9. Flooding and Surface Water

This chapter assesses the impacts of the proposed Wallarah 2 Coal Project on the flood regime of the surface area above the proposed mining area. An assessment of the consequences of subsidence on river flows and morphology is also provided.

9.1 Introduction

The effect on flooding and surface drainage as a result of subsidence from the W2CP has been identified as an important environmental issue to be assessed. Environmental Resources Management, Australia Pty Limited (ERM) was originally commissioned by the Wyong Areas Coal Joint Venture in 1999 to investigate and assess the potential impacts on flooding as a result of subsidence due to undergrounding mining within the Dooralong and Yarramalong Valleys and the Hue Hue Creek catchment. Assessments were made in 2000, 2003, 2006 and 2007 for previous mine plans which have been fundamental in the development of the final mine plan assessed in this EA. Several changes were made to the mine plan in 2006 and 2007 in order to further minimise impacts on existing river channels.

The flood model also became an integral component in the finalisation of the mine plan and has been developed in conjunction with subsidence and groundwater assessments. The process has been iterative with several modifications being made to the mine plan in order to achieve the best outcome for flood affected properties within the mining area and to minimise the extent and severity of potential flood impacts.

Of particular note were the benefits of adjusting the mine plan to eliminate flood impacts from almost all of the Yarramalong Valley and to reduce the risk of changes to the alignment of Little Jilliby Jilliby Creek as well as overall impacts in the Dooralong Valley and Hue Hue Creek.

The changes made to the mine plan have included variations to the longwall panel layout, location of main roadways within Little Jilliby Jilliby Creek valley and protection of its confluence with Jilliby Jilliby Creek, reduction in longwall extraction height and panel width within the valley area and restricting mining activity near Wyong River and the Yarramalong Valley. The iterative mine planning process also enabled further mine layout adjustments in 2006 and 2007 as a result of preliminary flood modelling to minimise impacts on existing river channels. The detailed topographic model developed specifically for this project in 2006 has enabled a greater degree of accuracy for the hydraulic model for existing and post mining conditions to determine the extent and depths of existing flooding and the changes resulting from subsidence.

A key outcome of this work has been the development of a comprehensive and robust flood model for the Wyong River and Jilliby Jilliby Creek which was originally provided to Wyong Council in 2000 to assist their planning and flood risk management obligations. Updated baseline flooding and topographic information derived from the current study has also been made available to Wyong Council for similar purposes. There was no significant difference in flood levels and extents calculated by the two models for existing topographic conditions.

The project's original hydrological modelling continued to be valid as no significant changes had occurred to rainfall and recorded flood data since the previous assessments. A slight change had occurred to the methodology for calculating the Probable Maximum Flood (PMF), resulting in a 4% increase in the PMF hydrographs used in the hydraulic model; otherwise all previously determined hydrographs were used in this assessment.

Key outcomes of the flood assessment undertaken for the Project are provided below, however it should be noted that despite the accuracy of the flood modelling, the precise impact on the number of dwellings and the degree of impact will be confirmed once subsidence monitoring data has been obtained and the model validated.

In order to properly assess the potential changes to local flood potential and levels as a result of underground coal extraction from the W2CP, it was essential that accurate predictions of subsidence levels were used. The detailed subsidence assessment (Appendix A) reported in Chapter 6 of this document was used in the flood assessment that follows.

Subsidence modelling undertaken for the W2CP predicts that subsidence will occur in a 5.2 km section of the Dooralong Valley floodplain (including part of the Jilliby Jilliby Creek, Little Jilliby Jilliby Creek and minor tributaries). Subsidence generally of between zero and up to 1.2 m will occur within the affected sections of the Jilliby Jilliby Creek channel. Isolated small areas of the adjacent floodplain may experience greater subsidence in the order of 1.6 m. Subsidence levels in the lower Jilliby Jilliby Creek channel (below the confluence with the Little Jilliby Jilliby Creek) are expected to be mostly less than 0.75 m. This change in the topography will cause changes in the flood depths of –1.1 m to +1.1m even though absolute flood levels (in mAHD) will drop by zero to 1.85 m. Greater subsidence is expected in the forested and unpopulated mountainous areas, but this will have no discernable impact on runoff characteristics or on flooding in the valleys.

For Hue Hue Creek, mining will result in subsidence of up to 0.95 m under the floodplain and will cause changes in flood depths of –0.1 m to +0.7 m with reductions in flood levels within or near the subsided areas of zero to 0.5 m. There will be almost no net increase in flood affected area in the Hue Hue Creek due to subsidence.

Subsidence will also cause several low points in roads and some bridges within the Dooralong Valley and Hue Hue Creek line to become untrafficable for longer periods than the existing situation during flood events. No significant impacts to roads or other infrastructure will occur in the Yarramalong Valley. Options are available to mitigate these impacts, including raising bridges, raising low sections of roads, and improving the hydraulic capacity of channels in some sections. It may also be possible to make flood proof some sections of road that are currently flood prone.

9.1.1 Independent Inquiry into Coal Mining in the Wyong LGA

The report by the independent expert panel for the Strategic Inquiry into coal mining potential in the Wyong LGA was reviewed following its release in December 2008. The Inquiry report findings and recommendations are consistent with the conclusions and proposed commitments set out in this flood impact assessment study. A detailed discussion is contained in Section 4.20 of this EA.

9.2 Existing Flood Regime

Baseline flood studies were carried out for the Yarramalong and Dooralong Valleys, and the Hue Hue Creek catchments, to determine the level of flooding experienced prior to surface subsidence created by the W2CP.

9.2.1 Yarramalong and Dooralong Valleys

The major waterways within the Yarramalong and Dooralong Valleys include the Wyong River, Jilliby Jilliby Creek and Little Jilliby Jilliby Creek which are accompanied by a number of small unnamed tributaries. The Wyong River flows through the Yarramalong Valley, while Jilliby Jilliby Creek drains the Dooralong Valley before joining the Wyong River approximately 2.8 km upstream of the F3 Freeway. Little Jilliby Jilliby Creek joins Jilliby Jilliby Creek approximately 5.7 km upstream of the confluence with Wyong River. The Wyong River then continues beyond the Freeway through the Wyong Industrial Estate, under the Old Pacific Highway and Main Northern Railway at Wyong and finally discharges to Tuggerah Lake at Tacoma.

This study concentrates on the floodplain within a 350 km^2 catchment upstream of Woodburys Bridge (Bridge 1) on Yarramalong Road, just upstream of the F3 Freeway.

The Wyong River rises in the Watagan Mountains in the Olney and Wyong State Forests. The river valley has been cleared for agricultural land uses, primarily grazing. The steep hillsides and ridges are heavily vegetated and generally located within State Forests and Jilliby State Conservation Area.

The Wyong River upstream of the Jilliby Jilliby Creek confluence has a total catchment area of 250 km^2. Within the study area there are 21 bridges over the Wyong River which alter the natural flooding patterns. The majority of the bridges provide access to private properties however, there are significant road crossings at Yarramalong Road and Bunning Creek Road.

Jilliby Jilliby Creek also rises in foothills of the Watagan Mountains. The upper sections of the Dooralong Valley are contained within the Olney and Wyong State Forests and are covered in dense vegetation. Further downstream, the floodplain has been partially cleared for mixed rural land uses, including grazing, orchards and turf farms.

Jilliby Jilliby Creek has a total catchment area of 98 km^2. There are 11 bridges that cross the creek within the study area. The major road into the valley is Dooralong Road, which crosses the creek and its tributaries at a number of locations. There are also significant bridges over Jilliby Jilliby Creek at Durren and Mandalong Roads.

Between the confluence of Jilliby Jilliby Creek with the Wyong River and Woodburys Bridge, the topography of the valley changes. The floodplain narrows as the river flows through this location and the northern bank becomes steeper and more vegetated. This creates a significant restriction to the passage of flood flows.

9.2.2 Hue Hue Creek

The Hue Hue Valley catchment is located to the west of Hue Hue Road between Wyong and Wyee on the Central Coast of New South Wales. It drains into Porters Swamp just downstream of the F3 Freeway. Porters Creek flows from Porters Swamp, under a bridge at Alison Street, Wyong, immediately prior to joining the Wyong River. For the purposes of this report, and consistency with previous reports, the creek is referred to as Hue Hue Creek.

The study area includes the Hue Hue Creek catchment above the F3 Freeway. The total area of this catchment is 8.2 km^2.

The majority of the upper reaches of the Hue Hue catchment and the steeper hillsides are heavily vegetated. The valley in the mid reaches of the catchment has been predominantly cleared and mainly consists of small rural and rural-residential land holdings. Residential development is concentrated in the area around Sandra Street and Hue Hue Road. There is a smaller residential subdivision at Cottesloe Road higher in the catchment.

The drainage system within the Hue Hue Valley consists of a series of small, poorly defined, ephemeral watercourses draining to the south east. There are three locations where roads cross the creek, these are:

- two separate culverts under the F3 Freeway;
- a culvert under Sandra Street; and
- a culvert at Hue Hue Road.

Two private access roads from the end of Cottesloe Road also cross Hue Hue Creek.

9.2.3 Importance of Existing Flood Regimes to W2CP

The baseline flood studies demonstrated that both the Yarramalong and Dooralong Valleys are currently significantly floodprone, as shown on Figure 9.1.

Baseline flooding studies for the Yarramalong Valley show that:

- the floodplain is relatively narrow (typically 300 to 600 m wide in comparison to the Dooralong Valley which is 900 to 1400 m wide);
- flood flows in the Yarramalong Valleys are twice as large as those in the Dooralong Valley;
- the floodway is approximately 100 to 200 m wide and restricted to the zone immediately adjacent to the river;
- the flood storage areas extend almost to the flood limits with the flood fringe making up less than 5% of the total floodplain area;

- flow velocities in the main channel range from 0.7 to 2.2 m/s and the overbank velocities range from 0.3 to 0.6 m/s; and
- the majority of the floodplain is classified as high hazard based on flood depths. Velocities are typically low except in the main river channel and downstream of bridges.

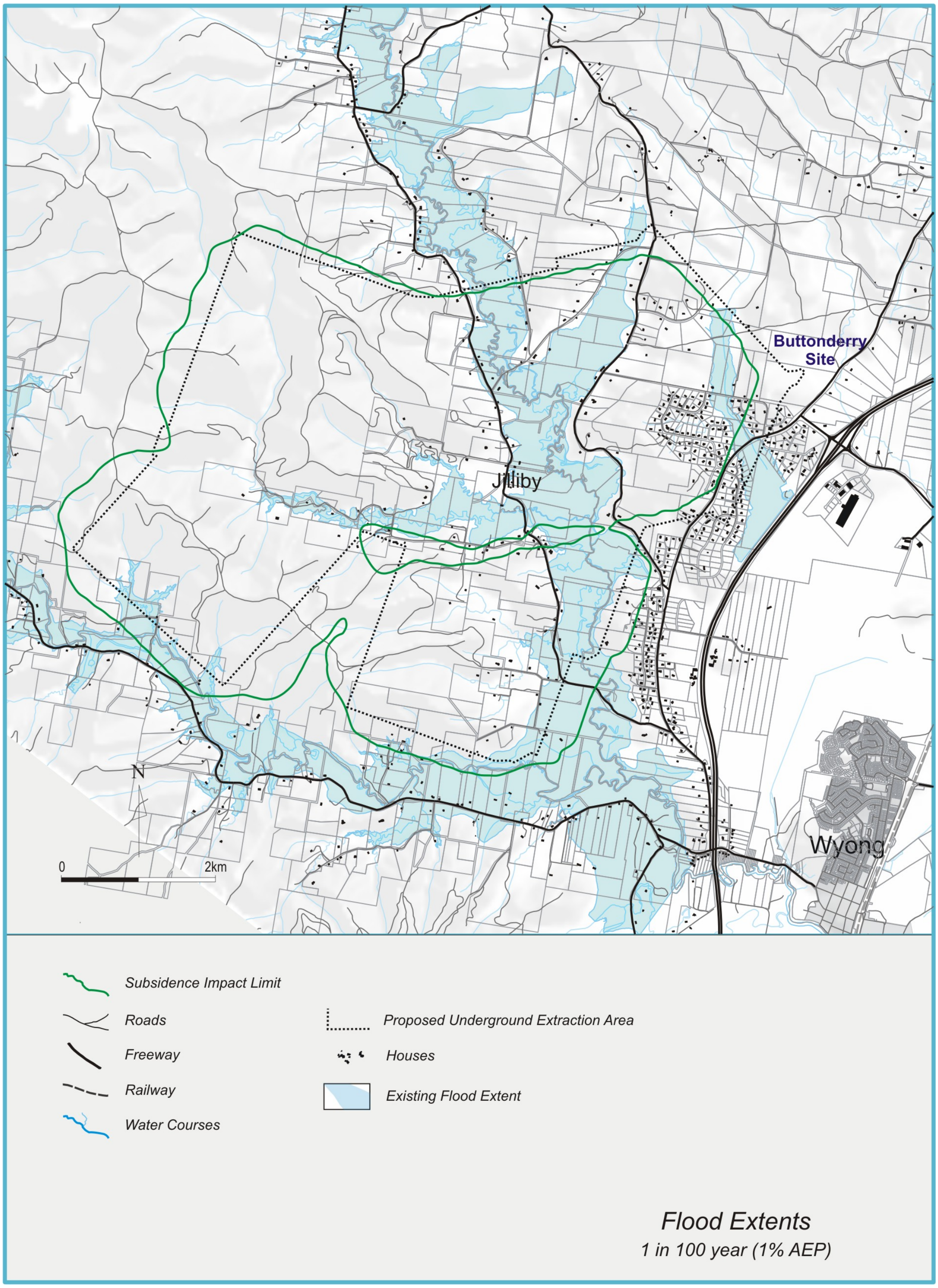


Figure 9.1 Existing Extent of 1% AEP Flood

The Dooralong Valley baseline flood study shows that:

- the flood fringe in the valley areas is more extensive than in the Yarramalong Valley. Flood fringe areas are generally between 10% and 20% of the floodplain area;
- the floodway is typically 50 to 100 m wide;
- the majority of the floodplain is classified as a low hazard storage;
- main channel velocities range from 0.5 to 2.0 m/s and the overbank velocities range from 0.02 to 0.6 m/s;
- high hazard zones are mainly restricted to low lying areas adjacent to Jilliby Jilliby Creek and large farm dams; and
- flood behaviour in the lower 2.5 km of the Dooralong Valley is dominated by backwater from the Wyong River and is classified as high hazard based on flood depths.

The floodplain is subject to regular inundation to significant depths. Bridges and culverts are cut off regularly and for long periods during relatively small floods. Large sections of the main roads into both valleys are flood affected and many of the access roads pass through the floodplain.

The Hue Hue Creek floodplain is different as flood depths are significantly less. The majority of flood prone land is located in rural or public open space areas of the catchment rather than in rural residential area.

Within the study area, there are 79 dwellings in the Yarramalong and Dooralong Valleys and 5 in the Hue Hue Creek floodplain, the majority of which lie in low hazard flood storage or low hazard flood fringe zones. Flood prone land is defined as land which experiences a one in a hundred year flood. The majority of flood prone houses are located outside the proposed mine plan.

Based on the existing flood details for the area, the following were considered to be key issues that required careful planning of the W2CP:

- flood affected dwellings and structures;
- flood liability;
- flood hazard assessment;
- property access;
- channel stability issues;
- time of ponding; and
- proposed flood mitigation measures.

The existing extent of flooding in the area under a 20% AEP flood (sometimes referred to as a 1 in 5 year event) is shown in **Figure 9.2**.

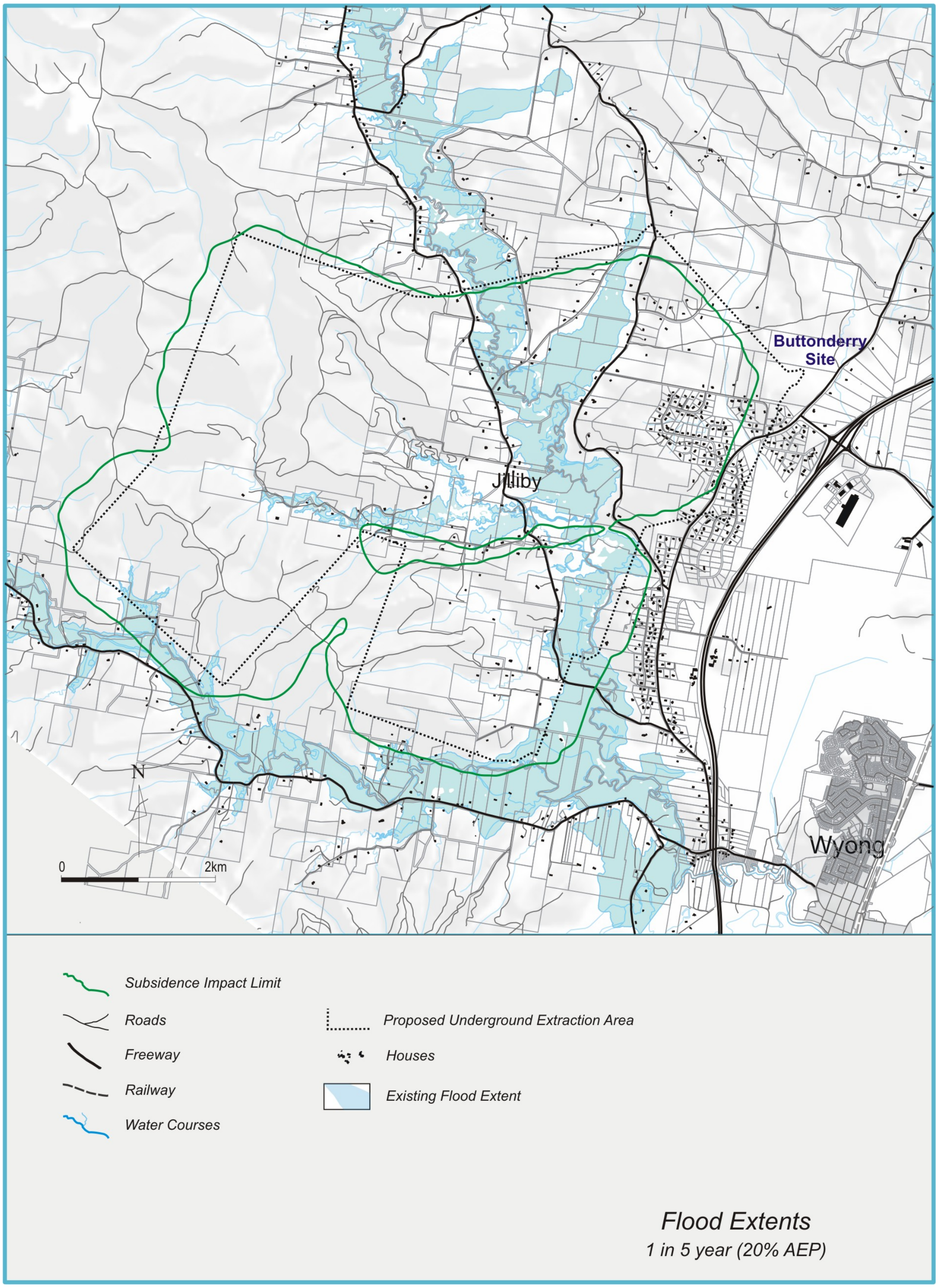


Figure 9.2 Existing Extent of 20% AEP Flood

9.3 Assessment of Impacts

9.3.1 Overview of Potential Subsidence Impacts

Subsidence can cause a change in floodplain storage or a change in hydraulic gradients within the floodplain. This will alter flooding behaviour to some extent with the significance depending on panel widths and orientation and their influence on subsided topography. Such effects can have adverse or beneficial impacts on flooding within the subsided area and in areas upstream and downstream, depending on the provisions made for flood management.

Access to properties may be temporarily disrupted if floodwaters overtop bridges or culverts, or extend across roads. A flood hazard may be posed by floodwaters of certain velocities and depths flowing across roads and in the vicinity of properties.

