Appendix A

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Airborne Laser Scanning (ALS)	A terrain definition process which utilises and airborne laser source to accurately measure the earth surface from computation of laser range and return signal intensity measurements recorded in-flight along with position and altitude data derived from airborne GPS and inertial subsystems. Falls into the category of airborne instrumentation known as LIDAR (Light Detection and Ranging).
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
American Standard Code for Information Interchange file(ASCII)	A file whose data is in ASCII characters and does not include formatting such as bold, italic, centred text, etc.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Canopy Elevation Model (CEM)	CEM is a grid that represents the mean canopy height above the ground surface. The CEM is generally derived from the first return LiDAR data. The CEM therefore represents the highest derived vegetation surface.
Colour digital aerial photography (RGB)	Digital photographic images captured by a digital sensor off an airborne platform such as a plane. Colour aerial photography includes red, green and blue wavelengths. To be acquired for the primary purpose of providing qualitative information of on-ground features, which will be used the development of the digital terrain model. However this could be used for other applications such as mapping broadly defined vegetation types.

consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
Digital Elevation Model (DEM)	The representation of continuous elevation values over a topographic surface by a regular array of sampled z-values, referenced to a common datum. To be expressed as a grid for the purposes of this tender process. The DEM excludes vegetation such as trees and shrubs, but includes bare ground and human constructed features such as shed and houses that are detectable within the accuracy of the Digital Elevation Model. The DEM is used for visualisation purposes and is not suitable for hydraulic modelling.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
Digital photography	A type of imagery that, in contrast to wet film photography, uses electronic devices to record and capture the image as binary or digital data that can be readily stored and edited on a computer. Aerial digital photography is digital photography taken from the vantage of a flighted vehicle such as a helicopter or aeroplane.
Digital Terrain Model (DTM)	A topographic model of the earth's surface in digital format as elevation data related to a rectangular grid and referenced to the Australian Height Datum. The DTM is a filtered version of the DEM that represents only bare earth surfaces. The DTM representation of ground includes works such as levees, banks and roads because this is the surface over which floods will flow.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in

the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.

effective warning time The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

emergency management A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.

ESRI Environmental Systems Research Institute.

flash flooding Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.

flood Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

flood awareness Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.

flood education Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.

flood fringe areas The remaining area of flood prone land after floodway and flood storage areas have been defined.

flood liable land Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).

flood mitigation standard The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.

floodplain Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.

floodplain risk management options The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.

floodplain risk management plan A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.

flood plan (local) A sub-plan of a disaster plan that deals specifically with flooding. They can exist

	at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
Focus Area	Priority areas identified within the NSW Wetlands Study Areas (comprising 1. Gwydir wetlands; 2. Macquarie Marshes; and 3. Murrumbidgee Floodplain/Great Cumbung Swamp) where a higher quality data is required, including a greater density of LiDAR points. The location of these areas is defined on the maps in Attachment 2 and the ESRI shape files of these areas provided to the tenderer are provided at Attachment 4.

freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Ground Sample Distance (GSD)	Ground resolution of airborne or satellite imagery, e.g. 30 cm GSD
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Image block file	Strip of digital imagery captured from a plane (or similar airborne platform) along a section of a flight run.
ICSM	Inter-Governmental Committee on Surveying and Mapping
LAS v1.1	LAS version 1.1 is a standard LiDAR file format, defined by The American Society of Photogrammetry and Remote Sensing's (ASPRS). LAS v1.1 defines, amongst other things, mandatory data fields and point categories. This includes mandatory metadata documentation. See full description at: http://www.lasformat.org/
LiDAR	Light Detection and Ranging (LiDAR). A technology that determines distance to a surface using laser pulses. Distance is computed by measuring the time delay between transmission and detection of the reflected signal.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
Local Site Datum	Established network of state survey control marks in close proximity to each project area.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Councils have discretion in determining whether urban drainage problems are

major drainage associated with major or local drainage. For the purpose of this manual major drainage involves:

- $ the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
- $ water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
- $ major overland flow paths through developed areas outside of defined drainage reserves; and/or
- $ the potential to affect a number of buildings along the major flow path.

mathematical/computer models The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State=s rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

Near-Infrared digital aerial photography (NIR) Digital near-infrared imagery captured by a digital sensor from an airborne platform such as a plane.

To be gained for the primary purpose of providing information of the distribution of standing and flowing water, which will be used the development of the digital terrain model

NSW Government — Means in general, entities which: a) have some form of public sector ownership; b) are engaged in trading goods and/or services; c) have a large measure of self sufficiency; and d) are subject to Executive control. In this context, the term NSW Government includes NSW Government Departments, Agencies, Statutory Authorities, Trusts, Public Trading Enterprises, and State Owned Corporations and General Government Businesses. NSW Government includes Catchment Management Authorities.

peak discharge — The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF) — The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP) — The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

probability — A statistical measure of the expected chance of flooding (see AEP).

Raw digital aerial photography — Digital aerial photography that has not been colour balanced, orthorectified or converted into a mosaic, and which still contains redundant imagery such as overlapping images.

Raw LiDAR survey data — Unprocessed LiDAR data that has been processed to correct for in flight error (such as roll, yaw, pitch), is georeferenced and contains x, y and z and intensity values for each point. No points are removed. That is, it includes all returns (1st, 2nd*etc.* up to the last return) and data still contains random or systematic errors, as well as redundant data on overlapping edges of LiDAR acquisition runs. The data is, however, *georeferenced*. The data includes the intensity of the 1st, 2nd*etc.* and last return for each point.

risk — Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

runoff — The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

SCIMS — The Survey Control Information Management System managed by NSW Department of Lands

SP1 — ICSM Special Publication No.1 - Standards and Practices for Control Surveys

stage — Equivalent to Awater level@. Both are measured with reference to a specified datum.

stage hydrograph — A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

Study Area	The area that is comprised of four wetlands: 1. Gwydir wetlands; 2. Macquarie Marshes; and 3. Murrumbidgee Floodplain/Great Cumbung Swamp, 4. Narrandra Forests, with the spatial extents of these areas defined according to total area represented by the maps in Attachment 2 and the ESRI shape files of these areas provided to the tenderer.
Surveyor General Directions	The directions detailed within the following website: http://www.lands.nsw.gov.au/publications/guidelines/surveyor_generals_directions
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B

TABLE 4.2

August 1986 and April 1988 Flood Levels

Stream	Location	Flood Level (m AHD) August 1986	Flood Level (m AHD) April 1988
South	Springfield Rd,Cth Fld	-	77.19
	Catherine Fields Road	-	67.24
	"	-	67.74
	Barry Ave, Rossmore	-	66.38
	Roben Cresent,Rossmore	-	63.62
	Masterfield Street	-	59.42
	Bringelly Road D/S	-	57.59
	May Street, Rossmore	-	56.09
	Wishart Rd, Kemps Ck	-	51.47
	Victor Ave, Kemps Ck	48.56	49.10
	Overett Ave, Kemps Ck	-	43.41
	Elizabeth Dr U/S	42.73	43.33
	D/S	42.06	42.66
	Bailey Bridge, D/S Dam	-	34.66
	Warragamba Pipeline	-	33.67
	"	-	33.28
	"		33.54
	Mandalong Pk, St Clair	-	32.47
	Luddenham Rd, St Clair	29.50	29.80
	Mamre House, St Clair	-	27.62
	F4 Freeway	-	26.94
	Schleicher St,St Clair	-	25.14
	Saddington St,St Clair	24.36	25.24
			25.20
	Great Western Highway	24.43	24.73
	Main Western Railway	-	22.89
	Dunheved Rd, Dunheved	21.14	21.25
	Dunheved Golf Course	-	21.19
	Eighth Ave,Shanes Park	16.92	16.74
			16.83
	138 Shane Park Road	15.09	14.97
	Stoney Creek Road	13.27	13.40
		13.26	13.48
	Blacktown/Richmond Rd	11.24	12.70
		11.17	
Ropes	Debrincat Ave, Tregear	28.38	28.45
	Forresters Rd,Dunheved	24.42	24.50
	Main Western Railway	33.47	32.37
	Great Western Highway	36.15	35.66
	F4 Freeway	41.68	41.53
	Warragamba Pipeline	-	54.04
Werring-ton	D/S John Oxley Drive	-	24.10
Kemps	Elizabeth Drive D/S	-	46.41
	U/S	-	47.40
	D/S Fifteenth Ave	-	55.83
	D/S Heath Road	-	84.25
Badgerys	Elizabeth Drive	-	46.13

table 4.2 from 1990 south ck study dwr

River Gauging Station No.212320 is the currently operating station and is located on the west bank of a pool in South Creek about 200m upstream of Elizabeth Drive. A concrete V-notched weir controls low flows for this station. The operation of this station was started in 1955 by the University of NSW and has been operated by predecessors of the Department of Infrastructure, Planning and Natural Resources (DIPNR) since 1970.

Water height information from Station No.212320, 'South Creek at Elizabeth Drive' for the previous week is available from the DIPNR website at the following address:

- www.waterinfo.dlwc.nsw.gov.au/drr/southcoast/

2.1.2 Major Floods of the 1980s

Two major flood events occurred in the South Creek catchment in the 1980s. The August 1986 flood and the April 1988 flood are two of the largest floods to have occurred in the catchment since European settlement. Large amounts of data from both of these floods were collected. **Table 2.1** summarises flood levels measured in the study area for these two floods.

TABLE 2.1: FLOOD LEVELS IN THE STUDY AREA FROM THE AUGUST 1986 AND APRIL 1988 FLOODS

LOCATION	AUGUST 1986 FLOOD LEVEL (mAHD)	APRIL 1988 FLOOD LEVEL (mAHD)
Opposite Masterfield Street, Rossmore (about 500m upstream (south) Bringelly Road)	—	59.42
Just downstream of Bringelly Road bridge	—	57.59
May Avenue, Rossmore (200m–1,200m downstream Bringelly Road)	—	56.09
Wishart Road, Kemps Creek (about 3,500m upstream of Elizabeth Drive)	—	51.47
Victor Avenue, Kemps Creek (about 2,800m upstream of Elizabeth Drive)	48.56	49.10
Overett Avenue, Kemps Creek (about 300m upstream of Elizabeth Drive)	—	43.41
Just upstream of Elizabeth Drive bridge	42.73	43.33
Just downstream of Elizabeth Drive bridge	42.06	42.66

Source: Department of Water Resources, 1990

2.1.3 Top Ten Floods in South Creek at Elizabeth Drive — 1955 to 1988

As well as the two major floods of the 1980s, large floods also occurred in South Creek in February 1956, November 1961 and June 1964. **Table 2.2** lists the ten largest floods in South Creek in terms of peak flow rate at Elizabeth Drive between 1955 and 1988. These historical floods are compared to the latest design flood levels (see **Section 3.2**). **Table 2.2** shows that the April 1988 flood was in the order of a 100 year flood through the study area, while the 1956 flood was about a 10 year flood and the 1961, 1964 and 1986 floods were all just larger than about a 5 year flood.

TABLE 2.2: HISTORICAL AND DESIGN FLOOD LEVELS AND FLOWS AT ELIZABETH DRIVE

HISTORICAL FLOODS (1955 to 1988)		DESIGN FLOOD[2]	PEAK WATER LEVEL[2]	PEAK FLOW[1]	COMMENTS[2],[3]
RANK	DATE	(ARI)	(mAHD)	(m^3/s)	
		PMF	44.68	1,710	
1	01 May 1988		43.30	440	Station 212320
		100 YEAR	42.91	433	
		50 YEAR	42.78	372	
		20 YEAR	42.48	281	
2	10 Feb 1956		43.0 (u/s) 42.14 (d/s)	230	Station 212321 (for d/s level)
3	19 Nov 1961		42.20	176	Station 212321
4	11 Jun 1964		42.14	162	Station 212321
5	06 Aug 1986		42.69	160	Station 212320
		5 YEAR	42.03	158	
6	15 Apr 1969		42.11	157	Station 212321
7	06 Mar 1967		42.11	157	Station 212321
8	13 Nov 1969		42.18	152	Station 212321
9	09 Nov 1966		42.08	152	Station 212321
10	08 Jan 1962		41.86	121	Station 212321

PMF — Probable maximum flood; ARI — Average Recurrence interval
mAHD — metres Australian Height Datum; d/s — downstream; u/s — upstream

Notes: (1) Floods are ranked by peak flow at Elizabeth Drive.
(2) Sources for historical flows and levels are Kinhill Engineers (1994) and Willing and Partners (1991); Source for peak design water levels is 2003 Model results (CS16.413), i.e. assumes current channel and bridge conditions at Elizabeth Drive (see ***Section 3.2****), Source for peak design flows for 20 year, 50 year, 100 year and PMF is Willing and Partners (1991); Source for peak flow for 5 year flood is Kinhill Engineers (1994).*
(3) River Gauging Station No.212321 was located about 50m downstream of Elizabeth Drive, while River Gauging Station No.212320 is located about 200m upstream of Elizabeth Drive..

