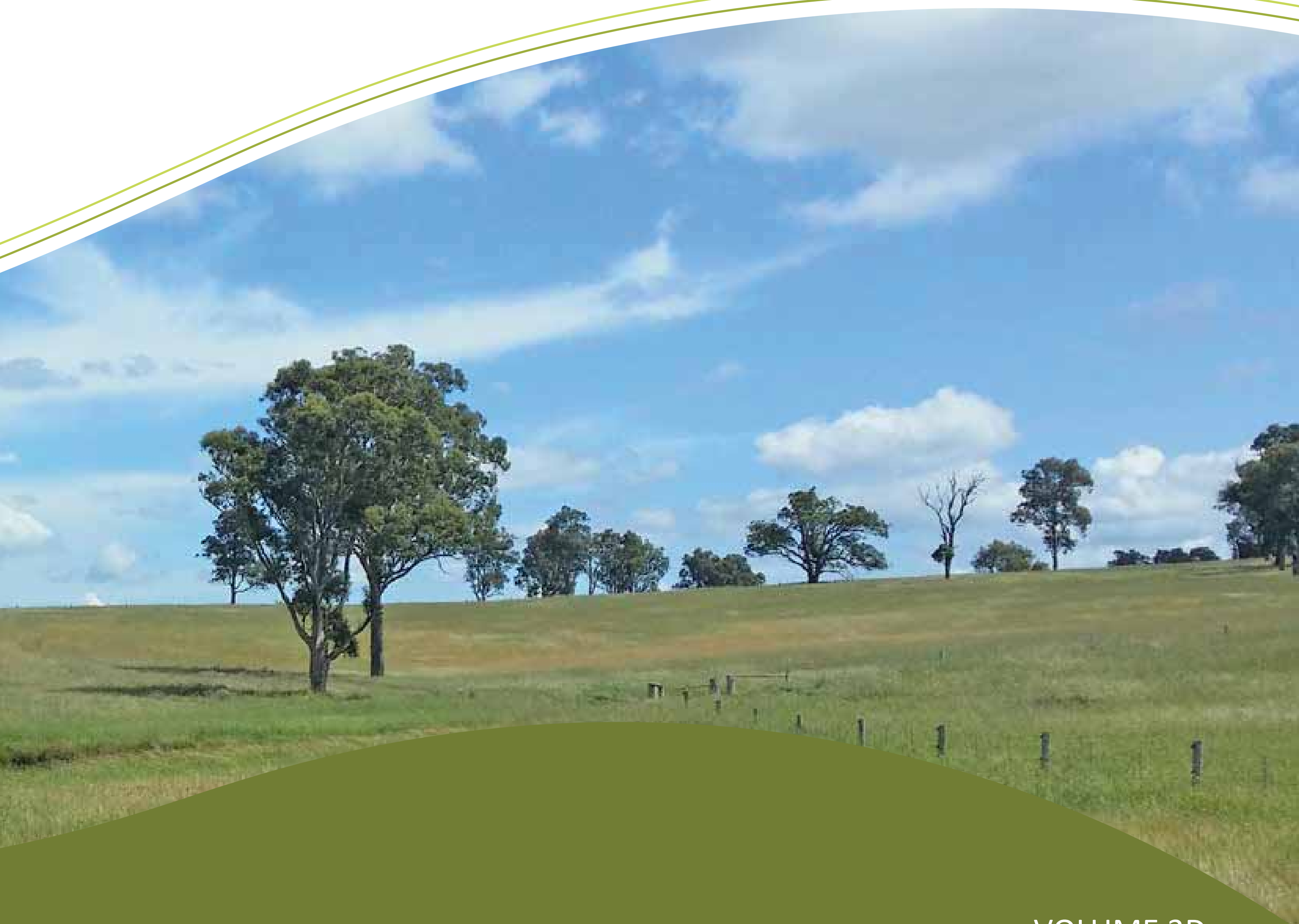
HUMECOAL PROJECT



VOLUME 3D

Hume Coal Project

Environmental Impact Statement

Appendix D
Berrima Rail Project Environmental Impact Statement
– Appendices K to M

Prepared for Hume Coal Pty Limited
March 2017

EMM

Appendix D

Berrima Rail Project Environmental Impact Statement
– Appendices K to M

Surface Water Assessment Report

Appendix K

Appendix K — Surface Water Assessment Report

K

HUME COAL

Berrima Rail Project Environmental Impact Statement

SURFACE WATER ASSESSMENT

FEBRUARY 2017

Berrima Rail Project
Environmental Impact Statement

SURFACE WATER ASSESSMENT

Hume Coal

REV	DATE	DETAILS
P	02/02/2017	Updated final with updated project description and discussion on construction phase
O	01/02/2017	Updated final to address Hume Coal and EMM comments
N	12/01/2017	Final report for issue

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GLOSSARY

Annual exceedence probability (AEP)	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%, there is a 5% chance (that is, a one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see 'average recurrence interval').
Australian Height Datum (AHD)	Reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of channels and water levels.
Average recurrence interval (ARI)	Long-term average number of years between the occurrences 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.
Baseline water quality	Existing water quality determined from available monitoring data.
Catchment	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.
Digital terrain model (DTM)	Digital representation of ground surface topography or terrain. It is also widely known as a digital elevation model (DEM).
Discharge	Rate of flow of water measured in terms of volume per unit time — for example, cubic metres per second (m3/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).
Environmental Values (EV)	Values that the community considers important for water use.
Erosion	The action of surface processes such as water flow that remove soil, rock, or dissolved material from one location on the Earth's crust, then transport it away to another location.
Flood	Relatively high streamflow that 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 it enters a watercourse; and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences, excluding tsunami.
Floodplain	Area of land that is subject to inundation by floods up to and including the probable maximum flood event — that is, flood-prone land.
Flow	Water moving steadily and continuously in a current or stream.
Geomorphology	The scientific study of the origin and evolution of topographic and bathymetric features created by physical, chemical or biological processes operating at or near the Earth's surface.
Hydrologic Engineering Centre River Analysis System (HEC-RAS) model	Software package that allows modellers to perform one-dimensional steady and unsteady flow river hydraulics calculations, sediment transport – mobile bed modelling and water temperature analysis.
Hydraulics	Study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

Hydrograph	Graph that shows how the discharge or flood level at a particular location varies with time during a flood.
Hydrology	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.
Hyetograph	A graphical representation of the distribution of rainfall over time.
Light detection and ranging (LiDAR)	Optical remote-sensing technology that can measure the distance to, or other properties of, a target by illuminating the target with light (often pulses from a laser).
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second. A unit of measurement for flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Model	Mathematical representation of the physical processes involved in runoff generation and streamflow. Models are often run on computers, due to the complexity of the mathematical relationships between runoff, streamflow and the distribution of flows across the floodplain.
Overland flow	The movement of water over the land, downslope toward a surface water body.
Peak discharge	Maximum discharge occurring during a flood event.
Probable maximum flood (PMF)	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)	Greatest depth of precipitation for a given duration that is meteorologically possible over a given size of storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends. It is the primary input to PMF estimation.
Runoff	Amount of rainfall that actually ends up as streamflow; also known as rainfall excess.
Scour	The removal of sediment such as sand or silt from around objects which disturb the flow, causing local high velocities which can remove the sediment particles and leave a local depression.
Velocity	Speed of floodwaters, usually in m/s (metres per second).
Water Quality Objectives	Agreed environmental values and long term goals for NSW's surface water. They include a range of water quality indicators to help assess whether the current condition of our waterways supports those values and users.
XP-RAFTS	Software package used for runoff routing for hydrologic and hydraulic analysis of drainage and conveyance systems.
Yield	The total outflow from a drainage basin through surface channels within a given period of time.

ABBREVIATIONS

AEP	Annual exceedence probability
ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average recurrence interval
AR&R	Australian Rainfall and Runoff
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
BOM	Bureau of Meteorology
DECC	Department of Environment and Climate Change
DEM	Digital elevation model
DP&E	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
DTM	Digital terrain model
DWG	AutoCAD drawing file
EAF	Elevation adjustment factor
EIS	Environmental impact statement
EPA	NSW Environment Protection Authority
EV	Environmental value
GSAM	Generalised Southeast Australia Method
GSDM	Generalised Short-Duration Method
ha	Hectares
HEC-RAS model	Hydrologic Engineering Centre River Analysis System model
HRC	Healthy Rivers Commission
IFD	Intensity frequency duration
km	Kilometres
LGA	Local government area

LiDAR	Light detection and ranging
LPI	NSW Land and Property Information
MAF	Moisture adjustment factor
MHL	Manly Hydraulics Laboratory
MHRDC	Maximum harvestable right dam capacity
ML	Megalitres
Mt	Million tonnes
Mtpa	Million tonnes per annum
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
MWD	Mine water dam
m/s	Metres per second
m^3/s	Cubic metres per second
mm/day	Millimetres per day
mm/hr	Millimetres per hour
NorBE	Neutral or Beneficial Effect
NOW	NSW Office of Water
NSW	New South Wales
NWQMS	National Water Quality Management Strategy
PMF	Probable maximum flood
PMP	Probable maximum precipitation
PRM	Probabilistic rational method
RCBC	Reinforced concrete box culvert
Q	Discharge
ROM	Run of mine
SCA	Sydney Catchment Authority
SEARs	Secretary’s Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SWQ	Surface Water Quality monitoring site
TAF	Topographic adjustment factor

TDS	Total dissolved solids
TIN	Triangulated Irregular Network
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
WAL	Water access licence
WM Act	NSW Water Management Act 2000
WSC	Wingecarribee Shire Council
WTP	Water treatment plant
WQO	Water quality objective

EXECUTIVE SUMMARY

This report presents the surface water assessment component of the Berrima Rail Project Environmental Impact Statement undertaken on behalf of Hume Coal Pty Limited. The project involves the construction and operation of a new rail spur and loop in the Southern Highlands region of New South Wales. Hume Coal is also seeking approval in a separate State significant development application to develop and operate the Hume Coal Project; an underground coal mine and associated mine infrastructure in the NSW Southern Coalfields, that will utilise the proposed new rail spur and loop to transport the coal produced by the Hume Coal Project.

The surface water assessment for the Berrima Rail Project addresses potential impacts of the new rail spur and loop on the following aspects of the surface water environment: flooding and drainage; erosion, sedimentation and scour; fish passage; and water quality. The following sections summarise the key findings of each aspect of the assessment.

Flooding and drainage assessment

The flooding and drainage assessment considers the existing flood behaviour and the impacts of the project on flooding in the local catchments, and mitigation measures required to minimise potential impacts and to protect the rail infrastructure during flood events.

The rail infrastructure is located within two stream catchments: Oldbury Creek and Stony Creek. Hydrologic and hydraulic models using XP-RAFTS and HEC-RAS respectively were used to define the flood levels and extents for existing conditions and operational scenarios for the 5, 20 and 100 year average recurrence interval events and the probable maximum flood.

The assessment considered the existing conditions and operation and rehabilitation scenarios of the project. A cumulative assessment including the Hume Coal Project was also undertaken.

The assessment found that the impacts on flooding for the operation and rehabilitation scenario are within proposed acceptability criteria, with the exception of five discrete locations for the operational phase. At all five locations the impacts are confined to land owned by either Hume Coal or Boral and generally are removed for the rehabilitation phase, with the exception of an impact east of the Berrima Cement works where the rail infrastructure is to be retained under the preferred option.

The cumulative impacts of the Hume Coal and Berrima Rail projects on flood level are also generally within the proposed impact criteria, with the same exceptions noted above.

Culverts will be constructed in a number of locations to allow water to pass the proposed infrastructure and reduce flooding impacts on nearby land. Peak velocities are expected to increase immediately upstream and downstream of culverts. Standard erosion and scour protection measures will be required around culvert inlets and outlets so that any localised increases in stream velocity do not cause erosion of the channel lining downstream of the culvert.

Erosion, sedimentation and scour assessment

A geomorphology assessment was undertaken to establish the baseline stability and characteristics of the creeks and drainage lines that will be intersected by the rail corridor. The assessment involved a site inspection to determine bed and bank condition and follow up desktop assessments of the hydraulic characteristics based on the available flood models and topographic data. The assessment was used to inform the erosion and sediment control and scour assessment.

Construction of the rail embankment will intercept overland flow and will concentrate the flow at culvert locations. This will likely cause increased ponding upstream of the culvert locations and increased flow velocity downstream of the culvert locations which could increase the risk of erosion and scouring. These risks can be successfully managed through implementation of industry standard erosion and scour protection measures, which are part of the standard culvert crossing design features.

An erosion and sedimentation control plan, developed in accordance with Landcom (2004) and DECC (2008) guidelines, will be prepared to ensure the erosion and sedimentation induced by construction activities will not adversely affect the surrounding environment. With the implementation of this plan, erosion and sedimentation impacts during the construction phase are expected to be minimal.

Fish passage assessment

The new rail infrastructure crossing streams in the project area has the potential to restrict fish passage.

The NSW Department of Primary Industries (DPI) have published guidelines (DPI 2013) which nominate the preferred waterway crossing type depending on waterway class. Using these guidelines all waterways in the project area are classified as unlikely key fish habitat (Class 4).

The waterway crossing types proposed for the project are consistent with the DPI guidelines (2013) for Class 4 waterways with the exception of two crossings on Oldbury Creek. The proposed rail line is in cut at this location and flow will need to be diverted around the rail line. The detailed civil design of the diversions will need to take the DPI requirements for fish passage into account.

Given the unlikely fish habitat classification for all assessed waterways, the design of the proposed crossings is appropriate for the waterways and, therefore, there is no restriction of fish passage predicted.

Water quality assessment

The project is located in the Hawkesbury-Nepean River catchment which is part of the Sydney drinking water catchment. The water quality assessment addresses the potential impacts of the project on surface water quality in the Sydney drinking water catchment during construction, operation and rehabilitation stages, as well as detail of proposed mitigation measures to minimise potential impacts.

Construction and rehabilitation phase impacts of the project on surface water quality are expected to be neutral by implementing best practice erosion and sediment control management measures in accordance with relevant legislation and guidelines.

The project activities that have the potential to impact on surface water quality during operation are as follows:

- Stormwater runoff from the operational rail line to the local waterways of Oldbury Creek and Stony Creek.
- Stormwater runoff from the rail maintenance access road to Oldbury Creek.
- Stormwater runoff from the rail maintenance facility to Oldbury Creek.