Conversely, the proposed mine is likely to provide flood mitigation benefits in alleviating existing flooding experienced downstream at Wyong. However, this should not be considered a benefit unless all adverse effects on properties within the valleys are adequately addressed or mitigated.

9.3.2 Subsidence Impacts on Flooding in Yarramalong and Dooralong Valleys

Mine subsidence will generally lower the topography of the Dooralong Valley and, to a lesser extent, the Yarramalong Valley and will subsequently cause a change in the flood behaviour within the valleys. This has the potential to impact on existing properties and future developments in the area. Maps for the post-mining subsided scenarios showing the 1% and 20% AEP flood extents are presented in Figure 9.3 and Figure 9.4 respectively.

Flood behaviour in the Yarramalong Valley will not significantly change as a result of subsidence. The model indicates flood levels generally reduce by 0.01 to 0.08 m in the vicinity of subsidence areas. Flood depths reduce by a similar amount with the exception of a 1.2 km section of the Wyong River between Chainage 21.580 and 22.757 km where depths increase by up to 0.13 m. With the exception of a small backwater between Chainage 21.308 and 21.552 and described below, lateral flood extents vary only by less than 5 m after mining. Flow velocities will be unaffected.

Results for the Dooralong Valley show that:

- post-subsidence flood levels within the study area were generally between zero and 1.31 m lower than levels for existing conditions (this is a function of water levels dropping with the subsided land surface);
- flood depths increased by up to 1.08 m and inundation extents increased by up to 150 m within the areas directly affected by subsidence;
- in some locations flood depths decreased by up to 1.1 m;
- changes to flood behaviour in Jilliby Jilliby Creek extended between Chainage 9.100 and 17.820 km i.e. over approximately 8.7 km of the 9 km upstream of its confluence with the Wyong River;
- post-subsidence flow velocities are similar to existing velocities.

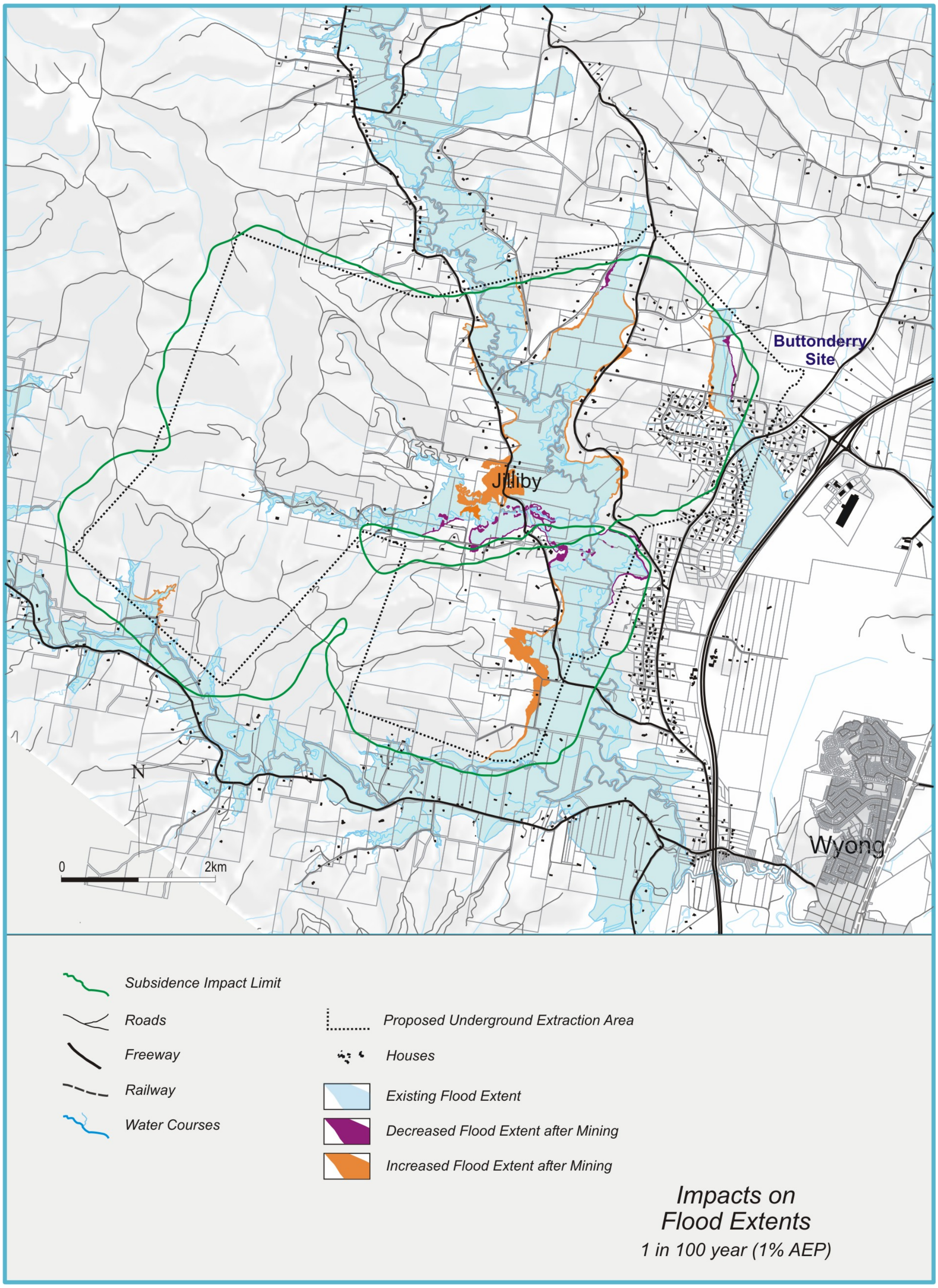


Figure 9.3 Impacts on Flood Extent of 1% AEP Flood

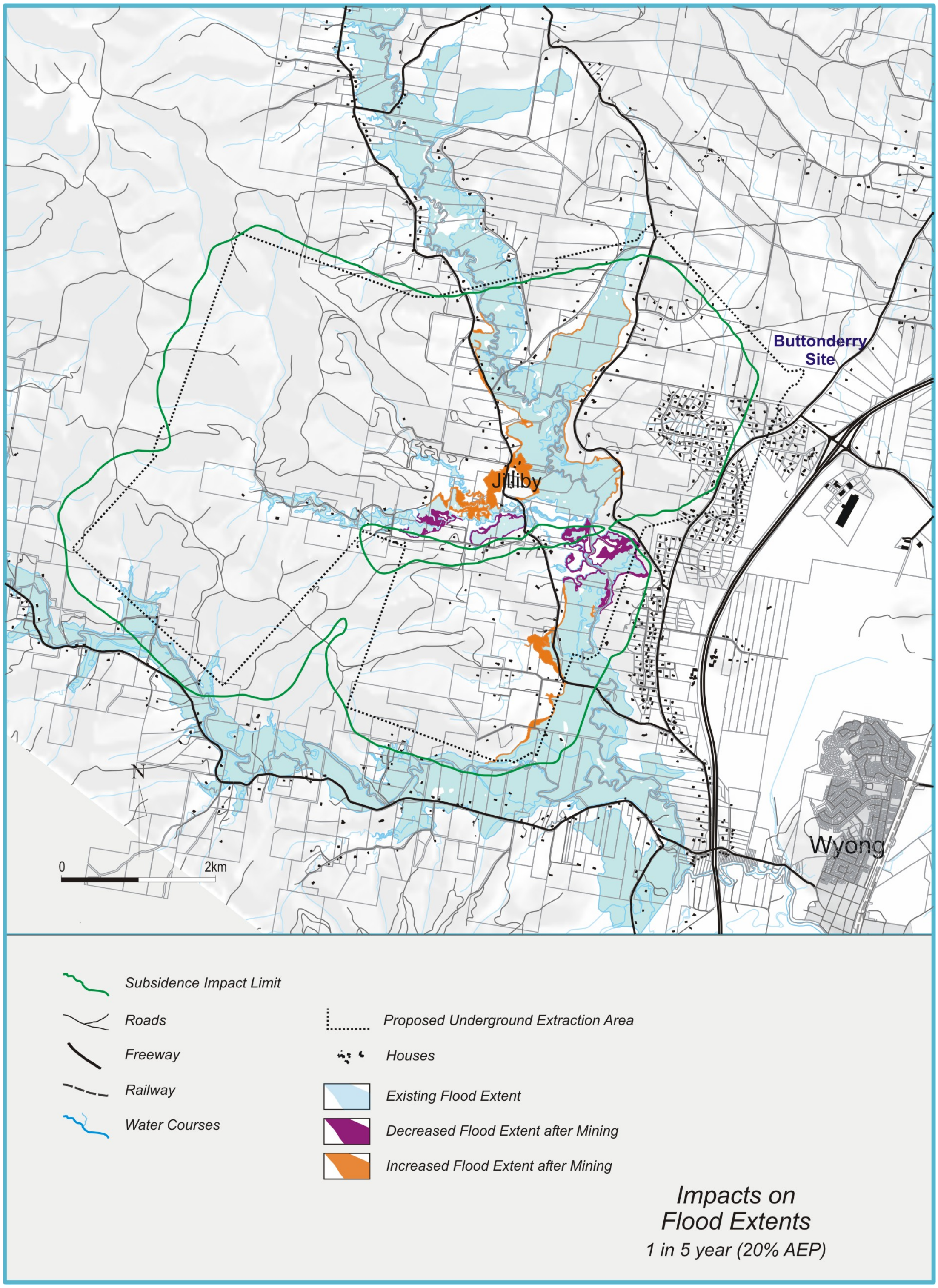


Figure 9.4 Impacts on Flood Extent of 20% AEP

In the 1% AEP flood, additional land within the Dooralong valley becomes flood prone. The major changes are summarised as follows:

- an increase in flood prone land of 0.8 ha on the right bank and a slight increase of 0.3 ha in flood prone land on the left bank of Jilliby Jilliby Creek upstream of the Durren Road culverts (Bridge C);

- a net increase in flood prone land of 23.3 ha on the right bank and 6.5 ha on the left bank of Jilliby Jilliby Creek between the junction with Little Jilliby Jilliby Creek and Durren Road;

- a net increase in flood prone land of 14.6 ha on the right bank and a net decrease of 0.6 ha on the left bank of Jilliby Jilliby Creek between the Wyong River and Little Jilliby Jilliby Creek;

- flood behaviour in the downstream reaches of Little Jilliby Jilliby Creek is effectively governed by flood levels in Jilliby Jilliby Creek. Following subsidence, flood behaviour in Little Jilliby Jilliby Creek is altered due to flooding of additional low lying areas.

Downstream of the confluence of Jilliby Jilliby Creek and the Wyong River flood levels reduce by up to 0.06 m with a consequent small reduction in inundation extent and area. This is a result of detention effects within the subsidence area within the Jilliby Jilliby Creek floodplain, which slightly reduces peak flows.

9.3.3 Flood Hazard and Hydraulic Categories

Hydraulic categories in the 1% and 20% AEP floods will be altered in several areas within the subsidence zone. In areas that are negatively impacted, development controls may be required to ensure appropriate land uses in the future.

The flood studies indicated that the major negative impacts in the Dooralong Valley may be:

- 28 ha previously classified as flood fringe would become flood storage; and
- 12 ha previously classified as flood storage would become floodway.

The major positive impacts in the Dooralong Valley were:

- 7 ha previously classified as flood storage would become flood fringe; and
- 4 ha previously classified as floodway would become flood storage.

The proposed mine plan has resulted in a reduction in impacts compared with previous mine plans due to the reduction in subsidence within the Jilliby Jilliby Creek floodplain.

There were no significant changes in flood hazard and hydraulic categories in the Yarramalong Valley for the currently proposed mine plan. This is mainly the result of curtailment of mining outside of the Wyong River floodplain. With the exception of a small backwater on the left bank of the Wyong River, there will be no discernable overall flood impacts. Within this backwater the 1% AEP flood fringe will extend by up to 15 m to cover an additional 0.8 ha of land. This would be due to direct subsidence impacts rather than changes to the 1% AEP flood levels.

A number of flood prone properties within the Dooralong Valley will be subjected to both positive and negative changes in flood hazard and flood hydraulic categories following mining. Areas of the floodplain that are negatively impacted may require mitigation measures that are appropriate to the new flood category. These will be developed as part of the Subsidence Management Plan process and will be carried out by the proponent at no cost to the land owner.

9.3.4 Property Hazard Assessment

Post-subsidence flood impacts to properties and dwellings were determined via a hazard assessment which aimed to:

- determine what changes, if any, would be required to existing dwellings so that existing flooding conditions are not exacerbated; and
- examine the development controls required for properties which have been negatively impacted due to a change in flood hazard or flood category.

Within the study area, there are 283 properties which have land located within the existing and post-mining floodplains of the Wyong River and Jilliby Jilliby Creek. Of these properties, there are 79 dwellings located within the floodplains, the majority of which are located in low hazard flood storage or low hazard flood fringe zones.

Flood behaviour near flood prone dwellings was determined for pre and post mining scenarios to determine which dwellings will be negatively impacted. The assessment included only those dwellings within the study area that are in the zone of changed flood behaviour. This includes all flood prone dwellings downstream of chainages DOR 7.690 km and YAR 15.554 km and upstream of chainage YAR 30.957 km.

Dwellings impacted by subsidence related changes to the 1% and 20% AEP floods are identified in Table 9.1. The extent of impacts for these floods is given in Table 9.2. It is known that at least five of the “dwellings” throughout the flood study areas are more accurately described as “sheds” and cannot be considered as primary dwellings.

In the study area, of the 79 flood affected dwellings, 34 dwellings (two of which area sheds) will be adversely affected, 38 dwellings (two of which area sheds) will be beneficially impacted to a slight marginal degree or better (i.e. reduced flooding) and seven will be unchanged.

Of the 34 dwellings adversely affected, 19 dwellings will be subjected to increased flood inundation (flood level greater than floor level) in the 1% AEP flood after subsidence. The majority of these dwellings are already subject to flooding in the 1% AEP flood but five of these will be dwellings that were not previously inundated. The remaining 15 will have reduced freeboard (height of floor above flood level) but will not be inundated and only three of these will have freeboard of less than 0.3 m.

For the 38 dwellings that are potentially beneficially affected, 28 will have some degree of very minor to negligibly decreased inundation and ten will have increased freeboard. Six dwellings were not previously identified as inundated and appear not to have been included in the 2000 and 2003 studies as they may have been constructed since these studies. There were also four dwellings with freeboard less than 0.3 m prior to subsidence and four with insufficient freeboard after subsidence although only two dwellings were common to both sets.

In the Yarramalong Valley seven houses and one shed are adversely affected as a direct result of subsidence rather than any change in flood levels. Only five of these buildings (D0767, D0615, D0049, D0041 and S0041) have the potential to become inundated. However, because floor levels were not known at the time of this study and were assumed as 0.3 m above ground level, this will need to be confirmed during the preparation of individual Property Subsidence Management Plans nearer to the time of mining in that locality.

For the 20% AEP flood after subsidence, 33 dwellings will be adversely affected 36 will be beneficially affected and 10 will be unchanged. Only 10 dwellings will be subjected to increased inundation and 9 will have decreased inundation during a 20% AEP flood. This is considered to be an appropriate indicator of the overall change in frequency of flood impacts on dwellings.

Impact categories were developed to summarise the severity of impacts that may occur to dwellings and to property inundation as a result of subsidence impacts on flooding. A summary of the predicted flood impacts on houses is illustrated in Figure 9.5. Details of the flood implications on residential structures are given in Table 9.3 and Table 9.4. It would be reasonable to expect that mitigation works will be required for dwellings in Category A (Major Impacts) and Category B (Moderate Impacts). However, dwellings in other categories are unlikely to require mitigation works.

Mitigation options need to be examined for dwellings which will be moderately or highly impacted by increased flood depths as a result of mine related subsidence. Options available to mitigate these impacts include construction of flood levees and raising or relocating houses to higher ground within the property. For impacted houses that are unable to be protected, raised or moved, properties may need to be purchased. Limited options are also available to reduce post-subsidence flooding by channel improvements.

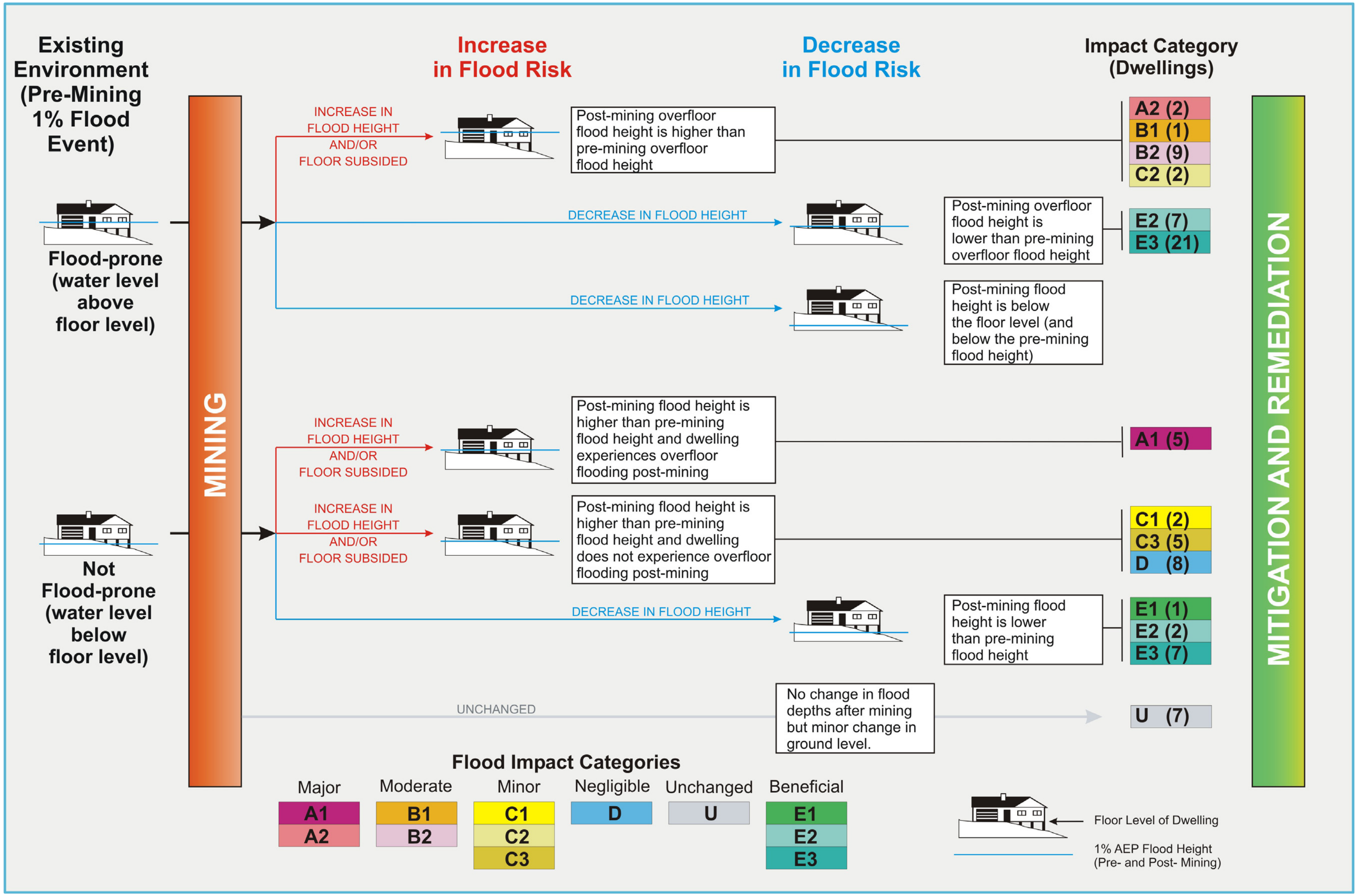


Figure 9.5 Summary of Post-Mining Flood Implications on Houses (1% AEP Flood)

