Sapphire Solar Farm

Environmental Impact Statement

Volume 3 - Appendices

Appendix I
Flood Hydrology Assessment

High level flood modelling for Sapphire Solar Farm

Prepared for
CWP Solar Pty. Ltd.

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Item	Detail
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1 Introduction

This document provides:

1. A summary of flooding conditions for the EIS addressing the assessment requirements, covering the following (where relevant):
    a. Existing Conditions;
    b. Potential Impacts; and,
    c. Mitigation measures (should they be required).
2. Technical detail of modelling undertaken for:
    a. Flow volumes using RORB; and,
    b. Water levels using HEC-RAS.

Modelling undertaken has adopted conceptual design features (**Figure 1-1**) to assess the likely effects on flooding associated with the proposed Sapphire Solar Farm (the Proposed Development), and the potential impacts of any changes on the downstream environment. Such modelling provides an opportunity to examine likely flood behaviour and to form an opinion as to whether the Proposed Development is likely to have a significant impact on flood behaviour and downstream flood risks.

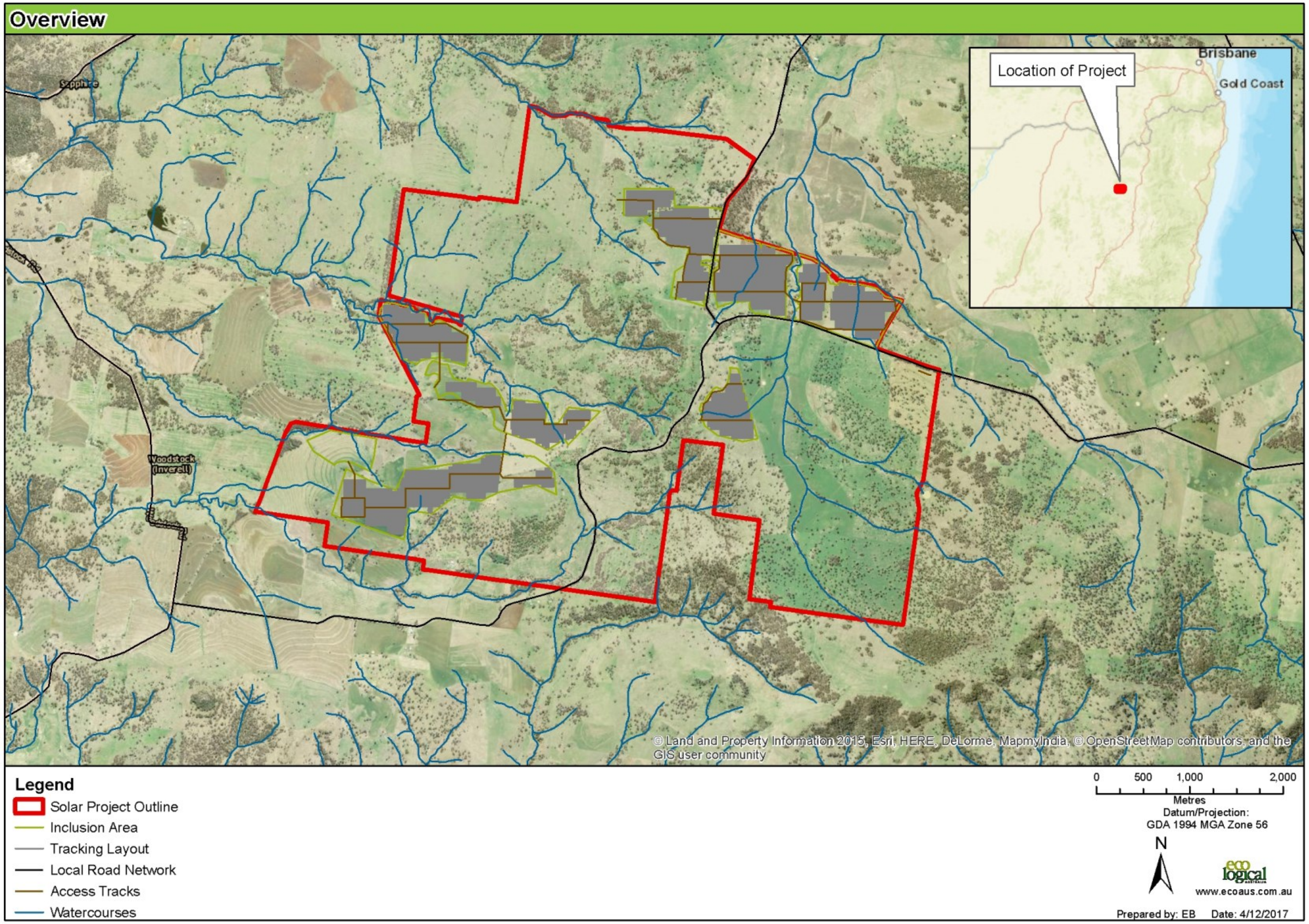

Figure 1-1 Overview of proposed development

2 Existing flood conditions

Figure 2-1 outlines the region where the Proposed Development will be located along with the key catchments and associated flow lines (noting that flow lines do not necessarily translate to defined waterways). For the purposes of identifying the existing flood conditions for the proposed region, only the key catchments that cover the solar array region were examined. The small areas of the wider study area that are not captured by the catchments would have an inconsequential impact on flooding should the array locations be moved to within these regions.

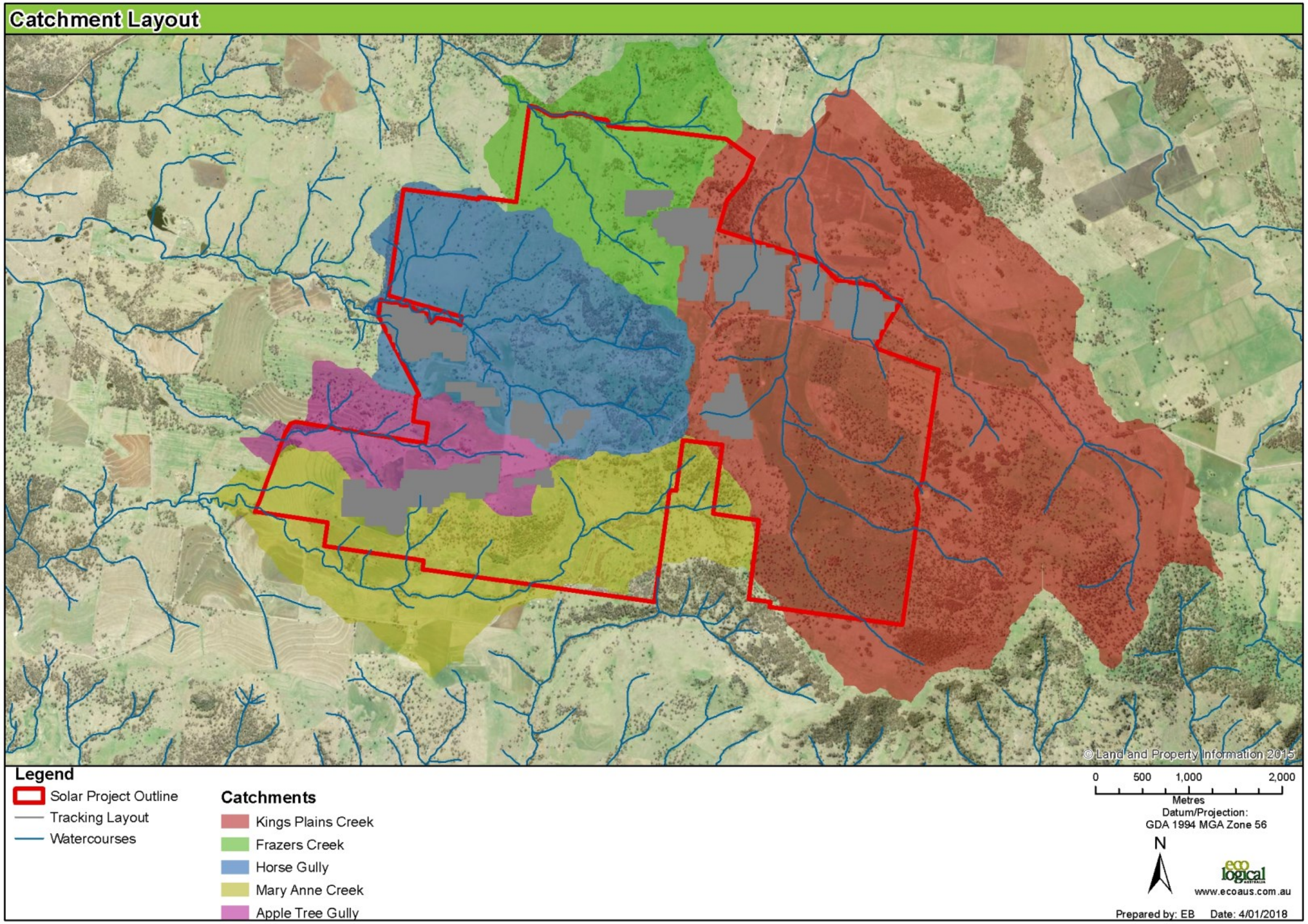

Figure 2-1: Catchment Layout

To categorise the existing design flood conditions for the area of interest, the use of regionalised flood models was required as no appropriate rainfall, water level or flow information exists in or near the catchment of interest. The flood volumes and levels were determined by the Regional Flood Frequency Estimation (RFFE) model (Western Sydney University), RORB (Monash University and Hydrology and Risk Consulting) and Hydrologic Engineering Centre's River Analysis System (HEC-RAS) (U.S. Army Corps of Engineers) programs, which calculate rainfall-runoff, flow and flood-height statistics, respectively.

The RFFE models were parameterised using GIS datasets. The models were used to determine representative runoff rates to calibrate the RORB models in the absence of local gauged data. The RORB models were parameterised using GIS datasets, Bureau of Meteorology's Intensity-Frequency-Duration (IFD) information, the Australian Rainfall and Runoff (2016) data hub and the RFFE outputs. The HEC-RAS models were parameterised using GIS datasets, RORB model outputs and local site information (e.g. land cover).

Event durations from 10 minutes to 7 days were run through the models to determine the critical flood duration and volume for the 10% Annual Exceedance Probability (AEP), 1% AEP, 0.5% AEP, 0.2% AEP and 0.1% AEP events. For this development, the probable maximum flood was not examined as it was not deemed appropriate given the site of interest is not on flood prone land; the Proposed Development is demonstrated to not increase flood risk (flow rates or levels), and there is negligible downstream development (i.e. only grazing land) that could potentially be impacted.

The critical flood (the flood with the highest peak flow) for these catchments are:

- Eastern Catchment (Kings Plains Creek): 6 hours or 12 hours;
- Northern Catchment (Frazers Creek): 6 hours or 12 hours except for the 0.1% AEP which is 24 hours;
- North-western Catchment (Horse Gully): 6 hours or 12 hours except for the 0.1%AEP which is 24 hours;
- Western Catchment (Mary Anne Creek): 3 hours or 6 hours; and,
- South-western catchment (Apple Tree Gully): 6 hours or 12 hours.

The resultant peak flows are outlined in **Table 2-1** at the downstream end (confluence) of the catchments (as shown in **Figure 2-1**). Please note that unless a specific catchment (relating to the RORB model) or chainage (reported in the HEC-RAS model) location is specified, all table results in this document refer to the downstream end of these catchments.

Table 2-1: Peak flows for existing conditions

AEP (%)	Catchment Peak flow (m^3/s)				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	40.4	6.9	11.2	10.8	6.4
1%	81.0	14.2	23.5	22.5	13.4
0.5%	93.8	16.9	27.4	26.3	15.6
0.2%	111.8	19.9	31.8	32.3	18.5
0.1%	128.2	22.4	35.4	36.5	20.4

The flows for the catchments in **Table 2-1** and flows for sub-catchments were used as inputs to the HEC-RAS models for each of the catchments. The cross sections for five catchments for the model are shown at **Figure 6-3** to **Figure 6-7**. The flow depths for the peak flows at the end of each of the catchments are shown in **Table 2-2**. The depths are the depth of water from the surface to the lowest point in the cross section in the Digital Elevation Model (DEM). Depending on the location of the proposed solar arrays these depths could be well downstream of the array locations. Specific array location-based results are presented in the technical section.

Table 2-2: Peak water levels for existing conditions

AEP (%)	Catchment Water Depths (m)				
	King Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.63	0.24	0.28	0.22	0.30
1%	0.99	0.37	0.41	0.35	0.49
0.5%	1.06	0.40	0.45	0.39	0.53
0.2%	1.17	0.44	0.49	0.44	0.65
0.1%	1.25	0.48	0.52	0.47	0.69

The regionalised model results provide a sound basis to compare the flood risk under existing levels of development (current conditions) with those under the Proposed Development.

3 Proposed development flood conditions

To determine the impact of the Proposed Development on flooding, an increase in impervious area was applied to the RORB model to represent the solar panels and the associated hard areas (e.g. operations and maintenance facilities). These impervious areas were determined based on GIS analysis of the supplied design information to determine the amount of impervious area in each of the RORB sub-areas.

As with the existing (no development) conditions, event durations from 10 minutes to 7 days were run through the models to determine the critical flood duration and volume for the 10% Annual Exceedance Probability (AEP), 1% AEP, 0.5% AEP, 0.2% AEP and 0.1% AEP events.

For the events modelled in RORB, the critical flood for the catchments were as per the existing conditions except for the north and north west 0.1%AEP events which reduced from 24 hours down to 6 hours. The peak flows showed minor decreases and increases in flows (-2.4% to 6.8%). These changes are due to the increase in impervious area resulting in the water running off in a different pattern and changing when peak flows occur compared to the existing conditions (fully pervious). The results are shown in **Table 3-1.**

Table 3-1: Peak theoretical flows for Proposed Development

AEP (%)	Catchment Peak flow (m^3/s) [Difference from existing (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	41.1 [0.8%]	7.2 [5%]	11.7 [4%]	10.8 [0.4%]	6.9 [6.8%]
1%	83.2 [3.2%]	14.5 [1.7%]	23.3 [-0.8%]	22.9 [1.5%]	13.3 [-0.8%]
0.5%	95.9 [3.2%]	16.5 [-2.4%]	26.9 [-1.8%]	26.5 [0.9%]	15.7 [1%]
0.2%	114.9 [6.6%]	20.3 [1.6%]	32.2 [1.3%]	31.8 [-1.6%]	18.9 [2.2%]
0.1%	129 [4.89%]	23.3 [3.9%]	36.2 [2.2%]	35.8 [-1.8%]	21.5 [5.2%]

The flows in **Table 3-1** and flows for the sub-catchments with the increased impervious areas were used as inputs to the HEC-RAS models. No change was made to the HEC-RAS models as the substation buildings will be placed outside the potential flood zone and the solar arrays should be designed and constructed so as to not impede the flow of flood water underneath them. **Table 3-2** outlines the water level results from the HEC-RAS models.

Table 3-2: Peak theoretical water levels for the Proposed Development

AEP (%)	Peak Water Level Depth (m) [Difference from existing (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.64 [1.6%]	0.25 [4.2%]	0.29 [3.6%]	0.23 [4.5%]	0.31 [3.3%]
1%	1 [1%]	0.37 [0%]	0.41 [0%]	0.35 [0%]	0.49 [0%]
0.5%	1.09 [2.8%]	0.4 [0%]	0.45 [0%]	0.4 [2.6%]	0.54 [1.9%]
0.2%	1.2 [2.6%]	0.45 [2.3%]	0.49 [0%]	0.44 [0%]	0.65 [0%]
0.1%	1.29 [3.2%]	0.49 [2.1%]	0.53 [1.9%]	0.48 [2.1%]	0.68 [-1.4%]

3.1 Potential for climate change impacts

Climate change assessment was undertaken using the Australian Rainfall and Runoff guidelines. The approach recommends applying a 5% change in design rainfall per degree of global warming. Predicted changes in temperature data is provided by the Australian Government through the Climate Change in Australia website (https://www.climatechangeinaustralia.gov.au). The assessment of the RCP 6 climate change scenario (median greenhouse gas emissions) for 2050 projected conditions (representing the design life of the Proposed Development) using the CMIP 5 global climate models (latest global climate models) produced a mean change in temperature of 1.5 degrees Celsius. Therefore, the IFD information used as part of the initial assessment was adjusted by 7.5% and the RORB models were re-run. The results are outlined in **Table 3-3** and **Table 3-4** and show that the peak flows increase by between 8.3% and 22.8% for existing conditions and between 7.3% and 19.2% for the proposed development conditions compared to the flows without climate change. Minor differences in percentage changes between the existing and proposed conditions are due to the change in runoff characteristics between the two models (i.e. increase in impervious area) and the use of the Monte Carlo (stochastic) approach to determine flows.

Table 3-3: Comparison of climate change flow results for RORB model for peak existing conditions

AEP (%)	Peak existing conditions climate change flow (m^3/s) [Difference to base design flows (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	47.5 [16.5%]	8.5 [22.8%]	13.6 [21%]	12.8 [18.9%]	7.5 [16.4%]
1%	90 [11.7%]	16.2 [14.1%]	25.8 [10%]	25.3 [12.3%]	14.5 [8.3%]
0.5%	103.9 [11.8%]	18.9 [11.6%]	30.7 [11.7%]	29.6 [12.5%]	17.3 [11.2%]
0.2%	123 [14.2%]	22.1 [10.8%]	35.9 [13.1%]	35.0 [8.3%]	20.6 [11%]
0.1%	137 [11.4%]	25.2 [12.6%]	39.2 [10.9%]	40.1 [9.9%]	23.1 [13.4%]

Table 3-4: Comparison of climate change flow results for RORB model for peak proposed conditions

AEP (%)	Peak existing conditions climate change flow (m^3/s) [Difference to base design flows (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	48.5 [18%]	8.2 [13.1%]	13.4 [14.5%]	12.9 [19.2%]	7.8 [13.9%]
1%	89.5 [7.6%]	16.4 [13.5%]	26.2 [12.3%]	25.8 [12.9%]	15.2 [14.4%]
0.5%	102.9 [7.3%]	19.2 [15.8%]	30.1 [11.7%]	29.9 [12.7%]	17.5 [11.3%]
0.2%	124.9 [8.7%]	21.9 [8.3%]	36.1 [12%]	34.3 [7.9%]	21 [11.1%]
0.1%	140.7 [9%]	25.1 [7.6%]	39.6 [9.6%]	39.1 [9.1%]	24.4 [13.5%]

These flows were applied to the HEC-RAS model to determine the effects of climate change on the water levels. The results show that for the critical duration storm event, the water levels will increase due to climate change. At the downstream end of the proposed site the levels are expected to increase by between 4.3% and 18.9% for the existing conditions events and between 3.1% and 16.7% for the proposed conditions events due to climate change (**Table 3-5** and **Table 3-6**). Comparing the climate change results within an event (e.g. the 1% AEP) shows that there is a slight increase in levels for the all the AEP events due to the critical duration of the peak flow event from the flows discussed above.

The difference between the existing conditions and the Proposed Development under current and climate change rainfalls show that there will be some differences under climate change. Any increases would be contained within or very near the channels (as modelled).

Table 3-5: Comparison of climate change water level results for the HEC-RAS model for peak existing conditions

AEP (%)	Peak existing conditions climate change water level (m) [Difference to base design water level (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.73 [15.9%]	0.27 [12.5%]	0.31 [10.7%]	0.25 [13.6%]	0.34 [13.3%]
1%	1.04 [5.1%]	0.39 [5.4%]	0.44 [7.3%]	0.37 [5.7%]	0.52 [6.1%]
0.5%	1.13 [6.6%]	0.43 [7.5%]	0.48 [6.7%]	0.42 [7.7%]	0.63 [18.9%]
0.2%	1.25 [6.8%]	0.47 [6.8%]	0.53 [8.2%]	0.47 [6.8%]	0.68 [4.6%]
0.1%	1.33 [6.4%]	0.51 [6.3%]	0.55 [5.8%]	0.5 [6.4%]	0.72 [4.3%]

Table 3-6: Comparison of climate change water level results for the HEC-RAS model for peak proposed conditions

AEP (%)	Peak proposed conditions climate change water level (m) [Difference to base design water level (%)				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.74 [15.6%]	0.27 [8%]	0.31 [6.9%]	0.25 [8.7%]	0.34 [9.7%]
1%	1.04 [4%]	0.4 [8.1%]	0.44 [7.3%]	0.39 [11.4%]	0.53 [8.2%]
0.5%	1.13 [3.7%]	0.43 [7.5%]	0.47 [4.4%]	0.42 [5%]	0.63 [16.7%]
0.2%	1.26 [5%]	0.47 [4.4%]	0.53 [8.2%]	0.47 [6.8%]	0.67 [3.1%]
0.1%	1.35 [4.7%]	0.51 [4.1%]	0.55 [3.8%]	0.52 [8.3%]	0.71 [4.4%]

4 Implications of results for the Proposed Development

The modelling undertaken as part of the EIS has been used to clarify whether the Proposed Development would have any significant impact on the flooding within and downstream of the development. Given the nature of a solar farm development, that is, the installation of solar panels raised above the ground (and therefore not impeding flow), the flow and water level analysis focused on whether the change in impervious area (hard surfaces) within the catchment would change the critical (peak) design flood flows.

As there was no historic flow or water level information for the catchment, the RORB (flow modelling) and HEC-RAS (water level modelling) models were parameterised based on regionalised information (including regionalised flood frequency estimates) and used to compare the differences between pre- and post-development conditions. Comparison of results based on similar models for the existing and proposed development cases) provides greater precision and accuracy than modelling of actual flows and levels and greater confidence can be paced on the relative change than on the actual level results. As the rationale for the modelling is to determine the potential impact of future changes to the catchment as a result of the proposed development, these impact assessments can be presented with a high level of confidence.

The overall outcome of analysing the effect of the development on flows and water levels shows that the development should have minimal impact on flooding associated with the critical storm for the catchments. The results show both minor increases and decreases in flow and level depending on which annual exceedance probability event is being examined for each catchment.

The rainfall events that result in an increase in flow levels would have negligible impact downstream of the site and those that show a decrease will act to reduce any flooding impact downstream for the critical storm duration (i.e. for 3, 6 or 12-hour durations, depending on the catchment).

5 Technical Detail of Water Volume Modelling

This section outlines the flow volume modelling that was undertaken to determine flows through the site. These flows were used as inputs to determine the water levels through the site.

5.1 Regional Analysis

To provide an estimate of the likely design flow volumes from the catchment the Regional Flood Frequency Estimation (RFFE) model (http://rffe.arr-software.org/) was used. It uses information from nearby similar catchments to provide an estimation of their 6-hour peak durations. The details required for this are:

- Catchment outlet location (latitude and longitude);
- Catchment centroid location (latitude and longitude); and
- Catchment area.

The results of RFFE models for all five catchments are shown in **Figure 5-1** to **Figure 5-5**.

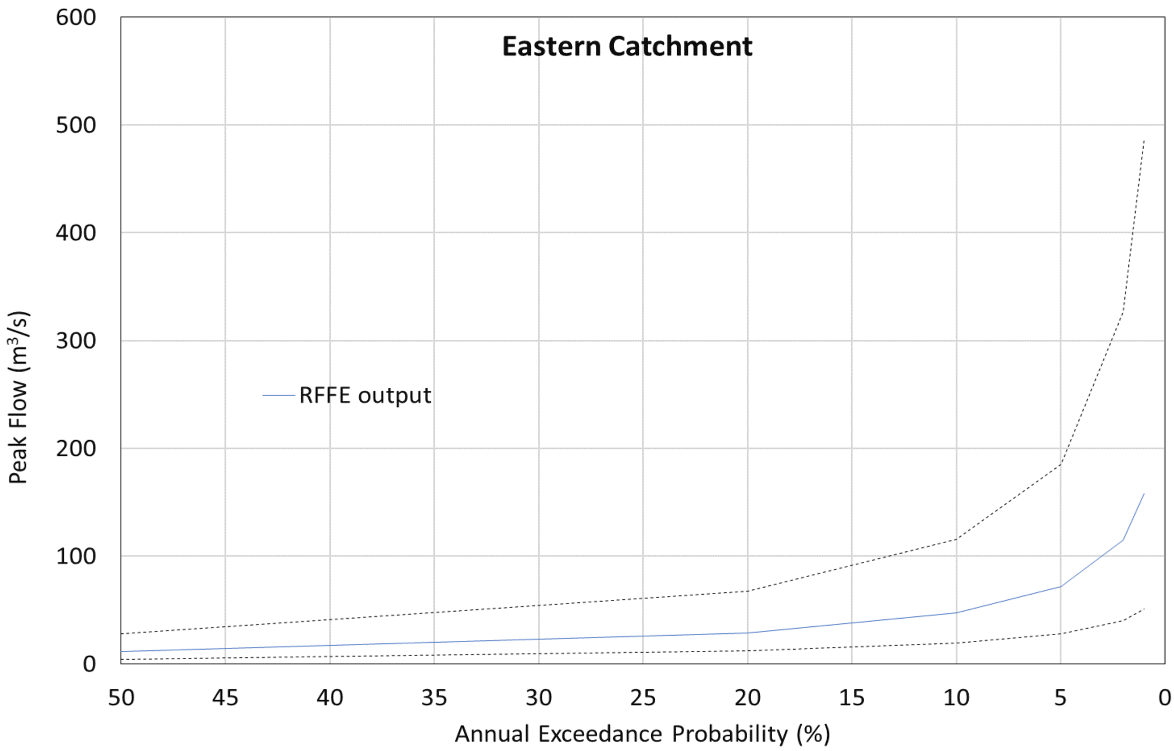

Figure 5-1 RFFE 6-hour estimates for Kings Plains Creek (Eastern Catchment) with dashed lines representing 5% and 95% confidence intervals.

