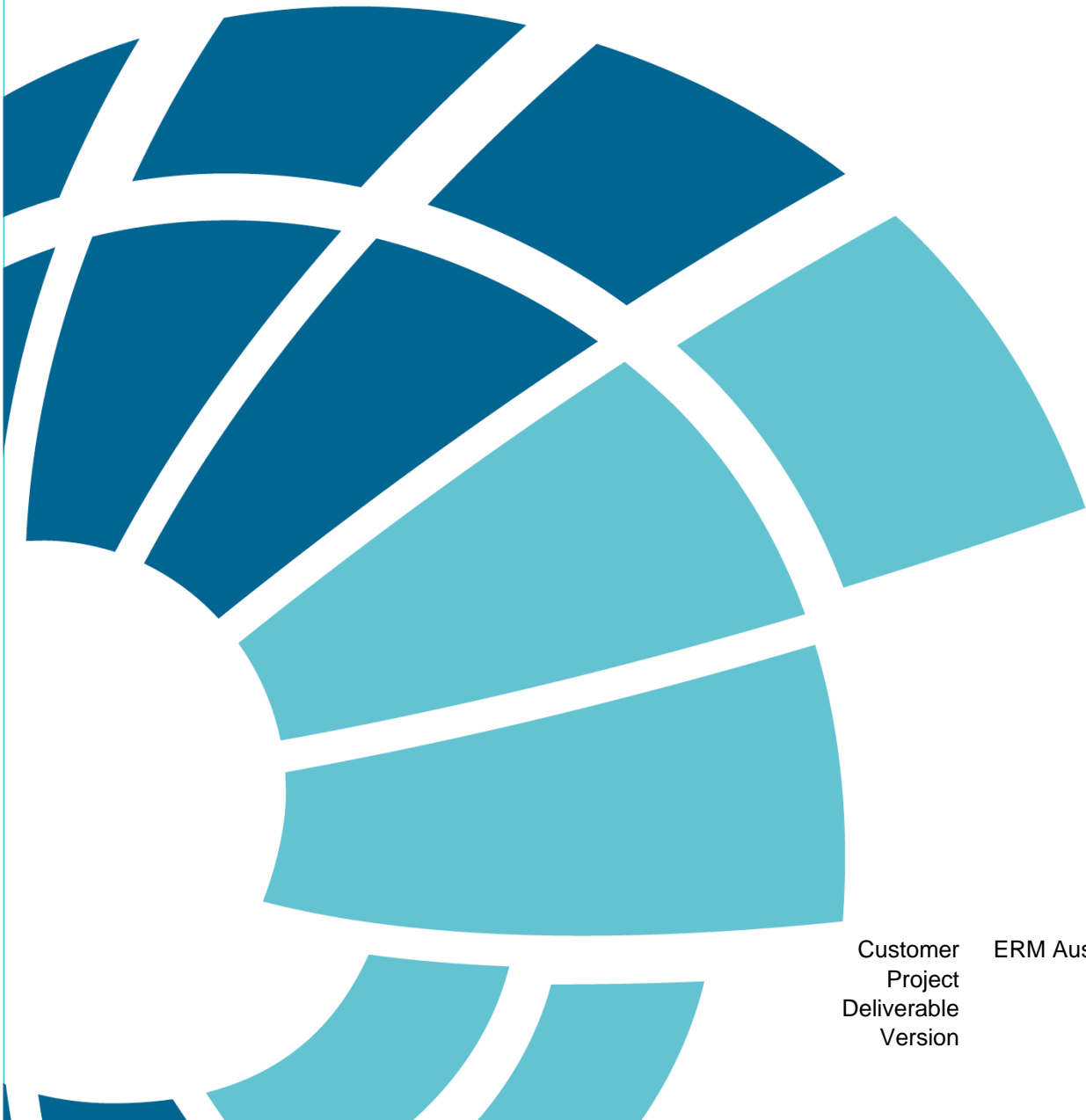


Winterbourne Wind Farm Rapid Flood Assessment



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Executive Summary

This report presents the rapid flood assessment undertaken to support the State Significant Development Application (SSD-10471) for the proposed Winterbourne Wind Farm (WWF) Project (the “Project”). This assessment was prepared in response to comments (Ref: DOC21/286181, included as Annex A:) from the Biodiversity and Conservation Division (BCD) of the Biodiversity, Conservation and Science Directorate in the Environment, Energy and Science Group of the Department of Planning, Industry and Environment (DPIE). BCD recommended an alternative approach (in addition to the methodology proposed by Footprint (NSW) Pty Ltd in a letter to BCD dated 29 March 2021, included as Annex B:) to undertaking a flood impact assessment for the proposed development to satisfy the Secretary’s Environmental Assessment Requirements (SEARs) for SSD-10471. Due to the limited footprint and positioning of the Project infrastructure primarily along catchment ridge lines, the completion of a typical flood impact assessment is not warranted as the potential flood impacts are likely to be minimal. Therefore, a rapid flood assessment was undertaken instead to support the SSD-10471 submission by determining indicative flood risks for the Project infrastructure including proposed turbine sites and waterway crossings. Another objective of this broad scale assessment is to provide indicative flood extents to enable the intersection of predicted flood extent and the proposed Project infrastructure to be determined.

As part of the rapid flood assessment, new flood models were developed using the TUFLOW modelling software based on the Australian Rainfall and Runoff 2019 (ARR 2019) data and methodology. Three (3) rain-on-grid (ROG) hydraulic models were developed to simulate the dynamic interactions between watercourses and floodplains as well as overland flow paths within the study area, for the 1% AEP (Annual Exceedance Probability) design flood event. The 1% AEP (or 1 in 100 AEP) event is generally a critical event used to assess flood risks and to reduce flood exposure and damage (NSW Floodplain Development Manual, 2005). To ensure the models are fit for purpose, the peak flows predicted by one of the models were compared against published peak flows based on at-site Flood Frequency Analysis (FFA) undertaken for a local stream flow gauge as well as previous modelling undertaken for a local catchment within the study area. This model validation found that the results are generally suitable for use in the subsequently flood assessment of the Project.

Indicative flood extents are provided as part of this report for the 1% AEP design flood event, which are sufficient to inform the appropriate siting of the Project infrastructure and to avoid areas subject to high flood risks where necessary. The flood risk to various components of the Project infrastructure has been ascertained based on the 1% AEP predicted flood extents. Detailed design of the cross-drainage structures located along the Project infrastructure will be required at the next stage of the Project to meet the local and road authorities’ requirements, including to cater for design flows and to achieve flood immunity for the proposed infrastructure. The design shall be undertaken based on detailed and more robust analysis of flood parameters such as flows, velocities and levels, utilising ground and watercourse bathymetry survey information once it becomes available as well as survey of relevant drainage structures which currently are not incorporated in the hydraulic models.

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1 Introduction

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2 Project Description

2.1 Overview

The Project is located in mid-north NSW approximately 6.5 km north-east of Walcha and 7 km south-east of Uralla within the Walcha Council and Uralla Shire Council Local Government Areas (LGAs). The Project Area encompasses approximately 22,285 ha. An overview of the study area and Project layout is shown in Figure 2.1.

2.2 Project Components

The Project involves the construction and operation of a wind farm with up to 119 wind turbine generators (WTG), together with associated and ancillary infrastructure.

The Project design has been revised and refined in response to the identification and assessment of environmental constraints, constructability requirements, and consideration of the outcomes of Agency, landowner, and community consultations.

The Project consists of the following key components:

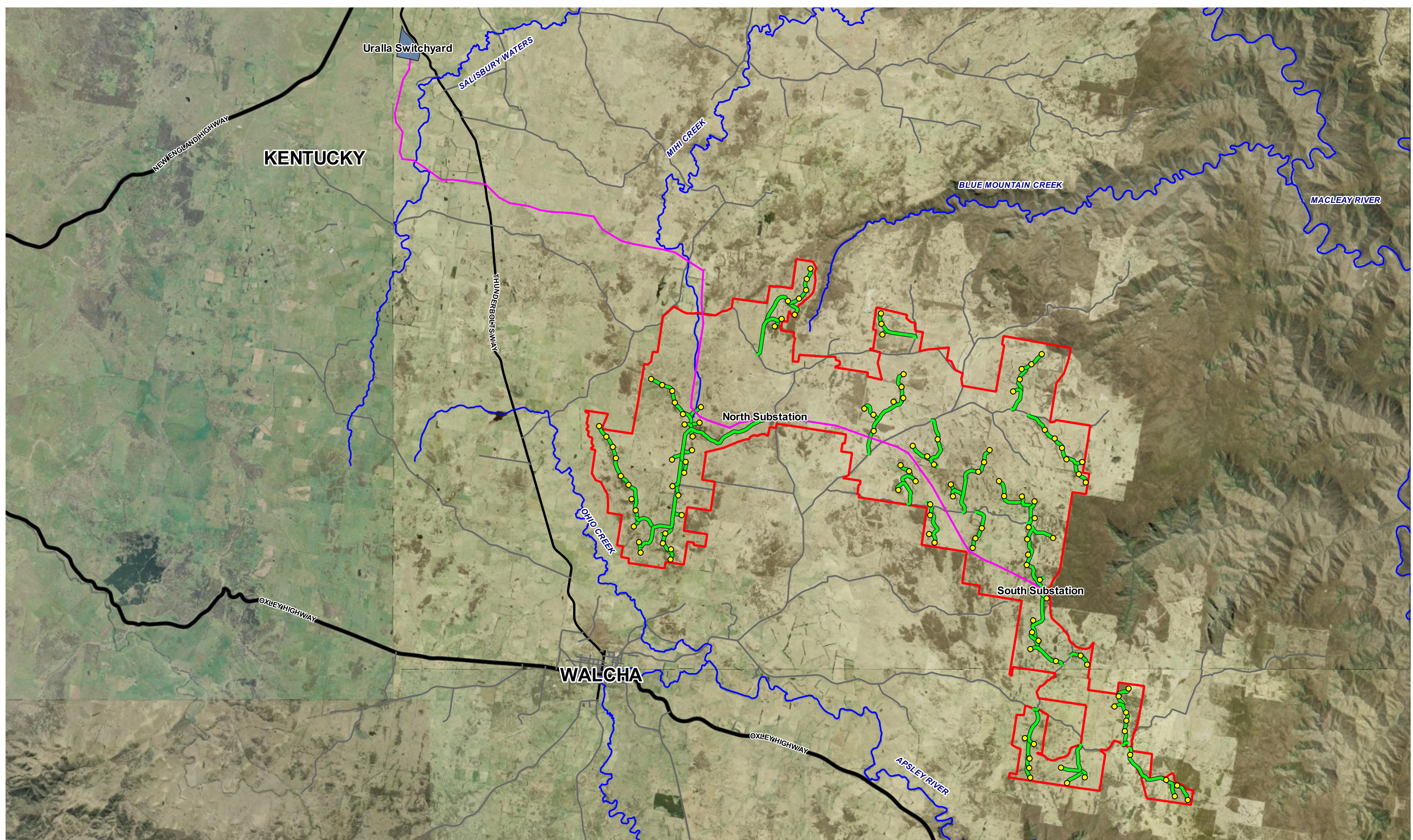
- up to 119 WTGs, each with:
 - a generating capacity of approximately 6.2 MW;
 - three blades mounted to a rotor hub (hub height of 149 m) on a nacelle above a tubular steel tower, with a blade tip height (blade length plus hub height) of up to 230 m AGL (above ground level);
 - a gearbox and generator assembly housed in the nacelle; and
 - adjacent hardstands for use as crane pads, assembly and laydown areas;
- decommissioning of four temporary meteorological monitoring masts and installation of up to two permanent meteorological monitoring masts for power testing. The permanent monitoring masts will be located close to a WTG location with a maximum height of approximately 149 m AGL, equivalent to the hub height of the installed WTGs;
- two 33/330 kV electrical substations, including control room, transformers, circuit breakers, switches and other ancillary equipment;
- an operations and maintenance (O&M) facility;
- a battery energy storage system (BESS) of up to 100 MW/200 MWh capacity (two hours of storage);
- aboveground and underground 33 kV electrical reticulation and fibre optic cabling connecting the WTGs to the onsite substations (generally following site access tracks);
- a 330 kV single or double circuit twin conductor overhead transmission line (transmission line) route of approximately 50 km connecting the two substations to a new electrical switchyard (including circuit breakers, switches and other ancillary equipment), located approximately 7 km south of Uralla and adjacent to TransGrid's 330 kV Tamworth to Armidale transmission line (Line 85);
- internal access tracks (combined total length of approximately 113 km) connecting the WTGs and associated Project infrastructure with the public road network; and
- upgrades to roads and intersections required for the delivery of oversize and overmass WTG components, transformers and associated construction-phase materials and vehicular movements.

The following temporary elements will be required during the construction phase of the Project:

- site buildings and facilities for construction contractors / equipment, including site offices, car parking and amenities for the construction workforce;
- mobile concrete batching plant/s to supply concrete for WTG footings and substation construction works;
- earthworks for access tracks, WTG platforms and foundations, potentially including controlled blasting in certain areas;
- potential rock crushing facilities for the generation of suitable aggregates for concrete batching and/or for access track and hardstand construction;
- hardstand laydown areas for the storage of construction materials, plant, and equipment;
- up to four temporary meteorological monitoring masts. The temporary monitoring masts will be located close to a WTG location with a maximum height of approximately 149 m AGL;
- external water supply and storage for concrete batching and construction activities;
- the transport, storage and handling of fuels, oils and other hazardous materials for construction and operation of wind farm infrastructure; and
- beneficial reuse of materials won from within the development footprint during cut and fill and WTG foundation excavation works for use in access track, hardstands and foundation material.

The Project may also require the subdivision of land for the substations and switchyard.

Ultimately the Project will be decommissioned and rehabilitated.

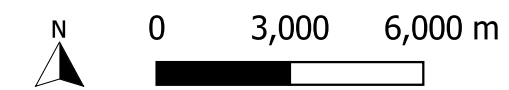


LEGEND

- Project_Boundary
- Watercourse
- WTG
- Internal Access Tracks
- Substation/Switchyard
- Major Road
- Transmission Line
- Minor Road

Title:
Overview of Study Area and Project Layout

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



Drawing: **Figure 2.1** Rev: **A**



3 Flood Assessment Approach

As mentioned previously, due to the limited footprint and positioning of the Project infrastructure primarily along catchment ridge lines, the completion of a typical flood impact assessment is not warranted as the potential flood impacts are likely to be minimal. Nevertheless, a rapid flood assessment has been undertaken herein using new flood models developed based on the Australian Rainfall and Runoff 2019 (ARR 2019) data and methodology to ascertain indicative flood risks for the Project infrastructure. This assessment would also aid in the placement of the Project infrastructure to ensure that they are located outside of predicted flood extents in addition to the mandated riparian setbacks for the relevant stream order. The assessment approach undertaken is discussed further in the following sections.

3.1 Input Data

To facilitate the assessment, the following datasets have been provided by ERM Australia Pty Ltd or obtained from publicly available sources on the internet (link provided):

- Aerial imagery of the study area;
- Project description and proposed layout of the Project components as detailed in Section 2.2 (Ref: Freeze Design.kmz, issued 1/11/2021);
- Digital Elevation Model (DEM) in 2m and 5m resolution tiles based on LiDAR aerial survey obtained from 2011 to 2018 by the NSW Government, available from the ELVIS webpage (<https://elevation.fsdf.org.au/>);
- Cadastral information and hydrolines (watercourses) from SIX Maps (<https://maps.six.nsw.gov.au/clipnship.html>);
- Bureau of Meteorology (BoM) 2016 design rainfalls (<http://www.bom.gov.au/water/designRainfalls/revised-iff/>);
- Storm losses and temporal patterns for design rainfalls from ARR Data Hub (<https://data.arr-software.org/>); and
- 2017 land use information from Department of Planning, Industry and Environment (DPIE) (<https://data.gov.au/dataset/ds-nsw-9b6781fe-279d-49c4-ae45-23907fa8bd8b/details?q=NSW%20Landuse%202017%20v1.2>).

The following flood studies and guidelines have also been referred to while undertaking the assessment:

- Walcha Flood Study (2004) prepared by WBM Oceanics Australia for Walcha Council;
- Bendemeer Flood Study (2012) prepared by SMEC for Tamworth Regional Council;
- Australian Rainfall and Runoff 2019 (ARR 2019); and
- Review of ARR Design Inputs for NSW (2019) prepared by WMAwater for NSW Office of Environment Heritage (OEH).

3.2 Model Development

As part of the rapid flood assessment, three (3) rain-on-grid (ROG) hydraulic models were developed based on the ARR 2019 data and methodology to facilitate the design flood simulation of the 1% AEP (Annual Exceedance Probability) event for the study area. The 1% AEP (or 1 in 100 AEP) event is generally a critical event used to assess flood risk and to reduce flood exposure and damage (NSW Floodplain Development Manual, 2005). The hydraulic models for the rapid flood assessment were developed to simulate the dynamic interactions between watercourses and floodplains as well as

overland flow paths within the study area, using the TUFLOW modelling software (version 2020-10-AB-iSP-w64 with HPC¹ solver). TUFLOW was developed by BMT and is a leading flood modelling software in Australia. An overview of the hydraulic models setup is shown in Figure 3.1.

Catchments

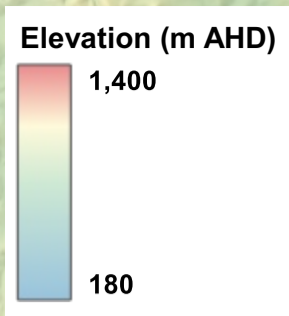
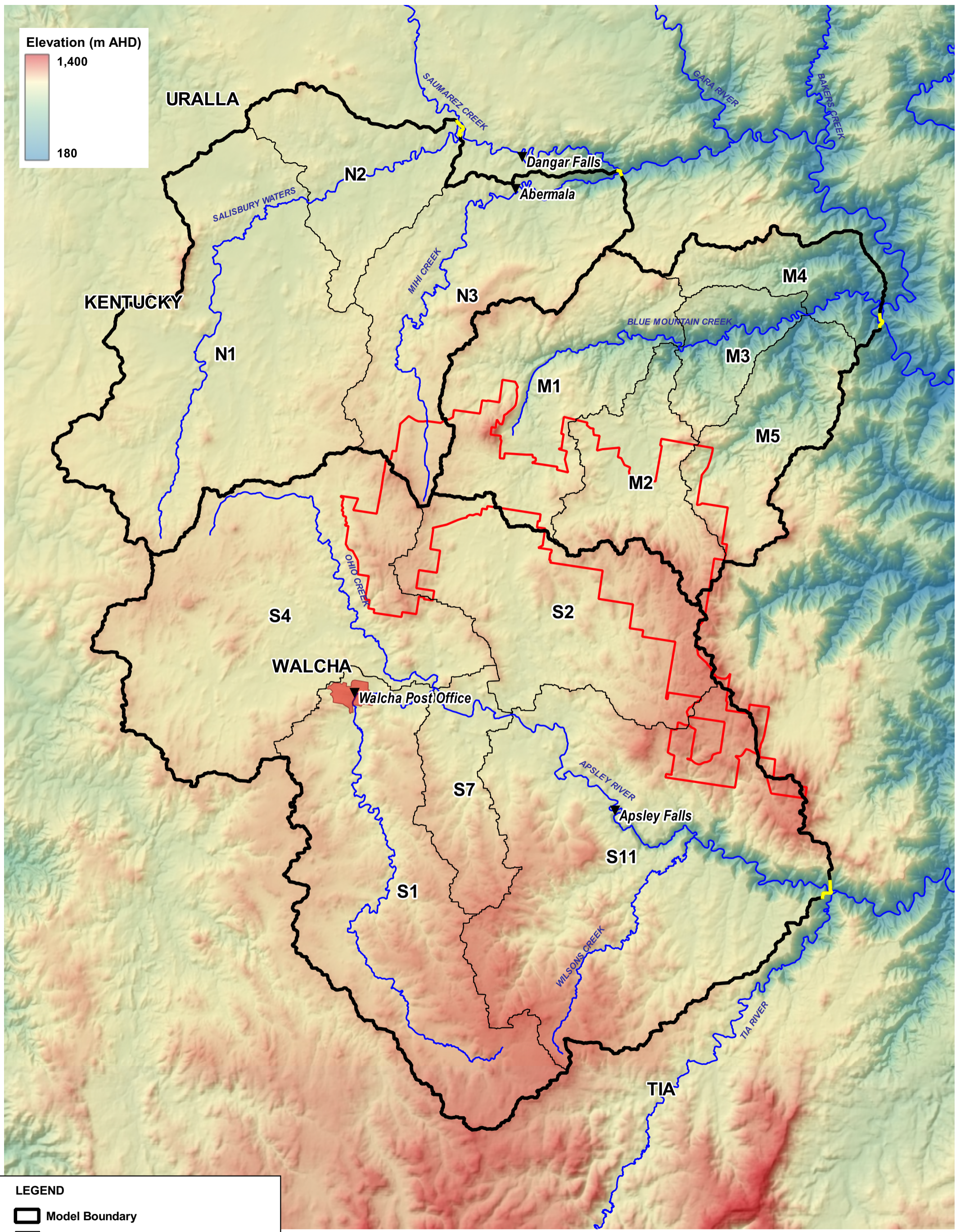
Initially, the ROG hydraulic model was developed for a single focus location or catchment which covers a critical section of the proposed Project infrastructure. The catchment selected is the Apsley River catchment with an approximate area of 1,150 km², or referred hereafter as the “Southern” catchment (with sub-catchments S1, S2, S4, S7 and S11 as shown in Figure 3.1). This catchment covers a significant area of the Project infrastructure and contained the Apsley Falls gauge (Station No.: 206018) which has approximately 67 years of stream flows record (Review of ARR Design Inputs for NSW, 2019). Further, the Walcha Flood Study (WBM Oceanics Australia, 2004) assessed the existing flood risks at the township of Walcha, which is located within this catchment. Therefore, the historical stream flows based on the Apsley Falls gauge and the design peak flows from the Walcha Flood Study (2004) were used to validate the peak flows predicted by the Southern catchment model.

