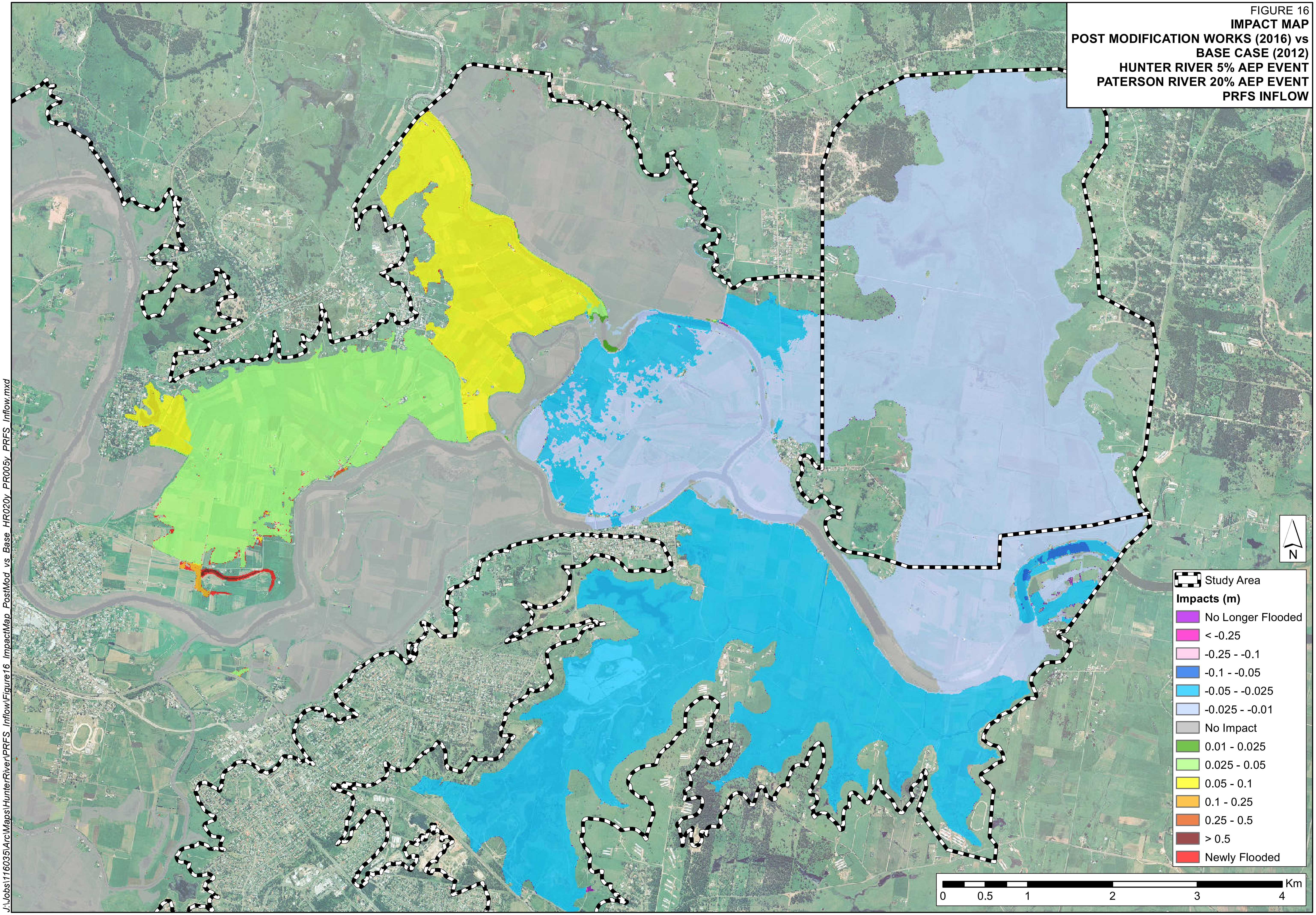

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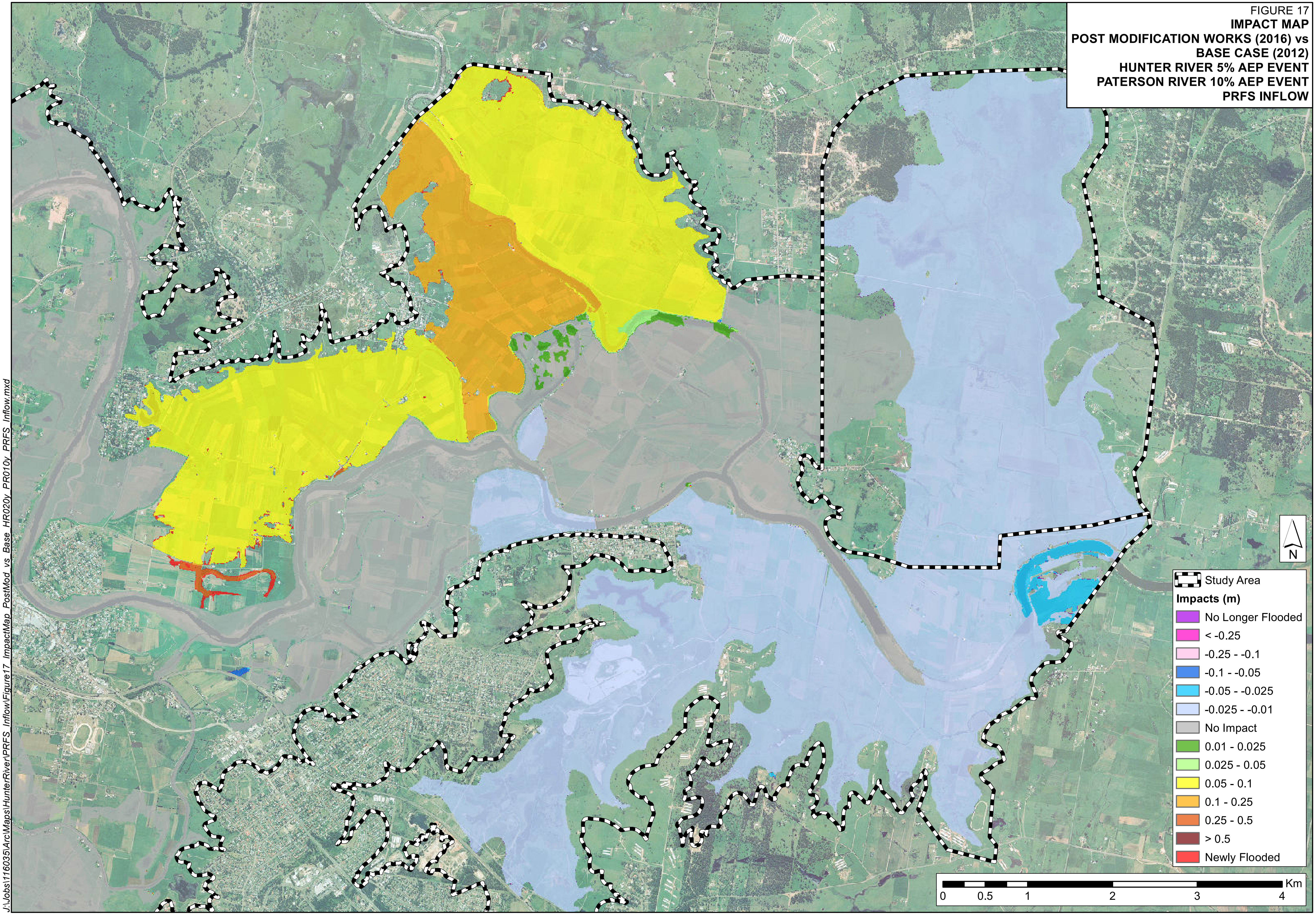

FIGURE 17
IMPACT MAP
POST MODIFICATION WORKS (2016) vs BASE CASE (2012)
HUNTER RIVER 5% AEP EVENT
PATERSON RIVER 10% AEP EVENT
PRFS INFLOW

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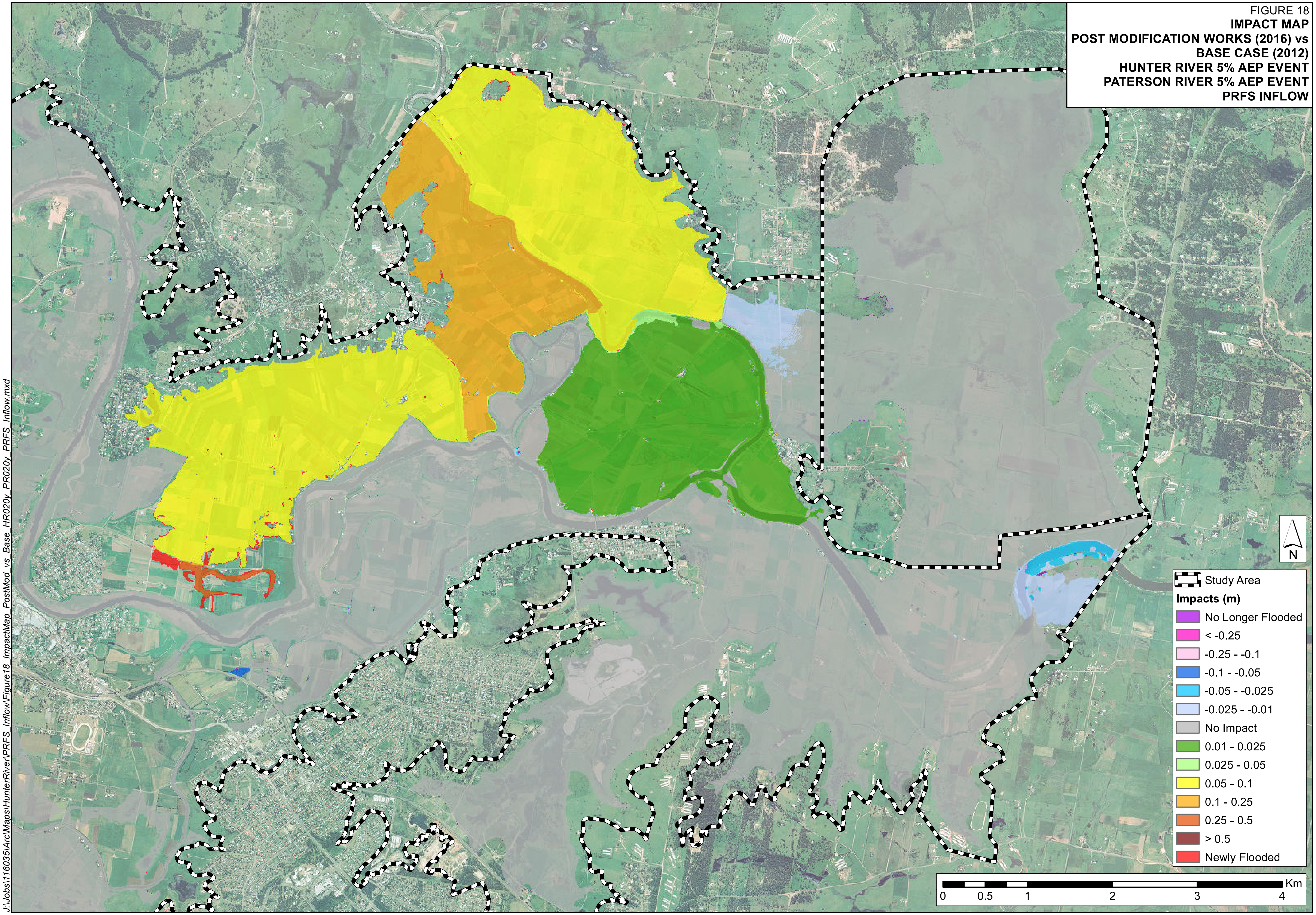

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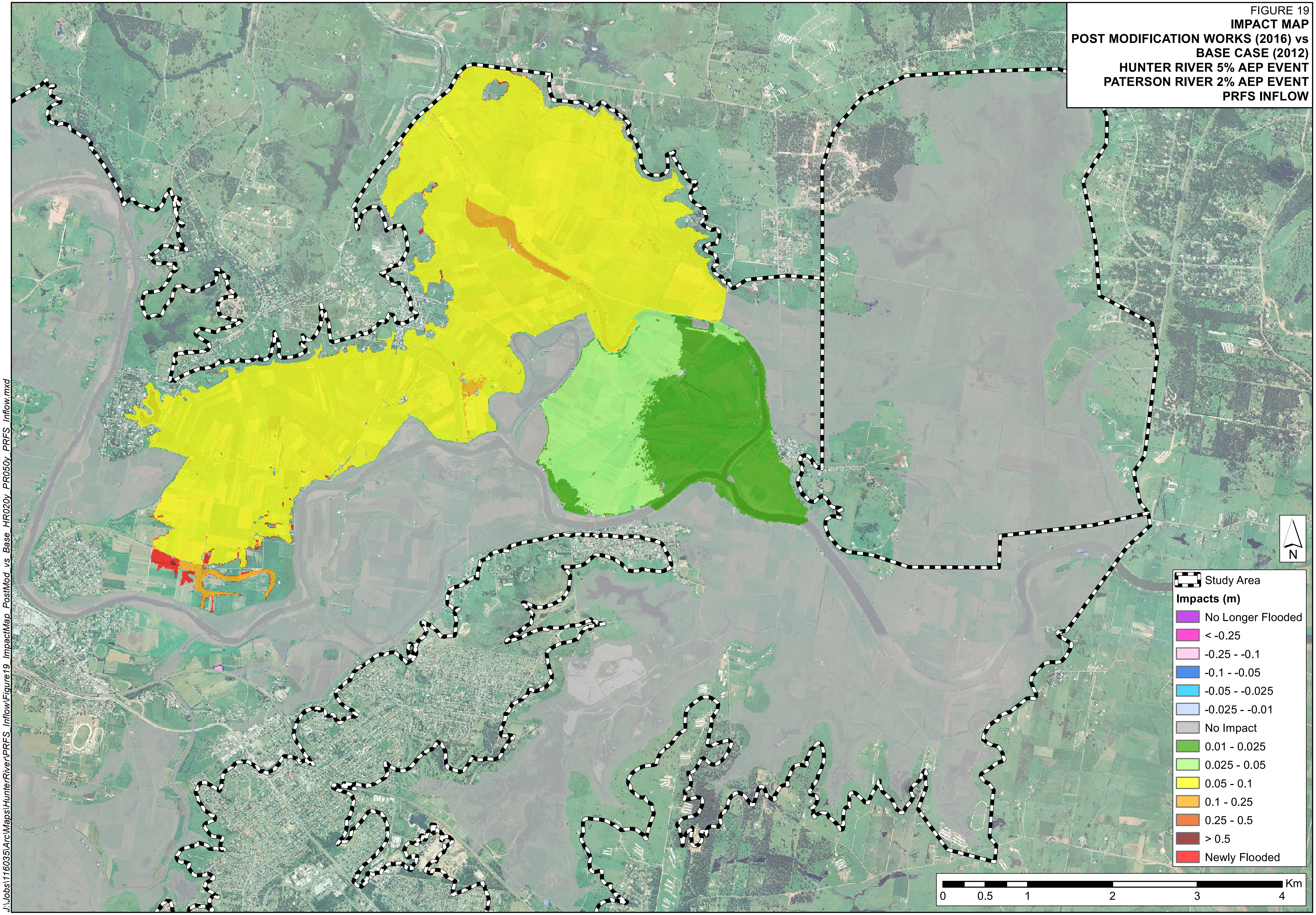

FIGURE 19
IMPACT MAP
POST MODIFICATION WORKS (2016) vs BASE CASE (2012)
HUNTER RIVER 5% AEP EVENT
PATERSON RIVER 2% AEP EVENT
PRFS INFLOW

