Appendix A

Water Quality Results

Table A1 Water quality results: Yarrangobilly River

	Unit	Month	February			March				April				Yarrangobilly River summary			
		Site	LH_SW_004	LH_SW_007	PN_SW_002	LH_SW_004	LH_SW_006	LH_SW_007	PN_SW_002	LH_SW_004	LH_SW_006	LH_SW_007	PN_SW_002				
		Date	14/02/2018	14/02/2018	14/02/2018	13/03/2018	13/03/2018	13/03/2018	13/03/2018	12/04/2018	12/04/2018	12/04/2018	9/04/2018				
		Guideline Value												**# Samples**	**10th Percentile**	**Median**	**90th Percentile**
Field Parameters																	
Temperature	^{o}C		21	23	19	19	21	22	21	15	13	14	15	11	14	19	22
Dissolved Oxygen (DO)	%	90 – 110[1]	-	-	-	**75**	**84**	88	**85**	**79**	93	90	**75**	8	75	84	93
Electrical Conductivity (EC)	µS/cm	30 – 350[1]	121	146	**28**	183	185	187	32	174	171	171	39	11	32	171	185
pH		6.5 – 8.5[1]	7.3	7.6	7.5	8.1	8.0	8.0	7.7	8.0	7.9	7.9	8.3	11	7.5	7.9	8.1
Oxidising and Reducing Potential (ORP)		-	119	104	112	132	128	130	137	120	167	144	143	11	112	130	144
Turbidity	NTU	6 - 25	<2	<2	5.14	<2	<2	<2	2.78	-	-	-	-	7	<2	<2	5
Analytical Results - General																	
Suspended Solids (SS)	mg/l	-	<5	<5	<5	<2	<2	2	2	<5	<5	<5	6	11	<5	<5	<5
Total Alkalinity (as $CACO_3$)	mg/l	-	68	86	15	109	106	109	16	-	-	-	-	7	15	86	109
Total Hardness (as $CACO_3$)	mg/l	-	-	-	-	-	-	-	-	86	97	91	9	4	9	89	97
Analytical Results - Nutrients																	
Ammonia	mg/l	0.02	<0.01	<0.01	<0.01	-	-	-	-	<0.01	<0.01	<0.01	<0.01	7	<0.01	<0.01	<0.01
Oxidised Nitrogen (NOx)	mg/l	0.04	**1.92**	0.04	0.02	-	-	-	-	0.03	<0.01	0.05	0.03	7	0.01	0.03	**1.92**
Total Kjeldahl Nitrogen (TKN)	mg/l	-	<0.1	<0.1	0.1	-	-	-	-	<0.1	<0.1	<0.1	<0.1	7	<0.1	<0.1	<0.1
Total Nitrogen (TN)	mg/l	0.25	**1.9**	<0.1	0.1	-	-	-	-	<0.1	<0.1	<0.1	<0.1	7	0.1	0.1	**1.9**
Reactive Phosphorus	mg/l	0.015	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01	4	<0.01	<0.01	<0.01
Total Phosphorus (TP)	mg/l	0.02	<0.01	0.02	<0.01	-	-	-	-	<0.01	<0.01	<0.01	<0.01	7	0.01	0.01	0.02
Total Organic Carbon	mg/l	-	-	-	-	-	-	-	-	6	1	23	16	4	1	11	23
Dissolved Organic Carbon	mg/l	-	-	-	-	-	-	-	-	<1	<1	<1	1	4	<1	<1	<1
Analytical Results - Inorganics (Dissolved)																	
Fluoride	mg/l	0.115	**0.6**	<0.1	<0.1	0.1	0.11	0.1	0.08	-	-	-	-	7	0.08	0.1	**0.6**
Analytical Results - Metals (Dissolved)																	
Aluminium (Al)	mg/l	0.055	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	**0.06**	4	0.01	0.01	**0.06**
Arsenic (As)	mg/l	0.013	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	4	<0.001	<0.001	<0.001
Barium (Ba)	mg/l	0.0083	-	-	-	-	-	-	-	**0.026**	**0.042**	**0.031**	**0.011**	4	0.011	0.0285	0.042
Boron (B)	mg/l	0.37	-	-	-	-	-	-	-	<0.05	<0.05	<0.05	<0.05	4	<0.05	<0.05	<0.05
Cobalt (Co)	mg/l	0.00143	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	4	<0.001	<0.001	<0.001
Total Chromium (Cr)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-	7	<0.001	<0.001	<0.001
Copper (Cu)	mg/l	0.0014	-	-	-	-	-	-	-	0.001	<0.001	<0.001	<0.001	4	<0.001	<0.001	<0.001
Manganese (Mn)	mg/l	1.9	-	-	-	-	-	-	-	<0.001	0.001	0.001	0.002	4	0.001	0.001	0.002
Nickel (Ni)	mg/l	0.011	-	-	-	-	-	-	-	0.001	<0.001	<0.001	<0.001	7	0.001	0.001	0.002
Lead (Pb)	mg/l	0.0034	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	4	<0.001	<0.001	<0.001
Selenium (Se)	mg/l	0.005	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01	4	<0.01	<0.01	<0.01
Silver (Ag)	mg/l	0.0005	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	4	<0.001	<0.001	<0.001
Vanadium (V)	mg/l	0.0063	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01	4	<0.01	<0.01	<0.01
Zinc (Zn)	mg/l	0.008	-	-	-	-	-	-	-	<0.005	<0.005	<0.005	<0.005	4	<0.005	<0.005	<0.005
Mercury (Hg)	mg/l	0.00006	-	-	-	-	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	4	<0.0001	<0.0001	<0.0001
Iron (Fe)	mg/l	0.33	-	-	-	-	-	-	-	<0.05	<0.05	<0.05	0.06	4	0.05	0.05	0.06

Notes:

1. Refer to Section 4.6.1 for further information on guideline values.

Bold *denotes Guideline Value or Range is exceeded.*

Table A2 Water quality results: Wallaces Creek

	Unit	Month	March			April			Wallaces Creek Summary			
		Site	LH_SW_001	LH_SW_002	LH_SW_003	LH_SW_001	LH_SW_002	LH_SW_003				
		Date	13/03/2018	13/03/2018	13/03/2018	12/04/2018	12/04/2018	12/04/2018				
		Guideline Value				**Dry**			**# Samples**	**Min**	**Median**	**Max**
Field Parameters												
Temperature	^{o}C		15	13	16	-	15	14	5	13	15	16
Dissolved Oxygen (DO)	%	85 – 110[1]	**75**	**77**	**78**	-	92	**85**	5	75	78	92
Electrical Conductivity (EC)	µS/cm	30 – 350[1]	65	185	176	-	183	178	5	65	178	185
pH		6.5 – 8.5[1]	7.5	7.5	7.6	-	8.4	7.9	5	7.5	7.6	8.4
Oxidising and Reducing Potential (ORP)		-	146	144	133	-	70	62	5	62	133	146
Turbidity	NTU	2 - 25	<2	<2	<2	-	-	-	3	<2	<2	<2
Analytical Results - General												
Suspended Solids (SS)	mg/l	-	2	<2	<2	-	<5	<5	5	2	2	5
Total Alkalinity (as CACO$_3$)	mg/l	-	38	104	99	-	-	-	3	38	99	104
Total Hardness (as CACO$_3$)	mg/l	-	-	-	-	-	87	94	2	87	90.5	94
Analytical Results - Nutrients												
Ammonia	mg/l	0.02	-	-	-	-	<0.01	<0.01	2	<0.01	<0.01	<0.01
Oxidised Nitrogen (NOx)	mg/l	0.04	-	-	-	-	0.04	0.03	2	0.03	0.035	0.04
Total Kjeldahl Nitrogen (TKN)	mg/l	-	-	-	-	-	<0.1	<0.1	2	<0.1	<0.1	<0.1
Total Nitrogen (TN)	mg/l	0.25	-	-	-	-	<0.1	<0.1	2	<0.1	<0.1	<0.1
Reactive Phosphorus	mg/l	0.015	-	-	-	-	<0.01	<0.01	2	<0.01	<0.01	<0.01
Total Phosphorus (TP)	mg/l	0.02	-	-	-	-	0.01	<0.01	2	<0.01	<0.01	<0.01
Total Organic Carbon	mg/l	-	-	-	-	-	8	25	2	8	16.5	25
Dissolved Organic Carbon	mg/l	-	-	-	-	-	1	1	2	<1	<1	<1
Analytical Results - Inorganics (Dissolved)												
Fluoride	mg/l	0.1153	0.09	0.1	0.1	-	-	-	3	0.09	0.1	0.1
Analytical Results - Metals (Dissolved)												
Aluminium (Al)	mg/l	0.055	-	-	-	-	<0.01	<0.01	2	<0.01	<0.01	<0.01
Arsenic (As)	mg/l	0.013	-	-	-	-	<0.001	<0.001	2	<0.001	<0.001	<0.001
Barium (Ba)	mg/l	0.008	-	-	-	-	**0.088**	**0.106**	2	**0.088**	**0.097**	**0.106**
Boron (B)	mg/l	0.37	-	-	-	-	<0.05	<0.05	2	<0.05	<0.05	<0.05
Cobalt (Co)	mg/l	0.00143	-	-	-	-	<0.001	<0.001	2	<0.001	<0.001	<0.001
Total Chromium (Cr)	mg/l	0.001	<0.002	<0.002	<0.002	-	-	-	3	<0.002	<0.002	<0.002
Copper (Cu)	mg/l	0.0014	-	-	-	-	<0.001	0.003	2	0.001	0.002	0.003
Manganese (Mn)	mg/l	1.9	-	-	-	-	0.001	0.002	2	0.001	0.0015	0.002
Nickel (Ni)	mg/l	0.011	-	-	-	-	0.001	<0.001	3	0.001	0.002	0.002
Lead (Pb)	mg/l	0.0034	-	-	-	-	<0.001	<0.001	2	<0.001	<0.001	<0.001
Selenium (Se)	mg/l	0.005	-	-	-	-	<0.01	<0.01	2	<0.01	<0.01	<0.01
Silver (Ag)	mg/l	0.0005	-	-	-	-	<0.001	<0.001	2	<0.001	<0.001	<0.001
Vanadium (V)	mg/l	0.0063	-	-	-	-	<0.01	<0.01	2	<0.01	<0.01	<0.01
Zinc (Zn)	mg/l	0.008	-	-	-	-	<0.005	<0.005	3	<0.005	<0.005	<0.005
Mercury (Hg)	mg/l	0.00006	-	-	-	-	<0.0001	<0.0001	2	<0.0001	<0.0001	<0.0001
Iron (Fe)	mg/l	0.33	-	-	-	-	<0.05	<0.05	2	<0.05	<0.05	<0.05

Notes:

1. Refer to Section 4.6.1 for further information on guideline values.

Bold *denotes Guideline Value or Range is exceeded.*

Table A3 Water quality results: Talbingo Reservoir

	Unit	Month															Talbingo Reservoir summary			
		Site	TAL01-S	TAL01-M	TAL01-B	TAL09-S	TAL09-M	TAL09-B	TAL15B-S	TAL15B-M	TAL15B-B	TAL19-S	TAL19-M	TAL20-S	TAL20-M	TAL15-S	TAL15-M				
		Date	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018	march 2018				
		Guideline Value[1]																# Samples	10^{th} Percentile	Median	90^{th} Percentile
Field Parameters																				
Temperature	°C		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Oxygen (DO)	%	90 – 110[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical Conductivity (EC)	µS/cm	30 – 350[1]	66	31	26	29	29	27	29	29	27	32	31	30	30	31	28	15	27	29	32
pH		6.5 – 8.5[1]	7	7	6.8	7	6.9	6.9	7	7	6.8	7.2	7.1	7.1	7.2	6.8	7.1	15	6.8	7.0	7.2
Oxidising and Reducing Potential (ORP)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	2 - 25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Analytical Results - General																				
Suspended Solids (SS)	mg/l	-	2.5	1.3	19	1	< 1	< 1	1.7	1.1	1.4	5.8	3.4	2.2	1	4	4.6	15	<1	2	6
Total Alkalinity (as $CACO_3$)	mg/l	-	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	15	<20	<20	<20
Total Hardness (as $CACO_3$)	mg/l	-	11	7.1	5.3	6.9	11	6.6	7.8	7.2	6.3	8.4	9.3	7.3	7.3	6.6	7.1	15	6	7	10
Analytical Results - Nutrients																				
Ammonia	mg/l	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	15	<0.01	<0.01	<0.01
Oxidised Nitrogen (NOx)	mg/l	0.04	< 0.05	< 0.05	**0.07**	< 0.05	< 0.05	**0.25**	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	15	0.05	0.05	0.07
Total Kjeldahl Nitrogen (TKN)	mg/l	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	15	<0.2	<0.2	<0.2
Total Nitrogen (TN)	mg/l	0.25	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	**0.3**	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	15	<0.2	<0.2	<0.2
Reactive Phosphorus	mg/l	0.015	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	15	<0.05	<0.05	<0.05
Total Phosphorus (TP)	mg/l	0.02	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	15	<0.05	<0.05	<0.05
Total Organic Carbon	mg/l	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	15	<5	<5	<5
Dissolved Organic Carbon	mg/l	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	15	<5	<5	<5
Analytical Results - Inorganics (Dissolved)																				
Fluoride	mg/l	0.1153	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	15	<0.5	<0.5	<0.5
Analytical Results - Metals (Dissolved)																				
Aluminium (Al)	mg/l	0.055	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	15	<0.05	<0.05	<0.05
Arsenic (As)	mg/l	0.013	< 0.001	0.001	0.001	0.001	< 0.001	0.001	0.001	0.001	0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	15	<0.001	0.001	0.001
Barium (Ba)	mg/l	0.008	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	15	<0.02	<0.02	<0.02
Boron (B)	mg/l	0.37	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	15	<0.05	<0.05	<0.05
Cobalt (Co)	mg/l	0.00143	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	15	<0.001	<0.001	<0.001
Total Chromium (Cr)	mg/l	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	15	<0.001	<0.001	<0.001
Copper (Cu)	mg/l	0.0014	< 0.001	< 0.001	0.001	< 0.001	**0.008**	**0.064**	**0.015**	**0.088**	**0.045**	**0.032**	**0.033**	< 0.001	< 0.001	0.001	< 0.001	15	0.001	**0.032**	**0.069**
Manganese (Mn)	mg/l	1.9	< 0.005	< 0.005	0.082	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	15	<0.005	<0.005	0.007
Nickel (Ni)	mg/l	0.011	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004	0.002	0.01	0.003	0.004	0.004	0.003	< 0.001	< 0.001	< 0.001	15	<0.001	<0.001	0.004
Lead (Pb)	mg/l	0.0034	0.002	0.002	0.003	0.002	< 0.001	0.003	0.002	**0.005**	< 0.001	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	15	<0.001	0.002	0.003
Selenium (Se)	mg/l	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	15	<0.001	<0.001	<0.001
Silver (Ag)	mg/l	0.0005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	15	<0.005	<0.005	<0.005
Vanadium (V)	mg/l	0.0063	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	15	<0.005	<0.005	<0.005
Zinc (Zn)	mg/l	0.008	< 0.005	< 0.005	< 0.005	0.006	**0.010**	**0.068**	**0.020**	**0.140**	**0.048**	**0.037**	**0.061**	**0.012**	< 0.005	**0.094**	0.006	15	<0.005	**0.024**	**0.065**
Mercury (Hg)	mg/l	0.00006	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	15	<0.0001	<0.0001	<0.0001
Iron (Fe)	mg/l	0.33	< 0.05	< 0.05	**0.67**	< 0.05	< 0.05	0.07	< 0.05	< 0.05	< 0.05	0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	15	0.05	0.05	0.066

Notes:

1. Refer to Section 4.6.1 for further information on guideline values.

Bold *denotes Guideline Value or Range is exceeded.*

Appendix B

Flood Assessment Method Statement

GRC Hydro
Level 9, 233 Castlereagh Street
Sydney NSW 2000

Tel: +61 432 477 036
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Job Number: *180021*
Date: *29 May 2018*

Chris Kuczera
EMM
Suite 01, 20 Chandos Street
ST LEONARDS NSW 2065

Dear Chris,

Re: Yarrangobilly River Flood Study

INTRODUCTION

The project

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme (Snowy Scheme). This would be achieved by establishing a new underground hydro-electric power station that would increase the generation capacity of the Snowy Scheme by almost 50%, providing an additional 2,000 megawatts (MW) generating capacity, and providing approximately 350 gigawatt hours (GWh) of storage available to the National Electricity Market (NEM) at any one time, which is critical to ensuring system security as Australia transitions to a decarbonised NEM. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and hydro-electric power station.

