APPENDIX N

Surface Water Impact Assessment

wrm water + environment

SURFACE WATER IMPACT ASSESSMENT FOR COALPAC CONSOLIDATION PROJECT

Coalpac Pty Ltd
15 November 2011

www.wrmwater.com.au

WRM Water & Environment Pty Ltd
ABN: 96 107 404 544 ACN: 107 404 544

Level 5, Paddington Central,
107 Latrobe Terrace, PO Box 809,
Paddington Qld 4064 Australia
tel +61 7 3367 1279 fax +61 7 3367 1679
www.wrmwater.com.au

REPORT TITLE: Surface Water Impact Assessment for Coalpac Consolidation Project
CLIENT: Coalpac Pty Ltd
REPORT NUMBER: 0718-01-C [Rev 8] DRAFT

Revision Number	Description	Report Date	Report Author	Reviewer
0 (Draft)	Draft report for comment.	18 March 2011	RC	GR
1	Revised based on comments from Hansen Bailey.	22 March 2011	RC	GR
2	Updated water balance modelling to include MWD J6-2.	28 March 2011	RC	GR
3	Revised based on comments from Coalpac.	12 April 2011	RC	GR
4	Updated to reflect new mine concept plans.	30 May 2011	RC	GR
5	Draft final report.	8 June 2011	RC	GR
6	Revised based on comments from Hansen Bailey.	15 June 2011	RC	GR
7	Final report.	30 June 2011	RC	GR
8 (Draft)	Revised in response to regulator comments	15 November 2011	RC	GR

For and on behalf of
WRM Water & Environment Pty Ltd

Greg Roads
Director

TABLE OF CONTENTS

Page

1 INTRODUCTION 1

2 EXISTING SURFACE WATER ENVIRONMENT 4

2.1 REGIONAL DRAINAGE NETWORK 4
2.2 LOCAL DRAINAGE NETWORK 4
2.3 REGIONAL SURFACE WATER QUALITY 9
2.4 RAINFALL AND EVAPORATION 11

3 EXISTING SURFACE WATER MANAGEMENT 13

3.1 INVINCIBLE COLLIERY 13
3.1.1 Surface Water Management System 13
3.1.2 Surface Water Management Structures 17
3.1.3 Process Water Demands 17
3.1.4 Environmental Protection Licence and Licensed Discharge Points 17
3.1.5 Surface Water Monitoring Data 18
3.1.6 Statistical Analysis of Available Surface Water Quality Monitoring Data 21
3.2 CULLEN VALLEY MINE 22
3.2.1 Surface Water Management System 22
3.2.2 Surface Water Management Structures 25
3.2.3 Process Water Demands 25
3.2.4 Environmental Protection Licence and Licensed Discharge Points 25
3.2.5 Surface Water Monitoring Data 26
3.2.6 Statistical Analysis of Available Surface Water Quality Monitoring Data 29

4 PROJECT DESCRIPTION 30

4.1 GENERAL 30
4.2 YEAR 2 MINE PLAN 32
4.2.1 Mining Operations 32
4.2.2 Surface Water Management 35
4.3 YEAR 8 MINE PLAN 37
4.3.1 Mining Operations 37
4.3.2 Surface Water Management 39
4.4 YEAR 14 MINE PLAN 41
4.4.1 Mining Operations 41
4.4.2 Surface Water Management 43
4.5 YEAR 20 MINE PLAN 45
4.5.1 Mining Operations 45
4.5.2 Surface Water Management 47

5 IMPACT ASSESSMENT 50

5.1 POTENTIAL IMPACTS 50
5.2 MINE SITE WATER REQUIREMENTS 50
5.2.1 Coal Processing Water Demand Estimate 52
5.2.2 Sand Quarrying Water Demand Estimate 52
5.2.3 Dust Suppression Water Demand Estimate 52
5.2.4 Sourcing of Water for Mine Site Water Requirements 53

5.2.5 Domestic Water Supply 55
5.3 HIGHWALL MINING ACTIVITIES 55
5.4 SURFACE WATER QUALITY 56
5.4.1 Surface Water Management Strategy 56
5.4.2 Sediment Dam Discharges 57
5.4.3 Future Discharges from Cullen Valley Licensed Discharge Points LD001 and LD004 57
5.4.4 Future Releases from Invincible Licensed Discharge Point LD002 58
5.4.5 Volumetric Impact Assessment of Future Releases 59
5.4.6 Domestic Wastewater Management 60
5.5 LOSS OF CATCHMENT AREA 60
5.5.1 During Active Mining Operations 60
5.5.2 Final Landform 61
5.6 POTENTIAL IMPACT OF FLOODING ON PROJECT INFRASTRUCTURE 63

6 MINE WATER BALANCE 64

6.1 OVERVIEW 64
6.2 SIMULATION METHODOLOGY 64
6.3 STORAGES 65
6.4 MODEL CONFIGURATION AND ASSUMPTIONS 66
6.5 PROCESS WATER DEMANDS 68
6.6 OPERATING RULES 68
6.7 CLIMATE DATA 69
6.7.1 Open Water Evaporation 69
6.7.2 Site Rainfall 69
6.8 CATCHMENT RUNOFF 70
6.8.1 Adopted Rainfall-Runoff Model 70
6.8.2 AWBM Model Calibration 71
6.8.3 Catchment Areas 72
6.9 WATER BALANCE MODEL RESULTS 74
6.9.1 Year 0 (Existing Case) 74
6.9.2 Year 2 76
6.9.3 Year 8 78
6.9.4 Year 14 81
6.9.5 Year 20 83
6.10 WATER BALANCE MODEL SUMMARY 85
6.10.1 Minesite Releases 85
6.10.2 Predicted Inflows and Extractions from Underground Workings 87

7 MITIGATION AND MANAGEMENT MEASURES 90

7.1 OVERVIEW 90
7.2 MINE SITE WATER MANAGEMENT SYSTEM 90
7.3 STRATEGIES FOR MINMISING POTENTIAL FOR RELEASES FROM EXISTING DISCHARGE POINTS 91
7.3.1 Cullen Valley LD001 and LD004 91
7.3.2 Invincible LD002 91
7.4 SEDIMENT CONTROL PLAN 91
7.5 SURFACE WATER MONITORING PROGRAM 92

8 SUMMARY OF FINDINGS 96

9 REFERENCES 98

LIST OF TABLES

		Page
Table 2.1	Description of Local Drainage Characteristics	6
Table 2.2	Available Water Quality Data, Neubecks Creek Upstream of Pine Dale Coal Mine	9
Table 2.3	Rainfall Station Details	11
Table 2.4	Monthly Rainfall Statistics, Portland (Jamieson St) (Station No. 063071), 1904-2010	11
Table 2.5	Mean Monthly Potential Evapotranspiration, Project Site	12
Table 3.1	Subcatchments Currently Disturbed by Mining, Invincible Colliery	16
Table 3.2	Invincible Colliery Storage Volumes, 2010 - 2011	17
Table 3.3	Invincible Colliery Discharge Water Quality Criteria, EPL 1095	17
Table 3.4	Invincible Main Colliery Dam (LD002) Water Quality Monitoring Data, January 2011 Discharge Event	18
Table 3.5	Invincible Colliery Water Quality Monitoring Data, 2008 AEMR Period	18
Table 3.6	Invincible Colliery Water Quality Monitoring Data, 2009 AEMR Period	19
Table 3.7	Invincible Colliery Water Quality Monitoring Data, 2010 AEMR Period	20
Table 3.8	Invincible Colliery Water Quality Monitoring Data, 2011 AEMR Period	21
Table 3.9	Statistical Summary of Water Quality Monitoring Data, Invincible Colliery LD002, SD C3-5 & Environmental Dam	22
Table 3.10	Subcatchments Currently Disturbed by Mining, Cullen Valley Mine	23
Table 3.11	Cullen Valley Mine Storage Volumes, 2010 - 2011	25
Table 3.12	Cullen Valley Mine Discharge Water Quality Criteria, EPL 10341	26
Table 3.13	Main Dam (LD001) Water Quality Monitoring Data, December 2010 Discharge Event	26
Table 3.14	Cullen Valley Mine Water Quality Monitoring Data, 2008 AEMR Period	27
Table 3.15	Cullen Valley Mine Water Quality Monitoring Data, 2009 AEMR Period	27
Table 3.16	Cullen Valley Mine Water Quality Monitoring Data, 2010 AEMR Period	28
Table 3.17	Cullen Valley Mine Water Quality Monitoring Data, 2011 AEMR Period	28
Table 3.18	Statistical Summary of Water Quality Monitoring Data, Cullen Valley Main Dam (LD001) & Dam 4 (LD004)	29
Table 4.1	Project Mine Subcatchments Affected by Disturbance, Year 2	35
Table 4.2	Project Mine Subcatchments Affected by Disturbance, Year 8	39
Table 4.3	Project Mine Subcatchments Affected by Disturbance, Year 14	43
Table 4.4	Project Mine Subcatchments Affected by Disturbance, Year 20	47
Table 5.1	Predicted Mine Site Water Requirements, Existing and Future Mining Operations	51
Table 5.2	Predicted Mine Site Water Demands and Supply Deficit	54
Table 5.3	Predicted Extractions from and Inflows to Flooded Underground Workings	55
Table 5.4	Estimated Catchment Area Captured Within Mine Water Management System	60

Table 5.5	Final Landform Project Subcatchments and Drainage Strategy	61
Table 6.1	Simulated Inflows and Outflows to Mine Water Management System	65
Table 6.2	Adopted Storage Details, Water Balance Model	65
Table 6.3	Mean Monthly Evaporation Depths from Storages	69
Table 6.4	Summary of AWBM Model Parameters	70
Table 6.5	Adopted AWBM Parameters	72
Table 6.6	Adopted Catchment Areas	72
Table 6.7	Water Balance Model Results, Year 0 (Existing Case)	74
Table 6.8	Water Balance Model Results, Year 2 Project Life	77
Table 6.9	Predicted Inflows to Active Pit Areas, Year 2 Project Life	78
Table 6.10	Predicted Storage and Pit Transfers, Year 2 Project Life	78
Table 6.11	Water Balance Model Results, Year 8 Project Life	80
Table 6.12	Predicted Inflows to Active Pit Areas, Year 8 Project Life	80
Table 6.13	Predicted Storage and Pit Transfers, Year 8 Project Life	80
Table 6.14	Water Balance Model Results, Year 14 Project Life	82
Table 6.15	Predicted Inflows to Active Pit Areas, Year 14 Project Life	82
Table 6.16	Predicted Storage and Pit Transfers, Year 14 Project Life	83
Table 6.17	Water Balance Model Results, Year 20 Project Life	84
Table 6.18	Predicted Inflows to Active Pit Areas, Year 20 Project Life	85
Table 6.19	Predicted Storage and Pit Transfers, Year 20 Project Life	85
Table 7.1	Surface Water Quality Monitoring Program	93

LIST OF FIGURES

		Page
Figure 1.1	Locality Plan, Coalpac Consolidation Project	2
Figure 2.1	Drainage Characteristics within the Project Boundary	5
Figure 2.2	Photograph Showing Typical Minor Drainage Line in Undisturbed Catchment Area within the Project Boundary	8
Figure 2.3	Photograph Showing Typical Minor Drainage Line in Cleared Catchment Area within the Project Boundary	8
Figure 2.4	Location of Water Quality Monitoring Point, Wangcol Creek Upstream of Pine Dale Coal Mine	10
Figure 2.5	Distribution of Monthly Rainfall (Portland, Jamieson St) and Potential Evapotranspiration	12
Figure 3.1	Existing Invincible Colliery Surface Water Management System	14
Figure 3.2	Existing Cullen Valley Mine Surface Water Management System	24
Figure 4.1	Conceptual Mine Layout and Surface Water Management Plan, Year 2	34
Figure 4.2	Conceptual Mine Layout and Surface Water Management Plan, Year 8	38
Figure 4.3	Conceptual Mine Layout and Surface Water Management Plan, Year 14	42
Figure 4.4	Conceptual Mine Layout and Surface Water Management Plan, Year 20	46
Figure 5.1	Proposed Final Landform Drainage Configuration	62
Figure 6.1	Conceptual Water Balance Model Configuration, Year 0 (Existing Case)	66
Figure 6.2	Conceptual Water Balance Model Configuration, Year 2 Project Life	67
Figure 6.3	Conceptual Water Balance Model Configuration, Year 8 & Year 14 Project Life	67
Figure 6.4	Conceptual Water Balance Model Configuration, Year 20 Project Life	68
Figure 6.5	Comparison of Mean Monthly Rainfalls from SILO Data Drill and Portland (Jamieson St) (063071), 1904 to 2010	70
Figure 6.6	Predicted Releases from Existing Licensed Discharge Points and Proposed Mine Water Dams, Median Runoff Year	86
Figure 6.7	Predicted Releases from Existing Licensed Discharge Points and Proposed Mine Water Dams, Wet Runoff Year (20th %ile Runoff)	86
Figure 6.8	Predicted Releases from Existing Licensed Discharge Points and Proposed Mine Water Dams, Wettest Runoff Year on Record	87
Figure 6.9	Predicted Inflow and Extractions from Underground Workings	89
Figure 7.1	Proposed Surface Water Monitoring Locations	95

1 INTRODUCTION

The Coalpac Consolidation Project (the Project) is located about 23 km north-west of Lithgow in New South Wales. The location of the Project is shown in Figure 1.1.

WRM Water & Environment Pty Ltd was commissioned by Hansen Bailey on behalf of Coalpac Pty Ltd (Coalpac) to undertake a surface water impact assessment for the Project. The assessment will form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support an application for a contemporary Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to consolidate the operations and management of the Cullen Valley Mine and Invincible Colliery sites under a single, contemporary planning approval. The Project would allow coal mining operations within its current mining tenements to continue for a further period of 21 years within the Project Boundary shown in Figure 1.1.

Specifically, the Project will consist of:

- Consolidation and extension of the existing Cullen Valley Mine and Invincible Colliery operations to produce up to a total of 3.5 Million tonnes per annum (Mtpa) product coal, including:
- The continuation of mining operations at Cullen Valley Mine (the area west of the Castlereagh Highway) via both open cut and highwall mining methods to access an additional resource of approximately 40 Million tonnes (Mt) Run of Mine (ROM); and
- The continuation of mining operations at Invincible Colliery including an extension north into the East Tyldesley area via open cut and highwall mining methods to access an additional resource of approximately 60 Mt ROM;
- Continuation of coal supply to the local Mount Piper Power Station (MPPS) via a dedicated coal conveyor over the Castlereagh Highway (to be constructed), and (emergency supply to) Wallerawang Power Station, with flexibility for supply to additional domestic destinations and Port Kembla for export;
- Upgrades to existing administration, transport and other infrastructure;
- Construction and operation of additional Offices at Cullen Valley Mine;
- Construction and use of the previously approved Coal De-shaling preparation Plant (CDP) at Cullen Valley Mine;
- Construction and use of a bridge over the Castlereagh Highway to link operations east and west of the highway and the development of required access roads to the East Tyldesley area;
- Construction and operation of a bridge and haul road across the Wallerawang - Gwabegar Railway line to permit access to mine the previously approved Hillcroft resource;
- The extraction of the Marangaroo Sandstone horizon from immediately below the Lithgow Coal Seam in the northern coal mining area of Cullen Valley Mine. This material will to be trucked for crushing on site prior to sale into the Sydney (and surrounds) industrial sand market;
- Construction of a rail siding and associated infrastructure to permit transport of product coal and sand products;
- Integration of the water management of both sites into a single system; and

- Integration of the management of mine rehabilitation and conceptual final landform outcomes for Cullen Valley Mine and Invincible Colliery.

