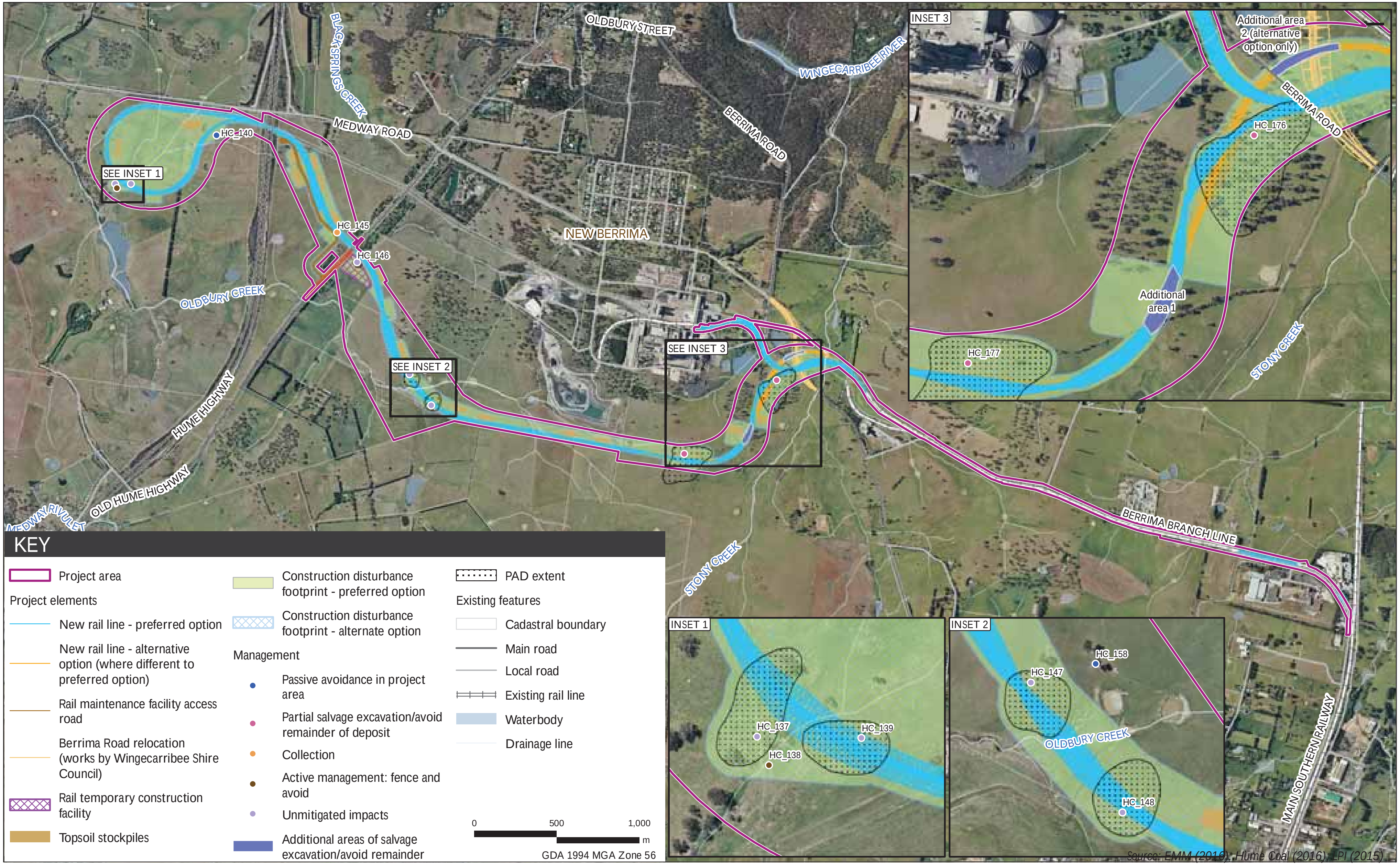

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Aboriginal site management - project preferred and alternative options

Berrima Rail Project

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Figure 10.10

EMM HUMECOAL

Table 10.7 Site management summary

Site Name	Property	Site type	Significance rating	Impact type	Level of impact	Consequence of impact	Management measure
HC_137	Mereworth	Subsurface artefact deposit	Low	Rail loop	Partial loss	Partial loss of value	Unmitigated impacts
HC_138	Mereworth	Grinding grooves	Moderate	None	None	None	Active management: fence and avoid
HC_139	Mereworth	Subsurface artefact deposit	Low	Rail loop/Overland conveyor	Partial loss	Partial loss of value	Unmitigated impacts
HC_140	Mereworth	Not a PAD	Low	None	None	None	Passive management: avoidance
HC_145	Mereworth	Isolated find	Low	Rail line	Total loss	Total loss of value	Collection
HC_146	Stonington	PAD	Low	Temporary accommodation	Total loss	Total loss of value	Unmitigated impacts
HC_147	Stonington	Subsurface artefact deposit	Low	Rail line	Partial loss	Partial loss of value	Unmitigated impacts
HC_148	Stonington	Subsurface artefact deposit	Low	Rail line	Partial loss	Partial loss of value	Unmitigated impacts
HC_158	Stonington	Potential scar tree	Low	None	None	None	Passive management: avoidance
HC_176	Boral Land	Subsurface artefact deposit	Higher moderate	Rail line	Partial loss	Partial loss of value	Partial salvage excavation/ avoid remaining deposit
HC_177	Leets Vale	PAD	Higher moderate	Rail line	Partial loss	Partial loss of value	Partial salvage excavation/ avoid remaining deposit

10.7.4 Special procedures

i Aboriginal ancestral remains

In the event that known or suspected human skeletal remains are encountered during construction, the following procedure will be followed as soon as the suspected remains are discovered:

- in the immediate-term all work in the vicinity will cease and the find will be reported to the work supervisor who will advise the site supervisor or other nominated senior staff member;
- the site supervisor or other nominated senior staff member will promptly notify the police and the state coroner (required for human remains discoveries);
- the site supervisor or other nominated senior staff member will contact OEH for advice on identification of the skeletal material as Aboriginal and management of the material; and
- if it is determined that the skeletal material is Aboriginal ancestral remains, the RAPs will be contacted and consultative arrangements will be made to discuss ongoing care or reinterment of the remains.

ii Aboriginal keeping place

RAPs have expressed that the objects recovered from the project area should be kept by an Aboriginal organisation. Yamanda Aboriginal Association requested to be the custodians of the recovered artefacts which will be confirmed during the development of the ACHMP. This would involve applying for a care agreement with OEH for transferring the objects to Yamanda for safekeeping. The facility for the recovered objects will be determined during the development of the ACHMP.

iii Discovery of new Aboriginal sites in the project area

In the event of the discovery of new Aboriginal sites in the project area, all construction work in the vicinity will halt and an archaeologist and the RAPs will be contacted to determine the significance of the object(s). Any new sites will be registered on the AHIMS database. Objects will be managed in a manner consistent with the measures outlined above and finalised in the ACHMP, including appropriate forms of salvage collection.

10.8 Conclusion

The archaeological landscape can be considered in relation to the two catchments that it traverses: the Oldbury Creek catchment in the western part of the project area and the Stony Creek catchment in the eastern part. Both areas are established farmland which has been generally cleared and ploughed with the exception of a few isolated pockets of remnant or regrowth native vegetation.

In the Oldbury Creek catchment of the project area, the project will impact sites assessed to be of low archaeological significance. These sites have sparse assemblages and moderately disturbed contexts which results in low research potential. Furthermore, the mapped areas of archaeological sensitivity suggest that linear tracts of land with very low to negligible artefact densities will be impacted by the project. Overall, the project impacts in the Oldbury Creek catchment will not result in a significant loss to the archaeological resource and further archaeological investigation in these areas is considered unwarranted.

In the Stony Creek catchment, the project will impact linear tracts of sites assessed to be of higher moderate significance. These lack the archaeological integrity to be considered of high significance but are likely to contain a good representative sample of stone artefacts that warrant salvage above the other sites in the project area. With the implementation of management measures, a sample of the archaeological resource can be retrieved to mitigate this loss. As the impacts are confined to the rail corridor, most of the archaeological resource will remain on the land surrounding the project footprint.

The project has been designed as far as possible to avoid areas of archaeological sensitivity. This combined with the large undisturbed areas in the surrounding region containing comparable archaeological sites the cumulative impact of the project is very low given the general richness of the archaeological landscape and the amount of ground disturbance required for the rail infrastructure.

11 Historic heritage

11.1 Introduction

This chapter provides a summary of the historic heritage assessment and statement of heritage impact (SOHI) prepared for the project, which is provided in full in Appendix I. It describes the historical context in and surrounding the project area, outlines heritage items identified in and surrounding the project area, and assesses the potential impact of the project on historic heritage.

The project area includes a property that is listed in Schedule 5 of the Wingecarribee LEP (LEP 2010: I351). The listing in the schedule describes the item as "Mereworth" house and garden, and is of local heritage significance. The significant components of the Mereworth property, being the house and garden, comprise a small part of the overall property and are not within the project area. A number of other registered heritage sites are in proximity to the project area but will not be physically or visually affected by the project.

Two unlisted historic items were identified in the project area: an old railway bridge and rail alignment recorded during field survey; and the Boral Cement Works garden on Berrima Road, which was designed by Paul Sorensen. The railway bridge will be removed and some of the garden will be removed under the preferred route.

11.1.1 Assessment guidelines and requirements

The historic heritage assessment was conducted using the principles of *The Australian International Council on Monuments and Sites, Charter for Places of Cultural Significance* (also known as the *Burra Charter,* Australia ICOMOS 2013) and the NSW *Heritage Manual* (Heritage Office 1996 and 2006).

OEH provides other leading practice guides which informed the assessment including:

- *Statements of Heritage Impact* (NSW Heritage Office and Department of Urban Affairs & Planning 2002);
- *Investigating Heritage Significance* (NSW Heritage Office 2004); and
- *Assessing Significance for Historical Archaeological Sites and 'Relics'* (Heritage Branch Department of Planning 2009).

This assessment has also been prepared in accordance with the SEARs issued for the project (refer to Appendix B). Table 11.1 lists the individual requirements relevant to the historic heritage assessment and identifies where they are addressed.

Table 11.1 Historic heritage - relevant SEARS

Requirement	Section addressed
Heritage - including an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development, having regard to OEH's requirements	Chapter 10 covers matters relating to Aboriginal cultural heritage. This chapter covers matters relating to historic heritage.

To inform the preparation of the SEARs, DP&E invited other government agencies to recommend matters to address in the EIS. OEH raised matters relevant to this assessment of heritage impact, which are listed in Table 11.2.

Table 11.2 Historic heritage - OEH's environmental assessment recommendations

Office of Environment and Heritage	Where addressed
The EIS must provide a heritage assessment including but not limited to an assessment of impacts to *State* and *local heritage* including conservation areas, natural heritage areas, places of Aboriginal heritage value, buildings, works, relics, gardens, landscapes, views, trees should be assessed. Where impacts to state or locally significant heritage items are identified, the assessment shall:	All of these aspects related to heritage are addressed in this chapter except for Aboriginal values, which are addressed in Chapter 10.
a. outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures) generally consistent with the NSW Heritage Manual (1996),	Section 11.7
b. be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria),	This report has been prepared by a suitably qualified heritage consultant – Pamela Kottaras BA (Hons).
c. include a statement of heritage impact for all heritage items (including significance assessment),	Section 11.6
d. consider impacts including, but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, landscape and vistas, and architectural noise treatment (as relevant), and	Section 11.6
e. where potential archaeological impacts have been identified develop an appropriate archaeological assessment methodology, including research design, to guide physical archaeological test excavations (terrestrial and maritime as relevant) and include the results of these test excavations.	Areas of historical archaeological sensitivity have been identified within the project area. Management measures are described in Section 11.7.

In accordance with the SEARS, the objectives of the historic heritage assessment were to:

- to investigate the potential for items of heritage value, including relics, to exist in the project area;
- to assess the significance of historic heritage items in the project area;
- to assess the potential impacts of the project on items of historic heritage in the project area; and
- to formulate management measures for the protection of historic heritage items in the project area.

11.2 Assessment method

A number of assessment methods were used in the historic heritage assessment including searches of statutory and non-statutory registers, primary and secondary research, and field survey.

Registers were searched online as listed below:

- Statutory:
  - The National Heritage List (NHL). This register is made under the EPBC Act;
  - The Commonwealth Heritage List (CHL). This register is also made under the EPBC Act;
  - The State Heritage Register (SHR). This register is made under Part 3A of the Heritage Act;
  - The Heritage and Conservation Register (s170 register). This register is made under Section 170 of the Heritage Act;
  - Schedule 5 of the Wingecarribee LEP. Division 4 of the EP&A Act includes provision for the making of LEPs by the Minister; and
  - The State Heritage Inventory (SHI), which was cross-checked with Schedule 5 of the Wingecarribee LEP and the s170 register. The SHI is not a single statutory register but a central collection of heritage items listed on statutory instruments. The SHI is maintained by the Heritage Division of OEH.
- Non-statutory:
  - National Trust of Australia, NSW (NT); and
  - Register of the National Estate (RNE). The RNE is an archived list of heritage items that were protected under the repealed *Australian Heritage Commission Act 1975*, which was replaced by the EPBC Act.

Primary research was undertaken by investigating archives that may hold original material which included Paul Sorensen's field books/diaries, newspaper articles, photographs, land titles information, maps, plans, sketches, and current and historic aerial photography.

Secondary research was conducted using published material such as books, journals and interpretive material, as well as unpublished sources such as university theses. Information was also obtained from people local to the area, which led to further research. The references section in Appendix I contains citations for all sources used.

Field survey for both the historic heritage and Aboriginal heritage assessments were completed on various dates in 2014 and 2015. Targeted field surveys for historical and Aboriginal heritage were completed on 25 – 27 March 2015 during which the project area was walked and recorded. Targeted field surveys of nearby historic heritage sites was undertaken in locations where access was permitted. This included the Mereworth property, in particular the house and gardens, and the paddocks on which project infrastructure is proposed. The Boral Cement Works garden was inspected on 17 November 2016. Other heritage items were viewed from the public domain where possible.

11.3 Historical background

The earliest colonial presence in the Southern Highlands dates back to 1798 when several explorers visited the area near the Wingecarribee River (Jervis 1986). However, it was not until 1864 that settlement in the region began in earnest. Early settlers in the area included John Atkinson who arrived in the region in 1822 and established a home, which he called Mereworth. The house that now stands on a ridge on the Mereworth property was built in 1964 by John Amory and is surrounded by a dense, mature garden designed by Paul Sorensen. Somewhere within the curtilage of the residence and surrounding buildings is likely to be the remains of John Atkinson's second home.

The region was initially commercially exploited for coal in the 1850s with a small mine opening at Black Bobs Creek to supply the Fitzroy Ironworks at Mittagong. Mining commenced in the Medway area, on the banks of the Medway Rivulet, in 1867 at the Cataract Mine. This closed in the early 1870s, re-opened in 1874 and the closed again in the late 1870s.

A mine was opened at Medway in 1880 by James John Atkinson (son of James Atkinson who built Oldbury). It primarily supplied coal to the NSW Railways for their steam locomotives. The company became official on 31 March 1881, when an act called "The Berrima Coal-mining and Railway Company (Limited)" was created so that a railway from the Berrima Coal mine to the Great Southern Railway near Moss Vale could be built. The rail line was built on a standard gauge and connected the coal mine at a gorge of the Wingecarribee River to the Government rail line at Bong Bong. The formal opening of the Berrima coal mine and railway took place in March the following year (SMH 2 March, 1882 p.6).

During the 1920s, three new mines opened in the West Berrima area (now Medway). The Loch Catherine Colliery (1923), the Flying Fox Mine and the Medway Colliery. The Medway Colliery was opened in 1924 by Arnold Stanley "Stan" Taylor with the coal used mainly for his cement works. The village of Medway is a result of the Medway mine and railway (refer Government Gazette 19 February, 1932, p. 729).

Taylor was a local industrialist – his first company was Australian Blue Metal Quarries Pty Ltd established at the base of Mount Gingenbullen, which was serviced by a short rail line that joined the Berrima rail line and then the Southern Railway at Berrima Junction (Southern Highland News 30 July 2012). The branch line ran from a siding on the Southern Portland Cement Railway line and turned south to the quarry. Even though it only operated for a few years and was largely dismantled in 1942 (Matthews 1959, p.23), the alignment is visible on the 1949 aerial photograph (Photograph 11.7) as well as current aerial photography.

The onset of the Great Depression (October 1929-1939) forced Taylor to sell the Southern Portland Company Limited to Southern Portland Cement Limited, headed by (Sir) Cecil Hoskins, which also bought the Medway Colliery and Railroad Company (SMH 17 December 1972, p. 19). The Broken Hill Proprietary Company (BHP) acquired Southern Portland Cement Limited in 1935 as a result of a financing arrangement (Ozark 2015, p. 11), with Cecil Hoskings remaining as chair until the 1950s (SHN 20 May, 2010 online).

The company was then purchased by Blue Circle Southern in 1974, which was an amalgamation of a number of Australian cement companies (including Portland Cement) in a joint venture between BHP and United Kingdom Company Blue Circle. Blue Circle Southern was sold to Boral Limited in 1988.

Berrima Colliery (also known as Medway Colliery) was the primary source of fuel for the kilns at Berrima Cement Works until its closure in 2013. Until the 1960s, pit ponies hauled coal from the coal face to a clipping where it was transported out on a rope skip way over the river by bridge and up to the railhead. The mine became mechanised in 1968 when modern mining machinery, conveyor belts and electrically hauled cable shuttle cars were introduced. As a result, it was reported that mechanisation replaced 60 men and 36 horses (SHN, 6 November 2013). Transportation of coal switched from rail to road. The closure of Berrima Colliery, formerly Medway Colliery, was announced in 2014 after initially halting production in 2013.

Railways were an essential part of the development of towns and industry in the region and followed the establishment of industry. The original Picton to Mittagong section of the Main Southern Railway opened in January 1867. By 1915 a deviation had been approved and the new double rail line, with its improved gradient, required far fewer engines and represented a significant improvement in efficiency. The development of the railway was facilitated by the mining of coal which provided a fuel source for the locomotives, as well as for domestic heating and cooking within the settlements.

With a trend in greening industrial sites beginning in the twentieth century, one of the industrialist families in the area, the Hoskins family, engaged Paul Sorensen to design and plant gardens in their private residences and commercial establishments. Sorensen, a Danish immigrant, was a landscape architect who was active in the Southern Highlands and designed a large number of gardens in NSW. His focus was on the Blue Mountains where he established a nursery, the Illawarra and the Southern Highlands. In addition to designing residential gardens, Sorensen played a role in the beautification of industrial and public sites. The former Australian Iron & Steel Co (established 1928, later BHP), the former Southern Portland Cement Company (now Boral Cement), New Berrima, and the Remembrance Driveway plantation on the Old Hume Highway south of Berrima are three of Sorensen's designs.

Industrial gardens in Australia followed a trend set in Britain at the end of WWI. This trend moved toward improving workers' productivity and health by organising spaces around factories to achieve this. The idea of industrial gardens in NSW gained momentum around the time that Sorensen was designing factory landscapes for the Hoskins.

The concept of planting trees as road memorials originated in Great Britain in 1918 as a way to transform existing highways "to the dignity of Roads of Remembrance adorned with trees" (Remembrance Driveway Committee Inc.). While the concept did not take off in Great Britain, it was adopted by Australia and Canada. The Hume Highway forms part of a larger road of remembrance that starts in Macquarie Place in Sydney and ends at the Australian War Memorial in the Australian Capital Territory.

11.4 Existing environment

11.4.1 Overview

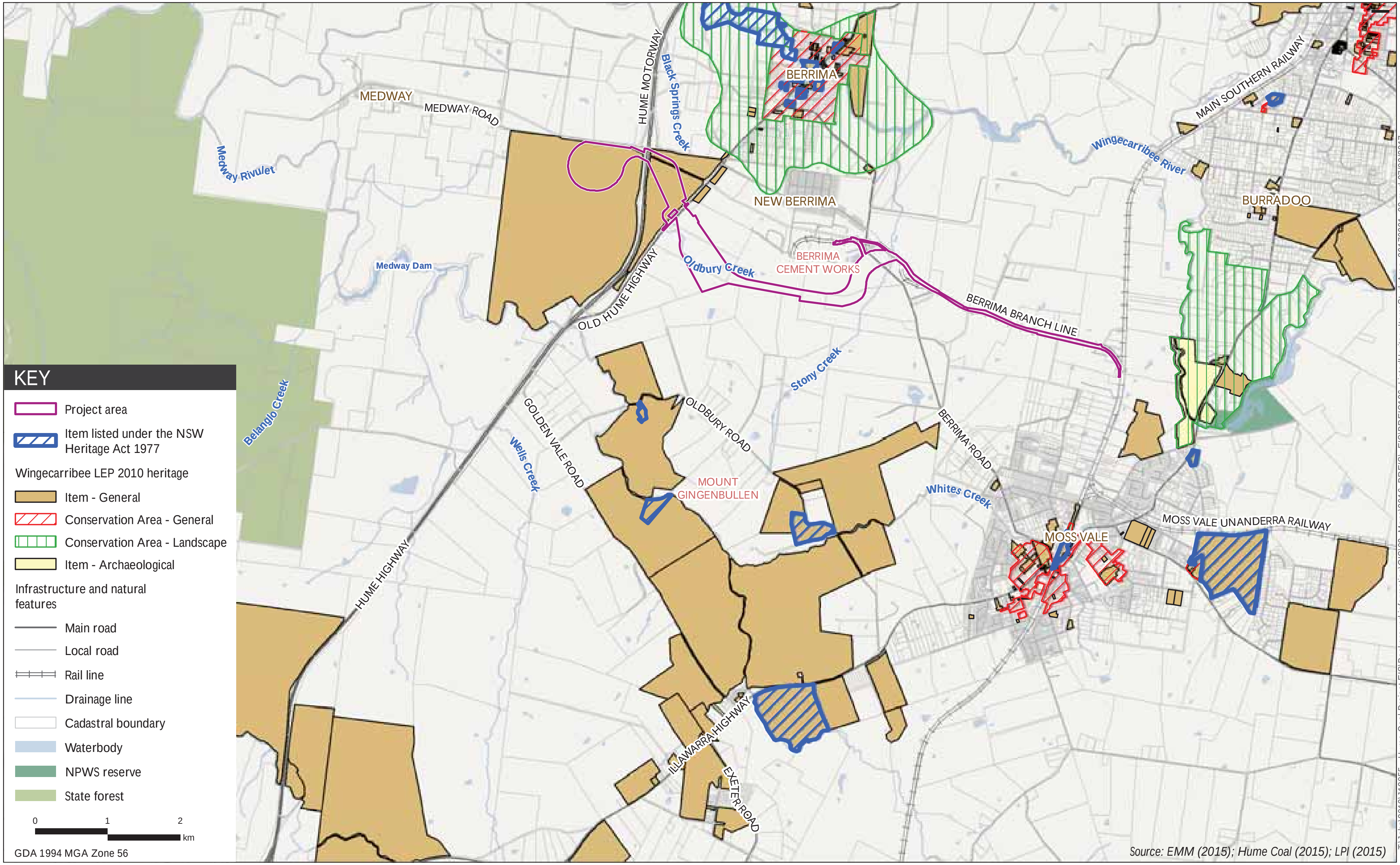
The project area includes a property that is listed in Schedule 5 of the Wingecarribee LEP (LEP 2010: I351). The listing in the schedule describes the item as "Mereworth" house and garden, and is of local significance. The broader Mereworth property covers Lot 100 DP 839316 and Lot 200 DP 839314 and is owned by Hume Coal. A more detailed assessment was undertaken as part of the SOHI, finding that the areas of heritage value at "Mereworth" are the house and garden itself (refer to Section 11.5), which are not within the project area.