Table 9.1 Dwellings Affected by Flooding

Dwelling ID	Existing Ground Level (mAHD)	Existing Floor Level (mAHD)	Subsidence (m)	Subsided Ground Level (mAHD)	Subsided Floor Level (mAHD)	Within Subsidence Zone	Within Existing 1% AEP Flood Extent	Within Subsided 1% AEP Flood Extent	Within Existing 20% Flood Extent	Within Subsided 20% Flood Extent	Comment
Adverse Impacts											
D0863[DV]	14.50	14.80*	-1.182	13.32	13.62	Y	N	Y	N	Y	Not currently inundated
D0870[DV]	11.16	11.46*	-0.928	10.23	10.53	Y	Y	Y	N	N	Not currently inundated
D0207[DV]	14.00	15.00	-1.166	12.83	13.83	Y	Y	Y	N	N	Not currently inundated
D0060[DV]	11.78	12.18	-1.311	10.46	10.86	Y	N	Y	N	N	Not currently inundated
D0737[DV]	11.29	11.92	-0.796	10.49	11.12	Y	Y	Y	N	N	Not currently inundated
S0041	15.11	15.41*	-0.068	15.04	15.34	Y	Y	Y	Y	Y	Increased Inundation
D0767	16.81	17.11*	-0.197	16.62	16.92	Y	Y	Y	Y	Y	Increased Inundation
D0017[DV]	9.50	10.08	-0.139	9.36	9.94	Y	Y	Y	Y	Y	Increased Inundation
D0063[DV]	10.29	10.79	-1.361	8.93	9.43	Y	Y	Y	Y	Y	Increased Inundation
D0237[DV]	13.33	13.63*	-1.120	12.21	12.51	Y	Y	Y	N	Y	Increased Inundation
D0851[DV]	14.89	15.19*	-1.311	13.58	13.88	Y	Y	Y	Y	Y	Increased Inundation
S0776[DV]	15.81	16.11	-1.404	14.41	14.71	Y	Y	Y	Y	Y	Increased Inundation
D0776[DV]	15.86	16.16*	-1.417	14.44	14.74	Y	Y	Y	Y	Y	Increased Inundation
D0041	17.46	17.76*	-0.096	17.36	17.66	Y	Y	Y	N	N	Increased Inundation
D0058[DV]	9.59	10.29	-0.173	9.42	10.12	Y	Y	Y	N	N	Increased Inundation
D0736[DV]	9.50	10.70	-0.042	9.46	10.66	Y	Y	Y	Y	Y	Increased Inundation
D0615	13.47	13.77*	-0.018	13.45	13.75	Y	Y	Y	N	N	Increased Inundation
D0061[DV]	10.36	11.06	-0.393	9.96	10.66	Y	Y	Y	N	N	Increased Inundation
D0049	14.13	14.43*	-0.027	14.11	14.41	Y	Y	Y	N	N	Increased Inundation
D0220[DV]	15.00	15.30*	-1.156	13.84	14.14	Y	N	Y	N	N	Freeboard less than 0.3m
D0773[DV]	16.37	17.47	-1.326	15.05	16.15	Y	Y	Y	Y	Y	Freeboard less than 0.3m
D0713[DV]	15.31	15.61*	-1.200	14.11	14.41	Y	N	Y	N	N	Freeboard less than 0.3m
D0050	14.01	14.81	-0.028	13.99	14.79	Y	Y	Y	N	N	Freeboard reduced, but > 0.3m
D0432[DV]	15.57	15.87*	-1.347	14.22	14.52	Y	N	Y	N	N	Freeboard reduced, but > 0.3m
D0862[DV]	15.00	15.30*	-0.881	14.12	14.42	Y	N	Y	N	N	Freeboard reduced, but > 0.3m
D0614	14.13	14.43*	-0.043	14.08	14.38	Y	Y	Y	N	N	Freeboard reduced, but > 0.3m
D0197[DV]	16.31	16.61*	-1.325	14.99	15.29	Y	N	Y	N	N	Freeboard reduced, but > 0.3m
D0209[DV]	15.33	15.60	-1.076	14.25	14.52	Y	Y	Y	N	N	Freeboard reduced, but > 0.3m
D0236[DV]	16.00	16.30*	-1.214	14.78	15.08	Y	Y	Y	N	N	Freeboard reduced, but > 0.5m

Dwelling ID	Existing Ground Level (mAHD)	Existing Floor Level (mAHD)	Subsidence (m)	Subsided Ground Level (mAHD)	Subsided Floor Level (mAHD)	Within Subsidence Zone	Within Existing 1% AEP Flood Extent	Within Subsided 1% AEP Flood Extent	Within Existing 20% Flood Extent	Within Subsided 20% Flood Extent	Comment
D0170 DV	21.38	21.60	0.000	21.38	21.60	N	Y	Y	N	N	Freeboard reduced, but > 0.5m
D0201 DV	21.15	22.15	0.000	21.15	22.15	N	Y	Y	N	N	Freeboard reduced, but > 0.5m
D0221 DV	16.00	16.30*	-1.010	14.99	15.29	Y	N	Y	N	N	Freeboard reduced, but > 0.5m
D0240 DV	17.00	17.30*	-0.355	16.65	16.95	Y	N	Y	N	N	Freeboard reduced, but > 0.5m
D0042	18.66	21.86	-0.515	18.15	21.35	Y	Y	Y	N	N	Freeboard reduced, but > 0.5m
Beneficial Impacts											
S0099	8.00	8.30*	0.000	8.00	8.30	N	Y	Y	Y	Y	Reduced Inundation
D0828	19.50	19.80*	0.000	19.50	19.80	N	Y	Y	Y	Y	Reduced Inundation
D0739	11.50	11.80*	0.000	11.50	11.80	N	Y	Y	Y	Y	Reduced Inundation
D0089	10.48	11.28	0.000	10.48	11.28	N	Y	Y	Y	Y	Reduced Inundation
D0876	19.11	19.41*	0.000	19.11	19.41	N	Y	Y	Y	Y	Reduced Inundation
S0824	16.71	17.01*	-0.017	16.69	16.99	N	Y	Y	Y	Y	Reduced Inundation
D0099	10.00	10.30*	0.000	10.00	10.30	N	Y	Y	Y	Y	Reduced Inundation
D0104	11.78	12.08*	0.000	11.78	12.08	N	Y	Y	Y	Y	Reduced Inundation
D0120	10.85	11.15*	0.000	10.85	11.15	N	Y	Y	Y	Y	Reduced Inundation
D0734	11.94	12.62	0.000	11.94	12.62	N	Y	Y	Y	Y	Reduced Inundation
D0820	20.32	20.62*	0.000	20.32	20.62	N	Y	Y	N	N	Reduced Inundation
S0101	10.49	10.79*	0.000	10.49	10.79	N	Y	Y	Y	Y	Reduced Inundation
D0052	12.42	12.92	0.000	12.42	12.92	N	Y	Y	Y	Y	Reduced Inundation
D0113	11.39	11.99	0.000	11.39	11.99	N	Y	Y	Y	Y	Reduced Inundation
D0002	19.50	19.80	0.000	19.50	19.80	N	Y	Y	Y	Y	Reduced Inundation
D0103	12.50	13.00	0.000	12.50	13.00	N	Y	Y	Y	Y	Reduced Inundation
D0381	8.32	8.92	0.000	8.32	8.92	N	Y	Y	Y	Y	Reduced Inundation
D0370	7.99	8.29	0.000	7.99	8.29	N	Y	Y	N	N	Reduced Inundation
D0110	13.00	13.30	0.000	13.00	13.30	N	Y	Y	Y	Y	Reduced Inundation
D0053	12.48	13.48	0.000	12.48	13.48	N	Y	Y	Y	Y	Reduced Inundation
D0013	19.16	19.46*	0.000	19.16	19.46	N	Y	Y	N	N	Reduced Inundation
S0371	8.83	8.83	0.000	8.83	8.83	N	Y	Y	N	N	Reduced Inundation
D0852 DV	15.50	15.80*	-1.197	14.30	14.60	Y	Y	Y	Y	Y	Reduced Inundation
D0091	13.20	13.70	0.000	13.20	13.70	N	Y	Y	N	N	Reduced Inundation
D0051	13.34	13.84	-0.005	13.33	13.83	N	Y	Y	N	N	Reduced Inundation

Dwelling ID	Existing Ground Level (mAHD)	Existing Floor Level (mAHD)	Subsidence (m)	Subsided Ground Level (mAHD)	Subsided Floor Level (mAHD)	Within Subsidence Zone	Within Existing 1% AEP Flood Extent	Within Subsided 1% AEP Flood Extent	Within Existing 20% Flood Extent	Within Subsided 20% Flood Extent	Comment
D0097	12.69	13.39	0.000	12.69	13.39	N	Y	Y	N	N	Reduced Inundation
D0108	11.00	11.30*	0.000	11.00	11.30	N	Y	Y	N	N	Reduced Inundation
D0012	18.97	20.17	0.000	18.97	20.17	N	Y	Y	N	N	Reduced Inundation
D0740	10.07	10.57	0.000	10.07	10.57	N	Y	Y	N	N	Increased freeboard
D0095	11.08	11.38	0.000	11.08	11.38	N	Y	Y	N	N	Increased freeboard
D0115	13.84	14.34	0.000	13.84	14.34	N	Y	Y	N	N	Increased freeboard
D0385	9.50	9.80	0.000	9.50	9.80	N	Y	Y	N	N	Increased freeboard
D0363	8.83	10.33	0.000	8.83	10.33	N	Y	Y	N	N	Increased freeboard
D0765 [DV]	28.47	29.18	-0.061	28.41	29.12	Y	Y	Y	N	N	Increased freeboard
D0100	12.51	13.00	0.000	12.51	13.00	N	Y	Y	N	N	Increased freeboard
D0009	21.57	22.57	0.000	21.57	22.57	N	Y	Y	N	N	Increased freeboard
D0004	19.66	21.86	0.000	19.66	21.86	N	Y	Y	N	N	Increased freeboard
D0003	22.84	23.80	0.000	22.84	23.80	N	Y	Y	N	N	Increased freeboard
Unchanged											
D0869	14.71	15.01*	0.000	14.71	15.01	N	Y	Y	Y	Y	No change to inundation
D0048	15.06	15.86	0.000	15.06	15.86	N	Y	Y	Y	Y	No change to inundation
D0035	13.73	14.13	0.000	13.73	14.13	N	Y	Y	Y	Y	No change to inundation
D0040	15.77	16.57	0.000	15.77	16.57	N	Y	Y	Y	Y	No change to inundation
D0038	16.50	16.80	0.000	16.50	16.80	N	Y	Y	Y	Y	No change to inundation
D0106	10.13	10.43*	0.000	10.13	10.43	N	Y	Y	N	N	No change to inundation
D0712 [DV]	20.85	21.15	0.000	20.85	21.15	N	Y	Y	N	N	No change to freeboard

* Indicates that floor level was estimated assuming clearance of 0.3m above ground level

[DV] Located in Dooralong Valley (Note: all other dwellings are in Yarramalong Valley)

Table 9.2 Extent of Flood Impacts on Dwellings

Dwelling ID	Cat.*	Existing 1% AEP Flood Level (mAHD)	Existing 1% AEP Flood Depth (m)	Existing 1% AEP Freeboard/ (Inund.) (m)	Subsided 1% AEP Flood Level (mAHD)	Subsided 1% AEP Flood Depth (m)	Subsided 1% AEP Freeboard/ (Inund.) (m)	Change in 1% AEP Freeboard/ Innund. (m)	Existing 20% AEP Flood Level (m)	Existing 20% AEP Flood Depth (m)	Existing 20%AEP Freeboard / (Inund.) (m)	Subsided 20% AEP Flood Level (m)	Subsided 20% AEP Flood Depth (m)	Subsided 20% AEP Freeboard/ (Inund.) (m)	Change in 20% AEP Freeboard/ Innund. (m)
Adverse Impacts															
D0863 DV	A1	14.336	0	0.46	14.354	1.04	(0.74)	-1.20	13.694	0	1.11	13.334	0.02	0.28	-0.82
D0870 DV	A1	11.114	0	0.34	11.022	0.80	(0.50)	-0.84	8.989	0	2.47	8.92	0	1.61	-0.86
D0207 DV	A1	14.332	0.33	0.67	14.019	1.19	(0.19)	-0.85	13.075	0	1.93	12.617	0	1.22	-0.71
D0060 DV	A1	11.092	0	1.08	10.998	0.53	(0.13)	-1.22	8.968	0	3.21	8.896	0	1.97	-1.24
D0737 DV	A1	11.25	0	0.67	11.195	0.70	(0.07)	-0.74	9.19	0	2.73	9.128	0	2.00	-0.73
S0041	B2	18.555	3.45	(3.15)	18.557	3.52	(3.22)	-0.07	16.482	1.37	(1.07)	16.487	1.45	(1.15)	-0.07
D0767	B2	19.223	2.41	(2.11)	19.158	2.54	(2.24)	-0.13	17.178	0.36	(0.06)	17.122	0.50	(0.20)	-0.14
D0017 DV	B1	11.386	1.89	(1.31)	12.163	2.80	(2.22)	-0.92	10.3	0.80	(0.22)	10.3	0.94	(0.36)	-0.14
D0063 DV	A2	11.657	1.37	(0.87)	11.342	2.42	(1.92)	-1.05	9.887	0	0.90	9.488	0.56	(0.06)	-0.96
D0237 DV	A2	14.352	1.03	(0.73)	14.024	1.82	(1.52)	-0.79	13.095	0	0.53	12.619	0.41	(0.11)	-0.64
D0851 DV	B2	16.254	1.36	(1.06)	15.052	1.47	(1.17)	-0.11	15.558	0.67	(0.37)	14.343	0.76	(0.46)	-0.10
S0776 DV	B2	17.084	1.28	(0.97)	15.798	1.39	(1.09)	-0.12	16.345	0.54	(0.24)	15.07	0.67	(0.37)	-0.13
D0776 DV	B2	17.068	1.21	(0.91)	15.784	1.35	(1.05)	-0.13	16.331	0.48	(0.18)	15.057	0.62	(0.32)	-0.14
D0041	B2	18.573	1.12	(0.82)	18.576	1.21	(0.91)	-0.10	16.496	0	1.26	16.503	0	1.16	-0.10
D0058 DV	B2	11.093	1.50	(0.80)	10.999	1.58	(0.88)	-0.08	8.969	0	1.32	8.896	0	1.22	-0.10
D0736 DV	B2	11.046	1.55	(0.35)	11.296	1.84	(0.64)	-0.29	9.326	0	1.37	9.278	0	1.38	0.01
D0615	C2	14.288	0.82	(0.52)	14.275	0.83	(0.53)	-0.01	12.467	0	1.30	12.459	0	1.29	-0.01
D0061 DV	B2	11.112	0.76	(0.05)	11.019	1.06	(0.36)	-0.30	8.987	0	2.07	8.918	0	1.75	-0.32
D0049	C2	14.453	0.32	(0.02)	14.442	0.34	(0.04)	-0.02	12.591	0	1.84	12.584	0	1.82	-0.02
D0220 DV	C1	14.302	0	1.00	14.012	0.17	0.13	-0.87	13.046	0	2.25	12.613	0	1.53	-0.72
D0773 DV	D	17.286	0.91	0.18	15.984	0.94	0.16	-0.02	16.529	0.16	0.94	15.247	0.20	0.90	-0.04
D0713 DV	C1	14.961	0	0.65	14.205	0.10	0.20	-0.44	14.029	0	1.58	12.852	0	1.56	-0.02
D0050	D	14.496	0.48	0.32	14.485	0.50	0.30	-0.02	12.627	0	2.19	12.62	0	2.17	-0.02
D0432 DV	C3	14.961	0	0.91	14.205	0	0.32	-0.59	14.029	0	1.84	12.852	0	1.67	-0.17
D0862 DV	C3	14.248	0	1.05	14.015	0	0.40	-0.65	13.019	0	2.28	12.648	0	1.77	-0.51
D0614	C3	13.947	0	0.48	13.935	0	0.45	-0.03	12.182	0	2.25	12.171	0	2.21	-0.03
D0197 DV	C3	15.877	0	0.74	14.839	0	0.45	-0.29	15.076	0	1.54	13.881	0	1.41	-0.13
D0209 DV	C3	14.518	0	1.08	14.069	0	0.45	-0.63	13.324	0	2.28	12.648	0	1.88	-0.40

Dwelling ID	Cat.*	Existing 1% AEP Flood Level (mAHD)	Existing 1% AEP Flood Depth (m)	Existing 1% AEP Freeboard/ (Inund.) (m)	Subsided 1% AEP Flood Level (mAHD)	Subsided 1% AEP Flood Depth (m)	Subsided 1% AEP Freeboard/ (Inund.) (m)	Change in 1% AEP Freeboard/ Innund. (m)	Existing 20% AEP Flood Level (m)	Existing 20% AEP Flood Depth (m)	Existing 20%AEP Freeboard / (Inund.) (m)	Subsided 20% AEP Flood Level (m)	Subsided 20% AEP Flood Depth (m)	Subsided 20% AEP Freeboard/ (Inund.) (m)	Change in 20% AEP Freeboard/ Innund. (m)
D0236 DV	D	15.695	0	0.60	14.565	0	0.52	-0.08	15.015	0	1.28	13.838	0	1.25	-0.04
D0170 DV	D	20.891	0	0.71	20.904	0	0.70	-0.01	19.973	0	1.63	19.982	0	1.62	-0.01
D0201 DV	D	21.063	0	1.08	21.074	0	1.07	-0.01	20.155	0	1.99	20.166	0	1.98	-0.01
D0221 DV	D	14.249	0	2.05	13.999	0	1.29	-0.76	12.998	0	3.30	12.607	0	2.68	-0.62
D0240 DV	D	15.932	0	1.37	15.604	0	1.34	-0.03	15.578	0	1.72	15.334	0	1.61	-0.11
D0042	D	19.532	0.87	2.33	19.456	1.31	1.89	-0.44	17.389	0	4.47	17.32	0	4.03	-0.45
Beneficial Impacts															
S0099	E3	12.34	4.34	(4.04)	12.321	4.32	(4.02)	0.02	10.505	2.51	(2.21)	10.489	2.49	(2.19)	0.02
D0828	E3	22.622	3.12	(2.82)	22.614	3.11	(2.81)	0.01	20.072	0.57	(0.27)	20.069	0.57	(0.27)	0.00
D0739	E3	14.493	2.99	(2.69)	14.482	2.98	(2.68)	0.01	12.624	1.12	(0.82)	12.617	1.12	(0.82)	0.01
D0089	E3	13.601	3.12	(2.32)	13.587	3.11	(2.31)	0.01	11.843	1.36	(0.56)	11.828	1.35	(0.55)	0.02
D0876	E3	21.536	2.43	(2.13)	21.521	2.42	(2.12)	0.02	19.232	0.13	0.17	19.223	0.12	0.18	0.01
S0824	E2	19.103	2.40	(2.10)	19.039	2.35	(2.05)	0.05	17.074	0.37	(0.07)	17.019	0.33	(0.03)	0.04
D0099	E3	12.369	2.37	(2.07)	12.348	2.35	(2.05)	0.02	10.535	0.54	(0.23)	10.519	0.52	(0.22)	0.02
D0104	E3	14.054	2.27	(1.97)	14.044	2.26	(1.96)	0.01	12.281	0.50	(0.20)	12.272	0.49	(0.19)	0.01
D0120	E3	13.027	2.18	(1.88)	13.01	2.16	(1.86)	0.02	11.271	0.42	(0.12)	11.256	0.41	(0.11)	0.02
D0734	E3	14.49	2.55	(1.87)	14.479	2.54	(1.86)	0.01	12.622	0.68	0.00	12.615	0.68	0.01	0.01
D0820	E3	22.267	1.95	(1.65)	22.257	1.94	(1.64)	0.01	19.791	0	0.83	19.787	0	0.84	0.00
S0101	E3	12.421	1.93	(1.63)	12.4	1.91	(1.61)	0.02	10.602	0.11	0.19	10.586	0.09	0.21	0.02
D0052	E3	14.51	2.09	(1.59)	14.5	2.08	(1.58)	0.01	12.641	0.22	0.28	12.634	0.22	0.28	0.01
D0113	E3	13.498	2.11	(1.51)	13.484	2.10	(1.50)	0.01	11.737	0.35	0.25	11.722	0.33	0.27	0.02
D0002	E3	21.299	1.80	(1.50)	21.282	1.78	(1.48)	0.02	19.035	0	0.77	19.024	0	0.78	0.01
D0103	E3	14.242	1.74	(1.24)	14.229	1.73	(1.23)	0.01	12.43	0	0.57	12.421	0	0.58	0.01
D0381	E2	10.149	1.83	(1.23)	10.093	1.77	(1.17)	0.06	8.396	0.07	0.53	8.35	0.03	0.57	0.05
D0370	E2	9.49	1.50	(1.20)	9.44	1.45	(1.15)	0.05	7.795	0	0.49	7.748	0	0.54	0.05
D0110	E3	14.418	1.42	(1.12)	14.406	1.41	(1.11)	0.01	12.568	0	0.73	12.561	0	0.74	0.01
D0053	E3	14.568	2.09	(1.09)	14.559	2.08	(1.08)	0.01	12.702	0.23	0.77	12.696	0.22	0.78	0.01
D0013	E2	20.445	1.29	(0.99)	20.404	1.25	(0.95)	0.04	18.249	0	1.21	18.225	0	1.23	0.02
S0371	E2	9.807	0.98	(0.98)	9.768	0.94	(0.94)	0.04	8.362	0	0.47	8.323	0	0.51	0.04
D0852 DV	E2	16.598	1.10	(0.80)	15.366	1.06	(0.76)	0.03	15.859	0.36	(0.06)	14.637	0.33	(0.03)	0.02