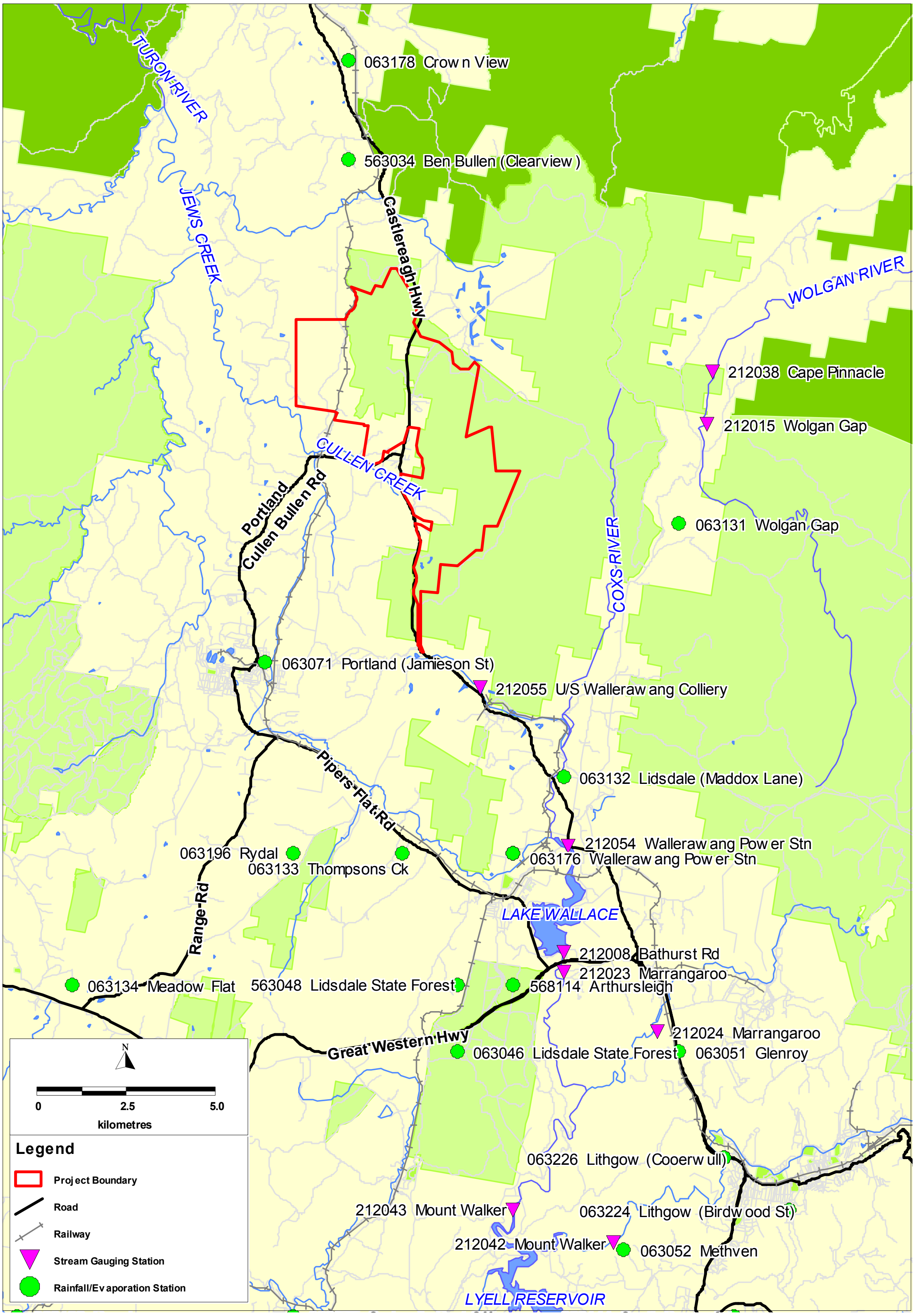

Figure 1.1 Locality Plan, Coalpac Consolidation Project

This report presents the methodology and results of surface water investigations undertaken to assess the potential impacts of the Project on local surface hydrology and water quality.

This report contains a further 8 sections:

- Section 2 describes the existing surface water environment, including the drainage network and the quantity and quality of surface runoff;
- Section 3 describes the existing mining operations and water-related infrastructure within the Project Boundary;
- Section 4 describes the proposed mining operations and surface water management structures for future mining operations proposed for the Project;
- Section 5 summarises the potential impacts of the Project on surface water resources and presents an assessment of the magnitude of these impacts;
- Section 6 presents the methodology and results of a detailed assessment of the site water balance;
- Section 7 presents the proposed mitigation and management measures that will be used to avoid or minimise the potential surface water impacts of the Project;
- Section 8 presents a summary of the surface water environmental assessment; and
- Section 9 provides a list of references.

2 EXISTING SURFACE WATER ENVIRONMENT

2.1 REGIONAL DRAINAGE NETWORK

The Project straddles the foothills at the western edge of the Great Dividing Range and is located wholly within the upper catchment area of the Turon River. The Turon River flows in a westerly direction before draining into the Macquarie River approximately 35km north-east of Orange. The Ben Bullen State Forest bounds the Project Boundary along the northern, eastern and southern boundaries and the township of Cullen Bullen is located midway along the western boundary.

The majority of the Project Boundary is drained by minor tributaries of Cullen Creek, Dulhuntys Creek and Jews Creek, which are all tributaries of the Turon River (see Figure 2.1). None of these creeks actually cross the Project Boundary. Jews Creek drains along the northern boundary of the Project and includes the Ben Bullen Creek, which drains the existing Baal Bone Colliery. Jews Creek drains into the Turon River some 5km downstream of the Castlereagh Highway. Cullen Creek drains along the southern boundary of the Project and includes runoff from the existing Invincible Colliery. Cullen Creek drains into Dulhuntys Creek, which in turn drains into Williwa Creek, which joins Jews Creek to form the Turon River. The southern tip of the Project Boundary drains south to Wangcol Creek, which is a tributary of Coxs River.

The Project is located on the western slopes of the Great Dividing Range at elevations between 900 – 940 m Australian Height Datum (AHD), with several steep sandstone escarpments dividing the site topographically as shown in Figure 2.1. With the exception of the steeply rising lands associated with the remnant sandstone escarpment features, the area is typified by moderately undulating terrain. To the west of the Project Boundary, the topography gently slopes downward towards Cullen Valley, to an elevation of approximately 840 m AHD.

2.2 LOCAL DRAINAGE NETWORK

Runoff from the Project Boundary drains in all directions. There are five catchments draining to Cullen Creek, labelled C1 to C5 in Figure 2.1. There are three catchments draining to Dulhuntys Creek, labelled D1 to D3 and seven catchments draining to Jews Creek labelled J1 to J7. A single catchment, W1, drains to south to Wangcol Creek. A description of each catchment under existing conditions is given in Table 2.1.

In undisturbed catchment areas the minor tributaries draining across the Project Boundary are generally poorly defined, often lacking clear bed and banks. Where catchments have been cleared for agriculture, significant erosion has occurred resulting in bare earth and grass lined channels with very steep banks. Figure 2.2 is a photograph of a typical minor drainage line in an undisturbed catchment within the Project Boundary, and Figure 2.3 is a photograph of a similar drainage line where it passes through a cleared catchment downstream of an undisturbed area.

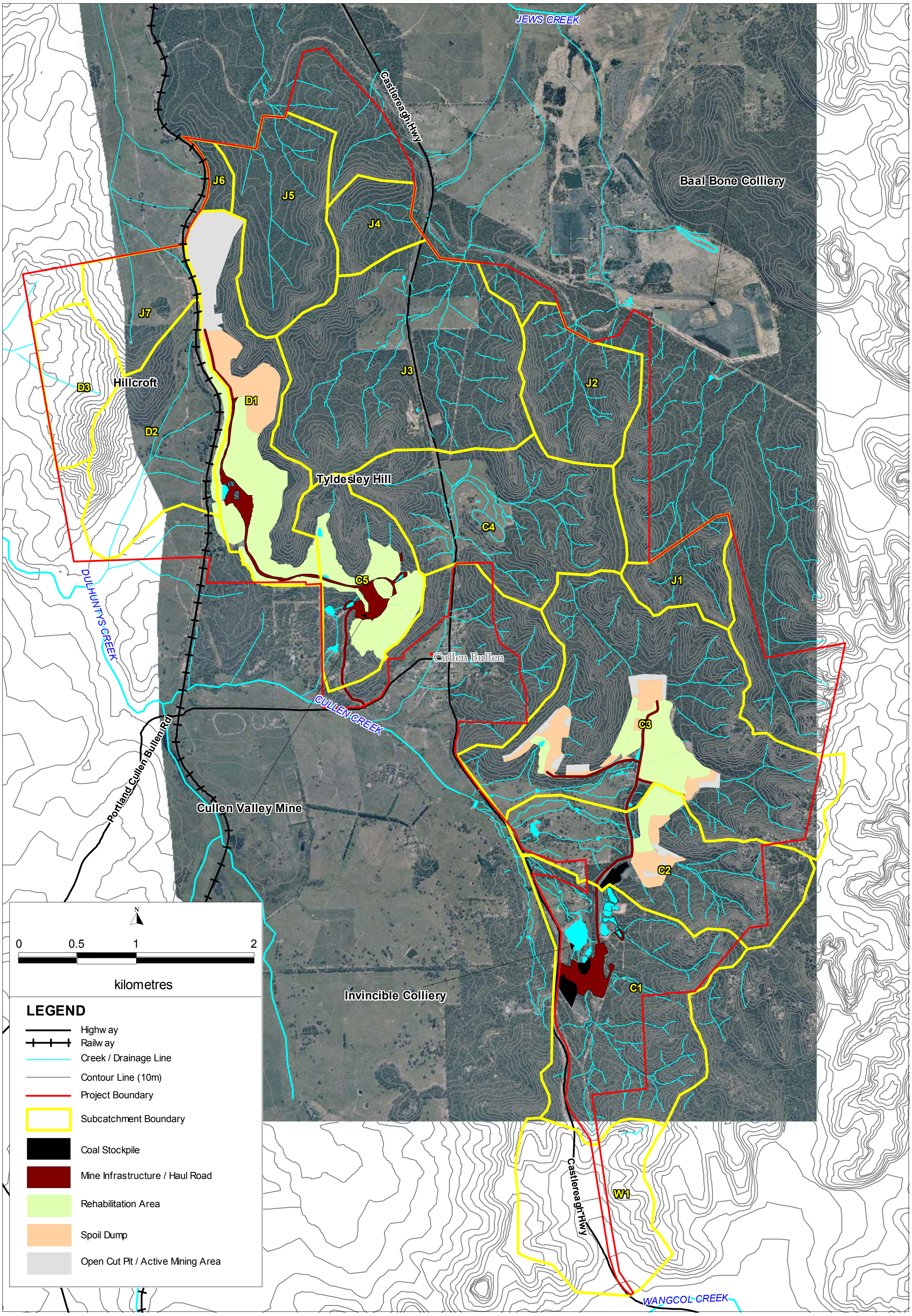

Figure 2.1 Drainage Characteristics within the Project Boundary

Table 2.1 Description of Local Drainage Characteristics

Catchment	Area (ha)	Description
Cullen Creek		
C1	253.4	• Drains the existing infrastructure and fine rejects storage dams at the Invincible Colliery. • Runoff from the disturbed areas are captured in several dams and used for mine site use (see Section 3.1). • The steep, well vegetated upper catchment is currently undisturbed and drains directly to the disturbed catchments. • The old Invincible Colliery and Ivanhoe underground workings underlie much of the catchment. • Subsidence caused by underground bord and pillar mining at the Ivanhoe Colliery has caused substantial changes in the runoff characteristics on the southern sections of the catchment. It is understood that very little surface runoff drains the areas subsided by underground mining and most, if not all surface runoff seeps into the underground workings via the surface cracks. The location of the subsided area is shown in Figure 3.1. • The lower parts of the catchment area, although not disturbed by mining activities, have been cleared and now support pasture and open stands of trees.
C2	186.1	• Drains the existing coal stockpile and south-eastern active mining, spoil dumps and rehabilitated areas at the Invincible Colliery. • Runoff from the disturbed areas is captured in sumps in the active open cut pits (see Section 3.1). • The steep, well vegetated upper catchment is currently undisturbed and contributes to runoff entering the open cut pits. • The area beneath the coal stockpile and active mining area is affected by underground bord and pillar mining subsidence, and as a result runoff that collects in sumps and dams in this area seeps into the abandoned underground workings which underlie the catchment. • Lower parts of the catchment are not disturbed by mining but have been cleared.
C3	390.6	• Drains the northern active mining, spoil dumps and rehabilitation areas at the Invincible Colliery. • Runoff from the disturbed areas is captured in sumps in the open cut pits and in several sediment dams (see Section 3.1). • The steep, well vegetated upper catchment is currently undisturbed and contributes to runoff entering the open cut pits. • Water collected in sediment dams is utilised for mine site use, however most water collected in the open cut pits is allowed to infiltrate into the abandoned underground workings which underlie the catchment. • Lower parts of the catchment are not disturbed by mining but have been cleared.
C4	209.2	• Drains undisturbed area north of Cullen Bullen. The lower, flatter part of the catchment has been partially cleared for agriculture. • The steep upper catchment areas are undisturbed and well vegetated.
C5	118.9	• Drains the existing infrastructure area and rehabilitated areas at the Cullen Valley Mine. • Runoff is captured in a number of dams, and reused for mine site demands or pumped into the Old Tyldesley Colliery underground workings, which underlie the catchment (see Section 3.2).

Catchment	Area (ha)	Description
Dulhuntys Creek		
D1	167.1	• Drains crusher & CDP infrastructure area, haul roads, rehabilitated areas, spoil dumps and active mining areas at the Cullen Valley Mine. • Includes small part of Jews Creek catchment which has been diverted by northern active mining works and small part of Cullen Creek catchment which is diverted north by rehabilitation area contour banks and the haul road. • Runoff from infrastructure area and rehabilitated areas drains to a number of sediment dams, and is reused for mine site demands, or pumped to Old Tyldesley Colliery underground workings via dams in catchment C5. • Runoff from active mining areas and spoil dumps is captured in sumps located in open cut pits. Water collected in sumps is pumped to dams for reuse.
D2	158.6	• Catchment undisturbed by mining. Due to mining disturbance at Cullen Valley Mine little or no runoff from upstream catchment drains across the railway. • The majority of the catchment has been cleared for agricultural use except for the upper escarpment areas, which include Hillcroft.
D3	66.7	• Catchment undisturbed by mining • The majority of the catchment has been cleared for agricultural use except for the upper escarpment areas, which include Hillcroft.
Jews Creek		
J1	50.6	• Catchment is undisturbed by mining, is very steep and well vegetated. • A part of the abandoned Invincible Colliery underground workings underlie much of the catchment. • Drains to the Baal Bone Colliery approximately 1.5km downstream, and there are several subsidence cracks along this drainage line, as a result of longwall mining subsidence from the Baal Bone Colliery below.
J2	99.1	• Catchment is undisturbed by mining, is very steep and well vegetated • Drains to the Baal Bone Colliery at the Project Boundary.
J3	309.0	• Catchment is undisturbed by mining, is very steep and well vegetated except for three parcels that have been cleared for agriculture. • Drains the northern side of Tyldesley Hill. • Small parts of the upper catchment are located above the abandoned Old Tyldesley Colliery underground workings. • Drains to the Baal Bone Colliery, approximately 1.3km downstream.
J4	47.0	• Catchment is undisturbed by mining, is very steep and well vegetated. • Drains to Jews Creek approximately 1.7km downstream
J5	131.7	• Catchment is undisturbed by mining, is very steep and well vegetated. • Drains to Jews Creek, approximately 2.1km downstream.
J6	52.4	• Catchment currently undisturbed by mining, is very steep and well vegetated. Area to be mined by Cullen Valley Mine in short term future under existing approvals. • When mined, the area will drain south to dams in catchment D2, reducing catchment area draining west to Jews Creek via downstream agricultural land.
J7	66.7	• Catchment currently undisturbed by mining. • The majority of the catchment has been cleared for agricultural use except for the upper escarpment areas, which includes Hillcroft.
Wangcol Creek		
W1	151.0	• Catchment currently undisturbed by mining, but includes Castlereagh Highway and cleared high voltage transmission easement. • Drains south to Wangcol Creek.