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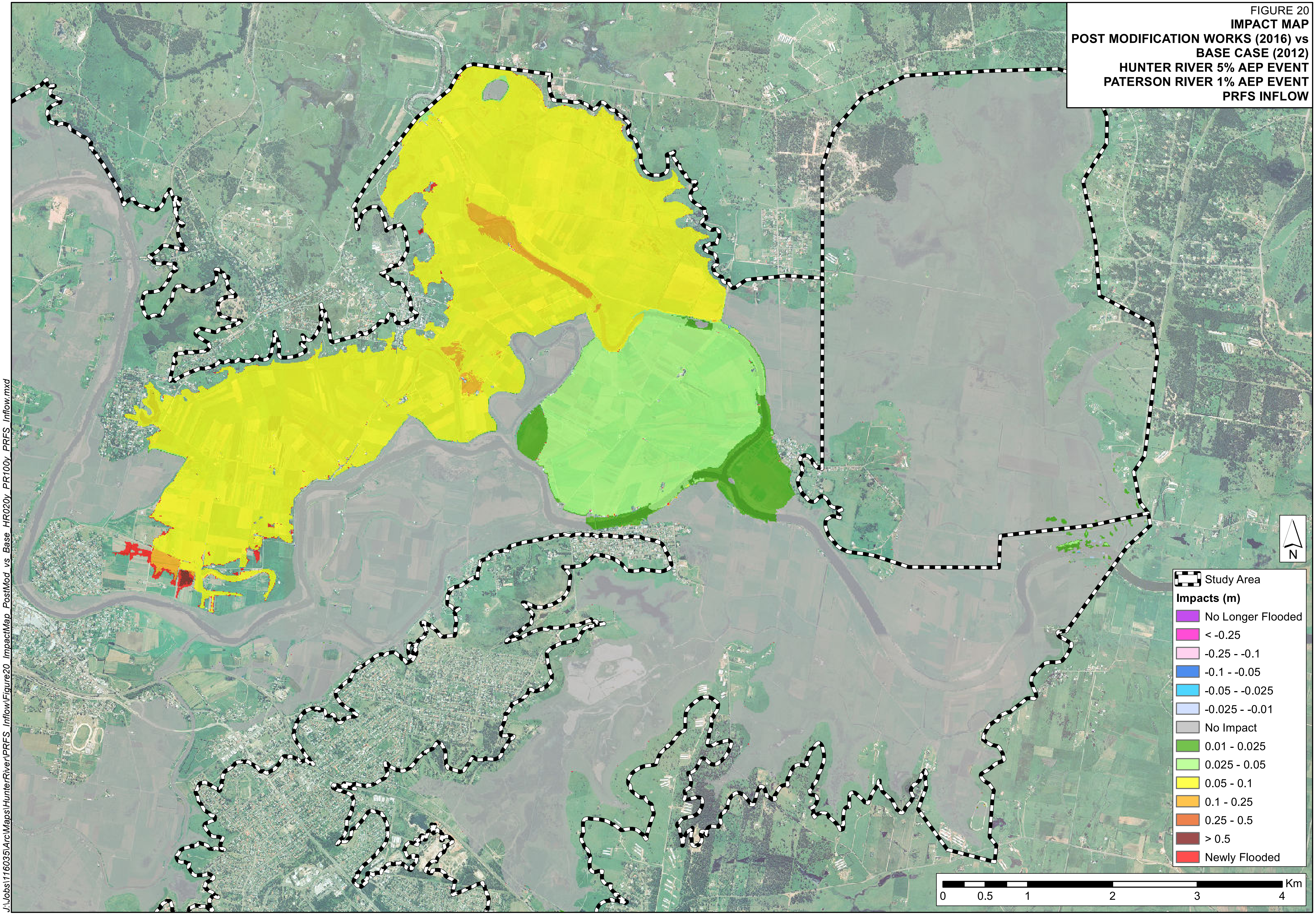

FIGURE 20
IMPACT MAP
POST MODIFICATION WORKS (2016) vs BASE CASE (2012)
HUNTER RIVER 5% AEP EVENT
PATERSON RIVER 1% AEP EVENT
PRFS INFLOW

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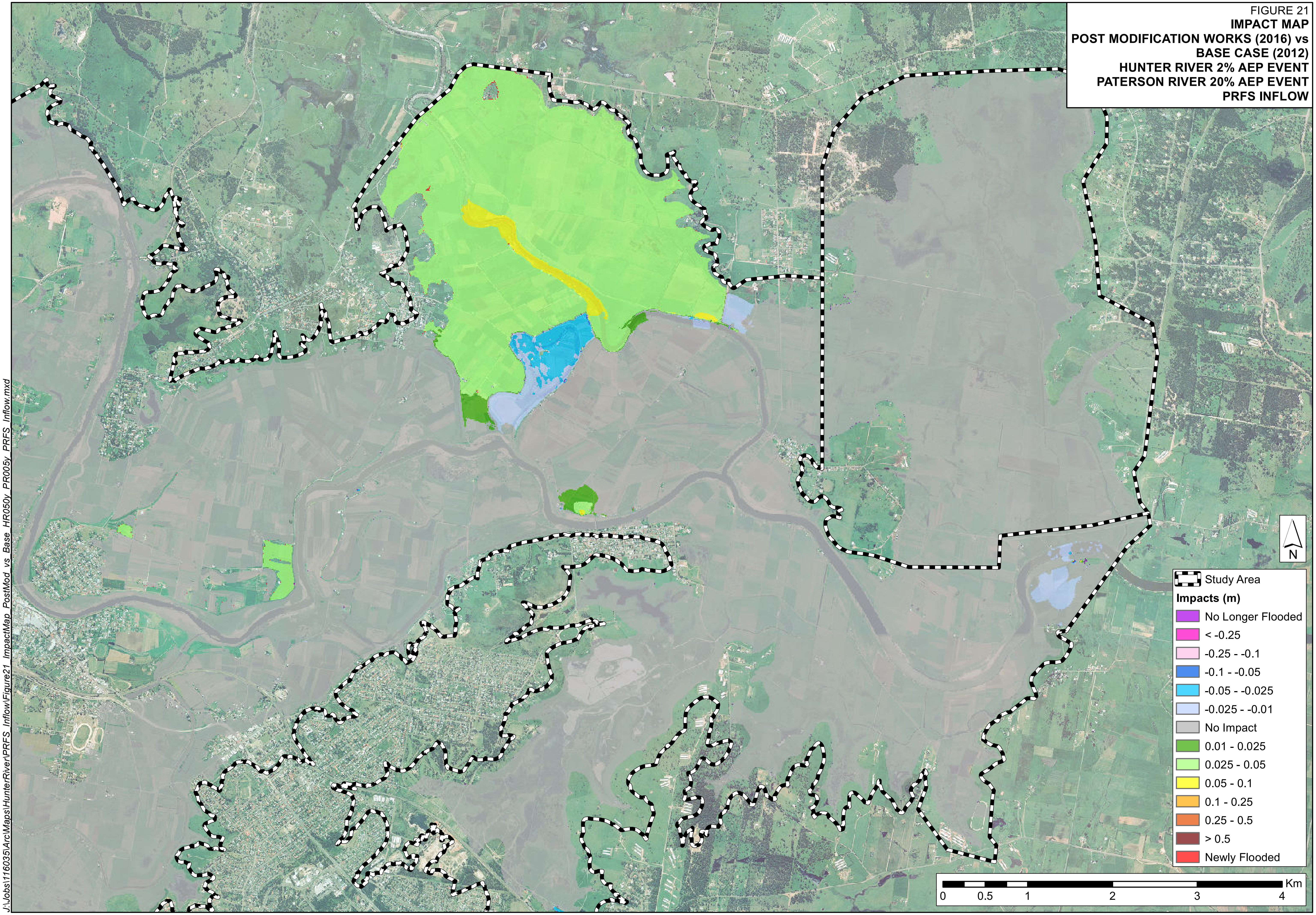

FIGURE 21
IMPACT MAP
POST MODIFICATION WORKS (2016) vs BASE CASE (2012)
HUNTER RIVER 2% AEP EVENT
PATERSON RIVER 20% AEP EVENT
PRFS INFLOW

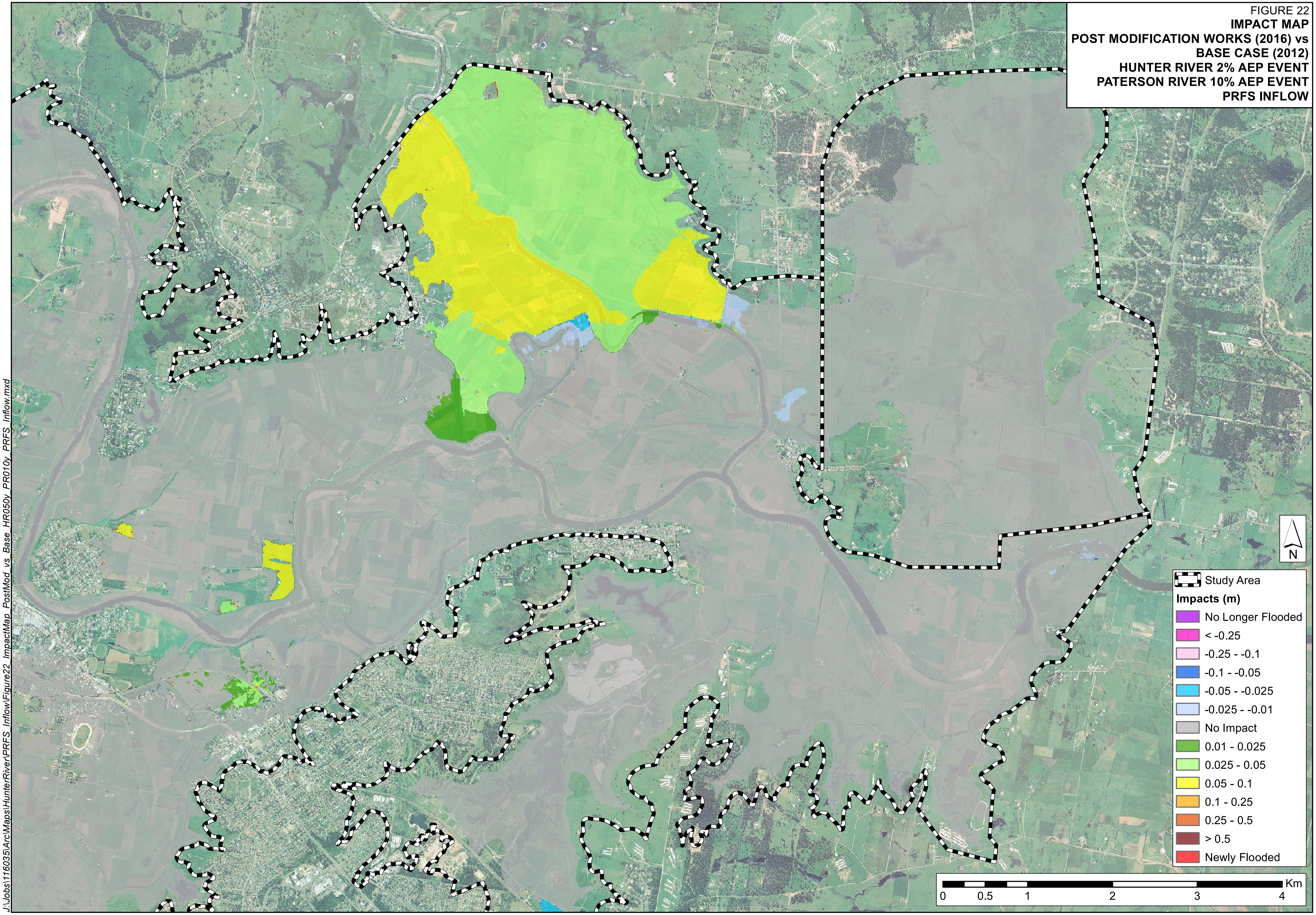
FIGURE 22
IMPACT MAP
POST MODIFICATION WORKS (2016) vs
BASE CASE (2012)
HUNTER RIVER 2% AEP EVENT
PATERSON RIVER 10% AEP EVENT
PRFS INFLOW
N
Study Area
Impacts (m)
No Longer Flooded
< -0.25
-0.25 - -0.1
-0.1 - -0.05
-0.05 - -0.025
-0.025 - -0.01
No Impact
0.01 - 0.025
0.025 - 0.05
0.05 - 0.1
0.1 - 0.25
0.25 - 0.5
> 0.5
Newly Flooded
0 0.5 1 2 3 4
Km
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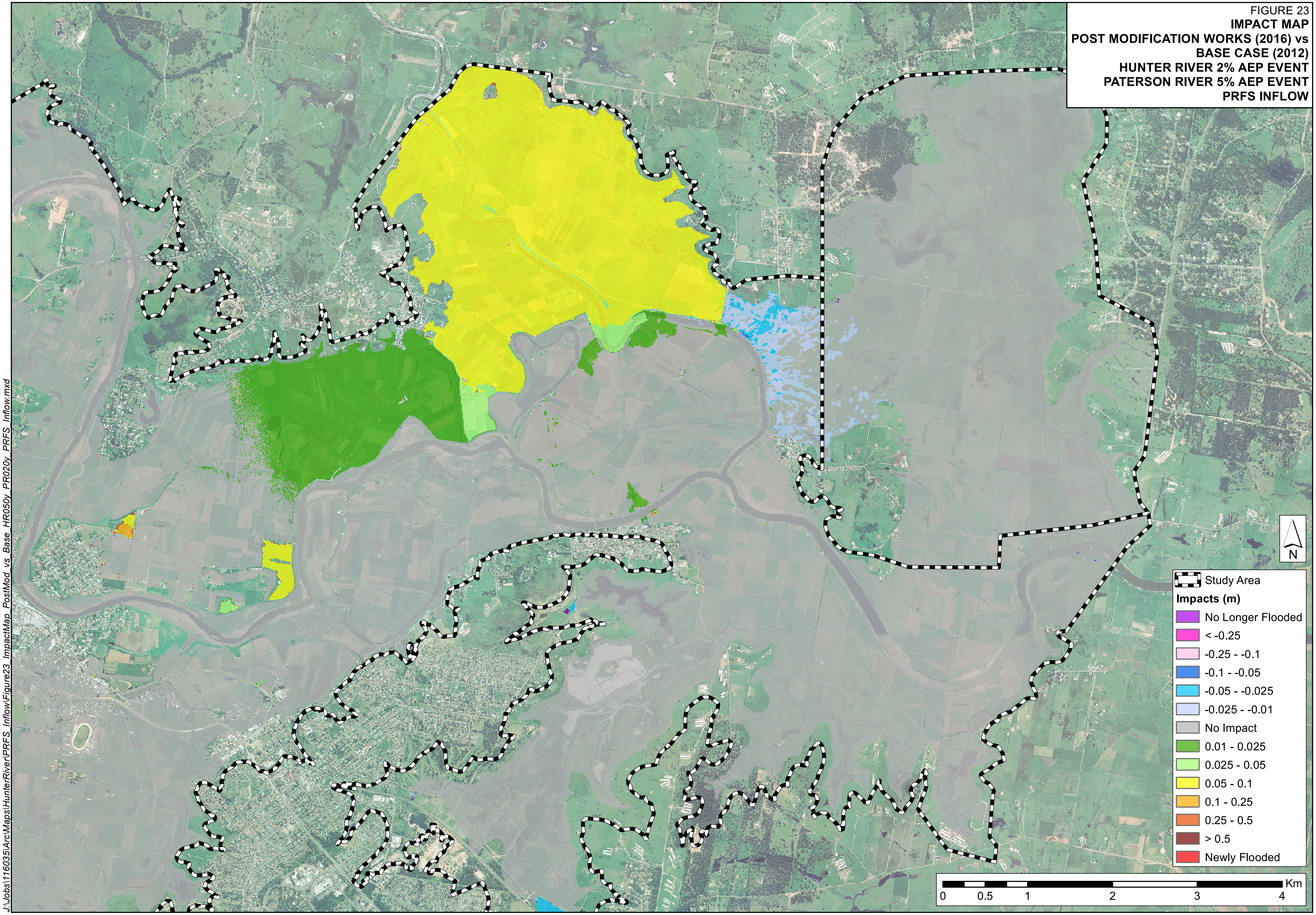