The purpose of the Exploratory Works for Snowy 2.0 is primarily to gain a greater understanding of the conditions at the proposed location of the power station, approximately 850 metres (m) below ground level. Understanding factors such as rock conditions (such as stress conditions) and ground temperature is essential to confirm the suitability of the site for the underground power station.

The Exploratory Works comprise:

- establishment of an exploratory tunnel to the site of the underground power station for Snowy 2.0;
- establishment of a construction pad;
- excavated rock management;
- establishment of an accommodation camp;
- road establishment and upgrades providing access and haulage routes during Exploratory Works;
- establishment of barge access infrastructure to enable access and transport by barge on Talbingo reservoir;
- establishment of services infrastructure such as diesel-generated power and communication; and

- geotechnical investigation to inform detailed design for Exploratory Works components listed above.

Yarrangobilly Flood Study

EMM Consulting Pty Ltd (EMM) requested a flood study be undertaken for the Yarrangobilly River at the site of Exploratory Works for Snowy 2.0 (the Site). The Yarrangobilly River is a tributary of the Tumut River, located upstream of Talbingo Dam in southern NSW (see Image 1).

The Site is subject to flooding from the Yarrangobilly River which flows through the Site in a westerly direction. Minor tributaries which enter the River from both the north and south within the Site are also subject to flooding.

The flood study objectives are to:

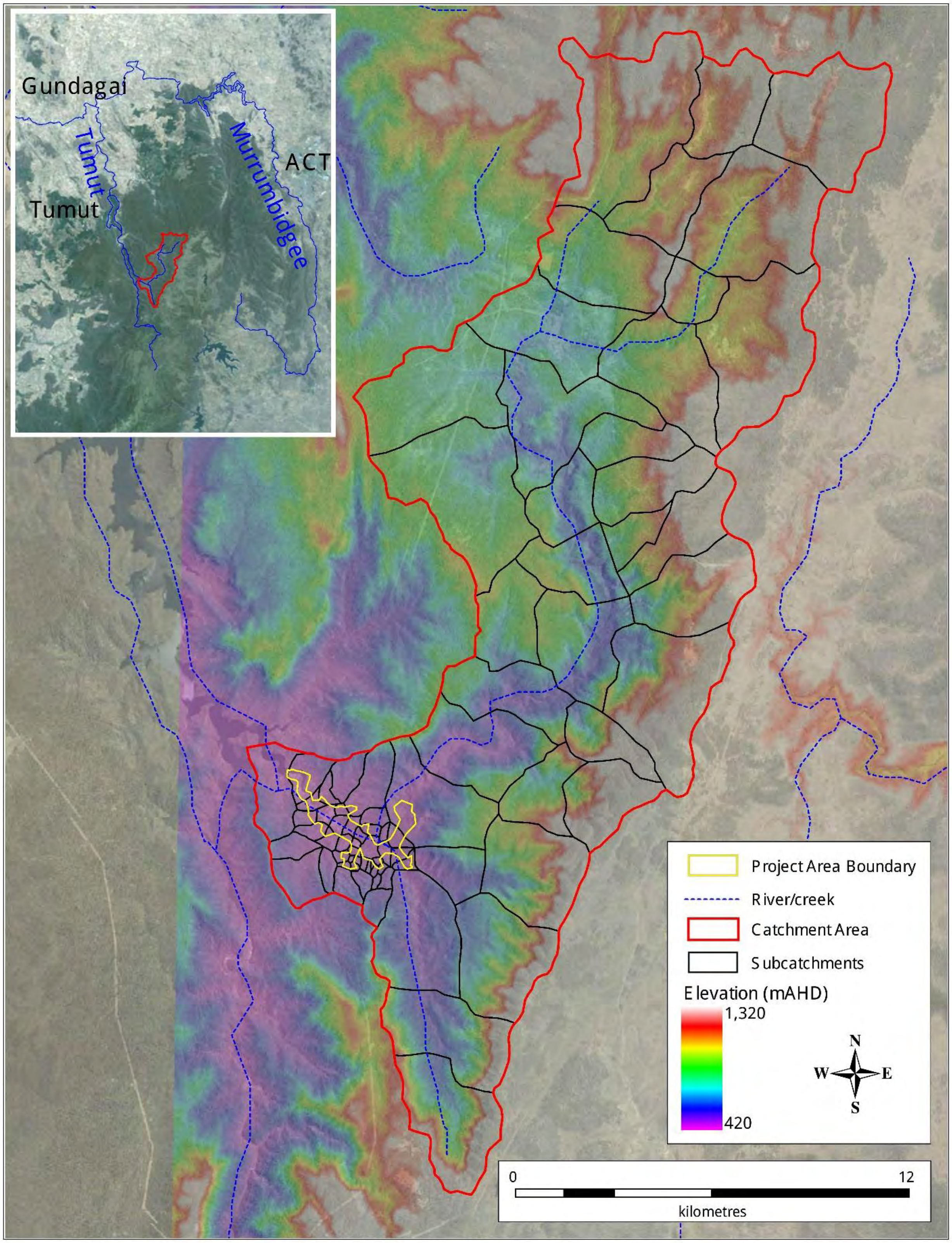
- Develop a XP-RAFTS hydrologic model;
- Undertake Flood Frequency Analysis (FFA) for the Yarrangobilly@Ravine (410574) stream gauge;
- Calibrate the XP-RAFTS model to FFA derived flows using Australian Rainfall and Runoff (ARR2016) methodology;
- Derive design flow hydrographs using ARR2016 methods for the 20%, 5%, 1%, 0.2% AEP, 0.05% and Probable Maximum Flood (PMF) events for the Yarrangobilly River;
- Validate the 1% Annual Exceedance Probability (AEP) flow estimate using regional flood frequency estimates;
- Develop a TUFLOW hydraulic model for the Site; and
- Model design flood behaviour for the above-mentioned events.

The purpose of this report is to describe the data analysis and modelling methodologies that have been applied to the Yarrangobilly Flood Study. Model results, flood impacts and flood risk management measures are presented and discussed in the surface water assessment for Exploratory Works.

HYDROLOGY

Hydrologic analysis consisted of the development of a XP-RAFTS hydrologic model which was then calibrated to FFA. The following sections outline the implemented approach.

Image 1: Yarrangobilly Sub-catchments, Project Area Boundary and Locality Map



Flood Frequency Analysis

FFA was performed on the annual maximum series of flows recorded at the Yarrangobilly@Ravine (410574) stream gauge (the Gauge). The gauge was commissioned in March 1972 and has a largely continuous and homogenous record period suitable for FFA. FFA was undertaken on the maximum annual flow for the 46 years of record from 1972 to 2017.

Table 1: Yarrangobilly@Ravine Annual Series (m³/s)

Year	Flow	Year	Flow	Year	Flow
1972	30	1988	96	2004	47
1973	61	1989	29	2005	92
1974	62	1990	60	2006	3
1975	126	1991	38	2007	40
1976	75	1992	66	2008	36
1977	44	1993	77	2009	14
1978	57	1994	11	2010	210
1979	42	1995	119	2011	64
1980	45	1996	78	2012	163
1981	94	1997	25	2013	28
1982	6	1998	50	2014	31
1983	58	1999	37	2015	19
1984	102	2000	75	2016	62
1985	41	2001	27	2017	49
1986	50	2002	27		
1987	39	2003	67		

The extreme value analysis software package 'FLIKE' was used for FFA, following the procedures outlined in ARR2016. A Log-Person Type 3 (LPIII) distribution was fitted to the annual series. Other distributions were also examined, however the LPIII distribution was noted to have the best fit to the annual series data. The Grubbs-Beck Test for statistical outliers was applied, with five events with a peak flow less than 25 m^3/s censored from the record during analysis. Application of the Grubbs-Beck test was undertaken in unison with visual assessment of the applied distribution. FFA design flow estimates for the Site are presented in Table 2 and the FFA plot is presented in Chart 4.

Table 2: FFA Design Flow Estimates

AEP	Expected Parameter Quantile (m³/s)	90% Confidence Limits (m³/s)	
0.2EY	83	69	101
10%	111	90	144
5%	142	111	201
2%	191	137	312
1%	233	157	428

Hydrologic Modelling

Hydrologic model design flows have been determined using ARR2016 guidelines. Selected model parameters and inputs are described in the ensuing sections.

Model Schematisation and Parameters

An XP-RAFTS model was developed for the Yarrangobilly River catchment downstream to Talbingo Dam. Details of the XP-RAFTS model schematisation are presented in Table 3 with sub-catchment delineation presented in Image 1.

Table 3: XP-RAFTS Model Schematisation

Total model catchment area (km²)	Area of catchment at the Gauge (km²)	Number of Catchments	Average catchment size (km²)
280	271	78	3.6

XP-RAFTS model parameters were determined via inspection of available data including photographs, aerial imagery and SRTM DEM. This information was used to inform sub-catchment Mannings, slope and lag times.

A global Mannings value of 0.07 was implemented which is consistent with the moderate to dense vegetation typical for the region and as identified via inspection of photographs and imagery. Sub-catchment slopes were determined via methods outlined in the XP-RAFTS user manual, where by the 'equal angle slope' was calculated based on a sub-catchment's minimum and maximum elevation and maximum stream length. Lag times for inter-catchment routing were determined using the major flow path length (L) and slope (S) and the formula outlined in the Laurenson's method (lag time = $L / S^{0.5}$).

Design Rainfall

ARR2016 design rainfall depths for various durations were obtained from the Bureau of Meteorology (BoM). Due to a significant rainfall gradient across the Yarrangobilly River catchment, a single uniformly applied rainfall depth was not appropriate for modelling of design rainfall. Instead, spatially varying design rainfalls were applied across the catchment with each sub-catchment receiving a unique rainfall depth. The Yarrangobilly River catchment's minimum, maximum and average rainfall depths are presented in Table 6.

Table 4: Design Rainfall Depths (Average / Minimum / Maximum)

Duration (min)	20% AEP Event	10% AEP Event	5% AEP Event	2% AEP Event	1% AEP Event	0.2% AEP Event	0.02% AEP Event
720	64 / 60 / 76	74 / 69 / 88	83 / 78 / 100	97 / 90 / 116	108 / 100 / 130		
1080	75 / 70 / 91	87 / 80 / 106	99 / 91 / 121	116 / 106 / 142	129 / 118 / 160		
1440	84 / 77 / 104	97 / 89 / 121	111 / 101 / 139	130 / 117 / 164	145 / 131 / 185	188 / 169 / 244	255 / 203 / 300
2160	97 / 88 / 122	112 / 101 / 142	127 / 115 / 163	150 / 134 / 193	167 / 149 / 218	212 / 186 / 283	304 / 220 / 345
2880	105 / 95 / 134	122 / 109 / 157	138 / 123 / 180	163 / 144 / 214	182 / 160 / 242	224 / 194 / 311	287 / 225 / 373

Probable Maximum Precipitation (PMP) rainfall depths were determined using the methods outlined in the GSDM. The catchment is defined as 100% 'Rough' and a Moisture Adjustment Factor of 0.64 was applied. PMP rainfall depths for 'Ellipse A' for various durations are presented in Table 5.

Table 5: PMP Rainfall Depths

Duration	1 hour	2 hour	3 hour	4 hour	5 hour	6 hour
Rain (mm)	320	480	580	660	730	770

Areal Reduction Factor

Areal Reduction Factors (ARF) were applied to design rainfall depths to adjust for the Catchment's areal average rainfall intensity. The ARFs were determined following the methods outlined in ARR2016 for the 'Southern Temporal' region. Calculated ARFs were based on the catchment's area and event's duration and probability. Applied ARFs are presented in Table 6.

Table 6: Areal Reduction Factors

Duration (min)	20% AEP Event	10% AEP Event	5% AEP Event	2% AEP Event	1% AEP Event	0.2% AEP Event	0.05% AEP Event
720	0.91	0.90	0.90	0.89	0.88		
1080	0.92	0.92	0.92	0.91	0.91		
1440	0.94	0.94	0.94	0.94	0.93	0.93	0.93
2160	0.95	0.94	0.94	0.94	0.94	0.94	0.94
2880	0.95	0.95	0.95	0.94	0.94	0.94	0.94

Rainfall Losses

An Initial and Proportional Loss (IL / PL) model was implemented for events up to an including the 1% AEP. ARR2016 notes that studies undertaken by Dyer et al (1994) and Hill et al (1996) found that 'the IL/PL model resulted in generally improved calibrations'.

It must be noted that calibration to FFA was first attempted using an Initial and Continuing Loss (IL / CL) model. The calibration was unsuccessful and required that CL's were increased with event magnitude. This is in contradiction with ARR2016 which notes that the 'majority of Australian studies of losses at catchment scale have concluded that both ILs and CL do not vary systematically with the severity of the event; that is loss is independent of AEP.' ARR2016 recommends 'to keep the ILs and CL values the same for AEPs unless there is specific evidence to suggest that there is a systematic variation of loss with AEP.' However, the opposite is true for the IL / PL model, with ARR2016 noting that the PL component of this model is noted to 'vary with the AEP of the event'.

Initial losses as recommended by ARR2016 have been used for design flood modelling. For events up to and including the 1% AEP, an IL of 26 mm has been adjusted to account for pre-burst as per ARR2016. The burst initial losses used in design flood modelling are presented in Table 6. Pre-burst adjusted initial losses range from 15 to 26 mm depending on the event duration and AEP. 0.2% and 0.05% AEP losses have been determined via interpolating between 1% AEP and PMF losses which follows methods outlined in ARR2016.

Table 7: Applied Initial Losses (incorporating pre-burst)

Duration (min)	20% AEP Event	10% AEP Event	5% AEP Event	2% AEP Event	1% AEP Event	0.2% AEP Event	0.05% AEP Event
720	23.9	23.7	23.5	18.8	15.3		
1080	25.2	24.7	24.1	21.1	18.9		
1440	25.7	25.5	25.4	24.6	24.1	7.8	2.9
2160	26.0	26.0	26.0	25.9	25.9	8.3	3.1
2880	26.0	26.0	26.0	26.0	26.0	8.3	3.1

A variable proportional loss has been applied for each design event. The applied PL for design events up to and including the 2% AEP event were determined via calibration to the FFA. Due to the relative short record period of available gauge data, reduced confidence is held in FFA design flow estimates for events rarer than the 2% AEP. For events larger than the 5% AEP, the PL was calculated following methods outlined in ARR2016, whereby it was assumed that PL vary linearly on a log-log plot of losses versus AEP, up until the recommended PMF loss. As the IL / CL model is recommended for the PMF, a conservative PL estimate of 0.01 was used in this interpolation. This method of determining loss values is more consistent with the interpolation procedure used for design rainfalls. The applied PL's are presented in Table 8.