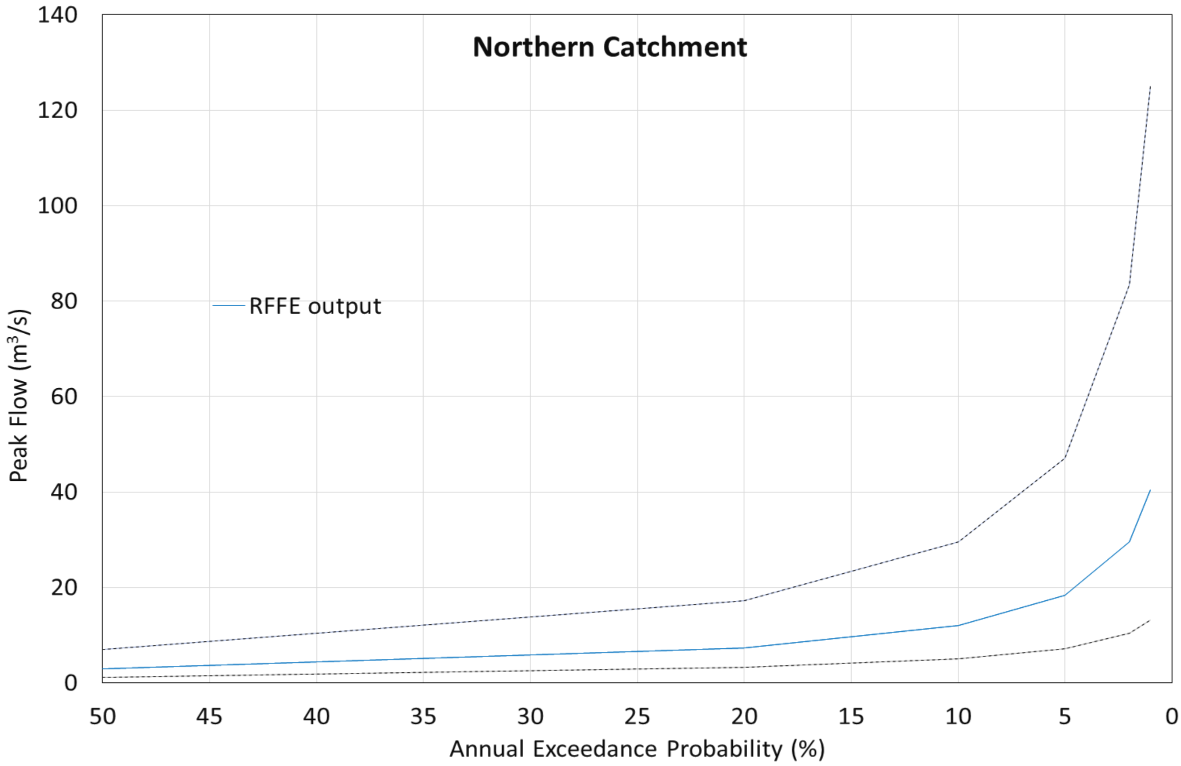

Figure 5-2 RFFE 6-hour estimates for Frazers Creek (Northern Catchment) with dashed lines representing 5% and 95% confidence intervals.

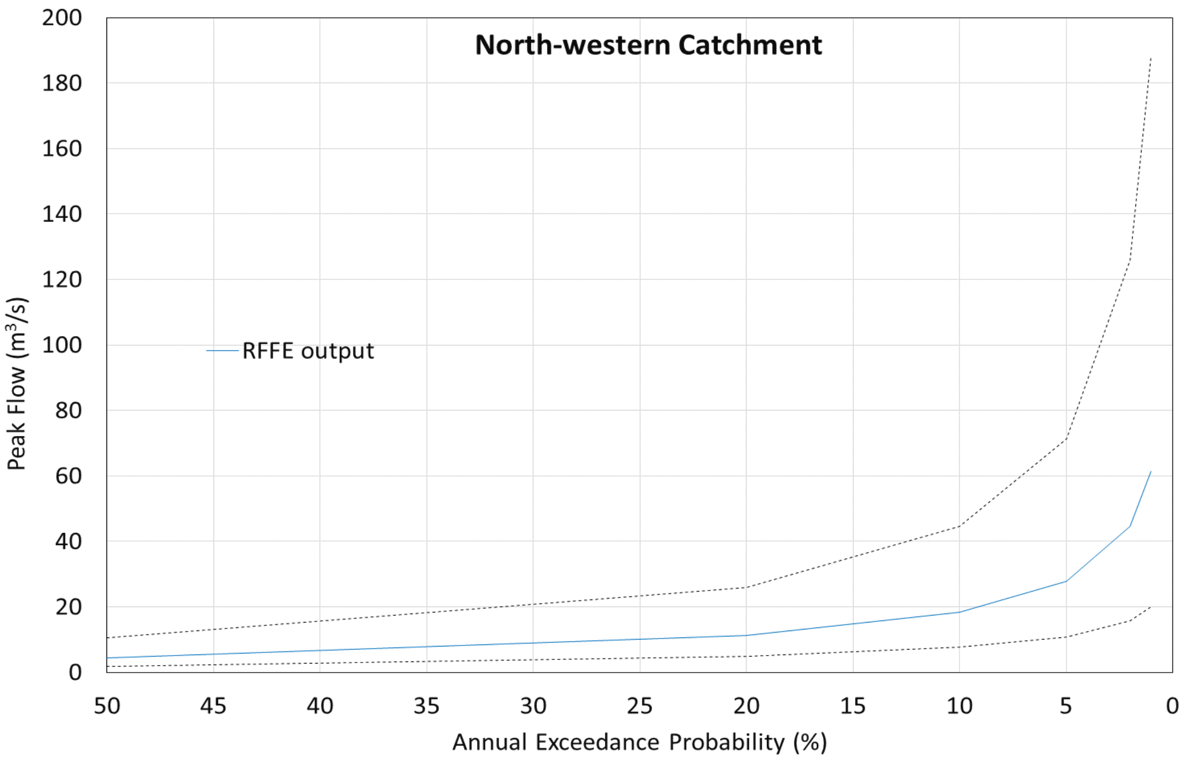

Figure 5-3 RFFE 6-hour estimates for Horse Gully (North-western Catchment) with dashed lines representing 5% and 95% confidence intervals.

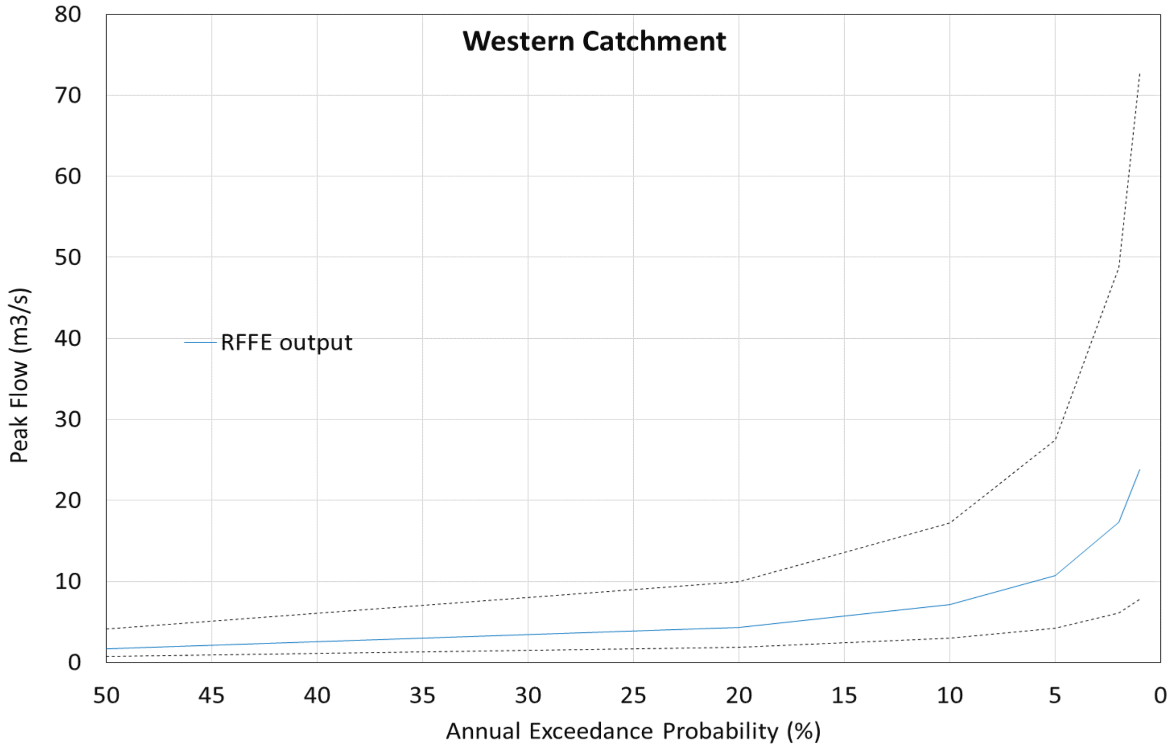

Figure 5-4 RFFE 6-hour estimates for Mary Anne Creek (Western Catchment) with dashed lines representing 5% and 95% confidence intervals.

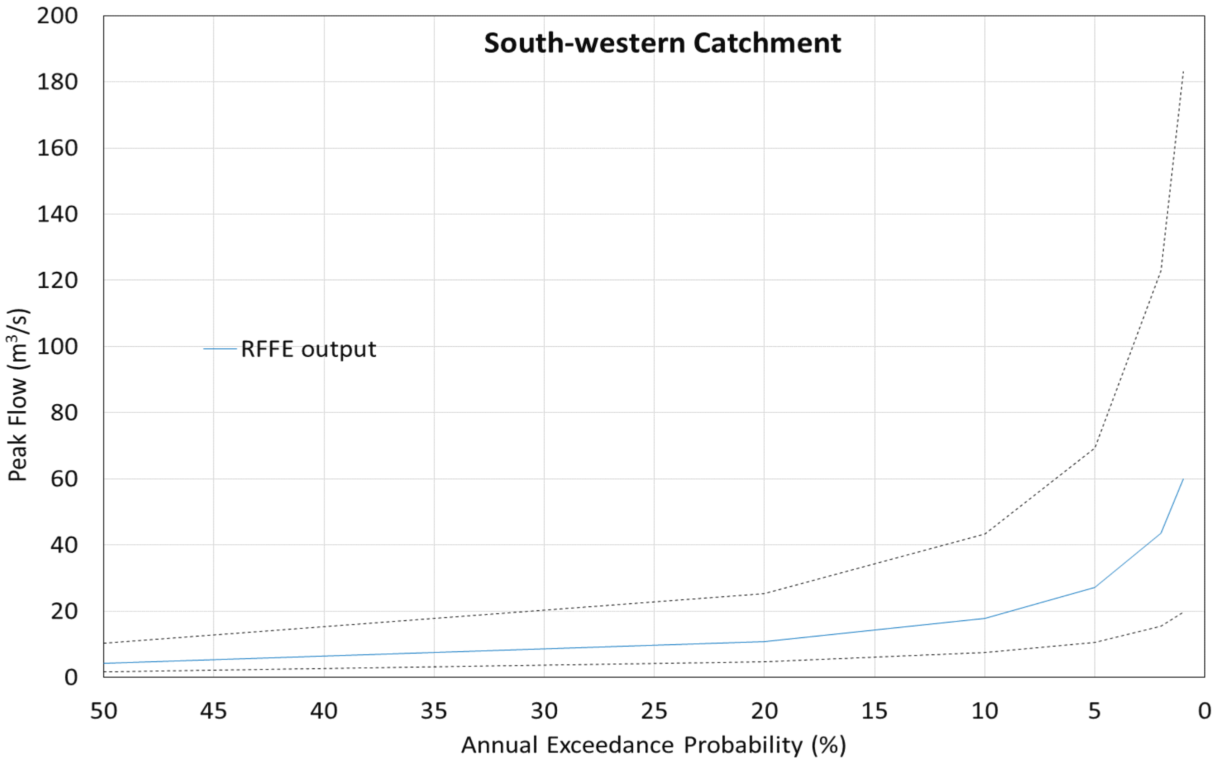

Figure 5-5 RFFE 6-hour estimates for Apple Tree Creek (South-western Catchment) with dashed lines representing 5% and 95% confidence intervals.

5.2 Catchments

Figure 2-1 shows the proposed site and the catchments determined based on the available DEM. The analysis of the proposed site and the DEM determined that most of the site fell within one watershed region. The components that fell within other watersheds were deemed to have negligible impact on flood volumes as:

- There would be minimal runoff generated from rainfall from such small areas;
- The regions are at the very top of the watershed; and,
- The solar arrays are mounted on steel piles above the ground and are not sensitive to flooding, as:
    - The PV panel is located approximately 1 m above ground level, and hence out of flood;
    - The piles are water resistant and do not impede the movement of floodwaters; and
    - Cabling and electrical equipment is water resistant and can be located in areas outside of flood risk.

For the purposes of RORB modelling the study area was divided up into five catchments (Eastern, Northern, North-western, Western and South-western catchments that represent Kings Plains Creek, Frazers Creek, Horse Gully, Mary Anne Creek and Apple Tree Gully respectively) and were further sub-divided into a number of sub-catchments for inclusion in the model. The catchment and link details for the existing and post solar farm conditions that are applied to the RORB catchment file, shown in **Figure 5-6** to **Figure 5-10**, are outlined in **Appendix A**. These characteristics were determined using GIS analysis in ArcMap. The percent impervious for the Proposed Development conditions was determined by averaging the impervious area of the Proposed Development across the Site and then determining the areas which fall within each of the RORB sub-areas.

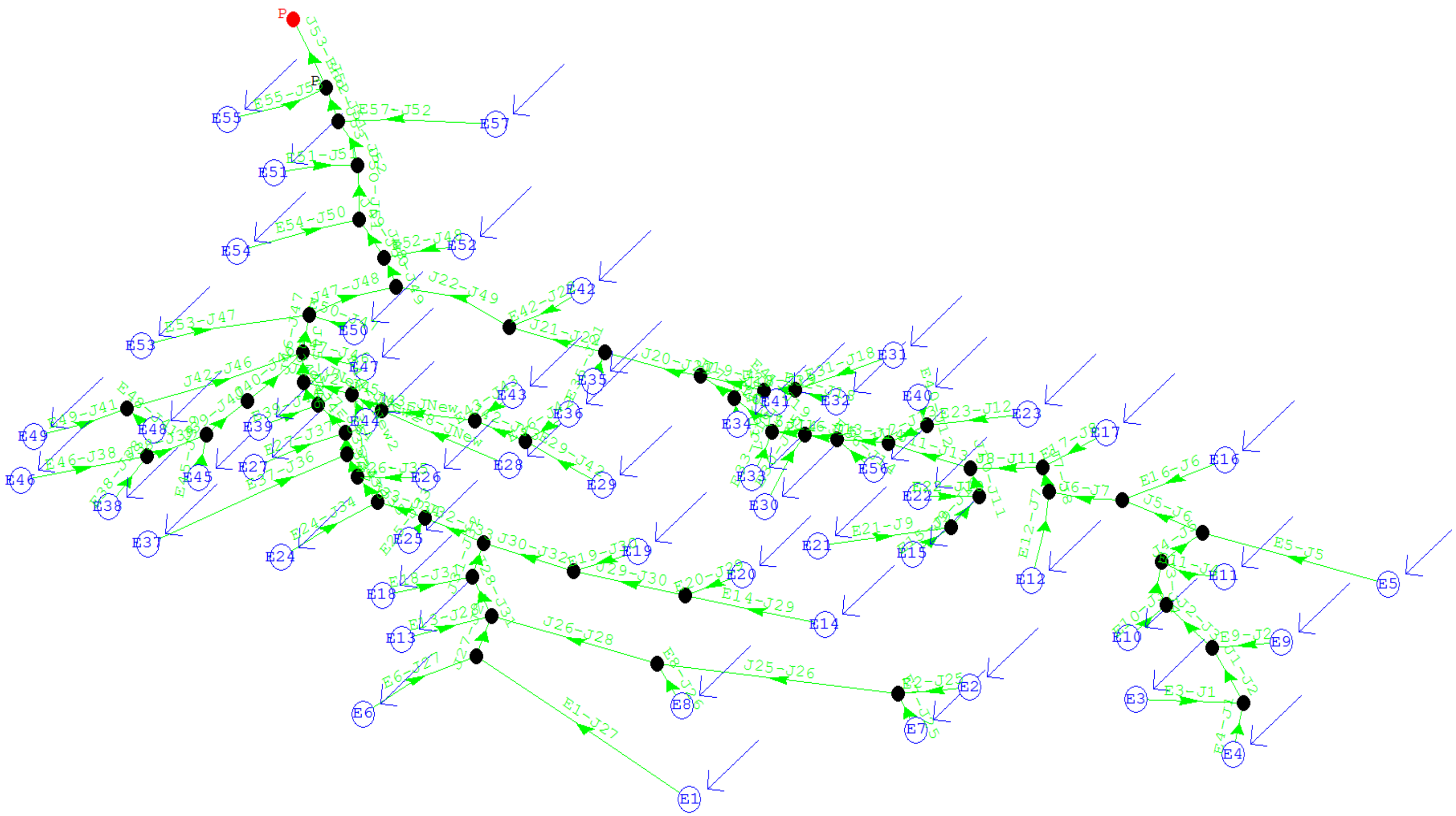

Figure 5-6 RORB catchment file for Eastern Catchment (Kings Plains Creek)

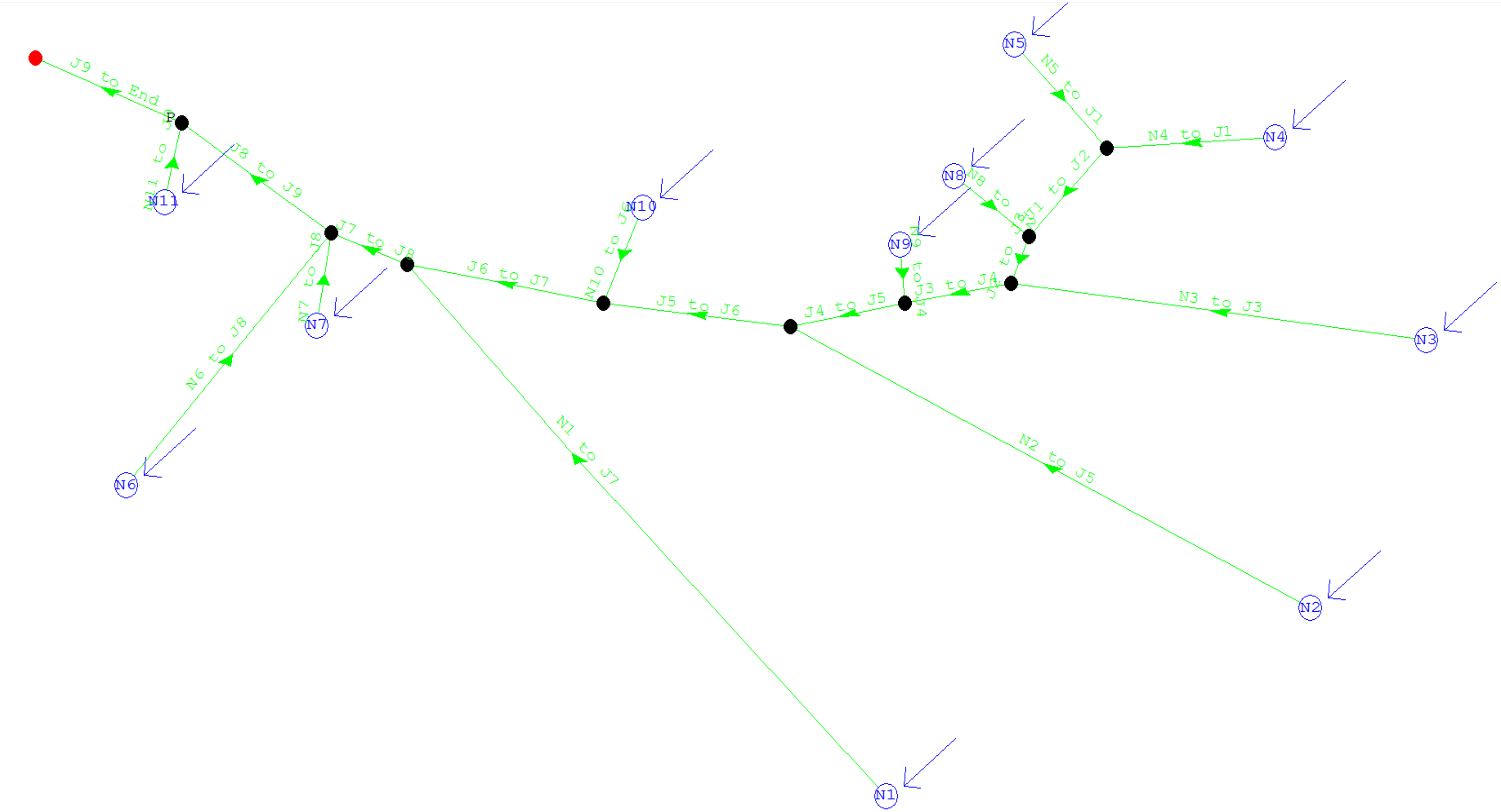

Figure 5-7 RORB catchment file for Northern Catchment (Frazers Creek)

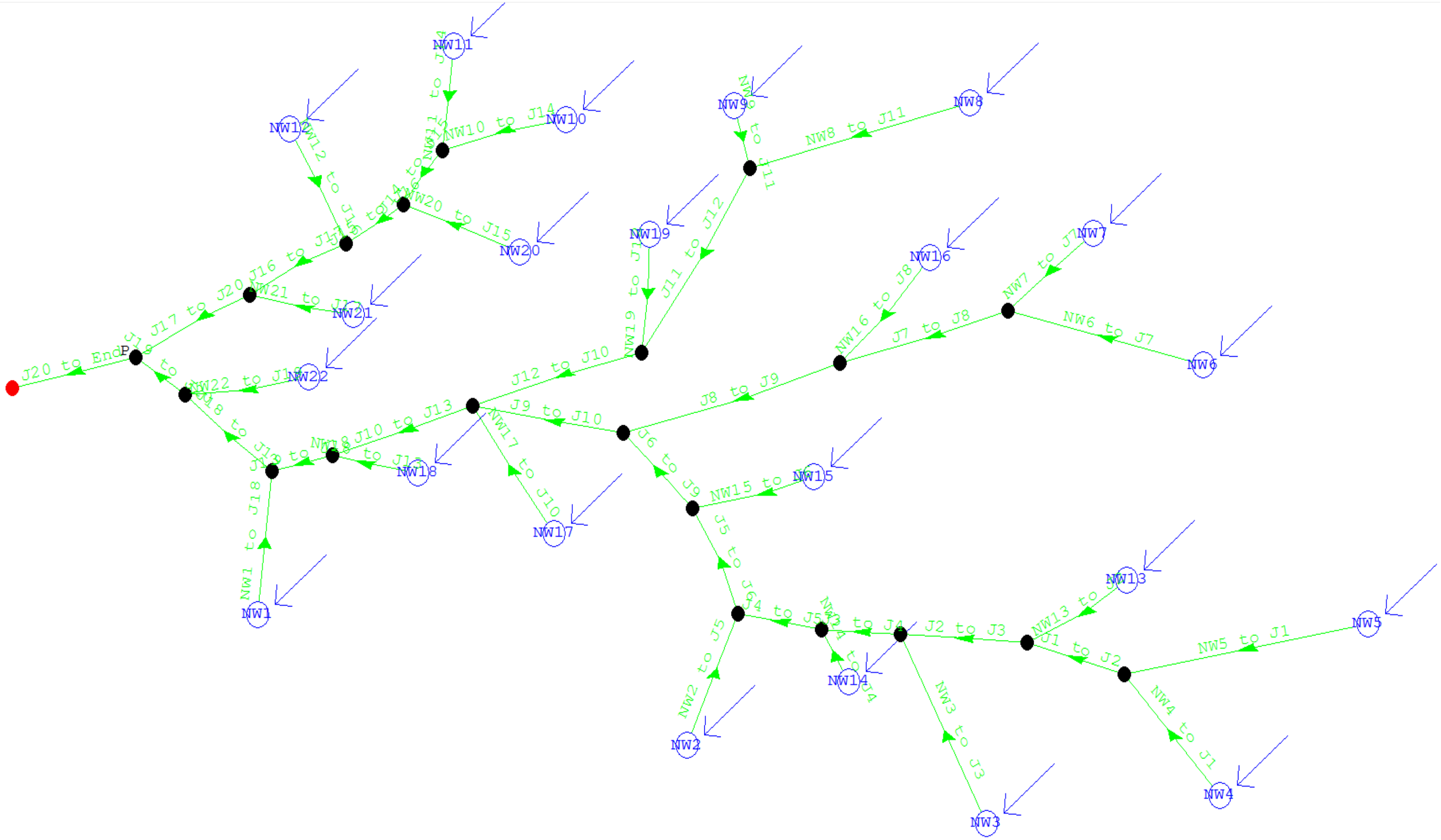

Figure 5-8 RORB catchment file for North-Western Catchment (Horse Gully)

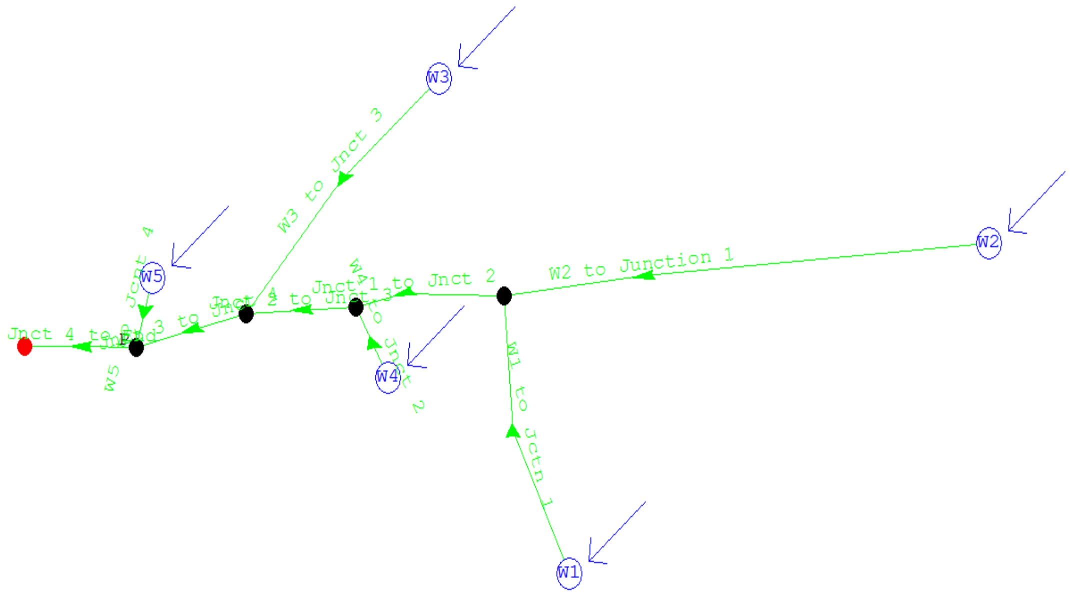

Figure 5-9 RORB catchment file for Western Catchment (Mary Anne Creek)

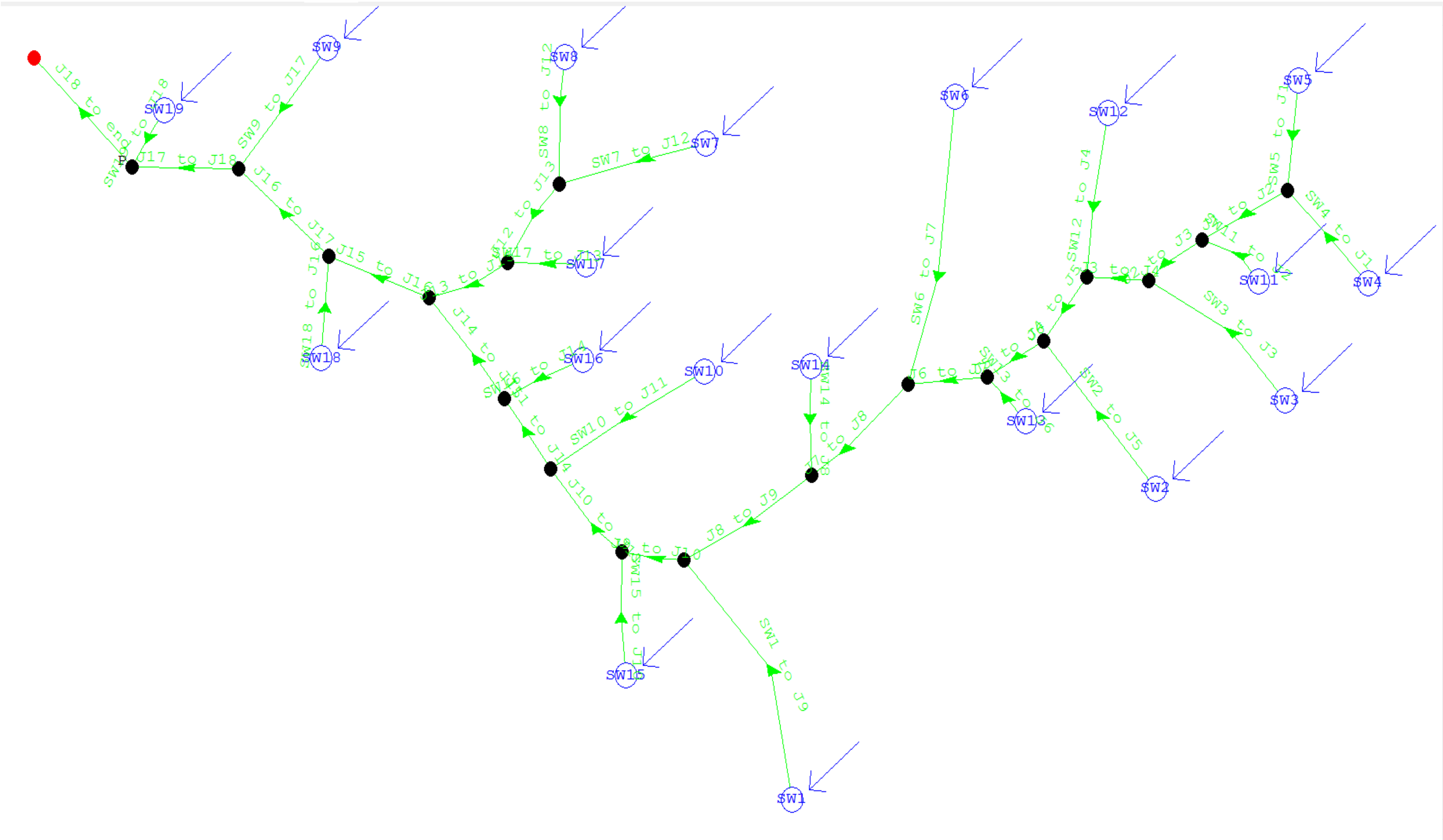

Figure 5-10 RORB catchment file for South-Western Catchment (Apple Tree Creek)

5.3 Intensity-Frequency-Duration (IFD) Information

The IFD information was sourced for the Site from the 2016 Bureau of Meteorology (BoM) IFD curves on November 20th, 2017 for coordinate 29.7125°S and 151.4375°E and is outlined in **Table 5-1**. Exceedances rarer than the 1% AEP less than 24 hours in duration were not available on the BoM website and were infilled based on a logarithmic regression.