Other registered heritage sites in the general area surrounding the project area (as shown in Figure 11.1) include Austermere House and Grounds (I398), the Berrima Landscape Conservation Area (C1843) and the Burradoo Landscape Conservation Area (C1834) which includes Bong Bong Common (A1191); the site of the 1820 township of Bong Bong.

Austermere House is approximately 720 m south-east of the eastern-most extent of the project area at Berrima Junction and is well screened from it by trees and plantings. Bong Bong Common and the Burradoo Landscape Conservation Area are to the east and north-east of Berrima Junction, approximately 1.5 km away. The edge of the Berrima Landscape Conservation Area is approximately 900 m north of the project area at its closest point.

Two unlisted historic items were identified in the project area: an old railway bridge (Photograph 11.9) recorded during field survey; and the Boral Cement Works garden on Berrima Road, which was designed by Paul Sorensen. The former Berrima Coal rail corridor also traverses the project area.

Figure 11.1 illustrates the regional historic heritage context in and surrounding the project area. Figure 11.2 shows the listed and newly identified historic heritage items in the area. These heritage items are described further in the sub-sections below.



Regional historical heritage context

Berrima Rail Project

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Figure 11.1

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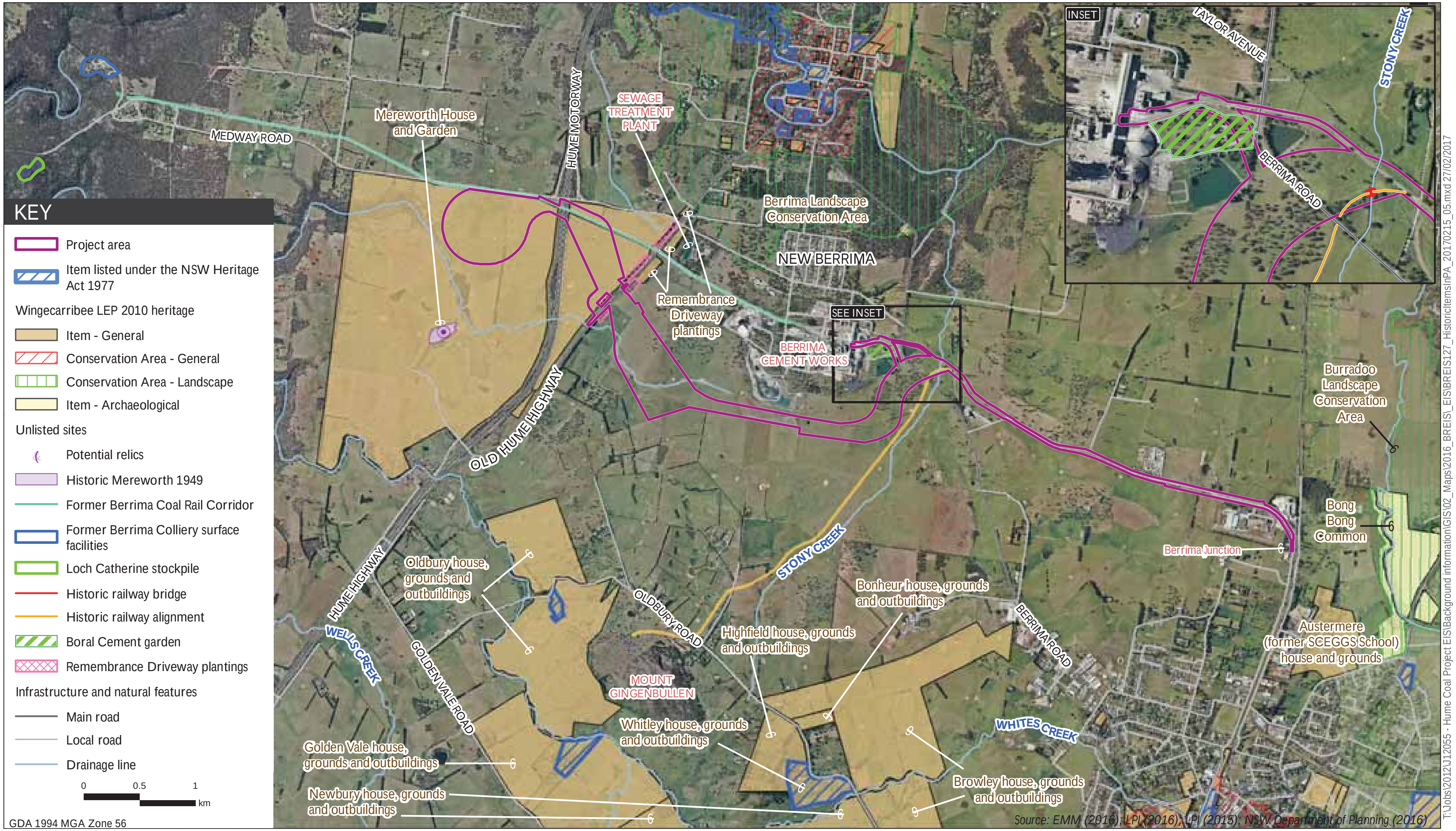

Listed and newly discovered heritage items in proximity to the project area

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Figure 11.2

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11.4.2 Mereworth House and Garden

The portion of the project area containing the rail loop and the rail maintenance facility and provisioning siding (refer to Figure 11.2) is within the Mereworth property. Importantly, the significant components of the Mereworth property, being the house and garden, comprise a small part of the overall property and are not within the project area. The Mereworth property is bisected by the Hume Motorway, which was constructed in the late 1980s.

The Mereworth house, which was constructed in 1965, was designed by John Amory (spelled Armoury in the SHI listing) in a French Provencal style. It is accessed by a long drive flanked by conifers and golden elms and is set in a large pastoral landscape with conifer windbreaks, rolling hills and dammed creeks.

The style and layout of the garden by renowned landscape designer Paul Sorensen is an important example of twentieth century taste. Planted approximately two years before the house was built, the garden embraces the house to create an experience that is secluded from the surrounding farmland. The avenue of trees creates a sense of arrival into a space that is unexpectedly European, even for the Southern Highlands.

Views from inside the gardens are predominantly retained within the garden as the tightly planted and now mature pines on the edge obscure views to the paddocks outside. The only place where views to the outside are possible, is across the ha-ha, which defines the outer edge of the lawn (Photograph 11.1).

Photograph 11.1 **View northwards from Mereworth house looking across the ha-ha towards the proposed rail loop. The photograph was taken from the master bedroom balcony.**

Photograph 11.2 View from the Hume Highway to Mereworth in the south-west

Photograph 11.3 View north from the ha-ha at Mereworth. The rail loop will be visible from this vantage point and will be on the far side of the dam.

11.4.3 Former Berrima Coal rail corridor

The former Berrima Coal rail corridor is partially within the project area and also on the Mereworth property. It is not a listed heritage item; however has been considered in the heritage assessment as it was part of the Berrima Coal and Southern Portland Cement operations which were seminal in the development of the Berrima area. What now remains of the rail line is the cutting and its embankments, which cross the northern portion of the Mereworth property. The existing rail underpass under the Hume Highway will be where the new Hume Coal rail line is constructed under the highway, eliminating the need to construct an additional crossing over or under the highway as part of the project.

11.4.4 Remembrance Driveway plantings

The Remembrance Driveway is a commemoration of Australia's fallen soldiers, and consists of planted avenues of trees, groves and memorial parks along the Hume Highway and Federal Highway between Sydney and Canberra. The Remembrance Driveway program was launched in 1953 by the then Premier of NSW, J J Cahill with plantings occurring between 1955 to 1979. Since the early 1990s, the practice has been renewed with the Roads and Traffic Authority (RTA, now RMS) taking on the sponsorship of the Remembrance Driveway Committee. The latest plantation was established in 2010 when 45,000 trees were planted along 15.5 km between Prestons and the Mount Annan Botanic Garden.

A small number of Remembrance Driveway plantings are located in the vicinity of the project area along a stretch of the Old Hume Highway, as shown in Figure 11.2. A number of these gardens have recently been listed on the Wingecarribee LEP as 'Remembrance Driveway Plantings'. While the recent listings do not identify the origin of their significance, Read and AGHS (2008) notes the Remembrance Driveway Plantations on the Old Hume Highway are Sorensen gardens, and based on visual inspection of aerial photographs, these planting comprise species that Sorensen used. The book *Australia's Master Gardener – Paul Sorenson and his Gardens* (Ratcliffe 1990, p. 64) also confirms Sorenson's involvement with these plantings.

The project area was defined to exclude the Remembrance Driveway Plantings, as can also be seen in Figure 11.2. The photograph below (11.4) is of the garden that has been excluded from the project area on the western side of the Old Hume Highway. The photograph was taken looking north-east.

Photograph 11.4 One of the groups of trees along the Remembrance Driveway on the Old Hume Highway alignment

11.4.5 Boral Cement garden

The mature trees on the Boral Cement front lawn screen the industrial plant from the road to a great extent, and are another Paul Sorensen garden in the Southern Highlands (Read and AGHS 2008; Sorensen diary July 1938). The garden was planted during 1937 and 1938 on land that had previously been a saw mill.

A survey of the garden identified the following species listed in Table 11.3. It is currently in an area that is seldom used by the cement plant but is directly south of the existing rail line.

Table 11.3 Boral 'Sorensen' garden species

Common name	Species	Common name	Species
Japanese maple	*Acer palmatum*	Swamp Spanish oak	*Quercus palustris*
Japanese cherry	*Prunus serrulata*	Weeping elm	*Ulmus glabra pendula*
Bald cypress	*Taxiodium distichum*	Copper beech	*Fagus sylvatica (purpurea)*
Strawberry tree	*Arbutus unedo*	Liquidamber	*Liquidambar styraciflua*
European ash	*Fraxinus excelsior aurea pendula*	Bhutan or Hymalayan cypress	*Cupressus torulosa*
Giant sequoia	*Sequoiadendron giganteum*	Coast redwood	*Sequoia semprevirens*
Douglas fir	*Pseudotsuga menziesii*	Cypress	*Cupressus sp*
Pine	*Pinus sp*	Creaegus or Mexican hawthorn	*Crataeugus mexicana*
Deodar cedar	*Cedrus deodara*	Blue atlas cedar	*Cedrus atlantica glauca*
Spruce	*Picea sp*	Oak	*Quercus sp*
False cypress	*Chamaecyparis sp*	Golden elm	*Ulmas glabra 'Lutescens'*

Notes: 1.Adapted from a list provided to Boral by the Australian Garden History Society (Southern Branch).

The current extent of the garden is shown in Figure 11.3. Research did not uncover documents identifying the curtilage of the garden, therefore what is shown in Figure 11.3 is based on visual inspection and descriptions only. Historic aerial photography suggests that the garden extended to the edge of the original cement plant buildings to the west.

Changes brought about by additions to the cement plant have removed some of the original plantings and reduced the size of the garden. More recently, new tube stock have been planted in rows (note blue tubes in Photograph 11.5). These new plantings were a response to a requirement of the EPL of the cement works. Notwithstanding, the garden has been identified by the Australian History Garden Society (AGHS) as a "landscape at risk" citing inappropriate native tube stock infill and the lack of recognition of the Sorensen design/character (AGHS "Landscapes at risk: watch and action list April 2016).

Inspection confirmed that the integrity of the garden varies across the site, with parts in poor condition and other areas supporting healthy trees. Trees in good health include the trees at the edge of the garden that are now between the dam and wire fence on the southern side of the site. The trees along the northern side of the site fence are also in good condition and include weeping elms (with numerous suckers), golden elms and Japanese cherries.

The garden is in variable condition at the centre of the site, near the Boral archive building. The two mature sequoias to the east of the archive building appear to be in good health (Photograph 11.5), along with the golden elm directly to the east; the Japanese maples to the east of the golden elm are stunted and woody.

A row of mature spruce trees survive in good condition at the southern end of the garden. The row of Bhutan pines (Photograph 11.6) on the northern side of the rail siding contribute to the garden aesthetic of the area but do not form part of the core garden complex under investigation.

Sorenson garden – Berrima Cement Works

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Figure 11.3

Photograph 11.5 **Sorensen's garden from Berrima Road looking into the Boral Cement plant. View west.**

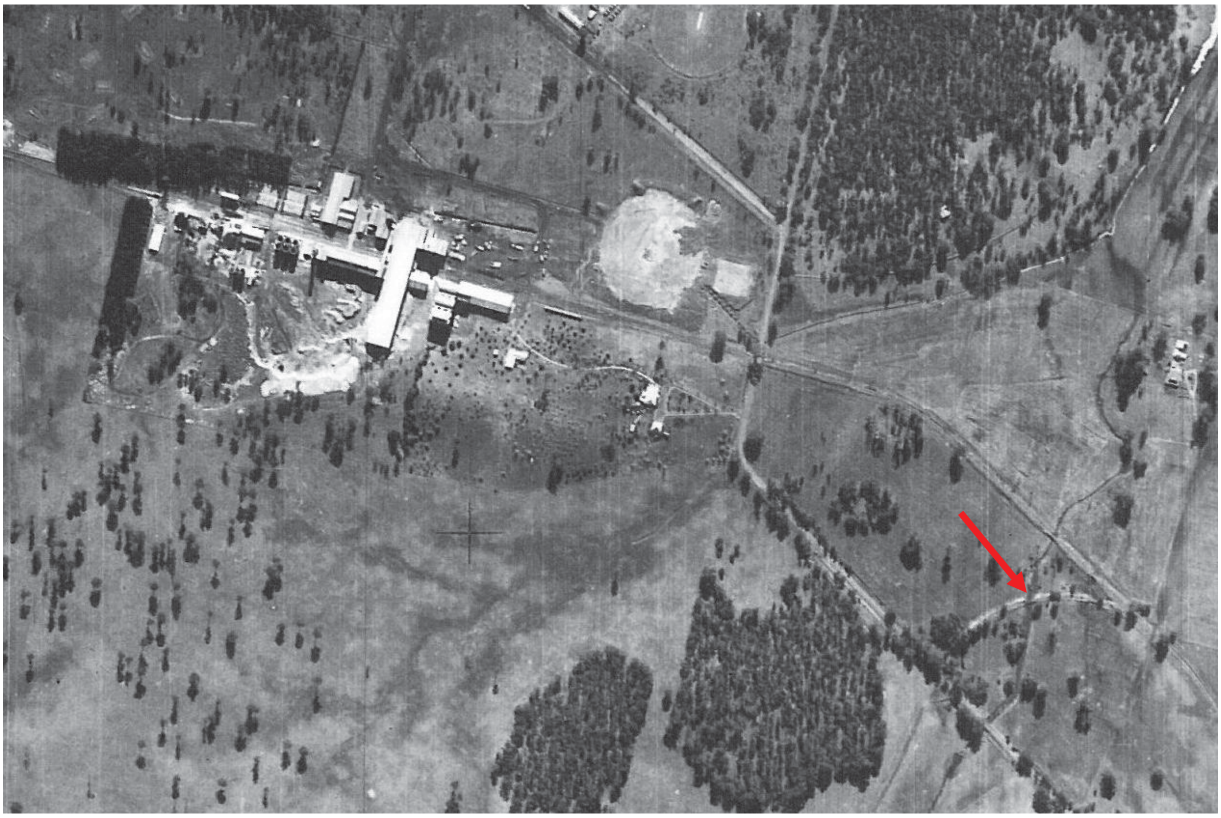
Photograph 11.6 **The row of Bhutan pine trees screening the Boral Cement plant from Berrima Road when viewed north of the railway level crossing. View west.**

11.4.6 Former Southern Blue Metal Railway Bridge

A dilapidated timber beam railway bridge spanning Stony Creek was identified during the field survey (Photographs 11.8 and 11.9). It lies within the project area and, at its closest point, is 6 m from the preferred rail line route.

The derelict bridge consists of vertical piers abutting the banks on either side of the creek and another in the centre of the bridge. It has a total span of approximately 10 m, and while the rail line embankment leading to the bridge remains, the iron rails and sleepers do not (Photograph 11.9).

The bridge was built in 1927 as part of the Southern Blue Metal Company's branch line that ran from a siding on the Southern Portland Cement Railway line, and served a blue metal quarry at Mount Gingenbullen (refer to Photograph 11.7). Thus the railway bridge and the remnants of the rail line, the embankment and cuttings, are part of the mining and transportation history of the region and contribute to the cultural landscape of the area.



Photograph 11.7 **Aerial photograph over the project area (1949) showing the location of the railway alignment and bridge (red arrow). (Moss Vale Run 1 June 1949 Landsphoto).**

Photograph 11.8 The railway bridge that spans Stony Creek to the south of the proposed rail spur, with embankments. View south-west.

Photograph 11.9 The old railway bridge. View north-east.

11.5 Assessments of significance

In NSW the assessment of heritage significance is based on the *Burra Charter* (Australia ICOMOS 1999) and further expanded upon in the Heritage Manual's Assessing Heritage Significance (Heritage Office 2001). It lists seven criteria to identify and assess heritage values that apply when considering if an item is of state or local heritage significance. The assessments of significance presented below have been evaluated against these criteria, which are presented in Table 11.4.

Table 11.4 NSW heritage assessment criteria

Criterion	Explanation
a)	*An item is important in the course or pattern of NSW's (or the local area's) cultural or natural history (Historical Significance).*
b)	*An item has strong or special association with the life or works of a person, or group of persons of importance in NSW's (or the local area's) cultural or natural history (Associative Significance).*
c)	*An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area) (Aesthetic Significance).*
d)	*An item has a strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons (Social Significance).*
e)	*An item has the potential to yield information that will contribute to an understanding of NSW's (or the local area's) cultural or natural history (Research Significance).*
f)	*An item possesses uncommon, rare or endangered aspects of NSW's (or the local area's) cultural or natural history (Rarity).*
g)	*An item is important in demonstrating the principle characteristics of a class of NSW's (or the local area's) cultural or natural places or environments (Representativeness).*

Assessments of significance have been conducted against the above criteria for the identified listed and unlisted heritage items relevant to the project. The outcomes of the assessments of significance are summarised in Tables 11.5 to 11.9.

11.5.1 Mereworth house and garden

Table 11.5 Significance assessment – Mereworth house and garden

Criterion		Explanation
a)	Historical significance	The property is part of the 1823 land grant of 2000 acres to John Atkinson, one of the earliest colonial landowners in the district who had strong ties in the area; his brother, James, established 'Oldbury" on the other side of the road to the south. The current house and garden have significance as they demonstrate the continued importance placed on the "homestead" in the Southern Highlands. The gardens have historical significance for the longevity of many of the plantings, particularly the trees, and for its ability to demonstrate the development of the garden character of the Southern Highlands. The garden is also historically significant for its ability to demonstrate a mid-twentieth century landscape design that was made popular by Paul Sorensen, but remained singular in quality. The item meets the threshold for **local significance** under this criterion.

Table 11.5 Significance assessment – Mereworth house and garden

Criterion		Explanation
b)	Associative significance	The garden is important for its connection with Paul Sorensen, the renowned twentieth century cold-climate garden designer who is responsible for a number of notable gardens in NSW and in the Southern Highlands. The item meets the threshold for **local significance** under this criterion.
c)	Aesthetic significance	The house has aesthetic significance in its design which incorporates a range of styles and materials that work together to create the French Provencal architectural style. The house can only be viewed from inside the garden with a different perspective from each side of the building. The garden and house also respond to each other at the four aspects – entry to the house is via the courtyard; the southern and western sides face the densest part of the cold climate 'forest' giving it an unexpectedly European character; the eastern side overlooks a swimming pool and beyond to the formal rose garden with gazebo and fountain. To the north, the porch with classically proportioned columns looks out beyond a pear tree to the lawn and a variety of plantings. The eye is then swept to the north-east through the golden elm trees across the ha-ha and glimpses of the farm paddocks. The garden is an imposing cold climate collection of plantings, reminiscent of a northern hemisphere forest. From within, the garden envelopes the house and grounds and obscures views out, except in selected places. From the outside, the garden is visible from a distance and identified by the tall evergreens in ordered rows located in a pastoral landscape. The long envelope of evergreens has a landmark effect on the landscape. This effect has been diminished by the construction of the Hume Highway, the 110 km speed limit and the obscuring effect of the road cuttings. The item meets the threshold for **local significance** under this criterion.
d)	Social significance	The house and garden do not have a known special association with a particular community or cultural group in the local area, although the significance of Sorensen's gardens is acknowledged by the Australian Garden History Society. The item meets the threshold for **local significance** under this criterion.
e)	Technical/research significance	The style and layout of the garden reflect early nineteenth century tastes and includes significant landscape elements. The item meets the threshold for **local significance** under this criterion. Evidence of John Atkinson's homestead may have survived in archaeological form within the curtilage of the house and garden complex. If archaeological resources survive, they are likely to be of **local significance.**
f)	Rarity	Sorensen did not commit his designs to paper, which may have resulted in some of his work being overlooked and therefore not reported widely. The item meets the threshold for **local significance** under this criterion.
g)	Representativeness	The garden at Mereworth is representative of Sorensen's work. The style and layout of the garden also reflect mid-twentieth century tastes and includes significant landscape elements. The item meets the threshold for **local significance** under this criterion.

11.5.2 Summary statement of significance - Mereworth house and garden

The house and garden at Mereworth are significant collectively as they signify the continuation of the homestead group, which was prevalent in the early colonial period. The garden is particularly significant for its aesthetic qualities and its association with the respected cold-climate landscape architect, Paul Sorensen.

The item is of local significance.

11.5.3 Former Berrima Coal rail corridor

Table 11.6 Significance assessment – Former Berrima Coal rail corridor

Criterion	Explanation
a) Historical significance	The former Berrima Coal rail corridor has some historical significance as a demonstration of the region's coal mining history. The item **does not** meet the threshold for **local significance** under this criterion.
b) Associative significance	The former Berrima Coal rail corridor has some associative significance in its relationship to Arnold 'Stan' Taylor, an important industrialist in the Southern Highlands who owned the Medway Mine, the Southern Blue Metal Quarry, and Southern Portland Cement. The rail line connected them all to the government-owned Southern Railway. The rail corridor also has associations with Boral, which purchased many of Taylor's industrial ventures and has a long history in Australian building manufacturing. The item **does not** meet the threshold for **local significance** under this criterion.
c) Aesthetic significance	The former rail corridor is a remnant on a landscape that is a palimpsest of uses dating from the first Australians, through to colonial Australia and the industrial revolution of the nation. It is a reminder of the many elements that combine to create the landscape as it is today. The item **does not** meet the threshold for **local significance** under this criterion.
d) Social significance	There is no information to support significance under this criterion. The item **does not** meet the threshold for local significance under this criterion.
e) Technical/research significance	The research significance of the former rail corridor does not reach the threshold for this criterion. The item **does not** meet the threshold for local significance under this criterion.
f) Rarity	The former rail corridor is one of many smaller branch lines that serviced local industry in the past and connected them to the Main Southern Rail Line. The item **does not** meet the threshold for local significance under this criterion.
g) Representativeness	The former rail corridor is representative of decommissioned rail lines in NSW. The item **does not** meet the threshold for local significance under this criterion.

11.5.4 Summary statement of significance – Berrima Coal rail corridor

Whilst the former Berrima Coal rail line responds to some of the criteria for local significance, it does not meet the threshold, and therefore is not considered to be of local significance. It is also noted that reusing the former rail corridor for its original intended purpose is considered to be a positive aspect of the proposal.