Following the major floods of the 1980s and from the conclusions reached as part of the *1991 Floodplain Management Study* (Willing and Partners, 1991), the Overett Avenue area, just upstream of Elizabeth Drive, was identified as one of the main flood problem areas of South Creek in the Liverpool LGA. A number of studies were undertaken during the 1990s to examine flood mitigation options for this area, and as a result, a number of flood mitigation works were undertaken in this area. These works are discussed in detail in **Section 10.1.2**.

These flood mitigation works have resulted in a reduction in flood levels of about 0.5m–0.8m in the Overett Avenue area (see **Section 10.1.2**). Therefore, the flood level upstream of Elizabeth Drive recorded in the 1956 flood would be equivalent to the current 100 year flood level with today's bridge and channel conditions at Elizabeth Drive. If a flood of the size of the 1956 flood occurred today, the flood level upstream of Elizabeth Drive would be likely to be more than 0.5m lower.

TABLE 2.4: ADOPTED FLOOD LEVELS FOR SOUTH CREEK FOR EXISTING CONDITIONS

MIKE-11 CHAINAGE (km)	CROSS-SECTION NAME	DESCRIPTION	100 Year ARI Flood Level (mAHD)			50 Year ARI Flood Level (mAHD)			20 Year ARI Flood Level (mAHD)			5 Year ARI Flood Level (mAHD)			PMF Level (mAHD)		
			Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference
SOUTH CREEK — MAIN CHANNEL																	
8.923	5.00	Just upstream Bringelly Road, Rossmore	59.36	59.30	-0.06	59.07	59.01	-0.06	58.60	58.55	-0.05	no calc	57.96		60.28	60.18	-0.10
9.003	4.35	Just downstream Bringelly Road, Rossmore	58.30	58.27	-0.03	58.20	58.18	-0.02	58.10	58.04	-0.06	57.90	57.80	-0.10	59.60	59.63	0.03
9.308	4.34		57.60	57.62	0.02	57.60	57.53	-0.07	57.40	57.40	0.00	57.20	57.16	-0.04	58.90	58.94	0.04
9.543	4.33	Opposite Bellfield Avenue, Rossmore	57.10	57.05	-0.05	57.00	56.97	-0.03	56.80	56.84	0.04	56.70	56.63	-0.07	58.40	58.40	0.00
9.888	4.32		56.10	56.05	-0.05	56.00	55.96	-0.04	55.80	55.82	0.02	55.60	55.58	-0.02	57.30	57.29	-0.02
10.283	4.31		55.50	55.44	-0.06	55.40	55.36	-0.04	55.20	55.22	0.02	55.10	54.99	-0.12	56.60	56.55	-0.05
10.693	4.30		54.60	54.57	-0.03	54.50	54.49	-0.01	54.40	54.36	-0.05	54.20	54.18	-0.02	55.80	55.83	0.03
11.063	4.29		53.80	53.76	-0.04	53.70	53.65	-0.05	53.50	53.47	-0.03	53.30	53.22	-0.08	55.30	55.26	-0.04
11.378	4.28	Confluence with Thompsons Creek	53.30	53.31	0.01	53.20	53.20	0.00	53.00	53.03	0.03	52.90	52.75	-0.15	54.80	54.79	-0.02
11.603	4.27		52.90	52.88	-0.02	52.80	52.78	-0.02	52.70	52.65	-0.05	52.50	52.38	-0.12	54.30	54.25	-0.05
11.726	4.26		52.60	52.54	-0.07	52.50	52.44	-0.06	52.30	52.30	0.00	52.10	52.02	-0.08	53.90	53.93	0.03
12.013			52.00	51.97	-0.03	51.90	51.86	-0.04	51.70	51.71	0.01	51.60	51.45	-0.15	53.40	53.41	0.01
12.298	4.25	Opposite Fifteenth Avenue, Kemps Creek	51.50	51.46	-0.04	51.40	51.36	-0.04	51.20	51.18	-0.02	51.00	50.89	-0.12	53.00	52.99	-0.01
12.738	4.24		50.70	50.67	-0.03	50.60	50.53	-0.07	50.30	50.31	0.01	50.10	49.95	-0.15	52.50	52.39	-0.12
13.218	4.23	Opposite Watts Road, Kemps Creek	49.90	49.87	-0.03	49.80	49.72	-0.08	49.50	49.49	-0.01	49.30	49.11	-0.20	51.80	51.66	-0.14
13.638	4.22	Opposite East/West part Victor Ave, Kemps Creek	49.10	49.11	0.00	49.00	48.97	-0.03	48.80	48.75	-0.05	48.50	48.37	-0.13	51.00	50.99	-0.02
13.958			48.10	48.09	-0.01	48.00	47.97	-0.03	47.80	47.80	0.00	47.60	47.48	-0.12	49.80	49.78	-0.02
14.303	4.21		47.00	46.94	-0.06	46.90	46.85	-0.05	46.70	46.70	0.00	46.50	46.39	-0.11	48.30	48.25	-0.05
14.583	4.20		46.40	46.39	-0.01	46.30	46.32	0.02	46.20	46.21	0.00	46.10	45.97	-0.13	47.70	47.67	-0.03
14.903	4.19		45.75	45.74	-0.01	45.68	45.66	-0.02	45.56	45.56	0.00	45.39	45.38	-0.01	47.16	47.15	-0.01
15.188			45.28	45.27	-0.02	45.20	45.18	-0.02	45.06	45.05	-0.01	44.81	44.80	-0.01	46.83	46.81	-0.02
15.473	4.18		44.70	44.68	-0.02	44.60	44.58	-0.02	44.43	44.43	0.00	44.09	44.08	-0.01	46.36	46.33	-0.03
15.653	4.17		44.27	44.25	-0.02	44.16	44.14	-0.02	43.99	43.98	-0.01	43.63	43.62	-0.01	46.01	45.97	-0.04
15.913			43.69	43.67	-0.02	43.58	43.56	-0.02	43.41	43.40	-0.01	43.08	43.08	0.00	45.51	45.45	-0.06
16.153	4.15	Opposite Overett Avenue, Kemps Creek	43.39	43.36	-0.03	43.25	43.22	-0.03	43.01	43.00	-0.01	42.58	42.61	0.03	45.30	45.22	-0.08
16.240			43.29	43.26	-0.03	43.15	43.12	-0.03	42.89	42.89	0.00	42.44	42.48	0.04	45.18	45.09	-0.09
16.413	4.14		42.96	42.92	-0.04	42.81	42.77	-0.04	42.52	42.49	-0.04	42.05	42.03	-0.02	44.80	44.69	-0.11
16.583	4.13	Just upstream Elizabeth Drive, Kemps Creek	42.65	42.64	-0.01	42.50	42.49	-0.01	42.21	42.21	0.00	41.79	41.80	0.01	44.52	44.42	-0.10
16.683	4.09	Just downstream Elizabeth Drive, Kemps Creek	42.63	42.61	-0.02	42.49	42.47	-0.02	42.20	42.20	0.00	41.78	41.79	0.01	44.23	44.16	-0.07
16.720			42.06	42.05	-0.02	41.98	41.96	-0.02	41.83	41.82	-0.01	41.58	41.57	-0.01	43.16	43.15	-0.01
16.780			not publ	41.99		not publ	41.92		not publ	41.79		not publ	41.56			43.00	
16.953	4.08		40.90	40.99	0.09	40.80	40.91	0.11	40.60	40.80	0.20	40.50	40.46	-0.04	42.00	42.16	0.16
17.243	4.07		40.20	40.18	-0.02	40.10	40.05	-0.05	39.90	39.86	-0.04	39.70	39.33	-0.37	41.60	41.61	0.01
17.573	4.06		39.70	39.66	-0.04	39.50	39.49	-0.01	39.30	39.22	-0.08	39.00	38.58	-0.42	41.20	41.17	-0.03
17.793	4.05		39.30	39.26	-0.04	39.10	39.10	0.00	38.90	38.84	-0.06	38.70	38.23	-0.47	40.90	40.85	-0.05
17.963	4.04		39.10	39.08	-0.02	39.00	38.93	-0.07	38.70	38.71	0.01	38.50	38.10	-0.40	40.70	40.66	-0.04
18.243	4.03		38.80	38.81	0.01	38.70	38.69	-0.02	38.50	38.49	-0.01	38.20	37.96	-0.24	40.30	40.35	0.05
18.663	4.02		38.70	38.64	-0.06	38.50	38.54	0.04	38.40	38.37	-0.03	37.90	37.86	-0.04	40.00	39.98	-0.02
18.963	4.01	Upstream extent of South Creek Dam	38.60	38.61	0.01	38.50	38.51	0.01	38.30	38.34	0.04	37.80	37.84	0.04	39.90	39.89	-0.01
19.278	4.00		38.60	38.60	0.00	38.50	38.51	0.01	38.30	38.34	0.04	37.80	37.84	0.04	39.90	39.87	-0.03

MIKE-11 CHAINAGE (km)	CROSS-SECTION NAME	DESCRIPTION	100 Year ARI Flood Level (mAHD)			50 Year ARI Flood Level (mAHD)			20 Year ARI Flood Level (mAHD)			5 Year ARI Flood Level (mAHD)			PMF Level (mAHD)		
			Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference	Previous Studies (1)	2003 Model	Difference
MINOR BRANCHES IN VICINITY OF OVERETT AVENUE																	
0.000		"OVERETT" (also CS15.913)	not publ	43.67		not publ	43.56		not publ	43.40		not publ	43.08		not publ	45.45	
1.245		"OVERETT" between No.10 Sumbray and 14 Overett	not publ	43.57		not publ	43.48		not publ	43.36		not publ	43.07		not publ	45.33	
1.495		"OVERETT" just upstream road (Overett Avenue)	43.60	43.54	-0.06	43.50	43.43	-0.07	43.40	43.16	-0.24	43.1	42.84	-0.26	45.10	44.92	-0.18
1.580		"OVERETT" just downstream road (Overett Avenue)	43.40	43.29	-0.12	43.30	43.18	-0.12	43.10	42.89	-0.21	42.8	42.58	-0.22	44.80	44.69	-0.11
1.880		"OVERETT" upstream side of Elizabeth Drive	not publ	43.22		not publ	43.14		not publ	42.80		not publ	41.38		not publ	44.15	
1.940		"OVERETT" downstream side of Elizabeth Drive	not publ	41.69		not publ	41.38		not publ	41.13		not publ	40.65		not publ	43.69	
2.360		"OVERETT"	not publ	40.99		not publ	40.91		not publ	40.80		not publ	40.46		not publ	42.16	
0.000		"2nd CHAN" (also CS16.413)	not publ	42.92		not publ	42.77		not publ	42.49		not publ	42.03		not publ	44.69	
0.130		"2nd CHAN" upstream side of Elizabeth Drive	42.70	42.78	0.08	42.50	42.62	0.12	42.20	42.33	0.13	41.7	41.87	0.17	44.40	44.52	0.12
0.180		"2nd CHAN" downstream side of Elizabeth Drive	42.40	42.46	0.06	42.30	42.34	0.04	42.00	42.10	0.10	41.7	41.74	0.03	43.10	43.28	0.18
0.215		"2nd CHAN"	not publ	42.29		not publ	42.19		not publ	42.02		not publ	41.72		not publ	43.10	
0.310		"2nd CHAN"	not publ	41.99		not publ	41.92		not publ	41.79		not publ	41.56		not publ	43.00	
0.000		"Link 2"	not publ	43.29		not publ	43.18		not publ	42.89		not publ	42.58		not publ	44.69	
0.200		"Link 2"	not publ	43.14		not publ	43.01		not publ	42.67		not publ	42.25		not publ	46.44	
0.500		"Link 2"	not publ	42.92		not publ	42.77		not publ	42.49		not publ	42.03		not publ	44.69	
0.000		"Link 3"	not publ	43.29		not publ	43.18		not publ	42.89		not publ	42.58		not publ	44.69	
0.250		"Link 3"	not publ	43.16		not publ	43.05		not publ	42.67		not publ	42.17		not publ	44.58	
0.450		"Link 3"	not publ	42.78		not publ	42.62		not publ	42.32		not publ	41.82		not publ	44.34	
0.510		"Link 3"	not publ	42.01		not publ	41.94		not publ	41.83		not publ	41.63		not publ	43.39	
0.580		"Link 3"	not publ	41.99		not publ	41.92		not publ	41.79		not publ	41.56		not publ	43.00	
0.000		"Link 4"	not publ	42.78		not publ	42.62		not publ	42.33		not publ	41.87		not publ	44.52	
0.100		"Link 4"	not publ	42.78		not publ	42.62		not publ	42.33		not publ	41.86		not publ	44.40	
0.200		"Link 4"	not publ	42.78		not publ	42.62		not publ	42.32		not publ	41.82		not publ	44.34	
THOMPSONS CREEK (2)																	
0.00	18.15	Just downstream of The Northern Road	69.80	69.77	-0.03	69.72	69.68	-0.04	69.62	69.58	-0.04	no calc	no calc	na	70.50	70.43	-0.07
0.47	18.14		67.06	67.04	-0.02	67.02	66.95	-0.07	66.93	66.83	-0.10	no calc	no calc	na	67.71	67.66	-0.05
0.93	18.13	Opposite corner Kelvin Park Drive & Medich Place	64.48	64.46	-0.02	64.39	64.37	-0.02	64.33	64.25	-0.08	no calc	no calc	na	64.90	64.88	-0.02
1.26	18.12		62.39	62.40	0.01	62.29	62.33	0.04	62.24	62.23	-0.01	no calc	no calc	na	63.00	62.94	-0.06
1.68	18.11		60.64	60.38	-0.26	60.51	60.28	-0.23	60.42	60.14	-0.28	no calc	no calc	na	61.43	61.28	-0.15
1.90	18.10	Approx. 120m upstream of The Retreat	59.14	59.07	-0.07	59.04	59.00	-0.04	59.00	58.92	-0.08	no calc	no calc	na	59.85	59.74	-0.12
2.09	18.08	Just upstream of The Retreat	58.86	58.90	0.04	58.81	58.87	0.06	58.78	58.81	0.03	no calc	no calc	na	59.42	59.41	-0.01
2.10	18.07	Approx. 20m downstream of The Retreat	58.53	58.63	0.09	58.49	58.53	0.04	58.45	58.37	-0.08	no calc	no calc	na	59.37	59.54	0.17
2.21	18.06		58.05	58.00	-0.05	57.90	57.86	-0.04	57.80	57.70	-0.10	no calc	no calc	na	58.84	58.95	0.11
2.41	18.05		57.19	57.26	0.07	57.11	57.16	0.05	57.05	57.07	0.02	no calc	no calc	na	57.77	57.82	0.05
2.56	18.04		56.78	56.78	0.00	56.70	56.73	0.03	56.65	56.68	0.03	no calc	no calc	na	57.24	57.29	0.05
2.89	18.03		55.24	55.26	0.02	55.15	55.19	0.04	55.11	55.06	-0.05	no calc	no calc	na	55.72	55.74	0.02
3.21	18.02		54.05	54.00	-0.05	53.98	53.95	-0.03	53.94	53.90	-0.04	no calc	no calc	na	54.43	54.43	0.00
3.41	18.01	Approx. 250m upstream confluence South Creek	52.90	52.88	-0.02	52.81	52.78	-0.03	52.66	52.65	-0.01	no calc	no calc	na	54.25	54.25	0.00