Once the Southern catchment model was fully established, two additional ROG hydraulic models were subsequently developed. The models are for the Blue Mountain Creek catchment with an approximate area of 430 km², or referred hereafter as the “Middle” catchment (with sub-catchments M1, M2, M3, M4 and M5 as shown in Figure 3.1); and the Salisbury Waters/Mihi Creek catchment with an approximate area of 550 km², or referred hereafter as the “Northern” catchment (with sub-catchments N1, N2 and N3 as shown in Figure 3.1).

Hydrology Setup

The ROG hydraulic models require hydrologic data as inputs, and therefore the 2016 IFD (intensity-frequency-duration) design rainfall estimates developed by BoM, which underpin the ARR 2019 guidelines, were used herein. The design rainfall grids covering the study area were obtained from the BoM website for a range of storm duration for the 1% AEP event. The grids have a grid cell spacing of 0.025 degrees (approximately 2.5 km) and provide the spatial distribution of design rainfall across the study area. The use of spatial varying design rainfall is adopted for the catchments modelled herein with the 1% AEP design rainfall depths at the centroid of the sub-catchments. The design rainfall depths for the Southern catchment model are provided in Table 3.1.

¹ TUFLOW HPC (Heavily Parallelised Compute) is a solver which utilises Graphics Processor Unit (GPU) hardware to undertake simulation runs.



LEGEND

- Model Boundary
- Subcatchment Boundary
- Urban Roughness Layer
- Project Boundary
- Downstream Boundary
- Watercourse
- ▼ Gauge Locations

Title: Overview of Model Setup		Drawing: Figure 3.1	Rev: A
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Table 3.1 1% AEP Design Rainfall Depths (mm) for the Southern Catchment Model

Duration (hours)	Sub-Catchments				
	S1	S2	S4	S7	S11
0.25	34.3	36.4	35.1	35.2	35.8
0.5	46.7	49.1	47.6	47.6	48.3
0.75	53.7	55.8	54.5	54.4	54.7
1	58.4	60.1	59.2	58.9	58.8
1.5	64.9	66	65.6	65	64.3
2	69.4	70.3	70.3	69.4	68.2
3	76.3	76.9	77.5	76	74.2
4.5	84.1	84.8	85.9	83.8	81.5
6	90.7	91.6	92.9	90.4	87.9
9	102	104	105	102	99.4
12	111	114	115	112	110
18	128	133	132	129	128

ARR 2019 recommends the application of an Areal Reduction Factor (ARF) in the determination of the design rainfall estimates for a catchment contributing flows to point of interest that is larger than 1 km². The ARF is the ratio between the average rainfall occurring on a specific area and the point rainfall computed for the same duration and AEP. This ratio is applied since design rainfall intensities at a point are not representative of the areal average rainfall intensity across the catchment. However, as the majority of the Project infrastructure is located primarily along catchment ridge lines, where the catchment contributing flows is generally small, a conservative ARF factor of 1 has been adopted across the study area (in other words, no reduction in the rainfall depth).

Rainfall losses for the study area were determined based on the 5-level hierarchical approach (refer to Table 3.2) found in the 'Review of ARR Design Inputs for NSW' (OEH, 2019) which guides the selection of rainfall losses for NSW catchments. Pre-existing flood studies undertaken for the entire study area were not found and the Walcha Flood Study (WBM Oceanics Australia, 2004) was the only local study that could provide information on rainfall losses within the catchments modelled herein. The flood modelling undertaken as part of the 2004 study, however, was calibrated against only a single historical event in 1962 which yielded a conservative Initial Loss (IL) of 0 mm and Continuing Loss (CL) of 0.75 mm/hr (due to the catchment being saturated prior to the rainfall event). As part of the model validation process herein (also refer Section 3.3), these rainfall losses were found to produce peak flows that are excessively over the recorded stream flow records. The Bendemeer Flood Study (SMEC, 2012) was the other study found for a catchment neighbouring the study area. This 2012 study reported an IL of 25 mm and CL of 2.5 mm/hr, which are largely based on the former Australian Rainfall and Runoff 1987 (AR&R 87) recommended loss values for the region. Hence, it was decided that the IL and CL values be adopted based on Approach 4 as outlined in Table 3.2 which is based on Flood Frequency Analysis (FFA), i.e. IL based on the Probability Neutral Burst Loss from the ARR Data Hub and the CL based on the FFA reconciled continuing losses (also refer Figure 3.2 to Figure 3.4 extracted from 'Review of ARR Design Inputs for NSW' (OEH, 2019) and Figure 3.1 for the FFA gauge locations). The adopted rainfall losses are summarised in Table 3.3. The catchment peak flows modelled based on these rainfall loss values

were found to be closer to the recorded stream flow records, hence more suitable for the assessment herein as discussed further in Section 3.3.

Table 3.2 Hierarchy of Loss Approach from Most (1) to Least Preferred (5)

Approach	Data to use	Storm Initial Loss	Pre-burst (transformational)	IL Burst	Continuing Loss
1	Current Study	Average Calibration	Not required or back calculated using $IL_{Storm} - IL_{Burst}$	Calculated using Equation 6*	Average Calibration
2	Other Studies within the Catchment	Average Calibration	Not required or back calculated using $IL_{Storm} - IL_{Burst}$	Calculated using Equation 6*	Average Calibration
3	Neighbouring Studies	Average Calibration	Not required or back calculated using $IL_{Storm} - IL_{Burst}$	Calculated using Equation 6*	Average Calibration
4	FFA (Flood Frequency Analysis)	NSW FFA reconciled initial loss	Not required or back calculated using $IL_{Storm} - IL_{Burst}$	Probability Neutral Burst Loss	NSW FFA reconciled continuing losses
5	ARR Data Hub	ARR Data Hub initial loss	Not required or back calculated using $IL_{Storm} - IL_{Burst}$	Probability Neutral Burst Loss	ARR Data Hub continuing losses multiplied x 0.4

* Equation 6 as found in 'Review of ARR Design Inputs for NSW' (OEH, 2019)

Table 3.3 Adopted Rainfall Losses

Catchment	Initial Loss (mm)	Continuing Loss (mm/hr)
Southern	Probability Neutral Burst Loss from ARR Data Hub	1.6 for all sub-catchments (refer Figure 3.2)
Middle		1.6 for all sub-catchments [#]
Northern		0.07 for sub-catchments N1 and N2 (refer Figure 3.3) 4.21 for sub-catchment N3 (refer Figure 3.4)

[#] No FFA information was available hence the Southern catchment CL was adopted

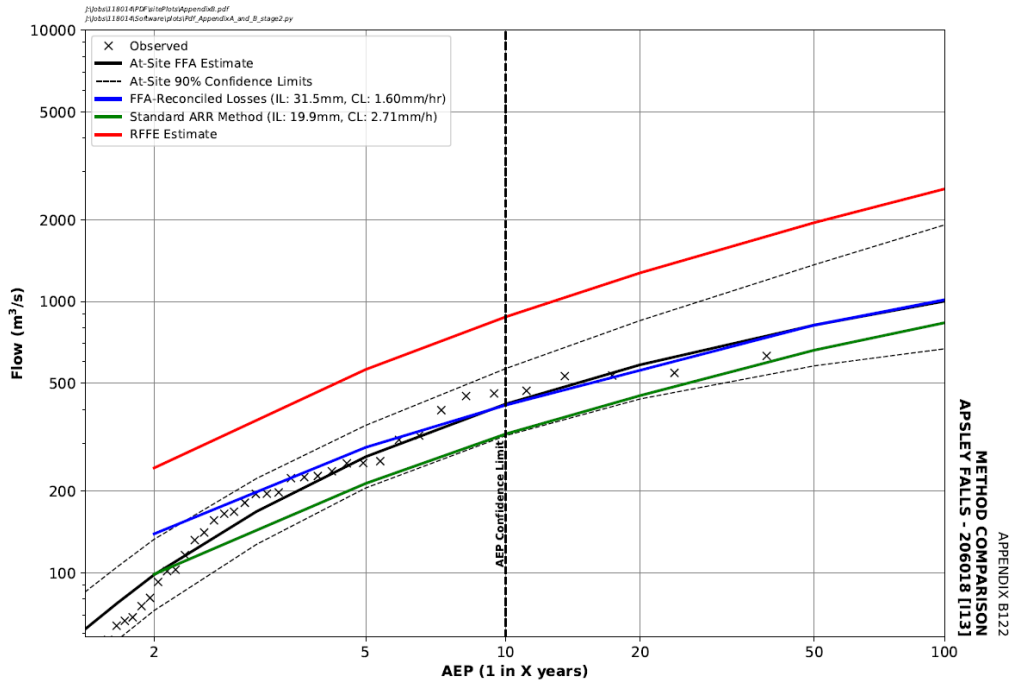


Figure 3.2 At-site Flood Frequency Analysis for Apsley Falls Gauge (206018) (Source: 'Review of ARR Design Inputs for NSW' (OEH, 2019))

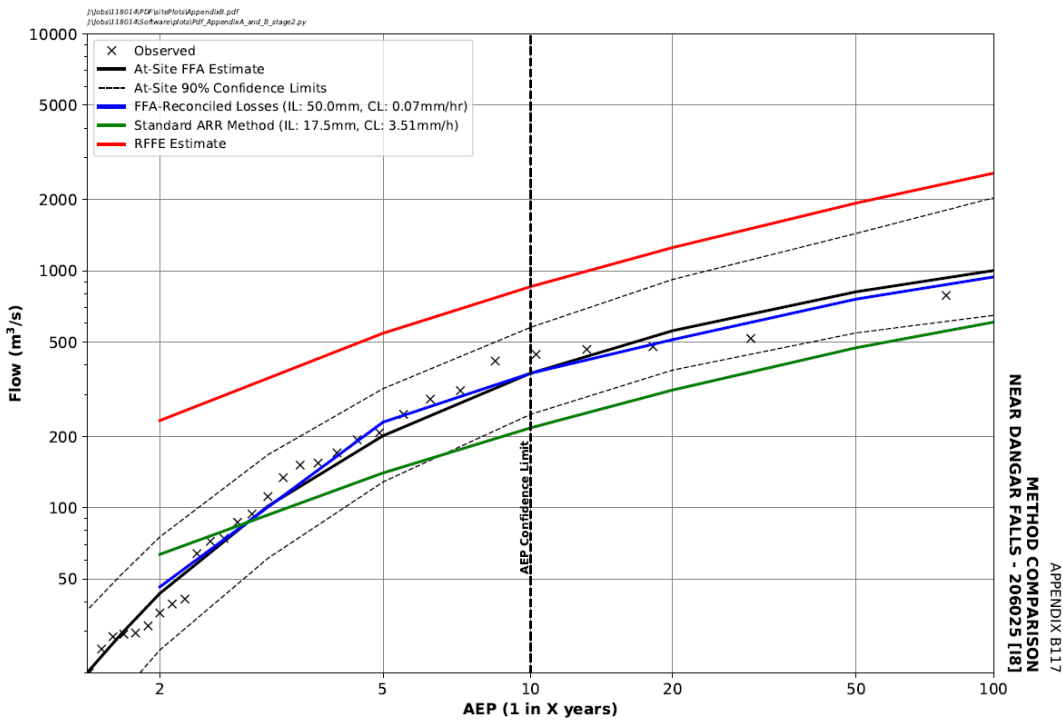


Figure 3.3 At-site Flood Frequency Analysis for Dangar Falls Gauge (206025) (Source: 'Review of ARR Design Inputs for NSW' (OEH, 2019))

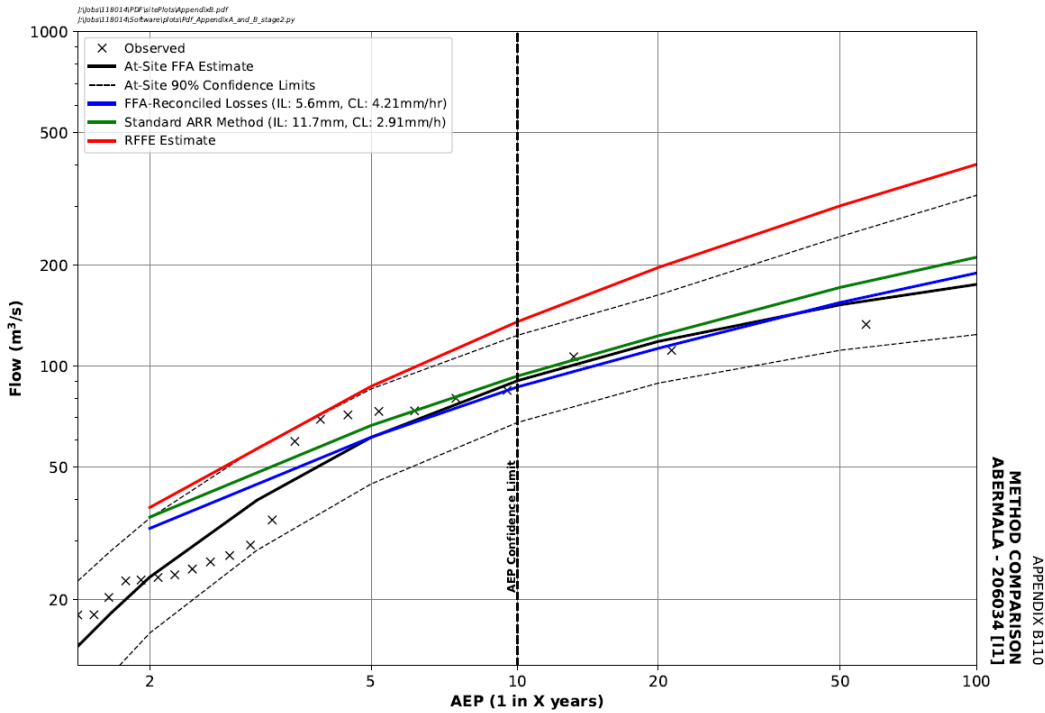


Figure 3.4 At-site Flood Frequency Analysis for Abermala Gauge (206034) (Source: ‘Review of ARR Design Inputs for NSW’ (OEH, 2019))

As per ARR 2019 recommendations, an ensemble of ten temporal patterns for each duration has been modelled for the 1% AEP design flood event as part of the assessment herein. The ten temporal patterns vary in terms of their distribution and variability (comprising front, middle and back loaded storms) and can result in a wide range of flooding behaviour within the catchments. Since each of the three (3) catchments (i.e. Southern, Middle and Northern) exceed 100 km², the areal temporal patterns were adopted for storm durations of 12 hours and above, in addition to the point temporal patterns adopted for storm durations below 12 hours (whereby no areal temporal patterns were available).

The procedures for ARR 2019 provide for the selection of the temporal pattern that gives the peak flow closest to the mean of the peak flows from all ten temporal patterns. This method was followed to find the critical temporal pattern for each storm duration.

Hydraulic Model Setup

For the assessment herein, a TUFLOW hydraulic model was developed for each of the three (3) catchments, i.e. Southern, Middle and Northern, with each model extent generally matching the catchment area which is 1,150, 430 and 550 km², respectively. The combination of the model extents covers majority of the Project infrastructure with the exception of three (3) WTGs (labelled as B127, B149 and B154) which are situated just beyond the Southern catchment model extent but sitting on the adjacent catchment ridge lines (hence deemed to have negligible flood risk).

Due to the sheer size of the model extents, the TUFLOW modelling software with HPC solver and sub-grid sampling (SGS) was used to improve simulation run times and enhance model resolution. To strike a balance between sufficiently representative overland flow distribution across the study area and reasonable simulation run times, a 40 m model cell size with 5 m SGS was adopted. The SGS allows the TUFLOW model to sample cell elevations at a 5 m interval from the 5 m grid resolution DEM developed for the study area which was generated from LiDAR data as detailed in Section 3.1.

Another input required in the development of the TUFLOW models is the assignment of hydraulic roughness zones to represent the variation of flow resistance across the floodplain. The spatial distribution of these zones (e.g. urban, forested areas, cleared land or vegetated areas) was informed by inspection of aerial photography as well as 2017 land use information from DPIE (as detailed in Section 3.1). It was found that for the catchments modelled herein, the large majority of the land is covered by agricultural or naturally vegetated areas interspersed by trees, with the exception of the urbanised area of the township of Walcha. Therefore, a hydraulic roughness value of 0.06 was adopted for the vegetated areas, which is within the values published in 'Open-channel Hydraulics' (Chow, 1959) for this surface type; and 0.1 for the urbanised area of Walcha to account for obstructive effects of building and fence structures typically found in this area.

The boundary conditions incorporated in the hydraulic models included rainfall inflows as defined in the section above and a free discharge boundary condition at the downstream catchment outlet, based on a stage-discharge relationship automatically generated by TUFLOW utilising the watercourse bed slope. The locations of the downstream boundary conditions are indicated in Figure 3.1.

It should be noted that the hydraulic models were primarily two-dimensional (2D) and no drainage or one-dimensional (1D) structures (i.e. pits, pipes, culverts and bridges) have been incorporated since this information is not available.

3.3 Model Validation

The hydraulic models developed were used to simulate the 1% AEP design flood event for a range of storm durations across the three (3) catchments, with the shorter storm duration found to be critical (yielding the peak flood levels) for the upstream catchment area where the majority of the Project infrastructure is located; and the longer storm duration found to be critical downstream.

As part of the model validation process, the peak flows produced by the Southern catchment model were compared against the design peak flows determined for the Apsley River adjacent to the Walcha Post Office (based on AR&R 87 methodology) in the Walcha Flood Study (2004), and also the at-site FFA stream flow estimates for Apsley Falls gauge (refer Figure 3.2). A critical storm duration assessment found that the 6-hour storm yielded the highest peak flows for the former location (refer Figure 3.5) and the 12-hour storm yielded the highest peak flows for the latter location (refer Figure 3.6). The critical storm duration is the one that produces the highest mean peak flow across the modelled storm durations.

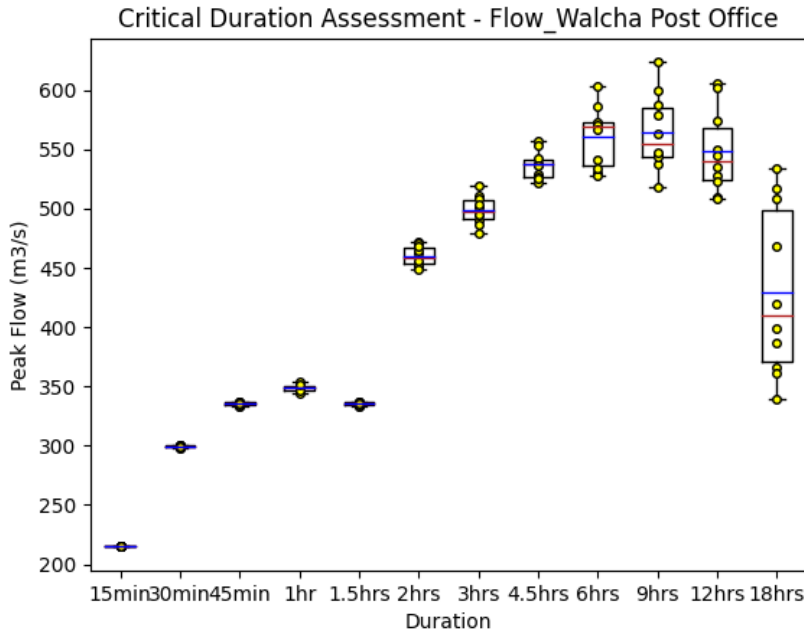


Figure 3.5 Critical Storm Duration Assessment for Walcha Post Office Peak Flows (red line – mean, blue line - median, yellow markers – individual peak flows for the 10 temporal patterns)

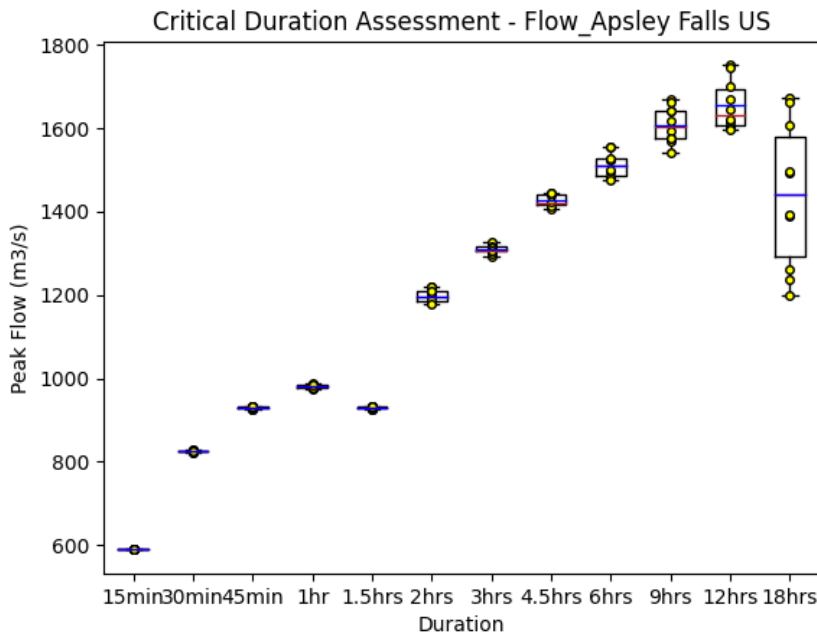


Figure 3.6 Critical Storm Duration Assessment for Apsley Falls Peak Flows (red line – mean, blue line - median, yellow markers – individual peak flows for the 10 temporal patterns)

Table 3.4 provides the comparison of the 1% AEP peak flows at the Walcha Post Office and Apsley Falls gauge, between the modelled flows herein and the published flows in the previous studies. It was found that the predicted 1% AEP peak flow at the Walcha Post Office is within 5% of that reported in the Walcha Flood Study (WBM Oceanics Australia, 2004), which is based on AR&R 87, whilst there is an over-estimation of the 1% AEP peak flow (+64%) at the Apsley Falls gauge when compared against the OEH (2019) study. Nevertheless, the results are deemed to be suitable for use in the subsequently flood assessment of the Project as the models are producing higher/more conservative flows and are within the 90% confidence limits as per Figure 3.2. The results presented in Table 3.4 also confirm that the use of the rainfall losses based on the Walcha Flood Study (WBM Oceanics Australia, 2004) is not suitable for this assessment since they will produce more conservative results comparatively.