The assessment has used water quality modelling to demonstrate that the runoff from the rail corridor, access road and maintenance facility will meet the Neutral or Beneficial Effect criteria for total suspended solids and nutrients set by the relevant legislation and guidelines, by using swales as the runoff treatment systems prior to discharge to local waterways.

The assessment has established preliminary water quality objectives to set targets for monitoring the performance of the project impact on Oldbury Creek and Stony Creek. Final water quality objectives should be developed using the additional surface water quality data collected prior to commencement of construction of the project. Surface water quality monitoring should be undertaken throughout construction, operation and rehabilitation at upstream and downstream sites on Oldbury Creek and Stony Creek to monitor changes in surface water quality in the receiving environment associated with the project and trigger the implementation of mitigation and remediation measures if required.

1 INTRODUCTION

1.1 Overview

Hume Coal Pty Limited (Hume Coal) is seeking approval for the construction and operation of a new rail spur and loop in the Southern Highlands region of New South Wales (NSW) (the Berrima Rail Project). Hume Coal is also seeking approval in a separate State significant development application to develop and operate the Hume Coal Project; an underground coal mine and associated mine infrastructure in the NSW Southern Coalfields. Coal produced by the Hume Coal Project will be transported to port for export or to domestic markets by rail via a new rail spur and loop, constructed as part of the Berrima Rail Project.

Approval for the Berrima Rail Project (the project) is being sought under Part 4, Division 4.1 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act). An environmental impact statement (EIS) is a requirement of the approval processes. This surface water assessment report forms part of the EIS. It documents the methodology and results of the assessment, the measures taken to avoid and minimise impacts and the additional mitigation and management measures proposed.

The location of the project is shown in Figure 1.1, and the local context around the project area is illustrated in Figure 1.2.

1.2 Project description

The Berrima Rail Project will enable the transportation of coal produced by the Hume Coal Project to various customers. The new rail spur and loop will be connected to the western end of the existing Berrima Branch Line; a privately owned line branching off the Main Southern Rail Line at the Berrima Junction approximately 2.5 km north of Moss Vale. The Berrima Branch Line is owned and used by Boral Cement Ltd (Boral) for the transportation of cement, limestone, coal and clinker to and from the Berrima Cement Works. It is also used by Inghams Enterprises Pty Limited (Inghams) for the transportation of grain to its feed mill east of the cement works, and by Omya (Australia) Pty Ltd (Omya) for the transportation of limestone to their Moss Vale plant at the Berrima Junction.

In addition to the construction of the new rail spur and loop, the project also involves upgrades to the Berrima Branch Line and the use of the rail infrastructure by Hume Coal and Boral. The rail project and the Hume Coal Project are the subject of separate development applications as the rail project involves rail infrastructure used by users other than Hume Coal, as noted above.

Hume Coal will rail product coal primarily to Port Kembla terminal for the international market, and possibly to the domestic market depending on market demand. Hume Coal will transport up to 3.5 Million tonnes per annum (Mtpa) of product coal which will require up to eight train paths per day (four in each direction), with a typical day involving four to six paths (two to three in each direction).

In summary the project involves:

- upgrades to Berrima Junction (at the eastern end of the Berrima Branch Line) to improve the operational functionality of the junction, including extending the number 1 siding, installation of new turnouts and associated signalling on the branch line. This does not involve any work at or beyond the interface with ARTC-controlled track;
- construction and operation of a railway bridge over Berrima Road;
- construction and operation of a new rail connection into the Berrima Cement Works from the railway bridge;
- decommissioning of the existing rail connection into the Berrima Cement Works including the Berrima Road level rail crossing;
- construction and operation of a new rail spur line from the Berrima Branch Line connection to the Hume Coal Project coal loading facility;

- construction and operation of a grade separated crossing (railway bridge) over the Old Hume Highway;
- construction and operation of maintenance sidings, a passing loop and basic provisioning facility on the western side of the Old Hume Highway, including an associated access road, car parking and buildings;
- construction and operation of the Hume Coal rail loop within the Hume Coal Project Area, adjacent to Medway Road; and
- construction and operation of associated signalling, services (including water, sewerage drainage), access tracks, power and other ancilliary infrastructure.

The conceptual project layout is illustrated in Figure 1.3. As shown, approval is sought for two alignments of the new rail line where it will cross Berrima Road. The preferred option is the blue rail alignment shown in Figure 1.3, which includes construction of a railway bridge over Berrima Road as described in the points above. This preferred project design has been developed in consultation with Boral as the owner of the Berrima Branch Line.

The alternative option (orange alignment in Figure 1.3) accounts for a proposal by Wingecarribee Shire Council (WSC) to realign approximately 700 m of Berrima Road between Taylor Avenue and Stony Creek to replace the T-intersection at Berrima Road and Taylor Avenue with a roundabout, and to replace the existing rail level crossing into the Berrima Cement Works with a rail overbridge. If WSC relocates Berrima Road to the alignment shown in Figure 1.3, then the following project components would vary:

- the turnout for the new spur line to service the Hume Coal Project would be installed on the existing Berrima Branch Line approximately 1000 m east of the cement works. A short section of the existing Berrima Branch Line would be shifted north, within the rail corridor on Boral-owned land, to accommodate the spur line;
- the construction of a railway bridge over Berrima Road would be replaced by a railway underpass beneath the realigned Berrima Road, constructed through the elevated embankment for the road;
- the construction of a new rail connection into the Berrima Cement Works from the railway bridge would no longer be required, and the cement works access would remain unchanged; and
- the existing rail connection into the Berrima Cement Works and the Berrima Road level rail crossing would not be decommissioned, since the road would be realigned to pass over the existing rail alignment using a bridge.

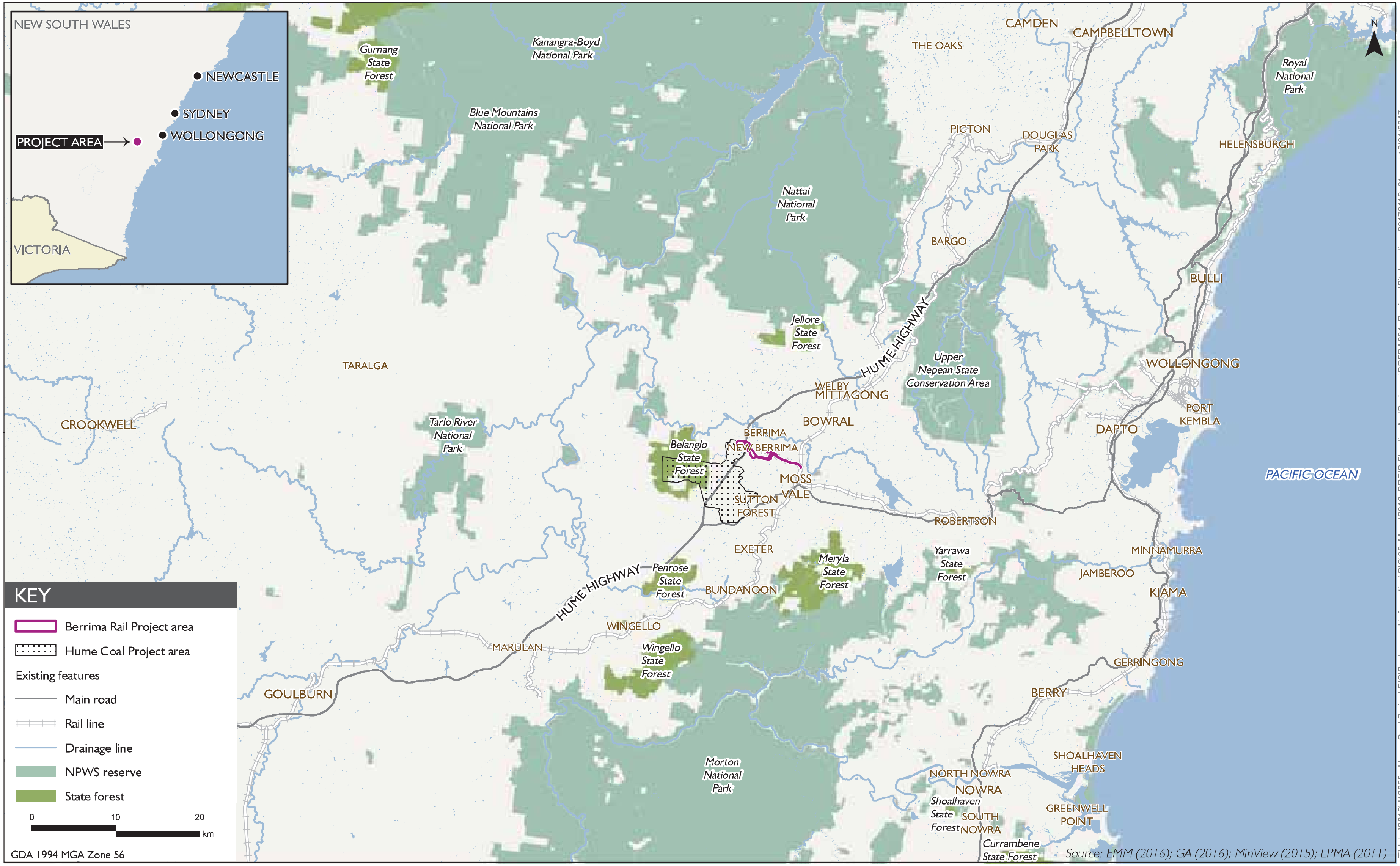
This surface water assessment has considered the impacts of both options shown in Figure 1.3.

1.3 Project area

The project area is located in the Southern Highlands region of NSW in the Wingecarribee local government area, approximately 100 km south-west of Sydney. It occupies a corridor that is around 8 km long, stretching from the Berrima Junction on the outskirts of Moss Vale, heading west in parallel with Douglas Road past the Berrima Feed Mill, around the southern side of the Berrima Cement Works, across the Old Hume Highway and under the Hume Highway through an existing underpass into the Hume Coal Project area, south of Medway Road.

The project area is in a semi-rural setting. It is surrounded by grazing properties, small-scale farm businesses, scattered rural residences, large and small industries and is traversed by the Hume Highway. The project area contains predominately cleared agricultural land consisting of improved pasture for grazing, and over a third of the area comprises the existing Berrima Branch Line.

The villages of New Berrima, Berrima and Moss Vale are located in the general vicinity. Medway is also located nearby while Bowral and Mittagong are located between 6 and 10 km north-east of the eastern end of the project area, respectively. There are also scattered homesteads, dwellings and other built structures associated with agricultural production surrounding the project area.



Regional Context

Berrima Rail Project
Flooding and drainage assessment
Figure 1.1

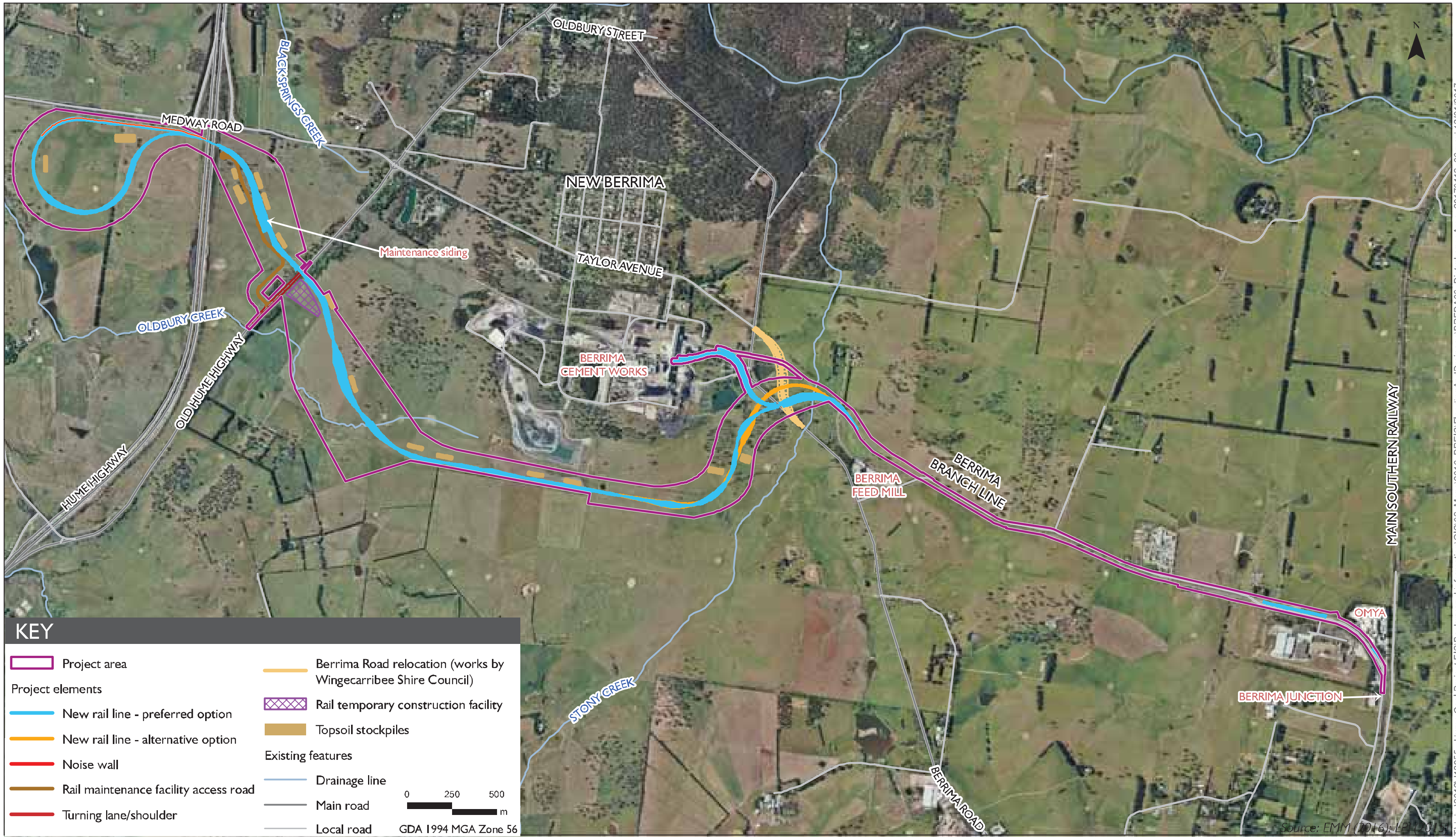
EMM HUMECOAL

Local context

Berrima Rail Project

Flooding and drainage assessment

Figure 1.2



Conceptual project components

Berrima Rail Project

Flooding and drainage assessment

Figure 1.3

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1.4 Scope of this report

This report documents the surface water assessment component of the EIS and provides an assessment of:

- Impacts of the project on flooding in the local catchments and mitigation measures required to minimise potential impacts and protect the rail infrastructure during flood events (Section 2);
- Scour and erosion risk around crossing structures and drainage outlets and typical treatment measures to protect adjacent land and receiving watercourses (Section 3);
- Potential impediments to fish passage associated with the rail infrastructure and mitigation measures to be employed to negate these impacts (Section 4); and
- Potential impacts on water quality and measures to control or reduce pollutants (Section 5).

