WALLARAH 2 COAL PROJECT
RESPONSE TO LETTER FROM THE PLANNING ASSESSMENT COMMISSION
for
Wyong Areas Coal Joint Venture

1 INTRODUCTION

The Minister for Planning and Infrastructure directed the Planning Assessment Commission (PAC) to undertake a review of the Wallarah 2 Coal Project (the Project) and to hold a public hearing. The public hearing was held at the Wyong Golf Club on 2 April 2014.

Following its review of the documentation for the Project and the public hearing, the PAC provided a letter to Kores on 14 April 2014 seeking additional information regarding four issues:

- Water Supply;
- Impacts on Jilliby Jilliby Creek and Little Jilliby Jilliby Creek;
- Flooding; and
- Subsidence.

The letter from the PAC letter is appended to this brief letter report as **Appendix I**.

The questions raised by the PAC in its letter dated 14 April 2014 are addressed in this document.

2 IMPACT ON WATER SUPPLY SCHEME

This section describes the predicted impacts of the Project on water resources and explains the implications of these impacts on the Gosford-Wyong water supply scheme.

2.1 DESCRIPTION OF THE WATER SUPPLY SCHEME

The Gosford-Wyong water supply scheme harvests water from four coastal streams: Wyong River, Mangrove Creek, Mooney Mooney Creek and Ourimbah Creek. The water supply scheme infrastructure consists of three dams, three weirs, seven groundwater bore fields, two water treatment plants and 40 reservoirs.

The major dam in the water supply scheme is Mangrove Creek Dam, located in the upper reach of Mangrove Creek. The dam has a catchment area of approximately 100 km^2 and a storage capacity of 190,000 ML. The Mangrove Creek Dam catchment is located a significant distance to the west of the Project.

Mooney Mooney Dam is located on Mooney Mooney Creek, approximately 21 km upstream of its confluence with the Hawkesbury River. The dam has a catchment area of 39 km^2 and a storage capacity of 4,600 ML.

Water collected in Mangrove Creek Dam and Mooney Mooney Dam is pumped to the Somersby Water Treatment Plant. The treated water is used to supply Gosford Local Government Area.

Mardi Dam is an off stream dam located approximately 4 km south-west of Wyong. The dam itself has a catchment area of 4 km^2. The majority of water retained in Mardi Dam is pumped to the dam from the Lower Wyong River Weir or Ourimbah Creek Weir. The Lower Wyong River Weir has a weir pool capacity of approximately 300 ML. Ourimbah Creek Weir has a pool capacity of approximately 100 ML. Mardi Dam has a storage capacity of approximately 7,400 ML.

Water collected in Mardi Dam is transferred to the Mardi Water Treatment Plant. The treated water is used to supply Wyong Shire.

There is also a mechanism for harvesting water from Porters Creek Weir during periods of extreme drought. Porters Creek is not ordinarily a part of the water supply scheme, but can be utilised as an emergency water source by pumping from the Porters Creek Weir to the Lower Wyong River Weir. This occurred during the most recent drought.

The Gosford-Wyong water supply scheme includes some groundwater extraction but not from the groundwater systems in the locality of the Project. During the most recent drought, the Gosford-Wyong Water Authority assessed the ability of the groundwater systems in the locality of the Project (Dooralong Valley) to supply groundwater. This investigation determined that there are no productive hard rock aquifers in this area due to the very low permeability of the sedimentary strata.

Groundwater extraction for water supply purposes was enhanced during the most recent drought. Groundwater is extracted from various sites including the Mardi Dam groundwater bore, Ourimbah groundwater bore fields, Narara groundwater bores and Somersby groundwater bore. None of these facilities will be affected by the Project.

2.2 LOCATION OF THE PROJECT

The Extraction Area for the Project is located beneath the catchments of Jilliby Jilliby Creek and Wyong River. The Extraction Area is located beneath the catchment of Wyong River upstream of the Lower Wyong River Weir, from which water is pumped to Mardi Dam (in accordance the water authority's licensed share component). The confluence of Jilliby Jilliby Creek is also upstream of this weir. Therefore, any water taken from these catchments has the potential to affect the volume in the Lower Wyong River Weir pool and ultimately Mardi Dam.

The Project does not interact with the catchments of Mangrove Creek, Mooney Mooney Creek and Ourimbah Creek. Accordingly, the Project will not impact upon stream flows draining to and the storage volumes of Mangrove Creek Dam and Mooney Mooney Dam. There will also be no impact on the storage component of Mardi Dam that is extracted from Ourimbah Creek.

2.3 SURFACE WATER IMPACTS

2.3.1 Demand for External Water

The modular water treatment plant at the Tooheys Road Site will treat all mine water generated by the Project. Being modular, the water treatment plant has the capacity to adapt to changes in flow volumes during the Project life. Wherever possible, treated water will be used to satisfy onsite water requirements. The reuse of treated water for operational activities significantly reduces the demand on external water sources. The total water requirement is also substantially reduced by avoiding the need for coal washing.

If most years of the Project, the volume of treated mine water and collected surface water will exceed site operational water requirements. However, there are some years where there will be insufficient treated water to satisfy site operational water demand. The shortfall in water will be obtained from the town water supply.

The maximum external water requirement is predicted to be 52 ML/year, occurring in the first year of the Project. This volume includes 10 ML to 20 ML of water that is required for drinking and bathhouse use. The remainder of the total external water requirement is used for construction and/or operational activities. WACJV will install rainwater tanks to reduce the Project's reliance on town water supplies. Harvested rainfall can be used for construction and operational purposes, but not for drinking or bathhouse use. To ensure that hygiene standards are satisfied, potable water for drinking and bathing will be obtained from the town water supply.

In the years where there is an excess of treated water, there will be no need to source potable water for construction and/or operational activities. In such years, the external water requirement will be limited to 10 ML to 20 ML for drinking and bathing purposes.

Use of potable water from the town water supply will occur only during the Project life. The use of town water does not require any water licences. The connections from the Project's surface facilities to the water and sewer systems have been investigated and costed in discussions with Wyong Shire Council (WSC), with the details included in the recent Voluntary Planning Agreement (VPA) negotiated with WSC.

The Project's potable water requirements are lower than other mines due to the Project not including a coal handling and preparation plant. The Project's operational water requirements are also low compared to other industrial land uses in the region. For example, the Bluetongue Brewery which consumes approximately 300 ML/year of potable water from the town water supply (GHD, 2008). It has been announced that the Bluetongue Brewery will close in late 2014.

2.3.2 Reduction in Catchment Area

The Tooheys Road Site and Buttonderry Site will capture a proportion of surface water runoff from the catchments in which they are constructed.

The Tooheys Road Site will be constructed within the catchment of Wallarah Creek. Drains will be constructed to divert clean water around the site, reducing the volume of runoff captured by the Project. The dams at the Tooheys Road Site will effectively reduce the catchment area by approximately 36 ha. This represents a 0.8% reduction in the Wallarah Creek catchment. This reduction in catchment area results in a reduction in runoff volumes of 150 ML/year (under average rainfall). Wallarah Creek flows to Lake Budgewoi. Neither Wallarah Creek nor Lake Budgewoi form part of the Gosford-Wyong water supply scheme.

The Buttonderry Site will be constructed within the catchment of Buttonderry Creek. The site will implement stormwater harvesting (from rooftops) and other drainage controls to detain site runoff. The worst case impact would be a reduction in catchment area of approximately 7.4 ha. This reduction in catchment area will reduce the runoff volumes to Buttonderry Creek by 30 ML/year (under average rainfall). Buttonderry Creek flows to Porters Creek (and the Porters Creek wetland), which has a catchment area of approximately 55 km^2. The worst case reduction in catchment area of 7.4 ha represents up to a 0.1% reduction in the catchment area of Porters Creek, which is negligible.

Site water storages will provide a resource for garden watering and site washdown purposes but will also function as sediment control facilities (settling ponds/dams). Sediment dams will overflow to the Porters Creek catchment during major rainfall events. Due to overflows from the sediment dam during wet periods, the impacts of catchment "reduction" will be less than the worst case impact assessed.

The capture of surface water runoff constitutes the "taking" of water, as defined by the *Water Management Act 2000*. Runoff volumes captured in mine water dams or sediment dams are exempt from licensing as these dams constitute 'excluded works'. WACJV will rely on its harvestable rights (under section 53 of the WM Act) to authorise the taking of the remaining volumes (that are not exempt). In addition, runoff intercepted from the Wallarah Creek catchment will be replaced through discharges of treated water (see **Section 2.3.3**).

Wallarah Creek does not contribute to the water supply scheme and harvesting from Porters Creek Weir is only relied on as a water source in drought emergencies. The water captured from the Buttonderry Creek catchment will only negligibly affect the availability of water for water supply purposes (under extreme conditions). Runoff that is collected, retained and used at the Buttonderry Site will be in accordance with the *Water Management Act 2000*. Use of intercepted runoff will reduce the volumes that need to be sourced from the town water supply.

The reduction in catchment area (i.e. the interception of a proportion of surface runoff) will occur as soon as construction of the surface facilities is commenced. This impact will persist until the sites are decommissioned and rehabilitated.

2.3.3 Discharges of Treated Water

Mine affected water will be treated at the onsite Water Treatment Plant. Treated water will be used for onsite activities in the first instance. Surplus treated water is currently proposed to be discharged to Wallarah Creek. The EIS has fully assessed the impacts of discharges on the water quantity and quality of Wallarah Creek. There may be opportunities in the future for surplus treated water to be made available for beneficial use.

The proposed water treatment plant utilises membrane filtration, ion exchange and reverse osmosis processes to produce treated water that is comparable in quality to the background water quality in Wallarah Creek. As such, there is anticipated to be no adverse water quality impacts resulting from discharges of treated water. The discharges will also replace the flows that are intercepted (taken) from the catchment by the Tooheys Road Site. There is predicted to be a net increase in Wallarah Creek flow volumes of 2 to 3%.

Water is not harvested from Wallarah Creek for water supply purposes. Therefore, the discharging of treated water to Wallarah Creek will not affect the quantity or quality of water available for town supply purposes.

WACJV has commencement consideration of alternative beneficial uses of surplus treated water. WACJV's commitment to conduct further studies is discussed in **Section 2.6**.

2.4 GROUNDWATER IMPACTS

2.4.1 Leakage Induced by Depressurisation

The extraction of coal generates a zone of depressurisation that extends outwards from the mine workings. Leakage refers to the downward flux of water from the shallow rock strata and alluvium towards the zone of depressurisation. This effect is illustrated in **Figure 1**. The Project is expected to induce leakage from the alluvium of up to a maximum of 7.3 ML/year and leakage from the shallow rock strata of up to a maximum of 29.2 ML/year.

The low rates of leakage are attributed to the low hydraulic conductivities of the claystone and siltstone strata within the Patonga Claystone and the Tuggerah Formation, and the relative low capacity for fracture flow.

Since the water supply scheme does not harvest any water from the groundwater systems in the vicinity of the Project, there is only the potential for impacts on the water supply if the groundwater impacts affect stream flow. The groundwater model predicts no measurable reduction in baseflow (see **Figure 2**).

The rate of rainfall recharge (130 ml/m^2/day during dry conditions) is significantly greater than the predicted rate of leakage from alluvial areas (2 ml/m^2/day). Thus, full recharge is expected to occur, ensuring that there is no decline in the water table. Following full recharge occurring, the volume of runoff draining to the streams would be reduced by up to 36.5 ML/year. This impact is negligible when compared to the average flow volume of 22,532 ML/year in Jilliby Jilliby Creek (measured from 1974 to 2009).

2.4.2 Inflows to Mine Workings

Mine water make occurs when water-bearing coal and adjacent rock is extracted. Inflow will begin as soon as drift development commences. However, inflow rates will be relatively low during drift development and first workings. During mining, the extraction of coal will result in water inflow into the mine workings (referred to as mine water make). This water make is derived almost entirely from interstitial storage in the coal seam and adjacent hard rock strata. The maximum rate of inflow during the Project life is predicted to be 2.5 ML/day, of which only a very small part (approximately 0.02 ML/day) is attributable to downwards leakage from the alluvial lands. The rate of inflow will reduce slightly in the later years of the mine life. The deep pore water in the coal seam and adjacent strata is neither accessible from the surface nor is it of a suitable quality for water supply purposes.

Mine water make will continue until pore pressures in the bedrock strata recover to pre-mining conditions. Due to the very low permeability of the rock strata, full recovery of pore pressures is expected to take more than 500 years. The longer term water make post-mining is estimated to be 0.22 ML/day drawn from deep regional storage within the coal seam and adjacent strata.

Mining may occasionally intercept localised water-bearing fracture networks. If such a fracture network is intercepted, there may be a temporary increase in inflows for weeks to months. It is estimated that inflow rates could increase by up to 0.5 ML/day during this period. Inflow rates will return to normal once the storage in the fracture network is depleted.

2.4.3 Change in Storage due to Cracking

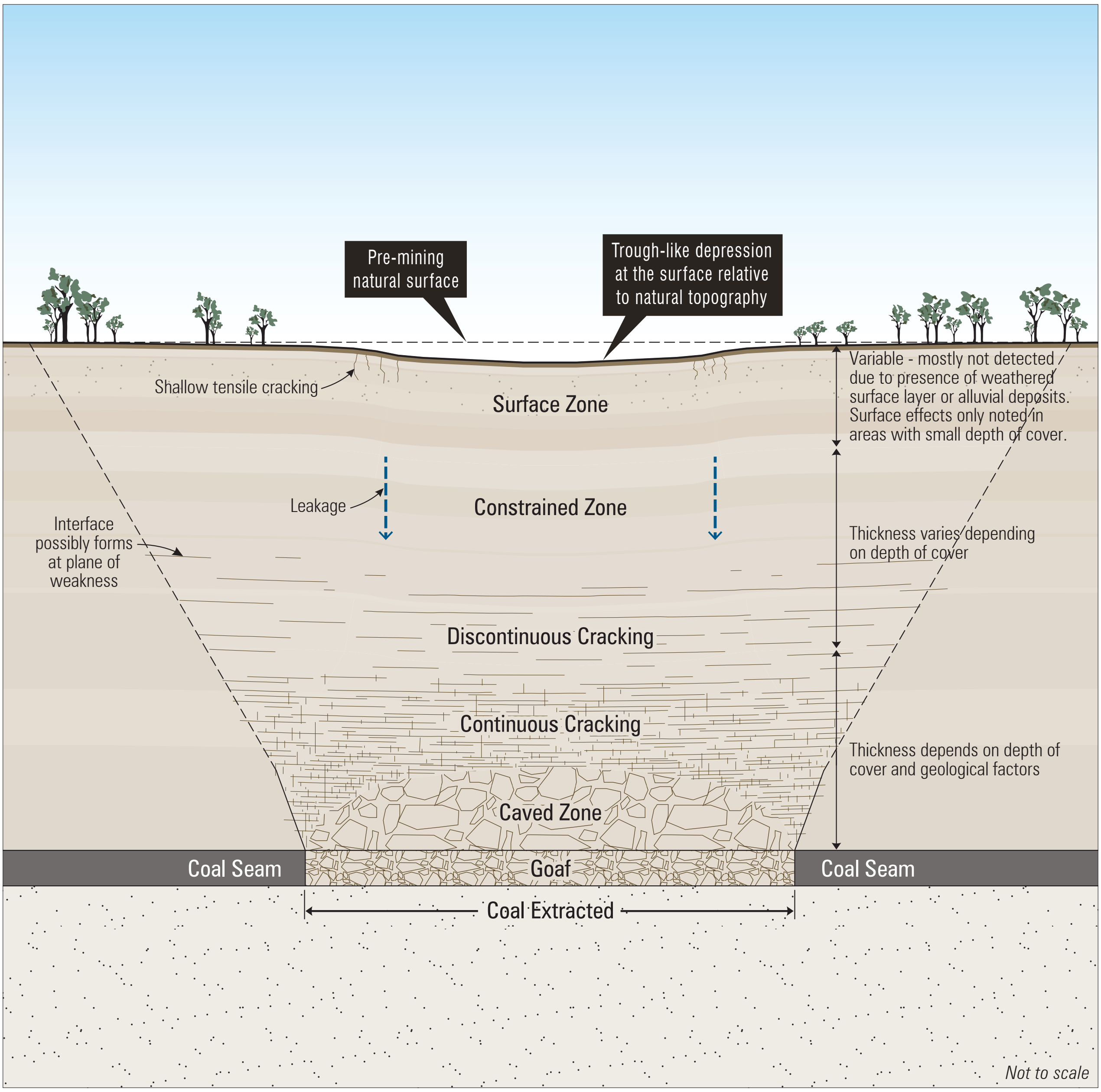
Subsidence induced shallow cracking of the upper surface of the bedrock beneath the alluvial lands has the potential to increase shallow groundwater storage.

Transient tensile cracking generally occurs above longwall panels as subsidence progresses along the length of the panel. Cracks in the bedrock would be filled by groundwater, resulting in minor leakage from connected shallow aquifers. Certain transient tensile cracks are expected to close within a short period (days to weeks). When these cracks close, water is expelled from the crack and returned to the groundwater system. Other cracks are expected to remain open (see **Figure 1**). These cracks may be infilled by alluvium or they may remain open without infill sediments. If the latter occurs, there would be an increase in groundwater storage. The increase in groundwater storage at the base of the alluvium is predicted to be approximately 0.9 kL per metre of panel length. This increase in groundwater storage is incremental over the period of mining and constitutes a "one-off" water retention (or take). The overall impact on the alluvial system storage is the re-direction of approximately 2.8 ML/year of surface runoff into the groundwater system. This impact will only occur during mining.

Cracking in hard rock areas may also result in localised diversion of groundwater to alternate flow paths. This water is likely to be returned to the drainage system further downstream. Due to the lack of connective vertical cracking, this water will not be diverted to the mine workings. As such, there is no loss of water or reduction in catchment yield.

2.4.4 Change in Storage due to Subsidence

Changes in water table elevation will occur following subsidence. As an area is subsided, the water table will be lowered relative to the surrounding unsubsided area. The resulting change in hydraulic gradient will result in an increase to groundwater storage as re-equilibration processes are initiated.