Table 3.4 1% AEP Peak Flow Comparison at Key Locations

Location	Source	Reported Flows (m ³ /s)	Modelled Flows (m ³ /s)
Walcha Post Office	Walcha Flood Study (WBM Oceanics Australia, 2004)	598	570.5 [#] (-4.6%)
Apsley Falls	Review of ARR Design Inputs for NSW (OEH, 2019)	1002	1643.5 [^] (+64.0%)

[#] Based on 6 hours critical storm duration and temporal pattern 7.

[^] Based on 12 hours critical storm duration and temporal pattern 5.

4 Results of Rapid Flood Assessment

4.1 Indicative Flood Extents

Using the TUFLOW models developed herein, the 1% AEP design flood event was simulated for the study area to establish the peak flood depths and indicative flood extents that can be used to assess the flood risks for the Project infrastructure. An overview of the 1% AEP design flood results is presented in Figure 4.1. The results presented are based on a maximum envelope grid using the mean peak flood depth grid for each duration modelled which therefore yields the highest peak flood depths across the study area. Additional inset flood maps showing further details of the flood risk to the Project infrastructure are also included in Annex C:. Both flooding from watercourses² and overland flow paths³ are shown in the flood maps. Results were filtered to remove areas from the design flood extents where flood depth did not exceed 0.01 m.

It should be noted that the flood mapping produced as part of the assessment herein provides only indicative flood extents across the study area. Details on flood parameters such as flows, velocities and levels will require further detailed and more robust analysis in future stages of the Project based on ground and watercourse bathymetry survey information once it becomes available. Nevertheless, the indicative flood extents presented are sufficient to inform the appropriate siting of the Project infrastructure and to avoid areas subject to high flood risks where necessary.

4.2 Indicative Flood Risks to Project

Referring to the inset flood maps provided in Annex C:, a rapid flood assessment was undertaken herein to examine the intersection of predicted 1% AEP flood extent and the proposed Project infrastructure as outlined in Table 4.1.

Table 4.1 Description of Indicative Flood Risks to Project

Inset Map (refer Annex C:)	Indicative Flood Risks to Project
Figure C.1	Possible presence of local overland flow paths to manage on the Uralla Switchyard site but no apparent flood risk from the closest watercourse.
Figure C.2	Height clearance required for the crossing of the transmission line over the watercourse.
Figure C.3	Height clearance required for the crossing of the transmission line over multiple watercourses.
Figure C.4	Height clearance required for the crossing of the transmission line over multiple watercourses.
Figure C.5	No apparent flood risk to the WTGs and Joint Box. Manage flood risk from overland flow path for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the watercourse and overland flow paths.
Figure C.6	No apparent flood risk to the WTGs, internal access track and MV reticulation.

² As indicated by the hydrolines obtained from SIX Maps.

³ Include flooding from minor watercourses which do not form the hydrolines from SIX Maps.

Inset Map (refer Annex C:)	Indicative Flood Risks to Project
Figure C.7	No apparent flood risk to the WTGs and Joint Box. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the watercourse and overland flow paths.
Figure C.8	No apparent flood risk to the WTGs, internal access track and MV reticulation.
Figure C.9	No apparent flood risk to the WTGs and Joint Boxes. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.10	No apparent flood risk to the WTGs and PCV Mast. Consider relocating Joint Box and Vestas Laydown outside of indicative flood extents. Manage flood risk from overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.11	No apparent flood risk to the WTGs and Batch Plant. Possible presence of local overland flow paths to manage on the Crane Pad, O&M Building, North Substation and Vestas Laydown sites but no apparent flood risk from the closest watercourse. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the watercourse and overland flow paths.
Figure C.12	No apparent flood risk to the WTGs, Joint Boxes and Vestas Laydown. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the watercourse and overland flow paths.
Figure C.13	No apparent flood risk to the WTGs and Joint Box. Manage flood risk from overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.14	No apparent flood risk to the WTGs. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the overland flow paths.
Figure C.15	No apparent flood risk to the WTGs and Joint Box. Manage flood risk from overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.16	No apparent flood risk to the WTGs and Vestas Laydown. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
FigureC.17	No apparent flood risk to the WTGs, Vestas Laydown and transmission line. Possible presence of local overland flow paths to manage on the Joint Boxes sites but no apparent flood risk from the closest watercourse. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.

Inset Map (refer Annex C:)	Indicative Flood Risks to Project
Figure C.18	No apparent flood risk to the WTGs and Joint Box. Possible presence of local overland flow paths to manage on the Crane Pad, Batch Plant and Vestas Laydown sites but no apparent flood risk from the closest watercourse. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the watercourse and overland flow paths.
Figure C.19	No apparent flood risk to the WTGs, Joint Box and South Substation. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation. Height clearance required for the crossing of the transmission line over the overland flow paths.
Figure C.20	No apparent flood risk to the WTGs and Crane Pad. Possible presence of local overland flow paths to manage on the Batch Plant and Vestas Laydown sites but no apparent flood risk from the closest watercourse. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.21	No apparent flood risk to the WTGs and Joint Boxes. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.22	No apparent flood risk to the WTGs, Joint Boxes and Vestas Laydown. Manage flood risk from watercourse or overland flow paths for the internal access track via provision of cross drainage, and either height clearance or underground installation for the MV reticulation.
Figure C.23	No apparent flood risk to the WTGs, Joint Box, internal access track and MV reticulation.

In summary, the following observations can be made on the flood risk to the Project infrastructure:

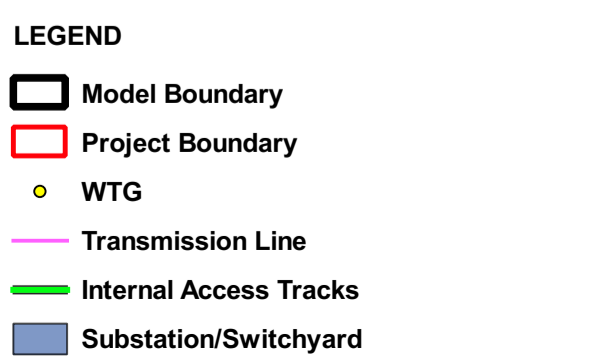
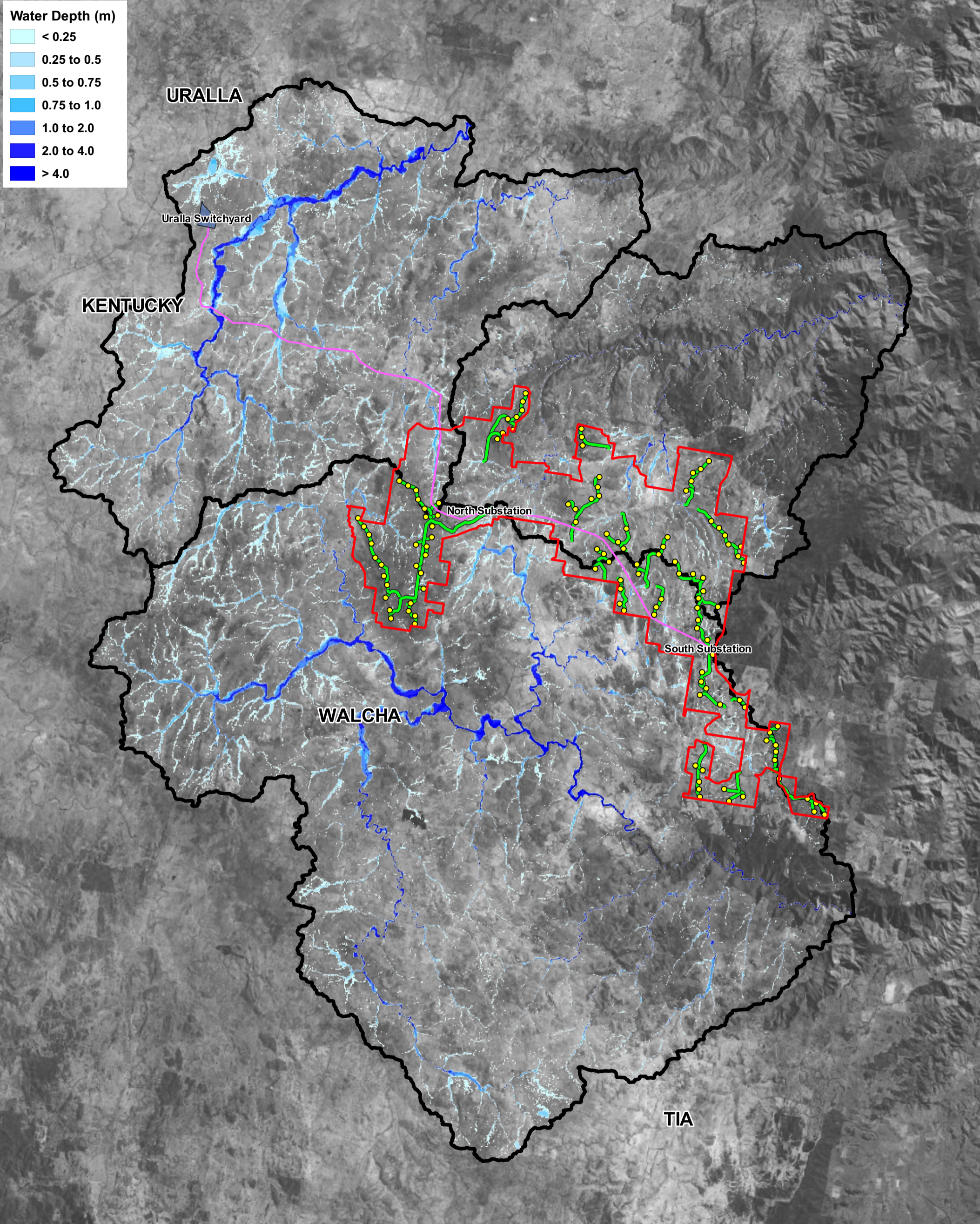
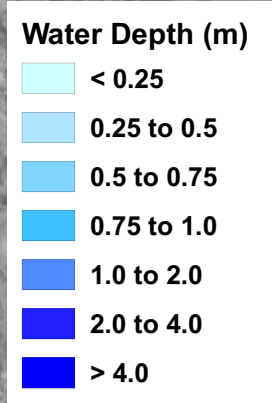
- With the exception of transmission lines, internal access tracks and MV reticulation, majority of the Project infrastructure are situated away from watercourses and high flood risk areas. The WTGs are generally located on catchment ridge lines or high grounds some distance away from the major watercourses;
- There may be presence of local overland flow paths at some sites such as the Uralla Switchyard, North Substation, Crane Pad, O&M Building, Vestas Laydown, Joint Box and Batch Plant which should be suitably managed or avoided (by relocation of the infrastructure if possible);
- Where the Project infrastructure traverses watercourses or overland flow paths such as for the transmission lines, internal access tracks and MV reticulation, the flood risk could be managed by provision of cross drainage, underground installation, or suitable height clearance above the watercourses or overland flow paths.

It should be noted that the flood risk for existing road infrastructure has not been assessed herein.

4.3 Assumptions and Limitations

The following are the assumptions and limitations associated with the rapid flood assessment undertaken for the WWF Project herein:

- Flood modelling has been undertaken for the 1% AEP design flood event only and for existing (present day climate) catchment conditions. The 1% AEP event is generally a critical event used to assess flood risk and to reduce flood exposure and damage (NSW Floodplain Development Manual, 2005);
- The 1% AEP design flood extents provided herein are indicative and should not be relied on to establish flows, velocities and levels that can be used to inform the detailed design of the Project infrastructure;
- The 1% AEP design flood results are based on existing (present day climate) catchment conditions prior to construction and operation of the Project and do not account for potentially additional runoff from the Project infrastructure due to changes to the ground surface imperviousness. It is assumed that appropriate detailed Stormwater Management Plan will be developed during the later stages of the Project to manage the additional runoff discharged from the surface of the Project infrastructure;
- No flood impact assessment has been undertaken herein to determine potential flood impacts due to the construction and operation of the Project that would extend to sensitive receptors such as adjacent homes or properties; and
- Detailed design of the cross-drainage structures located along the Project infrastructure will be required at the next stage of the Project to meet the local and road authorities' requirements, including to cater for design flows and to achieve flood immunity for the proposed infrastructure. The design shall be undertaken based on detailed and more robust analysis of flood parameters such as flows, velocities and levels, utilising ground and watercourse bathymetry survey information once it becomes available as well as survey of relevant drainage structures which currently are not incorporated in the hydraulic models.

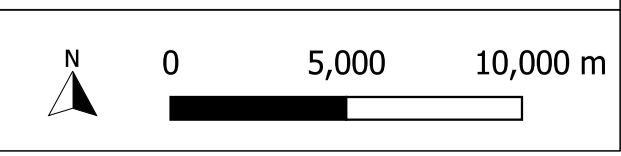


Title: **Overview of Existing 1% AEP Peak Flood Depth**

Drawing: **Figure 4.1**

Rev: **A**

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5 Conclusion

A rapid flood assessment was undertaken herein to support the State Significant Development Application (SSD-10471) for the proposed Winterbourne Wind Farm (WWF) Project. The 1% AEP design flood event was simulated for the study area. Peak flood depths and indicative flood extents were established and used to assess the flood risks for the Project infrastructure. Both flooding from watercourses and overland flow paths were assessed. The following key observations were made on the flood risk to the Project infrastructure:

- With the exception of transmission lines, internal access tracks and MV reticulation, majority of the Project infrastructure are situated away from watercourses and high flood risk areas. The WTGs are generally located on catchment ridge lines or high grounds some distance away from the major watercourses;
- There may be presence of local overland flow paths at some sites such as the Uralla Switchyard, North Substation, Crane Pad, O&M Building, Vestas Laydown, Joint Box and Batch Plant which should be suitably managed or avoided (by relocation of the infrastructure if possible);
- Where the Project infrastructure traverses watercourses or overland flow paths such as for the transmission lines, internal access tracks and MV reticulation, the flood risk could be managed by provision of cross drainage, underground installation, or suitable height clearance above the watercourses or overland flow paths.

Annex A: Letter from BCD



Our Ref: DOC21/286181
Your Ref: E-mail dated 8/4/2021

NGH Consulting
Unit 2, 54 Hudson Street
Hamilton NSW 2303

Attention: Ms Karie Wilson

Dear Ms Wilson

RE: Winterbourne Wind Farm, Walcha and Uralla Local Government area (SSD – 10471)

Thank you for your e-mail dated 8 April 2021 seeking comments from the Biodiversity and Conservation Division (BCD) of the Biodiversity, Conservation and Science Directorate in the Environment, Energy and Science Group of the Department of Planning, Industry and Environment on the flood impact assessment approach for the Winterbourne Wind Farm. I appreciate the opportunity to provide input.

We have reviewed the information provided by the NGH engineering consultant (Footprint Engineering) dated 29 March 2021, regarding an alternate solution that would satisfy the information requested in items 11 and 15 of the Secretary's Environmental Assessment Requirements (SEARs) for SSD – 10471. Footprint Engineering has proposed to use the NSW Department of Primary Industry (DPI) (Water), 2012 Guidelines to guide where the turbines could be placed after taking into consideration the minimum width required for the riparian corridor and to recommend the types of road crossings that would minimise potential flood impacts.

However, the DPI Water 2012 Guidelines do not provide flood risk levels for the turbines, waterway crossings, or access roads. Hence, we consider that using the DPI Water 2012 Guidelines alone may not be appropriate for siting these structures.

The BCD recommends that, in addition to the methodology set out in the letter from Footprint Engineering dated 29 March 2021, for an alternative solution for the flood impact assessment approach for the Winterbourne Wind Farm, rapid flood assessments must also be undertaken to provide indicative flood risk levels for the turbine sites and waterway crossings.

If you have any questions about this advice, please do not hesitate to contact Mr Bill Larkin, Senior Conservation Planning Officer, at bill.larkin@environment.nsw.gov.au or 6659 8216.

Yours sincerely

22 April 2021

DIMITRI YOUNG
Senior Team Leader Planning, North East Branch
Biodiversity and Conservation

Annex B: Letter from Footprint (NSW) Pty Ltd

29 March 2021

Bill Larkin
Senior Conservation Planning Officer
Biodiversity and Conservation Division
email: bill.larkin@environment.gov.au

Dear Bill,

**Winterbourne Wind Farm
Walcha and Uralla Local Government Areas (SSD-10471)**

Reference is made to your request to review and provide comment on the flooding requirements contained in the Secretary's Environmental Assessment Requirements (SEAR's) issued by the Biodiversity and Conservation Division (BCD) of the Environment, Energy and Science Group in the NSW Department of Planning, Industry and Environment for the above project dated 10 September 2020.

Typically, a SEAR's contains a list of standard and project specific requirements that may need to be addressed in the EIS. In this instance, it is noted, the flood related requirements described in Section 4 Flooding, items 11 to 15 are standard requirements that are typically contained in all SEAR's rather than project specific requirements.

The proposed development comprises the construction of wind turbines and associated infrastructure including, but not limited to, access roads and electrical reticulation. By virtue of the need for the turbines to be located where they receive the most wind, they are located along ridgelines rather than in gullies and therefore typically well outside flood prone areas. This is further demonstrated by riparian corridor mapping by ngh consulting (refer Annexure A) which show the location of the proposed infrastructure in relation to existing watercourses, including the ordering of streams in accordance with the Strahler system and the buffering of streams in accordance with the riparian corridor widths contained in the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012).

Like the turbines the proposed access roads are primarily located along the ridgelines to provide construction and maintenance access to each turbine from the existing road network. The roads would be constructed at close to existing surface levels without significant cut and fill and should therefore not adversely impact on existing flood hydrology or hydraulics. The location of proposed access road crossings of watercourses has also been identified on the riparian corridor mapping by ngh.

The project is spread over an area of approximately 225km² and undertaking the flood modelling requirements as described in items 12, 13 and 14 contained in the SEAR's is regarded as a very onerous requirement and is considered of little benefit given i) the location of the proposed wind turbines and access roads in relation to existing watercourses and ii) the typically low stream order of the watercourse crossings.

Rather, we propose an alternate solution that would satisfy the information requested in Item 11 and 15 of the SEARs, which will involve the preparation of a concise floodplain management report and will include general recommendations to minimise any potential impact on flooding, including but not limited to:

- Restricting the location of wind turbines to outside riparian corridor buffers as defined by Strahler Stream Order in accordance with the riparian corridor widths specified in Table 1 of the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012)
- Requiring any road crossing of existing watercourses associated with the proposed development to be of a type that is appropriate for the stream order as defined in Table 2 of the Guidelines for Riparian Corridors on Waterfront Land (DPI Water, 2012).
- Requiring any proposed road crossing to be designed and constructed in accordance with Guidelines for Watercourse Crossings on Waterfront Land (NSW DPI, 2012)
- Requiring any proposed service crossing (i.e. electrical reticulation) to be designed and constructed in accordance with Guidelines for Laying Pipes and Cable in Watercourses on Waterfront Land (NSW DPI, 2012)
- Requiring any security fencing within the floodplain be avoided or minimised and where required should be constructed in a manner which does not adversely affect the flow of floodwater.

We believe the above methodology is a more practical approach to addressing the requirements in item 15. We look forward to receiving your feedback regarding this alternative approach. Should you require any additional information please do not hesitate to contact Zeina Jokadar (zeina.j@nghconsulting.com.au) or the undersigned.