The temporal pattern used for this was sourced from Australian Rainfall and Runoff 2016 and is discussed in the Australian Rainfall and Runoff Section.

Table 5-1: IFD information for Sapphire Solar Farm Project site

Duration	Annual Exceedance Probability Rainfall Depths (mm)										
	63.2%	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.2%**	**0.1%**	**0.05%**
1 min	1.96	2.2	2.98	3.52	4.07	4.81	5.39	5.96	6.71	7.28	7.84
2 min	3.41	3.83	5.17	6.11	7.02	8.19	9.05	10.08	11.32	12.26	13.19
3 min	4.72	5.3	7.15	8.44	9.7	11.3	12.6	13.97	15.69	16.99	18.3
4 min	5.88	6.6	8.91	10.5	12.1	14.2	15.8	17.52	19.69	21.34	22.98
5 min	6.92	7.76	10.5	12.4	14.3	16.8	18.7	20.74	23.33	25.28	27.23
10 min	10.8	12.1	16.4	19.5	22.5	26.6	29.9	33.03	37.21	40.36	43.52
15 min	13.5	15.2	20.5	24.3	28.1	33.4	37.5	41.4	46.64	50.6	54.57
30 min	18.4	20.7	28.1	33.3	38.5	45.7	51.3	56.7	63.88	69.32	74.75
1 hour	23.8	26.6	35.9	42.5	49	57.9	64.8	71.63	80.6	87.39	94.18
2 hour	29.5	32.9	44	51.7	59.6	70.1	78.4	86.5	97.19	105.28	113.36
3 hour	33.3	37	49.1	57.5	66.1	77.7	86.8	95.61	107.3	116.15	125
6 hour	41	45.3	59.2	69	78.9	92.7	104	113.87	127.58	137.96	148.33
12 hour	50.7	55.8	72.4	84	95.8	112	126	137.51	153.85	166.21	178.58
24 hour	63	69.4	90	104	119	139	155	175	200	221	243
48 hour	77.5	85.8	112	130	147	170	188	206	231	251	271
72 hour	86.4	95.8	125	145	164	188	206	224	248	266	284
96 hour	92.5	103	134	154	174	198	217	234	257	275	292
120 hour	97	107	139	160	180	204	222	240	263	281	298
144 hour	100	111	143	163	183	206	225	243	267	284	302
168 hour	103	113	144	164	183	206	225	245	269	287	304

5.4 Australian Rainfall and Runoff Information

The other information required for setting up the RORB model was sourced from the Australian Rainfall and Runoff (2016) data hub (http://data.arr-software.org) for the same location as for the IFD information. The key information obtained were the temporal patterns and the losses. The region that these parameters are sourced from is the Border Rivers with the particular region being Semi-arid inland QLD.

For this region, the initial loss is 26.0 mm and the continuing loss is 2.8 mm/hr. Patterns were available for the durations outlined in **Table 5-2**, the shaded durations are durations were IFD information is not available (and therefore were not used).

Table 5-2: Temporal Pattern Durations from Australian Rainfall and Runoff

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

The temporal pattern information was used to provide inputs to the Monte Carlo model run in RORB. A base set of patterns were used as part of defining the IFD information in RORB. As a Monto Carlo run was being undertaken, the first pattern for each of the durations was used to complete the IFD specification.

5.5 Parameter File

As there is no observed flow data for this catchment, the RORB parameter file was set-up using the "Separate catchment and generated design storm(s)" option. The model operates using a single set of routing parameters for the whole model and an initial loss / continuing loss model. The design rainfall specification used is:

- A user defined IFD (detailed above);
- Monte Carlo simulation from 10 minute to 168 hour durations;
- Default time increments of 70;
- Uniform areal pattern; and
- Constant losses.

The parameter specification is:

- Main routing parameter for the overall catchment, with k_c values, as shown below, for each catchment to calibrate to RFFE analysis (results shown below)
    - Eastern catchment (Kings Plains Creek): 5.13
    - Northern catchment (Frazers Creek): 6.48
    - North-western catchment (Horse Gully): 5.98
    - Western catchment (Mary Anne Creek): 3.68
    - South-western catchment (Apple Tree Creek): 6.03

- Dimensionless exponent for non-linear routing, m of 0.8; and,
- Initial loss and continuing loss based on the Australian Rainfall and Runoff values discussed above.

The Monte Carlo simulation details are:

- Number of rainfall divisions: 50 (default);
- Number of samples per division: 20 (default);
- Temporal patterns as described above;
- No pattern censoring; and
- Fixed initial loss.

5.6 Calibration Results

The RORB model was calibrated to the RFFE analysis to fit within the confidence limits of the results. This calibration targeted obtaining the best possible fit across the 1%, 2%, 5%, 20% and 50% AEP results (closet to best estimate). The outcome of this is shown in **Figure 5-11** to **Figure 5-15** and shows that the 1%, 2%, 5%, 20% and 50% AEP results fall within the confidence limits of the RFFE analysis. For some of the catchments the 1% AEP result is at the lower end of the confidence limits. While not ideal, this is still acceptable as adjusting the model results to fit the 1% AEP result closer to the median of the RFFE results would push the other AEP results outside the confidence limits. The critical flood (the flood with the highest peak flow) for these catchments are:

- Eastern Catchment (Kings Plains Creek): 6 hours or 12 hours;
- Northern Catchment (Frazers Creek): 6 hours or 12 hours except for the 0.1% AEP which is 24 hours;
- North-western Catchment (Horse Gully): 6 hours or 12 hours except for the 0.1%AEP which is 24 hours;
- Western Catchment (Mary Anne Creek): 3 hours or 6 hours; and,
- South-western catchment (Apple Tree Gully): 6 hours or 12 hours.

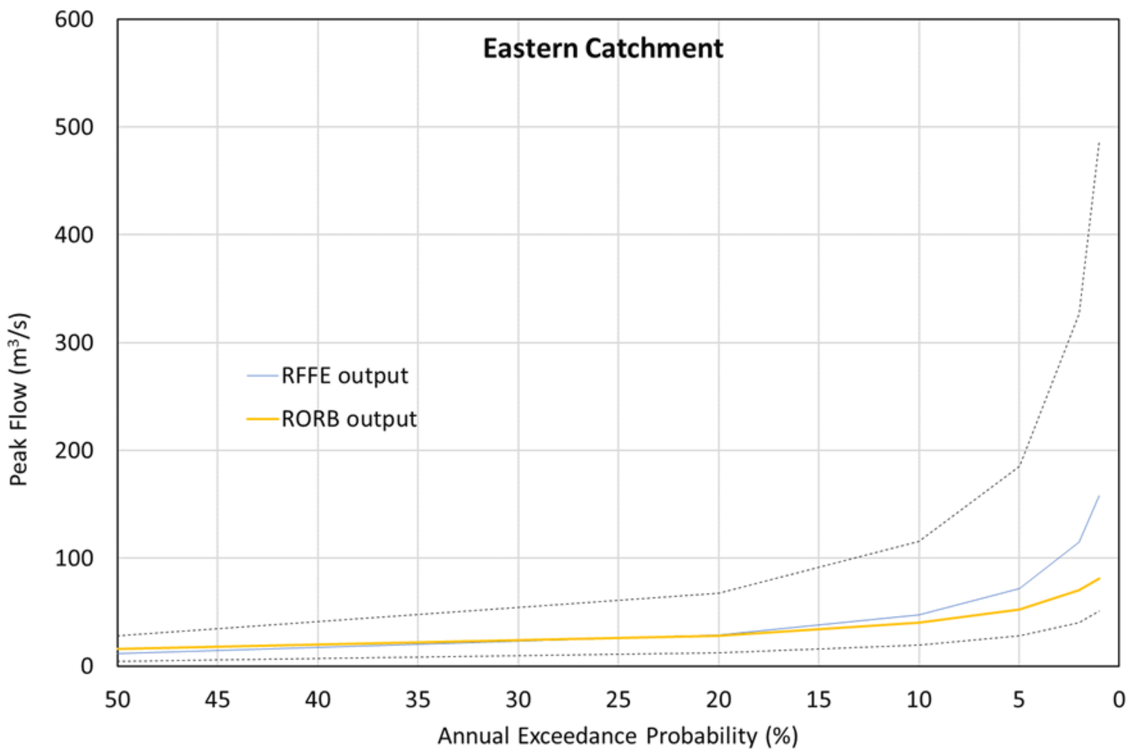

Figure 5-11 RFFE – RORB calibration for the Eastern Catchment (Kings Plains Creek)

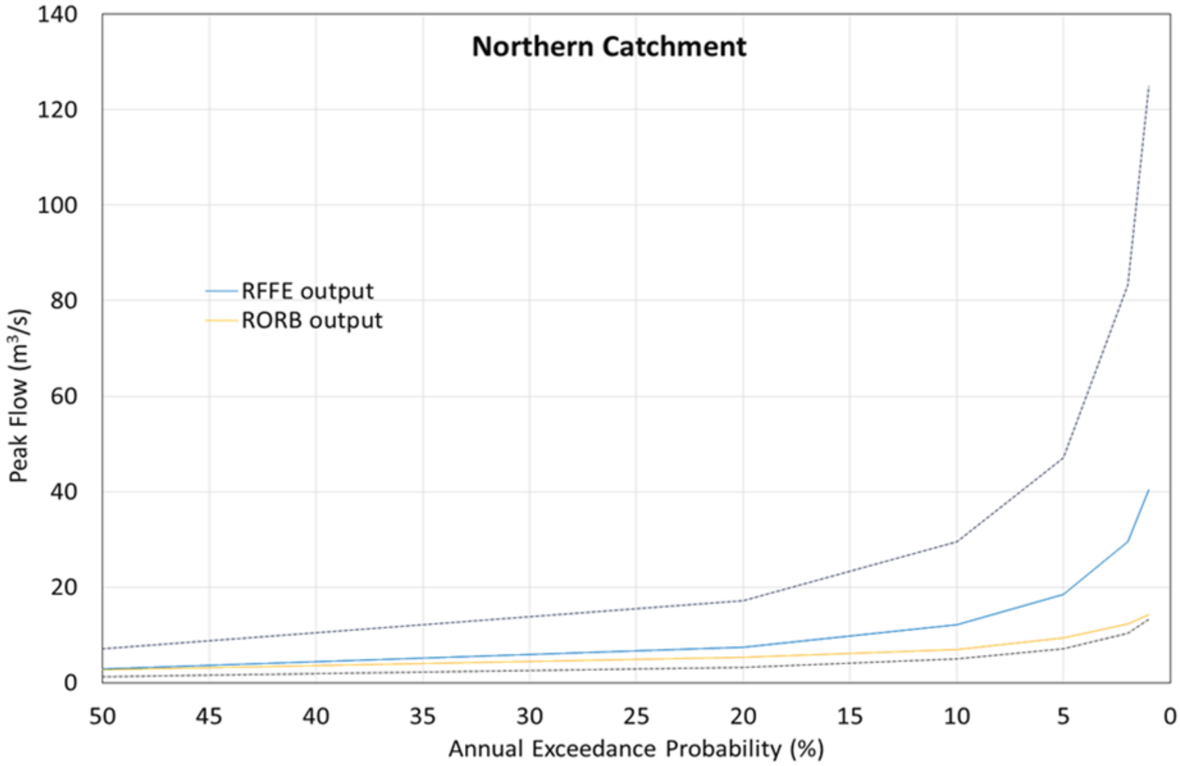

Figure 5-12 RFFE – RORB calibration for the Northern Catchment (Frazers Creek)

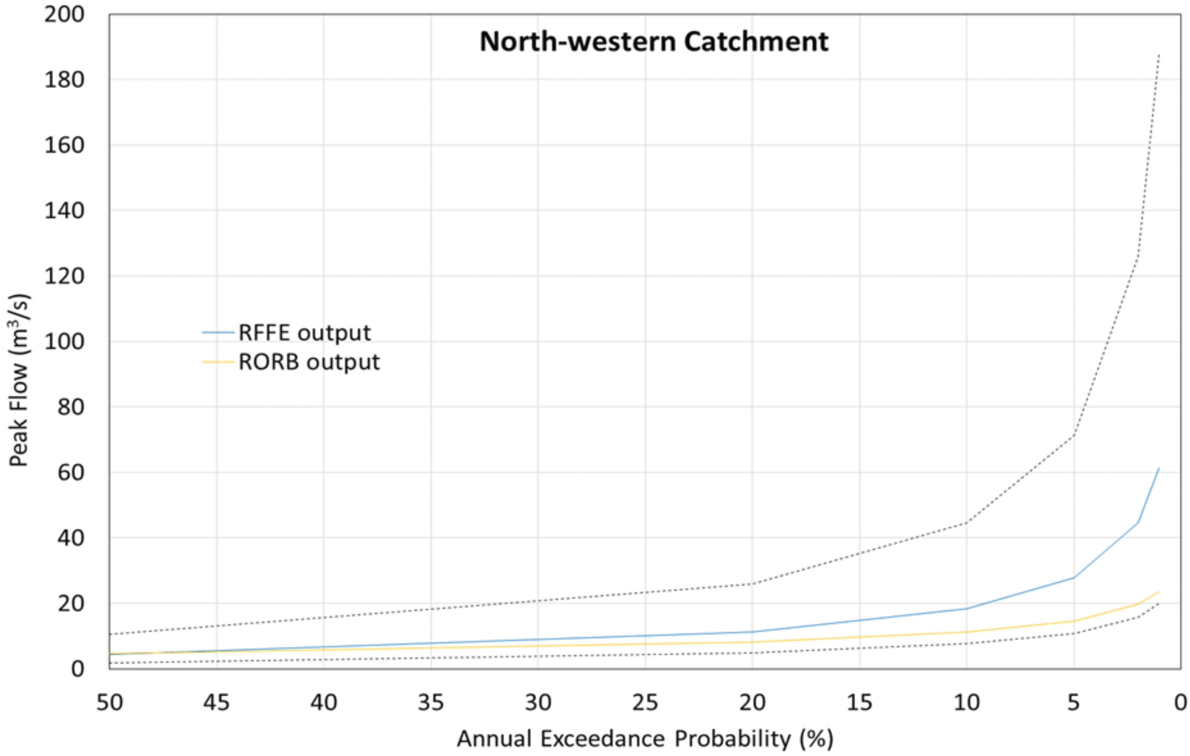

Figure 5-13 RFFE – RORB calibration for the North-western Catchment (Horse Gully)

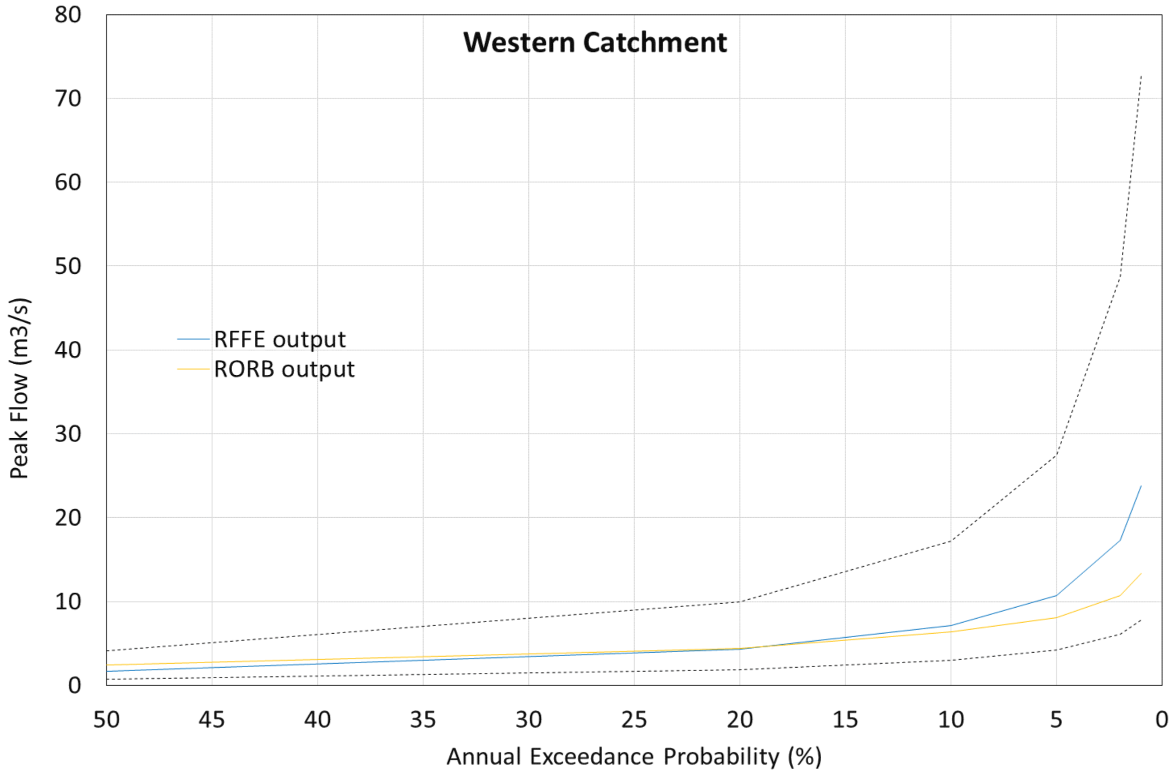

Figure 5-14 RFFE – RORB calibration for the Western Catchment (Mary Anne Creek)

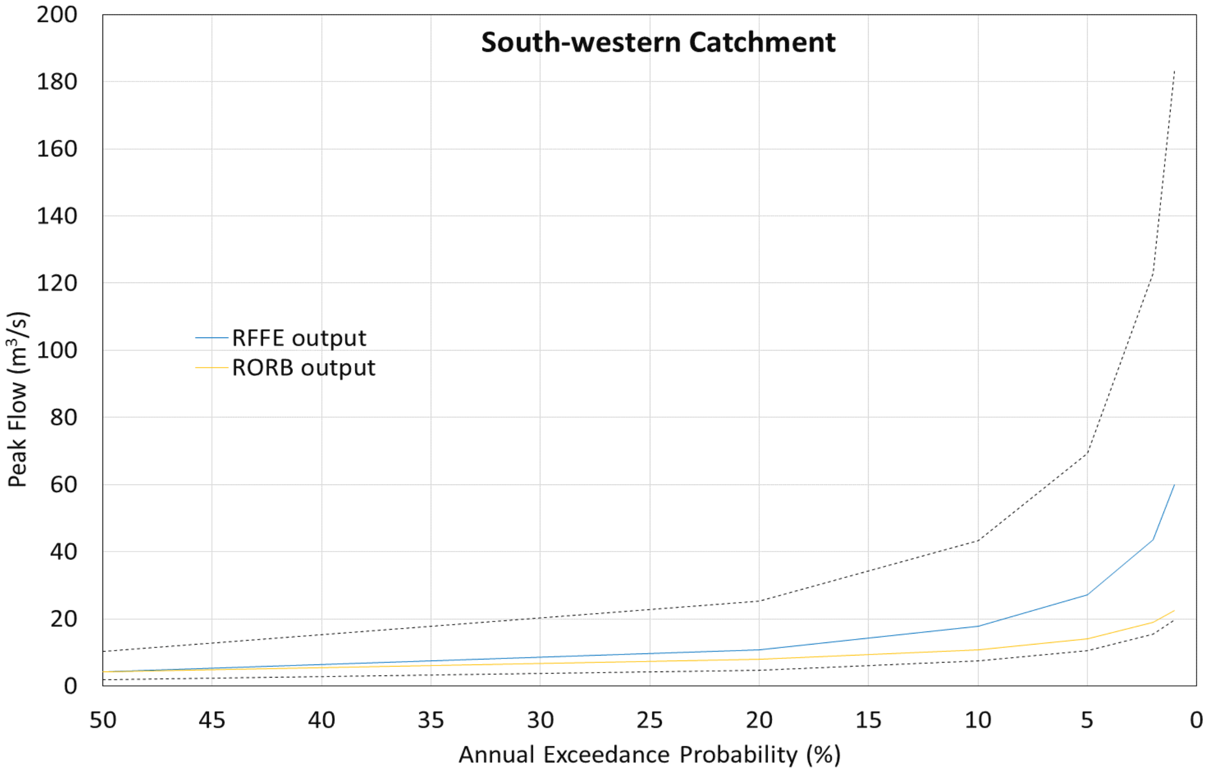

Figure 5-15 RFFE – RORB calibration for the South-western Catchment (Apple Tree Gully)

5.7 Climate Change Impacts

The latest release of Australian Rainfall and Runoff provides guidance on incorporating the effects of climate change in design rainfall and flood estimation. This guidance suggests that using lower frequency AEPs (e.g. the 0.5% AEP and 0.2% AEP events) in lieu of undertaking an actual climate change assessment was not appropriate. Therefore, a climate change assessment was undertaken using the Australian Rainfall and Runoff guidelines. The approach recommends applying a 5% change in design rainfall per degree of global warming.

To obtain the change in temperature, data provided by the Australian Government through the Climate Change in Australia website (https://www.climatechangeinaustralia.gov.au) was used. The assessment of the RCP 6 climate change scenario for 2050 projected conditions (representing the design life of the Proposed Development) using the CMIP 5 global climate models produced a mean change in temperature of 1.5 degrees Celsius for the Central Slopes climate region. Therefore, the IFD information used as part of the initial assessment (**Table 5-1**) was adjusted by 7.5% and the RORB models re-run (**Table 5-3**).

Table 5-3: Climate change IFD information for Sapphire Solar Farm Project site

Duration	Annual Exceedance Probability Rainfall Depths (mm)										
	63.2%	50%	20%	10%	5%	2%	1%	0.5%	0.2%	0.1%	0.05%
1 min	2.1	2.4	3.2	3.8	4.4	5.2	5.8	6.4	7.2	7.8	8.4
2 min	3.7	4.1	5.6	6.6	7.6	8.8	9.7	10.8	12.2	13.2	14.2
3 min	5.1	5.7	7.7	9.1	10.4	12.2	13.6	15.0	16.9	18.3	19.7
4 min	6.3	7.1	9.6	11.3	13.0	15.3	17.0	18.8	21.2	22.9	24.7
5 min	7.4	8.3	11.3	13.3	15.4	18.1	20.1	22.3	25.1	27.2	29.3
10 min	11.6	13.0	17.6	21.0	24.2	28.6	32.1	35.5	40.0	43.4	46.8
15 min	14.5	16.3	22.0	26.1	30.2	35.9	40.3	44.5	50.1	54.4	58.7
30 min	19.8	22.3	30.2	35.8	41.4	49.1	55.2	61.0	68.7	74.5	80.4
1 hour	25.6	28.6	38.6	45.7	52.7	62.2	69.7	77.0	86.7	93.9	101.2
2 hour	31.7	35.4	47.3	55.6	64.1	75.4	84.3	93.0	104.5	113.2	121.9
3 hour	35.8	39.8	52.8	61.8	71.1	83.5	93.3	102.8	115.4	124.9	134.4
6 hour	44.1	48.7	63.6	74.2	84.8	99.7	111.8	122.4	137.2	148.3	159.5
12 hour	54.5	60.0	77.8	90.3	103.0	120.4	135.5	147.8	165.4	178.7	192.0
24 hour	67.7	74.6	96.8	111.8	127.9	149.4	166.6	188.1	215.0	237.6	261.2
48 hour	83.3	92.2	120.4	139.8	158.0	182.8	202.1	221.5	248.3	269.8	291.3
72 hour	92.9	103.0	134.4	155.9	176.3	202.1	221.5	240.8	266.6	286.0	305.3
96 hour	99.4	110.7	144.1	165.6	187.1	212.9	233.3	251.6	276.3	295.6	313.9
120 hour	104.3	115.0	149.4	172.0	193.5	219.3	238.7	258.0	282.7	302.1	320.4
144 hour	107.5	119.3	153.7	175.2	196.7	221.5	241.9	261.2	287.0	305.3	324.7
168 hour	110.7	121.5	154.8	176.3	196.7	221.5	241.9	263.4	289.2	308.5	326.8

5.8 Model Outputs

The models were run to provide inputs to the HEC-RAS modelling. A summary of the peak flows for each exceedance probability are shown in the tables below (**Table 5-4** to **Table 5-7**). The differences across the range of AEP events are shown in **Figure 5-16** to **Figure 5-20** and compare the natural existing, natural developed, climate change existing and climate change developed results with each other for each catchment. It can be seen that there is minimal change between the climate change and the natural systems. Individual event duration flows are shown in **Appendix B**.