Table 8: Applied Proportional Losses

Event AEP	20%	10%	5%	2%	1%	0.2%	0.05%
Proportion al Loss	0.69	0.66	0.64	0.61	0.59	0.53	0.48

ARR2016 recommends caution for implementation of IL / PL model for estimating 'Very Rare' or 'Extreme' events. Accordingly, modelling was also undertaken using an IL / CL model for events exceeding the 1% AEP. A CL of 4.2 mm/hr was applied as per recommendations in ARR2016. ARR2016 recommends a method of estimating 'Very Rare' floods via interpolation methods between 'Rare' floods and the PMF. These methods were used to determine which loss model was most appropriate for implementation for the 0.2% and 0.05% AEP events. These works are discussed in the 'Calibration of the XP-RAFTS Model to FFA' section of this report.

PMF rainfall losses have been applied as an IL / CL model (IL = 0 mm, CL = 1 mm/hr) as per the methods outlined in the GSDM.

Rainfall Temporal Patterns

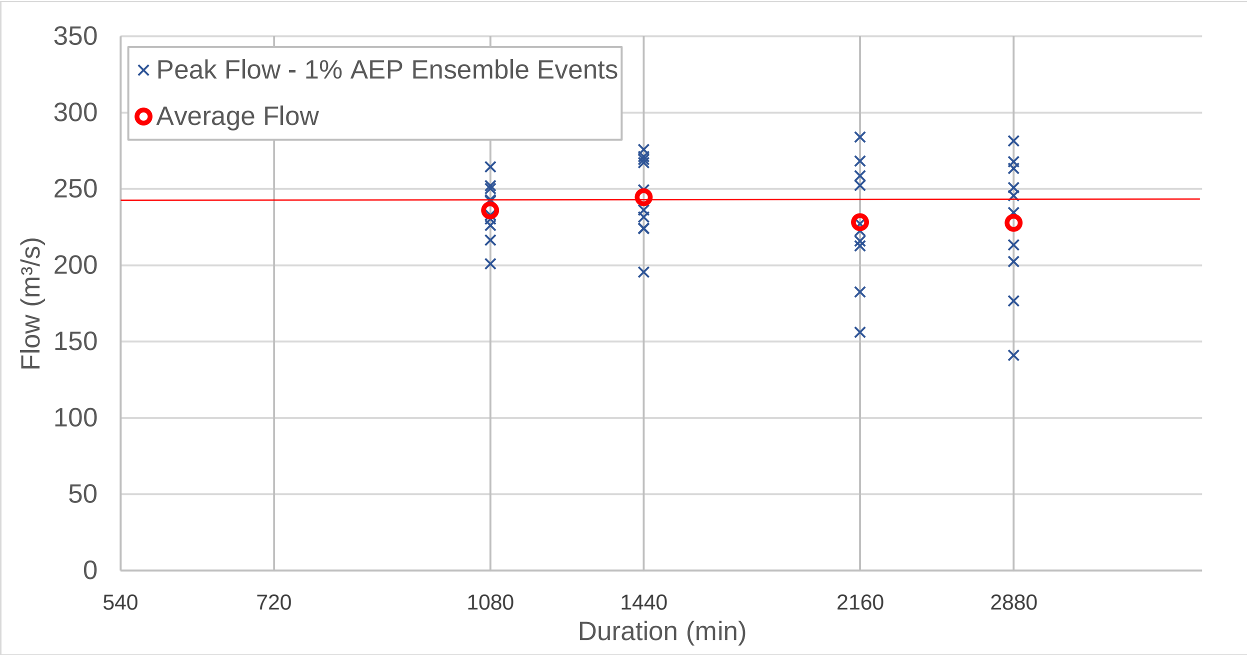
Rainfall temporal patterns are used to describe how rainfall is distributed as a function of time. The recommended ARR2016 ensemble approach to applying temporal patterns has been utilised in the current study. The ensemble approach to flood modelling applies a suite of 10 different temporal patterns for each duration. Areal Temporal Patterns have been implemented due to the catchment size exceeding 75 km². The temporal patterns were obtained from ARR2016 for the 'Murray Basin' region for a theoretical catchment area of 200 km². The implementation of the ensemble approach required the modelling of 300 design flood events (5 durations x 6 AEP x 10 temporal patterns) in the hydrologic model using the varying design rainfall depths, ARF and losses as presented above. Ensemble modelling techniques aim to overcome issues associated with the application of a single temporal pattern as per the methods used in ARR87.

ARR2016 recommends that for 'Very Rare' events, at-site and generalised PMP patterns be applied in an ensemble to ensure a smooth transition over the complete design flood frequency curve. The GSAM ensemble of temporal patterns were not available at the time of this study, and accordingly only at-site temporal patterns have been implemented. The GSDM temporal pattern was used in analysis of the PMF.

Hydrologic model design flows are presented in Chart 1 to Chart 3 for the 1%, 5% and 20% AEP events at the Yarrangobilly@Ravine (410574) stream gauge. Each blue 'x' indicates the peak flow of a modelled event. The red circle is the average flow for each duration. The ensemble method identifies the critical duration as the duration with the highest mean flow and each AEPs design event is selected as the event which is closest to, but above the mean.

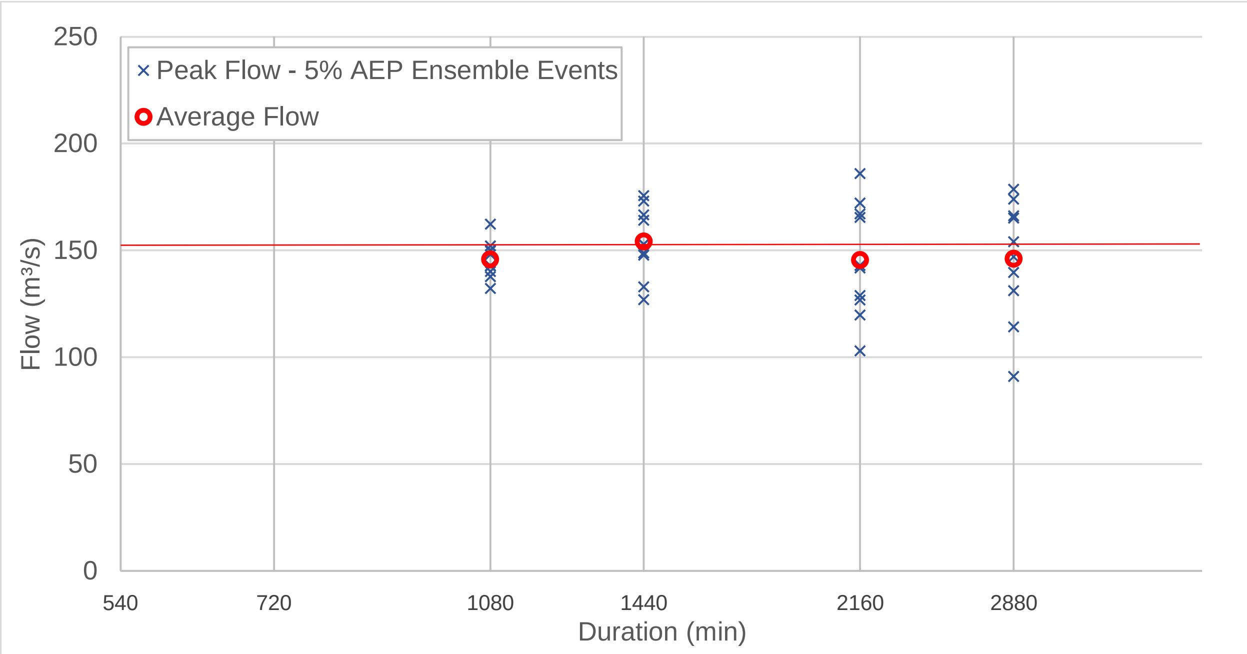
For the 1% AEP event the critical duration at the Site is the 24 hour event with an ensemble average flow of 244 m³/s.

Chart 1: 1% AEP Design Flow Results at Yarrangobilly@Ravine (410574) Stream Gauge Location



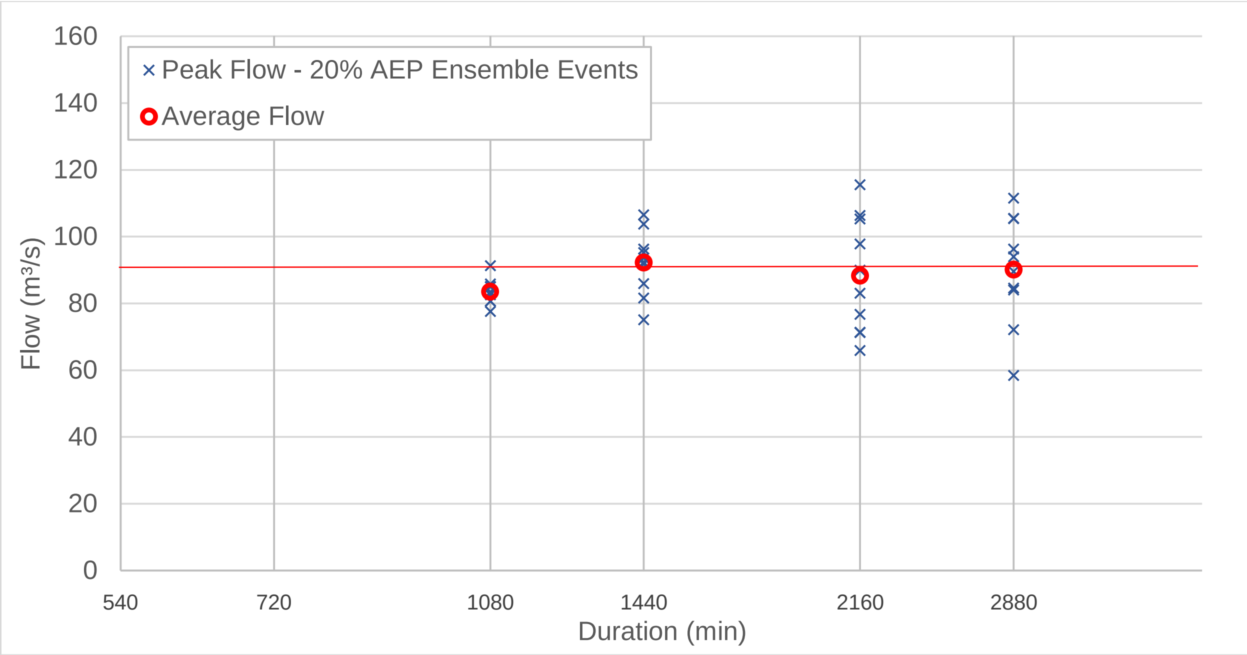
For the 5% AEP event the critical duration at the Site is the 24 hour event with an ensemble average flow of 154 m³/s.

Chart 2: 5% AEP Design Flow Results at Yarrangobilly@Ravine (410574) Stream Gauge Location



For the 20% AEP event the critical duration at the Site is the 24 hour event with an ensemble average flow of 92 m^3/s.

Chart 3: 20% AEP Design Flow Results at Yarrangobilly@Ravine (410574) Stream Gauge Location



The critical duration of the 10%, 2%, 0.2% and 0.05% AEP events were determined to be 24 hours. The PMF critical duration was determined to be 6 hours.

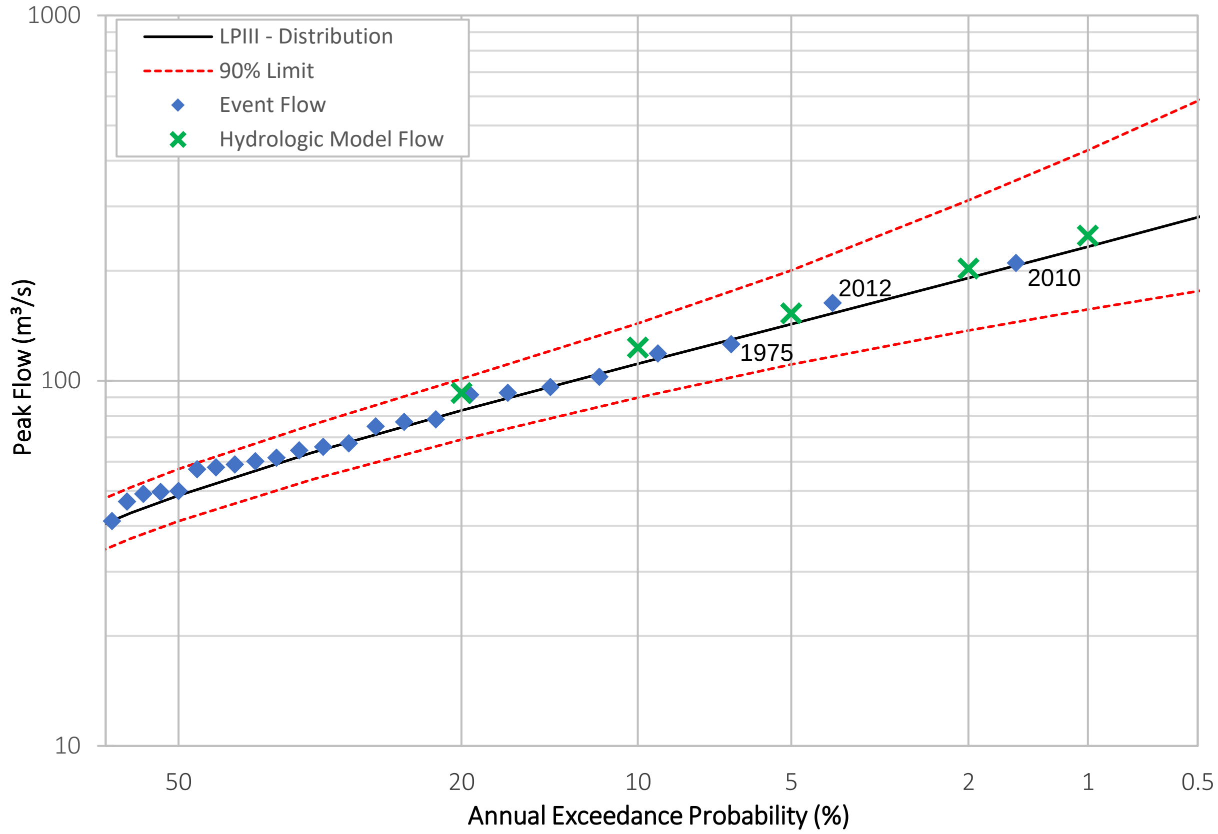
Calibration of the XP-RAFTS Model to FFA

Calibration of the XP-RAFTS model was undertaken by comparing model flows to FFA undertaken at the Yarrangobilly@Ravine (410574) stream gauge. Adjustment of applied proportional losses in the hydrologic model were made to obtain a good fit to the FFA design flows.

Chart 4 presents the Yarrangobilly@Ravine (410574) stream gauge FFA along with flows obtained from the XP-RAFTS hydrologic model (green 'X'). Hydrologic model flows for events from the 20% to the 1% AEP are a close match to the LPIII distribution expected quantile (black line) and within the 90% confidence interval limits (hashed red lines) indicating that the model is accurately reproducing design flood behaviour for these events. The 0.2 and 0.05% AEP events begin to diverge from the LPIII distribution and exceed FFA design flow estimates, however are well within the 90% confidence intervals.

