Barwon Solar Farm – Hydrology Assessment

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Executive Summary

Eco Logical Australia Pty Ltd (ELA) has been engaged by Urbis on behalf of Elgin Energy Pty Ltd to assess hydrological conditions associated with the existing and proposed conditions under 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% Annual Exceedance Probability (AEP) flood events for the proposed Barwon Solar Farm (the 'Project') located between Melbourne and Geelong, near Little River, in Victoria.

Datasets sourced for use in the assessment included:

- Digital Elevation Model (DEM) to represent the watershed (catchment) that drains the site and any adjacent waterways.
- Site survey within the Project Boundary.
- Development footprint for the Project.
- Intensity Frequency Duration (IFD) data representing the rainfall intensities for design rainfall events specific for this catchment.
- Australian Rainfall and Runoff (AR&R) information: for rainfall patterns and loss information for use in the flow rate modelling.
- Regional Flood Frequency Estimation (RFFE) modelling to validate the flow rate model results for design storm events.
- Gauged rainfall data representing the rainfall falling on the catchment at a sub-daily time step for use in calibration.
- Gauged flow data representing flows in the catchment for calibration of flow rates.

Flow rate modelling was undertaken using the RORB software package to determine sub-catchment flows to verify the flow rate from the subsequent water level modelling. The catchment being modelled is considered to be in a natural condition (i.e. it has no artificially-formed waterways, channels or drains) and has no impervious surfaces. Impervious surfaces in this context refers to impervious areas directly connected to waterways. The impervious regions of the model (e.g. roads and houses) are unlikely to be directly connected to the streamlines and any areas that are connected would be such a small proportion (<0.1%) of the overall catchment that they would not affect the modelled outcome. For the purpose of this assessment, the Upper Stony Creek Reservoir(s) and other larger water bodies have not been modelled explicitly. Their areas (<1% of total area) are assumed to runoff as per the rest of the catchment.

The RORB model was calibrated to the observed events and validated to the RFFE analysis to fit within the confidence limits of the RFFE results. For the observed events, the calibration ideally would match the peak flow rate, hydrograph shape and timing of the peak. Matching the exact time of the peak was not possible for these events, however, so only peak flow rate and hydrograph shape were calibrated (while getting the timing of the peak as close as possible). The adopted parameters for the design event modelling from the calibration were a k_c value of 22, an m value of 0.8 and an initial loss and continuing loss of 10 mm and 1.7 mm/hr, respectively.

The RORB model was run to provide verification flows for the water level modelling. Under post development conditions there will be additional impervious areas within the catchment associated with infrastructure, such as access tracks, compounds, substations and solar panels. This additional infrastructure may change the runoff characteristics of the catchment. However, this infrastructure, including the solar panels, where water runs off onto the ground underneath and between the panels and can seep into the ground, are not considered directly connected to the waterways. Therefore, no additional RORB model runs were required for post-development conditions.

Hydraulic modelling was then conducted to represent existing conditions using the HEC-RAS software package. HEC-RAS models were developed using a two-dimensional (2D) rain-on-grid analysis to determine flood extents and flood levels and flow velocities.

A computational mesh spacing of 50 metres by 50 metres was applied across the catchment with break lines used to alter the direction of grid cells to align with drainage lines and roads. For additional detail, a refinement region was specified within the Site Boundary with a computational mesh spacing of 10 metres by 10 metres. Rainfall was applied to the 2D area as a rainfall excess based on the IFD data and the RORB results.

Roughness coefficients are used to define how quickly water moves across the terrain and control the shape of flow hydrographs resulting from the rainfall and upstream flow. Typical roughness values are defined for the range of flow path extents, i.e. from concrete channels to floodplains. Modelling the full 2D catchment area, which extends outside of normal channels and their corresponding slopes, requires the use of much larger roughness values than are typically applied to models that just model stream flow. A roughness value of 0.06 was therefore adopted for all waterway regions of the model and roughness values of 0.06, 0.1, 0.2 and 0.3 were applied to broader catchment area within the model domain in combination with the 1% AEP rainfall to determine the change in flow rates. A regression relationship was applied between flow and roughness for this catchment, and this indicated a roughness value of 0.23 be adopted for the broader catchment area.

The modelled existing conditions' flood depths showed that the flows are generally concentrated to the waterways and defined overland flow paths in the region with sufficient terrain relief to limit the amount of sheet flow.

There are three main overland flow paths / waterways within the site area. The waterway through the middle is, in general, away from the proposed solar arrays, however there are isolated areas on the edge of the solar panel regions that may be close to or encroach upon the 1% AEP flood inundation area. Depths in some of these areas are shallow and will be able to pass under the arrays, however some points do have greater water depths (> 1 m) and an existing or proposed access track crosses the inundation area.

An overland flow path across the upper eastern part of the site travels under proposed sections of solar arrays. For the most part the 1% AEP depths are shallow (< 0.1 m) however as the overland flow path progresses downstream these depths increase to around 0.5 metre with the array region.

A third overland flow path and waterway in the south-eastern corner of the site also travels under the proposed solar array regions and across the proposed placement of the BESS facility. The 1% AEP depths are in general shallow (< 0.1 m) underneath the arrays and the proposed BESS location.

Adjusting the ground surface to raise the BESS facility above these flood waters would alter the localised flow paths of the area, however with an onsite farm dam immediately downstream of this, minimal impact to overall flood paths would occur.

The last key flood feature is Little River, along the northern border of the site. The solar array regions are clear of the 1% AEP extent for Little River in all areas except one small location where the overland flow path joins Little River in the central north of the site. There are existing access roads that cross Little River, the efficacy of these crossings within the 1% AEP flood event have not been assessed, as they are assumed to already be designed and sited appropriately.

The modelled velocities show that, in general, velocities across the site tend to be low (< 0.5 m/s) and below the threshold (i.e. < 2 m/s) where rock armouring to protect waterways and features is required. Some isolated higher velocities (> 1 m/s) occur through the overland flow path / waterway through the middle of the site and at other isolated locations under the current conditions. Should erosion form at these locations then erosion mitigation strategies should be implemented.

Flow velocities within the watercourses and overland flow paths vary such that most areas are below the level that might be expected to require artificial protection (i.e. rock armouring). During detailed design, this should be reviewed to ensure appropriate waterway protection is in place.

Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
2D	Two dimensional
AEP	Annual Exceedance Probability
ARF	Areal Reduction Factor
AR&R	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
DEM	Digital Elevation Model
ELA	Eco Logical Australia
ELVIS	Elevation and Depth – Foundation Spatial Data
HEC-RAS	Hydrologic Engineering Centre River Analysis System
ICSM	Australian Government's Intergovernmental Committee on Surveying and Mapping
IFD	Intensity-Frequency-Duration
IL/CL	Initial Loss and Continuing Loss
RFFE	Regional Flood Frequency Estimation
RORB	Runoff-Routing Model

1. Introduction

Eco Logical Australia Pty Ltd (ELA) has been engaged by Urbis on behalf of Elgin Energy Pty Ltd to assess hydrological conditions associated with the existing and proposed conditions under 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% Annual Exceedance Probability (AEP) flood events for the proposed Barwon Solar Farm (the 'Project') located between Melbourne and Geelong, near Little River, in Victoria (Figure 1-1).

This report provides the flood impact assessment of the Project and details the modelling approach and modelling results that underpin the assessment. This report presents:

1. The data sourced and applied as part of the assessment (Section 2).
2. Hydrology modelling undertaken to determine flow rates to verify the hydraulic modelling (Section 3).
3. Hydraulic modelling undertaken to determine water levels and velocities (Section 4).

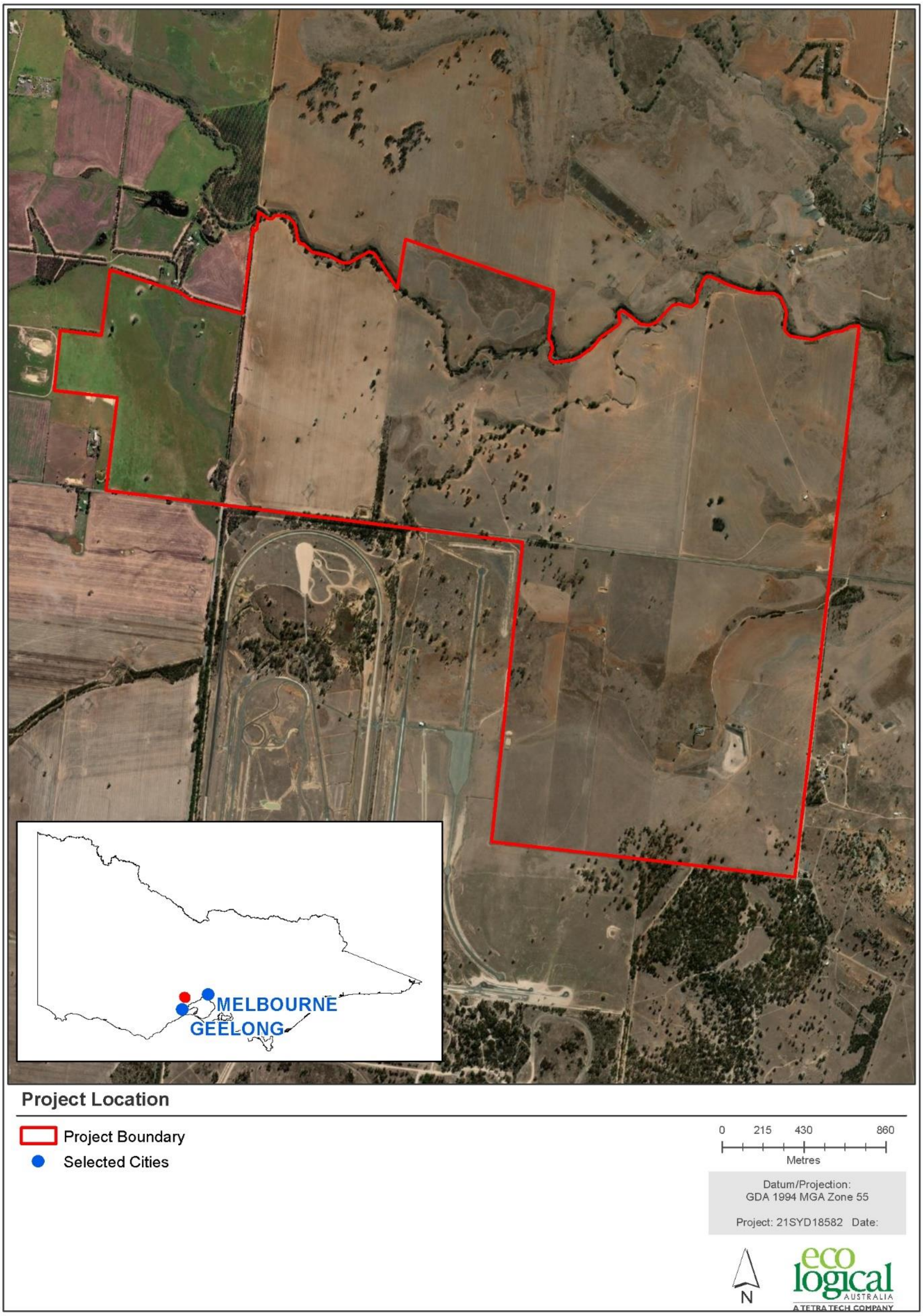

Figure 1-1 Site location

2. Data Requirements

The following datasets were sourced for use in this project:

- Digital Elevation Model (DEM) to represent the watershed (catchment) that drains the site and any adjacent waterways.
- Site survey within the Project Boundary.
- Development footprint for the Project.
- Intensity Frequency Duration (IFD) data representing the rainfall intensities for design rainfall events specific for this catchment.
- Australian Rainfall and Runoff (AR&R) information: for rainfall patterns and loss information for use in the flow rate modelling.
- Regional Flood Frequency Estimation (RFFE) modelling to validate the flow rate model results for design storm events.
- Gauged rainfall data representing the rainfall falling on the catchment at a sub-daily time step for use in calibration.
- Gauged flow data representing flows in the catchment for calibration of flow rates.

2.1 Digital Elevation Model (DEM)

A DEM was sourced to determine runoff catchments for waterways that drain to or through the Project Boundary. Elevation information was sourced from the Australian Government's Intergovernmental Committee on Surveying and Mapping (ICSM) Elevation and Depth – Foundation Spatial Data (ELVIS) website. The most detailed DEM available that covered the Project boundary, and its contributing catchment, was at a resolution of 10 metres by 10 metres. When combined with the available survey data, this was interpolated to a resolution of 1 metre by 1 metre (Figure 2-3).

2.2 Observed Streamflow

Observed streamflow information was available at the Ripley's Weir Balling gauge on the Little River (gauge number 232242A), located as per Figure 2-3 to calibration the RORB model (Section 3). Data was sourced from the Bureau of Meteorology (BoM) from 27 April 2009 to the retrieved date (13th December 2021). For use in the modelling, the data was interpolated to a 30-minute time step, resulting in the timeseries shown in Figure 2-1.

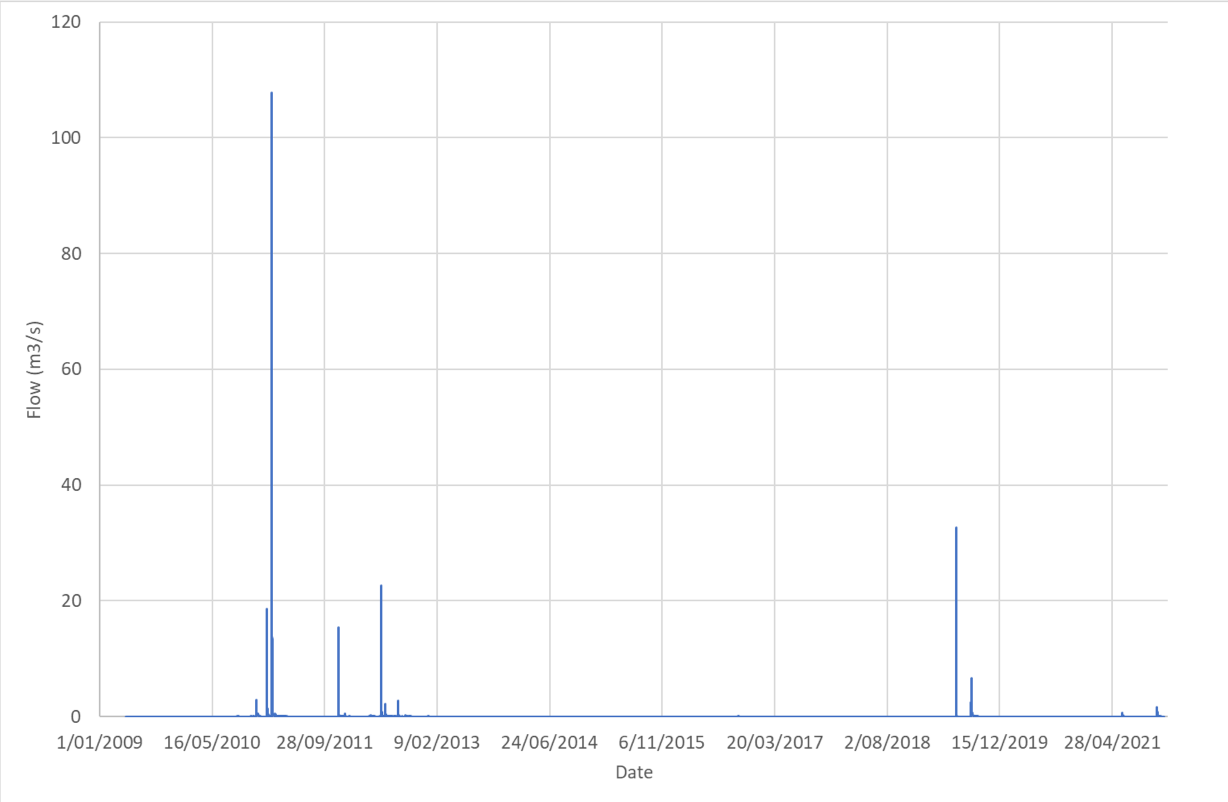

Figure 2-1 Observed streamflow at the Little River at Ripley's Weir Balling gauge

2.3 Observed Rainfall

To be able to use the observed streamflow in the model requires observed rainfall. Observed rainfall was available at Ripley's Weir Balling gauge on the Little River (gauge number 232242A), located as per Figure 2-3. Data was sourced from the BoM from 27 April 2009 to the retrieved date (13th December 2021). For use in the modelling, the data was aggregated to a 30-minute time step, resulting in the timeseries shown in Figure 2-2.

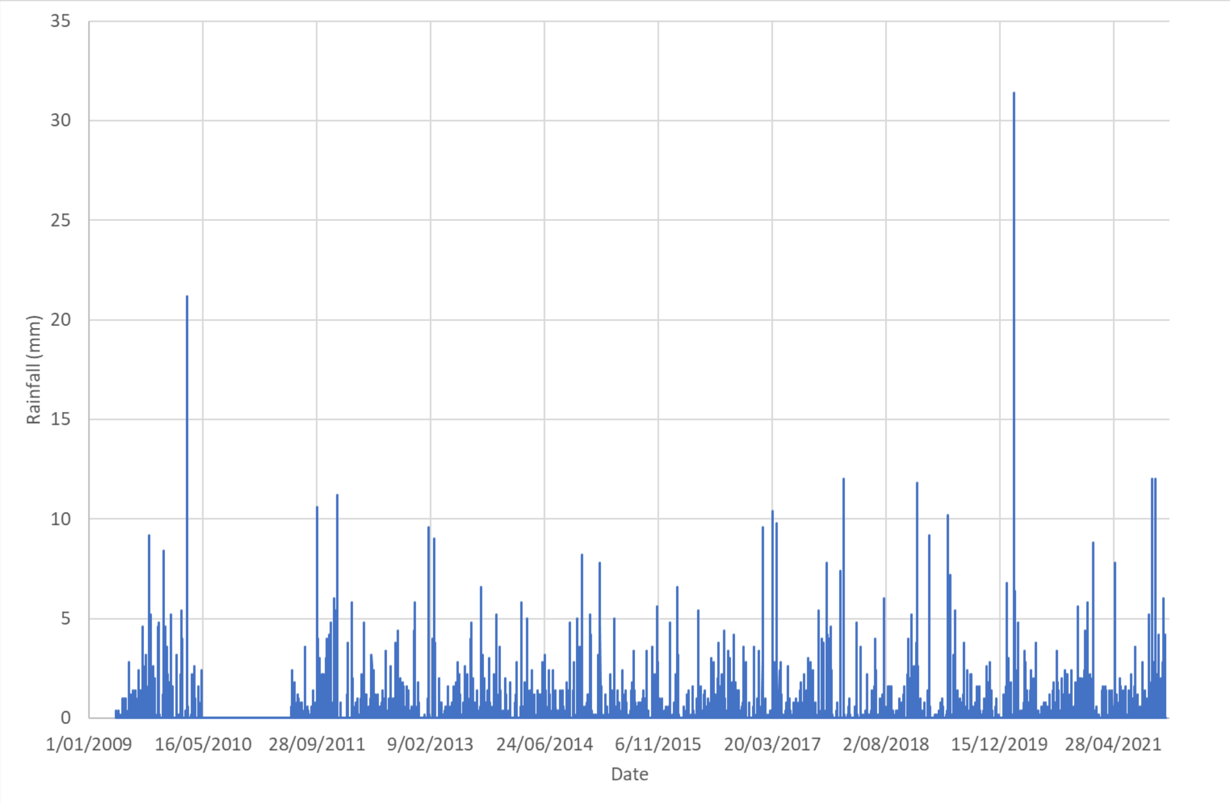

Figure 2-2 Observed rainfall at the Little River at Ripley's Weir Balling gauge

2.4 Intensity-Frequency-Duration (IFD) Information

The IFD information was sourced from the BoM IFD curves (retrieved September 5th, 2022) at coordinate 37.8375˚ (S) and 144.3125˚ (E), at the centroid of the contributing catchment area (Figure 2-3). IFD information is required to produce design (e.g. 1% AEP) flow and flood events from the modelling suite. The IFD data is presented in Appendix A1.

