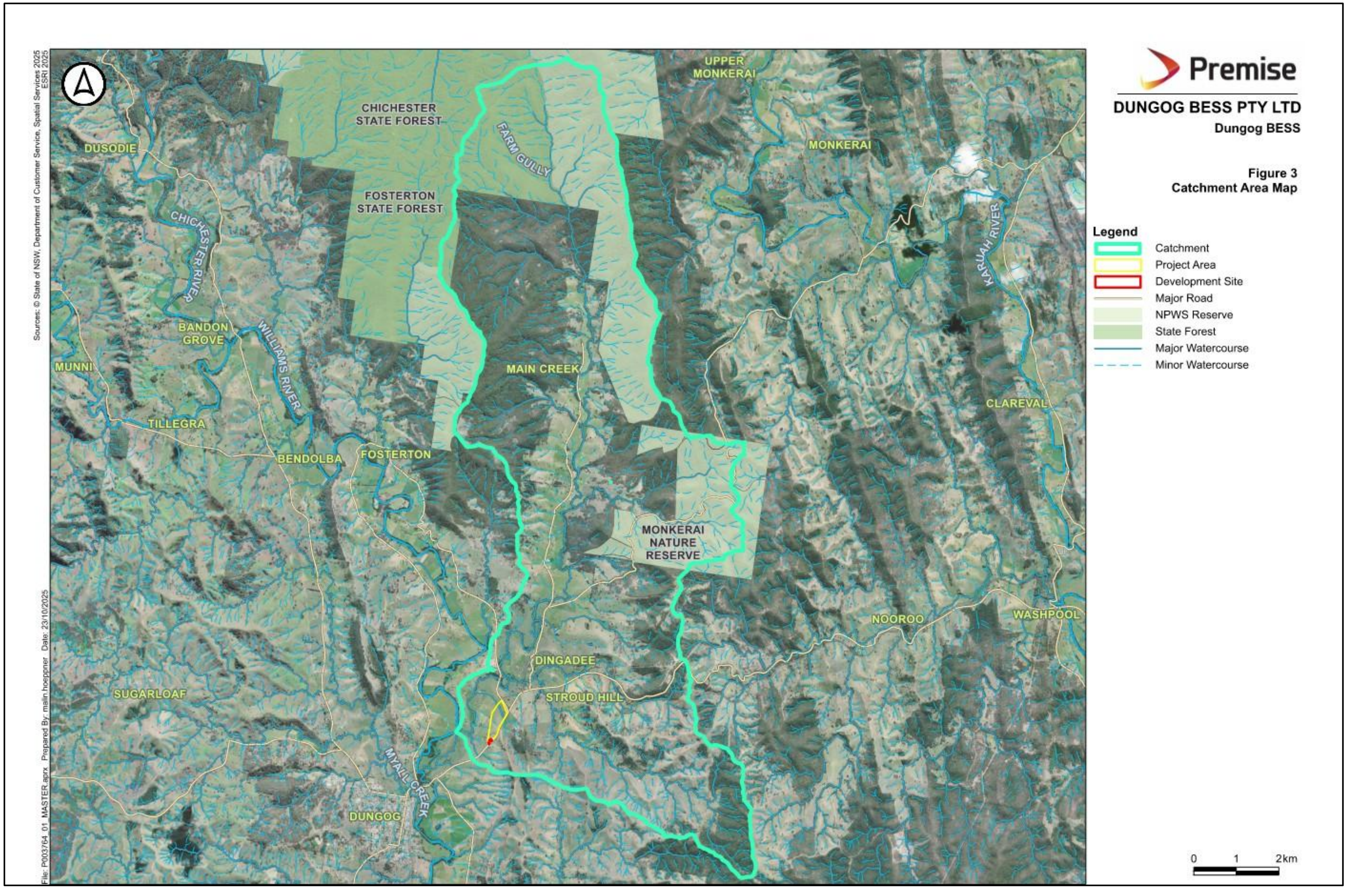
3.3 Land Use

The area of each land use type within the catchment is presented in **Table 3**. More than 70% of the catchment is covered by natural vegetation, while approximately 22% consists of pastures and farmland. Residential areas, roads, and water bodies occupy only a small proportion of the total catchment area.

Table 2 – Land Use Classification

Land Use	Area (Ha)	% Area
Residential Areas (Low Density)	6.82	< 1%
Services/Utilities	1.71	< 1%
Roads	79.75	< 1%
Water Sources	1.43	< 1%
Pasture/Farms	1761.62	21.8%
Open pervious areas, minimal vegetation (Grassed)	1770.36	22.0%
Open pervious areas, moderate vegetation (Shrubs)	2193.52	27.2%
Open pervious areas, thick vegetation (Trees)	2249.36	27.9%

Figure 3 – Catchment Area Map



3.4 Hydrological Modelling

3.4.1 10% AEP AND 1% AEP EVENT

The following steps were undertaken as part of the hydrological modelling process to estimate the design rainfall distribution for the 10% and 1% AEP events. The results are summarised in **Table 3**.