11.5.5 Remembrance Driveway plantings

Table 11.7 Significance assessment – Remembrance Driveway plantings

Criterion	Explanation
Historical significance	The Remembrance Driveway plantings have historical significance as one type of commemoration of Australia's war dead. While the program of roadside war memorials commenced in the mid-twentieth century, what they represent is significant to the development of the nation. The item meets the threshold for **local significance** under this criterion.
Associative significance	The plantings in the vicinity of the project are associated with the landscape architect Paul Sorensen who is recognised as an important figure in the industry. His designs, that he also planted, occur elsewhere in the Southern Highlands, the Illawarra and the Blue Mountains. The item meets the threshold for **local significance** under this criterion.
Aesthetic significance	The groups of trees along the Remembrance Highway that are associated with Paul Sorensen have aesthetic significance as they are cold-climate plantings, which is unusual along the length of the Remembrance Driveway. The groups of trees are reminiscent of little forests that are more familiar in the northern hemisphere but create a point of difference when juxtaposed to native trees and the more common monocultural plantings of liquid ambers found elsewhere along the alignment, The item meets the threshold for **local significance** under this criterion.
Social significance	The Remembrance Driveway has a high degree of social significance as it represents Australians who fell in the great wars. The item meets the threshold for **local significance** under this criterion.
Technical/research significance	Whilst it is likely Sorensen designed these gardens, further research will be able to confirm if they are Paul Sorensen gardens. The item meets the threshold for **local significance** under this criterion.
Rarity	Sorensen's lack of records means that his gardens are, in many cases, his only legacy. The item meets the threshold for **local significance** under this criterion.
Representativeness	The Remembrance Driveway represents the trend in Australia to commemorate her war dead. It is a practice that was adopted by countries belonging to the British Commonwealth and is therefore representative across a number of nations. The item meets the threshold for **local significance** under this criterion.

11.5.6 Summary statement of significance – Remembrance Driveway plantings

The groups of trees along the Remembrance Driveway are of local significance for the ability to demonstrate the historical decision to commemorate the nation's war dead. They have a high level of aesthetic and associative significance and are rare for their association with Paul Sorensen. The Remembrance Driveway plantings in the vicinity of the project are locally representative and have social value for what they signify.

11.5.7 Boral Cement garden

Table 11.8 Significance assessment – Boral Cement garden

Criterion	Explanation
Historical significance	The garden comprising of cold-climate forest species is historically significant for its contribution to beautification programs of industrial sites. The garden has a relationship with other gardens that were planted to enhance the "European" character of the area. The item meets the threshold for **local significance** under this criterion.
Associative significance	The garden is important for its connection with Paul Sorensen, the renowned twentieth century cold-climate garden designer who is responsible for a number of notable gardens in NSW and in the Southern Highlands. The item meets the threshold for **local significance** under this criterion.
Aesthetic significance	The garden has aesthetic significance, as it is a collection of European cold climate species in a region known for its introduced deciduous species (and autumnal changes), and for its role in the beautification of an industrial site, which was a common twentieth century practice in NSW. The garden's condition varies from good to poor, which has implications on its aesthetic significance. A number of trees are stunted and potentially not viable into the short-term future. The aesthetic significance is in the process of being diminished through the new plantings on site. The item meets the threshold for **local significance** under this criterion.
Social significance	The Boral Cement garden does not have a known special association with a particular community or cultural group in the local area but the significance of Sorensen's gardens is acknowledged by the Australian Garden History Society. The item meets the threshold for **local significance** under this criterion.
Technical/research significance	The garden has the potential to contribute to a better understanding of Paul Sorensen, his work and the historical aesthetic treatments of industrial sites. The item meets the threshold for **local significance** under this criterion.
Rarity	Sorensen's lack of records means that his gardens are, in many cases, his only legacy. The item meets the threshold for **local significance** under this criterion.
Representativeness	Representative of a disappearing type with respect to industrial gardens and mature cold-climate species. The item meets the threshold for **local significance** under this criterion.

11.5.8 Summary statement of significance – Boral Cement front garden

The Boral garden fronting Berrima Road in New Berrima is of local significance for its aesthetic and historical significance being representative of the beautification of industrial sites during the twentieth century. The garden's association with the notable landscape architect, Paul Sorensen, adds a layer of significance to these gardens as his designs are aesthetically outstanding and uncommon.

11.5.9 Former Southern Blue Metal rail-bridge and rail corridor

Table 11.9 Significance assessment – railway bridge and Gingenbullen Quarry rail corridor

Criterion	Explanation
Historical significance	The railway bridge and the remnants of the rail line, the embankment and cuttings, are part of the mining and transportation history of the region and contribute to the cultural landscape. These elements have survived to demonstrate the industrial history of Berrima. The item meets the threshold for **local significance** under this criterion.
Associative significance	The bridge, associated embankments and cutting are the remnants of the Southern Blue Metal Company's rail line that transported stone from the quarry at Mount Gingenbullen to the main rail lines. It has significance for its association with Arnold 'Stan' Taylor who established a complex industrial enterprise consisting of the Medway and Loch Catherine mines, the rail line from Medway to the main Southern Railway as well as this smaller branch line to the Mount Gingenbullen Quarry. The item meets the threshold for **local significance** under this criterion.
Aesthetic significance	The bridge is in a dilapidated state and is missing important elements such as sleepers and iron tracks. The item **does not** meet the threshold for local significance under this criterion.
Social significance	The bridge and associated remnants of the rail line have association with the local mining industry and one of the reasons for the growth of the region. However, it is a small remnant on private property and is not part of the public's awareness of the history of the Southern Highlands. The item **does not** meet the threshold for local significance under this criterion.
Technical/research significance	The bridge and associated remnants of the rail line have the potential to yield information that will contribute to an understanding of the area's mining and transportation history, especially when studied in association with historic maps, newspapers and accounts. The item meets the threshold for **local significance** under this criterion.
Rarity	The bridge and associated remnants of the rail line do not possess uncommon, rare or endangered aspects for its type or of the area's cultural history. The item **does not** meet the threshold for local significance under this criterion.
Representativeness	This structure is typical of timber beam road and rail-bridges commonly constructed in NSW in the nineteenth and early twentieth centuries. It is in a dilapidated state and is missing elements. The item **does not** meet the threshold for local significance under this criterion.

11.5.10 Summary statement of significance: timber rail-bridge and rail corridor

The rail-bridge and remnants of the Southern Blue Metal Company's rail line including embankments and cuttings are of local significance. These elements have survived to demonstrate the industrial history of Berrima and contribute to an understanding of local mining and transportation history. Despite its dilapidated state, it remains a representative example of nineteenth and early twentieth century rail-bridges.

11.6 Statement of heritage impact

11.6.1 Summary statement of heritage impact

Table 11.10 provides a summary of the potential impacts of the project associated with both the preferred and alternative rail alignments. The potential impacts for each item is discussed further in the sub-sections in Section 11.6.2.

Table 11.10 Summary of potential heritage impacts

Heritage item	Wingecarribee LEP	Project preferred option	Project alternative option
Mereworth house and garden	I351	The rail loop will traverse the northern paddocks of this property but will not have any impact on the heritage value of the house and gardens (Figure 11.5). There is the potential for the views and vistas from the Mereworth house to be impacted, particularly because it is elevated on a hill overlooking the project area. However, at present views of the project area are screened by the designed garden.	Impact as per project preferred option.
Railway bridge	Not listed	The railway bridge is in close proximity to the preferred rail alignment and will be removed by this option.	The bridge is outside of the direct disturbance footprint of the alternative option, although is within the construction disturbance footprint. The bridge will be avoided if possible during construction works.
Sorensen Garden – Boral Cement	Not listed	The new rail spur into the cement works will pass through a portion of this garden, and some trees will be removed (Figure 11.4).	No impact
Remembrance Driveway Plantings	Recently listed	No impact	No impact
Former Berrima rail corridor	unlisted	The project rail line will utilise the existing corridor where it traverses the Hume Highway. The impacts are anticipated to be minor when the entire rail corridor is considered.	Impact as per project preferred option.
Berrima Landscape Conservation Area	C1843	No impact	No impact
Burradoo Landscape Conservation Area	C1834	No impact	No impact
Bong Bong Common	A1191	No impact	No impact
Austermere House and Grounds	I398	No impact	No impact

Heritage impacts - project area east
Berrima Rail Project
Environmental impact statement
Figure 11.4

EMM HUMECOAL

Heritage impacts - project area west

Berrima Rail Project

Environmental impact statement

Figure 11.5

11.6.2 Statement of heritage impact

i Mereworth House and Garden

The Hume Coal rail loop will be built on the Mereworth House and Garden property. However, while the entire property is listed under Schedule 5 of the Wingecarribee LEP, the house and its surrounding gardens are the significant elements. The project area is located approximately 700 m north of the house and garden complex.

The only place where views from the house and garden will be affected is to the north-east across the ha-ha to the surrounding paddocks and dam. When viewed from the outside edge of the ha-ha there will be some noticeable change in sections of the existing landscape, with the addition of the rail loop. However , the view directly north will be to the west of the rail loop and views from inside the garden and from the house will, for the most part, be screened by the mature plantings along the perimeter of the garden.

Impacts to the setting of the house and garden will be moderate as the rail loop will be constructed on an earthen embankment up to 4 m high. The addition of the rail loop in the vicinity of Mereworth will affect the setting but only when viewed from within the property and from Medway Road.

ii Former Berrima Coal rail corridor

The former Berrima Coal rail alignment passes to the north of the Mereworth property and travels beneath the Hume Highway where it continues in a south-easterly direction until it joins the Berrima Cement Works (Figure 11.5). Impacts to the former rail alignment will be minimal as the rail loop will join the existing rail cutting to pass beneath the Hume Highway. Impacts will include cutting through the existing former rail corridor embankment to lay the project rail line. The new rail line will divert to the south away from the former rail corridor approximately 140 m to the east of the Hume Highway.

The reuse of the rail corridor for its original purpose is considered a positive aspect of the project in relation to historic heritage.

iii Former Southern Blue Metal rail-bridge and corridor

The railway bridge will be removed during construction of the preferred rail line option. The bridge will undergo photographic archival recording prior to removal.

Whilst outside the direct footprint of the alternative option, the timber rail bridge is within the construction footprint. It will be avoided where possible under this option.

iv Boral Cement garden

The Boral Cement garden that fronts Berrima Road was designed by Paul Sorensen and is one of a number of gardens he designed for the Hoskins family. It is also the result of a move towards beautifiying industrial landscapes. Today it provides a screen through which the cement plant can be seen; an obvious intention of the design, as well as being aesthetically pleasing in its own right. The garden comprises a variety of trees that add colour to the landscape and define the cement plant from surrounding industry (Photograph 11.10).

The original design garden has been modified by the introduction of new native plantings, set out in rows rather than in any formal landscape design but this native tube stock has been planted in compliance with EPA requirements. It would be beneficial to the aesthetic significance of the garden and its integrity if the tube stock currently within the curtilage of the Sorensen garden is removed and replanted elsewhere on the site. Further, a high proportion of what appear to be plantings in the original design are stunted and in poor health (Photograph 11.10).

Photograph 11.10 Japanese maples (foreground) are typical Sorensen species; the two in the front have not grown to their full potential. Sequoias and copper beech can also be seen.

The preferred rail alignment will remove some of the historical plantings that are in poor condition and likely to require removal in the future. However, some of the plants that will be removed are in good condition, and their removal will further diminish the value of the garden. Amelioration measures are therefore recommended (refer to Section 11.7). Figure 11.4 shows the area of the garden that will be affected by the direct footprint of the preferred rail design; trees within the construction disturbance footprint will be avoided where possible.

The addition of the proposed rail line within the cement plant garden will negatively impact on individual plantings but as most of these are in poor condition, these impacts will generally be minor, with the exception of the spruce trees and the ash tree in the south-east corner of the garden. Other plantings, including the visually outstanding sequoias, the copper beeches, weeping elms and golden elms will be retained.

The garden is not listed on a statutory instrument but has been assessed as having significance at a local level. It was designed within an industrial plant, which produces cement to this day and must be able to respond to changes in operational requirements. It is also a living assemblage, which means that parts of it have not thrived where other parts have successfully reached maturity to realise an aesthetic that is valued. In the last few years, the garden has diminished in quality in some areas but Boral will engage with experts to improve its quality and replace lost plantings elsewhere within its curtilage.

Whilst the project will remove some plantings associated with Sorensen (refer to Photographs 11.11 and 11.12), the garden will remain in keeping with the original principle of its design; it will remain a living garden, providing a screening around industrial elements.

The cement works are located on the site of an earlier saw mill, which existed for a short period of time. Relics in the garden area are not anticipated to occur; however, the unexpected finds protocol will apply in this area as in all areas of the project.

The project alternative option will avoid the garden by turning east before it reaches it.

Photograph 11.11 View along the proposed rail line in the central section of the garden. The pine tree on the right will be removed.

Photograph 11.12 The spruce and ash trees on the boundary with Berrima Road. These trees will be removed by the proposal. View south-east.

v Remembrance Driveway plantings

The project has been designed to avoid the Remembrance Driveway plantings along the Old Hume Highway trees (Figure 11.5). As such, none of the plantings along the Remembrance Driveway will be impacted by the project.

11.7 Management of impacts

The management measures committed to in this EIS are in keeping with the philosophy of the *Burra Charter 2013* (Australia ICOMOS 2013), where change to items of significance is managed to ensure that as much as necessary and as little as possible is the end result. The first option is avoidance, which removes the need for mitigation or amelioration.

The following measures will apply to the project with respect to historical heritage:

1. Where made possible in the detailed design, reduce the identified heritage impacts.

   Archival recording of the area prior to change will be undertaken, with particular attention to:

   a) the former Berrima Coal Mine rail corridor where the project rail loop traverses the Hume Highway;

   b) the Remembrance Driveway trees;

   c) the former Southern Blue Metal Company timber rail-bridge and former railway corridor; and

   d) the Boral Cement garden (for the project preferred option).

2. The Remembrance Driveway trees as shown in Figure 11.5 will be avoided during construction works. These trees will be marked out and clearly identified to ensure there are no inadvertent impacts.

3. The management of historic heritage items will be documented in the CEMP, and will include, but not limited to:

   a) Management of the Sorensen garden in the Boral Cement property *(for the project preferred option only)* – the CEMP will include a plan of action with supporting figures that identifies the plants for removal, and sets out the location and species for replacement plants in a manner that conforms to the spirit of Sorensen's vision by prioritising cold climate species over native species. This will be done in consultation with the Southern Highlands Branch of the Australian Garden History Society.

      Where practicable, impacts to mature plants will be avoided by working around the construction disturbance footprint.

      The option of re-locating mature trees will be investigated. Pending the outcomes of this investigation, and where practicable, mature plants will be re-located with the advice and involvement of a reputable tree re-location consultant.

   b) Avoidance measures for the Remembrance Driveway trees – The CEMP will include a section on the Remembrance Driveway trees that clearly marks them for retention.

   c) Unexpected finds protocol – if unexpected historical archaeology is discovered during construction, work in the immediate area must cease and an archaeologist must be contacted to make an assessment of the find. If it is determined to be a relic under the Heritage Act, further investigation may be required. Examples of unexpected finds may include bricks, sandstone blocks and artefact deposits.

   d) Rehabilitation – consideration of historic values will be incorporated into the rehabilitation plan for the project.

11.8 Conclusion

The project will avoid identified historic heritage items of local significance as shown in Figures 11.4 and 11.5. No physical impacts will occur as a result of the project on listed heritage items under both the preferred and alternative rail alignments.

Impacts to the existing landscape will be minor and restricted to the northern paddocks of the Mereworth property. The significant components of the property, being the house and garden, are outside the project area.

The proposed rail loop will be visible from some locations in the public domain (refer to visual assessment) and from Mereworth house and some parts of the gardens at the ha-ha. The impact of the rail loop to the setting of the house and garden of Mereworth is considered to be moderate. However, the project elements will not be visible from the entrance to the house and garden, and thus will not interfere with the effect produced by the avenue of trees upon arrival, nor will it be visible once inside the forest-effect of the garden.

Parts of the unlisted Boral Cement Works garden attributed to Paul Sorensen will be disturbed by the construction of the new rail siding into the cement works, under the preferred project option. However, the majority of trees to be removed are in poor condition and the garden will remain in keeping with the original principle of its design; that is a living garden providing screening around industrial elements.

12 Biodiversity

12.1 Introduction

12.1.1 Overview

This chapter provides a summary of the biodiversity assessment report (BAR) prepared by EMM and the aquatic ecology assessment completed by JSA Environmental. The biodiversity assessment report (BAR) is presented in full in Appendix J, which incorporates the methods and results of the aquatic ecology assessment.

The biodiversity assessment demonstrates how measures have been incorporated into the project design to avoid and minimise impacts on biodiversity and measures to mitigate impacts during construction and operation. A biodiversity offset strategy has been prepared to compensate for residual biodiversity impacts after avoidance, minimisation and mitigation measures have been applied. The study assesses the impacts of the preferred and alternative project options (refer to Figure 1.3).

12.1.2 Assessment requirements and guidelines

This BAR was prepared in accordance with the *Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014). It identified potential direct and indirect impacts of the project on threatened biodiversity listed under the TSC Act and Commonwealth EPBC Act. It also addresses potential impacts of the project on riparian land, aquatic environments and groundwater dependent ecosystems.

The SEARs for the project require an assessment of the potential impacts of the project on biodiversity. Table 12.1 lists the relevant assessment requirements and where they are addressed in this chapter.

Table 12.1 Biodiversity – relevant SEARs issued by DP&E

SEAR	Where addressed
An assessment of the likely biodiversity impacts of the development, in accordance with the Framework for Biodiversity Assessment, by a person accredited in accordance with s142(B)(1)(c) of the *Threatened Species Conservation Act 1995*, and having regard to OEH's and DPI's requirements and recommendations.	This assessment has been prepared in accordance with the SEARS by Katie Whiting of EMM, accredited assessor number 196. The compliance of the assessment against the FBA mapping requirements is provided in Appendix J.
A strategy to offset any residual impacts of the development in accordance with the NSW Biodiversity Offsets Policy for Major projects.	An offset strategy is presented in Section 12.7.

DP&E invited other government agencies to recommend matters to address in the EIS. NSW Fisheries, OEH, and DPI Water raised requirements relevant to biodiversity, as reproduced in Table 12.2.

Table 12.2 NSW Fisheries and OEH assessment recommendations relating to biodiversity

Agency	Requirement	Where addressed
NSW Fisheries	Analysis of any interactions of the proposed rail project with aquatic and riparian environments and predictions of any impacts upon aquatic and riparian environments (including fish and aquatic and riparian vegetation) from the rail project (both temporary and permanent). This should include assessment of both direct impacts (removal, disturbance, smothering) and indirect impacts (eg shading, permanent loss of habitat).	Indirect impacts on riparian vegetation are addressed in Section 12.4.3 (i) (v), while potential impacts on the riparian and aquatic environment are addressed in Section 12.4.3.
OEH	Assessment of the potential impact on biodiversity, including threatened species, populations, ecological communities, or their habitats likely to occur within or near the subject site.	An assessment of potential direct and indirect impacts of the project on threatened biodiversity is provided in Section 12.4.
OEH	Biodiversity impacts related to the proposed development are to be assessed and documented in accordance with the Framework for Biodiversity Assessment (FBA), unless otherwise agreed by OEH, by a person accredited in accordance with s142B(1)(c) of the *Threatened Species Conservation Act 1995*.	This biodiversity chapter has been prepared to meet the reporting requirements of the FBA by Katie Whiting, accredited assessor 196.
OEH	Impacts on the following populations will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment: • Black Gum (*Eucalyptus aggregata*)	The potential impacts of the project on Black Gum are assessed in Section 12.4.2.
DPI Water	Assessment of impacts on surface and groundwater sources (both quality and quantity) related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	An assessment of riparian land and groundwater dependent ecosystems is provided in Section 12.4.3, while mitigation measures are provided in Section 12.5.2. An assessment of surface and groundwater impacts and mitigation measures is provided in Chapter 13.

The study area for the biodiversity assessment is shown in Figure 12.1. The edge of a large patch of vegetation occurs in the study area. Accordingly, the study area was extended outside the project area in this location so that the patch of vegetation could be accurately characterised.

12.2 Assessment method

The biodiversity assessment comprised the following steps:

- Database searches to identify any threatened terrestrial flora and fauna species, important habitat for migratory species and/or critical habitats recorded in and surrounding the study area.
- Vegetation surveys comprising:
  - Review of existing mapping to provide information on the vegetation communities previously recorded or likely to occur in the study area.
  - Observing vegetation communities and extents in the field and preparing maps.
  - Plot based surveys and transects where vegetation species, cover and other characteristics were recorded.

  - Comparison of observatiosn to government information on threatend communities to determine if there are threatened ecological communities (TECs) in the study area.

  - Targeted searches for flora with potential to exist in the study area.

- Fauna surveys comprising:

  - Surveys targeting threatened species previously recorded within 10 km of the study area.

  - Assessment of fauna habitiat types and condition at each of the flora survey plots.

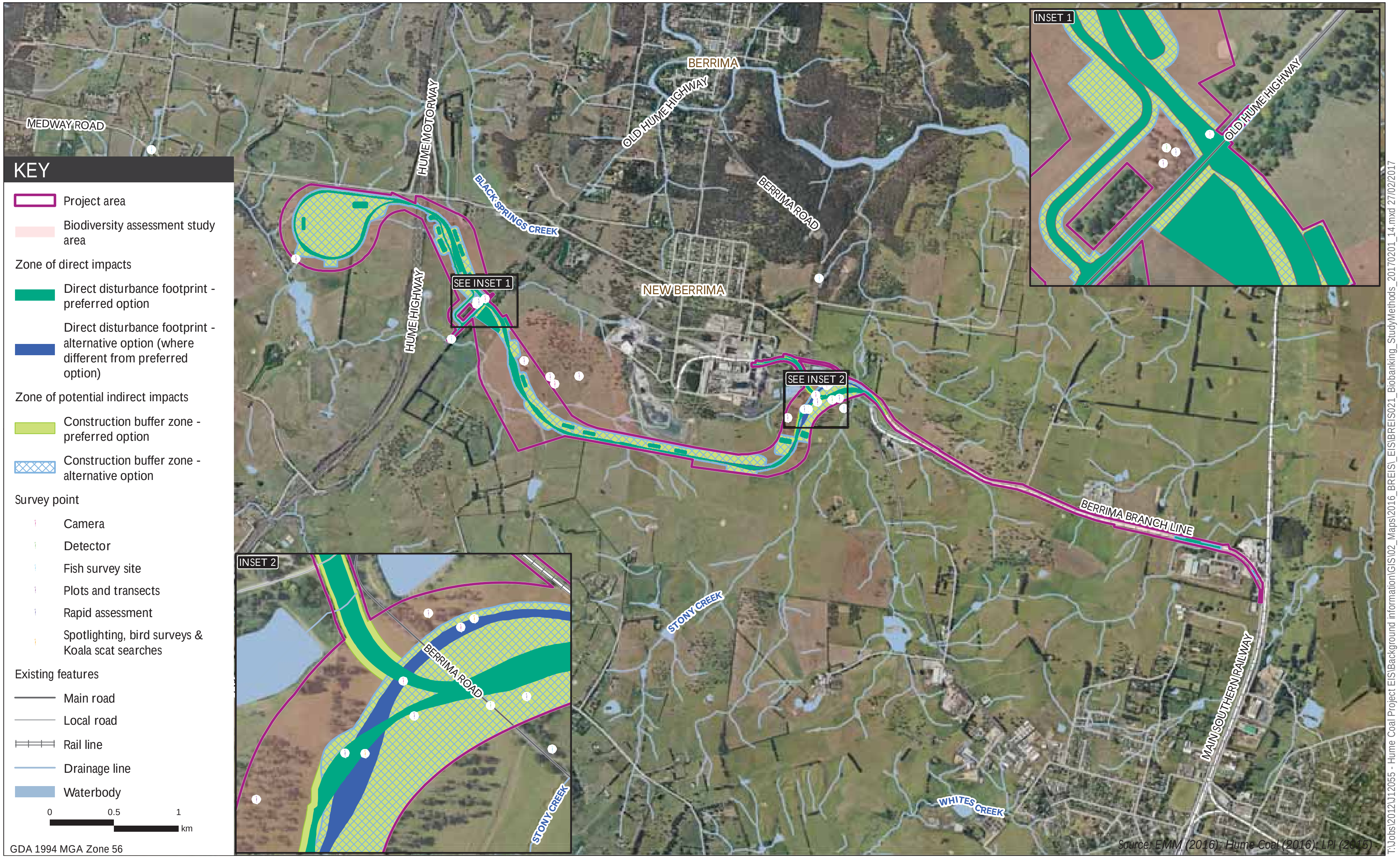
  - Searches for birds that are active during the day at four sites.