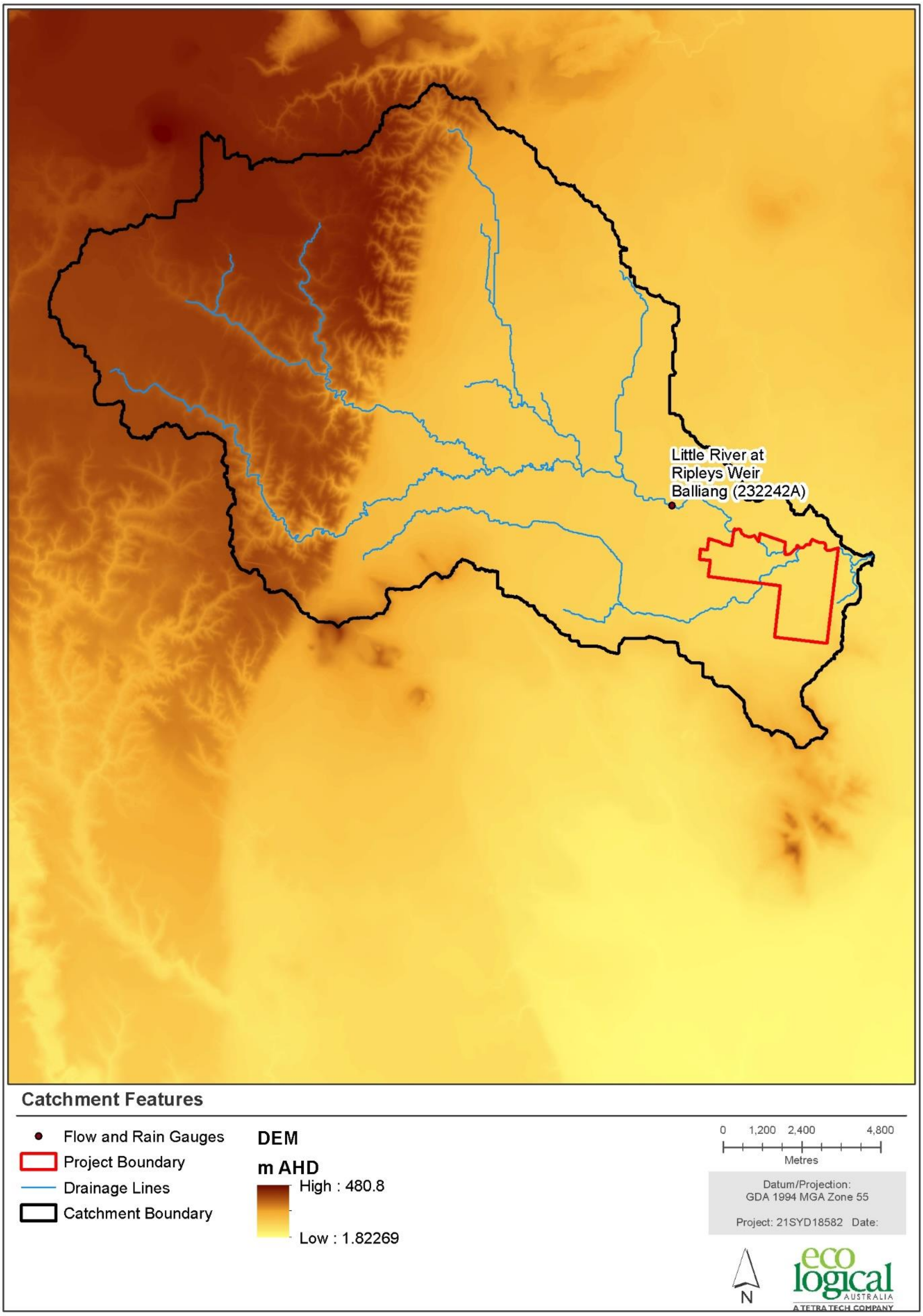

Figure 2-3 Catchment Features

2.5 Australian Rainfall and Runoff Data Hub Information

Information required for parameterising the models was sourced from the Australian Rainfall and Runoff (AR&R) data hub[1] (retrieved September 5th, 2022) at the coordinate location specified in Section 2.4. Relevant parameters were sourced from the South-East Coast (Victoria) Division, with the particular (sub) region being the Little River. Retrieved parameters include:

- Initial loss of 10.0 mm and continuing loss of 1.2 mm/hr
- Point and areal temporal patterns. Available durations of the point and areal temporal patterns, compared with the IFD durations, are shown in Appendix A2.
- Areal reduction factor (ARF) parameters from the South-East Coast (Victoria) Division.
    - a = 0.158
    - b = 0.276
    - c = 0.372
    - d = 0.315
    - e = 0.000141
    - f = 0.41
    - g = 0.15
    - h = 0.01
    - I = -0.0027

The full information from the data hub is provided in Appendix A3 with relevant information directly imported into the flow modelling software.

2.6 Regional Flood Frequency Estimation (RFFE) Modelling

The RFFE model[2] was run on September 6th 2022 and used to provide design flow comparison for the RORB model (Section 3) for the full catchment domain (Figure 2-3). This model uses information from nearby similar catchments to provide an estimation of the peak flow rates. The details required for this are:

- Catchment outlet: 144.454989° (E) and -37.870873° (S).
- Catchment centroid: 144.311144° (E) and -37.825561° (S).
- Catchment area: 248.1 km^2

The full information from the RFFE analysis is provided in Appendix A4.

[1] http://data.arr-software.org

[2] http://rffe.arr-software.org

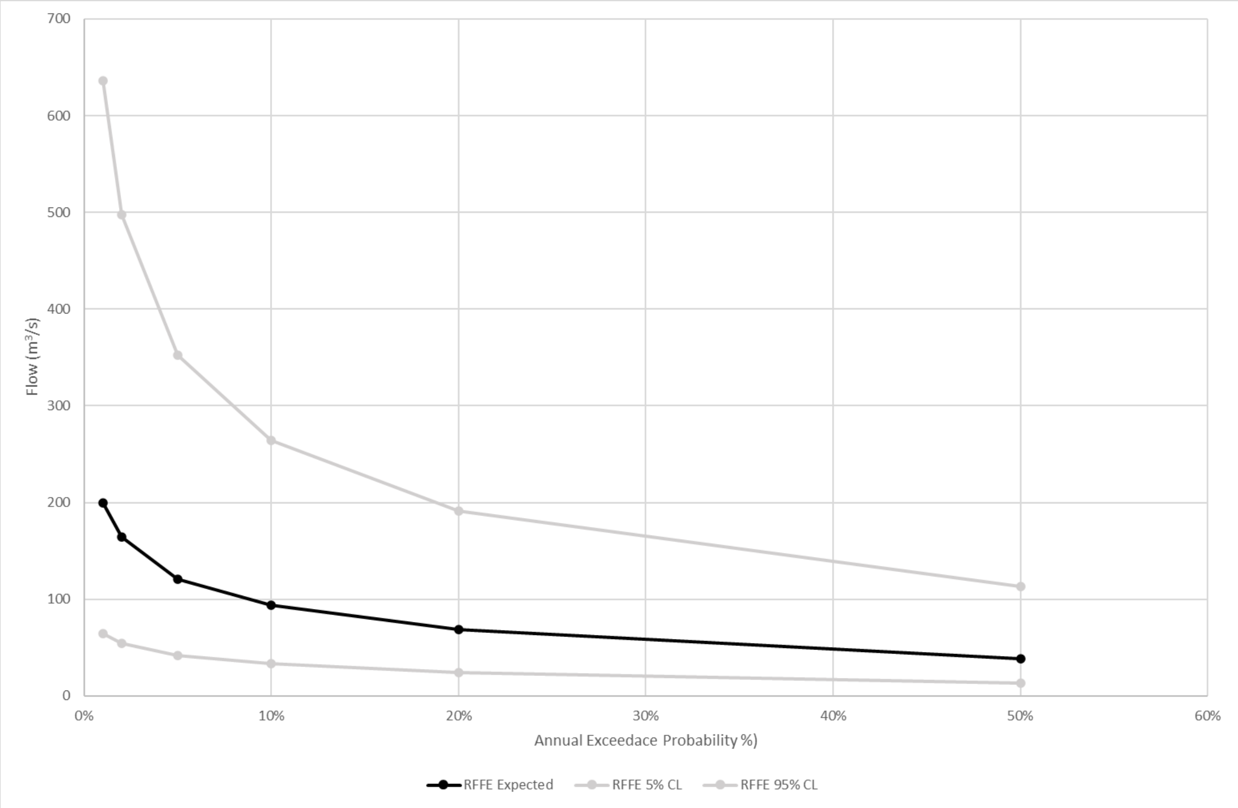

Figure 2-4 RFFE flow estimates including 5% and 95% confidence intervals

3. Flow Rate Modelling

Flow rate modelling was undertaken using the RORB software package[3] to determine sub-catchment flows for the region shown in Figure 2-3. These flows were used as inputs to verify the flow rate from the subsequent water level modelling (Section 4).

3.1 Model Setup

3.1.1 Catchment and Sub catchments

The digital elevation model presented in Figure 2-3 was used as input to create the overall catchment boundary and sub-catchment boundaries for use in the RORB modelling process. The Arc Hydro add-in to ArcGIS was applied to generate the catchment and sub catchment boundaries.

3.1.2 Catchment Input File

The RORB model requires a catchment file to specify how rainfall is applied to the area of interest and how water is routed through the catchment to the outlet. An add-in to ArcGIS, ArcRORB[4], was used to develop the catchment input file (Figure 3-1) through detailing the required information into shapefiles that are converted into a catchment input file for RORB (Figure 3-2).

The catchment being modelled is considered to be in a natural condition (i.e. no artificially formed waterways/channels/drains) and all reach types within the catchment file were set to "Natural" and the 'fraction impervious' for the whole domain was set to zero. The fraction impervious in this context refers to impervious areas directly connected to waterways. The impervious regions of the model (e.g. roads and houses) are unlikely to be directly connected to the streamlines and any areas that are connected would be such a small proportion (<0.1%) of the overall catchment that it would not affect the modelled outcome. For the purpose of this assessment the Upper Stony Creek Reservoir(s) and other larger water bodies have not been modelled explicitly. Their areas (<1% of total area) are assumed to runoff as per the rest of the catchment.

Reach and sub catchment details along with the catchment file layout are outlined in Appendix B.

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[3] Monash University and Hydrology and Risk Consulting https://www.harc.com.au/software/rorb/, version 6.45
[4] https://www.harc.com.au/software/arcrorb/

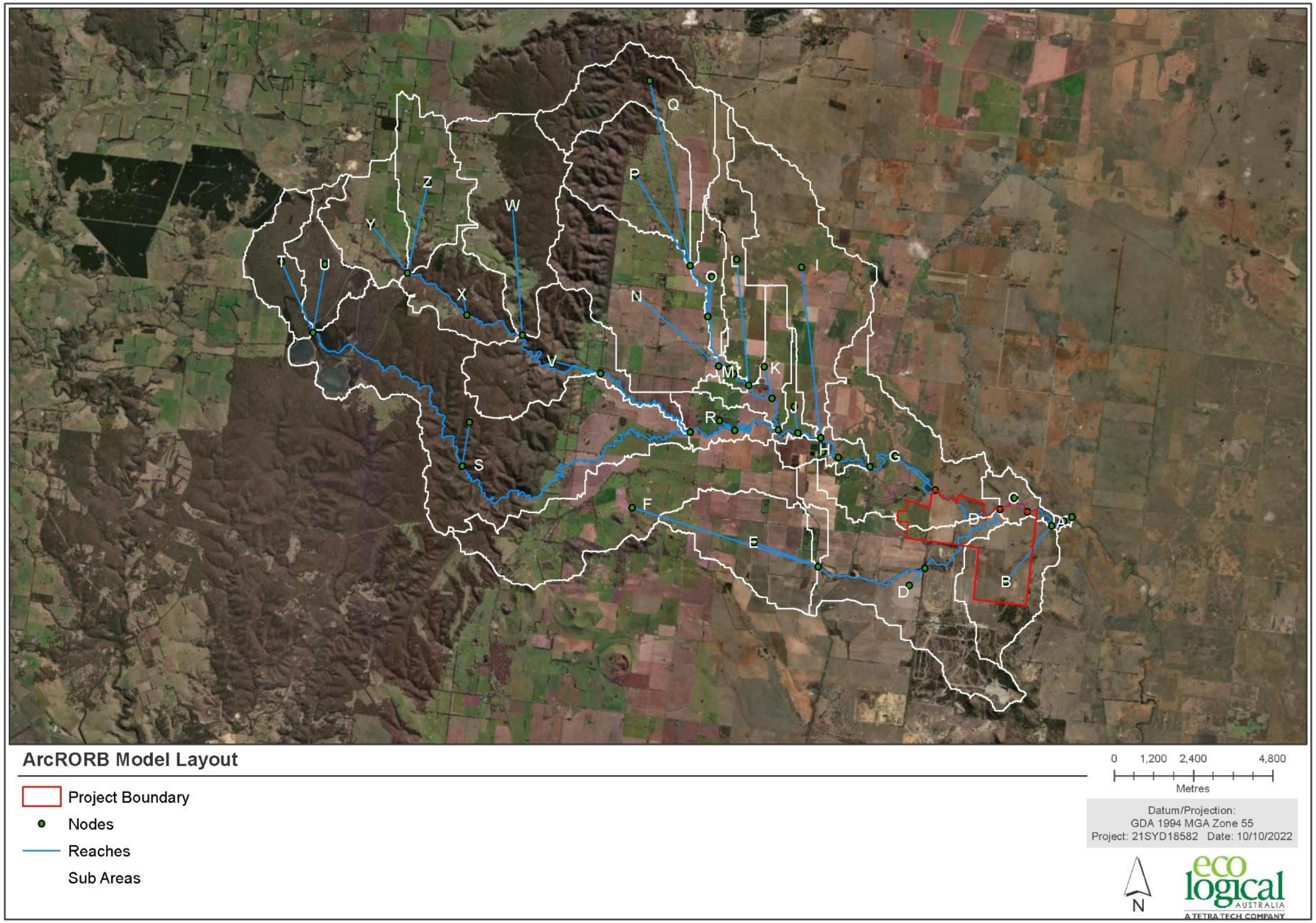

Figure 3-1 ArcRORB Model Layout

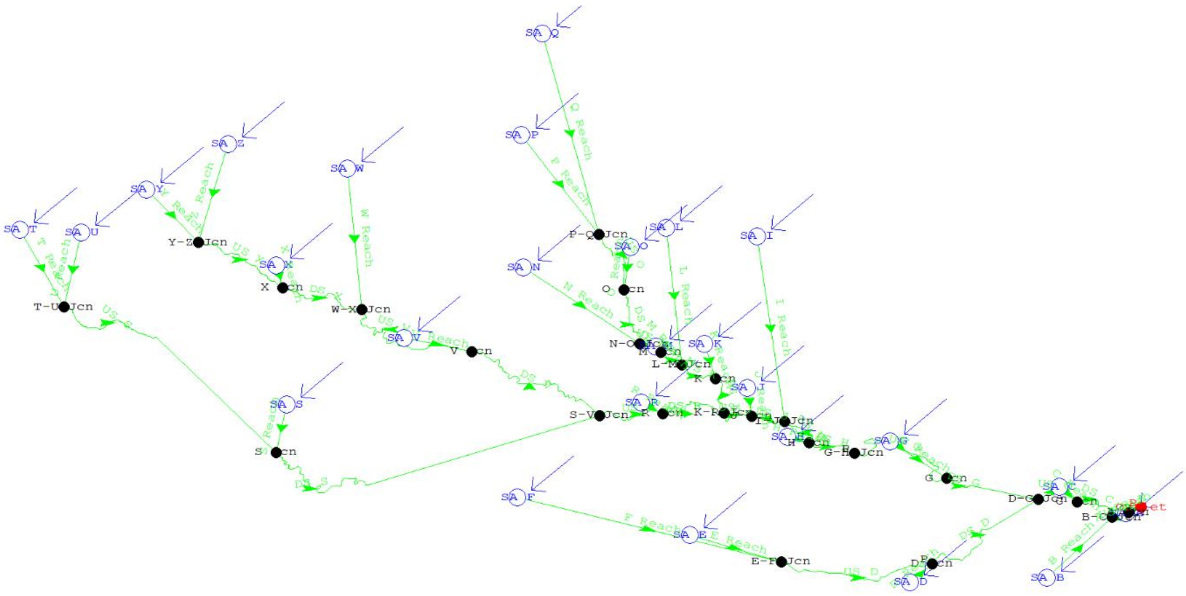

Figure 3-2 RORB Catchment File

3.1.3 Storm Files

When observed data is available, storm files provide the RORB model when observed rainfall and streamflow data at calibration points within the model. Two events were used to calibrate the model - June 2012 and June 2019 as shown in Figure 3-3 and Figure 3-4 respectively. These events were applied to the model at a 30-minute time step and used to calibrate the model.

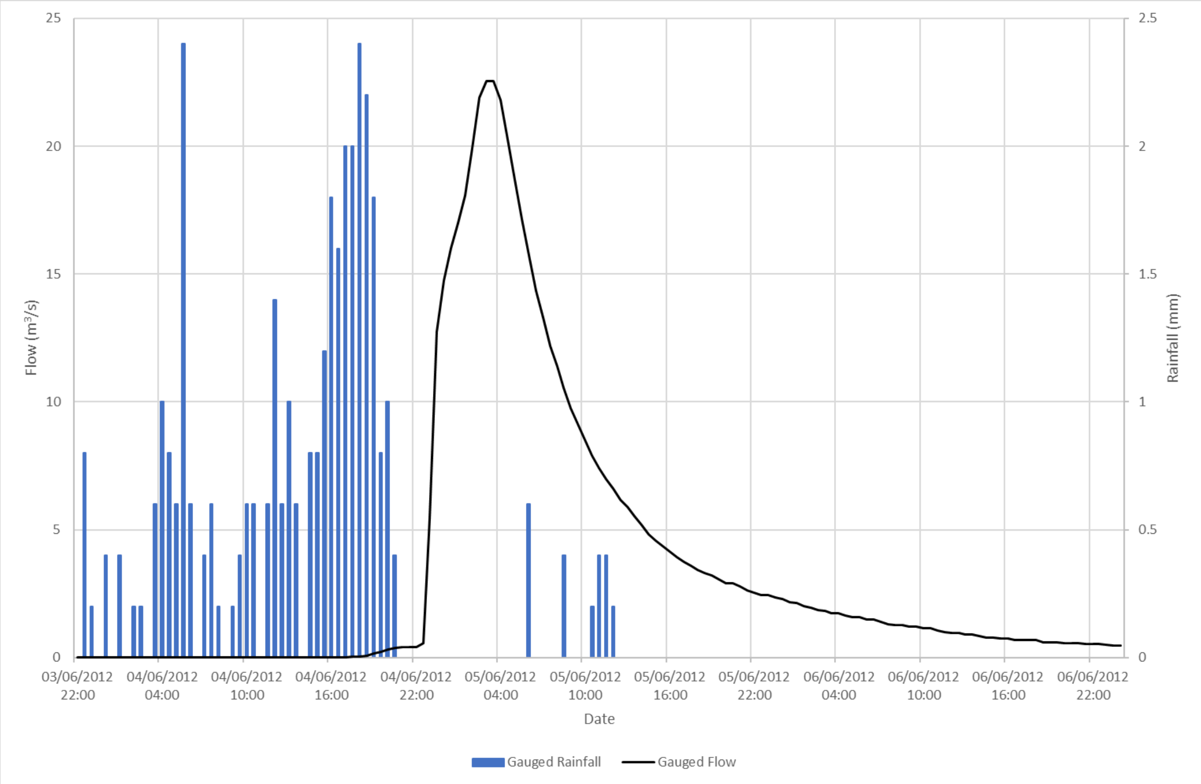

Figure 3-3 June 2012 Calibration Event

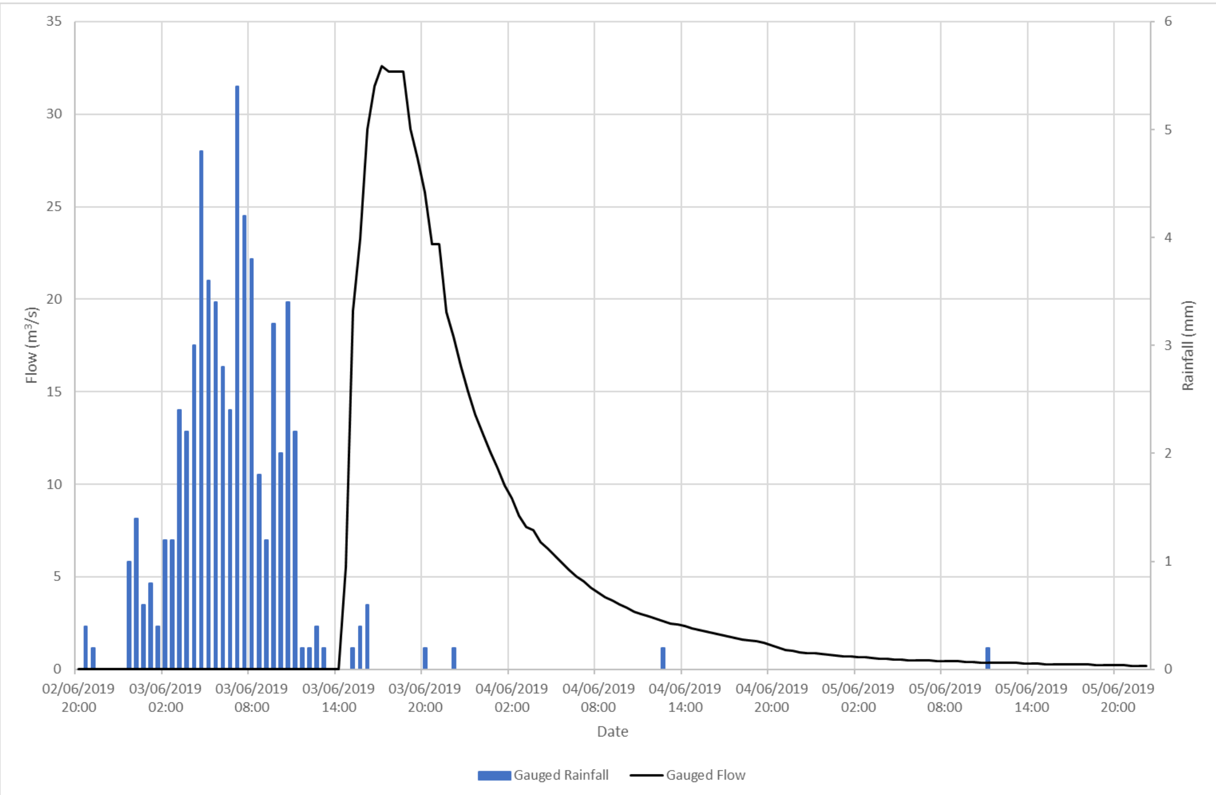

Figure 3-4 June 2019 Calibration Event

3.1.4 Parameter Files

Parameter files were created for the RORB model for calibration and design storm simulations. For the calibration runs the following setup parameterisation was used:

- Separate catchment and existing storm files
- RORB catchment (Figure 3-2) file
- Storm file corresponding to the event being modelled
- Single set of routing parameters
- Initial loss / Continuing loss model
- DESIGN run
- Parameters of m, kc, IL and CL as per calibration of the event.