Table 5-4: Peak design flows for existing conditions

AEP (%)	Catchment Peak flow (m³/s)				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	40.4	6.9	11.2	10.8	6.4
1%	81.0	14.2	23.5	22.5	13.4
0.5%	93.8	16.9	27.4	26.3	15.6
0.2%	111.8	19.9	31.8	32.3	18.5
0.1%	128.2	22.4	35.4	36.5	20.4

Table 5-5: Peak design flows for Proposed Development

AEP (%)	Catchment Peak flow (m³/s) [Difference from existing (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	40.4 [-0.1%]	7.2 [5%]	11.7 [4%]	10.8 [0.4%]	6.9 [6.8%]
1%	82.5 [1.9%]	14.5 [1.7%]	23.3 [-0.8%]	22.9 [1.5%]	13.3 [-0.8%]
0.5%	95.4 [1.8%]	16.5 [-2.4%]	26.9 [-1.8%]	26.5 [0.9%]	15.7 [1%]
0.2%	113.3 [1.3%]	20.3 [1.6%]	32.2 [1.3%]	31.8 [-1.6%]	18.9 [2.2%]
0.1%	128.2 [0.03%]	23.3 [3.9%]	36.2 [2.2%]	35.8 [-1.8%]	21.5 [5.2%]

Table 5-6: Comparison of climate change design flow results for RORB model for peak existing conditions

AEP (%)	Peak existing conditions climate change flow (m³/s) [Difference to base design flows (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	47.0 [16.2%]	8.5 [22.8%]	13.6 [21%]	12.8 [18.9%]	7.5 [16.4%]
1%	89.3 [10.3%]	16.2 [14.1%]	25.8 [10%]	25.3 [12.3%]	14.5 [8.3%]
0.5%	103.0 [9.8%]	18.9 [11.6%]	30.7 [11.7%]	29.6 [12.5%]	17.3 [11.2%]
0.2%	122.1 [9.2%]	22.1 [10.8%]	35.9 [13.1%]	35.0 [8.3%]	20.6 [11%]
0.1%	137.3 [7.1%]	25.2 [12.6%]	39.2 [10.9%]	40.1 [9.9%]	23.1 [13.4%]

Table 5-7: Comparison of climate change design flow results for RORB model for peak proposed conditions

	Peak existing conditions climate change flow (m³/s) [Difference to base design flows (%)]

AEP (%)	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	48.2 [19.2%]	8.2 [13.1%]	13.4 [14.5%]	12.9 [19.2%]	7.8 [13.9%]
1%	89.1 [8%]	16.4 [13.5%]	26.2 [12.3%]	25.8 [12.9%]	15.2 [14.4%]
0.5%	102.2 [7.1%]	19.2 [15.8%]	30.1 [11.7%]	29.9 [12.7%]	17.5 [11.3%]
0.2%	124.7 [10.1%]	21.9 [8.3%]	36.1 [12%]	34.3 [7.9%]	21 [11.1%]
0.1%	141.2 [10.1%]	25.1 [7.6%]	39.6 [9.6%]	39.1 [9.1%]	24.4 [13.5%]

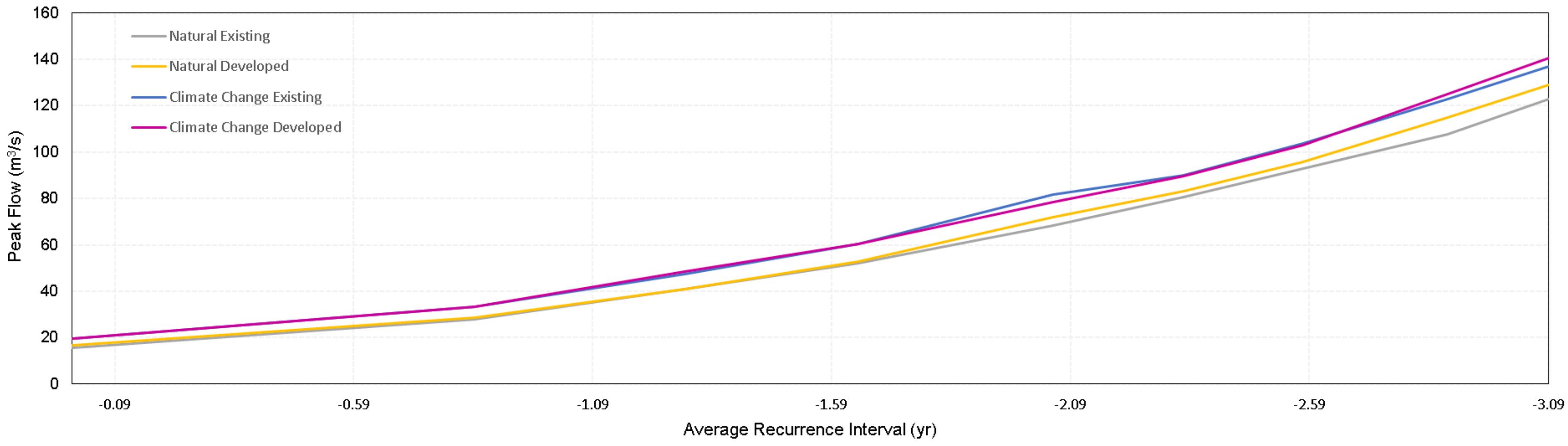

Figure 5-16 Kings Plains Creek (Eastern Catchment) Peak Design Flows

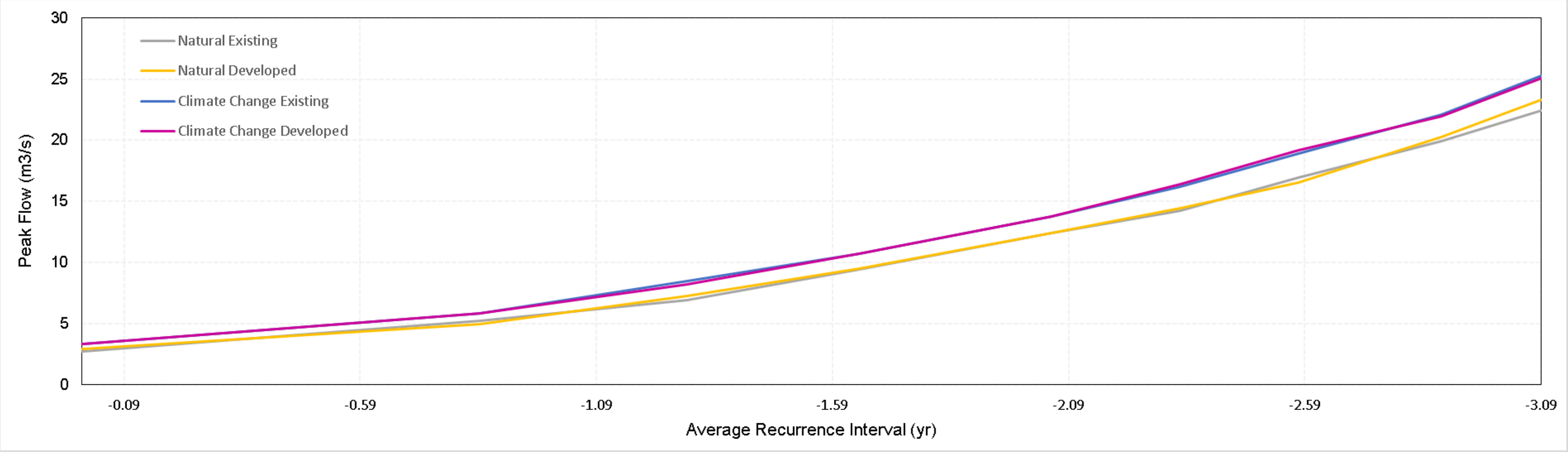

Figure 5-17 Frazers Creek (Northern Catchment) Peak Design Flows

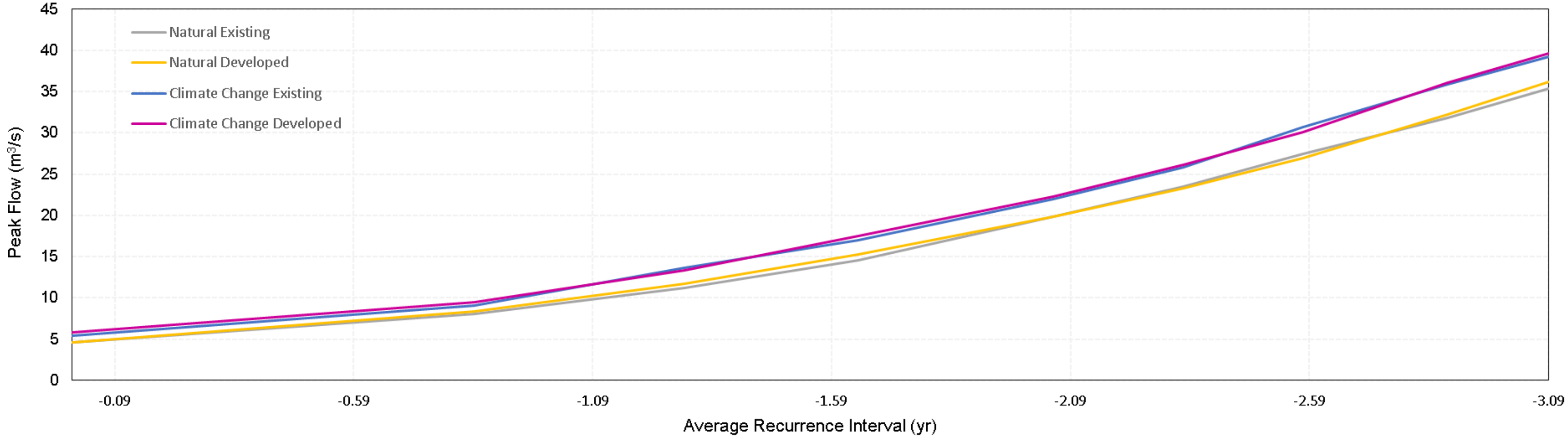

Figure 5-18 Horse Gully (North-western Catchment) Peak Design Flows

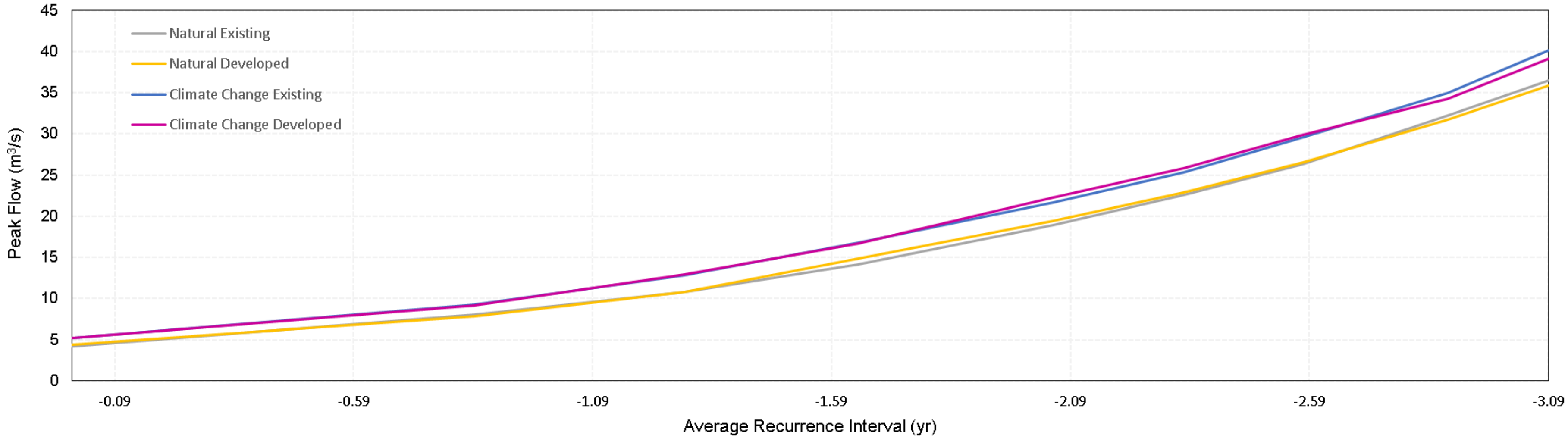

Figure 5-19 Apple Tree Gully (South-western Catchment) Peak Design Flows

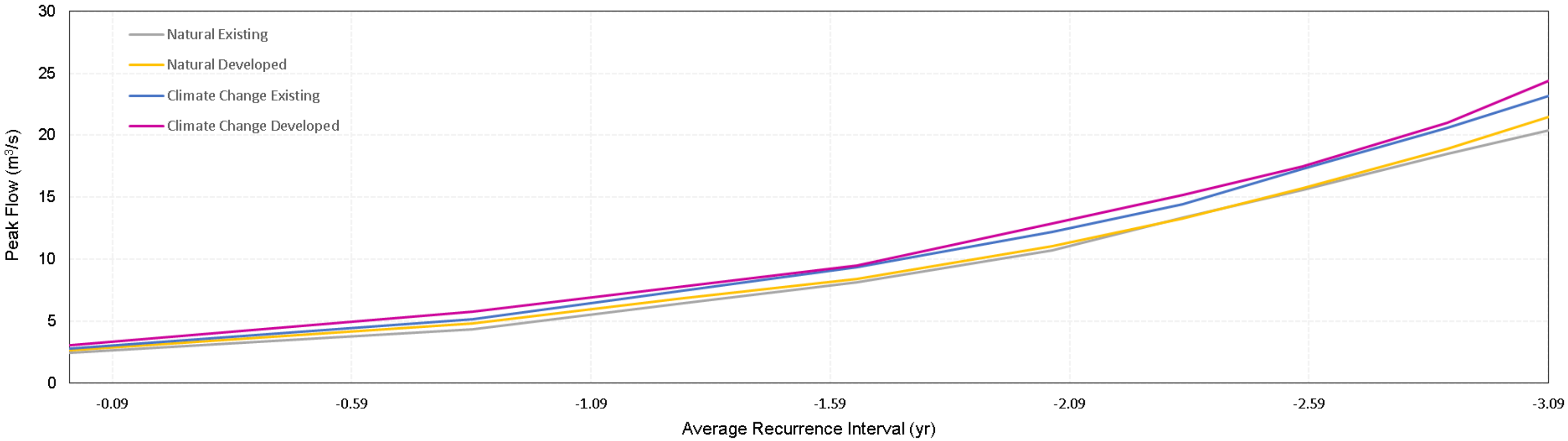

Figure 5-20 Mary Anne Creek (Western Catchment) Peak Design Flows

6 Technical Detail of Water Level Modelling

To model the water levels that correspond to the design flows produced by the RORB modelling a HEC-RAS model was developed to investigate the potential water levels within the Proposed Development region. As with the RORB model, the region modelled is the key watershed that drains most of the Proposed Development.

6.1 Model Geometry

To set up the model required a number of GIS-based input sets and these were produced using the HEC-GeoRAS add-in to ArcMap. The key spatial datasets required for HEC-RAS were:

- The drainage centre line;
- Bank locations; and,
- The drainage cross sections.

This information was produced using a digital elevation model (DEM) based on the terrain contours of the area. Initial results from this DEM showed that the streams were not been captured adequately based on at site observations. This would therefore show that water would extend further into the catchment that would actually be the case. There has been no detailed surveys undertaken for the creek lines within the catchments (for the risks associated with this development, one does not need to be undertaken), therefore the channel layout across the HEC-RAS model domain needs to be assumed. The most conservative option is to include no channels within the DEM and have all the water flowing overland. Given that there is chanelisation of these streams and that a recent rainfall event, rarer than the 1% AEP rainfall, did not break the banks of the streams, some chanelisation needs to be represented.

As outlined above, undertaking a survey of the entire creek lines is not justifiable for the risks associated with the development, therefore a repeatable and defensible approach was needed to be implemented. Based on spot measurements of stream widths and depths across the catchments relationships were developed between upstream catchment area and stream width (**Figure 6-1**) and upstream catchment area and stream depth (**Figure 6-2**). The result of these relationships is a stream network that is integrated with the original DEM with changing width and depth from upstream to downstream. Given the relationships show only low to moderate correlations (r^2) there will be areas where the stream representation may underestimate or overestimate the stream dimensions. The upshot of this is the potential that using these relationships may understatement the extent of the flooding if the channels hold more water than the actual streams can. Examining the catchment features, the location of the solar arrays and the risks associated with underestimating the flood extents, it was determined that the HEC-RAS models would be set up based on the DEM with these relationships as the result would be closer to the likely outcomes.

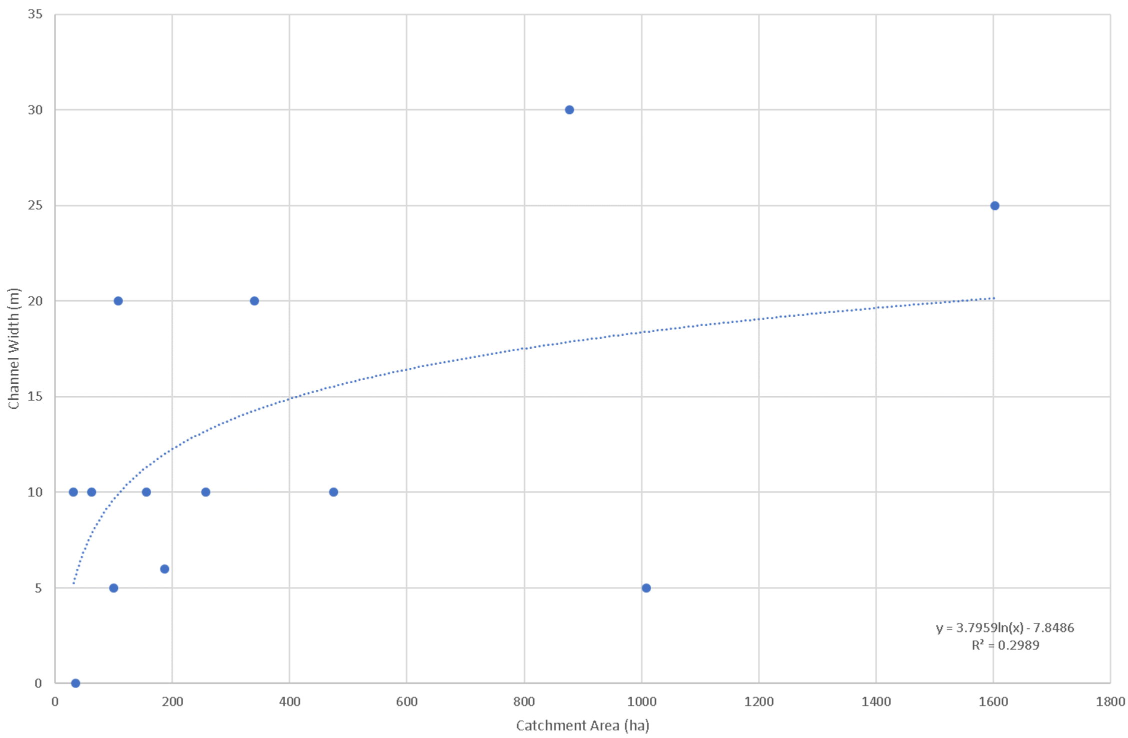

Figure 6-1 Catchment area and stream width relationship

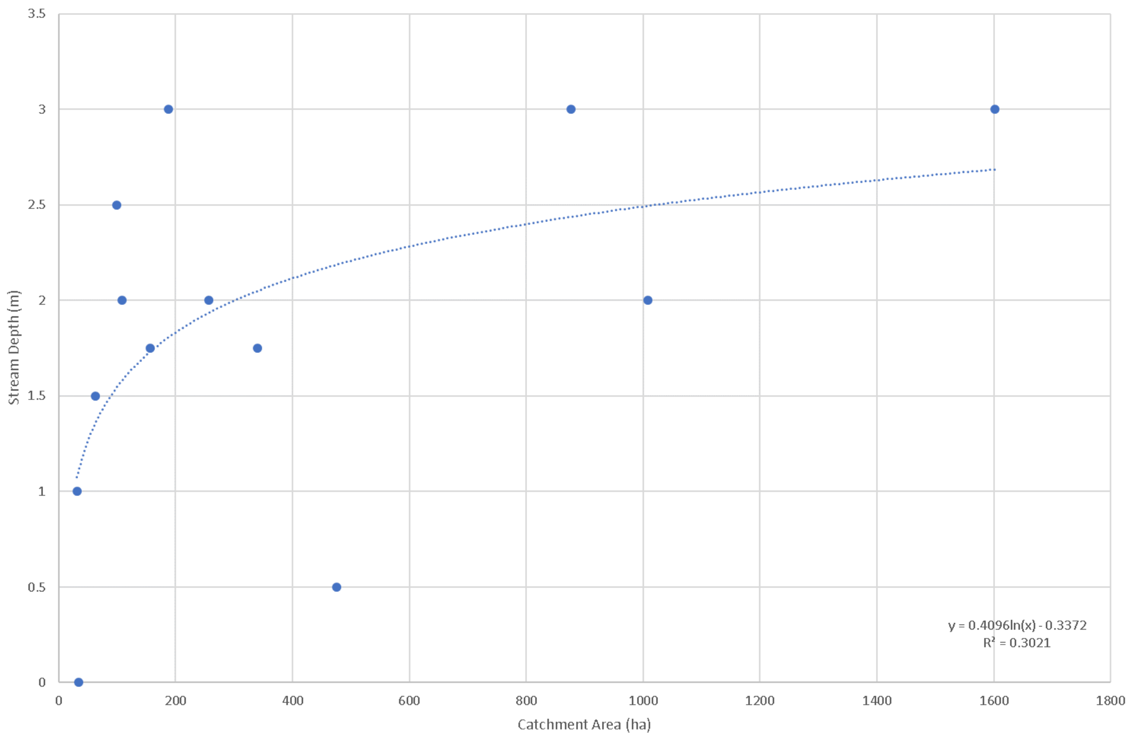

Figure 6-2 Catchment area to stream depth relationship

Using the DEM and the stream network produced from it, the HEC-RAS input spatial information was calculated. These data were turned into a HEC-RAS specific geometry input file using HEC-GeoRAS. Once imported into HEC-RAS the following were defined or modified for each cross section:

- left and right overbank stations (i.e. point where main channel ends on left and right side) were defined for each of the cross sections based on the cross-section elevations. Initial locations were determined in ArcMap but were adjusted to the top of the modelled banks due to the interpolation between elevations within the cross sections;
- distance downstream to the next cross section for the left and right overbank regions were set equal to the distance downstream of the channel that was set based on the drainage centre line;
- Manning's n (roughness) values for the left, right and channel regions of the cross section. Manning's n for the channel region was set to 0.03 and for the left and right regions was set to 0.035 based on the characteristics of the site. The value was sourced from guidelines within the HEC-RAS user manual; and,
- Obstructions were put into specific cross sections if water was flowing in regions outside of the floodplain in preference to the channel or floodplain. This occurs as HEC-RAS fills water from the lowest point of the cross section upwards and will pick up multiple regions if they are within those elevations.

No changes were made to the geometry of the HEC-RAS model between the existing conditions and the proposed conditions as it has been assumed that buildings (e.g. power sub-stations) will be situated out of the flow paths and the solar panels will be designed to be above the relevant design flood level. The model layouts are shown in Figure 6-3 to Figure 6-7.