> A storage–routing hydrological model was developed for the delineated catchment using the WBNM (Watershed Bounded Network Model) approach within the DRAINS modelling package, in accordance with ARR 2019 recommendations.

> The model was simulated for the 10% and 1% AEP events to determine the critical storm duration and temporal pattern for each event.

> The IFD burst depth corresponding to the critical duration was identified from the BoM design rainfall data.

> The Event ID associated with the critical duration and temporal pattern of each event was identified.

> The areal reduction factor (ARF) for each event and its critical duration was calculated following ARR 2019 guidelines and applied to derive the final design rainfall depth

> The final rainfall depth was distributed according to the selected Event ID to develop the design rainfall hyetograph.

> The probability-neutral initial loss for each event and its corresponding critical duration was identified from ARR data.

Table 3 – Hydrological Modelling Results

Parameter	10% AEP Event	1% AEP Event
Critical Duration (hr)	6	6
Temporal Pattern	Storm 1	Storm 1
IFD Burst Depth (mm)	88.4	145
Event ID	4732	4406
ARF	0.9112	0.8864
Probability Neutral Burst Initial Loss (mm)	12.1	3.5

3.4.2 PMF EVENT

Based on the methods recommended by the Bureau of Meteorology (BoM) in *Design Rainfalls: Water Information: Bureau of Meteorology*, the Generalised Short-Duration Method (GSDM) was adopted to estimate the Probable Maximum Precipitation (PMP) for the catchment at the Goolma Road bridge. The catchment lies within the 6-hour limit zone, and the PMP duration limit was interpolated to be 6 hours.

The GSDM estimation, as outlined in Appendix 1 (GSDM Calculation Sheet) of the BoM guideline, is presented in **Table 4**. The following parameters and assumptions were applied in accordance with the BoM methodology:

> Based on catchment topography, 20% of the area was classified as smooth (S) and 80% as rough (R).

> As the maximum elevation of the catchment is below 1500 m AHD, the elevation adjustment factor (EAF) was taken as 1.0.

> From **Figure 3** of the guideline, the moisture adjustment factor (MAF) was estimated to be 0.75.

- From **Figure 4** of the guideline, the initial depths for both the smooth (D_S) and rough (D_R) categories were obtained for a catchment area of 80 km² for durations up to 6 hours.
- The PMP depths for each duration were then calculated using the PMP estimation equation.
- The estimated PMP values were rounded to the nearest 10 mm.
- For this study, the 6-hour PMP depth was adopted and temporally distributed as per **Figure 5** of the guideline to develop the hyetograph for the PMP event.

Table 4 – GSDM Calculation

Location Information				
Catchment Area: 80.64 km^2				
Duration Limit: 6 hrs				
Latitude: 32°23'16.69"S				
Longitude: 151°46'44.21"E				
Portion of Area Considered: Smooth, S = 0.20 (0.0 - 1.0) Rough, R = 0.80 (0.0 - 1.0)				
Elevation Adjustment Factor (EAF)				
Mean Elevation: 205.76 m				
Adjustment for Elevation (-0.05 per 300m above 1500m): NA				
EAF = 1.00 (0.85 - 1.00)				
Moisture Adjustment Factor (MAF)				
MAF = 0.75 (0.40 - 1.00)				
PMP Values (mm)				
Duration (hours)	**Initial Depth - Smooth (D_S)**	**Initial Depth- Rough (D_R)**	**PMP Estimate = (D_S x S + D_R x R) x MAF x EAF**	**Rounded PMP Estimate (nearest 10 mm)**
0.25	170	170	127.5	130
0.5	255	255	191.3	190
0.75	320	320	240.0	240
1.0	390	390	292.5	290
1.5	440	500	366.0	370
2.0	500	570	417.0	420
2.5	530	650	469.5	470
3.0	565	700	504.8	500
4.0	630	790	568.5	570
5.0	675	865	620.3	620
6.0	720	920	660.0	660

4. FLOOD MODELLING

4.1 Model Development

A rain-on-grid TUFLOW hydraulic model was developed for the entire catchment using a 5 m grid resolution. The following input files were prepared for model simulations:

- Geometry control file.
- Boundary control file.
- Time control file.

These files were supported by sub-files containing topographic data (DEM), rainfall inputs and land use. For each design storm event, probability-neutral burst initial losses and continuing losses were applied. Land use information was defined through material ID files, and the corresponding Manning's roughness coefficients were assigned based on the land use classification. The adopted roughness values used in the hydraulic model are presented in **Table 5**.

Table 5 – Manning's Values

Land Use	Values
Residential Areas (Low Density)	0.100
Roads	0.022
Water Sources	0.030
Pasture/Farms	0.040
Open pervious areas, minimal vegetation (Grassed)	0.045
Open pervious areas, moderate vegetation (Shrubs)	0.060
Open pervious areas, thick vegetation (Trees)	0.090

4.2 Model Simulation Scenarios

Flood modelling was carried out for the existing conditions (Pre-development). The hydraulic model was simulated for the DFE (1% AEP Event). Additional model simulations were carried out for 10% AEP and PMF events to compare results.