1.5 Assessment requirements

This surface water assessment has been prepared in accordance with the relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies. The relevant guidelines and policies are listed in the individual technical sections of the report.

The assessment was prepared in accordance with the requirements of the NSW Department of Planning and Environment (DP&E). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued on 20 August 2015. A copy of the SEARs is attached to the EIS as Appendix B, while Table 1.1 lists the individual requirements relevant to this assessment and where they are addressed in this report.

Table 1.1 Surface water assessment requirements

Requirement	Agency	Section where addressed
The impacts of surface water changes should include the potential for flooding adjacent to the railway embankment and its impacts on grazing land usability including mitigation measures.	Agriculture NSW	Section 2
The impacts on existing dam levels should also be assessed to ensure surface water flowing into dams is not impacted.	Agriculture NSW	There will be no impacts to dams as surface water flows to existing dams will not be impacted by the project. The project will not involve the take of water and will not impede the flow of water to existing dams as culvert structures will be constructed where the rail crosses waterways.
We note that the proposed rail line crosses Stony Creek along with numerous tributaries and drainage lines. The potential impacts, especially upon downstream water quality and aquatic habitats in Stony Creek are of particular interest to this Department.	Fisheries NSW	Section 5
Impacts on water quality during all road construction activities and from stormwater runoff and road drainage during the ongoing use of the rail project.	Fisheries NSW	Section 5
Description of potential impediments to fish passage as a result of the works (e.g. temporary coffer dams, instream bunds or work platforms) and possible mitigation measures to be employed to negate these impacts.	Fisheries NSW	Section 4
Predictions of impacts upon water quality of the proposed rail project, including in Stony Creek, both during the construction and operational phases.	Fisheries NSW	Section 5

Requirement	Agency	Section where addressed
Safeguards to mitigate any impacts upon aquatic species and environments and water quality during construction and operation of the rail project. In particular, provide details on proposed revegetation of riparian areas, proposals for erosion and sediment control (to be incorporated into a Construction Environmental Management Plan - CEMP) and proposed stormwater and ongoing drainage management measures. Water quality management for the rail project should be designed to achieve no nett increase in pollutant run-off to Stony Creek.	Fisheries NSW	Section 5
Fisheries NSW recommends the use of best practice sediment and erosion control, and water quality and stormwater management provisions to safeguard and mitigate impacts on water quality at the site and downstream.	Fisheries NSW	Sections 3 and 5
The design and construction of any watercourse crossings on the site should be undertaken in accordance with the Department's Policy and Guidelines for Fish Friendly Waterway Crossings (2004) and Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (2004). These documents are available on our website www.dpi.nsw.gov.au, under 'Aquatic Habitats' and 'Publications'.	Fisheries NSW	Section 4
A detailed and consolidated site water balance.	DPI Water	The project will not involve the take of surface water during construction, operation or rehabilitation. A site water balance is therefore not required for the project.
Assessment of impacts on surface water sources (both quality and quantity), related infrastructure, watercourses, riparian land, and measures proposed to reduce and mitigate these impacts.	DPI Water	Sections 2 and 5
An assessment of impediment to surface water flow, and potential flood impacts.	DPI Water	Section 2
Proposed surface water monitoring activities and methodologies.	DPI Water	Section 5
Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	DPI Water	Section 2
Identification of all surface water features including watercourses, wetlands and floodplains transected by or adjacent to the proposed project.	DPI Water	Section 2.2
Detailed description of dependent ecosystems and existing surface water users within the area, including basic landholder rights to water and adjacent/downstream licensed water users.	DPI Water	There will be no impacts to dependent ecosystems or existing surface water users. The project will not involve the take of water and will not impede the flow of water as culvert structures will be constructed where the rail crosses waterways.
Description of all works and surface infrastructure that will intercept, store, convey, or otherwise interact with surface water resources.	DPI Water	Section 2.1
Assessment of predicted impacts on the following: → flow of surface water, sediment movement, channel stability, and hydraulic regime,	DPI Water	 Section 3

Requirement	Agency	Section where addressed
→ water quality, → flood regime, → dependent ecosystems, → existing surface water users.		Section 5 Section 2 There will be no impacts to dependent ecosystems or existing surface water users. The project will not involve the take of water and will not impede the flow of water as culvert structures will be constructed where the rail crosses waterways.
The EIS should address the potential impacts of the project on all watercourses likely to be affected by the project, existing riparian vegetation and the rehabilitation of riparian land. It is recommended the EIS provides details on all watercourses potentially affected by the proposal, including: → Photographs of the watercourses/wetlands and a map showing the point from which the photos were taken. → A detailed description of all potential impacts on the watercourses/riparian land. → A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime. → A description of the design features and measures to be incorporated to mitigate potential impacts. → Geomorphic and hydrological assessment of water courses including details of stream order (Strahler System), river style and energy regimes both in channel and on adjacent floodplains.	DPI Water	Section 3.2 Sections 3.2, 3.3, 3.4 and 3.5 There are no wetlands in the project area Sections 2.6, 3.6, 4 and 5 Section 3.2
It is noted that on page 63, the proposed water quality assessment includes evaluation against neutral and beneficial effect (NorBE) criteria in accordance with State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011. However, water management should also be assessed using approaches outlines in the National Water Quality Management Strategy, ANZECC 2000. These are described in more detail in the standard SEARS, but in summary the EIS should: → Identify relevant Water Quality Objectives for surface water, including indicators and associated trigger values or criteria, in accordance with National Water Quality Management Strategy Guidelines. Reference the water quality objectives for the Wingecarribee River catchment in the "NSW Healthy Rivers Commission of Inquiry into the Hawkesbury Nepean Catchment". Identify any downstream users and uses of the discharged water classified in accordance with relevant ANZECC 2000. → Estimate the chemical composition and load of chemical and physical stressors and toxicants in any discharge of mine water. Compare the level of physical and chemical stressors in any discharge with ANZECC 2000 trigger values for the various environmental values for the waterway. → Investigate options to reduce the levels of pollutants in the discharge of water to protect the environment from harm as a result of that pollution. Identify all practical measures to control or reduce pollutants in the surface water discharges. Identify preferred measures and their justification. → If WQOs cannot be met for the project, demonstrate that all practical options to avoid water discharge have been	NSW EPA	Section 5

Requirement	Agency	Section where addressed
implemented and outline any measures taken to reduce the pollutant loads where a discharge is necessary. Where a discharge is proposed, analyse the expected discharges in terms of impact on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm.		

2 FLOODING AND DRAINAGE ASSESSMENT

This section provides an assessment of the impacts of the Berrima Rail Project on flooding in the local catchments and mitigation measures required to minimise potential impacts and protect the rail infrastructure during flood events.

2.1 Methodology

The project is located within the catchments of Oldbury Creek and Stony Creek, which form the study area for this assessment (see Figure 2.1). Hydrologic modelling was undertaken to determine runoff generated from rainfall on these catchments. The runoff estimates were then used in the hydraulic modelling to simulate flow and assess the effects of obstructions such as the rail line on flow in stream channels and floodplains. Details of the data sources and modelling undertaken are provided in the following sections.

2.1.1 Data sources

2.1.1.1 Topography and aerial photography

Catchment delineation for the hydrology modelling and development of a digital terrain model (DTM) for the hydraulic modelling used light detection and ranging (LiDAR) data obtained from aerial laser survey of the project area on 25 October 2013 (Hume Coal 2013). The LiDAR data were supplied as thinned ground points in ASCII format, and a triangulated irregular network was created to form the DTM. The accuracy of the LiDAR dataset is approximately +/-150 mm.

Aerial photography was used for catchment delineation and to estimate channel and floodplain roughness in the hydraulic model.

Cross-section surveys undertaken by Manly Hydraulics Laboratory (MHL) during installation of streamflow gauge SW08 on Oldbury Creek (Figure 2.1) (Parsons Brinckerhoff 2016) were included in the hydraulic model.

There are two inline storages on Oldbury Creek and two inline storages on the north-west tributary of Stony Creek. These were surveyed so that embankment height and water levels could be input to the XP-RAFTS models. Survey data for the inline storages is provided in Appendix B.

2.1.1.2 Design events and terminology

Changes to flood behaviour were assessed for the 5 year, 20 year and 100 year average recurrence interval (ARI) events and the Probable Maximum Flood (PMF).

Australian Rainfall and Runoff (AR&R) is a national guideline for the estimation of design flood characteristics in Australia (Engineers Australia 1987). AR&R suggests that the annual exceedance probability (AEP) terminology is preferred to the ARI terminology. The ARI and the AEP are both a measure of the probability of occurrence of a rainfall event. ARIs greater than 10 years are very closely approximated by the reciprocal of the AEP. The ARI terminology has been used throughout this report.

ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random. AEP is defined as the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

With ARI expressed in years, the relationship is:

$$AEP = 1 - \exp\left(\frac{-1}{ARI}\right)$$

A summary of the conversion between ARI and AEP is shown in Table 2.1.

Table 2.1 Conversion from ARI to AEP

ARI (years)	AEP
1	0.632
2	0.393
5	0.181
10	0.095
20	0.049
50	0.020
100	0.010

2.1.1.3 Design rainfall intensity data

Design rainfall intensity estimates were derived using AR&R (Engineers Australia 2001). Intensity frequency duration (IFD) input parameters adopted in the hydrologic models for the Oldbury Creek and Stony Creek catchments are provided in Table 2.2. The IFD data for Oldbury and Stony Creeks are provided in Tables 2.3 and 2.4. Design rainfall hyetographs for PMF storm events were calculated by proportioning from storm data derived from the IFD method, as defined in Chapter 2 of AR&R, Volume 2 (Engineers Australia 1987, 2001) and input to XP RAFTS.

Table 2.2 IFD parameters

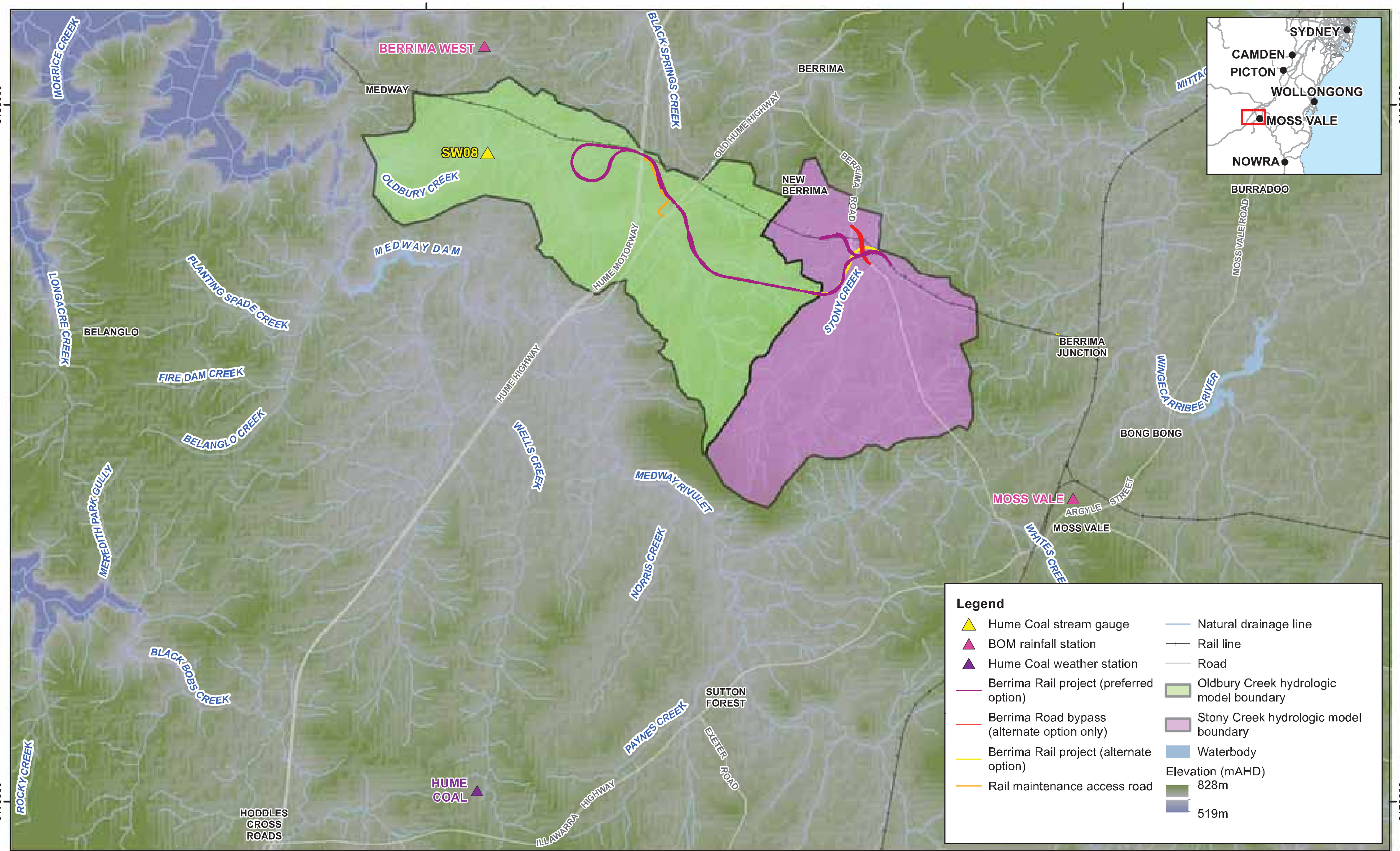
Variable	Symbol	Oldbury Creek	Stony Creek
Rainfall intensity (mm/h) (2-year ARI; 1-hour storm duration)	${}^{2}I_{1}$	28.8	29.4
Rainfall intensity (mm/h) (2-year ARI; 12-hour storm duration)	${}^{2}I_{12}$	6.28	6.45
Rainfall intensity (mm/h) (2-year ARI; 72-hour storm duration)	${}^{2}I_{72}$	1.87	1.94
Rainfall intensity (mm/h) (50-year ARI; 1-hour storm duration)	${}^{50}I_{1}$	58.46	59.52
Rainfall intensity (mm/h) (50-year ARI; 12-hour storm duration)	${}^{50}I_{12}$	12.78	13.22
Rainfall intensity (mm/h) (50-year ARI; 72-hour storm duration)	${}^{50}I_{72}$	3.84	3.98
Average coefficient of skewness	G	0.04	0.04
Geographical factor (2-year ARI)	F2	4.29	4.29
Geographical factor (50-year ARI)	F50	15.73	15.73