Figure 2.2 Photograph Showing Typical Minor Drainage Line in Undisturbed Catchment Area within the Project Boundary

Figure 2.3 Photograph Showing Typical Minor Drainage Line in Cleared Catchment Area within the Project Boundary

2.3 REGIONAL SURFACE WATER QUALITY

No water quality data is available for the watercourses which drain the Project Site (Cullen Creek, Dulhunty's Creek and Jews Creek). A background water quality monitoring program in Cullen and Dulhunty's creeks was initiated by Coalpac in October 2011, however at the time of reporting no data from this monitoring program was available.

In order to provide some indication of the likely background water quality in the watercourses draining the Project Site, water quality data for Wangcol Creek was obtained from the Pine Dale Coal Mine. The Pine Dale Wangcol Creek surface water quality monitoring point is shown in Figure 2.4, and is located approximately 4.9km south of the Invincible Colliery. It is of note that the Pine Dale water quality monitoring location is referred to as Neubecks Creek Upstream, however the monitoring location is actually on Wangcol Creek. The Wangcol Creek catchment upstream of the Pine Dale monitoring location is characterised by similar topography, geology and land use to that of the Cullen Creek and upper Dulhunty's Creek catchments. The Cullen and Dulhunty Creek catchments are located immediately north of the Wangcol Creek catchment area. As such, the water quality data collected for Wangcol Creek may be representative of water quality data in Cullen and Dulhunty's creeks, which are located immediately north of the Wangcol Creek catchment area.

Table 2.2 lists the available water quality data for the Neubecks Creek Upstream monitoring location. Water quality data has been collected at this location on a quarterly basis since May 2009. The following is of note with regards to Table 2.2:

- The available data suggests that pH values in Wangcol Creek generally ranges between 6.7 and 7.7, although typically is slightly alkaline.
- Total Suspended Solids (TSS) concentrations in Wangcol Creek are low, typically less than 5mg/L. The highest TSS concentrations coincide with higher than usual turbidity measurements, although little change in pH value is evident in these instances.
- Iron levels are generally low and not of concern, however isolated high conductivity and sulphate levels do occur, although these instances are not associated with high TSS or turbidity readings.

In absence of more appropriate data, it is considered that the water quality data collected for Wangcol Creek is representative of water quality data in Cullen and Dulhunty's creeks, which are located immediately north of the Wangcol Creek catchment area.

Table 2.2 Available Water Quality Data, Neubecks Creek Upstream of Pine Dale Coal Mine

Sample Date	pH	Conductivity (µS/cm)	Sulphate (mg/L)	Iron (filterable) (mg/L)	TSS (mg/L)	Turbidity (NTU)
4/05/2009	7.3	295	53	0.33	2.0	NA
24/08/2009	7.8	630	294	0.14	3.0	5.7
27/11/2009	6.8	1490	746	0.37	4.0	2.4
22/02/2010	6.8	NA	191	0.34	3.0	7.8
28/05/2010	7.4	560	175	0.09	2.5	8.4
30/08/2010	7.0	385	180	0.28	8.0	15.0
22/11/2010	7.4	418	158	0.25	6.8	13.5
21/02/2011	7.3	651	166	0.20	<5	3.2
1/06/2011	7.6	473	117	0.22	<5	6.5
1/09/2011	7.2	566	212	0.13	7.0	3.0
Average	*7.3*	*608*	*229*	*0.24*	*4.5*	*7.3*
Maximum	*7.8*	*1490*	*746*	*0.37*	*8.0*	*15.0*
Minimum	*6.8*	*295*	*53*	*0.09*	*2.0*	*2.4*
20th %ile	*7.0*	*405*	*150*	*0.14*	*2.7*	*3.1*
80th %ile	*7.4*	*638*	*228*	*0.33*	*6.9*	*10.4*
Median	*7.3*	*560*	*178*	*0.24*	*3.5*	*6.5*

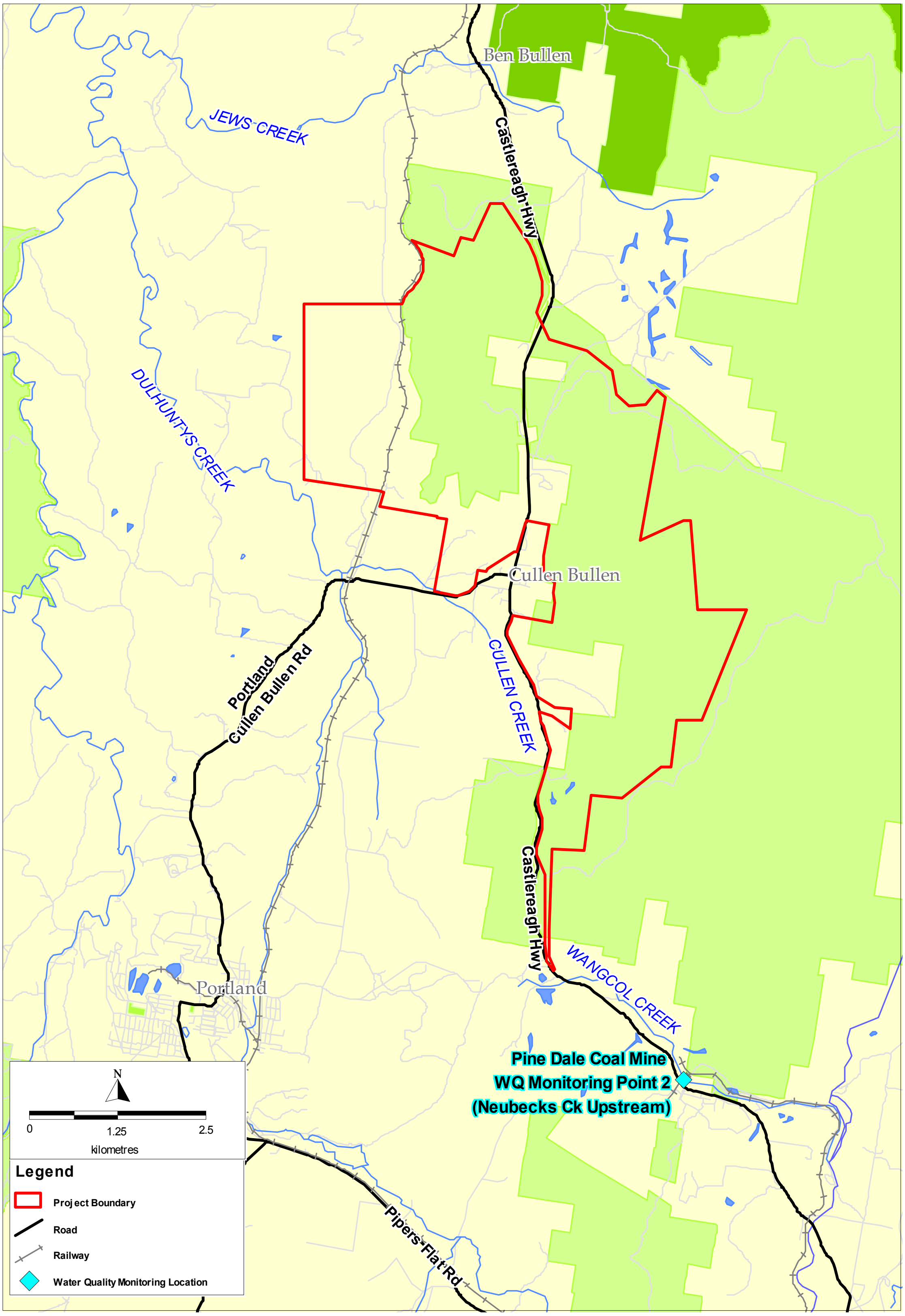

Figure 2.4 Location of Water Quality Monitoring Point, Wangcol Creek Upstream of Pine Dale Coal Mine

2.4 RAINFALL AND EVAPORATION

Daily rainfalls have been recorded at Portland (Jamieson St) (BoM Station No. 063071), about 6.5 km south-west of the Project Boundary since 1904. Rainfall data recorded at this station would be representative of rainfall that occurs within the Project Boundary. The location of the rainfall station is shown in Figure 1.1. Table 2.3 shows summary details of the rainfall station. Table 2.4 shows a summary of rainfall statistics for the Portland (Jamieson St) station. Rainfall is generally spread evenly throughout the year with slightly higher rainfalls in late spring and summer. The lowest rainfalls occur over the autumn months.

Table 2.3 Rainfall Station Details

Station No.	Station Name	Elevation (m)	Latitude	Longitude	Distance from Site (km)	Opened	Closed
063071	Portland (Jamieson St)	925	33.35° S	149.99° E	6.5	1904	-

Table 2.4 Monthly Rainfall Statistics, Portland (Jamieson St) (Station No. 063071), 1904-2010

	Monthly Rainfall (mm)												
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	76.0	64.5	55.9	45.1	48.2	53.5	56.4	59.2	51.2	66.5	63.5	61.4	690.3
Lowest	3.3	0.0	0.0	0.0	3.6	0.0	1.5	0.4	0.5	1.4	1.5	0.0	203.3
5th %ile	11.8	8.3	5.7	1.6	6.6	10.1	11.6	11.9	16.2	11.2	9.2	7.6	378.9
10th %ile	18.9	13.2	8.9	4.2	8.4	14.8	16.5	18.5	20.6	20.2	15.4	13.4	428.6
Median	68.5	55.6	45.6	41.2	37.6	43.8	47.3	53.0	47.3	61.0	59.4	51.3	689.2
90th %ile	145.3	133.6	106.4	88.9	94.8	105.9	102.1	97.4	84.3	110.8	115.8	111.7	908.2
95th %ile	168.7	150.6	159.9	108.6	112.3	135.2	122.8	112.5	101.6	123.9	145.8	146.5	1009.9
Highest	236.6	300.3	217.8	246.6	188.2	195.8	227.6	331.8	150.4	320.0	190.4	192.3	1417.3

Table 2.5 shows mean monthly potential evapotranspiration (based on Mortons method) from the Silo Data Drill database (Jeffrey *et al*, 2001) obtained from the Bureau of Meteorology in the vicinity of the Project Boundary. Mean annual potential evapotranspiration is 1,444mm, which is just over twice the annual average rainfall.

Figure 2.5 shows the annual distribution of average monthly rainfall and potential evapotranspiration. Potential evapotranspiration is greater than rainfall in all months except for June and July.

Table 2.5 Mean Monthly Potential Evapotranspiration, Project Site

Month	Mean Monthly Pot. Evapotranspiration (mm)
January	202
February	161
March	142
April	96
May	64
June	42
July	50
August	72
September	100
October	144
November	169
December	201
Total	1,444

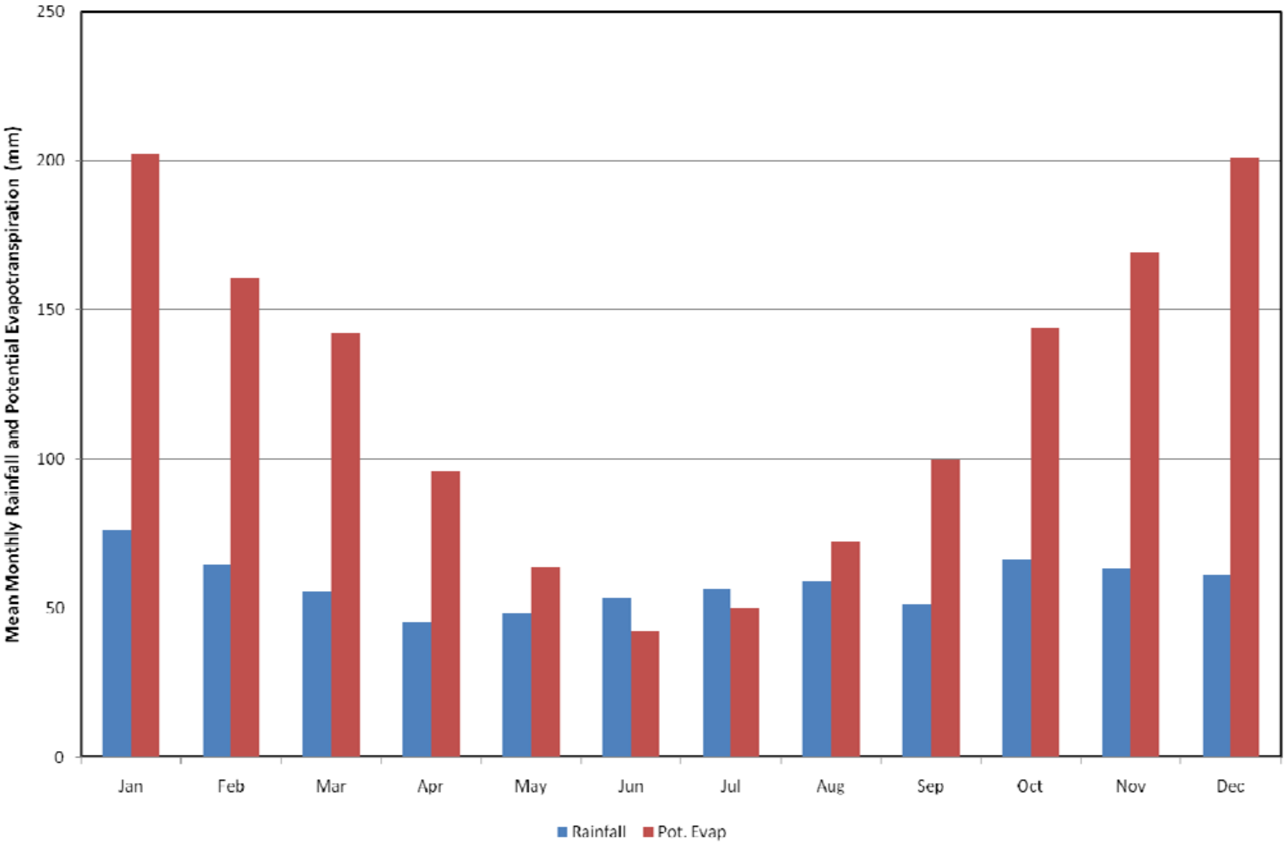

Figure 2.5 Distribution of Monthly Rainfall (Portland, Jamieson St) and Potential Evapotranspiration

3 EXISTING SURFACE WATER MANAGEMENT

Existing surface water management systems within the Project Boundary for existing operations (Invincible Colliery and Cullen Valley Mine) are designed to ensure the following objectives are met:

- To ensure all current legislative requirements with respect to water management within the Project Boundary are met; including project approval conditions and Environment Protection Licence (EPL) conditions.
- Maintain the segregation of clean and dirty water, and install and maintain appropriate pollution control structures to ensure any discharges are kept to a minimum and comply with water quality criteria outlined in the two site EPLs.
- Implement best practice water management procedures across the site to ensure that any environmental impacts related to surface and ground water are minimised.

The water streams from the existing Invincible Colliery and Cullen Valley Mine can be divided into the two categories listed below:

Dirty water: This generally comprises stormwater runoff generated in disturbed areas of the open cut, around the pit top, coal handling and processing areas, coal stockpiles and rejects storage areas, spoil dumps and mine infrastructure areas. This water has the potential for contamination from sediment, coal fines and/or oil and grease.

Clean water: This comprises runoff from undisturbed parts of the Project Boundary and surrounding catchments.

Water management at Invincible Colliery and Cullen Valley Mine is centred on the separation of clean and dirty water. Wherever possible, clean water runoff is diverted around the sites to avoid contamination and reduce the load on the dirty water management systems.
The existing EPL conditions, surface water management systems and structures for both operations are discussed below.

3.1 INVINCIBLE COLLIERY

3.1.1 Surface Water Management System

The Invincible Colliery is located south-east of Cullen Bullen, in the upper catchment of Cullen Creek. Surface water management at the Invincible Colliery is generally undertaken in accordance with the Water Management Plan (Coalpac, 2009) prepared as part of the Invincible Open Cut Coal Mine Extension approval process. Figure 3.1 shows the existing surface management system at the Invincible Colliery.