For the design storm simulations RORB requires a different setup, as shown in Table 3-1. It also applies the Monte Carlo framework to examine the impact of different temporal patterns upon the design flow rate results.

Table 3-1 RORB Parameter file specification for design storms

Parameter File Section	Detail
Data Hub Files	• Data hub file as discussed in Section 2.5. • Temporal patterns as discussed in Section 2.5. • Use regional losses is unchecked[5]. • Use ARFs from file is checked.
Design Rainfall Specification	• A user defined IFD as discussed in Section 2.4. • Monte Carlo simulation from 10 minute to 168-hour durations. • Default time increments of 200. • Uniform areal pattern. • No pre burst. • Constant losses.
Parameter Specification	• k_c from the calibration results (Section 3.2). • m from the calibration results (Section 3.2). • IL from AR&R Datahub (Section 2.5). • CL from the calibration results (Section 3.2).
Monte Carlo Specification	• Number of rainfall divisions: 50 (default). • Number of samples per division: 20 (default). • Temporal patterns as described above. • Monte-Carlo sample initial loss.

[5] Due to a bug (identified from model use) in the RORB software, this needs to be unchecked, so the loss values are not reset every time the model is run

3.2 Calibration Results

The RORB model was calibrated to the observed events and validated to the RFFE analysis to fit within the confidence limits of the results. For the observed events, the calibration ideally would match the peak flow rate, hydrograph shape and timing of the peak. Matching the exact time of the peak was not possible for these events, so peak flow rate and hydrograph shape were calibrated to (while getting the timing of the peak as close as possible).

The results of the calibration are shown in Figure 3-5 and Figure 3-6 with the calibration parameters shown in Table 3-2. Comparing the initial loss (IL) and continuing loss (CL) values with those from AR&R (10.0 mm and 1.2 mm/hr, respectively), shows that to match the results in the catchment higher initial and continuing losses were required. This is not unexpected as the soils in that region are of a sandy nature and therefore would have greater infiltration prior to runoff.

Table 3-2 RORB calibration parameters

Event	m	k_c	IL (mm)	CL (mm)
June 2012	0.8	22.5	20	1.7
June 2019	0.8	21.5	44	1.7
Adopted for design events	0.8	22	10	1.7

For the design model runs, the AR&R initial loss was adopted as the antecedent conditions variable and the lower initial loss would provide a more conservative estimate. Using these parameters and the design RORB results were compared to the RFFE results, as shown in Figure 3-7. The results show that the RORB model produces results close to the expected RFFE results. An additional comparison is outlined in Figure 3-8 and shows the area weighted design event results for nearby gauged catchments and the RORB model. The results shown that the RORB model fits within the middle of the nearby gauged catchment results. The design events are therefore applicable for use in providing target flow rates for the hydraulic modelling in Section 4.

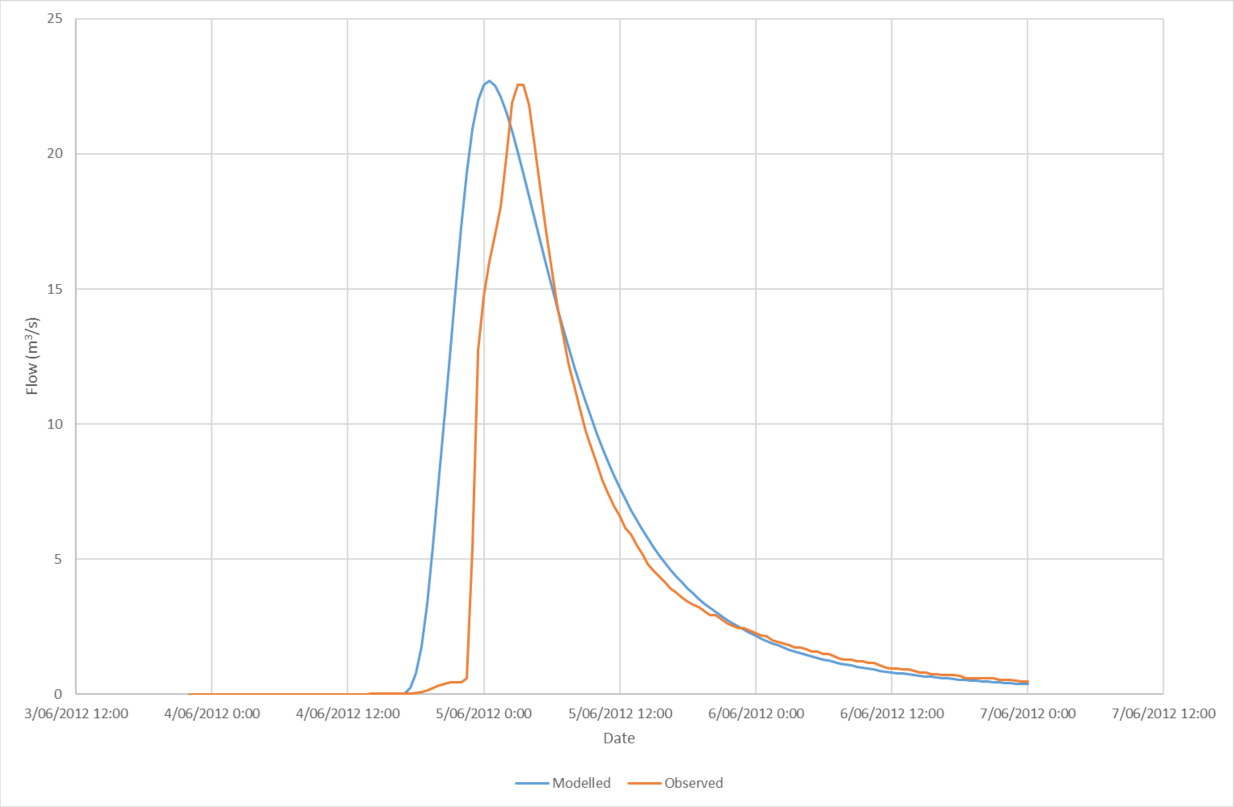

Figure 3-5 June 2012 calibration result

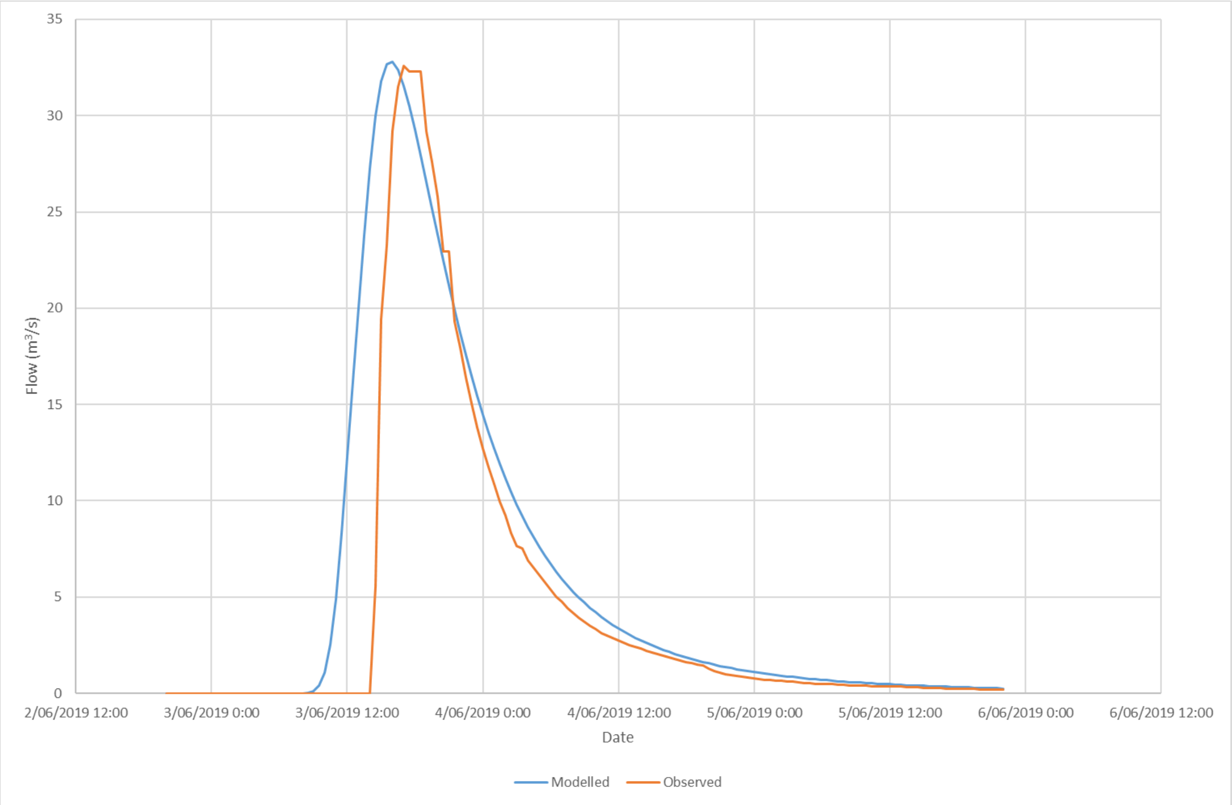

Figure 3-6 June 2019 calibration result

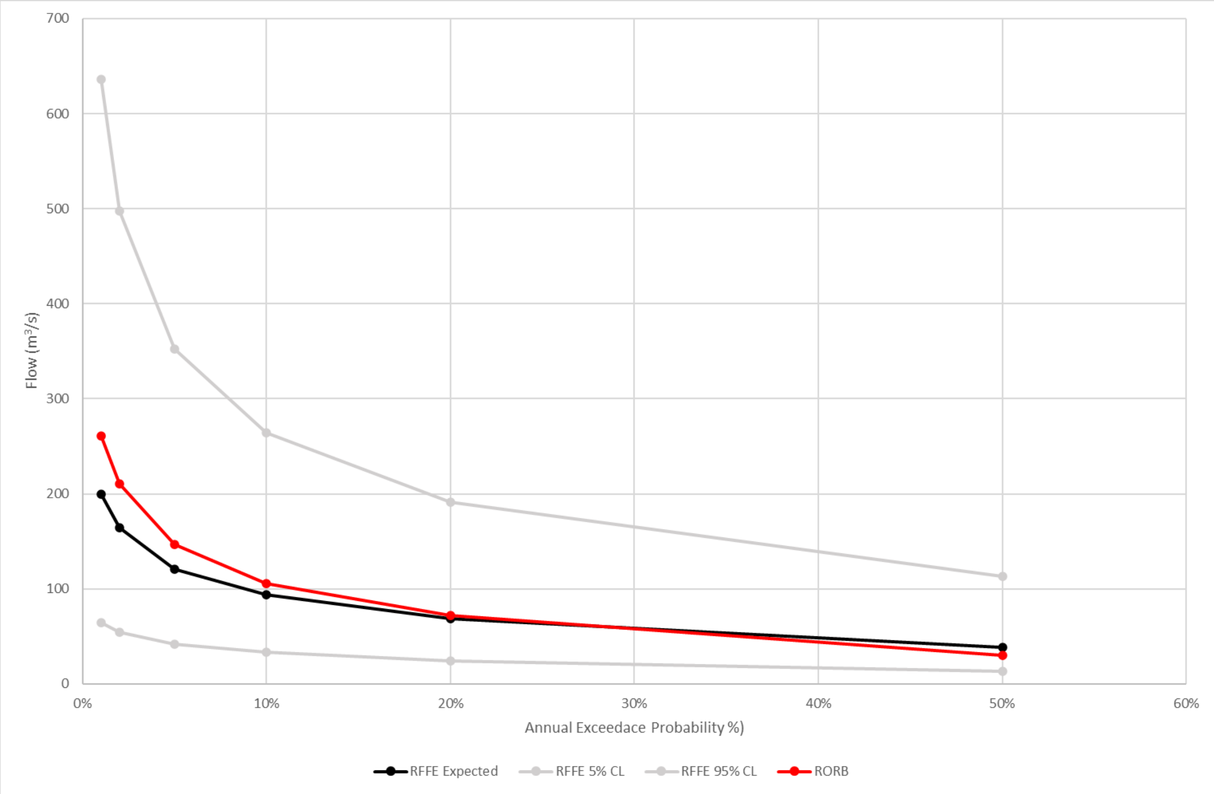

Figure 3-7 RORB end of catchment validation for design events

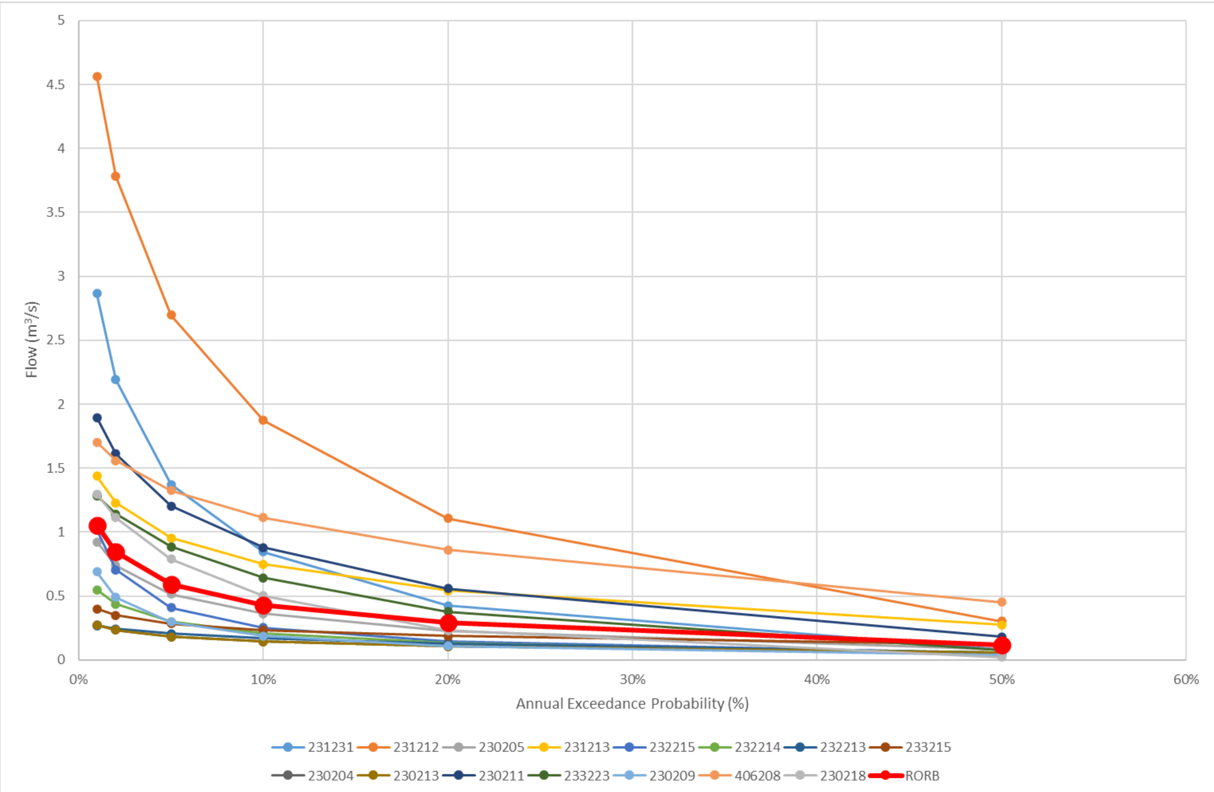

Figure 3-8 RFFE area weighted nearby catchments comparison

3.3 Hydrology Results

The RORB model was run to provide verification flows for the water level modelling. A summary of the peak flows for each exceedance probability at the catchment outlet is provided in Table 3-3.

Table 3-3 RORB design event peak flow rates at the end of the RORB model

AEP (%)	Peak flow (m^3/s)
63.2%	18.9
50%	29.7
20%	72.2
10%	105.6
5%	146.4
2%	210.0
1%	260.6
0.5%	333.2
0.2%	413.0
0.1%	496.7

Under post development conditions, there will be additional impervious areas within the catchment associated with infrastructure, such as access tracks, compounds, substations and solar panels. This additional infrastructure may change the runoff characteristics of the catchment. However, this infrastructure, including the solar panels, where water runs off onto the ground underneath and between the panels and can seep into the ground, are not considered directly connected to the waterways. Therefore, no additional RORB model runs are required for post development conditions.

4. Water Level Modelling

Hydraulic modelling was conducted representing existing conditions using the HEC-RAS[6] software package. HEC-RAS models were developed using a two-dimensional (2D) rain-on-grid analysis to determine flood extents and flood levels and flow velocities.

4.1 Model Setup

The model terrain was developed to model based on the DEM outlined in Figure 2-3.

4.1.1 Computational Mesh

A 2D flow area was delineated in HEC-RAS to coincide with the catchment boundary. A computational mesh spacing of 50 metres by 50 metres was applied across the catchment, as shown in Figure 4-1. HEC-RAS recognises the sub-grid terrain resolution within individual computational cells, and the flow transfer calculations between individual grid cells account for the geometry of the underlying surface at the terrain resolution. This computational mesh was applied except as noted surrounding break lines (Section 4.1.1.1) and the refinement region (Section 4.1.1.2).

4.1.1.1 Break lines

Break lines are used to alter the direction of grid cells to align with features within the catchment. The following break lines were implemented in the model, with examples shown in Figure 4-1:

- Drainage lines, as per Figure 2-3.
- Road centre lines within one kilometre of the Site Boundary.

4.1.1.2 Refinement regions

Refinement regions are used to denote areas where the computation mesh resolution needs to be at a finer scale than the overall mesh. A refinement region was specified for the region contained within the Site Boundary with a computational mesh spacing of 10 metres by 10 metres. The cell sizes are stepped within the intermediate region between the Site Boundary and the wider mesh to allow for a smooth computational transition, as shown in Figure 4-1.

4.1.1.3 Applied Computational Mesh

Figure 4-1 outlines an example region of the computation mesh applied, showing the mesh spacing, computation points, break lines and refinement regions applied.