Notes: (1) *'Previous Studies' indicates 'Best available design flood levels from Previous Studies' as presented in* ***Appendix C***
(2) *MIKE-11 chainages for Thompsons Creek are slightly different to HEC-2 chainages given in 1991 FPM Study*
not publ = no published flood level available; no calc = has not been calculated in previous studies; na = not applicable; no flow = modelling indicates cross-section would be dry.
Source: output file J1184_M11_sum4.xls

Appendix C

29024_090715_sg

16 July 2009

Attention: Quoting Surveyor

Re: Survey to facilitate Upper South Creek Flood Study

PREAMBLE

Camden Council (CC) has commissioned WMAwater (WMA) to undertake a flood study of the Upper South Creek catchment. The wider study area is shown in the attached Figure 1.

Most data for the study is provided via Airborne Laser Survey (ALS). There is however a requirement to pick up structure details and creek cross-sections which are not able to be resolved by ALS.

The following Brief documents the detailed survey requirements of the project.

SCOPE OF WORK

The approximate location of the survey required is shown in Figure 2. Note that the locations of structures to be surveyed are shown in red (red dots). For each of the structure locations noted in Figure 2 and then listed below in Table 1 details of the drainage structures and road levels are to be provided in accordance with the General Specifications presented later in this document, as well as upstream and downstream cross-sections to be surveyed.

Cross-sections surveyed will need to be taken in accordance with the general specifications of this Brief.

Webb, McKeown & Associates Pty Ltd (trading as WMAwater)

ABN 50 366 075 980

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Table 1: List of structures identified in Figure 1

Id	Comment	X	Y
001	Culvert_Bringelly_rd_west_of_South_Ck	291708.38	6242114.39
002	Culvert_The_northern_rd_near_Robinson_rd	290919.56	6241379.79
003	Culvert_Robinson_rd_near_Northern_rd	291193.92	6241511.90
004	Bridge_Bringelly_rd_South_Ck	292373.73	6242007.37
005	Culvert_Rossmore_crescent_near_Allenby_rd	293114.59	6240872.59
006	Culvert_Bringelly_rd_Kemps_Ck	295683.80	6241405.44
007	Culvert_Eastwood_rd_near_McCann_rd	295915.32	6240573.60
008	Culvert_Heath_rd_near_Dickson_rd	295889.38	6239760.19
009	Culvert_Barry_ave_junction_Sth_Ck_and_Rileys_Ck	292703.09	6240540.91
010	Culvert_Anthony_rd_near_Barry_ave	293204.11	6239526.90
011	Culvert_Deepfields_rd_enar_Chisholm_rd	294048.80	6236825.93
012	Culvert_Camden_Valley_way_near_pond	295417.17	6235988.98
013	Culvert_Camden_Valley_way_near_Raby_rd	295688.16	6236369.05
014	Culvert_Camden_Valley_way_near_Cobbity_rd	293360.54	6233558.70
015	Culvert/bridge_unnamed_rd_near_Dam	290513.16	6238455.46
016	Culvert_unnamed_rd_near_Dam	289160.62	6238343.12
017	Culvert_The_Northern_rd_west_of_Robens_Cres	291074.08	6239697.44
018	Culvert_unnamed_rd_near_Dam	290333.33	6238177.12
019	Culvert_Riley_rd_near_Woolgen_Park_rd	295796.62	6238043.63
020	Bridge_Bringelly_rd_Thompsons_Ck	288999.66	6242231.54

General Specifications

Preparation of the surveyed cross-section data should conform to the following specifications:

- Each surveyed point should include a survey code. The point coding shall readily identify the feature being surveyed.
- The labelling of sections should follow a consistent protocol and clearly indicate which branch of the system the cross-section belongs to. Any labelling should be clearly marked and explained.
- Cross sections should be taken approximately perpendicular to the watercourse and are to include details of the streambed profile below the water surface and the overbank area to a width of approximately 10 m from top of bank. A representative photograph (or photographs) should be taken to show the terrain along the surveyed line and immediately upstream and downstream of each section.
- Where sections include culverts or bridge waterway crossings, the following information is needed:
- *Culvert dimensions:* u/s and d/s inverts, length, height, width (or diameter), and section along the top of road.
- *Bridge dimensions:* bridge waterway details and section along top of road.
- An appropriate photograph and diagram at any culvert or bridge showing these details is required on an A4 sheet. An example diagram is provided in Figure 3 (or you can just label the digital photograph accordingly). At these locations (i.e. at creek/channel crossings), there will

need to be additional cross-sections surveyed both upstream and downstream of the structure. These cross-sections should be located approximately 10m away from the crossing or at a section which is representative of the typical watercourse upstream and downstream of the crossing. Please note that permission is necessary if any access to private property is required.
- Excessive vegetation or other obstructions that are likely to restrict flood flows should be marked on the plans and photographed.

ADDITIONAL SURVEY NOTES

- All survey data is to be reduced to Australian Height Datum (AHD) and Map Grid of Australia (MGA94) co-ordinates. Heights should be given in metres AHD to 2 decimal places (e.g. 2.65 m) and distance in metres to 1 decimal place.
- Sections should show the distances relative to a zero point on the left bank looking downstream.
- Within the creeks, it is preferable to take more levels up the sides of the channel rather than to inadequately define a section. Data points should be taken at any significant change in grade.
- If property access issues are deemed to be an issue in completing this work, then please contact Peter Nunn at Camden Council on 4654 7777. Please note that permission is necessary if any access to private property is required.
- The surveyor is to follow all DECC/Council protocols for entering private property and the relevant Occupational Health and Safety requirements for working in traffic.

DELIVERY OF DATA

Cross sections should be provided in digital form (on a CD or via email). An overall plan is to be provided showing all the data points, section names and notes etc. Preferred digital formats include 12D or CivilCAD. A textfile should be returned with the ASCII listing of each section in the specified format (see Figure 4 attached). Note that the order of the points as listed should define the cross-section as if viewed from left to right looking downstream. Details of bridges/culverts can be provided as per Figure 3 or a suitably annotated photograph.

Could you please respond (email or fax) by COB Friday 24th July 2009 with a fixed priced quote and timeframe to undertake the above survey tasks.

If you have queries regarding any of the information requested above, please do not hesitate to contact me on (02) 9299 2855 or via email at gray@wmawater.com.au.