Dwelling ID	Cat.*	Existing 1% AEP Flood Level (mAHD)	Existing 1% AEP Flood Depth (m)	Existing 1% AEP Freeboard/ (Inund.) (m)	Subsided 1% AEP Flood Level (mAHD)	Subsided 1% AEP Flood Depth (m)	Subsided 1% AEP Freeboard/ (Inund.) (m)	Change in 1% AEP Freeboard/ Innund. (m)	Existing 20% AEP Flood Level (m)	Existing 20% AEP Flood Depth (m)	Existing 20%AEP Freeboard / (Inund.) (m)	Subsided 20% AEP Flood Level (m)	Subsided 20% AEP Flood Depth (m)	Subsided 20% AEP Freeboard/ (Inund.) (m)	Change in 20% AEP Freeboard/ Innund. (m)
D0091	E3	14.415	1.22	(0.72)	14.403	1.21	(0.71)	0.01	12.566	0	1.13	12.559	0	1.14	0.01
D0051	E3	14.523	1.19	(0.69)	14.512	1.18	(0.68)	0.01	12.652	0	1.18	12.645	0	1.19	0.00
D0097	E3	14.019	1.33	(0.63)	14.008	1.32	(0.62)	0.01	12.249	0	1.14	12.239	0	1.15	0.01
D0108	E3	11.805	0.81	(0.50)	11.785	0.79	(0.48)	0.02	10.308	0	0.99	10.302	0	1.00	0.01
D0012	E2	20.438	1.46	(0.26)	20.397	1.42	(0.22)	0.04	18.243	0	1.93	18.22	0	1.95	0.02
D0740	E2	10.371	0.30	0.20	10.313	0.54	0.26	0.06	9.475	0	1.10	9.464	0	1.11	0.01
D0095	E3	11.099	0.02	0.28	11.093	0.01	0.29	0.01	10.202	0	1.18	10.2	0	1.18	0.00
D0115	E1	14.205	0.37	0.13	14	0.16	0.34	0.21	12.5	0	1.84	12.5	0	1.84	0.00
D0385	E3	9.44	0	0.36	9.423	0	0.38	0.02	8.376	0	1.42	8.347	0	1.45	0.03
D0363	E3	9.95	1.12	0.38	9.925	1.09	0.41	0.02	8.738	0	1.60	8.715	0	1.62	0.02
D0765 DV	E2	28.687	0.22	0.49	28.598	0.19	0.52	0.03	27.999	0	1.18	27.924	0	1.20	0.01
D0100	E3	12.313	0	0.69	12.294	0	0.71	0.02	10.48	0	2.52	10.464	0	2.54	0.02
D0009	E3	21.596	0.03	0.97	21.581	0.01	0.99	0.02	19.282	0	3.29	19.273	0	3.30	0.01
D0004	E3	20.474	0.81	1.39	20.434	0.77	1.43	0.04	18.27	0	3.59	18.247	0	3.62	0.02
D0003	E3	21.336	0	2.46	21.32	0	2.48	0.02	19.066	0	4.73	19.055	0	4.75	0.01
Unchanged															
D0869	U	18.354	3.64	(3.34)	18.358	3.64	(3.34)	0.00	16.309	1.60	(1.30)	16.311	1.60	(1.30)	0.00
D0048	U	18.189	3.13	(2.33)	18.190	3.13	(2.33)	0.00	16.172	1.12	(0.32)	16.180	1.12	(0.32)	0.00
D0035	U	16.171	2.44	(2.04)	16.172	2.44	(2.04)	0.00	14.032	0.31	0.10	14.032	0.31	0.10	0.00
D0040	U	17.602	1.83	(1.03)	17.602	1.83	(1.03)	0.00	15.575	0	0.99	15.574	0	0.99	0.00
D0038	U	17.661	1.16	(0.86)	17.662	1.16	(0.86)	0.00	15.633	0	1.17	15.631	0	1.17	0.00
D0106	U	10.692	0.56	(0.26)	10.690	1.13	(0.26)	0.00	9.982	0	0.45	9.977	0	0.46	0.00
D0712 DV	U	21.12	0.27	0.03	21.12	0.27	0.03	0.00	20.1	0	1.05	20.1	0	1.05	0.00

*** Refer to Table 9.3 for description of Impact Categories**

Table 9.3 Impact Categories for Dwellings

Category	Description	Number Affected	Houses Affected	Impacts
A	***Major Impacts***			
A1	House floor not flooded by 1:100 yr ARI (1%AEP) flood prior to mining but becomes flooded after mining.	5	D0863, D0870, D0207, D0060, D0737 (Note these houses remain unaffected by the 1:5 yr (20%AEP) flood after mining)	Significant Impact – major increase in damage costs.
A2	House floor flooded by 1:100 yr (1%) flood prior to mining with >0.3m increase in flooding after mining PLUS house floor not flooded by 1:5 yr (20%) flood prior to mining but becomes flooded after mining	2	D0063, D0237	Major Impact – increase in frequency of damage plus some increase in maximum damage costs
B	***Moderate Impacts***			
B1	House floor flooded by 1:100 yr (1%) flood prior to mining with >0.3m increase in flooding after mining BUT will remain unaffected by 1:5 yr (20%) flood	1	D0017 (Also a local heritage silo affected)	Moderate Impact – moderate increase in frequency and cost of damage from larger floods.
B2	House floor flooded by 1:100 yr (1%) flood prior to mining with only minor (<0.3m) increase in flooding after mining.	9	D0767, D0851, D0776, D0041, D0058, D0736, D0061 and includes two sheds: S0041 S0776,	Moderate Impact - minor increase in frequency and cost of damage from very large floods
C	***Minor Impacts***			
C1	House floor not flooded by 1:100 yr flood (1%) prior to mining nor flooded after mining, BUT freeboard reduced from >0.5m before mining to < 0.3m after mining.	2	D0713, D0220	Minor Impact - no change in risk and no direct cost impacts but planning constraints no longer satisfied for freeboard.
C2	House floor flooded by 1:100 yr flood (1%) prior to mining with negligible (<0.05m) increase in flooding after mining	2	D0049, D0615	Minor Impact - negligible change in risk or cost impacts
C3	House floor not flooded by 1:100 yr (1%) flood prior to mining nor flooded after mining, BUT freeboard reduced to < 0.5m	5	D0432, D0862, D0614, D0197, D0209	Minor Impact - less than desirable freeboard but no risk or cost impacts
D	***Negligible Impacts***			
D	House floor not flooded by 1:100 yr (1%) flood prior to mining nor flooded after mining and/or change in freeboard <0.05m	8	D0773, D0050, D0236, D0170, D0201, D0221, D0240, D0042	No impacts and no significant change
E	***Beneficial Impacts***			
E1	Significant (>0.2m) reduction in flood levels in 1:100yr (1%) flood after mining PLUS achieving a freeboard	1	D0115	Moderate Beneficial Impact

Category	Description	Number Affected	Houses Affected	Impacts
	of at least 0.3m after mining.			
E2	Minor (<0.2m) reduction in flood levels in 1:100yr flood (1%) after mining and no change to flood category after mining.	9	D0381, D0370, D0013, D0852, D0012, D0740, D0765 and includes two sheds: S0824, S0371	Minor Beneficial Impact
E3	Negligible (<0.05m) reduction in flood levels and/or freeboard after mining for all floods	28	(see Table 6.2)	No impacts and no significant change
U	***Unchanged***			
U	No change in flood depths after mining but minor change in ground levels	7	D0869, D0048, D0035, D0040, D0038, D0106, D0712	No impacts

Table 9.4 Impact Categories for Properties

Category	Description	Number Affected	Land / Properties Affected	Impacts
L1	Reduction in Flood Extent of 1:100 yr flood (1%) by more than 5% of individual property area after mining	2	Generally grazing land near property boundary.	Moderate Beneficial Impact.
L2	Reduction in Flood Extent of 1:100 yr flood (1%) by less than 5% of individual property area after mining.	3	Generally grazing land near property boundary.	Moderate Beneficial Impact.
L3	Increase in Flood Extent of 1:100 yr flood (1%) by more than 5% but less than 20% of individual property area after mining.	4	Mostly grazing land plus some areas of non-agricultural and uncleared land.	Minor to Moderate Impact.
L4	Increase in Flood Extent of 1:100 yr flood (1%) by more than 20% of individual property area (or other major effect) after mining.	6	Agricultural land plus a plant nursery and one cattle property.	Moderate to Major Impact

Dwellings were also examined for changes to hydraulic and hazard categories. In the 1% AEP flood, subsidence will result in:

- five dwellings which are currently flood free changing to low hazard flood fringe;
- three dwellings located in a low hazard flood storage area changing to high hazard flood storage;
- one dwelling located in a low hazard flood fringe area changing to high hazard flood fringe;
- one dwelling located in a low hazard flood fringe area changing to low hazard flood storage; and
- no changes in hydraulic and hazard categories for dwellings in the Yarramalong Valley.

Changes to hydraulic and hazard categories are usually more significant for the land within property boundaries than for existing dwellings, sheds and other buildings on the properties. In cases where properties are subjected to adverse changes in hydraulic and hazard categories, additional mitigation measures or development controls may be required. Impacts on properties are discussed below.

9.3.5 Property Access

Flood duration, or length of time a community or single dwelling is cut off by floodwaters can significantly impact on the costs and disruption associated with flooding. Subsidence will result in an increase in the flood duration at low points along access routes within the Dooralong Valley. There are no expected impacts of subsidence on property access in the Yarramalong Valley. Mitigation measures will be required in affected locations to maintain existing flood access.

Access Routes

Primary and secondary access routes to the Dooralong and Yarramalong Valleys were documented in the Flood Impact Assessment. This included the identification of the most direct route to the Newcastle/Sydney Freeway along with emergency evacuation routes.

For any residence, the primary access route is the most direct route to the Newcastle/Sydney Freeway. This generally includes Yarramalong Road for residents in the Yarramalong Valley, and Jilliby Road for residents in the Dooralong Valley. Jilliby Road and the two secondary routes to the Freeway from the Dooralong Valley (Durren Road and Mandalong Road) were investigated to identify which had the shortest duration of inundation.

The primary access route for dwellings on the right bank (western side) of the Dooralong Valley was found to be Jilliby Road which crosses Jilliby Jilliby Creek at Flack's Bridge. The primary access road for properties on the left bank of Dooralong Valley is Mandalong Road to Morisset.

The primary access route for dwellings on the right bank (southern side) of the Yarramalong Valley is Yarramalong Road. Most dwellings on the left bank are accessed by short link roads to Yarramalong Road which cross the Wyong River over low bridges.

A secondary route for dwellings on the right bank of Dooralong Valley is Mandalong Road via Durren Road. An alternative secondary route is Mandalong Road directly from Jilliby Road.

Determination of Key Low Points

Key locations that will be affected directly by subsidence or by subsidence induced increases in flood depth comprise low points on roads and bridges that are inundated during the initial stages of flooding. These locations are considered critical if floodwaters will cut off access to dwellings or restrict emergency evacuation routes for long periods of time.

Cross section locations adjacent to each low point were identified and recorded to link low points to the hydraulic model.

For each low point along the primary access route, the depth at which the road becomes untrafficable and the duration of inundation for the relevant scenarios are presented in Table 9.5.

Table 9.5 Primary Access Impacts

Low Point ID	Maximum Existing Trafficable RL (m AHD)	Maximum Subsided Trafficable RL (m AHD)	Existing Inundation Duration (hours)		Post-mining Inundation Duration (hours)		Increase in Inundation Duration (hours)	
			1% AEP	20% AEP	1% AEP	20% AEP	1% AEP	20% AEP
D10 (Bridge D)	24.41	24.41	11	4	11	4	Nil	Nil
D20	20.0	20.0	19	9	19	9	Nil	Nil
D30	19.3	19.3	5	0	5	0	Nil	Nil
D40	18.35	18.35	19	8	19	8	Nil	Nil
D50	10.0	8.7	19	0	44	35	25	35
D60 (Bridge A)	7.9	7.9	36	18	36	19	Nil	1
D70	13.0	11.7	18	0	37	26	19	26
D80 (Bridge B)	14.9	13.7	8	0	22	15	14	15
D90 (Bridge E)	27.3	27.3	0	0	0	0	Nil	Nil
Y10 (Bridge 13)	18.09	18.09	48	45	48	45	Nil	Nil
Y20 (Bridge 12)	17.34	17.34	54	50	54	50	Nil	Nil
Y30	19.2	19.2	30	28	30	28	Nil	Nil
Y40	17.5	17.5	44	42	44	42	Nil	Nil
Y50 (Bridge 10)	15.17	15.17	60	57	60	57	Nil	Nil
Y60 (Bridge 11)	17.50	17.50	38	37	38	37	Nil	Nil
Y70	16.5	16.5	45	44	45	44	Nil	Nil
Y80	12.6	12.4	71	68	73	69	2	1
Y90 (Bridge 7)	13.06	12.95	62	54	63	55	1	1
Y100 (Bridge 6)	13.88	13.83	49	48	49	48	Nil	Nil
Y110	13.9	13.9	47	45	47	45	Nil	Nil
Y120	14.0	14.0	40	38	40	38	Nil	Nil
Y130 (Bridge 5)	12.95	12.95	58	56	58	56	Nil	Nil
Y140	13.4	13.4	46	45	46	45	Nil	Nil
Y150 (Bridge 4)	11.65	11.65	69	66	69	66	Nil	Nil
Y160	12.7	12.7	50	49	50	49	Nil	Nil
Y170 (Bridge 3)	9.84	9.84	51	49	51	49	Nil	Nil
Y180 (Bridge 2)	9.20	9.20	51	50	51	50	Nil	Nil
Y190	9.3	9.3	37	32	37	32	Nil	Nil
Y200	9.2	9.2	22	12	22	12	Nil	Nil
Y210	8.5	8.5	22	3	22	3	Nil	Nil
Y220 (Bridge 1)	10.48	10.48	0	0	0	0	Nil	Nil
Y230	8.10	8.10	9	0	9	0	Nil	Nil

1. primary access route only

Safe Evacuation Levels

A velocity/depth relationship was used to determine vehicle stability in floodwaters. Vehicles can become unstable when flood depths over roads exceed 0.15 - 0.30 m (depending on flow velocity and vehicle characteristics) and when flood velocities exceed 2 m/s. Trafficable flow depths were determined at each low point based on the relevant velocities shown in Table 9.6.

Table 9.6 Safe Depth for Vehicles at Specified Flow Velocities

Flow Velocity (m/s)	Maximum Safe Depth (m)
0 – 0.5	0.30
0.5 – 1.0	0.25
1.0 – 1.5	0.20
1.5 – 2.0	0.15

Source: NSW Floodplain Management Manual (2001 and updated in 2005)

Note: No depth is considered safe for flow velocities greater than 2m/s

Access Impact Assessment

In the case of Primary Access Routes in the Yarramalong Valley, the results show that for all events modelled, post mining flooding durations are similar or less than existing durations for almost all low points within the Yarramalong Valley. There will be no dwellings in this valley that will have access cut off where it is not cut off under existing conditions.

Only three dwellings (D0016, D0028 and D0042) within the Yarramalong Valley will be adversely affected in terms of duration of impacts on access along the primary access route. Following subsidence, these dwellings will be cut off at low point Y80 for a maximum duration of 73 hours during the critical 1% AEP flood event. This is an increase of 2 hours over the existing situation.

In the case of the Dooralong Valley, there will be no dwellings in the Dooralong valley that will have primary access cut off where it is not cut off under existing (pre-mining) conditions. Up to 218 dwellings within the Dooralong Valley may be adversely affected in terms of duration of impacts on access out of the valley along their relevant primary access route. These include:

- 172 dwellings that will be cut off at low point D50 for a maximum duration of 44 hours during the critical 1% AEP flood event and 35 hours in the 20% AEP flood. This is an increase of 25 and 35 hours respectively over the existing situation;
- 20 additional dwellings will be cut off at low point D60 (Bridge A) for a maximum duration of 35 hours during the critical 1% AEP flood event and 19 hours during the 20% AEP flood. This is an increase of 17 hours for only the 20% AEP flood over the existing situation; and
- 26 additional dwelling will be cut off at low point D70 for a maximum duration of 37 hours during the critical 1% AEP flood event and 26 hours for the 20% AEP flood. This is an increase of 19 and 26 hours respectively over the existing situation.

Point D80 (Bridge B) will impact most of the same dwellings as point D50 but the durations of inundation will be less and the increase in duration will also be less, as a result of subsidence.

Up to 198 dwellings within the Dooralong Valley can be adversely affected in terms of access out of the valley if both primary and secondary access routes are inundated. This would occur if both D50 and D70 were cut off simultaneously. The shortest duration dwellings will be cut off under these circumstances will be dependent on low point D70 and will be for a maximum duration of 37 hours during the critical 1% AEP flood event after mine subsidence. This is an increase of 19 hours over the existing (pre-mining) situation.

9.3.6 Subsidence Impacts on Flooding in the Hue Hue Catchment

Hydraulic modelling indicated that flood depths may increase as a result of subsidence by up to 0.27 m in some locations. Within the subsidence affected area, modelling indicated that an average increase in flood depth of 0.08 m may be expected.

Modelling of existing conditions indicates that three of the four road/access road crossings of Hue Hue Creek which are upstream of the Sydney-Newcastle Freeway are inundated during a 1% AEP event. It is only the bridge across the Cottesloe Road that does not overtop. This is also the case under subsided conditions. The model indicates that the Sydney-Newcastle Freeway is well above the 1% AEP flood level both for existing and subsided conditions.

There are a number of dwellings (including at least one shed or non-primary dwelling) located along the length of Hue Hue Creek, with most located between Sandra Street and the Freeway and two dwellings located just upstream of Sandra Street. Currently six of these dwellings are flood affected during a 1% AEP event. Of these:

- two dwellings are inundated (i.e. flood water above floor levels) during the 1% AEP flood under existing conditions,
- one is flood affected as a result of having access cut during a 1% AEP flood, and
- three have less than 0.5 m freeboard.

The HEC-RAS model indicates that subsidence would cause one of the dwellings with insufficient freeboard to become inundated in a 1% AEP flood, and an additional dwelling that is currently not flood impacted to have freeboard reduced to less than 0.5 m. Table 9.7 indicates which dwellings are affected, their estimated floor level and predicted 1% AEP flood level.