  - Surveys for microchiropteran bats.

  - Searches for nocturnal birds and mammals.

  - Use of the spot assessment technique to survey for presence and level of activity of koalas in the study area.

- Aquatic assessment, where key fish habitat maps were reviewed to identify potential fish habitat in the project area and potential aquatic habitat near road and rail crossings in the study area surveyed.



Biodiversity assessment study area and methods

Berrima Rail Project

Environmental impact statement

Figure 12.1

12.3 Existing environment

12.3.1 Streams and aquatic habitat

Two streams and minor drainage lines intersect the study area. These streams and their Strahler Order are summarised in Table 12.3. There are no wetlands in the study area.

Table 12.3 Streams in the study area and their Strahler order

Stream name	Strahler order
Stony Creek	1, 2, 4, 5
Oldbury Creek	1, 2, 3, 4

Notes: 1. Source: Strahler (1995).

Stony Creek and Oldbury Creek are identified on the Key Fish Habitat map for Wingecarribee LGA (DPI no date), and shown in Figure 12.2.

A larger dam upstream of the small dam on Stony Creek would prevent fish passage, and as such the waterway is likely to only provide habitat for common reptiles including the Eastern Snake-necked Turtle (*Chelodina longicollis*) and Yabby (*Cherax destructor*).

The tributaries of Oldbury Creek did not contain water during the survey. Although Oldbury Creek and its tributaries are identified on the Key Fish Habitat map for Wingecarribee LGA, they do not contain key fish habitat. Streams intersecting the project area have been heavily modified by agricultural activities and the creation of dams, leaving them dry most of the time, and therefore do not represent key fish habitats as defined by DPI (2013).

Based on the findings of the field survey, these drainage lines have been classified as Class 4 - unlikely fish habitat as they are waterways with intermittent flow following rain only, with little or no defined drainage channel, and little to no flow or free standing water or pools post rain (ie dry gullies or shallow floodplain depressions with no aquatic flora present). Although the dam on Stony Creek has standing water and is on a minor waterway, it does not connect with any wetlands or Class 1 to 3 fish habitats and flow to the Wingecarribee River is impeded by the dam wall. Therefore, the dam on Stony Creek and upstream sections has been classified as Class 4 unlikely fish habitat. Streams intersecting the study area do not contain habitat for the Macquarie Perch.

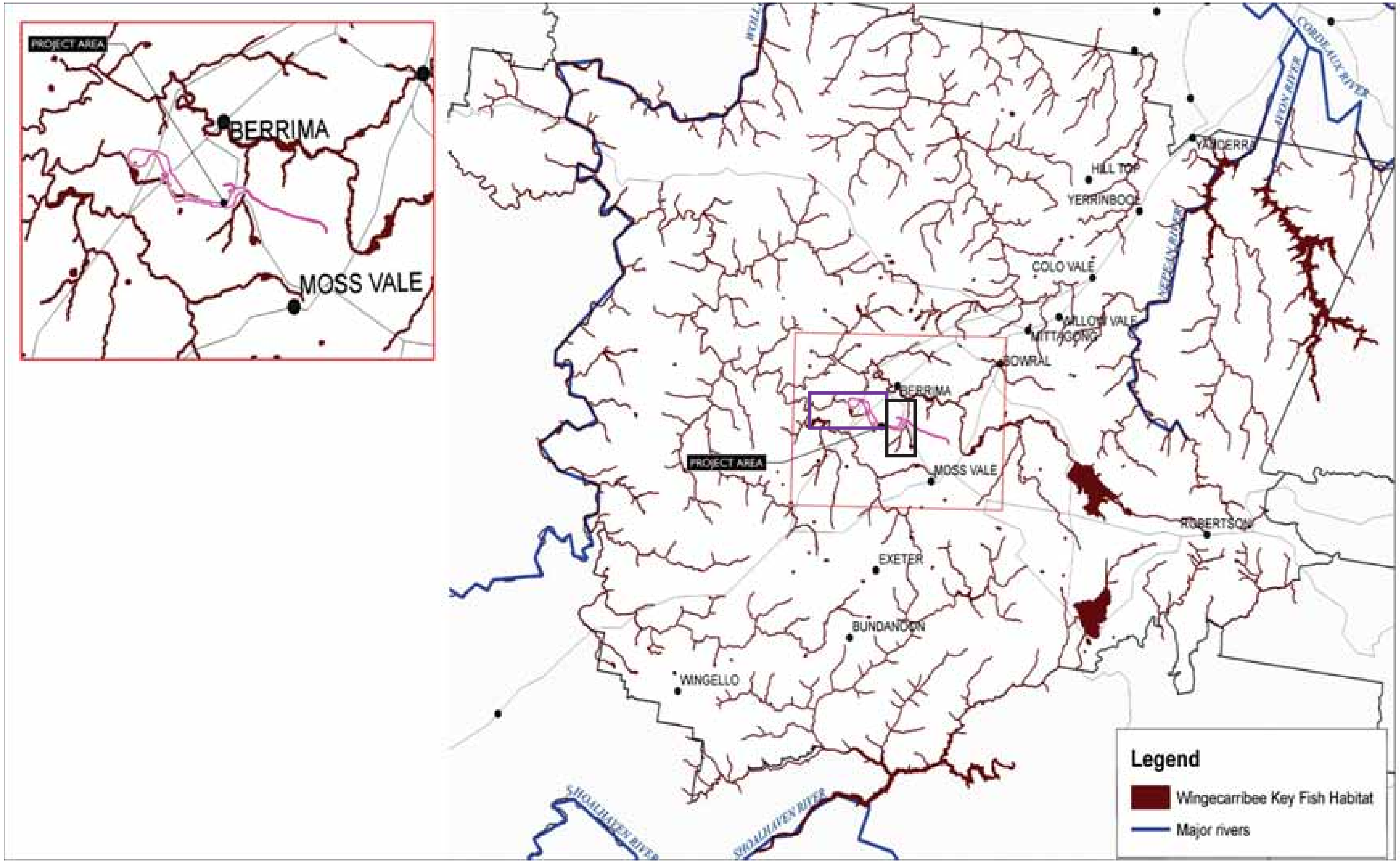


Figure 12.2 Mapped key fish habitats (Stony Creek indicated by black box, Oldbury Creek indicated by purple box)

12.3.2 Vegetation

The majority of the disturbance footprint is characterised by exotic pasture which is used for grazing. Some larger patches of native vegetation occur, however many are small and highly fragmented. The remaining patches of native vegetation are grazed and have a highly degraded understorey. Consequently, native vegetation in the study area exists as native canopy trees with an exotic understorey.

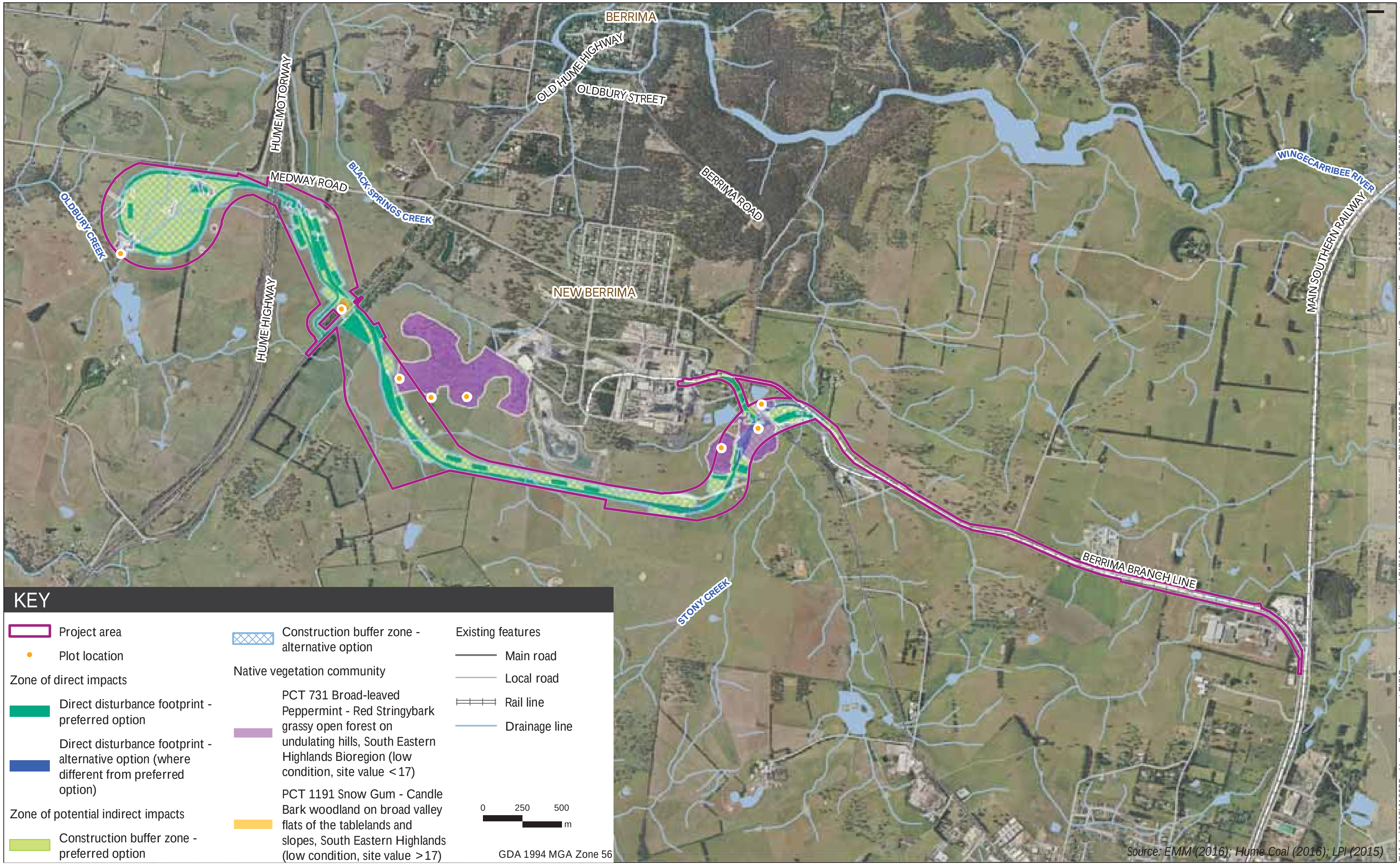
Descriptions of the vegetation communities recorded in the study area and their plant community types (PCT) are provided in Table 12.4 and illustrated in Figure 12.3.

Table 12.4 Vegetation communities in the study area

Vegetation community	Dominant canopy species[1]	Plant community type (PCT)	Dominant midstorey species[1]	Dominant understorey species[1]	Landscape position and soils
Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland	Broad-leaved Peppermint (*Eucalyptus dives*), Narrow-leaved Peppermint (*E. radiata*), Paddy's River Box (*E. macarthurii*)	PCT 731 Broad-leaved Peppermint - Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion	None	Kikuyu (*Pennisetum clandestinum**), Finger Grass (*Dactyloctenium radulans*), Cocksfoot (*Dactylis glomerata**) and Lambs Tongues (*Plantago lanceolata**).	Occurs on gently undulating land at approximately 700 m above sea level (ASL) on deep shale soils.
Snow Gum woodland	Snow Gum (*E. pauciflora* subsp. *pauciflora*)	PCT 1191 Snow Gum - Candle Bark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion	None	Glossy Nightshade (*Solanum americanum*), Basket Grass, Tussock Grass (*Poa labillardieri*), *Rytidosperma racemosum* var. *racemosum,* Spiny-headed Mat Rush, Catsear (*Hypochaeris radicata**), Cocksfoot and Serrated Tussock (*Nassella trichotoma**).	Occurs in frost hollow flats and footslopes in undulating tableland areas between 600 and 1100 m ASL.
Cleared land	None	N/A	None	Paddock Lovegrass (*Eragrostis leptostachya*), Catsear, Hairy Hawkbit (*Leontodon taraxicoides**), Subterranean Clover (*Trifolium subterraneanum**), Couch (*Cynodon dactylon*), Perennial Ryegrass (*Lolium perenne**), Paspalum (*Paspalum dilatatum**) and Kentucky Bluegrass (*Poa pratensis**).	Occurs on undulating land from 650-700 m ASL on clay loam soils.

Notes: 1. Dominant species are those that have a high projected foliage cover, or those that are present across most vegetation sampling points.

2. *denotes introduced species.



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Plant community types
Berrima Rail Project
Environmental impact statement
Figure 12.3

The Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland has some representative species of 'Southern Highlands Shale Woodland in the Sydney Basin Bioregion', which is listed as an endangered ecological community (EEC) under the TSC Act. The Snow Gum Woodland has a representative canopy species of 'Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions; which is listed as an EEC under the TSC Act.

These communities do not contain representative species of the remaining TECs previously recorded in the Moss Vale subregion and therefore were not considered further.

12.3.3 Threatened species

Threatened species identified in and around the project area are illustrated in Figure 12.4. As shown, Paddy's River Box is the only threatened species recorded in the study area.

i Ecosystem credit species

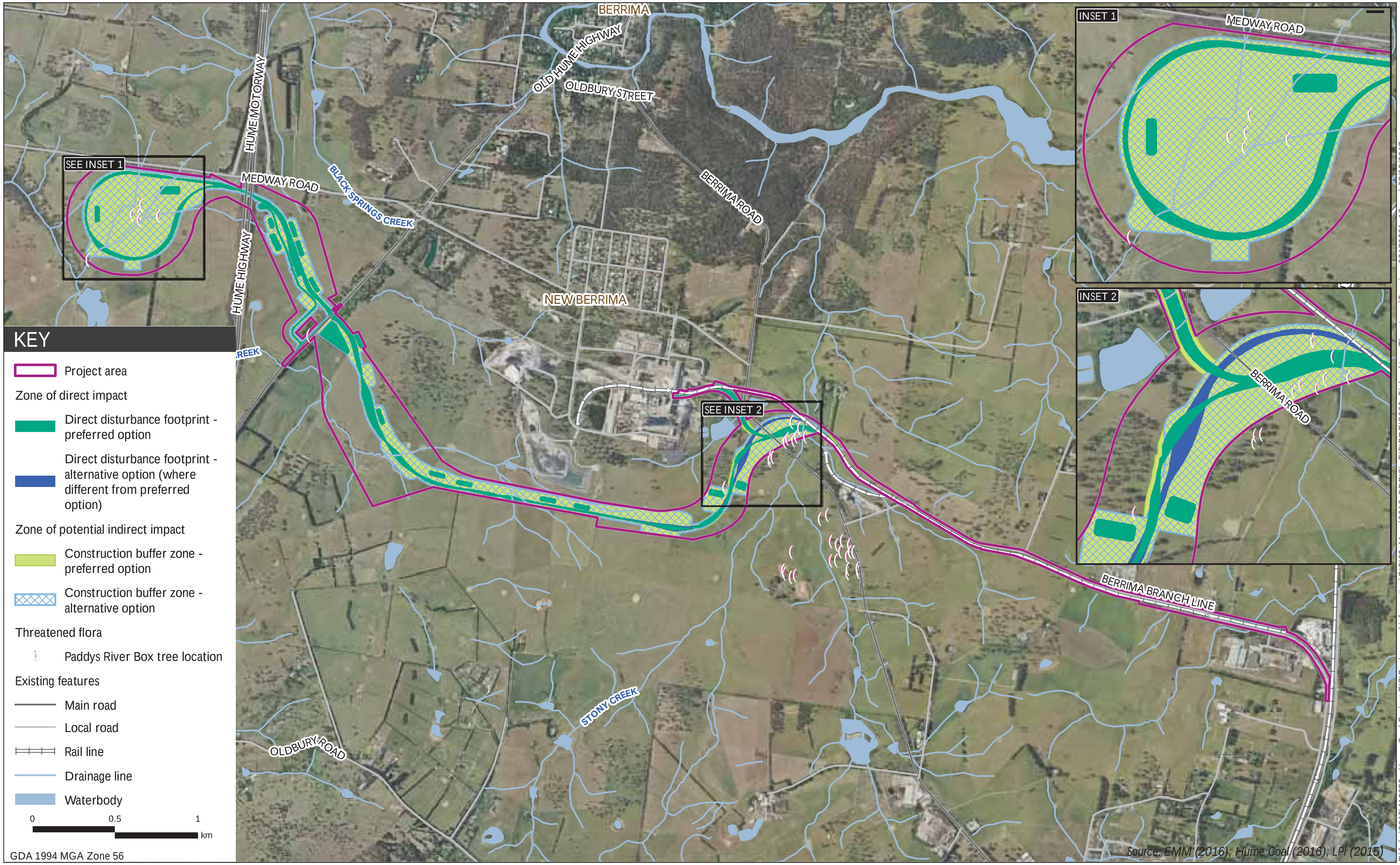
No ecosystem credit species were predicted by the Biobanking Calculator as related to the plant community types that occur in the study area. Additionally, no ecosystem credit species were recorded in the study area.

Potential habitat is present for the following ecosystem credit species that have previously been recorded near the study area, but were not recorded during the survey:

- Little Eagle;
- Gang-gang Cockatoo;
- Scarlet Robin;
- Flame Robin;
- Powerful Owl; and
- Masked Owl.

ii Species credit species

The Biobanking calculator predicted that six species credit species may occur in the study area (refer to Table 12.5).



Threatened species

Berrima Rail Project

Environmental Impact Statement

Figure 12.4

Table 12.5 Predicted species credit species

Species	TSC Act conservation status	EPBC Act conservation status	Habitat in the study area
Dwarf Kerrawang	E	E	Low likelihood. The Snow Gum Woodland contains potential habitat for the species, however targeted surveys completed throughout this small area (0.2 ha) failed to detect the species.
Eastern Pygmy Possum *Cercartetus nanus*	V	-	None. The study area does not contain heathy vegetation with *Banksia* spp. and myrtaceous shrubs.
Hoary Sunray *Leucochrysum albicans* var. *tricolor*	-	E	Low likelihood. This species may potentially occur in woodland along roadsides; however they are highly dependent on the presence of bare ground. As the groundcover (native and exotic) in woodland of the study area is dense they are unlikely to occur and were not recorded during targeted surveys.
Koala	V	V	Low likelihood. Although koalas have been recorded north-east of the study area, this is fragmented from the study area by Berrima Road and the Berrima Branch line. In addition, the fragmented patches of native vegetation only contains a small number of feed tree species (Cabbage Gum) and is dominated by Peppermint species that are not classified as feed trees.
Paddy's River Box	E	Preliminary listing for endangered	Recorded in the study area, however the design has been modified such that any direct impacts to the species will be avoided.
Squirrel Glider	V	-	Moderate likelihood. Large eucalypts containing hollows may provide denning and foraging habitat for the species.

Notes *1. TSC Act - Threatened Species Conservation Act 1995, EPBC Act - Environment Protection and Biodiversity Conservation Act 1999, V - vulnerable, E – endangered.*

As mentioned above only one threatened species was recorded in the study area; Paddy's River Box, which is a species credit species. Sixteen Paddy's River Box were recorded in the study area/project area with a further 24 indivduals recorded in a patch to the south-east of the study area, south-east of the Berrima Cement Works. The Squirrel Glider has a moderate likelihood of occurrence in the study area given the presence of large eucalypts containing hollows. No other species credit species are predicted to occur in the study area.

12.4 Preferred and alternative option impact assessment

This section describes the offsetting requirements associated with native vegetation clearance and the indirect impacts from construction and operation of the project.

12.4.1 Impacts requiring offsetting

The direct disturbance footprint has been designed to minimise direct impacts on native vegetation. Direct impacts on Paddy's River Box will be avoided by the alternative option. However, one tree will be removed for the preferred option. Both preferred and alternative options will involve the clearing of approximately 2 ha of native vegetation.

Potential direct impacts to biodiversity include vegetation clearing, loss of fauna and flora habitat, habitat fragmentation, edge and barrier effects, injury and mortality and changed hydrology. The project will directly impact the following vegetation communities and threatened flora species through clearing:

- approximately 1.8 ha of low condition Broad-leaved Peppermint - Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion (PCT 731);
- approximately 0.2 ha of low condition Snow Gum - Candlebark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion (PCT 1191);
- approximately 2 ha of potential habitat that contains suitable hollow bearing-trees for the Squirrel Glider, a species credit species; and
- removal of one Paddy's River Box (preferred option only).

As the two plant communities in the project area contain habitat for threatened species, both communities require offsetting in accordance with the FBA.

12.4.2 Matters for further consideration

Matters that require further consideration in accordance with Section 9.2 of the FBA are those that are considered to be complicated or severe. The SEARs have identified impacts to Black Gum, a threatened species and population in the Wingecarribee LGA, as a matter for further consideration in the EIS.

Surveys targeted Black Gum throughout the study area, however none were observed. There are eight records of Black Gum in the wider area (Figure 12.5). These records could not be confirmed during the field survey as they were located on private property. However, for the purposes of this study, it is conservatively assumed that they are still present. None of these individuals will be directly impacted by the preferred or alternative options as they are outside the surface infrastructure areas.

No other impacts related to the project meet the thresholds for matters for further consideration in accordance with Section 9.2.1.3 of the FBA.

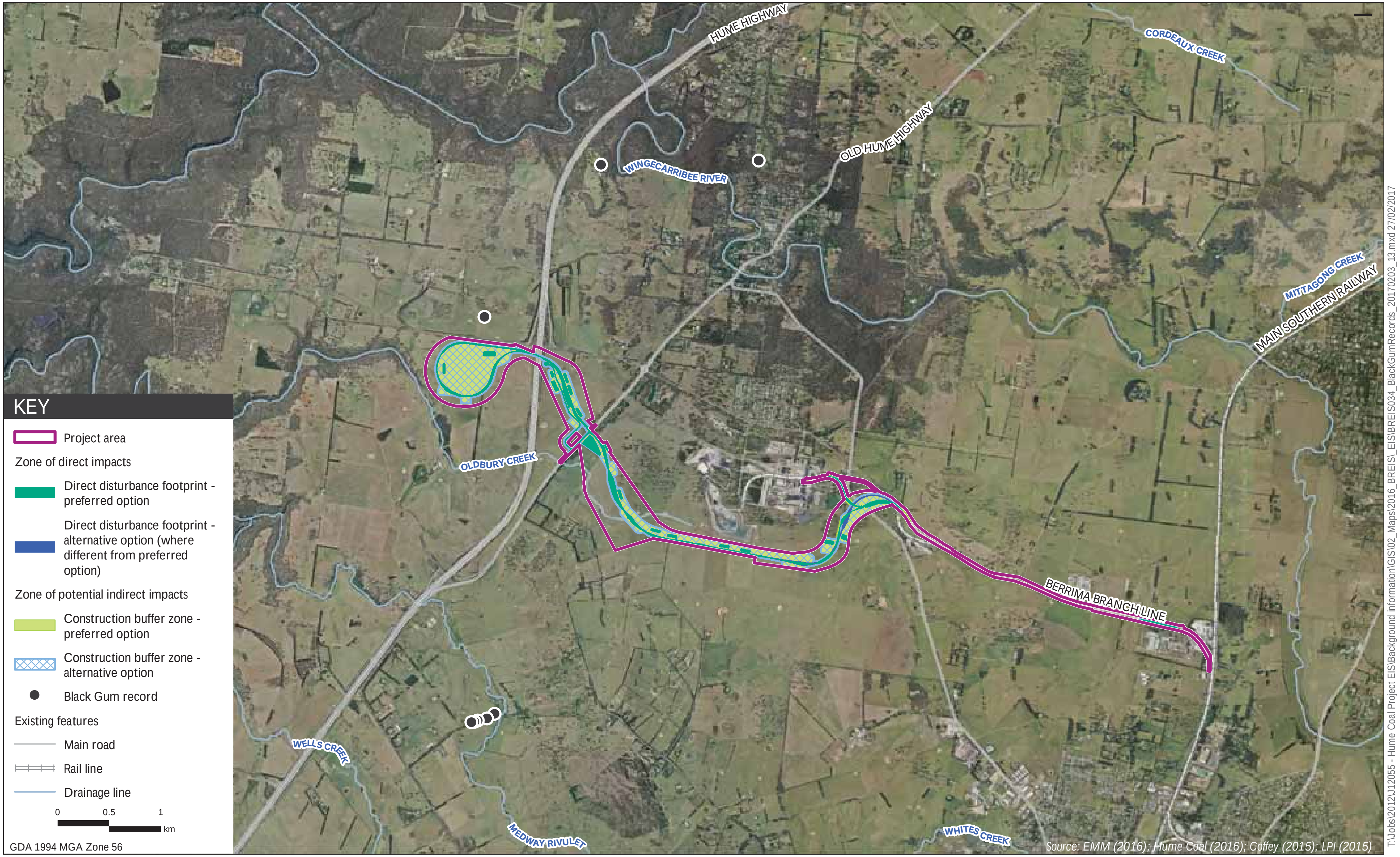
12.4.3 Impacts not assessed under the FBA

i Aquatic and riparian environment

The preferred and alternative options intersect the same five streams, comprising:

1. Stony Creek at the Berrima Road intersection;
2. Oldbury Creek south of the Berrima Cement Works;
3. a tributary of Oldbury Creek south of the Berrima Cement Works;
4. a tributary of Oldbury Creek at the intersection with the Old Hume Highway; and
5. the intersection of the ephemeral tributary of Oldbury Creek within the rail loop.