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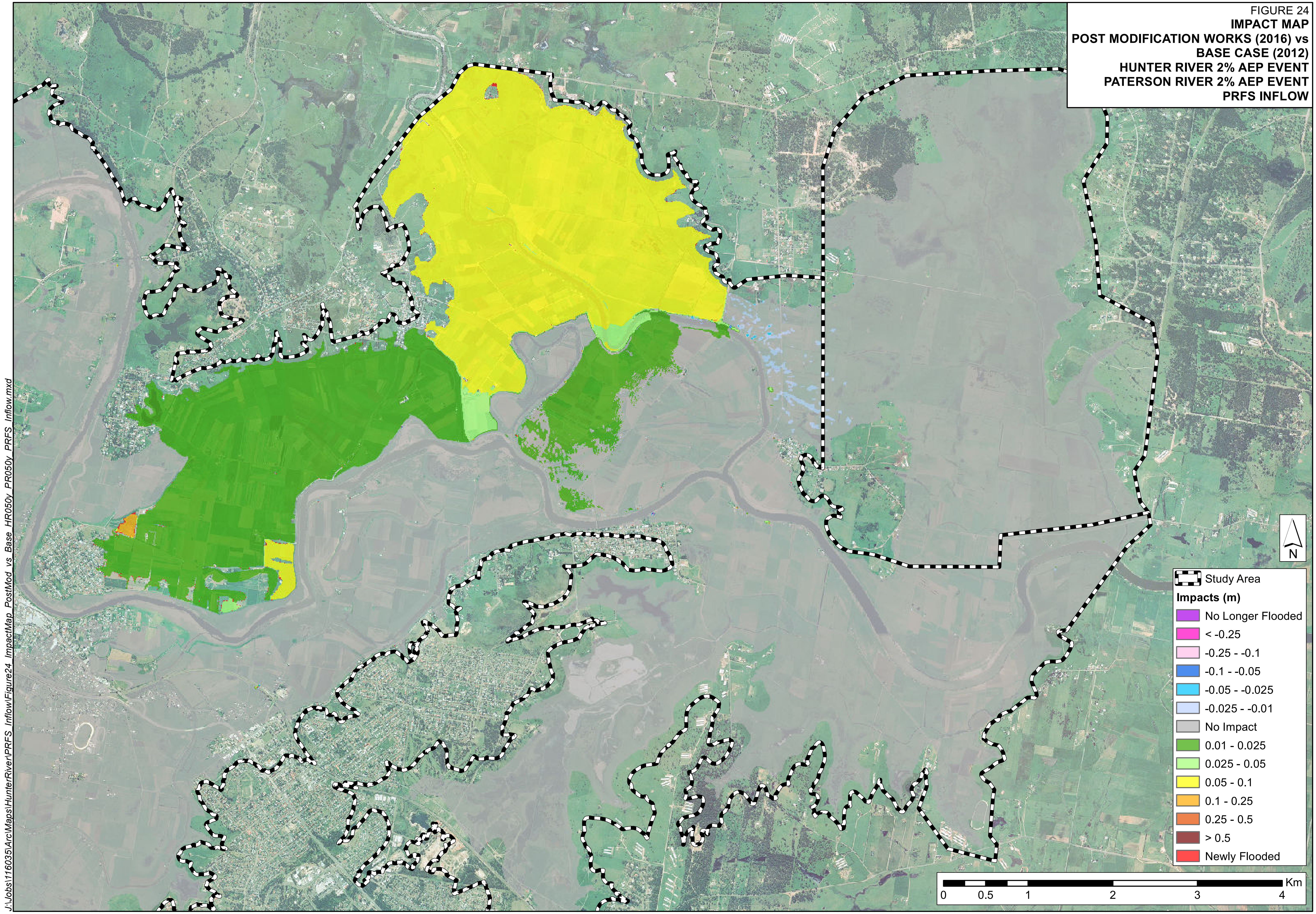
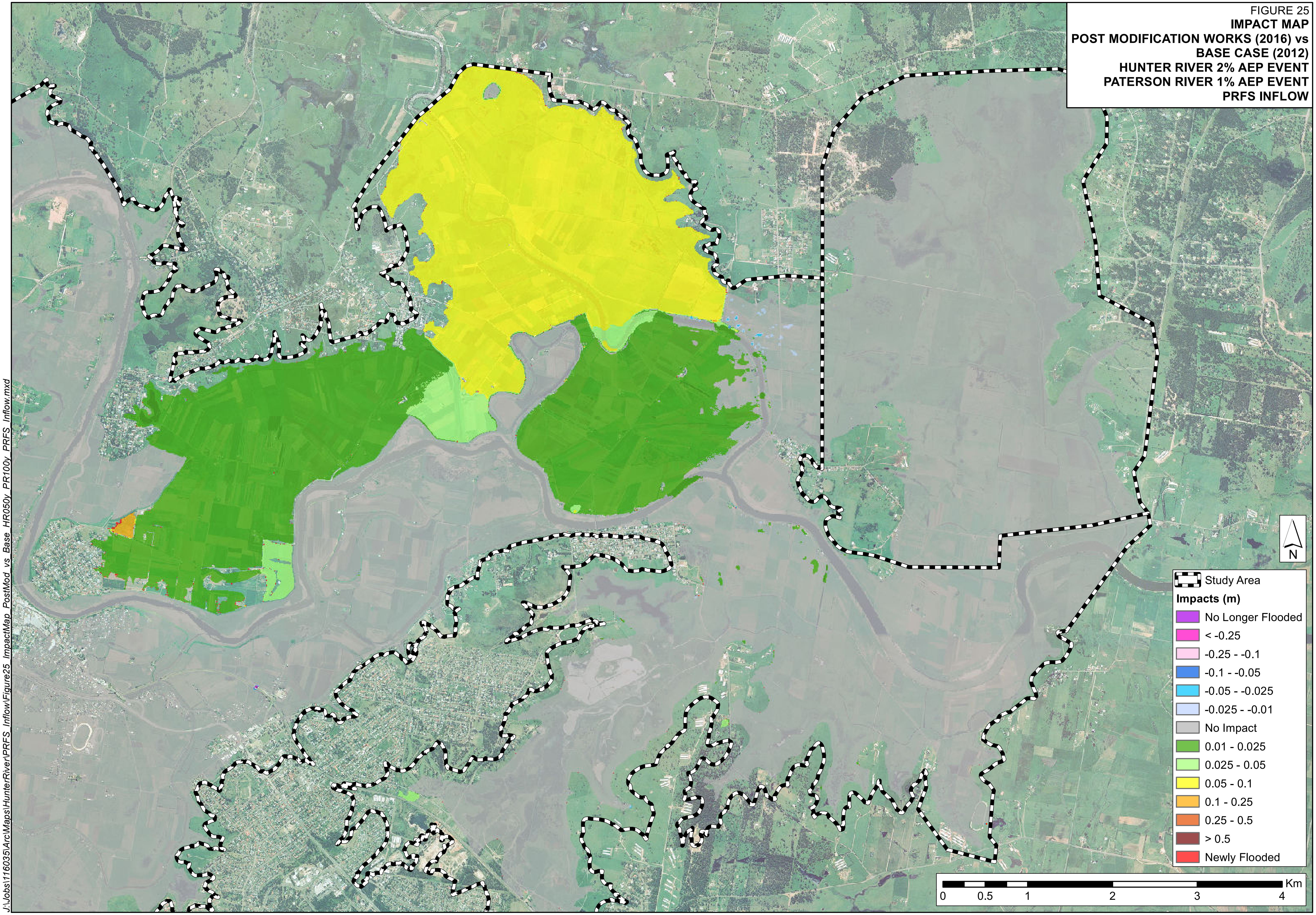


FIGURE 24
IMPACT MAP
POST MODIFICATION WORKS (2016) vs
BASE CASE (2012)
HUNTER RIVER 2% AEP EVENT
PATERSON RIVER 2% AEP EVENT
PRFS INFLOW
Study Area
Impacts (m)
No Longer Flooded
< -0.25
-0.25 - -0.1
-0.1 - -0.05
-0.05 - -0.025
-0.025 - -0.01
No Impact
0.01 - 0.025
0.025 - 0.05
0.05 - 0.1
0.1 - 0.25
0.25 - 0.5
> 0.5
Newly Flooded
N
0
0.5
1
2
3
4
Km
J:\Jobs\116035\ArcMaps\HunterRiver\PRFS_Inflow\Figure24_ImpactMap_PostMod_vs_Base_HR050y_PR050y_PRFS_Inflow.mxd

FIGURE 25
IMPACT MAP
POST MODIFICATION WORKS (2016) vs BASE CASE (2012)
HUNTER RIVER 2% AEP EVENT
PATERSON RIVER 1% AEP EVENT
PRFS INFLOW



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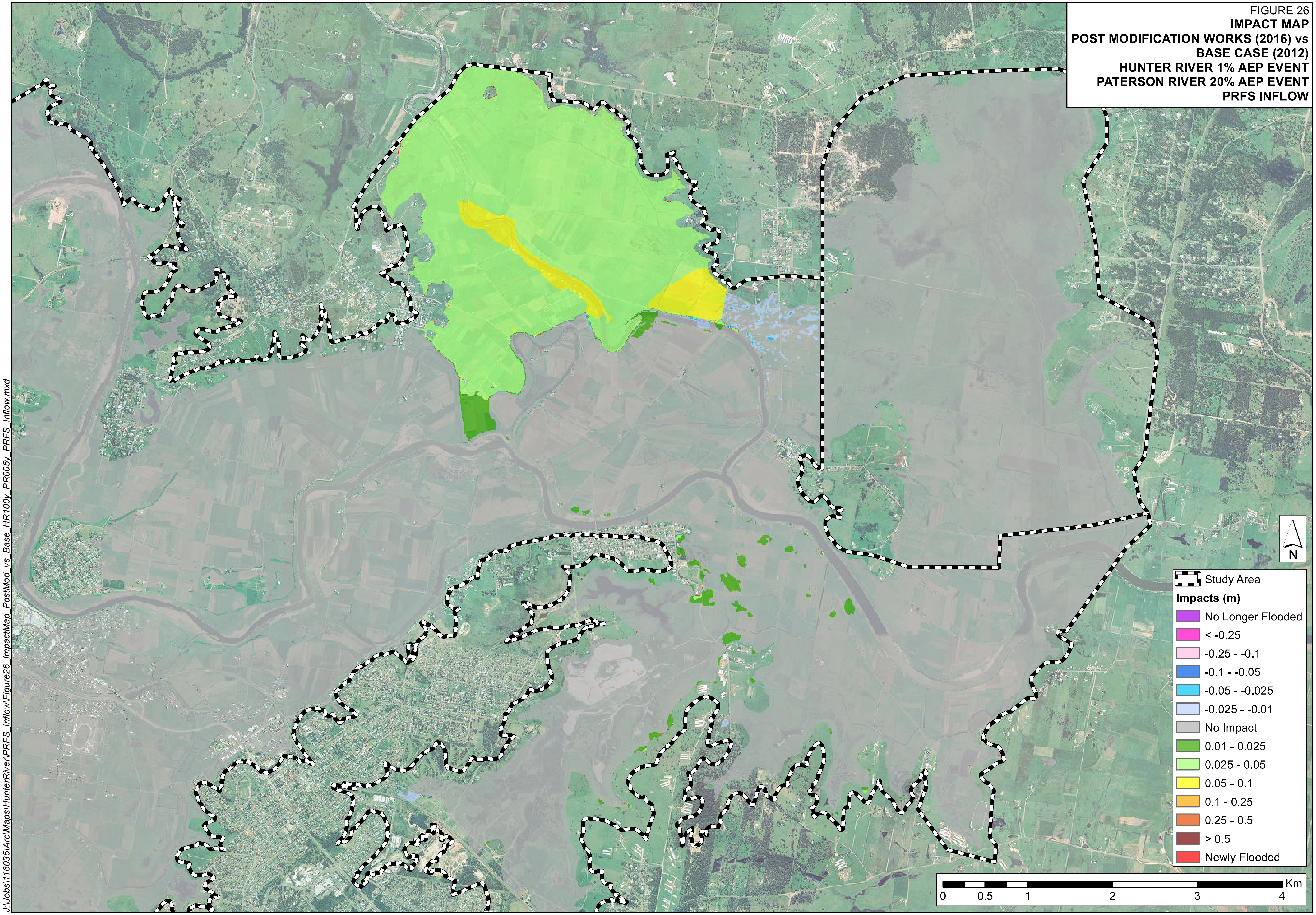
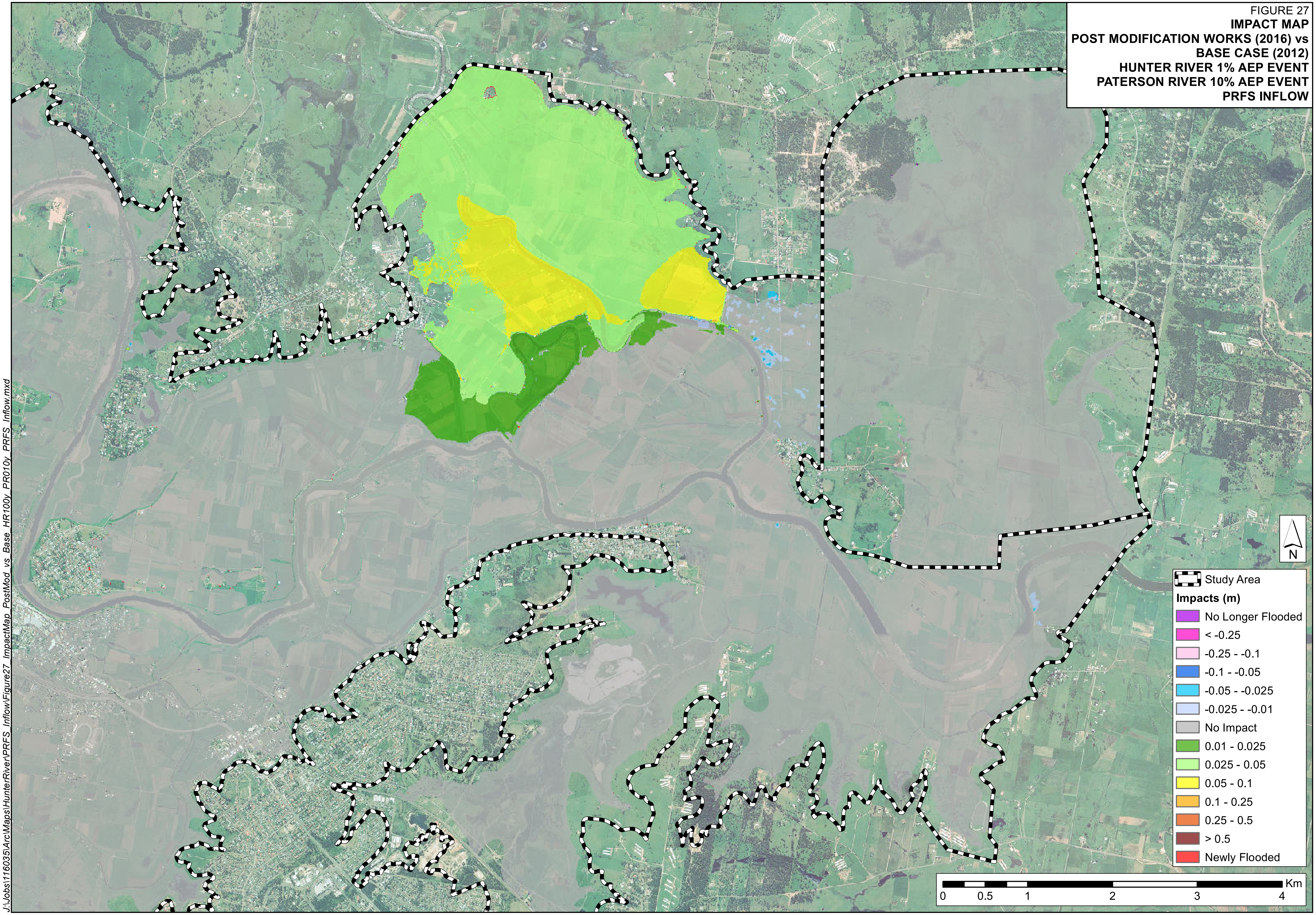


FIGURE 26
IMPACT MAP
POST MODIFICATION WORKS (2016) vs
BASE CASE (2012)
HUNTER RIVER 1% AEP EVENT
PATERSON RIVER 20% AEP EVENT
PRFS INFLOW
N
Study Area
Impacts (m)
No Longer Flooded
< -0.25
-0.25 - -0.1
-0.1 - -0.05
-0.05 - -0.025
-0.025 - -0.01
No Impact
0.01 - 0.025
0.025 - 0.05
0.05 - 0.1
0.1 - 0.25
0.25 - 0.5
> 0.5
Newly Flooded
0
0.5
1
2
3
4
Km