As indicated in Table 9.7, the primary impacts are to dwellings D0430, D0415, D0513, and D0589. Dwelling D0430 currently has less than 0.5 m freeboard and subsidence with cause this dwelling to become flood prone. Dwelling D0415 currently has less than 0.5 m freeboard and as a result of subsidence will no longer be flood affected. This is due to its location on the opposite side of Hue Hue Creek to where most of the subsidence is predicted to occur. Dwelling D0513 is currently not flood affected, and subsidence will mean that this dwelling will have insufficient freeboard during a 1% AEP flood event. Dwelling D0589 is currently flood prone and subsidence will cause the 1% AEP flood depth at this dwelling to be an additional 0.3 m above its current depth.

The flood effects on dwellings downstream of Hue Hue Road will not be altered as a result of subsidence. The predicted extent of subsidence does not extend this far down Hue Hue Creek and flooding in this reach is governed by the culverts under the freeway and vegetation in the creek.

Table 9.7 Flood Affected Dwellings, Hue Hue Creek

Dwelling	Cat. [2.]	HEC-RAS Cross Section	Existing Ground level	Existing Floor Level [1.]	Existing Flood Level (1% AEP)	Existing Freeboard (m)	Comment	Subsided Ground Level	Subsided Floor Level	Subsided Flood Level (1% AEP)	Subsided Freeboard (m)	Comment
D0430	A1	3.38	14.42	14.42	14.1	0.32	Insufficient freeboard	13.6	13.6	13.82	-0.22	Inundated
D0415	E1	3.38	14.2	14.5	14.1	0.40	Insufficient freeboard	14.1	14.4	13.82	0.58	Beneficial Impact
SANDRA STREET												
D0513	C1	3.25	14.5	14.5	13.86	0.64		13.78	13.78	13.73	0.05	Insufficient freeboard
D0507	D	3.19	14.5	14.5	13.82	0.68		14.3	14.3	13.70	0.60	
D0587	D	2.87	13.9	13.9	12.83	1.07		13.7	13.7	12.84	0.86	
D0588	D	2.87	13.4	13.4	12.83	0.57		13.35	13.35	12.84	0.51	
D0589	B2	2.82	12.35	12.35	12.55	-0.20	Inundated	12.3	12.3	12.53	-0.23	Inundated
D0590	E3	2.82	14	14	12.55	1.45		14	14	12.54	1.46	
D0753	U	2.69	14.2	14.2	11.96	2.24		14.2	14.2	11.96	2.24	
HUE HUE ROAD												
D0461	U	2.32	10	10.8	9.93	0.87		10	10.8	9.93	0.87	
D0462	U	2.28	10.5	10.5	9.7	0.80		10.5	10.5	9.7	0.80	
D0463	U	2.22	9.5	9.5	9.4	0.10	Insufficient freeboard	9.5	9.5	9.4	0.10	Insufficient Freeboard
D0464	U	2.14	9	9	9.02	-0.02	Inundated	9	9	9.02	-0.02	Inundated
D0465	U	2.06	8.6	9.3	8.62	0.68	Flood affected access	8.6	9.3	8.62	0.68	Flood affected access
D0466	U	2.06	9	9.3	8.62	0.68		9	9.3	8.62	0.68	
D0467	U	1.98	9	9	8.22	0.78		9	9	8.22	0.78	
D0468	U	1.98	9.5	9.5	8.22	1.28		9.5	9.5	8.22	1.28	

Notes: 1. Floor levels estimated from Dwelling Status Report Flood Prone Areas, Preliminary report, MEGS for COAL, 2001, and topographic data from WACJV DTM
2. Refer Table 9.3 for description of Impact Categories

9.4 Mitigation Measures

9.4.1 Property Hazard Mitigation Measures - Yarramalong and Dooralong Valleys

It will not be the responsibility of the mine to address the existing (pre-mining) impacts of flooding in the Yarramalong and Dooralong Valleys. However, where properties become more flood prone as a result of mining induced subsidence, mitigation measures will be developed as part of the Subsidence Management Plan (SMP) process. The SMP process involves detailed analysis through individual Property Subsidence Management Plans which are prepared in advance of mining. All costs associated with mitigating the impacts of flooding as a result of mining will be borne by the WACJV. Potential management measures are outlined in the NSW Floodplain Management Manual (2005) and are listed in Table 9.8. They are grouped into three categories:

- ❒ *Property modification* – modify properties and/or impose controls on property and infrastructure development;
- ❒ *Response modification* – modify the response of the population at risk to better respond to a flood event; and
- ❒ *Flood modification* –modify the behaviour of the flood.

Table 9.8 Flood Management Measures

Category	Measure
Property modification	Zoning Voluntary purchase House raising Building and development controls Flood proofing buildings Raising roads and bridges
Response modification	Community awareness Community readiness Flood predictions and warning Local flood plans Evacuation arrangements Recovery plans
Flood modification	Flood control dams Retarding dams Flood levees Bypass floodways Channel improvements Flood gates

1. NSW Floodplain Management Manual (2001 and updated in 2005)

There are a number of options available to mitigate flooding impacts; however many options may not be practical for the existing circumstances or for the type of impacts that result from subsidence. Further, due to the current scale of flooding in the valleys, flood modification structures such as flood control dams or bypass floodways would not be practical or effective. Four mitigation options are recommended for properties significantly impacted by the project within the study area. These are:

- flood levees;
- house raising;
- house relocation; and
- voluntary purchase or other compensation measures.

In the case of house raising and/or relocation, the design floor level would include a freeboard above the 1% AEP post-subsidence flood. This is preferably 500 mm but is usually within the range of 300 mm to 500 mm, depending on the potential for wind waves and turbulence. Council planning requirements also need to be considered. In the case of flood levees, the impacts of the levees themselves on other properties need to be considered.

House Raising and House Relocation

House raising is a widely accepted method of reducing flood damage and has been implemented in many flood prone areas in New South Wales. House relocation involves the complete relocation of the dwelling to higher ground preferably nearby within the land-owner's property.

Not all houses are suitable for raising or relocation. Houses best suited to raising or relocation are timber framed and clad with non-masonry materials. There are methods for raising houses constructed on slabs, however these are usually not cost effective.

The following dwellings impacted by subsidence have floor joists and are timber framed. Depending on the existing floor height above the ground level, it may be possible to raise or relocate these dwellings to achieve the required design height:

- Dwelling D0060 – raise 0.63m, or relocate;
- Dwelling D0061 – raise 0.86m, or relocate; and
- Dwelling D0237 – raise 2.02m, or relocate.

Other timber framed dwellings may exist for which similar measures can be taken.

Flood Levees

Ring levees are frequently the most economically viable measure to protect single dwellings in flood prone areas. Ring levees are generally a grassed earthen bund constructed around the dwelling and can be constructed from select fill material obtained from the property. The design also requires a controlled outlet at the lowest point of the levee to drain stormwater and a pump to dewater during rain whenever floodwaters are high. Flood levees are typically designed to protect dwellings from floodwaters up to the 1% AEP flood.

The use of flood levees may be suitable for the following dwellings subject to discussions with the property owners:

- Dwelling D0017 – 1% AEP flood depth 2.8 m;
- Dwelling D0058 – 1% AEP flood depth 1.6 m;
- Dwelling D0207 – 1% AEP flood depth 1.2 m;
- Dwelling D0737 – 1% AEP flood depth 0.7 m;
- Dwelling D0773 – 1% AEP flood depth 0.9 m; and
- Dwelling D0063 – 1% AEP flood depth 2.4 m.

These measures have the added benefit of potentially reducing or even eliminating existing flooding impacts on an already partly flood prone property. These works may therefore increase the overall property value and improve agricultural capability.

Voluntary Purchase

In certain high hazard areas of the floodplain it is impractical to mitigate the impacts of flooding on properties at risk. Under such circumstances, the property may need to be purchased at an equitable price or other negotiated compensation may need to be made.

It may be necessary to purchase some properties due to post mining changes in flooding behaviour and if raising or relocating the dwellings or constructing flood levees is impracticable.

9.4.2 Development Controls - Yarramalong and Dooralong Valleys

The NSW Floodplain Management Manual of 2005 outlines interim guidelines which identify the types of land use, developments and conditions that are generally appropriate to the various hydraulic and hazard categories of flood prone land. These guidelines are used to develop planning controls for land which is impacted by flooding.

The guidelines outlined in the manual recommend development controls based on land use and development categories. The land uses are defined as residential, commercial, industrial, open space, rural/non-urban, and special use.

Residential and rural/non-urban land uses have been reviewed for this study. Development categories which have been reviewed are existing development, infill development and redevelopment.

Development controls for the six flood categories are shown in Table 9.9. A number of the controls listed are based on the Flood Planning Level (FPL). Typically, councils in New South Wales adopt the 1% AEP flood for the FPL.

Table 9.9 Development Controls for New Developments

Hydraulic and Hazard Categories	Development Guideline		SPECIAL
	Residential	Rural/ non-urban	
High hazard floodway	1,2,3,5 and SPECIAL	1,2,3,5 and SPECIAL where warranted	Incorporate measures to ensure the safe evacuation of people from the area should a design flood or greater occur. Ensure development does not significantly increase flood hazard or flood damage to other properties or adversely affect flood behaviour

Table 9.9 Development Controls for New Developments

Hydraulic and Hazard Categories	Development Guideline Residential	Rural/ non-urban	SPECIAL
High hazard flood storage	1,2,3,5 and SPECIAL	1,2,3,5 and SPECIAL	Incorporate measures to ensure the safe evacuation of people from the area should a design flood or greater occur. Ensure development does not significantly increase flood levels or flood hazard, either at the proposed site or elsewhere
High hazard flood fringe	1,2,3,5 and SPECIAL	1,2,3 and 5	Incorporate measures to ensure the safe evacuation of people from the area should a design flood or greater occur. Ensure that the displacement of these people will not significantly add to the overall cost and community disruption caused by the flood.
Low hazard floodway	1,2,3,5 and SPECIAL	1,2,3,5 and SPECIAL	Ensure development does not significantly increase flood levels or flood hazard at the proposed site or elsewhere.
Low hazard flood storage	1,2,3 and SPECIAL	1,2,3 and SPECIAL where warranted	Ensure development does not significantly increase flood levels or flood hazard at the proposed site or elsewhere.
Low hazard flood fringe	1,2 and 3	1,2 and 3	None

Source: NSW Floodplain Management Manual (2001 and updated in 2005)

1. Any portion of a building or structure below the Flood Planning Level (FPL) should be built from flood compatible materials
2. The habitable floors of new residences and new commercial and industrial developments, together with normally occupied floors of special use developments, should either have a floor level at or above the FPL or be flood proofed to this level
3. Special consideration should be given to caravan parks
5. Building or structure should be able to withstand the force of flowing floodwaters

9.4.3 Access Mitigation Options - Yarramalong and Dooralong Valleys

Subsidence will cause the roads at low points D50, D70 and D80 to become untrafficable for longer periods than for the existing situation. In addition, low points Y80 and Y90 will be marginally impacted in the 1% AEP flood and D60 will be slightly impacted by the 20% AEP flood. Mitigation options are assessed for each low point below.

Low Point D50

The 1% AEP flood levels in the vicinity of D50 vary from RL11.4 to 11.6 m AHD for existing and RL11.1 to 11.3 m AHD for subsided conditions. Parts of the road currently at about RL9.7 m AHD will drop to about RL8.4 m AHD due to subsidence. To reinstate the status quo of 19 hours for which the D50 would be untrafficable would require raising the road over a distance of 440 m to RL9.5 m AHD after subsidence.

Low Point D60

Low point D60 at RL7.52 m AHD is located approximately 160 m to the northwest of Bridge A. Bridge A itself is at RL8.3 m AHD and is also outside the subsidence area. It may be possible therefore to raise the approach roads by up to 0.8 m for a distance of 330 m to the west and 160 m to the east of Bridge A to reduce the duration this route is untrafficable from 35 hours to 27 hours. There may be slight impacts of flood levels in the vicinity of the raised road but the advantage of reducing duration of inundation would outweigh this effect.

Low Point D70

This low point is significantly affected by subsidence for all floods. The lowest point on the road will subside from RL12.7 to 11.4 m AHD, thereby increasing duration and frequency of inundation. It is relatively simple to raise this road to RL14.0 m AHD over a distance of 400 m after subsidence has occurred. This would ensure the road is flood free for all events up to the 1% AEP flood.

Low Point D80

Low point D80 (RL14.61 m AHD) is currently located on Jilliby Road approximately 120 m to the north of Bridge B spanning Little Jilliby Jilliby Creek. After subsidence this low point will shift approximately 520 m to the north where the road is currently at RL14.7 m AHD and will drop to approximately RL13.4 m AHD. To mitigate these impacts would require raising the road by up to 1.1 m to RL14.5 m AHD over a distance of about 480 m. Because this would be in the flood fringe, there would be no significant change in final flood levels.

It may be possible to flood proof this section of road by raising to RL15 m AHD. However, significant culverts would be required to maintain flow capacity.

Low Point Y80

Three dwellings are affected by flooding increases at low point Y80 for up to 74 hours in the 1% AEP flood, which is an increase of 2 hours on existing conditions. The road could be raised by up to approximately 0.4 m over a distance of 80 m to mitigate the increase in flooding duration at the low point.

Low Point Y90 (Bridge 7)

The access across the Wyong River (Bridge 7) will become the critical low point if Y80 is raised sufficiently to reduce inundation duration to less than 63 hours in the 1% AEP flood. Because this bridge may subside by approximately 0.1 m it would be beneficial if the bridge were also raised by at least this amount.

9.4.4 Emergency Evacuation Routes - Yarramalong and Dooralong Valleys

Access routes to higher ground were investigated for the case when primary and secondary access routes become untrafficable. It was found that for most dwellings, access to higher ground is available during large floods.

While many access roads in the Yarramalong and Dooralong Valleys become untrafficable during floods, there are roads which provide residents with access to higher ground if required. These include Bantman Drive and Watagan Forest Drive. Although these routes pass through catchments where flood levels are unknown, residents are able to use these routes during emergencies.

The primary access route for residents in the Yarramalong Valley is Yarramalong Road which runs along the right bank of the Wyong River and joins the Newcastle-Sydney Freeway to the east of the study area. Emergency evacuation routes for residents in the Yarramalong Valley are:

- ❒ Yarramalong Road to the west which provides access to the Yarramalong district; and
- ❒ Bantman Road (unsealed single lane) which provides access to the Sydney-Newcastle Freeway.

The primary access route for residents on the right bank of Dooralong Valley is Jilliby Road (sealed, single/two lane) which joins Hue Hue Road (sealed, two lanes). Hue Hue Road then joins the Sydney-Newcastle Freeway to the east of the study area. The secondary access routes are:

- ❒ Durren Road (unsealed, single lane) which crosses Jilliby Jilliby Creek and joins Dickson Road (unsealed, single lane). Dickson Road joins Hue Hue Road which provides access to the Sydney-Newcastle Freeway. Dickson Road also joins Mandalong Road (unsealed, two lane) to the north which provides access to Morisset; and
- ❒ Mandalong Road (sealed/unsealed, single/two lane) which crosses Jilliby Jilliby Creek and provides access to Morisset.

An emergency evacuation route for residents on the left bank of the Yarramalong Valley and right bank of Dooralong Valley is Watagan Forest Drive, this road provides access to Morisset.

9.4.5 Hue Hue Catchment

To reduce the impacts of subsidence, and to minimise impact of flooding to the houses located within the Hue Hue Creek catchment, four main options were investigated to improve flow in the creek. These included:

- ❒ Upgrading Sandra Street and Hue Hue Road crossings;
- ❒ Improve the channel, by modifying the slope and providing a more defined low flow channel;
- ❒ A combination of channel improvements and upgrading Sandra Street and Hue Hue Road crossings; and

- A combination of channel improvements, upgrading the Hue Hue Road crossing and raising the level of Sandra Street and its crossing.

Each of the above options is detailed below.

Option 1

The Sandra Street and Hue Hue Road crossings currently consist of box culverts. The Sandra Street culvert provides an 8.25 m opening and the Hue Hue Road culvert providing a 9 m opening. Option 1 (a) involves widening the opening under each road crossing to 60 m.

Modelling results indicate that there is no significant improvement to the condition of flood affected dwellings achieved through upgrading the road crossings to provide an opening of 60 m.

The effect of increasing the width of the openings further (120 m bridges at each crossing) was investigated as Option 1 (b), to assess any additional benefit this may bring.

Modelling results indicate that there is no significant benefit in providing the additional openings.

Option 2

The second option assessed involved improving the channel along Hue Hue Creek in a section between Sandra Street and Hue Hue Road as well as a section downstream of Hue Hue Road. Improvements included provision of a defined channel, with a 10m base and sides sloping at 1V:3H, and steepening of the channel in these sections. The impacts of the altered channel are presented in Table 9.10.

The channel improvements modelled downstream of Hue Hue Road resulted in no dwellings in this section of Hue Hue Creek being flood prone; two dwellings however will have freeboards less than the 0.5 m used for assessment purposes in this report (one dwelling will have a freeboard of 0.27 m and the other 0.15 m). It should be noted that this area will not be affected by subsidence. These dwellings are currently flood prone and the suggested mitigation options would assist owners of these properties by alleviating current flood impacts.

The channel improvements assessed in the section of Hue Hue Creek between Sandra Street and Hue Hue Road produce similar results to improving the crossing at Hue Hue Road. Dwelling D0430 is flood prone under both scenarios, however Option 2 reduces the depth of inundation by 7 cm. Dwelling D0513 has insufficient freeboard under both scenarios, however the freeboard is 1 cm greater with Option 2. Dwelling D0589 is flood prone under both scenarios, however Option 2 reduces the depth of inundation by 1 cm.

Option 3

This option assesses a combination of implementing both Option 1(a) and Option 2. Results of the modelling of this option are presented in Table 9.11.

Table 9.10 Option 2 Impacts

Dwelling	HEC-RAS Cross Section	Subsided Ground level	Subsided Floor Level	Flood Level after works (1% AEP)	Freeboard after works (m)	Comment
D0430	3.38	13.6	13.6	13.83	-0.23	No change
D0415	3.38	14.1	14.4	13.83	0.57	No change
SANDRA STREET						
D0513	3.25	13.78	13.78	13.73	0.05	No change
D0507	3.19	14.3	14.3	13.71	0.59	No change
D0587	2.87	13.7	13.7	12.84	0.86	No change
D0588	2.87	13.35	13.35	12.84	0.51	No change
D0589	2.82	12.3	12.3	12.5	-0.2	No change
D0590	2.82	14	14	12.5	1.5	Increased Freeboard
D0753	2.69	14.2	14.2	11.94	2.26	Increased Freeboard
HUE HUE ROAD						
D0461	2.32	10	10.8	9.82	0.98	Increased Freeboard
D0462	2.28	10.5	10.5	9.64	0.86	Increased Freeboard
D0463	2.22	9.5	9.5	9.23	0.27	Increased Freeboard
D0464	2.14	9	9	8.85	0.15	No longer inundated
D0465	2.06	8.6	9.3	8.54	0.76	Increased Freeboard
D0466	2.06	9	9.3	8.54	0.76	Increased Freeboard
D0467	1.98	9	9	8.09	0.91	Increased Freeboard
D0468	1.98	9.5	9.5	8.09	1.41	Increased Freeboard

Table 9.11 Option 3 Impacts

Dwelling	HEC-RAS Cross Section	Subsided Ground level	Subsided Floor Level	1%AEP Flood Level after works	Freeboard after works (m)	Comment
D0430	3.38	13.6	13.6	13.9	-0.3	Inundation increased 80mm
D0415	3.38	14.1	14.4	13.9	0.5	No significant change
SANDRA STREET						
D0513	3.25	13.78	13.78	13.73	0.05	No significant change
D0507	3.19	14.3	14.3	13.7	0.6	No significant change
D0587	2.87	13.7	13.7	12.84	0.86	No significant change
D0588	2.87	13.35	13.35	12.84	0.51	No significant change
D0589	2.82	12.3	12.3	12.47	-0.17	Reduced inundation
D0590	2.82	14	14	12.47	1.53	Increased Freeboard
D0753	2.69	14.2	14.2	12.04	2.16	Reduced Freeboard
HUE HUE ROAD						
D0461	2.32	10	10.8	9.82	0.98	Increased Freeboard
D0462	2.28	10.5	10.5	9.64	0.86	Increased Freeboard
D0463	2.22	9.5	9.5	9.23	0.27	Increased Freeboard
D0464	2.14	9	9	8.85	0.15	No longer inundated
D0465	2.06	8.6	9.3	8.54	0.76	Increased Freeboard
D0466	2.06	9	9.3	8.54	0.76	Increased Freeboard
D0467	1.98	9	9	8.09	0.91	Increased Freeboard
D0468	1.98	9.5	9.5	8.09	1.41	Increased Freeboard

The model indicates that this option will produce similar results to Option 2.