Drainage culverts will be constructed at stream intersections 2 to 5 for the preferred and alternative options. Although in different locations, culverts will be installed at the Stony Creek intersection for both the preferred and alternative options. Therefore, drainage will be maintained at all the stream intersections.



Black Gum records in the locality

Berrima Rail Project

Environmental Impact Study

Figure 12.5

EMM HUMECOAL

The streams were not found to contain aquatic vegetation or fish habitat. There will be some temporary disturbance of habitat for Eastern Snake-necked Turtles and Yabbies during construction of the drainage culverts at Stony Creek for the preferred or alternative option. These will be managed through the implementation of sediment and erosion controls and aquatic habitat management measures in Section 12.5.2.

ii Edge effects

The clearing of native vegetation for the project will only result in minor edge effects given that only two patches will be fragmented, while connectivity with other patches will be retained. Several invasive weeds including African Lovegrass and Serrated Tussock dominate the understorey in the study area. This constitutes the key threatening process (KTP) listed under the TSC Act "Invasion of native plant communities by exotic perennial grasses". As the understorey of native vegetation in the study area is dominated by exotic species, the potential for new weed species to invade following clearing for the project is low, and additional mitigation is not considered necessary.

iii Fragmentation

Native vegetation in the study area is in a highly fragmented state given its agricultural setting. The alignment of the project has been designed such that further fragmentation is minimised by avoiding native vegetation.

The project will remove the edge of a larger patch of woodland south-west of the Berrima Cement Works. As only the edge of this patch will be removed, it will not have adverse effects on vegetation connectivity. The project will fragment two larger patches of woodland directly south-west of Berrima Road. These patches will be managed such that edge effects are minimised.

The existing level of aquatic connectivity will be maintained through the installation of drainage culverts at each stream intersection.

iv Introduced species

European Rabbit (*Oryctolagus cuniculus*) and Red Fox (*Vulpes vulpes*) scats were recorded in the study area. These pest species can spread into new areas and compete with native species with the creation of new linear developments that fragment large tracts of native vegetation and increase the ease of access for these species. However, given the project's agricultural setting and the poor condition and fragmentation of vegetation; the project is unlikely to increase opportunities for such species.

v Noise

The study area is bisected by Berrima Road, the Berrima Branch Line, the Hume Highway and the Old Hume Highway. The area has high levels of existing traffic noise which can be a deterrent to native fauna species. The minor clearance of native vegetation and operation of the project will not significantly increase traffic noise (both road and rail) from existing levels in retained areas of native vegetation and fauna habitats. The project will result in up to four train movements per day (in both directions), which would increase noise from existing levels. However, as the project is located between the existing Hume Highway and Berrima Road, fauna in the area are likely to be more tolerant of noise disturbances and are expected to acclimatise to additional noise.

vi Groundwater dependent ecosystems and riparian vegetation

The interactive map on the Atlas of Groundwater Dependent Ecosystems (BOM 2016) was queried to identify the presence of any groundwater dependent ecosystems in the study area, which reported that the vegetation has a low potential for groundwater interaction and dependence.

The project will not intersect or take groundwater from underlying systems and there will be no impact to groundwater levels or flow as a result of the project (see Chapter 13). Therefore, the project will not result in any changes or impacts on groundwater availability or groundwater dependent ecosystems.

Riparian vegetation is absent from the study area. Potential indirect impacts including weed invasion of riparian vegetation along the nearby Wingecarribee River will be managed through the implementation of erosion and sediment control measures (Section 12.5).

vii Protected matters search

A 10 km radius around the study area was searched for matters listed under the EPBC Act using the protected matters search tool (DoE 2015). The search tool predicted that this area may contain three TECs, comprising:

- Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion;
- Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion; and
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

The protected matters search tool also predicted that 28 threatened species listed under the EPBC Act may occur in the study area and/or surrounds. Paddy's River Box, formerly only listed under the TSC Act, was listed as an endangered species under the EPBC Act on 5 May 2016.

The protected matters search tool predicted that nine terrestrial and wetland migratory birds may occur in the study area.

A discussion of the species identified by the protected matters search, their likelihood of occurrence and potential to be impacted by the project is provided in the following sub-sections.

a. Listed ecological communities

The soils, geology, structure, floristics and location of each vegetation community were compared against the listing advice for each of the TECs predicted to occur by the protected matters search tool (DoE 2015).

In accordance with the *Approved Conservation Advice (including listing advice) for Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion* (TSSC 2015), to be considered a matter of national environmental significance under the EPBC Act, areas of the ecological community must meet:

- the key diagnostic characteristics:
  - an open forest or woodland with a canopy dominated by one or more eucalypt species listed in Table 1 of the Approved Conservation Advice (TSSC 2015);
  - has a ground layer including native grasses and/or other herbs;
  - occurs in the Southern Highlands in the Sydney Basin Bioregion;

- occurs at elevations between 470 to 830 m ASL on clay soils derived from Wianamatta Shale; and

- at least the minimum condition thresholds for moderate quality.

The TECs predicted to occur in the region do not meet the above characteristics as follows:

- Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion –
  - The Broad-leaved Peppermint Narrow-leaved Peppermint grassy woodland community shares similarities with this TEC. However, it does not satisfy the minimum condition thresholds for moderate quality.
  - The Snow Gum Black Sallee grassy woodland was also compared to this TEC. Although it contains Snow Gum, it also contains Black Sallee which is recognised in the advice as a contra-indicative species (ie indicates that the community is not present).
- Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion – Snow Gum Black Sallee grassy woodland was also compared to the listing advice for this TEC. However, its dominant canopy species is Snow Gum, which do not form part of the listed community.
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland – Grasslands recorded in the study area are dominated by exotic species and do not meet the criteria for this TEC.

b. Listed flora

The study area and project area contain 16 Paddy's River Box trees, listed as an endangered species under the EPBC Act. A further 24 individuals were recorded south of the study area, and had a similar height to those individuals in the study area, but appeared to be older. Some mature trees with greater than 1 m diameter at breast height were recorded south of the study area.

The preferred option requires the removal of one Paddy's River Box tree, while the alternative option avoids all direct impacts. The closest Paddy's River Box to the alternative option is 4 m, and would be protected from inadvertent damage from vehicles and plant during construction and operation by fencing.

An assessment of significance was completed for potential impacts on Paddy's River Box from the preferred and alternative options. The assessment concluded that the project will not result in significant impacts on Paddy's River Box, as:

- direct impacts will be largely avoided by the preferred option, with only 1 of 16 individuals in the study area to be potentially removed by the project (ie preferred option only);
- direct impacts will be completely avoided by the alternative option; and
- indirect impacts will be managed in accordance with the CEMP.

The assessment found that the study area does not contain habitat for any other listed threatened flora species.

c. Listed fauna

The protected matters search tool predicted that habitat may be present for 17 listed fauna species in the study area. An assessment of the likelihood that these species would occur was completed. A farm dam directly adjacent to the study area may contain potential habitat for the endangered Australian Painted Snipe, which was recorded at a farm dam in Berrima in 2010 (OEH 2016b). This assessment is relevant to both the preferred and alternative options.

An assessment of significance was completed for the Australian Painted Snipe, which concluded that the project is unlikely to significantly impact it as:

- direct impacts will not occur as its potential habitat is outside the study area; and
- only a minor increase in indirect impacts (ie light and noise) is expected as part of the project area which contains an existing rail line.

The study area is not predicted to provide habitat for any other listed fauna species.

d. Migratory fauna

There is a moderate likelihood that four migratory species, namely the Great Egret (*Ardea alba*), Cattle Egret (*Ardea ibis*), Rainbow Bee-eater (*Merops ornatus*) and Latham's Snipe (*Gallinago hardwickii*) may occur in a low-lying area east of Berrima Road following high rainfall events. This assessment is relevant to both the preferred and alternative options.

An assessment of significance was completed for the Rainbow Bee-eater, Great Egret, Cattle Egret and Latham's Snipe, which concluded that the project is unlikely to significantly impact them as:

- important habitat is absent from the study area and therefore will not be substantially modified;
- the project will not increase the spread of invasive species; and
- the lifecycle of an ecologically significant proportion of the migratory species populations will not be disrupted, as breeding occurs outside the study area.

The study area is not predicted to provide habitat for any other listed migratory species.

e. Wetlands of international importance, world heritage properties and national heritage places

The closest Ramsar wetlands is Towra Point Nature Reserve (DoE 2016a), located over 95 km north-east of the study area. The closest waterways to Towra Point Nature Reserve (the Georges and Nepean Rivers) terminate 56 km and 26 km north of the study area in Cataract and East Kangaloon, respectively.

The project will not have any direct or indirect impacts to wetlands of international importance (declared Ramsar wetlands). There is no potential for the project to affect the Ramsar wetland in Towra Point Nature Reserve.

There are no world heritage properties or national heritage places within or adjoining the preferred or alternative options.

12.4.4 Analysis of results including summary of design impact differences

The preferred and alternative options will result in similar, and minor, impacts to biodiversity. Both options will result in approximately 2 ha of native vegetation clearing and will require the installation of culverts at five different stream intersections. The only difference between the two is that the preferred option requires the removal of one Paddy's River Box tree, while the alternative option would avoid all direct impacts to the species.

12.4.5 Cumulative impacts

The potential cumulative biodiversity impacts have been assessed with the following projects:

- the proposed Hume Coal Project – which will be serviced by the project. This project will result in minor residual impacts on potential Squirrel Glider habitat. Species credits have been generated for the Squirrel Glider for both projects, and appropriate offsets will be provided to offset the minor cumulative impact to their potential habitat.

- New Berrima Clay/Shale Quarry (The Austral Brick Company Pty Ltd (Austral)) – no construction or extraction operations have been undertaken since Project Approval was granted. The quarry is approximately 4 km from the eastern boundary of the project area. The project's biodiversity assessment found no threatened flora/fauna species or ecological communities listed under the TSC or EPBC acts occurr at the site.

- Green Valley Sand Quarry (Rocla Materials Pty Ltd (Rocla)) – The quarry is not yet operational.The quarry is approximately 28 km south-west of Berrima and 14 km north-east of Marulan. Similar vegetation types were reported as for the proposed Sutton Forest Quarry, which are different to the vegetation communities of the project area, and therefore no cumulative loss of similar vegetation types will occur. There will be a minor cumulative impact on Squirrel Glider habitat, removing an additional 2 ha of potential habitat. While Paddys River Box occurs within the project area, none of these individuals will be impacted by the design for the alternative option, while one would be impacted for the preferred option. Therefore, if the alternate option is selected, there will be no cumulative loss of Paddys River Box between the project and the proposed Green Valley Sand Quarry. However, if the preferred option is selected, there will be a cumulative impact in the loss of one additional Paddys River Box tree.

- Sutton Forest Quarry – SEARs for the Sutton Forest Quarry were issued on 7 February 2014 but a development application has not been submitted yet. The quarry will be approximately 20 km south-west of Moss Vale. There will be no cumulative loss of similar vegetation types between the project and the proposed Sutton Forest Quarry, should it proceed.

12.5 Impact avoidance, minimisation and mitigation

12.5.1 Impact avoidance and minimisation

The project area is in a predominantly cleared agricultural area. The new rail line has been designed to avoid clearing of native vegetation, and the vegetation to be cleared is in poor condition. In particular, the rail line has been designed to avoid direct impacts to the endangered Paddy's River Box with the exception of the clearance of one individual tree if the preferred option is constructed. As such, impacts on native vegetation and threatened species habitats have been largely avoided.

In addition, mature trees within the Boral cement garden will be avoided as much as possible during construction of the new rail siding into the cement works (under the preferred option). The Southern Highlands Branch of the Australian Garden History Society will be consulted about the trees to be removed for the rail line.

The project will result in the residual impact of 2.0 ha of native vegetation clearing. This clearing cannot be avoided due to specific alignment requirements and the requirement to meet track design standards. Measures are proposed to mitigate and offset these residual impacts in the following section.

12.5.2 Impact mitigation

The following measures will be incorporated into the CEMP to minimise impacts to biodiversity.

- Prior to construction commencing, Paddy's River Box trees in the project area will be identified and marked to ensure they are avoided during construction.
- The site will be inspected before clearing to mark all hollow-bearing trees to be removed, for later management during construction.
- Felling of hollow-bearing trees in the project area will follow a two-stage clearing protocol, whereby surrounding non-hollow vegetation is cleared 24 hours prior to the hollow trees to allow fauna time to move.
- A suitably trained and experienced ecologist or fauna handler will be present during hollow-bearing tree clearing to rescue and relocate displaced fauna.
- Erosion and sedimentation control measures will be implemented in accordance with the measures outlined in Chapter 14.
- Appropriate drainage infrastructure (such as culverts) will be installed within the rail loop embankment to ensure that existing overland flow paths through the rail loop area are maintained throughout the life of the project. This is to avoid the potential risk of impact on the Paddy's River Box within the rail loop through the alteration of surface water flows.
- Weed management control measures will be implemented during the construction phase of the project.

12.6 Biodiversity credit report

A biodiversity Credit Report was prepared using data collected in accordance with the FBA. This data was entered into the Credit Calculator Version 4.0 Major Projects. A total of six ecosystem credits are required to compensate for the project's impact on Snow Gum – Candle Bark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion as it provides habitat for the Masked Owl and Powerful Owl (refer to Figure 12.6). Areas not requiring offsetting are shown in Figure 12.7.

A total of 44 species credits are required to compensate for the project's impacts on potential habitat for the Squirrel Glider. If the preferred option is adopted, 14 species credits will be required for Paddy's River Box. The area of Squirrel Glider habitat to be offset is the 0.2 ha of the Snow Gum – Candlebark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion and the 1.8 ha of Broad-leaved Peppermint – Red Stringybark grassy open forest on undulating hills, South Eastern Highlands Bioregion (refer to Figure 12.8).

Vegetation mapping and threatened species records were reviewed for the project area to determine if potentially suitable offset areas were present, that would satisfy the offset requirements for both the Hume Coal Project and Berrima Rail Project (see Appendix H of the Hume Coal BAR for potential offset calculations). A potential offset site was assessed in the north of the project area, along Oldbury Creek. Investigations will continue to secure a suitable offset for the project. Hume Coal will prepare a Biodiversity Offset Package in consultation with OEH and DP&E, and will submit the draft to the Secretary for approval within 12 months of development consent being granted.

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Ecosystem credits to be offset

Berrima Rail Project

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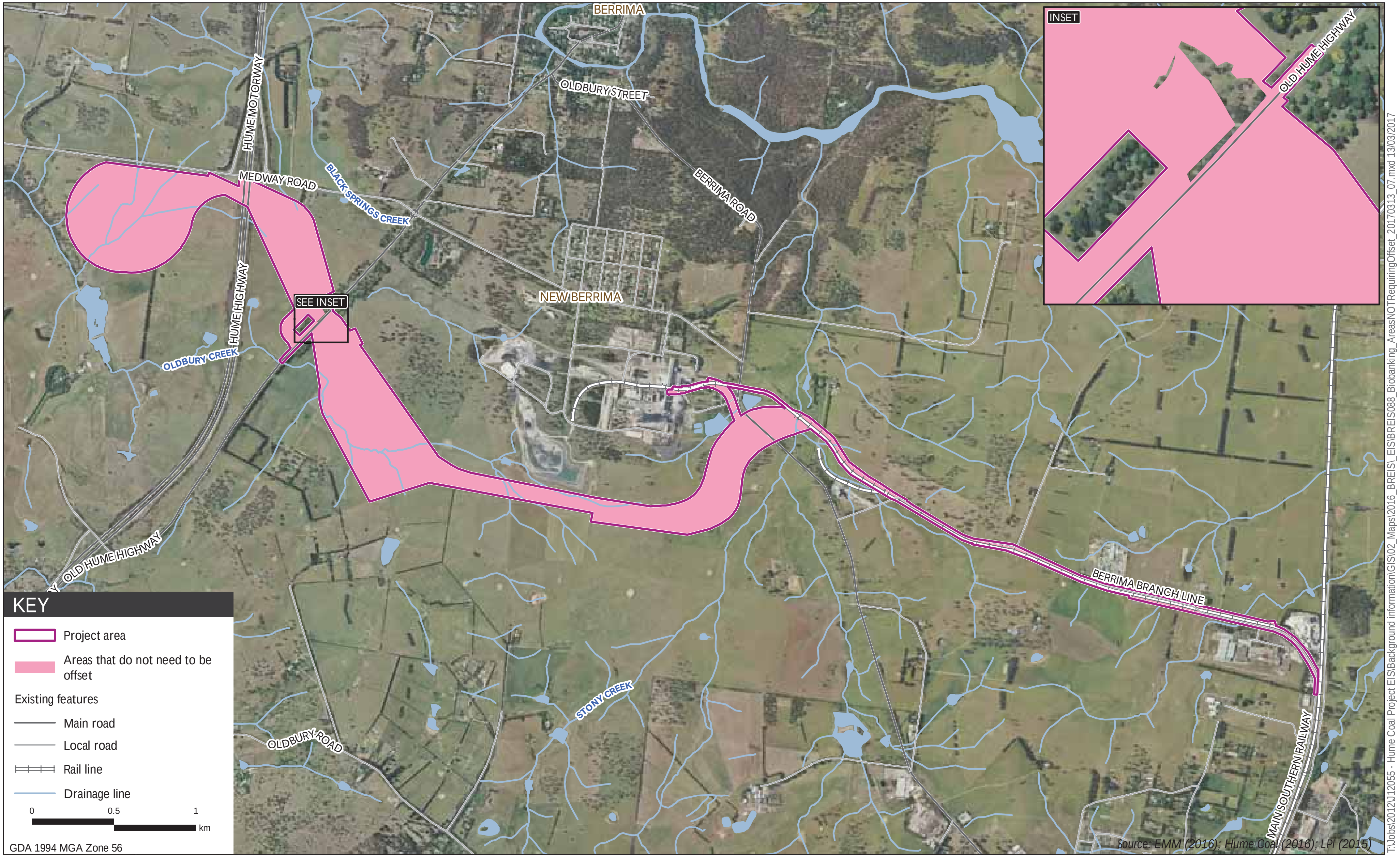
Figure 12.6

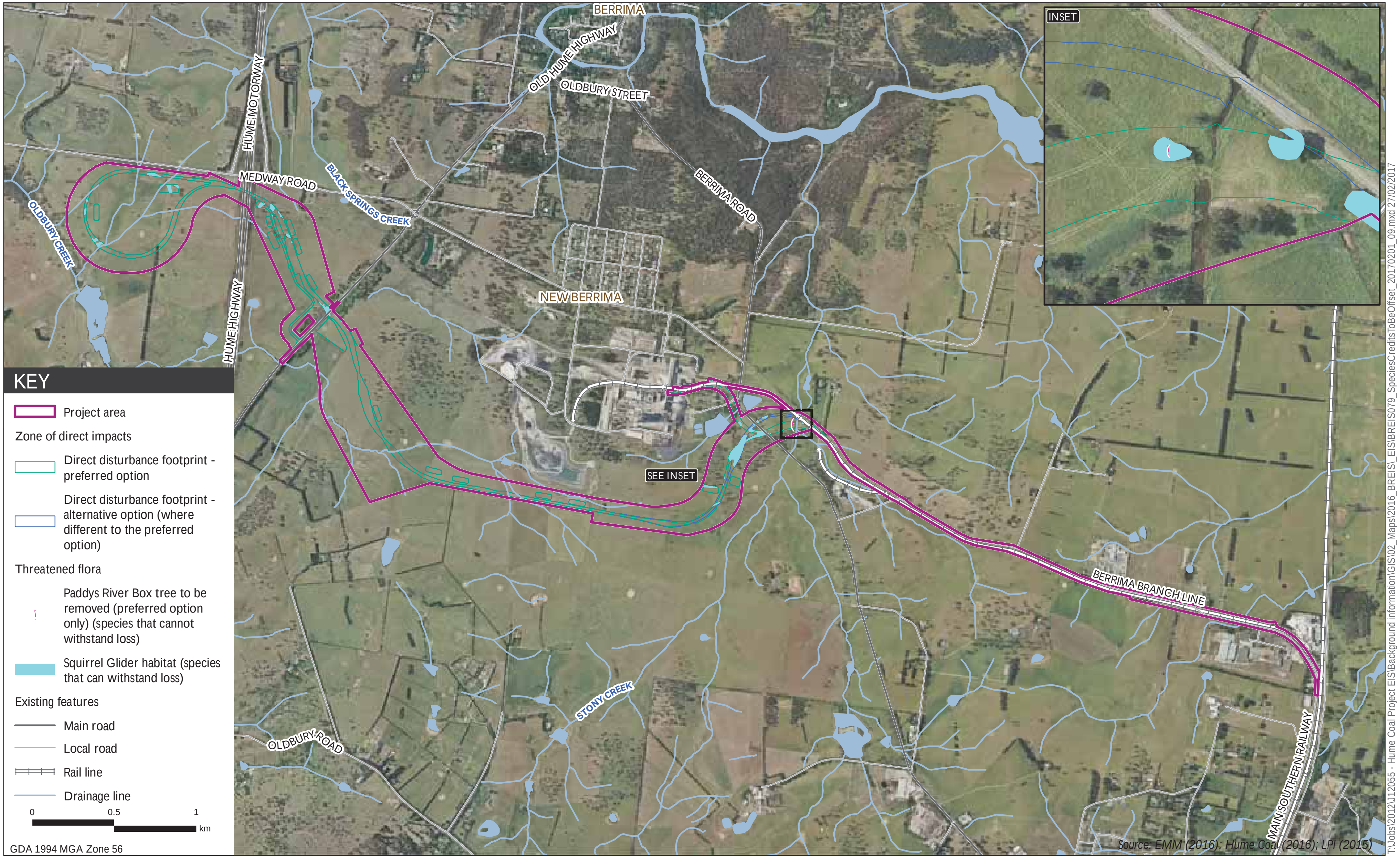


Areas that do not need to be offset

Berrima Rail Project

Environmental Impact Statement

Figure 12.7



Species credit to be offset
Berrima Rail Project
Environmental impact statement
Figure 12.8

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12.7 Conclusion

The biodiversity assessment of the study area recorded two native vegetation communities, a population of the endangered Paddy's River Box and potential habitat for the vulnerable Squirrel Glider, endangered Australian Painted Snipe, and migratory species comprising the Great Egret, Cattle Egret, Rainbow Bee-eater and Latham's Snipe. No key fish habitats or habitat for threatened fish species were recorded.