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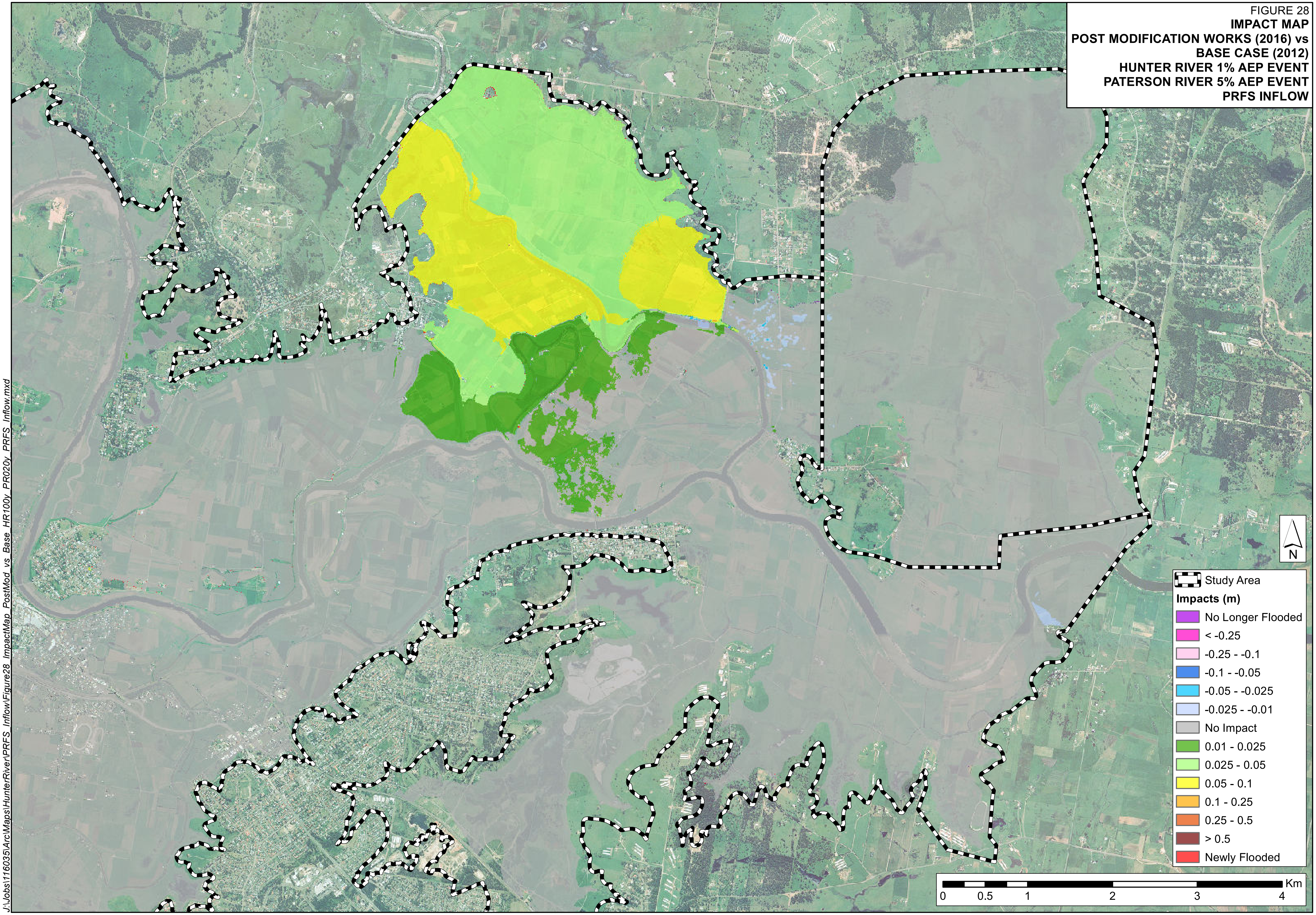

FIGURE 28
IMPACT MAP
POST MODIFICATION WORKS (2016) vs BASE CASE (2012)
HUNTER RIVER 1% AEP EVENT
PATERSON RIVER 5% AEP EVENT
PRFS INFLOW

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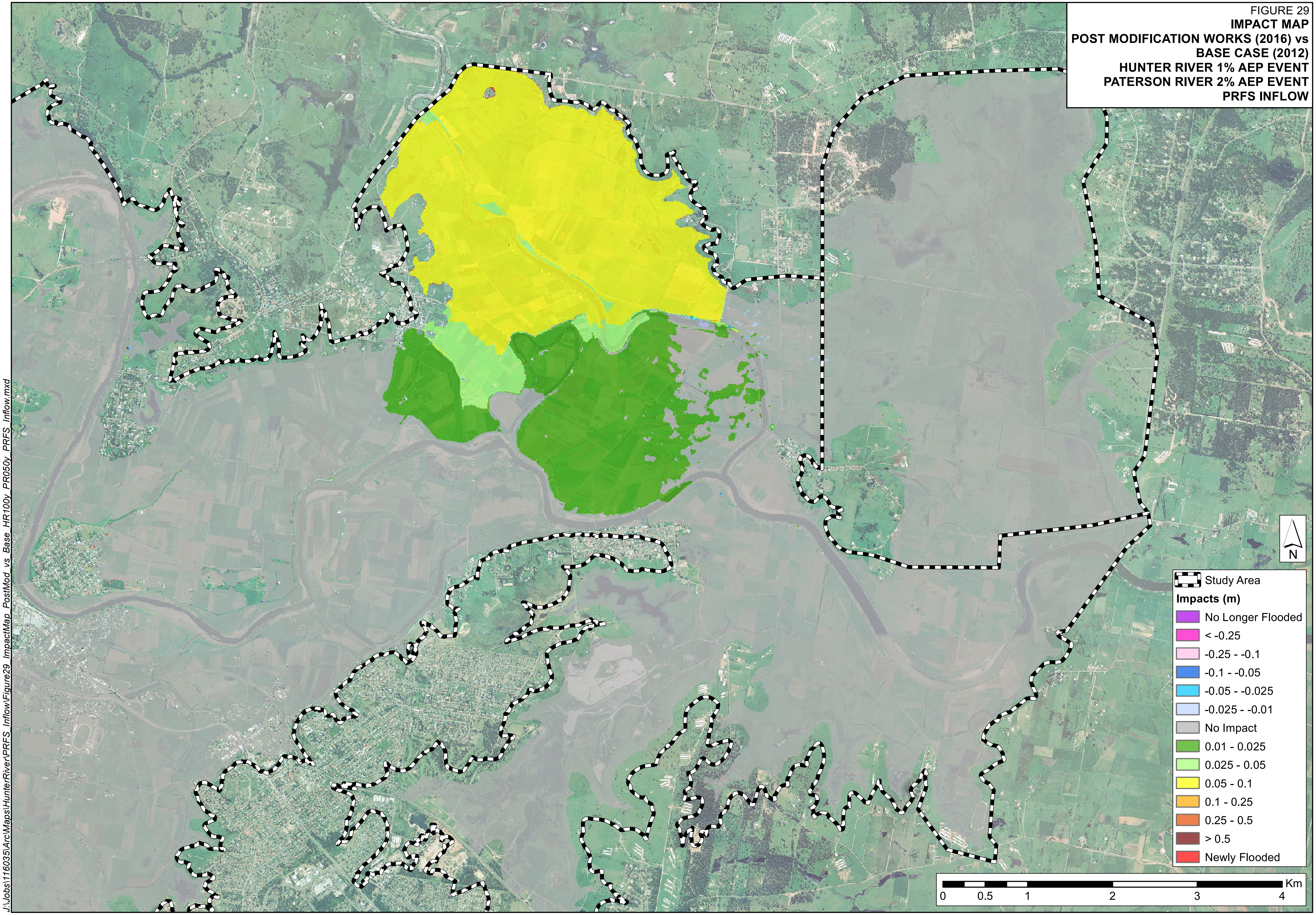

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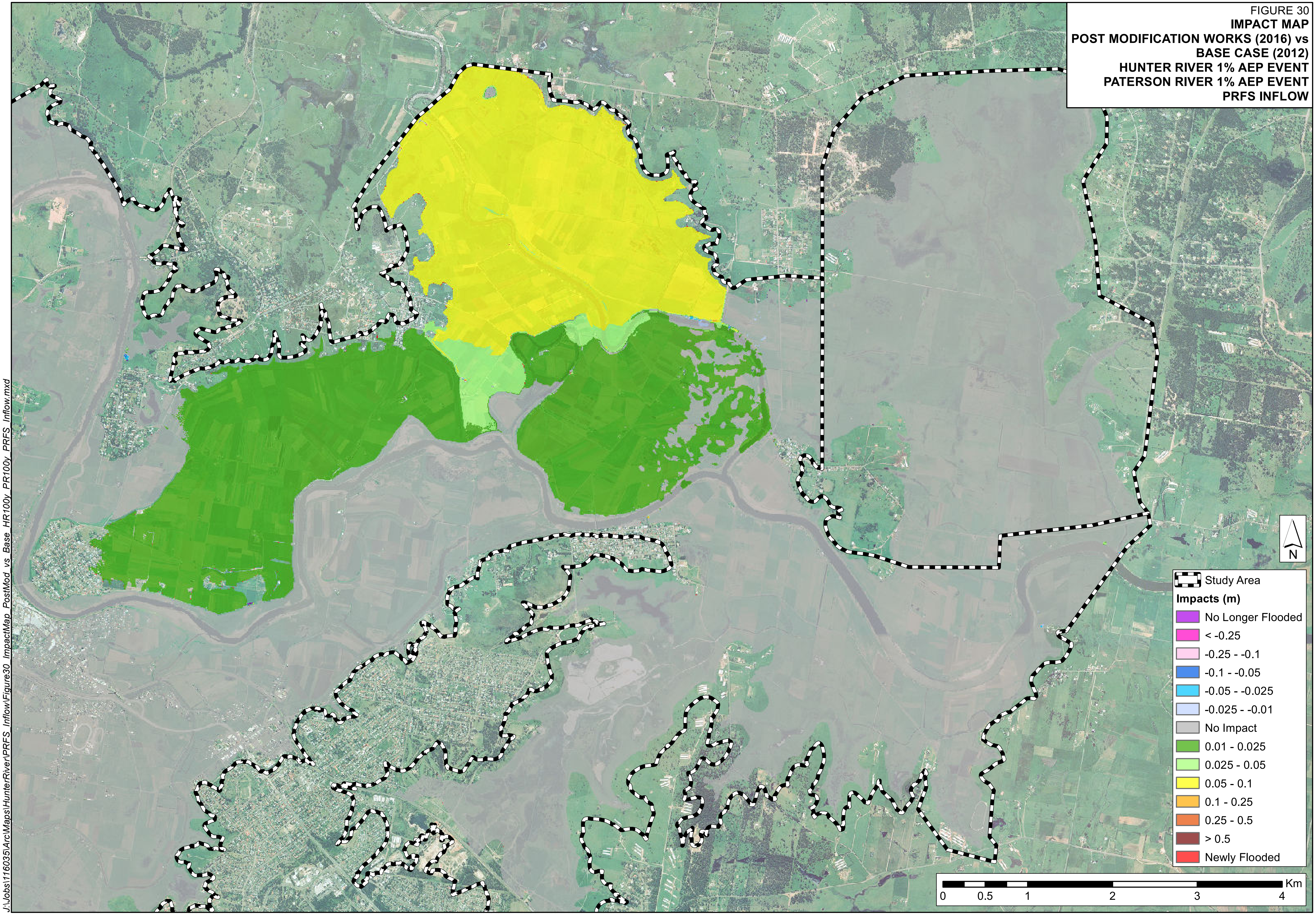

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FIGURE 31
PATERSON RIVER LEVEE PROFILE
EASTERN LEVEE
PATERSON RIVER FLOOD STUDY DESIGN EVENTS