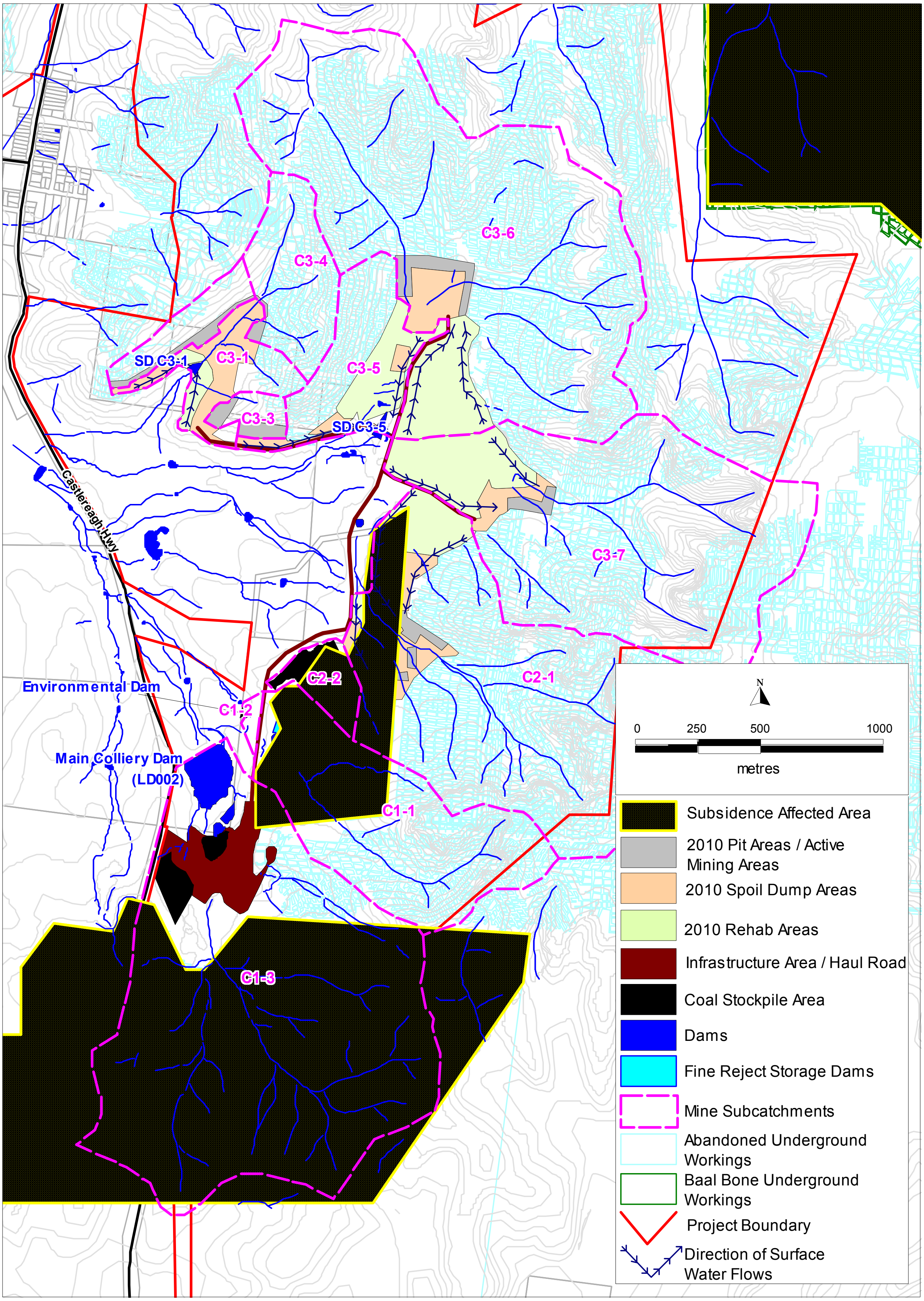

Figure 3.1 Existing Invincible Colliery Surface Water Management System

The Invincible Colliery surface water management system is designed to avoid the discharge of dirty water from the site. A number of sumps located in the open cut areas collect dirty runoff from the active mining areas and spoil dumps. However clean runoff from undisturbed catchment areas upstream of the active mining area also drains into these sumps, as it is not possible to completely divert runoff from the upstream catchments due to the steep nature of the topography in the area. Water collected in the sumps seeps into abandoned underground workings beneath the site or is used for dust suppression. Mine subcatchments which drain to open cut pit sumps include C2-1, C3-2, C3-3, C3-4, C3-6 and C3-7 (see Figure 3.1).

Runoff from rehabilitated landforms and shaped spoil dumps is collected in a series of sediment dams. There is still some exposed ground in these rehabilitated areas, and as such runoff from these catchments is treated as dirty water. Similarly to the pit sumps, the sediment dams also collect clean runoff from upstream undisturbed catchments. Water collected in sediment dams is used for dust suppression. Dirty runoff from haul roads drains to roadside sediment sumps. Water collected in roadside sumps is periodically pumped to sediment dams for settling prior to use for dust suppression. Sediment dams at Invincible Colliery overflow into natural drainage lines and other downstream dams located on the site. Mine subcatchments C3-1 and C3-5 drain to sediment dams.

Dirty runoff from the mine infrastructure area and upstream undisturbed catchment (mine subcatchment C1-3) drains by gravity to the Main Colliery Dam. Water stored in the Main Colliery Dam is used in the Invincible Colliery Coal Preparation Plant (ICPP) and for dust suppression. Dirty runoff draining to the fine reject dams (mine subcatchment C1-1) and coal stockpile areas (mine subcatchment C2-2) is captured and stored on the eastern side of the mine haul road where it infiltrates to the abandoned underground workings located beneath the site.

The Environmental Dam is located on the western side of the haul road downstream of the fine rejects storage dams and coal stockpile area. The Environmental Dam collects seepage from the fine rejects storage dams and runoff from a minor undisturbed catchment (mine subcatchment C1-2). Water stored in the Environmental Dam is pumped to the Main Colliery Dam. Seepage water from the fine rejects storage dams is generally acidic and of poor quality.

Due to the permeable nature of the underlying geology and proximity to abandoned underground workings, the majority of surface water runoff collected in pit sumps, fine reject dams and coal stockpile areas seeps into the abandoned underground workings shortly after a runoff event occurs. This is supported by groundwater modelling undertaken by AGE Consulting on behalf of Coalpac (AGE, 2011), which indicates significant volumes of water are held in the abandoned Invincible and Old Invincible Colliery underground workings beneath the surface operations area. Further, the AGE study suggests that water stored in the abandoned underground workings is passing through the Lithgow Coal Seam into the Baal Bone Colliery underground workings, located to the north-east of the Invincible Colliery. Discussions with Coalpac staff indicate that little or no groundwater seeps into the pits or storages at the site.

Significant portions of the catchments draining the Invincible Colliery site are affected by pre-existing subsidence from underground Bord and Pillar mining in the abandoned Renown Colliery and Ivanhoe Colliery underground workings. Large sinkholes are evident along drainage lines in these portions of the catchment, and it is expected that a substantial portion of surface water runoff which drains through these subsidence affected areas does not report to downstream surface water management structures, and instead enters the sinkholes and reports directly to the abandoned underground workings.

Table 3.1 lists the mine subcatchments currently disturbed by mining activities at Invincible Colliery and the treatment measures for stormwater runoff in each subcatchment.

Table 3.1 Subcatchments Currently Disturbed by Mining, Invincible Colliery

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Cullen Creek			
C1-1	56.8	• Fine Reject Storage Dams	Drains to Fine Reject Storage Area then infiltrates to abandoned Renown Colliery underground workings via subsidence cracking.
C1-2	1.3	• Seepage from Fine Reject Storage Dams	Drains to Environmental Dam then pumped to Main Colliery Dam.
C1-3	170.1	• Mine infrastructure area, coal processing plant.	Drains to Main Colliery Dam then reused. Significant subsidence cracking in upper catchment reduces inflows from natural catchment.
C2-1	121.8	• Active mining areas • Spoil dumps • Proposed rehabilitation areas	All runoff reports to sumps located in the active mining open cut pits. Water collected in sumps seeps into the Old Invincible underground.
C2-2	7.4	• Coal stockpiles	Runoff collected against haul road and allowed to infiltrate into the abandoned Renown Colliery underground.
C3-1	15.3	• Spoil dumps • Proposed rehabilitation areas	Runoff reports to sediment dam SD C3-1 and is reused for dust suppression. Excess runoff overflows to Cullen Creek.
C3-2	9.1	• Active mining areas	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps seeps into the Old Invincible underground.
C3-3	4.5	• Active mining areas	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps seeps into the Old Invincible underground.
C3-4	21.2	• Active mining areas	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps seeps into the Old Invincible underground
C3-5	25.9	• Spoil dumps • Proposed rehabilitation areas	Runoff reports to sediment dam SD C3-5 and is reused for dust suppression. Excess runoff overflows to Cullen Creek.
C3-6	155.8	• Active mining areas • Spoil dumps • Proposed rehabilitation areas	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps seeps into the Old Invincible underground.
C3-7	109.9	• Active mining areas • Spoil dumps • Proposed rehabilitation areas	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps seeps into the Old Invincible underground.

3.1.2 Surface Water Management Structures

Surface water runoff at the Invincible Colliery is managed via a number of sediment dams (SD C3-1 and SD C3-5) and in-pit and roadside sumps, one mine water storage dam (Main Colliery Dam LD002) and a tailings seepage dam (Environmental Dam). There are also three active and four inactive fine reject dams located on the site. The locations of the key surface water management structures are labelled in Figure 3.1. It should be noted that there are a number of smaller sediment dams located around the site which have not been included in this assessment due to their small size. Volumes available in each of the key storages are provided in Table 3.2.

Table 3.2 Invincible Colliery Storage Volumes, 2010 - 2011

Dam ID	Volume (ML)
SD C3-1	10
SD C3-5	60
Environmental Dam	0.03
Main Colliery Dam (LD002)	115

3.1.3 Process Water Demands

Under existing conditions, the Invincible Colliery uses approximately 130ML of water per year for dust suppression activities, and a further 144ML per year to process 1.2 Mt per year of ROM coal. Demands for coal processing are sourced from the Main Colliery Dam, and dust suppression water is drawn from all storages on site as required.

Shortfalls in dust suppression water supply have also been made up in the past from water stored at the nearby Cullen Valley Mine, which may include water obtained from the existing bore to the abandoned Old Tyldesley underground (see Section 3.2.2).

3.1.4 Environmental Protection Licence and Licensed Discharge Points

The Invincible Colliery surface water management system operates in accordance with EPL 1095, which sets out licensed discharge points, discharge water quality criteria and surface water monitoring requirements for the site. The spillway of the Main Colliery Dam is listed as a licensed discharge point for the Invincible Colliery (referred to as LD002). A second licensed discharge point (LD001) exists in the Ben Bullen State Forest at Long Swamp Gully (a tributary of Coxs River) to the east of the Invincible site, however no mine water has been released at this location since June 2008. There is a discharge volume limit of 2000 kL/day at LD001, however the LD002 (Main Colliery Dam) is a wet weather discharge point, and does not have a volume limit at present.

Table 3.3 lists the EPL 1095 discharge water quality criteria for all surface water discharges from the Invincible Colliery.

Table 3.3 Invincible Colliery Discharge Water Quality Criteria, EPL 1095

Pollutant Parameter	Units of Measure	100 Percentile Concentration Limit / Range
Oil & Grease	mg/L	<10
pH	pH	6.5 – 8.5
TSS	mg/L	<30

3.1.5 Surface Water Monitoring Data

The 2008 (Coalpac, 2008), 2009 (Coalpac, 2010) and 2010 (Coalpac, 2011) Annual Environmental Management Reports (AEMRs) for the Invincible Colliery state that no discharges of surface water from the site occurred in these reporting periods. The 2010 AEMR for Invincible Colliery indicates that a discharge from the Main Colliery Dam did occur in January 2011 after a protracted period of high rainfall; however all water discharged during this event was within the criteria stipulated under EPL 1095. The results of water quality testing in the Main Colliery Dam during the January 2011 discharge event are shown in Table 3.4.

Table 3.4 Invincible Main Colliery Dam (LD002) Water Quality Monitoring Data, January 2011 Discharge Event

Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
Main Colliery Dam (LD002)	12	6.9	5
EPL 1095 Discharge Limit	*30*	*6.5 – 8.5*	*10*

In accordance with EPL 1095 surface water quality monitoring has been undertaken at Invincible Colliery since 2001. Water quality samples from the Main Colliery Dam (LD002) and Environmental Dam and SD C3-5 (referred to as 'silt dam' in AEMRs) are taken on a monthly basis, and tested for Oil & Grease, pH and TSS. Water quality samples were also taken from the Long Swamp Gully discharge point (LD001) until May 2008, when mine water discharges at this location ceased. Table 3.5, Table 3.6, Table 3.7 and Table 3.8 list the results of the water quality monitoring undertaken at the Invincible Colliery in 2008, 2009, 2010 and 2011 (at time of reporting) respectively. Table 3.5, Table 3.6, Table 3.7 and Table 3.8 indicate that water quality in storages at the Invincible Colliery is generally within the discharge water quality criteria listed in Table 3.3. However some TSS values have exceeded the criteria at times and pH in the Environmental Dam is regularly below the limits due to acid seepage. It should be noted that despite these exceedances, discharges of water exceeding the water quality criteria have not occurred.

Table 3.5 Invincible Colliery Water Quality Monitoring Data, 2008 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
15/02/2008	Long Swamp (LD001)	No Discharge	No Discharge	No Discharge
	Main Colliery Dam (LD002)	6	6.9	5.0
	Environmental Dam	7	3.0	5.0
	SD C3-5	17	7.2	5.0
17/03/2008	Long Swamp (LD001)	No Discharge	No Discharge	No Discharge
	Main Colliery Dam (LD002)	12	7.9	6.2
	Environmental Dam	10	3.1	5.9
	SD C3-5	24	8.0	0.0
16/04/2008	Long Swamp (LD001)	26	7.0	0.0
	Main Colliery Dam (LD002)	6	7.5	0.0
	Environmental Dam	2	3.0	0.0
	SD C3-5	13	7.7	0.0
16/05/2008	Long Swamp (LD001)	42	7.4	0.0
	Main Colliery Dam (LD002)	3	7.2	0.0
	Environmental Dam	3	3.1	0.0
	SD C3-5	36	7.7	0.0
16/06/2008	Main Colliery Dam (LD002)	65	7.1	2.0
	Environmental Dam	2	2.9	2.0
	SD C3-5	NA	NA	NA
14/07/2008	Main Colliery Dam (LD002)	2	6.5	2.0

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
	Environmental Dam	3	2.9	2.0
	SD C3-5	NA	NA	NA
08/09/2008	Main Colliery Dam (LD002)	32	7.2	2.0
	Environmental Dam	2	3.0	2.0
	SD C3-5	NA	NA	NA
08/10/2008	Main Colliery Dam (LD002)	32	7.0	2.0
	Environmental Dam	5	2.9	2.0
	SD C3-5	NA	NA	NA
12/11/2008	Main Colliery Dam (LD002)	41	7.0	2.0
	Environmental Dam	2	2.8	2.0
	SD C3-5	NA	NA	NA
17/12/2008	Main Colliery Dam (LD002)	7	7.2	2.0
	Environmental Dam	2	3.1	2.0
	SD C3-5	57	7.8	2.0
2008 Monthly Average	*Long Swamp (LD001)*	*34*	*7.2*	*0.0*
	Main Colliery Dam (LD002)	*21*	*7.2*	*2.3*
	Environmental Dam	*4*	*3.0*	*2.3*
	SD C3-5	*29*	*7.7*	*1.4*

'NA' No water quality data supplied for sample date (low water level)
Note: No water quality monitoring data supplied for January or August 2008