4.3 Model Exclusions

The current assessment was carried out to evaluate flooding associated with Carowiry Creek. The potential breakout flooding impacts from the Williams River were not considered in this assessment.

5. MODEL RESULTS AND ASSESSMENT

5.1 Inundation Area

The maximum flood depth for the 1% AEP event is shown in **Figure 4**. Flood depths of less than 50 mm were considered negligible for the purposes of flood mapping. Areas with maximum flood depths greater than 50 mm were defined as the Flood Planning Area (FPA) for the Design Flood Event (DFE). The modelling indicates that the proposed BESS development footprint is located outside the mapped 1% AEP FPA and remains free from inundation during the design flood event. Flooding is generally confined to the western floodplain associated with the adjacent creek and to minor drainage paths crossing the surrounding land.

A local overland flow path has been identified from the farm dam located east of Stroud Hill Road. This drainage path crosses Stroud Hill Road and conveys runoff towards the creek west of the site. As the proposed access road intersects this flow path, appropriate consideration should be given during detailed design to maintain the existing drainage function and avoid adverse impacts on flood behaviour.

However, the proposed internal access road would comprise a low-impact gravel surface and is unlikely to impede or alter existing overland flow paths. The road has been designed as a simple access track with minimal earthworks and will generally follow the existing site topography, thereby reducing the need for significant cut and fill activities. As a result, the proposal is not anticipated to materially change the direction, velocity or volume of overland stormwater flows across the site, nor create any adverse flooding impacts on adjoining land. Accordingly, the development is considered to maintain the existing overland flow regime and is compatible with the site's natural drainage characteristics.

Flood depth maps for 10% and PMF events are shown in **Appendix A** for reference. As the proposed development is located outside the mapped flood inundation extent for the design flood event (1% AEP), post-development hydraulic modelling was not considered necessary at this stage. Given the separation of the development footprint from flood-affected areas, the proposed works are not expected to result in any material changes to existing flood behaviour, including flood levels, flow paths, velocities, or flood extents. Consequently, the potential hydraulic impacts of the development are considered negligible.

5.2 Flood Level

The maximum flood levels for the 1% AEP event are shown in **Figure 5.** Flood levels around the proposed development site range from 67 m to 72 m AHD, with the maximum level at the development footprint being 72.2 m AHD at the proposed BESS location. To provide a 500 mm freeboard and prevent damage to electrical equipment, the proposed Flood Planning level (FPL) for the development is recommended to be 72.7 m AHD. Flood level maps for 10% and PMF events are shown in **Appendix A**. Maximum flood level for at the development footprint is 72.75 m AHD for the PMF event.

5.3 Flood Velocity

The maximum velocities for the 1% AEP event are shown in **Figure 6**. The majority of the site experiences negligible or very low flood velocities, reflecting the absence of inundation across the proposed BESS footprint. Higher velocities are generally confined to defined drainage channels and overland flow paths, particularly where runoff crosses Stroud Hill Road and flows towards the western creek. Localised velocities along these drainage paths are significantly greater than those across the surrounding floodplain and may result in erosion if disturbed. Accordingly, any works associated with the access road crossing or drainage infrastructure should incorporate suitable scour protection and erosion control measures during detailed design as conditioned by Council.

5.4 Hydraulic Hazard

The provisional hydraulic hazard for the 1% AEP event, based on flood depth and velocity as outlined in the Flood Manual, is shown in **Figure 7**. The updated assessment indicates that the proposed BESS footprint is located within an area of negligible to low hydraulic hazard. Areas of higher hazard are limited to the main creek corridor and defined flow paths located west of the development site and do not extend into the proposed BESS area. Consequently, hydraulic hazard is not considered to constrain the proposed development footprint.

Figure 4 – Flood Depth Map (1% AEP Event)

Figure 5 – Flood Level Map (1% AEP Event)