Table 2.3 IFD data for Oldbury Creek

Duration	Rainfall Intensity (mm/hr)						
	1 year ARI	2 year ARI	5 year ARI	10 year ARI	20 year ARI	50 year ARI	100 year ARI
5 mins	72.3	93.9	123	141	164	195	218
6 mins	67.6	87.9	115	132	153	182	204
10 mins	55.2	71.8	94.2	108	125	149	167
20 mins	40.2	52.2	68.4	78.1	90.8	108	121
30 mins	32.6	42.3	55.5	63.3	73.5	87.1	97.7
1 hr	22.1	28.7	37.5	42.8	49.7	58.9	66.0
2 hrs	14.6	18.9	24.8	28.2	32.8	38.9	43.5
3 hrs	11.4	14.7	19.3	22.0	25.6	30.3	33.9
6 hrs	7.41	9.60	12.6	14.3	16.7	19.7	22.1
12 hrs	4.82	6.25	8.19	9.35	10.9	12.9	14.4
24 hrs	3.10	4.03	5.28	6.03	7.02	8.32	9.33
48 hrs	1.94	2.52	3.31	3.78	4.40	5.23	5.86
72 hrs	1.44	1.86	2.45	2.80	3.26	3.87	4.35

Table 2.4 IFD data for Stony Creek

Duration	Rainfall Intensity (mm/hr)						
	1 year ARI	2 year ARI	5 year ARI	10 year ARI	20 year ARI	50 year ARI	100 year ARI
5 mins	73.7	95.6	125	143	166	197	220
6 mins	69	89.5	117	134	155	184	206
10 mins	56.4	73.2	95.8	109	127	150	168
20 mins	41	53.2	69.6	79.4	92.1	109	122
30 mins	33.3	43.2	56.5	64.3	74.7	88.5	99.1
1 hr	22.6	29.3	38.3	43.6	50.7	60.0	67.2
2 hrs	14.9	19.3	25.3	28.9	33.5	39.7	44.5
3 hrs	11.6	15.1	19.8	22.6	26.2	31.1	34.8
6 hrs	7.59	9.85	12.9	14.8	17.2	20.4	22.8
12 hrs	4.94	6.42	8.43	9.64	11.2	13.3	14.9
24 hrs	3.2	4.15	5.46	6.24	7.26	8.61	9.66
48 hrs	2.01	2.61	3.43	3.92	4.56	5.41	6.07
72 hrs	1.49	1.93	2.54	2.91	3.38	4.02	4.50



Map: 2200569A_GIS_020_A3	Author: RP
Date: 4/11/2016	Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal

1:50,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Figure 2.1

Study area and data sources

2.1.1.4 Probable maximum precipitation

The probable maximum precipitation (PMP) design rainfall intensity was determined using the method outlined in the Bureau of Meteorology (BOM 2003) publication *Generalised Short-Duration Method* (GSDM) for durations from 15 minutes up to 6 hours. Table 2.5 shows the parameters used in the PMP calculation for Oldbury Creek and Stony Creek and Table 2.6 provides a summary of the resulting PMP rainfall depths.

Table 2.5 Parameters used for PMP calculation

Parameter	Oldbury Creek	Stony Creek
Catchment area	13.3 km^2	9.91 km^2
GSDM parameters		
Elevation adjustment factor (EAF)	1 (below 1500 m elevation)	1 (below 1500 m elevation)
Moisture adjustment factor (MAF)	0.68	0.68
Portion of catchment area considered rough	100% (entire catchment considered rough because there are elevation changes of 50m or more within horizontal distances of 400m nearby the catchment.)	100% (entire catchment considered rough because there are elevation changes of 50m or more within horizontal distances of 400m nearby the catchment.)

Table 2.6 PMP depths

Storm duration	PMP depth (mm)	
	Oldbury Creek	Stony Creek
15 minutes	150	150
30 minutes	210	220
45 minutes	270	280
1 hour	320	320
1.5 hours	410	410
2 hours	470	480
2.5 hours	520	530
3 hours	570	580
4 hours	650	660
5 hours	710	730
6 hours	820	780

2.1.1.5 Pluviograph data

The rainfall data used in the flooding assessment was collected from BOM rainfall stations in the vicinity of the study and the Hume Coal weather station installed in the project area in February 2012. The locations of the stations are shown on Figure 2.1, while details of the stations are provided in Table 2.7.

Table 2.7 Summary of rainfall stations

Station	Station number	Easting	Northing	Elevation (mAHD)	Period of record#	Data frequency
Moss Vale (BOM)	68045	259560.3	6174849.0	675	1870 – 2015	Daily
Berrima West (BOM)	68186	251120.2	6181286.9	655	1970 – 2015	Daily
MET01 (Hume Coal)	N/A	250727	6170163	675	2012 – 2015	10 minute

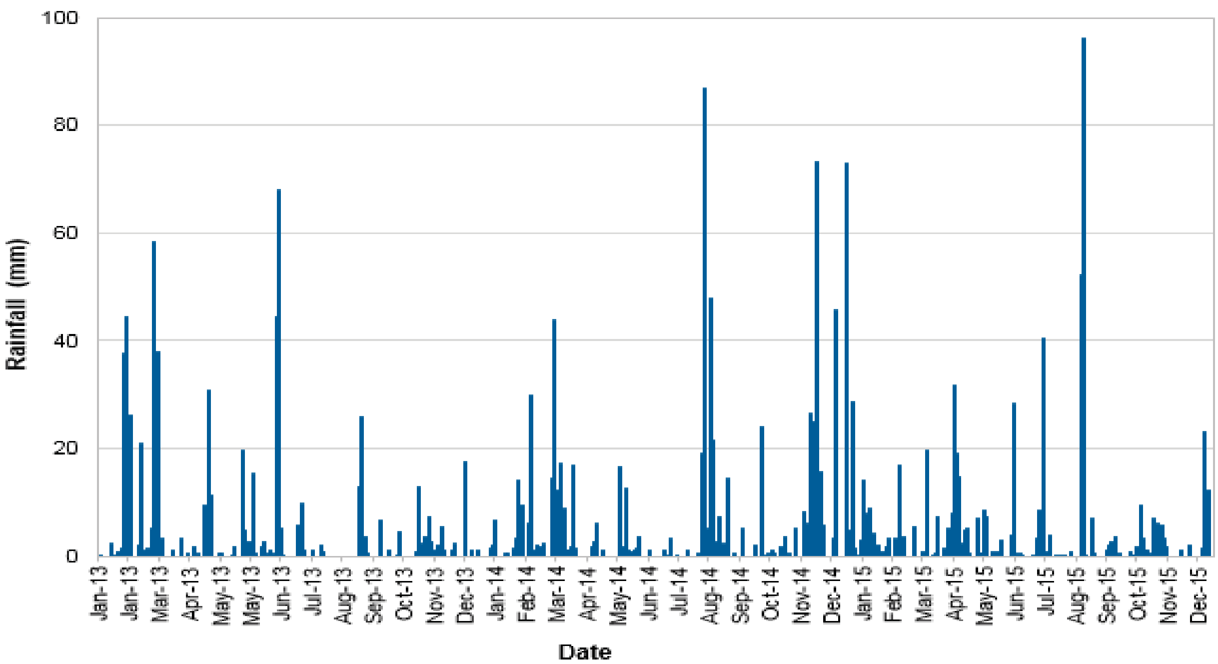
(1) # All weather stations have some data gaps, however data is available each month in each year

The nearest BOM weather station to the project is the station at Berrima West (68186). Daily rainfall data collected at this station for the baseline monitoring period from 2013 to 2015 is presented in Figure 2.2. Peak rainfall events during the baseline monitoring period occurred on:

- 26 June 2013
- 8 August 2014
- 7 December 2014
- 5 January 2015
- 25 August 2015

The largest event occurred on 25 August 2015. Data from the MET01 station was used for this event for calibration of the hydrologic model for Oldbury Creek. IFD rainfall data from BOM was used to identify the duration and ARI of the August 2015 rainfall event. Given the Berrima West rainfall station only records daily totals, an analysis of 10 minute rainfall data from the MET01 station was carried out instead and concluded that the August 2015 event was approximately a 1 year ARI 2 hour event.

Figure 2.2 Daily rainfall at the Berrima West weather station from 2013 to 2015



Ideally for calibration a larger event is preferred, given that the hydrologic models are used to simulate events up to the 100 year ARI event. Data from local rainfall stations and flow gauges on the Wingecarribee River with a longer period of record were reviewed to assess whether a relationship could be established between the flow gauge on the Wingecarribee River, flow gauge SW08 on Oldbury Creek and local rainfall stations with sub-daily rainfall data. There were no rainfall stations with sub-daily data within 20 km of SW08 recording rainfall data before the year 2000. The rainfall depth recorded in the August 2015 event was similar to the depth of other major storm events in the early 2000s, and therefore the August 2015 event was considered to be a representative major storm event in the recent flood history for calibration.

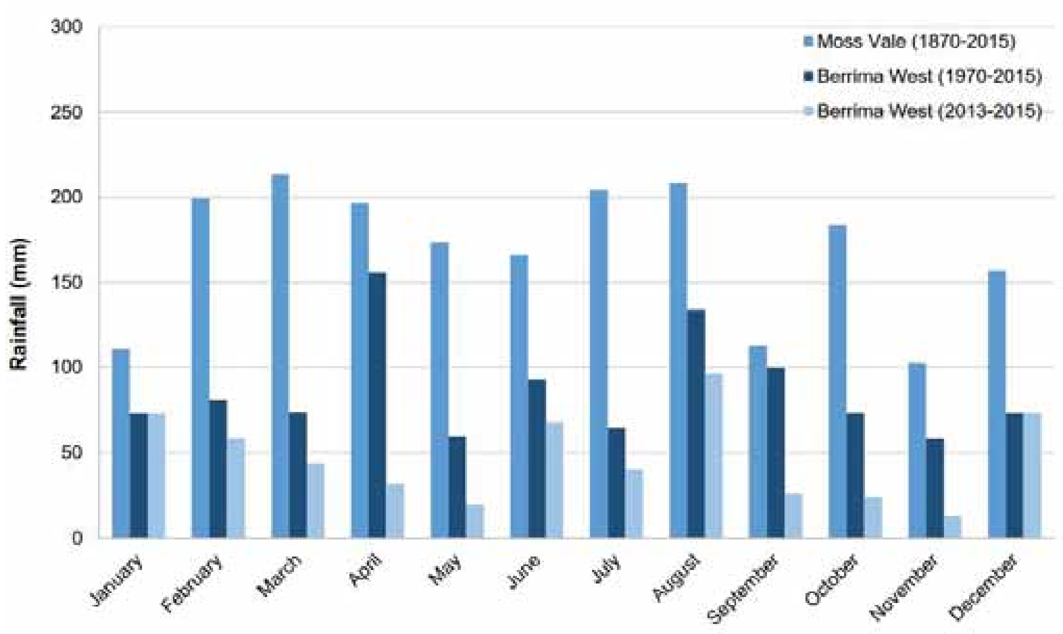
Comparison of rainfall at the Berrima West rainfall station to rainfall at the Hume Coal MET01 weather station indicated that rainfall at MET01 is higher than at Berrima West, which is consistent with the regional rainfall datasets that show reduced rainfall from south to north and from west to east across the region . The total rainfall for each day during the August 2015 storm event at MET01 was therefore factored down accordingly. The adjustment factor was determined by comparing total daily rainfall at Berrima West with total daily rainfall at MET01 during the August 2015 event – see Table 2.8 below.

Table 2.8 Total daily rainfall data at Berrima West and Hume Coal rainfall stations

Date	Berrima West (68186)	Hume Coal (MET01) station
24/08/2015 9:00am	1.2	0.1
25/08/2015 9:00am	52.2	78.8
26/08/2015 9:00am	96.2	200.6
27/08/2015 9:00am	9.6	0.0
Total	159.2	279.5
Factor	**0.57**	

The highest daily rainfall data in each month for the baseline monitoring period (2013 – 2015) at the BOM station at Berrima West (68186) was compared against the data for the period of record (1970 – 2015) as well as the data for the period of record (1870 – 2015) at the BOM rainfall station at Moss Vale (68045) – see Figure 2.3 below. The comparison indicates that the highest daily rainfall in each month has been lower during the baseline monitoring period.

Figure 2.3 Highest daily rainfall in each month at Moss Vale and Berrima West rainfall stations



2.1.1.6 Streamflow data

A dedicated surface water monitoring network was installed by Hume Coal and monitored to provide baseline data for the project. The network includes 11 operational stream gauges installed by Xylem and MHL. Details of the stream gauge network are provided in the *Water Fieldwork and Monitoring Report* (Parsons Brinckerhoff 2016).

The stream flow data used for calibration of the hydrology model for the Oldbury Creek catchment was collected from SW08 on Oldbury Creek. The location of this stream gauge is shown on Figure 2.1. Details of the gauge are provided in Table 2.9. There are no stream gauges on Stony Creek.

Table 2.9 Stream gauge details

Location	Stream gauge ID	Easting	Northing	Elevation of cease to flow (mAHD)	Data available for this assessment	Data frequency
Oldbury Creek	SW08	250876	6179319	627.074	14/05/2015* to 30/09/2016	15 minute

* Date monitoring at this stream gauge commenced

Water level data collected at SW08 during the August 2015 event was converted to flow data using the rating curve in Figure 2.4 below from the HEC-RAS model for the Oldbury Creek catchment (refer to Section 2.1.3).