Regards,

Steve Gray

Associate

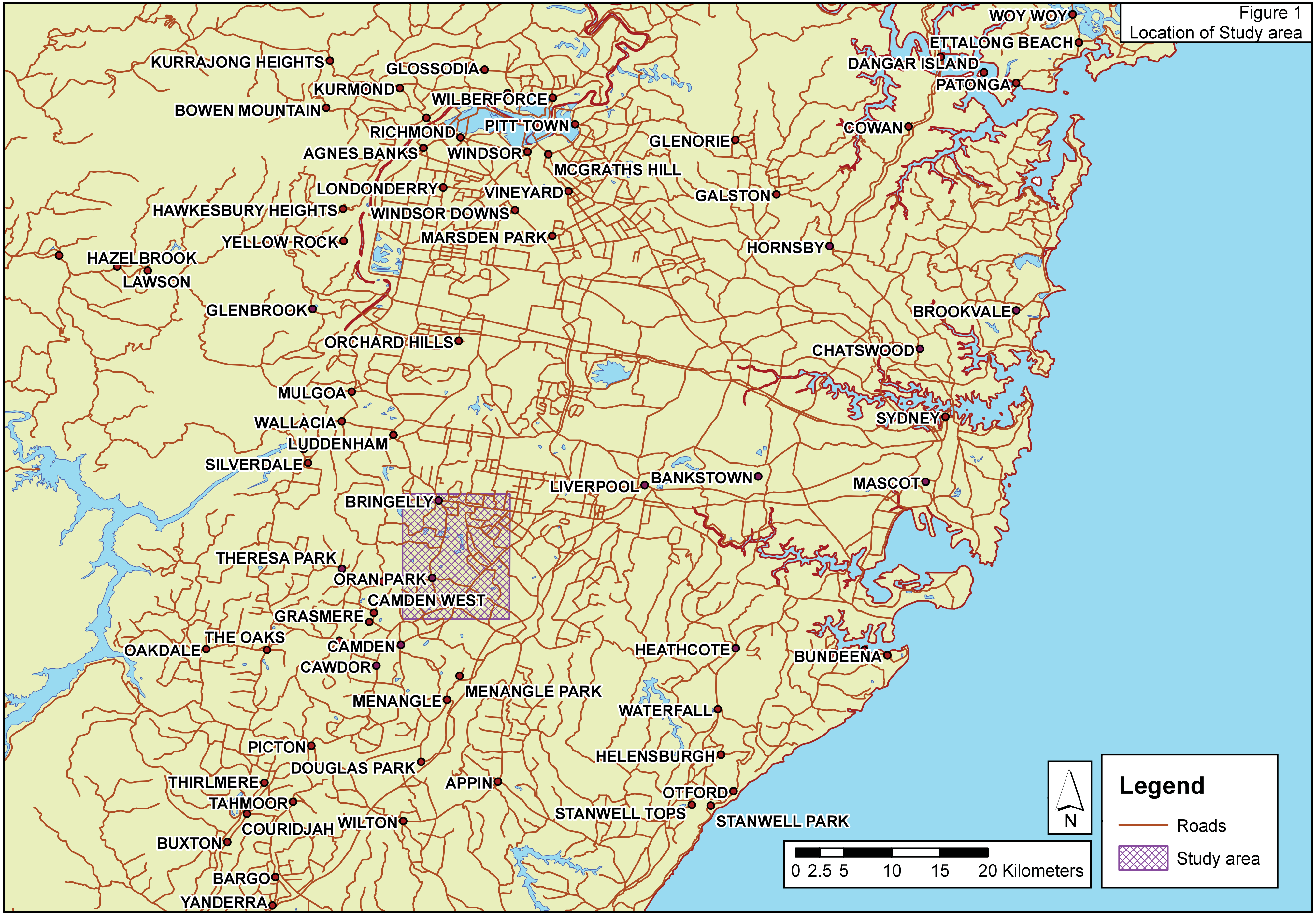

Figure 1
Location of Study area

Figure 2
Location of Hydraulic Structures

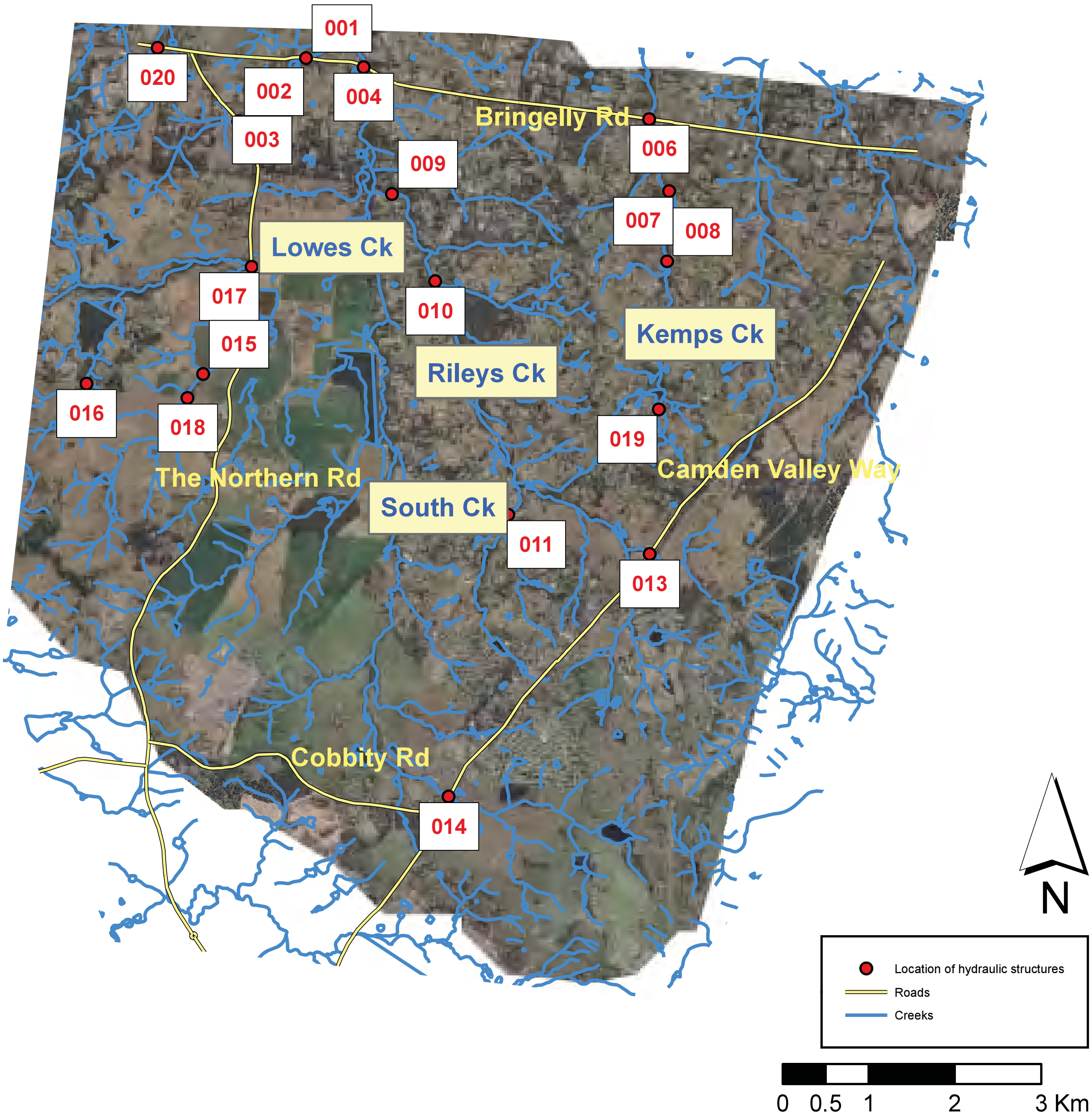

FIGURE 3
EXAMPLE SECTION

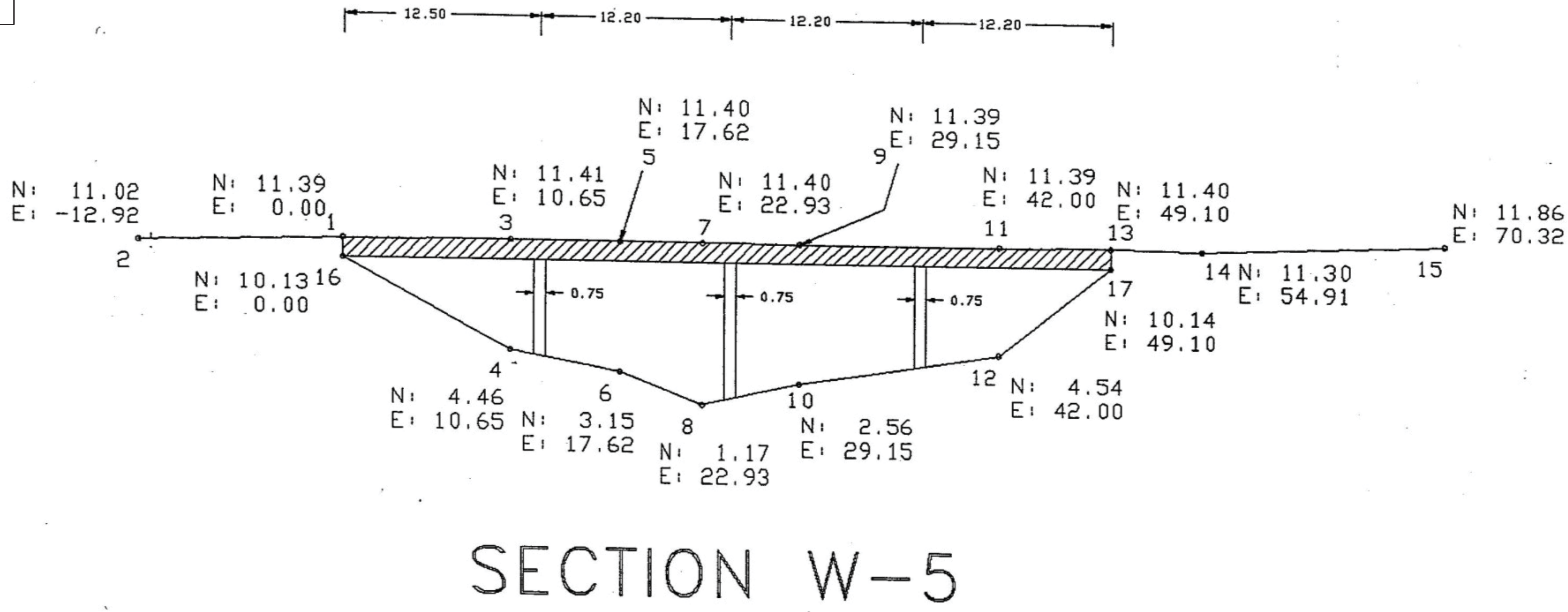

FIGURE 4
EXAMPLE OUTPUT

FORMAT OF ASCII DATA LISTING OF SECTIONS

Note that the order of points should define the cross-section as if viewed from left to right looking downstream

```
SECTION_NAME
Easting,Northing,Elevation
Easting,Northing,Elevation,
.,.,.
.,.,.
Easting,Northing,Elevations
NEXT_SECTION_NAME
Easting,Northing,Elevation
Easting,Northing,Elevation,
.,.,.
.,.,.
Easting,Northing,Elevation
```