Table 3.6 Invincible Colliery Water Quality Monitoring Data, 2009 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
19/01/2009	Main Colliery Dam (LD002)	2	6.3	2.0
	Environmental Dam	10	3.1	2.0
	SD C3-5	37	7.9	2.0
26/02/2009	Main Colliery Dam (LD002)	19	6.7	2.0
	Environmental Dam	2	3.0	2.0
	SD C3-5	27	8.3	2.0
11/03/2009	Main Colliery Dam (LD002)	7	6.4	2.0
	Environmental Dam	3	3.2	2.0
	SD C3-5	23	8.2	2.0
29/04/2009	Main Colliery Dam (LD002)	5	5.8	2.0
	Environmental Dam	2	3.3	2.0
	SD C3-5	13	7.6	2.0
21/05/2009	Main Colliery Dam (LD002)	NA	NA	NA
	Environmental Dam	3	3.4	2.0
	SD C3-5	17	6.9	2.0
04/06/2009	Main Colliery Dam (LD002)	3	4.4	2.0
	Environmental Dam	6	3.1	2.0
	SD C3-5	10	6.9	2.0
24/07/2009	Main Colliery Dam (LD002)	14	4.0	2.0
	Environmental Dam	6	3.1	2.0
	SD C3-5	24	7.6	2.0
20/08/2009	Main Colliery Dam (LD002)	21	4.2	2.0
	Environmental Dam	3	3.3	2.0
	SD C3-5	15	8.3	2.0
10/09/2009	Main Colliery Dam (LD002)	121	4.3	2.0
	Environmental Dam	2	3.3	2.0
	SD C3-5	21	7.8	2.0

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
08/10/2009	Main Colliery Dam (LD002)	288	4.9	2.0
	Environmental Dam	3	3.2	2.0
	SD C3-5	16	8.5	2.0
09/11/2009	Main Colliery Dam (LD002)	10	4.5	27.0
	Environmental Dam	5	3.2	2.0
	SD C3-5	47	7.7	2.0
09/12/2009	Main Colliery Dam (LD002)	9	6.5	2.0
	Environmental Dam	3	3.2	2.0
	SD C3-5	18	8.2	2.0
2009 Monthly Average	*Main Colliery Dam (LD002)*	*45*	*5.3*	*4.3*
	Environmental Dam	*4*	*3.2*	*2.0*
	SD C3-5	*22*	*7.8*	*2.0*

'NA' No water quality data supplied for sample date (low water level)

Table 3.7 Invincible Colliery Water Quality Monitoring Data, 2010 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
21/01/2010	Main Colliery Dam (LD002)	3	6.9	2.0
	Environmental Dam	9	3.2	2.0
	SD C3-5	29	7.3	2.0
10/02/2010	Main Colliery Dam (LD002)	16	7.1	2.0
	Environmental Dam	8	3.3	2.0
	SD C3-5	51	7.2	2.0
03/03/2010	Main Colliery Dam (LD002)	2	6.8	2.0
	Environmental Dam	2	3.4	2.0
	SD C3-5	24	7.5	2.0
21/04/2010	Main Colliery Dam (LD002)	3	7.3	2.0
	Environmental Dam	11	3.6	2.0
	SD C3-5	8	7.6	2.0
18/05/2010	Main Colliery Dam (LD002)	18	6.7	2.0
	Environmental Dam	35	3.4	2.0
	SD C3-5	9	6.5	2.0
17/06/2010	Main Colliery Dam (LD002)	2	6.1	2.0
	Environmental Dam	8	3.4	2.0
	SD C3-5	12	6.0	2.0
05/07/2010	Main Colliery Dam (LD002)	2	6.1	2.0
	Environmental Dam	8	3.4	2.0
	SD C3-5	12	6.0	2.0
19/07/2010	Main Colliery Dam (LD002)	2	7.6	2.0
	Environmental Dam	2	3.2	2.0
	SD C3-5	17	7.3	2.0
09/08/2010	Main Colliery Dam (LD002)	3	6.8	2.0
	Environmental Dam	2	3.4	2.0
	SD C3-5	12	7.4	2.0
09/09/2010	Main Colliery Dam (LD002)	2	7.1	2.0
	Environmental Dam	2	3.1	2.0
	SD C3-5	29	7.7	2.0
11/10/2010	Main Colliery Dam (LD002)	4	6.4	2.0
	Environmental Dam	5	3.2	2.0
	SD C3-5	20	7.0	2.0

09/11/2010	Main Colliery Dam (LD002)	8	6.7	2.0
	Environmental Dam	2	3.3	2.0
	SD C3-5	15	7.1	2.0
13/12/2010	Main Colliery Dam (LD002)	8	7.1	5.0
	Environmental Dam	8	3.1	5.0
	SD C3-5	24	6.6	5.0
2010 Monthly Average	*Main Colliery Dam (LD002)*	*6*	*6.8*	*2.2*
	Environmental Dam	*8*	*3.3*	*2.2*
	SD C3-5	*20*	*7.0*	*2.2*

Table 3.8 Invincible Colliery Water Quality Monitoring Data, 2011 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
19/01/2011	Main Colliery Dam (LD002)	<2	7.1	2.0
	Environmental Dam	<2	3.3	2.0
	SD C3-5	7	7.8	2.0
24/02/2011	Main Colliery Dam (LD002)	5	6.2	2.0
	Environmental Dam	3	3.3	2.0
	SD C3-5	16	6.6	2.0
23/03/2011	Main Colliery Dam (LD002)	7	6.9	2.0
	Environmental Dam	7	3.2	2.0
	SD C3-5	39	7.6	2.0
7/04/2011	Main Colliery Dam (LD002)	<2	6.7	2.0
	Environmental Dam	<2	3.3	2.0
	SD C3-5	20	8.1	2.0
9/05/2011	Main Colliery Dam (LD002)	7	6.8	2.0
	Environmental Dam	<2	3.6	4.0
	SD C3-5	9	6.8	2.0
10/06/2011	Main Colliery Dam (LD002)	47	7.2	2.0
	Environmental Dam	<2	3.4	2.0
	SD C3-5	<2	7.1	2.0
8/07/2011	Main Colliery Dam (LD002)	<2	7.3	2.0
	Environmental Dam	<2	3.7	2.0
	SD C3-5	11	8.0	2.0
4/08/2011	Main Colliery Dam (LD002)	<2	6.9	2.0
	Environmental Dam	2	5.7	2.0
	SD C3-5	3	7.2	2.0
6/09/2011	Main Colliery Dam (LD002)	<2	6.2	2.0
	Environmental Dam	3	3.8	2.0
	SD C3-5	12	7.8	2.0
2011 Monthly Average	*Main Colliery Dam (LD002)*	*8*	*6.8*	*2.0*
	Environmental Dam	*3*	*3.7*	*2.2*
	SD C3-5	*13*	*7.4*	*2.0*

3.1.6 Statistical Analysis of Available Surface Water Quality Monitoring Data

Table 3.9 gives a statistical summary of the water quality monitoring data for the Main Colliery Dam (LD002), Environmental Dam and SD C3-5 at the Invincible Colliery, covering the period February 2008 to September 2011. Full details of the disturbance types within the catchment of each dam under existing conditions are given in **Error! Reference source not found.**. The following is of note with regards to Table 3.9:

- Despite collecting runoff from heavily disturbed catchments, including coal handling and processing areas, water stored in LD002 and SD C3-5 is generally suitable for release. Water stored in the Environmental Dam is typically unacceptable for release due to low pH values.
- The median TSS concentrations in LD002, SD C3-5 and the Environmental Dam are well below the EPL discharge criteria of 30mg/L.
- The 80th percentile TSS concentrations in LD002 and SD C3-5 are 18mg/L and 28mg/L respectively, indicating that TSS concentrations have exceeded the EPL discharge criteria less than 20% of the time over the data period. The Environmental Dam shows very little variation in TSS concentration across the samples.
- The median pH values for LD002 and SD C3-5 (6.8 and 7.6 respectively) are within the EPL discharge criteria (pH between 6.5 and 8.5).
- The 80th percentile pH values for LD002 and SD C3-5 are 6.2 and 7.0 respectively, indicating that approximately 20% of the time water in LD002 may be unsuitable for release due to low pH. It should be noted that the 80th percentile pH values are not greatly dissimilar to naturally occurring pH values in surrounding watercourses (Refer Section 2.3).
- Median, average and 80th percentile oil and grease concentrations in all three storages are well below the 10mg/L EPL limit, although isolated occurrences of high oil and grease concentrations have occurred in LD002.

Table 3.9 Statistical Summary of Water Quality Monitoring Data, Invincible Colliery LD002, SD C3-5 & Environmental Dam

Water Quality Parameter	Main Colliery Dam (LD002)			Environmental Dam			SD C3-5		
	TSS (mg/L)	pH	Oil & Grease (mg/L)	TSS (mg/L)	pH	Oil & Grease (mg/L)	TSS (mg/L)	pH	Oil & Grease (mg/L)
Average	*20*	*6.5*	*2.7*	*5*	*3.3*	*2.2*	*20*	*7.4*	*2.0*
Maximum	*288*	*7.9*	*27.0*	*35*	*5.7*	*5.9*	*57*	*8.5*	*5.0*
Minimum	*2*	*4.0*	*0.0*	*2*	*2.8*	*0.0*	*2*	*6.0*	*0.0*
20th %ile	*2*	*7.1*	*2.0*	*2*	*3.4*	*2.0*	*12*	*7.9*	*2.0*
80th %ile	*18*	*6.2*	*2.0*	*7*	*3.1*	*2.0*	*28*	*7.0*	*2.0*
Median	*7*	*6.8*	*2.0*	*3*	*3.2*	*2.0*	*17*	*7.6*	*2.0*

3.2 CULLEN VALLEY MINE

3.2.1 Surface Water Management System

The Cullen Valley Mine is located north-west of Cullen Bullen, in the catchments of Cullen and Dulhuntys Creeks. Surface water management at the Cullen Valley Mine is generally in accordance with the Environmental Management Plans prepared as part of the Cullen Valley Mine approval process (Lithgow Coal Company, 2006). Figure 3.2 shows the existing surface management system at the Cullen Valley Mine.

The Cullen Valley Mine surface water management system is designed to avoid discharge of water from the site. Sumps located in the open cut areas collect dirty runoff from the active mining areas and spoil dumps, and also receive runoff from undisturbed areas above the open cut pits (mine subcatchment D1-1). Water collected in the open cut pit sumps is periodically pumped to Dam 4 for reuse.

Runoff from rehabilitated landforms, infrastructure areas, coal stockpile areas and shaped spoil dumps at the northern end of the Project Boundary is collected in a series of contour banks and drained to Dam 4 for reuse on site. Runoff from rehabilitated areas is considered as dirty due to the large amount of exposed earth evident in these catchments. Runoff from undisturbed catchment areas above the rehabilitated areas and spoil dumps also drains to Dam 4. Mine subcatchment D1-2 drains to Dam 4.

A 3m high bund extends along the western side of the haul road to minimise noise impacts and drain surface water runoff towards Dam 4. The western face of this bund is rehabilitated and drains west into regional catchment D2. It is not possible to collect runoff from the western face of the bund and drain it to any of the existing dams on site.

Rehabilitated areas and infrastructure areas at the south-eastern extent of the Cullen Valley Mine drain to three large sediment dams (Main Dam, SD C5-1 and SD C5-2), located to the south-west of the infrastructure area. The mine subcatchments draining to these dams are C5-1, C5-2 and C5-3. Runoff collected in these storages is reused on site or transferred to the abandoned Old Tyldesley underground workings which are located beneath these catchments.

Pumping infrastructure exists to transfer water between all of the dams on site. Based on discussions with Coalpac staff, groundwater inflows to pits and storages at Cullen Valley Mine are minimal.

Table 3.10 lists the mine subcatchments currently disturbed by mining activities at Cullen Valley Mine and the treatment measures for stormwater runoff in each subcatchment.

Table 3.10 Subcatchments Currently Disturbed by Mining, Cullen Valley Mine

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Cullen Creek			
C5-1	35.6	• Proposed Rehabilitation • Haul Road	Drains to SD C5-1, which in turn drains via gravity to Main Dam for reuse or transfer to the Old Tyldesley Colliery underground workings.
C5-2	48.3	• Proposed Rehabilitation • Haul Road • Mine infrastructure area • Coal processing plant	Drains to SD C5-2, which in turn drains via gravity to Main Dam for reuse or transfer to the Old Tyldesley Colliery underground workings.
C5-3	22.8	• Proposed Rehabilitation • Haul Road	Drains to Main Dam for reuse or transfer to the Old Tyldesley Colliery underground workings.
Dulhuntys Creek			
D1-1	52.4	• Active mining areas • Spoil dumps	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to Dam 4 as required.
D1-2	114.8	• Proposed Rehabilitation • Haul Road • Mine infrastructure area • Coal processing plant	All runoff reports to Dam 4 for reuse or transfer to the Old Tyldesley underground workings via the Main Dam.

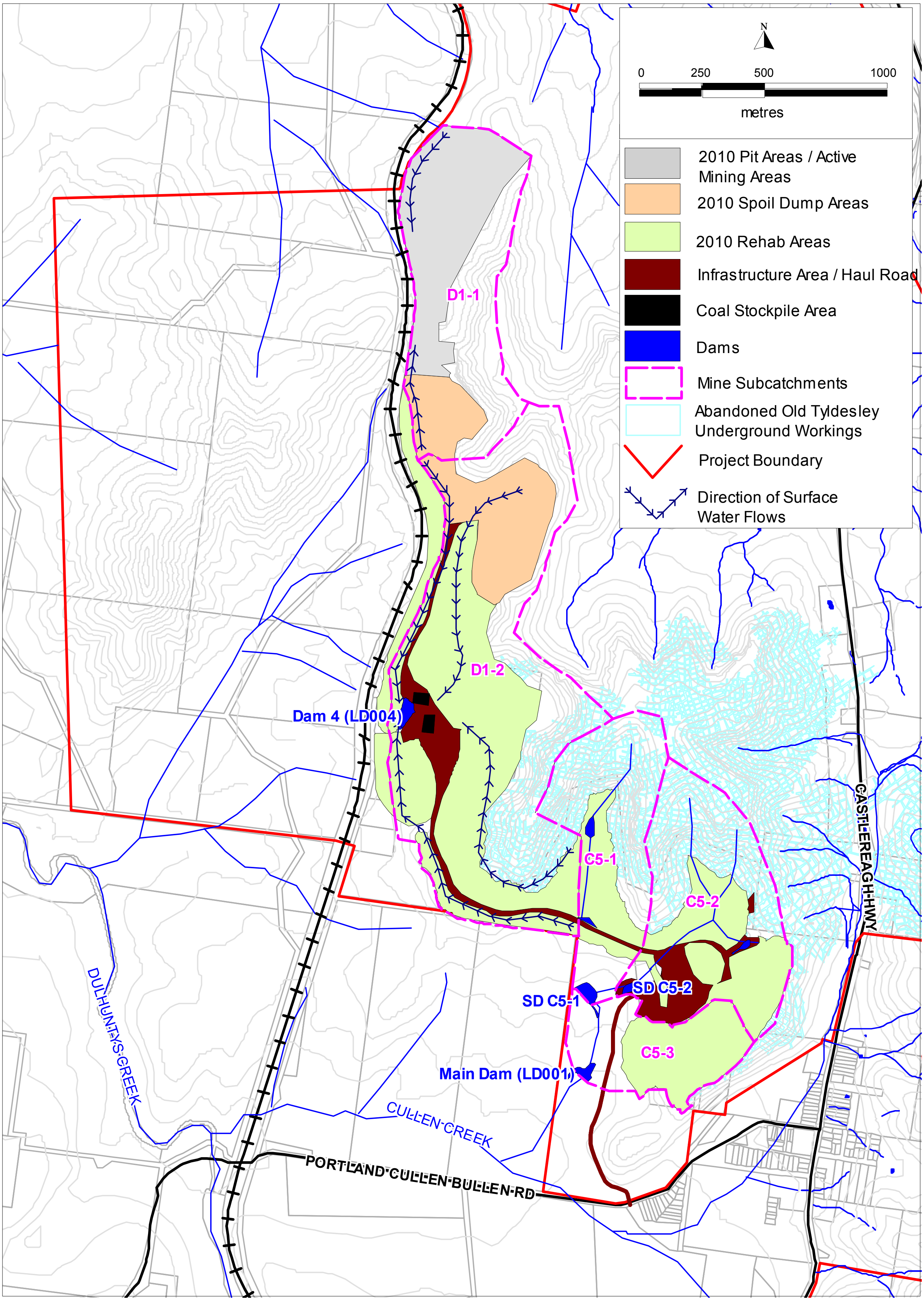

Figure 3.2 Existing Cullen Valley Mine Surface Water Management System

3.2.2 Surface Water Management Structures

Surface water runoff at the Cullen Valley Mine is managed via a number of sediment dams and in-pit and roadside sumps, and two release point dams (Main Dam LD001 and Dam 4 LD004). The locations of the key surface water management structures are labelled in Figure 3.2. All storages at the site are connected via pumping infrastructure. Overflows from SD C5-2 drain to SD C5-1, which in turn overflows to Main Dam (LD001), one of the two licensed discharge points for the Cullen Valley Mine. Releases from the Main Dam drain to Cullen Creek. The second licensed discharge point is at Dam 4 (LD004), which is located adjacent to the railway. Releases from Dam 4 would drain to Dulhuntys Creek. It should be noted that there are a number of smaller sediment dams located around the site which have not been included in this assessment due to their small size. Note that SD C5-1 and SD C5-2 are referred to as Sediment Dam 2 and Sediment Dam 3 respectively in the Cullen Valley Mine AEMRs. The naming convention for these sediment dams has been updated to avoid confusion with other existing and proposed sediment dams.