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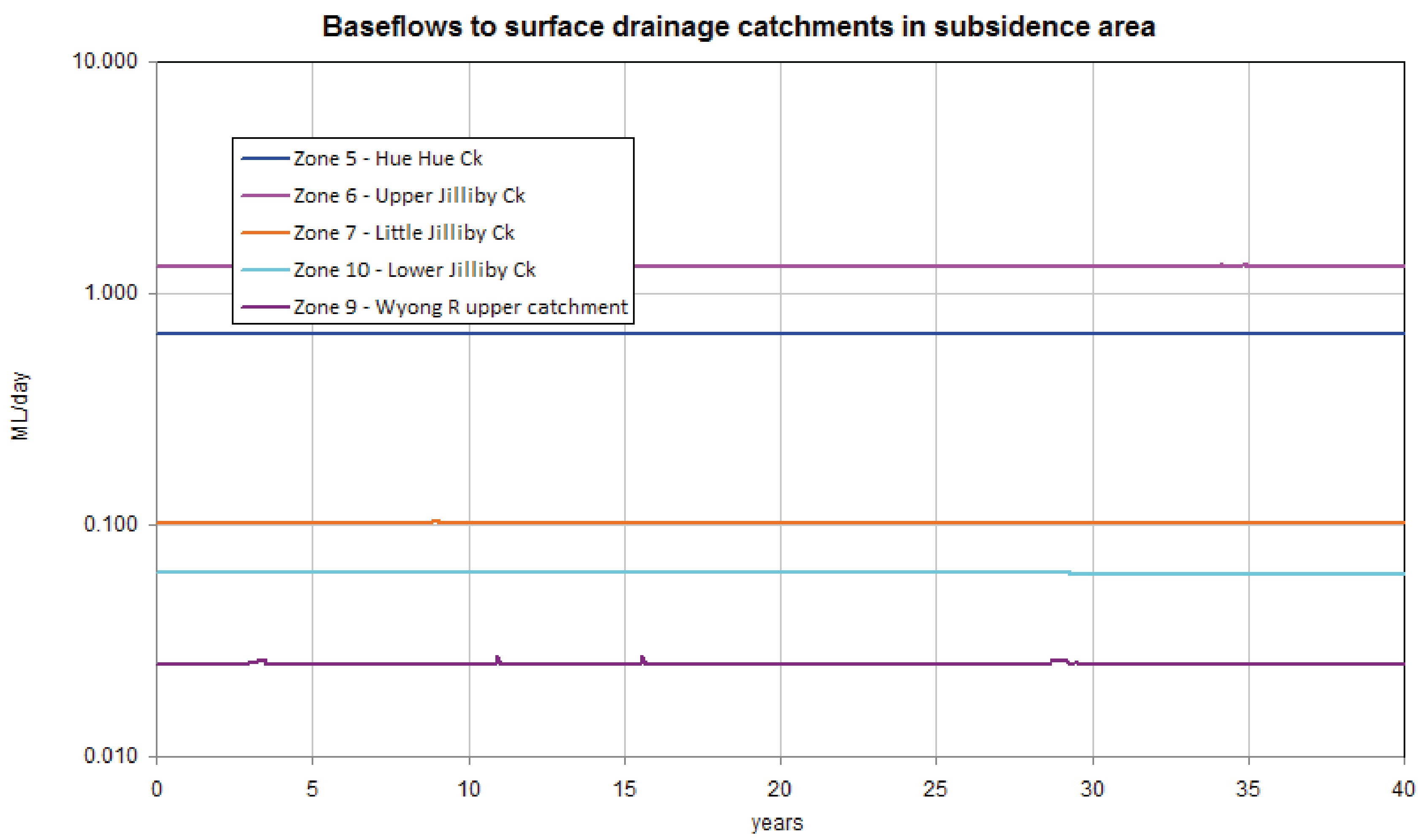
Groundwater Impacts Schematic

FIGURE 1



Source: MER (2013)

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Predicted Change in Baseflow

FIGURE 2

The effect of changes in hydraulic gradient is diminished in the elevated hard rock areas because the topographic slope is significantly greater than the effect of subsidence. However, in the flatter alluvial valleys, the elevation difference between a subsided area and an unsubsided area results in a perceptible hydraulic gradient towards the subsided area. Groundwater will migrate from the unsubsided area to the subsided area until equilibrium is reached. Due to the initial lowering of the water table in the subsided area, a greater volume of water becomes stored within these alluvial sediments to attain equilibrium. The magnitude of the increase in storage is dependent on the area of alluvium that is undermined by each longwall panel. The predicted increases in storage for each longwall panel are presented in Table 4 of the Groundwater Impact Assessment (MER, 2013).

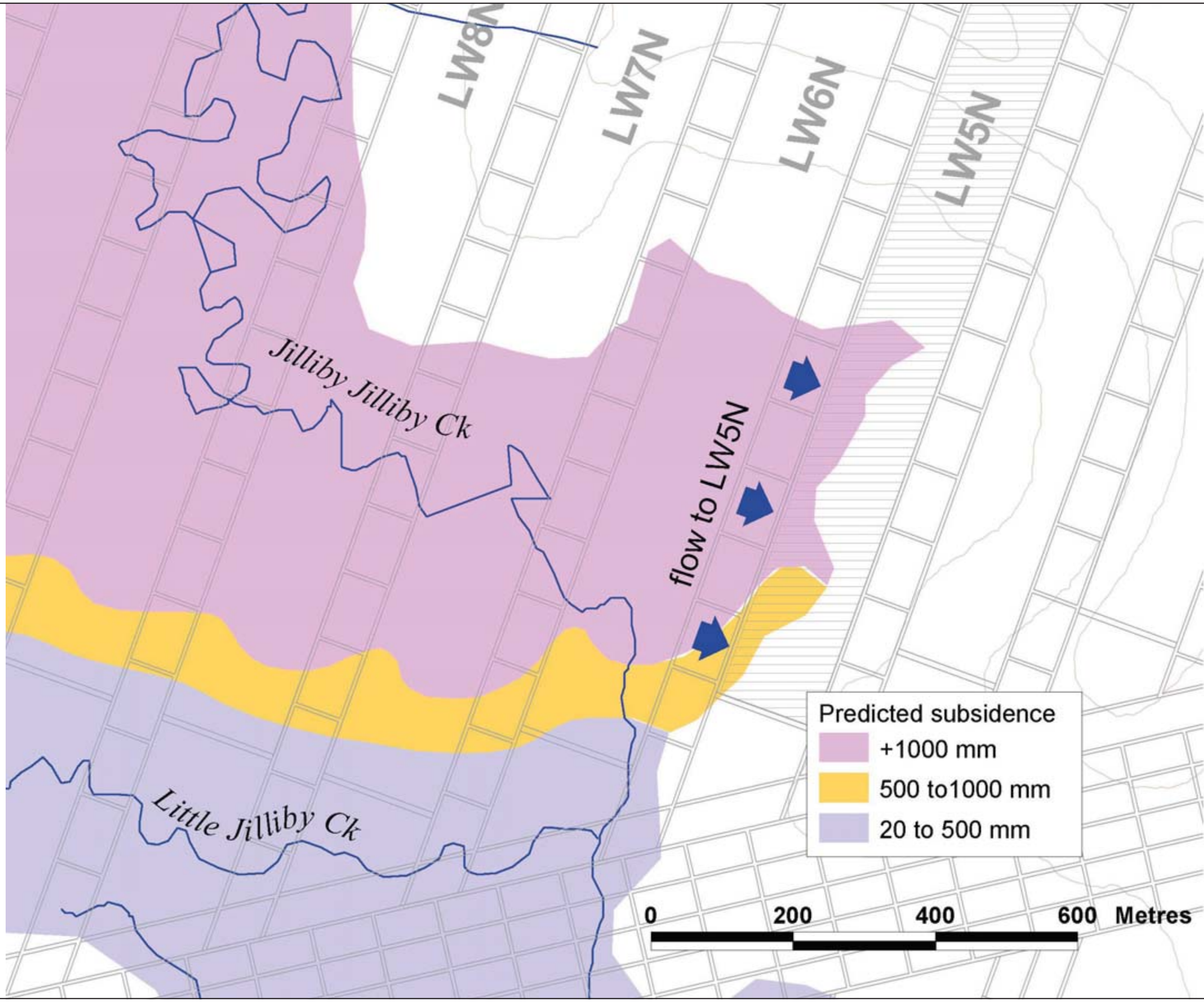
In the Dooralong Valley, this process will first become evident above LW5N (see **Figure 3**). As LW5N is extracted, groundwater will flow from the alluvium above the unmined LW6N to the subsided alluvium above LW5N. This results in a lowering of the alluvial water table above LW6N, which will be replenished by rainfall recharge. The maximum redirection of runoff into alluvial storage is approximately equivalent to the subsided porous storage which has been estimated at 29 ML for LW5N.

Following subsidence of the next panel (LW6N) underlying Jilliby Jilliby Creek, groundwater will flow from the alluvium above the unmined LW7N to the subsided alluvium above LW6N. This results in a lowering of the water table above LW7N, which will be replenished by rainfall recharge. In addition, the temporary hydraulic gradient to the east (between the alluvial areas above LW6N and LW5N) will re-equilibrate towards a pre-mining scenario. As a result, groundwater will migrate from the alluvial sediments above LW5N back to the alluvial sediments above LW6N (see **Figure 4**).

The volume of additional storage is predicted to increase as mining progresses from east to west with the maximum additional alluvial storage (181 ML) associated with the mining of LW9N. The additional storage decreases as mining progresses from LW9N to LW15N. Since the increase in storage lessens as mining progresses west of LW9N, the surplus groundwater that does not migrate west (with extraction of successive longwall panels) is returned to the stream as baseflow.

Changes in groundwater storage will also take place in the Wyong River alluvium. The behaviour of the Wyong River alluvium will be similar to the behaviour of the Jilliby Jilliby Creek alluvium. However, the magnitude of the change in storage will be substantially less due to the smaller area of alluvium that will be subsided.

The increase in storage begins to occur shortly after the alluvium is first subsided and persists until subsidence of the alluvium is complete. The long term flow system is expected to closely resemble pre-mining conditions since the bed elevation of Jilliby Jilliby Creek is the fundamental control on the elevation of the groundwater table in the alluvium. The lowering and re-equilibration of the water table is illustrated in **Figure 5**.



Source: MER (2014)

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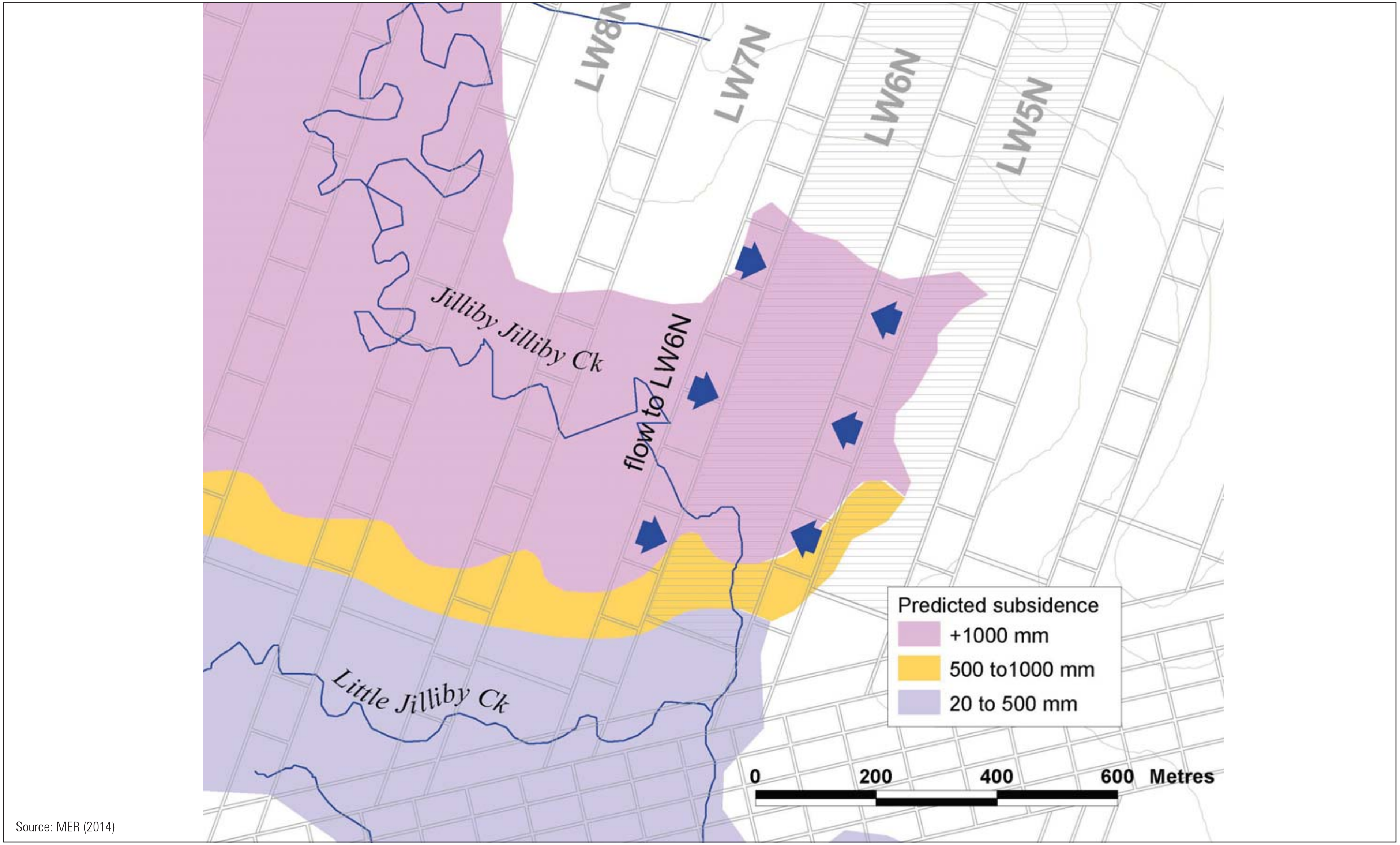
Alluvial Groundwater Flow During Mining of LW5N

FIGURE 3



Source: MER (2014)

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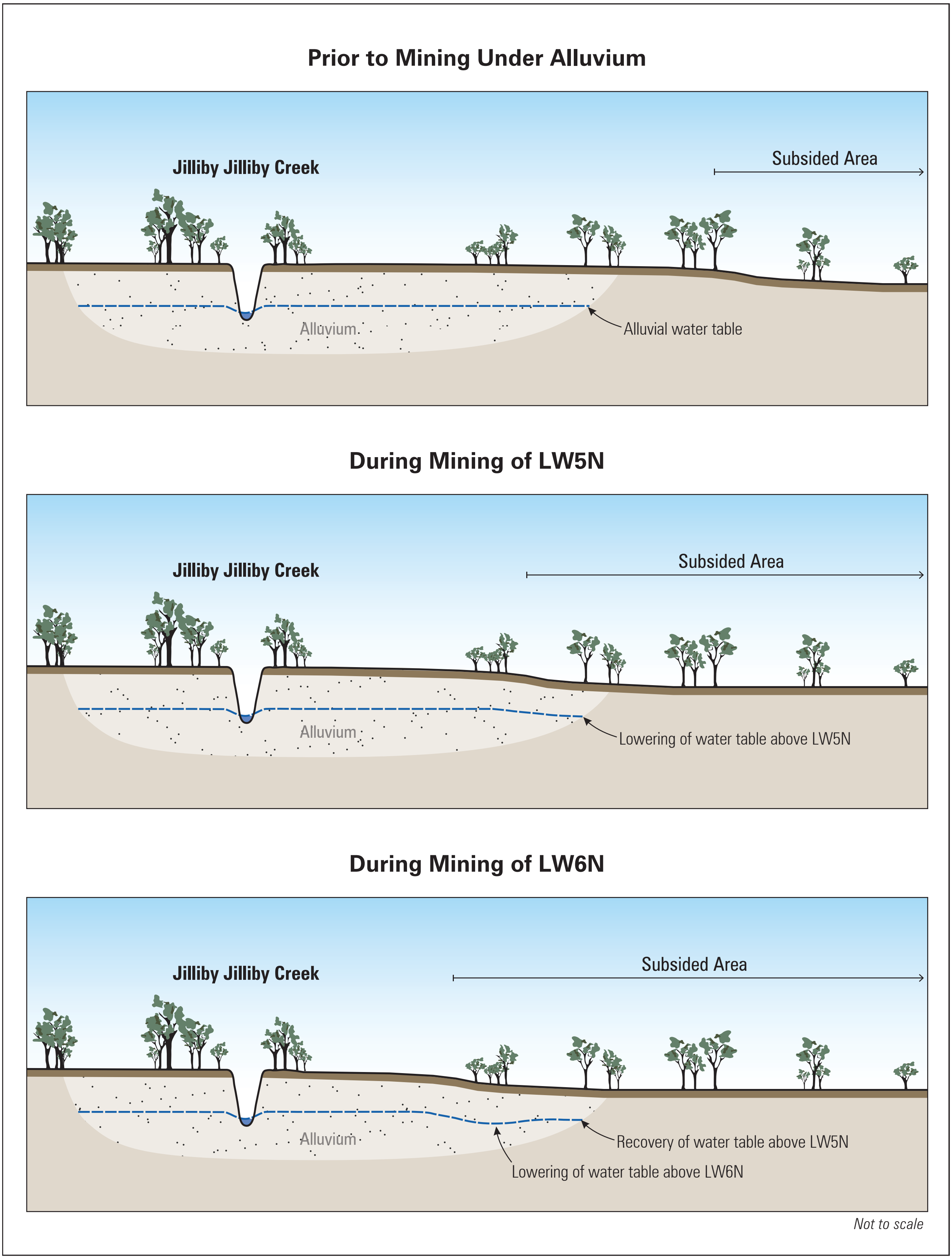
Alluvial Groundwater Flow During Mining of LW6N

FIGURE 4



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Increase in Alluvial Storage – Schematic

FIGURE 5

The progression of the body of alluvial storage along a longwall panel is illustrated in **Figure 6** to **Figure 9**.

There are three areas where there will remain some differential subsidence after the completion of mining. These occur at the furthest extents of the mine plan and where the longwall panels meet the main headings (see **Figure 10**).

- Area 1 – the northern fringe of the subsided alluvium where the long term range in elevations of the water table to the north of subsided areas may fall slightly while to the south, the range may rise slightly;
- Area 2 – above the main headings and extending westward where the cumulative impacts of subsided panels to the north and south are expected to lead to a slight fall in the range in elevations of the water table;
- Area 3 – the southern fringe of the subsided alluvium where the long term range in elevations of the water table to the north of subsided areas may rise slightly while to the south, the range may fall slightly.