EXAMPLE LISTING

```
UPPER CREEK Xs50
323777.500,1265590.895,56.965
323777.528,1265590.794,56.881
323777.566,1265590.657,56.880
323777.694,1265590.192,55.389
323777.696,1265590.185,55.380
323778.137,1265588.585,55.108
323778.146,1265588.551,55.108
323778.469,1265587.379,55.181
323778.469,1265587.377,55.181
323778.469,1265587.375,55.181
323778.468,1265587.374,55.181
323778.323,1265586.285,56.978
323778.065,1265584.352,57.393
323778.229,1265582.479,57.845
323778.375,1265580.838,58.241
323778.375,1265580.837,58.241
UPPER CREEK Xs60
323799.969,1265589.013,56.186
323799.968,1265589.011,56.186
323799.569,1265587.583,55.025
323799.094,1265585.883,55.074
323799.094,1265585.883,55.074
323799.094,1265585.883,55.074
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Appendix D

FIGURE D1A
UPPER SOUTH CREEK
PEAK FLOOD HEIGHTS

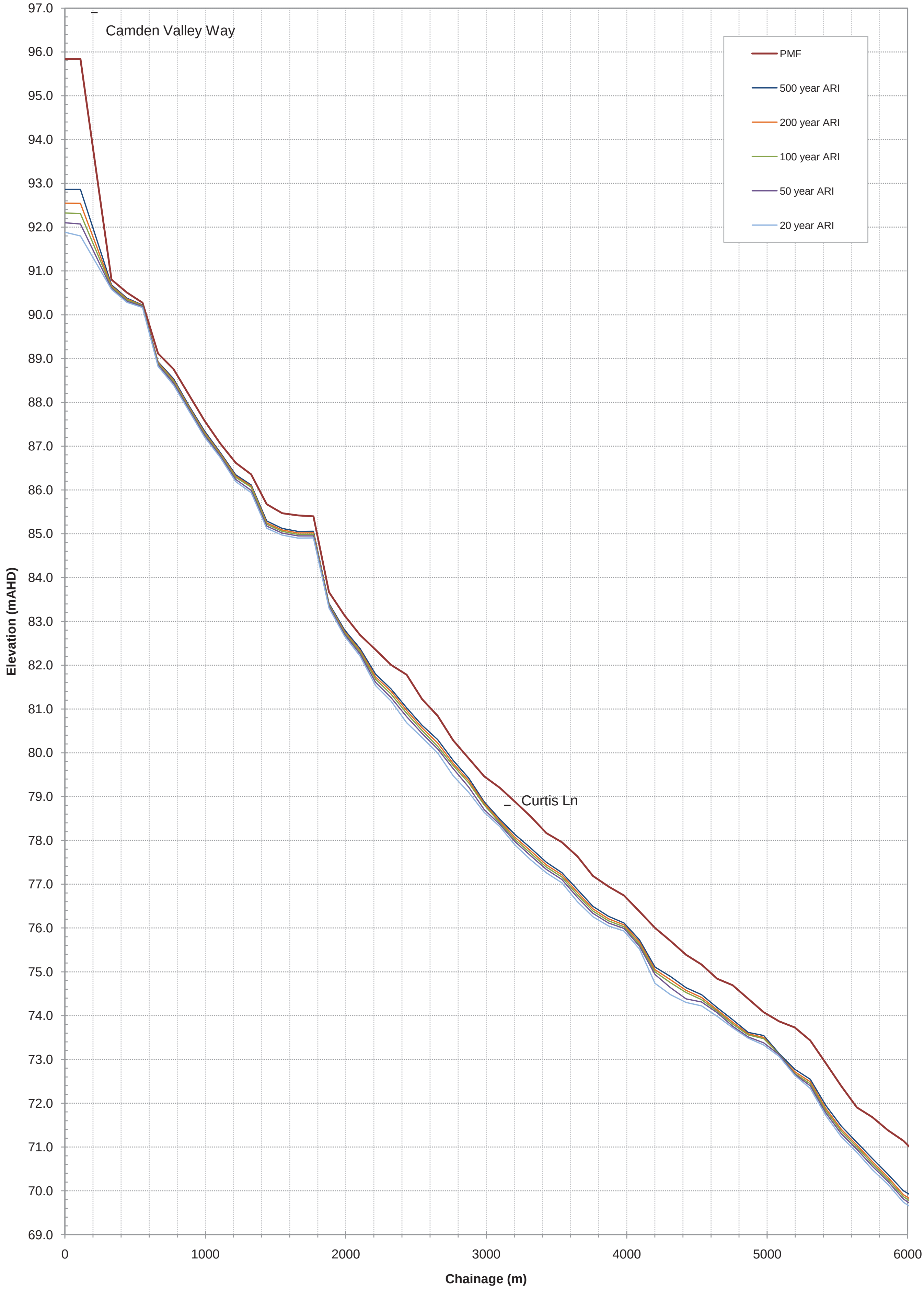


FIGURE D1B
UPPER SOUTH CREEK
PEAK FLOOD HEIGHTS

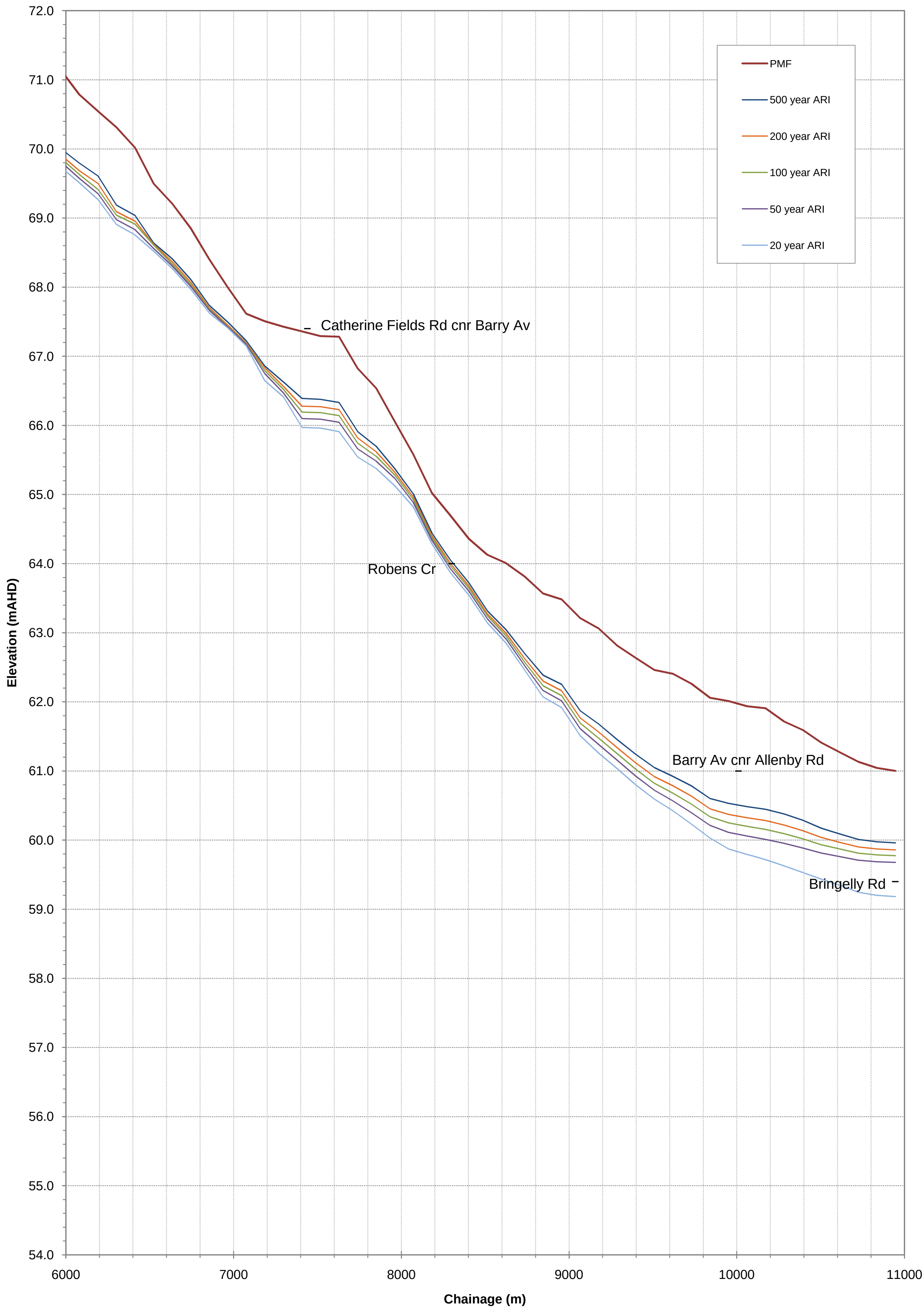


FIGURE D2A
KEMPS CREEK
PEAK FLOOD HEIGHTS

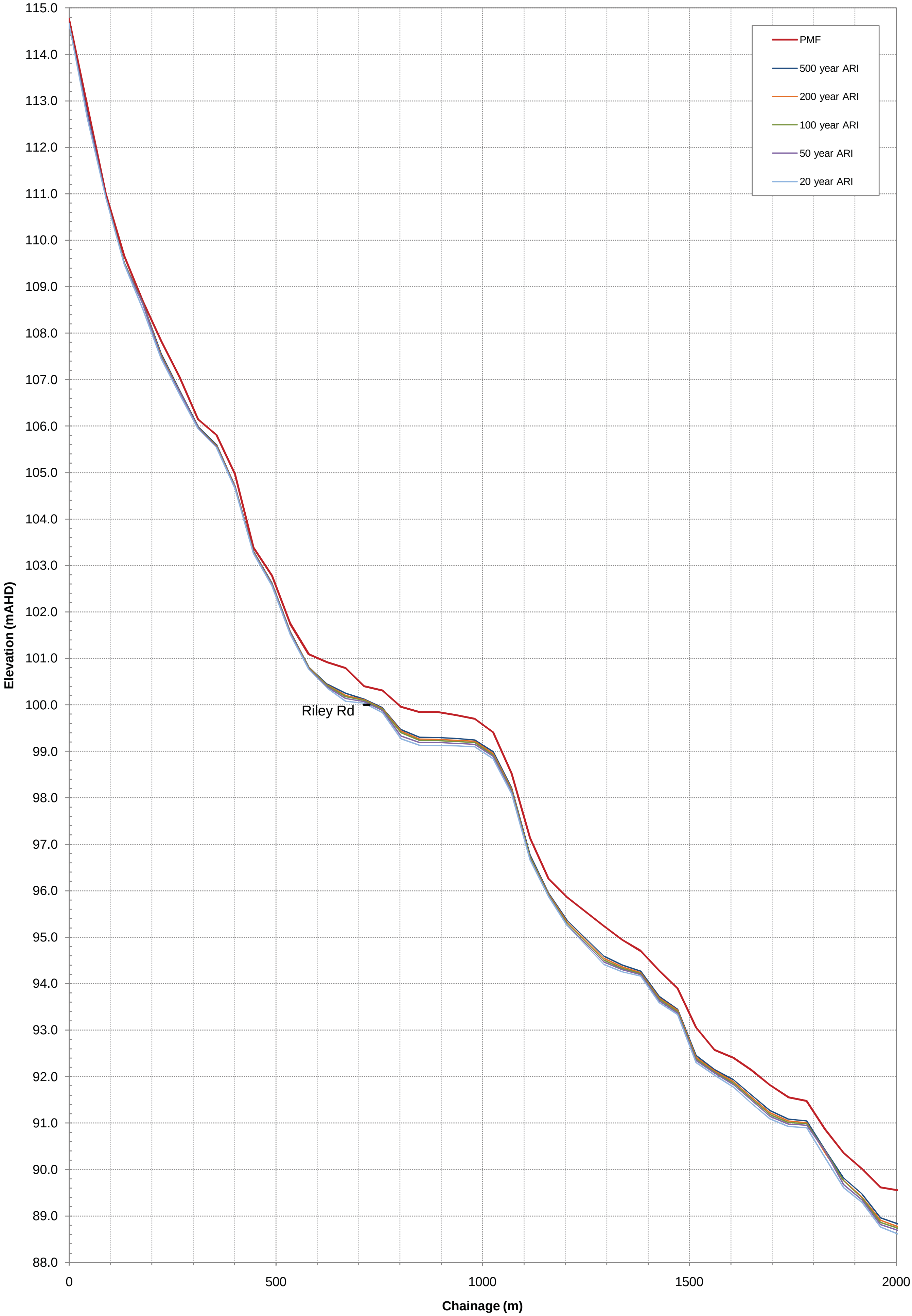


FIGURE D2B
KEMPS CREEK
PEAK FLOOD HEIGHTS

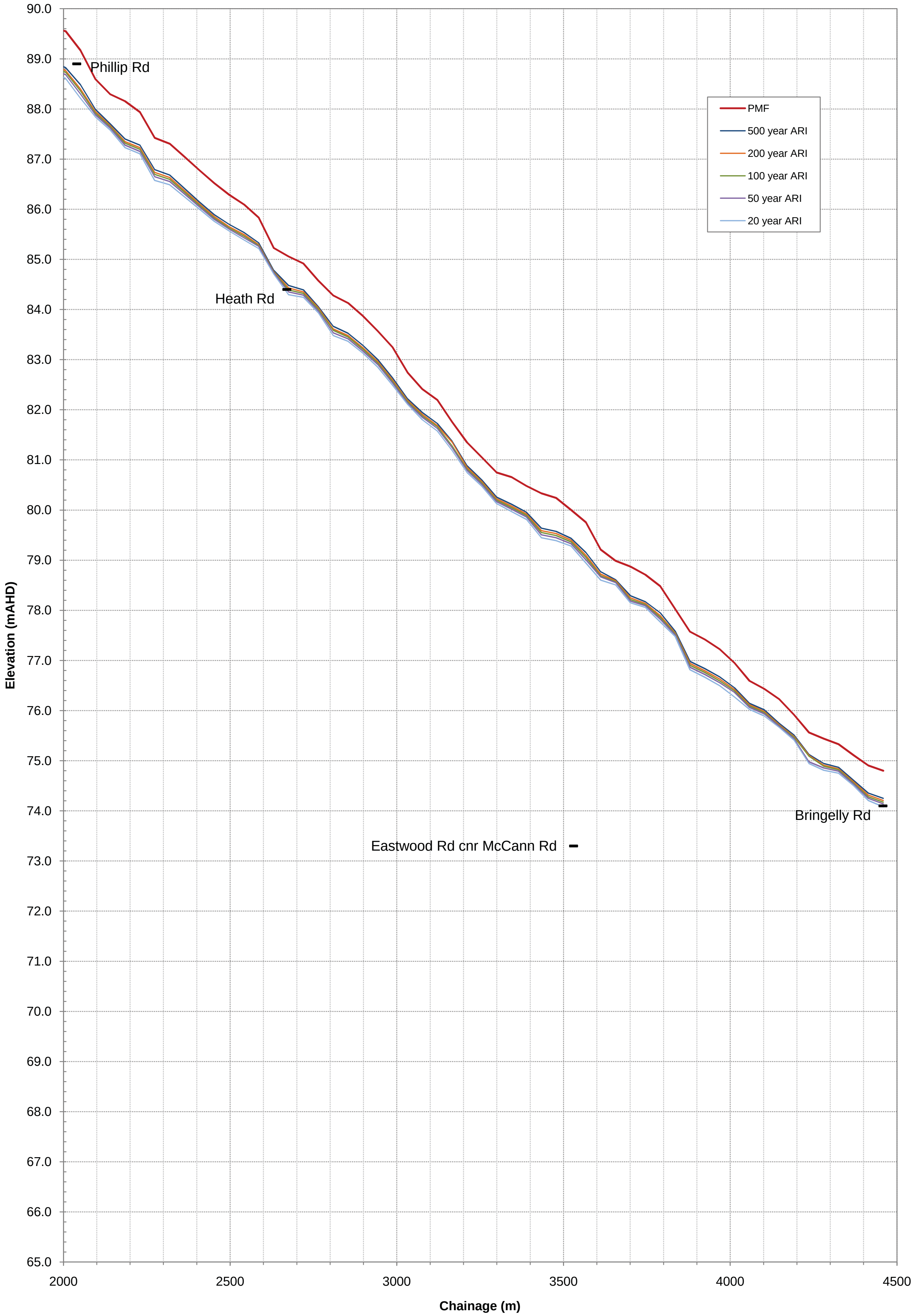


FIGURE D3A
BONDS CREEK
PEAK FLOOD HEIGHTS

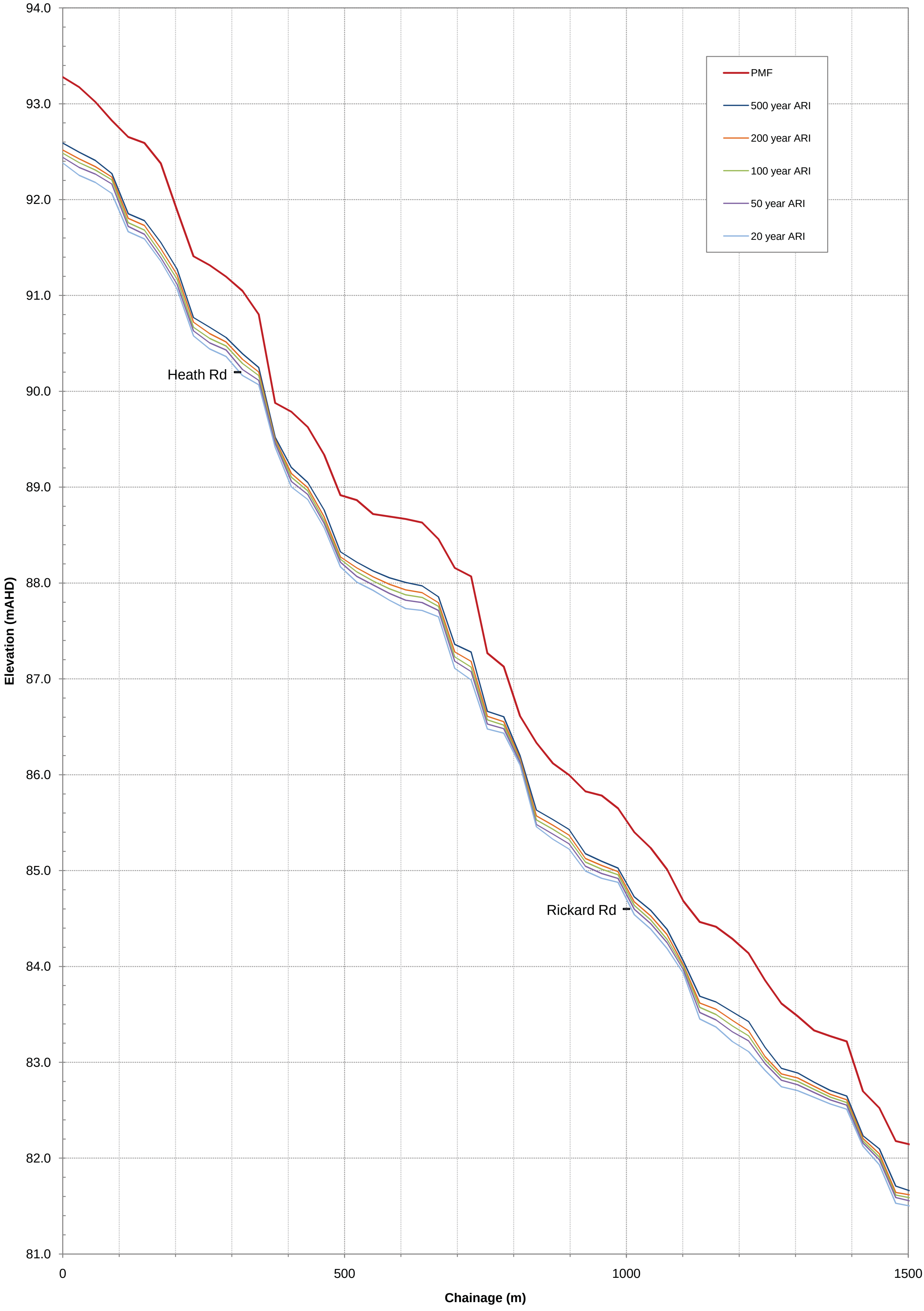