[6] U.S. Army Corps of Engineers' HEC-RAS Version 6.3 (USACE 2022)

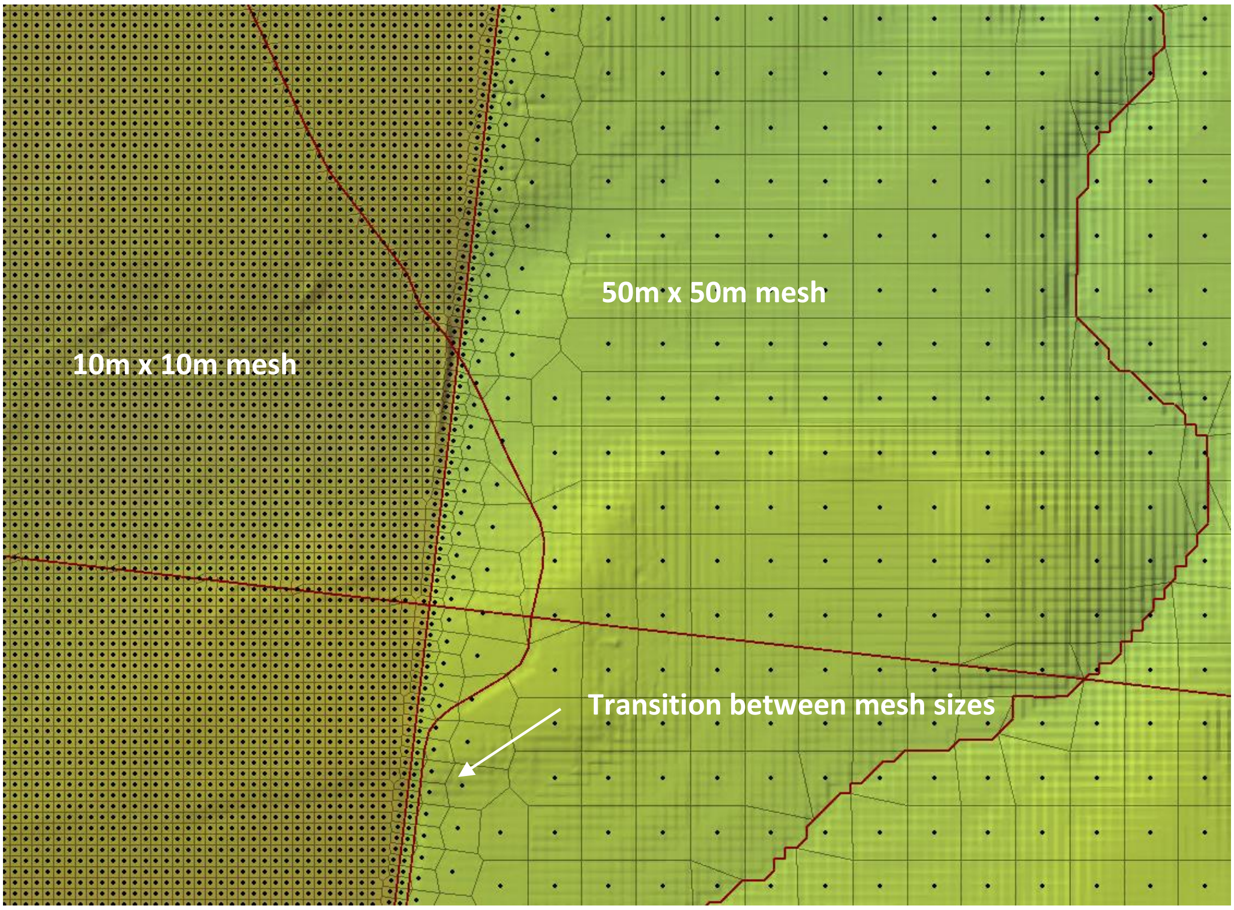

Figure 4-1 Computational mesh (black lines), computational points (black dots) and break lines (red lines), as annotated.

4.1.2 Inflows/Rainfall

No inflow hydrographs were required as inputs to this model as the entire catchment is within the model domain and there are no water transfers into the catchment.

Rainfall is applied to the 2D area based on the IFD data and the RORB results. That is, the rainfall temporal pattern that produced the peak storm in the RORB model was used in conjunction with the IFD rainfall depths and initial and continuing losses to provide the rainfall input to the hydraulic model as an unsteady time series inflow boundary condition. The patterns applied are shown in Figure 4-2. Note that that all the 10% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and 0.1% AEP events are 36 hours in duration, as determined from the RORB results.

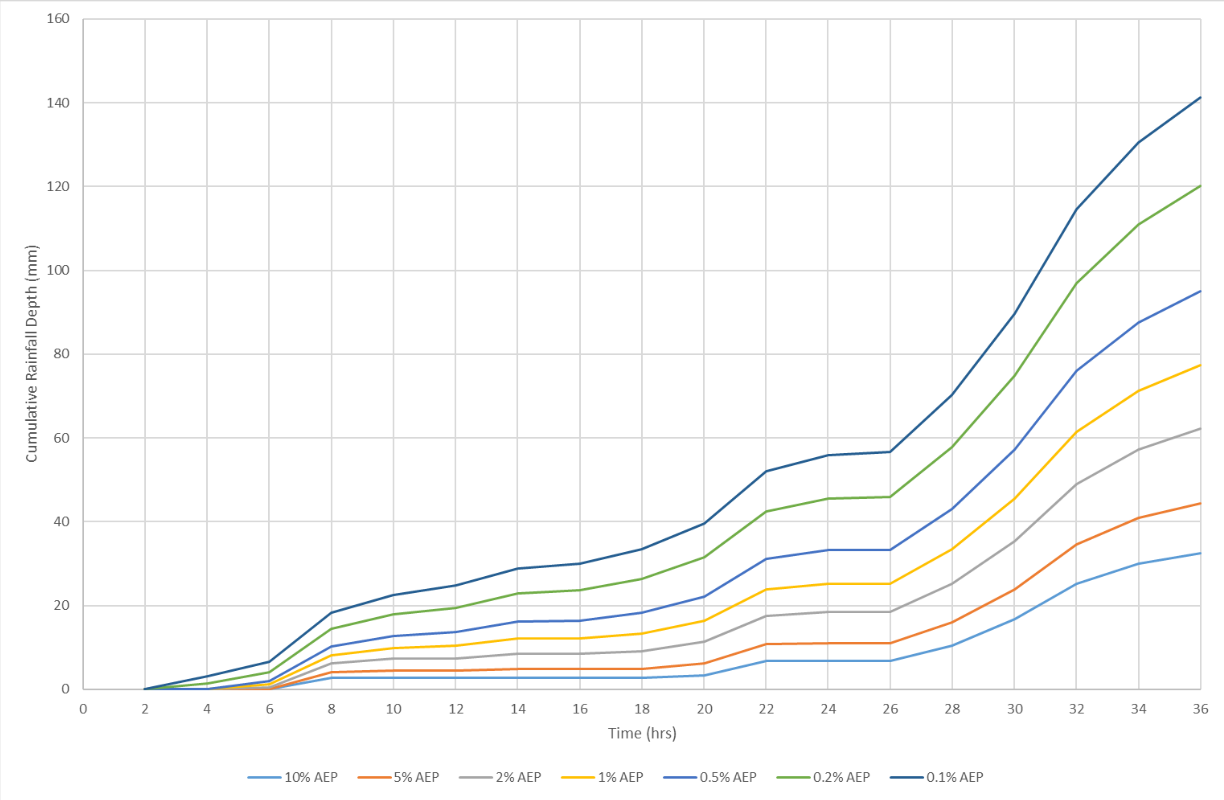

Figure 4-2 Rainfall depths applied to 2D flow area for the 10%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP design events

While the current version of HEC-RAS (6.3) includes the ability to infiltrate rainfall, it does not account for both initial and continuing losses. Therefore, a rainfall excess time series (the amount of rain that runs off after the losses) is directly applied to the model. An example of this is outlined in Figure 4-3 for the 1% AEP event. It shows the initial loss consuming the rainfall at the start of the event and the continuing loss being applied across the rest of the event.

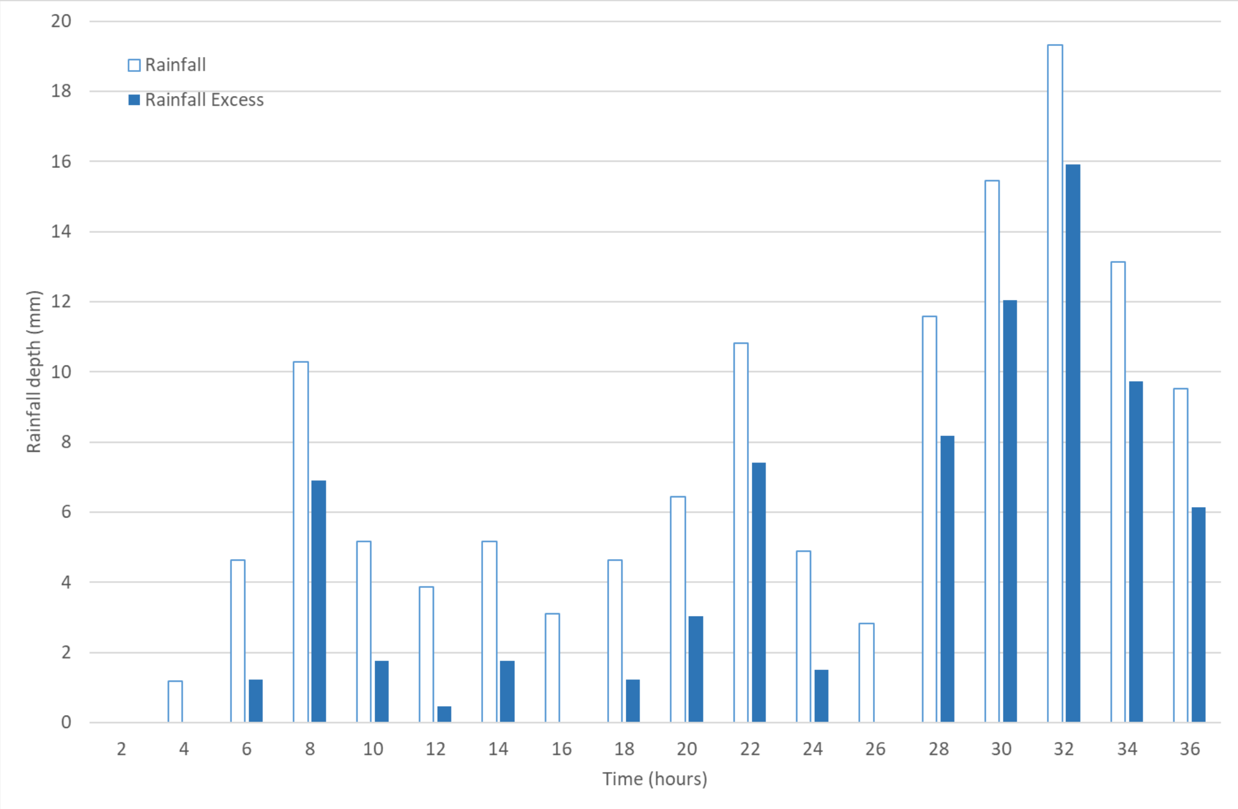

Figure 4-3 1% AEP design event rainfall pattern applied to HEC-RAS after losses removed

4.1.3 Outflows

Locations where water exits the model domain (outflows) require boundary conditions to be specified. The concentrated flow path that exits the model domain was set to a normal depth boundary condition, using the uniform bed slope of that flow path as the estimated energy slope, as measured from the available terrain data. The normal depth boundary condition applied to the outlet was 0.005.

4.1.4 Roughness

Roughness coefficients are used to define how quickly water moves across the terrain and controls the shape of flow hydrographs resulting from the rainfall and upstream flow. Typical roughness values are defined for the range of flow path extents, i.e. from concrete channels to floodplains. Modelling the full 2D catchment area which extends outside of normal channels and their corresponding slopes requires much larger roughness values than are typically applied to models that just model stream flow.

An initial roughness coefficient of 0.06, representing a natural channel condition, was applied to the whole model. This roughness was used in combination with a 10% AEP rainfall event to define waterway channel extents.

HEC-RAS has the ability to apply different roughness coefficients spatially across the model domain. This is achieved through applying a shapefile of "land cover" regions to the model. To calibrate the flow rate of the runoff with the flow rates obtained from the RORB modelling, land cover representing the channels (roughness of 0.06) and the broader catchment were applied to the model with the broader catchment roughness being altered. Roughness values of 0.06, 0.1, 0.2 and 0.3 were applied to broader catchment area within the model domain in combination with the 1% AEP rainfall to determine the change in flow rates, as shown in Figure 4-4. A regression relationship was applied between flow and roughness for this catchment and resulted in a roughness value of 0.23 being adopted.

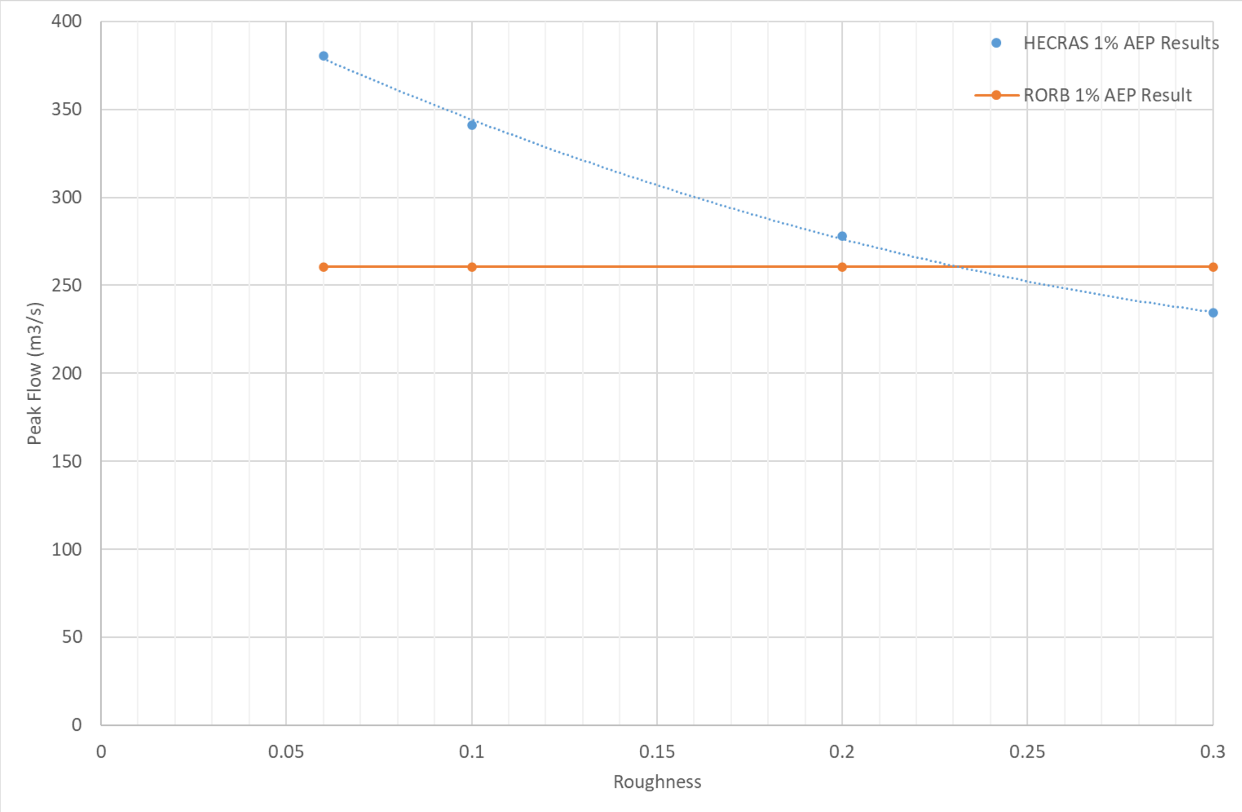

Figure 4-4 Peak 1% AEP flow rate outputs from HEC-RAS

4.1.5 Computational Settings

An adaptive computational time-step was applied based on a maximum Courant Number of 2.0. This results in a minimum adopted time-step of approximately 2 seconds. The Full Momentum equation set was adopted in the model to account for the varying flow directions. Mass balance errors and water surface elevation convergence errors were checked for model stability and to confirm that imbalances remained below reasonable thresholds for model stability. A 48-hour simulation window was applied to capture critical-duration peak discharges and allow the flood peaks to propagate through the model.

Default threshold depths were decreased by one order of magnitude to capture the flow transfer effects of direct precipitation sheet flow across the catchment. Except where otherwise noted, other program defaults have been applied to all remaining coefficients, options, tolerances and model settings.

4.1.6 Summary Model Parameterisation

Table 4-1 summarises the model parameters used for the selected HEC-RAS model runs.

Table 4-1 Summary of model parameters

Model Parameter	Value
Inflow	10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP frequency storm excess precipitation hyetographs
Outflow	Normal depth slope of 0.5%
Simulation window	48 hour
Computation time step	Controlled by Courant number
Computation mesh grid	50 metres by 50 metres to 10 metres by 10 metres
Roughness	0.06 for waterways and 0.23 for catchment
Equation set	Full Momentum
DEM grid resolution	1 metre by 1 metre to 10 metre by 10 metre

4.2 Hydraulic Results

For each AEP event, depth and velocity were extracted across the model domain and are discussed below. Maximum flood depths and maximum flood velocities across the site are presented in Appendix C1 and Appendix C2, respectively.

4.2.1 Depths

The existing conditions' flood depths (Appendix C1) show that, in general, the flows are concentrated to the waterways and defined overland flow paths in the region with sufficient terrain relief to limit the amount of sheet flow.

There are three main overland flow paths / waterways within the site. Sandy Creek, the waterway through the middle of the Site, is, in general, away from the proposed solar arrays, however there are isolated areas on the edge of the solar panel regions that may be close to or encroach upon the 1% AEP flood inundation area. Depths in some of these areas are shallow and will be able to pass under the arrays, however some points do have greater water depths (> 1 m) and an existing or proposed access track crosses the inundation area.

The overland flow path across the upper eastern part of the site travels under proposed sections of solar arrays. For the most part the 1% AEP depths are shallow (< 0.1 m) however as the overland flow path progresses downstream these depths increase to around 0.5 metre with the array region.

The overland flow path and waterway in the south-eastern corner of the site also travels under the proposed solar array regions and across the proposed placement of the BESS facility. The 1% AEP depths are in general shallow (< 0.1 m) underneath the arrays and the proposed BESS location. Adjusting the ground surface to raise the BESS facility above these flood waters would alter the localised flow paths of the area, however with an onsite farm dam immediately downstream of this, minimal impact to overall flood paths would occur.

The last key flood feature is Little River, along the northern border of the site. The solar array regions are clear of the 1% AEP extent for Little River in all areas except one small location where the overland flow path joins Little River in the central north of the site. There are existing access roads that cross

Little River, the efficacy of these crossings within the 1% AEP flood event have not been assessed, as they are assumed to already be designed and sited appropriately.

The owners of the property to the east of the Project Boundary have concerns with regards flooding to their property, in particular with regards to their on-site farm dam. The modelling shows that there is not expected to be any change to flows into or out of that dam as the flow paths are separate from those that drain through the Project Boundary.

4.2.2 Velocities

The modelled velocities (Appendix C2) show that, in general, velocities across the site tend to be low (< 0.5 m/s) and below the threshold (< 2 m/s) where rock armouring to protect waterways and features is required. Some isolated higher velocities (> 1 m/s) occur through the overland flow path / waterway through the middle of the site and at other isolated locations under the current conditions. Should erosion form at these locations then erosion mitigation strategies should be implemented.

4.2.3 Shear Stress

Flow velocities within the watercourses and overland flow paths vary such that most areas are below the level that might be expected to require artificial protection (i.e. rock armouring). During detailed design, this should be reviewed to ensure appropriate waterway protection is in place.

Facing material, as classified in Table 4-2 and Figure 4-5 and described in Table 4-3, may be beneficial for reducing localised scour and erosion along specific drainage lines, surrounding the BESS or waterways within the development footprint, should it occur.

Table 4-2 Design of rock slope protection (from Table 3.11, Austroads 2013, Table 5.1, MRWA 2006)

Velocity (m/s)	Class of rock protection (tonnes)	Section thickness (m)
< 2	None	N/A
2 – 2.6	Facing	0.5
2.6 – 2.9	Light	0.75
2.9 – 3.9	0.25	1
3.9 – 4.5	0.5	1.25
4.5 – 5.1	1	1.6
5.1 – 5.7	2	2
5.7 – 6.4	4	2.5
> 6.4	Special	N/A

Table 4-3 Standard classes of rock slope protection (from Table 406.1, MRWA 2006)

Rock Class	Diameter of rock sizes within rock class (m)	Rock mass for rock sizes (kg)	Minimum proportion of rock sizes [rocks larger than] (%)
Facing	0.4	100	0
	0.3	35	50
	0.15	2.5	90
Light	0.55	250	0

Rock Class	Diameter of rock sizes within rock class (m)	Rock mass for rock sizes (kg)	Minimum proportion of rock sizes [rocks larger than] (%)
	0.4	100	50
	0.2	10	90
0.25 tonne	0.75	500	0
	0.55	250	50
	0.3	35	90
0.5 tonne	0.9	1000	0
	0.7	450	50
	0.4	100	90
1 tonne	1.15	2000	0
	0.6	1000	50
	0.55	250	90
2 tonnes	1.45	4000	0
	1.15	2000	50
	0.75	500	90
4 tonnes	1.8	8000	0
	1.45	4000	50
	0.9	100	90

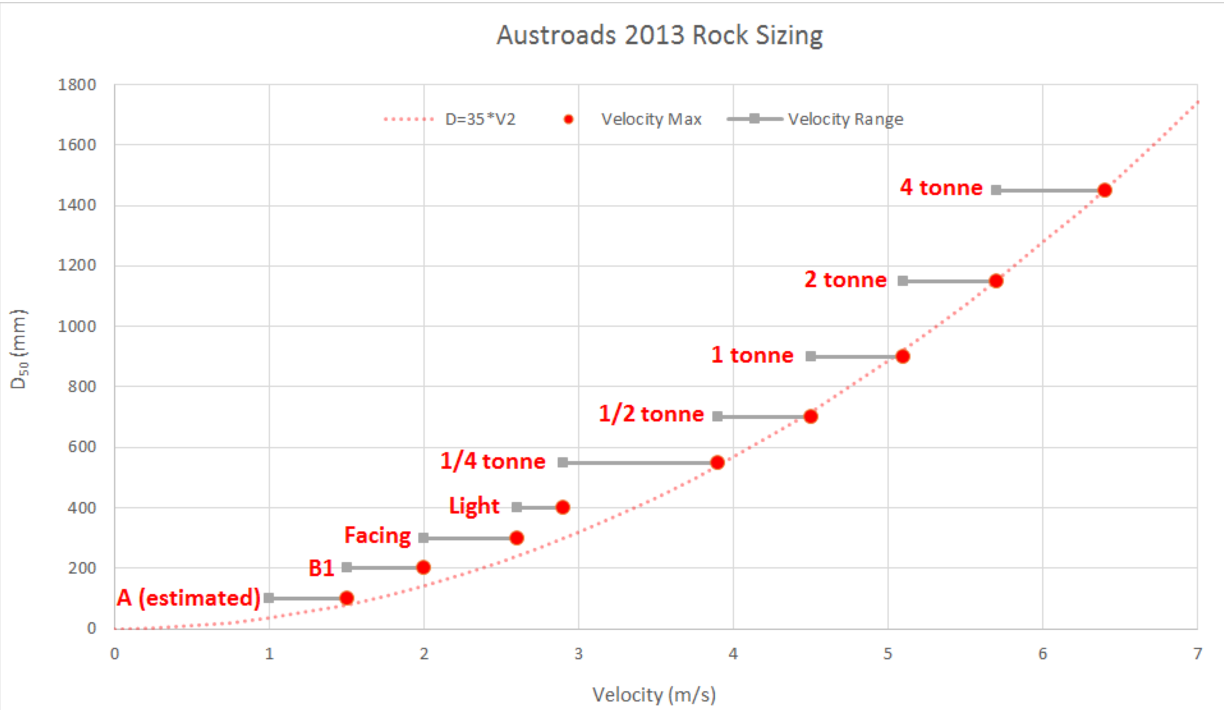

Figure 4-5 Velocity vs median stone size (based on Austroads 2013 Rock Sizing)

5. Summary and Conclusions

ELA has been engaged by Urbis on behalf of Elgin Energy to assess hydrological conditions associated with the existing and proposed conditions under 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP flood events for the Project located between Melbourne and Geelong, near Little River, in Victoria.