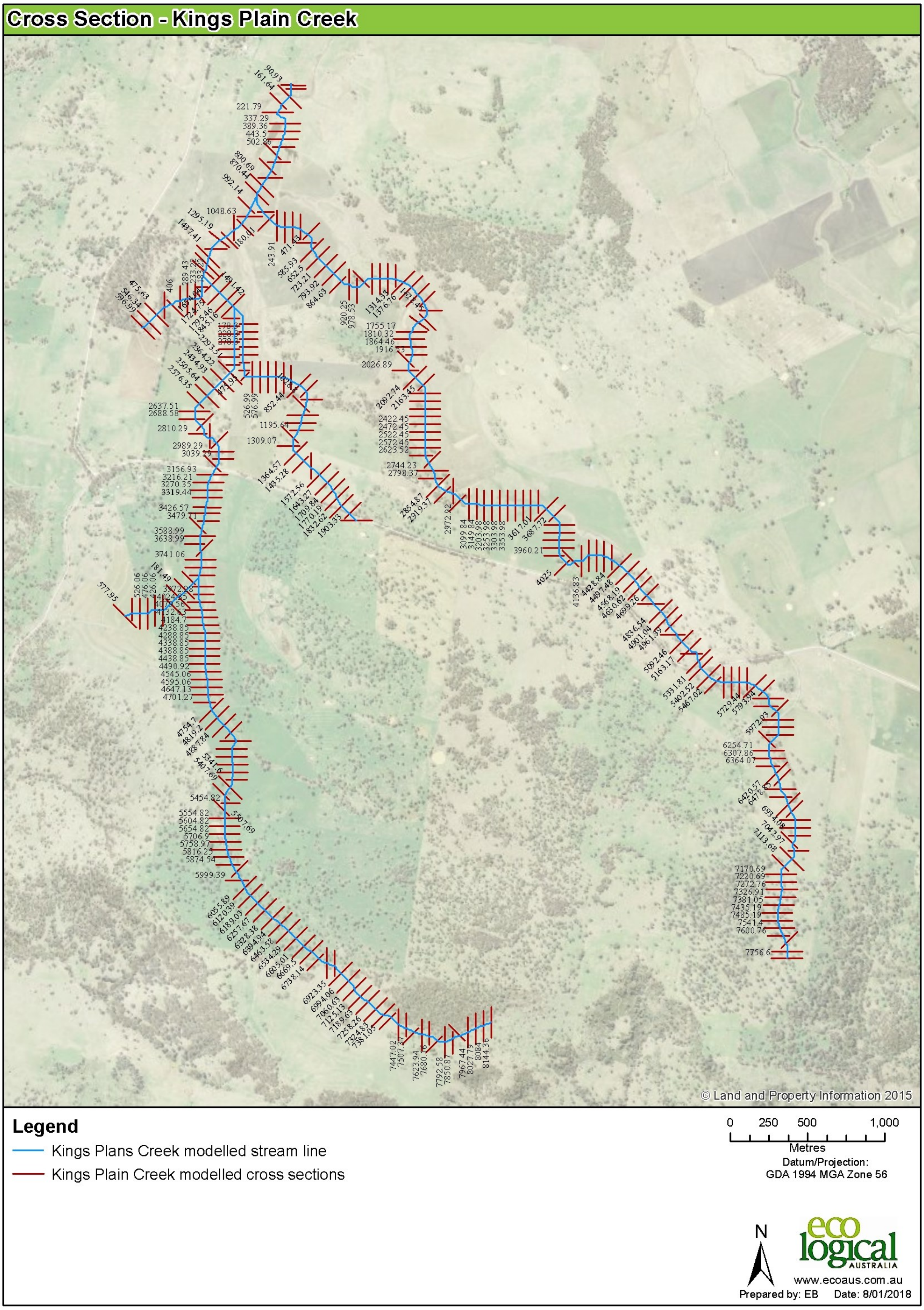

Figure 6-3: Kings Plains Creek cross sections

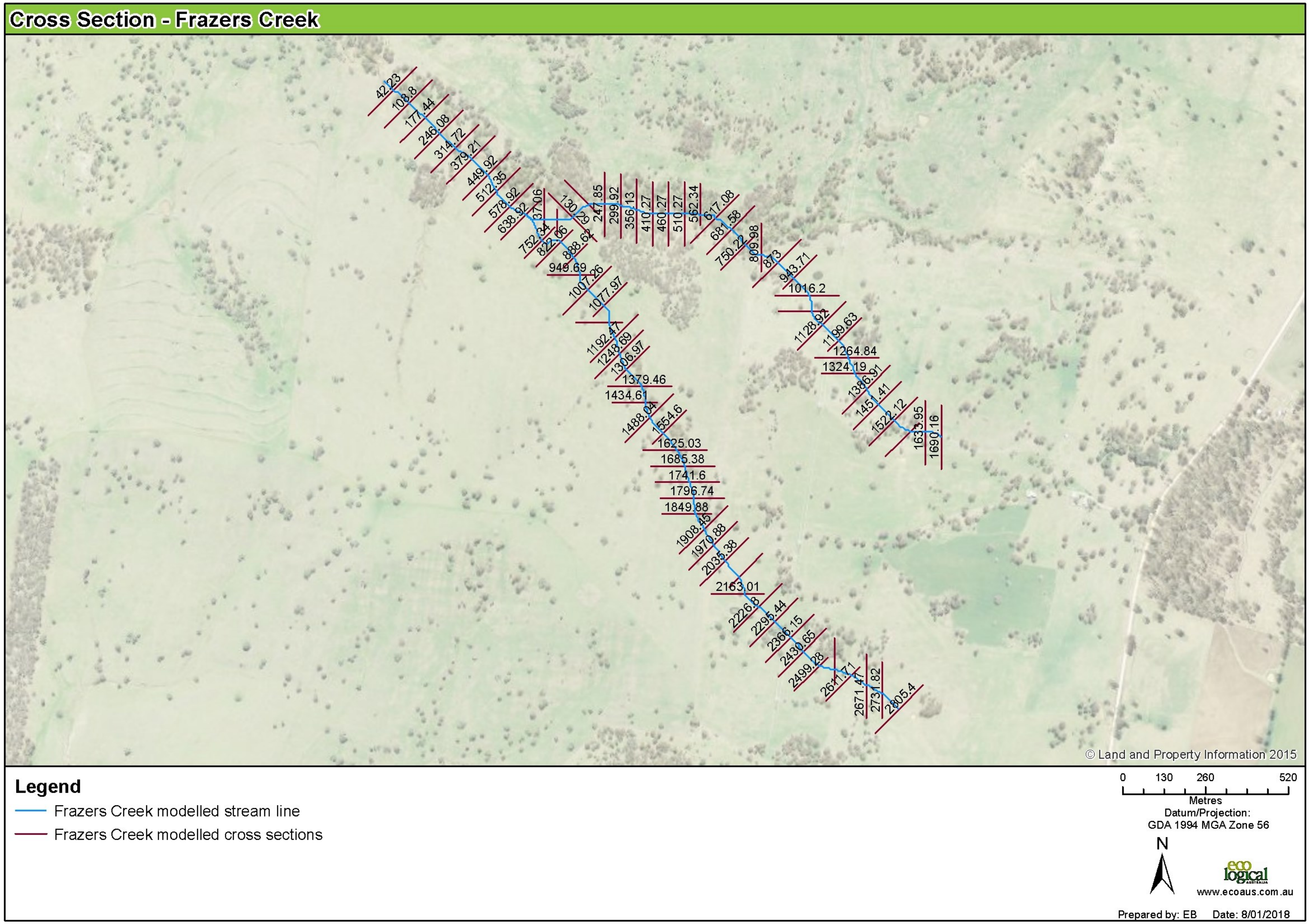

Figure 6-4 Frazers Creek cross sections

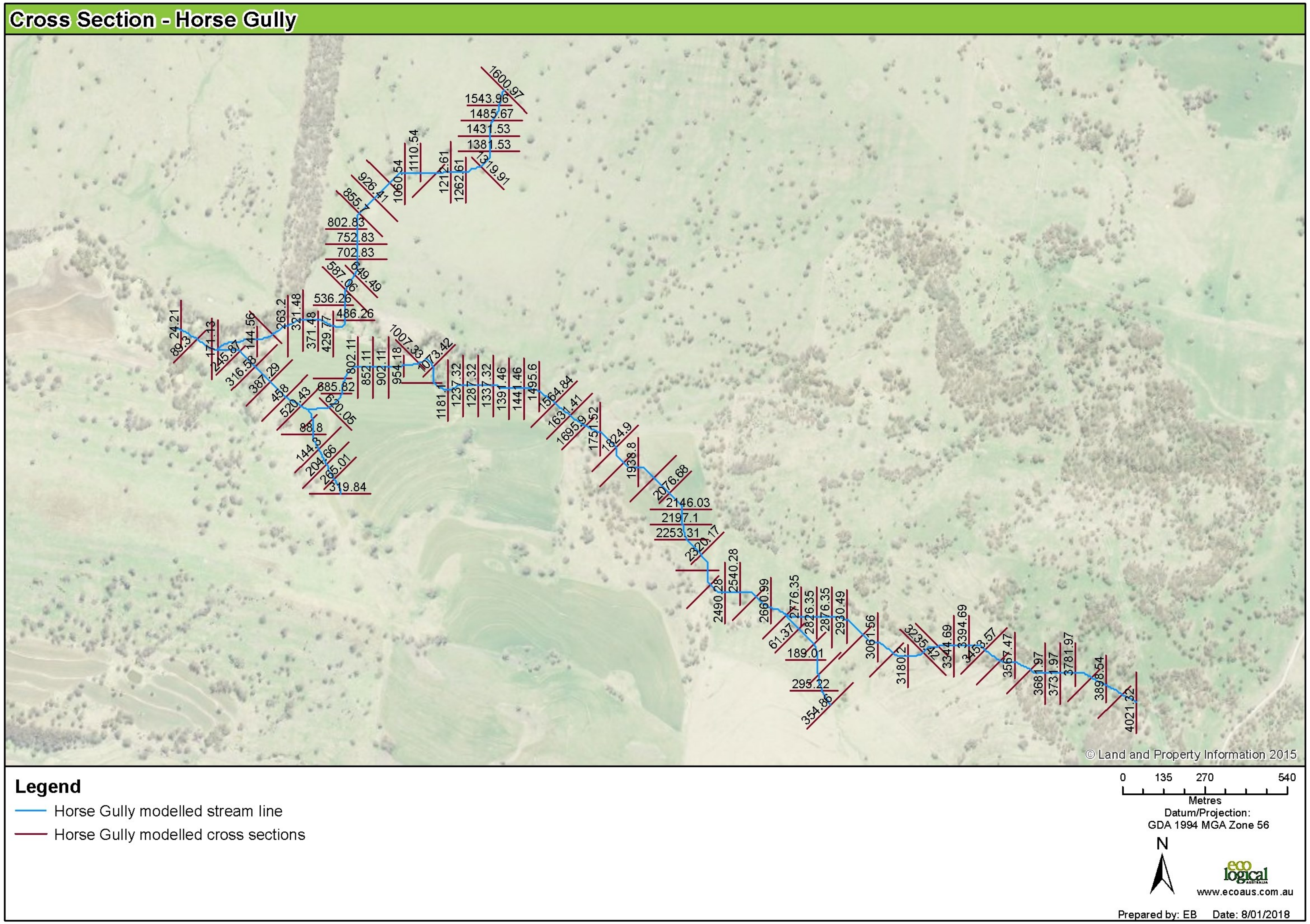

Figure 6-5 Horse Gully cross sections

Figure 6-6 Mary Anne Creek cross sections

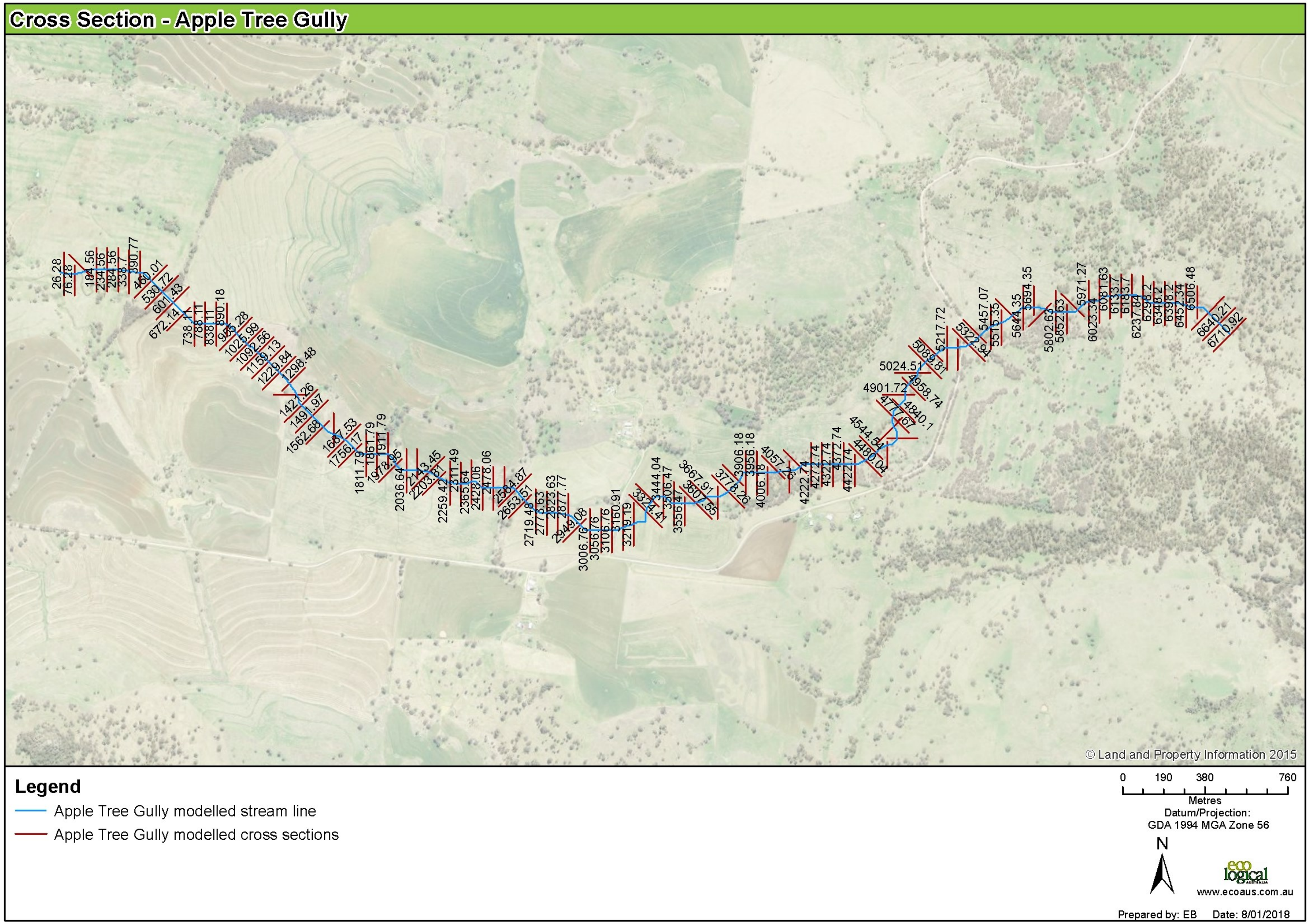

Figure 6-7 Apple Tree Gully cross sections

6.2 Model Flows

The model requires flow conditions to be specified to allow the HEC-RAS calculations to determine their corresponding water levels. These flows can be specified for a number of profiles and at cross sections in the model. Flows were specified at cross sections that corresponded to the catchments from the RORB model for the 10%, 1%, 0.5%, 0.2% and 0.1% AEP. **Appendix C** outlines the flows for the existing conditions for each of the HEC-RAS models. To complete the flow setup a boundary conditions needs to be setup. For each of these conditions a critical depth downstream condition was implemented.

6.3 Climate Change Impacts

The climate change flows determined for the site were applied to the HEC-RAS model to determine the effects of climate change on the water levels.

6.4 Results

The extent and depth of the model results are shown in **Appendix D** for the 1% AEP for the proposed development conditions. Summary results for the downstream end of the model are shown in the tables below for all scenarios. The results show that for the critical duration storm event the water levels will, in general, increase slightly between the existing and proposed condition models. This result is due to the impervious area characteristics changing from none in the existing model to a proportion of each of the catchments in the proposed model. As the critical durations for the peak flows are relatively short, the flows increase due to the development and hence the increase in levels.

As these changes are very small and are contained within the channel, it is considered that the Proposed Development will not have a significant impact on flood levels.

Table 6-1: Peak water levels for existing conditions

AEP (%)	Catchment Water Depths (m)				
	King Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.63	0.24	0.28	0.22	0.30
1%	0.99	0.37	0.41	0.35	0.49
0.5%	1.06	0.40	0.45	0.39	0.53
0.2%	1.17	0.44	0.49	0.44	0.65
0.1%	1.25	0.48	0.52	0.47	0.69

Table 6-2: Peak theoretical water levels for the Proposed Development

AEP (%)	Peak Water Level Depth (m) [Difference from existing (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.64 [1.6%]	0.25 [4.2%]	0.29 [3.6%]	0.23 [4.5%]	0.31 [3.3%]
1%	1 [1%]	0.37 [0%]	0.41 [0%]	0.35 [0%]	0.49 [0%]
0.5%	1.09 [2.8%]	0.4 [0%]	0.45 [0%]	0.4 [2.6%]	0.54 [1.9%]
0.2%	1.2 [2.6%]	0.45 [2.3%]	0.49 [0%]	0.44 [0%]	0.65 [0%]
0.1%	1.29 [3.2%]	0.49 [2.1%]	0.53 [1.9%]	0.48 [2.1%]	0.68 [-1.4%]

Under climate change conditions, the water levels will increase. At the downstream end of the catchments the levels are expected to increase by between 4.3% and 18.9% under the existing conditions and an increase by between 3.1% and 16.7% for the proposed conditions events due to climate change. Comparing the climate change results within an event (e.g. the 1% AEP) shows that there is a slight increase in water levels between the existing and proposed conditions for all AEP events. This is in line with the changes in flows observed from the RORB model.

Table 6-3: Comparison of climate change water level results for the HEC-RAS model for peak existing conditions

AEP (%)	Peak existing conditions climate change water level (m) [Difference to base design water level (%)]				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.73 [15.9%]	0.27 [12.5%]	0.31 [10.7%]	0.25 [13.6%]	0.34 [13.3%]
1%	1.04 [5.1%]	0.39 [5.4%]	0.44 [7.3%]	0.37 [5.7%]	0.52 [6.1%]
0.5%	1.13 [6.6%]	0.43 [7.5%]	0.48 [6.7%]	0.42 [7.7%]	0.63 [18.9%]
0.2%	1.25 [6.8%]	0.47 [6.8%]	0.53 [8.2%]	0.47 [6.8%]	0.68 [4.6%]
0.1%	1.33 [6.4%]	0.51 [6.3%]	0.55 [5.8%]	0.5 [6.4%]	0.72 [4.3%]

Table 6-4: Comparison of climate change water level results for the HEC-RAS model for peak proposed conditions

AEP (%)	Peak proposed conditions climate change water level (m) [Difference to base design water level (%)				
	Kings Plains Creek	Frazers Creek	Horse Gully	Mary Anne Creek	Apple Tree Gully
10%	0.74 [15.6%]	0.27 [8%]	0.31 [6.9%]	0.25 [8.7%]	0.34 [9.7%]
1%	1.04 [4%]	0.4 [8.1%]	0.44 [7.3%]	0.39 [11.4%]	0.53 [8.2%]
0.5%	1.13 [3.7%]	0.43 [7.5%]	0.47 [4.4%]	0.42 [5%]	0.63 [16.7%]
0.2%	1.26 [5%]	0.47 [4.4%]	0.53 [8.2%]	0.47 [6.8%]	0.67 [3.1%]
0.1%	1.35 [4.7%]	0.51 [4.1%]	0.55 [3.8%]	0.52 [8.3%]	0.71 [4.4%]

Appendix A Catchment Characteristics

Table A-5 Catchment characteristics for Kings Plains Creek (Eastern Catchment)

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
E1	224.3	0	0
E7	18.8	0	0
E2	67.4	0	0
E3	36.6	0	0
E4	49.4	0	0
E9	23.4	0	0
E5	68.2	0	0
E10	28.9	0	0
E11	29	0	0
E12	69.9	0	0
E16	46.2	0	0
E8	148.8	0	0
E14	70.6	0	0
E15	36.8	0	0
E17	119.8	0	0
E23	23.3	0	0
E22	1.7	0	0
E56	0.2	0	0
E40	28.7	0	0
E32	19.3	0	0
E33	11.7	0	0
E21	1.7	0	0
E30	31	0	0.027
E20	19.6	0	0
E19	66.6	0	0
E6	27.2	0	0
E13	19.9	0	0
E18	58.6	0	0
E24	66.7	0	0.135
E25	5.7	0	0
E26	30.4	0	0
E29	56.9	0	0.108
E28	28.5	0	0.113
E35	23	0	0.016
E36	20.5	0	0.171
E34	9.2	0	0
E41	2.7	0	0
E42	110.5	0	0
E57	58.3	0	0
E43	14.8	0	0.002
E44	23.3	0	0.038
E27	67.3	0	0.092
E37	29.2	0	0
E38	21.9	0	0.055
E46	29	0	0.272
E49	71.5	0	0.148
E53	35.2	0	0
E54	18	0	0
E45	2.7	0	0.209
E39	25.1	0	0.141
E48	7.4	0	0.039
E47	13.1	0	0.044
E50	16.4	0	0
E52	0.7	0	0

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
E51	19.1	0	0
E55	0.5	0	0
E31	118.1	0	0

Table A-6 Link Parameters for Kings Plains Creek (Eastern Catchment)

Link Name	Reach Length (km)	Slope	Reach Type
E4-J1	0.665	0	Natural
E3-J1	0.673	0	
J1-J2	0.241	0	
E9-J2	0.376	0	
J2-J3	0.241	0	
E10-J3	0.608	0	
J3-J4	0.372	0	
E11-J4	0.379	0	
J4-J5	0.517	0	
E5-J5	0.577	0	
J5-J6	0.32	0	
E16-J6	0.369	0	
J6-J7	0.32	0	
E12-J7	0.797	0	
J7-J8	0.675	0	
E17-J8	0.678	0	
E15-J9	0.901	0	
E21-J9	0.535	0	
J9-J10	0.132	0	
E22-J10	0.186	0	
J8-J11	0.675	0	
J10-J11	0.132	0	
E40-J12	0.568	0	
E23-J12	0.43	0	
J11-J13	0.128	0	
J12-J13	0.128	0	
J13-J14	0.128	0	
E56-J14	0.195	0	
J14-J15	0.196	0	
E30-J15	0.355	0	
J15-J16	0.391	0	
E33-J16	0.71	0	
J16-J17	0.391	0	
E34-J17	0.348	0	
E31-J18	0.888	0	
E32-J18	0.319	0	
J18-J19	0.059	0	
E41-J19	0.242	0	
J17-J20	0.141	0	
J19-J20	0.059	0	
J20-J21	0.037	0	
E35-J21	0.46	0	
J21-J22	0.037	0	
E42-J22	1.051	0	
E7-J25	0.458	0	
E2-J25	0.553	0	
J25-J26	0.96	0	
E8-J26	1.096	0	
E1-J27	1.374	0	
E6-J27	0.39	0	
J27-J28	0.19	0	
E13-J28	0.268	0	
E14-J29	0.831	0	
E20-J29	0.416	0	

Link Name	Reach Length (km)	Slope	Reach Type
J29-J30	0.408	0	
E19-J30	0.767	0	
J28-J31	0.19	0	
E18-J31	0.597	0	
J30-J32	0.408	0	
J31-J32	0.92	0	
J32-J33	0.408	0	
E25-J33	0.178	0	
J33-J34	0.197	0	
E24-J34	0.658	0	
J34-J35	0.3	0	
E26-J35	0.508	0	
J35-J36	0.3	0	
E37-J36	0.535	0	
J36-J37	0.169	0	
E27-J37	1.122	0	
E38-J38	1.189	0	
E46-J38	0.826	0	
J38-J39	0.095	0	
E45-J39	0.871	0	
J39-J40	0.095	0	
E48-J41	0.603	0	
E49-J41	0.748	0	
J26-J28	0.96	0	
E29-J42	0.941	0	
E36-J42	0.4	0	
J42-J43	0.209	0	
E43-J43	0.498	0	
E28-JNew	0.621	0	
J37-J44	1.325	0	
J43-JNew	0.209	0	
J44-J45	0.235	0	
E44-JNew2	0.356	0	
E39-J44	0.4	0	
J45-J46	0.083	0	
E47-J46	0.252	0	
J42-J46	0.083	0	
J46-J47	0.083	0	
J40-J46	0.095	0	
E53-J47	0.488	0	
E50-J47	0.273	0	
J47-J48	0.199	0	
E52-J48	0.078	0	
J48-J49	0.199	0	
E54-J50	0.51	0	
J50-J51	0.096	0	
E51-J51	0.496	0	
J22-J49	1.938	0	
J51-J52	0.096	0	
E57-J52	0.665	0	
J52-J53	0.096	0	
E55-J53	0.063	0	
J53-End	0.5	0	
J49-J50	0.096	0	
JNew-JNew2	0.1	0	
JNew2-J45	0.235	0	

Table A-7 Catchment characteristics for Frazers Creek (Northern Catchment)

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
N1	167.2	0	0.026

N2	65.2	0	0.093
N3	75.4	0	0
N4	31.3	0	0
N5	23.5	0	0
N6	30	0	0
N7	8.6	0	0
N8	3.9	0	0
N9	6.1	0	0
N10	43.5	0	0
N11	11.2	0	0

Table A-8 Link Parameters for Frazers Creek (Northern Catchment)

Link Name	Reach Length (km)	Slope	Reach Type
N4 to J1	0.552	0	Natural
N5 to J1	0.416	0	
N8 to J2	0.231	0	
N3 to J3	0.66	0	
J2 to J3	0.104	0	
N9 to J4	0.278	0	
J3 to J4	0.153	0	
J4 to J5	0.153	0	
N2 to J5	0.762	0	
N10 to J6	0.537	0	
J5 to J6	0.382	0	
J6 to J7	0.382	0	
N1 to J7	1.239	0	
J7 to J8	0.2	0	
N7 to J8	0.278	0	
J8 to J9	0.429	0	
N11 to J9	0.319	0	
N6 to J8	0.627	0	
J9 to End	0.5	0	
J1 to J2	0.104	0	

Table A-9 Catchment characteristics for Horse Gully (North-western Catchment)

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
NW1	32.6	0	0.047
NW18	57.6	0	0.163
NW17	14.6	0	0.063
NW15	53.9	0	0.042
NW2	24.1	0	0.178
NW3	28.2	0	0.161
NW4	24.4	0	0.038
NW5	55.9	0	0
NW13	18.6	0	0.01
NW14	4.3	0	0.032
NW6	114.5	0	0
NW7	18.8	0	0
NW16	35.9	0	0
NW8	28.1	0	0
NW19	18.6	0	0
NW9	33.9	0	0.03
NW10	22.1	0	0
NW11	25.8	0	0
NW20	13.9	0	0
NW12	44.1	0	0
NW21	25.8	0	0.031
NW22	3.4	0	0.148

Table A-10 Link Parameters for Horse Gully (North-western Catchment)

Link Name	Reach Length (km)	Slope	Reach Type
NW5 to J1	0.784	0	Natural
NW4 to J1	0.488	0	
J1 to J2	0.212	0	
NW13 to J2	0.402	0	
J2 to J3	0.212	0	
NW3 to J3	0.531	0	
J3 to J4	0.141	0	
NW14 to J4	0.283	0	
J4 to J5	0.141	0	
NW2 to J5	0.347	0	
J5 to J6	0.351	0	
NW15 to J6	0.522	0	
NW6 to J7	0.822	0	
NW7 to J7	0.487	0	
J7 to J8	0.467	0	
NW16 to J8	0.619	0	
J8 to J9	0.467	0	
J6 to J9	0.351	0	
J9 to J10	0.171	0	
NW17 to J10	0.34	0	
NW8 to J11	0.593	0	
NW9 to J11	0.582	0	
J11 to J12	0.278	0	
NW19 to J12	0.445	0	
J12 to J10	0.278	0	
J10 to J13	0.44	0	
NW18 to J13	0.523	0	
NW10 to J14	0.371	0	
NW11 to J14	0.491	0	
J14 to J15	0.234	0	
NW20 to J15	0.359	0	
J15 to J16	0.234	0	
NW12 to J16	0.503	0	
J16 to J17	0.396	0	
NW21 to J17	0.486	0	
J13 to J18	0.44	0	
NW1 to J18	0.479	0	
J18 to J19	0.183	0	
NW22 to J19	0.276	0	
J19 to J20	0.183	0	
J17 to J20	0.396	0	
J20 to End	0.5	0	

Table A-11 Catchment characteristics for Apple Tree Gully (South-western Catchment)

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
SW1	26.4	0	0
SW2	22.2	0	0
SW3	23.2	0	0
SW4	73.4	0	0
SW5	25.3	0	0
SW6	47.9	0	0.015
SW12	37.2	0	0
SW11	6.1	0	0
SW13	2.9	0	0
SW14	129.7	0	0
SW10	20.1	0	0
SW15	14	0	0
SW16	35.8	0	0

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
SW17	13.7	0	0.045
SW7	25.8	0	0.007
SW8	20.9	0	0.195
SW18	145.2	0	0.018
SW9	59	0	0.051
SW19	21.5	0	0

Table A-12 Link Parameters (South-western Catchment)

Link Name	Reach Length (km)	Slope	Reach Type
SW5 to J1	0.549	0	Natural
SW4 to J1	0.658	0	
J1 to J2	0.235	0	
SW11 to J2	0.242	0	
J2 to J3	0.223	0	
SW3 to J3	0.489	0	
SW12 to J4	0.54	0	
J3 to J4	0.238	0	
SW2 to J5	0.444	0	
J4 to J5	0.238	0	
SW13 to J6	0.206	0	
J5 to J6	0.112	0	
J6 to J7	0.112	0	
SW6 to J7	0.507	0	
J7 to J8	0.889	0	
SW14 to J8	1.011	0	
J8 to J9	0.889	0	
SW1 to J9	0.354	0	
J9 to J10	0.194	0	
SW15 to J10	0.325	0	
J10 to J11	0.194	0	
SW10 to J11	0.722	0	
SW8 to J12	0.516	0	
SW7 to J12	0.64	0	
J12 to J13	0.197	0	
J11 to J14	0.177	0	
SW16 to J14	0.386	0	
J14 to J15	0.177	0	
SW17 to J13	0.365	0	
J13 to J15	0.197	0	
J15 to J16	0.866	0	
SW18 to J16	1.062	0	
J16 to J17	0.866	0	
SW9 to J17	0.668	0	
J17 to J18	0.541	0	
SW19 to J18	0.432	0	
J18 to end	0.5	0	