At these locations along Jilliby Jilliby Creek, there is expected to be localised by gradual undulation in the stream bed profile due to differential subsidence. A small component of the runoff re-directed into alluvial storage is expected to be retained in storage until the natural stream profile is restored. Once natural stream bed gradients are re-established, the additional water retained in the alluvium will be returned to the creek.

Approximately 6 km of the Jilliby Jilliby Creek main channel upstream of its confluence with Little Jilliby Jilliby Creek is expected to be subsided. The maximum subsidence along this reach is predicted to be 1,400 mm. An additional 1 km of the main channel downstream of the confluence is predicted to experience subsidence of up to 1,000 mm. At Area 1 (see **Figure 10)**, there is predicted to be a "drop" in the channel of approximately 600 mm as the channel passes from unsubsided to subsided areas, resulting in a steepening of the average bed gradient. At Area 3, there is predicted to be a "rise" in the channel of approximately 400 mm as the main channel passes from subsided to unsubsided areas. This results in a flattening of the average stream bed gradient. The changes in gradient at Areas 1 and 3 are illustrated in **Figure 11**.

There is negligible subsidence associated with the development of primary headings. The 700 m long reach of Jilliby Jilliby Creek that overlies the main roadways will be subject to less subsidence compared to the reaches that overlie longwall panels. As a result, Area 2 (see **Figure 10**) is expected to experience a "rise" in the main channel of approximately 700 mm as the creek passes over the primary headings. The change in gradient as the stream passes over the primary headings is illustrated in **Figure 12**.

Figure 11 and **Figure 12** both use significant vertical exaggeration to clearly illustrate the changes in gradient. Consequently, the actual changes in gradient are not as pronounced as they appear in these figures.

There is anticipated to be a change in scour potential at areas 1, 2 and 3. There will also be temporary changes in the Jilliby Jilliby Creek stream bed grade upstream of the confluence with Little Jilliby Jilliby Creek as longwall mining progresses across the floodplain.

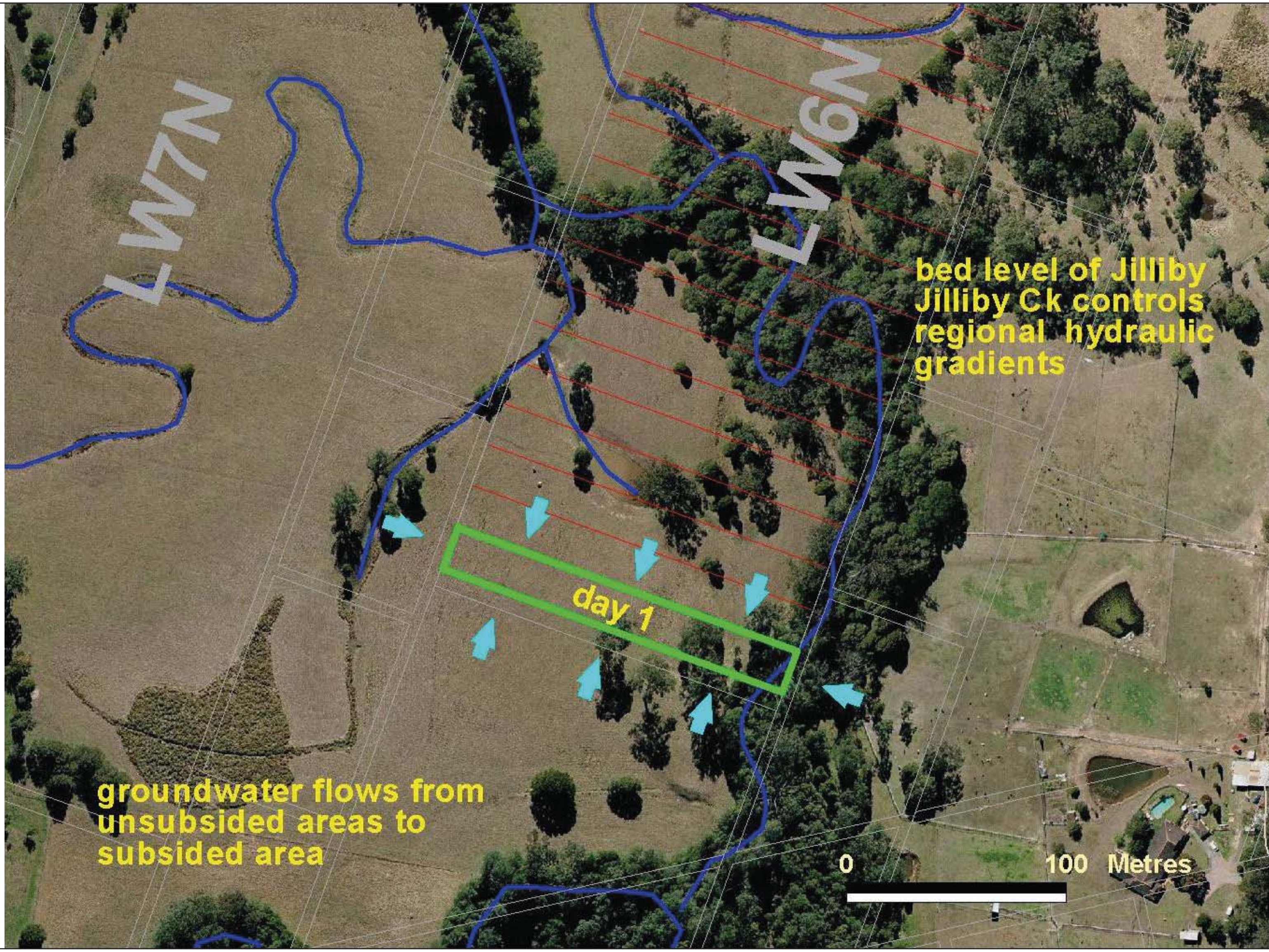
It is anticipated that average stream bed grades will be re-established at close to existing equilibrium values (0.1% average) through limited and localised scour and accretion. Much of this process may occur during a single flood or over a period of several months of low flows. In relative terms, these changes will be well within the range of natural changes to the stream bed due to local bank failures or fallen trees partially blocking the main channel.

The accretion upstream of the "rise" shown in **Figure 12** and scour through the section will each be in the order of 300 to 400 mm and will have a negligible (beneficial) impact on flood levels calculated for the subsided case. While it would be possible to establish the final profile quickly using channel engineering improvements over a reach of approximately 900 m, it is preferable to avoid such disturbance and to allow the stream to naturally restore its profile.

The elevation of the creek bed is the main control of the water table elevation. Once the pre-mining stream bed profile is re-established through scour and accretion, water levels will return to pre-mining conditions.

Therefore, the changes in water table elevation due to subsidence do not result in any permanent loss of water from the drainage system. Rather, the effect is a temporary increase in storage. The additional rainfall and surface runoff temporarily redirected into the alluvial aquifer will be returned to the creek as baseflow once the water table re-equilibrates.

The Gosford-Wyong water supply scheme principally harvests water from streams. The additional rainfall and runoff volumes re-directed into the alluvial aquifer would have otherwise drained (at least partially) to Jilliby Jilliby Creek, potentially accumulating at Lower Wyong River Weir (unless it is overflowing). This additional water stored in the alluvium during the period is temporarily unavailable for water supply purposes. As a result, there may be a temporary marginal reduction in the flows to Wyong River and a potential reduction in the volume available to be accessed by the water authority.



Source: MER (2014)

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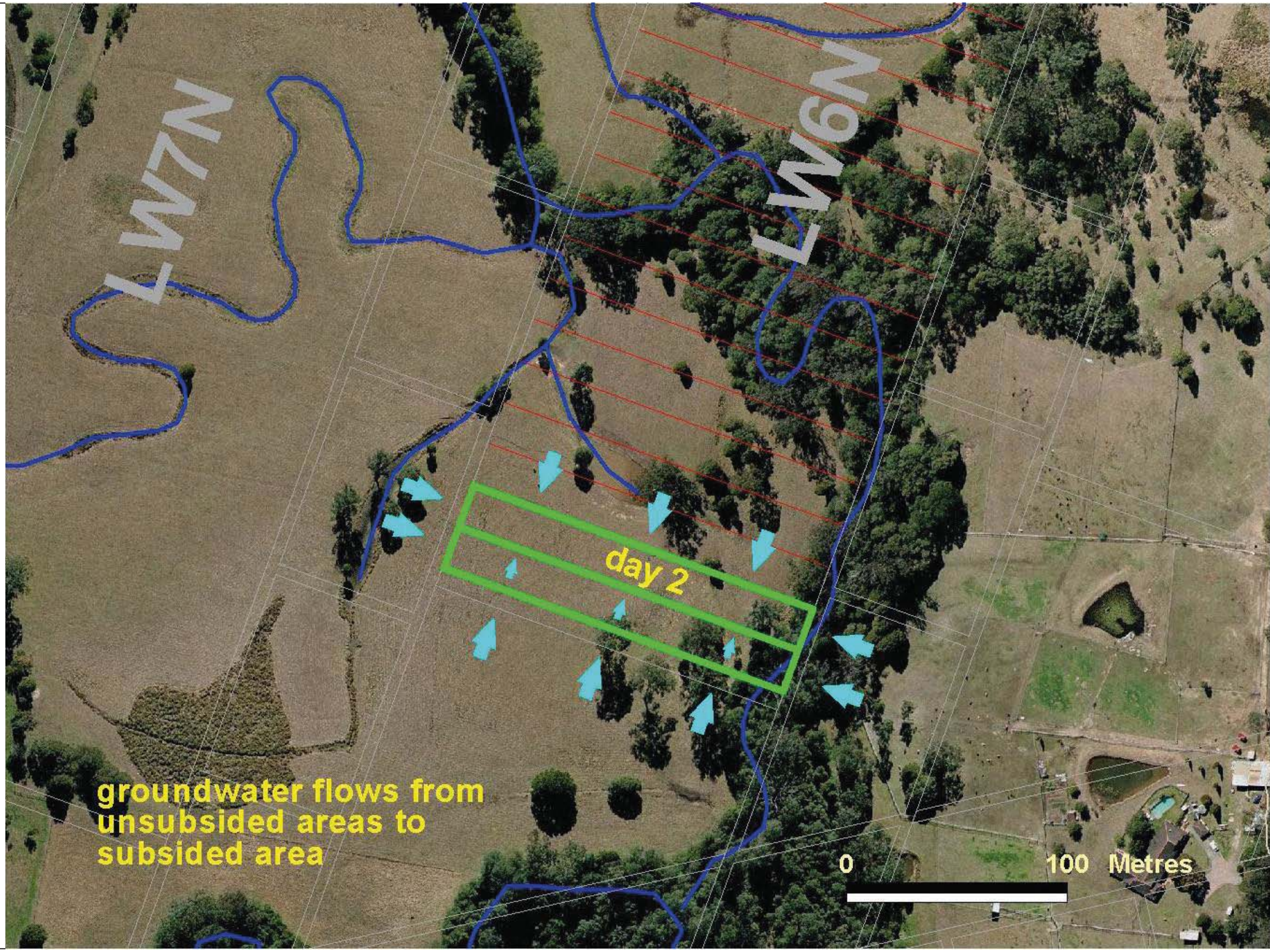
Local Scale Alluvial Groundwater Flows – Day 1

FIGURE 6



Source: MER (2014)

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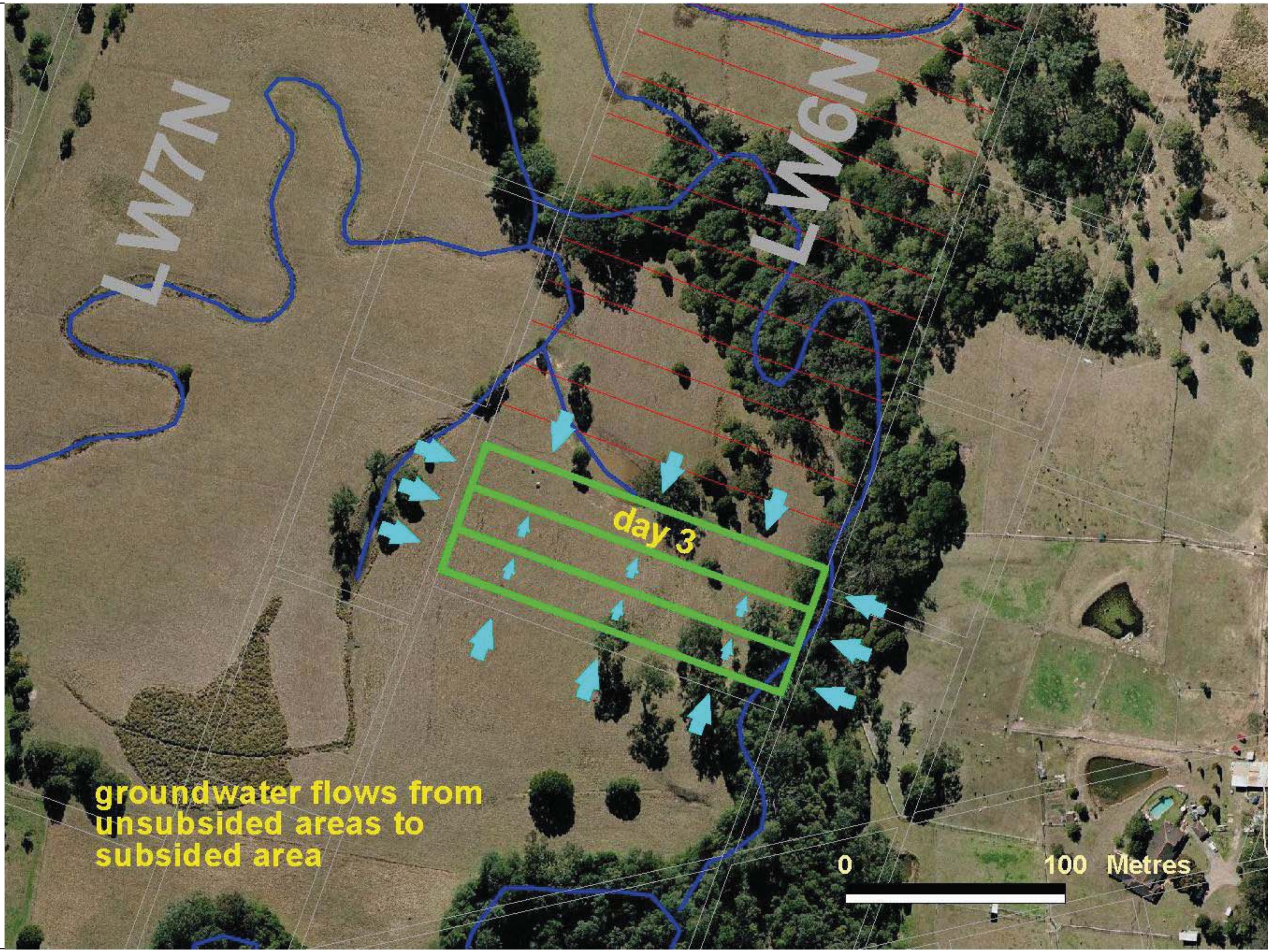
Local Scale Alluvial Groundwater Flows – Day 2

FIGURE 7



Source: MER (2014)

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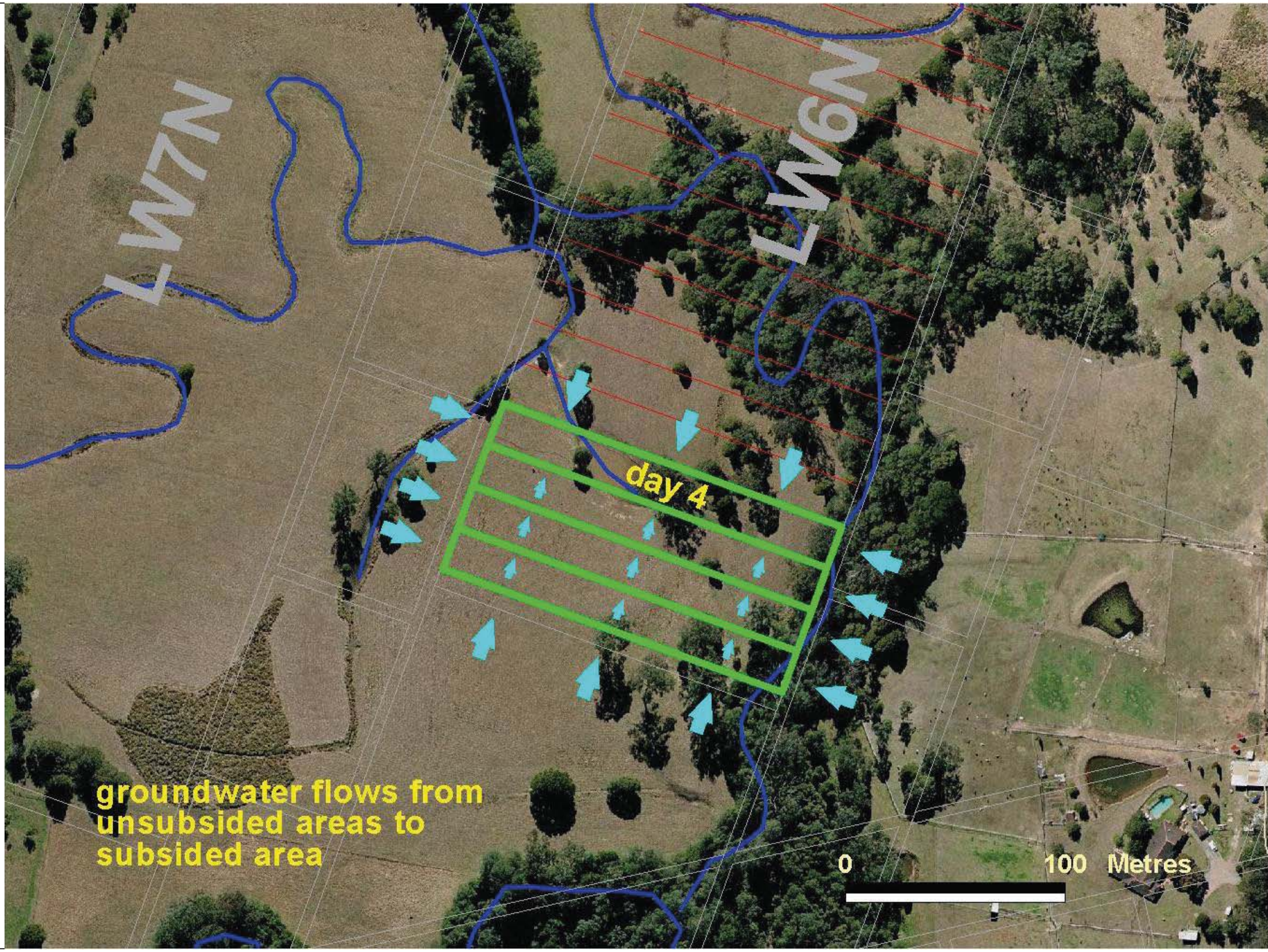
Local Scale Alluvial Groundwater Flows – Day 3