The preferred and alternative options have been specifically designed to minimise impacts on native vegetation and threatened species habitats. Both preferred and alternative options will result in minor residual impacts on 2.0 ha of native vegetation and potential Squirrel Glider habitat. The preferred option will also remove one Paddy's River Box tree, while the alternative option would retain it.

Potential indirect impacts to biodiversity will be mitigated through the preparation and implementation of the project CEMP, which will include measures to manage biodiversity during construction.

An offset strategy has been prepared to compensate for the residual impacts on 2 ha of native vegetation and potential Squirrel Glider habitat, and the removal of one Paddy's River Box tree, should the preferred option be adopted. The offset strategy will be finalised within 12 months of project approval in consultation with OEH and DP&E.

13 Water resources

13.1 Introduction

A surface water assessment was conducted for the project to investigate:

- 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 13.2);
- scour and erosion risk around crossing structures and drainage outlets and typical treatment measures to protect adjacent land and receiving watercourses (Section 13.3);
- potential impediments to fish passage associated with the rail infrastructure and mitigation measures to be employed to negate these impacts (Section 13.4); and
- potential impacts on water quality and measures to control or reduce pollutants (Section 13.5).

This chapter summarises the findings of the detailed surface water assessment which is containted in full in Appendix K.

13.1.1 Assessment requirements

The environmental assessment requirements relating to water resources, and the sections of the EIS where the requirements are addressed, are provided in Table 13.1.

Table 13.1 Water resources – relevant assessment requirements

Requirement	Agency	Section where addressed
An assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the EPA's, DPI's and Water NSW's requirements and recommendations.	DP&E	Sections 13.2, 13.3, 13.5. The project will not intersect or take groundwater from underlying systems and there will be no impact to groundwater levels or flow as a result of the project.
An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users.	DP&E	Impacts on watercourses and water users are addressed in this chapter. Impacts on riparian land are addressed in Chapter 12.
An assessment of the likely flooding impacts of the development.	DP&E	Section 13.2
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 13.2

Table 13.1 Water resources – relevant assessment requirements

Requirement	Agency	Section where addressed
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 13.5
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 13.5
Description of potential impediments to fish passage as a result of the works (eg temporary coffer dams, instream bunds or work platforms) and possible mitigation measures to be employed to negate these impacts.	Fisheries NSW	Section 13.4
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 13.5
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 13.5
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 13.3 and 13.5
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 13.4
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.

Table 13.1 Water resources – relevant assessment requirements

Requirement	Agency	Section where addressed
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 13.2 and 13.5
An assessment of impediment to surface water flow, and potential flood impacts.	DPI Water	Section 13.2
Proposed surface water monitoring activities and methodologies.	DPI Water	Section 13.5
Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	DPI Water	Section 13.2
Identification of all surface water features including watercourses, wetlands and floodplains transected by or adjacent to the proposed project.	DPI Water	Section 13.2.2
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.		Section 13.2.1
Assessment of predicted impacts on the following:	DPI Water	
flow of surface water, sediment movement, channel stability, and hydraulic regime,		Section 13.3
water quality,		Section 13.5
flood regime,		Section 13.2
dependent ecosystems, existing surface water users.		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.

Table 13.1 Water resources – relevant assessment requirements

Requirement	Agency	Section where addressed
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:	DPI Water	
Photographs of the watercourses/wetlands and a map showing the point from which the photos were taken.		Section 13.3.2
A detailed description of all potential impacts on the watercourses/riparian land.		Sections 13.3.2, 13.3.3, 13.3.4 and 13.3.5
A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime.		There are no wetlands in the project area
A description of the design features and measures to be incorporated to mitigate potential impacts.		Sections 13.2.6, 13.3.6, 13.4 and 13.5
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.		Section 13.3.2
It is noted that on page 63, the proposed water quality assessment includes evaluation against neutral and beneficial effect (NOBE) 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 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.	NSW EPA	Section 13.5

13.2 Flooding and drainage

An assessment of the potential impacts of the project on flooding in the local catchments was conducted, identifying the mitigation measures required to minimise potential impacts and protect the rail infrastructure during flood events. The outcomes of the assessment are summarised in the below sub-sections.

13.2.1 Assessment methodology

The project area is located within the Oldbury Creek and Stony Creek catchments, as illustrated in Figure 13.1. 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 below.

i Data sources

Light detection and ranging (LiDAR) data for the project area was obtained from an aerial laser survey of the area on 25 October 2013 (Hume Coal 2013). This date was used in catchment delineation for the hydrology modelling and in development of a digital terrain model (DTM) for the hydraulic modelling. 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 during installation of streamflow gauge SW08 on Oldbury Creek (Figure 13.1) were included in the hydraulic model.

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).

Design rainfall intensity estimates were derived using AR&R (Engineers Australia 2001). Design rainfall hyetographs for PMF storm events were calculated by proportioning from storm data derived from the Intensity frequency duration (IFD) method, as defined in Chapter 2 of AR&R, Volume 2 (Engineers Australia 1987, 2001) and input to XP RAFTS.

The rainfall data used in the flooding assessment was collected from BoM rainfall stations in the vicinity of the project area and the Hume Coal weather station installed in the project area in February 2012. The locations of the stations are shown on Figure 13.1, while details of the stations are provided in Table 13.2.

Table 13.2 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
Hume Coal (MET01)	n/a	250727	6170163	675	2012 – 2015	10 minute

Note: # All weather stations have some data gaps, however data is available each month in each year.

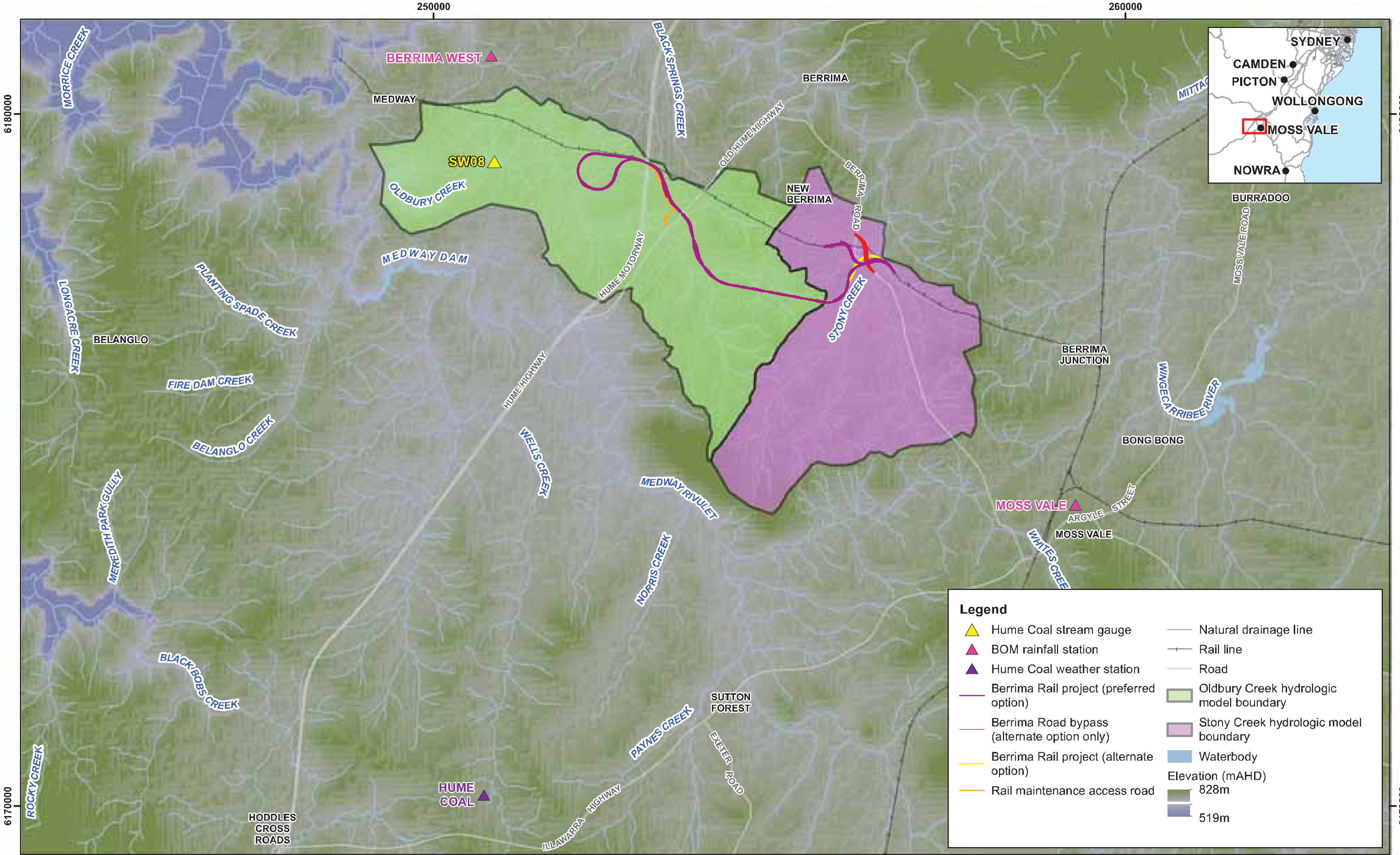
The nearest BOM weather station to the project is the station at Berrima West (68186). From analysis of the Berrima West station record, peak rainfall events during the baseline monitoring period from 2013 to 2105 occurred on:

- 26 June 2013;
- 8 August 2014; and
- 25 August 2015.

The largest event occurred on 25 August 2015. Data from the Hume Coal 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 Hume Coal weather station was carried out instead and concluded the August 2015 event was approximately a 1 year ARI 2 hour event.

A larger event is preferred for calibration. Data from local rainfall stations and flow gauges on the Wingecarribee River with a longer period of record were therefore 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 2000's, 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 weather station indicated that rainfall at the Hume Coal station is higher than at Berrima West. The total rainfall for each day during the August 2015 storm event at the Hume Coal MET01 station was therefore factored down accordingly. The adjustment factor was determined by comparing total daily rainfall at the Berrima West station with total daily rainfall at the Hume Coal station during the August 2015 event.



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Data source: © Land and Property Information 2015, Hume Coal			Scale ratio correct when printed at A3

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Figure 13.1

Study area and data sources

a. 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 13.3 shows the parameters used in the PMP calculation for Oldbury Creek and Stony Creek and Table 13.4 provides a summary of the resulting PMP rainfall depths.

Table 13.3 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 13.4 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

b. Streamflow

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 Manly Hydraulics Laboratory.

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 in Figure 13.1. Details of the gauge are provided in Table 13.5. There are no stream gauges on Stony Creek.

Table 13.5 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* – 30/09/2016	15 minute

Note: * Date monitoring at this stream gauge commenced.

Water level data collected at SW08 during the August 2015 event was converted to flow data using a rating curve from the HEC-RAS model for the Oldbury Creek catchment (refer to Section 13.2.1 iii).

Figure 13.2 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 rainfall data – refer to Section 13.2.1 i) was used to calibrate the hydrologic model for Oldbury Creek.

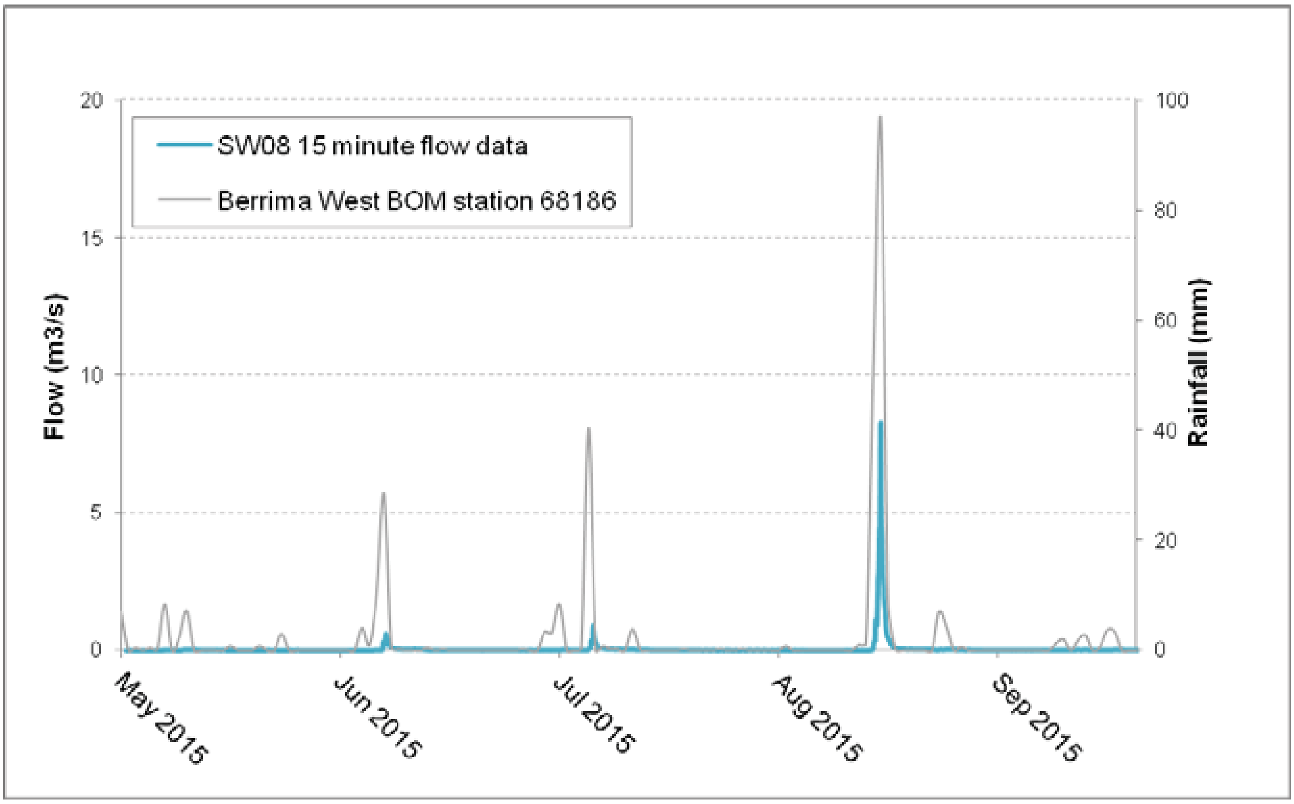


Figure 13.2 Stream flow at SW08

ii Hydrologic modelling

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.

The XP-RAFTS models of the Oldbury Creek and Stony Creek catchments 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 alternative option (refer to Section 2.3.1) 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. 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 13.2.1 ii b.

a. 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 and the Stony Creek catchment was divided into 16 sub-catchments 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 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.

The catchment parameters adopted for the existing and rehabilitation scenarios are the same. Percentage impervious was increased for the operation case in sub-catchments 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 13.2.1 i b).

Probable maximum precipitation design rainfall

The parameters used in the PMP calculation for Oldbury Creek and Stony Creek are provided in Table 13.3 and the PMP rainfall depths are provided in Table 13.4. 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.

b. Model calibration and checks

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 13.6 for both Oldbury Creek and Stony Creek. The results from the calibration are presented in Figure 13.3 which shows that the model achieved a good predictive estimate of the observed event.

Table 13.6 Adopted loss and B factor values

XP-RAFTS input	Value 5 yr, 20 yr and 100yr ARI	Value PMP
Initial loss (mm)	20	0
Continuing loss (mm/hr)	3.7	3.7
B factor	1.0	1.0

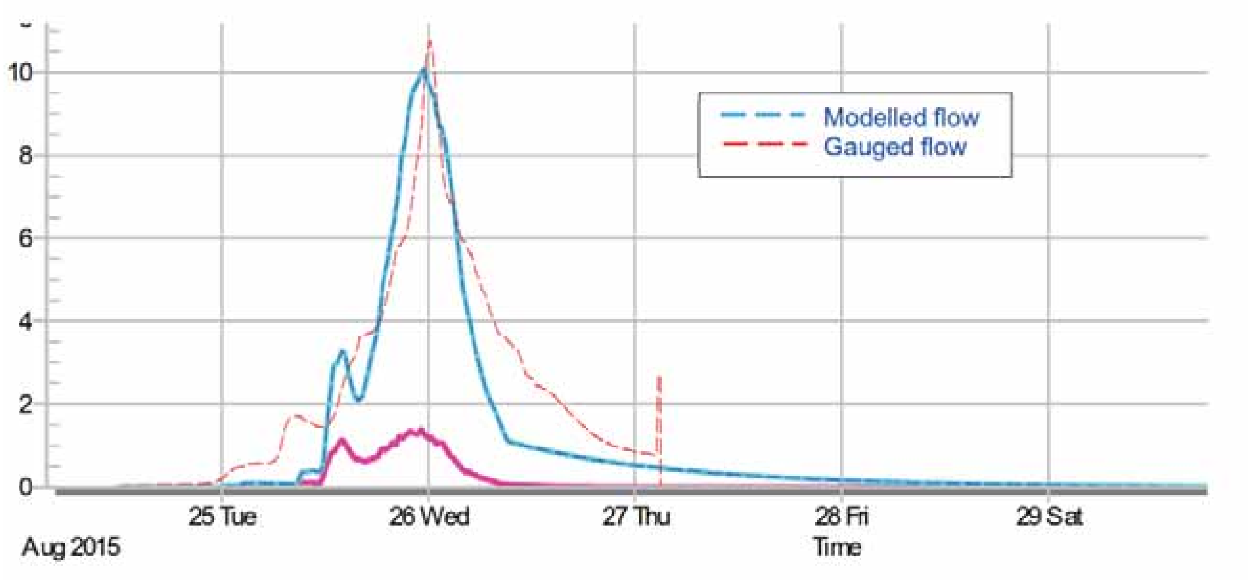


Figure 13.3 Oldbury Creek XP-RAFTS calibration output

A check of the hydrologic model was undertaken by comparing the model flow estimates against probabilistic rational method (PRM) calculations for the 5 year, 20 year and 100 year ARI events for Oldbury Creek. The results are provided in Table 13.7 and show a reasonable agreement between the XP-RAFTS and PRM peak flow estimates.

Table 13.7 Check of peak flows in Oldbury Creek using PRM

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%

c. Design event modelling

Peak flows generated within the Oldbury Creek and Stony Creek catchments for the critical storm durations were extracted from the XP-RAFTS models. 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 were input to the hydraulic model to assess changes in flood behaviour due to the proposed project infrastructure.

iii 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 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.

a. 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 13.2.1 ii a).

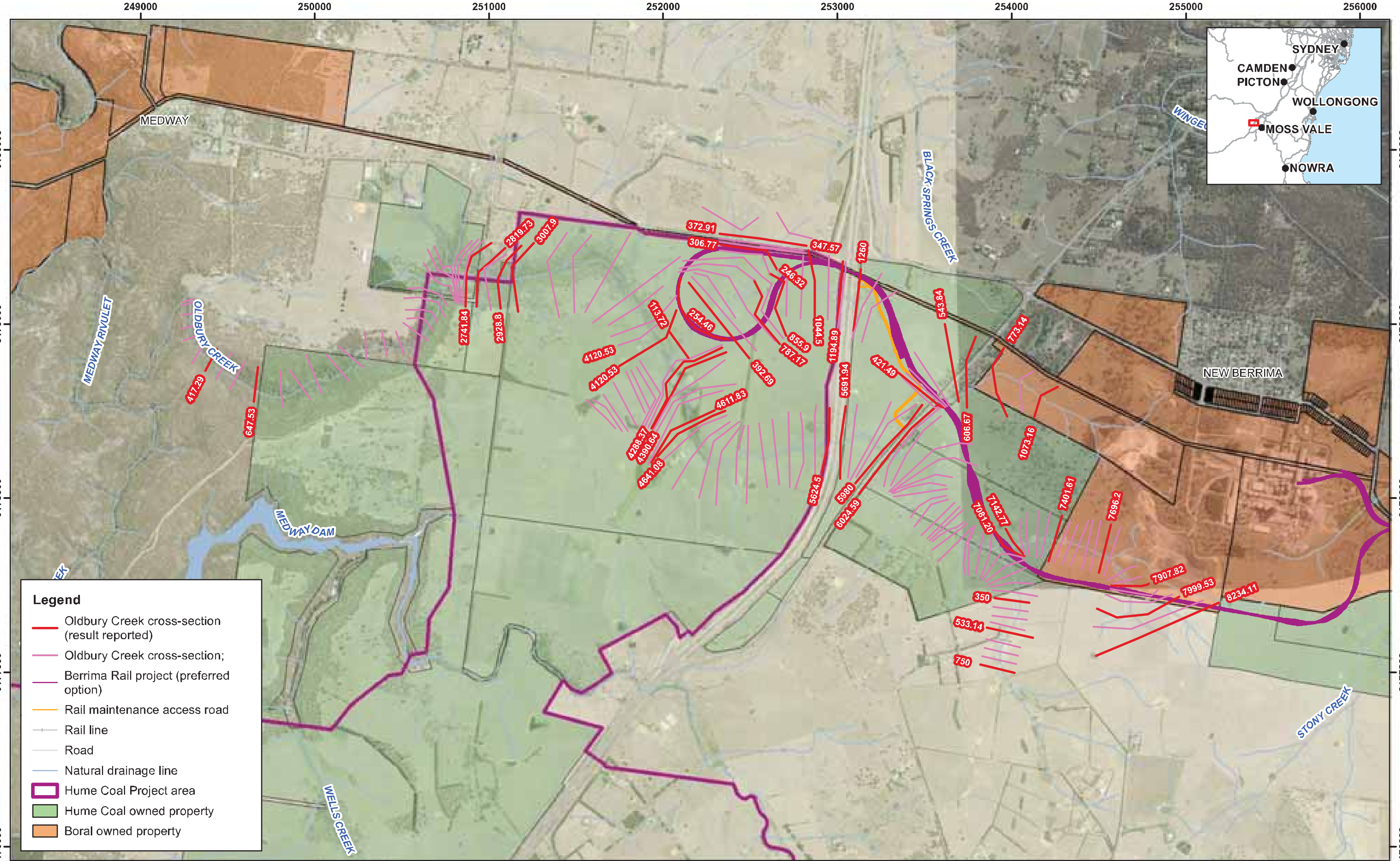
Cross-sections of the river channel and floodplain were extracted from the DTM approximately every 100 m along the length of Oldbury Creek, Stony Creek and minor tributaries. Cross sections were added to locations where there is hydraulic constraint such as road crossings to ensure all topographical 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 13.4, 13.5 and 13.6 show the modelled reaches and cross-sections.

Cross-sections at stream gauge SW08 were surveyed by Manly Hydraluics Laboratory 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 13.2.1 ii b).

Boundary conditions

Inflows were assigned to reaches of the hydraulic model for each stream/tributary, based on the flow outputs of the hydrologic model.

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.