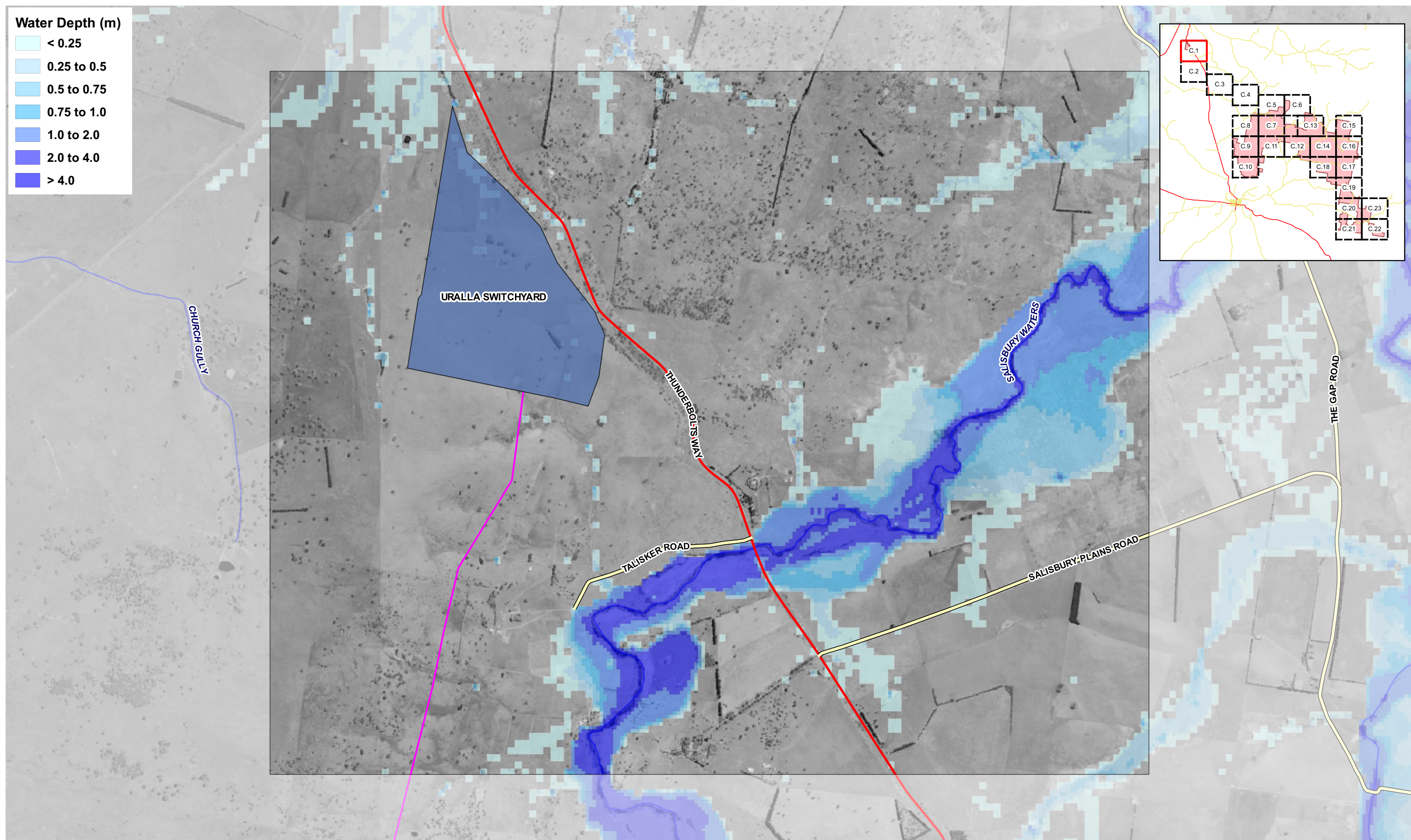
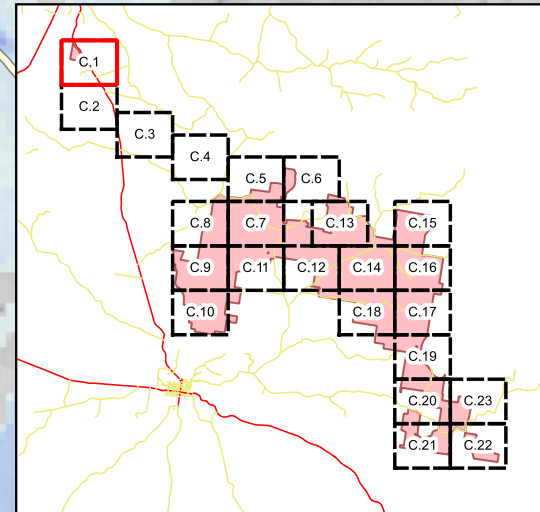
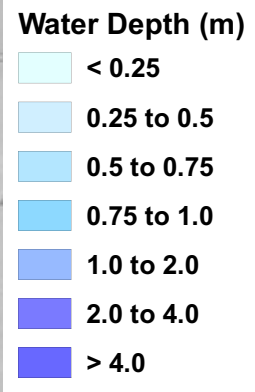
Yours sincerely



Ashley Bond
Director/Principal Engineer

Encl. Riparian Corridor Mapping

Annex C: Additional Inset Flood Maps



LEGEND

- | | | |
|-----------------------|-------------------|----------------|
| Substation/Switchyard | Transmission Line | Major road |
| | | Minor Road |
| | | Watercourse |
| | | Culvert/Bridge |

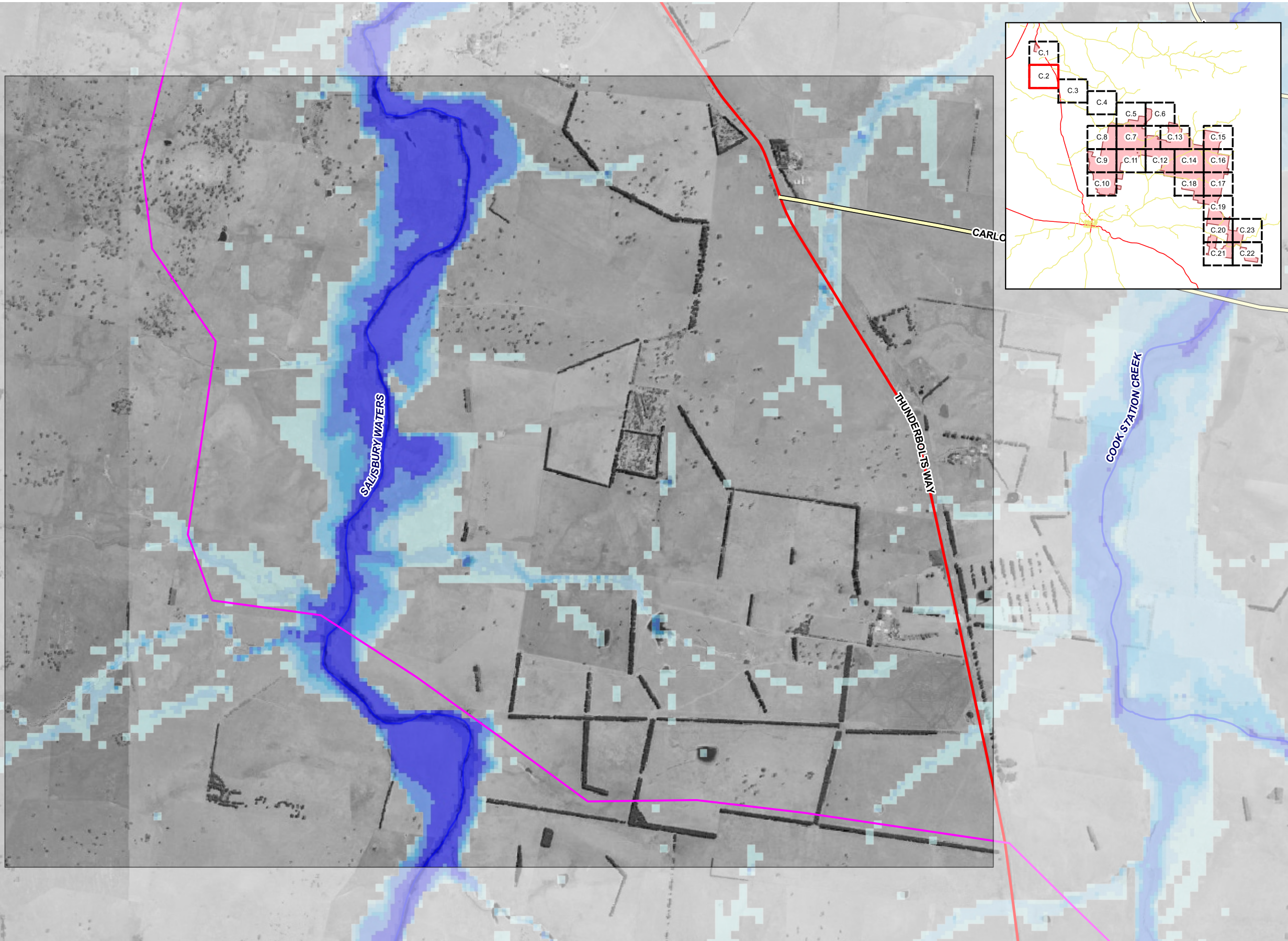
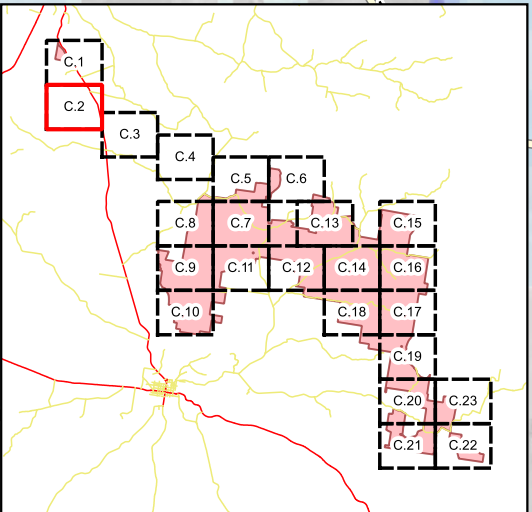
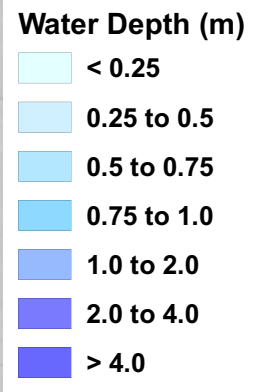
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Existing 1% AEP Peak Flood Depth and Extent

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Drawing: **Figure C.1** Rev: **A**





LEGEND

— Transmission Line

— Major road

— Minor Road

— Watercourse

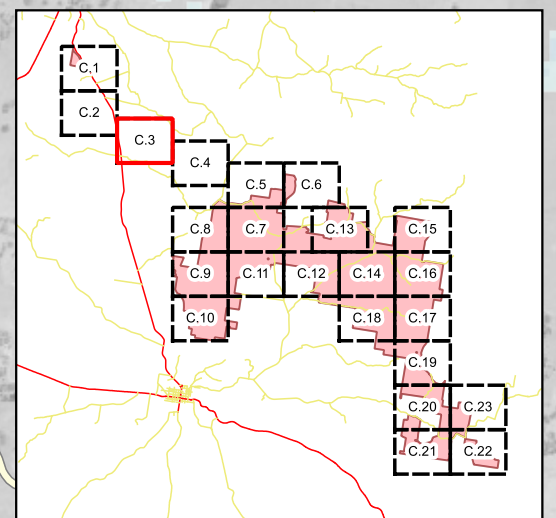
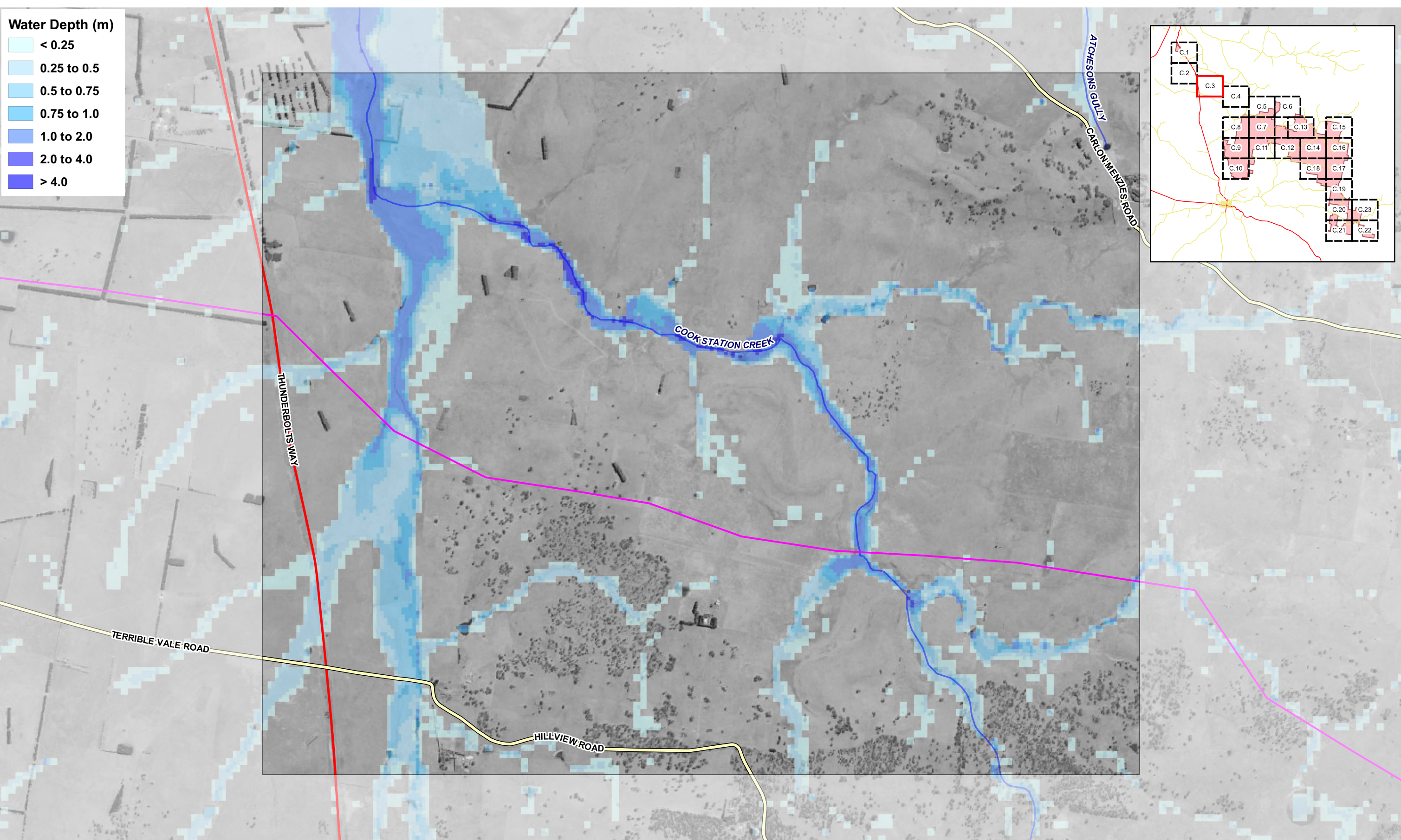
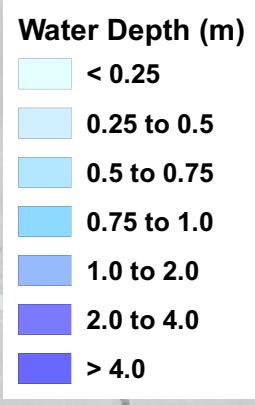
) (Culvert/Bridge

Title: **Existing 1% AEP Peak Flood Depth and Extent**

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LEGEND

Transmission Line

Major road

Minor Road

Watercourse

Culvert/Bridge

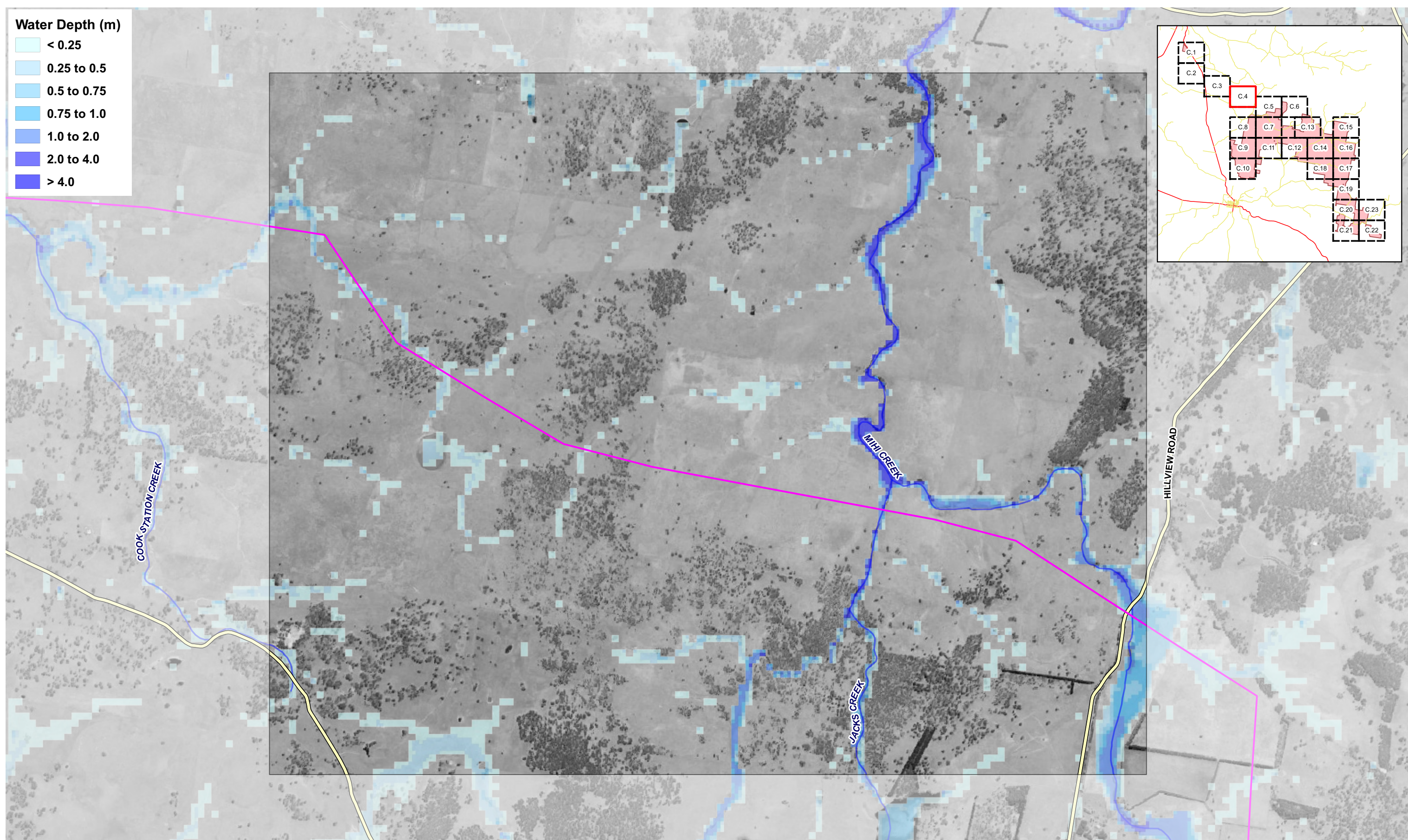
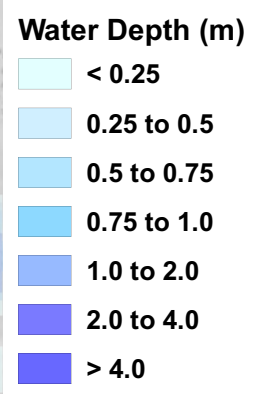
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LEGEND

Transmission Line

Major road
 Minor Road
 Watercourse
 Culvert/Bridge

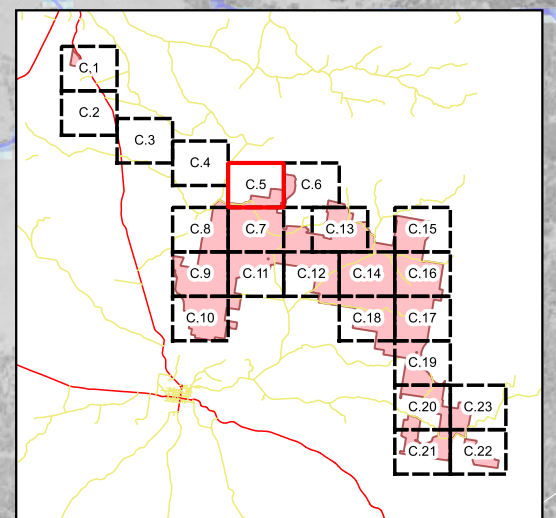
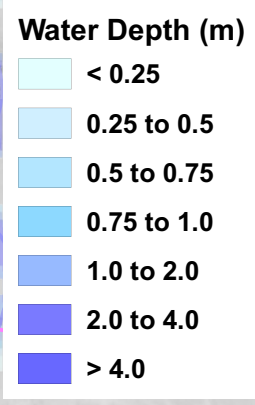
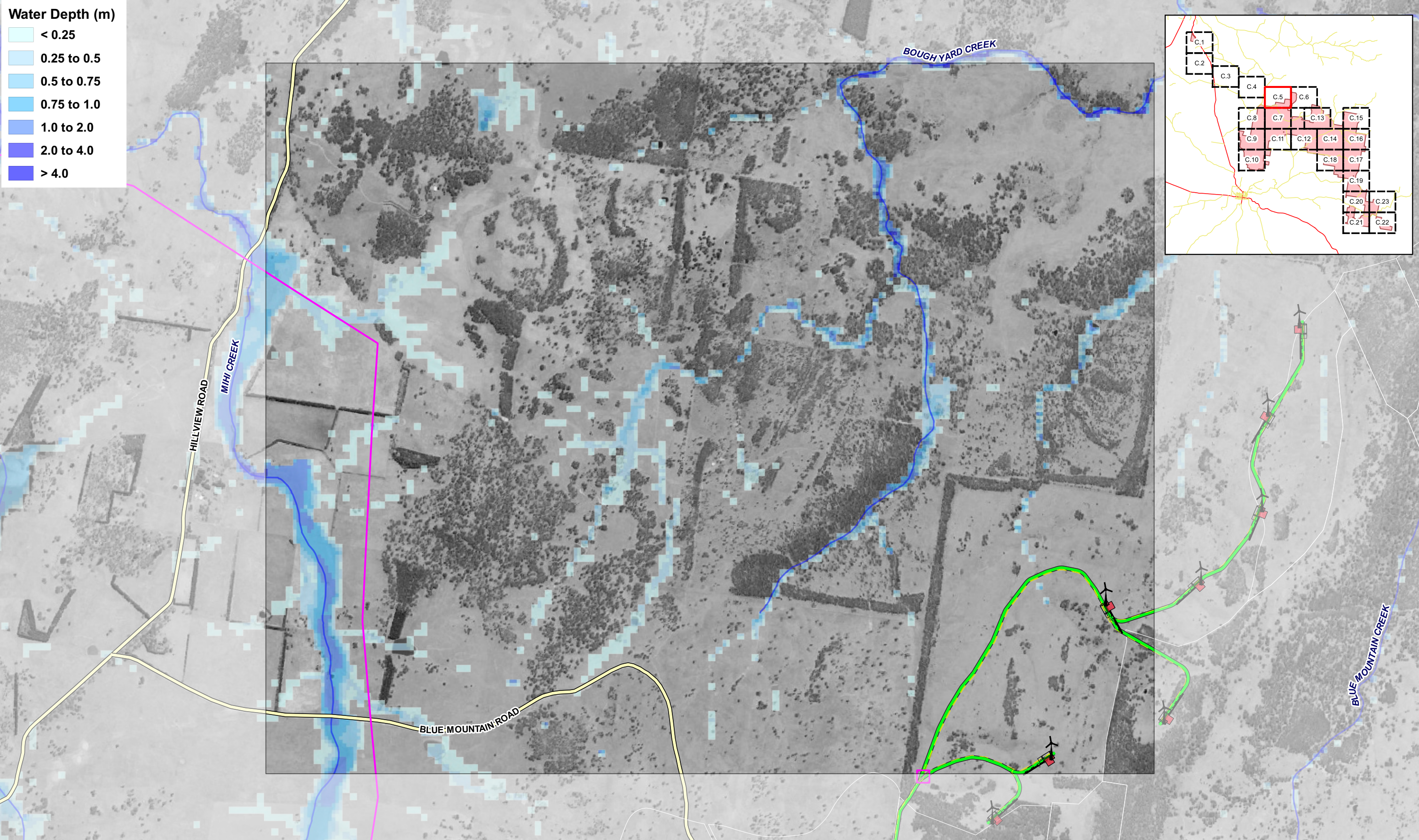
Title:
Existing 1% AEP Peak Flood Depth and Extent