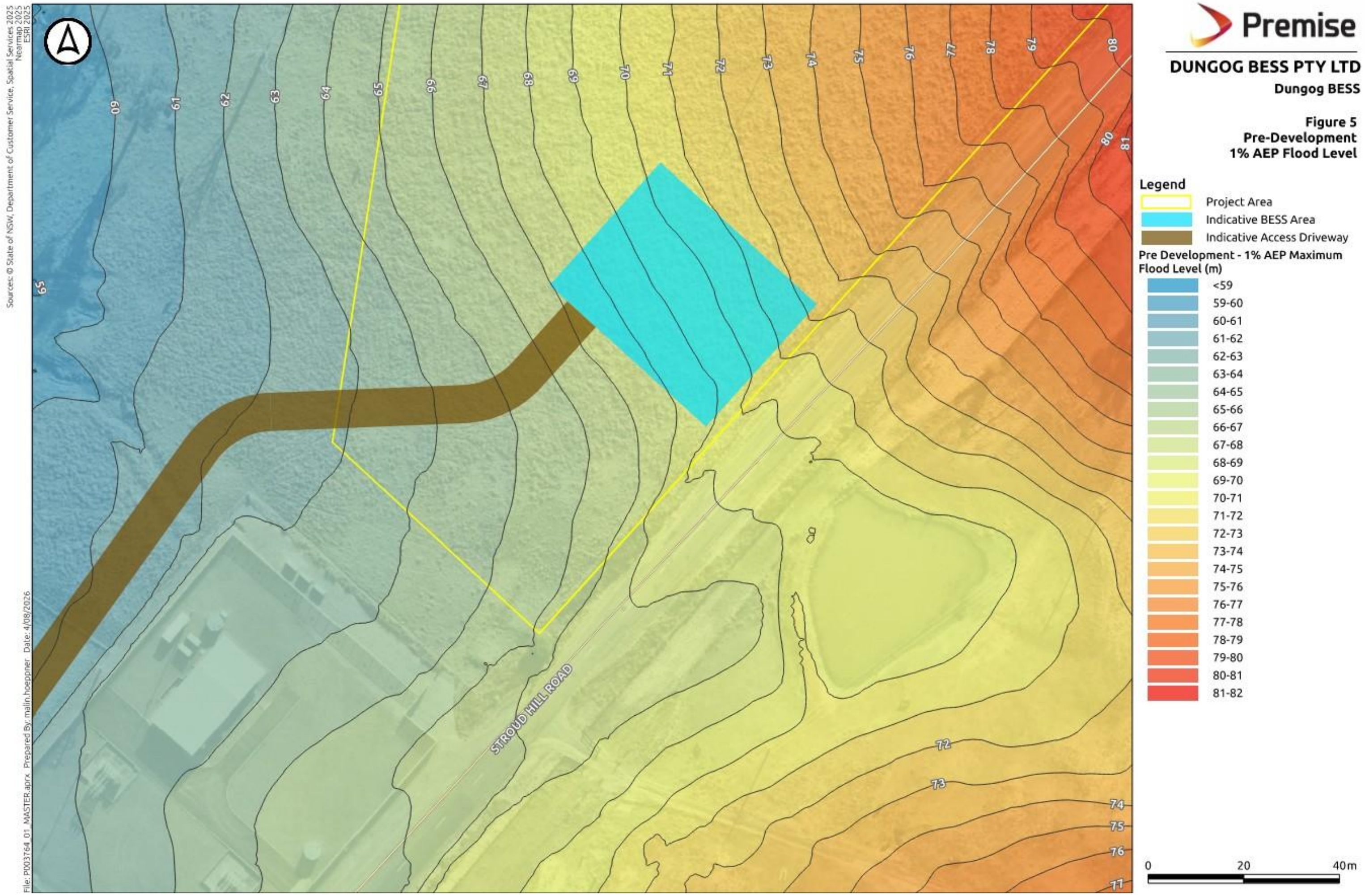


Figure 6 – Flood Velocity Map (1% AEP Event)