Volumes available in each of the key storages are provided in Table 3.11.

Table 3.11 Cullen Valley Mine Storage Volumes, 2010 - 2011

Dam ID	Volume (ML)
Main Dam (LD001)	7
SD C5-1	30
SD C5-2	5
Dam 4 (LD004)	38

3.2.3 Process Water Demands

Process water demands at the Cullen Valley Mine mainly consist of water for dust suppression (100ML/year). Approximately 5ML of water per year is consumed in coal crushing activities. Coal crushing water is drawn from Dam 4, and water for dust suppression is taken from all storages on site as required. The majority of coal extracted from the Cullen Valley Mine does not require washing and is supplied directly to the MPPS. Any shortfall in process water is made up using water obtained from a bore connected to the flooded Old Tyldesley underground workings which underlie the site, in accordance with bore licence 80BL244942. During future mining operations (refer Section 4.0), any shortfall in process water will be made up by water extracted from a bore connected to the flooded Old Tyldesley underground workings which underlie the site (in accordance with bore licence 80BL244942) or a new pump and bore to the flooded Invincible and Old Invincible underground workings.

3.2.4 Environmental Protection Licence and Licensed Discharge Points

The Cullen Valley Mine surface water management system operates under EPL 10341, which sets out licensed discharge points, discharge water quality criteria and surface water monitoring requirement for the site. The spillways of Main Dam (LD001) and Dam 4 (LD004) are listed as licensed discharge points for the site. Both LD001 and LD004 are wet weather discharge points and do not have discharge volume limit.

Table 3.12 lists the EPL 10341 discharge water quality criteria for all surface water discharges from the Cullen Valley Mine.

Table 3.12 Cullen Valley Mine Discharge Water Quality Criteria, EPL 10341

Pollutant Parameter	Units of Measure	100 Percentile Concentration Limit / Range
Oil & Grease	mg/L	<10
pH	pH	6.5 – 8.5
Total Suspended Solids (TSS)	mg/L	<50

3.2.5 Surface Water Monitoring Data

The 2008 (Coalpac, 2008a), 2009 (Coalpac, 2010a) and 2010 (Coalpac, 2011a) Annual Environmental Management Reports (AEMRs) for the Cullen Valley Mine indicate that no discharges of surface water from the site occurred the 2008 and 2009 reporting periods. However, a discharge from Main Dam (LD001) did occur on 4th December 2010. The 2010 AEMR states that the discharge occurred following a week of prolonged rainfall, with approximately 125mm of rain recorded at the site. There was no discharge from Dam 4 (LD004) during the 2010 reporting period. The sampling results and discharge criteria from the Main Dam (LD001) discharge event are provided in Table 3.13.

Table 3.13 Main Dam (LD001) Water Quality Monitoring Data, December 2010 Discharge Event

Location	TSS (mg/L)	pH	Oil & Grease (mg/L)	EC (µS/cm)	Iron (mg/L)	Manganese (mg/L)
Main Dam (LD001)	84	6.2	<2	145	2.4	0.39
EPL 10341 Discharge Limit	*50*	*6.5 – 8.5*	*10*	*NA*	*NA*	*NA*

'NA' No discharge limit for pollutant provided in EPL

Table 3.13 indicates that the December 2010 discharge from the Main Dam (LD001) exceeded water quality criteria for TSS and had a pH below the lower limit of the criteria range given in the EPL. It is likely that the December 2010 discharge from the Main Dam could have been prevented by enlarging the existing dams at the Cullen Valley Mine, or providing additional storages upstream of the Main Dam (LD001).

Water quality samples from the Main Dam (LD001) and Dam 4 (LD004) are taken on a monthly basis, and tested for Oil & Grease, pH and TSS. Table 3.14, Table 3.15, Table 3.16 and Table 3.16 list the results of the water quality monitoring undertaken at the Cullen Valley Mine in 2008, 2009, 2010 and 2011 (at time of reporting) respectively. Table 3.14, Table 3.15, Table 3.16 and Table 3.16 indicate that water quality in storages at the Cullen Valley Mine is generally within the discharge water quality criteria listed in Table 3.12. However periods of high TSS have occurred following runoff events or transferral of water between storages, as occurred with the Main Dam (LD001) discharge in December 2010. Periods of low pH have typically been recorded following extended dry periods and increased retention times in the storages (Coalpac, 2008a & 2010a), although low pH may also occur during runoff events. A statistical analysis of the available water quality monitoring dataset is presented in Section 3.2.6.

Table 3.14 Cullen Valley Mine Water Quality Monitoring Data, 2008 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
15/02/2008	Main Dam (LD001)	64	6.8	2.0
	Dam 4 (LD004)	48	6.5	2.0
02/04/2008	Main Dam (LD001)	58	6.3	2.0
	Dam 4 (LD004)	29	6.2	2.0
02/05/2008	Main Dam (LD001)	24	6.0	2.0
	Dam 4 (LD004)	N/A	N/A	N/A
14/05/2008	Main Dam (LD001)	N/A	N/A	N/A
	Dam 4 (LD004)	2	6.8	2.0
03/06/2008	Main Dam (LD001)	27	6.7	2.0
	Dam 4 (LD004)	12	6.4	2.0
02/07/2008	Main Dam (LD001)	42	6.9	2.0
	Dam 4 (LD004)	5	6.6	2.0
01/08/2008	Main Dam (LD001)	4	6.6	2.0
	Dam 4 (LD004)	6	6.5	2.0
02/09/2008	Main Dam (LD001)	67	6.9	2.0
	Dam 4 (LD004)	15	6.6	2.0
02/10/2008	Main Dam (LD001)	4	6.8	2.0
	Dam 4 (LD004)	8	6.5	2.0
12/11/2008	Main Dam (LD001)	19	7.0	2.0
	Dam 4 (LD004)	4	6.8	2.0
17/12/2008	Main Dam (LD001)	182	5.0	2.0
	Dam 4 (LD004)	13	6.1	2.0
2008 Monthly Average	*Main Dam (LD001)*	*49*	*6.5*	*2.0*
	Dam 4 (LD004)	*14*	*6.5*	*2.0*

'NA' No water quality data supplied for sample date

Table 3.15 Cullen Valley Mine Water Quality Monitoring Data, 2009 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
19/01/2009	Main Dam (LD001)	29	6.5	2.0
	Dam 4 (LD004)	16	6.6	2.0
26/02/2009	Main Dam (LD001)	32	7.0	2.0
	Dam 4 (LD004)	9	6.7	2.0
11/03/2009	Main Dam (LD001)	2	7.0	2.0
	Dam 4 (LD004)	11	6.8	2.0
29/04/2009	Main Dam (LD001)	2	6.0	2.0
	Dam 4 (LD004)	36	6.9	2.0
21/05/2009	Main Dam (LD001)	14	6.7	2.0
	Dam 4 (LD004)	18	6.5	2.0
04/06/2009	Main Dam (LD001)	13	6.1	2.0
	Dam 4 (LD004)	24	6.4	2.0
24/07/2009	Main Dam (LD001)	50	6.1	2.0
	Dam 4 (LD004)	11	6.2	2.0
20/08/2009	Main Dam (LD001)	16	7.0	2.0
	Dam 4 (LD004)	5	7.2	2.0
10/09/2009	Main Dam (LD001)	63	6.3	2.0
	Dam 4 (LD004)	6	5.9	2.0
08/10/2009	Main Dam (LD001)	38	7.3	2.0
	Dam 4 (LD004)	14	6.8	2.0
09/11/2009	Main Dam (LD001)	2	8.1	2.0

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
	Dam 4 (LD004)	17	6.7	2.0
09/12/2009	Main Dam (LD001)	2	6.7	2.0
	Dam 4 (LD004)	4	7.1	2.0
2009 Monthly Average	*Main Dam (LD001)*	*22*	*6.7*	*2.0*
	Dam 4 (LD004)	*14*	*6.7*	*2.0*

Table 3.16 Cullen Valley Mine Water Quality Monitoring Data, 2010 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
21/01/2010	Main Dam (LD001)	20	6.6	2.0
	Dam 4 (LD004)	36	6.3	2.0
10/02/2010	Main Dam (LD001)	49	6.9	2.0
	Dam 4 (LD004)	36	6.2	2.0
03/03/2010	Main Dam (LD001)	10	7.1	2.0
	Dam 4 (LD004)	79	6.9	3.0
21/04/2010	Main Dam (LD001)	5	7.9	2.0
	Dam 4 (LD004)	11	6.8	2.0
20/05/2010	Main Dam (LD001)	6	8.0	2.0
	Dam 4 (LD004)	19	7.1	2.0
28/05/2010	Main Dam (LD001)	6	6.0	2.0
	Dam 4 (LD004)	19	7.1	2.0
17/06/2010	Main Dam (LD001)	10	6.5	2.0
	Dam 4 (LD004)	11	6.9	2.0
19/07/2010	Main Dam (LD001)	34	8.2	2.0
	Dam 4 (LD004)	4	6.9	2.0
09/08/2010	Main Dam (LD001)	22	8.1	2.0
	Dam 4 (LD004)	11	7.0	2.0
09/09/2010	Main Dam (LD001)	28	8.3	2.0
	Dam 4 (LD004)	12	7.3	2.0
11/10/2010	Main Dam (LD001)	5	8.1	2.0
	Dam 4 (LD004)	14	6.6	2.0
09/11/2010	Main Dam (LD001)	43	7.0	2.0
	Dam 4 (LD004)	29	6.7	2.0
13/12/2010	Main Dam (LD001)	184	6.6	5.0
	Dam 4 (LD004)	74	6.7	5.0
2010 Monthly Average	*Main Dam (LD001)*	*32*	*7.3*	*2.2*
	Dam 4 (LD004)	*27*	*6.8*	*2.3*

Table 3.17 Cullen Valley Mine Water Quality Monitoring Data, 2011 AEMR Period

Sample Date	Location	TSS (mg/L)	pH	Oil & Grease (mg/L)
19-Jan-11	Main Dam (LD001)	61	7.4	3.0
	Dam 4 (LD004)	93	7.0	3.0
24-Feb-11	Main Dam (LD001)	17	7.5	2.0
	Dam 4 (LD004)	18	6.8	2.0
23-Mar-11	Main Dam (LD001)	97	8.1	2.0
	Dam 4 (LD004)	56	6.8	2.0
07-Apr-11	Main Dam (LD001)	44	7.3	2.0
	Dam 4 (LD004)	42	6.8	2.0

09-May-11	Main Dam (LD001)	15	7.5	2.0
	Dam 4 (LD004)	17	7.4	2.0
10-Jun-11	Main Dam (LD001)	16	6.8	2.0
	Dam 4 (LD004)	60	5.8	2.0
08-Jul-11	Main Dam (LD001)	22	8.5	2.0
	Dam 4 (LD004)	10	7.7	2.0
04-Aug-11	Main Dam (LD001)	9	7.6	2.0
	Dam 4 (LD004)	168	7.1	2.0
06-Sep-11	Main Dam (LD001)	26	7.5	2.0
	Dam 4 (LD004)	22	6.4	2.0
2011 Monthly Average	*Main Dam (LD001)*	*34*	*7.6*	*2.1*
	Dam 4 (LD004)	*54*	*6.9*	*2.1*

3.2.6 Statistical Analysis of Available Surface Water Quality Monitoring Data

Table 3.18 gives a statistical summary of the water quality monitoring data for the Main Dam (LD001) and Dam 4 (LD004) at Cullen Valley Mine, covering the period February 2008 to September 2011. Full details of the disturbance types within the catchment of each dam under existing conditions are given in Table 3.10. The following is of note with regards to Table 3.18:

- Despite collecting runoff from heavily disturbed catchments, including coal handling and processing areas, water stored in LD001 and LD004 is generally suitable for release.
- The median TSS concentrations in LD001 and LD004 (22mg/L and 16mg/L respectively) are well below the EPL discharge criteria of 50mg/L.
- The 80th percentile TSS concentration in LD001 and LD004 are 52mg/L and 36mg/L respectively, indicating that TSS concentrations have exceeded the EPL discharge criteria less than 20% of the time over the data period.
- The median pH values for LD001 and LD004 (6.9 and 6.8 respectively) are within the EPL discharge criteria (pH between 6.5 and 8.5).
- The 80th percentile pH values for LD001 and LD004 are 6.5 and 6.4 respectively, which are only marginally outside of the EPL discharge criteria. It should be noted that the 80th percentile pH values are similar to naturally occurring pH values in surrounding watercourses (Refer Section 2.3).
- Oil and grease concentrations in both LD001 and LD004 have not exceed 5mg/L over the available data period, well below the EPL limit of 10mg/L.

Table 3.18 Statistical Summary of Water Quality Monitoring Data, Cullen Valley Main Dam (LD001) & Dam 4 (LD004)

Water Quality Parameter	Main Dam (LD001)			Dam 4 (LD004)		
	TSS (mg/L)	pH	Oil & Grease (mg/L)	TSS (mg/L)	pH	Oil & Grease (mg/L)
Average	*35*	*7.0*	*2.1*	*26*	*6.7*	*2.1*
Maximum	*184*	*8.5*	*5.0*	*168*	*7.7*	*5.0*
Minimum	*2*	*5.0*	*2.0*	*2*	*5.8*	*2.0*
20th %ile	*6*	*7.7*	*2.0*	*9*	*7.0*	*2.0*
80th %ile	*52*	*6.5*	*2.0*	*36*	*6.4*	*2.0*
Median	*22*	*6.9*	*2.0*	*16*	*6.8*	*2.0*

4 PROJECT DESCRIPTION

4.1 GENERAL

Figure 4.1 to 4.4 show indicative locations of the key features of the mine, including infrastructure related to the management of water within the Project Boundary for four different stages of mining:

- Year 2;
- Year 8;
- Year 14; and
- Year 20;

The main components of water-related infrastructure required for each stage of mining include:

- Sediment dams to collect and treat runoff from overburden emplacement areas and rehabilitation areas;
- Dirty water drains to divert sediment-laden runoff from overburden emplacements, infrastructure areas and rehabilitation areas to sediment dams;
- Pumping infrastructure to enable water to be transferred between storages within the Project Boundary;
- Clean water drains to divert runoff from undisturbed catchments around areas disturbed by mining; and
- Sumps in open cut pits to collect dirty runoff from active mining areas.

A summary of the potential surface water impacts associated with the Project is given in Section 5. Details of proposed mine site storages, including indicative storage sizes and pumping rules are provided in Section 6.