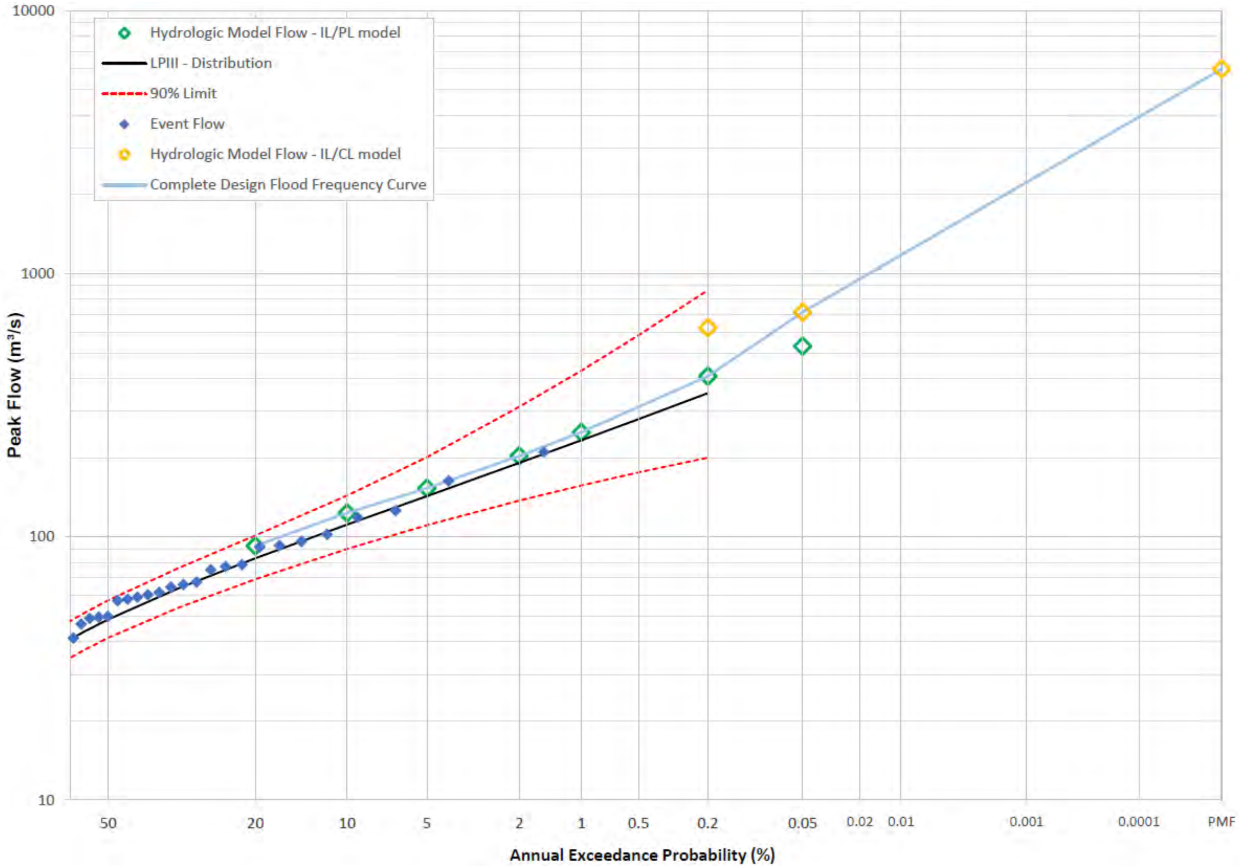
The calibration process indicates that the XP-RAFTS model is accurately producing design flood behaviour thus providing confidence in design flow estimates.

Chart 4: Comparison of Hydrologic Model Flows to FFA



ARR2016 outlines a method of estimating 'Very Rare' floods via interpolation methods between 'Rare' floods and the PMF. This method was used to determine the preferred loss model for calculation of the 0.2% and 0.05% AEP events. An approximation of the complete design flood frequency curve was derived by interpolating between the 'Rare' events and the PMF (see Chart 5). The findings from this analysis indicated that use of the recommended ARR2016 CLs overestimated 0.2% AEP flows and the IL/PL loss method underestimated the 0.05% AEP event. Accordingly, the IL/PL method was applied for events up to and including the 0.2% AEP event and the IL/CL method was applied for the 0.05% AEP event.

Chart 5: Approximation of the Complete Design Flood Frequency Curve



Validation of the 1% AEP Flow to Regional Flood Frequency Estimates

The ARR2016 RFFE model was used to determine the 1% AEP flow at the Yarrangobilly@Ravine (410574) gauge location. The 1% AEP flow at the gauge was determined to be 191 m^3/s, which is similar to the 245 m^3/s determined by hydrologic modelling. This adds robustness to the design flow estimates from the hydrologic model.

Design Flow Results

Design flows obtained from the XP-RAFTS model have been implemented in the TUFLOW model. Design flows at the Yarrangobilly@Ravine (410574) gauge location are presented in Table 9.

Table 9: Hydrologic Model flows at Yarrangobilly@Ravine stream gauge

AEP	Hydrologic Model Flows (m^3/s)
20%	92
5%	154
1%	244
0.2%	408
0.05%	714
PMF	6,000

Hydrologic model flows have also been extracted at Wallace Creek which is a major tributary of the Yarrangobilly River (see Table 10).

Table 10: Hydrologic Model flows on Wallace Creek

AEP	Hydrologic Model Flows (m^3/s)
20%	20
5%	31
1%	58
0.2%	89
0.05%	236
PMF	1,146

HYDRAULIC MODELLING

Hydraulic Model Setup

A TUFLOW hydraulic model was constructed for the Site. TUFLOW is 2D numerical modelling package which is suitable for modelling complex flood behaviour of channels and floodplains such as those at the Site.

Various data and parameters implemented in the TUFLOW model are discussed below and are presented in Image 2:

- *Model Domain and Grid Size* – The hydraulic model domain covers an area of 3.2 km^2, extending from 500 m upstream of the construction pad on Yarrangobilly River, and 400 m upstream on Wallace Creek. The downstream boundary is situated approximately 2.5 km downstream of the accommodation camp. A model grid size of 5 m x 5 m has been implemented which is considered suitable for adequately modelling key hydraulic features of the Yarrangobilly River.
- *Digital Elevation Model (DEM)* – A 1 m DEM provided by EMM has been used to inform the topography of the 2D hydraulic model
- *Mannings Roughness* **–** Mannings values were selected based on inspection of aerial imagery and photographs of the Site. Selected Mannings values are consistent with ARR2016 and are presented in Table 11;

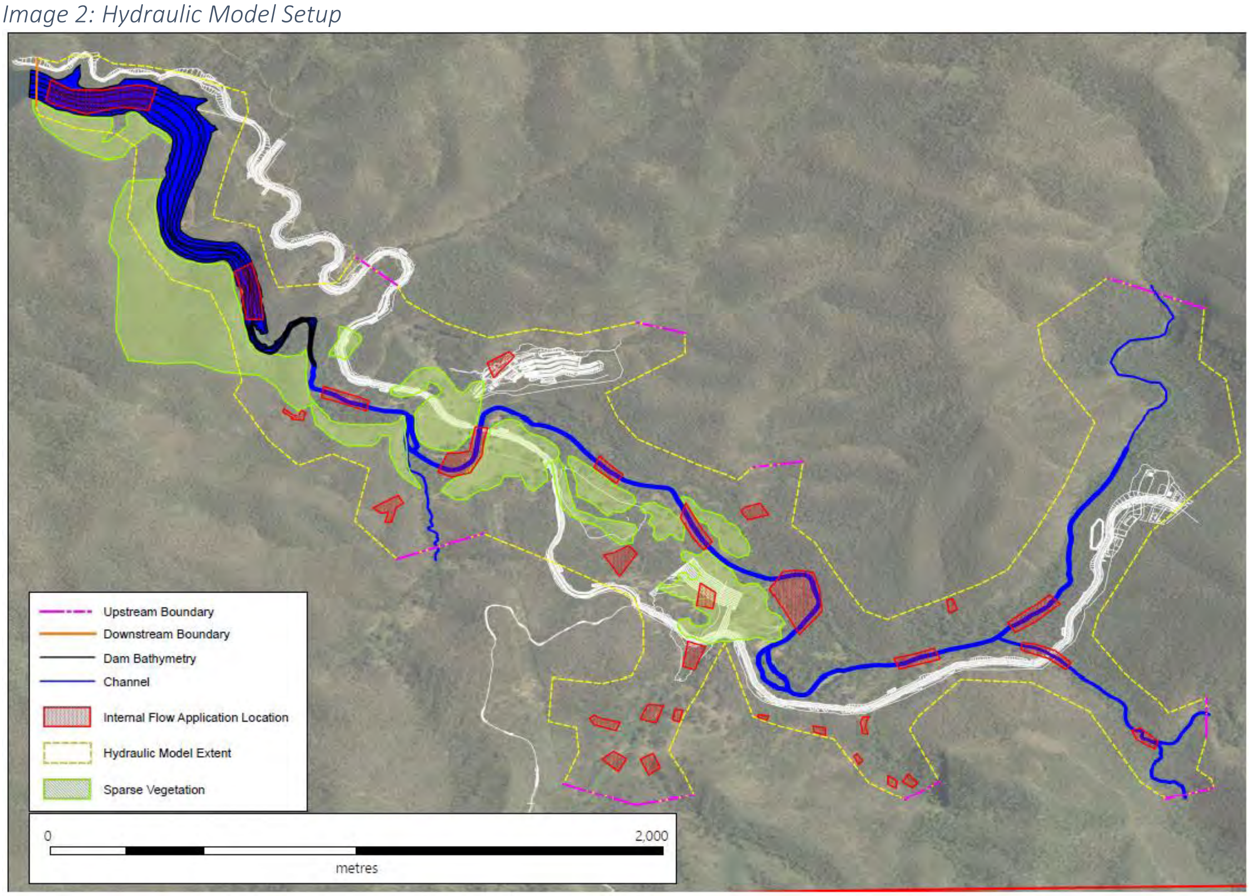
Table 11: Mannings roughness values

Land Use	Mannings
River / creek channel	0.05
Sparse vegetation	0.06
Dense vegetation	0.09

- *Boundary Conditions* – The inflows to the TUFLOW were obtained from the calibrated XP-RAFTS model discussed previously. The downstream boundary was set as a fixed water level boundary in Talbingo Dam. The following levels were implemented:
    - 20% to 0.2% AEP events – Full Supply Level (FSL) of 543.3 mAHD; and
    - PMF event – Spillway invert (544.7 mAHD) plus one meter of overtopping flow.

Implementing the various details discussed above, a Base Case model was constructed to model existing conditions flood behaviour for the Site.

Image 2: Hydraulic Model Setup



*Note: the proposed development works are presented in white. These have not been included in the hydraulic model and is shown purely for representational purposes.

Hydraulic Model Results

Design results for the 20%, 5%, 1%, 0.2% AEP events and the PMF have been developed. The results present flood depths, levels, velocities and flood hazard.

Design flood levels at the Yarrangobilly@Ravine (410574) gauge location are presented in Table 12.

Table 12: Design Flood Levels and Gauge Stage at the Yarrangobilly@Ravine (410574) Stream Gauge

AEP	Hydraulic Model Gauge Level (mAHD)	Estimated Gauge Stage (m)*
0.2EY	563.8	2.3
5%	564.3	2.8
1%	564.8	3.3
0.2%	565.3	3.8
0.05%	566.2	4.7
PMF	572.2	10.7

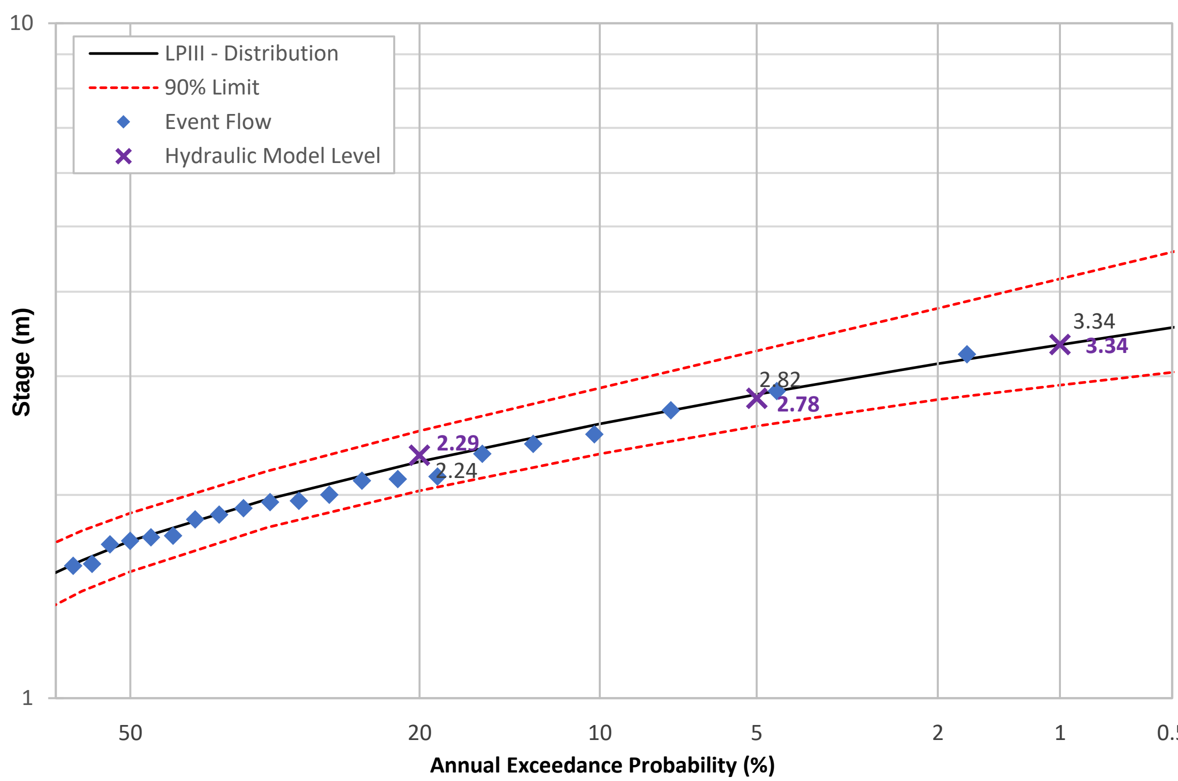
* Note that gauge stage has been estimated by assuming a gauge zero of 561.48 mAHD. The gauge zero has been estimated via interrogation of the LiDAR and is subject to an accuracy of approximately ±0.3 m, however gauge zero levels are likely to not exceed a level of 561.48 mAHD.

Validation of Hydraulic Model Results

Frequency analysis was performed on the annual maximum series of gauge stages' at the Yarrangobilly@Ravine (410574) stream gauge. The frequency analysis was undertaken for the period of 1982 to 2017 as gauge levels were not available for the period prior to 1982. The analysis was undertaken using the same methods outlined for the flow FFA. The results are presented in Chart 6.

A comparison of hydraulic model stage and frequency analysis stage is presented in Chart 6. Results indicate an excellent match to the LPIII distribution expected quantile (black line) indicating that the model is accurately reproducing design flood levels at the gauge location.