Table A-13 Catchment characteristics for Mary Anne Creek (Western Catchment)

Sub-area	Area (ha)	Percent Impervious (%)	
		Existing condition	Proposed condition
W2	157.8	0	0.069
W1	38.2	0	0.136
W3	29.4	0	0
W4	3.3	0	0
W5	46.4	0	0

Table A-14 Link Parameters for Mary Anne Creek (Western Catchment)

Link Name	Reach Length (km)	Slope	Reach Type
W2 to Junction 1	1.17	0	Natural
W1 to Jctn 1	0.512	0	
Jnct 1 to Jnct 2	0.125	0	
W3 to Jnct 3	0.43	0	
Jnct 2 to Jnct 3	0.125	0	
Jnct 3 to Jnct 4	0.987	0	
Jnct 4 to End	0.5	0	
W4 to Jnct 2	0.199	0	
W5 to Jcnt 4	0.722	0	

Appendix B RORB Results

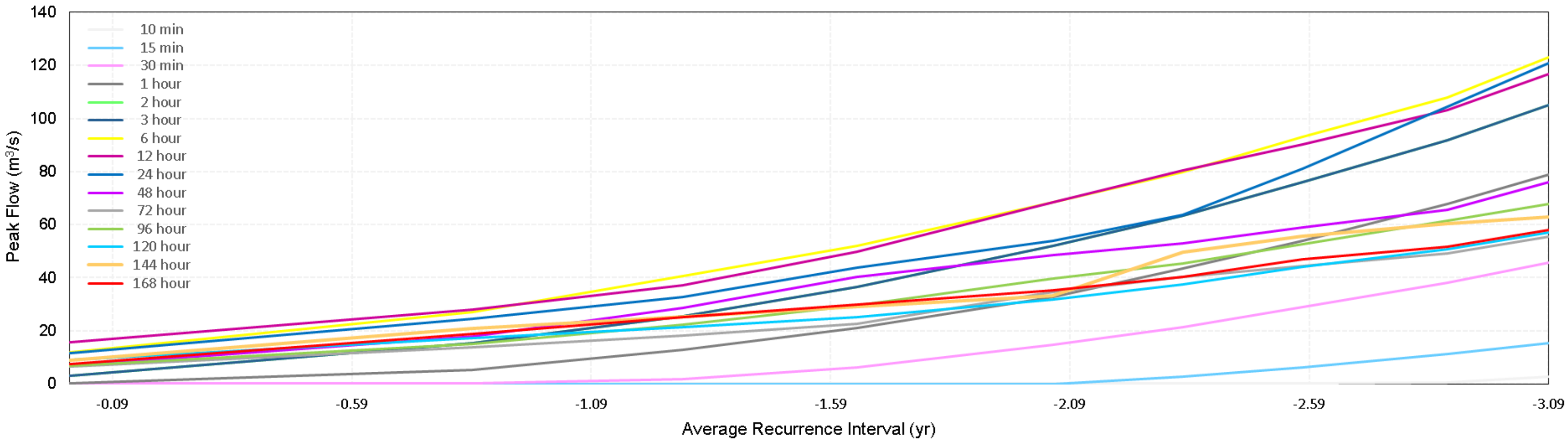

Figure B-1 Kings Plains Creek (Eastern Catchment) Natural Existing Design Flows

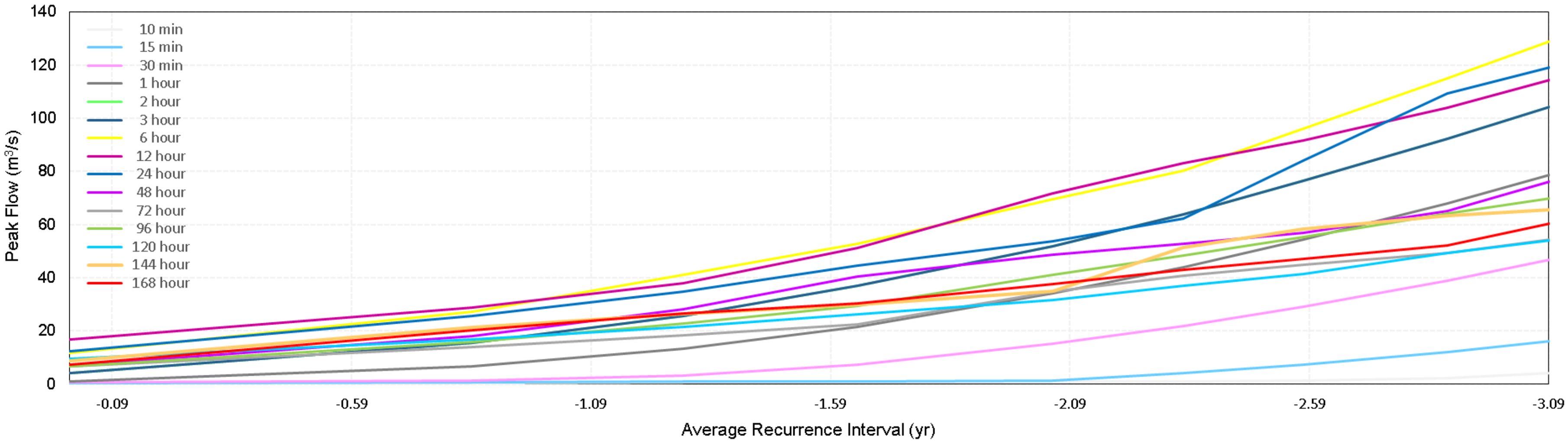

Figure B-2 Kings Plains Creek (Eastern Catchment) Natural Developed Design Flows

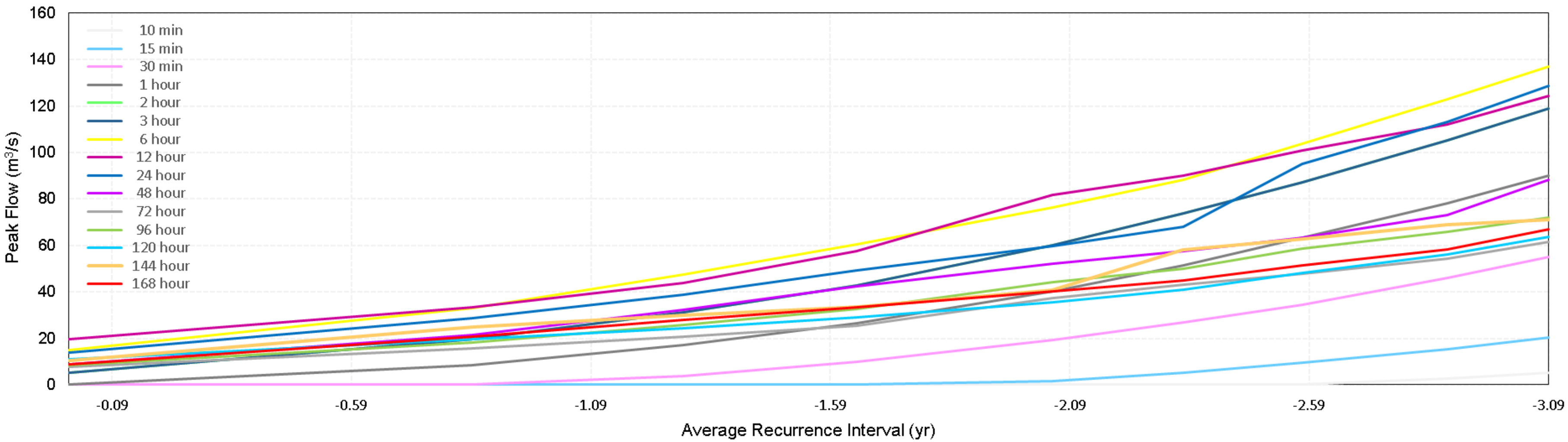

Figure B-3 Kings Plains Creek (Eastern Catchment) Climate Change Existing Design Flows

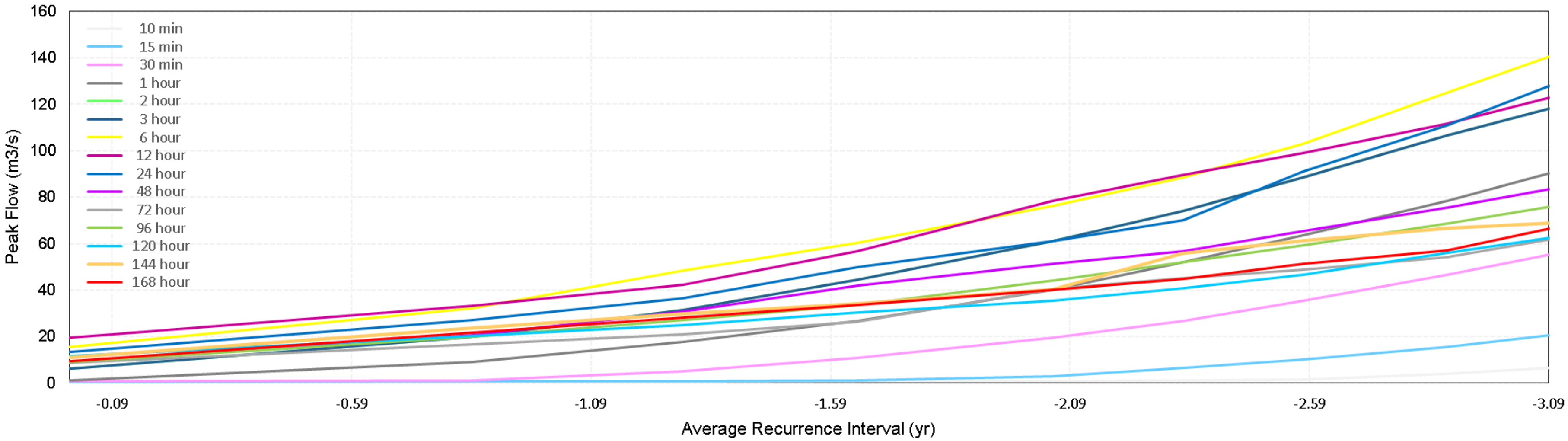

Figure B-4 Kings Plains Creek (Eastern Catchment) Climate Change Developed Design Flows

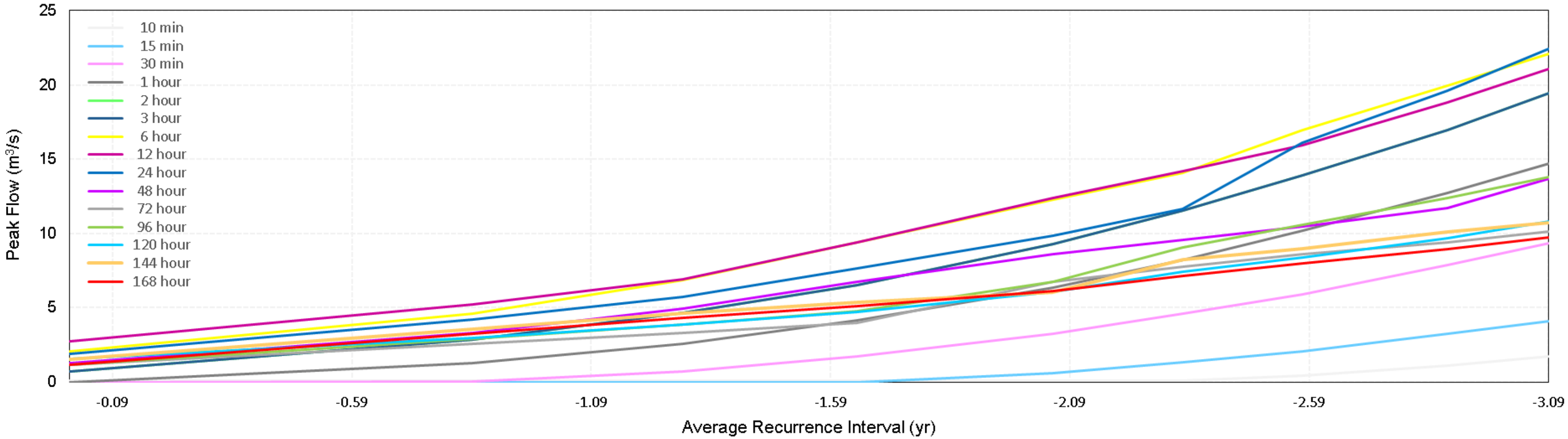

Figure B-5 Frazers Creek (Northern Catchment) Natural Existing Design Flows

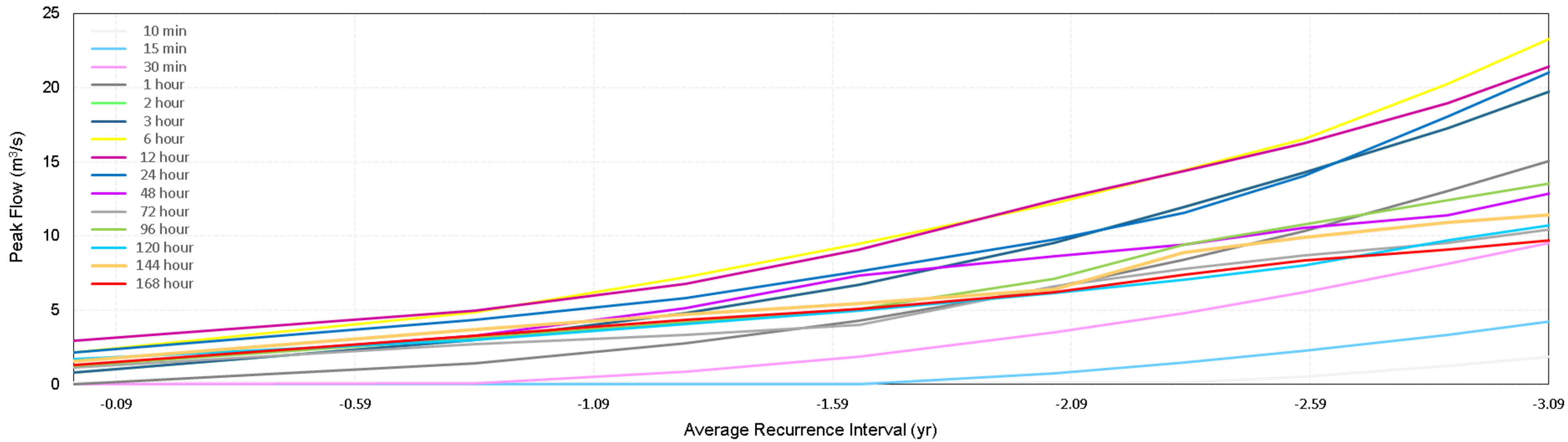

Figure B-6 Frazers Creek (Northern Catchment) Natural Developed Design Flows

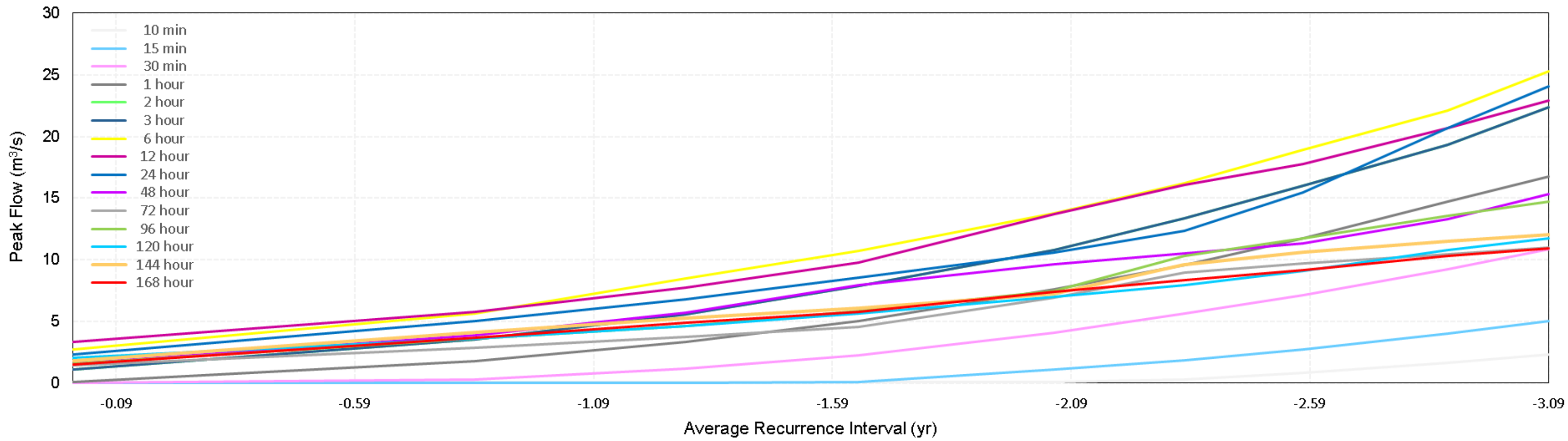

Figure B-7 Frazers Creek (Northern Catchment) Climate Change Existing Design Flows

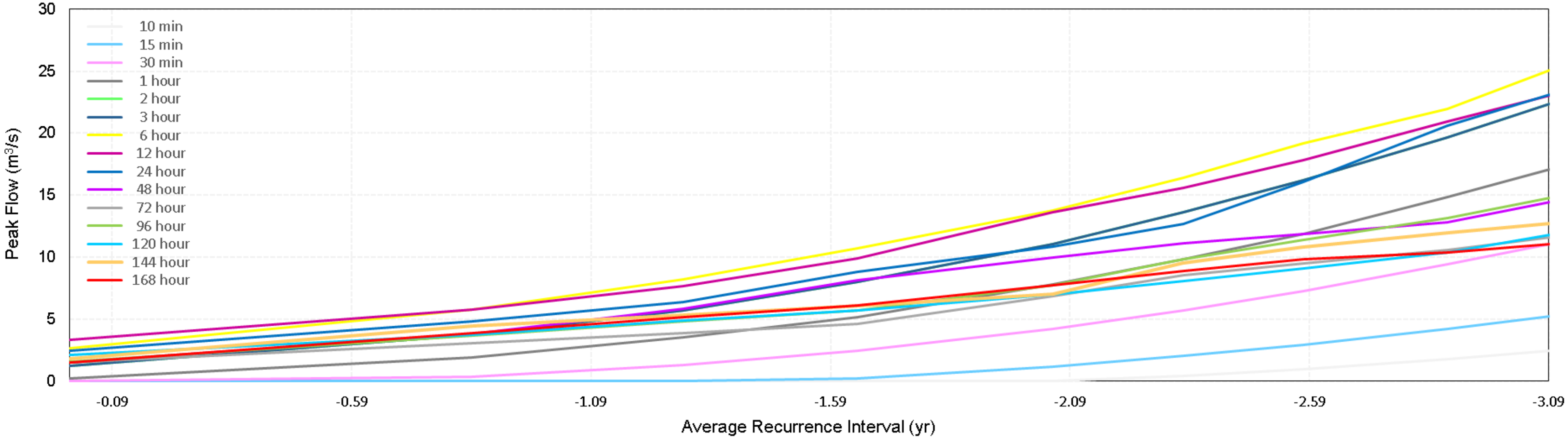

Figure B-8 Frazers Creek (Northern Catchment) Climate Change Developed Design Flows

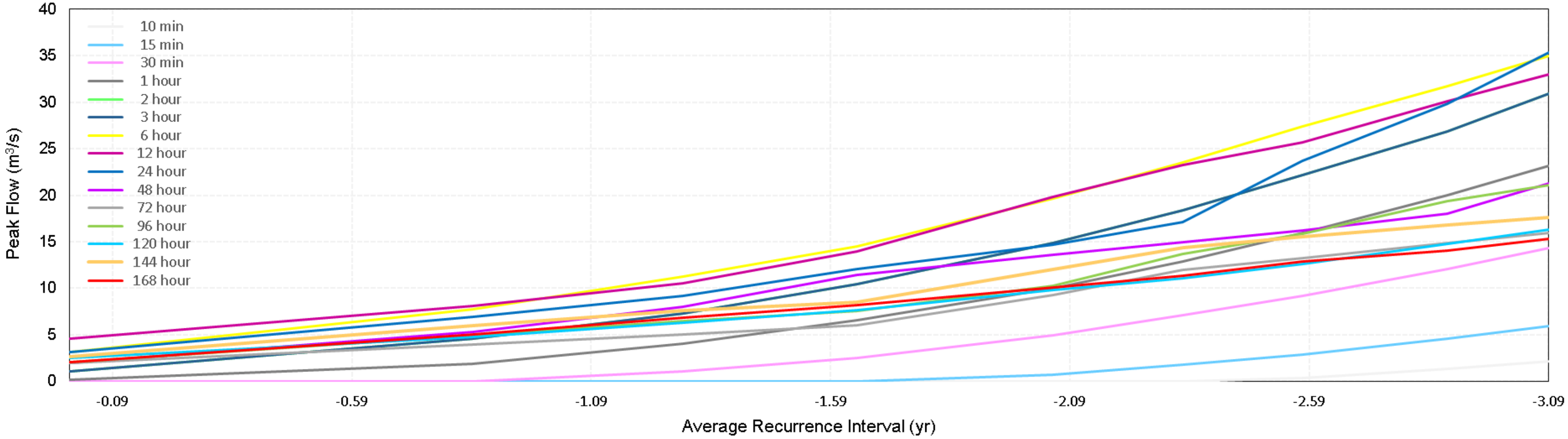

Figure B-9 Horse Gully (North-western Catchment) Natural Existing Design Flows

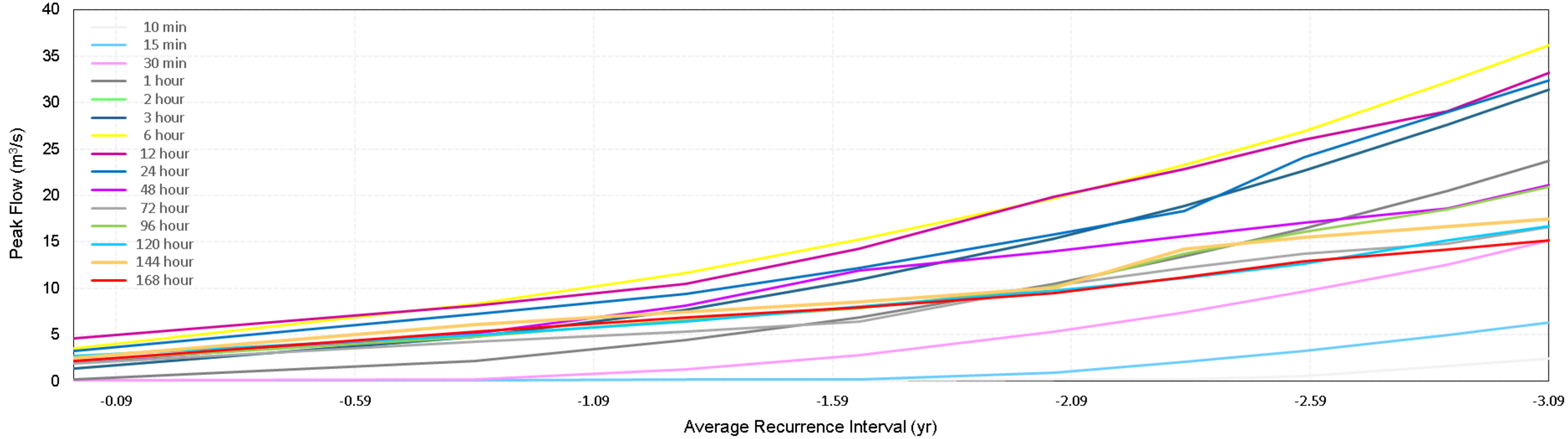

Figure B-10 Horse Gully (North-western Catchment) Natural Developed Design Flows

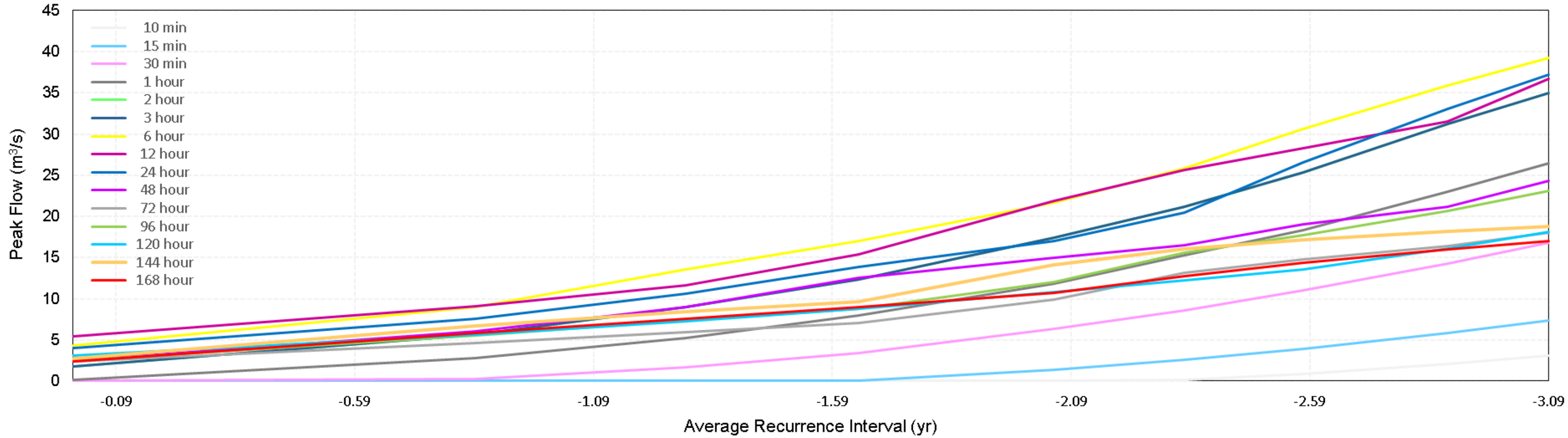

Figure B-11 Horse Gully (North-western Catchment) Climate Change Existing Design Flows