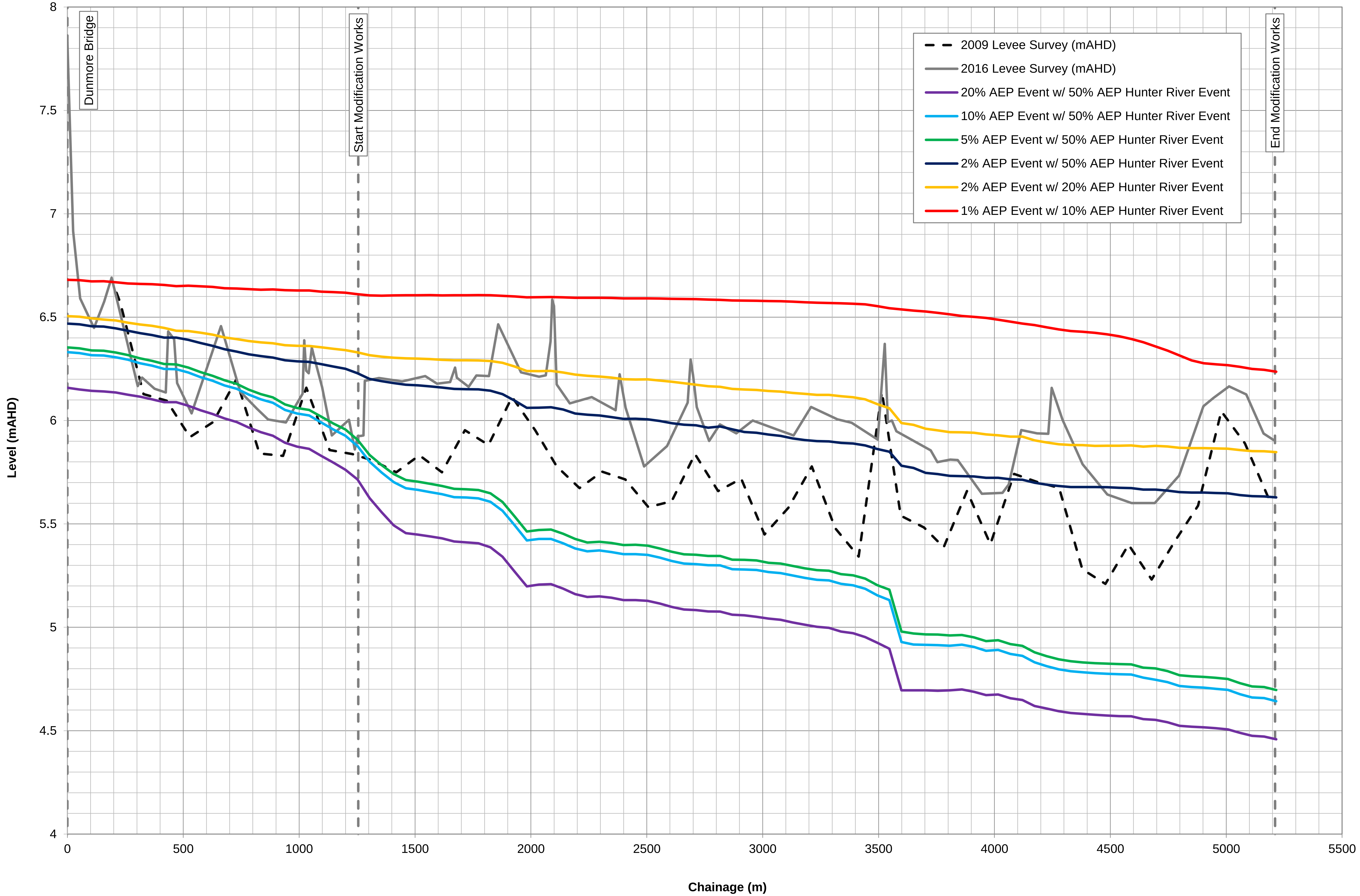


FIGURE 32
PATERSON RIVER LEVEE PROFILE
WESTERN LEVEE
PATERSON RIVER FLOOD STUDY DESIGN EVENTS

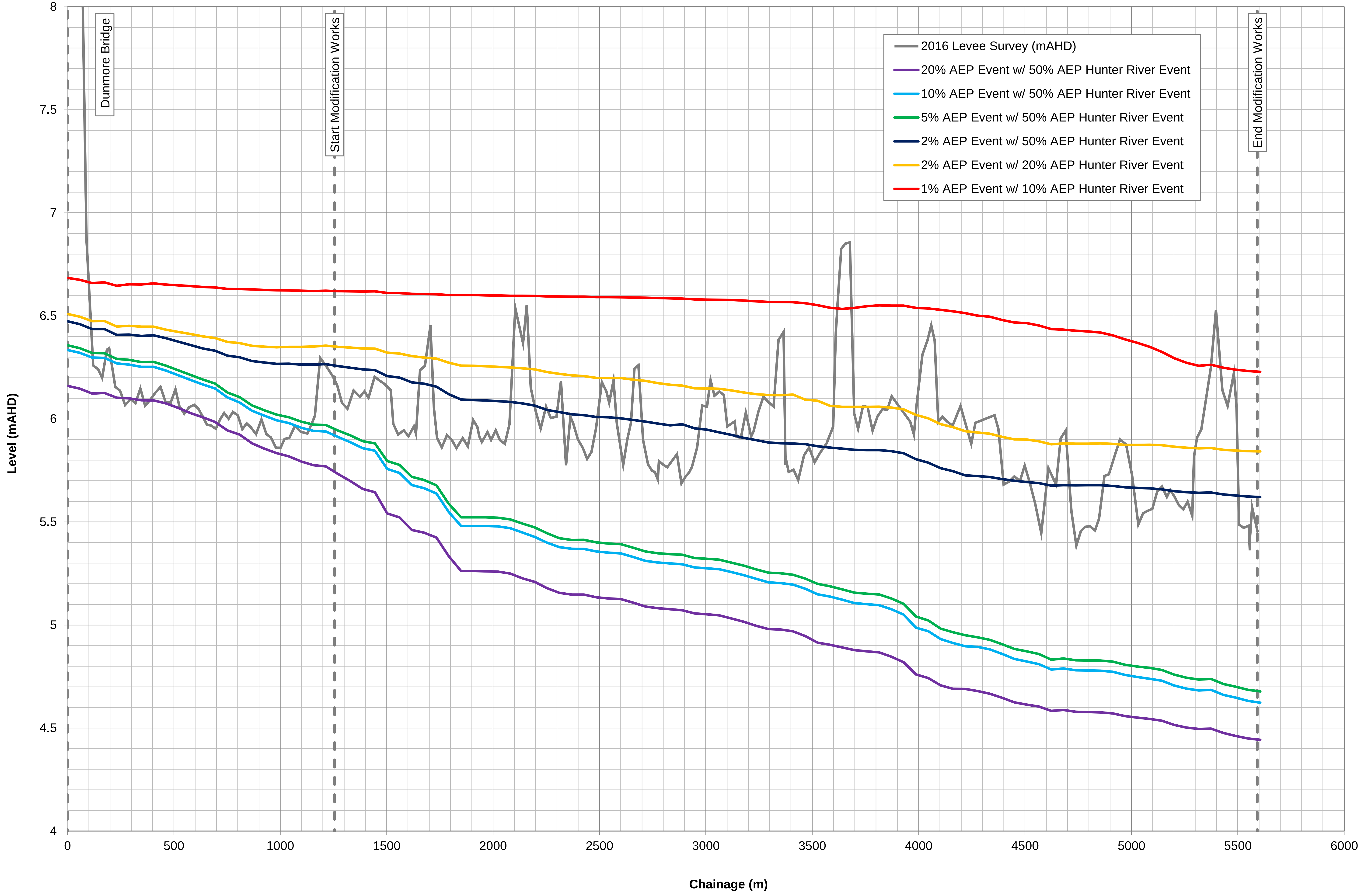


FIGURE 33
PATERSON RIVER LEVEE PROFILE
EASTERN LEVEE
PATERSON RIVER FLOOD STUDY MODELLED HISTORICAL EVENTS

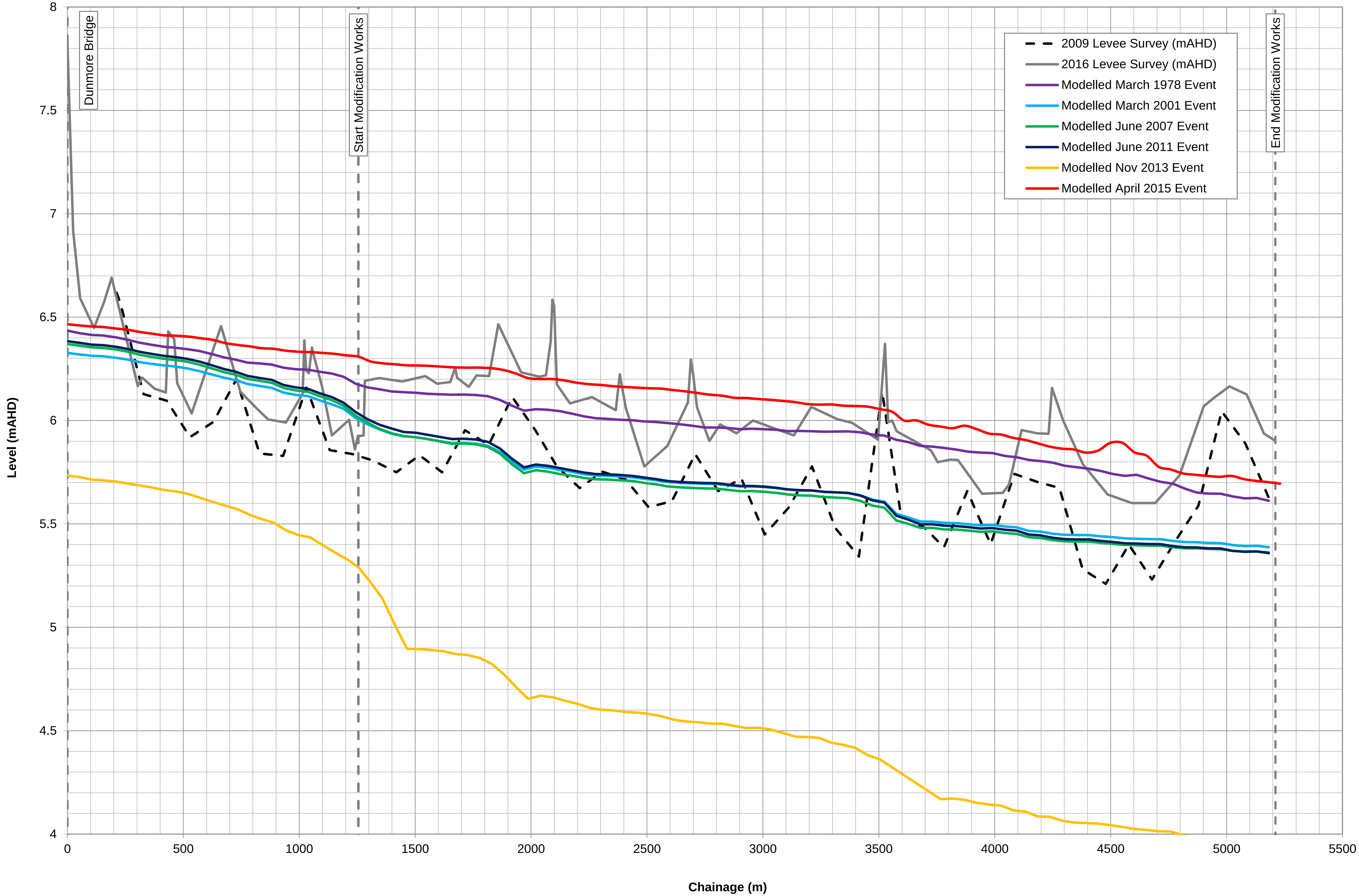


FIGURE 34
PATERSON RIVER LEVEE PROFILE
WESTERN LEVEE
PATERSON RIVER FLOOD STUDY MODELLED HISTORICAL EVENTS

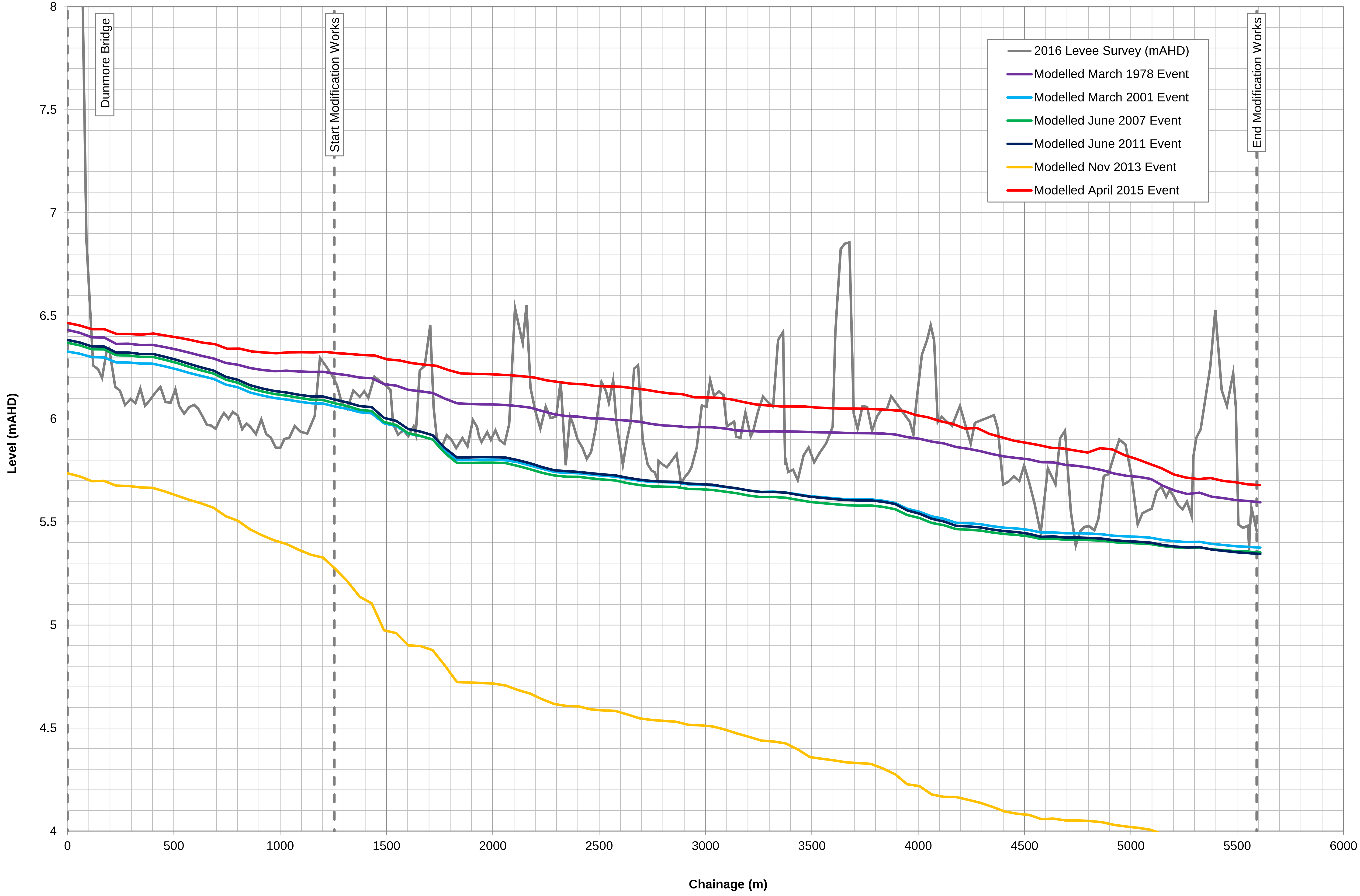


FIGURE 35
PATERSON RIVER LEVEE PROFILE
EASTERN LEVEE
HUNTER RIVER FLOOD STUDY DESIGN EVENTS

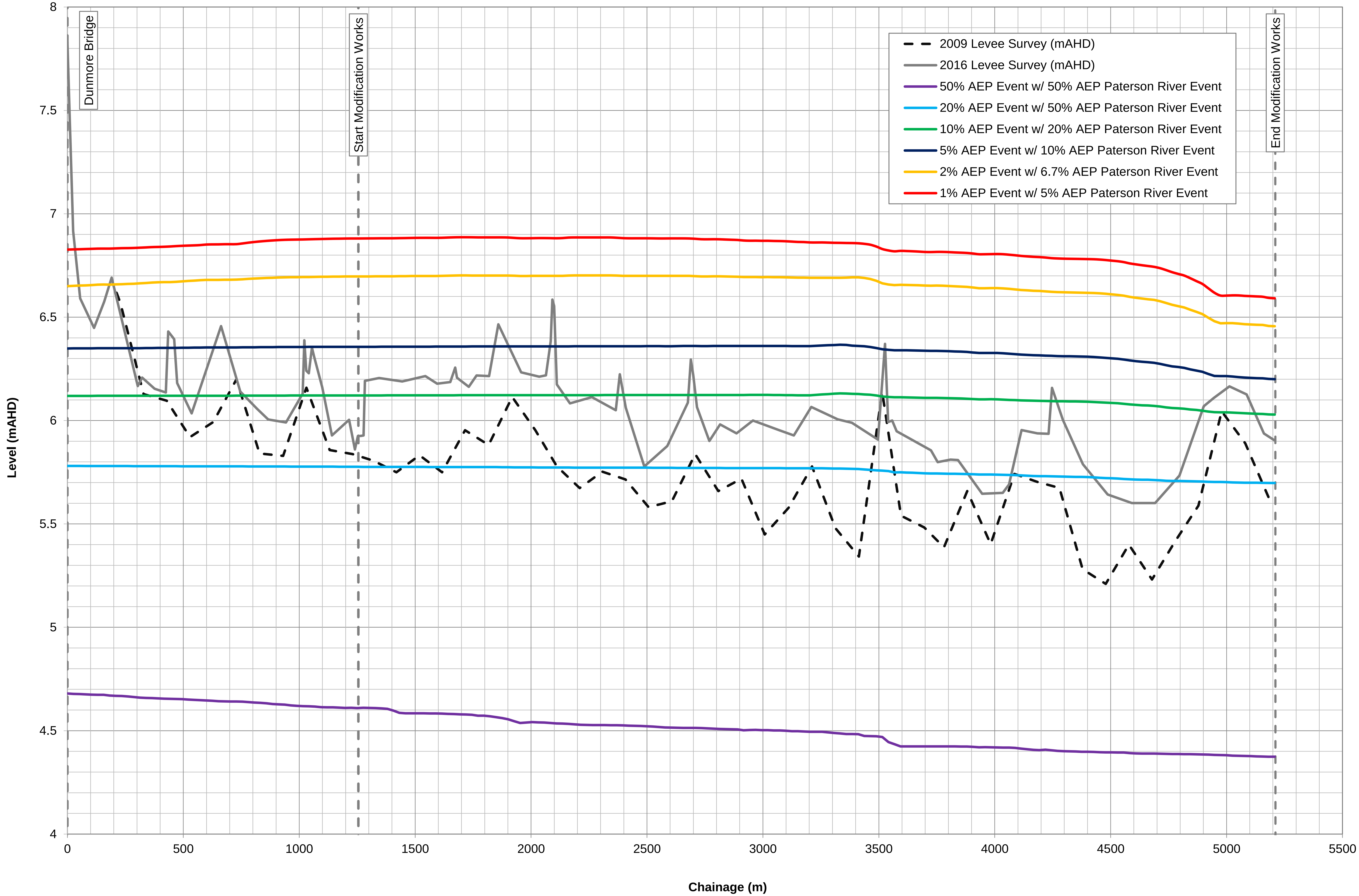


FIGURE 36
PATERSON RIVER LEVEE PROFILE
WESTERN LEVEE
HUNTER RIVER FLOOD STUDY DESIGN EVENTS

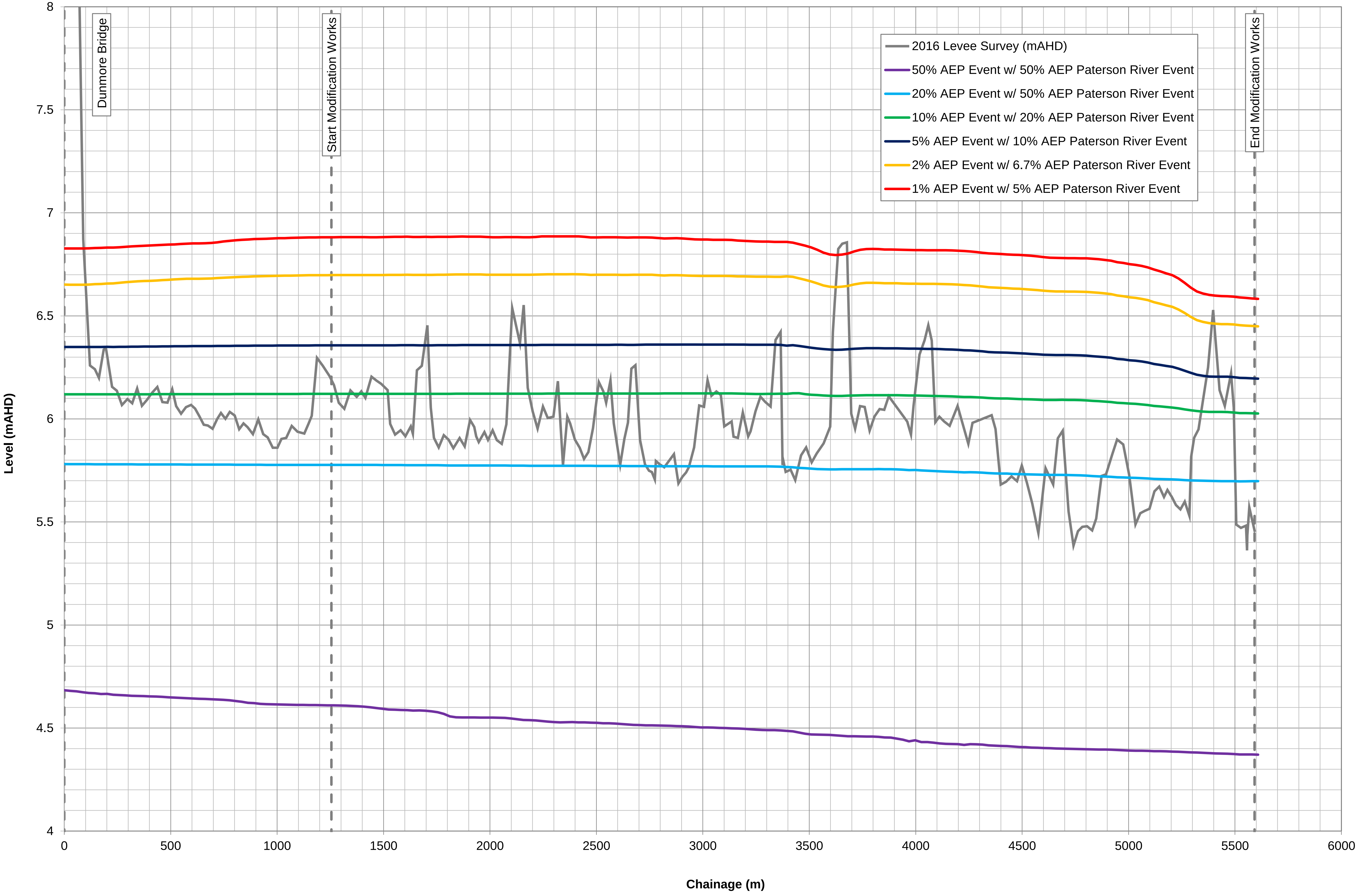


FIGURE 37
PATERSON RIVER LEVEE PROFILE
EASTERN LEVEE
HUNTER RIVER FLOOD STUDY MODELLED HISTORICAL EVENTS

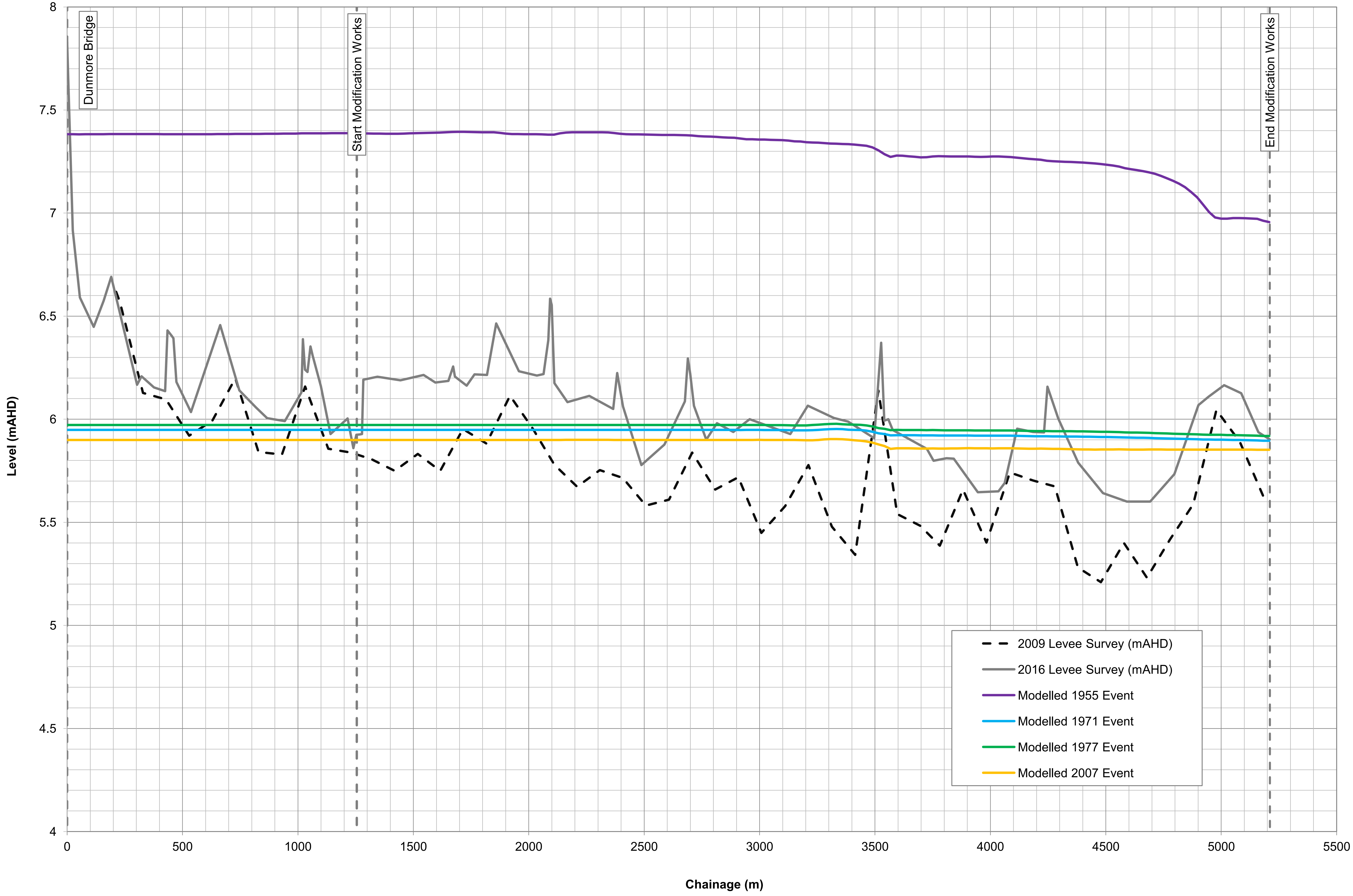
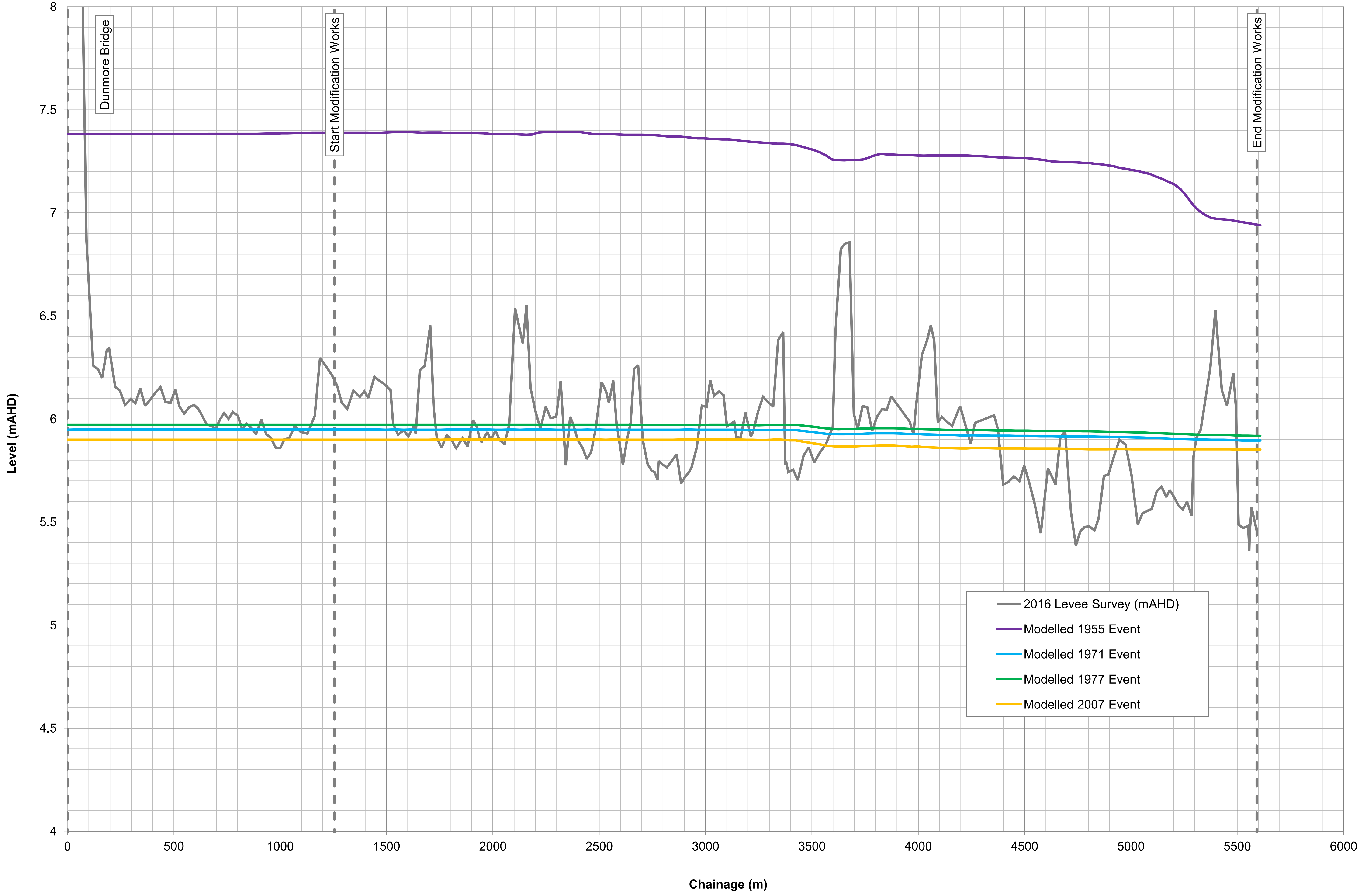


FIGURE 38
PATERSON RIVER LEVEE PROFILE
WESTERN LEVEE
HUNTER RIVER FLOOD TUDY MODELLED HISTORICAL EVENTS



Appendix A

APPENDIX A. GLOSSARY

FLOOD RISK TERMINOLOGY

Australian Rainfall and Runoff (ARR, editors Ball et al, 2016) recommends terminology that is not misleading to the public and stakeholders. Therefore the use of terms such as "recurrence interval" and "return period" are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

ARR 2016 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table above describes how they are subtly different.

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore an AEP is not assigned to the PMF>

This report has adopted the approach recommended by ARR and uses % AEP for all events rarer than the 50 % AEP and EY for all events more frequent than this.

Terms 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.
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.
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.
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.