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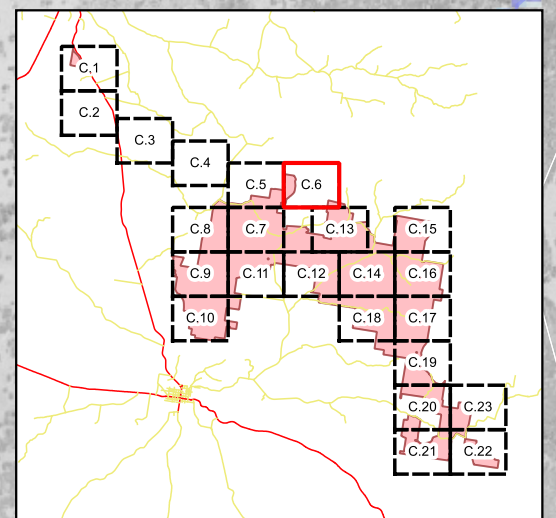
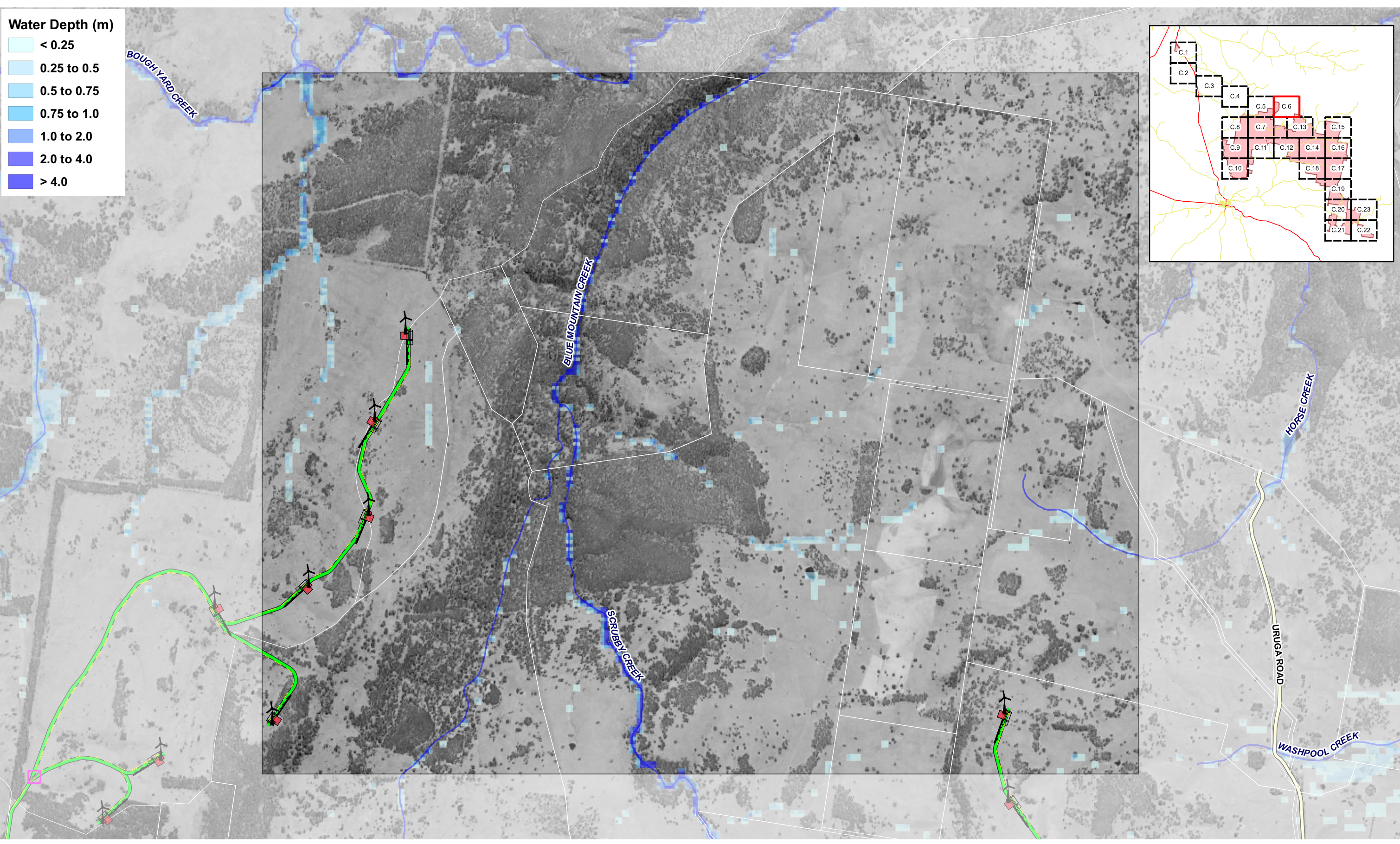
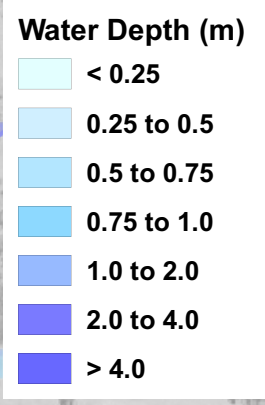




LEGEND			
	WTG		Joint Box
	WTG Hardstand		Transmission Line
	MV Reticulation		Internal Access Track
	Major road		Minor Road
	Watercourse		Culvert/Bridge

Title: Existing 1% AEP Peak Flood Depth and Extent		Drawing: Figure C.5	Rev: A
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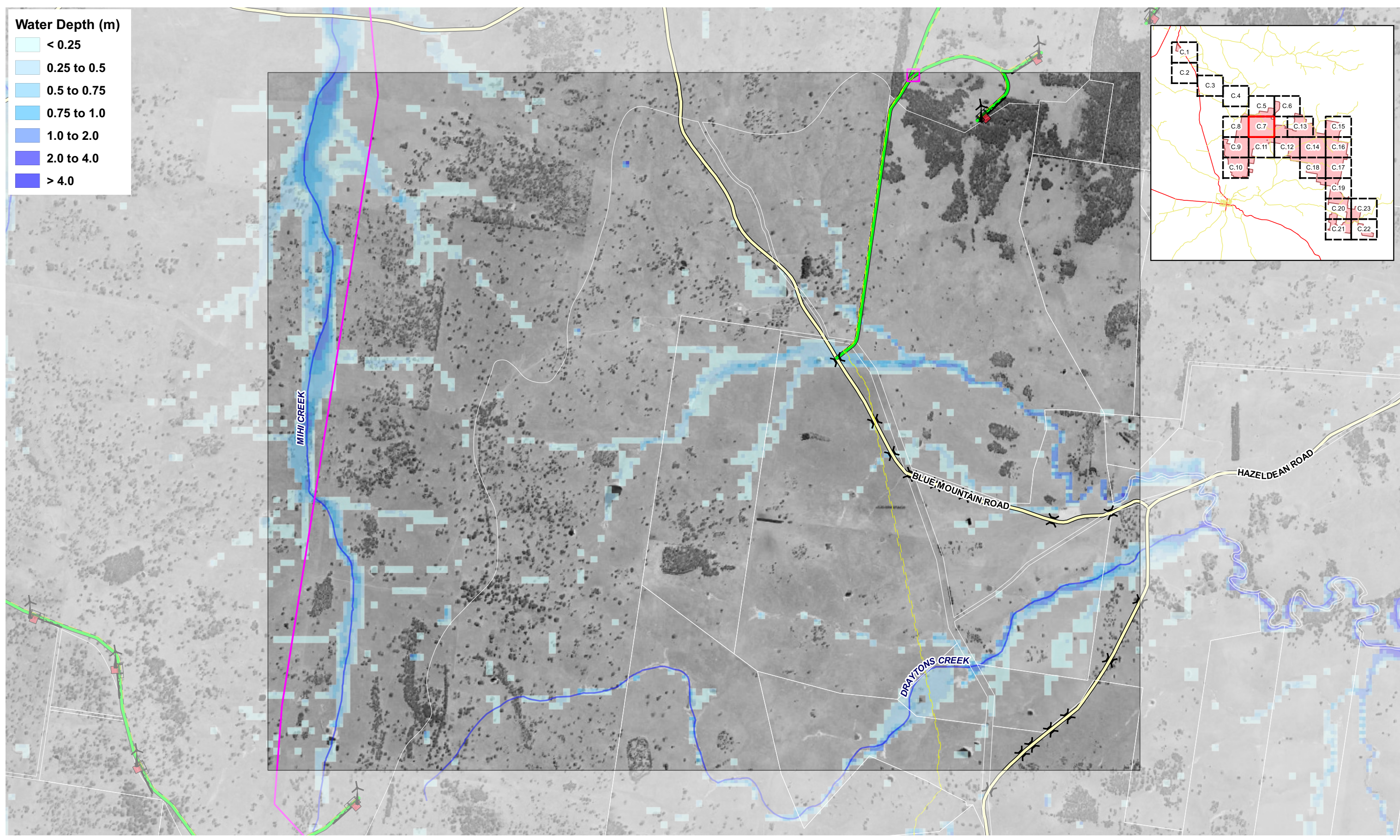
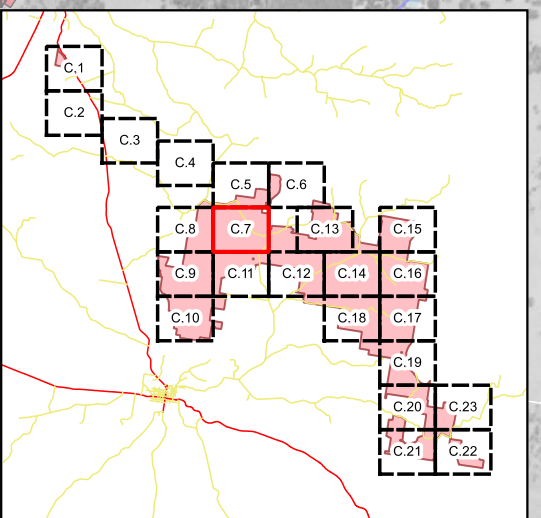
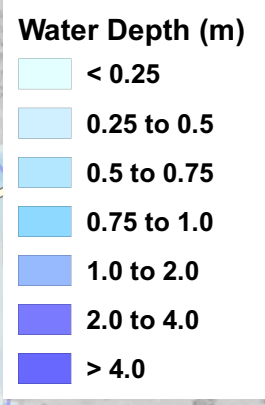
WTG	MV Reticulation	Internal Access Track	Major road
WTG Hardstand			Minor Road
			Watercourse
			Culvert/Bridge

Title: **Existing 1% AEP Peak Flood Depth and Extent**

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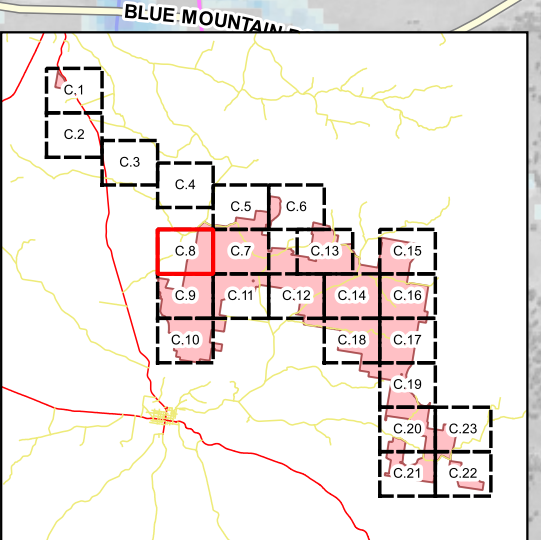
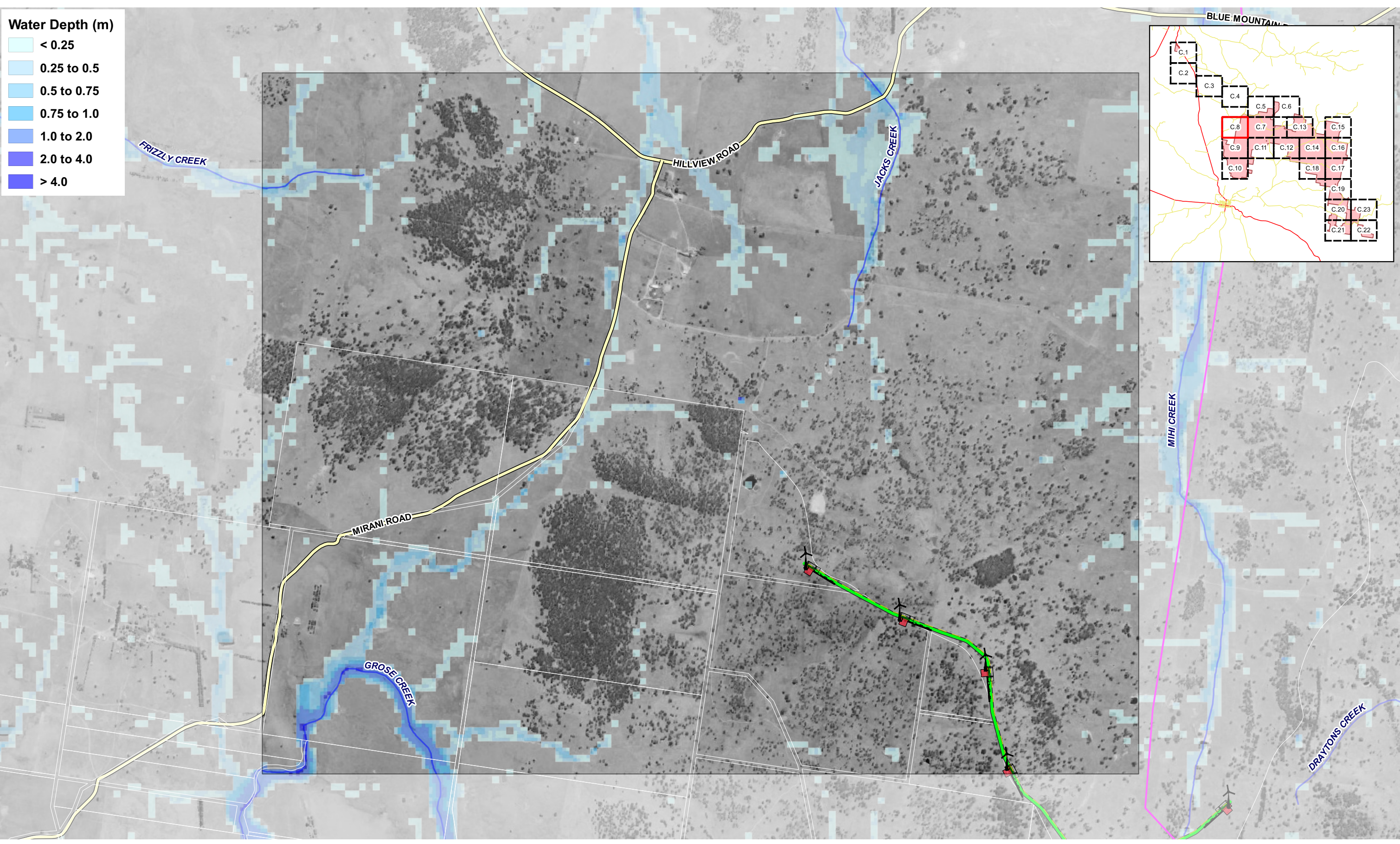
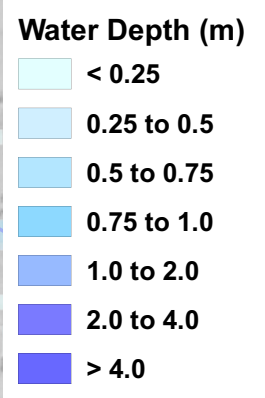
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LEGEND

WTG	Joint Box	MV Reticulation	Major road
WTG Hardstand	Transmission Line	Internal Access Track	Minor Road
			Watercourse
			Culvert/Bridge

Title: Existing 1% AEP Peak Flood Depth and Extent		Drawing: Figure C.7	Rev: A
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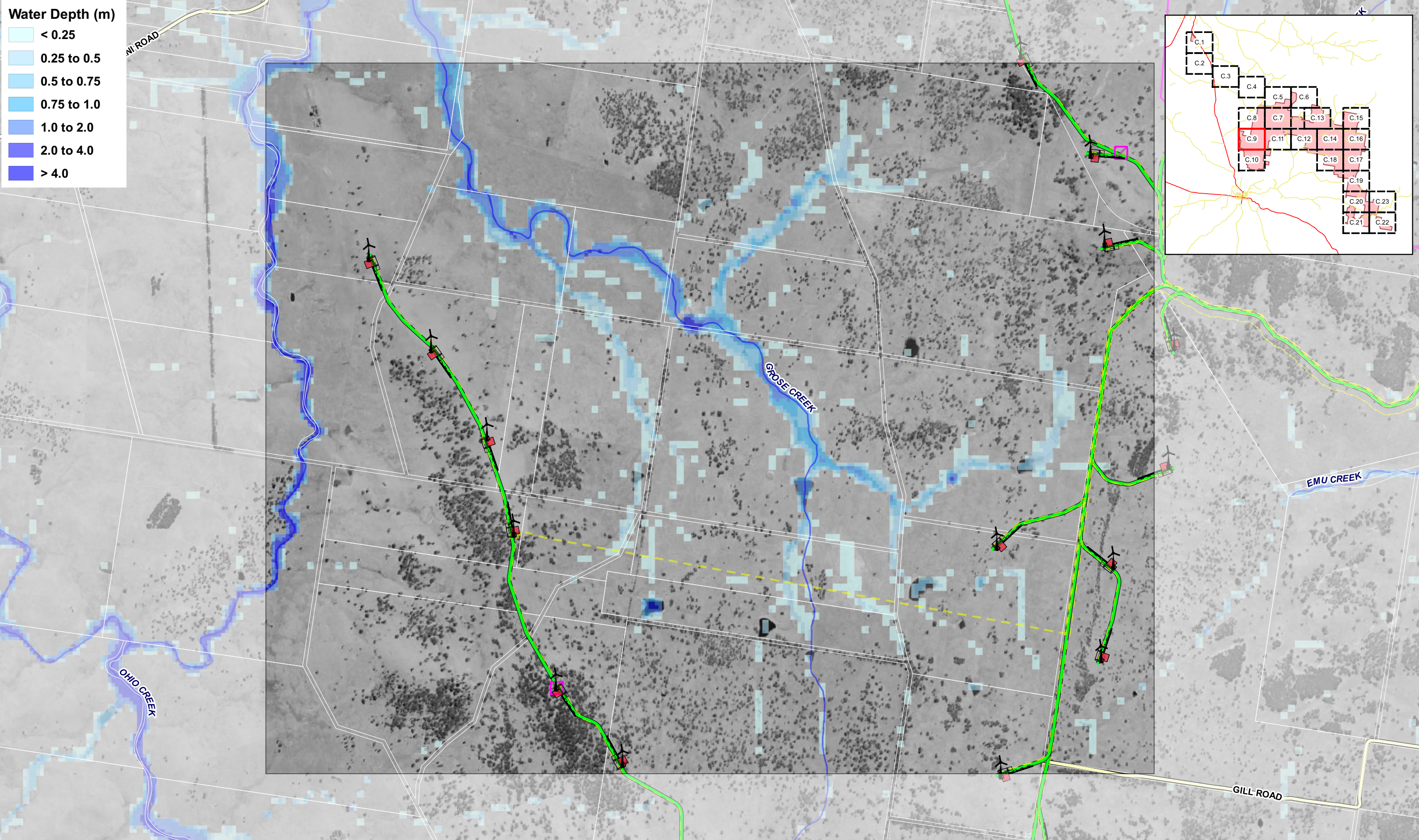


LEGEND

WTG	MV Reticulation	Internal Access Track	Major road
WTG Hardstand		Minor Road	Watercourse
			Culvert/Bridge

Title: Existing 1% AEP Peak Flood Depth and Extent		Drawing: Figure C.8	Rev: A
<p>BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.</p>			
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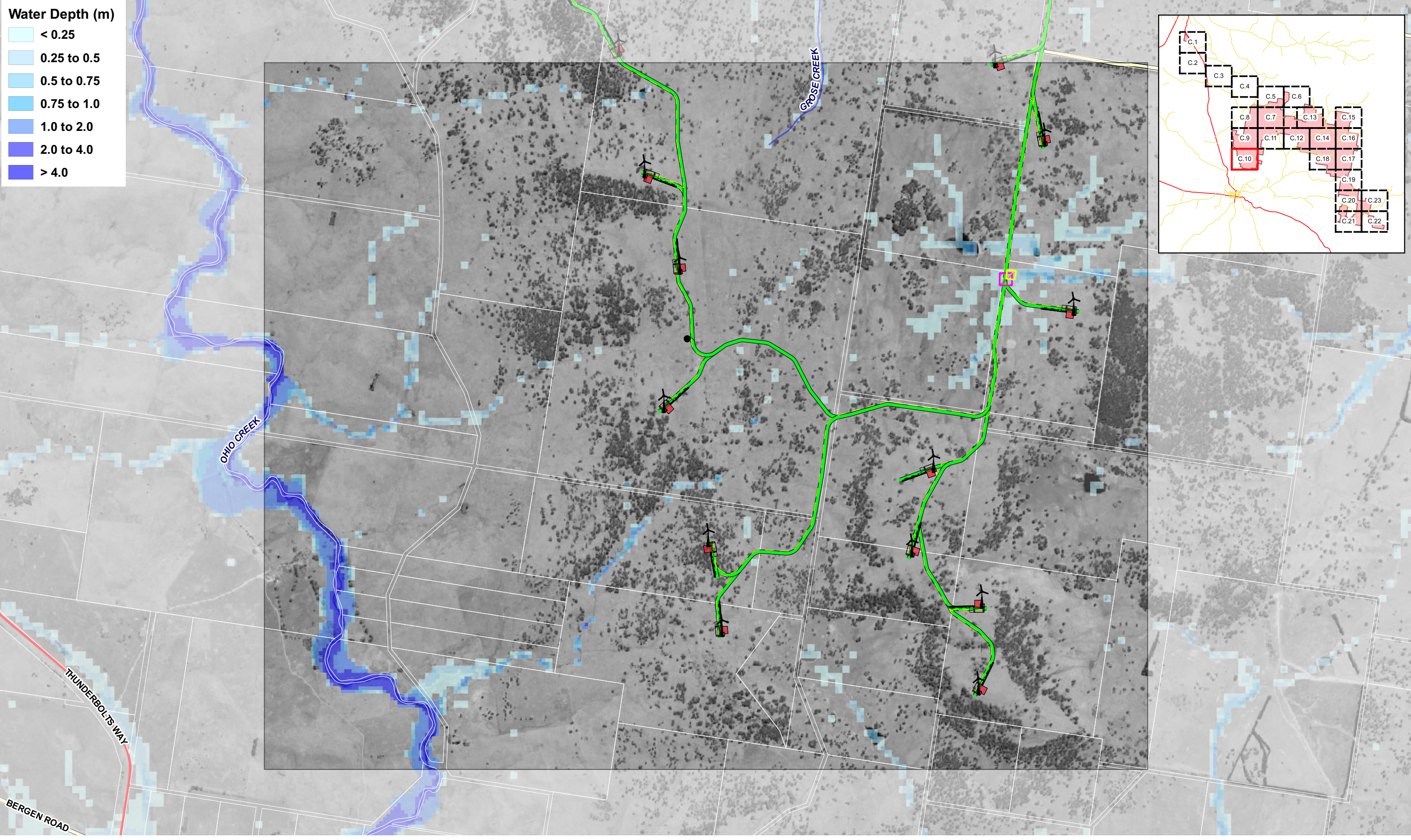