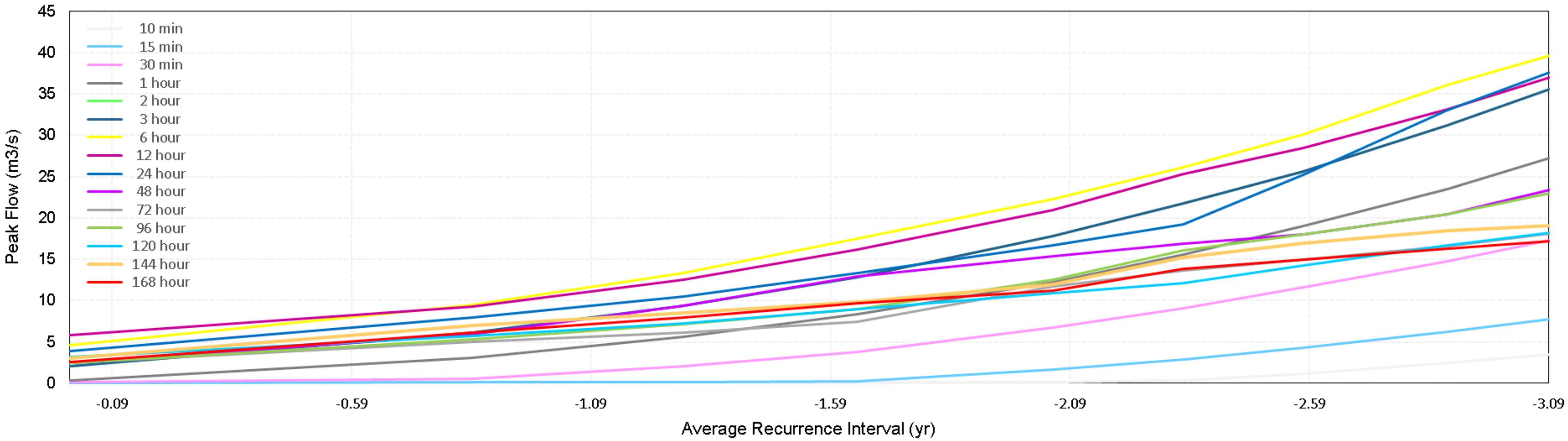

Figure B-12 Horse Gully (North-western Catchment) Climate Change Developed Design Flows

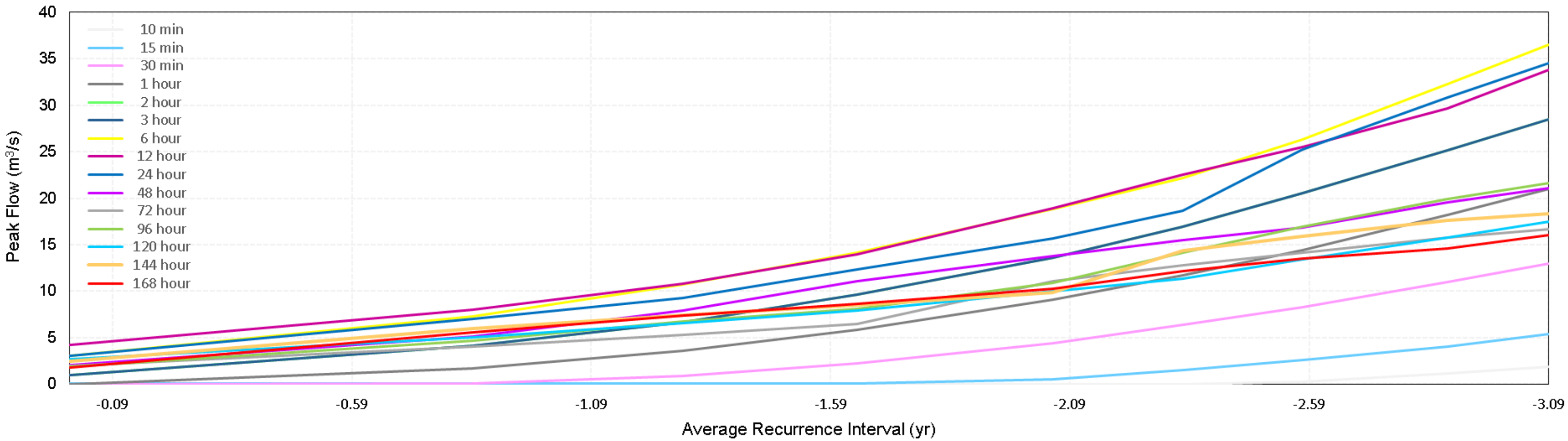

Figure B-13 Apple Tree Gully (South-western Catchment) Natural Existing Design Flows

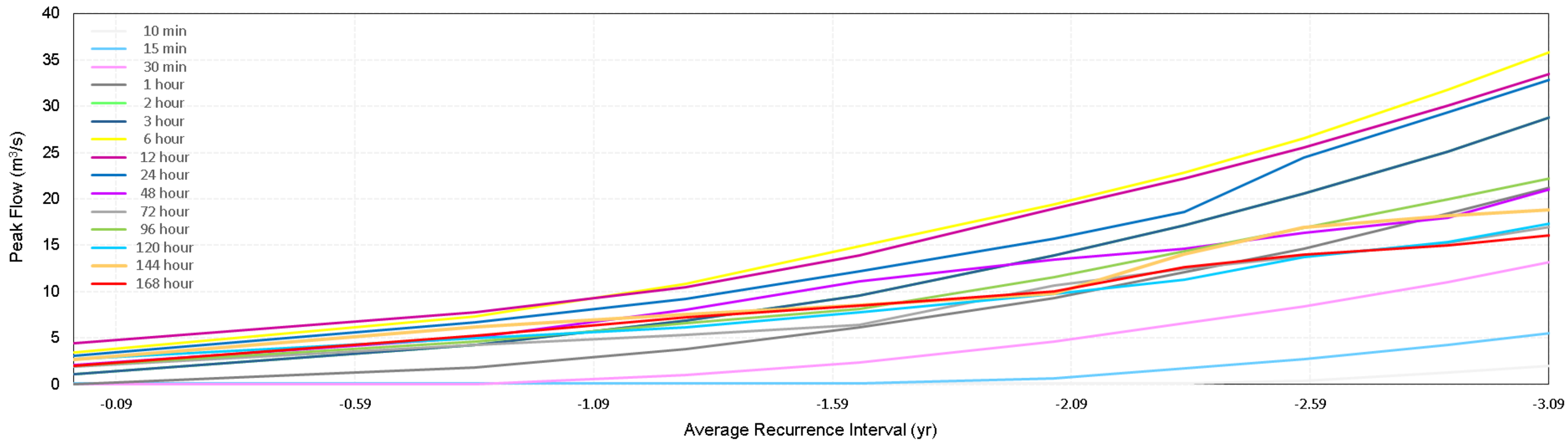

Figure B-14 Apple Tree Gully (South-western Catchment) Natural Developed Design Flows

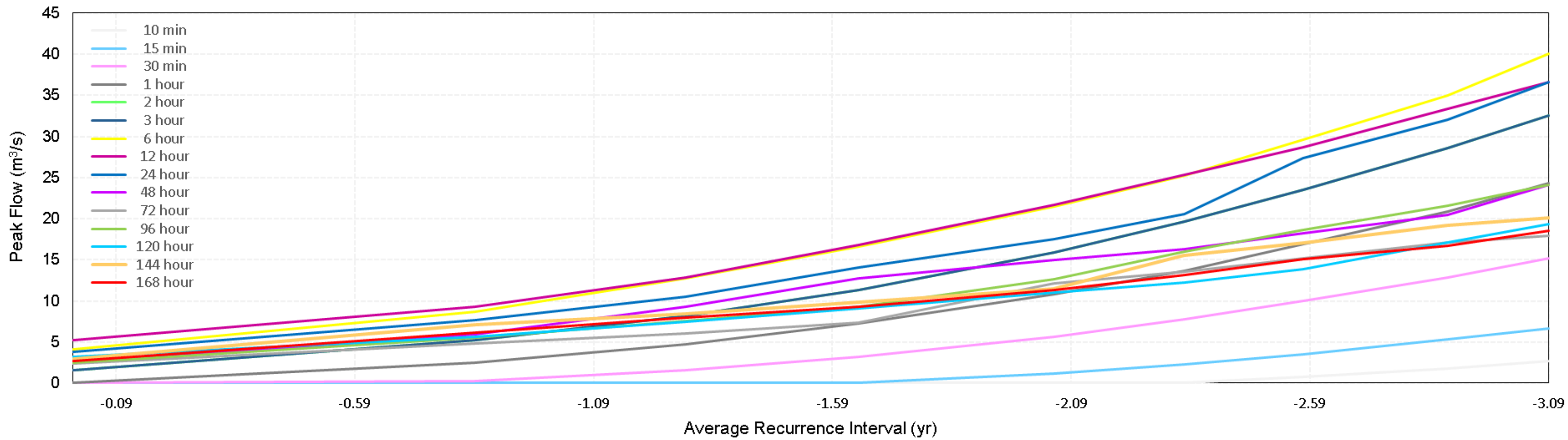

Figure B-15 Apple Tree Gully (South-western Catchment) Climate Change Existing Design Flows

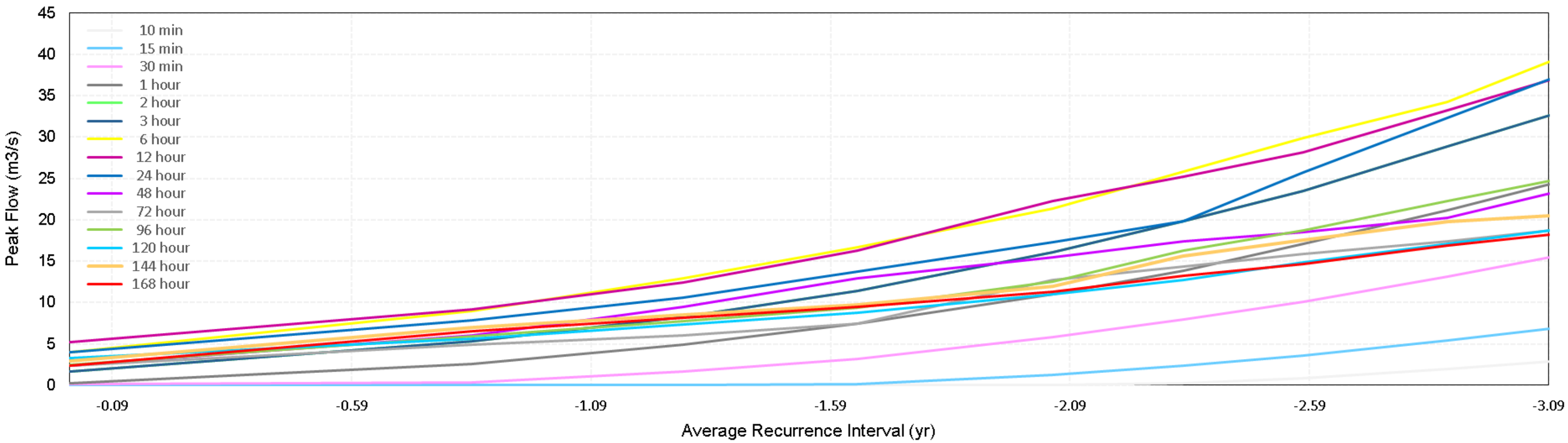

Figure B-16 Apple Tree Gully (South-western Catchment) Climate Change Developed Design Flows

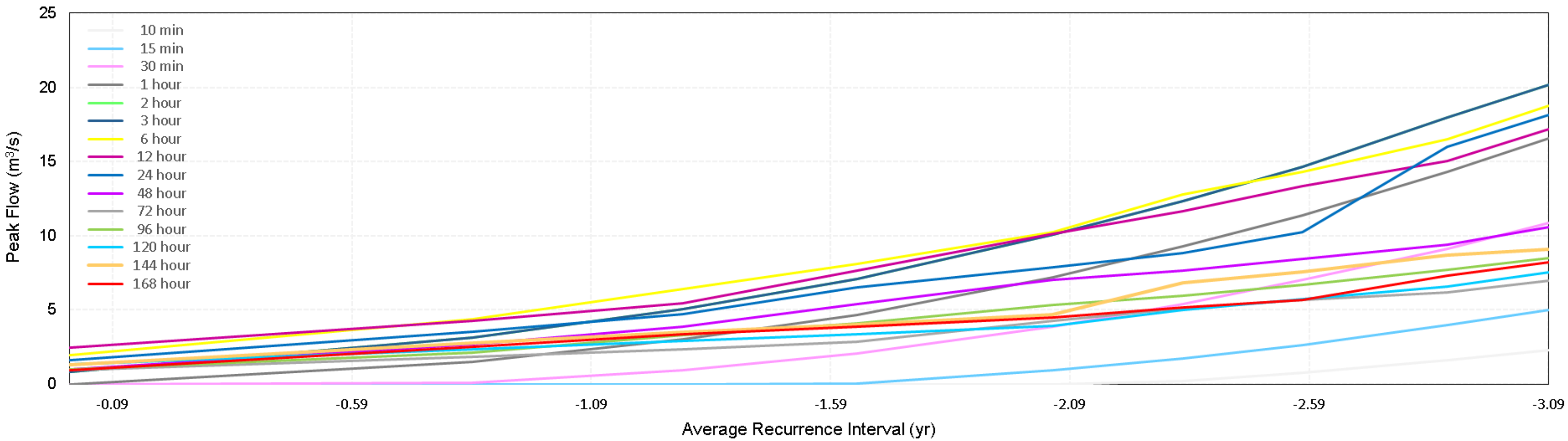

Figure B-17 Mary Anne Creek (Western Catchment) Natural Existing Design Flows

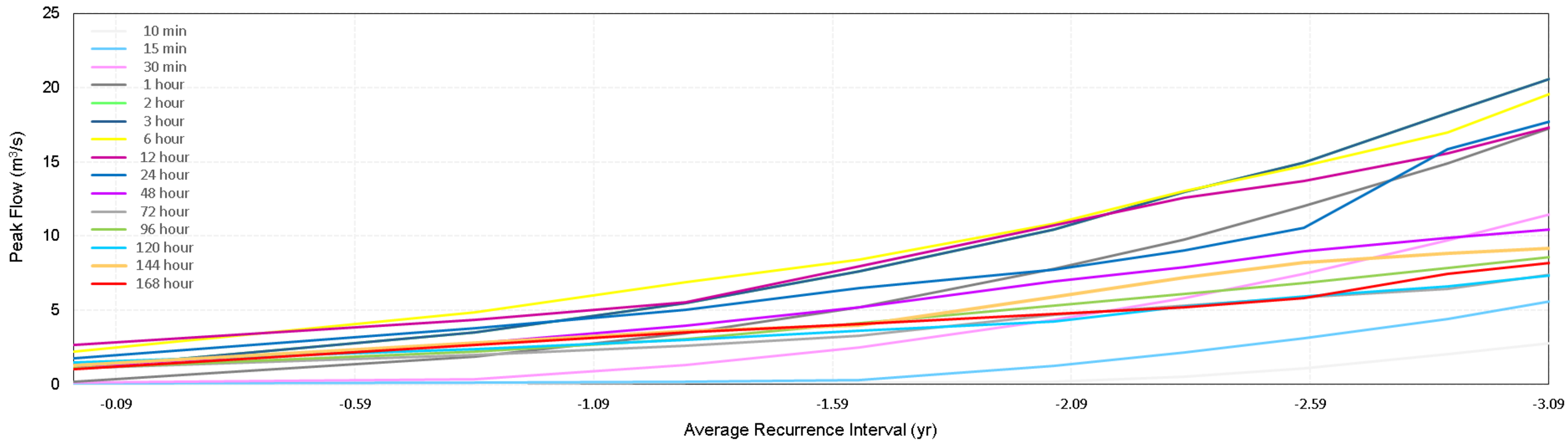

Figure B-18 Mary Anne Creek (Western Catchment) Natural Developed Design Flows

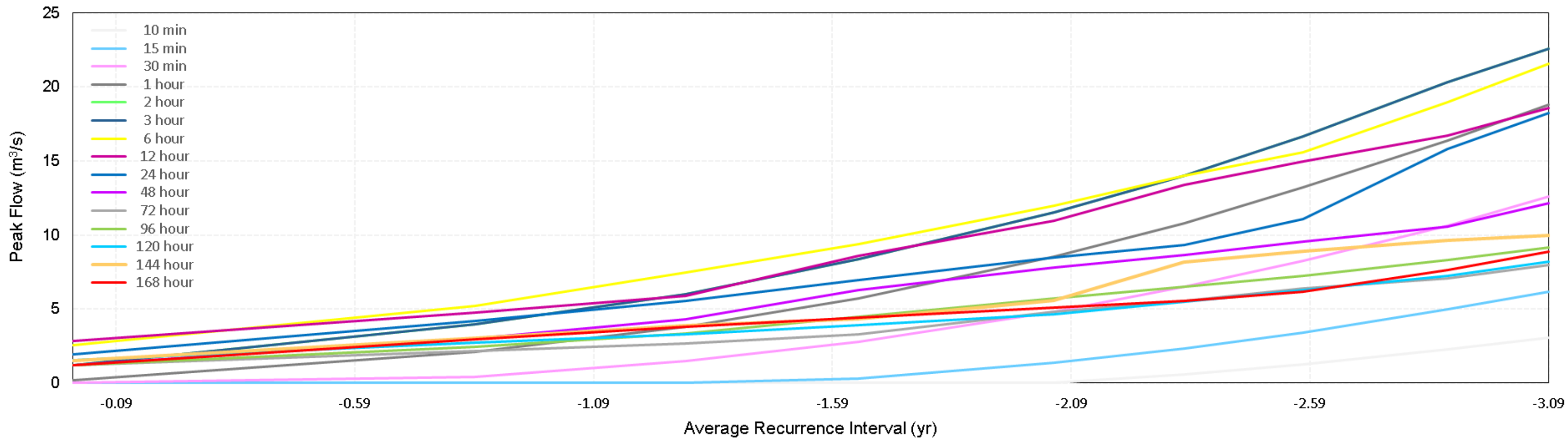

Figure B-19 Mary Anne Creek (Western Catchment) Climate Change Existing Design Flows

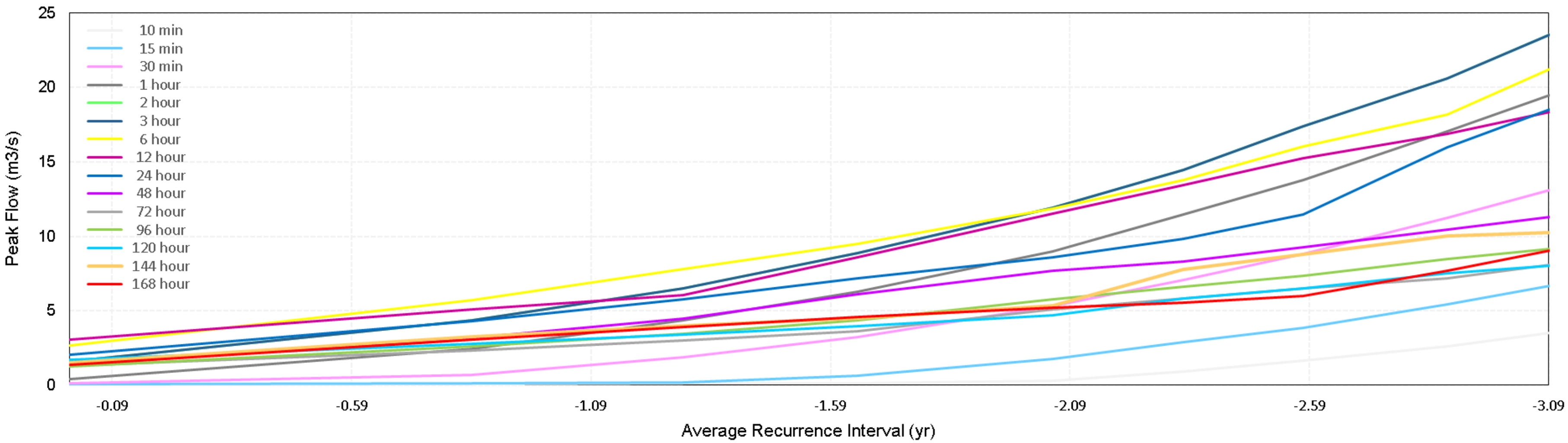

Figure B-20 Mary Anne Creek (Western Catchment) Climate Change Developed Design Flows

Appendix C HEC-RAS Flows

Table C-15: Kings Plains Creek (Eastern Catchment) existing conditions design flow inputs from RORB

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
E1-J27	Kings Plains Ck	8144.359	1.2	2.7	3.1	3.7	4.1
E1-J27	Kings Plains Ck	7447.019	2.1	4.4	5.1	6.2	6.8
E1-J27	Kings Plains Ck	6994.062	4.2	8.9	10.2	12.3	13.6
E1-J27	Kings Plains Ck	6328.376	6.2	13.3	15.3	18.5	20.4
E1-J27	Kings Plains Ck	5706.896	8.3	17.8	20.4	24.6	27.2
J27-J28	Kings Plains Ck	5407.691	9.4	19.8	22.8	27.6	30.8
J28-J31	Kings Plains Ck	5021.688	15.4	30	34.9	42.9	47.7
J31-J32	Kings Plains Ck	4887.838	15.4	29.7	34.4	42.1	47
J31-J32	Kings Plains Ck	4545.058	15.3	29.4	33.9	41.2	46.3
J31-J32	Kings Plains Ck	4338.845	15.2	29.1	33.4	40.3	45.6
J31-J32	Kings Plains Ck	4132.632	15.2	28.9	32.9	39.5	44.9
J32-J33	Kings Plains Ck	4024.348	19.7	37.7	42.9	51.4	58.5
J33-J34	Kings Plains Ck	3922.277	19.6	37.5	43.1	51.9	58.3
J34-J35	Kings Plains Ck	3846.276	20.6	39.1	45	53.5	60.9
J35-J36	Kings Plains Ck	3638.992	20.7	39.4	45.2	53.8	60.9
J35-J36	Kings Plains Ck	3319.44	20.9	39.7	45.4	54.2	61

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m^3/s)	1% AEP flow (m^3/s)	0.5% AEP flow (m^3/s)	0.2% AEP flow (m^3/s)	0.1% AEP flow (m^3/s)
J36-J37	Kings Plains Ck	3216.21	21.2	40.2	46.1	55	61.4
J37-J44	Kings Plains Ck	3039.287	20.4	38.8	44.9	53.1	60.2
J37-J44	Kings Plains Ck	2637.51	19.7	37.4	43.8	51.2	59
J44-J45	Kings Plains Ck	2434.931	19.7	37.8	43.9	51.4	59.5
J44-J45	Kings Plains Ck	1932.943	19.7	38.3	44.1	51.6	60
J45-J46	Kings Plains Ck	1845.158	20.2	39.4	45.4	53	61.3
J45-J46	Kings Plains Ck	1724.751	20.6	40.1	46.3	53.9	62.2
J45-J46	Kings Plains Ck	1654.041	21.4	41.9	48.5	56.1	64.5
J46-J47	Kings Plains Ck	1538.353	22	43.3	49.8	57.7	66.1
J46-J47	Kings Plains Ck	1295.195	23.3	46.4	52.9	61.3	70
J47-J48	Kings Plains Ck	992.142	23.8	47	54	62.2	71
J50-J51	Kings Plains Ck	800.6924	39.9	79.8	91.4	106.4	121.9
J51-J52	Kings Plains Ck	502.8597	40	80	91.6	106.7	121.5
J51-J52	Kings Plains Ck	90.92579	40.1	80.2	91.8	106.9	121.1
E4-J1	E Lge Tributary	7756.6	1.2	2.6	2.9	3.4	3.9
E4-J1	E Lge Tributary	7170.693	2.5	5.1	5.8	6.9	7.7
J1-J2	E Lge Tributary	7113.678	3.6	7.8	8.7	10.8	11.9
J2-J3	E Lge Tributary	6875.13	4.4	9.4	10.6	13.2	14.7
J2-J3	E Lge Tributary	6775.13	4.8	9.9	11.2	14	15.6
J3-J4	E Lge Tributary	6598.206	5.1	10.4	11.8	14.9	16.6

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m^3/s)	1% AEP flow (m^3/s)	0.5% AEP flow (m^3/s)	0.2% AEP flow (m^3/s)	0.1% AEP flow (m^3/s)
J4-J5	E Lge Tributary	5972.935	5.5	10.7	12.4	15.4	17.1
J5-J6	E Lge Tributary	5914.363	7.3	14.3	16.3	19.7	22.5
J6-J7	E Lge Tributary	5729.442	7.9	15.3	17.5	21.2	24.2
J6-J7	E Lge Tributary	5277.666	8.5	16.3	18.8	22.8	25.9
J7-J8	E Lge Tributary	5163.168	9.8	18.7	21.4	25.9	28.7
J8-J11	E Lge Tributary	4699.259	11	20.9	24	28.7	32.7
J8-J11	E Lge Tributary	4024.995	12.2	23.1	26.6	31.5	36.6
J11-J13	E Lge Tributary	3687.716	13.4	25.2	29	34.6	40
J13-J14	E Lge Tributary	3403.982	14.7	27.7	31.7	37.9	43.6
J14-J15	E Lge Tributary	3203.982	14.6	27.5	31.8	37.7	43.2
J15-J16	E Lge Tributary	2972.916	14.8	28	32.3	38.5	43.5
J16-J17	E Lge Tributary	2572.449	14.8	27.9	32.1	38.4	43.7
J17-J20	E Lge Tributary	2222.449	14.8	28.1	32.6	38.3	43.6
J20-J21	E Lge Tributary	2092.741	17.1	32.5	37.4	44.5	50.2
J21-J22	E Lge Tributary	1975.477	17.4	33.2	38.2	45.3	51.3
J22-J49	E Lge Tributary	1509.899	17.1	33.1	38	44.8	51
J22-J49	E Lge Tributary	978.5302	16.8	33	37.8	44.2	50.6
J22-J49	E Lge Tributary	113.1541	16.4	32.8	37.4	43.5	50.2
J42-J46	NW Tributary	596.9849	2.2	4.6	5.2	6.3	7
J42-J46	NW Tributary	74.14214	3.7	7.7	8.7	10.5	11.7

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
E29-J42	E Sml Tributary	1967.168	1.1	2.4	2.8	3.3	3.7
E29-J42	E Sml Tributary	1028.797	2.3	4.8	5.5	6.7	7.4
J42-J43	E Sml Tributary	916.9338	3.1	6.6	7.5	9.2	10.2
JNew-JNew2	E Sml Tributary	576.9869	3.9	8.1	9.2	11.4	12.6
JNew-JNew2	E Sml Tributary	475.9506	4.6	9.7	10.9	13.6	15.1
E24-J34	SW Tributary	577.9468	2.5	5	5.6	6.8	7.5
E24-J34	SW Tributary	181.4893	3.5	7.1	8.1	9.7	10.7

Table C-16: Frazers Creek (Northern Catchment) existing conditions design flow inputs from RORB

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
N1 to J7	Frazers Creek	2805.402	0.5	1	1.3	1.5	1.7
N1 to J7	Frazers Creek	1908.452	1.8	3.5	4.2	4.9	5.5
N1 to J7	Frazers Creek	1306.97	2.6	5.2	6.3	7.4	8.3
N1 to J7	Frazers Creek	752.3439	3.5	7	8.3	9.9	11.1
J7 to J8	Frazers Creek	638.9193	6.7	13.7	16.1	19.1	21.6
J8 to J9	Frazers Creek	379.2131	6.8	14	16.6	19.7	22.2
End of Model	Frazers Creek	108.7968	6.9	14.2	16.9	19.9	22.4
N2 to J5	N Tributary	1690.16	0.7	1.4	1.7	2	2.2
N2 to J5	N Tributary	1199.629	1.3	2.6	3.2	3.8	4.2
N2 to J5	N Tributary	872.9999	1.7	3.5	4.2	5	5.6