FIGURE 8



Source: MER (2014)

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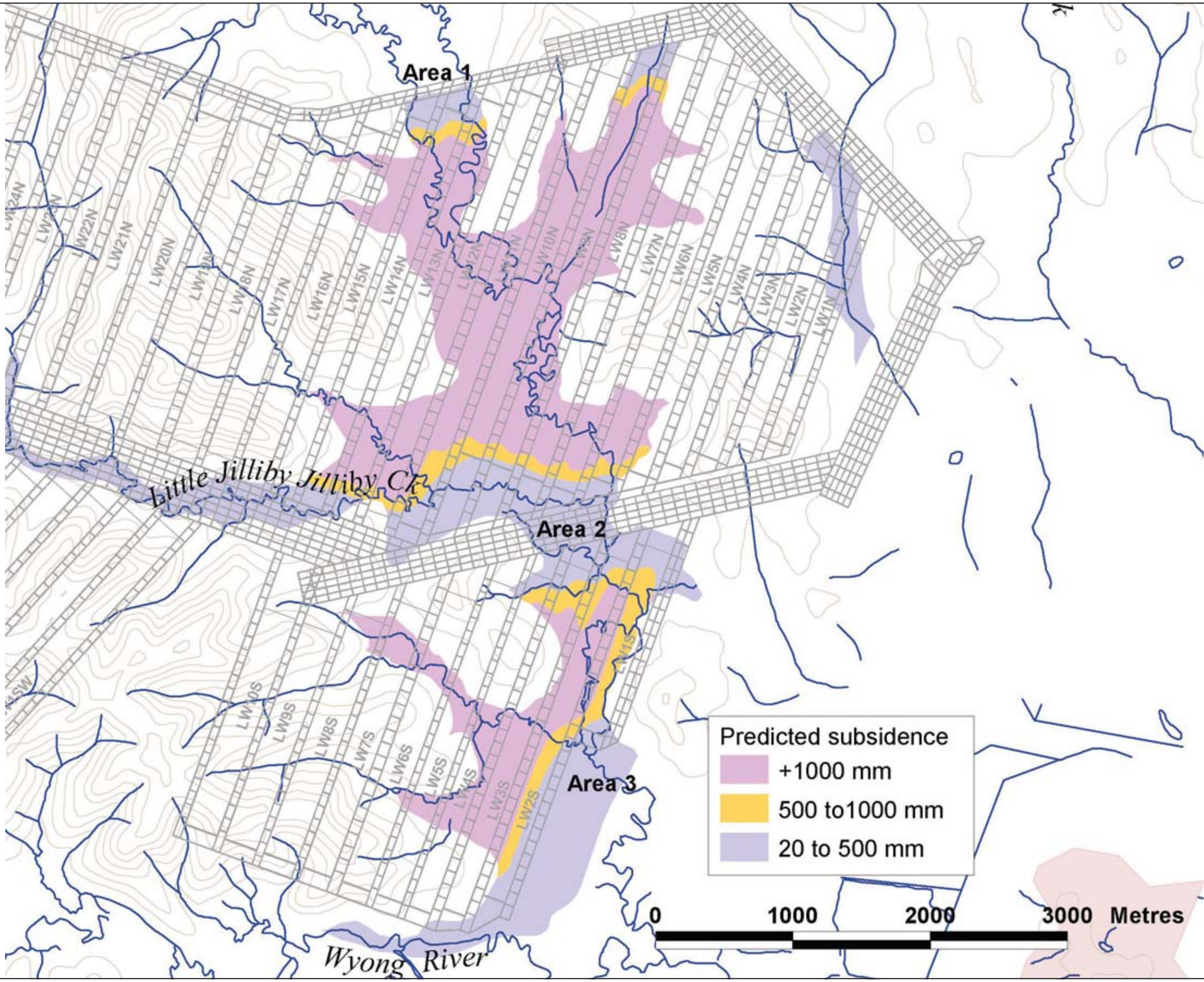
Local Scale Alluvial Groundwater Flows – Day 4

FIGURE 9



Source: MER (2014)

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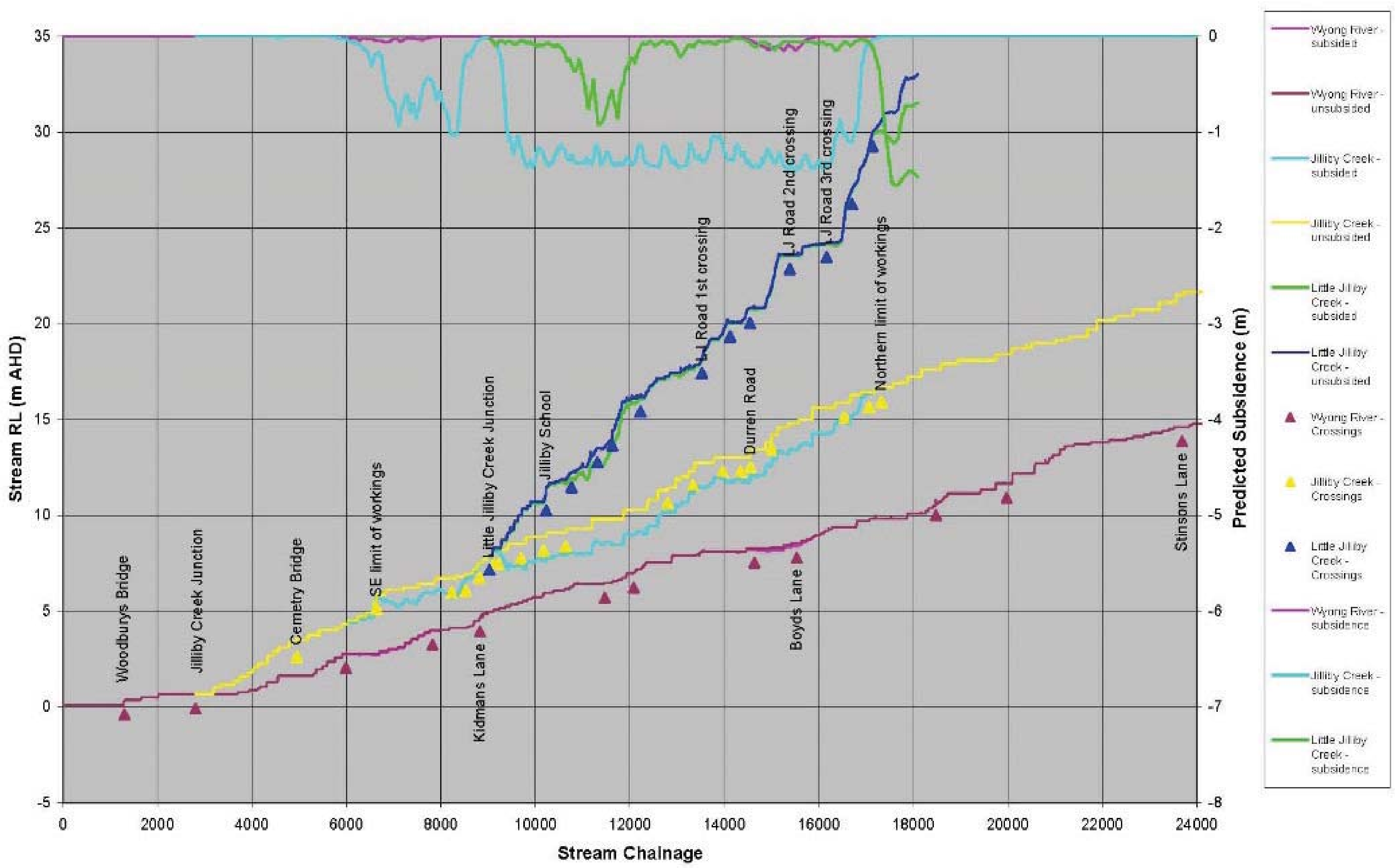
Areas of Longer Term Change in Alluvial Storage

FIGURE 10



Source: GHA (2014)

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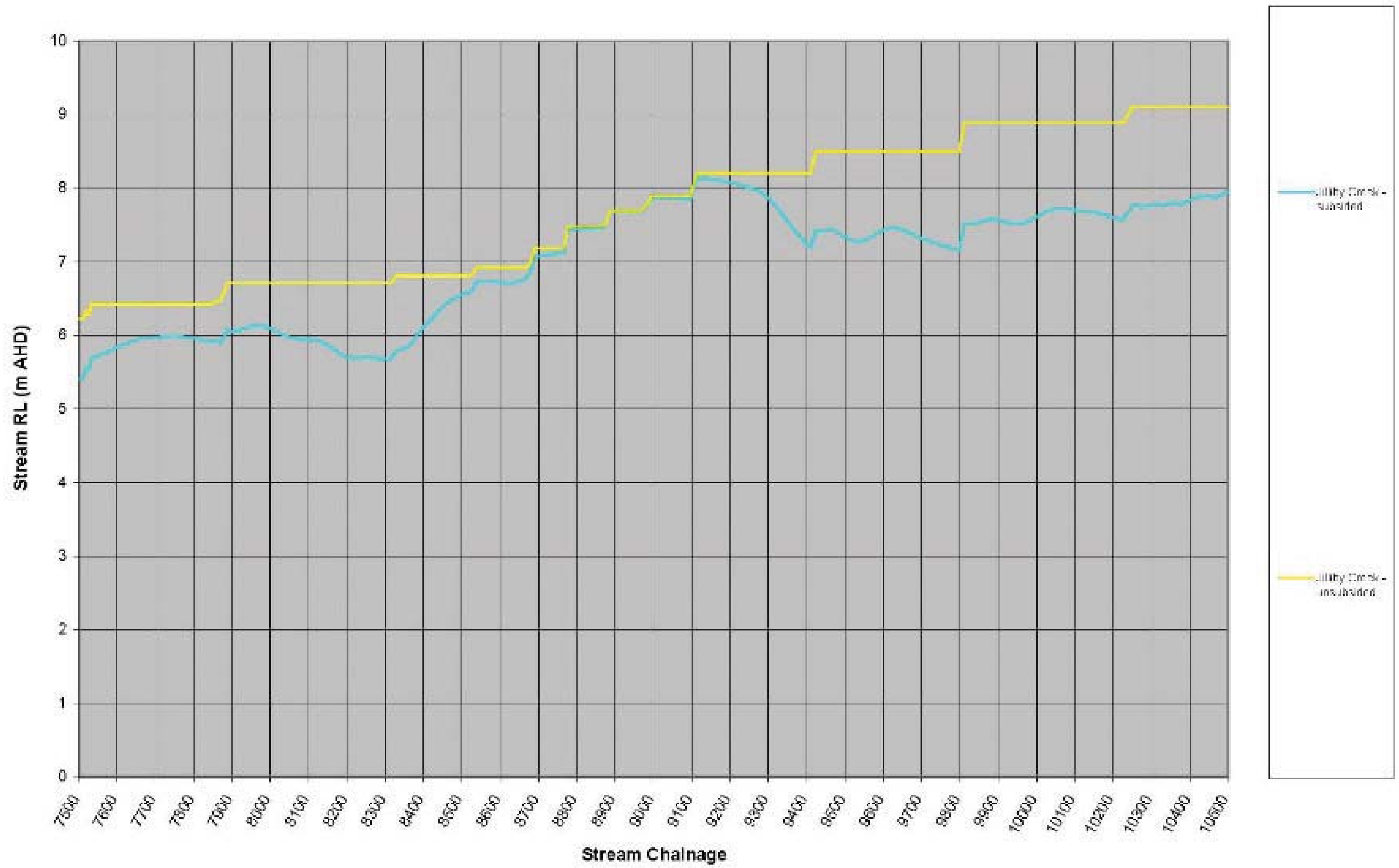
Change in Stream Bed Gradient due to Subsidence

FIGURE 11



Source: GHA (2014)

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Change in Stream Bed Gradient above Primary Headings

FIGURE 12

The water authority's ability to pump water from the Lower Wyong River Weir is limited by its licensing share component. It is unlikely that the minor quantity of alluvial storage will result in any significant reduction in the volumes that would be held in or extracted from the pump pool. In addition, the Water Authority is entitled to pump water from other streams. As currently occurs, the Water Authority can extract its licensed water supply entitlements from a number of water sources in the water supply scheme and no loss to the drinking system would result.

Once the additional storage is returned to the creek as baseflow following re-equilibration of the water table, there will be a slight increase in flows along Jilliby Jilliby Creek. The volume available for water supply purposes will therefore be marginally greater when this occurs. As a result, there is no long term net loss from the water supply scheme. The water authority's ability to extract from the pump pool remains constrained by its licensed entitlement.

2.5 SUMMARY OF IMPACTS

All potential impacts of the Project on water quantity and quality have been assessed. A distinction needs to be drawn between impacts that "take" water from the drainage system and impacts that merely redirect water within the system. Impacts that merely re-direct water do not result in any reduction in catchment yield.

The Project will need to source potable water from the water supply scheme to satisfy operational water demands. The maximum external water requirement is predicted to be 52 ML/year. In most years, the Project will only source potable water for drinking and bathing purposes (10 to 20 ML/year).

The runoff that is captured by the Project's surface facilities (see **Section 2.3.1**) is taken from the respective catchment's drainage system. Within the Wallarah Creek catchment, the runoff that is captured by the Tooheys Road Site is completely offset by the discharges of treated water. The Buttonderry Site captures a portion of runoff from the Buttonderry Creek catchment, but this is partially offset by overflows from sediment dams. Buttonderry Creek flows to Porters Creek which has a large catchment area of 55 km^2. Wallarah Creek is not harvested for water supply purposes and Porters Creek is only relied on as an additional emergency water source during extreme droughts. The maximum impact on the Porters Creek catchment is very minor (approximately 0.1% reduction in catchment area) and will result in only a negligible impact on availability of water retained by Porters Creek weir.

Groundwater leakage induced by depressurisation (see **Section 2.4.1**) is a minor but ongoing take from the drainage system. The alluvium is expected to be fully recharged as the rate of leakage (2 ml/m^2/day) is greatly exceeded by the average rate of rainfall recharge (130 ml/m^2/day). The proportion of the rainfall required to recharge the aquifers (1.5% of rainfall recharge) would no longer be available to runoff to Jilliby Jilliby Creek. In context, the vast majority (over 90%) of the Wyong River water supply catchment is unaffected by mining induced leakage and the consequential impacts on catchment yield are expected to be negligible. Leakage may result in a worst case reduction in the volume available for water supply purposes of 36.5 ML/year. This impact represents less than 0.05% of the current annual average yield of the Gosford-Wyong Water Supply Scheme (46,000 ML/year excluding the potential contribution from the Hunter water pipeline).

Groundwater inflows to the mine workings are largely derived the coal seam and the adjacent coarse grain sedimentary rocks. Since the water supply scheme does not source water from the coal seam or basement rocks, mine water make will not affect the water supply scheme.

The impact of subsidence induced cracking (see **Section 2.4.2**) is a redirection of surface water into shallow cracks within the upper horizon of bedrock. The infilling of the cracks constitutes a "one-off" taking of water from the system. Once the cracks fill with water, surface runoff volumes will be restored. In the case of transient cracking, the water will be returned to the system once the cracks close. Semi-permanent cracking will retain the water for a longer period, but runoff volumes will return to pre-subsidence volumes once the cracks become inundated. Therefore, subsidence induced shallow cracking may result in a "one-off" short-term loss to the water supply scheme.

The change in alluvial storage due to subsidence (see **Section 2.4.4**) is a temporary re-direction of a proportion of surface water into the alluvial sediments. The re-directed runoff is not immediately available to contribute to stream flow. This additional water stored in the alluvium will be returned to the stream as baseflow. The slight increase in alluvial storage may temporarily reduce flows at the Lower Wyong River Weir during the undermining of the alluvium. However, once the alluvium has fully subsided, the additional alluvial storage will be returned to Jilliby Jilliby Creek, resulting in a minor increase in flows at the weir. Therefore, the change in alluvial storage does not result in any long term net loss in water available for town supplies.

2.6 MITIGATION AND COMPENSATORY MEASURES

WACJV acknowledges the PAC's expectation that the Project should ensure "No Net Loss" of water from the Gosford-Wyong Water Supply Scheme. WACJV confirms that it is technically feasible to return surplus treated water generated by the Project to the water supply catchment.

WACJV agrees to consult with the Central Coast Water Corporation, WSC, NSW Office of Water and other appropriate Government authorities to develop a framework agreement (between all parties) regarding opportunities and strategies for managing surplus treated water for the benefit of the water supply scheme. The agreed strategy for the provision of surplus treated water will be implemented prior to the commencement of longwall extraction under the Jilliby Jilliby Creek alluvial floodplain. The framework agreement will encompass the principles of adaptive management through the combined application empirical monitoring data and calibrated predictive models.

2.7 RESPONSES TO PROFESSOR PELLS' SUBMISSION

2.7.1 Source of Groundwater Inflow

The predicted peak inflow of 2.5ML/day is sourced largely from storage within the coal seam (see MER, 2013, Section 8, pp. 32) with a very small contribution from alluvium leakage of about 0.02 ML/day. The stored groundwater is part of a regional groundwater flow system that is in quasi-equilibrium with natural recharge. That equilibrium is also governed by the geometry and the material properties (hydraulic conductivities and porosities) of the rock strata.