Flow rate modelling was undertaken using the RORB software package to determine sub-catchment flows to verify the flow rate from the subsequent water level modelling. The RORB model was calibrated to the observed events and validated to the RFFE analysis to fit within the confidence limits of the results.

Hydraulic modelling was conducted representing existing conditions using the HEC-RAS software package. HEC-RAS models were developed using a 2D rain-on-grid analysis to determine flood extents and flood levels and flow velocities.

The existing conditions' flood depths showed that, in general, the flows are concentrated to the waterways and defined overland flow paths in the region with sufficient terrain relief to limit the amount of sheet flow.

There are three main overland flow paths / waterways within the site. Sandy Creek, the waterway through the middle of the Site, is, in general, away from the proposed solar arrays, however there are isolated areas on the edge of the solar panel regions that may be close to or encroach upon the 1% AEP flood inundation area. Depths in some of these areas are shallow and will be able to pass under the arrays, however some points do have greater water depths (> 1 m) and an existing or proposed access track crosses the inundation area.

An overland flow path across the upper eastern part of the site travels under proposed sections of solar arrays. For the most part the 1% AEP depths are shallow (< 0.1 m) however as the overland flow path progresses downstream these depths increase to around 0.5 metre with the array region.

A third overland flow path and waterway in the south-eastern corner of the site also travels under the proposed solar array regions and across the proposed placement of the BESS facility. The 1% AEP depths are in general shallow (< 0.1 m) underneath the arrays and the proposed BESS location. Adjusting the ground surface to raise the BESS facility above these flood waters would alter the localised flow paths of the area, however with an onsite farm dam immediately downstream of this, minimal impact to overall flood paths would occur.

The last key flood feature is Little River, along the northern border of the site. The solar array regions are clear of the 1% AEP extent for Little River in all areas except one small location where the overland flow path joins Little River in the central north of the site. There are existing access roads that cross Little River, the efficacy of these crossings within the 1% AEP flood event have not been assessed, as they are assumed to already be designed and sited appropriately.

The modelled velocities show that, in general, velocities across the site tend to be low (< 0.5 m/s) and below the threshold (< 2 m/s) where rock armouring to protect waterways and features is required. Some isolated higher velocities (> 1 m/s) occur through the overland flow path / waterway through the middle of the site and at other isolated locations under the current conditions. Should erosion form at these locations then erosion mitigation strategies should be implemented.

Flow velocities within the watercourses and overland flow paths vary such that most areas are below the level that might be expected to require artificial protection (i.e. rock armouring). During detailed design, this should be reviewed to ensure appropriate waterway protection is in place.

Flood modelling has shown that there is the potential for minor flood impacts to the proposed Barwon Solar Farm. However, depending on the actual soil type at the site, this may represent a conservative approach. That is, if the soils are sandy, more rainfall will likely infiltrate reducing the flow rates and flood extents across the site. For detailed design an understanding of infiltration rates across the site (and its contributing catchments) is required to provide greater insight into likely flood results.

As solar farm arrays are installed above the natural ground surface, overland flood waters should flow underneath without altering flow patterns. Other aspects of the design, such as the BESS could affect localised flooding depending on its placement. Therefore, flood management will need to be considered in final design of Barwon Solar Farm. Key aspects are the (i) location of the BESS facility and other facilities that cannot have water flow through or under them, (ii) solar panels and (iii) access roads.

Detailed design should re-examine the flood levels and impacts from this assessment to determine specific flood depths and areas of inundation and appropriate measures to allow water to pass through the site. Specifically:

- BESS: Local changes to flows that occur from raising the ground to appropriate height for flood protection.
- Roads: Ensure that causeways or culverts are included in designs where flow paths cross.
- Solar arrays: Ensure that likely water depths can pass safely under the arrays and relevant electrical systems.

6. References

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Appendix A AR&R Inputs

A1 IFD Tables

Table 6-1 Rainfall depths for 12EY to 0.2EY design rainfall events

Duration	Annual Exceedance Probability Rainfall Depths (mm)									
	12EY	6EY	4EY	3EY	2EY	63.20%	50%	0.5EY	20%	0.2EY
1 min	0.402	0.467	0.591	0.688	0.838	1.14	1.32	1.46	1.93	1.96
2 min	0.635	0.742	0.943	1.1	1.34	1.81	2.08	2.31	2.96	3.02
3 min	0.852	0.998	1.27	1.49	1.82	2.47	2.85	3.17	4.07	4.15
4 min	1.05	1.23	1.57	1.83	2.25	3.07	3.54	3.93	5.09	5.19
5 min	1.22	1.43	1.83	2.14	2.63	3.59	4.16	4.62	6.01	6.13
10 min	1.88	2.19	2.79	3.26	4	5.48	6.36	7.06	9.34	9.52
15 min	2.34	2.72	3.43	4	4.88	6.66	7.75	8.6	11.4	11.6
20 min	2.69	3.11	3.91	4.54	5.53	7.5	8.73	9.69	12.9	13.1
25 min	2.98	3.43	4.3	4.98	6.04	8.16	9.49	10.5	13.9	14.2
30 min	3.22	3.71	4.63	5.35	6.46	8.69	10.1	11.2	14.8	15.1
45 min	3.8	4.35	5.4	6.21	7.46	9.93	11.5	12.8	16.7	17
1 hour	4.24	4.85	5.99	6.87	8.22	10.9	12.6	13.9	18.1	18.5
1.5 hour	4.94	5.64	6.94	7.93	9.45	12.4	14.2	15.8	20.2	20.6
2 hours	5.49	6.27	7.71	8.81	10.5	13.7	15.6	17.3	22	22.4
3 hours	6.4	7.32	9	10.3	12.2	15.9	18	20	25	25.5
4.5 hour	7.48	8.57	10.6	12.1	14.4	18.7	21.1	23.4	29	29.6
6 hours	8.37	9.63	11.9	13.7	16.3	21.2	23.8	26.4	32.6	33.2
9 hours	9.84	11.4	14.2	16.3	19.4	25.4	28.5	31.6	38.9	39.7
12 hours	11	12.8	16	18.4	22	29	32.5	36.1	44.4	45.3
18 hours	13	15	18.9	21.8	26.2	34.7	39.1	43.4	53.7	54.8
24 hours	14.4	16.8	21.1	24.4	29.4	39.1	44.3	49.2	61.3	62.6
30 hours	15.6	18.2	22.8	26.5	31.9	42.6	48.5	53.8	67.6	69
36 hours	16.6	19.3	24.3	28.1	34	45.5	51.9	57.7	72.9	74.4
48 hours	18.1	21	26.4	30.6	37.1	49.7	57.2	63.4	81.2	82.8
72 hours	20	23.2	29.1	33.7	40.7	54.6	63.4	70.4	91.5	93.4
96 hours	21.1	24.4	30.6	35.4	42.7	57.2	66.5	73.8	97	99
120 hours	21.7	25.1	31.5	36.4	43.9	58.5	67.9	75.4	99.8	102
144 hours	22	25.5	32	37	44.6	59.3	68.5	76	101	103
168 hours	22.1	25.7	32.4	37.4	45.1	59.7	68.5	76	101	103

Table 6-2 Rainfall depths for 10% to 0.005% design rainfall events

Duration	Annual Exceedance Probability Rainfall Depths (mm)							
	10%	5%	2%	1%	0.05%	0.02%	0.01%	0.005%
1 min	2.37	2.83	3.48	4	4.56	5.31	5.92	6.58
2 min	3.6	4.26	5.13	5.82	6.55	7.55	8.35	9.19
3 min	4.95	5.87	7.1	8.08	9.12	10.5	11.7	12.9
4 min	6.21	7.37	8.97	10.2	11.6	13.5	15	16.5
5 min	7.35	8.74	10.7	12.2	13.9	16.2	18	19.9
10 min	11.5	13.8	17	19.6	22.4	26.1	29.2	32.4
15 min	14.1	16.9	20.9	24.1	27.6	32.1	35.9	39.9
20 min	15.9	19	23.5	27.2	31	36.1	40.3	44.8
25 min	17.2	20.6	25.4	29.4	33.5	39	43.5	48.3
30 min	18.3	21.8	26.9	31.1	35.4	41.2	45.9	50.9
45 min	20.5	24.5	30.1	34.6	39.3	45.7	50.9	56.4
1 hour	22.1	26.4	32.2	37	42	48.8	54.3	60.2
1.5 hour	24.6	29.2	35.5	40.6	46.1	53.6	59.6	66
2 hours	26.6	31.5	38.2	43.6	49.6	57.6	64.2	71.1
3 hours	30.2	35.5	42.9	48.9	55.7	64.9	72.3	80.2
4.5 hour	34.8	40.8	49.2	56.1	64	74.7	83.4	92.7
6 hours	39	45.6	55	62.7	71.6	83.7	93.6	104
9 hours	46.5	54.2	65.4	74.6	85.4	99.9	112	125
12 hours	53.1	61.9	74.7	85.2	97.5	114	128	142
18 hours	64.3	75.2	90.7	103	118	138	154	172
24 hours	73.7	86.3	104	118	135	157	175	194
30 hours	81.5	95.6	115	131	150	174	194	216
36 hours	88.1	104	125	142	162	188	209	231
48 hours	98.5	116	140	158	179	206	228	251
72 hours	112	133	159	179	199	227	249	272
96 hours	119	142	169	190	211	239	261	284
120 hours	123	146	174	196	217	247	270	294
144 hours	124	148	176	199	221	253	277	302
168 hours	124	148	177	199	224	257	283	311

A2 Available Temporal Patterns

Available durations of point and areal temporal patterns are shown in Table 6-3 and Table 6-4, respectively, compared to available IFD information. The unshaded boxes are those where IFD information is available, but for which no temporal pattern durations are available. Areal temporal patterns are typically used for catchments greater than 75 km² in size. Using the point temporal patterns over the areal patterns will produce a more conservative (higher) estimation of the peak flows within the catchment.

Table 6-3 Available Point Temporal Pattern Durations from Australian Rainfall and Runoff

Durations				
1 minute	15 minutes	1.5 hours	12 hours	72 hours
2 minutes	20 minutes	2 hours	18 hours	96 hours
3 minutes	25 minutes	3 hours	24 hours	120 hours
4 minutes	30 minutes	4.5 hours	30 hours	144 hours
5 minutes	45 minutes	6 hours	36 hours	168 hours
10 minutes	1 hour	9 hours	48 hours	

Table 6-4 Available Areal Temporal Pattern Durations from Australian Rainfall and Runoff

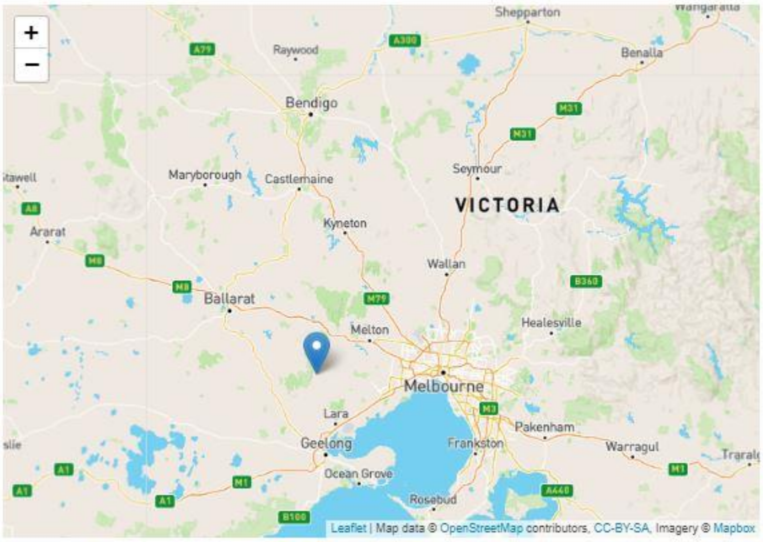
Durations				
1 minute	15 minutes	1.5 hours	12 hours	72 hours
2 minutes	20 minutes	2 hours	18 hours	96 hours
3 minutes	25 minutes	3 hours	24 hours	120 hours
4 minutes	30 minutes	4.5 hours	30 hours	144 hours
5 minutes	45 minutes	6 hours	36 hours	168 hours
10 minutes	1 hour	9 hours	48 hours	

A3 Data Hub Results

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	144.311
Latitude	-37.826
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Baseflow Factors	show



Data

River Region

Division	South East Coast (Victoria)
River Number	8
River Name	Little River

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^b - c\log_{10}Duration\right)Duration^{-d} + eArea^f Duration^g\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
Southern Temperate	0.158	0.276	0.372	0.315	0.000141	0.41	0.15	0.01	-0.0027

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2016_v1

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in Victoria the advice provided on losses and pre-burst in the VIC specific tab of the ARR Data Hub should be considered.

ID	3411.0
Storm Initial Losses (mm)	10.0
Storm Continuing Losses (mm/h)	1.2

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2016_v1

Temporal Patterns | Download (.zip)

code	SSmainland
Label	Southern Slopes (Vic/NSW)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip)

code	SSmainland
arealabel	Southern Slopes (Vic/NSW)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2016_v2

BOM IFDs

Click here to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	05 September 2022 08:17PM

Median Preburst Depths and Ratios

Note: As this point is in Victoria the advice provided on losses and pre-burst in the VIC specific tab of the ARR Data Hub should be considered.

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	3.3 (0.264)	2.3 (0.127)	1.6 (0.073)	1.0 (0.037)	1.5 (0.048)	2.0 (0.053)
90 (1.5)	1.4 (0.096)	2.2 (0.108)	2.7 (0.110)	3.2 (0.111)	2.5 (0.072)	2.0 (0.050)
120 (2.0)	1.5 (0.094)	2.2 (0.101)	2.7 (0.101)	3.2 (0.101)	3.3 (0.086)	3.4 (0.077)
180 (3.0)	0.9 (0.048)	2.4 (0.095)	3.4 (0.112)	4.3 (0.122)	3.0 (0.069)	1.9 (0.039)
360 (6.0)	0.2 (0.008)	0.2 (0.007)	0.3 (0.007)	0.3 (0.006)	1.7 (0.030)	2.7 (0.043)
720 (12.0)	0.0 (0.000)	0.7 (0.016)	1.2 (0.023)	1.7 (0.027)	2.2 (0.029)	2.5 (0.030)
1080 (18.0)	0.0 (0.000)	0.4 (0.008)	0.7 (0.011)	1.0 (0.013)	1.5 (0.016)	1.8 (0.017)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.3 (0.003)	0.5 (0.004)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.1 (0.011)	0.1 (0.004)	0.0 (0.002)	0.0 (0.000)	0.1 (0.002)	0.1 (0.003)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.001)	0.1 (0.001)
180 (3.0)	0.0 (0.000)	0.0 (0.001)	0.1 (0.002)	0.1 (0.002)	0.0 (0.001)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	11.8 (0.940)	10.8 (0.598)	10.2 (0.460)	9.6 (0.363)	12.0 (0.373)	13.9 (0.375)
90 (1.5)	11.2 (0.785)	12.1 (0.599)	12.8 (0.519)	13.4 (0.459)	14.1 (0.397)	14.6 (0.359)
120 (2.0)	10.2 (0.654)	11.6 (0.528)	12.5 (0.470)	13.4 (0.427)	14.3 (0.374)	15.0 (0.343)
180 (3.0)	11.5 (0.641)	13.5 (0.537)	14.7 (0.488)	15.9 (0.449)	13.9 (0.324)	12.4 (0.254)
360 (6.0)	6.2 (0.260)	7.9 (0.243)	9.1 (0.232)	10.2 (0.223)	16.5 (0.301)	21.3 (0.340)
720 (12.0)	1.7 (0.053)	6.7 (0.151)	10.0 (0.188)	13.2 (0.212)	16.3 (0.218)	18.7 (0.219)
1080 (18.0)	1.2 (0.032)	5.5 (0.102)	8.3 (0.129)	11.0 (0.146)	13.4 (0.148)	15.3 (0.148)
1440 (24.0)	1.3 (0.029)	2.8 (0.046)	3.9 (0.052)	4.8 (0.056)	8.6 (0.082)	11.3 (0.096)
2160 (36.0)	0.4 (0.008)	2.0 (0.028)	3.1 (0.035)	4.1 (0.040)	4.9 (0.039)	5.5 (0.039)
2880 (48.0)	0.0 (0.000)	0.4 (0.005)	0.6 (0.006)	0.9 (0.008)	2.7 (0.019)	4.0 (0.025)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.5 (0.003)	0.8 (0.005)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	20.3 (1.615)	22.6 (1.247)	24.1 (1.087)	25.5 (0.968)	27.5 (0.854)	29.0 (0.785)
90 (1.5)	23.7 (1.663)	26.1 (1.290)	27.7 (1.126)	29.3 (1.003)	30.4 (0.858)	31.3 (0.771)
120 (2.0)	25.1 (1.610)	25.2 (1.147)	25.3 (0.949)	25.3 (0.805)	30.7 (0.804)	34.7 (0.795)
180 (3.0)	21.3 (1.182)	25.9 (1.033)	28.9 (0.958)	31.8 (0.897)	34.8 (0.811)	37.1 (0.757)
360 (6.0)	19.3 (0.813)	25.3 (0.778)	29.3 (0.752)	33.1 (0.727)	38.3 (0.696)	42.1 (0.672)
720 (12.0)	12.9 (0.398)	17.9 (0.402)	21.1 (0.398)	24.3 (0.392)	29.6 (0.396)	33.6 (0.395)
1080 (18.0)	11.5 (0.295)	16.0 (0.298)	18.9 (0.294)	21.8 (0.290)	26.6 (0.293)	30.2 (0.292)
1440 (24.0)	6.1 (0.138)	15.7 (0.257)	22.1 (0.300)	28.2 (0.327)	25.4 (0.244)	23.4 (0.197)
2160 (36.0)	12.2 (0.236)	14.4 (0.197)	15.8 (0.179)	17.1 (0.165)	24.6 (0.197)	30.2 (0.213)
2880 (48.0)	1.6 (0.027)	6.9 (0.085)	10.5 (0.106)	13.8 (0.119)	18.7 (0.134)	22.3 (0.141)
4320 (72.0)	0.8 (0.012)	11.3 (0.124)	18.3 (0.164)	25.0 (0.189)	27.9 (0.175)	30.0 (0.168)

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	RCP 8.5
2030	**0.648 (3.2%)**	0.687 (3.4%)	**0.811 (4.0%)**
2040	**0.878 (4.4%)**	0.827 (4.1%)	**1.084 (5.4%)**
2050	**1.081 (5.4%)**	1.013 (5.1%)	**1.446 (7.3%)**
2060	**1.251 (6.3%)**	1.229 (6.2%)	**1.862 (9.5%)**
2070	**1.381 (7.0%)**	1.460 (7.4%)	**2.298 (11.9%)**
2080	**1.465 (7.4%)**	1.691 (8.6%)	**2.719 (14.2%)**
2090	**1.496 (7.6%)**	1.906 (9.7%)	**3.090 (16.3%)**