LEGEND

WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	MV Reticulation	Minor Road	Watercourse
		Culvert/Bridge	

Title: Existing 1% AEP Peak Flood Depth and Extent		Drawing: Figure C.9	Rev: A
<p>BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.</p>			
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LEGEND

WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	PCV Mast	Minor Road	Watercourse
Vestas Laydown	MV Reticulation	Culvert/Bridge	

Title: **Existing 1% AEP Peak Flood Depth and Extent**

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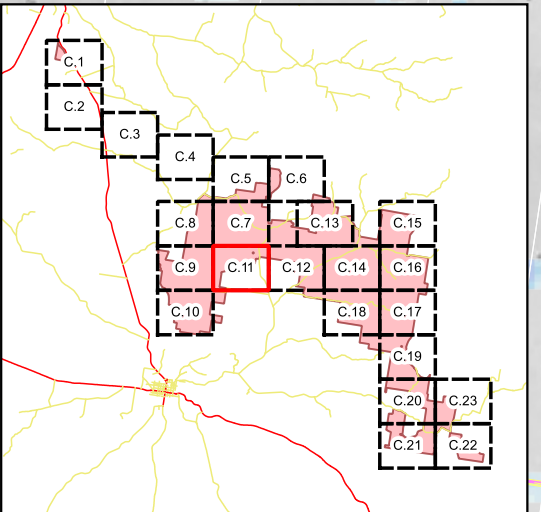
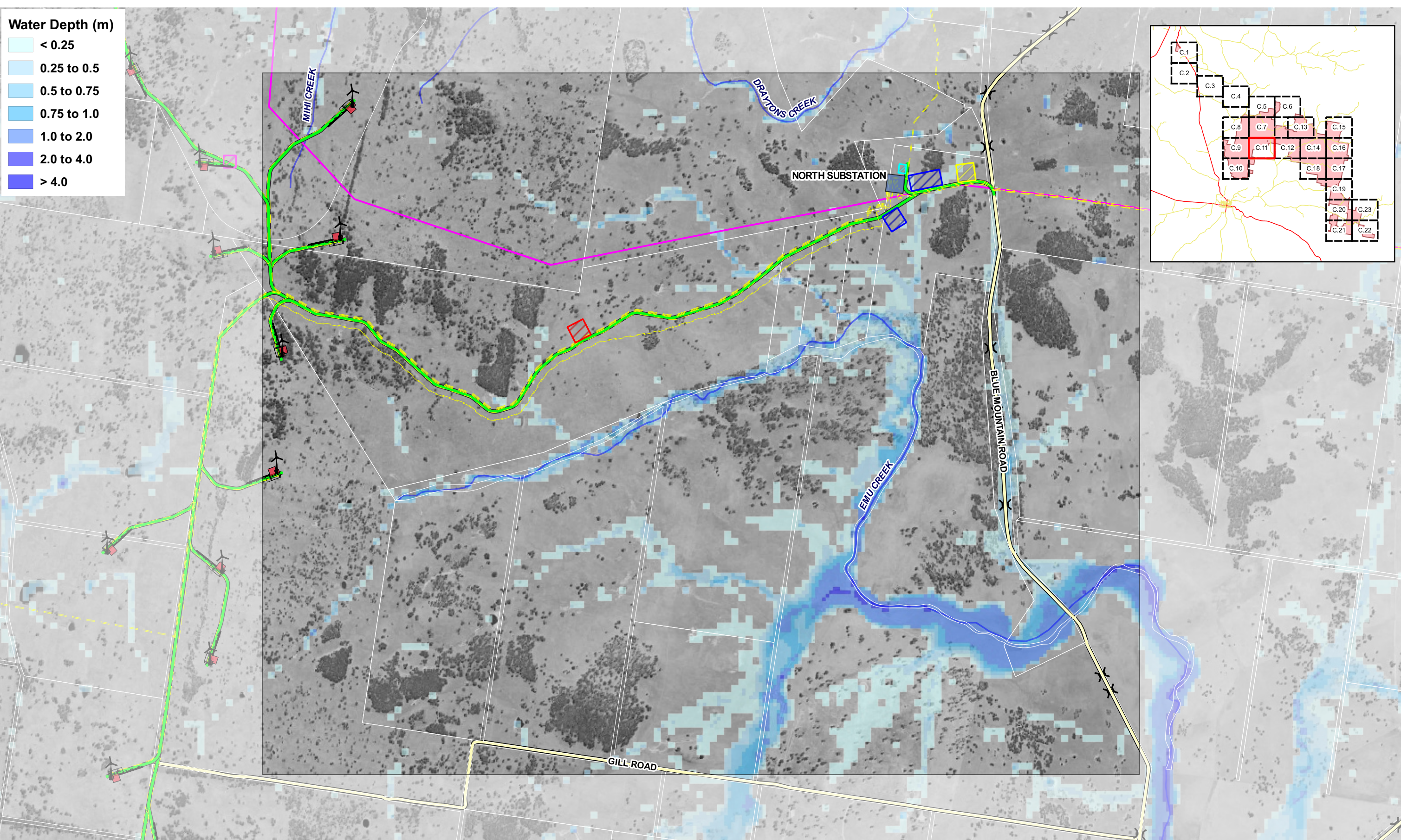
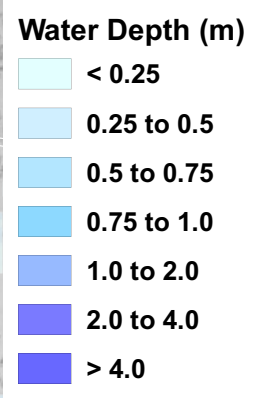
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Drawing: **Figure C.10**

Rev: **A**

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LEGEND

WTG	Batch Plant	MV Reticulation	Major road
WTG Hardstand	Vestas Laydown	Internal Access Track	Minor Road
Substation/Switchyard	O&M Building	Watercourse	Culvert/Bridge
Crane Pad	Transmission Line		

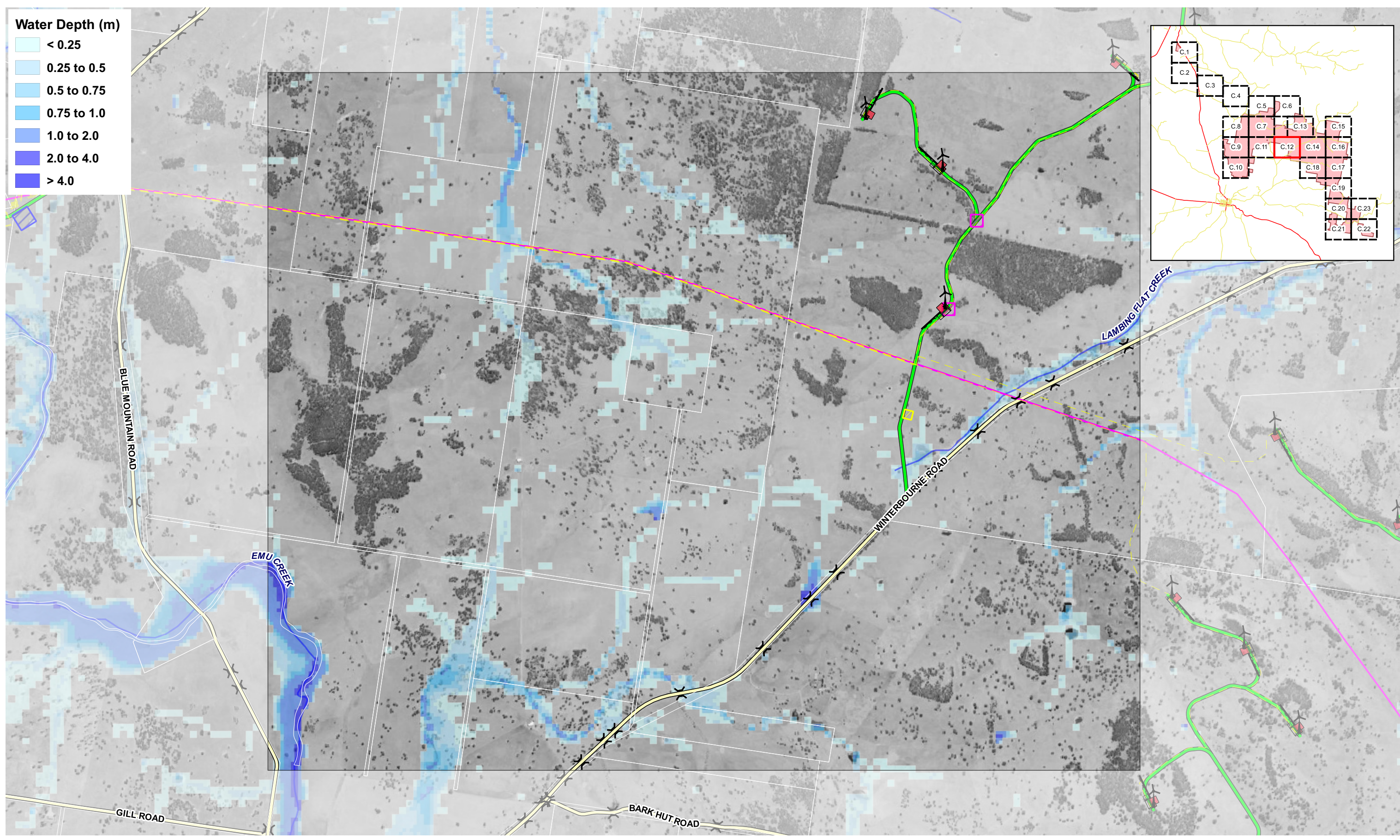
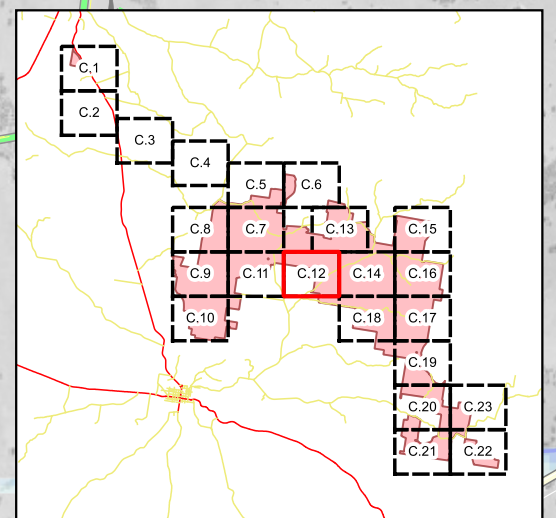
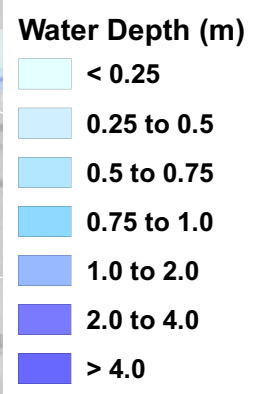
Title: **Existing 1% AEP Peak Flood Depth and Extent**

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Drawing: **Figure C.11** Rev: **A**

Scale: 0 500 1,000 m

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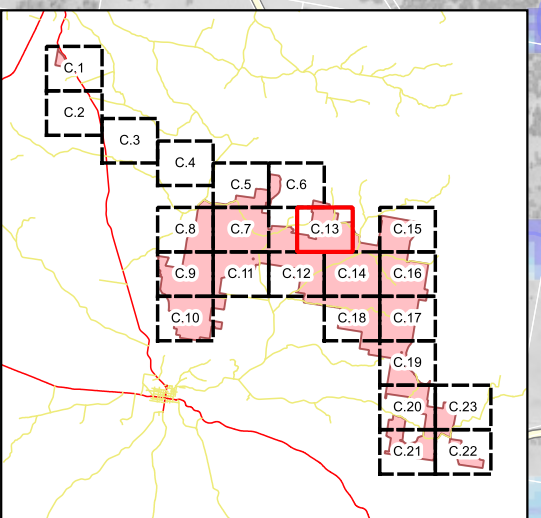
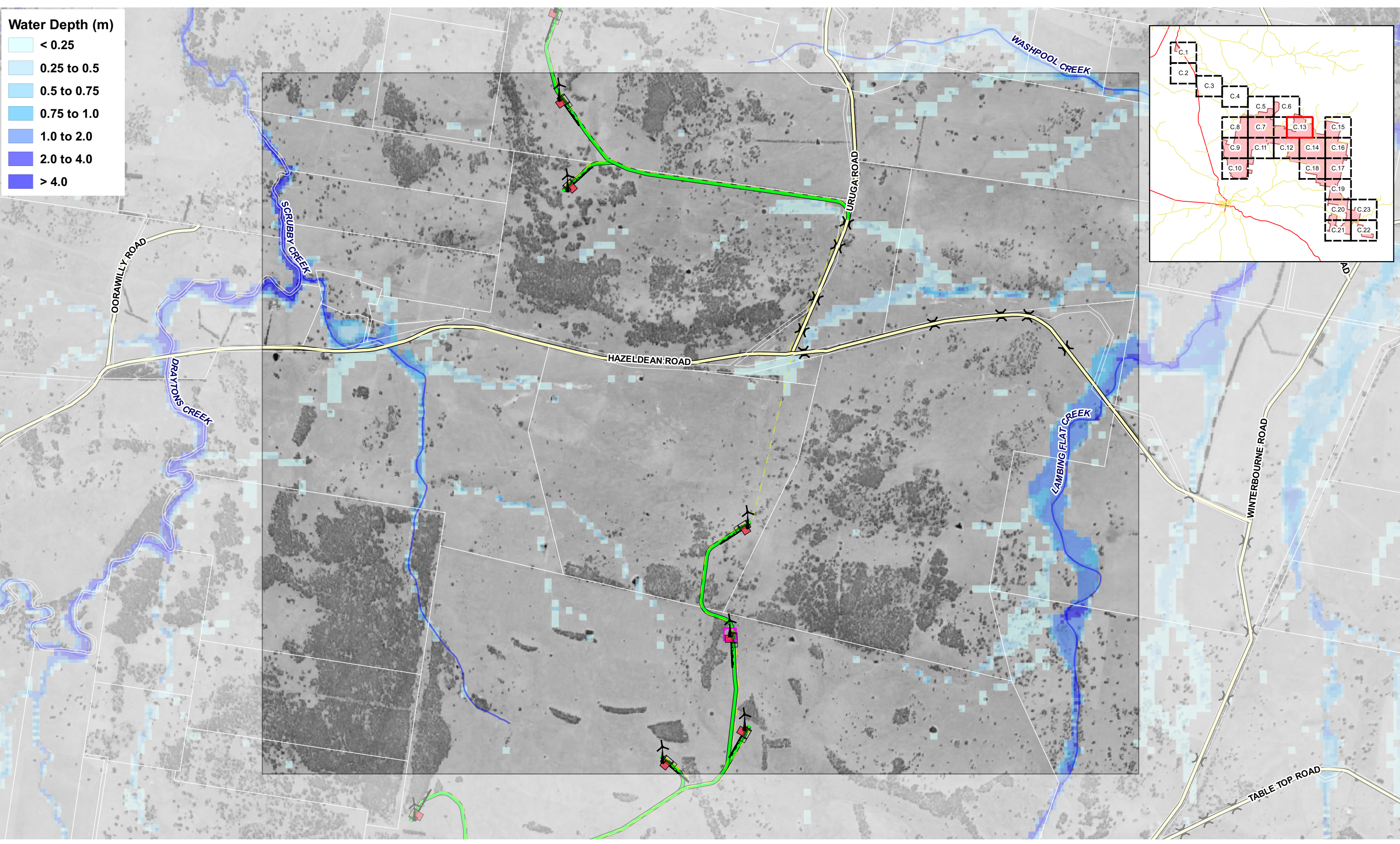
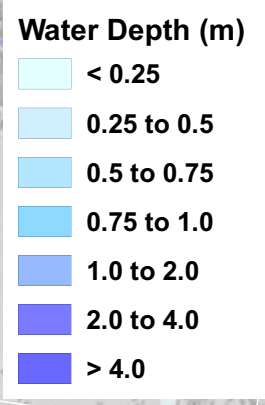
LEGEND

WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	Transmission Line	Minor Road	Watercourse
Vestas Laydown	MV Reticulation	Culvert/Bridge	

Title: **Existing 1% AEP Peak Flood Depth and Extent**

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Drawing: **Figure C.12** Rev: **A**



LEGEND

WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	MV Reticulation	Minor Road	Watercourse
		Culvert/Bridge	

Title: **Existing 1% AEP Peak Flood Depth and Extent**

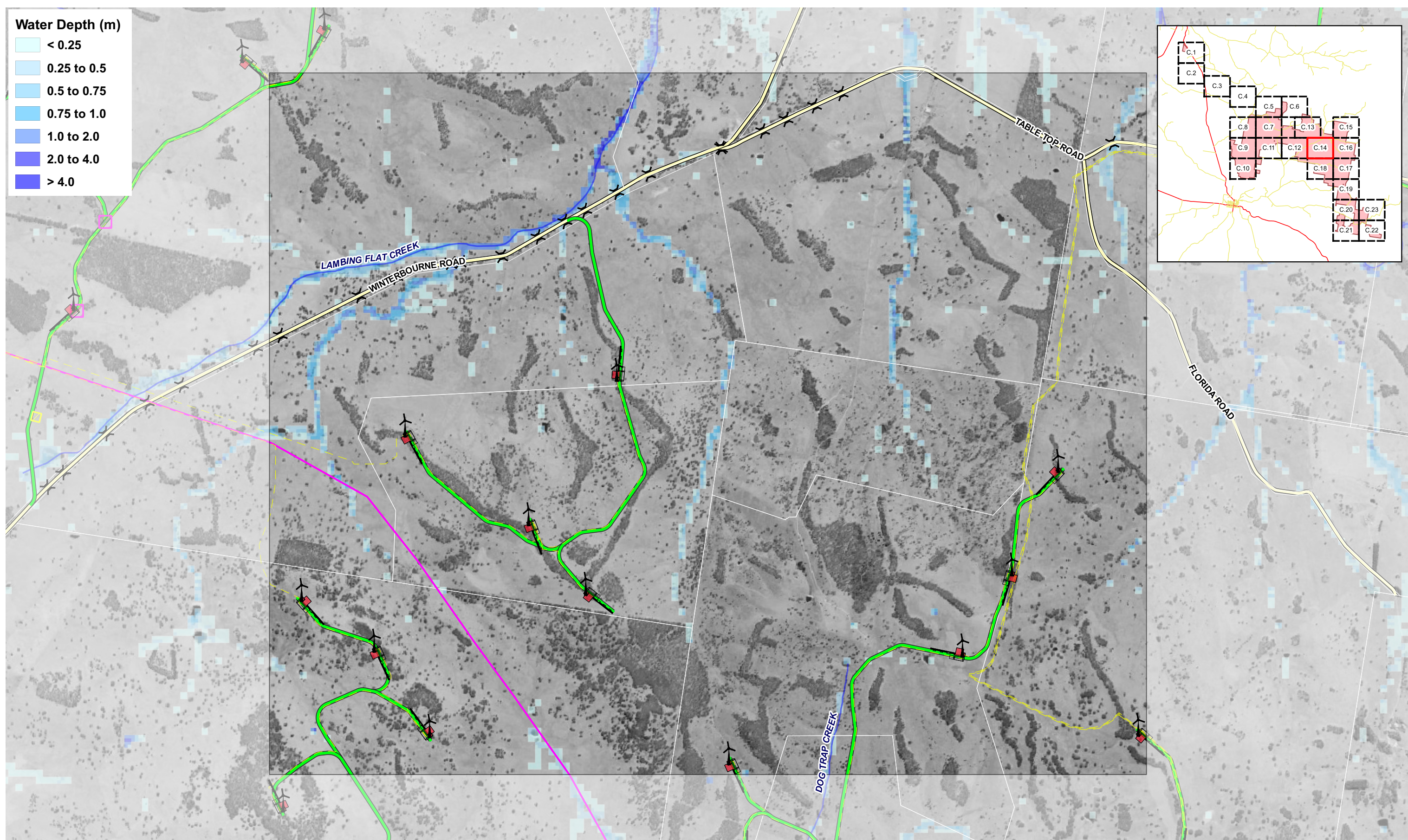
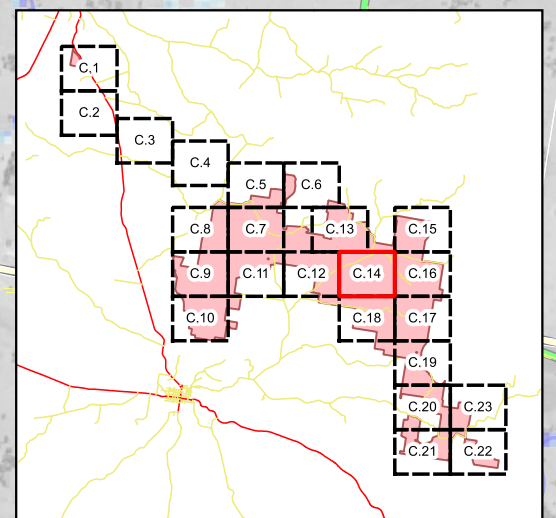
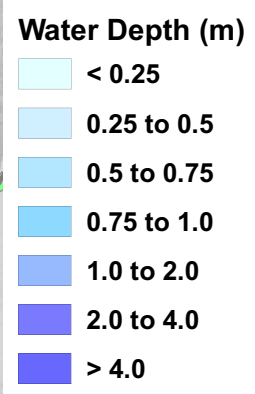
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Drawing: **Figure C.13**