Groundwater flow modelling has been employed to investigate changes in the flow system due to the Project. Model outcomes demonstrate that significant strata depressurisation will occur above the proposed mining operations and that some downwards leakage from the alluvial lands will ultimately occur. These alluvial lands host the drainage systems to which Professor Pells refers. However, the underlying strata (beneath the alluvial lands) exhibit low hydraulic conductivities that are predicted to support rates of leakage losses from the alluvium of the order of 2 millilitres/day per square metre of alluvial land or approximately 0.02 ML/day for the entire alluvium. A small part of this leakage might be viewed as diversion of groundwater flows away from baseflows during extreme drought periods while the remainder is simply vertical (downwards) leakage at the base of the alluvium. The impact on baseflows for Jilliby Jilliby Creek above the confluence with Little Jilliby Jilliby Creek, is estimated to be a reduction of about 0.001 ML/day at the end of mining. This estimate is based on interrogation of boundary conditions representing stream systems in the groundwater flow model.

Measurable impact on baseflows to streams is more likely to be attributed to changing flow patterns within the alluvial lands associated with subsidence of those lands rather than leakage losses from the alluvial lands to the deeper strata. The calculated leakage losses to deeper strata are based on the finding that vertical hydraulic conductivities in the constrained zone are not enhanced as a result of mining. This finding is based on numerical modelling (FLAC model) of subsidence using geological and geotechnical data obtained from the extensive exploration program for the Project.

2.7.2 Impact on Borehole Yield

There will be substantial depressurisation of deep rock strata within the proposed footprint of mining. Any boreholes that draw water from partially depressurised strata should exhibit some lowering of the standing water level within the borehole casing. However loss of yield is not expected to be significant since only the confining (pressure) head above the water bearing zone(s) will be reduced. Explicitly, there are two storage components that contribute to borehole yield. These are the confined or elastic storativity and the unconfined drainable porosity. The water released per metre decline in pressure head from confined storativity is typically one or more orders of magnitude lower than the volumetric release from drainable porosity when an aquifer becomes unconfined. Consequently, any boreholes that have a reduced pressure head above the water yielding zone as a result of mining, are mainly affected by loss of confined storativity. Existing boreholes within the mine footprint are predicted to retain a pressure head (albeit potentially reduced) above their respective water bearing zones when impacted but unconfined yield is expected to be largely maintained.

The head equipotentials prepared by Professor Pells (and appended to PAC letter) are approximately correct. However it is noted that the depths of determination of head losses in the three hypothetical boreholes are greater than any existing boreholes identified within the mine footprint; hypothetical borehole A is 300m deep, B is 70m deep and C is 150m deep.

The existing boreholes intercept water bearing zones at depths less than 50 m (see Table 5 of the Groundwater Impact Assessment). At the recorded depths, the loss of confined head is predicted to be generally less than 5 m, resulting in very minor potential loss of yield.

3 IMPACTS ON JILLIBY JILLIBY CREEK

This section suggests appropriate performance measures for evaluating impacts on Jilliby Jilliby Creek and Little Jilliby Jilliby Creek.

The Project will not extract water from any watercourse and only has the potential to impact Jilliby Jilliby Creek and its tributaries through subsidence. Every section of the creek that will be undermined will typically experience four 'episodes' of subsidence associated with the progression of longwall panels. The majority of subsidence will occur when the longwall directly underlying a creek section is extracted. A smaller amount of subsidence will occur during the subsidence episodes associated with the previous longwall panel and the two subsequent longwall panels are mined. Each of these four panels will result in a subsidence 'episode'. The incremental subsidence from these four episodes combine to result in the total subsidence at any location.

Due to the dynamic nature of streams in the locality of the Project, many of the changes associated with subsidence are capable of being repaired by natural hydrological processes. Therefore, it is not necessary to undertake remediation measures as soon as physical changes are identified. In fact, undertaking in-stream works can result in greater harm than the impact that it seeks to remediate due to potential vegetation disturbance associated with remediation works. In most instances, it is preferable to allow a stream to repair itself through readjustment of the altered geometry, as occurs in the existing stream system.

The assessment of hydraulic impacts on the affected streams presented in the EIS indicates that post-subsidence hydraulic parameters are likely to be within the range of existing values. Hence, the focus of the management approach, to be documented in management plans, will be regular monitoring of physical and vegetation changes in affected stream reaches. Regular visual inspections and comparative ground level survey will be undertaken to assess changes in the streams during mining. Event-based monitoring of suspended sediment will also be undertaken upstream of, within and downstream of active subsidence areas as an additional indicator of potential impacts. Based on the monitoring data, a suitably qualified expert will provide advice on whether remediation works are needed, or whether the impact is capable of being remedied by natural processes. If remediation works are required, WACJV will undertake the reactive repairs (using soft engineering techniques wherever practicable).

WACJV's aim will be to ensure that once a section of creek has been fully impacted by subsidence (i.e. after completion of the four longwall panels comprising the subsidence episodes at that creek location), the stream will have similar characteristics to pre-disturbance conditions and there will be no impacts that "Post cannot be repaired by natural processes. Impacts that are capable of being naturally repaired are considered to be consistent with the definition of "minor impacts". WACJV suggests the following performance measures for Jilliby Jilliby Creek and Little Jilliby Jilliby Creek:

- *"No greater than minor impacts following the completion of all longwall panels with the potential to subside a section of the stream";* or
- *"Post-subsidence stream characteristics consistent with undisturbed reaches and pre-subsidence conditions"*.

4 FLOODING

This section describes the predicted impacts of the Project on flooding in relation to pillar yield, potentially developable land, commercial enterprises within the floodplain and emergency vehicle access.

4.1 PILLAR YIELD INFLUENCE ON FLOOD IMPACTS

Under a scenario where none of the pillars yield, the total predicted subsidence would reduce to approximately 55% of maximum predicted subsidence (where all pillars yield). As part of the Flood Impact Assessment, sensitivity analysis of flood levels and flows was undertaken for 50%, 75% and 100% of maximum subsidence. In the case of both 50% and 75% of maximum predicted subsidence, flood depth impacts were reduced at all locations (refer to Table 6.6 of Flood Impact Assessment). Reduced flood depths are also expected for a case where non-yielding pillars result in lower total subsidence.

In the hypothetical case of a part of a pillar failing to yield in an isolated location, changes to the predicted flood impacts would be limited to the area within 300 to 500 m of the non-yielded zone. There would be a slight increase in flood depths (less than 30 mm) upstream of the non-yielded zone. The flood depths directly over the non-yielded zone will reduce by a magnitude approximately equal to the resultant reduction in subsidence (i.e. up to 50% of 1.4 m or 0.7 m reduction in flood depth). Downstream of the non-yielded zone, there is expected to be a slight decrease in flood depth (less than 30 mm).

Depending on the location of any hypothetical non-yielding, there may be some localised changes to the predicted flood impacts on properties and access routes. However, overall impacts elsewhere in within the Subsidence Impact Limit will be unchanged. If a non-yielding zone were to occur under the flood fringe there would be no significant adverse impacts upstream or downstream of the zone but there would be a beneficial impact to dwellings or properties directly above the non-yielded zone. Within the flood storage zone, where flow velocities are less than 0.6 m/s, additional adverse impacts due to localised non-yielding of a pillar would be very small. Flood depth may increase by approximately 10mm to 20mm of within approximately 300m upstream of the non-yielded area.

Within the floodway, where flow velocities are higher (up to 2.2 m/s), the increase in flood depths (afflux) could be over 40 mm immediately upstream of an non-yielded zone. However, this would be attenuated over time as scour and accretion within the main channel re-establishes an average grade similar to existing stream bed grades. This process was described in **Section 2.4.4**.

The changes to flooding impacts due to an isolated instance of a pillar not yielding is considered a hypothetical scenario, as the subsidence studies have indicated that such a situation is almost impossible.

4.2 POTENTIAL IMPACTS ON LAND SUITABLE FOR FUTURE SUBDIVISION

The Flood Impact Assessment (GHA, 2013) identifies the dwellings and properties that are not inundated during the 1% Average Exceedance Probability (AEP) flood under existing (unsubsided) conditions but would become inundated by the 1% AEP flood after subsidence (refer to section 6.6 of Flood Impact Assessment). There are only 5 dwellings that would become flood affected after subsidence that are not currently within the 1% AEP flood extent. Four of these dwellings are located in the Dooralong Valley and the other is located near Hue Hue Creek. Mitigation measures for flooding are proposed to be developed on a case by case basis with individual property owners during the preparation of Property Subsidence Management Plans (PSMPs).

The increase in flood extent due to subsidence is shown in **Figure 13**. There are only four properties that will experience a significant increase in the property area that will become inundated during a 1% AEP flood. These properties are located near the intersection of Jilliby Road and Beavers Lane. A number of other properties are expected to experience minor increases in the property area that will become inundated during a 1% AEP flood.

The *Wyong Local Environment Plan 2013* (Wyong LEP) prescribes a "minimum subdivision lot size" (clause 4.1). Land cannot be subdivided into lots that are smaller than the minimum lot size. The minimum lot size for the four properties near the intersection of Jilliby Road and Beavers Lane varies from 20 ha to 40 ha. All four of these properties are smaller than the minimum lot size, and are therefore not eligible for subdivision. Therefore, the flooding impacts of the Project do not preclude any potential subdivisions that would currently be permissible under the Wyong LEP.

Increases in flood depths over land already within the 1% AEP flood extent will not have impacts on potential for redevelopment other than to set higher freeboard requirements for residences. Future dwellings will need to be constructed at higher levels to account for subsidence (in accordance with MSB's directions) to comply with Wyong Shire Council's freeboard requirements. Mitigation measures for all adversely affected landowners will be developed and implemented through PSMPs.

4.3 POTENTIAL IMPACTS ON COMMERCIAL ENTERPRISES

There are no commercial enterprises located within the area that is currently not flood prone, but will become flood prone after subsidence. There is one active turf farm located on Durren Road (see **Figure 13**) that is currently within the 1% AEP flood extent. This turf farm has an operational area of approximately 40 ha and undergoes two harvesting periods per year. This farm will experience more frequent flooding and for slightly greater durations.

This turf farm will experience an increase in flood duration of less than 30 minutes (for all floods) and an increase in flood depth of approximately 0.4 m during the 1% AEP flood event. There will be no significant increase in the frequency that the turf farm will be inundated. There is also no significant increase in the extent of the property that is subject to inundation. This property is located within the existing 20% AEP flood extent both before and after subsidence.

There is a decommissioned former turf farm immediately downstream of Little Jilliby Jilliby Creek (between Jilliby Jilliby Creek and Dickson Road). This property has not operated as a turf farm for several years and has since changed ownership and is currently being used for grazing. The Water Access Licence (for 185 units) formerly used for the turf farm was purchased by the proponent in 2013. At this property, there will be a small decrease of 0.1 m to 0.3 m in flood depth and a decrease in duration of flooding during a 1% AEP event.

Turf farms and other commercial enterprises located outside the Subsidence Impact Limit will not experience any changes to flood behaviour as a result of the Project.

Compensation for commercial enterprises (such as turf farms) is governed by the *Mining Act 1992*. Section 265 of the Mining Act states:

> *"On the granting of a mining lease, a landholder of any land (whether or not subject to the lease) becomes entitled to compensation for any compensable loss suffered, or likely to be suffered, by the landholder as a result of the exercise of the rights conferred by the lease"*.

The term "compensable loss" is defined in section 262 of the Act and includes *"damage to the surface of land, to crops, trees, grasses or other vegetation (including fruit and vegetables)"*. Therefore, compensation will be provided for loss of agricultural productivity as a result of mining. In accordance with section 265 of the Mining Act, WACJV will consult with landowners regarding compensation for any losses attributable to the Project.

4.4 POTENTIAL IMPACTS ON EMERGENCY VEHICLE ACCESS

The changes in flood durations for access routes was assessed in the Flood Impact Assessment (refer to Sections 6.7 and 6.8). In summary, there are 15 key low points servicing 3 dwellings in the Yarramalong valley and approximately 218 dwellings in the Dooralong valley that will be adversely affected. The 3 dwellings in the Yarramalong valley are only slightly affected due to increased flooding of driveways and internal property access and all have unchanged secondary/emergency access through neighbouring properties.

A number of mitigation options were suggested in Section 7.3 of the Flood Impact Assessment to address the long term reinstatement of general access. These options mainly involved raising existing roads and, to a limited extent, bridges. It would be possible in some locations to make roads that are currently flood prone fully accessible during floods (even after subsidence). However, raising of roads to completely avoid flood may have adverse effects on dwellings and properties immediately upstream of the road modifications. Therefore, the aim of mitigation measures is to reinstate the status quo (i.e. no increase to existing durations of road closures during large floods) rather than to make access routes entirely flood proof.

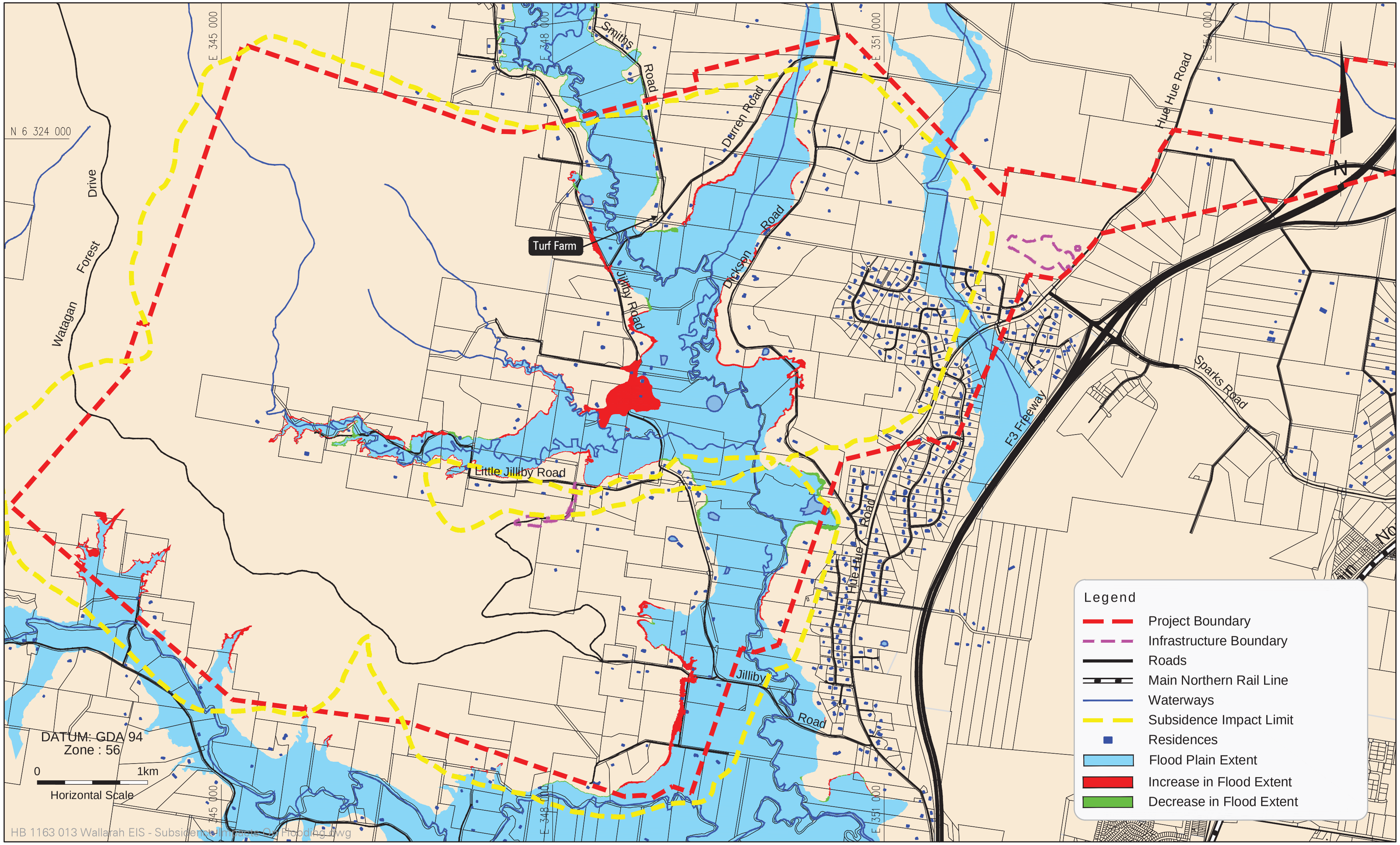
Most dwellings, other than those located within the 1% AEP flood extent (30 existing plus 4 new dwellings), have viable emergency evacuation routes via secondary roads (as described in Section 7.4 of the Flood Impact Assessment).

The primary access routes to dwellings in the Dooralong Valley are Jilliby Road and Little Jilliby Road. Section of both these routes are flood prone under existing conditions. The effect of subsidence is an increase in the duration of inundation at key low points along these routes. The changes to duration of inundation are presented in Table 6.10 of the Flood Impact Assessment. If an emergency arises whilst the primary access routes are inundated, emergency vehicles must rely on secondary access routes. Access to dwellings via secondary access routes will not be affected by the Project. However, due to the increases in flood duration along the primary access routes, emergency vehicles will need to rely on secondary routes for a longer period.

Dickson Road serves as the secondary access routes for most dwellings in the Dooralong Valley. Dickson Road is predicted to experience an increase in inundation duration at low point D70 (see Table 6.10 of Flood Impact Assessment) as a result of subsidence. The section of Dickson Road that is flood prone is located at the flood fringe.

The secondary access route for dwellings in Jilliby is the Watagans Forest Drive. This route is unaffected by flooding but involves a substantial increase in travel times. As is currently the case, if an emergency occurs during flooding, and time is of the essence, emergency access via other modes of transportation (e.g. rescue helicopter) may be utilised instead of vehicular access. In this area, retrieval of patients by helicopter would be the preferred method of emergency rescue, regardless of flooding or other events impeding road access.

Therefore, there are measures for ensuring that emergency access is maintained during flood events. WACJV will be available to assist with the provision of data and expert advice to WSC for emergency planning.



WALLARAH 2 COAL PROJECT

Subsidence Impacts on Flooding - 100 Year ARI Flood

FIGURE 13

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5 SUBSIDENCE

This section discusses the implications of the chain pillars not yielding, the duration of subsidence impacts, and the interaction of the Project with the Buttonderry Waste Management Facility.