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Baseflow Factors

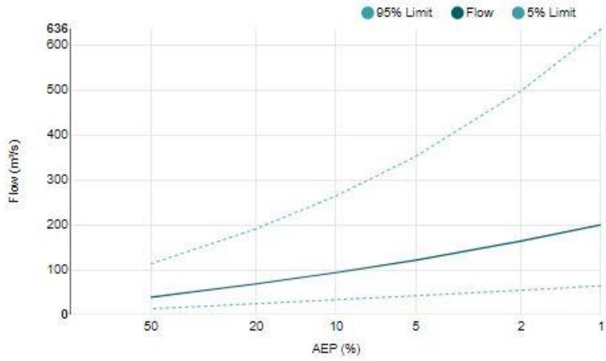
Downstream	0
Area (km2)	501.583328
Catchment Number	11191
Volume Factor	0.404269
Peak Factor	0.145579

Layer Info

Time Accessed	05 September 2022 08:17PM
Version	2016_v1

A4 RFFE Results

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	38.4	12.9	113
20	68.4	24.5	191
10	93.4	33.1	264
5	121	42.1	352
2	164	54.2	498
1	200	64.1	636

Input Data	
Date/Time	2022-09-06 10:49
Catchment Name	Catchment1
Latitude (Outlet)	-37.870873
Longitude (Outlet)	144.454989
Latitude (Centroid)	-37.825561
Longitude (Centroid)	144.311144
Catchment Area (km^2)	248.1
Distance to Nearest Gauged Catchment (km)	11.8
50% AEP 6 Hour Rainfall Intensity (mm/h)	3.96483
2% AEP 6 Hour Rainfall Intensity (mm/h)	9.137169
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.86
Interpolation Method	Natural Neighbour
Bias Correction Value	0.284

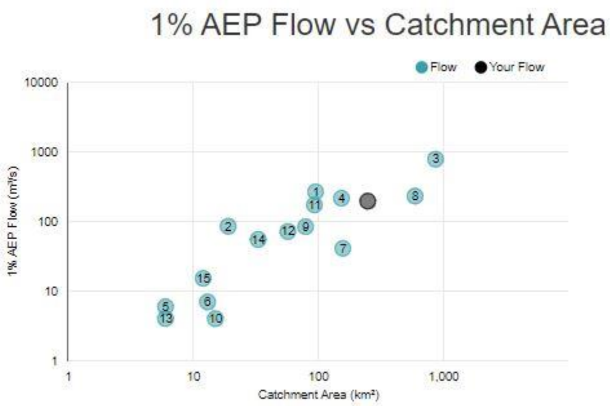
Statistics

Variable	Value	Standard Dev
Mean	3.708	0.654
Standard Dev	0.664	0.217
Skew	0.141	0.030

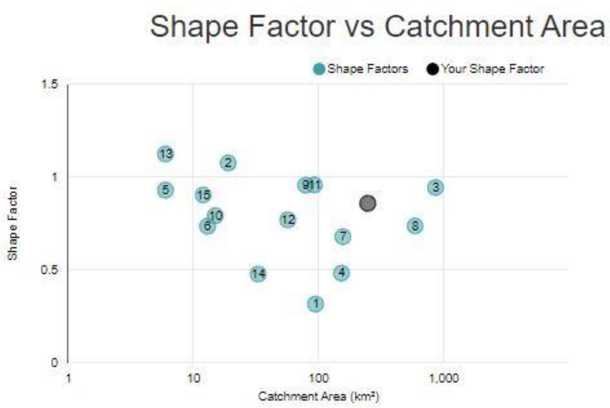
Note: These statistics come from the nearest gauged catchment. Details.

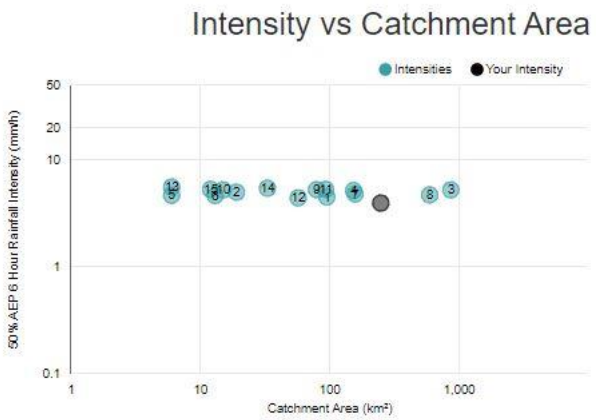
Correlation		
1.000		
-0.330	1.000	
0.170	-0.280	1.000

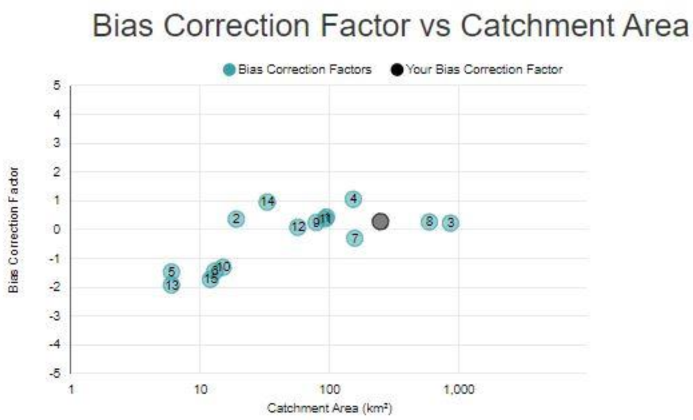
Note: These statistics are common to each region. Details.


1% AEP Flow vs Catchment Area
Flow
Your Flow
10000
1000
100
10
1
1% AEP Flow (m³/s)
1
10
100
1,000
Catchment Area (km²)


Ballarat
Melbourne
Geelong
Leaflet | © OpenStreetMap contributors


Shape Factor vs Catchment Area
Shape Factors
Your Shape Factor
1.5
1
0.5
0
Shape Factor
1
10
100
1,000
Catchment Area (km²)


Intensity vs Catchment Area
Intensities
Your Intensity
50% AEP 6 Hour Rainfall Intensity (mm/h)
Catchment Area (km²)


Bias Correction Factor vs Catchment Area
Bias Correction Factors
Your Bias Correction Factor
Bias Correction Factor
Catchment Area (km²)

Appendix B RORB Details

Table 6-5 RORB reach details

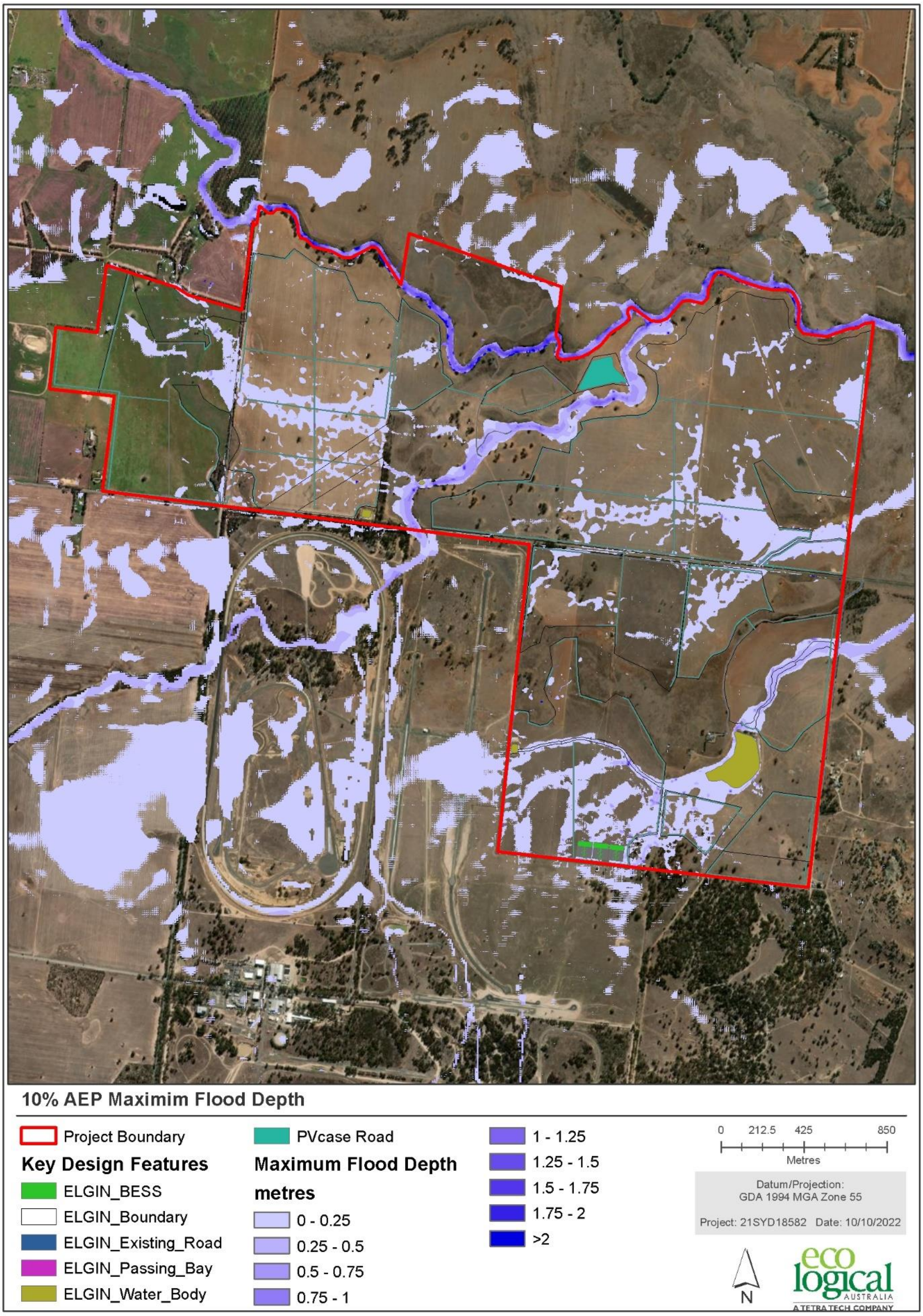
No.	Reach Name	Reach Type	Reach Length (km)	No.	Reach Name	Reach Type	Reach Length (km)
1	A Reach	1. Natural	0.066	27	DS A	1. Natural	0.343
2	B Reach	1. Natural	2.184	28	US A	1. Natural	0.452
3	C Reach	1. Natural	0.569	29	DS C	1. Natural	1.207
4	D Reach	1. Natural	0.703	30	US C	1. Natural	1.226
5	E Reach	1. Natural	2.090	31	DS D	1. Natural	4.073
6	F Reach	1. Natural	5.902	32	US D	1. Natural	3.860
7	G Reach	1. Natural	1.598	33	DS G	1. Natural	2.943
8	H Reach	1. Natural	0.497	34	US G	1. Natural	3.959
9	I Reach	1. Natural	5.188	35	DS H	1. Natural	1.296
10	J Reach	1. Natural	0.798	36	US H	1. Natural	1.020
11	K Reach	1. Natural	0.997	37	DS J	1. Natural	0.806
12	L Reach	1. Natural	3.830	38	US J	1. Natural	0.952
13	M Reach	1. Natural	0.202	39	DS K	1. Natural	1.217
14	N Reach	1. Natural	3.263	40	US K	1. Natural	1.033
15	O Reach	1. Natural	1.200	41	DS M	1. Natural	0.647
16	P Reach	1. Natural	3.219	42	US M	1. Natural	0.918
17	Q Reach	1. Natural	5.726	43	DS O	1. Natural	1.853
18	R Reach	1. Natural	0.544	44	US O	1. Natural	2.064
19	S Reach	1. Natural	1.350	45	DS R	1. Natural	2.734
20	T Reach	1. Natural	2.354	46	US R	1. Natural	2.395
21	U Reach	1. Natural	2.107	47	DS S	1. Natural	12.967
22	V Reach	1. Natural	1.500	48	US S	1. Natural	9.326
23	W Reach	1. Natural	3.936	49	DS V	1. Natural	5.058
24	X Reach	1. Natural	0.648	50	US V	1. Natural	4.567
25	Y Reach	1. Natural	1.843	51	DS X	1. Natural	2.341
26	Z Reach	1. Natural	2.808	52	US X	1. Natural	2.734

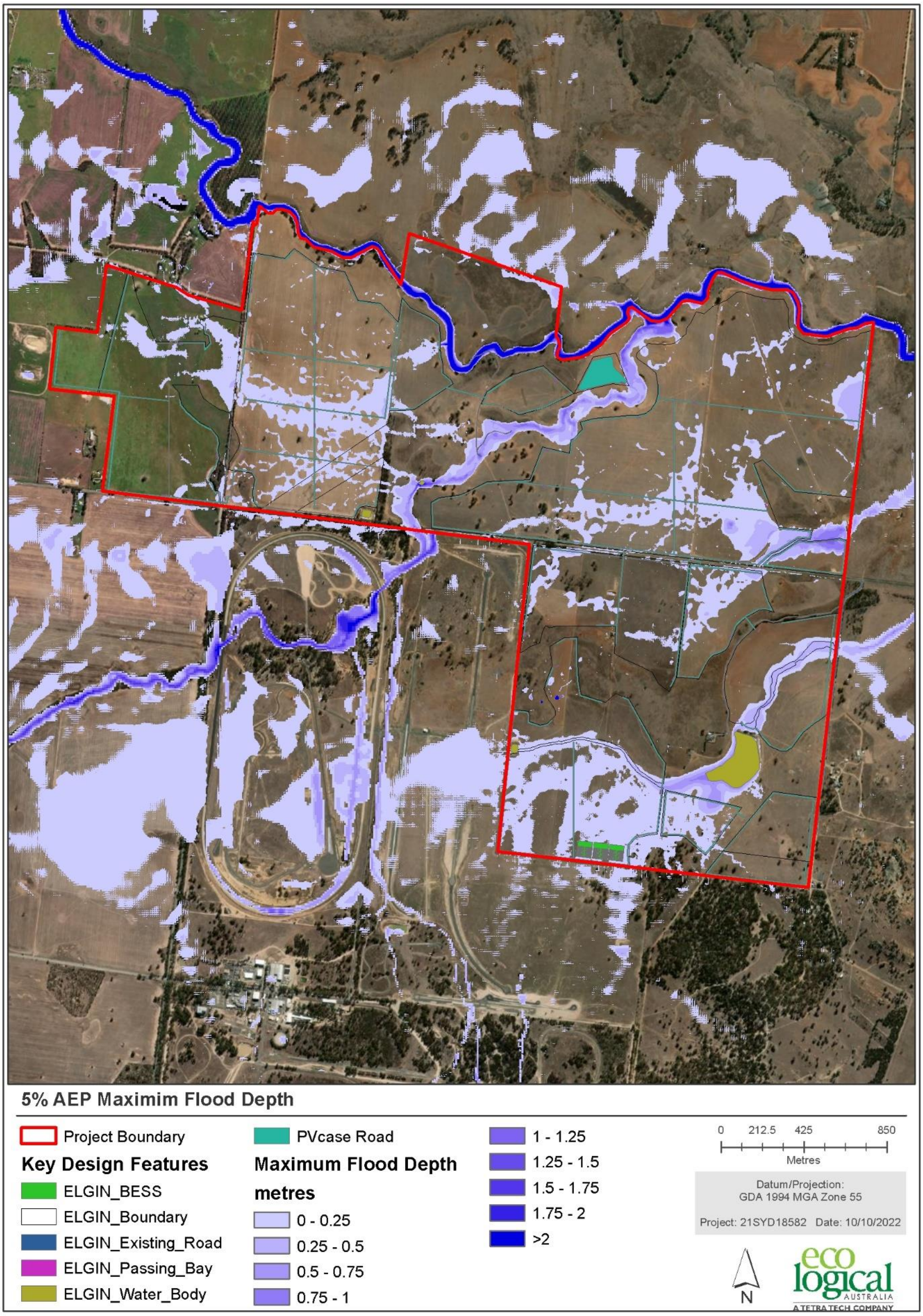
Table 6-6 RORB sub-catchment area details

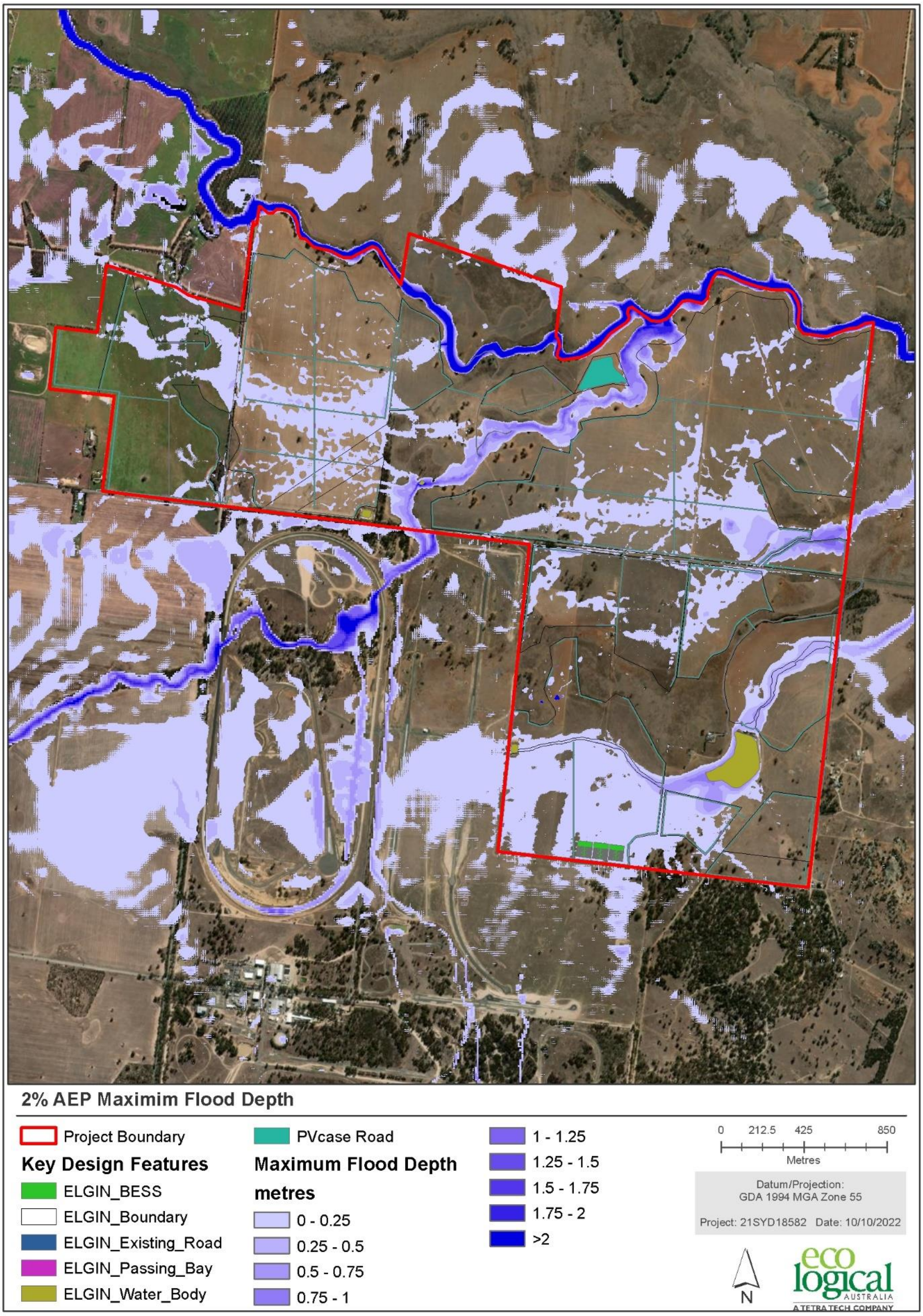
No.	Node Name	Node Area (km²)	No.	Node Name	Node Area (km²)	No.	Node Name	Node Area (km²)
1	SA A	0.192	10	SA J	1.385	19	SA S	34.816
2	SA B	8.662	11	SA K	4.351	20	SA T	5.218
3	SA C	1.991	12	SA L	7.169	21	SA U	5.008
4	SA D	18.491	13	SA M	0.690	22	SA V	11.817
5	SA E	10.406	14	SA N	17.924	23	SA W	15.051
6	SA F	20.056	15	SA O	2.587	24	SA X	6.680
7	SA G	15.716	16	SA P	10.999	25	SA Y	6.687
8	SA H	2.203	17	SA Q	11.069	26	SA Z	8.031
9	SA I	17.564	18	SA R	3.325			