Figure 2.4 Rating curve for stream gauge SW08 on Oldbury Creek

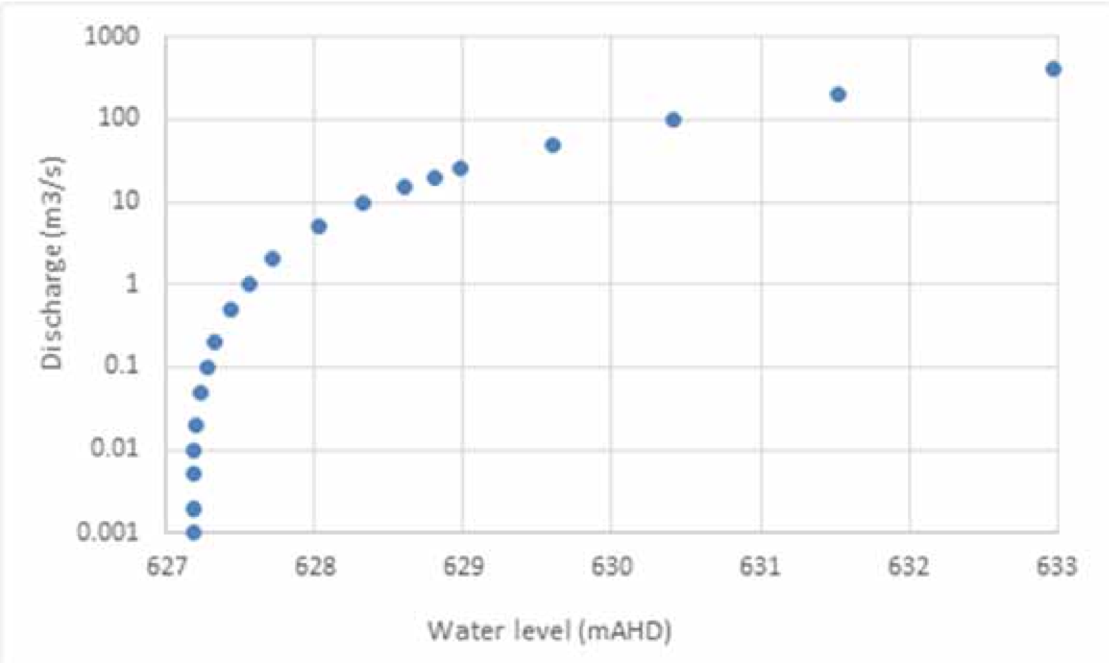
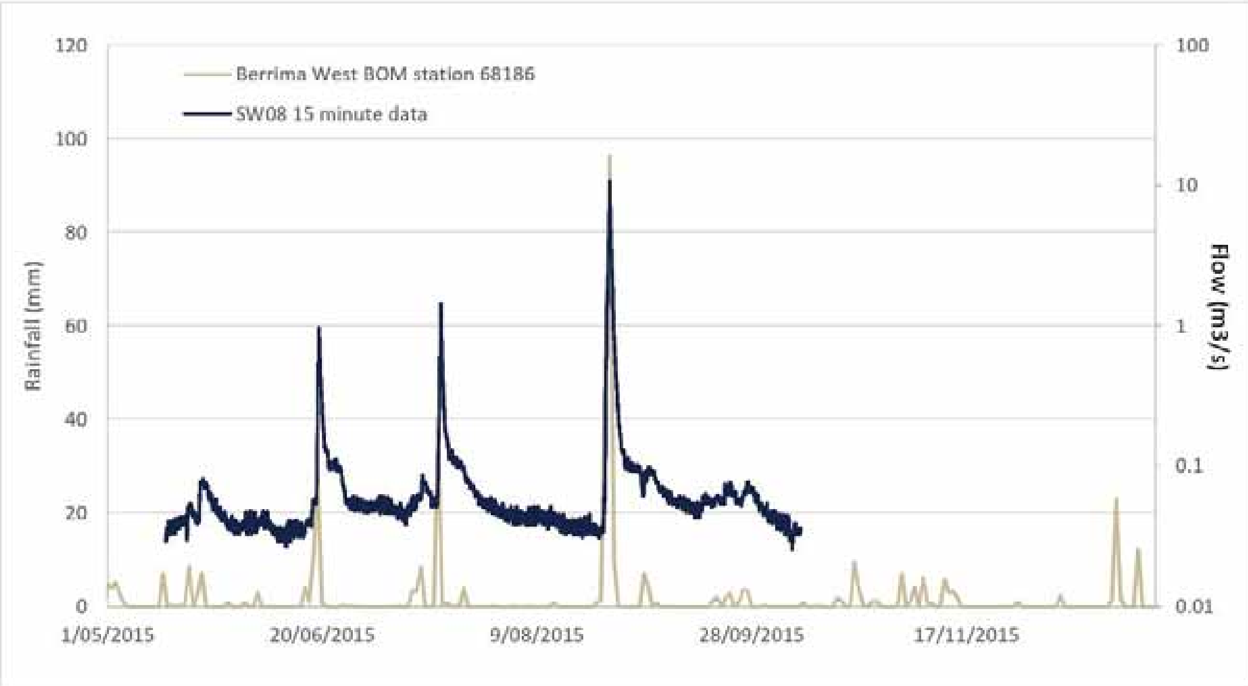


Figure 2.5 presents stream flow data for SW08. The hydrograph shows that Oldbury Creek is an ephemeral waterway.

The largest flow event occurred on 25 August 2015 and data from this event (along with the rainfall data discussed in Section 2.1.1.5) was used to calibrate the hydrologic model for Oldbury Creek.

Figure 2.5 Stream flow data at gauge SW08 on Oldbury Creek



2.1.2 Hydrologic modelling

Hydrologic modelling is the process of estimating runoff generated from rainfall on a catchment. The runoff estimates are then used by the hydraulic analysis, as described in Section 2.1.3. Factors affecting the volume and peak of runoff generated include:

- size and slope of the catchment and adjoining channels;
- level of development (fraction impervious) and type of catchment land use;
- condition of the catchment (dry or saturated) when the rainfall starts;
- intensity and temporal pattern of rainfall; and
- ability of the catchment and other features to store runoff.

Simple analytical methods exist for estimating the amount of runoff from a catchment (i.e. peak flow methods like the Probabilistic Rational Method [PRM]). However, a rainfall-runoff model is necessary to allow more accurate prediction of the response of large and complex catchments to rainfall over time, and the interaction between sub-catchments. For this assessment, hydrologic models of the Oldbury Creek and Stony Creek catchments were developed using the XP-RAFTS software program.

XP-RAFTS has been used extensively across NSW for urban and rural flood investigations. XP-RAFTS is an event-based hydrologic model that calculates flood hydrographs from either recorded storm rainfall hyetographs or design storm rainfall parameters. The catchment is represented in the model as a series of sub-catchments for which factors affecting runoff, such as land use (proportion of pervious versus impervious land surfaces), rainfall losses, and runoff routing through the catchment and channels, are defined.

Details of how XP-RAFTS was used to represent the Oldbury Creek and Stony Creek catchments are provided below. The models of the Oldbury Creek and Stony Creek catchments developed for this study were used to estimate flow generated from the catchment for the 5 year, 20 year and 100 year ARI and PMF design storm events to represent a reasonable range of extreme event flood conditions. The models estimated flow for the preferred option and alternate option (refer to Section 1.2) for the following scenarios:

- The existing scenario, which represents the current state of the Oldbury Creek and Stony Creek catchments based on LiDAR data collected on 25 October 2013.
- The operational scenario, which incorporates the proposed surface infrastructure for the project and associated mitigation measures. AutoCAD drawing (DWG) files of the proposed surface infrastructure were merged with LiDAR data to create the landform to be modelled.
- The rehabilitation scenario, which is the final landform at completion of the project. DWG files of the final landform were merged with LiDAR data to create the landform to be modelled.

Calibration of the Oldbury Creek model was undertaken and is described in Section 2.1.2.2.

2.1.2.1 Model set up

Separate hydrologic models were developed for the Oldbury Creek and Stony Creek catchments.

CATCHMENT AREA

The Oldbury Creek catchment was divided into 15 sub-catchments (refer to Figure 2.6) and the Stony Creek catchment was divided into 16 sub-catchments (refer to Figure 2.7) for greater definition of catchment parameters within the XP-RAFTS models.

Catchment parameters for the existing scenario, including sub-catchment area, percentage imperviousness, sub-catchment links and channel definition, were defined using the DTM and a review of aerial photography of the area. Operational three dimensional (3D) drawings and plans were used for the operational scenario and final landform 3D drawings and plans were used for the rehabilitation scenario along with LiDAR and aerial photography.

Catchment parameters adopted in the model are provided in Appendix A. The catchment parameters for the existing and rehabilitation scenarios are the same. Percentage impervious was increased for the operation case in sub-catchments OC6, OC7, OC8, SW08, SC8, SC10 and T4 where the proposed infrastructure is to be located, on the basis that the ballast and formation level components of the rail corridor will have similar characteristics to unsealed roads and will be more impervious than the current rural / agricultural land use.

MODEL PARAMETERS

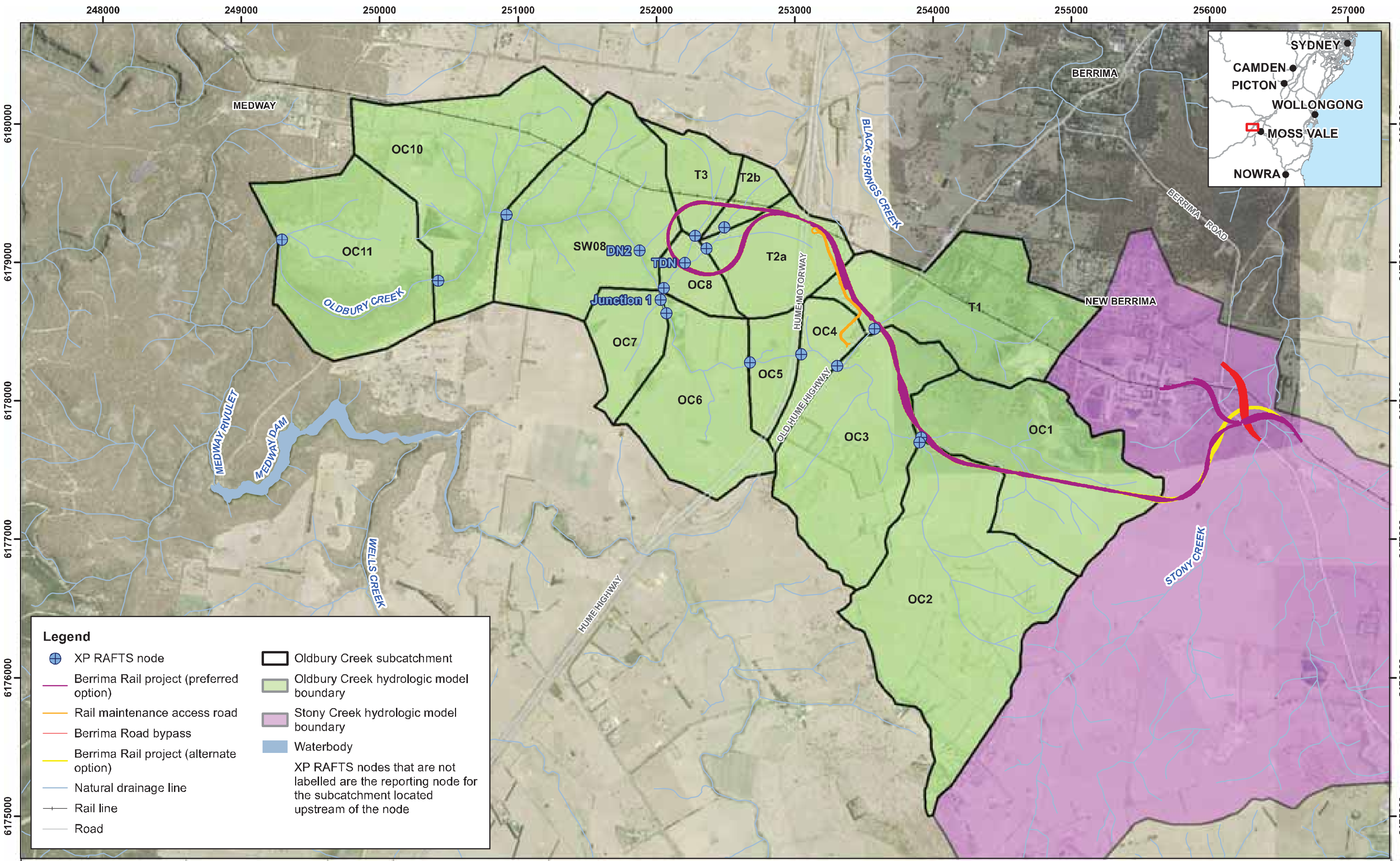
Initial loss and continuing loss refer to rainfall loss parameters which are input to the hydrologic model. Initially, rainfall losses adopted were in line with standard values; 2.5 mm/hr continuing loss rate and 20 mm initial loss.

The storage delay coefficient is another hydrologic model input parameter and was calculated for each sub-catchment using the average vectored slope of the catchment together with catchment area, percentage impervious, Manning's n value, loss rates and rainfall data. The average vectored slope of each sub-catchment was measured using the DTM.

Translation, or lagging of the hydrograph was applied to links within the models to represent the routing of flow through the stream network. The lag times were estimated by dividing the channel length, measured in GIS, by an estimated channel velocity. Channel velocity was estimated using the slope of the channel based on LiDAR and corresponding approximate velocity in AR&R (Engineers Australia 2001).

ESTIMATION OF DESIGN RAINFALL

Design rainfall hyetographs for storm events up to the 100 year ARI were generated in XP-RAFTS using the IFDs (refer to Section 2.1.1.3).