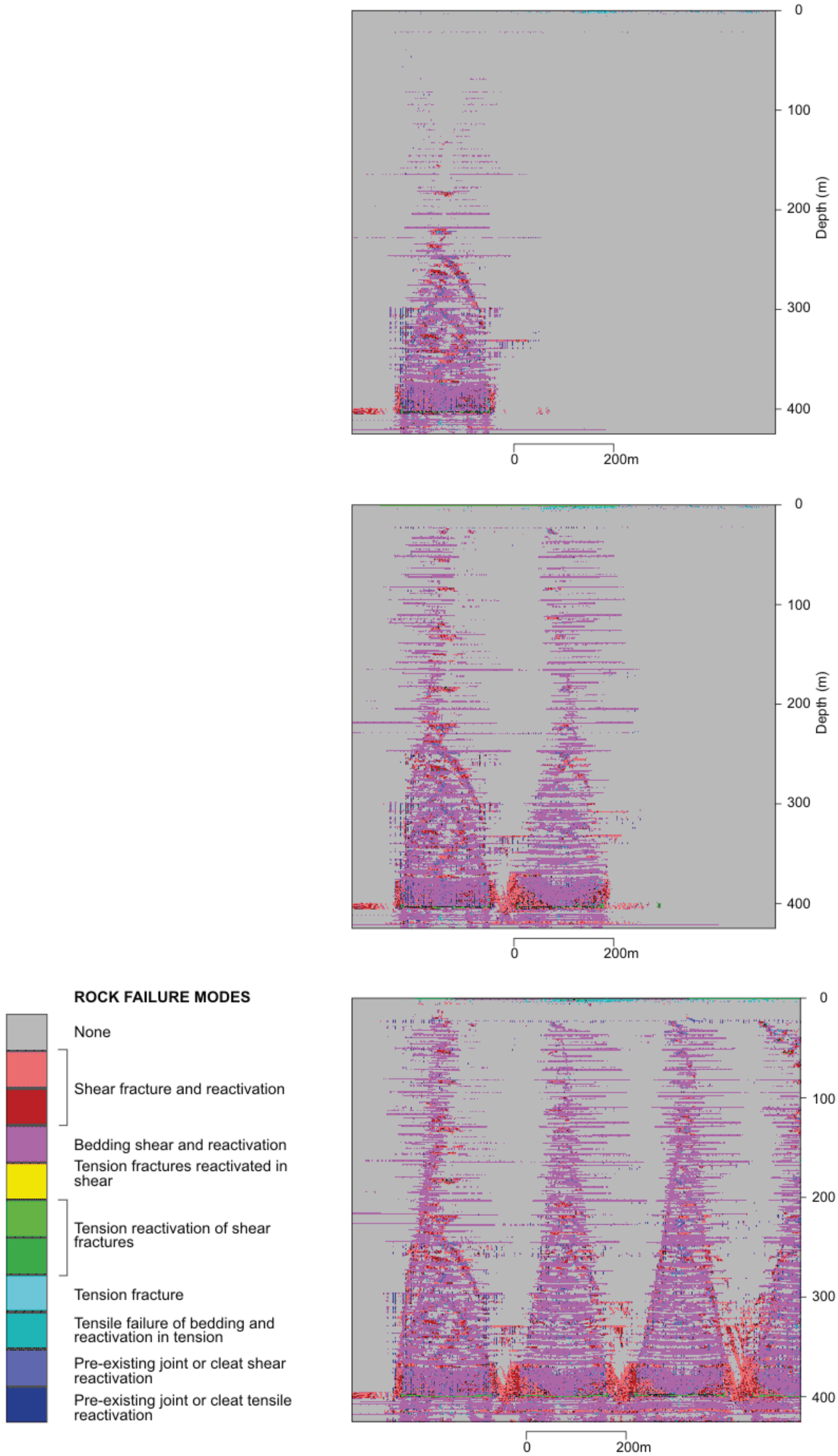
5.1 YIELDING PILLAR SYSTEM PROPOSED FOR THE PROJECT

The pillar system comprises the coal seam and the strata above and below the seam. If any part of this system fractures, its capacity to transfer stress through the other components of the system is severely limited and the overall strength of the system is reduced.

Yielding of pillars in this manner is common in deep mines and has been validated by micro seismic monitoring conducted in research studies. Computer modelling of such cases also demonstrates the strata fracture in the pillar system as clearly indicated in **Figure 14**. Cases of known fracture related yield behaviour are documented for Appin mine and the subsidence characteristics are consistent for the southern coalfield mines operating in the Bulli seam. Recent back analysis indicates that the phenomenon also occurs in the Greta seam in the Cessnock area. The empirical data indicates that typical chain pillars exhibit signs of yield at depths of 250 m or greater. Since the depths of cover for the Project exceed 350 m, the probability of the pillars not yielding is very low.

For the Project, it is planned for the strata in the roof and the immediate floor to fracture, allowing the pillar system to yield but maintain a design load. In this manner, the ground will subside and cause load to develop in the goaf area between the chain pillars. This goaf load and the yield load on the pillars will therefore allow a stable load balance and controlled subsidence of the overburden.

The aim of incorporating this phenomenon into the chain pillar design is to ensure that there will be no time dependent sudden collapse of the pillars, as has been attributed to some cases of old workings on soft floors in the Lake Macquarie area.



Source: SCT (2012)

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Predicted Fracture Development

FIGURE 14

5.2 EFFECT OF NON-YIELDING PILLARS

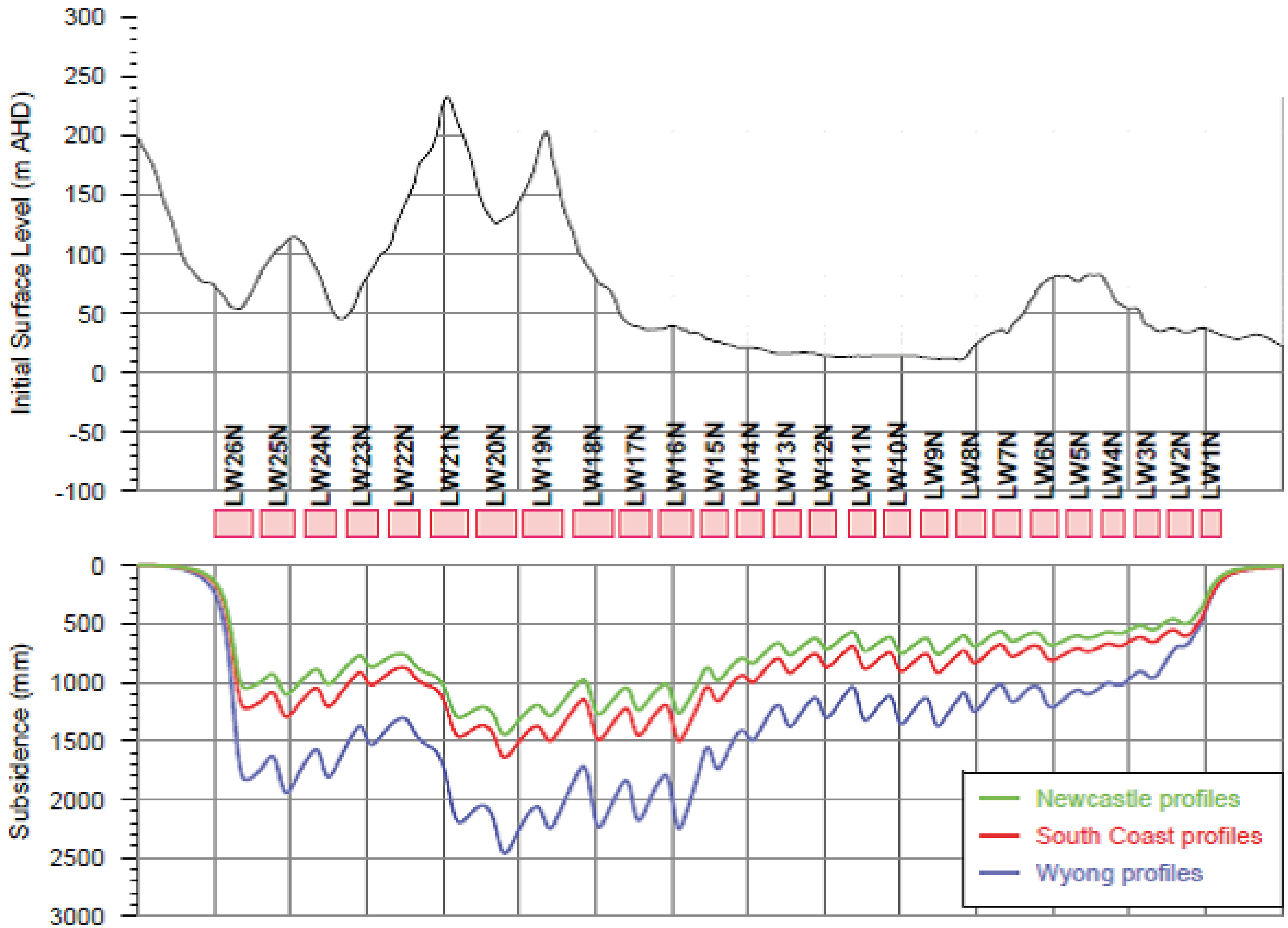
Observed subsidence profiles over mined panels include components associated with sag subsidence, elastic pillar compression, elastic compression of the surrounding strata, yielding of the pillar system and various other geological and topographical movements. In the case of the Project, the detailed chain pillar design strategy includes consideration of the sag subsidence, the elastic compression of the pillar, the overlying and underlying strata, and the yielding of the pillar system.

The Subsidence Modelling Study (SCT, 2012) indicates that the predicted levels of subsidence for the Project are one and a half to two times higher than the predicted levels of subsidence in Newcastle and South Coast regions (see **Figure 15**). This is a combined result of the relatively weak strata immediately above and below the seam, the deeper depths of cover, the lack of massive strata within the overburden, the relatively large extracted seam thickness and the known instability of chain pillars at these depths. This latter factor has been incorporated into the chain pillar design to mitigate the uncertainty and unpredictability of unplanned pillar collapses as has been experienced in some old workings in the Lake Macquarie area.

Figure 15 incorporates a large vertical exaggeration to clearly illustrate the ground profile and predicted subsidence profiles. The vertical exaggeration for the surface topography is approximately 10 (10V to 1H) and the vertical exaggeration for the subsidence profiles is approximately 100 (100V to 1H).

The Subsidence Impact Study and associated planning has therefore been based around the conservative premise that the subsidence will be significantly greater than that predicted and observed elsewhere.

In the highly unlikely event that none of the pillars yield, the predicted vertical subsidence over both chain pillars and longwall panels will be significantly reduced. However, the tilts and strains will not be higher than those currently predicted. This is because the proposed longwalls have width-to-depth ratios ranging between 0.3 and 0.5 (i.e. they are subcritical in width). That is, the depth of the overburden is approximately two to three times the widths of the proposed longwall blocks.



Source: MSEC (2014)

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WALLARAH 2 COAL PROJECT

Comparative Subsidence Profiles based on Newcastle, South Coast and Wyong Prediction Curves

FIGURE 15

In this case, the overburden essentially acts as a deep beam spanning between the chain pillars and solid coal edges. The vertical subsidence at the surface is governed by two main components:

- Compression of the chain pillars; and
- Sagging of the strata between the chain pillars and solid coal edges.

The vertical subsidence directly above the chain pillars is primarily the result of the chain pillar compression component. The vertical subsidence directly above the extracted voids results from the combination of the chain pillar compression and sagging components. Hence, the additional vertical subsidence above the panels, compared to that above the chain pillars, is primarily the result of the sagging component.

If it were to be assumed that the chain pillars for the Project did not yield as designed, there would be a reduced pillar compression component, which would result in reduced vertical subsidence across the proposed mining area, not just above the chain pillars. This is because the difference in the vertical subsidence above the panels compared to that above the pillars does not increase, as this is governed by the sagging component.

Within the floodplain area, the relative difference due to sagging is only in the order of 300 to 400 mm. Consequently, it is impossible to portray this difference on a cross-section without enormous vertical exaggeration since it represents a 300-400 mm deep flexure across a span of approximately 200 m. Furthermore, these subsidence troughs are not apparent in the post-mining topographic model since their amplitude is within the normal topographic variation of the floodplain.

The comparative subsidence profiles for the yielded, non-yielded and partially yielded cases are illustrated diagrammatically in **Figure 16**, **Figure 17** and **Figure 18**. In normal scale, the small difference between unsubsided (pre-mining) and subsided (post-mining) topography is indistinguishable on a figure. These figures use a 5:1 vertical exaggeration (500%) in order to show the difference in surface ground levels for the three cases of different pillar response.

Figure 16, **Figure 17** and **Figure 18** show the existing and subsided surface profiles along Prediction Line 1 (refer to Subsidence Modelling Study) resulting from the extraction of the proposed longwalls LW9N to LW13N. **Figure 16** shows the case where the chain pillars yielding due to deep cover and weak floor and roof conditions (the proposed case). **Figure** 17 illustrates the case where the chain pillars do not yield despite the deep cover and weak roof and floor conditions (very unlikely case). **Figure 18** shows a theoretical case where only chain pillars at LW11N and LW12N do not yield (very unlikely case).

Figure 16 and **Figure 17** demonstrate that the subsidence is very regular across the profile in both the yielded and non-yielded cases, although involving reduced subsidence in the latter case. Importantly, there is insignificant differential subsidence between the various panels and chain pillars across the profile and this will be within background topographic variation.

The partially yielded pillars case (**Figure 18**) shows only minor and gradual changes in surface gradient.

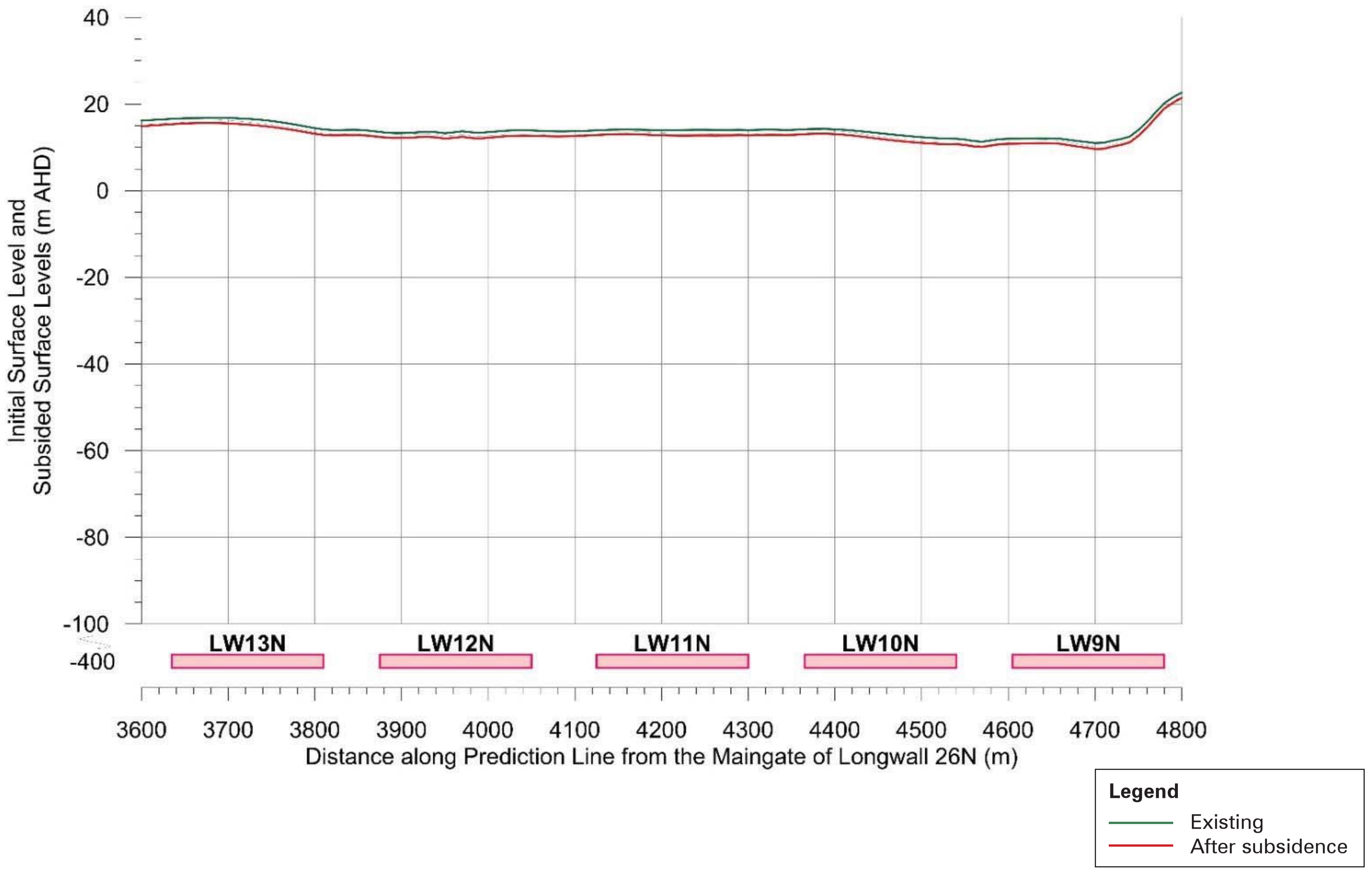
Subsidence behaviour is analogous to a beam supported on springs where bending of the beam represents the sagging component and compression of the springs represents the pillar compression component. Non-yielding chain pillars would be analogous to stiffer springs, which reduce the vertical movement along the full length of the beam.

The potential for impacts on natural and built features on the surface are typically governed by the differential movements (i.e. tilt, curvature and strain) rather than the absolute movements (i.e. vertical subsidence). These differential movements are governed by the variations in the subsidence profile across the subsidence bowl, which for subcritical longwall panels, are governed by the sagging component. The potential for increased ponding along the streams is dependent on the absolute vertical subsidence, which is reduced if the pillars do not yield. Hence, the potential impacts on the natural and built features at the surface would not increase as a result of the chain pillars not yielding.

If pillar yield does not occur, the impacts on surface features will be similar to or less than the impacts presented in the Subsidence Predictions and Impact Assessments (MSEC, 2013) including the potential impacts on stream morphology and flow characteristics, and all types of built infrastructure.

The timeframes for the development of subsidence for the non-yielding chain pillar case are similar to those for the yielding pillar case (discussed in **Section 5.4**).