A description of mine operations and proposed surface water management measures for each stage of mining is provided below. The following is of note with regards to the conceptual mine plans and surface water management plans discussed below:

- All pit areas on the western side of the Castlereagh Highway are referred to as Cullen Valley Mine pit areas. Pit areas east of the highway but located in the catchment of Cullen Creek are referred to as Invincible Colliery pit areas. Pit areas on the eastern side of the Highway, and north of the township of Cullen Bullen are referred to as East Tyldesley pit areas. Mining will commence in the East Tyldesley pit areas in Year 2.
- Established rehabilitation areas will support mature vegetation and a have a good ground covering, limiting the amount of sediment contained in runoff from these areas. As such established rehabilitation is not considered a disturbance, and no stormwater treatment measures are proposed for such catchment areas.
- Spoil dumps and proposed or unestablished rehabilitation areas may generate runoff with elevated levels of sediment. Such catchment areas are to be treated with an appropriately designed sediment dam.

- Where haul roads are not located within the catchment of a proposed storage the haul road will drain to roadside sumps for settling and release or reuse in dust suppression.
- Runoff from undisturbed areas upstream of highwall mining activities will be diverted around and away from active mining and disturbed areas. If this is not possible, runoff from upstream areas will be diverted around highwall working areas and collected within in pit sumps.
- Proposed sediment dam locations and catchment areas for each stage of mining are provided. All proposed sediment dams will be designed in accordance with Landcom (2004). It should be noted that where a single sediment dam is proposed for a large mine subcatchment, and the construction of one large sediment dam is impractical, a number of smaller sediment dams may be constructed within the subcatchment. This may be particularly suitable in catchments containing spoil dumps such as C4-1, J3-2 and J5-3 (Refer Figures 4.1 and 4.2).
- The proposed sediment dams will be dewatered within 5 days after the conclusion of a runoff event, and in accordance with Landcom (2004) design criteria, sediment dams will spill during severe storm events. Any spills from sediment dams which have been designed in accordance with Landcom (2004) are expected to meet water quality criteria and would be considered clean runoff. As such no new licensed discharge points will be required downstream of the proposed sediment dams.
- Runoff from active mining, coal stockpiles and processing areas, and mine infrastructure areas is likely to contain elevated levels of salts and may be potentially acidic. Runoff from these areas is collected on site in mine water dams and reused for dust suppression and process water demands. Mine water dams collecting runoff from these catchments will be sized to provide minimum storage capacity to contain runoff from the 10 Year ARI 72 hour storm event (171mm).
- Discharges from the proposed mine water dams are expected to meet water quality criteria given that they only occur during severe storm events when water quality in mine storages would be heavily diluted with clean runoff. In addition, existing water quality data given in Section 3 generally supports this view. Although proposed mine water dams will be managed to limit any discharge of water, additional licensed discharge points may be required at the Project Boundary downstream of proposed mine water dams. Management strategies for avoiding discharges from the proposed mine water dams are discussed in Section 6.10.1.
- Runoff from all disturbed catchment areas will be collected and treated on site. Where possible, the water management system will be designed and operated to minimise the potential for discharges from the site.
- Catchment areas and dam locations are based on conceptual mine layouts and ground surface contours for each stage of mining. The location and size of proposed storages will be reassessed as mining progresses.
- Extraction of make up water from the existing bore and pump connected to the flooded Old Tyldesley underground workings will be restricted in order to assist with mitigation of the underground heating at Cullen Valley Mine, with any shortfall in process or dust suppression water obtained from a new bore or bores connected to the flooded Invincible and Old Invincible underground workings.
- Sand quarrying activities in Cullen Valley will take place in areas where active coal mining is taking place, as shown in Figures 4.1 to 4.4, and as such, any overflow of water from the silt cells or wet screening water supply dam will be collected in stormwater sumps in the active mining area and enter the mine water management system. No additional sediment and erosion control measures beyond those proposed for the water management strategy are therefore required to manage sand quarrying activities.

4.2 YEAR 2 MINE PLAN

Figure 4.1 shows the conceptual mine layout and surface water management plan for Year 2 of the Project. Proposed mining activities and surface water management structures and systems are described below.

4.2.1 Mining Operations

Mining operations in Year 2 can be summarised as follows:

- Mining will commence in the vicinity of Hillcroft (mine subcatchments D2-1, D2-2, D3-1 and J7-1). A haul road will be constructed west across the railway from the existing Cullen Valley Mine haul road.
- Mining will be completed along the northern tip of the existing Cullen Valley Mine active mining area (mine subcatchments J6-1 and J6-2). These areas will be rehabilitated.
- A new open cut pit will be started to the north-west of the existing Cullen Valley Mine active mining areas (mine subcatchment J5-1). An associated spoil dump will be constructed to the north of the pit area (mine subcatcment J5-2) to act as a noise and visual impact bund. This mining area will be served by an extension of the existing Cullen Valley Mine haul road.
- Sand quarrying operations will be carried out at Cullen Valley in the active mining areas (subcatchment J5-1).
- Rehabilitation works across much of the existing Cullen Valley Mine area (mine subcatchments D1-2, C5-1, C5-2, C5-3) will be established, with limited sediment transport expected from these areas. The mine infrastructure and coal processing plant in C5-2 will be replaced with carparking.
- A new office and carparking area will be established at Cullen Valley Mine, immediately south of the Main Dam (LD001). This area will consist of roof and sealed areas only, and will not be utilised for coal handling activities. Runoff from the offices and carparking area will be treated with appropriate sediment and erosion controls during construction, but will not require construction of a sediment dam for operational use.
- Two new open cut pits will be established to the north-east of Cullen Bullen in the East Tyldesley mining area, with associated spoil dumping (mine subcatchments J3-1, C4-3 and C4-4). These pits will be served by new haul road passing across the Castlereagh Highway from the existing Cullen Valley Mine haul road.
- A new coal processing plant will be constructed at East Tyldesley (mine subcatchment C4-2). A new mine water dam (MWD C4-2) will also be constructed to serve the East Tyldesley CHPP. A bund (the Pine Lodge Noise Bund) will also be constructed along the eastern side of the Castlereagh Highway (mine subcatchments C4-1 and J3-1).
- In order to maintain the size of the existing catchment areas draining to Cullen and Jews creeks, spills from proposed sediment dam SD C4-1 will enter a constructed overflow channel that will direct water around the northern extent of the Pine Lodge Noise Bund, and south (along the western toe of the bund). The design and layout of this drain should be taken into consideration when constructing the Pine Lodge Noise Bund.
- A new open cut pit will be established to the south of the Invincible Colliery infrastructure area, and an associated spoil dump located to the east of the infrastructure area. Existing active mining areas in the northern and eastern parts of the Invincible Colliery will begin rehabilitation.
- Rehabilitation works will occur in several mine subcatchments that are currently affected by subsidence from previous mining operations. It is assumed that the rehabilitation works will restore surface water drainage characteristics to natural conditions, and limit the loss of surface water runoff into subsidence cracking which currently occurs.

- A new rail siding and noise and visual bund will be constructed within the existing Cullen Valley mine area (mine subcatchment J6-2). A mine water dam will be constructed in this subcatchment to collect runoff from the rail siding.
- A new conveyor to the MPPS will be constructed to the south of the existing Invincible Colliery. Disturbance from the construction of the conveyor will be located within mine subcatchments C1-3, C1-4 and W1. There will be no ongoing disturbance from the operation of the conveyor. Appropriate sediment and erosion control structures will be put in place during construction of the conveyor.

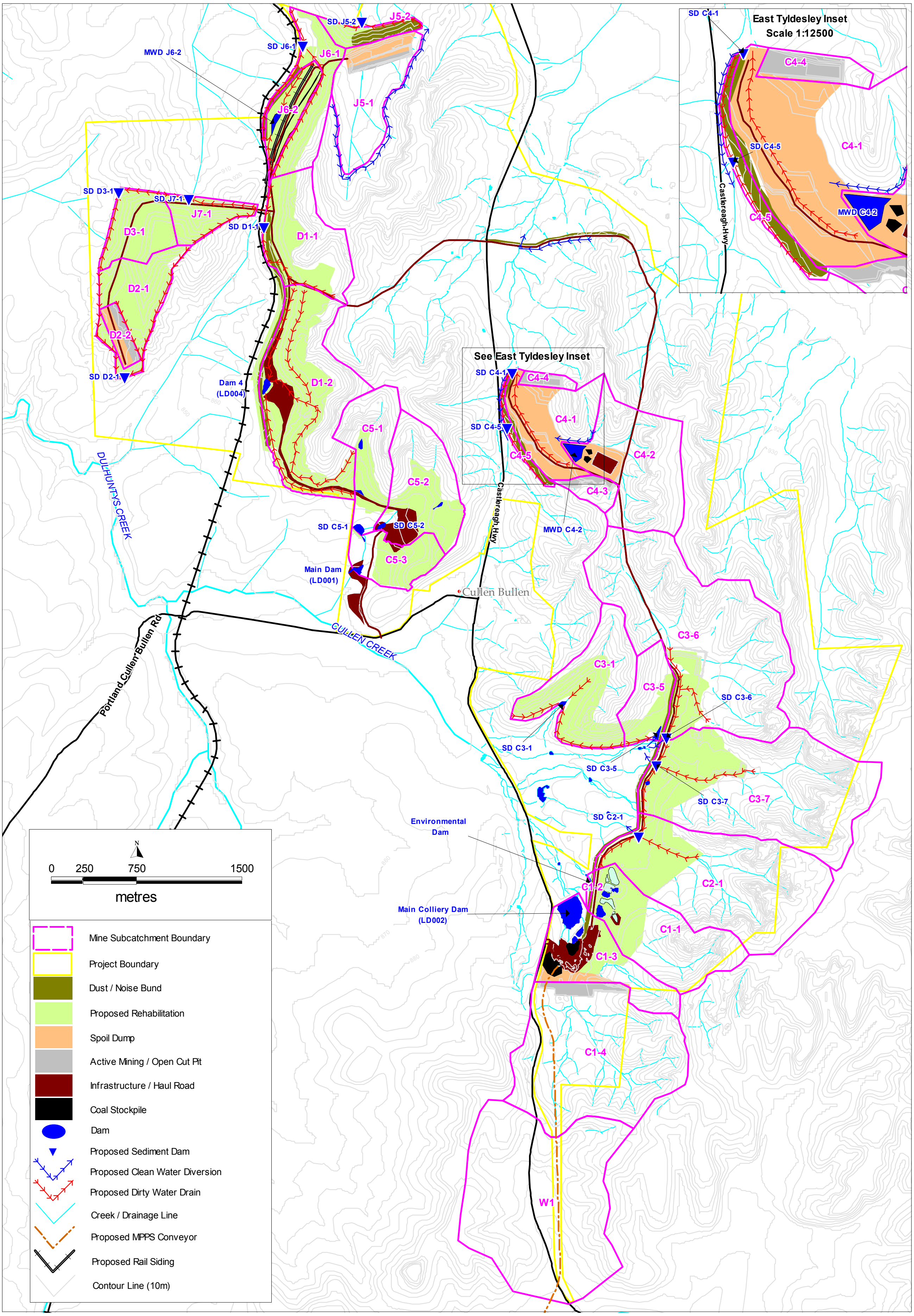

Figure 4.1 Conceptual Mine Layout and Surface Water Management Plan, Year 2

4.2.2 Surface Water Management

Table 4.1 lists the mine subcatchment areas disturbed by mining in Year 2, and indicates the type of stormwater management measure proposed for each catchment.

Table 4.1 Project Mine Subcatchments Affected by Disturbance, Year 2

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Cullen Creek			
C1-1	58.2	• Proposed rehabilitation • Fine Reject Storage Dam	Drains to Fine Reject Storage Area then infiltrates to Old Invincible underground. Inflows from upstream natural catchment reduced due to subsidence cracking.
C1-2	1.0	• Seepage from Fine Reject Storage Dams	Drains to Environmental Dam then pumped to Main Colliery Dam.
C1-3	45.7	• Mine infrastructure area • Coal processing plant • Spoil dump • Conveyor construction • Proposed Rehabilitation	Drains to Main Colliery Dam then reused.
C1-4	124.3	• Active mining area • Conveyor construction	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to the Main Colliery Dam or seeps into the Invincible underground. Inflows from upstream natural catchment reduced due to subsidence cracking.
C2-1	114.2	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD C2-1.
C3-1	56.1	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD C3-1.
C3-5	22.8	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD C3-5.
C3-6	155.1	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD C3-6.
C3-7	137.7	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD C3-7.
C4-1	42.1	• Spoil dump	All runoff reports to proposed sediment dam SD C4-1. Spills from SD C4-1 drain south along western toe of Pine Lodge Noise Bund.
C4-2	64.7	• Mine infrastructure • Coal processing • Spoil dump •	All runoff reports to proposed MWD C4-2 for reuse at East Tyldesley CHPP.
C4-3	7.9	• Active mining area	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to MWD C4-2 for reuse at East Tyldesley CHPP
C4-4	4.5	• Active mining area	All runoff reports to sumps located in the active

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
			mining open cut pit. Water collected in sumps is pumped to MWD C4-2 for reuse at East Tyldesley CHPP
C4-5	5.4	• Noise and dust bund • Proposed rehabilitation	Runoff from western side of noise and dust bund reports to proposed sediment dam SD C4-5.
C5-1	35.6	• Haul road	Drains to SD C5-1, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.
C5-2	48.3	• Haul road • Carparking	Drains to SD C5-2, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.
C5-3	24.0	• Haul road	Drains to Main Dam for reuse or transfer to Old Tyldesley Underground.
Dulhuntys Creek			
D1-1	47.0	• Proposed rehabilitation • Haul road	Runoff from rehabilitation slopes on eastern side of railway reports to proposed sediment dam SD D1-1.
D1-2	93.2	• Haul road • Mine infrastructure area • Coal processing plant	All runoff reports to Dam 4 for reuse or transfer to Old Tyldesley underground via Main Dam.
D2-1	33.1	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD D2-1.
D2-2	7.4	• Active mining area • Spoil dump	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to MWD J6-2.
D3-1	25.6	• Proposed rehabilitation • Spoil dump	All runoff reports to proposed sediment dam SD D3-1.
Jews Creek			
J5-1	43.5	• Active mining area • Spoil dump • Sand quarrying	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to MWD J6-2. Upstream undisturbed catchment area diverted east around active mining area.
J5-2	10.1	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD J5-2.
J6-1	29.8	• Haul road • Proposed rehabilitation	All runoff reports to proposed sediment dam SD J6-1, located on eastern side of haul road. Dirty water drain installed to convey runoff from rehabilitation on eastern side of rail siding.
J6-2	16.9	• Haul road • Proposed rehabilitation • Rail siding • Coal stockpile	All runoff from rail siding catchment is collected in proposed MWD J6-2, located against the eastern face of the noise bund. Receives pumped flows from Cullen Valley Mine pits. Water from MWD J6-2 reused at Cullen Valley or pumped to MWD JC4-2 for reuse at East

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
			Tyldesley.
J7-1	16.6	• Haul road • Proposed rehabilitation	All runoff reports to proposed sediment dam SD J7-1.
Wangcol Creek			
W1	151.0	• Conveyor construction	Runoff from areas disturbed by construction of conveyor will be treated with appropriate sediment and erosion control structures. Once operational, disturbance from the conveyor would be minimal.

4.3 YEAR 8 MINE PLAN

Figure 4.2 shows the conceptual mine layout and surface water management plan for Year 8 of the Project. Proposed mining activities and surface water management structures and systems are described below.