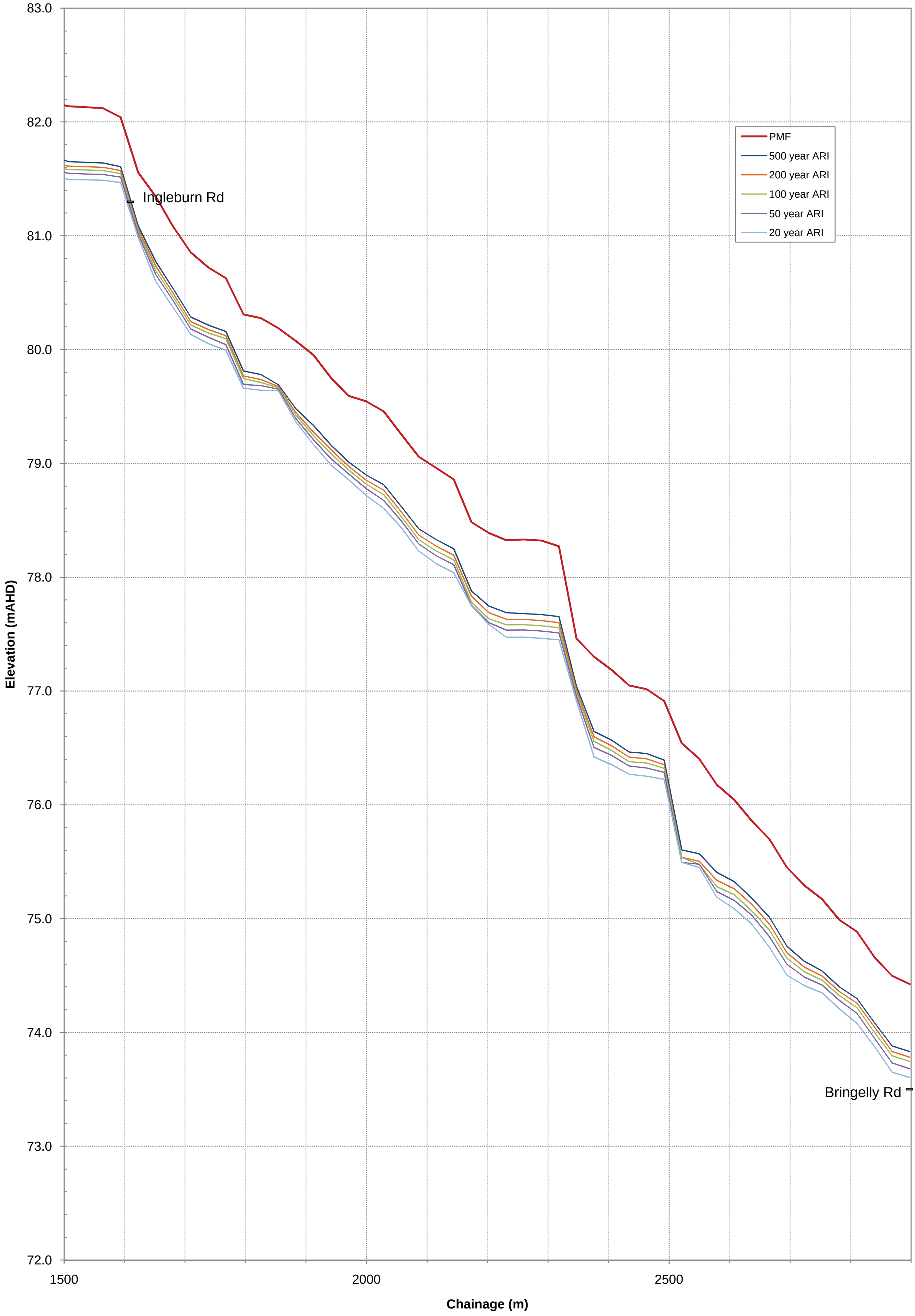


FIGURE D3B
BONDS CREEK
PEAK FLOOD HEIGHTS



Appendix E

FIGURE E1
5% AEP PROVISIONAL HAZARD

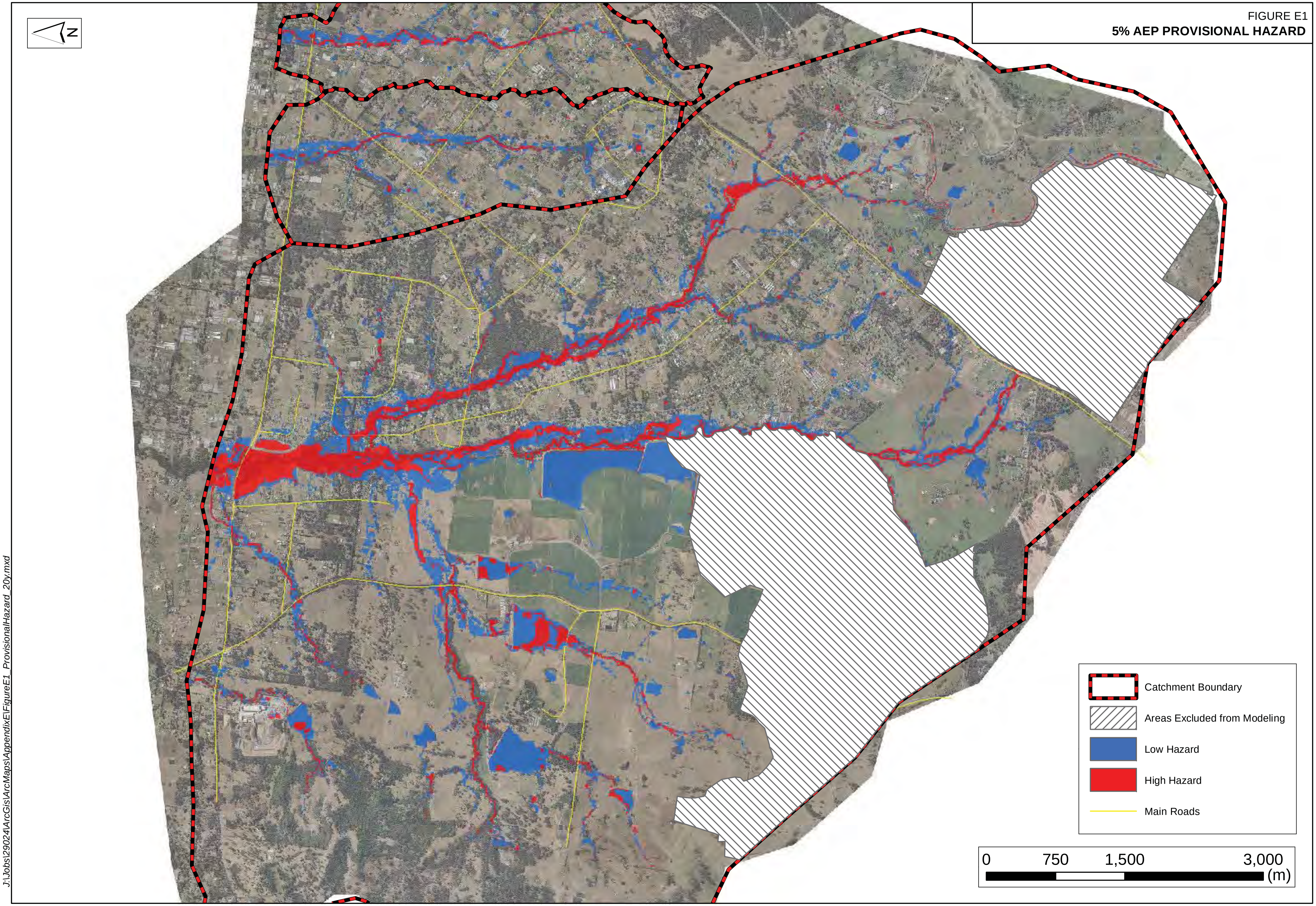


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FIGURE E2
5% AEP HYDRAULIC CATEGORISATION

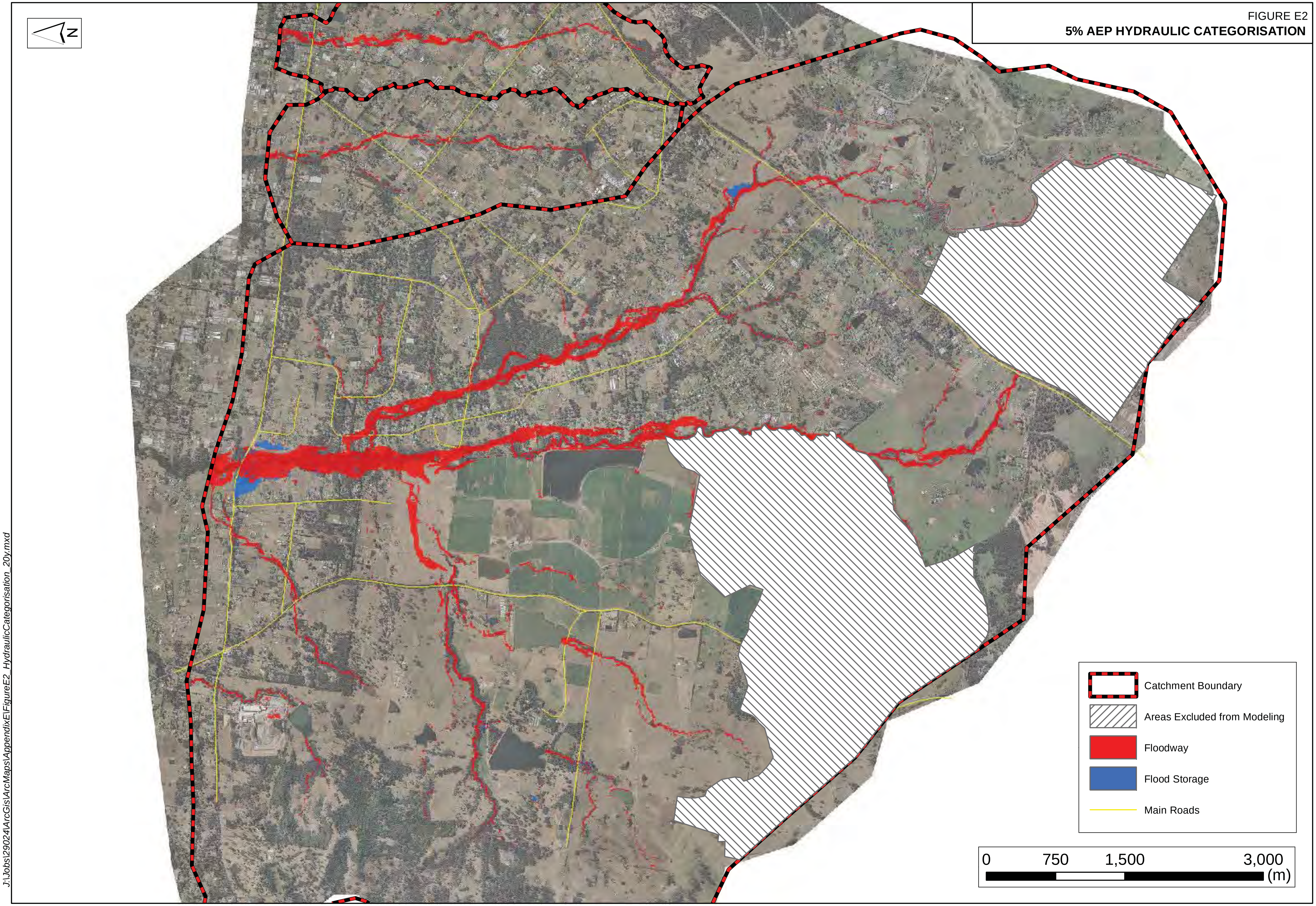

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FIGURE E3

2% AEP PROVISIONAL HAZARD

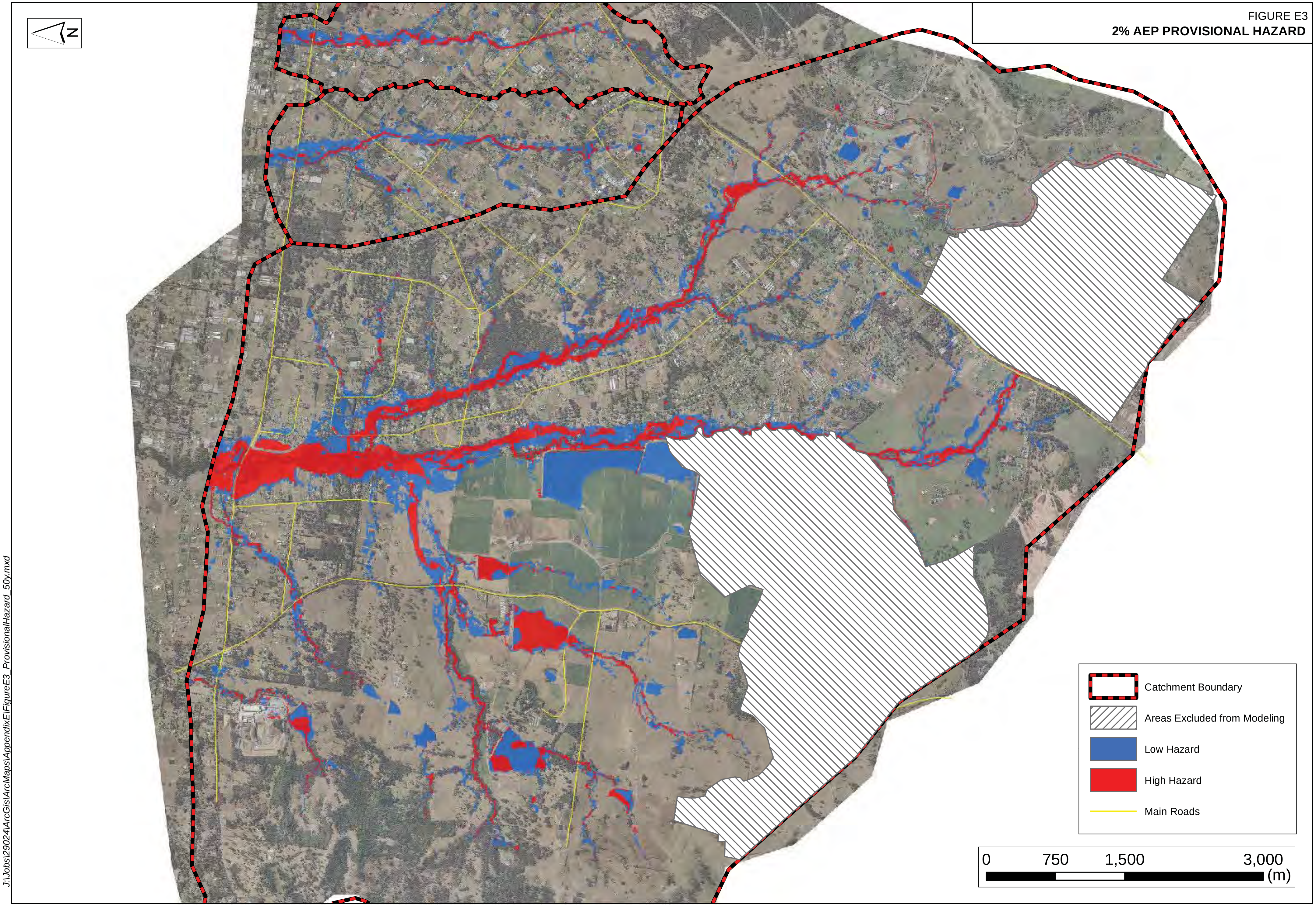

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FIGURE E4

2% AEP HYDRAULIC CATEGORISATION

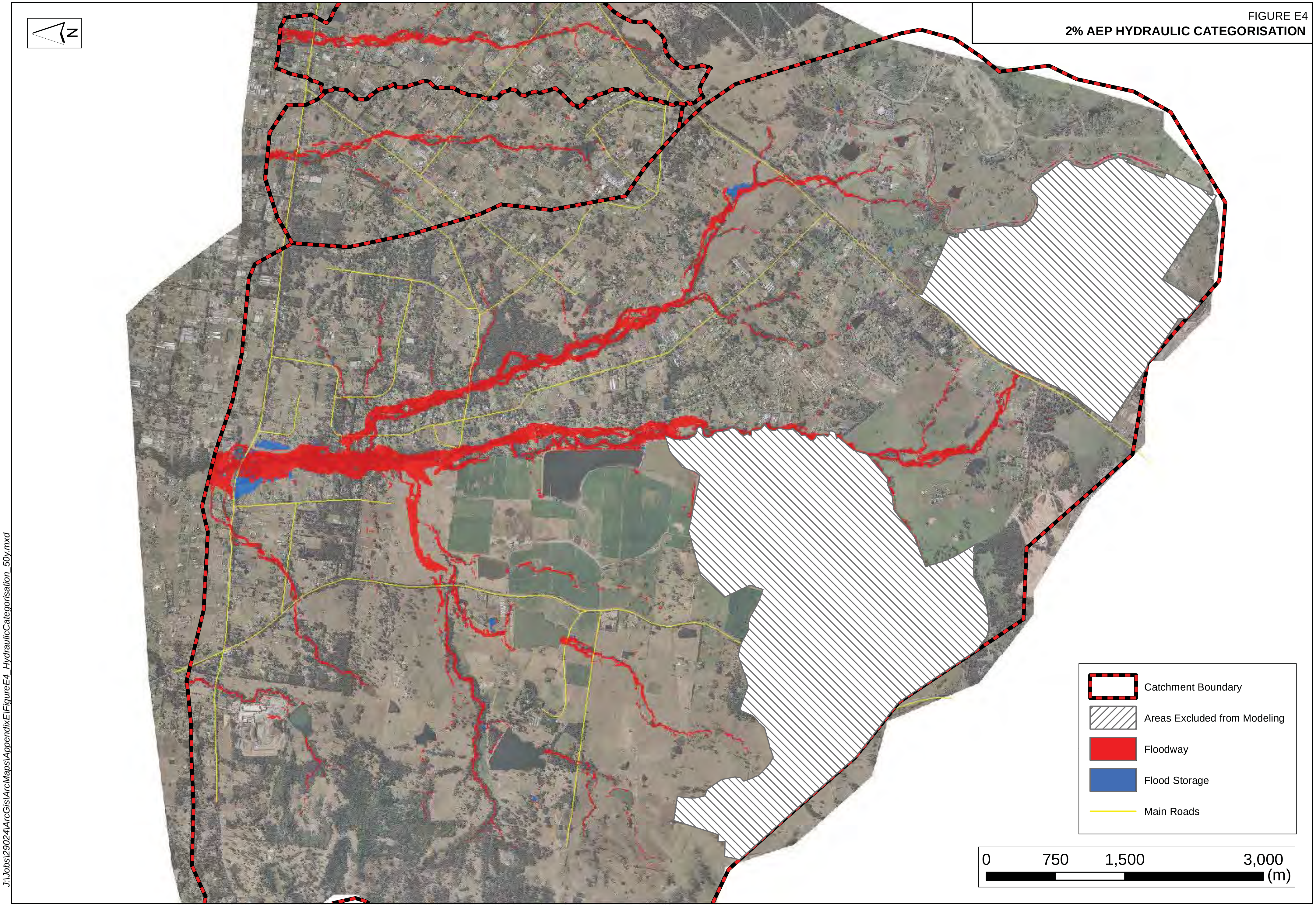