Option 4

This option includes the same works assessed in Option 3, as well as raising of Sandra Street to a level of 14 m AHD. The existing level of Sandra Street where it crosses Hue Hue Creek is 13.62 m AHD, which falls to 13.5 m AHD as a result of subsidence. This Option was assessed as a means of protecting dwelling D0513, located immediately downstream of Sandra Street. The modelling results for this option are shown in Table 9.12.

Table 9.12 Option 4 Impacts

Dwelling	HEC-RAS Cross Section	Subsided Ground level	Subsided Floor Level	1%AEP Flood Level after works	Freeboard after works (m)	Comment
D0430	3.38	13.6	13.6	14.01	-0.41	Inundation increased 130mm
D0415	3.38	14.1	14.4	14.01	0.39	No significant change
SANDRA STREET						
D0513	3.25	13.78	13.78	13.73	0.05	No significant change
D0507	3.19	14.3	14.3	13.70	0.60	No significant change
D0587	2.87	13.7	13.7	12.84	0.86	No significant change
D0588	2.87	13.35	13.35	12.84	0.51	No significant change
D0589	2.82	12.3	12.3	12.47	-0.17	Reduced inundation
D0590	2.82	14	14	12.47	1.53	Increased Freeboard
D0753	2.69	14.2	14.2	12.04	2.16	Reduced Freeboard
HUE HUE ROAD						
D0461	2.32	10	10.8	9.82	0.98	Increased Freeboard
D0462	2.28	10.5	10.5	9.64	0.86	Increased Freeboard
D0463	2.22	9.5	9.5	9.23	0.27	Increased Freeboard
D0464	2.14	9	9	8.85	0.15	No longer inundated
D0465	2.06	8.6	9.3	8.54	0.76	Increased Freeboard
D0466	2.06	9	9.3	8.54	0.76	Increased Freeboard
D0467	1.98	9	9	8.09	0.91	Increased Freeboard
D0468	1.98	9.5	9.5	8.09	1.41	Increased Freeboard

This option makes flood conditions worse at dwelling D0430. It reduces the freeboard at dwelling D0415 to approximate existing conditions. The freeboard at dwelling D0513 is similar to the other options assessed but flows would be reinstated to the main channel rather than across the subsided low point adjacent to this dwelling. Results at other flood affected properties are similar to Option 3.

9.4.6 Mitigation Measure Summary

The following list provides a summary of the above analysis of mitigation options in relation to each flood affected property:

- *Dwelling D0430*: This property currently has 0.39 m freeboard for existing conditions. As a result of subsidence, this house will become flood prone, with the 1% AEP flood level being 0.22 m above the estimated subsided floor level, which is 0.82 m lower than the existing floor level. The mitigation options considered above are unable to alleviate flooding at this property. Two options are considered appropriate for mitigation of flood impacts resulting from subsidence to this dwelling:

1. Construct a levy around the property, the height of which would depend on what other mitigation works were being undertaken along Hue Hue Creek. Based on the modelling results from the options considered above the levy would need to be between 0.20 m and 0.41 cm high.

2. Purchase the property or provide other appropriate negotiated compensation.

- *Dwelling D0415*: This dwelling currently has 0.4 m freeboard. As a result of subsidence, this dwelling will not be flood affected partly because it is located on the opposite side of Hue Hue Creek to where most of the subsidence is predicted to occur. It is estimated that the floor level of this dwelling will drop by 0.1 m. Of the options considered above, only Option 4 results in a change to this, where flood conditions would return to approximate existing conditions at this property.

- *Dwelling D0513*: This dwelling is currently not flood affected. Its existing floor level is 0.64 m above the existing 1% AEP flood level. As a result of subsidence, the floor level of this dwelling is estimated to drop by 0.72 m, and freeboard will reduce to 0.04 m. Sandra Street, located just upstream from this dwelling, also subsides by a similar amount resulting in more of the flow passing over this side of the valley and hence creating additional impacts. None of the options considered above alleviate flooding at this property. However implementing Option 4 (raising Sandra Street) combined with construction of a small levy would mean that this property could be protected.

- *Dwelling D0589*: This dwelling is understood to be a ‘granny flat’ located on the same property as Dwelling D0588. This dwelling is currently flood prone, with flood levels being about 0.2 m above existing floor levels. As a result of subsidence, this dwelling would remain flood prone with flood levels being 0.23 m above estimated subsided floor levels. The channel improvements assessed would result in flood levels being reduced to 0.17 m above estimated subsided floor levels. Given the proximity of this property to Hue Hue Creek, and its location within the floodway, there are few practical options available to protect against flooding.

- *Dwellings D0463, D0464 and D0465*: These properties are downstream of the area affected by subsidence. They are currently flood prone and the predicted subsidence upstream of these properties will not impact on flooding at these properties. Channel improvements in this section of Hue Hue creek were modelled to assess potential for alleviating flooding. The channel improvements modelled were found to result in none of the dwellings in this area being flood prone and left only two with freeboards less than 0.3 m (dwellings D0463 and D0464).

9.5 Conclusion

9.5.1 General Impacts

Impacts of subsidence on flooding are generally limited to subsidence areas. Downstream of subsidence areas flood depths reduced slightly due to the detention affects of extra flood storage volumes in subsided areas. Upstream of subsided areas flood depths reduced as a result of lower tailwater levels. The effects of these reductions generally dissipated within 600 m of the subsidence areas.

There will be no measurable impacts on hydrology, catchment yield or overall flood volumes as a result of subsidence. There will be a very small reduction in peak flows as a result of detention effects which will be matched by a very slight increase in flood durations; however, these effects will be insignificant (2% reduction in peak flow, 6% increase in duration and 0% reduction in volume at the freeway).

It was found that negligible changes will occur to flood extents and depths in the Yarramalong Valley (Wyong River) as a result of predicted mine subsidence. Subsidence predictions suggest that the maximum subsidence under the main channel of the Wyong River will be in the order of 0.15 m over a very short section.

In the Dooralong Valley (Jilliby Jilliby Creek and tributaries) subsidence generally of between zero and up to 1.3 m will occur within the affected sections of the channel. Isolated small areas of the adjacent floodplain experiencing subsidence of the order of approximately 1.6 m. Subsidence levels in the lower Jilliby Jilliby Creek channel (below the confluence with Little Jilliby Jilliby Creek) are expected to be mostly less than 0.75 m. Reductions of flood levels within or near the subsided areas of 0 to 1.85 m and changes in flood depth of -1.1 m to +1.1 m can be expected.

For Hue Hue Creek, mining will result in subsidence of up to 0.95 m under the floodplain and will cause reductions in flood levels within or near the subsided areas of 0 to 0.5 m with changes in flood depths of -0.1 m to +0.7 m.

9.5.2 Impacts on Dwellings and Properties

Only 3 dwellings near Hue Hue Creek will be adversely impacted by changes to flooding as a result of mine subsidence and 1 dwelling will have a beneficial impact of greater freeboard (height of floor level above the 1% AEP flood).

Of the 79 dwellings in the Yarramalong/Dooralong study area located within the 1 in 100-year ARI floodplain, 34 will be subject to some degree of potential adverse impacts. Of these dwellings subject to potential adverse impacts, 19 will be subject to increased flood inundation. The majority of these are already subject to inundation by the existing 1% AEP flood but five are not currently inundated in the 1% AEP flood.

In terms of impact categories:

- Seven dwellings will experience major impacts, comprising five dwellings that will become newly subject to flooding by the 1% AEP event (1 in 100 year flood) and two that are already subject to these floods but which will experience additional flood depths of more than 0.3 m in flood level;

- Ten dwellings will experience moderate impacts, mostly comprising dwellings already affected by the 1% AEP flood but which will be expected to experience minor additional flood depths of less than 0.3 m post-mining; and

- 17 will experience minor or negligible impacts, mainly comprising dwellings thatare flood free but will have reduced freeboard (height of floor level above the flood).

The majority (45) of the 79 dwellings in the Yarramalong/Dooralong study area will not be adversely affected, and a proportion will in fact be beneficially impacted:

- One dwelling will experience a significant benefit in reduction of flood levels and will achieve a freeboard of more than 0.3 m post-mining;

- Nine dwellings will experience a minor benefit in reduction of flood levels after mining (<0.2 m);

- 28 dwellings (the largest proportion of the 79 dwellings in the study area) will register negligible to very minor beneficial impacts; and

- Seven dwellings will experience no change or effect as a result of subsidence impacts on flooding.

A number of additional properties may be subject to changes in floodwaters on their land but will otherwise not be impacted by changes to flood conditions as a result of subsidence. A total of 55.8 ha of additional land, mainly in the Dooralong Valley, will be inundated in the 1% AEP flood following the subsidence as a result of mining. However, 9 ha will no longer be classified as flood prone after mining. The consequences of this additional extent of floodable land are expected to be minor as most is grazing land. However, each property will need to be assessed individually as part of the Property Subsidence Management planning process to confirm land use and potential for damage closer to the time of mining in that location.

9.5.3 Impacts on Flood Hazard and Risk

There will be no significant changes in flood hazard with the exception of the additional land inundated which will become part of the flood fringe. There will be no significant changes in flood velocities but increase in flood depths can be viewed as a form of increased hazard. Dwellings on higher ground within the flood extent will have increased risk of evacuation routes being cut off wherever subsidence increases flood depths.

9.5.4 Impacts on Access Routes

Three low points (D50, D70 and D80) on two primary access routes (Jilliby Road and Dickson Road) will be adversely impacted by changes to the 1% AEP as a result of subsidence. The depth and duration of inundation will increase at these low points. Only one property access road affecting three properties in the Yarramalong Valley will be affected by subsidence (at points Y80 and Y90).

9.5.5 Mitigation Options

General measures proposed to reduce flood levels include channel improvements and provision of additional waterway area at bridges and other constrictions. These types of options have limited benefit and are often not cost effective. However, for the reach of Jilliby Jilliby Creek between Chainage 13.6 km and 14.6 km, the main channel may need regrading to prevent ponding of water upstream of the unsubsided zone over the main underground mine access roadways.

Measures proposed to mitigate flood impacts on dwellings include construction of flood levees, raising houses in-situ and relocating or reconstructing houses on higher ground within the property. Where impacted dwellings are unable to be protected, raised or moved, properties may need to be purchased or the landowners compensated in accordance with the regulatory provisions including conditions of approvals and leases. Prior to mining taking place in that particular location, each dwelling will need to be assessed individually and properties where land but not dwellings are affected will also need to be considered.

Measures proposed to mitigate impacts on access routes include raising bridges, raising low sections of roads, and improving the hydraulic capacity of channels in some sections. All low points can be addressed by moderate road raising.

9.5.6 Benefits

There are a number of dwellings that will have slight beneficial impacts as a result of subsidence related changes to flooding. While these are small (generally less than 20 mm reduction in flood levels) they should be considered in overall assessments.

There are also opportunities to improve situations compared to existing conditions in many locations. Dwellings that are currently flood prone which are raised, relocated or reconstructed will become flood free. Several roads including Jilliby Road, Dickson Road, Hue Hue Road and Sandra Street can be raised or otherwise modified to reduce inundation to less than existing conditions.

9.6 Surface Hydrology and Water Quality

An issue that has been identified as important to both the community and government departments, is the impact of the W2CP on surface hydrology. Detailed assessment of the existing river and drainage systems above the proposed mining areas has been carried out. It is anticipated that the only potential impact on surface hydrology will be as a result of subsidence. The assessment has shown there is little if any risk of water quality contamination from metals such as iron and manganese or methane as can occur in the Southern Coalfield. This is due to differing geology, depth, near surface stratigraphy, lack of continuous cracking and integrity of the deep surface alluvials.

Potential impacts that may be seen as a result of subsidence include:

- Localised alterations to flow volumes – A decrease in the volume of water held in each section of the creek is obviously undesirable for current users of the water source. It is important to note however, that if the volume of water held in a particular spot is reduced, the volume of water held in a location further downstream will be increased. The overall net effect will be neutral.

- Localised alterations to flow velocities - this may in fact have a potential positive impact on the creek systems if the water is slowed down, creating greater residence time and reducing the potential for erosion.

- Localised widening or narrowing of the water stream – areas where the water stream narrows is not expected to result in any substantial interruption to normal use and operation of the area, however widening of the channel could have the following implications:

  - Widening of areas of water crossings may result in an existing water crossing being made unsuitable and a new/extended creek crossing may be required;

  - If a fence line is currently in close proximity to the creekline, a widening of the creek may result in the fence becoming inundated and would therefore be required to be moved.

- Localised increases in the depth of pools within the channel – this may also have implications for creek crossings.

- Localised areas where there is an increased risk of bank erosion – creek banks that are not vegetated may be subject to additional erosional forces if the flow velocity is increased as a result of subsidence. In areas where there is an established vegetative cover along the bank, the risk of increased erosion resulting from changes in flow velocity will not be significant.

While all of these impacts have the potential to occur as a result of subsidence related to the W2CP, it is important to remember that not all impacts will be seen in each section of the river.

Many stream assessment methods have been developed worldwide. Within Australia, methods that have been developed and tested include the State of the Rivers Survey, Index of Stream Condition and Geomorphic River Styles. Although based on a method developed in the United Kingdom, the AusRivAS and Habitat Predictive Modelling methods have been successfully adapted to Australian conditions.

The various methods for assessing surface hydrology have been described below, together with their applicability to use in assessing the W2CP.

9.6.1 AusRivAS Assessment Method

The AusRivAS method is a nationally standardised and predictive approach to biological assessment that has recently been used to determine the condition of around 6000 river sites across Australia. The United States Environmental Protection Agency's HABSCORE method of stream assessment was used within the AusRivAS predictive model.

The AusRivAS system uses macroinvertebrate information as a basis for assessing the ecological condition of river sites. Macroinvertebrates are a commonly used group of organisms in the biological monitoring of water quality. Macroinvertebrates are used to assess river condition because they are common in many different river habitats, they show responses to a wide range of environmental stresses and they act as continuous monitors of the water that they inhabit, and the structure of the benthic macroinvertebrate community indicates the state of the entire ecosystem.

AusRivAS assesses site condition by comparing the macroinvertebrates that are predicted to occur at a test site, with the macroinvertebrates that are actually collected at a test site. The difference between the number of taxa expected to occur and the number of taxa that are actually observed (observed:expected ratio) is a measure of the ecological condition of a site. If the number, or type, of taxa collected at a test site does not fulfil expectations, then it is likely that water quality or habitat conditions are limiting the biological potential of the site.

While the AusRivAS system is widely used throughout Australia for predicting and assessing river health, it's use in assessment of surface hydrology surrounding the W2CP is limited for the following reasons:

- The AusRivAS system requires field sampling at test sites along the river. Much of the river is located on or between private properties where access to the river could not be obtained;
- The AusRivAS system is based on the response of the biota to water quality. It is not anticipated that the W2CP will have a significant impact on water quality, but rather alter the physical characteristics of the river.

The AusRivAS system was therefore not considered to be the most appropriate method for using in assessing the impact of the W2CP on surface hydrology.

9.6.2 HABSCORE (USEPA Rapid Bioassessment Protocols)

The United States Environmental Protection Agency (USEPA) has developed Rapid Bioassessment Protocols (RBP) that use fish, macroinvertebrates or periphyton to assess stream condition.

Information on the structural, functional and process elements of the biotic community are calculated for a site, and aggregated into an index, which represents the biological condition of a site. Physical and chemical information about each site is also recorded.

HABSCORE is a visually based habitat assessment that evaluates the structure of the surrounding physical habitat that influences the quality of the water resource, and the condition of the resident aquatic community. It includes factors that characterise stream habitat on a micro-scale (e.g. embeddedness) and a macro-scale (e.g. channel morphology), as well as factors such as riparian and bank structure which influence the micro and macro-scale features.

The HABSCORE system would be useful in assessing the impact of subsidence from the W2CP on surface hydrology, however its applicability to the project is limited due to the same factors as the AusRivAS system.

9.6.3 Index of Stream Condition (ISC)

The ISC measures stream condition within reaches that are between 10 and 30 km in length, and uses a rating system to assess stream or river condition, when compared to a reference site.

The ISC is based on the premise that the hydrology, physical form, streamside zone, water quality and aquatic life components indicate the processes and functions that act to influence stream condition. As with the other two methods, access to the creeks to undertake field assessment greatly restricts the use of this method.

9.6.4 W2CP Hydromorphology Assessment

The parameters and methodology employed in the above three assessment schemes were combined and implemented as far as practicable to provide the most detailed assessment of the creek conditions as was possible using aerial photography and field observations from all available sites. Aerial photographs used were taken in 2006.

Potential impacts on Jilliby Jilliby Creek, Little Jilliby Jilliby Creek and their major tributaries from subsidence relating to the W2CP have been assessed. It is not considered necessary to carry out the same level of assessment on the Wyong River, since the mine plan has been design to ensure that the River is protected from subsidence related impacts.

Both Jilliby Jilliby Creek and Little Jilliby Jilliby Creek, and their major tributaries were divided into sections based on the existing riparian vegetation, with section coordinates recorded to identify each section for assessment. The delineation was based on the riparian vegetation for the following reasons:

- Riparian vegetation was easily visible and measurable from aerial photography;

- Erosion of creek banks is considered to be the greatest potential threat to the creeklines as a result of changes to flow volume and velocity created through subsidence. The most effective mitigation measure against erosion of banks is the structure and integrity of existing riparian vegetation. By identifying areas along the creeks where riparian vegetation is absent or limited, these areas may be considered to be at a greater risk of erosion as an indirect effect of subsidence. In these areas the WACJV would be seeking to undertake monitoring of the banks and developing mitigation strategies in conjunction with relevant landowners; and

- Areas where there is a wide or dense band of riparian vegetation naturally limit access and use of the land immediately adjacent to the creek, and the potential impact of stream width widening or narrowing as a result of subsidence will not be as significant since the area is not one of high or intense use.

For each section of the creek, the following observations were recorded using aerial photography only:

- Coordinates of the section (E/N);
- Section Length (m);
- Width of the water channel (m);
- Topography eg whether the section of the creek runs through a broad flat valley or a deep gorge etc.;
- The type of riparian vegetation on each bank;
- The width of riparian vegetation on each bank;
- Surrounding land use on each bank;
- The presence or absence of water in the channel;
- Any creek crossing; and
- Any existing obstructions to water flow.

In addition to the physical characteristics of the creek systems above the mining area, water quality was analysed at selected locations where public access to the water channel was available. Since access to the creek could not be obtained for each section identified in the assessment, water quality could only be assumed to be uniform between the sites where access was possible and water quality data could be obtained.

A total of 28 sites were sampled for water quality on a monthly basis during late 2006. The location of monitoring sites is shown on Figure 9.6. Sampling methodology was carried out in accordance with the *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (DEC).