Map: 2200569A_GIS_022_A4	Author: RP
Date: 4/11/2016	Approved by: LR

Data source: NSW Land and Property Information 2015, Hume Coal

0 500 1,000 m

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Figure 2.6
XP-RAFTS model layout - Oldbury Creek

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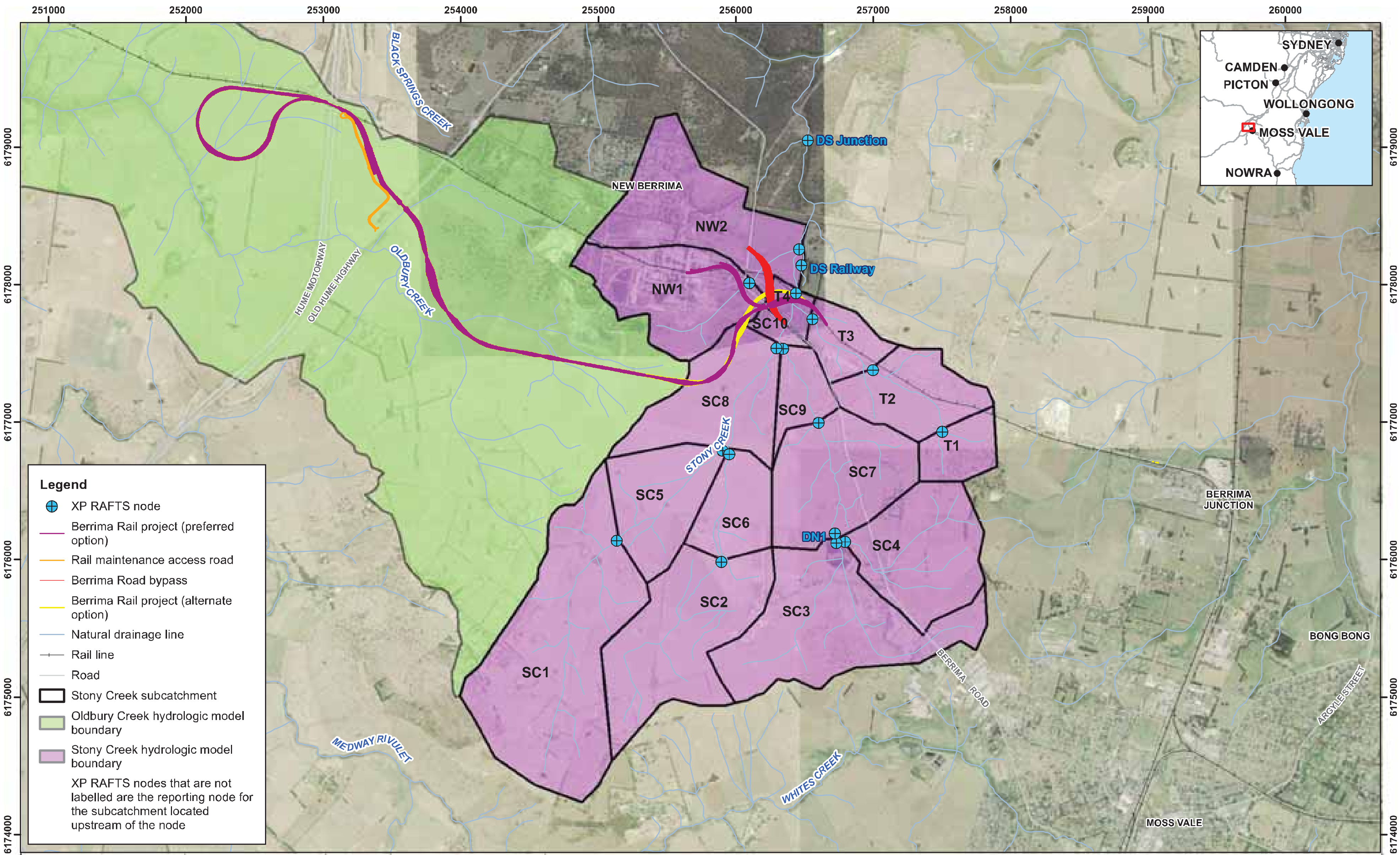

Map: 2200569A_GIS_019_A5

Author: RP

Date: 4/11/2016

Approved by: LR

Coordinate system: GDA 1994 MGA Zone 56

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Figure 2.7

XP-RAFTS model layout - Stony Creek

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PROBABLE MAXIMUM PRECIPITATION DESIGN RAINFALL

The parameters used in the PMP calculation for Oldbury Creek and Stony Creek are provided in Table 2.5 and the PMP rainfall depths are provided in Table 2.6. PMP rainfall depths were distributed into hyetographs using the GSDM temporal pattern for the 15 minute to 6 hour and the GSAM temporal pattern for the 24 hour to the 96 hour events. The GSDM temporal pattern was run for the 12 hour event. These rainfall hyetographs were used as input to the XP-RAFTS models for the PMP rainfall event.

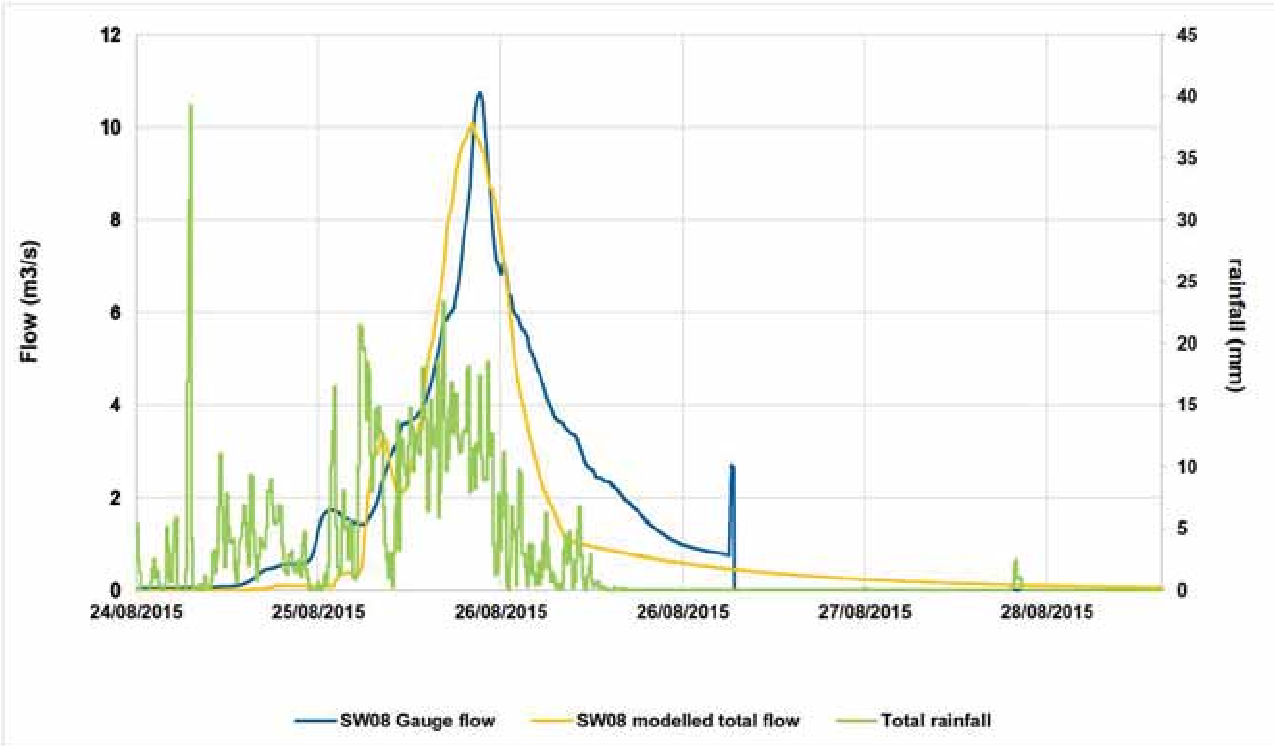
2.1.2.2 Model calibration and validation

Initial and continuing rainfall losses, catchment storage and B factor were determined during the calibration of the Oldbury Creek model. Values were adjusted within reasonable ranges based on values within AR&R (Engineers Australia 2001) until model calibration was achieved. Adopted loss and B factor values are given in Table 2.10 for both Oldbury Creek and Stony Creek. The results from the calibration are presented in Figure 2.8 which shows that the model achieved a good predictive estimate of the observed event.

Table 2.10 Adopted hydrological model loss and B factor values

XP-RAFTS input parameter	Values for 5, 20 and 100 year ARI events	Values for PMP
Initial loss (mm)	20	0
Continuing loss (mm/hr)	3.7	3.7
B factor	1.0	1.0

Figure 2.8 Oldbury Creek XP-RAFTS calibration result



A check of the hydrologic model was undertaken by comparing the model flow estimates against PRM calculations for the 5, 20 and 100 year ARI events for Oldbury Creek. The results are provided in Table 2.11 and show a reasonable agreement between the XP-RAFTS and PRM peak flow estimates.

Table 2.11 Comparison of peak flows predicted by XP-RAFTS and PRM for Oldbury Creek

Design event	XP-RAFTS simulated peak flow (m^3/s)	PRM estimated peak flow (m^3/s)	Difference (%)
5 year ARI	40.7	48.4	19%
20 year ARI	70.7	78.2	11%
100 year ARI	103.0	130.9	27%

2.1.2.3 Design event modelling

The Oldbury Creek and Stony Creek hydrologic models were run for the 5 year, 20 year and 100 year ARI and the PMP rainfall events for the existing, operation and rehabilitation scenarios. The 5 year, 20 year and 100 year events were run for durations of 15 minutes to 48 hours, and the PMF event was run for durations up to 96 hours, in order to determine the critical duration for each event.

Peak flows generated within the Oldbury Creek and Stony Creek catchments are presented in Tables 2.12 and 2.13 along with the critical duration identified for each return period. The critical duration for both creeks was 9 hours for events up to the 100 year ARI and 2.5 and 1.5 hours for the PMF for Oldbury Creek and Stony Creek respectively.

The flow values in the tables were input to the hydraulic model to assess changes in flood behaviour due to the proposed project infrastructure.

Table 2.12 XP-RAFTS design flows for Oldbury Creek

Model node	Peak flow (m^3/s)							
	Existing and rehabilitation scenarios				Operation scenario			
	5 year ARI (9 hr)	20 year ARI (9 hr)	100 year ARI (9 hr)	PMF (2.5 hr)	5 year ARI (9 hr)	20 year ARI (9 hr)	100 year ARI (9 hr)	PMF (2.5 hr)
OC2	9.3	14.2	19.6	166.1	9.3	14.2	19.6	166.1
T3	2.0	2.7	3.6	26.8	2.0	2.7	3.6	26.8
OC1	6.9	10.2	13.9	113.9	6.9	10.2	13.9	113.9
OC4	28.6	42.3	57.2	484.6	28.6	42.3	57.2	484.6
DN2	29.3	50.5	73.9	671.4	27.4	47.9	70.1	641.8
SW08	32.9	56.8	83.2	753.9	30.2	52.8	77.2	707.1
T2a	3.2	4.6	6.1	49.4	3.2	4.6	6.1	49.4
T DN	6.1	8.6	11.3	88.8	6.1	8.6	11.3	88.8
OC8	7.3	10.5	13.7	107.1	7.4	10.5	13.7	107.0
T2b	1.0	1.4	1.9	13.7	1.0	1.4	1.9	13.7
T1	5.1	7.7	10.3	86.3	5.1	7.7	10.3	86.3
OC7	2.3	3.3	4.3	33.6	1.2	1.6	2.1	16.1

Table 2.13 XP-RAFTS design flows for Stony Creek

Model node	Peak flow (m^3/s)							
	Existing and rehabilitation scenarios				Operation scenario			
	5 year ARI (9 hr)	20 year ARI (9 hr)	100 year ARI (9 hr)	PMF (1.5 hr)	5 year ARI (9 hr)	20 year ARI (9 hr)	100 year ARI (9 hr)	PMF (1.5 hr)
SC1	7.19	11.11	15.51	133.10	7.19	11.11	15.51	133.10
SC5+SC6	16.67	25.26	34.77	294.50	16.67	25.26	34.77	294.50
SC8+SC9	34.56	52.07	71.05	597.40	35.04	52.58	71.61	598.50
DS Railway	41.09	61.13	82.90	680.10	41.57	61.66	83.48	681.54
DN1	8.87	13.46	18.38	154.60	8.87	13.46	18.38	154.60
SC2	4.86	7.33	10.00	84.90	4.86	7.33	10.00	84.90
T4	6.53	9.27	12.20	98.00	6.54	9.28	12.21	98.00
Trib NW1*	10.42	20.40	27.90	151.96	10.42	20.40	27.90	151.96
Trib NW2*	13.36	27.57	43.58	267.00	13.36	27.57	43.58	267.00
DS Junction	51.50	75.30	101.30	819.80	51.50	75.30	101.30	819.80

* Critical duration is 2 hours for the 5, 20 and 100 year ARI events and 15 minutes for the PMF

2.1.3 Hydraulic modelling

HEC-RAS hydraulic models were developed for Oldbury Creek, Stony Creek and their tributaries to assess extreme flood levels in the project area.

HEC-RAS is a one dimensional (1D) hydraulic model that can simulate steady or unsteady flow in rivers and open channels. The river channel and floodplain is represented in HEC-RAS as a series of topographic cross-sections. The model can assess the effects of obstructions, such as bridges, culverts, weirs, and structures in the channel and floodplain.

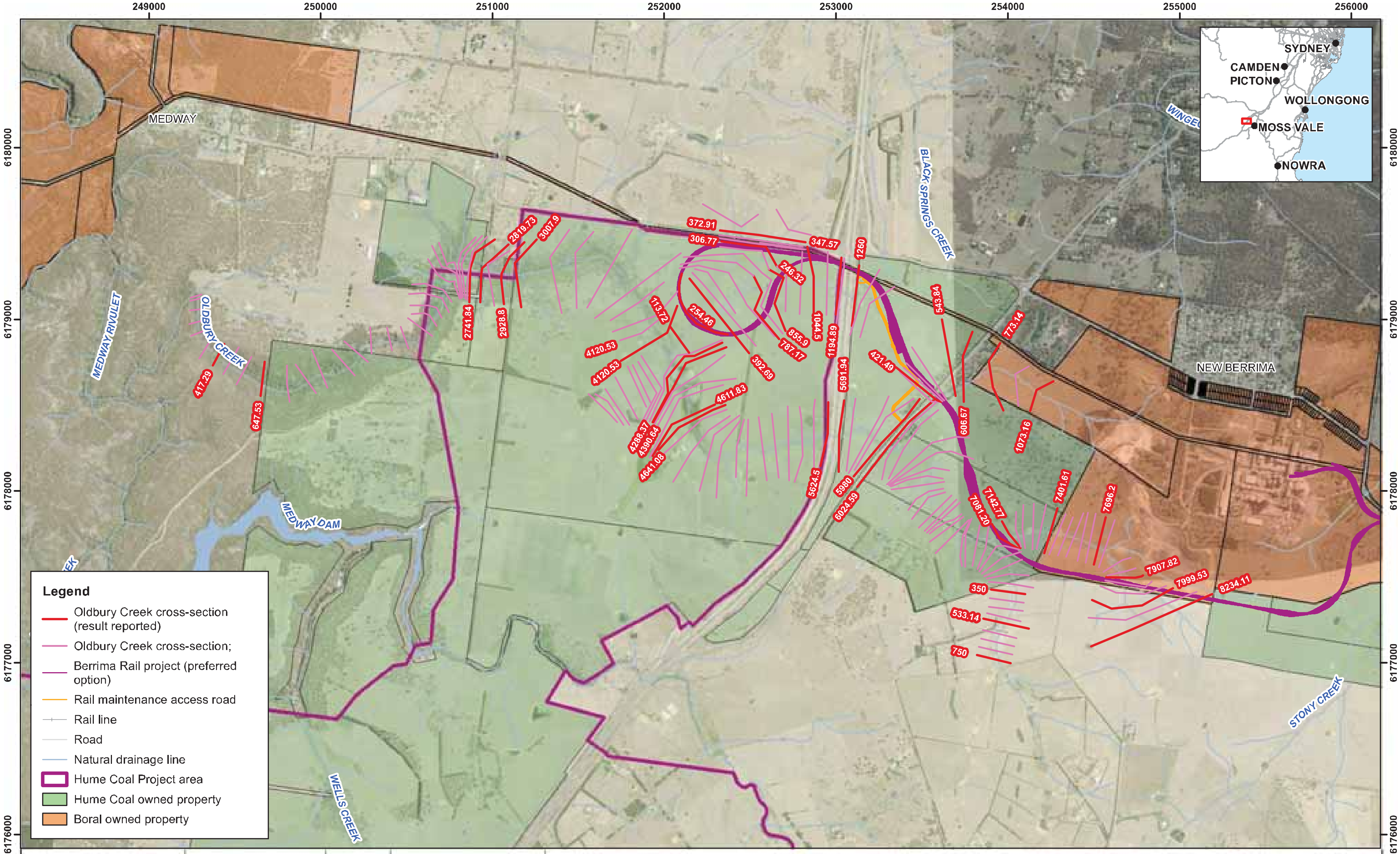
2.1.3.1 Model set-up

CROSS SECTION GEOMETRY DEVELOPMENT

A DTM covering the extent of the hydraulic model was constructed using LiDAR data from 25 October 2013 (refer to Section 2.1.1.1).