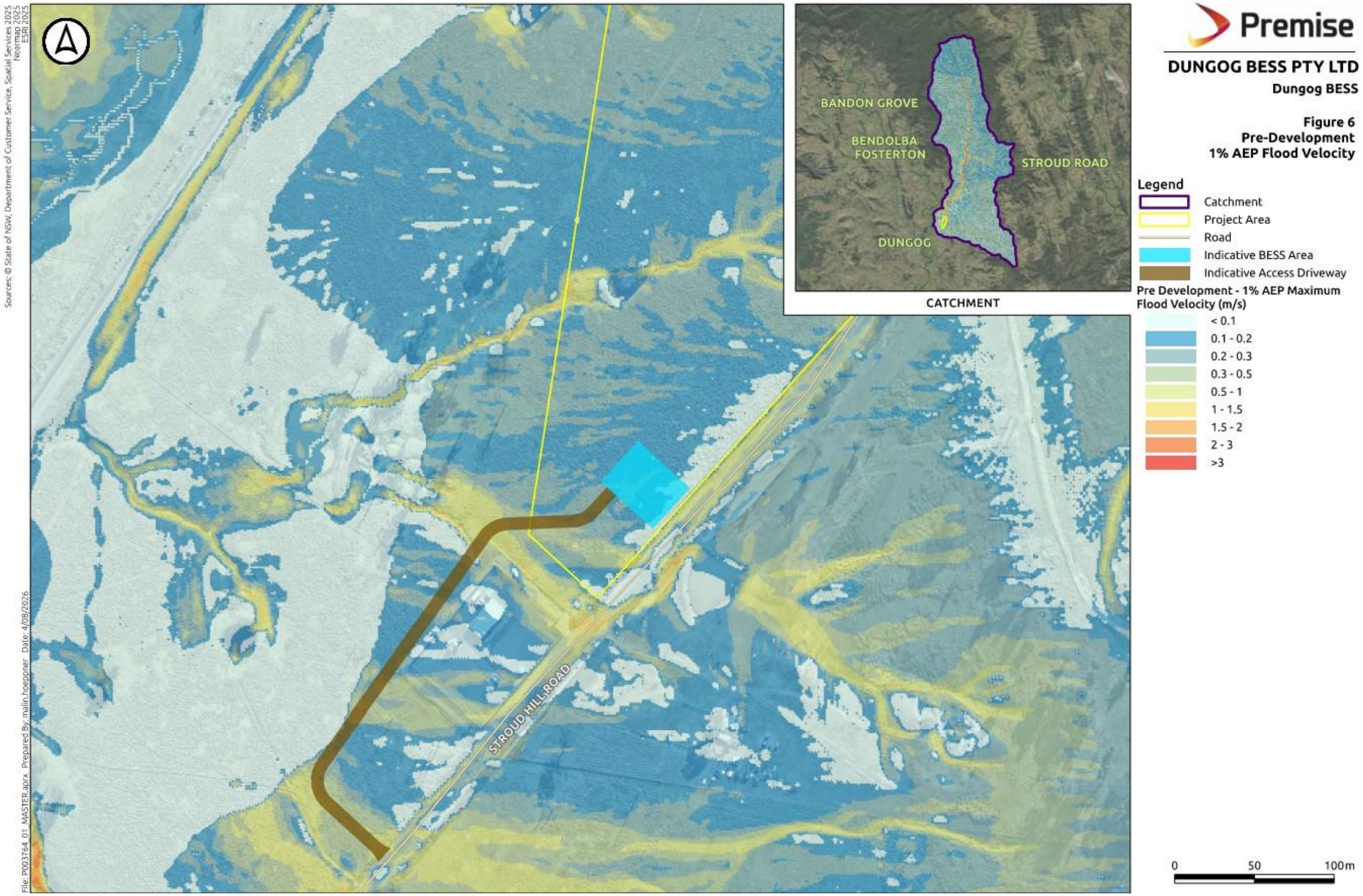
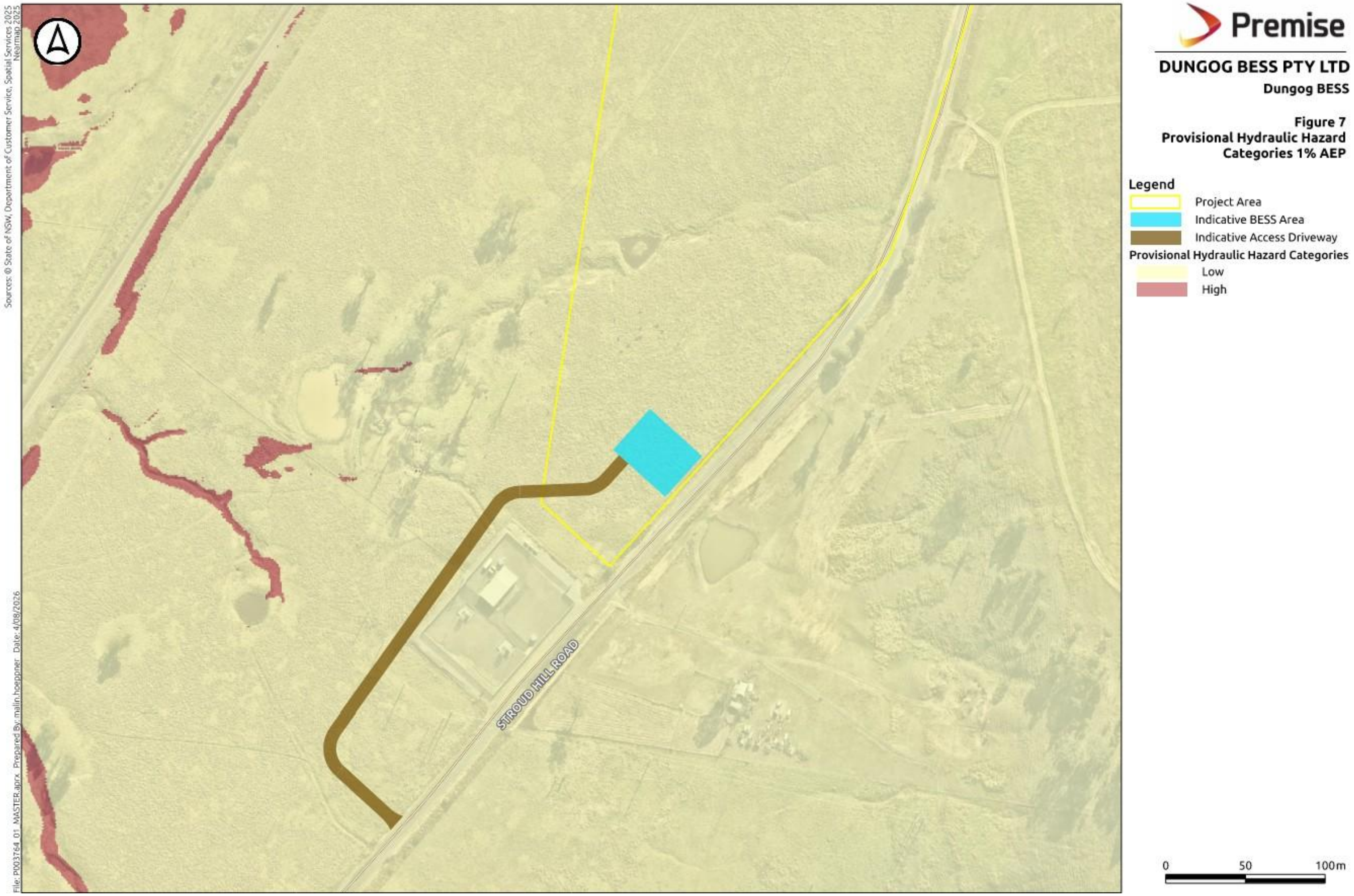