Chart 6: Comparison of Stage Frequency Analysis to the Hydraulic Model at Yarrangobilly@Ravine



IMPACT OF PROPOSED INFRASTRUCTURE ON FLOOD REGIMES

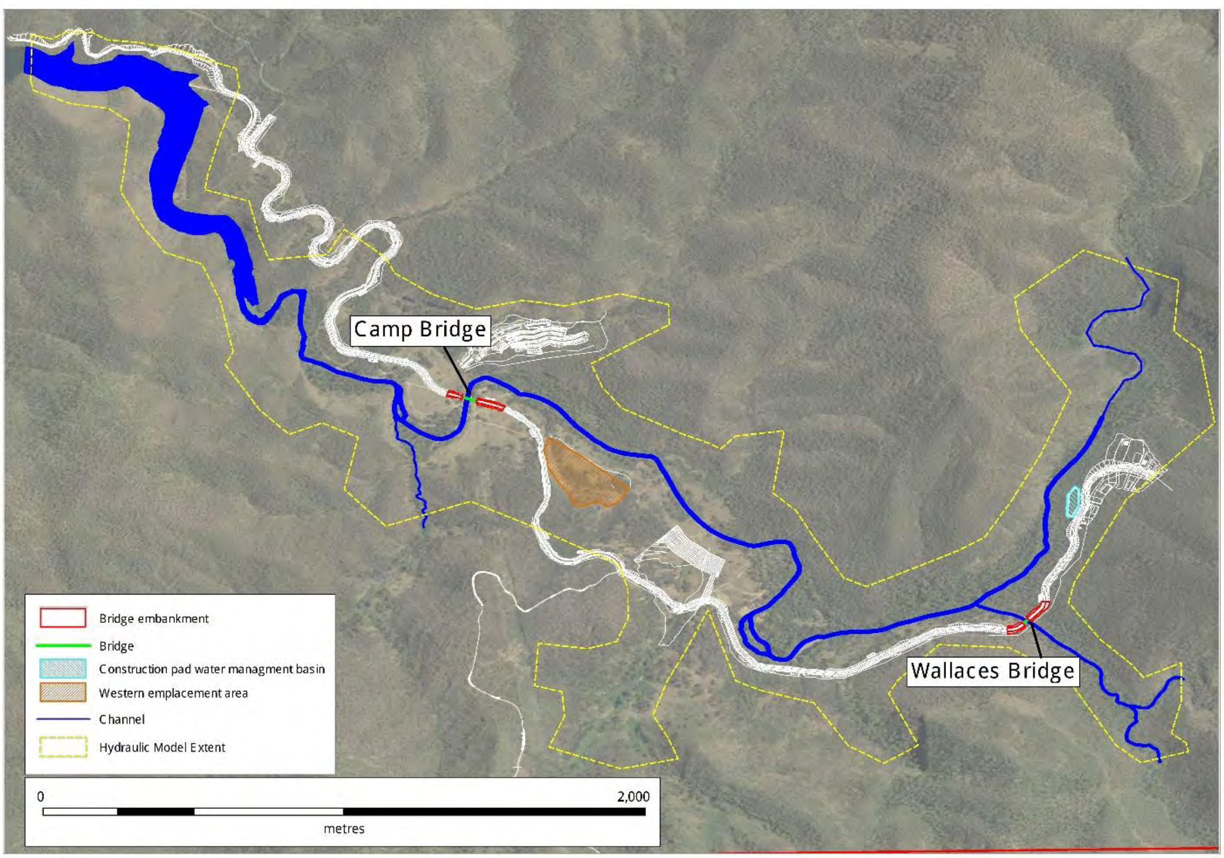
The TUFLOW hydraulic model was used to assess changes to the existing flooding regime associated with the following infrastructure:

- Camp Bridge – Lobbs Hole Road crossing over the Yarrangobilly River;
- Wallaces Bridge – Mine Trail Road crossing over Wallaces Creek;
- Western emplacement area; and the
- Construction pad water management basin.

The TUFLOW model was modified to incorporate the above infrastructure with the locations of these infrastructure presented in Image 3. The following modelling methods were applied:

- The assumed surface levels (also referred to as the digital elevation model) were updated to include the design levels and footprints of the road embankments;
- The dam and western stockpile footprints were 'nulled' from the model domain to simulate areas of zero flow; and
- Bridge structures were included in the model using layered flow constriction cells. This method accounts for blockage and form losses at bridge structures associated with the bridge piers and deck structures.

Image 3: Hydraulic Model Setup for Proposed Infrastructure



The proposed infrastructure works were modelled in the TUFLOW hydraulic model for a full range of events from the 20% AEP to the PMF. For each event, changes to the existing flooding regime have been quantified by calculating the difference in peak flood level and velocities between existing and proposed floodplain conditions. The resulting changes are shown spatially in:

- Flood level difference maps that show the areas and magnitude of flood level changes; and
- Velocity difference maps that show changes to velocity expressed as a percentage.

CONCLUSIONS

EMM requested a flood study be undertaken for the Yarrangobilly River at the site of Exploratory Works for Snowy 2.0. The Site is subject to flooding from the Yarrangobilly River which flows through the Site in a westerly direction.

The flood study methodology is summarised below:

- Development of a XP-RAFTS hydrologic model;
- Flood Frequency Analysis (FFA) for the Yarrangobilly@Ravine (410574) stream gauge;
- Calibration of the XP-RAFTS model to FFA derived flows using ARR2016 methodology;
- Derivation of design flow hydrographs using ARR2016 methods for the 20%, 5%, 1%, 0.2% AEP, 0.05% and PMF events for the Yarrangobilly River;
- Validation of the 1% AEP flow estimate using regional flood frequency estimates;
- Development of a TUFLOW hydraulic model for the Site; and
- Model design flood behaviour for the above-mentioned events.

The calibration/validation procedures indicate that both the hydrologic and hydraulic models are providing robust design flow and level estimates for events up to and including the 1% AEP event. The 0.2 and 0.05% AEP events required examination of the applied loss model through comparison to an approximation of the complete design flood frequency curve, and have used the at-site temporal pattern ensemble rather than a combined GSAM/at-site temporal pattern ensemble. This approach has likely led to a conservative estimate of these events. The PMF was determined using the methods outlined in the GSDM.

Yours Sincerely

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Director

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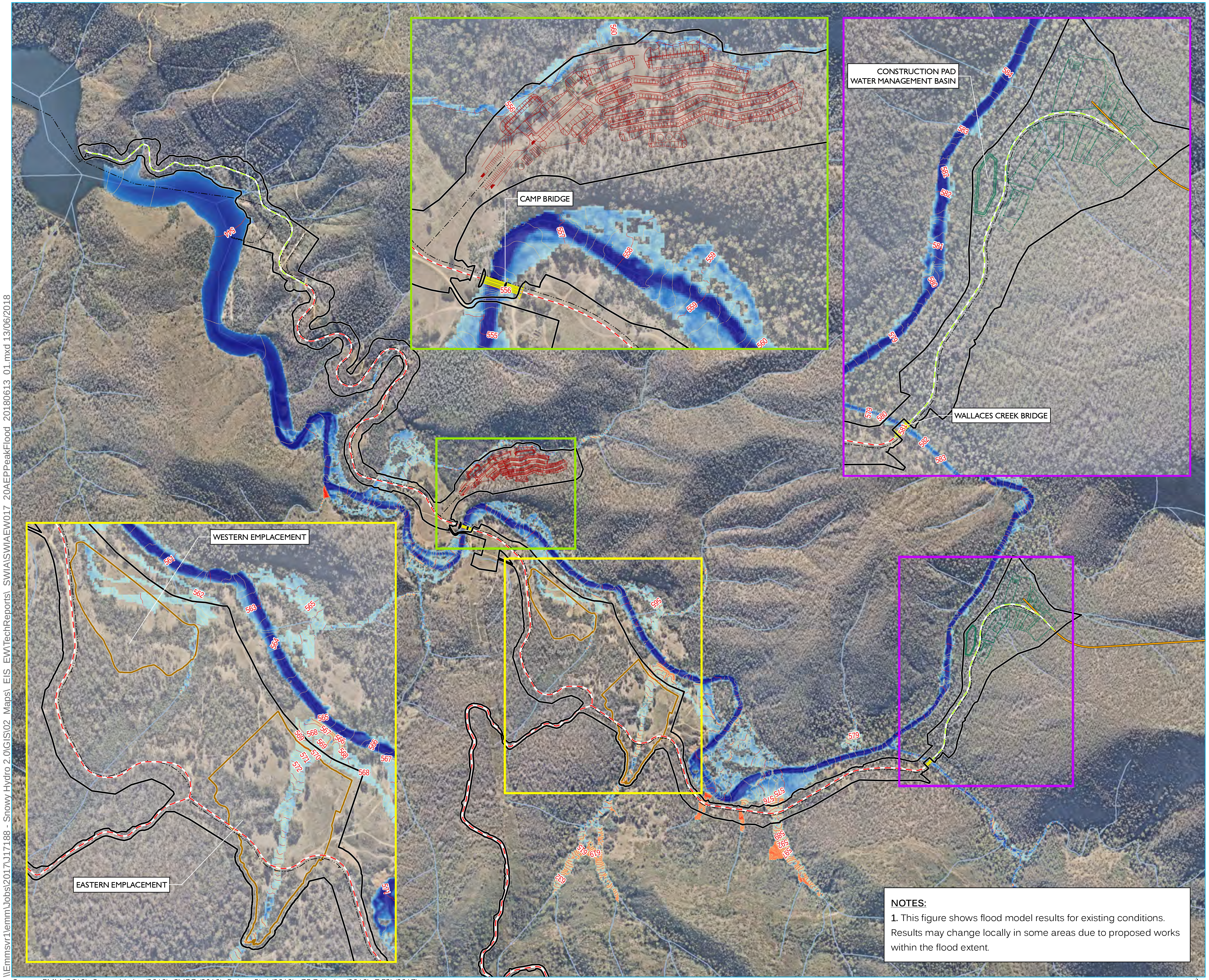
Tel: +61 432 477 036

Appendix C

Flood Maps



NOTES:
1. This figure shows flood model results for existing conditions. Results may change locally in some areas due to proposed works within the flood extent.

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line
- Major flood level contour (1 m AHD)
- Minor flood level contour (0.2 m AHD)

Peak flood depth
2 m
0 m

20% AEP event - Peak flood depth and level Existing conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C1

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

0 0.5 1 km
1:15,000 @ A3
GDA 1994 MGA Zone 55
N

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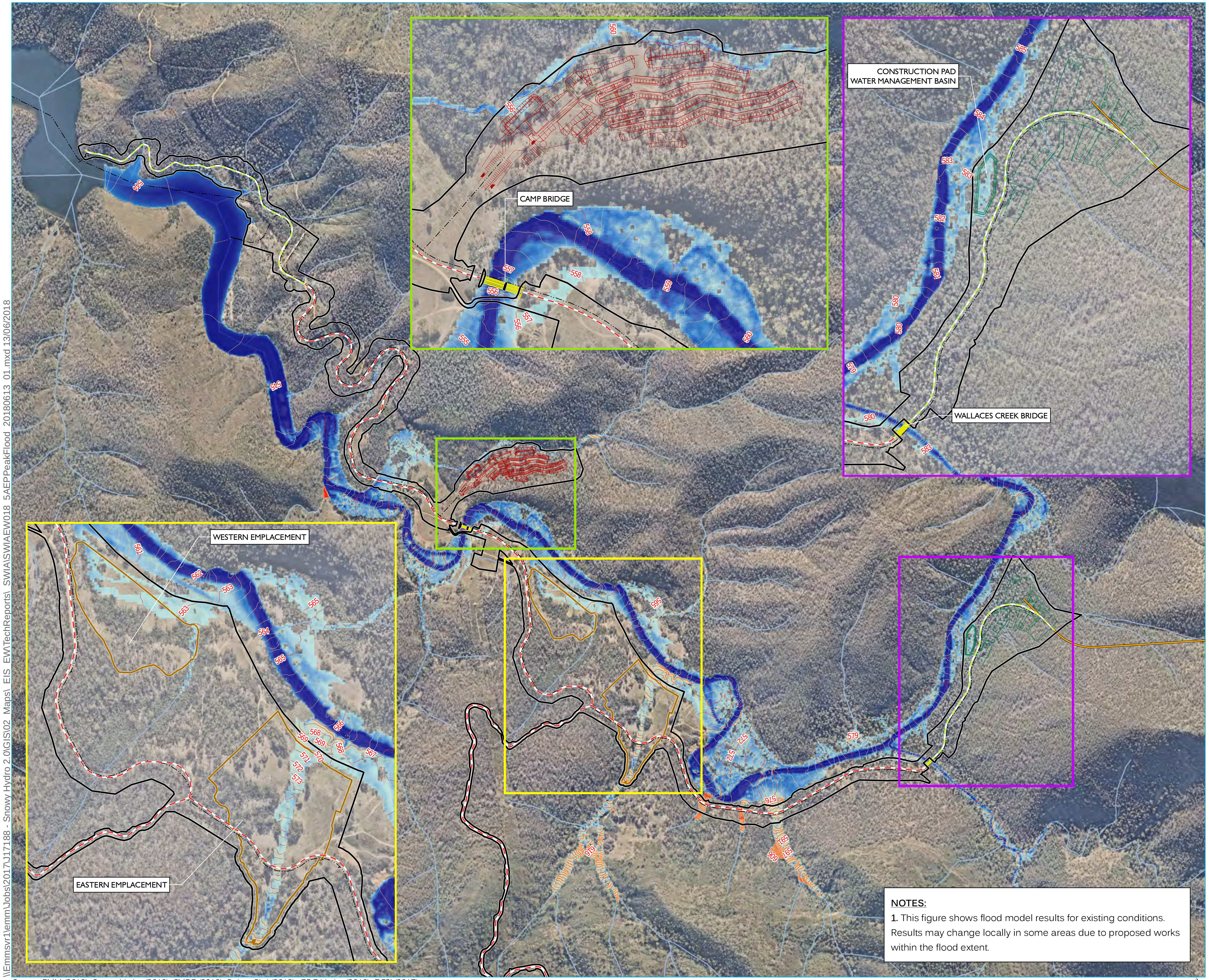

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Peak flood depth

2 m

0 m

NOTES:

1. This figure shows flood model results for existing conditions. Results may change locally in some areas due to proposed works within the flood extent.

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

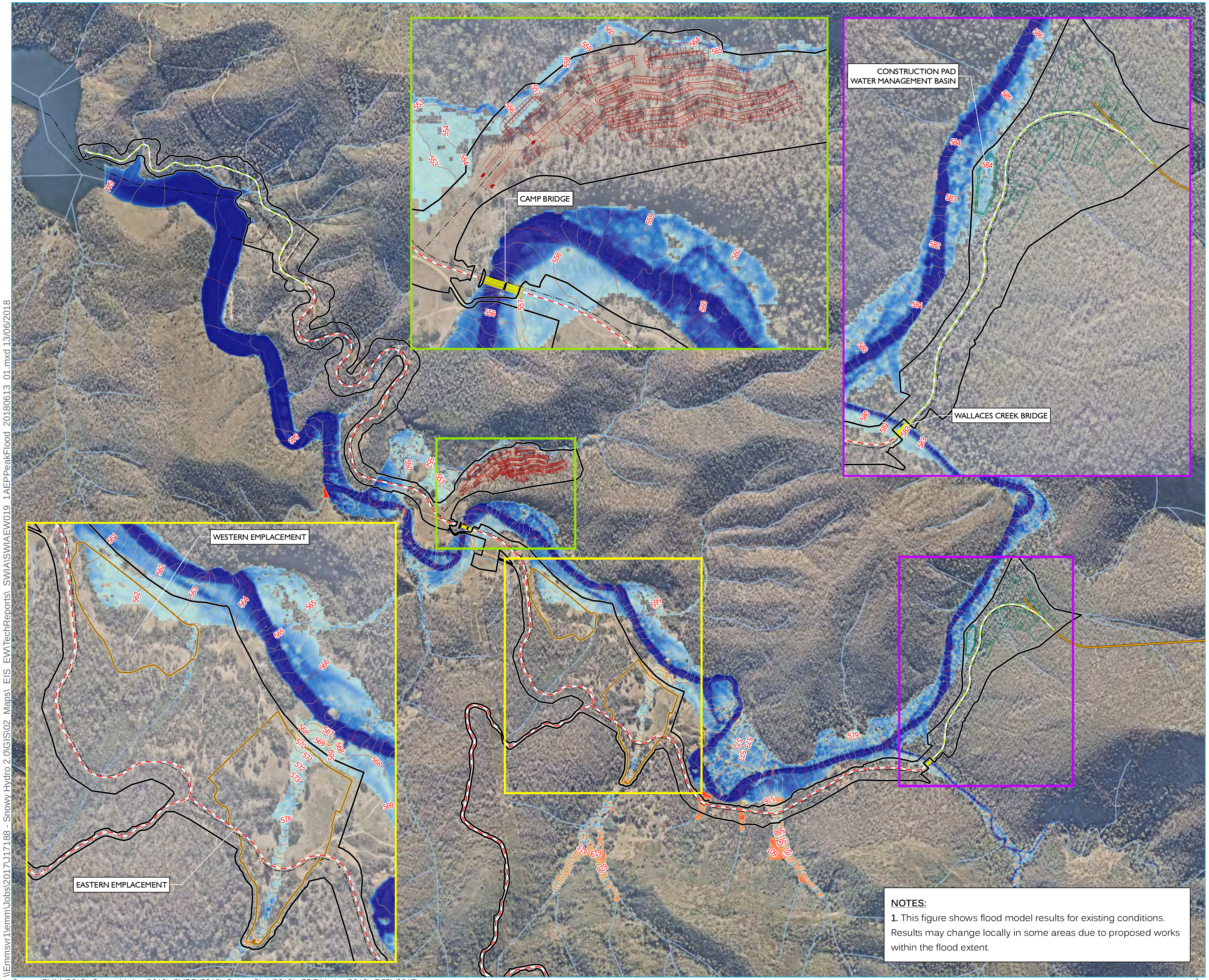
\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW018_5AEPPeakFlood_20180613_01.mxd 13/06/2018