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

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Figure 13.4

Oldbury Creek cross-sections

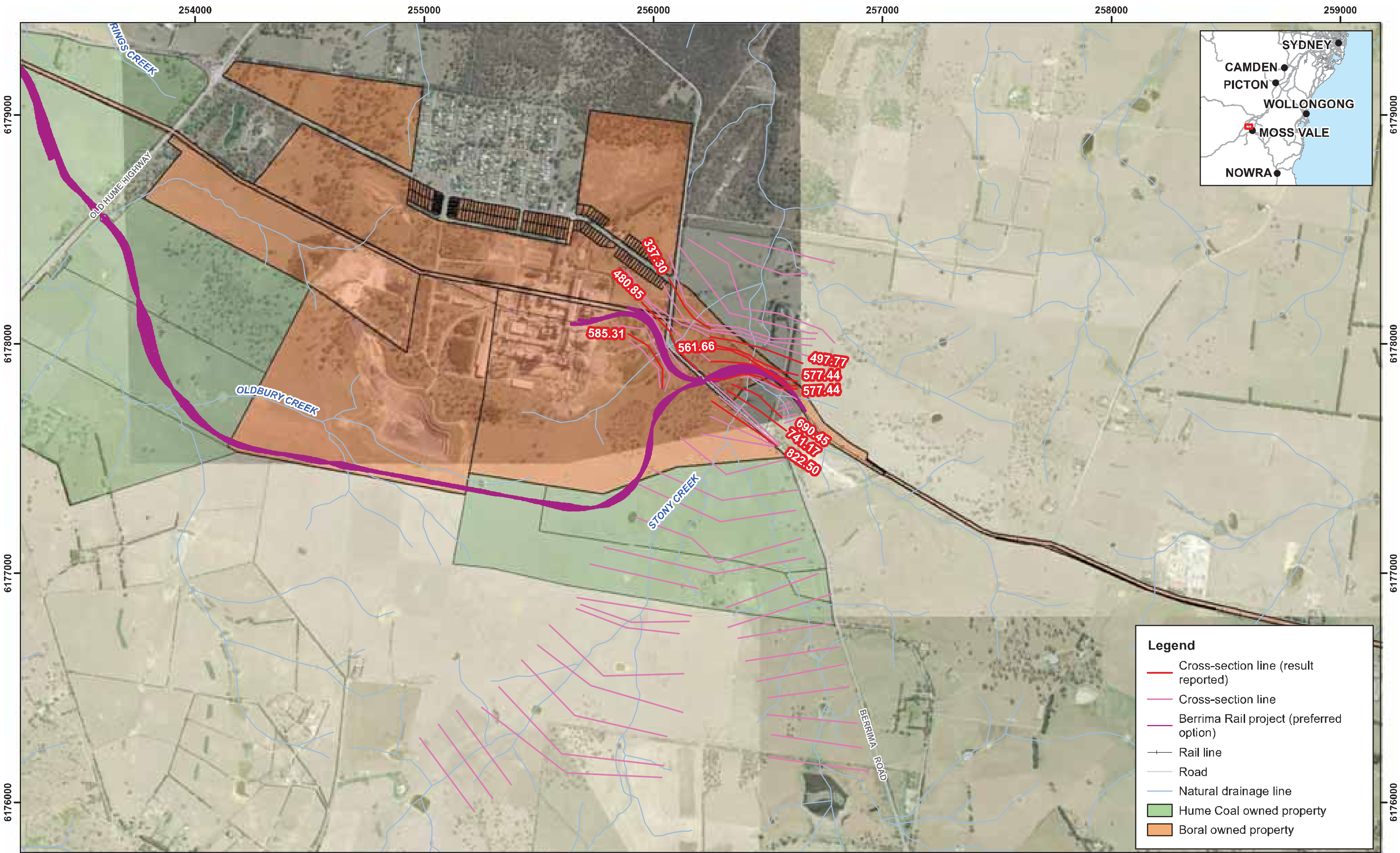

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Figure 13.5

Stony Creek cross-sections (preferred option)

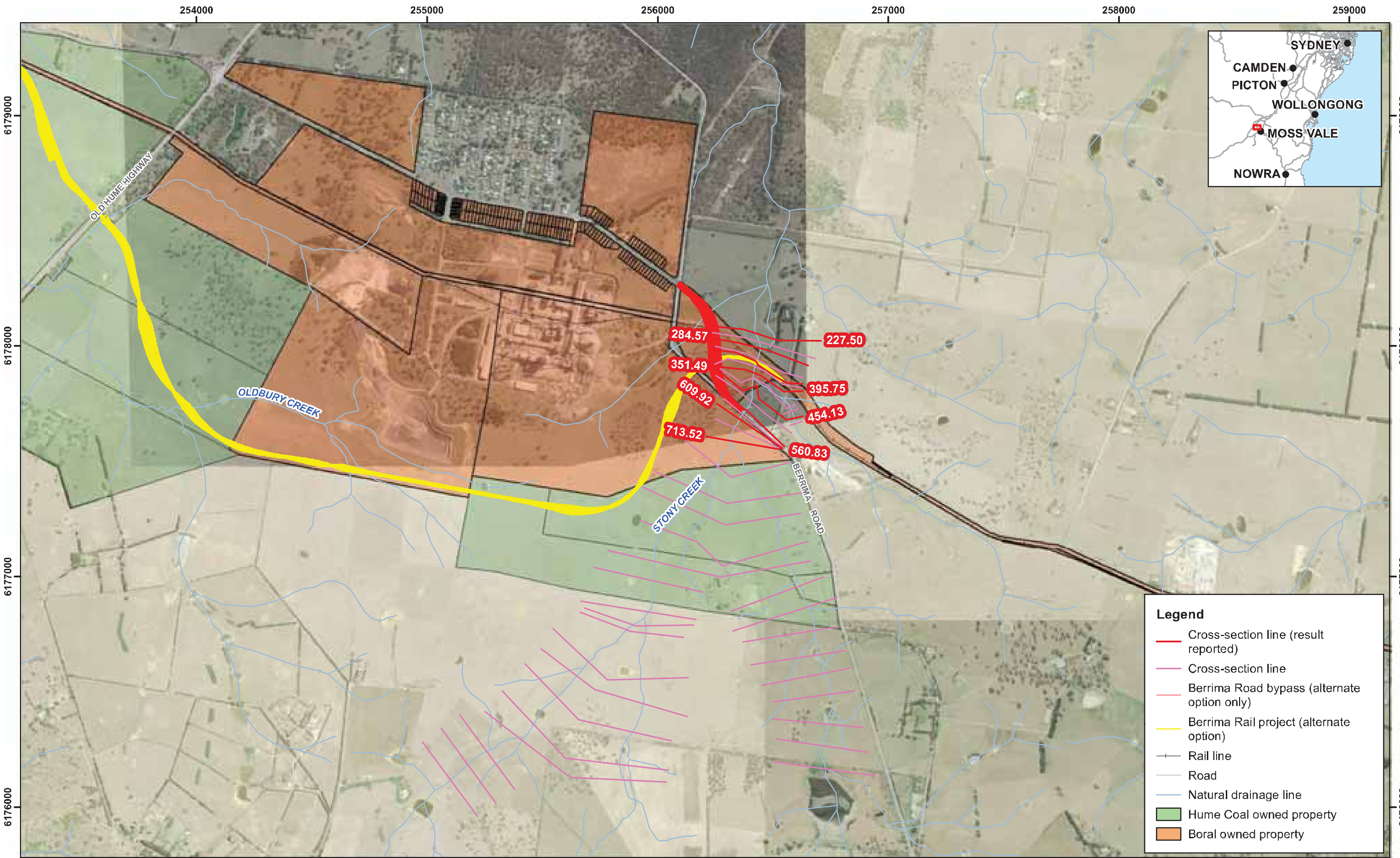

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Figure 13.6

Stony Creek cross-sections (alternate option)

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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 13.8 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 13.8 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

b. Modelled scenarios

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

c. 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 box culverts 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 box culvert 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 box culvert located under the existing rail line at the northwest tributary Stony Creek.

d. Modelled structures - 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 iv below) up to the 100 year ARI event. The proposed structures included in the models are provided in Table 13.9.

Table 13.9 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	Alternative	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 alternative	3 x 750 mm diameter pipe
Tributary of Oldbury Creek	South eastern side of rail loop	Preferred and alternative	2 x 1400 mm diameter pipe
Oldbury Creek	East of Old Hume Highway	Preferred and alternative	5 x 2000 mm x1200mm RCBC
Drainage depression alongside Hume Highway	Immediately east of Old Hume Highway	Preferred and alternative	4 x 1800 mm x 900 mm RCBC
Overland flow path (flowing to tributary of Oldbury Creek)	Eastern side of rail loop	Preferred and alternative	1400 mm diameter pipe
Oldbury Creek	South east of Berrima Cement Works	Preferred and alternative	5 x 2000 mm x1200mm RCBC

Note: RCBC – Reinforced concrete box culvert.

iv 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 area. In the absence of detailed flood assessment criteria in the SEARs the following criteria are nominated 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.

13.2.2 Existing environment

i 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 (Figure 13.1).

Oldbury Creek flows in a westerly direction from its headwaters in New Berrima to its discharge into Medway Rivulet (Figure 13.1).

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 (Figure 13.1).

ii 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 (Figure 13.1).

Stony Creek flows in a northerly direction towards the Wingecarribee River (Figure 13.1).

Land use within the catchment is predominantly cleared farm land for grazing with some irrigation (Figure 13.1).

13.2.3 Preferred option impact assessment

i Flood extent

Figure 13.7 presents a comparison of the 100 year ARI flood extent for the existing and operation scenarios for the preferred option. Figures showing the 5 year and 20 year ARI and PMF flood extents for the existing and operation scenarios are presented in the Surface Water Assessment Report (2200569A-WAT-REP-001).

Figure 13.8 presents a comparison of the 100 year ARI flood extent for the existing and rehabilitation scenarios. Figures comparing the 5 year and 20 year ARI and PMF flood extents for the existing and rehabilitation scenarios are presented in the Surface Water Assessment Report (2200569A-WAT-REP-001).

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.

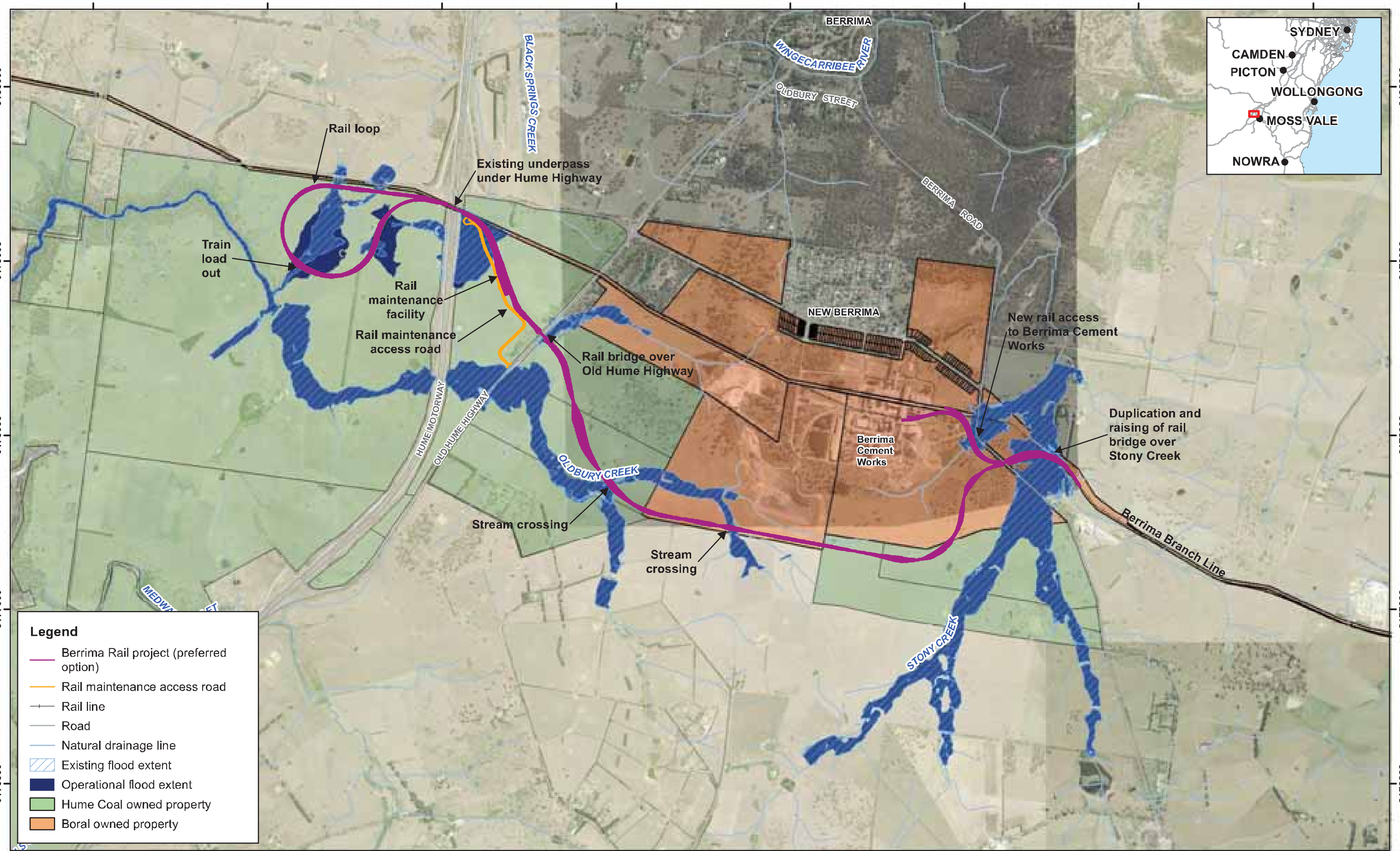
The flooded land area for the 100 year ARI event for each scenario is as follows, indicating that the flood extent increases by around 7% during operation but reverts to close to existing conditions following rehabilitation:

- Existing: 137.6 ha;
- Operation: 147.2 ha; and
- 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 associated pit. The increase in flood levels up to the 100 year ARI east of the cement 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 cement 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 will be modified by the rail infrastructure; however, the dominant flow regime (ie normal flow to regular floods, for example 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, as also discussed in Section 12.5.2 (biodiversity).

As shown in Figure 13.8, 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.



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

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Coordinate system: GDA 1994 MGA Zone 56
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Berrima Rail Project
Figure 13.7
100 Year ARI flood extent - Operation (preferred option)

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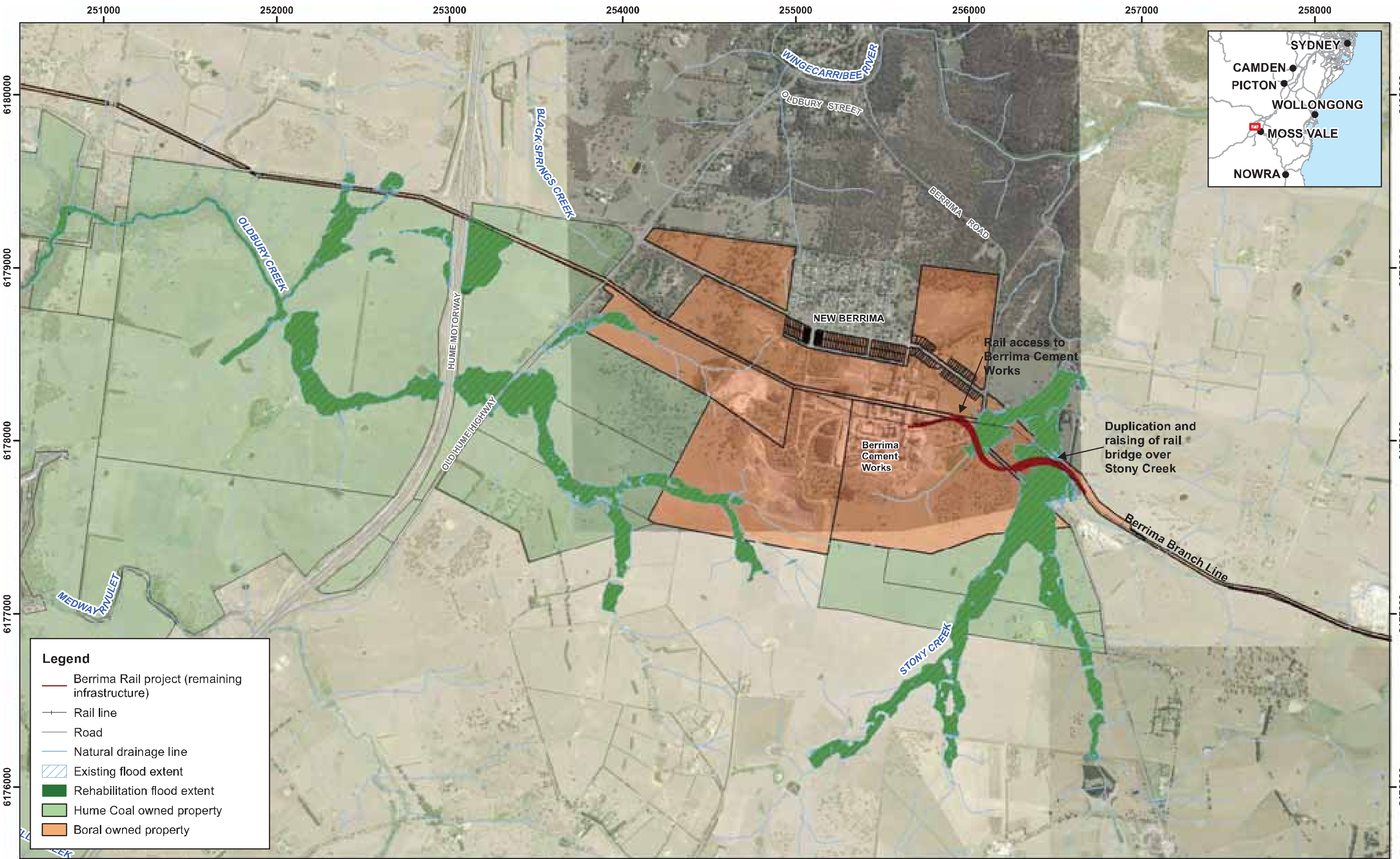

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Date: 15/11/2016	Approved by: LR

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

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

Berrima Rail Project

Figure 13.8

100 Year ARI flood extent - Rehabilitation (preferred option)

Hume Coal

ii Flood levels

Afflux results for Oldbury Creek are presented in Table 13.10. Results are presented for the cross-sections shown in red on Figure 13.4. Afflux results for Stony Creek are presented in Table 13.11. Results are presented for the cross-sections shown in red on Figure 13.5. 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 13.10 and 13.11 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 any event.
- 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 cement 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 13.11). 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 cement 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.

Table 13.10 Oldbury Creek catchment afflux results (preferred option)

Cross-section number	Stream	Location	Operation Afflux (m)				Rehabilitation Afflux (m)			
			5-year	20-year	100-year	PMF	5-year	20-year	100-year	PMF
246.32	Tributary 2b	DS Medway Road	0.01	0.00	0.00	-0.02	0.02	0.03	0.03	0.05
306.77	Catchment tributary 2	DS Medway Road	0.00	0.02	0.03	0.53	0.00	0.00	0.00	0.00
347.57	Tributary 2b	US Medway Road	-0.02	-0.01	0.00	0.01	0.01	0.00	0.00	0.01
350	Branch	Rural land	-0.13	-0.16	-0.20	-0.62	0.00	0.00	0.00	0.00
372.91	Catchment tributary 2	US Medway Road	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
417.29	Oldbury Creek	Rural land	-0.07	-0.16	-0.21	-1.93	0.00	0.00	0.00	0.00
533.14	Branch	Rural land	-0.17	-0.19	-0.23	-0.62	0.00	0.00	0.00	0.00
543.84	Tributary T1	Old Hume Hwy	-0.05	-0.06	-0.07	0.93	0.04	0.06	0.06	0.00
606.67	Tributary T1	Rural land and Old Hume Hwy	0.03	0.05	0.06	0.69	0.00	0.00	0.00	0.00
647.53	Oldbury Creek	Rural land	0.04	-0.02	-0.10	-0.80	0.00	0.00	0.00	0.00
750	Branch	Rural land	-0.18	-0.22	-0.25	-0.67	0.00	0.00	0.00	0.00
773.14	Tributary T1	Rural land	-0.04	-0.04	-0.04	-0.10	0.01	0.01	0.01	0.03
1073.16	Tributary T1	Rural land	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1194.89	Tributary 2	DS Hume Hwy	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00
1260	Tributary 2	US Hume Hwy	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
2741.84	Oldbury Creek	Private land	0.00	-0.13	-0.20	-0.04	0.00	0.00	0.00	0.00
2819.73	Oldbury Creek	Private land	0.09	0.01	-0.04	-0.31	0.04	0.00	0.00	0.00
2928.8	Oldbury Creek	Private land	0.05	0.00	-0.04	-0.18	0.02	0.00	0.00	0.00
3007.9	Oldbury Creek	Private land	-0.31	-0.41	-0.45	-0.73	-0.32	-0.42	-0.47	-0.50
4120.53	Oldbury Creek	Embankment DS inline storage	0.04	0.07	0.08	-0.02	0.04	0.07	0.09	0.06
4288.37	Oldbury Creek	Embankment DS inline storage	-0.14	-0.22	-0.26	-0.16	0.39	0.37	0.34	0.10
4390.64	Oldbury Creek	Embankment US inline storage	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00

Table 13.10 Oldbury Creek catchment afflux results (preferred option)

Cross-section number	Stream	Location	Operation Afflux (m)				Rehabilitation Afflux (m)			
			5-year	20-year	100-year	PMF	5-year	20-year	100-year	PMF
4611.83	Oldbury Creek	US inline storage	0.02	0.00	0.02	-0.01	0.00	0.00	0.00	0.00
4641.08	Oldbury Creek	US inline storage	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00
5624.5	Oldbury Creek	DS Hume Hwy	-0.04	-0.06	0.07	0.10	0.00	0.02	0.00	0.04
5691.94	Oldbury Creek	US Hume Hwy	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00
5980	Oldbury Creek	DS Old Hume Hwy	-0.02	-0.01	0.01	0.00	0.06	0.08	0.07	0.00
6024.59	Oldbury Creek	US Old Hume Hwy	-0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00
7081.2	Oldbury Creek	DS 5 x 2000 mm x 2000 mm RCBC on Oldbury Creek	0.03	0.02	0.01	0.00	0.05	0.04	0.02	0.00
7142.77	Oldbury Creek	Hume Coal Land	0.02	0.01	0.01	2.80	0.00	0.00	0.00	0.00
7401.61	Oldbury Creek	Hume Coal Land	0.01	0.00	0.01	1.32	0.00	0.00	0.00	0.01
7696.2	Oldbury Creek	Private land (Boral)	0.01	0.02	0.01	0.05	0.00	0.01	0.00	0.01
7907.82	Oldbury Creek	Private land (Boral)	0.01	0.02	0.02	0.03	0.07	0.10	0.14	0.26
7999.53	Oldbury Creek	US 5 x 2000 mm x 1200 mm RCBC on Oldbury Creek Private Land	0.00	-0.01	0.00	2.04	0.15	0.18	0.23	0.47
8234.11	Oldbury Creek	Private Land	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
421.49	Oldbury Creek	DS Culvert under design rail bridge	0.10	0.11	0.12	0.28	0.00	0.00	0.01	0.19
392.69	Tributary 2	US 2 x 1400 mm pipe under rail loop	0.00	0.62	1.78	4.09	0.03	0.04	0.05	0.15
855.9	Tributary 2	US 1400 mm diameter pipe under rail loop	3.42	3.88	4.74	5.89	0.00	0.00	0.00	0.00

Table 13.10 Oldbury Creek catchment afflux results (preferred option)

Cross-section number	Stream	Location	Operation Afflux (m)				Rehabilitation Afflux (m)			
			5-year	20-year	100-year	PMF	5-year	20-year	100-year	PMF
787.17	Oldbury Creek	DS Culvert under rail loop	0.01	0.03	0.04	0.30	0.03	0.03	0.02	0.30
254.46	Tributary 2	US 2 x 1400 mm diameter pipe on tributary of Oldbury Creek	1.32	1.9	3.02	4.81	0.14	0.16	0.17	0.02
113.72	Oldbury Creek Tributary 2	DS Culvert under rail loop	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: US – upstream; DS – downstream; Hwy – Highway.