Cross-sections of the river channel and floodplain were extracted from the DTM approximately every 100 m along the length of Oldbury Creek, Stony Creek and minor tributaries. Cross sections were added to locations where there is hydraulic constraint such as road crossings to ensure all topographical features critical to hydraulic conveyance characteristics of the waterways are captured in the model. Cross-sections varied in length from about 300 m to 1500 m depending on the depth and size of the channel and width of floodplain. Figures 2.9, 2.10 and 2.11 show the modelled reaches and cross-sections.

Cross-sections at stream gauge SW08 were surveyed by MHL in 2015. Cross-section surveys were undertaken at the control and at the pool where the gauge is located. These cross-section surveys aim to measure low to medium flows, so their applicability to flood modelling is limited. However, the cross-sections at the surface water gauge location was added into the HEC-RAS model for Oldbury Creek to add more detail to the model for the development of rating curves and calibration of the hydrologic model (refer to Section 2.1.2.2).



Map: 2200569A_GIS_021_A6	Author: RP
Date: 14/11/2016	Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal

1:20,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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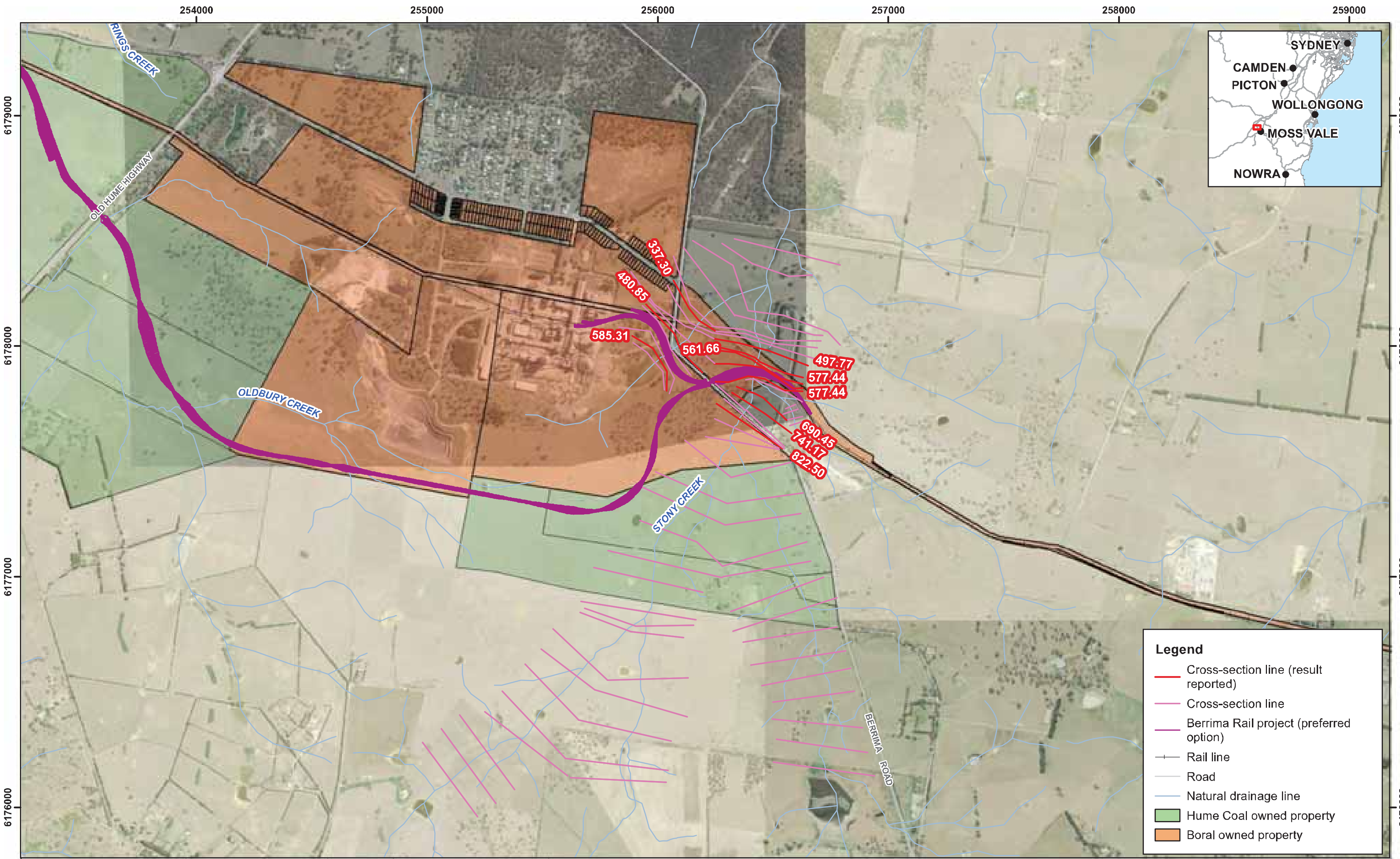
Figure 2.9

Oldbury Creek cross-sections



Map: 2200569A_GIS_025_A5	Author: RP	0 200 400 m 1:15,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 4/11/2016	Approved by: LR	

Data source: © Land and Property Information 2015, Hume Coal

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Figure 2.10
Stony Creek cross-sections (preferred option)

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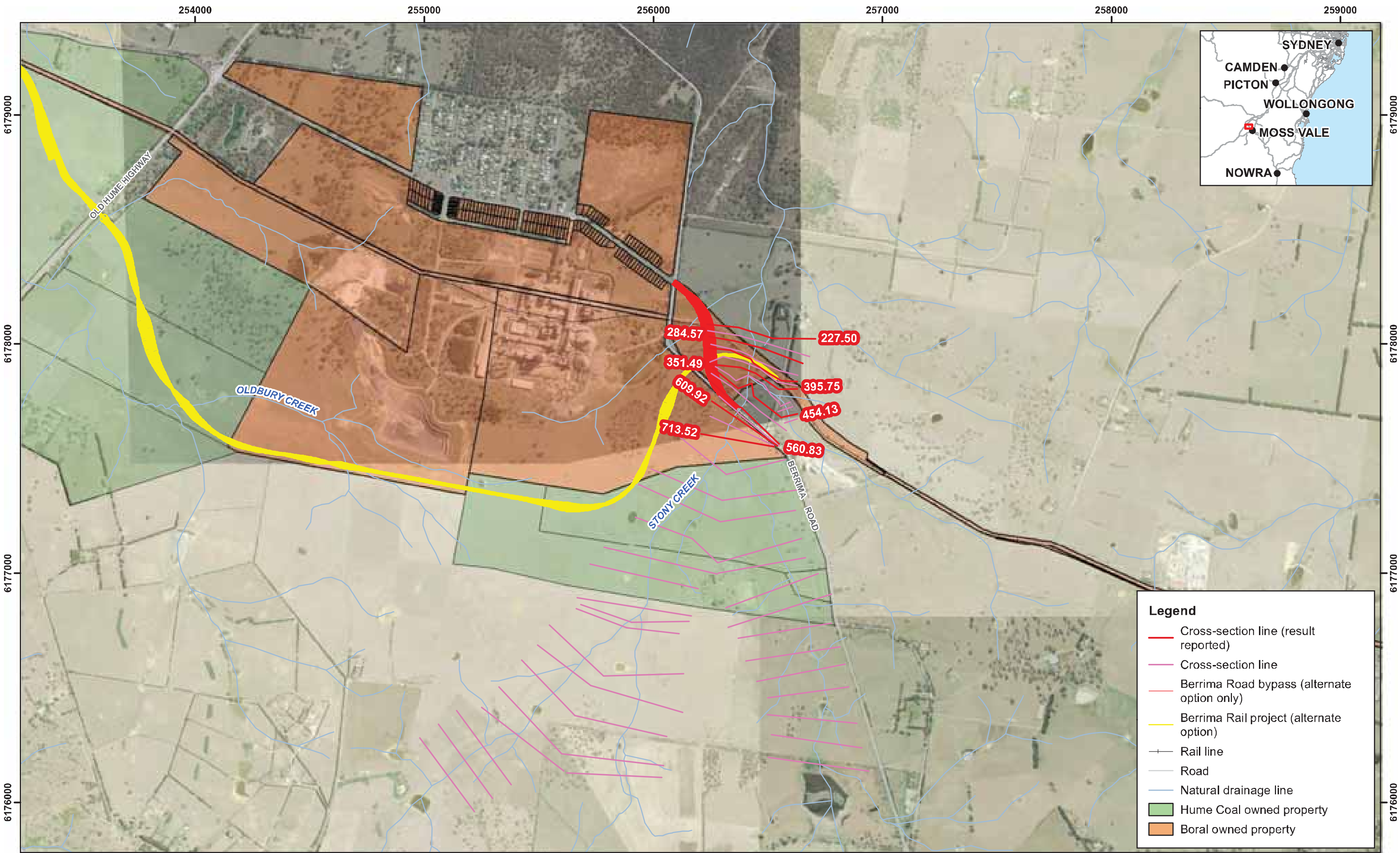

Map: 2200569A_GIS_018_A3	Author: RP
Date: 3/11/2016	Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal

0 200 400 m

1:15,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Figure 2.11

Stony Creek cross-sections (alternate option)

BOUNDARY CONDITIONS

Inflows were assigned to reaches of the hydraulic model for each stream/tributary, based on the flow outputs of the hydrologic model (refer to Tables 2.12 and 2.13).

Normal depth boundary conditions were applied at the downstream ends of the Oldbury Creek and Stony Creek models at locations sufficiently far downstream of the project area so that the effect of hydraulic change is fully realised within the modelled extent. Channel slopes of 0.07% and 0.08% were determined using the DTM for Oldbury Creek and Stony Creek respectively.

HYDRAULIC ROUGHNESS

Manning's *n* roughness parameters are used to represent the type of channel and varying land cover across a floodplain to allow the model to simulate changes in flow behaviour as water crosses different surfaces. Each cross-section is assigned Manning's *n* roughness values based on the channel characteristics and land cover across the floodplain. The Manning's *n* values adopted for the modelled channels and overbank sections were based on knowledge of the site developed during site inspections, aerial photograph interpretation and engineering judgement and experience.

The predominant Manning's *n* values adopted in the hydraulic models for the channel and overbank areas are given in Table 2.14 and are the same for the Oldbury Creek and Stony Creek models. In some sections more vegetation / trees were evident in the channel when compared to the cleared agricultural land in the adjacent overbank areas and in these cases the Manning's *n* value was set higher in the creek channel than in the overbank.

Table 2.14 Manning's *n* values used in HEC-RAS models

Location	Description	Manning's *n*
In channel	Eroded gully	0.035
	Grassed channel, clean and straight	0.035-0.04
	Grassed channel with some pools and shoals	0.04
	Channel with some vegetation	0.05
	Densely vegetated with deep pools	0.08
Overbank areas	Short grass	0.035
	Mature crop field	0.04
	Light bush and trees	0.05
	Dense vegetation/ trees	0.10

2.1.3.2 Modelled scenarios

Flood modelling was undertaken for the preferred and alternate options. For each option, the model was run for the 5, 20 and 100 year ARI events and the PMF for the following scenarios:

- The existing scenario, which represents the current state of the Oldbury Creek and Stony Creek catchments based on LiDAR data collected on 25 October 2013. For the alternate option, the existing scenario included the proposed Berrima Road Bypass without the road bridge.
- The operational scenario, which incorporates the proposed rail infrastructure and associated mitigation measures. DWG files of the proposed rail infrastructure were converted to Triangulated Irregular Network (TIN) files and merged with LiDAR data to create the landform to be modelled.

- The rehabilitation scenario, which is the proposed final landform at completion of the project. DWG files of the proposed final landform were converted to TIN files and merged with LiDAR data to create the landform to be modelled. For the preferred option, the rehabilitation scenario included the bridge over Stony Creek and the new access into the Boral Cement works. For the alternate option, the rehabilitation scenario included the proposed Berrima Road Bypass and road bridge.
- The cumulative operation scenario, which incorporates the proposed surface infrastructure for the Hume Coal project and the proposed infrastructure for the Berrima Rail project.
- The cumulative rehabilitation scenario, which incorporates the proposed final landform at completion of the Hume Coal Project and the proposed final landform at completion of the Berrima Rail Project.

In relation to construction, the proposed surface infrastructure is all located outside of the 1 in 100 year floodplain with the exception of the rail bridge / culvert crossings of the creeks. Management of the construction of the crossings with respect to flooding will be determined during detailed design when the construction method and staging for each structure is known and the outcomes and management measures, if required, will be documented in the Construction Environmental Management Plan.