5% AEP event - Peak flood depth and level
Existing conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C2

snowy 2.0

EMM



Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW019_1AEPPeakFlood_20180613_01.mxd 13/06/2018

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line
- Major flood level contour (1 m AHD)
- Minor flood level contour (0.2 m AHD)

Peak flood depth

2 m

0 m

0 0.5 1 km

1:15,000 @ A3

GDA 1994 MGA Zone 55

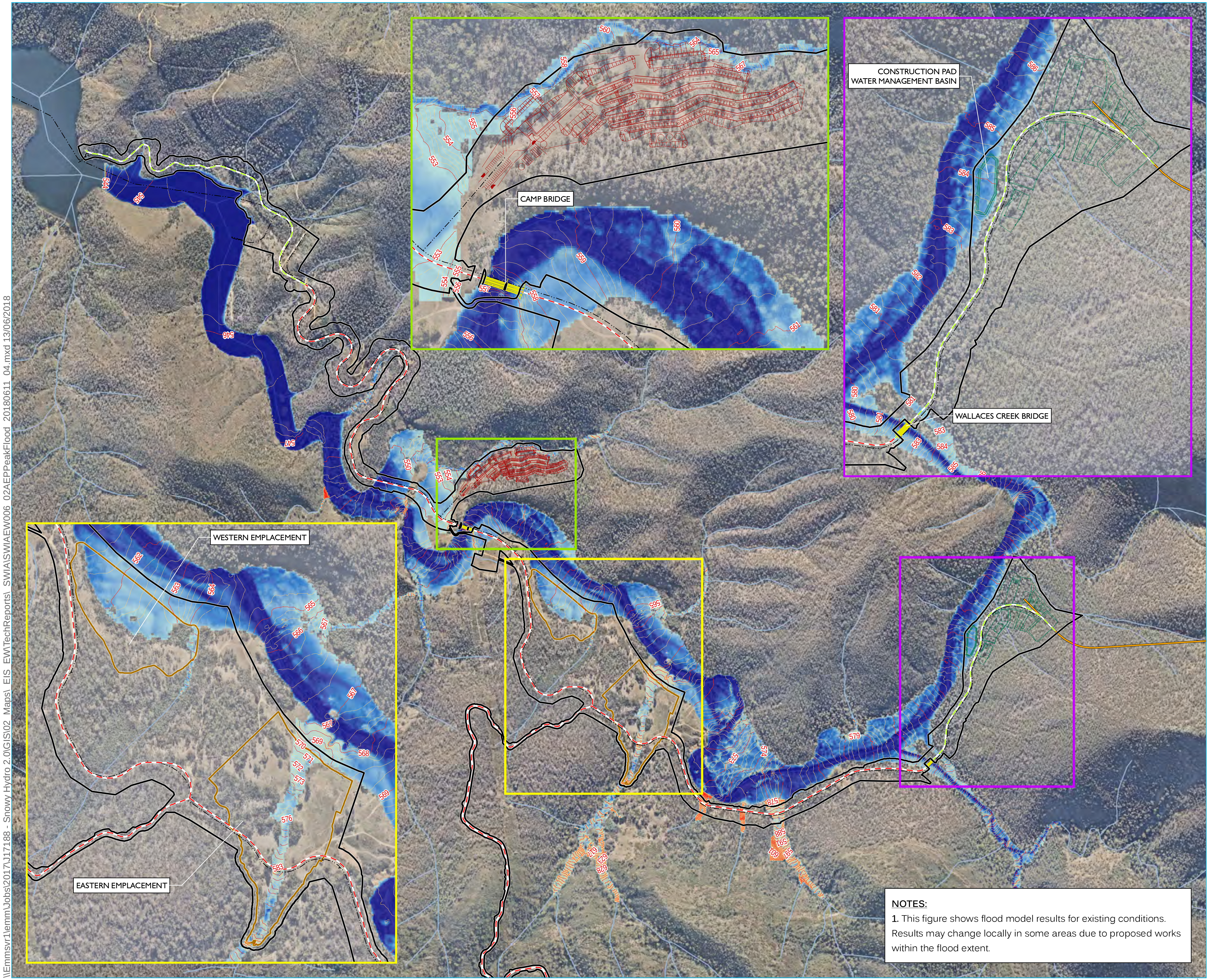
N

1% AEP event - Peak flood depth and level
Existing conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C3

snowy 2.0

EMM



NOTES:

1. This figure shows flood model results for existing conditions. Results may change locally in some areas due to proposed works within the flood extent.

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

0 0.5 1 km
1:15,000 @ A3
GDA 1994 MGA Zone 55
N

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line
- Major flood level contour (1 m AHD)
- Minor flood level contour (0.2 m AHD)

Peak flood depth

2 m

0 m

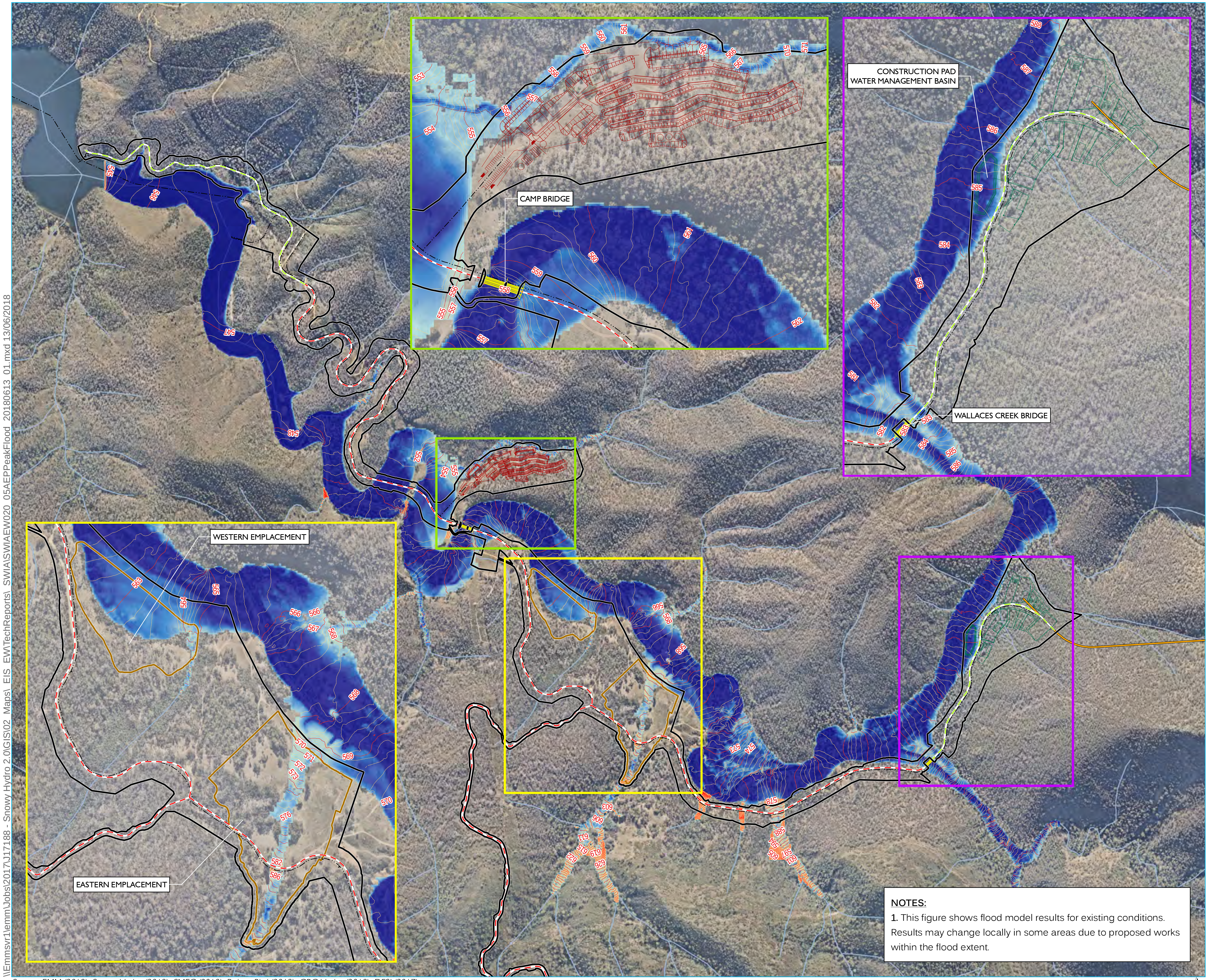
0.2% AEP event - Peak flood depth and level Existing conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C4

snowy 2.0

EMM

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW006_02AEPPeakFlood_20180611_04.mxd 13/06/2018



NOTES:
1. This figure shows flood model results for existing conditions. Results may change locally in some areas due to proposed works within the flood extent.

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line
- Major flood level contour (1 m AHD)
- Minor flood level contour (0.2 m AHD)

Peak flood depth

2 m

0 m

0.05% AEP event - Peak flood depth and level Existing conditions

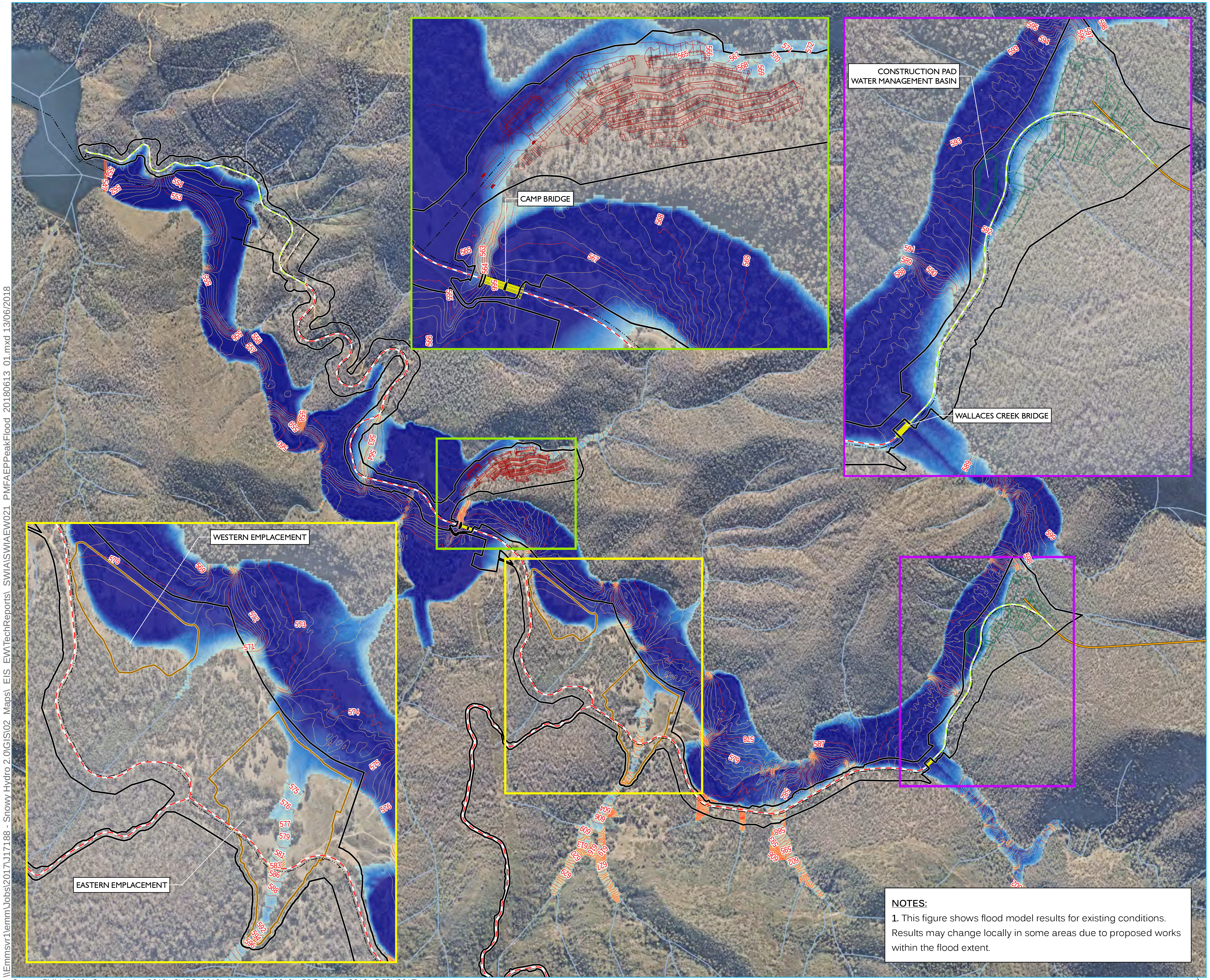
Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C5

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

0 0.5 1 km

1:15,000 @ A3 GDA 1994 MGA Zone 55 N

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps\EIS_EWTechReports\SWIA\SWIAEW020_05AEPPeakFlood_20180613_01.mxd 13/06/2018



NOTES:
1. This figure shows flood model results for existing conditions. Results may change locally in some areas due to proposed works within the flood extent.