Figure 7 – Provisional Flood Hazard Map (1% AEP Event)



6. CONCLUSION

A hydrologic and hydraulic assessment was undertaken to evaluate the potential flood impacts associated with the proposed Dungog Distribution Battery Energy Storage System (DBESS) at Lot 2 DP 211171 & Lot 30 DP 1113705, 2243 Stroud Hill Road, Alison. The assessment was carried out in accordance with the Flood Risk Management Guideline LU01 and other relevant planning and technical references.

Based on the results of the flood modelling for the 10%, 1% Annual Exceedance Probability (AEP), and Probable Maximum Flood (PMF) events, the following conclusions are drawn:

> The proposed development footprint is located outside the Flood Planning Area (FPA) for the Defined Flood Event (DFE) (1% AEP). Therefore, post-development hydraulic modelling was not considered necessary at this stage.

> The recommended Flood Planning Level (FPL) for the site is 72.7 m AHD, this provides a 500 mm freeboard above the 1% AEP flood level at the development footprint.

> Flood hazard within the proposed development area is classified as low hazard for DFE, indicating minimal flood risk to the proposed infrastructure.

> A spill flow path from a nearby farm dam crosses Stroud Hill Road adjacent to the proposed access road. This should be carefully addressed through detailed design and appropriate drainage or erosion control measures in accordance with *Managing Urban Stormwater: Soils and construction - Volume 1* (Landcom, 2004).

> During the PMF event, the site may be subject to flood depths exceeding 3m; therefore, it is recommended that emergency response and evacuation procedures be established for such extreme events.

Overall, the proposed Dungog DBESS development is considered suitable from a flood risk perspective, provided that the recommended design levels, drainage provisions, and management measures are implemented during detailed design and operation.

APPENDIX A

FLOOD MAPS

Figure 8 – Flood Depth Map (10% AEP Event)