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
J5 to J6	N Tributary	750.2181	4.2	8.3	9.8	11.6	13.5
J6 to J7	N Tributary	562.3423	4.4	8.6	10.1	12.1	14
J6 to J7	N Tributary	356.1291	4.5	8.8	10.2	12.3	14.2
J6 to J7	N Tributary	77.1341	4.5	9	10.4	12.5	14.5

Table C-17: Horse Gully (North-western Catchment) existing conditions design flow inputs from RORB

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
NW5 to J1	Horse Gully	4021.322	0.8	1.7	2	2.4	2.7
NW5 to J1	Horse Gully	3681.972	1.2	2.5	3	3.5	4.1
NW5 to J1	Horse Gully	3293.704	1.6	3.4	4	4.7	5.4
J1 to J2	Horse Gully	3180.195	2.2	4.5	5.2	6.1	7
J2 to J3	Horse Gully	2826.348	2.5	5.3	6	7.2	8.3
J3 to J4	Horse Gully	2660.992	3.2	6.6	7.5	9.1	10.3
J4 to J5	Horse Gully	2599.163	3.2	6.7	7.6	9.1	10.4
J5 to J6	Horse Gully	2432.594	3.4	7	7.9	9.6	10.9
J6 to J9	Horse Gully	2197.098	3.8	7.7	8.9	10.5	12
J6 to J9	Horse Gully	1751.52	4.1	8.4	9.8	11.5	13.1
J9 to J10	Horse Gully	1695.903	7.5	15.3	17.7	20.9	23.8
J10 to J13	Horse Gully	1495.601	8.8	18.2	21.2	24.6	28.4
J13 to J18	Horse Gully	1181.104	8.9	18.4	21.5	24.9	28.5

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m^3/s)	1% AEP flow (m^3/s)	0.5% AEP flow (m^3/s)	0.2% AEP flow (m^3/s)	0.1% AEP flow (m^3/s)
J13 to J18	Horse Gully	520.4263	9	18.5	21.8	25.3	28.6
J18 to J19	Horse Gully	457.9998	9.2	18.9	22.4	25.9	28.7
J19 to J20	Horse Gully	245.8678	9.1	18.9	22.2	25.8	28.2
NW11 to J14	N Tributary	1600.973	0.8	1.8	2.1	2.5	2.8
NW11 to J14	N Tributary	1431.531	0.9	2	2.3	2.8	3.1
J14 to J15	N Tributary	1319.907	1.5	3.2	3.7	4.2	4.9
J15 to J16	N Tributary	1212.611	1.6	3.4	3.9	4.6	5.3
J15 to J16	N Tributary	997.1251	1.7	3.7	4.1	4.9	5.7
J16 to J17	N Tributary	926.4144	2.6	5.3	6	7.2	8.2
J17 to J20	N Tributary	702.8307	2.7	5.4	6.1	7.4	8.4
J17 to J20	N Tributary	536.2621	2.7	5.5	6.3	7.5	8.6
J17 to J20	N Tributary	321.4844	2.8	5.6	6.4	7.7	8.8
J17 to J20	N Tributary	144.5605	2.8	5.7	6.6	7.9	9
NW1 to J18	SW Tributary	319.8419	0.9	2	2.3	2.7	3.1
NW1 to J18	SW Tributary	88.79881	1.2	2.6	3.1	3.6	4.1
NW3 to J3	SE Tributary	354.8628	0.8	1.6	1.9	2.3	2.6
NW3 to J3	SE Tributary	132.081	1	2.1	2.4	2.9	3.3

Table C-18: Mary Anne Creek (Western Catchment) existing conditions design flow inputs from RORB

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
W2 to Junction 1	Mary Anne Creek	3278.444	1.3	2.9	3.4	4	4.5
W2 to Junction 1	Mary Anne Creek	2634.951	2.7	5.7	6.7	8	9.1
W2 to Junction 1	Mary Anne Creek	1917.203	4	8.6	10.1	12	13.6
W2 to Junction 1	Mary Anne Creek	1300.929	5.3	11.4	13.4	16	18.1
Jnct 1 to Jnct 2	Mary Anne Creek	1185.835	6.9	14.6	17.2	20.4	23.2
Jnct 2 to Jnct 3	Mary Anne Creek	1020.348	6.8	14.4	17	20.3	23.1
Jnct 3 to Jnct 4	Mary Anne Creek	903.7798	5.4	11.2	13.2	15.6	17.4
Inter	Mary Anne Creek	744.4133	5.9	12.3	14.4	17.1	18.9
Inter	Mary Anne Creek	536.129	6.2	12.8	15	17.8	19.7
End of Catchment	Mary Anne Creek	217.4894	6.4	13.4	15.6	18.5	20.4

Table C-19: Apple Tree Gully (South-western Catchment) existing conditions design flow inputs from RORB

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m³/s)	1% AEP flow (m³/s)	0.5% AEP flow (m³/s)	0.2% AEP flow (m³/s)	0.1% AEP flow (m³/s)
SW4 to J1	Apple Tree Gully	6710.924	1.7	3.6	4.2	4.8	5.4
SW4 to J1	Apple Tree Gully	6133.698	3.3	7.1	8.3	9.7	10.8
J1 to J2	Apple Tree Gully	6023.343	4	8.3	9.8	11.4	12.8
J2 to J3	Apple Tree Gully	5905.786	4	8.1	9.7	11.3	12.8
J3 to J4	Apple Tree Gully	5802.632	4.5	9.1	10.8	12.6	14.7
J4 to J5	Apple Tree Gully	5457.069	5.4	10.9	12.8	15.1	17.7

RORB Location	HEC-RAS river	HEC-RAS cross section river station (m)	10% AEP flow (m^3/s)	1% AEP flow (m^3/s)	0.5% AEP flow (m^3/s)	0.2% AEP flow (m^3/s)	0.1% AEP flow (m^3/s)
J5 to J6	Apple Tree Gully	5322.943	6	12.1	14.1	16.5	19.4
J6 to J7	Apple Tree Gully	5089.806	6	12.1	14.2	16.5	19.4
J7 to J8	Apple Tree Gully	5024.506	6	11.8	13.5	16	18.4
J8 to J9	Apple Tree Gully	4544.537	6.4	12.6	14.5	17.4	19.9
J8 to J9	Apple Tree Gully	4006.175	6.9	13.4	15.5	18.8	21.5
J8 to J9	Apple Tree Gully	3718.896	7.3	14.2	16.5	20.2	23.1
J8 to J9	Apple Tree Gully	3219.19	7.8	15	17.5	21.6	24.6
J9 to J10	Apple Tree Gully	3106.764	7.9	15.5	18.2	22.3	25.5
J11 to J14	Apple Tree Gully	2719.485	8.2	16.2	19.3	23.4	26.9
J14 to J15	Apple Tree Gully	2428.063	8.5	16.9	20.1	24.5	28
J15 to J16	Apple Tree Gully	2311.495	9	18.2	21.3	26.3	30
J16 to J17	Apple Tree Gully	2036.642	9.3	19	22.2	27.4	31.2
J16 to J17	Apple Tree Gully	1624.51	9.6	19.7	23.1	28.4	32.4
J16 to J17	Apple Tree Gully	1229.838	9.9	20.5	24	29.5	33.6
J16 to J17	Apple Tree Gully	601.4313	10.2	21.3	24.9	30.6	34.7
J17 to J18	Apple Tree Gully	530.7206	10.7	22.3	25.9	31.9	36.1
End of model	Apple Tree Gully	131.5006	10.8	22.5	26.3	32.3	36.5

Appendix D Flood extents and depths

The following figures outline the 1% AEP flood results for the proposed development under a natural climate.

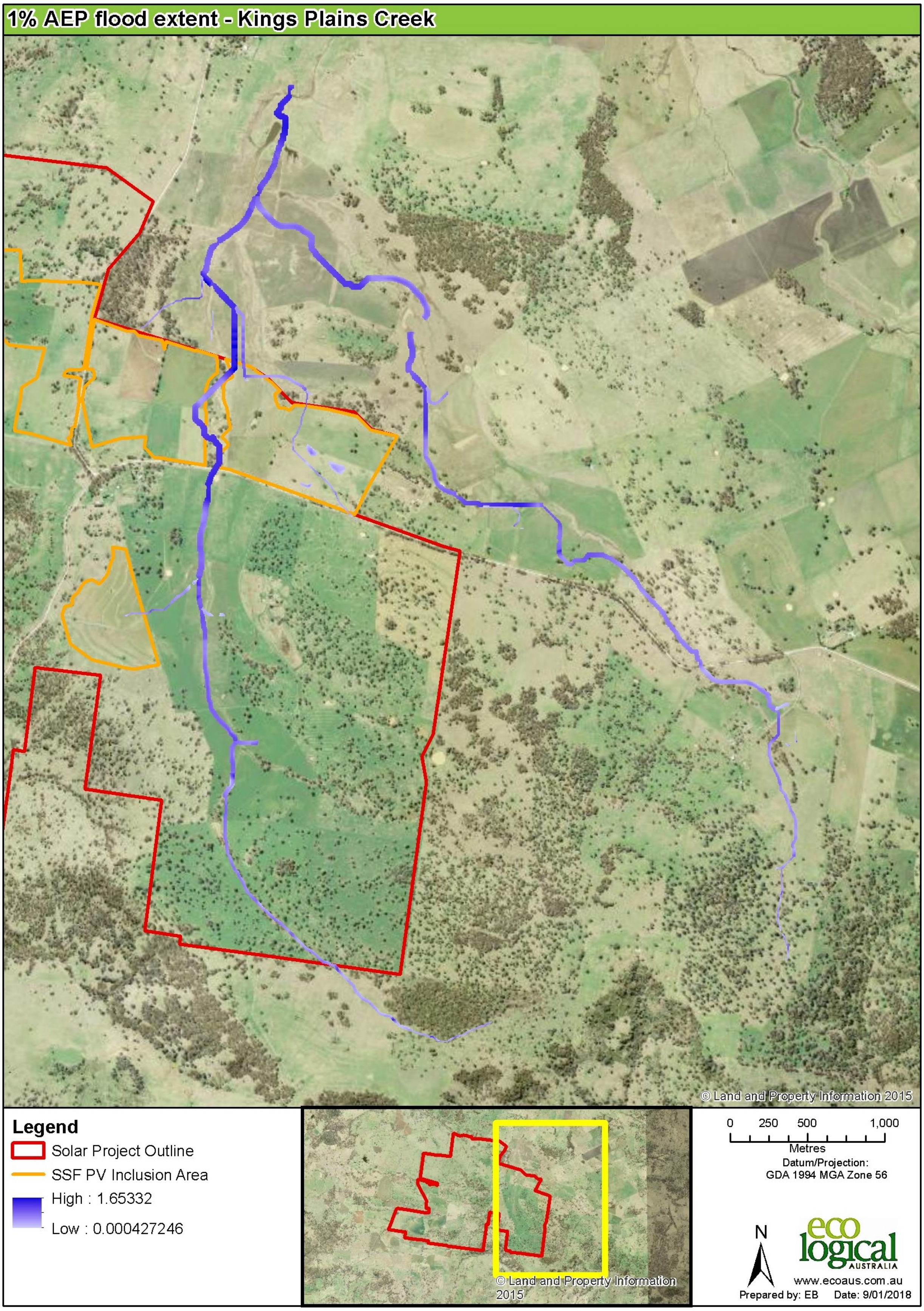

Figure D-21 Kings Plains Creek 1% AEP flood extent under natural climate for the proposed development

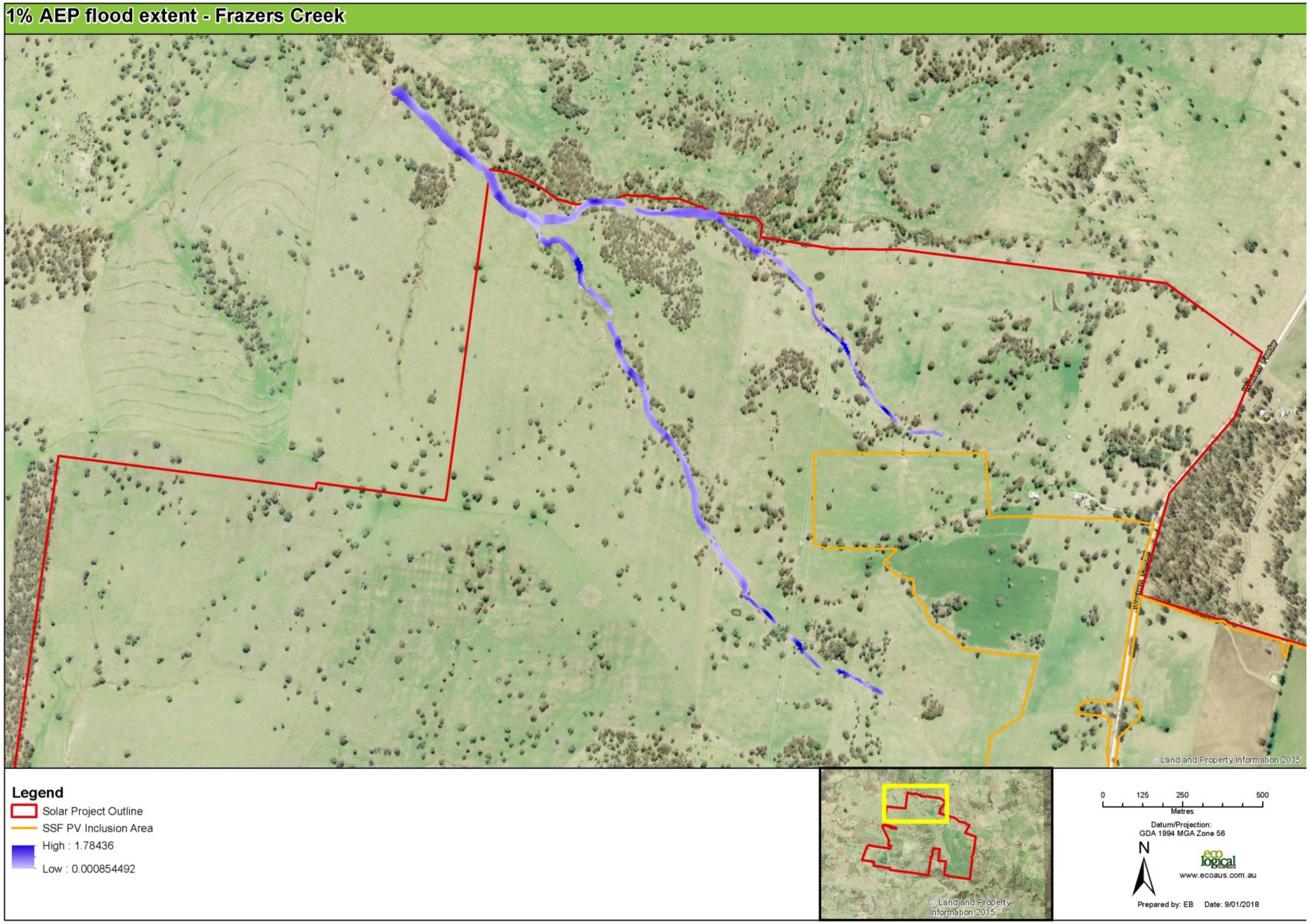

Figure D-22 Frazers Creek 1% AEP flood extent under natural climate for the proposed development

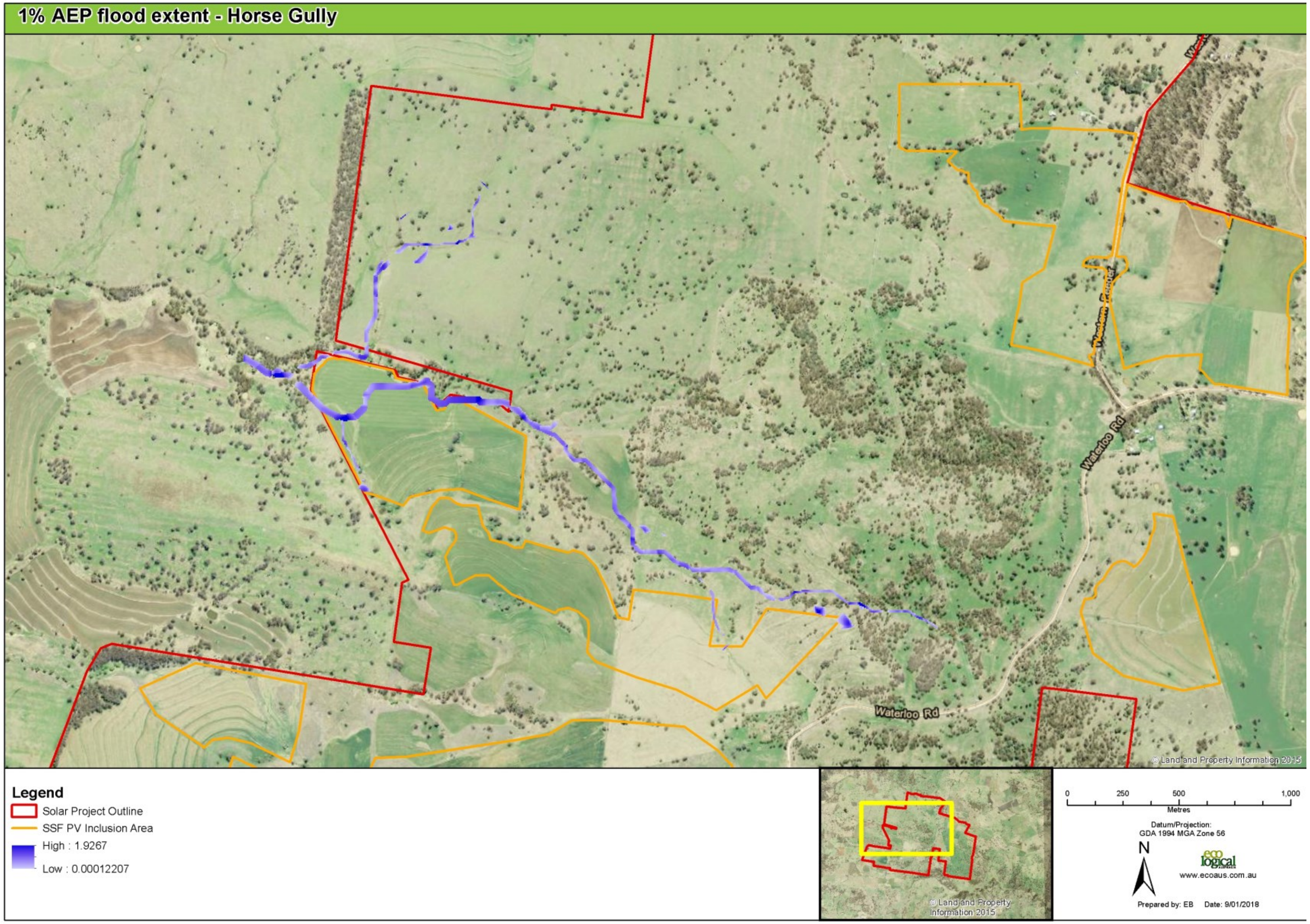

Figure D-23 Horse Gully 1% AEP flood extent under natural climate for the proposed development

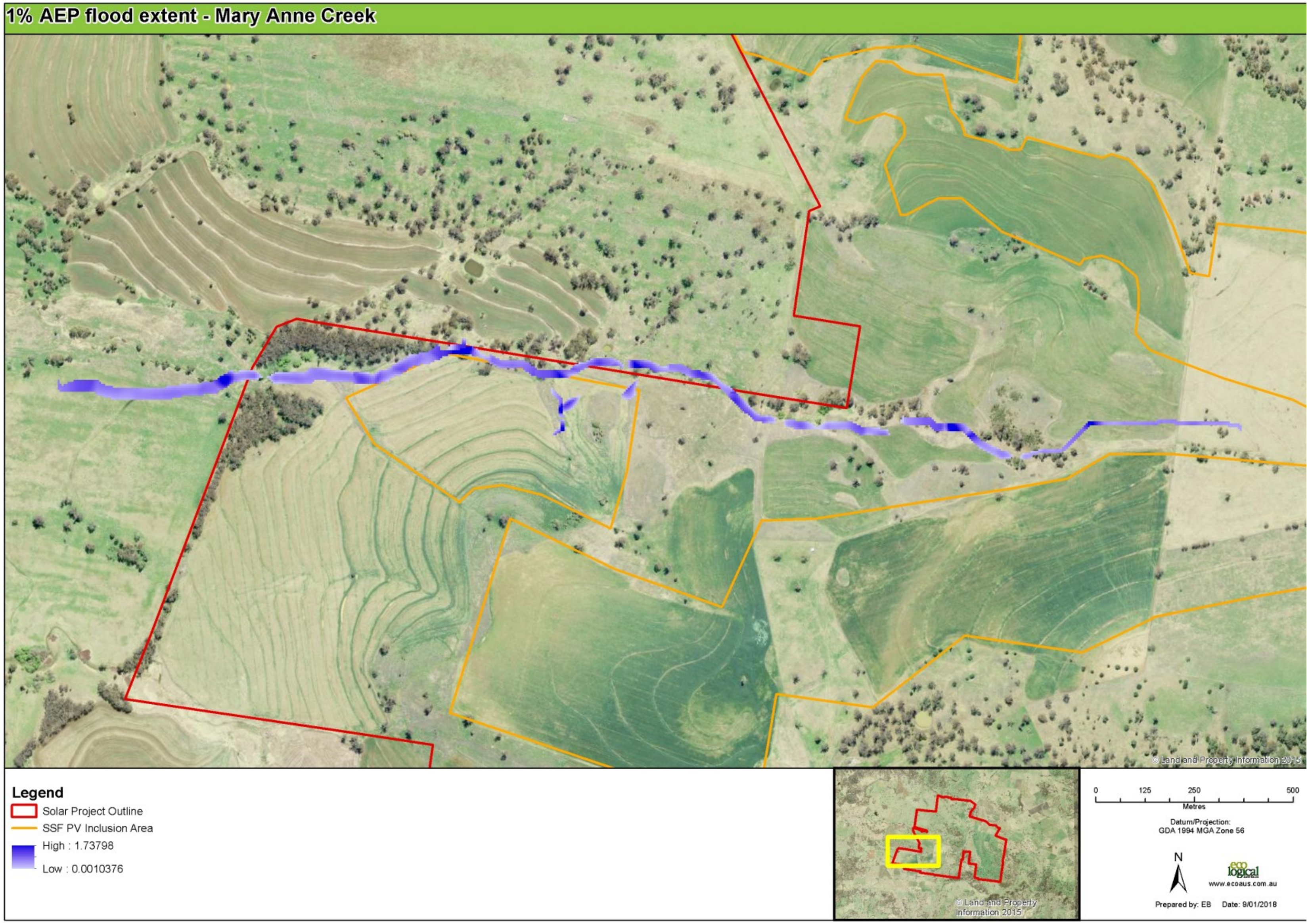

Figure D-24 Mary Anne Creek 1% AEP flood extent under natural climate for the proposed development

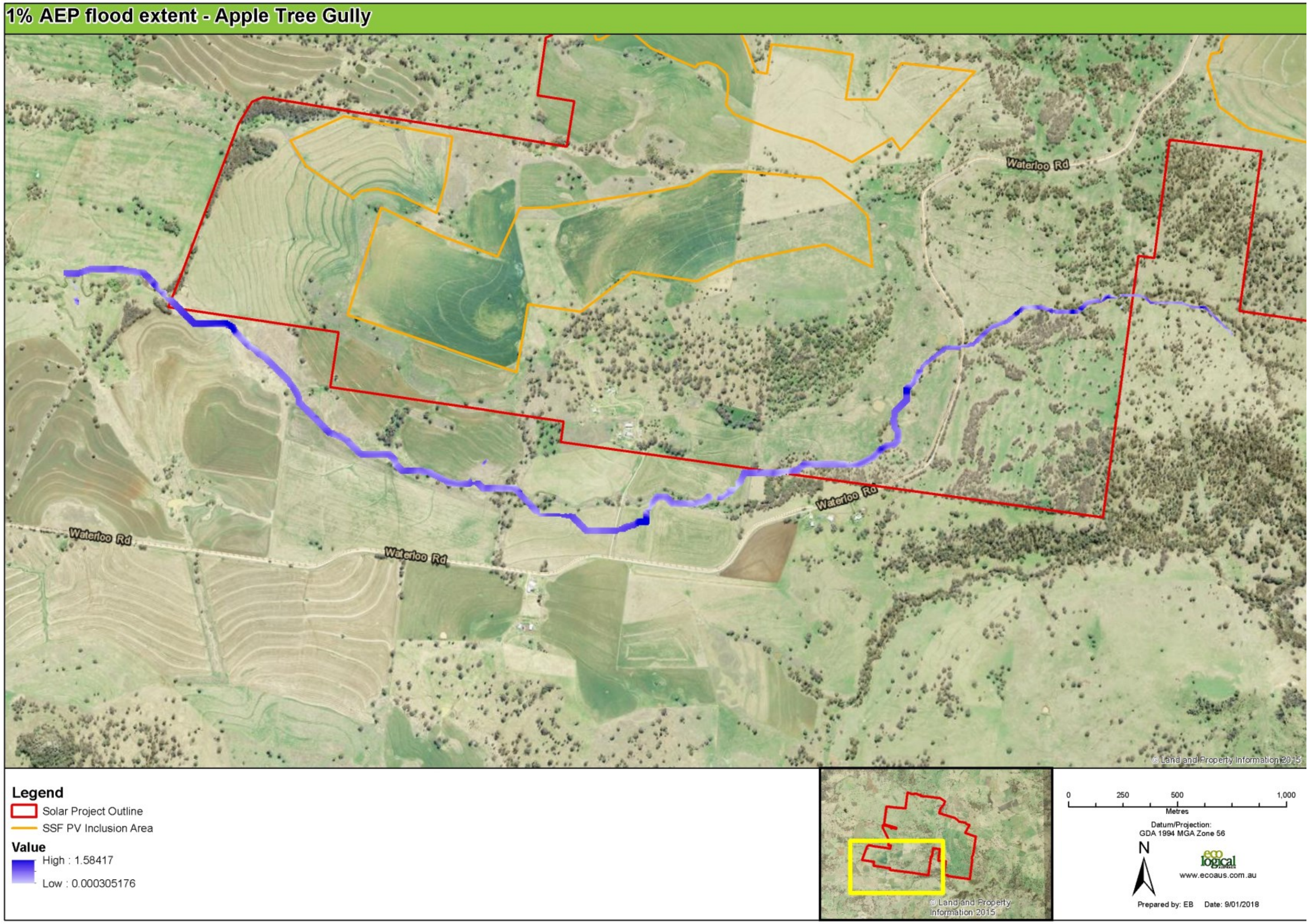

Figure D-25 Apple Tree Gully 1% AEP flood extent under natural climate for the proposed development

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