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW021_PMFAEPPeakFlood_20180613_01.mxd 13/06/2018

0 0.5 1 km
1:15,000 @ A3
GDA 1994 MGA Zone 55
N

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line
- Major flood level contour (1 m AHD)
- Minor flood level contour (0.2 m AHD)

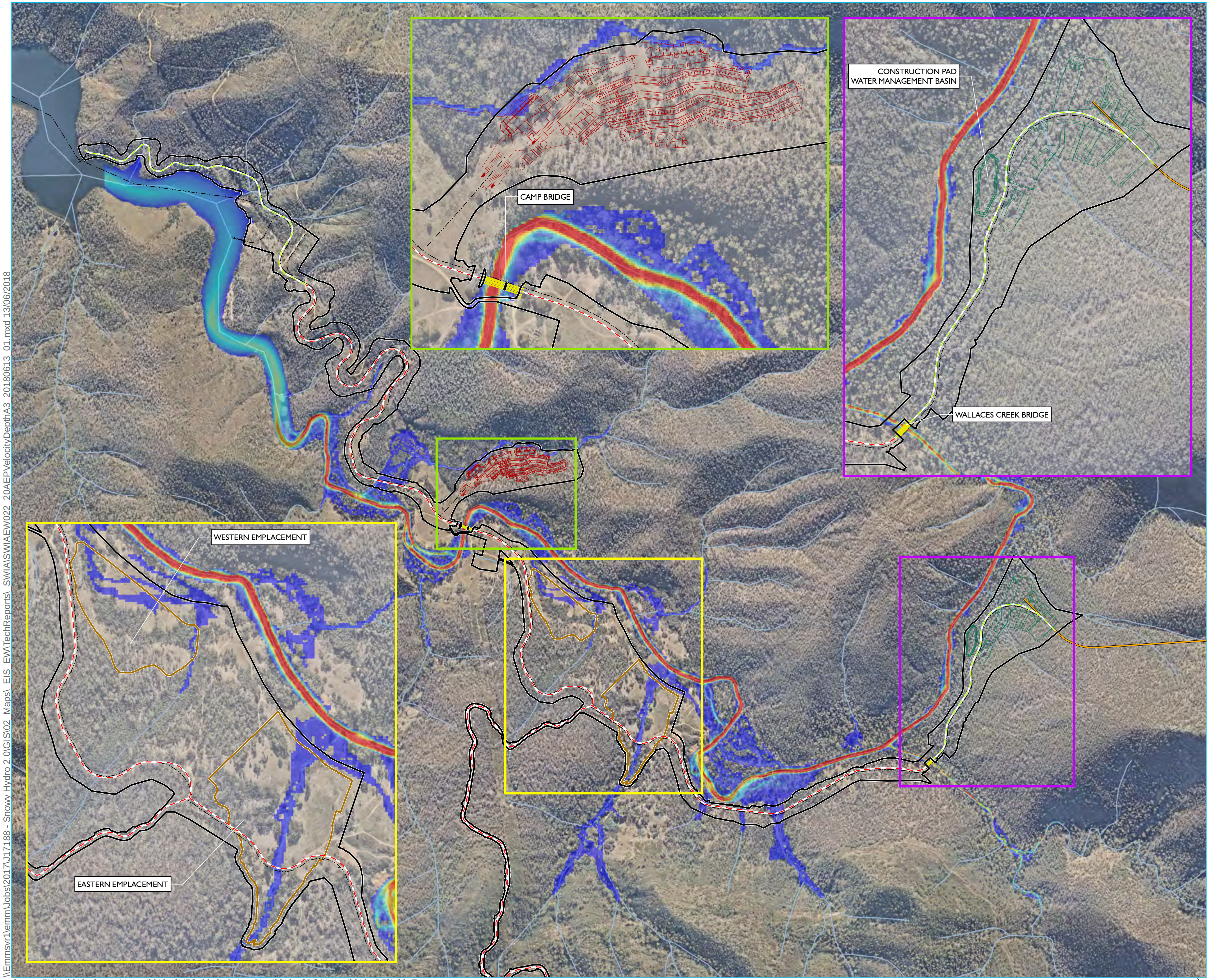
Peak flood depth
8 m
0 m

Probable Maximum Flood event - Peak flood depth and level Existing conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C6

snowy2.0

EMM



Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

0 0.5 1 km

1:15,000 @ A3

GDA 1994 MGA Zone 55

N

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

Peak velocity depth

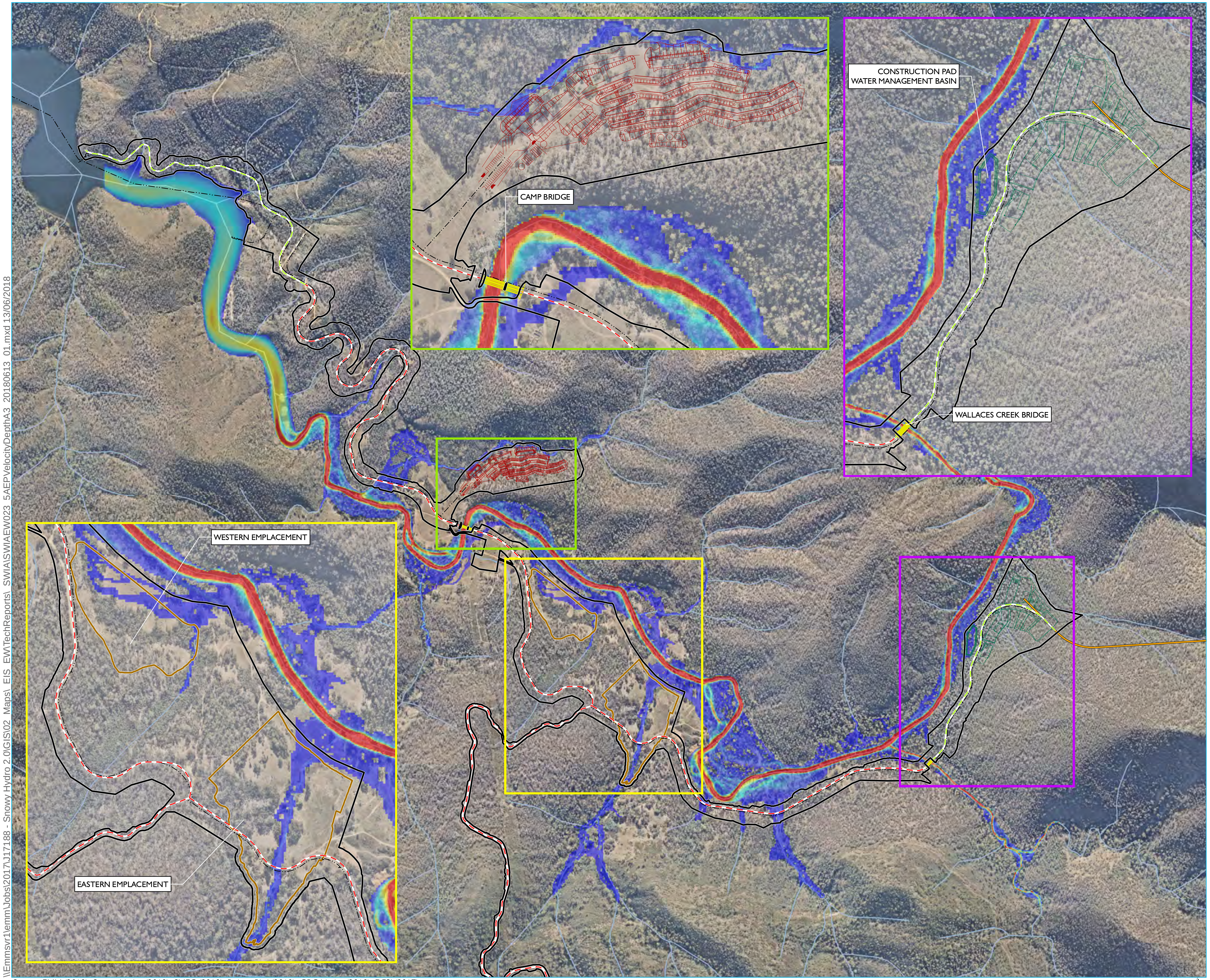
4 m^2/s

0 m^2/s

20% AEP event - Peak velocity depth
Existing Conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C7

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW022_20AEPVelocityDepthA3_20180613_01.mxd 13/06/2018



\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW023_5AEPVelocityDepthA3_20180613_01.mxd 13/06/2018

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

0 0.5 1 km

1:15,000 @ A3 GDA 1994 MGA Zone 55

N

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

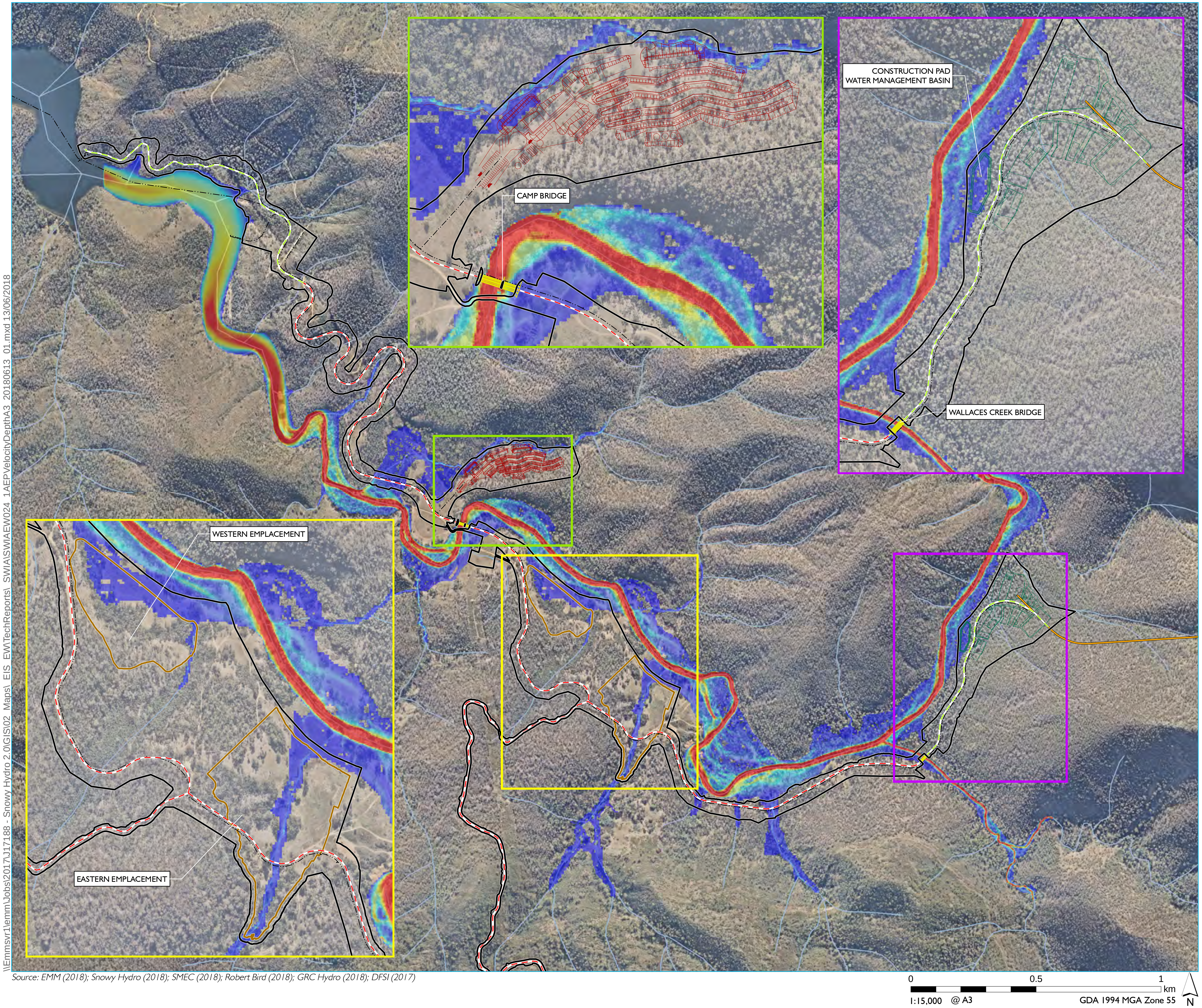
Peak velocity depth

4 m^2/s

0 m^2/s

5% AEP event - Peak velocity depth
Existing Conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C8

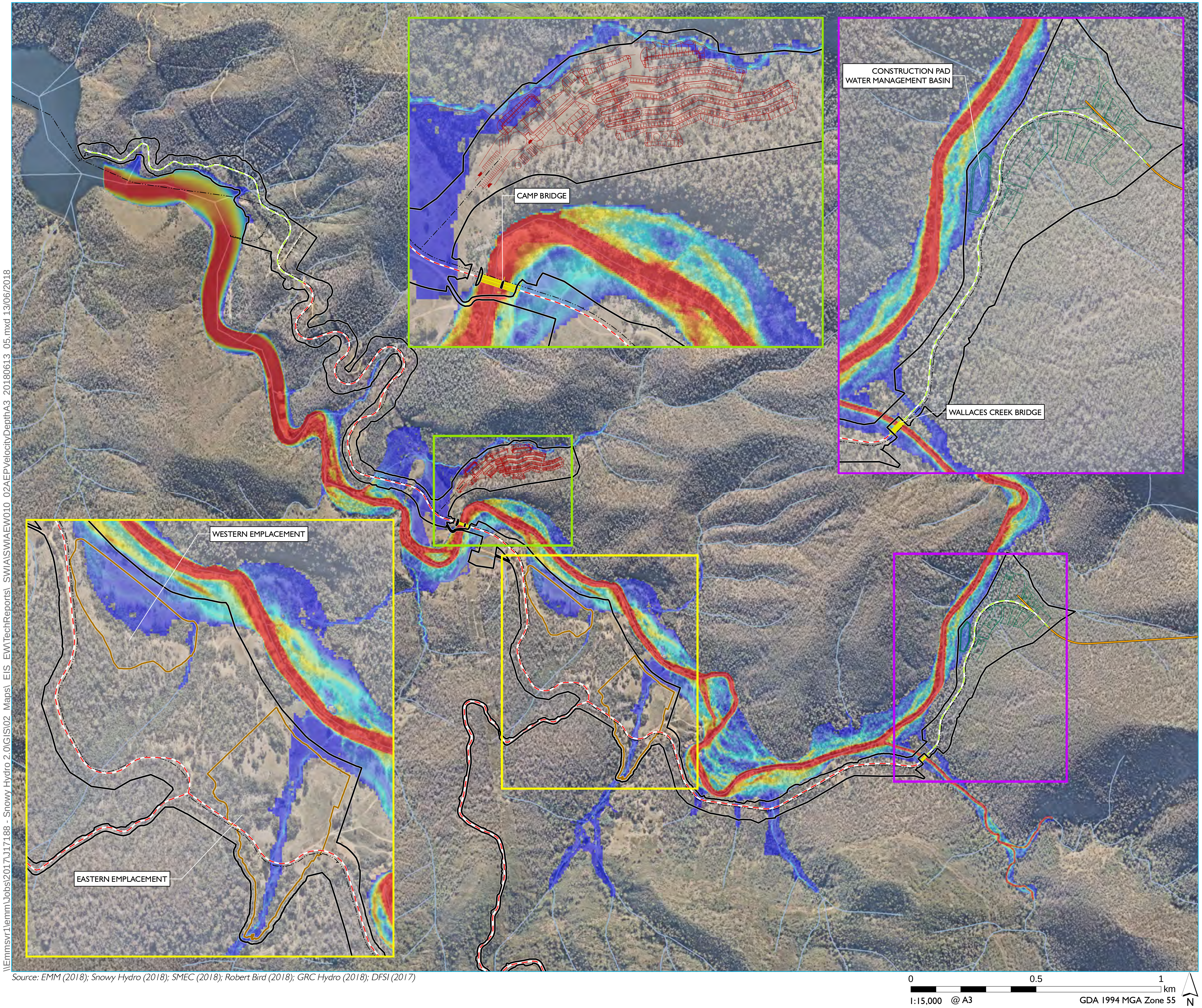


\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW024_1AEPVelocityDepthA3_20180613_01.mxd 13/06/2018

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

1% AEP event - Peak velocity depth
Existing Conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C9



Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW010_02AEPVelocityDepthA3_20180613_05.mxd 13/06/2018