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).
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.
early overtops	These are sections of levees that are intended to take initial overtopping flows. Consequently at the time of overtopping there is little to no tail water. To protect against scour, EOT have moderate land-side batters are typically in the order of 1 in 5 to 1 in 10, depending on the height of the levee.
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.
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

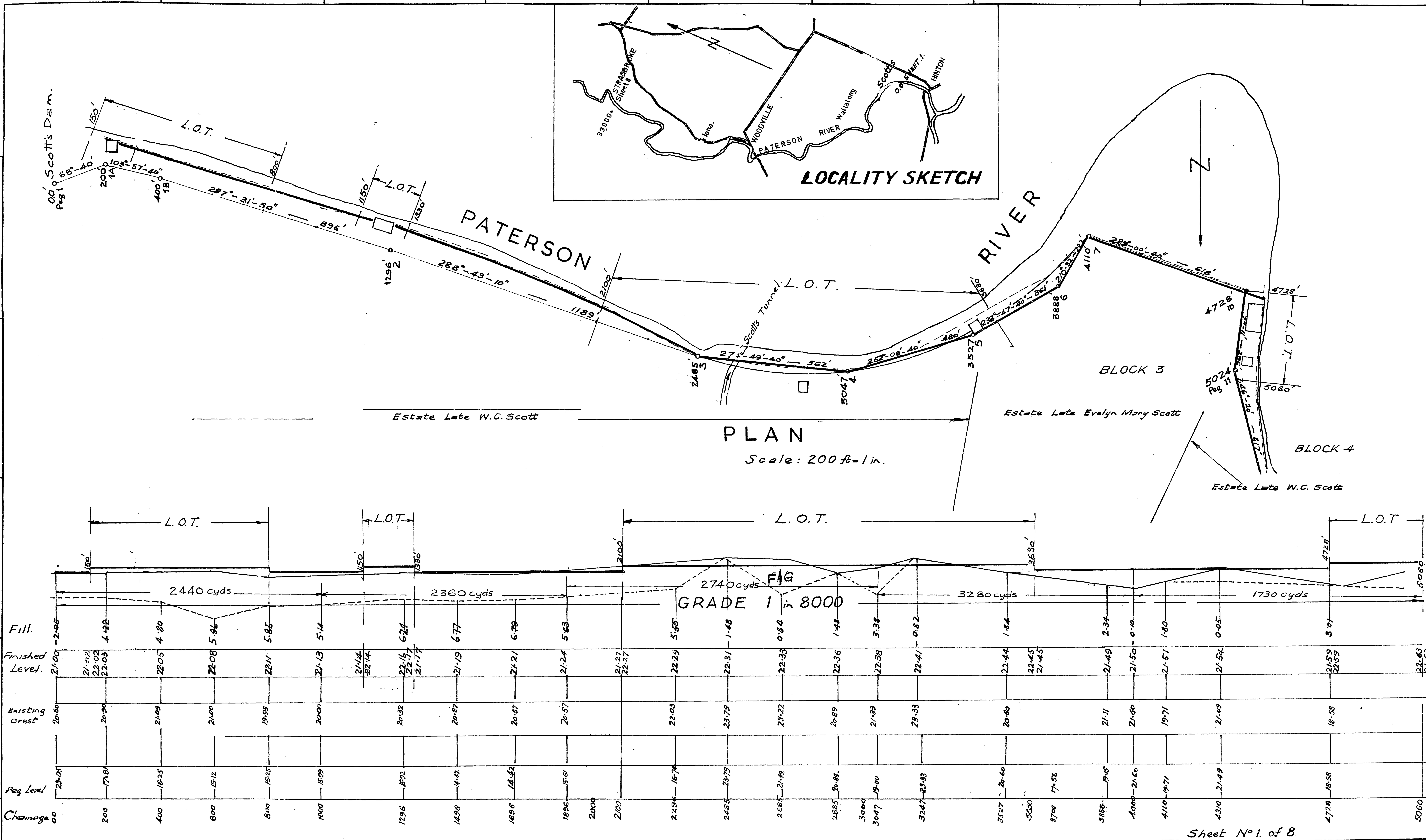
	of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a 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.
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.
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.
late overtops	These are sections of levees that are typically 300mm higher than EOT. They are intended to provide additional protection to infrastructure such as floodgates and farm sheds. LOT were designed so that there was significant depth of tail water at overtopping, resulting in a lower risk of scour. LOT have steep land-side batters are typically in the order of 1 in 2.5.

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.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are 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 States 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.
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).
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.
spillways	Spillways are sections of levee designed to carry large flows of water for long periods. They typically have very flat back slopes (generally in the order of 1 in 50) which are protected by either grass or rock held in place by wire mesh and steel cable.
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.
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

APPENDIX B. HUNTER VALLEY FLOOD MITIGATION SCHEME



LONGITUDINAL SECTION

Scales: Hor. 1" = 200 ft.
Vert. 1" = 10 ft.