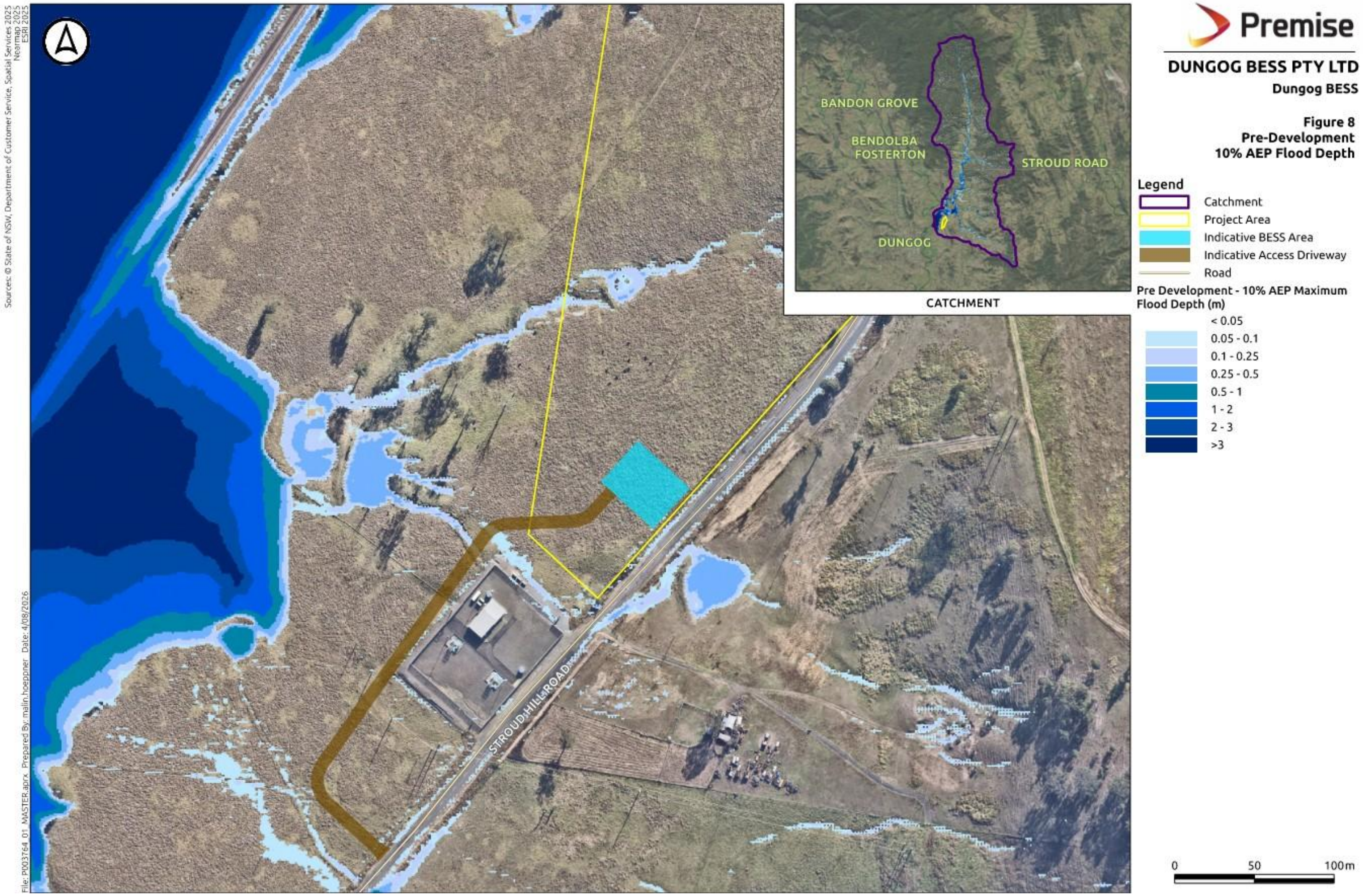


Figure 9 – Flood level Map (10% AEP Event)