Rev: **A**

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LEGEND

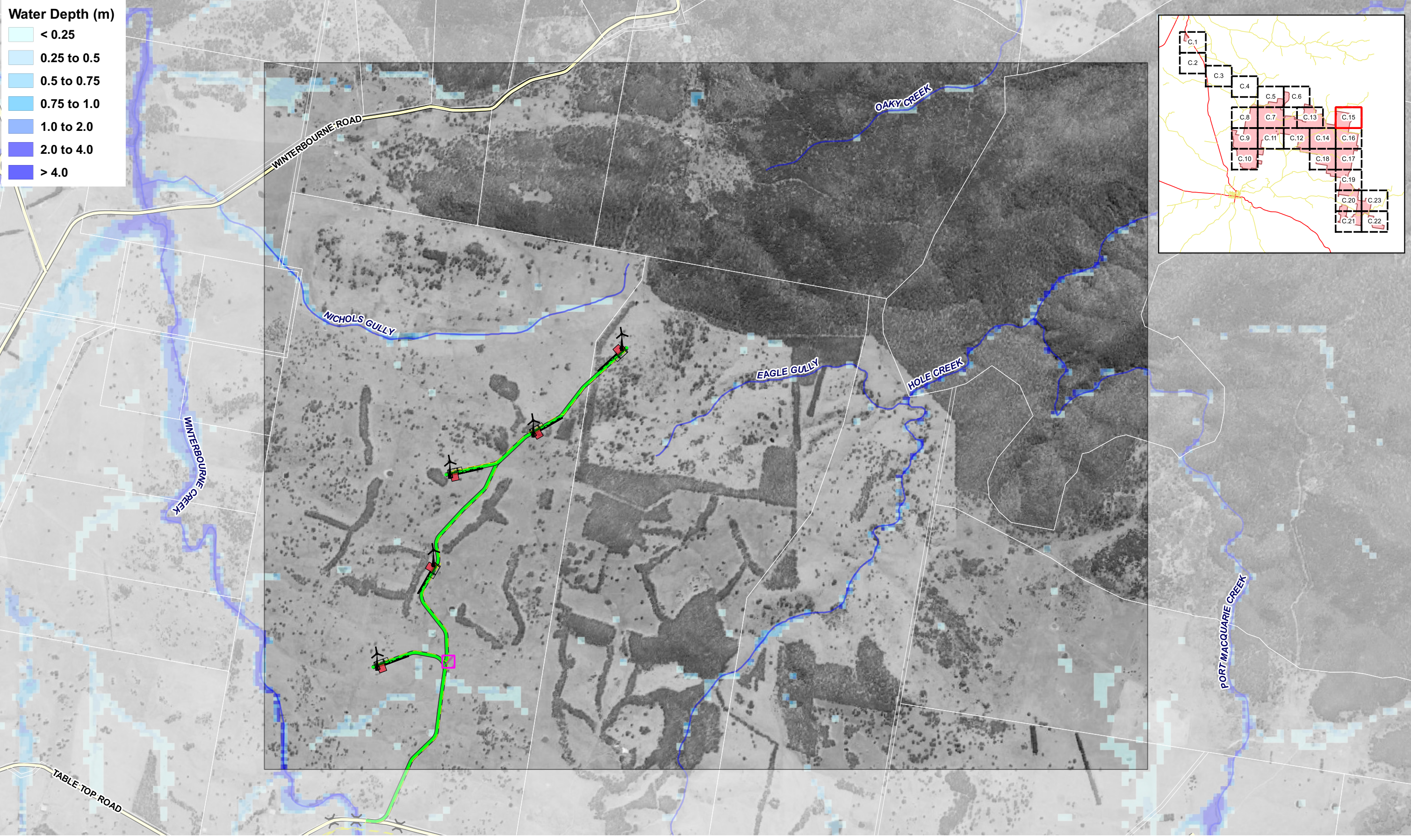
WTG	Transmission Line	Internal Access Track	Major road
WTG Hardstand	MV Reticulation	Minor Road	Watercourse
		Culvert/Bridge	

Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.14** Rev: **A**

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LEGEND

WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	MV Reticulation		Minor Road
			Watercourse
			Culvert/Bridge

Title:
Existing 1% AEP Peak Flood Depth and Extent

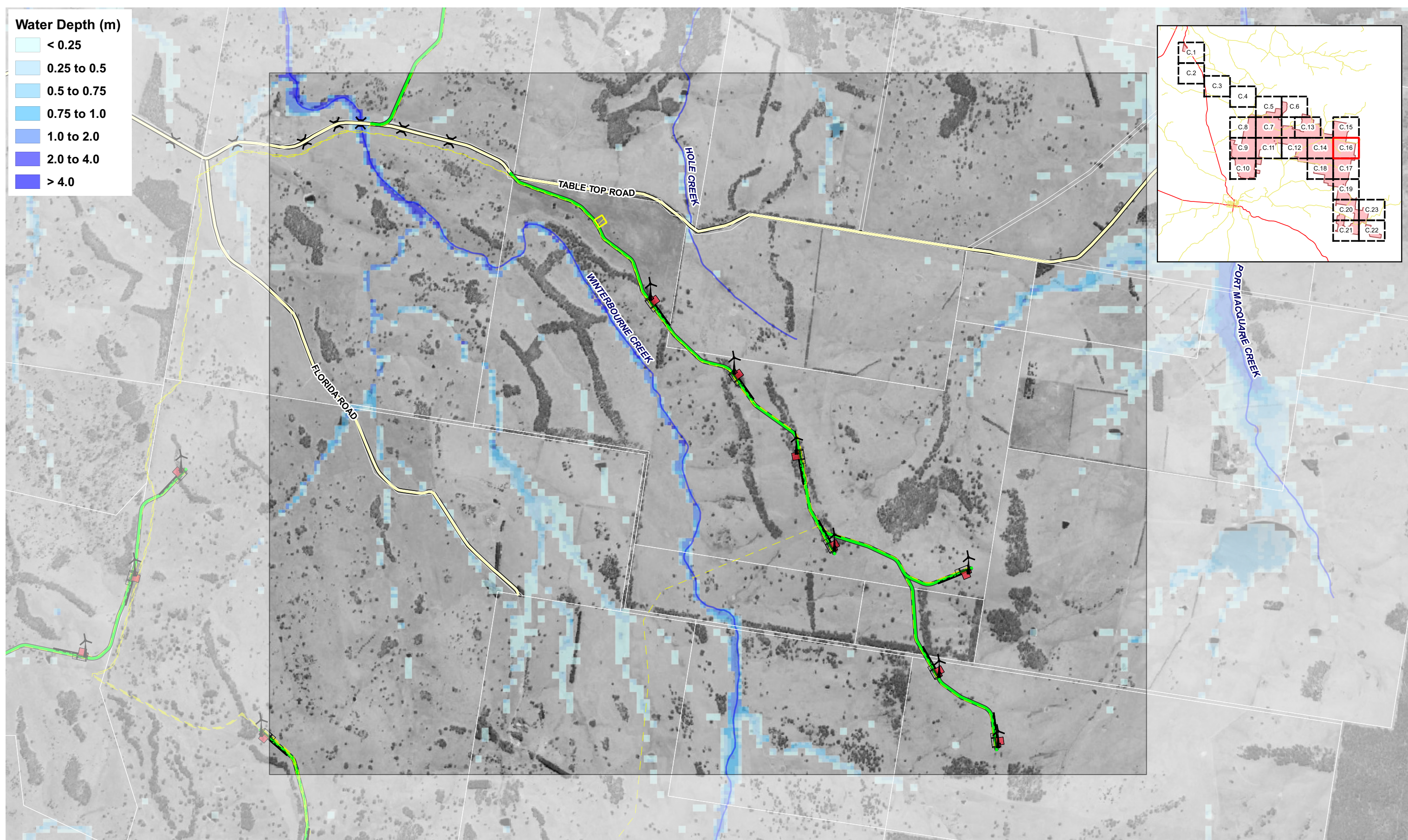
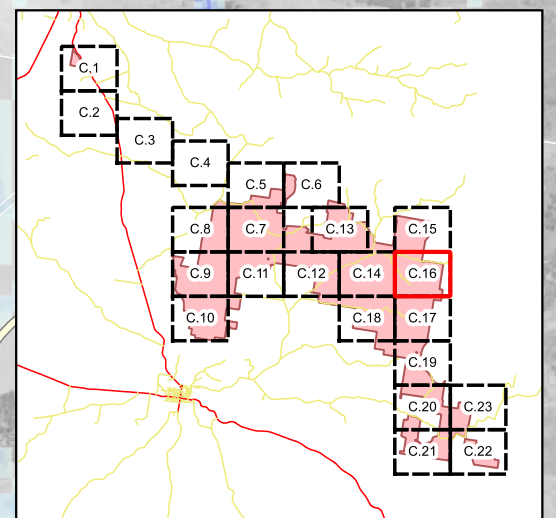
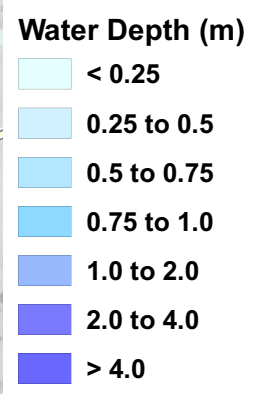
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Drawing:
Figure C.15

Rev:
A



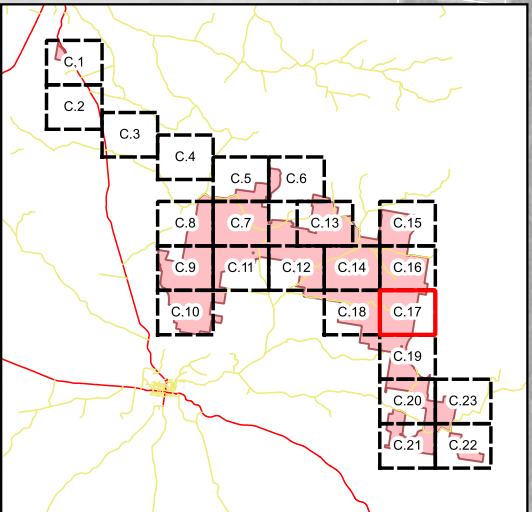
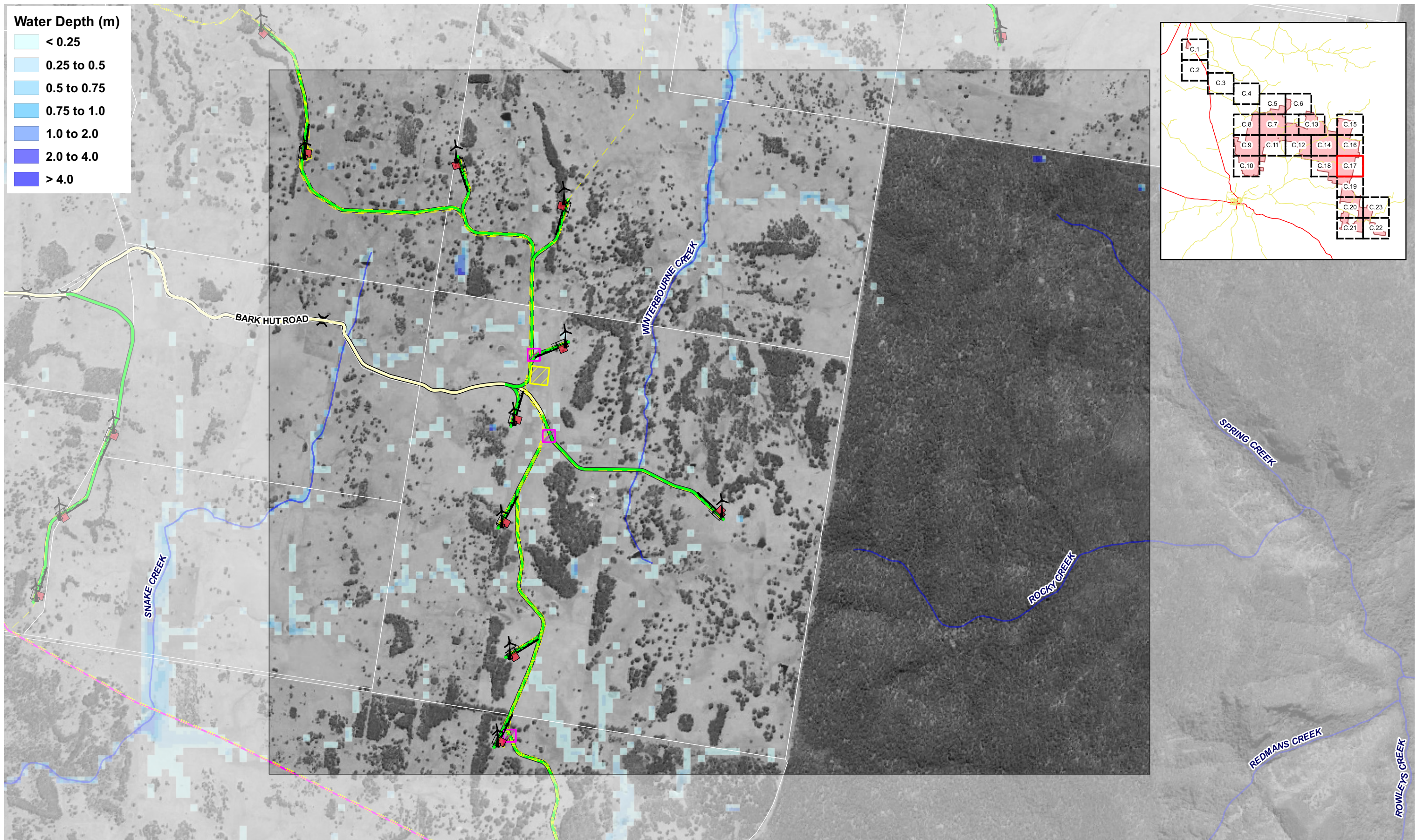
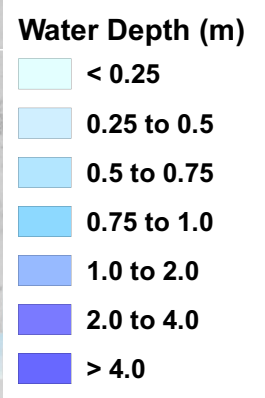
LEGEND			
	WTG		Internal Access Track
	WTG Hardstand		MV Reticulation
	Vestas Laydown		Major road
	Internal Access Track		Minor Road
	Watercourse		Culvert/Bridge

Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.16** Rev: **A**

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LEGEND			
	WTG		Joint Box
	WTG Hardstand		Internal Access Track
	Vestas Laydown		Transmission Line
	Major road		MV Reticulation
	Minor Road		Watercourse
	Culvert/Bridge		

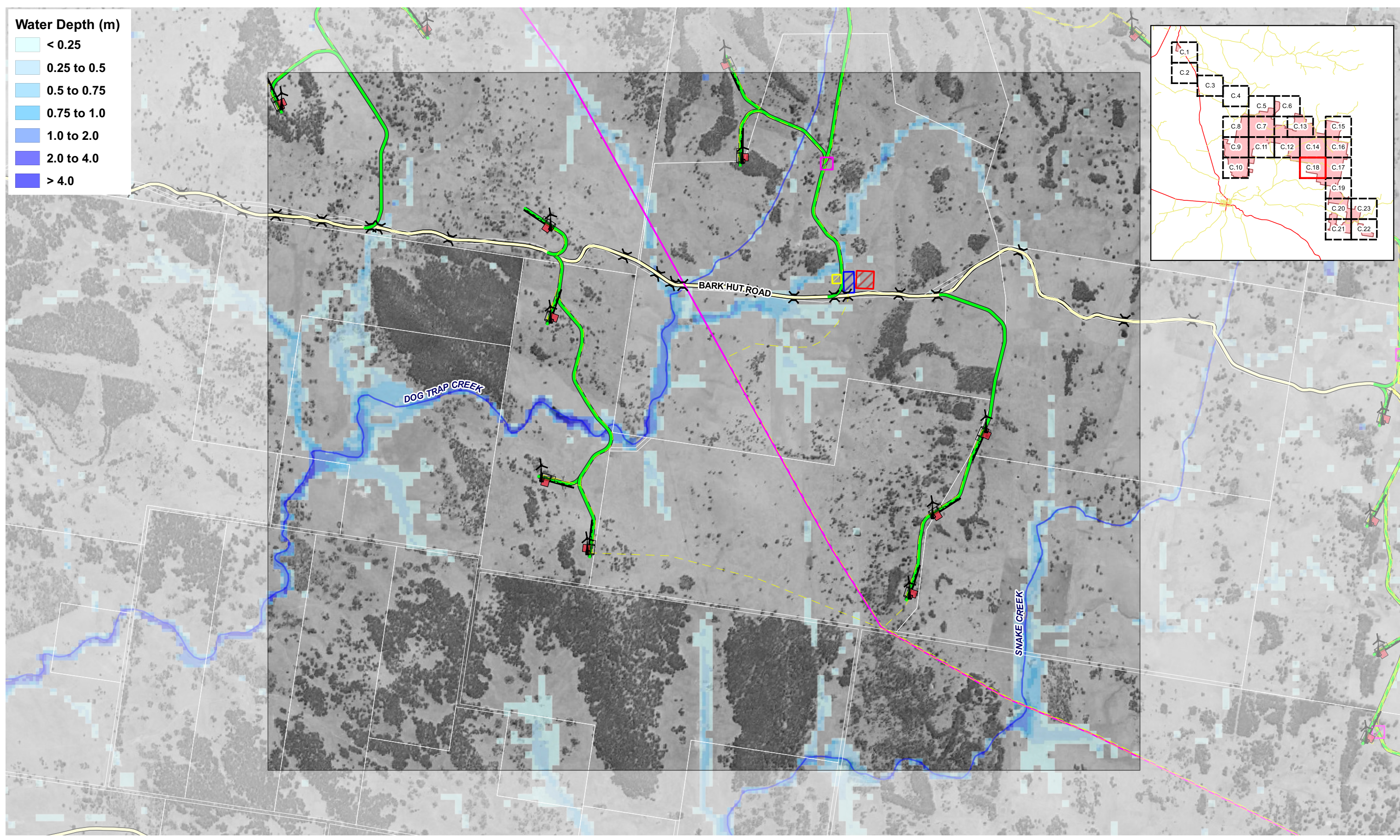
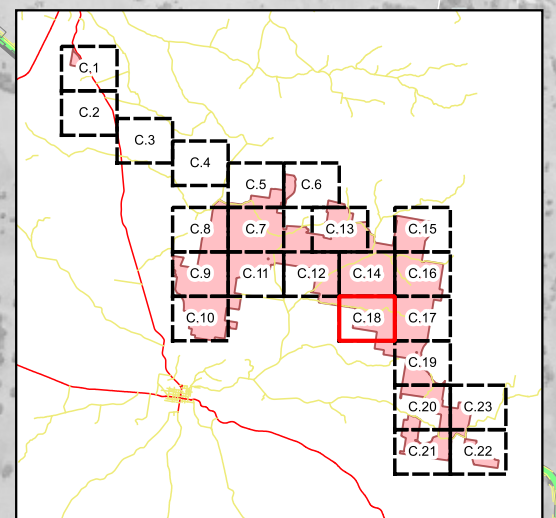
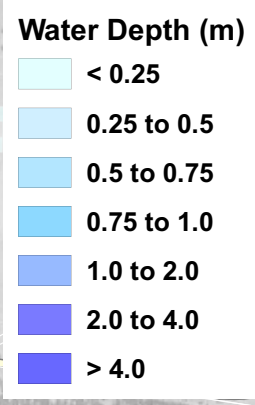
Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.17**

Rev: **A**

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LEGEND			
	WTG		Batch Plant
	WTG Hardstand		Vestas Laydown
	Crane Pad		Joint Box
	Transmission Line		MV Reticulation
	Internal Access Track		Major road
	Watercourse		Minor Road
	Culvert/Bridge		