DRAWN FROM SURVEY BY Mr B. PHEASANT
Jan 1967.

Sheet No 1. of 8.

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DRAWN B Jan '67
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J.C. HUMPHREY.
DIRECTOR OF PUBLIC WORKS
per
a/ CHIEF ENGINEER

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HARBOURS AND RIVERS BRANCH

HUNTER VALLEY FLOOD MITIGATION
WOODVILLE – WALLALONG
GREENWATTLE – LEVEES

C 719 | SCALE:– AS SHOWN

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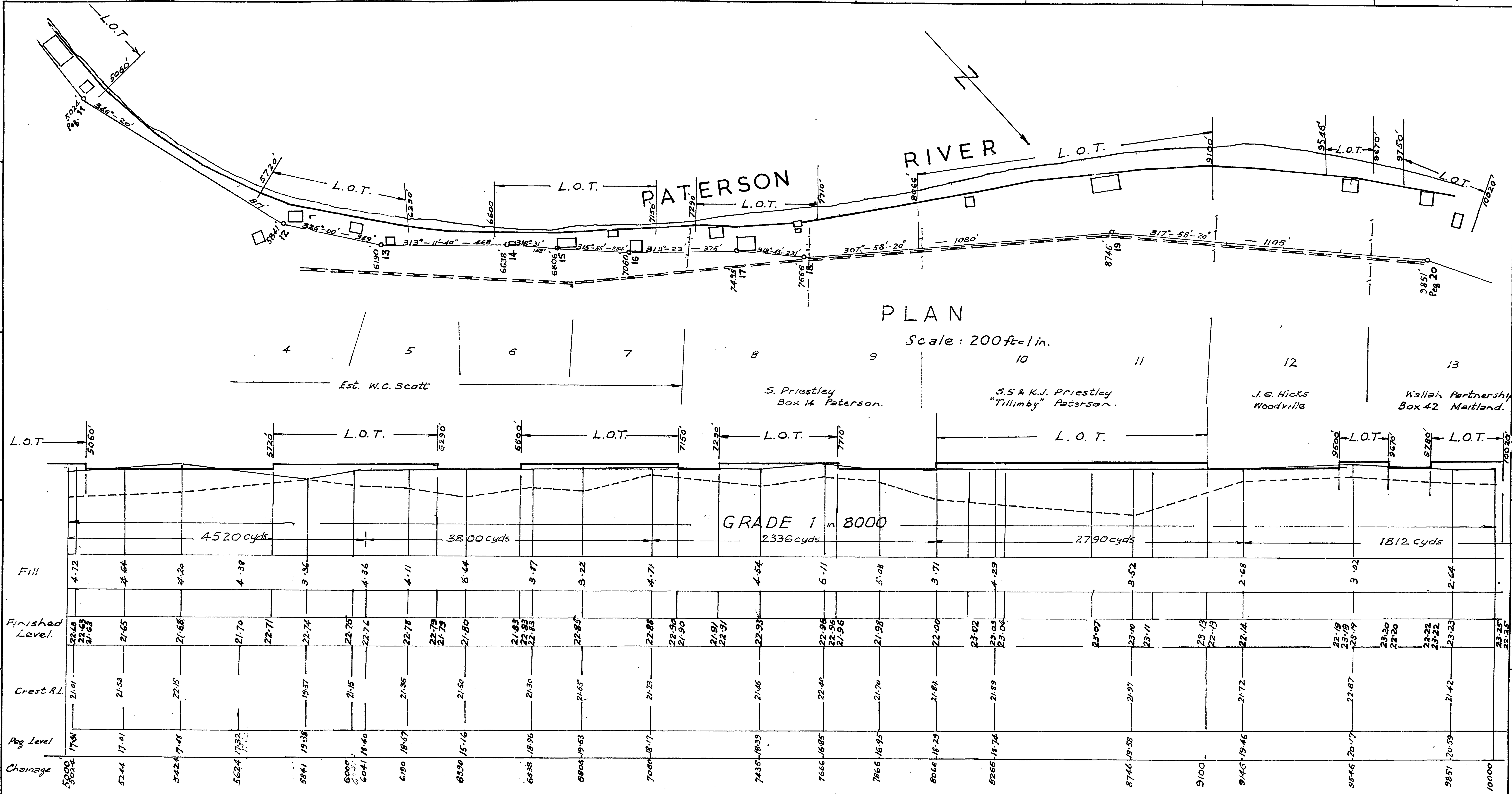

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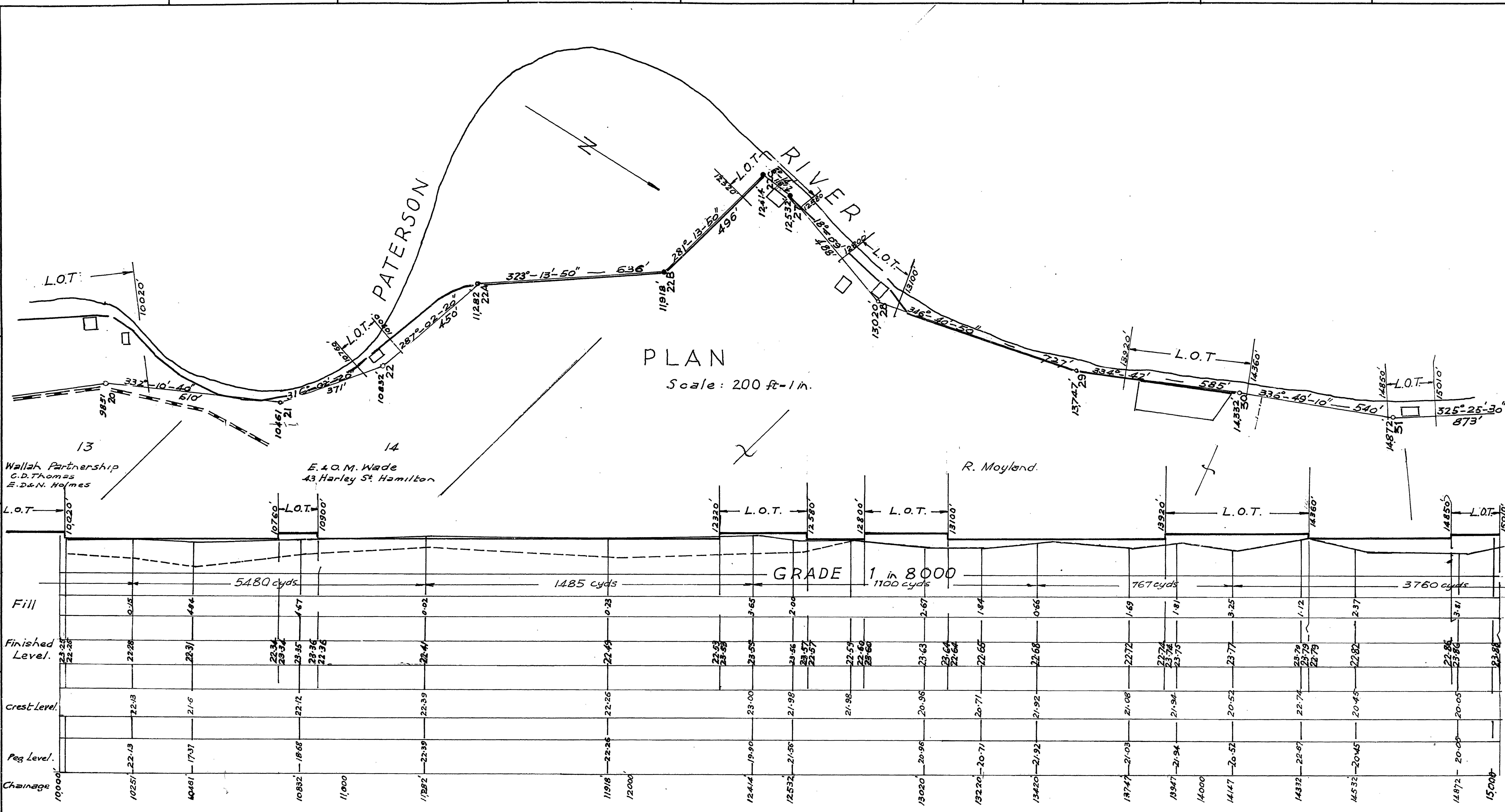
HUNTER VALLEY FLOOD MITIGATION

WOODVILLE WALLALONG GREENWATTLE LEVEES

C 719

SCALE:— AS SHOWN



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Vert. 1"=10'.

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HUNTER VALLEY FLOOD MITIGATION

WOODVILLE WALLALONG

GREENWATTLE LEVEES

C 719

SCALE:— AS SHOWN

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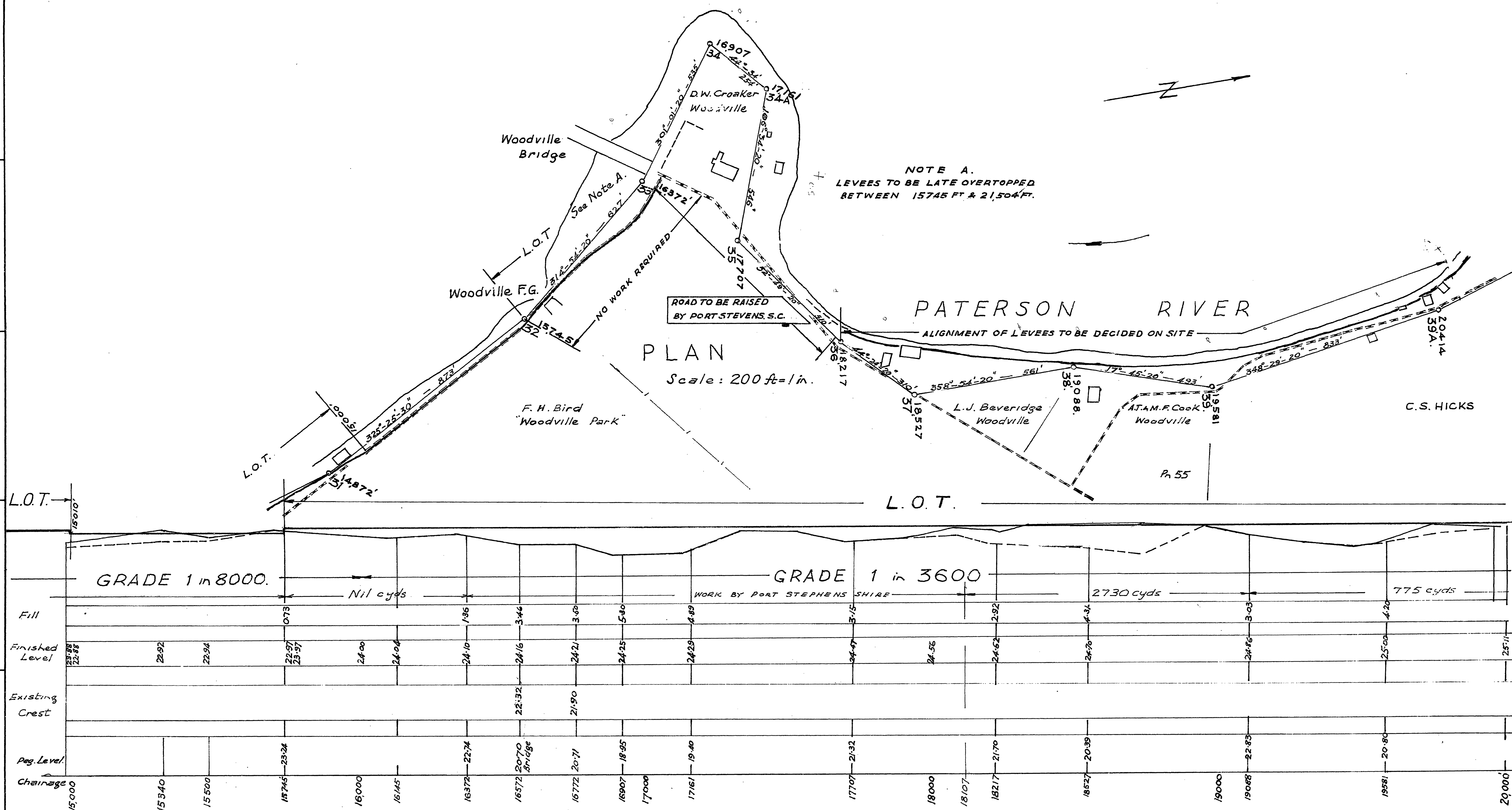

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HUNTER VALLEY FLOOD MITIGATION
WOODVILLE WALLALONG GREENWATTLE LEVEES

C 719 — SCALE:— AS SHOWN

LONGITUDINAL SECTION

Scales: Hor. 1"=200'.
Vert. 1"=10'.

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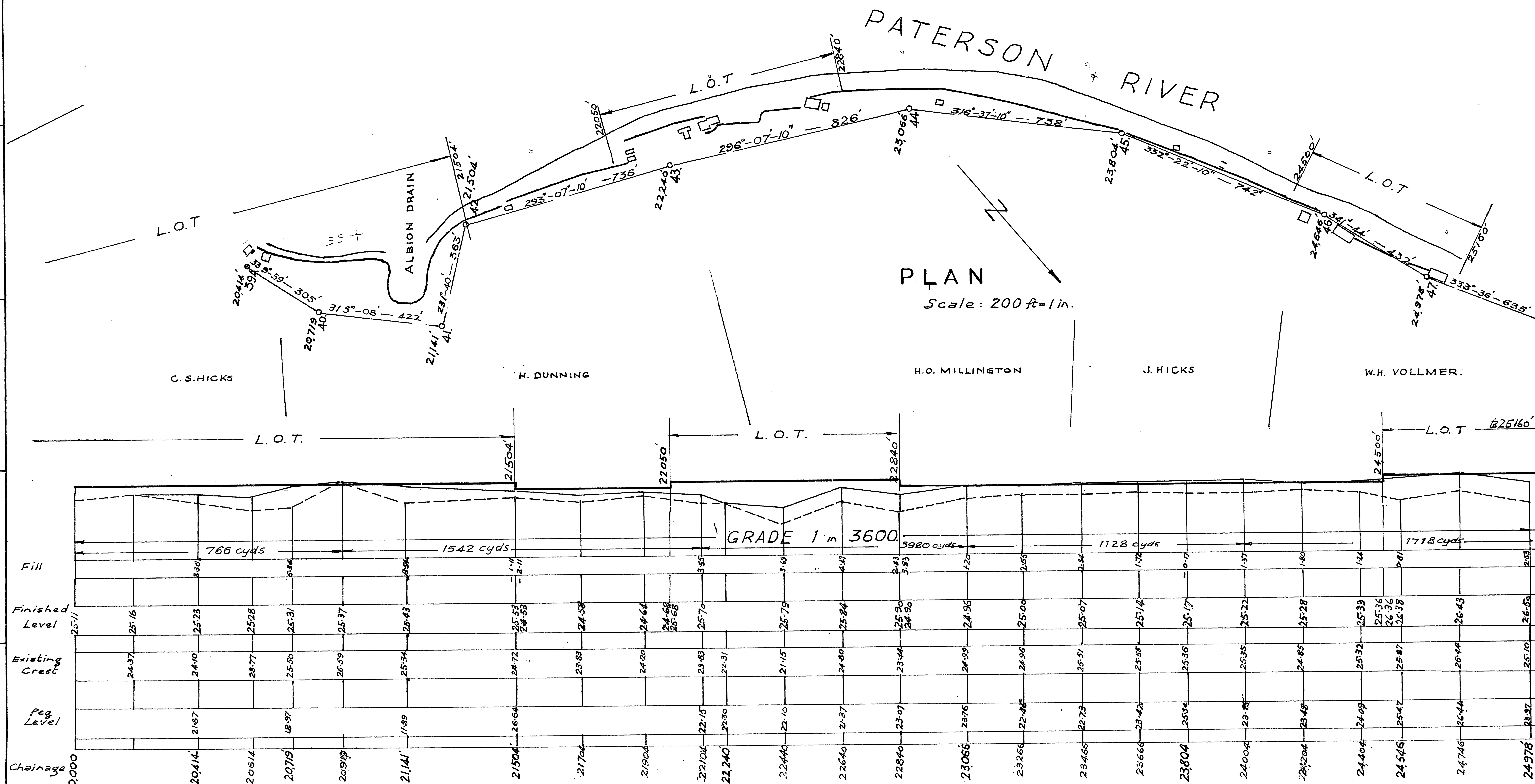

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Vert. 1"=10'.