2.1.3.3 Modelled structures

EXISTING

The HEC-RAS model for Oldbury Creek included the following existing structures:

- the two inline storages and associated embankments on Oldbury Creek downstream of the proposed rail infrastructure;
- the reinforced concrete box culvert (RCBC) located where the Hume Highway crosses Oldbury Creek downstream of the proposed rail infrastructure;
- the plank bridge located where the Old Hume Highway crosses Oldbury Creek downstream of the proposed rail infrastructure;
- the culverts located where Medway Road crosses the tributaries of Oldbury Creek north of the proposed rail loop;
- the culverts located where the old rail embankment near Medway Road crosses the tributaries of Oldbury Creek north of the proposed rail loop; and
- the culvert located where the Hume Highway crosses a tributary of Oldbury Creek to the east of the proposed rail loop.

The HEC-RAS model for Stony Creek included the following existing structures:

- the rail bridge over Stony Creek located approximately 150 m downstream of Berrima Road;
- the four cell RCBC located under Berrima Road to the south of the proposed rail infrastructure;
- the inline storage and associated embankments on the northwest tributary of Stony Creek;
- the single pipe culvert located under Berrima Road at the northwest tributary Stony Creek; and
- the single RCBC located under the existing rail line at the northwest tributary Stony Creek.

Details of these structures are provided in Appendix B.

PROPOSED

Proposed structures have been included in the HEC-RAS models for Oldbury Creek and Stony Creek. These structures will allow flow to pass through the proposed rail embankments and reduce flooding impacts on nearby land. The structures were designed to pass the 20 year ARI flow with afflux checked against the flooding assessment criteria (see section 2.1.4 below) up to the 100 year ARI event. The proposed structures included in the models are provided in Table 2.15.

Table 2.15 Proposed cross drainage structures

Waterway rail will cross	Crossing location	Design option	Proposed structure
Stony Creek	South of existing rail bridge crossing Stony Creek	Preferred	9 x 3600 mm x 3000 mm RCBC
Stony Creek	Immediately south of existing rail bridge crossing Stony Creek	Alternate	Duplication of existing bridge structure
Northwest tributary of Stony Creek	Downstream of Berrima Road	Preferred	7 x 2000 mm x 1500 mm RCBC
Overland flow path (flowing to tributary of Oldbury Creek)	Northern side of rail loop	Preferred and alternate	3 x 750 mm diameter pipe
Tributary of Oldbury Creek	South eastern side of rail loop	Preferred and alternate	2 x 1400 mm diameter pipe
Oldbury Creek	East of Old Hume Highway	Preferred and alternate	5 x 2000 mm x1200mm RCBC
Drainage depression alongside Hume Highway	Immediately east of Old Hume Highway	Preferred and alternate	4 x 1800 mm x 900 mm RCBC
Overland flow path (flowing to tributary of Oldbury Creek)	Eastern side of rail loop	Preferred and alternate	1400 mm diameter pipe
Oldbury Creek	South east of Berrima Cement Works	Preferred and alternate	5 x 2000 mm x1200mm RCBC

2.1.4 Assessment criteria

Acceptability criteria have been proposed for flooding events up to the 100 year ARI to ensure that the flooding impact is acceptable to land users adjacent to the project. In the absence of detailed flood assessment criteria in the SEARs the following criteria are proposed based on previous project experience:

- Buildings – less than 50 mm afflux if the building is already flooded and no new flooding of buildings not currently flooded due to proposed works is allowed unless owner's consent is obtained.
- Public roads/rail - less than 100 mm afflux if the road/rail is already flooded and no new flooding of public roads/rail that are not currently flooded.
- Private properties – less than 250 mm afflux.
- No increase in velocity above a threshold of 1.5 m/s, where existing conditions velocities are below the threshold. No more than a 10% increase in velocity where existing conditions velocities are above this threshold.

2.2 Existing environment

2.2.1 Oldbury Creek

The Oldbury Creek catchment used in this assessment covers an area of approximately 13.3 km^2. The downstream limit of the catchment is just upstream of the confluence with Medway Rivulet (see Figure 2.1). The creek flows in a westerly direction from its headwaters in New Berrima to its discharge into Medway Rivulet. Oldbury Creek's natural flow is impeded by several instream farm dams used for agricultural water supply. To the west of the Hume Highway, Oldbury Creek is confined by Hawkesbury Sandstone banks which form a steep gully. Land use within the catchment is predominantly cleared farm land for grazing with some irrigation. Urban areas are associated with Medway and New Berrima.

2.2.2 Stony Creek

The Stony Creek catchment used in this assessment covers an area of approximately 9.91 km^2. The downstream limit of the catchment is 200 m downstream of the confluence with the northwest tributary (see Figure 2.1). The creek flows in a northerly direction towards the Wingecarribee River. Land use within the catchment is predominantly cleared farm land for grazing with some irrigation.

2.3 Preferred option impact assessment

2.3.1 Flood extent

Figure 2.12 presents a comparison of the 100 year ARI flood extent for the existing and operation scenarios for the preferred option. Figures showing the 5 and 20 year ARI and PMF flood extents for the existing and operation scenarios are presented in Appendix C.

Figure 2.13 presents a comparison of the 100 year ARI flood extent for the existing and rehabilitation scenarios. Figures comparing the 5 and 20 year ARI and PMF flood extents for the existing and rehabilitation scenarios are presented in Appendix D.

Comparison of the 100 year ARI flood extents shows that changes in flood extent during operation of the rail infrastructure will occur:

- upstream of where the rail line crosses Oldbury Creek south west of Berrima Cement works;
- upstream of where the rail line crosses a tributary of Stony Creek to the east of the Berrima Cement works;
- just upstream of the Hume Highway on a tributary of Oldbury Creek; and
- in the vicinity of the rail loop.

The changes in flood extent all occur on land owned by Hume Coal or Boral. The increased flood extent upstream of the Hume Highway is minor.

The flooded land area for the 100 year ARI event for each scenario is as follows, indicating that the flood extent increases by around 7% during operation but reverts to close to existing conditions following rehabilitation:

- Existing: 137.6 ha
- Operation: 147.2 ha
- Rehabilitation: 136.2 ha

The increase in flood levels up to the PMF to the south west of Berrima Cement works has no impact on the works or the pit. The increase in flood levels up to the 100 year ARI east of the works has no impact on the works; however, the increase in the PMF level has the potential to impact on the dams east of the works in the upper reach of this tributary. These dams would be full and overtopped in the PMF so additional flooding under these conditions would result in more prolonged flooding rather than a significant increase in the dam failure risk.

A colony of Paddy's River Box trees exists within the rail loop that is reliant on surface water. The flood extent in this area is modified by the rail infrastructure, however, the dominant flow regime (i.e. normal flow to regular floods, e.g. up to the 2 year ARI flood) will be unchanged as the rail fill will have cross drainage culverts to maintain the existing flow paths and the cut sections will have diversion drains and turnouts to allow the regular flows and low order flood events to pass through the alignment. Refer to the Berrima Rail Project Biodiversity Assessment Report (EMM, 2016) for further details.

As shown in Figure 2.13, once the rail infrastructure is removed during rehabilitation, the flood extent in these areas will return to existing conditions, apart from just upstream of the Hume Highway where the minor increase in flood extent will remain and in the Stony Creek tributary east of the Berrima Cement works where the rail access to the works will be retained.

2.3.2 Flood levels

Afflux results for Oldbury Creek are presented in Table 2.16. Results are presented for the cross-sections shown in red on Figure 2.9. Afflux results for Stony Creek are presented in Table 2.17. Results are presented for the cross-sections shown in red on Figure 2.10. The cross-sections target key areas of interest including privately owned land, locations where existing roads cross streams and locations where new infrastructure is proposed to cross streams.

Afflux results are presented for the operation and rehabilitation cases. The results are the difference between the flood levels under the operational or rehabilitation and existing cases. In some areas negative afflux values are predicted where the rail line results in minor diversion of flows or downstream of the rail embankment where the rail line has a positive afflux impact on the upstream side of the embankment and a negative afflux impact downstream.

Tables 2.16 and 2.17 show generally minor afflux impacts. Comparison to the acceptability criteria for flooding events up to 100 year ARI for the operation and rehabilitation scenarios indicates the following:

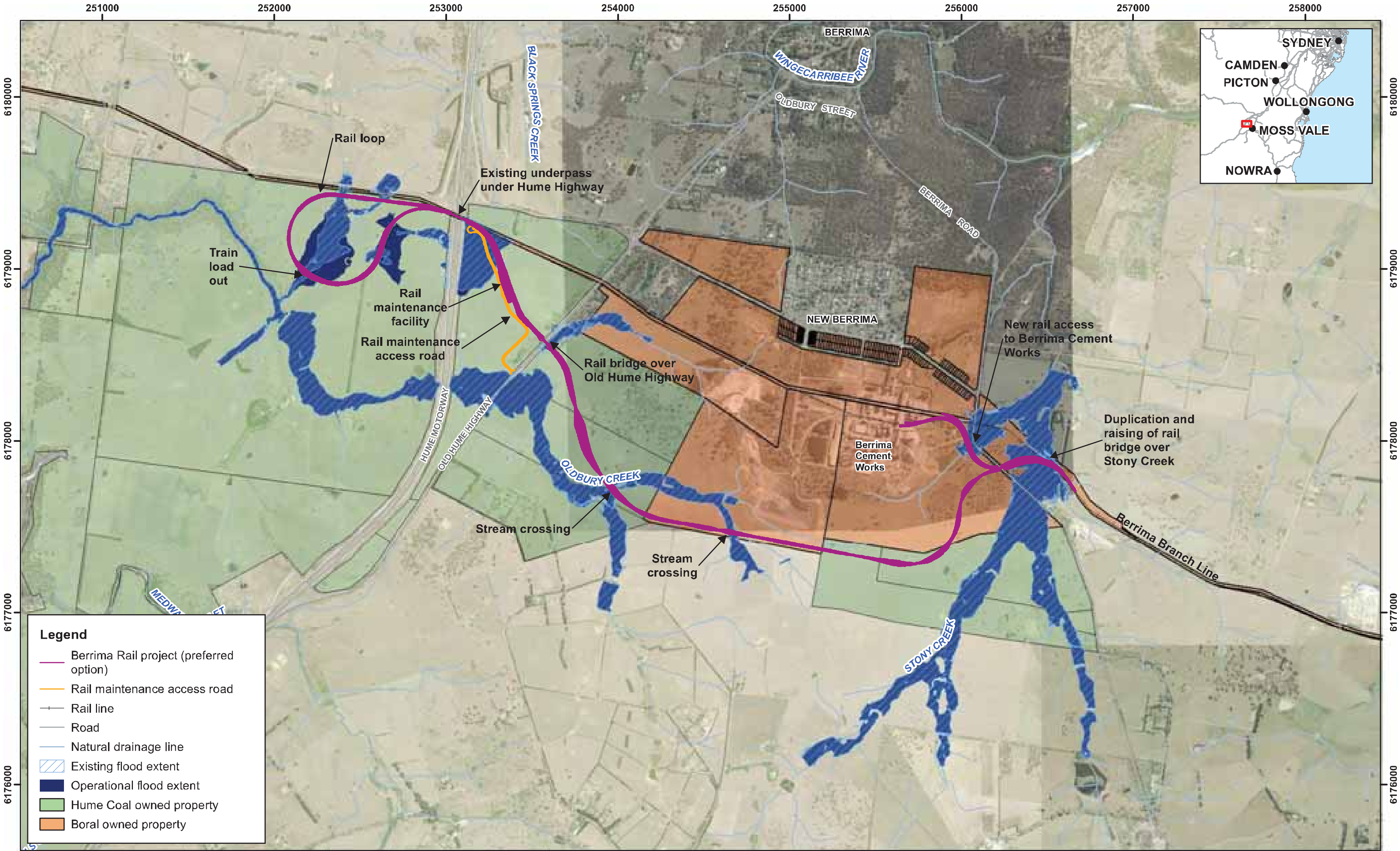
- Buildings – there are no buildings located within the flood extents
- Public roads/rail – predicted afflux will generally be less than 100 mm. The afflux at Oldbury Creek cross-section 421.49, which is just downstream of the bridge, exceeds the proposed acceptable limit, however this impact is localised and the water level is lower than the Old Hume Highway road level in all modelled events.
- Private properties – most land located along the Berrima Rail alignment is owned by Hume Coal or Boral. Predicted afflux at private properties downstream is within the acceptability criteria (less than 250 mm).
- Berrima Cement works – as identified in the previous section, in the tributary to the east of the works the rail access into the works causes afflux that exceeds the acceptability criteria for the 20 year and 100 year ARI events (see cross section 585.31 in Table 2.17). This afflux remains for the rehabilitation scenario as the rail infrastructure is retained. The afflux up to the 100 year ARI event will have no impact on the works or the dams to the east of the works. For the PMF the afflux has the potential to impact on the dams. As these dams would be full and overtopped in the PMF, any additional flooding under these conditions would result in more prolonged flooding rather than a significant increase in the dam failure risk.

2.3.3 Flood velocities

Infrastructure crossing streams, including bridges and culverts, has the potential to change the velocity of stream flow local to the infrastructure. An increase in the velocity of stream flow can cause erosion and scour of bed sediments and impact on surface water quality and the stability of instream structures. Peak velocities downstream of the new infrastructure crossing streams in the project area (see Table 2.15) are presented in Table 2.18. Note that in some cases the PMF velocity is reduced downstream of the structures due to backing up of flow behind the rail embankment.

The project will not include any structures that pose significant obstruction to or constriction of flood flows. Peak velocities are expected to increase immediately downstream of culverts and scour protection measures will need to be implemented. Scour protection should be provided upstream and downstream of structures to protect against erosion of the channel due to local changes in velocity at the inlets and outlets of the structures.

Changes in peak velocity downstream of the new infrastructure are generally within the range +/- 0.8 m/s. Higher velocity changes are predicted at culvert outlets on Oldbury Creek at cross section 7081.2 and on the Oldbury Creek Tributary at cross section 113.72; however, the Table 2.18 shows that these velocity changes reduce downstream of the culvert outlets and the velocity changes can therefore be managed locally at the outlets. The velocity increases at these locations exceed the acceptability criterion, but these exceedances are local to the culvert outlets and can be managed through appropriate energy dissipating structures. At detailed design opportunities to reduce pipe and/or channel grades at the inlet and outlet of the structures should be investigated to reduce the high velocities at these locations.



Map: 2200569A_GIS_014_A7	Author: RP
Date: 14/11/2016	Approved by: - LR

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0 250 500 m

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Coordinate system: GDA 1994 MGA Zone 56

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Figure 2.12

100 Year ARI flood extent - Operation (preferred option)