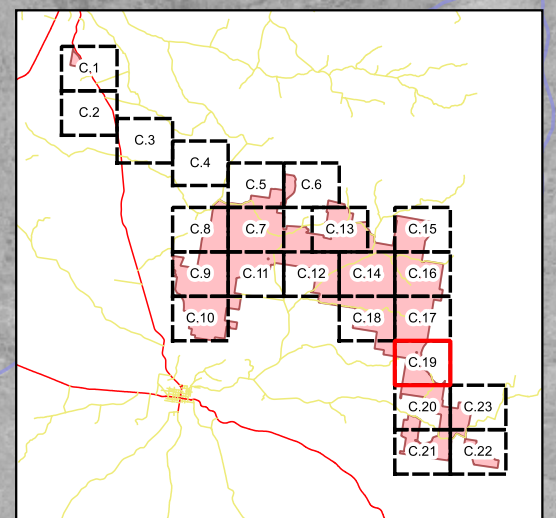
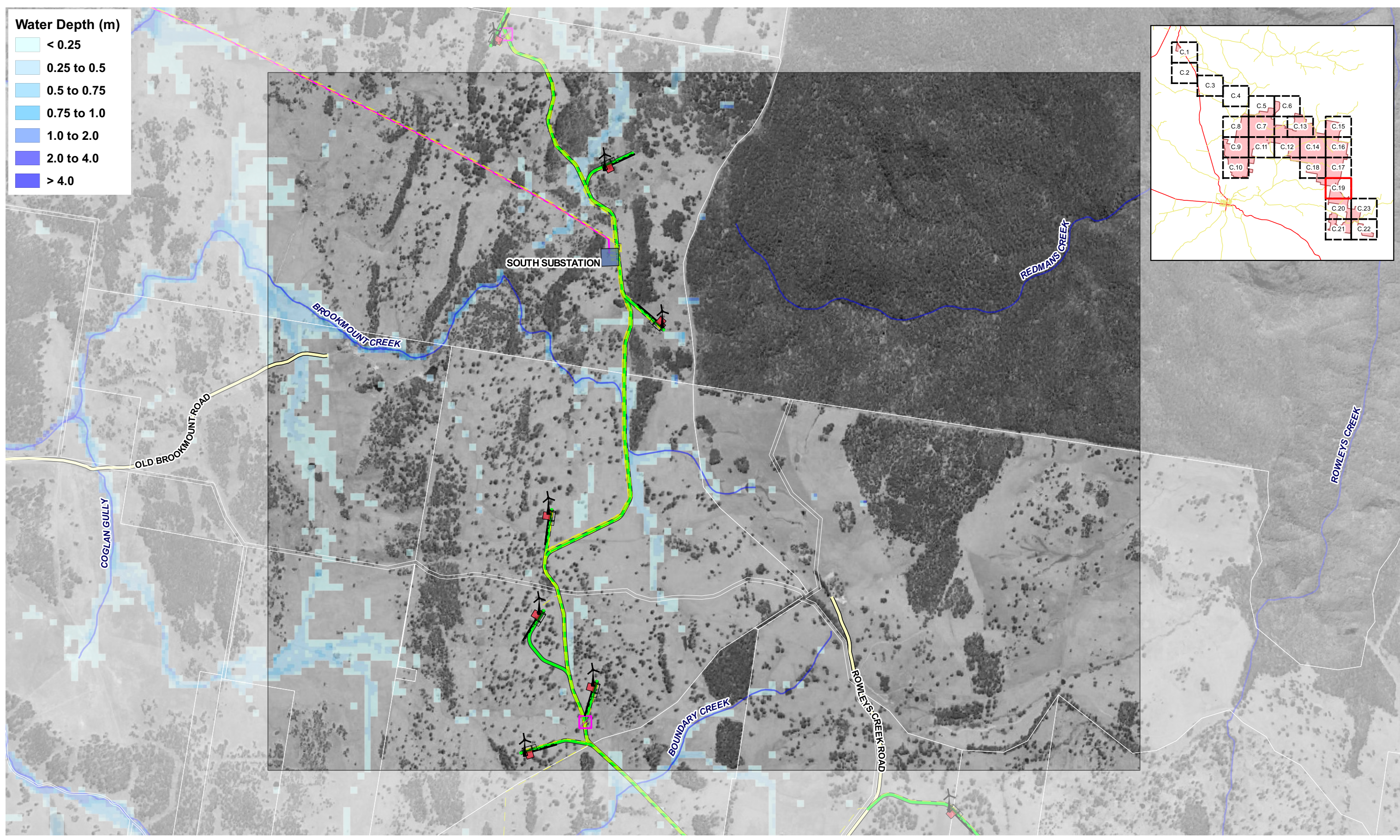
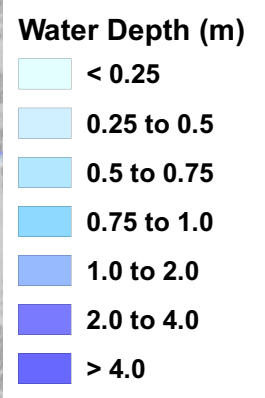
Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.18**

Rev: **A**

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LEGEND

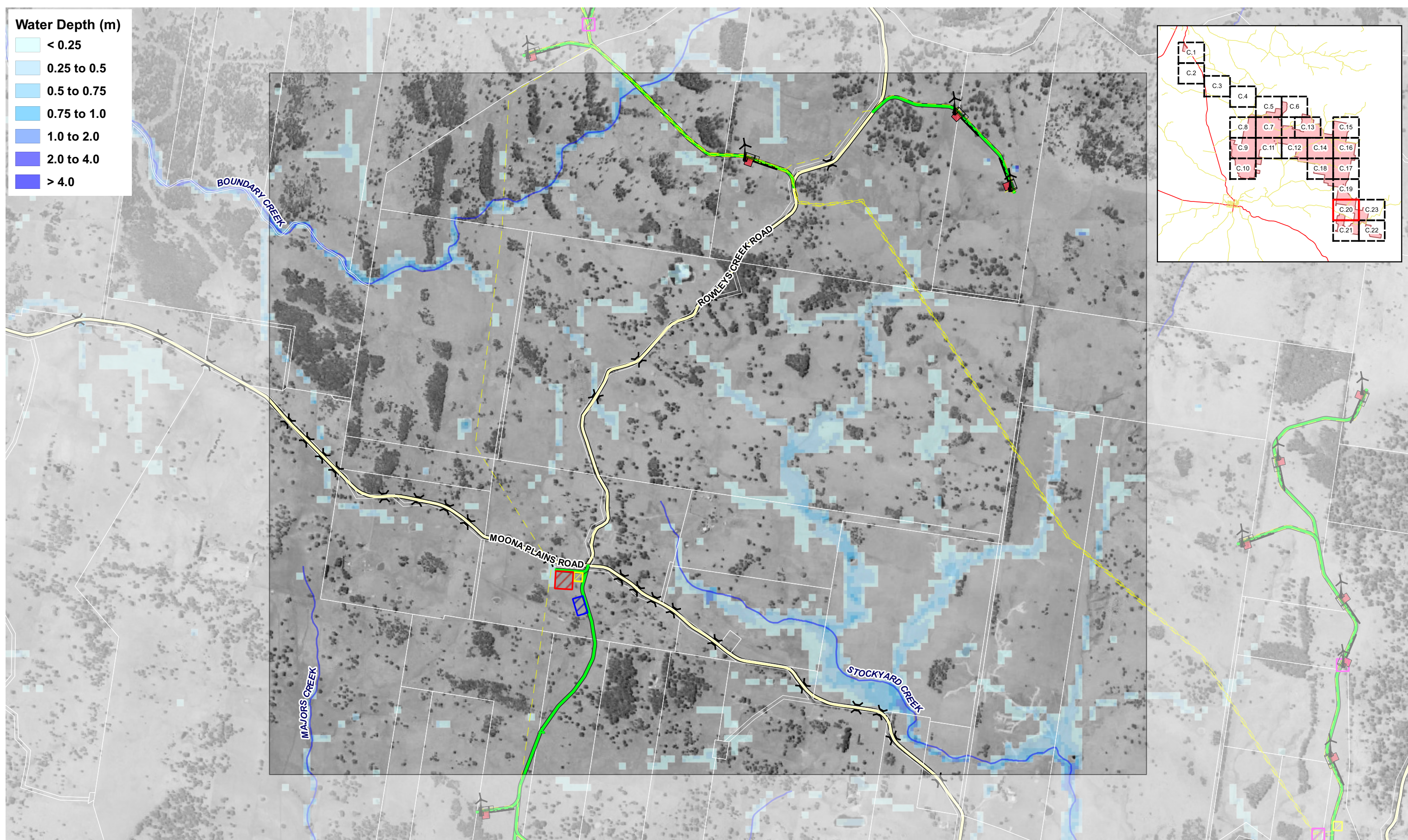
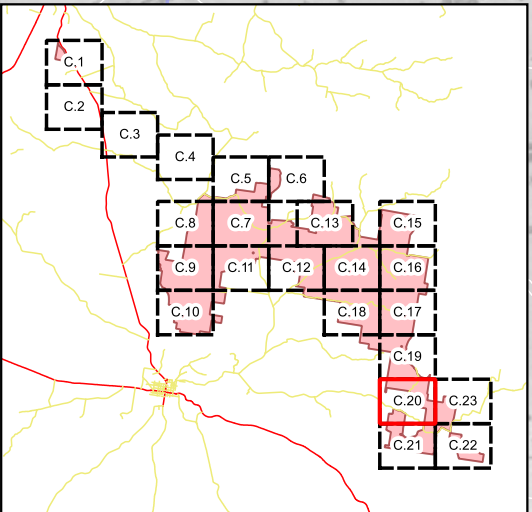
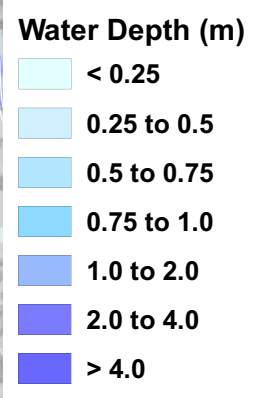
WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	Transmission Line	Minor Road	Watercourse
Substation/Switchyard	MV Reticulation	Culvert/Bridge	

Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.19** Rev: **A**

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LEGEND			
	WTG		Batch Plant
	WTG Hardstand		Internal Access Track
	Crane Pad		Vestas Laydown
			MV Reticulation
			Major road
			Minor Road
			Watercourse
			Culvert/Bridge

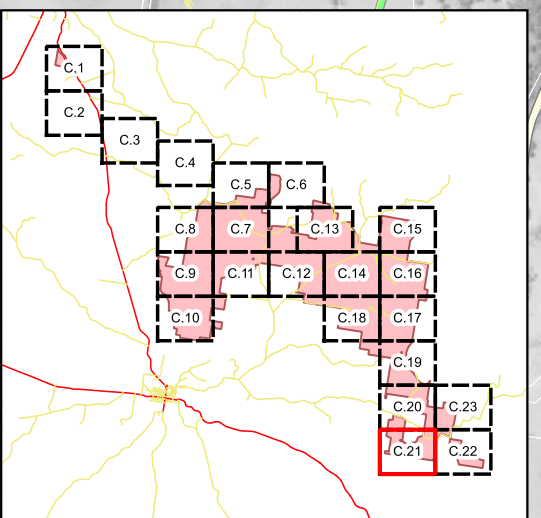
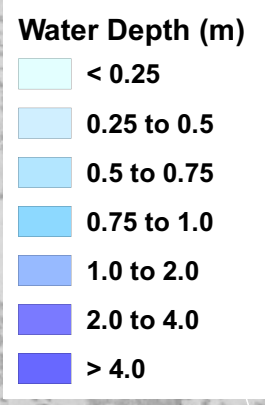
Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.20**

Rev: **A**

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LEGEND

WTG	Joint Box	Internal Access Track	Major road
WTG Hardstand	MV Reticulation		Minor Road
			Watercourse
			Culvert/Bridge

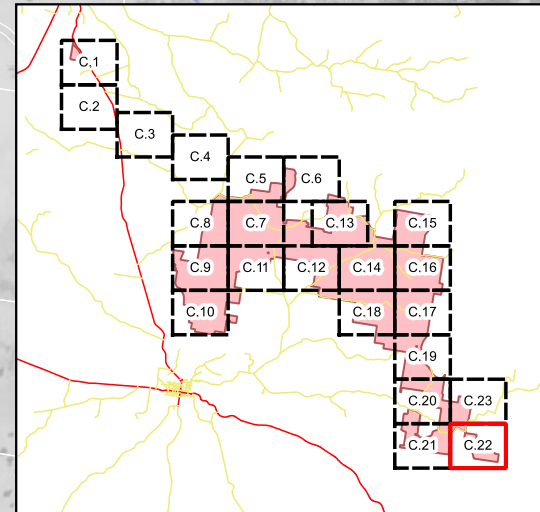
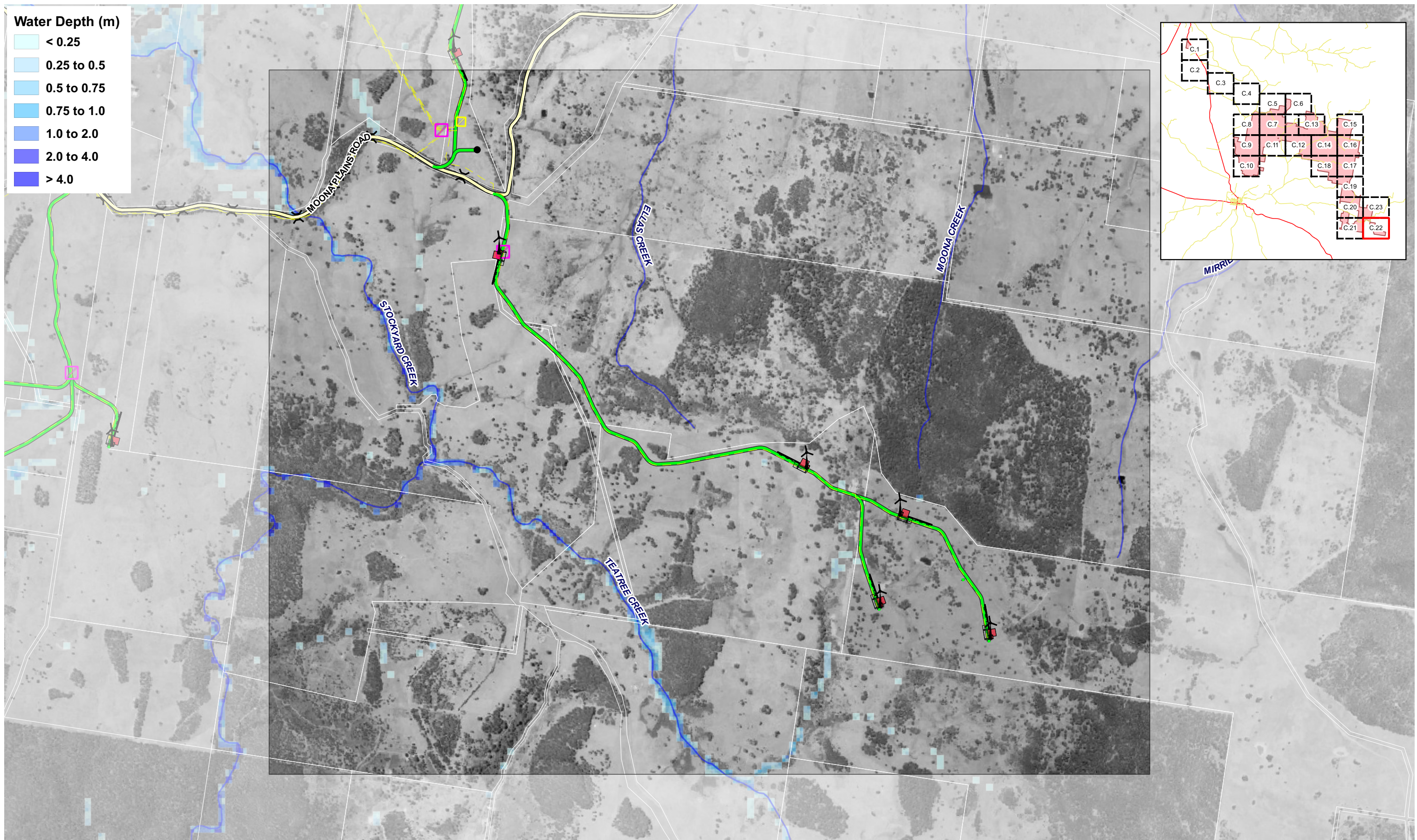
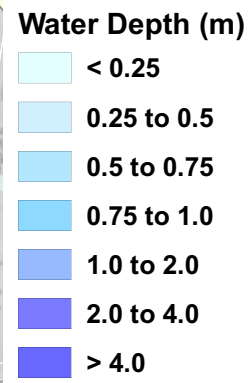
Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.21** Rev: **A**

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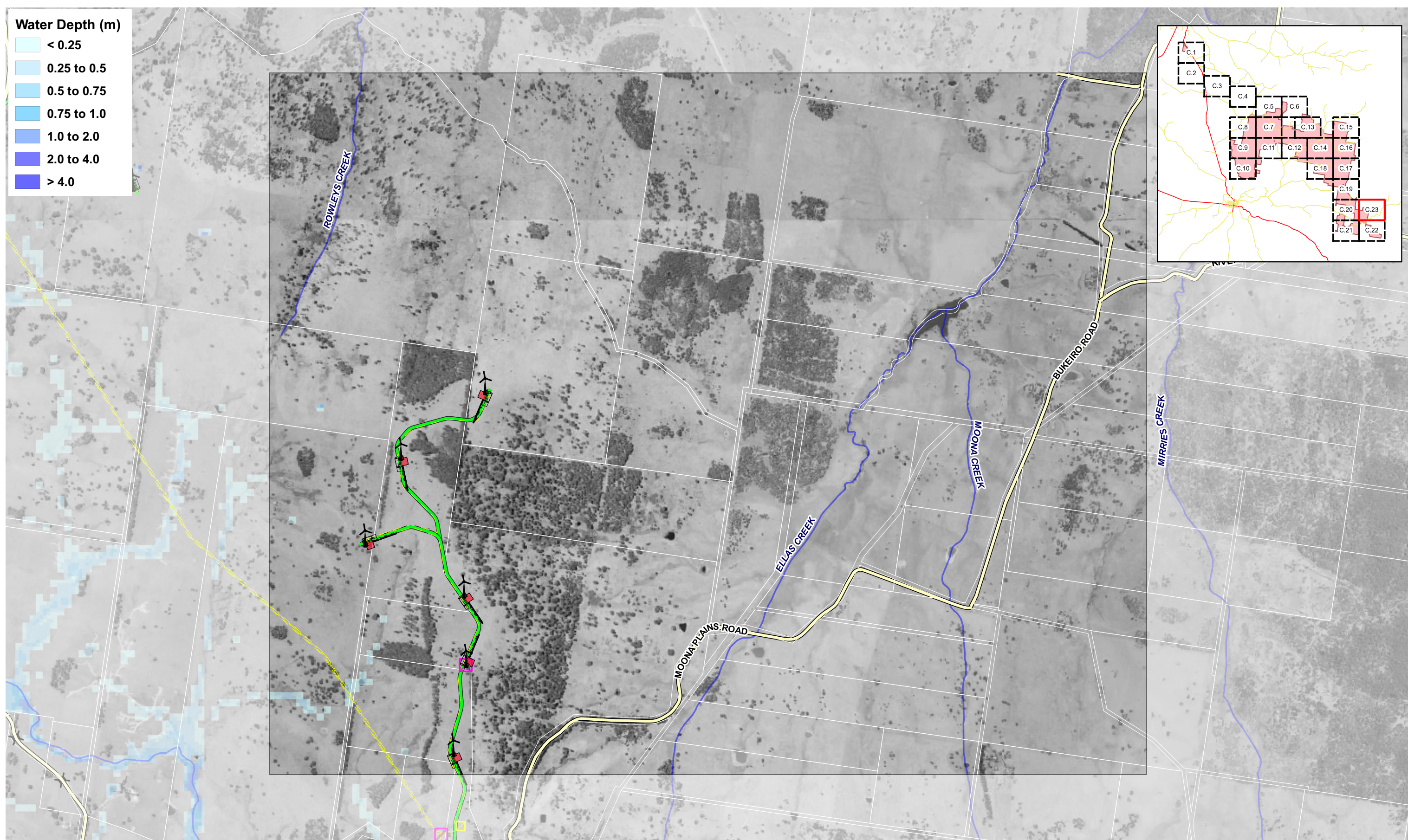
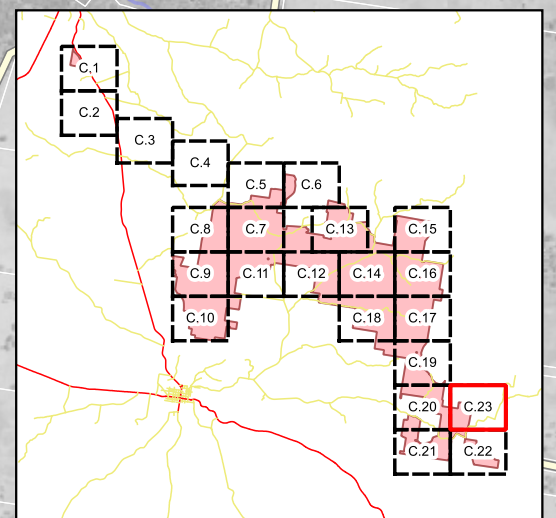
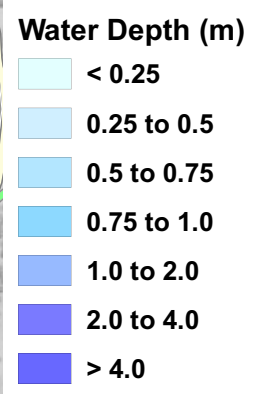
LEGEND			
	WTG		Joint Box
	WTG Hardstand		PCV Mast
	Vestas Laydown		MV Reticulation
	Internal Access Track		Major road
	Minor Road		Watercourse
	Culvert/Bridge		

Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.22** Rev: **A**

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LEGEND

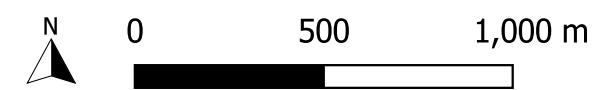
	WTG		Joint Box		Internal Access Track		Major road
	WTG Hardstand		MV Reticulation				Minor Road
							Watercourse
							Culvert/Bridge

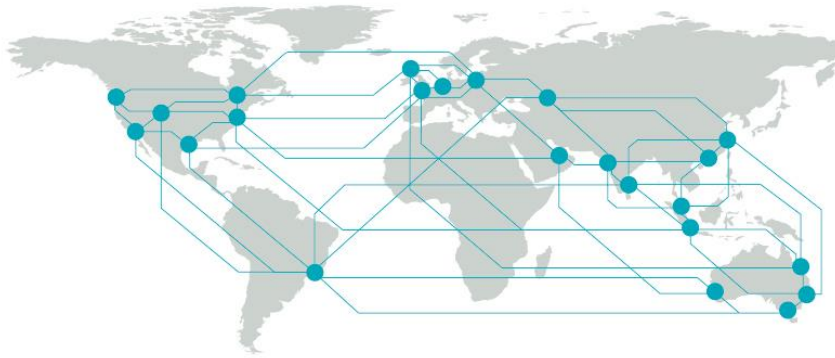
Title: **Existing 1% AEP Peak Flood Depth and Extent**

Drawing: **Figure C.23**

Rev: **A**

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