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FIGURE E5
0.5% AEP PROVISIONAL HAZARD

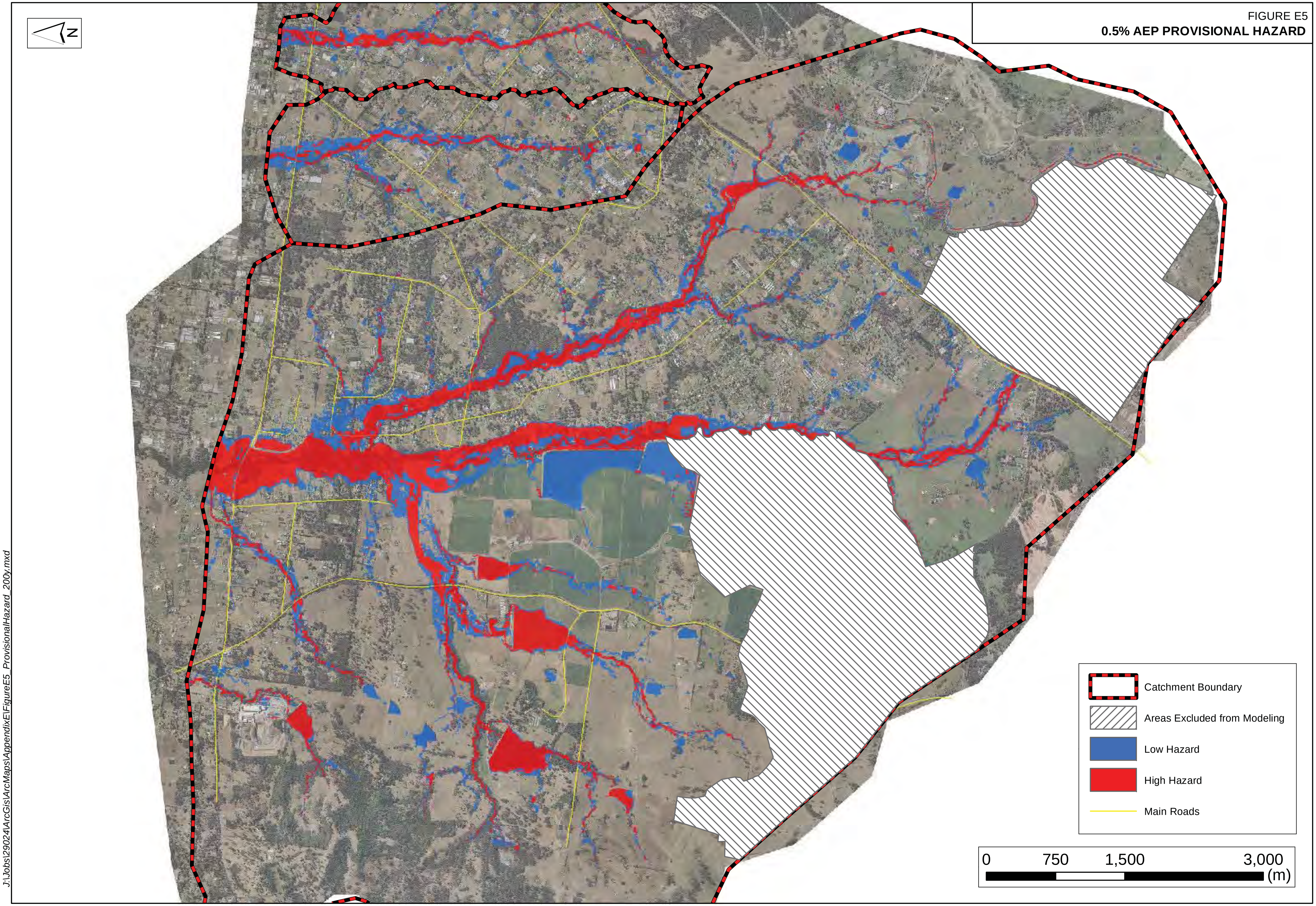

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FIGURE E6
0.5% AEP HYDRAULIC CATEGORISATION

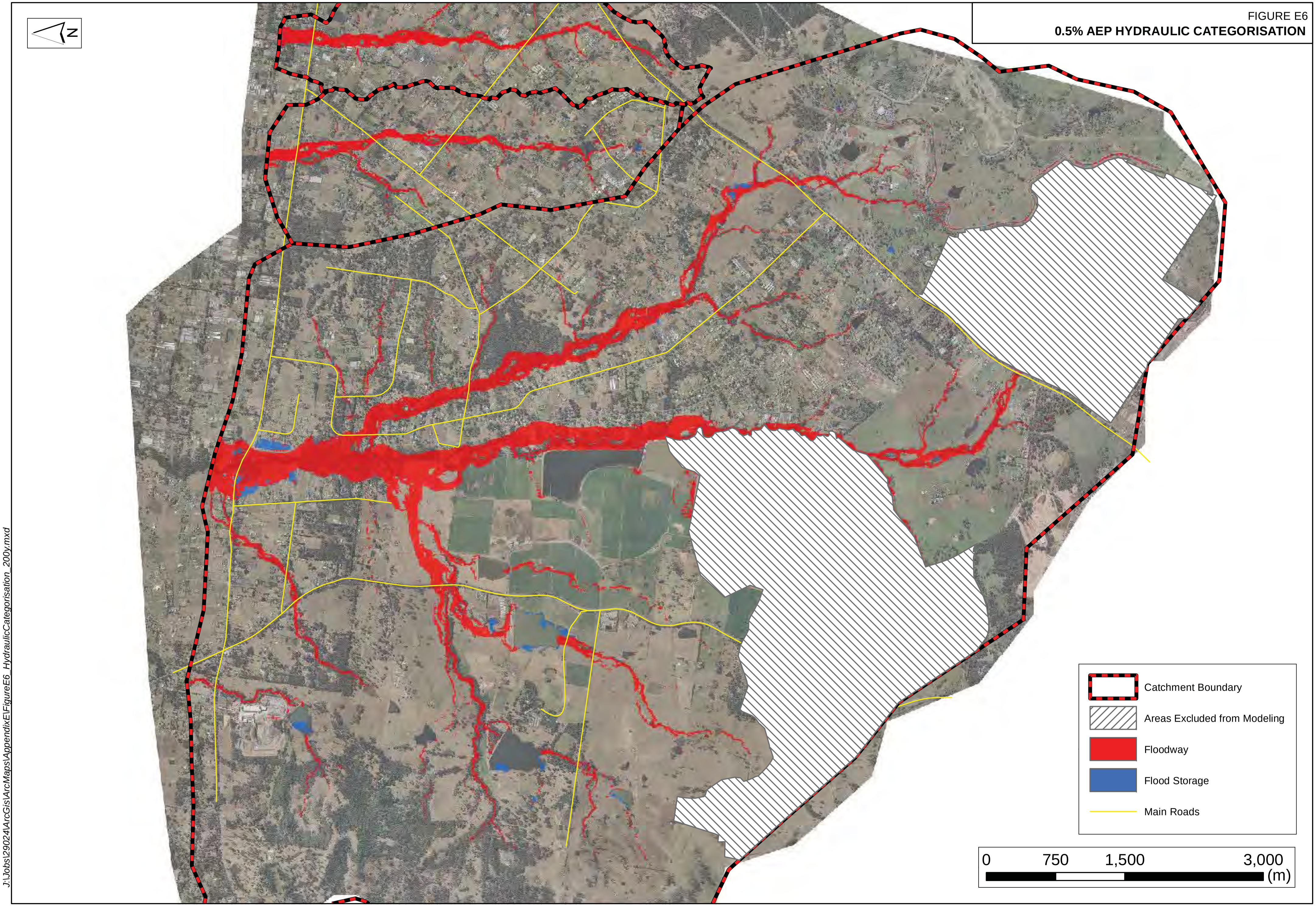

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FIGURE E7
0.2% AEP PROVISIONAL HAZARD

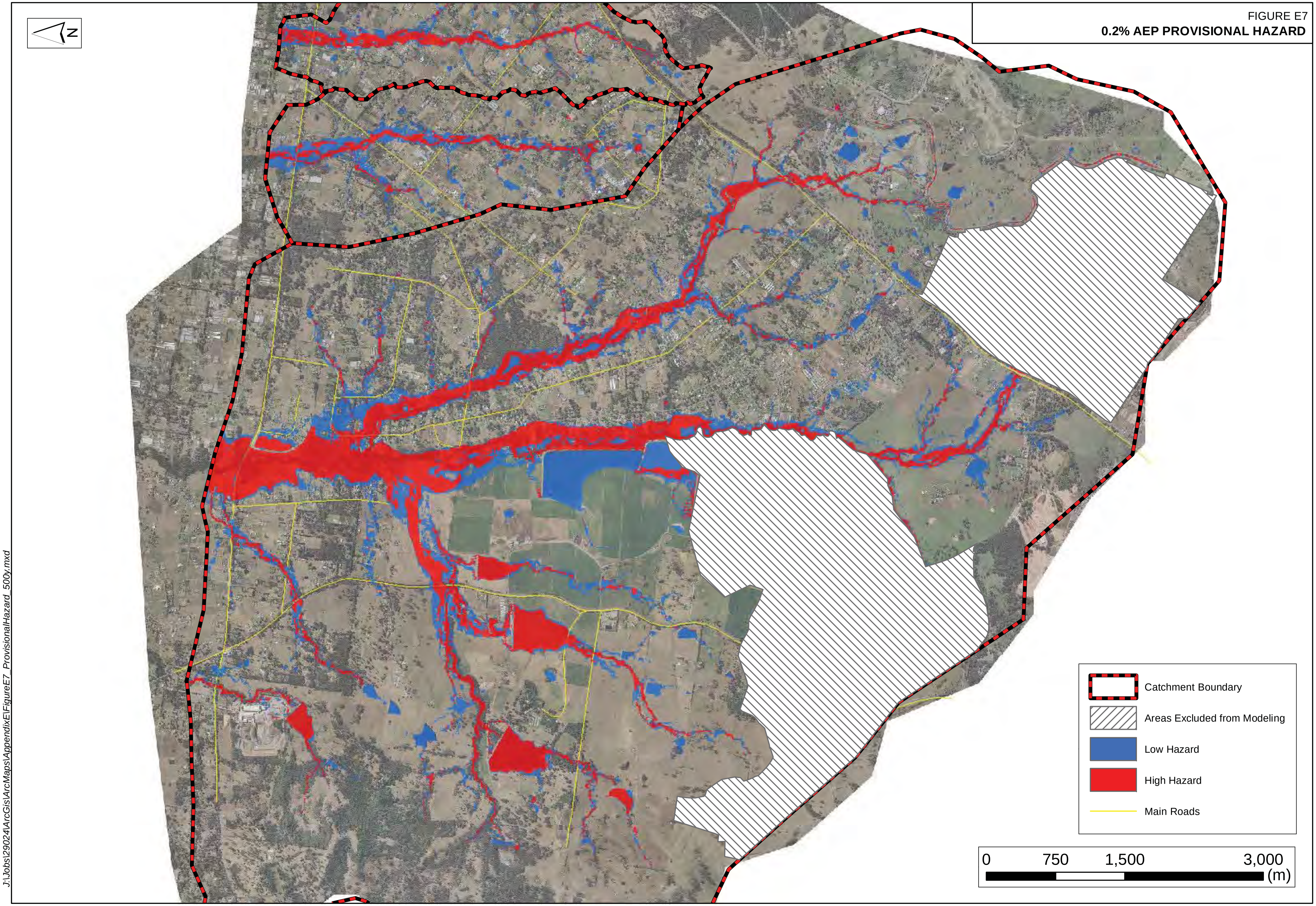

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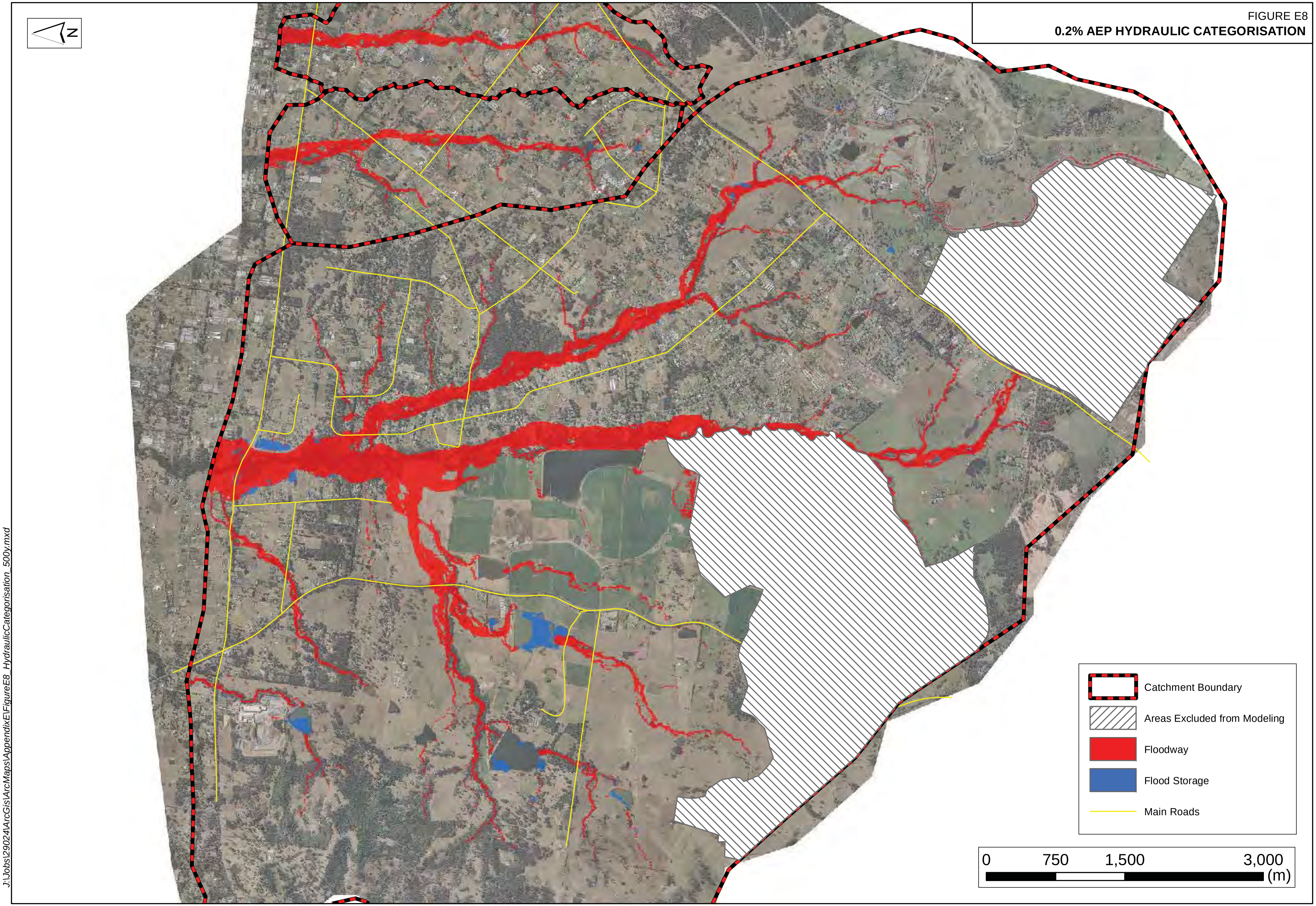
FIGURE E8

0.2% AEP HYDRAULIC CATEGORISATION



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