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

Peak velocity depth

4 m^2/s

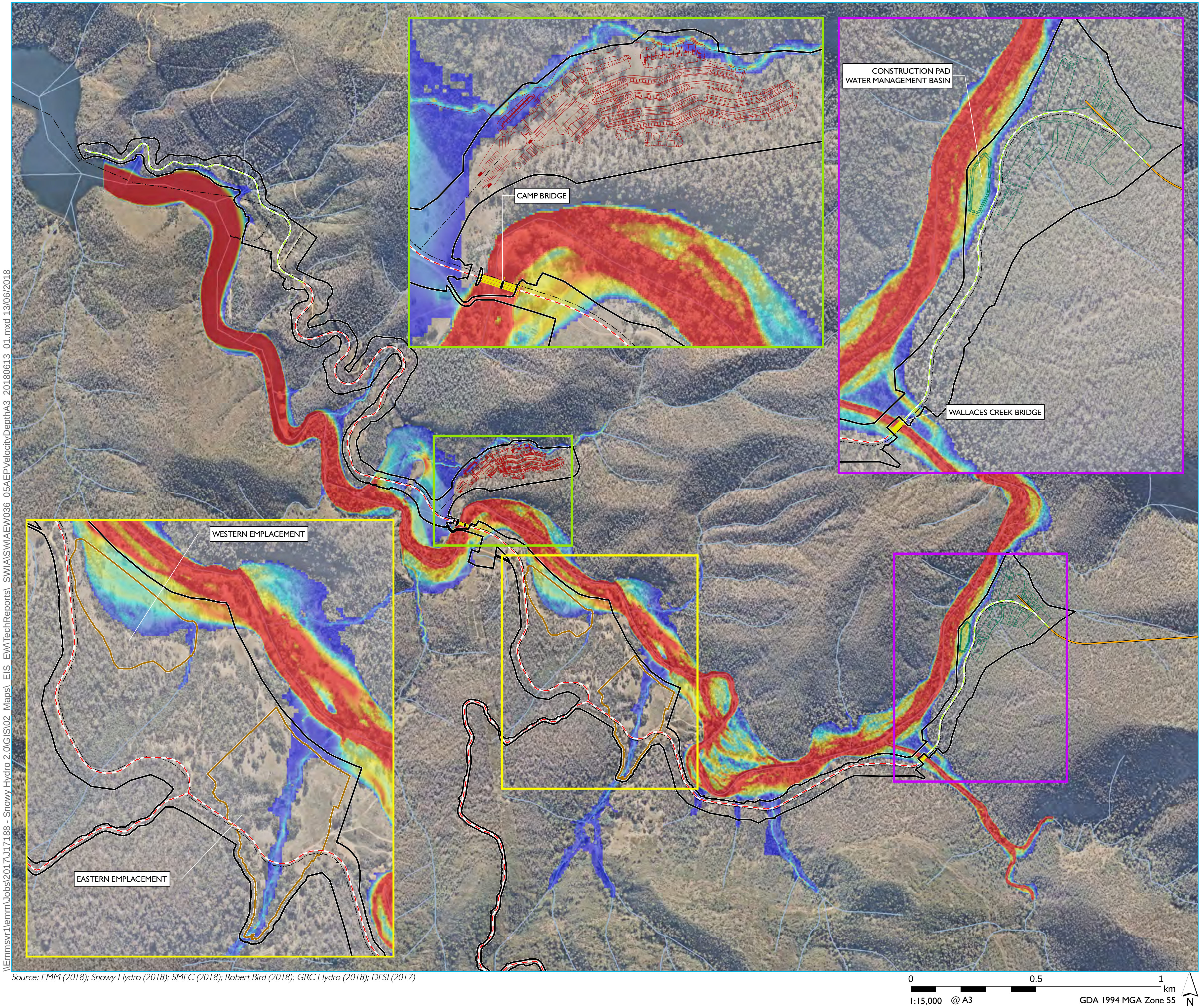
0 m^2/s

0.2% AEP event - Peak velocity depth
Existing Conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C10

snowy 2.0

EMM



Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\TechReports_SWIA\SWIAEW036_05AEPVelocityDepthA3_20180613_01.mxd 13/06/2018

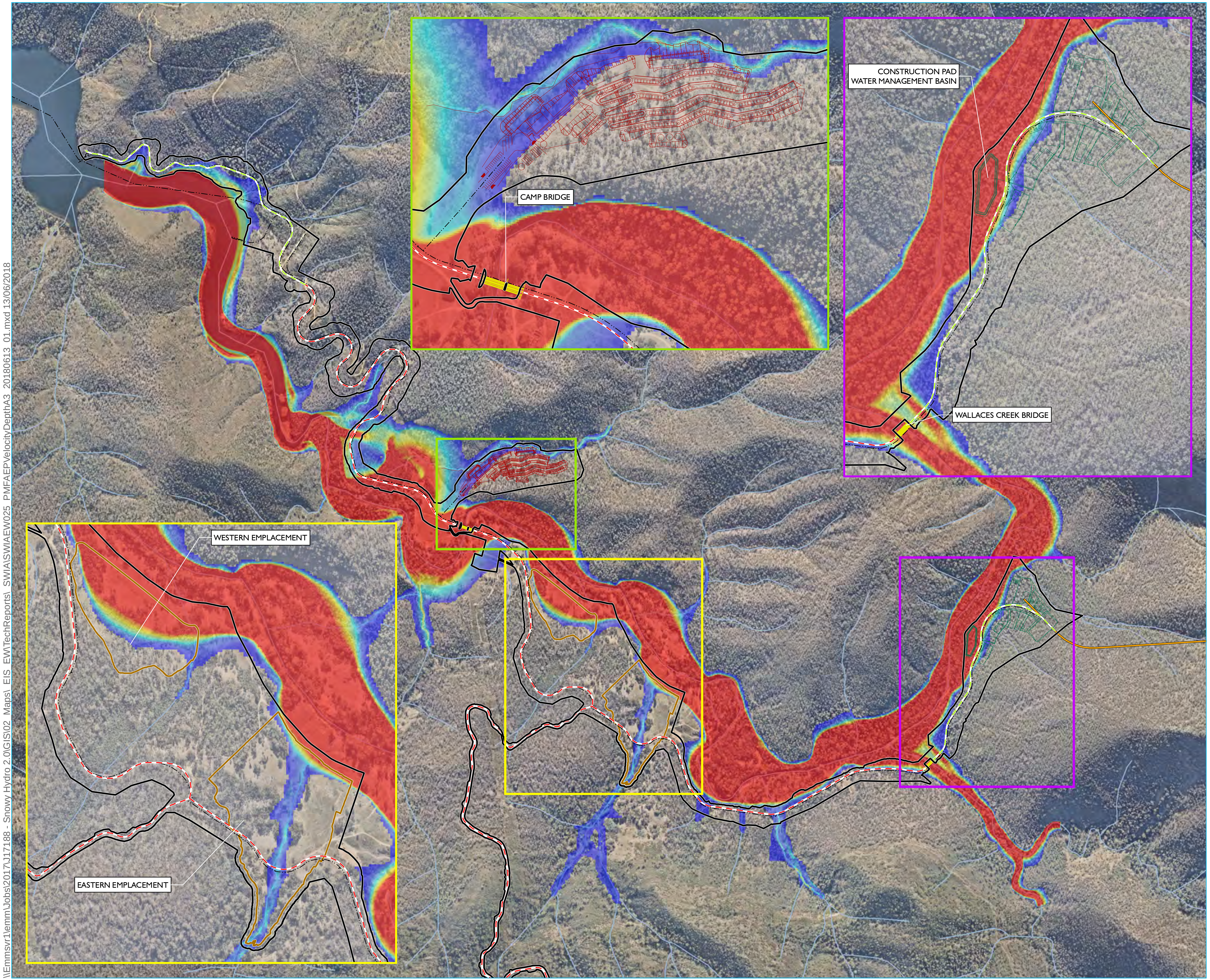
KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

Peak velocity depth
- 4 m^2/s
- 0 m^2/s

0.05% AEP event - Peak velocity depth Existing Conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C11



KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

Peak velocity depth

12 m²/s

0 m²/s

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

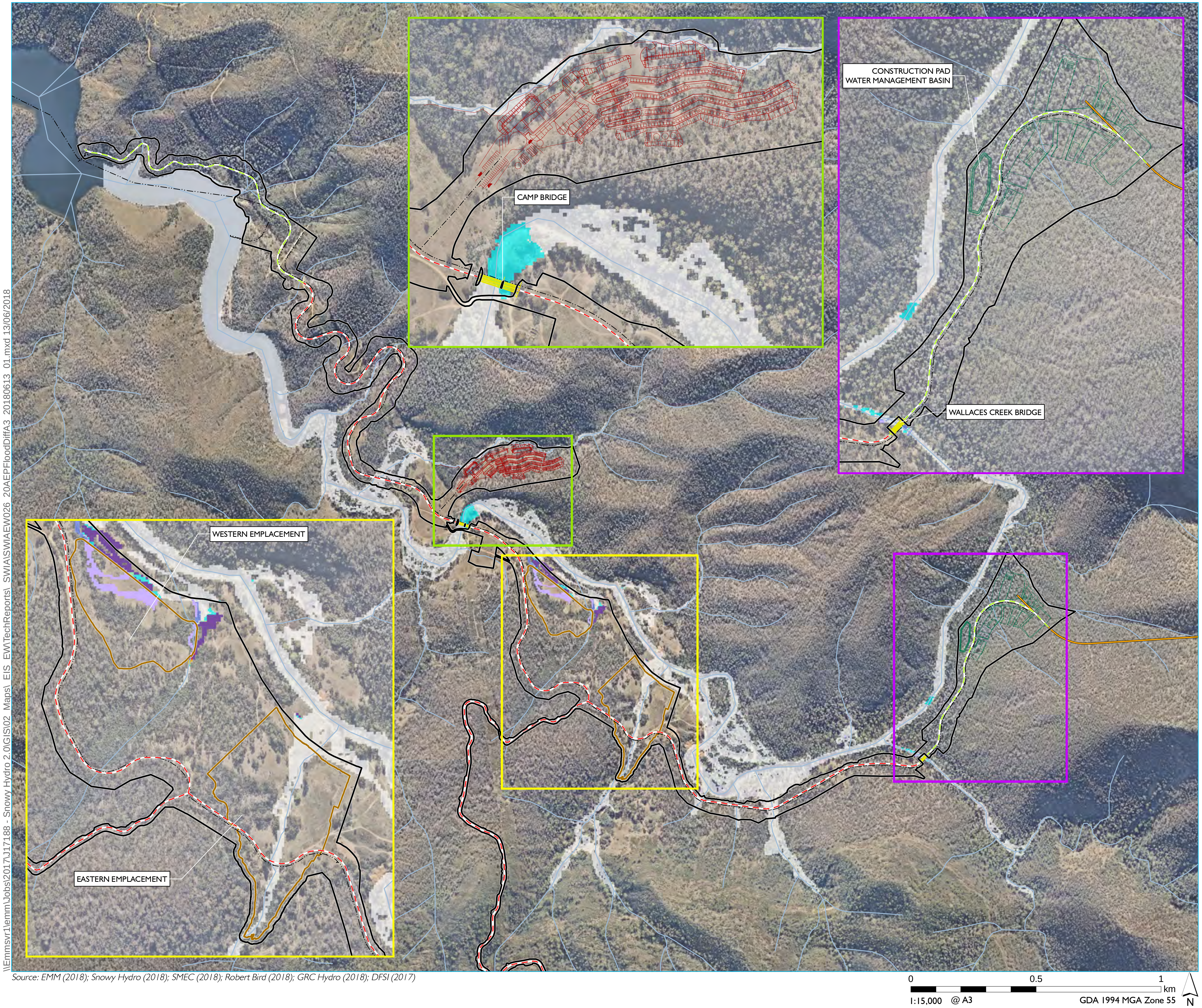
0 0.5 1 km

1:15,000 @ A3 GDA 1994 MGA Zone 55 N

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EW\TechReports_SW\A\SWIAEW025_PMFAEPVelocityDepthA3_20180613_01.mxd 13/06/2018

Probable Maximum Flood event - Peak velocity depth Existing Conditions

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C12



Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SWIA\SWIAEW026_20AEPFloodDiffA3_20180613_01.mxd 13/06/2018

KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

Changes in flood level (m)

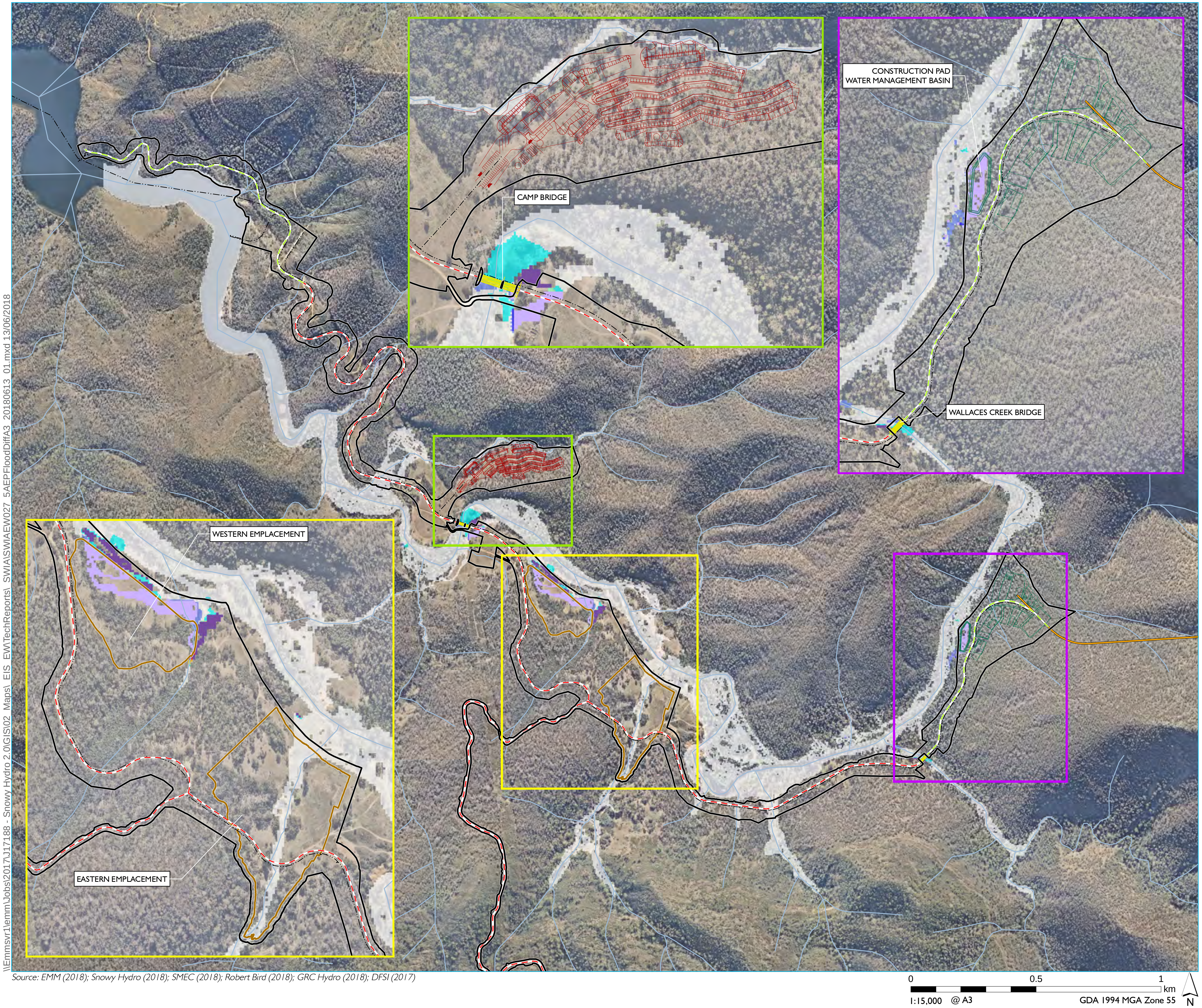
- < -0.1
- -0.1 to -0.01
- No change
- 0.01 to 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- > 0.9
- No longer flooded
- Newly flooded

20% AEP event - Changes to peak flood levels

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C13

snowy 2.0

EMM



KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Accommodation camp conceptual layout
- Portal construction pad conceptual layout
- Exploratory tunnel
- Communications cable and water services pipeline location
- On land rock emplacement area
- Disturbance footprint
- Watercourse / drainage line

Changes in flood level (m)

- < -0.1
- -0.1 to -0.01
- No change
- 0.01 to 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- > 0.9
- No longer flooded
- Newly flooded

5% AEP event - Changes to peak flood levels

Snowy 2.0
Surface Water Assessment
Exploratory Works
Figure C14

snowy 2.0

EMM

Source: EMM (2018); Snowy Hydro (2018); SMEC (2018); Robert Bird (2018); GRC Hydro (2018); DFSI (2017)

\\Emmsvr1\emm\Jobs\2017\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_EWTechReports_SW\A\SW\AEW027_5AEPFloodDiffA3_20180613_01.mxd 13/06/2018