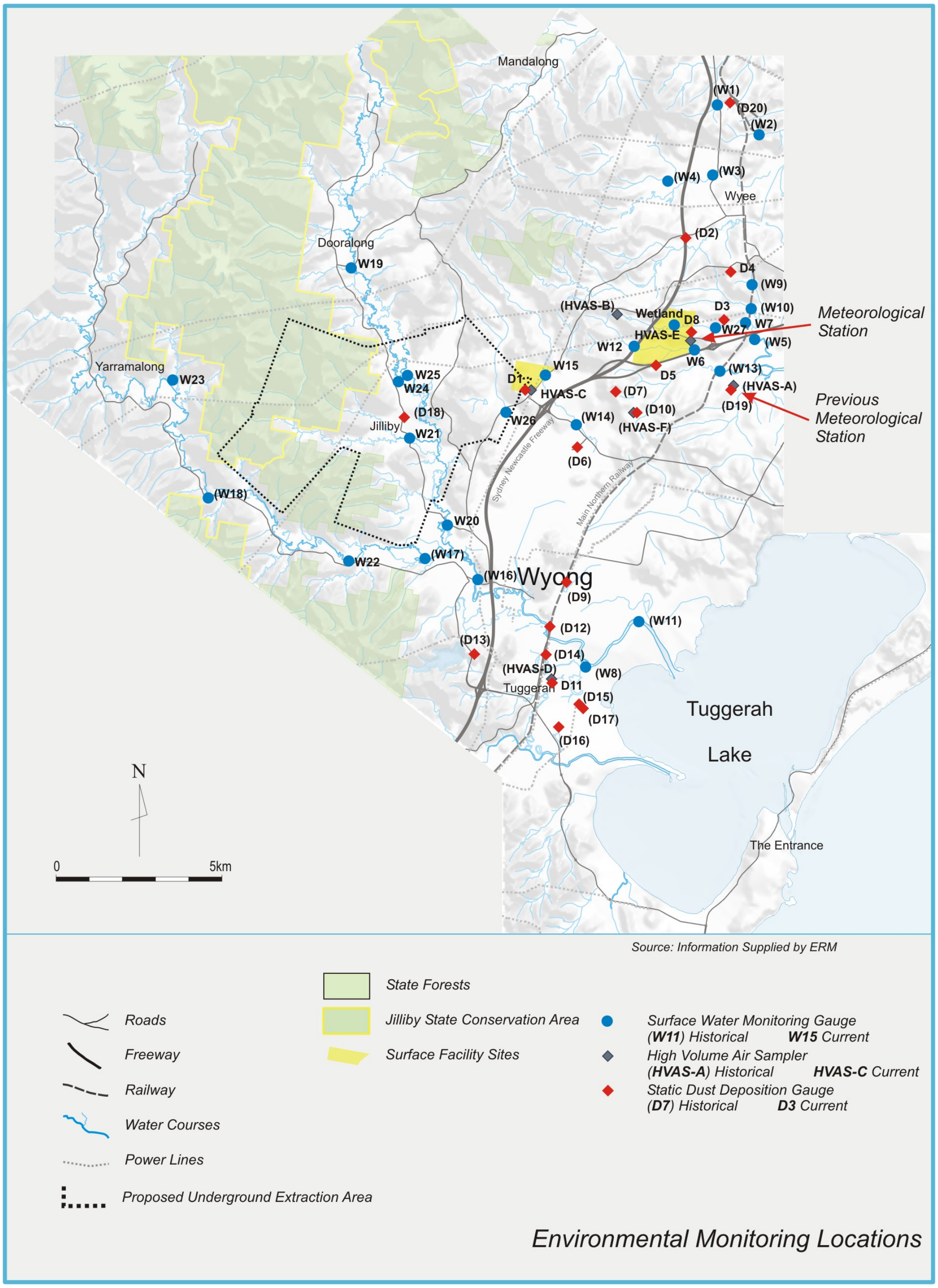


Figure 9.6 Environmental Monitoring Locations

Field readings of pH and conductivity were taken for each site, and a water sample was analysed for the following parameters:

Suspended Solids; Total Alkalinity as $CaCO_3$; Sulphate as SO_4; Chloride; Reactive Phosphorus as P; Calcium; Sodium; Magnesium; Potassium; Arsenic; Barium; Cadmium; Chromium; Copper; Lead; Manganese; Nickel; Selenium; Zinc; Iron; Mercury; Ammonia as N; Nitrite as N; Nitrate as N; Total Kjeldahl Nitrogen as N; Total Phosphorus as P; Faecal Coliforms; and Oil and Grease.

9.6.5 Existing Condition of Jilliby Jilliby Creek and Tributaries

Jilliby Jilliby Creek is one of the major tributaries of the Wyong River with the main arm of the creek running south for a distance of approximately 36 km. Jilliby Jilliby Creek has a catchment area of approximately 10,000 ha. The creek stretches from its headwaters in the Olney State Forest to its confluence with the Wyong River at Jilliby Park.

The W2CP proposes to mine underneath approximately 5 km of Jilliby Jilliby Creek, which represents approximately 14% of the length of the creek. The section of the creek involved is located between 334513.55:1323960 (E/N) and 336375.80:1318604.12 (E/N).

According to the Lake Macquarie/Tuggerah Lakes/Brisbane Waters Catchment Stressed Rivers Assessment Report (DLWC, 1999) (a desktop assessment) 74% of the catchment still remains vegetated with 52.4% of the catchment occurring within the Olney State Forest. As part of the Stressed River Report, environmental thresholds for the stream were determined. The report stated that no reach of Jilliby Jilliby Creek had greater than 75% of riparian vegetation cleared, 100% of the banks were stable along its length and 0% of the stream length is subject to stream bed degradation / sedimentation. However, this data has not been field validated. Land use within the catchment is varied and includes:

- grazing / orcharding / vegetable growing / horticulture / turf;
- miscellaneous mixed uses such as areas zoned rural residential; and
- animal breeding / horse studs / beef cattle.

Vegetation cover along the length of Jilliby Jilliby Creek above the proposed mining area is fairly consistent in its density, being a tall open forest with increasing proportions of exotic species that increase in the lower half, mainly due to greater impacts by humans. Typical riparian vegetation is listed in Table 9.13. This list has been adapted from the "*Geomorphic Categorisation of Streams within the Central Coast Catchment Management Board Area"*, and updated/supplemented by recent vegetation analysis by OzArk Environmental and Heritage Management Pty Ltd specifically for the W2CP Environmental Assessment.

Riparian vegetation plays a very important role in the stabilisation of Jilliby Jilliby Creek due to the highly erodible nature of the bed and bank material. The vegetation increases bed and bank cohesiveness and any loss of this vegetation will result in channel instability. Riparian vegetation also directly influences large woody debris loading, which provides the dominant geomorphic controls within Jilliby Jilliby Creek. A loss of the large woody debris will increase bedload transport capacity, which in turn could lead to bed degradation and an overall increase in channel instability.

Table 9.13 Riparian Vegetation of Jilliby Jilliby Creek

Scientific Name	Common Name	Source*
Eucalyptus punctata	Grey Gum	1
Eucalyptus saligna	Sydney Blue Gum	1
Eucalyptus amplifolia	Cabbage Gum	1
Syncarpia glomulifera	Turpentine	1
Pteridium esculentum	Bracken Fern	1
Acmena smithii	Lillypilly	1
Lomandra longifolia	Mat Rush	1
Acacia implexa	Hickory	1
Acacia decurrens	Sydney Green Wattle	1
Melaleuca stypheloides	Prickly-leaved Paperbark	1
Commersonia fraseri	Black Fellow Hemp	1
Tristaniopsis laurina	Water Gum	1
† *Tradescantia albiflora*	Wandering Jew	1
† *Lantana camara*	Lantana	1
† *Ligustrum sinense*	Small-leaved Privet	1
† *Cinnamomum camphora*	Camphor Laurel	1
† *Solanum mauritianum*	Wild Tobacco Tree	1
† *Ageratina adenophora*	Crofton Weed	1

* Source 1 = *Geomorphic Categorisation of Streams within the Central Coast Catchment Management Board Area*. Department of Infrastructure, Planning and Natural Resources, 2004.
Source 2 = OzArk vegetation assessment carried out specifically for the W2CP Environmental Assessment, 2009.
† Introduced species.

9.6.6 Existing Condition of Little Jilliby Jilliby Creek and Tributaries

Little Jilliby Jilliby Creek is a major tributary of Jilliby Jilliby Creek. It flows in a west-easterly direction, and is approximately 4.3 km in length. Little Jilliby Jilliby Creek joins Jilliby Jilliby Creek approximately 5.5 km upstream from the confluence with the Wyong River.

Little Jilliby Jilliby Creek drains the south-western section of the catchment, having its origins within the Wyong State Forest, and the entire length of the creek is located above proposed mining areas for the W2CP.

Within certain reaches of Little Jilliby Jilliby Creek the riparian vegetation is inconsistent with the majority being exotic and consisting of such species as Camphor Laurel, Lantana and Privet, although there are some areas of remnant vegetation evident. The areas of remnant vegetation are more common in the upstream reaches, mainly within the Wyong State Forest, and could provide natural recruitment to the stream if the exotic species are effectively managed. Nevertheless, the vegetation present is providing an important function as it is supplying the creek with a consistent supply of large woody debris and is helping to bind the bed and banks of the creek itself.

Little Jilliby Jilliby Creek is rated as having a moderate geomorphic condition due to the fact that there are localised areas of degradation of river character and behaviour that are typically marked by modified patterns of geomorphic units. An example of this degradation is evident downstream of the Jilliby Road Bridge, where a loss of riparian vegetation has resulted in accelerated erosion of both the bed and banks.

9.6.7 Water Quality

Existing water quality data has been obtained where possible to gain a baseline indication of water quality, to which monitoring results can be compared post mining. The existing water quality is provided in Appendix D, with monitoring locations shown on Figure 2, also found in Appendix D.

From the water quality data available, the following general conclusions can be made:

Hue Hue Creek

- ❒ Levels of manganese often exceeded drinking water and recreational / aesthetic guidelines;
- ❒ Levels of iron often exceeded drinking water and recreational / aesthetic guidelines;
- ❒ Levels of phosphorus often exceeded aquatic ecosystem guidelines;
- ❒ Levels of zinc often exceeded aquatic ecosystem guidelines;
- ❒ Levels of ammonia often exceeded aquatic ecosystem and recreational / aesthetic guidelines; and
- ❒ Faecal coliforms regularly exceeded drinking water and recreational / aesthetic guidelines by a gross amount.

Jilliby Jilliby Creek

- ❒ Levels of manganese often exceeded aquatic ecosystem, drinking water and recreational / aesthetic guidelines;
- ❒ Levels of zinc often exceeded aquatic ecosystem guidelines;
- ❒ Levels of iron often exceeded drinking water and recreational / aesthetic guidelines;
- ❒ Levels of ammonia often exceeded aquatic ecosystem and recreational / aesthetic guidelines;
- ❒ Faecal coliforms regularly exceeded drinking water and recreational / aesthetic guidelines by a gross amount; and
- ❒ At the lowest sampling point arsenic exceeded guidelines for irrigation, recreation and drinking water.

Little Jilliby Jilliby Creek

- ❒ Levels of manganese often exceeded drinking water and recreational / aesthetic guidelines;
- ❒ Levels of iron often exceeded drinking water and recreational / aesthetic guidelines;

- Levels of phosphorus often exceeded aquatic ecosystem guidelines;
- Levels of zinc often exceeded aquatic ecosystem guidelines;
- Levels of ammonia often exceeded aquatic ecosystem and recreational / aesthetic guidelines; and
- Faecal coliforms regularly exceeded drinking water and recreational / aesthetic guidelines by a gross amount.

Wyong River

- Levels of manganese often exceeded drinking water and recreational / aesthetic guidelines;
- Levels of iron often exceeded drinking water and recreational / aesthetic guidelines;
- Levels of phosphorus often exceeded aquatic ecosystem guidelines;
- Levels of zinc often exceeded aquatic ecosystem guidelines;
- Levels of ammonia often exceeded aquatic ecosystem and recreational / aesthetic guidelines; and
- Faecal coliforms regularly exceeded drinking water and recreational / aesthetic guidelines by a gross amount.

9.6.8 Anticipated Impact on Jilliby Jilliby Creek and Tributaries

Graph 1 shows the existing profile of Jilliby Jilliby Creek, and the expected profile of the channel following subsidence. Based on the anticipated levels of subsidence, the creekbed is expected to drop in a fairly uniform pattern along its length within the impact zone, with the exception of the junction with Little Jilliby Jilliby Creek. Given that fairly uniform levels of subsidence are anticipated with the above exception, it is expected that the impact on the creek channels will be negligible, except in the following sections (refer to Graph 1):

- Around the upstream point where subsidence begins (approximately 334700.51:1323879.95). The impact expected at this location will be a steeper grade in the bed of the channel, where the upstream section remains unsubsided, and flows down into the subsided section. The potential at this point is for increased erosion of the channel bed, as flow velocities are likely to increase with the change in the bed profile.
- Around the confluence with Little Jilliby Jilliby Creek the mine plan has been designed to prevent subsidence in this area. The expected resulting impact in this situation will be the creation of a deeper pool upstream of the confluence (increased depth of up to 68 cm), and increased potential for erosion of the creekbed immediately downstream of the confluence, as in the case above where the water flows down a steeper gradient going from an unsubsided to a subsided section.

- ❐ At the downstream section of the channel above the limit of underground extraction. This will create an area where there is a deeper pool in the subsided section adjacent to the unsubsided area.

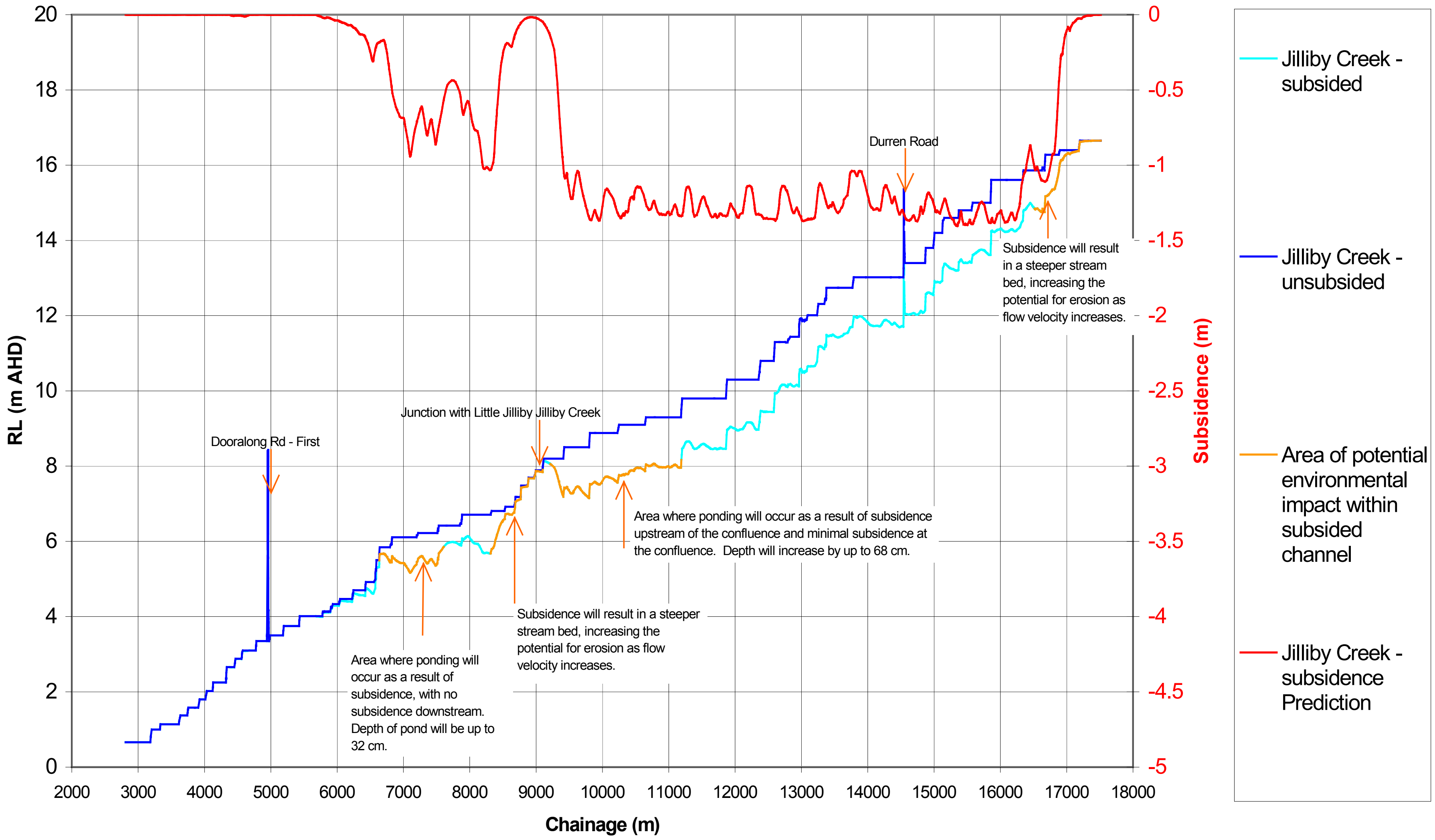
This section of the creek was assessed in the *Geomorphic Categorisation of Streams within the Central Coast Catchment Management Board Area,* Department of Infrastructure, Planning and Natural Resources, 2004, as having a "High Recovery Potential – Connected" since it exhibits a high capacity to recover from disturbance, but is presently in a moderate geomorphic condition. It is therefore considered, that with the implementation of the mitigation strategies described in Section 9.6.15, that the overall impact on the creek stability and water quality will be negligible.

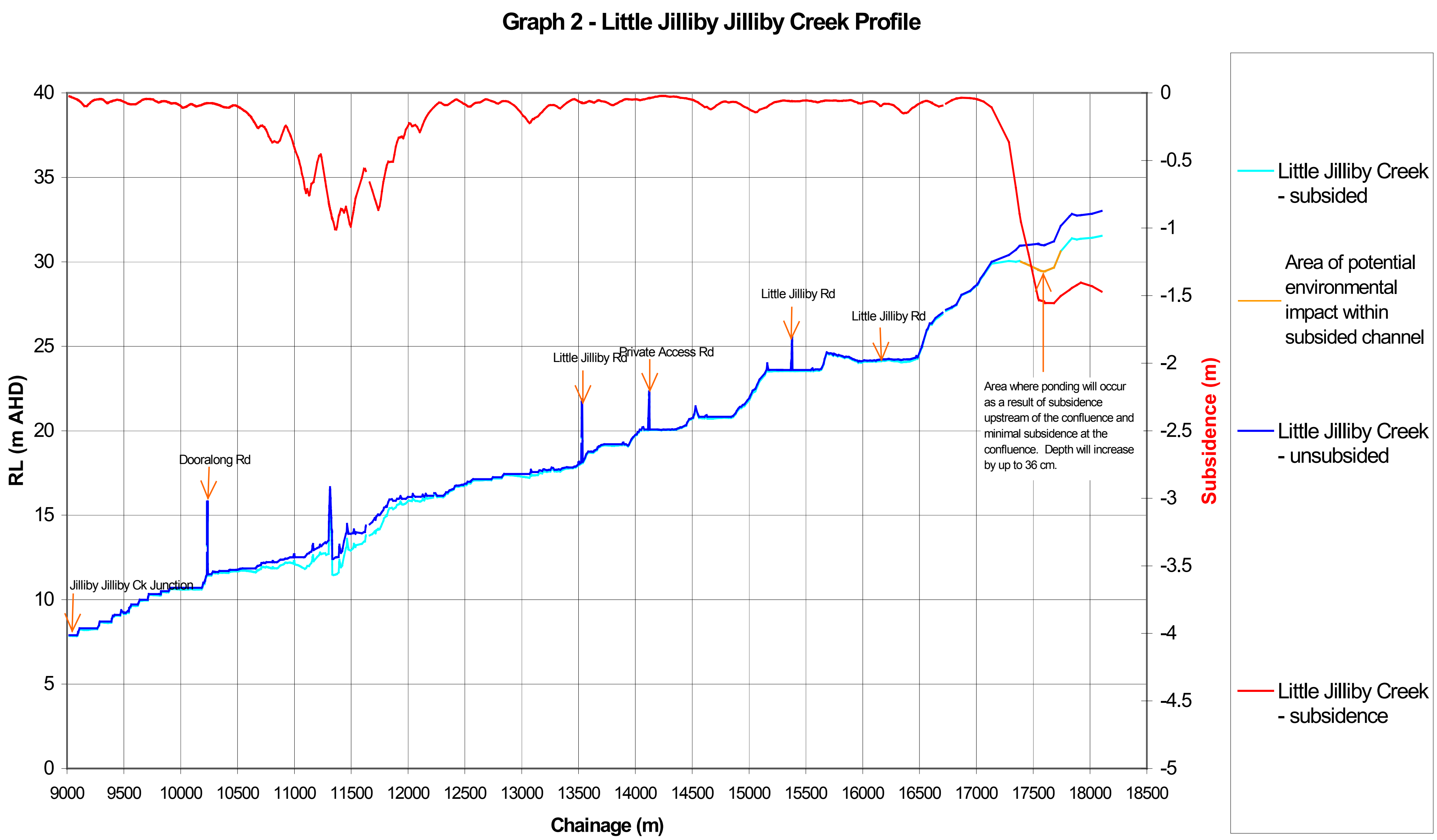
9.6.9 Anticipated Impact on Little Jilliby Jilliby Creek and Tributaries

Little Jilliby Jilliby Creek, for the majority of its length, runs parallel or directly above the main east-west underground roadways rather than beneath longwall panels. The mine plan has been designed to ensure that the creek remains above permanently stable roadway pillars as far as possible. The result of this is that there will be negligible subsidence of the creek, as shown in Graph 2.