Sheet No 5 of 8

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HUNTER VALLEY FLOOD MITIGATION

WOODVILLE WALLALONG

GREENWATTLE LEVEES

C 719 SCALE:— AS SHOWN

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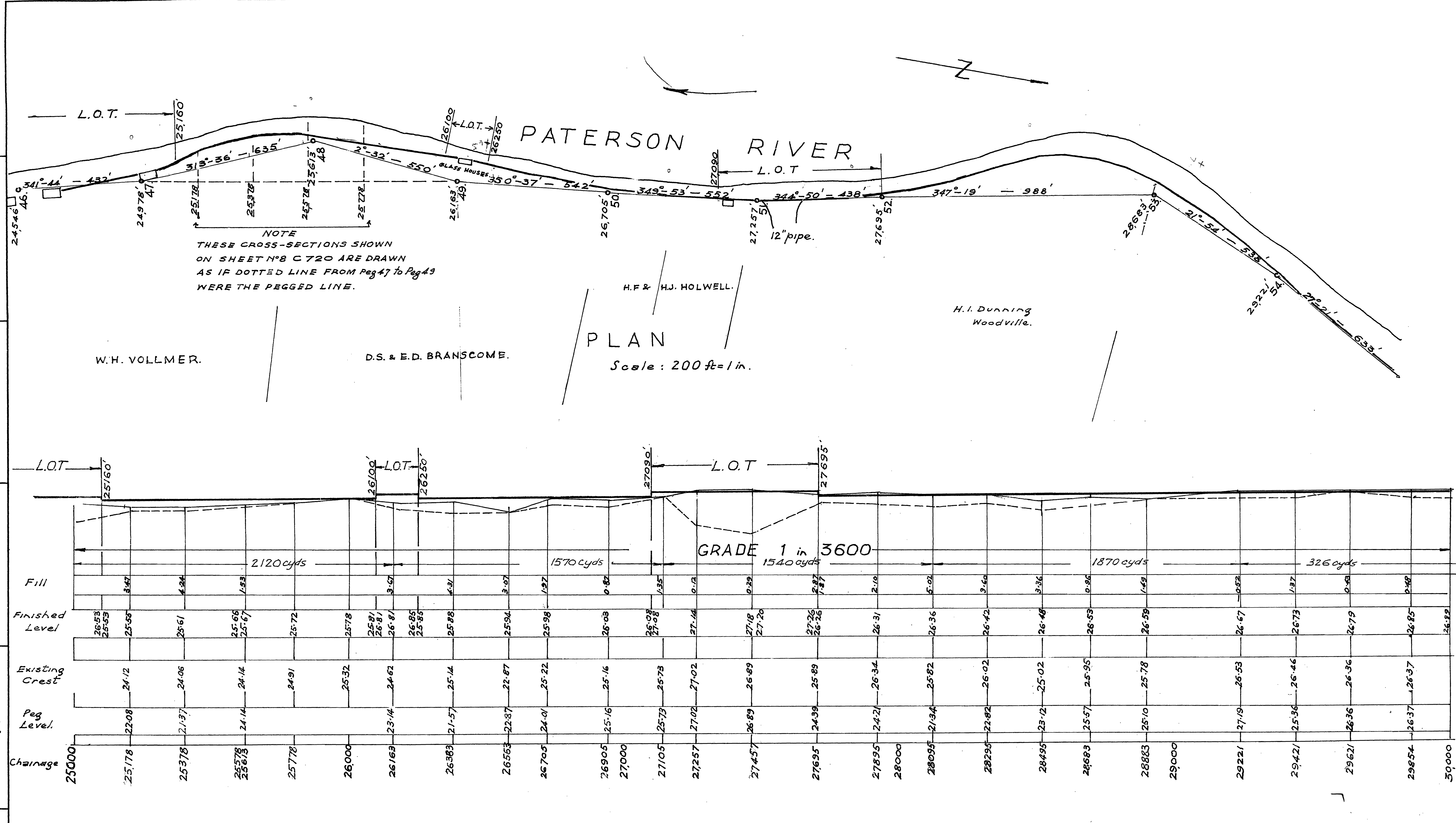

LONGITUDINAL SECTION

Scales: Hor. 1" = 200'.
Vert. 1" = 10'.

Sheet Nº 6 of 8

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HUNTER VALLEY FLOOD MITIGATION
WOODVILLE WALLALONG
GREENWATTLE LEVEES

C 719 | SCALE:— AS SHOWN

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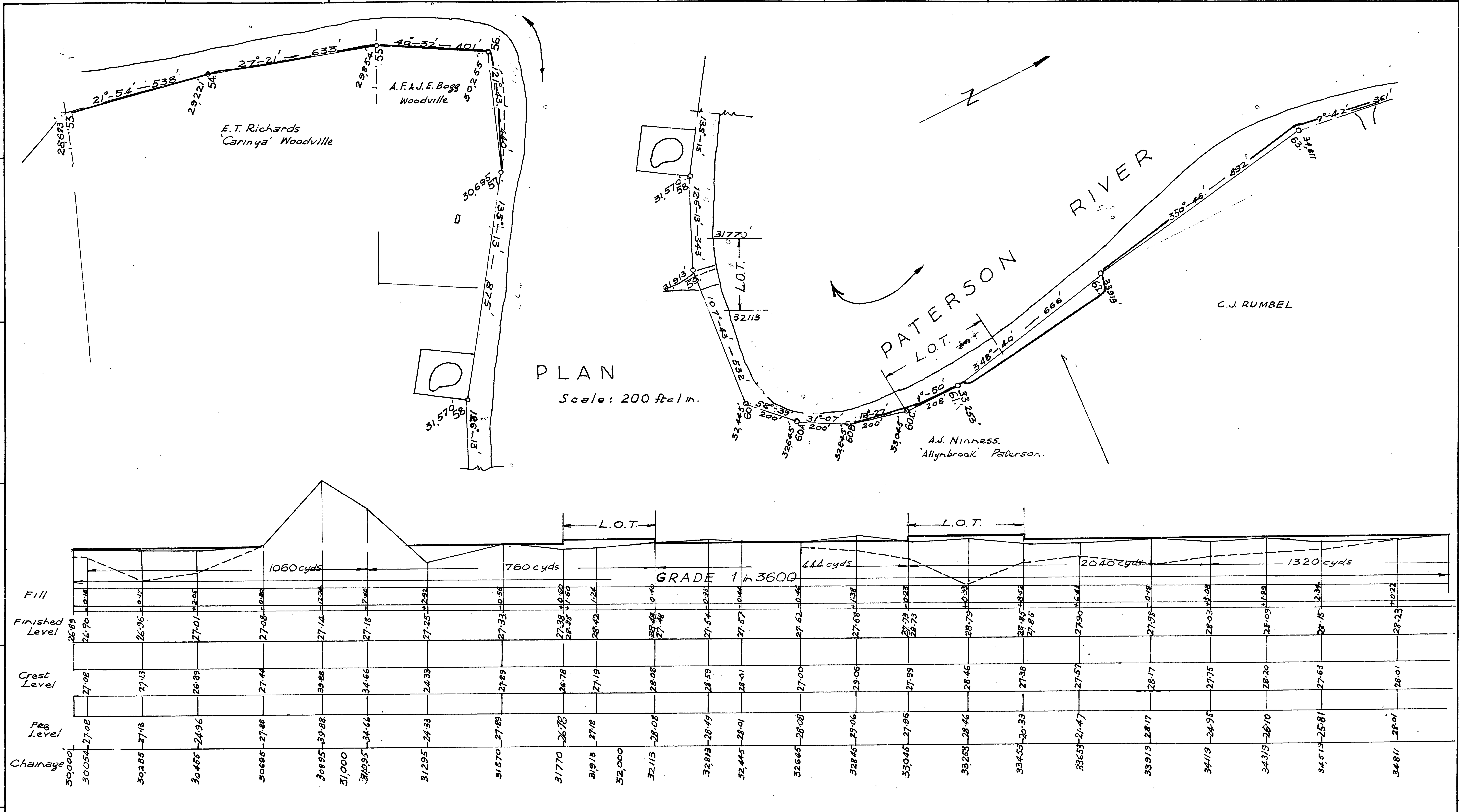

LONGITUDINAL SECTION

Scales: Hor. 1" = 200'.
Vert. 1" = 10'.

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HUNTER VALLEY FLOOD MITIGATION

WOODVILLE WALLALONG GREENWATTLE LEVEES

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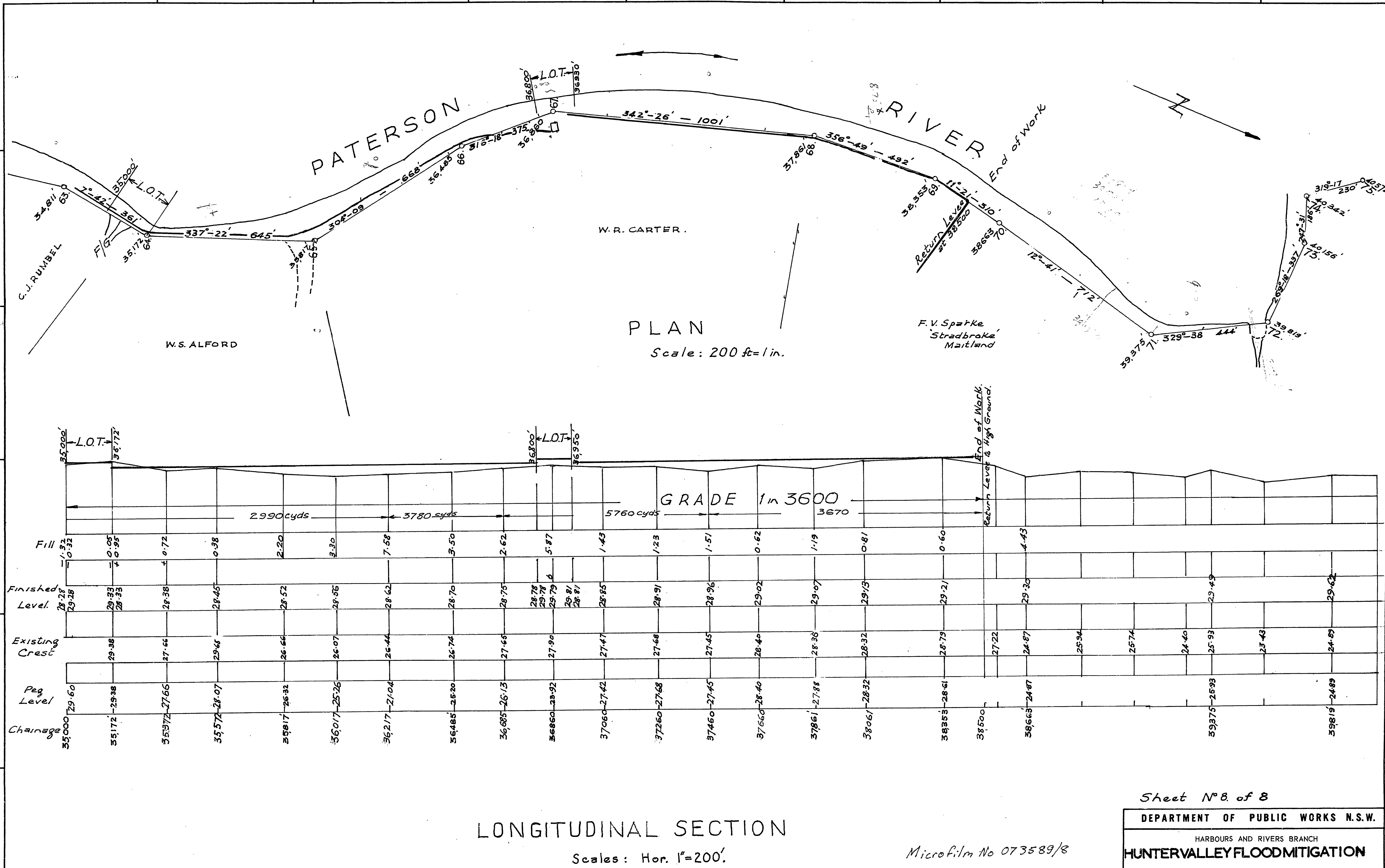

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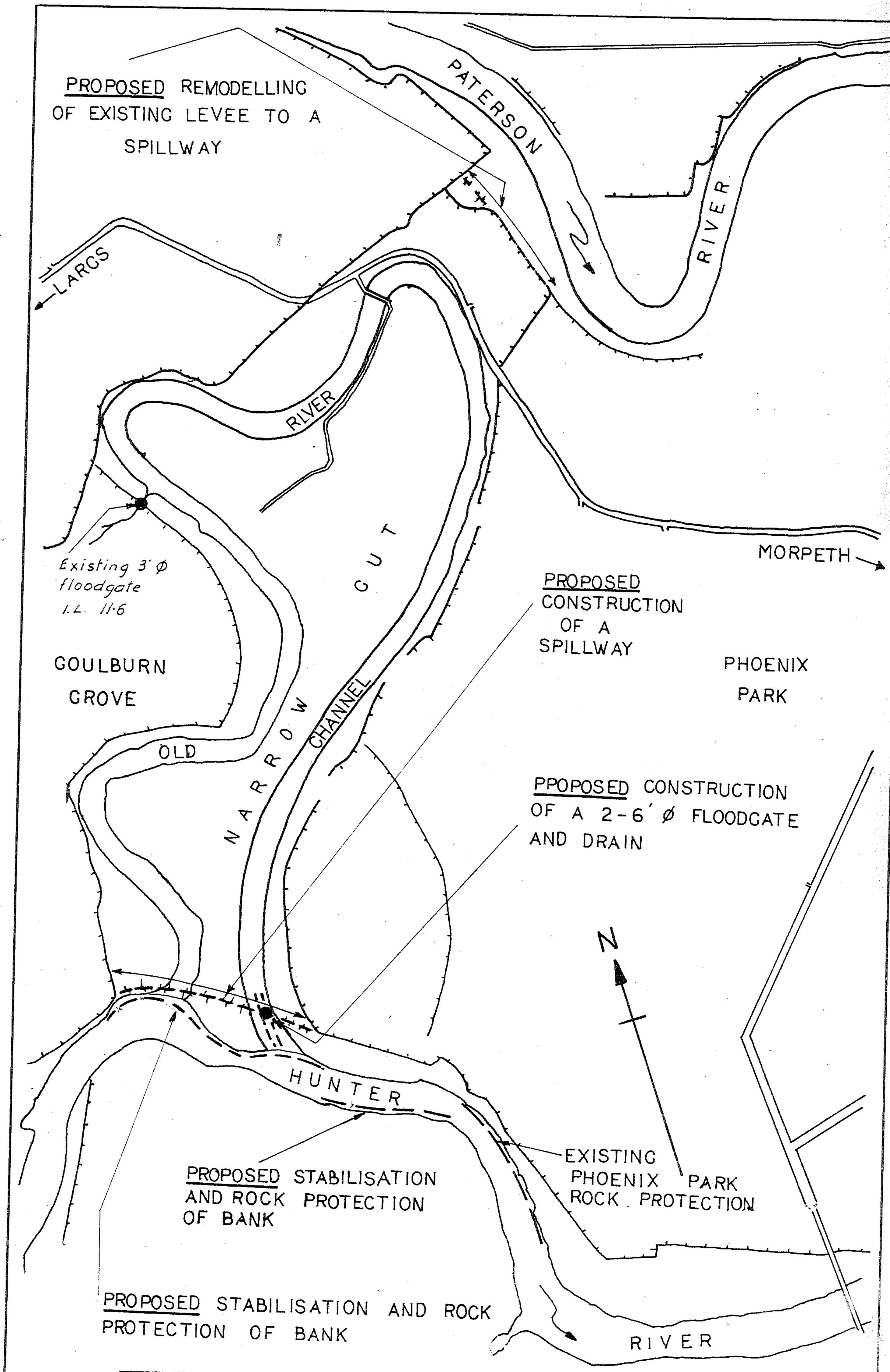
WOODVILLE WALLALONG
GREENWATTLE LEVEES

C719 SCALE:—AS SHOWN

PT 98 V.C.N. Blight, Government Printer



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