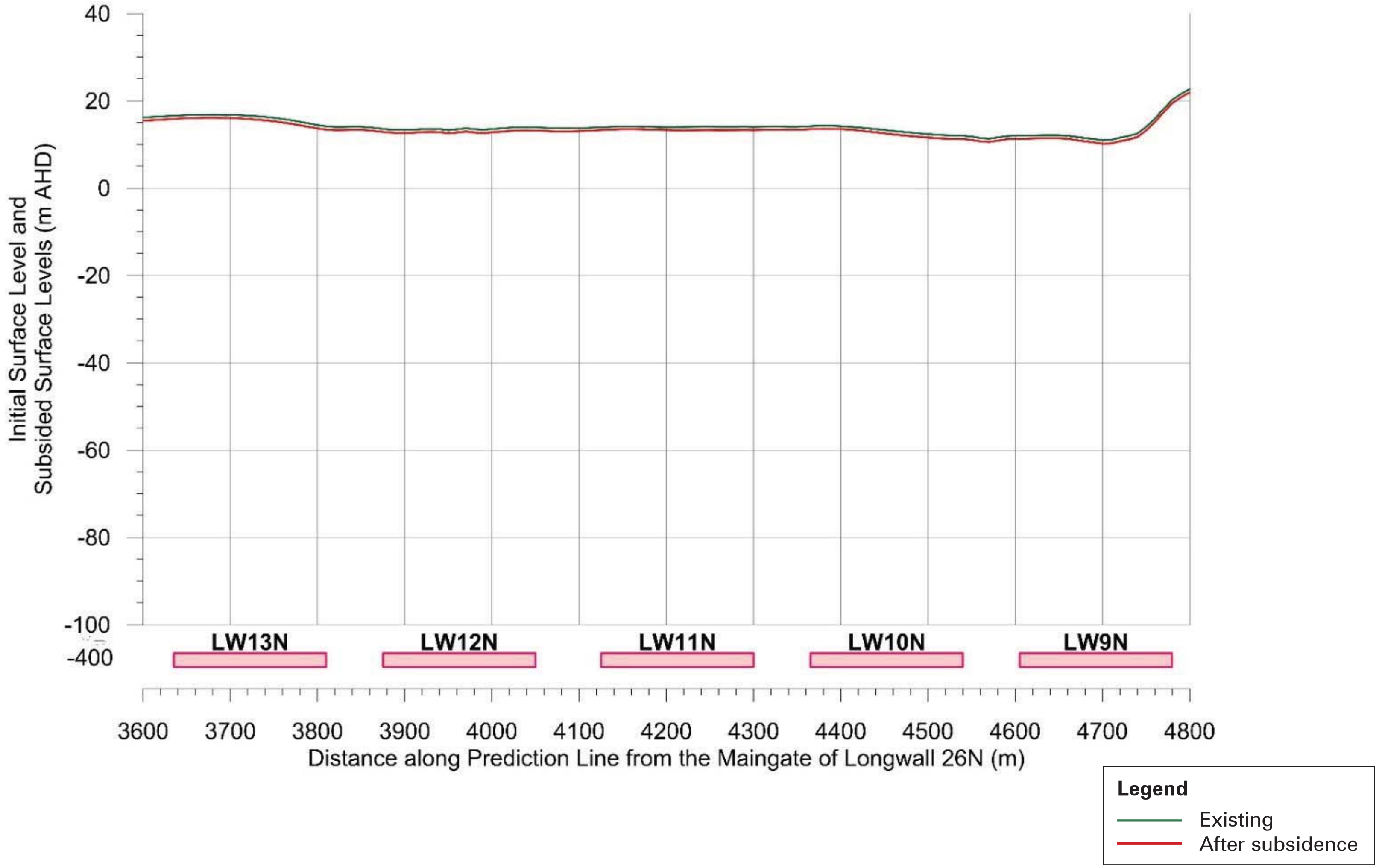
Experience in deep coal mining, as proposed by the Project, indicates that the likely occurrence of random, non-yielding of pillars is very low. It would be analogous to removing all but one or two piers from beneath a building and expecting those piers not to crush. If random non-yielding were to occur, then the worst case scenario would be the generation of tilts and strains lower than those that would occur at a final longwall goaf edge adjacent to an unmined area. For the Project, the maximum tilts and strains predicted at the boundary of mined and unmined areas are predicted to be 15 mm/m and 4 mm/m respectively. While it could be expected that a structure subjected to these movements would remain "safe, serviceable and repairable", it would probably fall into Repair Category R3 (Substantial Repair) or R4 (Extensive Repair), as defined in the Subsidence Predictions and Impact Assessments. This categorisation is mainly due to the likely need for the structure to be re-levelled. All repairs would be undertaken by the MSB.



Source: MSEC (2014)

Ground Profiles Based on Pillars Yielding

FIGURE 16



Source: MSEC (2014)

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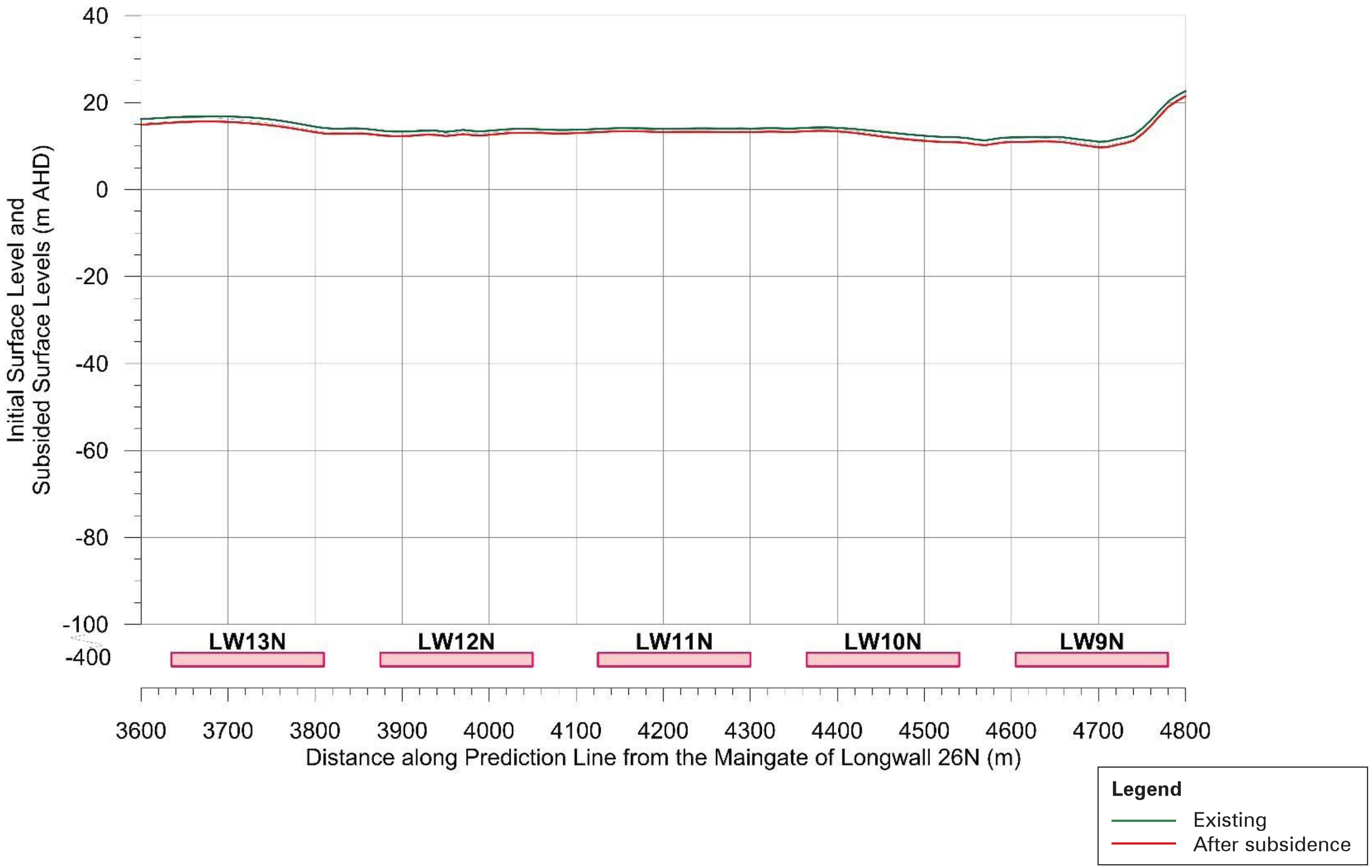
Ground Profiles Based on Pillars Not Yielding

FIGURE 17



Source: MSEC (2014)

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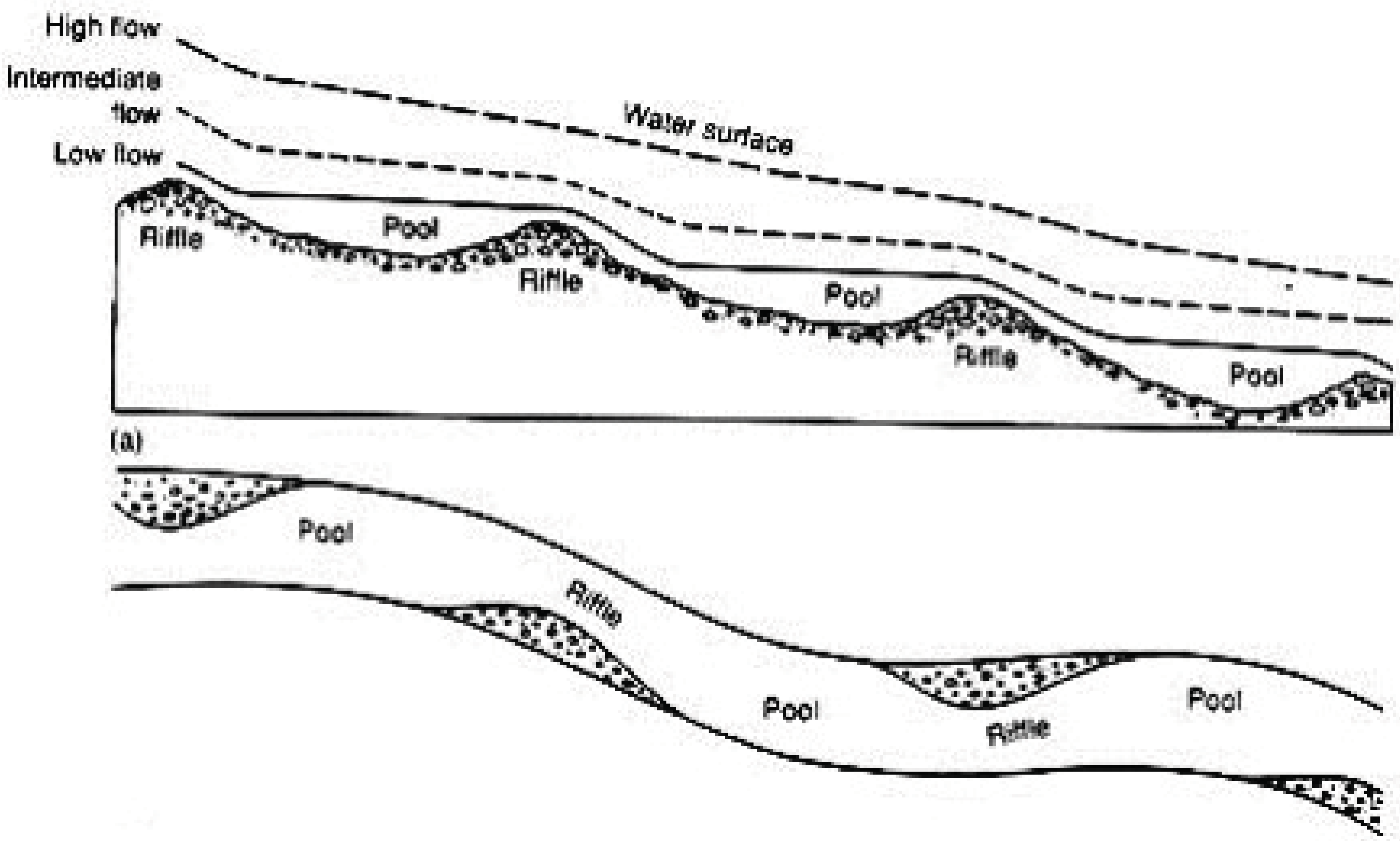
Ground Profiles Based on Two Pillars Not Yielding (LW11N and LW12N)

FIGURE 18

5.3 IMPACTS ON STREAM MORPHOLOGY

Modelling results and past experience indicate that chain pillars will yield to achieve a relatively uniform topographical outcome across the mined area at the end of mining. A chain pillar which has not yielded as expected, would produce a more locally undulating ground surface than expected (as there will be less subsidence above the un-yielded pillar location). Stream morphology impacts of an un-yielded pillar would depend on the location, however expected impacts can be generalised as follows:

- Initially, the un-yielded pillar would cause a decrease in bed slope upstream of its location. There will also be a localised increase in bed slope downstream of the chain pillar. This process is similar to the natural development of a pool and riffle sequence of a stream (see **Figure 19**). The change in bed slope and the development of a pool and riffle sequence is expected to be indistinguishable from the existing natural pool and riffle sequence.
- For low flows, stream velocities upstream of the non-yielded zone will decrease, forming a pool and potentially a deposition zone. Downstream of the non-yielded zone, stream velocities will locally increase. In locations where the bed is well armoured, it will form a riffle. If it is not armoured, the increased bed slope may cause headward erosion, which will eventually erode the localised undulation caused by the non-yielded pillar.
- For medium and high flows, the change in hydraulic gradient is not significant, as shown in, therefore no significant change in bed and channel erosion is expected.



Source: Dunne & Leopold (1978)

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Cross-section and Plan view of Pool Riffle Sequence

FIGURE 19

5.4 TIMING OF SUBSIDENCE

The subsidence will develop gradually at the surface as the longwall face mines directly beneath or adjacent to a particular location. The rate of development of subsidence is dependent on a number of factors including longwall width; depth of cover; extraction height; and extraction rate.

As the longwall extraction face approaches a feature on the surface, subsidence will start to develop when the face is approximately half the depth of cover away (i.e. at distances typically between 200 and 300 m). When the longwall face is located directly beneath the feature, approximately 10% of the subsidence due to that particular longwall will develop.

The maximum rate of development of subsidence occurs when the longwall face has mined approximately half the depth of cover past the location (i.e. at distances typically between 200 and 300 m). The majority of the immediate subsidence (90 to 95%) for that longwall will develop after the extraction face has mined approximately 1.2 times the depth of cover beyond that location (i.e. at distances typically between 500 and 700 m).

Long term residual movements continue to develop primarily over the following 3 months, but up to 12 months, as equilibrium in the overburden is established. These low level movements represent approximately 5 to 10% of the incremental subsidence for that longwall.

The potential for impacts generally occur when the rates of development of subsidence are the greatest. Typically this occurs when the longwall face is located between 0.25 to 0.75 times the depth of cover beyond that location (i.e. distances from approximately 100 to 150 m to approximately 300 to 450 m). Based on an average extraction rate of 15-20 m per day (i.e. 100 metres per week), the potential impacts at any given location generally occur over a period of approximately 2 to 3 weeks.

The extraction of subsequent longwalls in the series, adjacent to a particular location, results in the development of additional subsidence due to the chain pillar compression and reactivation of the existing goaf. **Figure 20** illustrates the subsidence as percentages of the total final subsidence for two locations on the surface: Point X directly above the panel and Point Y directly above the chain pillar.

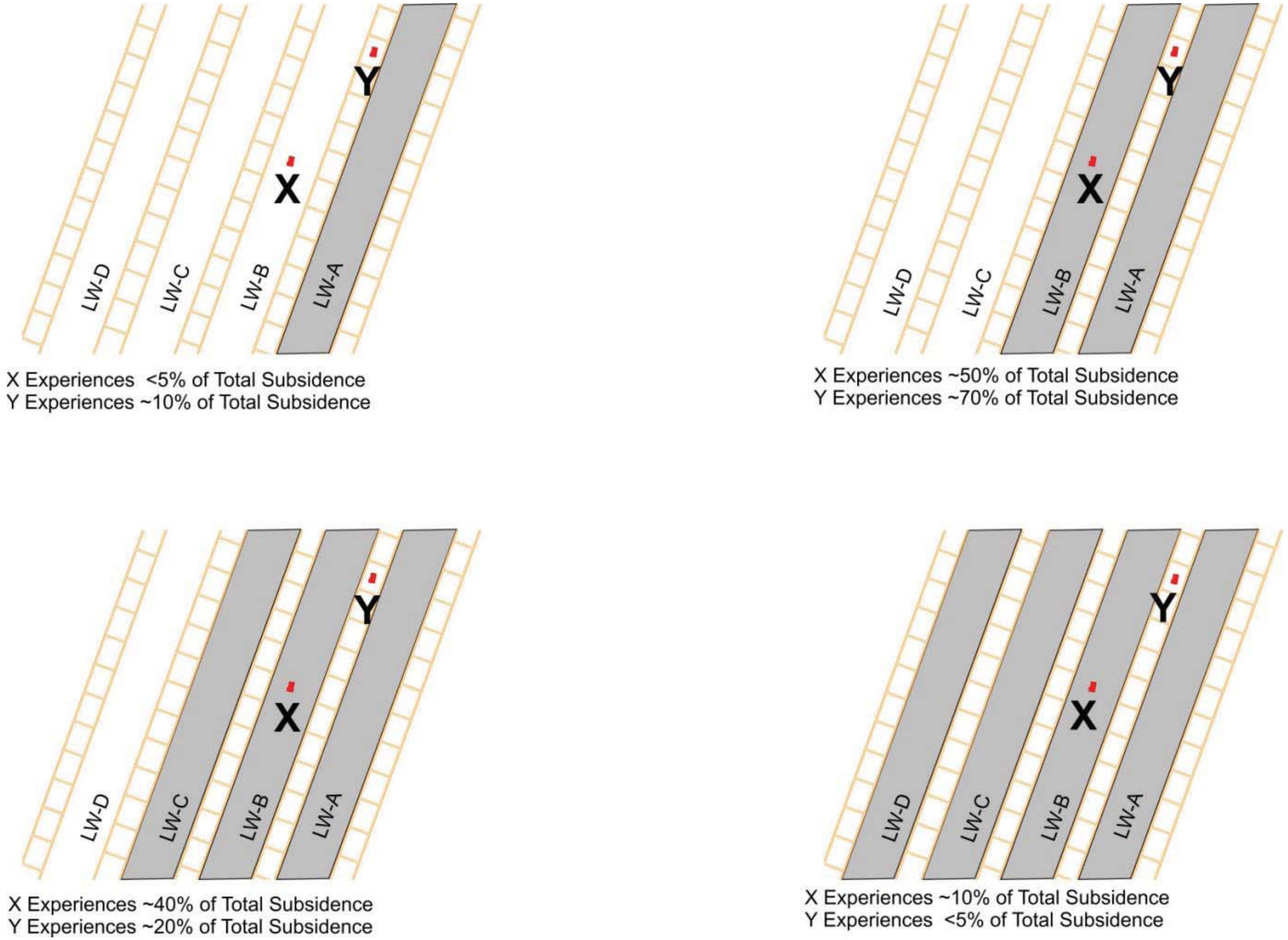
Figure 20 shows that for a point located directly above a panel, the majority of the total subsidence develops during the longwall which is extracted directly beneath it, with additional but lesser levels of subsidence developing during extraction of the following two longwalls.