Table 13.11 Stony Creek catchment afflux results (preferred option)

Cross-section number	Stream	Location	Operation				Rehabilitation			
			5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)	5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)
822.50	Stony Creek	US of Berrima Road	0.00	0.01	0.01	0.59	0.00	0.01	0.01	0.59
741.17	Stony Creek	DS of Berrima Road	0.01	0.01	0.01	0.63	0.01	0.01	0.01	0.63
690.45	Stony Creek	DS of Berrima Road	0.01	0.01	0.01	0.64	0.01	0.01	0.01	0.64
622.8	Stony Creek	DS old Berrima Rail	0.01	0.01	0.01	0.95	0.01	0.01	0.01	0.95
577.44	Stony Creek	DS Berrima Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
561.66	Stony Creek	US Existing Rail Bridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
547.77	Stony Creek	DS Existing Rail Bridge	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
497.77	Stony Creek	DS Existing Rail Bridge	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
585.31	NW tributary	US of Berrima Road	0.00	0.50	0.71	3.82	0.00	0.50	0.71	3.82
480.85	NW tributary	DS Berrima Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
337.3	NW tributary	DS Existing Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

iii Peak 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 are presented in Table 13.12. 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 +/- 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 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. During detailed design opportunities to reduce pipe and/or channel grades at the inlet and outlet of the structures will be investigated to reduce the high velocities at these locations.

Table 13.12 Peak velocities downstream of new infrastructure (preferred option)

Cross-section	Stream	Proposed structure	Cross-section distance downstream from infrastructure (m)	5 year ARI velocities (m/s)			20 year ARI velocities (m/s)			100 year ARI velocities (m/s)			PMF velocities (m/s)		
				Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff
421.49	Drainage depression alongside Hume Highway (tributary of Oldbury Creek)	4 x 1800 mm x 900 mm RCBC	3	1.04	1.74	0.70	1.13	1.89	0.76	1.20	2.03	0.83	3.44	2.74	-0.70
			38	1.29	1.33	0.04	1.38	1.37	-0.01	1.45	1.51	0.06	2.93	2.82	-0.11
787.13	Overland flow path (flowing to tributary of Oldbury Creek)	1400 mm diameter pipe	22	0.57	0.51	-0.06	0.75	0.59	-0.16	0.80	0.67	-0.13	1.32	0.72	-0.60
113.72	Tributary of Oldbury Creek	2 x 1400 mm diameter pipe	0	0.71	3.08	2.37	0.78	3.77	2.99	0.86	5.49	4.63	1.52	7.29	5.77
			2	0.71	1.71	1.00	0.78	1.86	1.08	0.86	2.04	1.18	1.52	3.56	2.04
7907.82	Tributary of Oldbury Creek	5 x 2000mm x 1200mm RCBC	0	0.88	1.93	1.13	1.00	2.19	1.19	1.1	2.41	1.31	1.94	5.36	3.42
			2	0.88	0.95	0.07	1.00	1.06	0.06	1.1	1.11	0.01	1.94	2.16	0.22
			14	1.06	1.05	-0.01	1.21	1.18	-0.03	1.35	1.29	-0.06	2.63	2.29	-0.34
7081.2	Oldbury Creek	5 x 2000mm x 2000mm RCBC	0	1.86	1.2	-0.66	1.88	1.33	-0.55	1.91	1.48	-0.43	1.32	5.79	4.47
			82	0.87	0.87	0.00	0.96	0.95	-0.01	1.06	1.05	-0.01	1.55	1.86	0.31
246.32	Tributary of Oldbury Creek	3 x 750 mm diameter pipe	32	0.81	0.74	-0.70	0.83	0.73	-0.1	0.92	0.82	-0.10	1.69	1.54	-0.15
561.66	Stony Creek	9 x 3600 mm x 3000 mm RCBC	26	0.14	0.14	0.00	0.21	0.21	0.00	0.28	0.28	0.00	1.39	1.39	0.00
480.85	NW Tributary of Stony Creek	7 x 2000 mm x 1500 mm RCBC	54	0.39	0.39	0.00	0.47	0.47	0.00	0.57	0.57	0.00	0.98	0.99	0.01

Note: Ex – Existing; Op – Operation; Diff – Difference

13.2.4 Alternative option impact assessment

i Flood extent

Figure 13.9 presents a comparison of the 100 year ARI flood extent for the existing and operation scenarios. Figures comparing the 5 and 20 year ARI and PMF flood extents for the existing and operation scenarios are presented in the Surface Water Assessment Report (2200569A-WAT-REP-001).

Figure 13.10 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 the Surface Water Assessment Report (2200569A-WAT-REP-001).

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;
- 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.

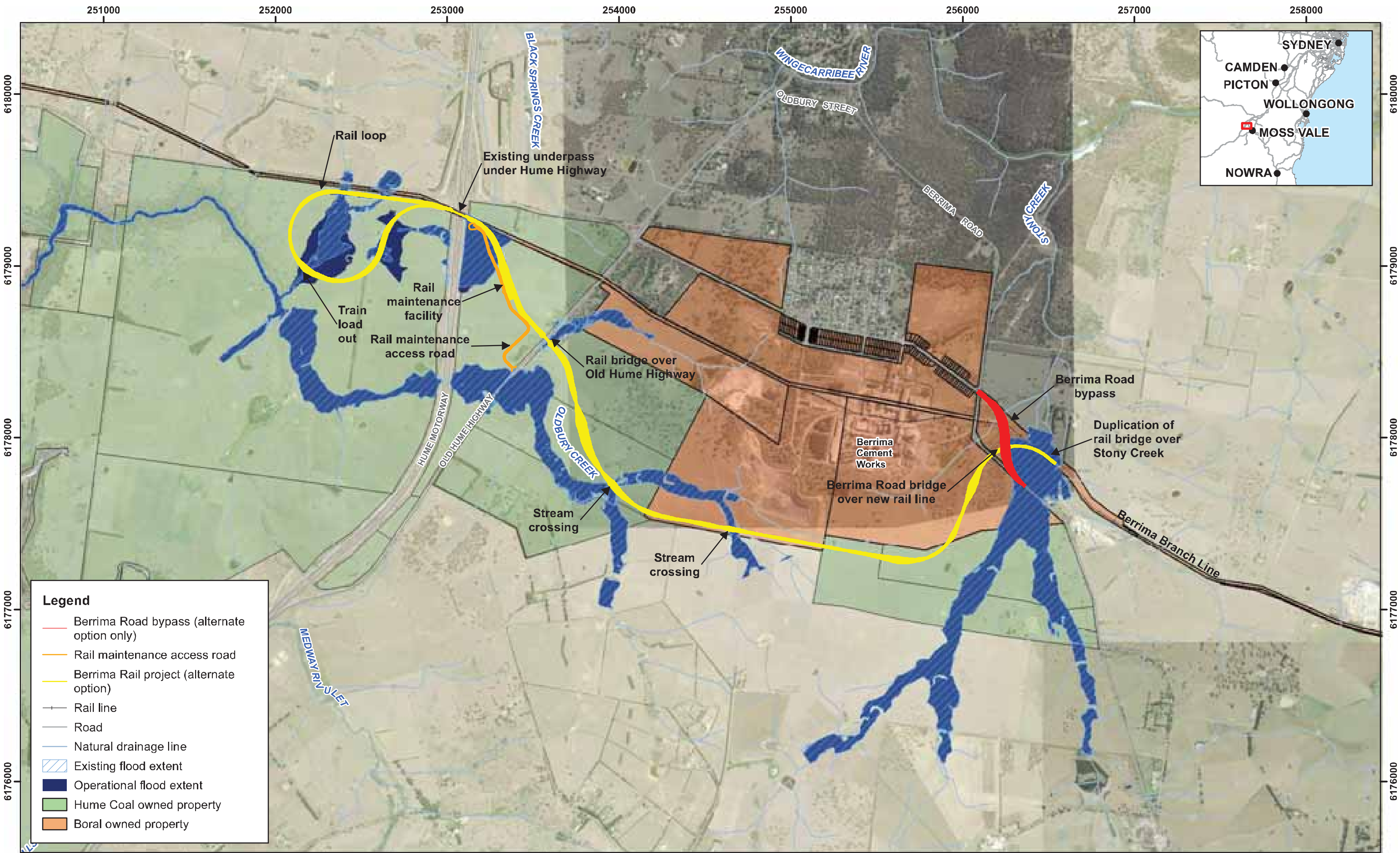
The flooded land area for the 100 year ARI event for each scenario is as follows, indicating that the flood extent increases by around 9% during operation but reverts to close to existing conditions following rehabilitation:

- Existing: 127.2 ha
- Operation: 138.3 ha
- Rehabilitation: 127.3 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.

As for the preferred option, the high order flood event behaviour will change within the rail loop in the area containing the colony of Paddy’s River Box trees; however, the dominant flow regime in the area of the trees will not change.

As shown in Figure 13.10, 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 due to remnant features in the rehabilitation landform.



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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Figure 13.9

100 year ARI flood extent - Operation (alternate option)

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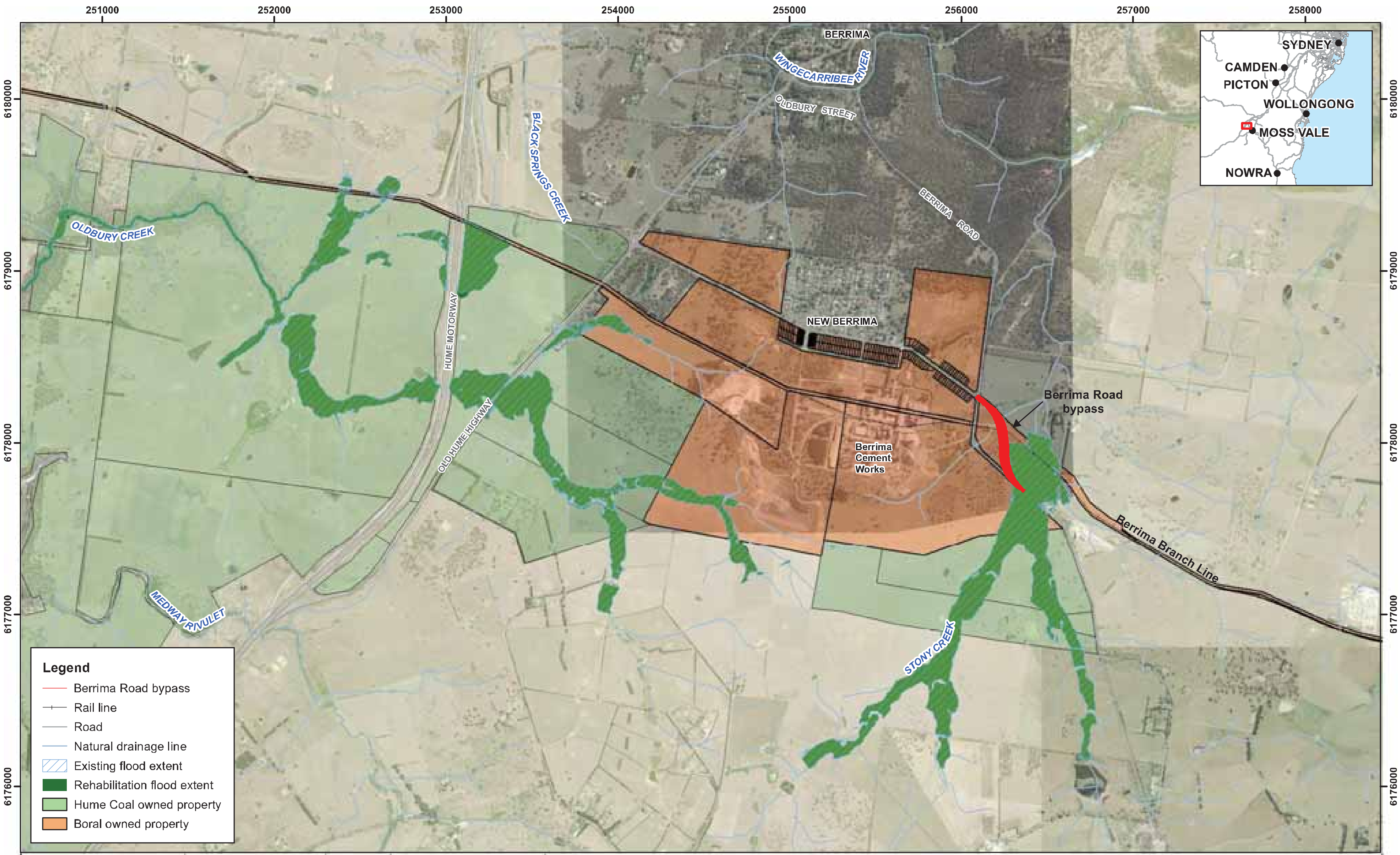

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Figure 13.10

100 year ARI flood extent - Rehabilitation (alternate option)

ii Flood levels

Afflux results for Oldbury Creek are presented in Table 13.13. Results are presented for the cross-sections shown in red on Figure 13.4. Afflux results for Stony Creek are presented in Table 13.14. Results are presented for the cross-sections shown in red on Figure 13.6. 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 13.13 and 13.14 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 any event.
- 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).

Table 13.13 Oldbury Creek catchment afflux results (alternative option)

Cross-section number	Stream	Location	Operation Afflux (m)				Rehabilitation Afflux (m)			
			5-year	20-year	100-year	PMF	5-year	20-year	100-year	PMF
246.32	Tributary 2b	DS Medway Road	0.01	0.00	0.00	-0.02	0.02	0.03	0.03	0.05
306.77	Catchment tributary 2	DS Medway Road	0.00	0.02	0.03	0.53	0.00	0.00	0.00	0.00
347.57	Tributary 2b	US Medway Road	-0.02	-0.01	0.00	0.01	0.01	0.00	0.00	0.01
350	Branch	Rural land	-0.13	-0.16	-0.20	-0.62	0.00	0.00	0.00	0.00
372.91	Catchment tributary 2	US Medway Road	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
417.29	Oldbury Creek	Rural land	-0.07	-0.16	-0.21	-1.93	0.00	0.00	0.00	0.00
533.14	Branch	Rural land	-0.17	-0.19	-0.23	-0.62	0.00	0.00	0.00	0.00
543.84	Tributary T1	Old Hume Hwy	-0.05	-0.06	-0.07	0.93	0.04	0.06	0.06	0.00
606.67	Tributary T1	Rural land and Old Hume Hwy	0.03	0.05	0.06	0.69	0.00	0.00	0.00	0.00
647.53	Oldbury Creek	Rural land	0.04	-0.02	-0.10	-0.80	0.00	0.00	0.00	0.00
750	Branch	Rural land	-0.18	-0.22	-0.25	-0.67	0.00	0.00	0.00	0.00
773.14	Tributary T1	Rural land	-0.04	-0.04	-0.04	-0.10	0.01	0.01	0.01	0.03
1073.16	Tributary T1	Rural land	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1194.89	Tributary 2	DS Hume Hwy	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00
1260	Tributary 2	US Hume Hwy	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
2741.84	Oldbury Creek	Private land	0.00	-0.13	-0.20	-0.04	0.00	0.00	0.00	0.00
2819.73	Oldbury Creek	Private land	0.09	0.01	-0.04	-0.31	0.04	0.00	0.00	0.00
2928.8	Oldbury Creek	Private land	0.05	0.00	-0.04	-0.18	0.02	0.00	0.00	0.00
3007.9	Oldbury Creek	Private land	-0.31	-0.41	-0.45	-0.73	0.00	0.00	0.00	0.00
4120.53	Oldbury Creek	Embankment DS inline storage	0.04	0.07	0.08	-0.02	0.04	0.07	0.09	0.06
4288.37	Oldbury Creek	Embankment DS inline storage	-0.14	-0.22	-0.26	-0.16	0.39	0.37	0.34	0.10
4390.64	Oldbury Creek	Embankment US inline storage	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00

Table 13.13 Oldbury Creek catchment afflux results (alternative option)

Cross-section number	Stream	Location	Operation Afflux (m)				Rehabilitation Afflux (m)			
			5-year	20-year	100-year	PMF	5-year	20-year	100-year	PMF
4611.83	Oldbury Creek	US inline storage	0.02	0.00	0.02	-0.01	0.00	0.00	0.00	0.00
4641.08	Oldbury Creek	US inline storage	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.01
5624.5	Oldbury Creek	DS Hume Hwy	-0.04	-0.06	0.07	0.10	0.00	0.02	0.00	0.04
5691.94	Oldbury Creek	US Hume Hwy	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00
5980	Oldbury Creek	DS Old Hume Hwy	-0.02	-0.01	0.01	0.00	0.06	0.08	0.07	0.00
6024.59	Oldbury Creek	US Old Hume Hwy	-0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
7081.2	Oldbury Creek	DS 5 x 2000 mm x 2000 mm RCBC on Oldbury Creek	0.03	0.02	0.01	0.00	0.05	0.04	0.02	0.00
7142.77	Oldbury Creek	Hume Coal Land	0.02	0.01	0.01	2.80	0.00	0.00	0.00	0.00
7401.61	Oldbury Creek	Hume Coal Land	0.01	0.00	0.01	1.32	0.00	0.00	0.00	0.00
7696.2	Oldbury Creek	Private land (Boral)	0.01	0.02	0.01	0.05	0.00	0.00	0.00	0.00
7907.82	Oldbury Creek	Private land (Boral)	0.01	0.02	0.02	0.03	0.07	0.10	0.14	0.26
7999.53	Oldbury Creek	US 5 x 2000 mm x 1200 mm RCBC on Oldbury Creek Private Land	0.00	-0.01	0.00	2.04	0.15	0.18	0.23	0.47
8234.11	Oldbury Creek	Private Land	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
421.49	Oldbury Creek	DS Culvert under design rail bridge	0.10	0.11	0.12	0.28	0.00	0.00	0.01	0.19
392.69	Tributary 2	US 2 x 1400 mm pipe under rail loop	0.00	0.62	1.78	4.09	0.03	0.04	0.05	0.15
855.9	Tributary 2	US 1400 mm diameter pipe under rail loop	3.42	3.88	4.74	5.89	0.00	0.00	0.00	0.00
787.17	Oldbury Creek	DS Culvert under rail loop	0.01	0.03	0.04	0.30	0.03	0.03	0.02	0.30

Table 13.13 Oldbury Creek catchment afflux results (alternative option)

Cross-section number	Stream	Location	Operation Afflux (m)				Rehabilitation Afflux (m)			
			5-year	20-year	100-year	PMF	5-year	20-year	100-year	PMF
254.46	Tributary 2	US 2 x 1400 mm diameter pipe on tributary of Oldbury Creek	1.32	1.9	3.02	4.81	0.14	0.16	0.17	0.02
113.72	Oldbury Creek Tributary 2	DS Culvert under rail loop	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: US – upstream; DS – downstream; Hwy – Highway

Table 13.14 Stony Creek catchment afflux results (alternative option)

Cross-section number	Stream	Location	Operation				Rehabilitation			
			5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)	5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)
713.52	Stony Creek	US of Berrrima Road	0.02	-0.03	0.06	0.15	0.02	-0.03	0.06	0.15
609.92	Stony Creek	US of Berrrima Road	0.02	-0.03	0.06	0.16	0.02	-0.03	0.06	0.16
560.83	Stony Creek	DS Berrima Road	0.02	-0.02	0.06	0.19	0.02	-0.02	0.06	0.19
454.13	Stony Creek	DS Berrima Road	0.02	-0.02	0.06	0.19	0.02	-0.02	0.06	0.19
395.75	Stony Creek	DS old Berrima Rail	0.02	0.00	0.07	0.28	0.02	0.00	0.07	0.28
351.49	Stony Creek	DS old Berrima Rail	-0.02	-0.04	0.01	-0.10	-0.02	-0.04	0.01	-0.10
335.12	Stony Creek	DS Existing Rail Bridge	-0.09	-0.89	-0.12	-0.10	-0.09	-0.89	-0.12	-0.10
284.57	Stony Creek	DS Existing Rail Bridge	0.00	0.07	0.05	0.06	0.00	0.07	0.05	0.06
227.5	Stony Creek	DS Existing Rail bridge	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01

Note: US – upstream; DS – downstream; Hwy – Highway

iii Peak velocities

Peak velocities downstream of new infrastructure crossing streams in the project area are presented in Table 13.15.

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 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.

Table 13.15 Peak velocities at new infrastructure (alternative option)

Cross-section	Stream	Proposed structures	Cross-section distance downstream from infrastructure (m)	5 year ARI velocities (m/s)			20 year ARI velocities (m/s)			100 year ARI velocities (m/s)			PMF velocities (m/s)		
				Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff
421.49	Drainage depression alongside Hume Highway	4 x 1800 mm x 900 mm RCBC	3	1.04	1.74	0.70	1.13	1.89	0.76	1.20	2.03	0.83	3.44	2.74	-0.70
			38	1.29	1.33	0.04	1.38	1.37	-0.01	1.45	1.51	0.06	2.93	2.82	-0.11
787.13	Overland flow path (flowing to tributary of Oldbury Creek)	1400 mm diameter pipe	22	0.57	0.51	-0.06	0.75	0.59	-0.16	0.80	0.67	-0.13	1.32	0.72	-0.60
113.72	Tributary of Oldbury Creek	2 x 1400 mm diameter pipe	0	0.71	3.08	2.37	0.78	3.77	2.99	0.86	5.49	4.63	1.52	7.29	5.77
			2	0.71	1.71	1.00	0.78	1.86	1.08	0.86	2.04	1.18	1.52	3.56	2.04
7907.82	Tributary of Oldbury Creek	5 x 2000mm x 1200mm RCBC	0	0.88	1.93	1.13	1.00	2.19	1.19	1.1	2.41	1.31	1.94	5.36	3.42
			2	0.88	0.95	0.07	1.00	1.06	0.06	1.1	1.11	0.01	1.94	2.16	0.22
			14	1.06	1.05	-0.01	1.21	1.18	-0.03	1.35	1.29	-0.06	2.63	2.29	-0.34
7081.2	Oldbury Creek	5 x 2000mm x 2000mm RCBC	0	1.86	1.2	-0.66	1.88	1.33	-0.55	1.91	1.48	-0.43	1.32	5.79	4.47
			82	0.87	0.87	0.00	0.96	0.95	-0.01	1.06	1.05	-0.01	1.55	1.86	0.31
351.59	Stony Creek	Duplication of bridge over Stony Creek	0	0.50	0.51	0.01	0.72	0.70	-0.02	0.90	0.87	-0.03	2.72	2.98	0.26

Note: Ex – Existing; Op – Operation; Diff – Difference

13.2.5 Cumulative impacts

The cumulative impacts of the Hume Coal Project and Berrima Rail Project were assessed in the Oldbury Creek catchment where infrastructure from both projects is located. There is no difference between the preferred and alternative Berrima Rail Project options in the Oldbury Creek catchment.

The Oldbury Creek hydrologic model was used to estimate runoff for the cumulative Oldbury Creek HEC-RAS model.

The Oldbury Creek HEC-RAS model was revised to include cross-sections targeting key infrastructure for both the Hume Coal Project and Berrima Rail Project during operation and rehabilitation. The cumulative Oldbury Creek HEC-RAS model cross-sections are shown on Figure 13.11.

The cumulative Oldbury Creek HEC-RAS model was run for the 2 year, 5 year, 100 year ARI and PMF events for the following scenarios:

- 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.

Proposed cross drainage structures were included in the cumulative Oldbury Creek HEC-RAS model. These structures will allow flow to pass through the proposed rail embankments and reduce flooding impacts on nearby land that would otherwise have occurred. The proposed structures included in the models are described in Table 13.9.