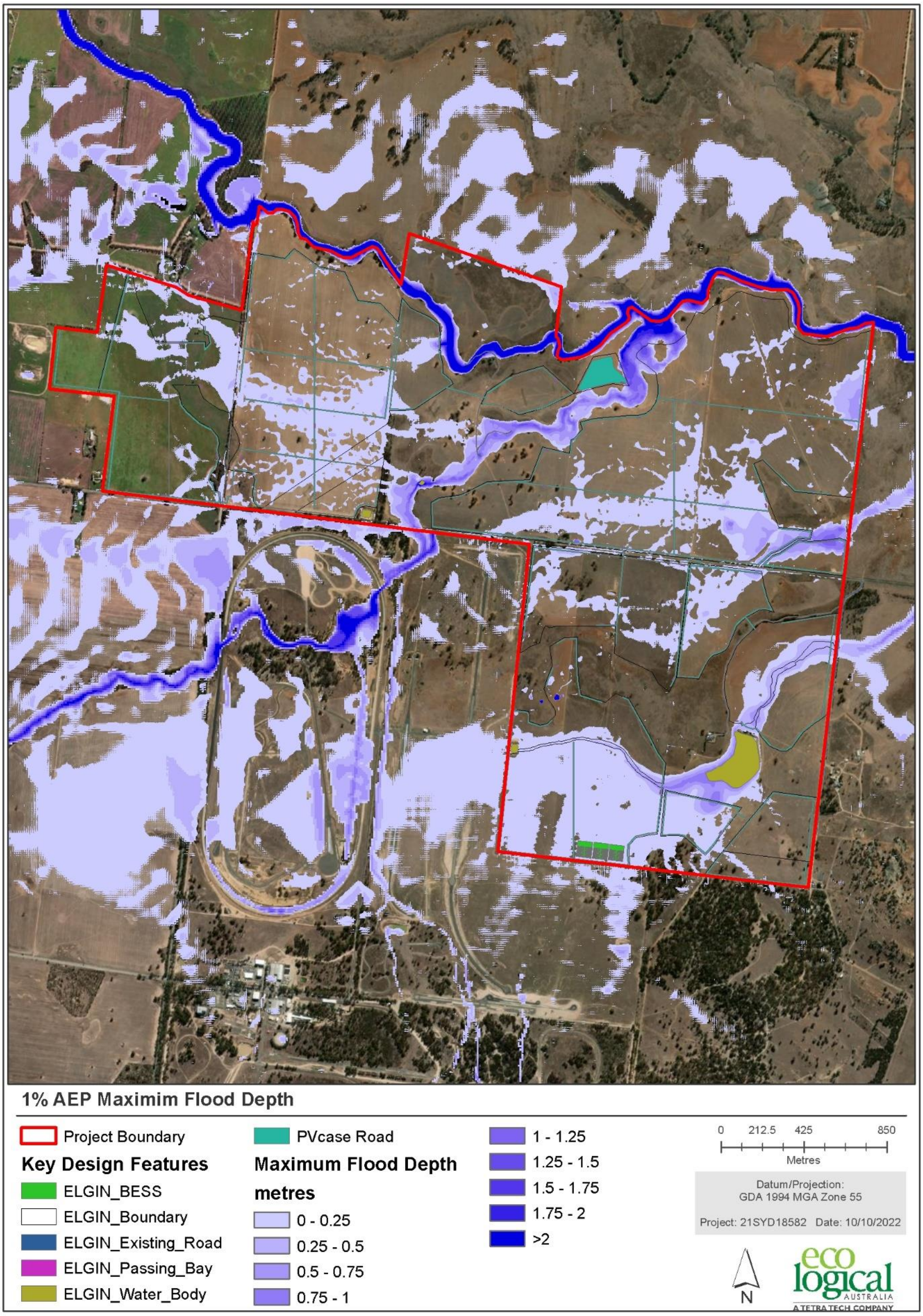
Appendix C HEC-RAS Results

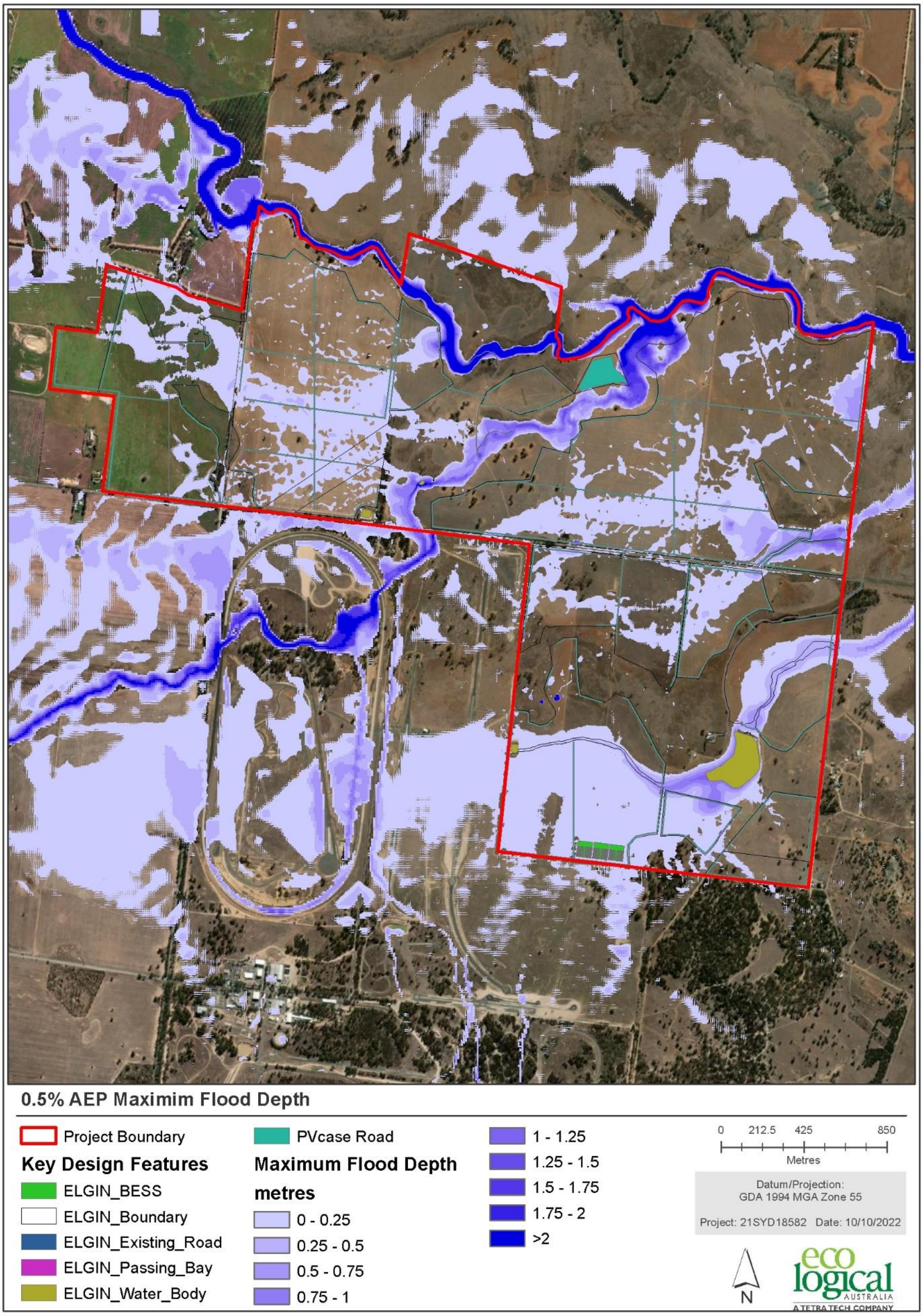
C1 Flood depths

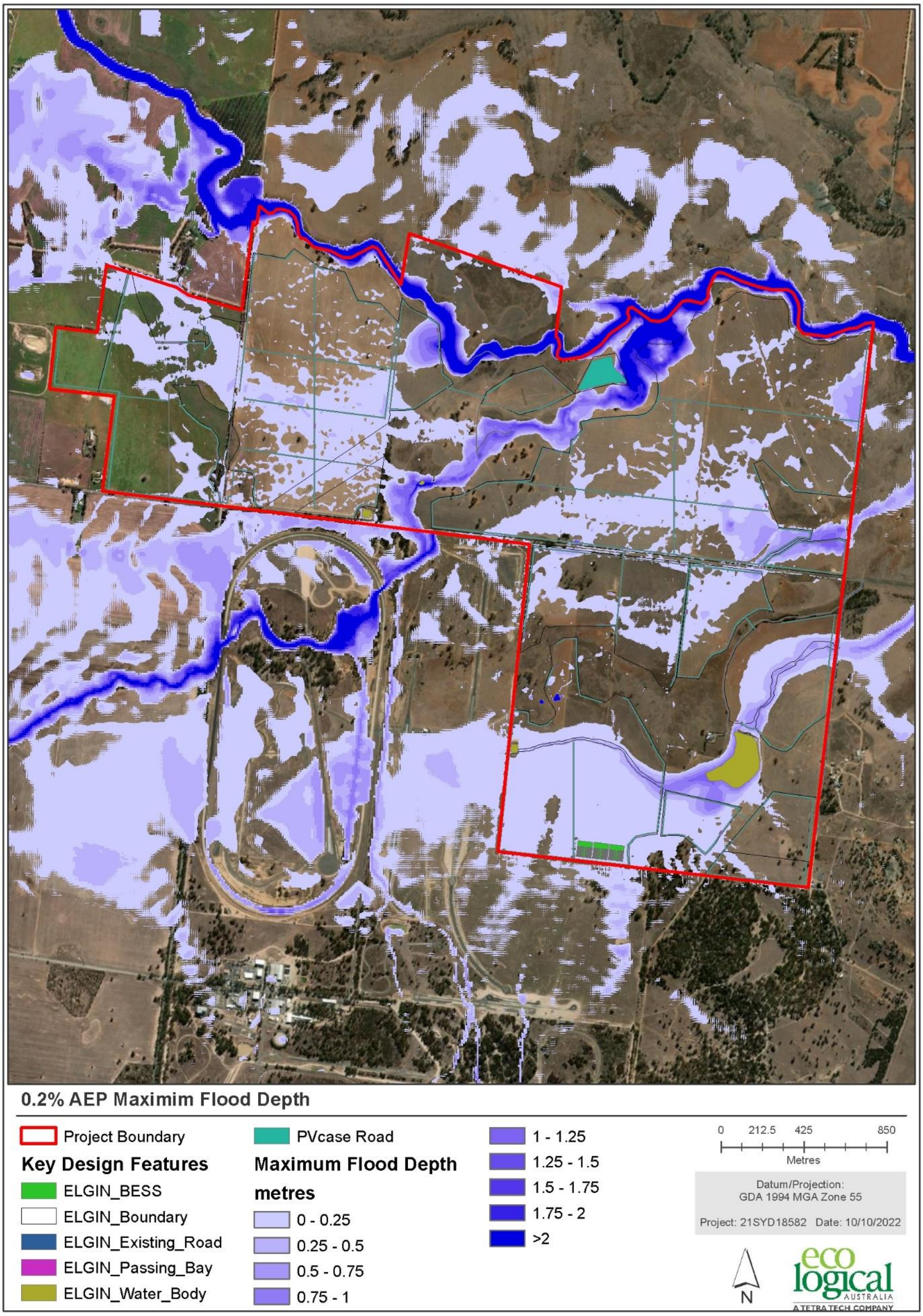

10% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0
212.5
425
850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY

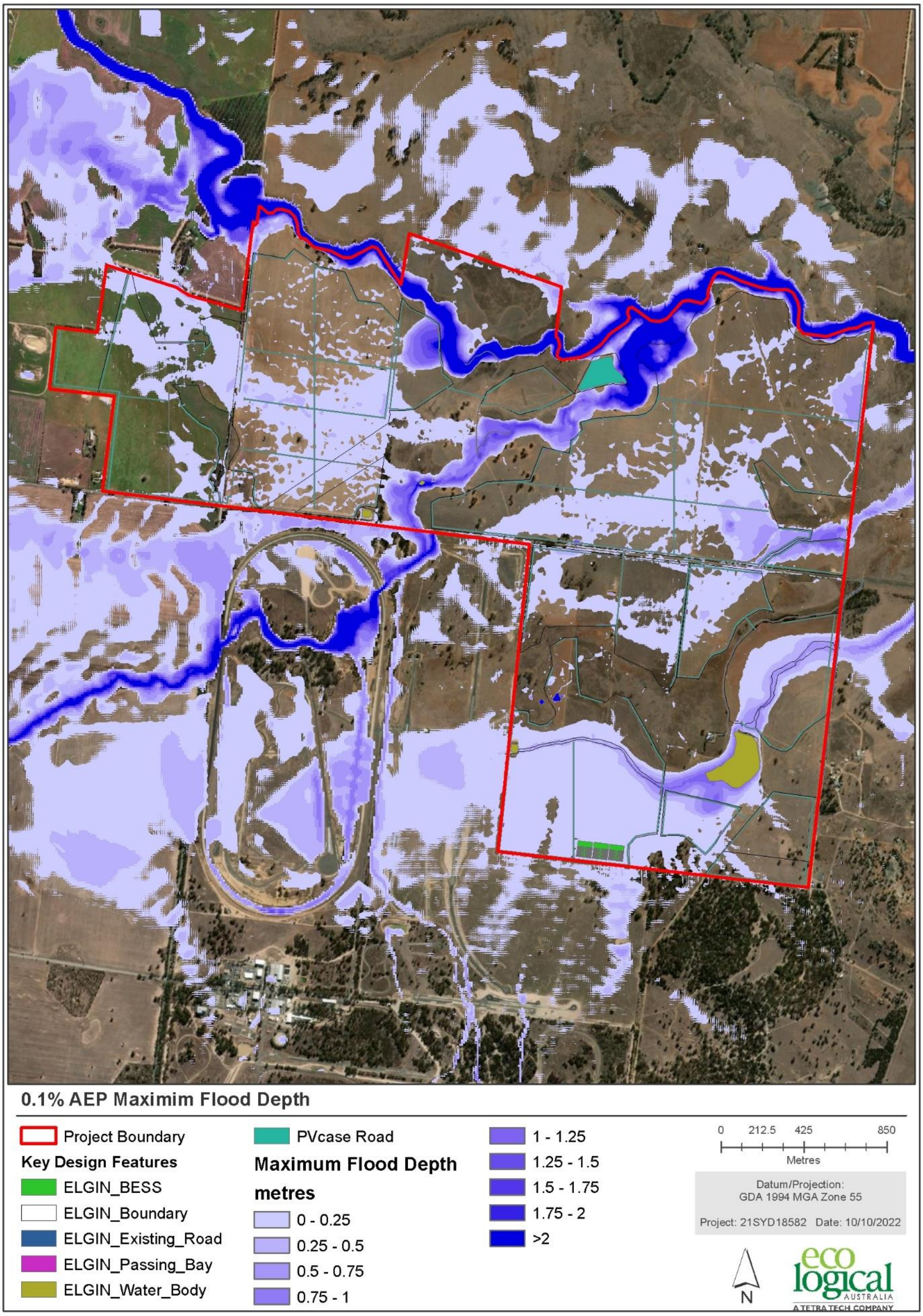

5% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0
212.5
425
850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY


2% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N


1% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY


0.5% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N


0.2% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY


0.1% AEP Maximim Flood Depth
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Depth metres
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
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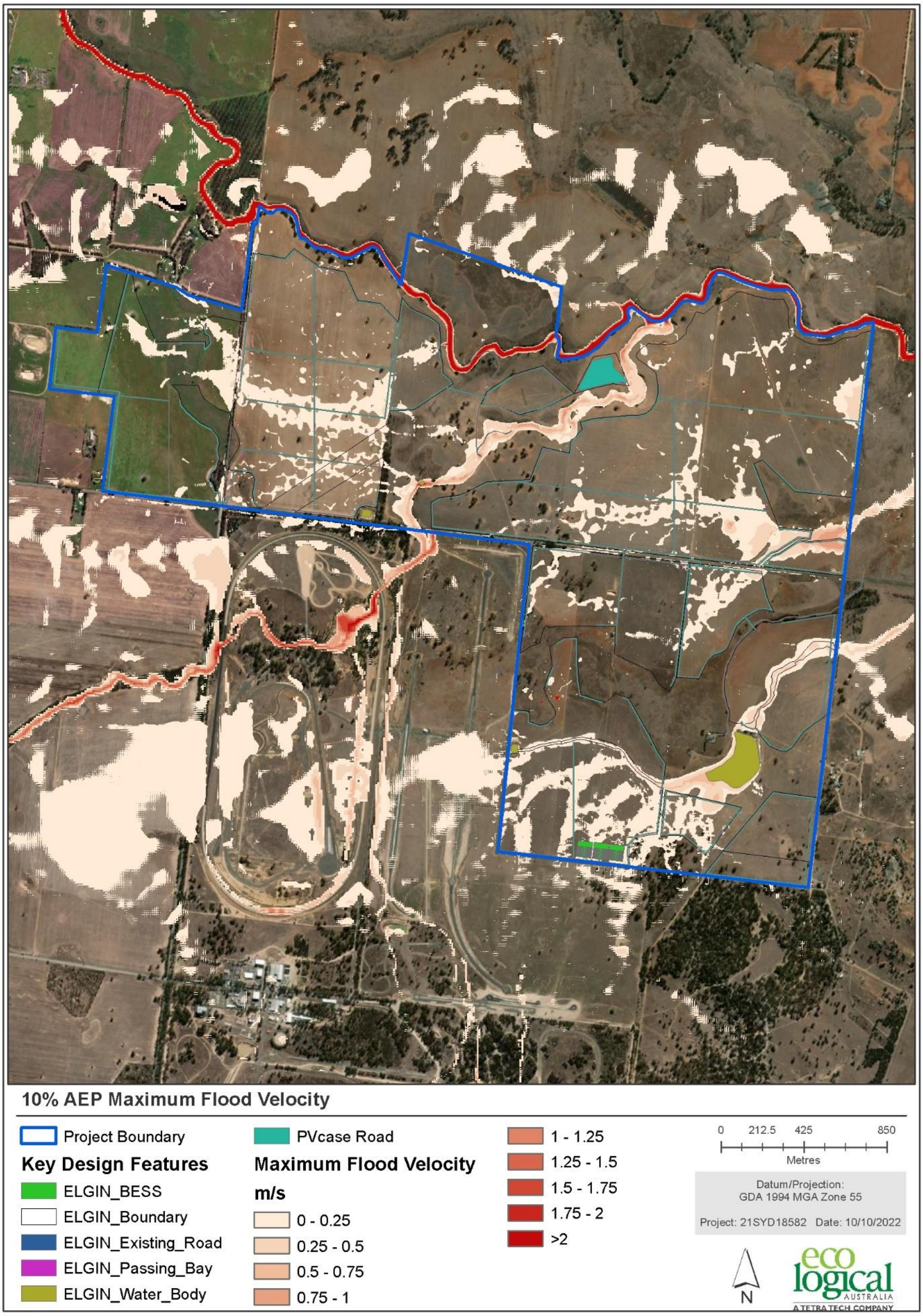
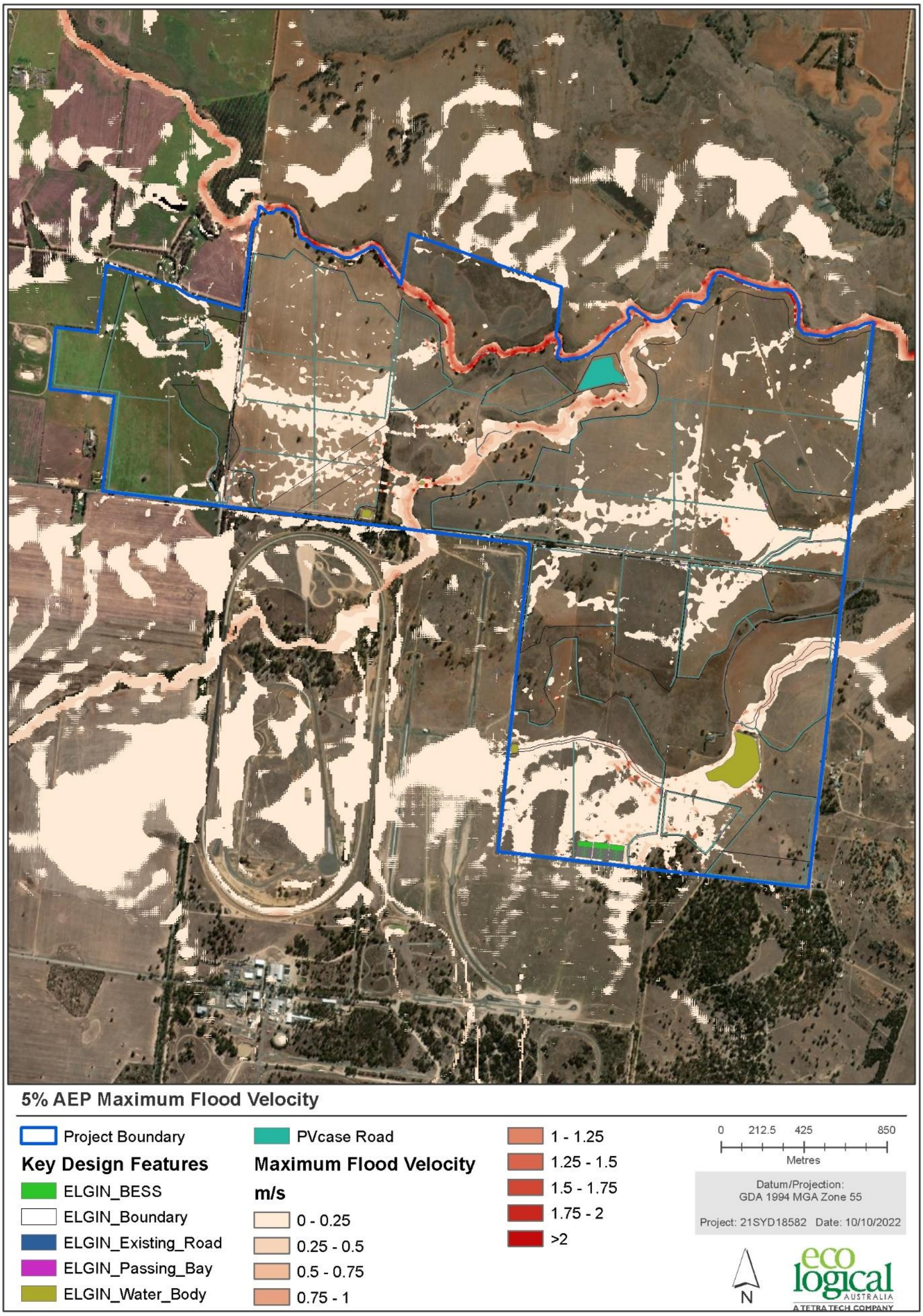
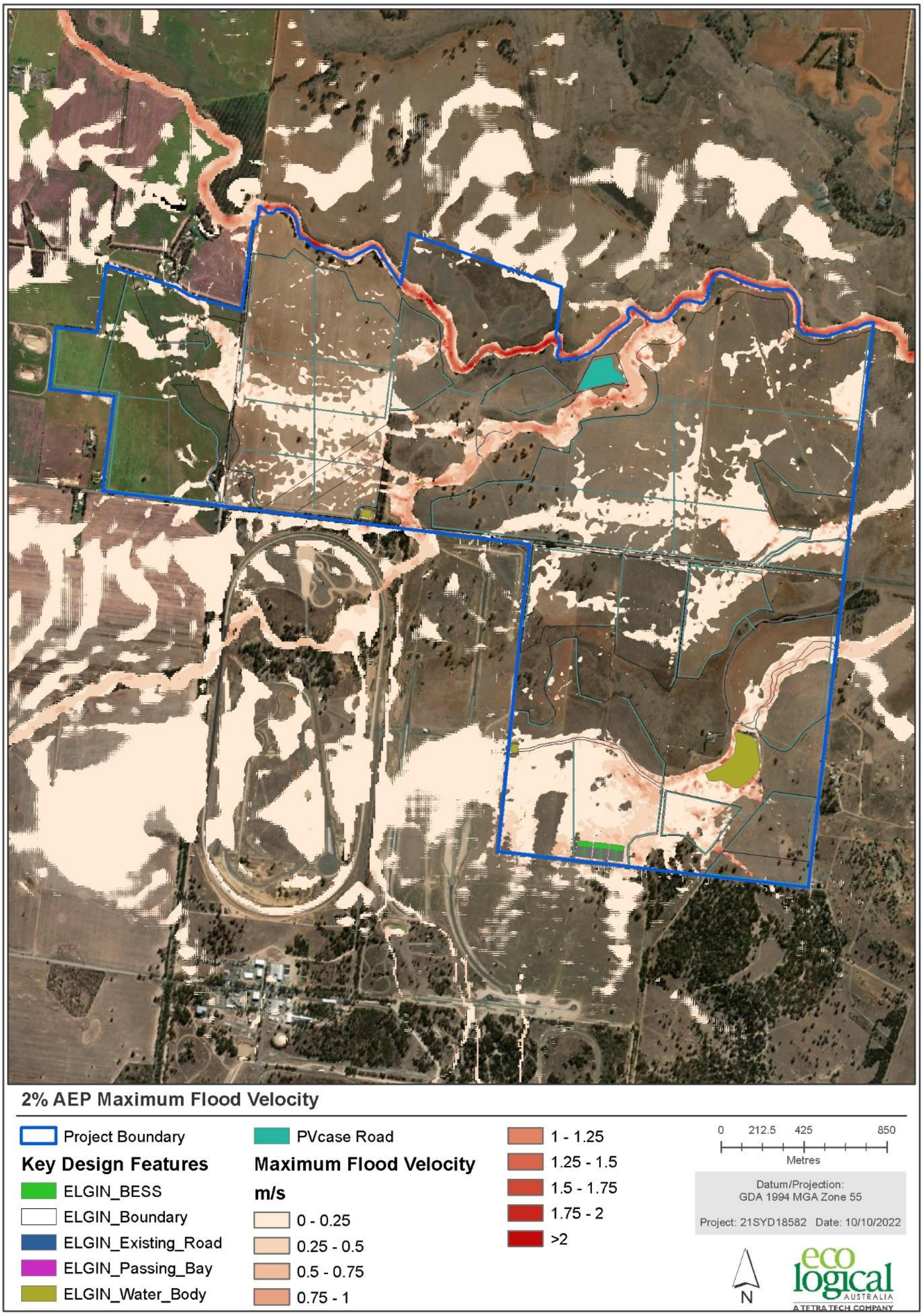
C2 Velocities