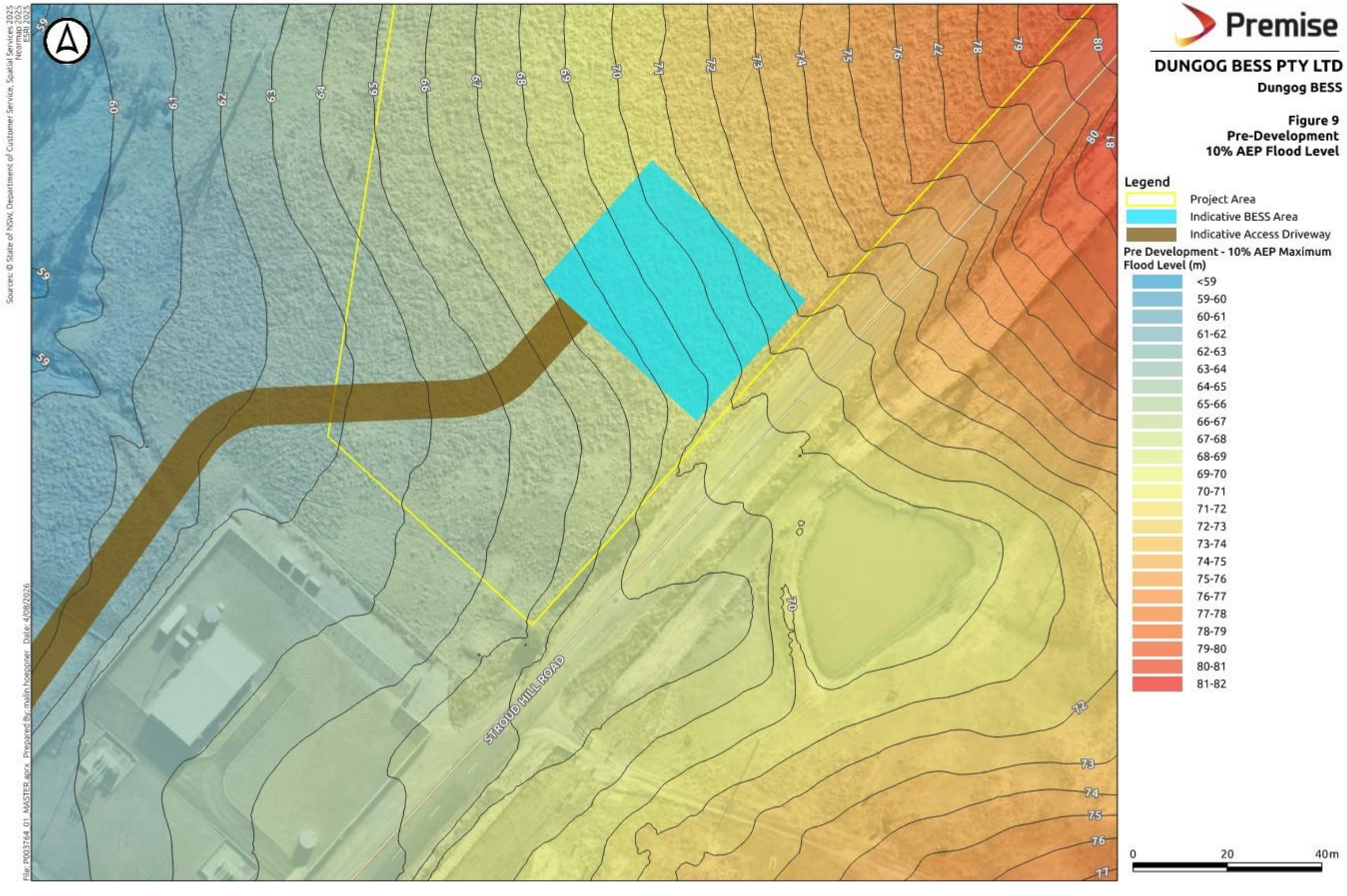


Figure 10 – Flood Depth Map (PMF Event)

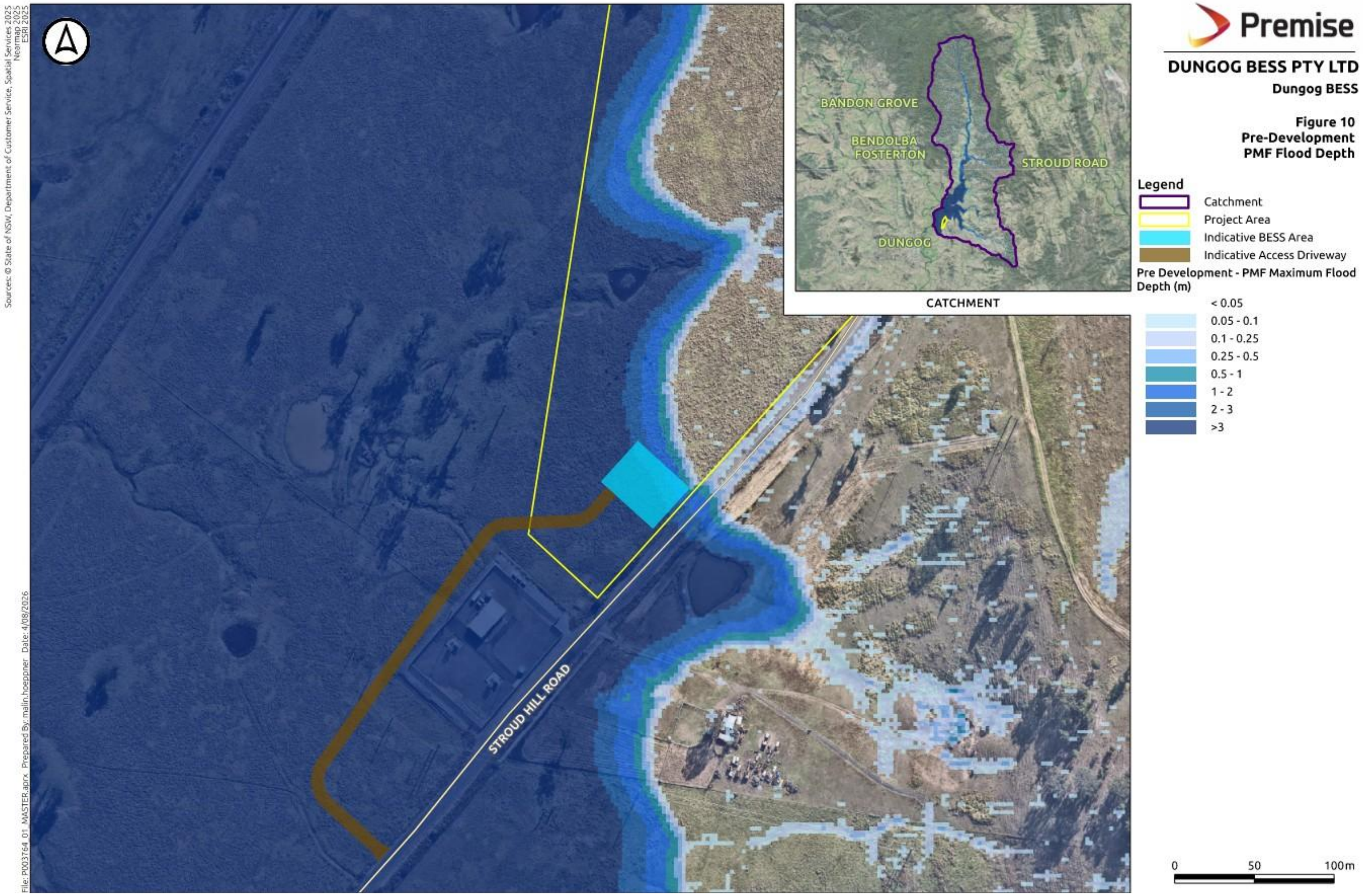


Figure 11 – Flood Level Map (PMF Event)