The greatest impact on Little Jilliby Jilliby Creek will occur in the upper reaches, where up to 1.55 m of subsidence may occur around a location (331779:1322133 EN) in the Wyong State Forest. The resulting impact at this location will be the deepening of an existing pool in the channel. However, given the isolated nature of this section, and the good condition of the banks and riparian vegetation, it is anticipated that this will not be a major impact, nor will it effect long term water quality or create erosion of the creekline.

Graph 1 - Jilliby Jilliby Creek Profile




Graph 2 - Little Jilliby Jilliby Creek Profile
RL (m AHD)
Subsidence (m)
Chainage (m)
Jilliby Jilliby Ck Junction
Dooralong Rd
Little Jilliby Rd
Private Access Rd
Little Jilliby Rd
Little Jilliby Rd
Area where ponding will occur as a result of subsidence upstream of the confluence and minimal subsidence at the confluence. Depth will increase by up to 36 cm.
Little Jilliby Creek - subsided
Area of potential environmental impact within subsided channel
Little Jilliby Creek - unsubsided
Little Jilliby Creek - subsidence

9.6.10 Regional Setting

The WACJV has committed to protecting the water supply of the Central Coast, in terms of both water quality and water volumes. In order to do this, the mine plan has been designed to prevent extraction of coal from beneath the Wyong River. The WACJV commitment to protect surface waters and catchments is consistent with the aims of the Water Management Act, NSW Rivers and Estuaries Policy and the Draft Catchment Action Plan for the Hunter – Central Rivers CMA objectives to prevent negative impacts on the waterways and improve catchments.

However, two of the major tributaries of the Wyong River, Jilliby Jilliby Creek and Little Jilliby Jilliby Creek, are present above the mining area. It is therefore important that these two creeks are protected from adverse impacts such as erosion and sedimentation, and changes in water volumes, since a deterioration in these creeks would ultimately impact on the region's water supply.

Based on the subsidence data provided for the hydrogeomorphic assessment contained in Appendix D, and the implementation of the mitigation strategies and monitoring plan described in the following sections, it appears highly unlikely that there will be a negative impact on water quality or volumes in the region as a result of the W2CP.

9.6.11 Pre-Mining Work

This hydrogeomorphic assessment has undertaken to document the existing condition of Jilliby Jilliby Creek, Little Jilliby Jilliby Creek, and their tributaries in terms of both water quality, and the physical condition of the channels. This information is included in Appendix D and includes the channel width, riparian vegetation type and width, and surrounding land uses.

This work is valuable as a monitoring tool, where it provides baseline data on the creek's stability prior to mining and subsidence, and has identified areas where rehabilitation work may be required prior to coal extraction to remedy any existing erosion that has the potential to be exacerbated through subsidence.

In areas identified as being at risk of further erosion from subsidence, permission will be sought from the appropriate landowner to carry out necessary work to stabilise the channel. This work will be in consultation with the landowner, and the Gosford Wyong Joint Water Authority.

Rehabilitation and stabilisation works that may be offered to landowners include:

- ❒ Revegetation of riparian areas where vegetation is currently cleared or of poor quality;
- ❒ Strategic removal of weeds along the river bank, ensuring however that their removal is not likely to be detrimental to the stability of the banks; and
- ❒ Repair of existing areas of erosion that have the potential to be exacerbated following subsidence.

9.6.12 Monitoring

Monitoring is an important tool for land managers and planners to firstly verify the predicted impacts of an activity, but most importantly, to provide timely detection of deterioration in water quality or stream stability.

9.6.13 Water Quality

Extensive baseline data has been systematically collected by the WACJV on local water quality, and will be an important tool following subsidence. Water quality monitoring at these sites will continue through the life of the project and results compared to baseline data to provide an indication of the influence of mining and subsidence on the water quality in these creeks. By measuring total suspended solids an indication can also be gained of increased erosion that may be occurring upstream, and trigger a more detailed search for areas where stabilisation works may be required.

Surface water monitoring will be carried out on a monthly basis, or following significant rain events.

9.6.14 Creek Stability

The most appropriate method of determining deterioration in the stability of creek beds and banks is through visual inspection of the channel. However, the majority of the length of Jilliby Jilliby Creek and Little Jilliby Jilliby Creek within the mining area is bounded by privately owned lands. In order to carry out visual inspections of the creek landowner consent must be obtained for access to the channels. These access arrangements will play a major role in the quality of the monitoring plan that is implemented.

Subject to landowners providing access, it is proposed to monitor the stability of the creeks through visual inspection on the ground under the following timeframe:

- 12 months prior to mining an area. This will provide baseline data and information on the existing channel stability prior to mining and subsidence;
- within 6 months following underground extraction of the section of creek. This will allow for subsidence to occur;
- on a 6 monthly basis thereafter for the first 3 years;
- after the first 3 years, inspections will be carried out annually for the life of the project or at a time agreed to by relevant stakeholders when it is evident that no further impacts are likely; and
- at other times subject to a request from a landowner who believes an impact has occurred and not been detected.

The inspections will involve recording information such as areas of erosion, damage to riparian vegetation, and any obstructions to water flow. This information will be recorded as both written data and supplemented with photographs.

9.6.15 Rehabilitation

Rehabilitation will be carried out to rectify degradation that occurs to the creeks as a result of mine subsidence. Rehabilitation will be in accordance with the *Rehabilitation Manual for Australian Streams* (Land and Water Resources Research and Development Corporation, 2000). It is expected that the impact with the greatest potential to occur is erosion of the creek banks. These will be repaired through the following techniques:

- laying of a geotextile fabric over the eroded section to prevent further loss of material;
- if possible, sediment traps such as silt stop fencing or hay bales may be placed temporarily in the creekline to capture any sediment. This will only be possible in sections of the creek that are relatively dry, and not expected to take a large flow;
- re-shaping of the eroded banks to a more stable profile that will resist further erosion. In some situations, such as sections of the creeks with dense riparian vegetation, it may be necessary to undertake this work by hand to prevent damage to riparian vegetation;
- sowing newly shaped banks with a sterile cover crop to aid in rapid stabilisation without introducing a potentially unwanted species to the creekbanks, while native species can be established; and
- planting of native species suitable for the riparian zone to assist in bank stability. These areas will then be subject to ongoing maintenance to ensure that the newly planted vegetation does not become overtaken by weed species.

All rehabilitation works will be site specific, and developed in consultation with the affected landowner. Rehabilitation works will be carefully monitored to ensure their long term success.

9.7 Lake Macquarie and Tuggerah Lakes Water Quality and River Flow Objectives

The NSW Water Quality Objectives are the agreed environmental values and long-term goals for NSW surface waters. They set out the community's values and uses for our waterways, and a range of water quality indicators to help assess whether the current condition of the waterways supports those values and uses.

The Objectives are consistent with the agreed national framework for assessing water quality set out in the ANZECC 2000 Guidelines. The Water Quality Objectives provide environmental values for NSW waters and the ANZECC 2000 Guidelines provide the technical guidance to assess the water quality needed to protect those values.

The DECCW has developed Water Quality and River Flow Environmental Objectives specific to each of the Catchment Management Areas (CMA) of the state. The W2CP falls within the lake Macquarie and Tuggerah Lakes CMA.

In developing the Objectives for the Lake Macquarie and Tuggerah Lakes CMA, the government has recognised that environmental problems are widespread in our coastal river systems and estuaries. These include sewer overflows and leaks, stormwater, excessive nutrient inputs, algal blooms, acid sulfate soils, and declining fish populations.

The Objectives for the waterways within this CMA differ, depending on the classification of the stream. Within the proposed W2CP mining area are waterways that include the following classifications:

- Controlled River – the Wyong River;

- Uncontrolled Stream – the majority of Jilliby Jilliby Creek and a section of Little Jilliby Jilliby Creek;

- Mainly Forested Areas – the majority of Little Jilliby Jilliby Creek and the headwaters of Jilliby Jilliby Creek; and

- National Parks, Nature Reserves and State Forests - the majority of Little Jilliby Jilliby Creek and the headwaters of Jilliby Jilliby Creek.

9.7.1 Water Sharing Plan for the Jilliby Jilliby Creek Water Source

The Water Sharing Plan (WSP) for the Jilliby Jilliby Creek Water Source commenced on 1 July 2004, and applies to 30 June 2014. The WSP was slightly revised in 2009 following consultation in late 2008 and early 2009. The purpose of the Plan is to allocate water for the environment, as well as specifying how the water is to be shared among the different water users. The changes gazetted in 2009 were necessary to provide adequate protection for the environment, particularly during periods of low flow when the demand for water is greatest, and to more clearly define the rights of individual licence holders.

The Jilliby Jilliby Creek WSP applies only to the surface water resources occurring on land shown on the plan at Schedule 2 of the Jilliby Jilliby Creek WSP (which includes Jilliby Jilliby Creek itself) and any lakes and wetlands in the water source area. The WSP does not include any water contained within the aquifers underlying the water source.

The W2CP will not be seeking a licence to extract any water from this system.

The purpose of the Plan is to set limits on the overall extraction of water from the Creek on an annual basis (the long-term average extraction limit) and also set limits on the daily extractions (the total daily extraction limit, TDEL).

A series of “flow classes” have been developed to manage and control the daily extractions, and include:

Very low flow class or A class

- Flows at or less than 0.5 ML/day (Year 1 of the Plan);
- 0.75 ML/day (Year 2); and
- ML/day (Year 3 onwards).

Moderate flows or B class

- flows greater than 0.5 ML/day and at or less than 3.3 ML/day (Year 1);
- flows greater than 0.75 ML/day and or at or less than 3.3 ML/day (Year 2); and
- flows greater than 1 ML/day and at or less than 3.3 ML/day (Year 3 onwards).

High flows or C class

- flows greater than 3.3 ML/day and at or less than 8 ML/day.

Very high flows or D class

- flows greater than 8 ML/day.

Within each of these flow classes, the Plan defines how much water can be extracted under each category of water access licence. This is the Total Daily Extraction Limit (TDEL).

The Water Management Act requires that water be allocated for the fundamental health of a river and its dependent ecosystems, such as wetlands and floodplains, as a first priority. The Plan does this by setting aside a proportion of each flow class for environmental needs.

A cease to pump condition applies for the majority of water access licences (those known as unregulated river access licences which cover irrigation, farming, industrial and recreational uses) when the flow is at, or below, 0.5 ML/day (Year 1), 0.75 ML/day (Year 2) or 1.0 ML/day (Year 3 onwards) (measured at the flow reference point). The cease to pump conditions are the first stage of the implementation of the daily flow classes.

Limited volumes are available below the cease to pump threshold for basic landholder rights (0.51 ML/day) and for licence holders that require continued access to water for hygiene and health purposes, that is, those listed on Schedule 6 of the Plan. At the start of the Plan there were no such licence holders identified in the water source.

In the other flow classes (B, C and D), the TDEL will determine how much water can be taken by water extractors - the rest (other than that extracted for basic rights) will remain in the water source for the environment.

Other than basic landholder rights, water extraction must be authorised under a water access licence.

9.7.2 Forested Areas / National Parks, Reserves and State Forests

Water quality objectives for the sections of waterways within the Forested Areas or National Parks, Reserves and State Forests classification are listed below:

- Aquatic Ecosystems – Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.
- Visual Amenity – aesthetic qualities of water.
- Secondary Contact Recreation – Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed.
- Primary Contact Recreation – Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.

- Drinking water (includes disinfection, clarification and disinfection, and groundwater) – Refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment.

River flow objectives for the sections of waterway within the Forested Areas classification are listed below:

- Protect pools in dry times – protect natural water levels in pools of creeks and rivers and wetlands during period of no flows.
- Protect natural low flows – water extraction and storage are high in dry times and impose long artificial droughts that increase the stress on aquatic plants and animals.
- Maintain natural flow variability – maintain or mimic natural flow variability in all streams.
- Manage groundwater for ecosystems – maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.
- Minimise effects of weirs and other structures – minimise the impact of instream structures.

9.7.3 Uncontrolled Steams

Water quality objectives for the sections of waterways within the Forested Areas classification are listed below:

- Aquatic Ecosystems – Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.
- Visual Amenity – aesthetic qualities of water.
- Secondary Contact Recreation – Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed.
- Primary Contact Recreation – Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.
- Livestock Water Supply – Protecting water quality to maximise the production of healthy livestock.
- Irrigation Water Supply – Protecting the quality of waters applied to crops and pasture.
- Homestead Water Supply – Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.
- Drinking Water – refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment.

- Aquatic Foods (Cooked) – Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.

River flow objectives for the sections of waterways within the Forested Areas classification are listed below:

- Protect pools in dry times – protect natural water levels in pools of creeks and rivers and wetlands during periods of no flow.

- Protect natural low flows – water extraction and storage are high in dry times and impose long artificial droughts that increase the stress on aquatic plants and animals.

- Protect important rises in water levels – protect or restore a proportion of moderate flows and high flows.

- Maintain wetland and floodplain inundation – maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems.

- Maintain natural flow variability – maintain or mimic natural flow variability in all streams.

- Manage groundwater for ecosystems – maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.

- Minimise effects of weirs and other structures – minimise the impact of instream structures.

9.7.4 Controlled Rivers

Water quality objectives for the sections of controlled waterways are listed below:

- Aquatic Ecosystems – Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.

- Visual Amenity – aesthetic qualities of water.

- Secondary Contact Recreation – Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed.

- Primary Contact Recreation – Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.

- Livestock Water Supply – protecting water quality to maximise the production of healthy livestock.

- Irrigation Water Supply – Protecting the quality of water applied to crops and pastures.

- Homestead Water Supply – Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.

- Drinking Water at Point of Supply – refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment.

- Aquatic Foods (Cooked) – Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.

River flow objectives for controlled waterways are listed below:

- Protect pools in dry times – protect natural water levels in pools of creeks and rivers and wetlands during periods of no flow.

- Protect natural low flows – water extraction and storage are high in dry times and impose long artificial droughts that increase the stress on aquatic plants and animals.

- Protect important rises in water levels – protect or restore a proportion of moderate flows and high flows.

- Mimic natural drying in temporary waterways – mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways.

- Maintain natural flow variability – Mimic the natural frequency, duration and seasonal natural of drying periods in naturally temporary waterways.

- Maintain natural rates of change in waterways – maintain rates of rise and fall of river heights within natural bounds.

- Manage groundwater for ecosystems – maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.

- Minimise effects of weirs and other structures – minimise the impact of instream structures.

- Minimise effects of dams on water quality – minimise downstream water quality impacts of storage releases.

The potential for the W2CP to impact on the waterways is primarily through subsidence over the mining area. However, it is anticipated that the project is not inconsistent with the objectives of the Lake Macquarie and Tuggerah Lakes CMA. Details of the compatibility are provided in Table 9.14.

Table 9.14 W2CP and the Objectives of the CMA

Objective	W2CP
Water Quality	
Aquatic Ecosystems	The ecological assessment contained in Chapter 13, and Appendix Q concluded that the project will not have a significant impact on aquatic ecosystems. Furthermore, the W2CP has committed to assist landowners in the restoration of already degraded riparian zones.

Table 9.14 W2CP and the Objectives of the CMA

Objective	W2CP
Visual Amenity	All runoff leaving the surface facilities will be of a suitable quality in accordance with an Environment Protection Licence to ensure that there will be no impact on the visual appearance of the waterways, eg through high turbidity or elevated nutrients that could lead to algal blooms. Above the mining area, the only potential impact to the visual amenity of waterways would be through sedimentation of the water if erosion was to result following subsidence. However, mitigation measures to repair any areas that may represent an erosion hazard as a result of mining induced subsidence will be quickly repaired before an impact is seen on the visual amenity of the surrounding waterways.
Secondary / Primary Contact Recreation	All water discharged from the surface facilities will be of a suitable quality that will either maintain or improve the existing water quality. Impacts on waterways above the mining area will not affect the quality of water such that it would pose a threat to secondary or primary contact through recreation.
Drinking Water	The WACJV has committed to protect the quality and quantity of the regions drinking water (refer to Chapter 7).
Livestock Water Supply	All water discharged from the surface facilities will be of a suitable quality that will either maintain or improve the existing water quality. Impacts on waterways above the mining area will not affect the quality of water such that it would reduce the quality of water available as a water supply for livestock.
Irrigation Water Supply	All water discharged from the surface facilities will be of a suitable quality that will either maintain or improve the existing water quality. Impacts on waterways above the mining area will not affect the quality of water such that it the quality of water for irrigation would be reduced.
Homestead Water Supply	All water discharged from the surface facilities will be of a suitable quality that will either maintain or improve the existing water quality. Impacts on waterways above the mining area will not affect the quality of water such that it would reduce the quality of water being collected and used for domestic purposes.
Aquatic Foods	All water discharged from the surface facilities will be of a suitable quality that will either maintain or improve the existing water quality. Impacts on waterways above the mining area will not affect the quality of water such that it would reduce the suitability for healthy aquatic species to be consumed.
River Flow	
Protect pools in dry times	The W2CP will have a net beneficial impact on water flows with the mine being water producer once it becomes fully operational.

Table 9.14 W2CP and the Objectives of the CMA

Objective	W2CP
Protect natural low flows	The W2CP will have a net beneficial impact on water flows with the mine being water producer once it becomes fully operational.
Protect important rises in water levels	The W2CP will have a net beneficial impact on water flows with the mine being water producer once it becomes fully operational.
Maintain wetland and floodplain inundation	The detailed flood study contained in Appendix C and summarised in this chapter discusses the potential changes to water levels and flows as a result of subsidence from the mine. Overall, the net impact is predicted to be minimal.
Maintain natural flow variability	Surplus water produced by the mine could be available to supply other industries, direct to the Gosford Wyong Water Supply Scheme or for environmental flows within surrounding creeks. If the water is discharged into a natural waterway, it will be in consultation with all relevant stakeholders to ensure that the discharge reflects natural processes.
Manage groundwater for ecosystems	The ecological assessment concluded that groundwater dependent ecosystems will not be significantly impacted by the W2CP (refer to Section 13.2.6).
Minimise effects of weirs and other structures	The W2CP is not proposing to dam any of the natural watercourses. A culvert will need to be placed in Wallarah Creek to facilitate the new access road to the Tooheys Road site, however this will in no way obstruct the flow of water in the creek.
Mimic natural drying in temporary waterways	With the mine expected to be a net water producer once fully operational, there is the potential to alter natural drying patterns of the creeks the water is discharged into. Options exist to instead supply this water to surrounding industry and water users, or direct to the Gosford Wyong Water Supply System, rather than increasing natural flows.
Maintain natural rates of change in waterways	The W2CP will not alter flow regimes of temporary waterways.
Minimise effects of dams on water quality	All discharges from site dams will be of a quality that is the same or better than the existing background water system.