5% AEP Maximum Flood Velocity
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Velocity m/s
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N


2% AEP Maximum Flood Velocity
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Velocity m/s
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
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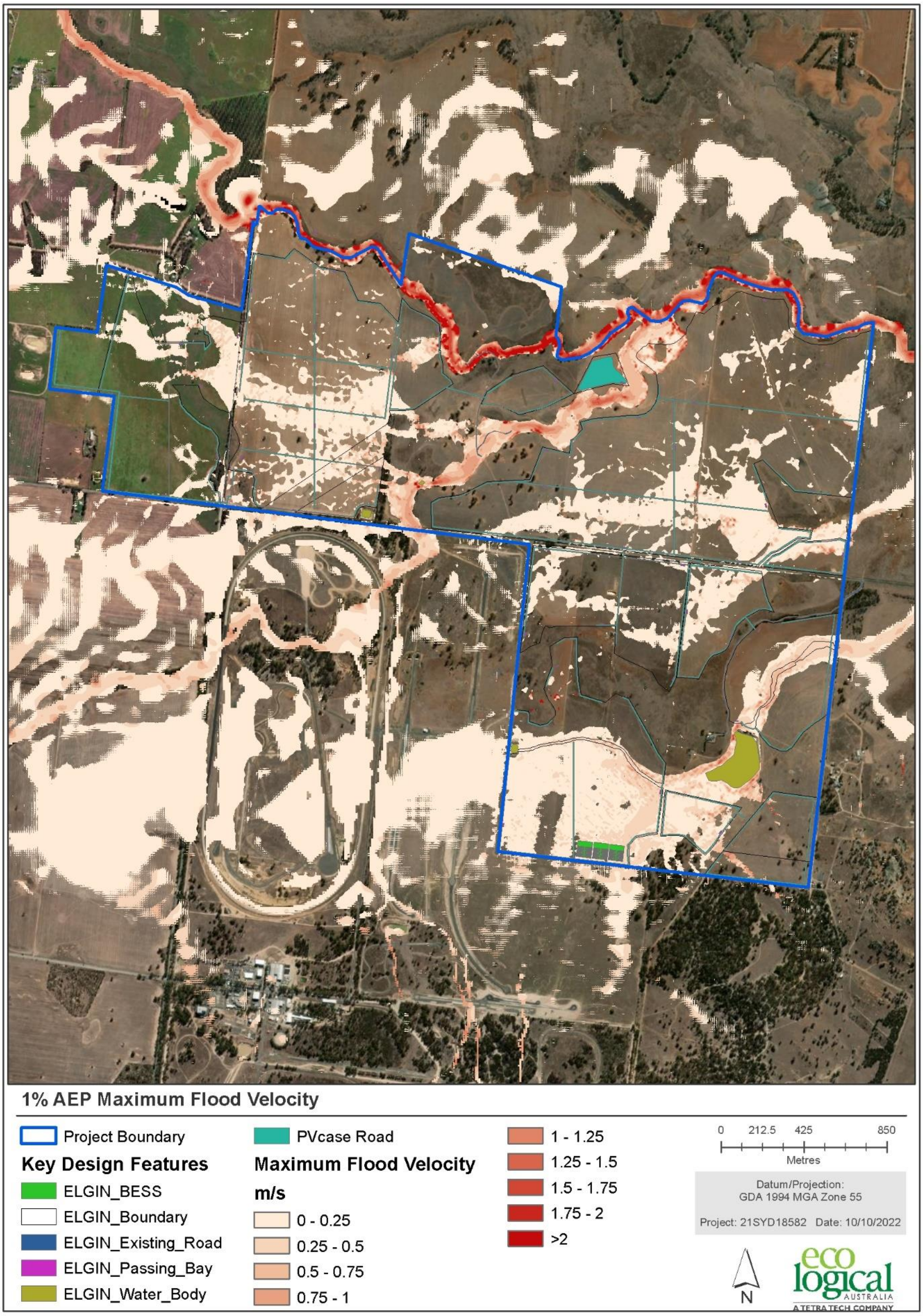
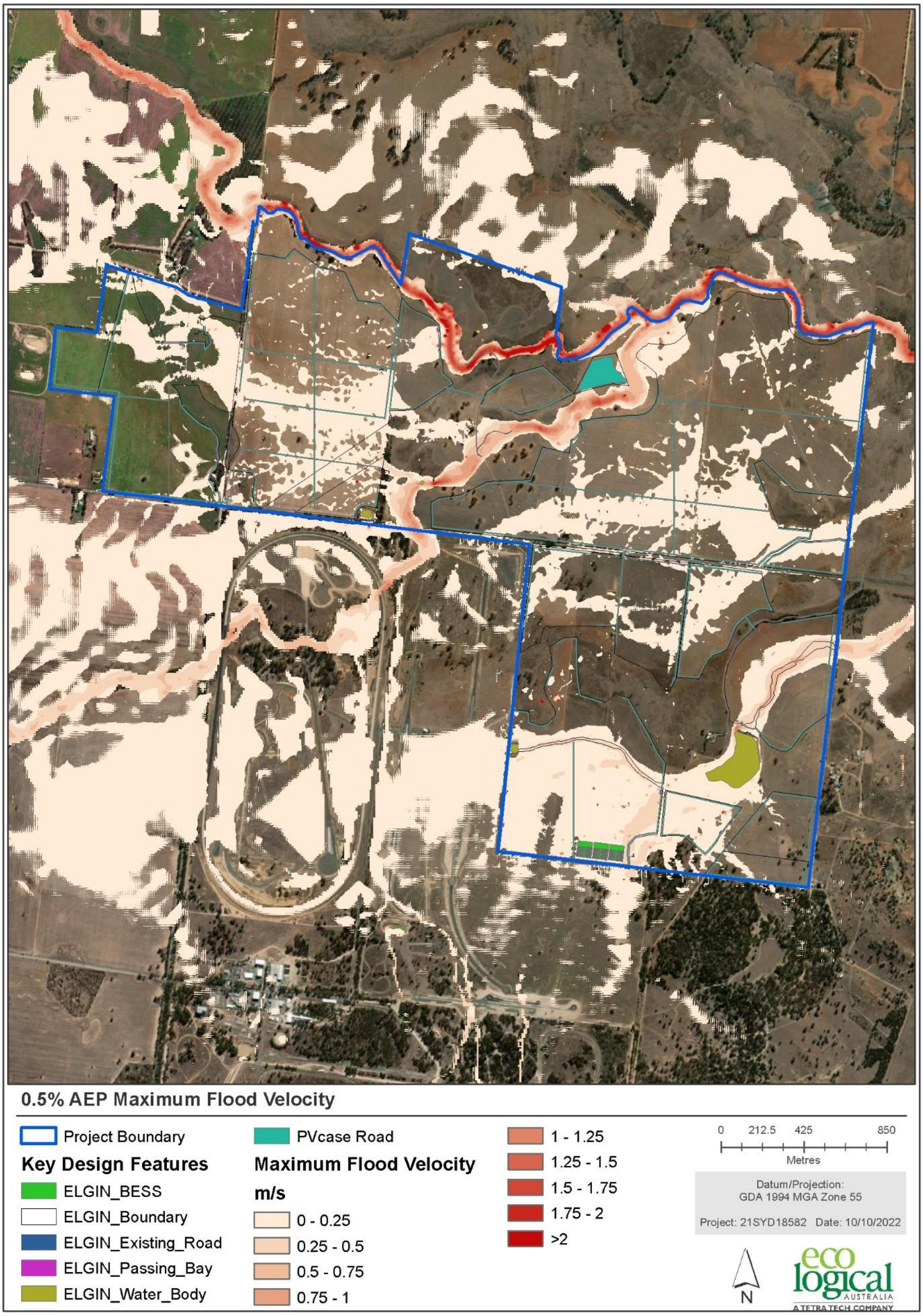
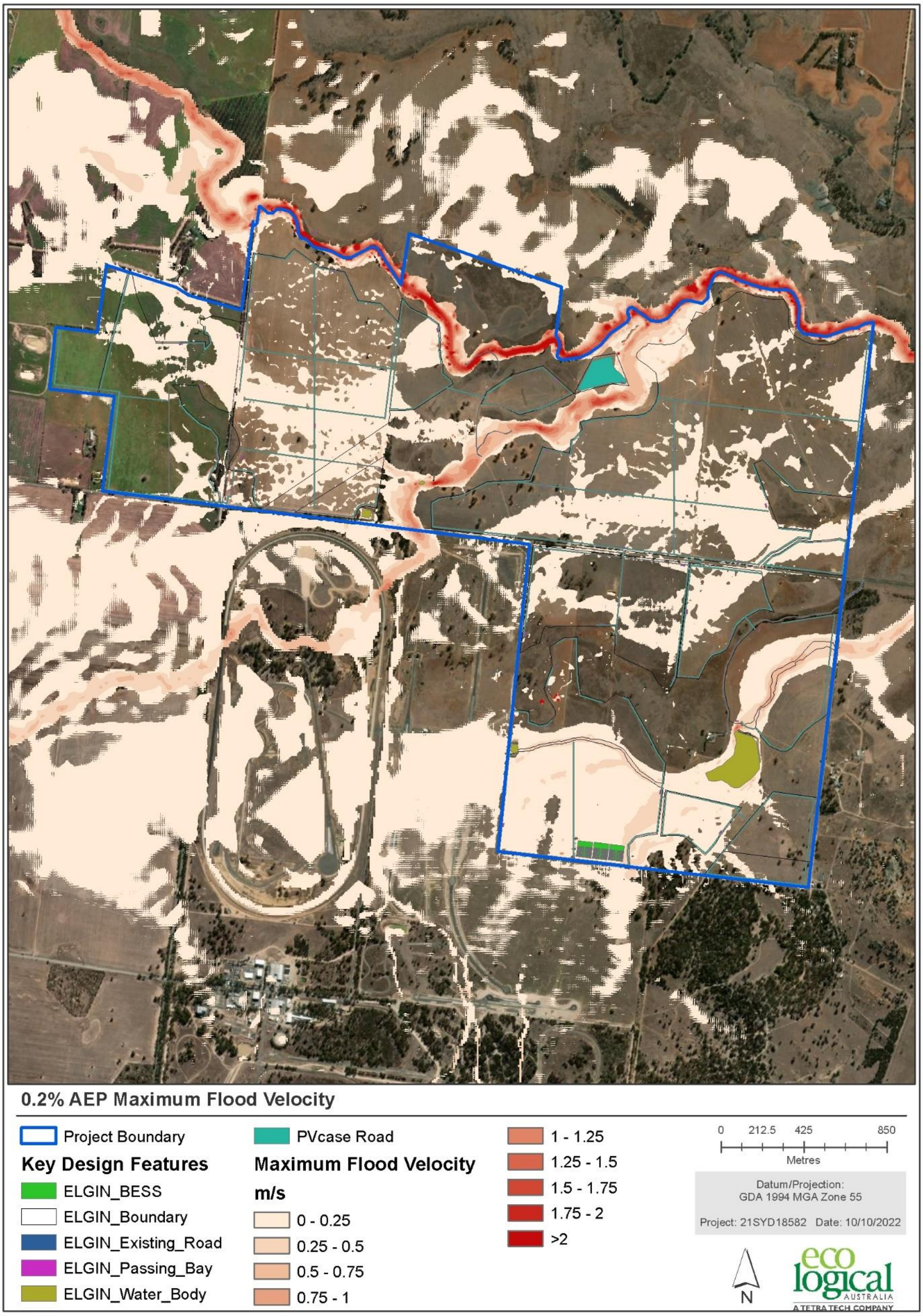
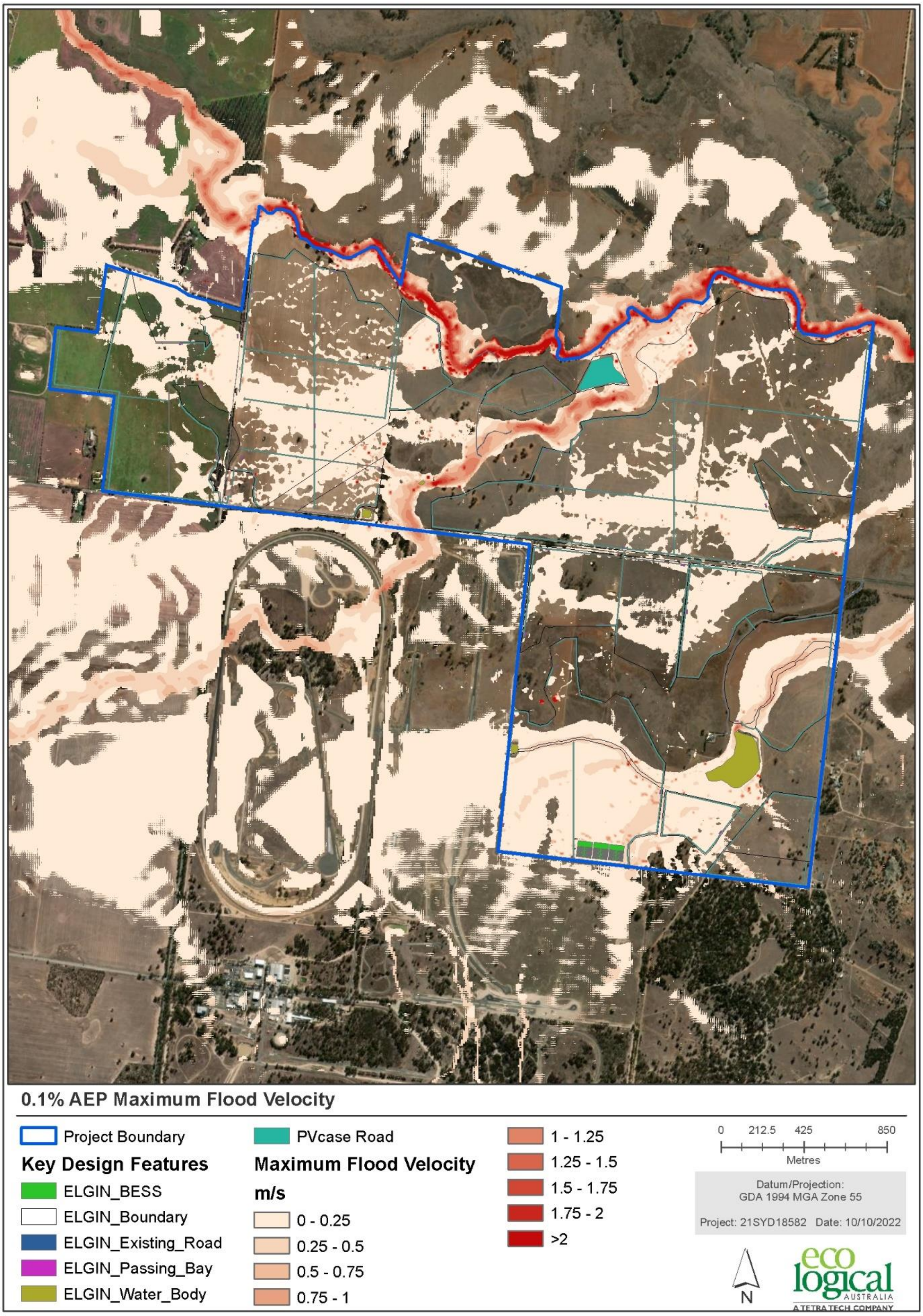

1% AEP Maximum Flood Velocity
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Velocity m/s
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY


0.5% AEP Maximum Flood Velocity
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Velocity m/s
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection: GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY


0.2% AEP Maximum Flood Velocity
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Velocity m/s
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N
eco logical AUSTRALIA
A TETRA TECH COMPANY


0.1% AEP Maximum Flood Velocity
Project Boundary
Key Design Features
ELGIN_BESS
ELGIN_Boundary
ELGIN_Existing_Road
ELGIN_Passing_Bay
ELGIN_Water_Body
PVcase Road
Maximum Flood Velocity m/s
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2
0 212.5 425 850
Metres
Datum/Projection:
GDA 1994 MGA Zone 55
Project: 21SYD18582 Date: 10/10/2022
N