For a point located directly above a chain pillar, a small percentage of subsidence develops when the feature is located above the longwall maingate pillar, the majority of the subsidence develops when it is located above the longwall tailgate pillar, and low level subsidence develops for the subsequent longwall.

There is potential for additional impacts or reactivation of earlier impacts on a feature during the extraction of the subsequent longwall in the series after the feature has been directly mined beneath. Any such impacts are typically lesser than those which occur when the feature is directly mined beneath, due to the lower levels of additional subsidence. These impacts occur when the rate of development of subsidence is greatest. That is, these impacts typically occur over a period of approximately 2 to 3 weeks (based on an average extraction rate of 15 to 20 m per day).

Impacts are remediated by the Mine Subsidence Board (MSB) to pre-mining conditions. Serviceability impacts (i.e. door swings, sticky windows, issues with drainage) are generally remediated by the Board when they occur (i.e. during active subsidence).

Impacts such as cracking in internal finishes or cracking in brickwork are generally remediated after the completion of active subsidence, so that these repairs are not affected by the ongoing subsidence movements. In some cases, temporary repairs are undertaken after a feature is directly mined beneath, with the final repairs completed after the extraction of the subsequent longwall in the series, so that these repairs are not damaged by the additional subsidence movements.



Source: MSEC (2014)

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Percentage of Subsidence Experienced with Incremental Extraction

FIGURE 20

5.5 BUTTONDERRY WASTE MANAGEMENT FACILITY

WSC's Buttonderry Waste Management Facility (located on Hue Hue Road) consists of an extensive network of earthworks, landfill, buildings, concrete hardstands and a gas collection system.

The Buttonderry Waste Management Facility is situated approximately 1.1 kilometres north-east of LW1N (at its closest point to the proposed longwalls) and is outside the Subsidence Impact Limit. As such, it is not expected to experience any conventional subsidence movements. The facility may be subject to small far-field horizontal movements, which can only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain (generally less than the order of survey tolerance). These predicted levels of movement are generally not significant, and are not expected to cause damage to the liner material or any other component of the waste management facility.

WACJV provided advice to the MSB in 2007 and 2009 regarding proposed infrastructure developments at the waste management facility, stating that the site is beyond the predicted Subsidence Impact Limit and will not be affected by conventional subsidence.

Should development consent be granted, WACJV agrees to the request by WSC to engage a suitably qualified professional to undertake a dilapidation report for the Buttonderry Waste Management Facility, prior to the commencement of longwall extraction for LW1N.

5.6 LONGWALL PANELS ADJACENT TO WYONG CREEK

The longwall panels nearest to Wyong Creek are LW3S, LW4S and LW5S is the southern area and LW3SW, LW4SW and LW5SW in the south western area. The panels in the southern area are 250-300 m from Wyong Creek and the panels in the south western area are 150-200 m from the creek (with the closest proposed panel being 154 m from the creek). Under the current mine plan, the panels in the southern area (LW3S, LW4S and LW5S) are scheduled to be extracted in Project Years 19-20. The closest panel (LW5SW) is scheduled for extraction in Project Year 25. Whilst the impact of the proposed mine layout on Wyong Creek will be negligible, there is sufficient flexibility to enable these distances to be increased if necessary, on the basis of detailed subsidence monitoring results throughout the life of the Project.

6 MISCELLANEOUS ISSUES

6.1 PROPONENT OWNED LAND

The PAC inquired about WACJV's land holdings within the Subsidence Impact Limit. WACJV owns the Honeysuckle Park property within the Dooralong Valley, which has an area of 24.8 ha. The property was purchased in late 2009.

This property on the alluvial floodplain is almost wholly flood prone and hosts 13 bore holes in the alluvium and basement rock clustered in five locations. The land extends across almost the full extent of the alluvial floodplain and fronts approximately 800 m of the riparian zone of Jilliby Jilliby Creek. The riparian section of this property is at the location of the initial stream section that will be affected by subsidence and at the location of the upper section of the non-subsiding area above the permanent main headings.

Other properties within the mine plan area are subject to landowner agreement for access for permanent monitoring facilities (such as groundwater bores) and for periodic surveys for aquatic ecology, stream monitoring or other scientific purposes.

6.2 GROUNDWATER MONITORING DATA

At the public hearing, a question was raised regarding whether the monitoring data gathered from the bores at Honeysuckle Park was relied on in the Groundwater Impact Assessment. Monitoring data from these bores (HP1, HP2, HP3, HP4, HP5) was used in the assessment and is presented in Appendix C of the Groundwater Impact Assessment.

The groundwater monitoring network at the Honeysuckle Park property has provided continuous data since it was commissioned in April 2010. Accurate rainfall monitoring apparatus was also installed at the site to enhance the data gathering and analysis capability.

7 REFERENCES

- Dunne T & Leopold LB (1978) *Water in Environmental Planning*, 1st edn., W. H. Freeman.
- G Herman & Associates (2013) *Wallarah 2 Coal Project, Flood Impact Assessment*.
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- SCT Operations Pty. Ltd (2012) *Wallarah 2 Coal Project Subsidence Modelling Study*.
- WRM Water and Environment (2013) *Wallarah 2 Coal Project, Surface Water Impact Assessment.*
- Wyong Shire Council & Gosford Shire Council (2007) *Water Plan 2050: A Long Term Water Supply Strategy for the Central Coast*

Appendix A

Letter from PAC (dated 14 April 2014)

14 April 2014

Mr In-sik Kim
Wyong Areas Coal Joint Venture
PO Box 3039
TUGGERAH NSW 2259

Dear Mr Kim,

Wallarah 2 Coal Project

Following the meeting on 1 April between the Commission and WACJV, the Commission has had the benefit of input from the Public Hearing and has received additional information from other sources. As indicated at the meeting, the Commission has identified a number of concerns that it considers significant. The purpose of this letter is to outline those concerns and give WACJV, as Proponent, an opportunity to address them. The Commission expects that it will receive responses in writing, but is also prepared to meet with the Proponent and any relevant experts on either 28 April or 29 April 2014. Written responses will be received up until COB 2 May 2014.

1. Water Supply

The Commission considers that the most controversial aspect of this project is its potential impact on Central Coast water supplies.

Most of the information available to the Commission regarding water and subsidence is strongly contested. In broad terms the Commission needs to be confident that it has identified: the possible sources of impact; the quantum of impact from each possible source; when each impact might commence; and the likely duration of each impact. At this point the Commission is aware of three possible sources of impact: operational requirements of the mine; subsidence impacts on the alluvial aquifers leading to loss of baseflow to the streams; and (possibly) loss of baseflow to streams as a result of mine-induced groundwater depressurisation. These are discussed further below along with a series of questions in relation to Central Coast water supplies.

Wyong Council and multiple presenters at the Public Hearing raised major concerns about the risk of any loss of water from the Gosford-Wyong Water Supply System (GWWSS). The principal reasons given were the history of severe water restrictions in the Central Coast (in 2007 only 10% supply remaining with doubts about the accessibility of the last 4% of this), the fact that the long-term records show far worse droughts than 2007, and the substantial increases in population forecasts for the area to be supplied by GWWSS (up to 27%).

There are two ‘subsidence-related’ impacts. The first is the impact on the alluvial aquifers and the second is on the deeper aquifers that contribute to mine-water make and the filling of the goaf voids.

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Dealing with the first of these, the Department of Planning & Infrastructure's Preliminary Assessment Report (PAR) states that, as a result of subsidence impacts, 270ML/y will be lost from the Jilliby Jilliby Creek source and 30ML/y from the Central Coast Unregulated Water Source (see p.33). The Department's PAR does not indicate the likely duration of this subsidence-related impact.

The Proponent contends that the impact of 270ML/y on the Jilliby Jilliby Creek source is the maximum impact and that it occurs in year 10 of mining. It states that in other years the impact will be less, that re-charge of the alluvial aquifer will occur rapidly and implies that there will be no further impact once this occurs. Presumably this can only be correct if there is <u>no</u> connection between the alluvium and the zone of depressurisation caused by extraction of the coal. This is a contested issue and will be discussed further below.

The proposed solution in the PAR to this water loss is the purchase by the Proponent of water licences ('probably for irrigation or some other farming purpose') and NOW is stated to have confirmed that sufficient transferable licences exist to cover the deficit. However, Wyong Council and many other submitters have asserted that the purchase of licences as a solution fails to address three issues:

(i) the subsidence-induced loss is not controllable (i.e. it can't be turned off);
(ii) some of the licences available for purchase will not have been in use (i.e. 'non-active') and therefore there will be a loss in real terms from the system; and
(iii) that in dry times there is insufficient water in the system to meet the needs of the existing population (i.e. water restrictions come into force).

The Proponent's response on the water loss[1] can be summarised as:

(i) the Water Sharing Plans (WSP) are designed to ensure that all licensed users can take their maximum allowance and still maintain ecosystem health (but far less definitive phrases are also used, i.e. 'satisfy <u>basic</u> landholder rights'. '<u>generally</u> consistent with extraction limits', etc.[2]);
(ii) that the distinction between active and non-active licences is immaterial and that it would in fact be detrimental to remove active licences from the system;
(iii) a long-term extraction limit of 36,750ML/y applies to the GWWSS and the availability of water for town supply is therefore governed by the WSP, not the quantity of water in the dams; and
(iv) the subsidence impact on water flow in Jilliby Jilliby Creek would be temporary with the exception of some small areas where flow would be redirected.

At this stage of the review the Commission is not convinced that the purchase of water licences will offset the impacts of the mine on water supply under drought conditions.

The second issue is the deeper groundwater impact associated with voids in the goaf, at least some of which manifests itself as mine-water make (i.e. water predicted to be pumped from the mine daily). This amounts to 2.5ML/d plus possibly another 0.5ML/d from the fractured zone.

The Department's PAR at p.25 suggests that there would be no direct connection (i.e. no connective cracking) between the surface and the mine and that any indirect connection would not be significant 'in terms of overall drawdown, groundwater inflow and (most importantly) surface water

[1] Response from Hansen Bailey to DP&I Issues, dated 18 March 2014. This arose from the Commission seeking further information from the Department on a number of issues arising from the Commission's initial review of the Department's Preliminary Assessment Report.
[2] Emphasis added

resources'. This is a strongly contested issue. At the public hearing on 2 April 2014 Professor Pells[3] made the following points:

(i) the predicted 2.5ML/d inflow to the mine includes 0.04ML/d from the hard rock aquifer, but the source for the rest of the 2.5ML/d is unstated. It must come from somewhere and that 'somewhere' must be in equilibrium with natural recharge and therefore must ultimately affect river flow;

(ii) there will be substantial changes in the groundwater regimes caused by the post-mining zone of depressurisation with substantial drops in bore levels. These changes to groundwater will cause a decrease in base flow to Jilliby Jilliby Creek;

(iii) flows in Jilliby Jilliby Creek vary substantially with seasonal conditions. In dry times the flows are consistently below 1ML/d for long periods and for the time since 1972 the flows for 20% of the time have been below 0.74ML/d.

In relation to potential impacts from the zone of depressurisation there are three issues for the Commission:

- whether there is, in fact, a connection between baseflow to Jilliby Jilliby Creek and the zone of depressurisation;
- what the quantum of that impact might be; and
- when the impact might occur and its duration.

The mine will have a variable operational water requirement (approximately 20ML/y average). The Commission understands that this will be drawn directly from the catchment rather than from the GWWSS. Presumably the Proponent has a water licence for the amount under the WSP.

The Commission has directed a number of questions to other parties concerning the above material. The Commission is also prepared to receive input from the Proponent on any aspect of this material. However, responses to the following specific questions would be appreciated:

1. If the duration of impact on baseflow to the streams depends in part on the effective sealing of fractures beneath the alluvium, what robust evidence does the Proponent have that would convince the Commission that there would not be a continuing impact?
2. In the context of the possible impacts of the zone of depressurisation on groundwater, can the Proponent indicate whether it accepts the drawdown figures indicated on Professor Pell's diagrams showing hypothetical bores at year 0 and year 20 of mining? If not, why not?
3. Does the Proponent accept that there will be an impact of the zone of depressurisation of the mine on the baseflow to the streams supplying the GWWSS (a) during mining or (b) at any time in the future? If the answer to either (a) or (b) is positive, can the Proponent please provide details of the likely impact and when it might occur?
4. In relation to the operational requirement of 20ML/y, does the Proponent consider that it will be able to draw this water under licence from the catchment under severe drought conditions? If not, how does the Proponent propose to access water for the project under these conditions?

The Commission is inclined at this stage to recommend a nil impact on the water available to GWWSS as a condition of consent. This will involve consideration of all the issues discussed above. It will also involve consideration of possible mechanisms to augment the supply at the Proponent's cost consistent with any impacts it cannot avoid.

[3] Professor Pells was the Wyong Shire Council expert on water issues. The presentation at the public hearing was as a representative of the Australian Coal Alliance. The relevant slides from his presentation are included as Annexure 1.

The only possible solution to the risk of impacts on supply that the Commission can identify at this stage is to have the Proponent treat the mine water to an acceptable standard for return to the catchment rather than the currently proposed discharge of treated water to Wallarah Creek. The water for discharge to Wallarah Creek will be processed through a Reverse Osmosis plant and will already be required to meet the water quality guidelines applicable to that creek. Conceptually it should be possible to increase the level of treatment to meet any further requirements of raw water supply. Theoretically there should be 2.5ML/d available if required (i.e. more than enough to offset the predicted losses to GWWSS). The options would be to discharge the treated water to the impacted stream(s) or to discharge the water in close proximity to the weir. Does the Proponent have any views as to whether the return of treated water to the catchment would be feasible and whether either of the discharge options suggested could work? If not, what other options could be pursued?

2. Impacts on Jilliby Jilliby Creek and Little Jilliby Jilliby Creek

The Department's Preliminary Assessment Report suggests that the subsidence impacts on these steams will be limited to 'negligible' impacts over 80% of the stream length and 'minor' over 20%. This is unenforceable and, although it has been used in some previous approvals, cannot be supported by the Commission in this case.

The Commission considers that applying a single classification of 'negligible impact' to the whole stream length would not be consistent with the predictions and compliance could not be achieved. However, the Commission is not prepared to relax the performance measure to 'minor impact' over the whole stream either, since this would allow an unacceptable level of impact without the need for action by the Proponent to prevent or repair avoidable damage.

What is required is a performance measure (or measures) that require the predictions not to be exceeded at all points along the streams and then require the Proponent to prevent adverse consequences (i.e. headcuts, bank erosion, etc.) in the areas of risk. In this context the Commission notes that changes in gradient as individual longwalls impact the stream will be much greater than the average change in gradient along the stream once subsidence stabilises.

For water quality impacts, the Commission considers that, given the highly variable nature of flows in the streams and the other non-mine related influences on water quality, a system of assessing mine-related impacts will need to be developed including contemporaneous sampling above and below areas of current mining impact.

The Commission is prepared to consider further submissions from the Proponent on these issues. The Commission recognises that with the mine progressing up-catchment, project-specific solutions may be achievable.

3 Flooding

The Commission has four concerns:

(i) that uncertainties associated with use of a yielding pillar mine design in the Project Area geology may mean that surface deformation is not as predicted (either in extent or timeframe). What flood studies have been done that incorporate potential variations in surface topography resulting from possible variations in pillar behaviour? What are the potential consequences compared to those predicted?

(ii) While compensation, modifications, etc., are proposed for potential impacts on existing residences, etc., what is proposed for situations where there is increased risk of flooding on land that would have been suitable for development (e.g. subdivision)? How many properties are in this category (details please)?

(iii) What proposals exist for assessment and compensation for impacts on enterprises such as the turf farm? In this context the Commission notes that impacts may be direct (i.e. loss of production) or indirect (e.g. loss of markets due to failure to supply).

(iv) The Commission notes that there are some 15 roads and bridges that are predicted to have an increased risk of flooding from the project. Has the potential impact on emergency vehicle access been considered and, if so, can the Proponent supply details?

4. Subsidence

The Commission has a number of residual concerns:

(i) The yielding pillar approach in this mine design has not been attempted in this area previously. The Commission accepts that it is conceptually attractive as a means of achieving a relatively uniform topographical outcome while maximising resource recovery. However, the Commission wishes to understand the potential consequences if pillars do not behave as expected in either the short or long term. Relevant issues include:

- Potential impacts on stream morphology and flow characteristics arising from changes in gradient greater or less than those predicted;
- Potential impacts on built infrastructure; and
- Timeframes for reaching surface stability.

(ii) The expected period from initial impact on a feature or built infrastructure to final stability may be affected by the yielding pillar design. Can the Proponent provide estimates of this period of impact for the proposed mining method including the upper bounds.

(iii) Buttonderry WMF. Council has advised this is valued at $1.3bn and will be very difficult to repair/remediate if it is impacted by subsidence. The Commission considers that a nil/negligible impact performance measure may be appropriate combined with a pre-mining dilapidation report and appropriate monitoring thereafter. Does the Proponent wish to comment on this?

The Commission's report is due mid-May so written responses would be needed by 2 May 2014. Please call Mrs Paula Poon on (02) 9383 2101, if you have any questions in relation to this request.

Yours sincerely

Dr Neil Shepherd AM
Chair, Wallarah 2 Coal Project Review