4.3.1 Mining Operations

Mining operations in Year 8 can be summarised as follows:

- Mining will be completed in the vicinity of Hillcroft (mine subcatchments D2-1, D3-1 and J7-1). This area will be rehabilitated.
- The open cut pit and associated spoil dump in mine subcatchment J5-1 will be extended south. Rehabilitation works will commence in the previously mined regions of this catchment.
- A new open cut pit and associated spoil dump will be developed immediately to the west of the Castlereagh Highway in mine subcatchments J3-2 and J3-3. A noise bund will be constructed along the western side of the Castlereagh Highway.
- Rehabilitation works across much of the existing Cullen Valley mine area (mine subcatchments D1-2, C5-1, C5-2, C5-3) will be established, with limited sediment transport expected from these areas. Coal processing activities will no longer be carried out at Cullen Valley Mine at this stage. Existing sediment dams and licensed discharge dams draining these catchments will remain in place.
- The previously mined areas to the west of the East Tyldesley CHPP will be rehabilitated.
- A new open cut pit will be established north of the East Tyldesley CHPP, with an associated spoil dump (mine subcatchment J2-1).
- Mining activities will be completed to the south of the Invincible CHPP, and this area will be rehabilitated, with the full catchment being restored to the Main Colliery Dam.
- A new open cut pit and associated spoil dump will be developed north-east of the Invincible CHPP in mine subcatchment C2-2.
- Construction of the MPPS conveyor will be completed, and disturbance south of the Invincible Colliery mining areas will be minimal.
- Sand quarrying operations will be ongoing in the Cullen Valley active mining areas (subcatchment J5-1).

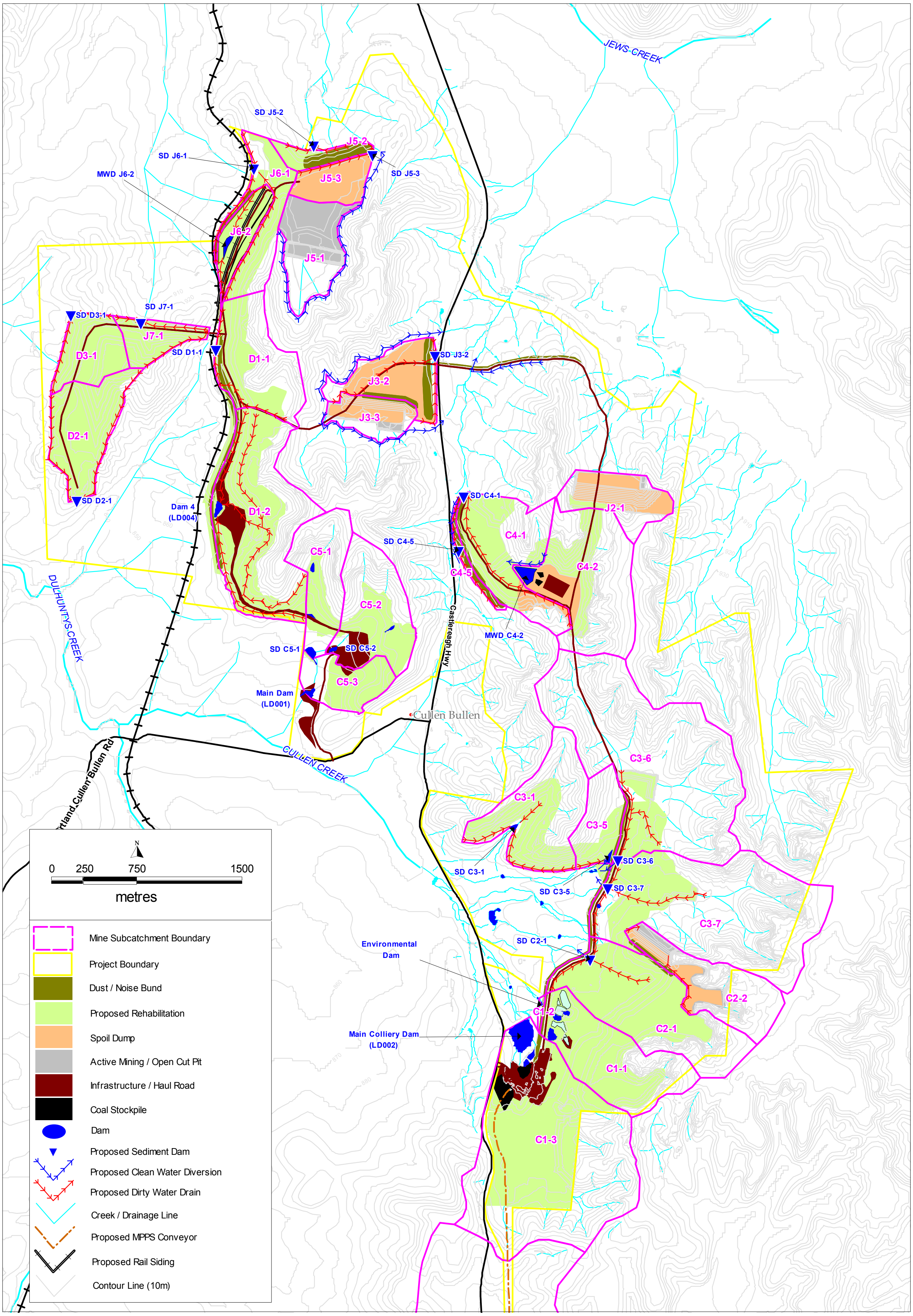

Figure 4.2 Conceptual Mine Layout and Surface Water Management Plan, Year 8

4.3.2 Surface Water Management

Table 4.2 lists the mine subcatchment areas disturbed by mining in Year 8, and indicates the type of stormwater management measure proposed for each catchment.

Table 4.2 Project Mine Subcatchments Affected by Disturbance, Year 8

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Cullen Creek			
C1-1	58.2	• Proposed rehabilitation • Fine Reject Storage Dam	Drains to Fine Reject Storage Area then infiltrates to Old Invincible underground. Inflows from upstream natural catchment reduced due to subsidence cracking.
C1-2	1.0	• Seepage from Fine Reject Storage Dams	Drains to Environmental Dam then pumped to Main Colliery Dam.
C1-3	170.1	• Mine infrastructure area • Coal processing plant • Proposed rehabilitation	Drains to Main Colliery Dam then reused.
C2-1	78.4	• Proposed rehabilitation •	All runoff reports to existing sediment dam SD C2-1.
C2-2	42.8	• Active mining area • Spoil Dump	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to the Main Colliery Dam or seeps into the Old Invincible underground.
C3-1	56.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-1.
C3-5	22.8	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-5.
C3-6	155.1	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-6.
C3-7	130.7	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-7.
C4-1	54.6	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C4-1.
C4-2	72.8	• Mine infrastructure • Coal processing • Spoil dump • Proposed rehabilitation	All runoff reports to proposed MWD C4-2 for reuse at East Tyldesley CHPP.
C4-5	5.4	• Noise and dust bund • Proposed rehabilitation	All runoff reports to existing sediment dam SD C4-5.
C5-1	35.9	• Haul road	Drains to SD C5-1, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.
C5-2	48.3	• Haul road	Drains to SD C5-2, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
C5-3	24.0	• Haul road	Drains to Main Dam for reuse or transfer to Old Tyldesley Underground.
Dulhuntys Creek			
D1-1	47.0	• Proposed rehabilitation • Haul road	Runoff from rehabilitation slopes on eastern side of railway reports to proposed sediment dam SD D1-1.
D1-2	93.2	• Haul road	All runoff reports to Dam 4 for reuse or transfer to Old Tyldesley underground via Main Dam.
D2-1	40.5	• Proposed rehabilitation	All runoff reports to existing sediment dam SD D2-1.
D3-1	25.6	• Proposed rehabilitation	All runoff reports to existing sediment dam SD D3-1.
Jews Creek			
J2-1	28.2	• Active mining area • Spoil dump • Proposed rehabilitation	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to MWD C4-2 for reuse.
J3-2	31.2	• Spoil dump • Haul road	All runoff reports to proposed sediment dam SD J3-2.
J3-3	18.3	• Active mining area • Spoil Dump • Haul Road	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to MWD J6-2 for reuse.
J5-1	34.7	• Active mining area • Sand quarrying	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to MWD J6-2 for reuse.
J5-2	10.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD J5-2.
J5-3	17.5	• Spoil Dump	All runoff reports to proposed sediment dam SD J5-3.
J6-1	29.6	• Haul road • Proposed rehabilitation	All runoff reports to existing sediment dam SD J6-1, located on eastern side of haul road. Dirty water drain installed to convey runoff from rehabilitation on eastern side of rail siding.
J6-2	16.9	• Rail siding • Coal stockpile • Haul road • Proposed rehabilitation	All runoff from rail siding catchment is collected in proposed MWD J6-2, located against the eastern face of the noise bund. Water from MWD J6-2 reused at Cullen Valley or pumped to MWD JC4-2 for reuse at East Tyldesley.
J7-1	14.7	• Haul road • Proposed rehabilitation	All runoff reports to existing sediment dam SD J7-1.

4.4 YEAR 14 MINE PLAN

Figure 4.3 shows the conceptual mine layout and surface water management plan for Year 14 of the Project. Proposed mining activities and surface water management structures and systems are described below.

4.4.1 Mining Operations

Mining operations in Year 14 can be summarised as follows:

- The open cut pit and associated spoil dump in mine subcatchment J5-1 will be extended further south along the valley towards the Cullen Valley Mine. Rehabilitation works will commence in the previously mined regions of this catchment (mine subcatchment J5-3).
- The open cut pit west of the Castlereagh Highway will be extended south towards Tyldesley Hill (mine subcatchment J3-3). Rehabilitation works will commence on previously mined areas (mine subcatchment J3-2).
- The open cut pit and associated spoil dump to the north of the East Tyldesley CHPP will continue to the north into mine subcatchments J3-4 and J2-3. Areas previously mined (mine subcatchments J2-1 and J2-2) will be rehabilitated. A clean water diversion drain will be constructed around the western side of the spoil dump (parallel to the Castlereagh Highway) in order to convey discharges from the undisturbed catchment upstream of the haul road around the area disturbed by mining and north to the Project Boundary. The design and location of this drain should be taken into consideration when constructing the spoil dump.
- Mining activities will be complete at the open cut pit and associated spoil dump north-east of the Invincible CHPP (mine subcatchments C2-2) and these areas will be rehabilitated.
- A new open cut pit and spoil dump will be established in mine subcatchment C3-8.
- Sand quarrying operations in Cullen Valley are expected to finish in Year 14.

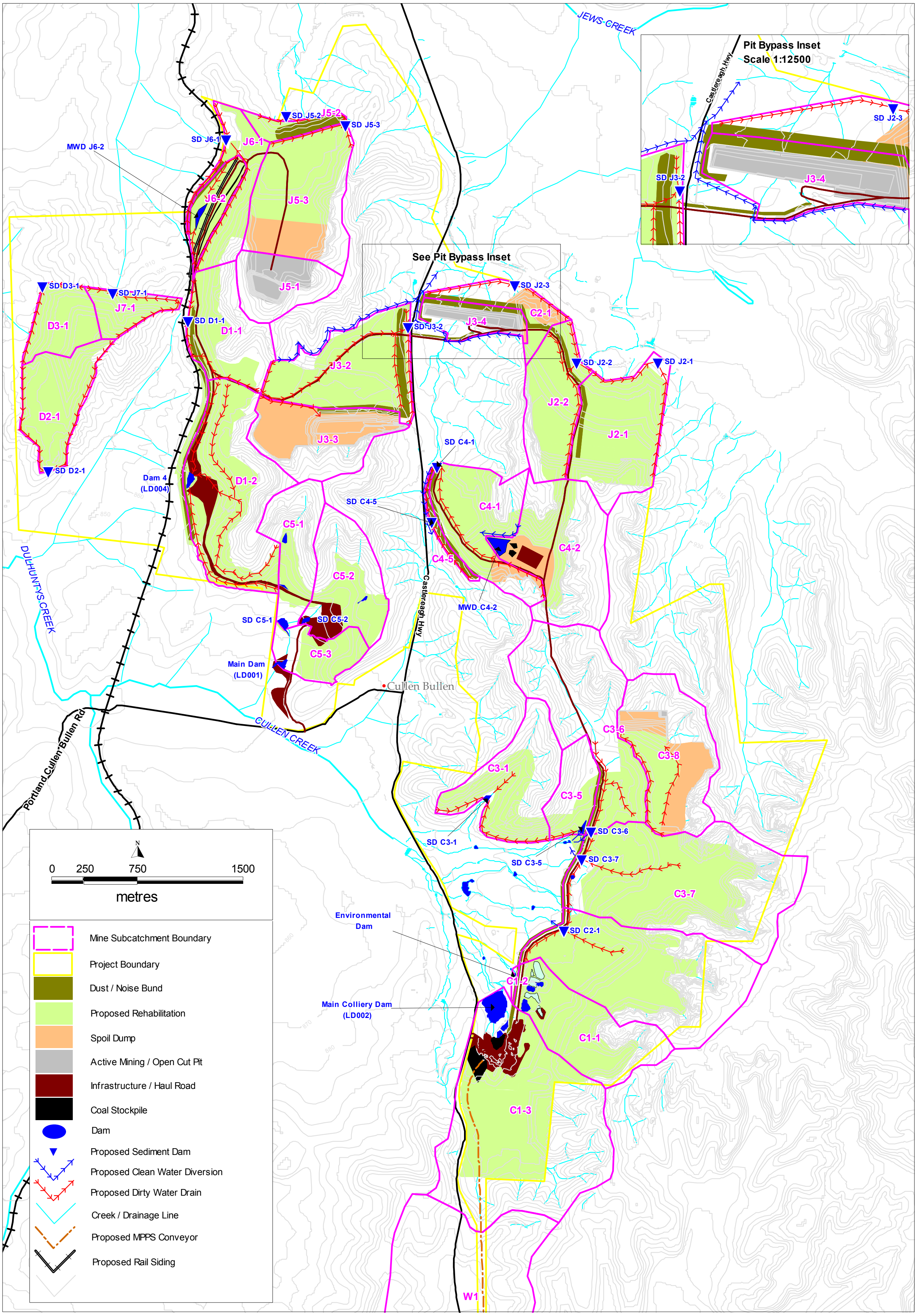

Figure 4.3 Conceptual Mine Layout and Surface Water Management Plan, Year 14

4.4.2 Surface Water Management

Table 4.3 lists the mine subcatchment areas disturbed by mining in Year 14, and indicates the type of stormwater management measure proposed for each catchment.

Table 4.3 Project Mine Subcatchments Affected by Disturbance, Year 14

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Cullen Creek			
C1-1	58.2	• Proposed rehabilitation • Fine Reject Storage Dams	Drains to Fine Reject Storage Area then infiltrates to Old Invincible underground. Inflows from upstream natural catchment reduced due to subsidence cracking.
C1-2	1.0	• Seepage from Fine Reject Storage Dams	Drains to Environmental Dam then pumped to Main Colliery Dam.
C1-3	170.1	• Mine infrastructure area • Coal processing plant • Proposed rehabilitation	Drains to Main Colliery Dam then reused.
C2-1	114.9	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C2-1.
C3-1	56.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-1.
C3-5	22.8	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-5.
C3-6	86.2	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-6.
C3-7	136.7	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-7.
C3-8	69.4	• Active Mining • Spoil Dump • Proposed rehabilitation	All runoff reports to sumps located in the active mining open cut pit. Water collected in sumps is pumped to the Main Colliery Dam or seeps into the Old Invincible underground.
C4-1	54.6	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C4-1.
C4-2	74.8	• Mine Infrastructure • Coal Processing • Proposed rehabilitation • Spoil Dump	All runoff reports to proposed MWD C4-2 for reuse at East Tyldesley CHPP.
C4-5	5.4	• Noise and dust bund • Proposed rehabilitation	All runoff reports to existing sediment dam SD C4-5.
C5-1	35.9	• Haul Road	Drains to SD C5-1, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.
C5-2	48.3	• Haul Road	Drains to SD C5-2, which in turn drains via gravity to Main Dam for reuse or transfer to

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
			Old Tyldesley underground.
C5-3	24.0	• Haul Road	Drains to Main Dam for reuse or transfer to Old Tyldesley Underground.
Dulhuntys Creek			
D1-1	45.3	• Proposed rehabilitation • Haul Road	All runoff reports to existing sediment dam SD D1-1.
D1-2	92.5	• Haul Road	All runoff reports to Dam 4 for reuse or transfer to Old Tyldesley underground via Main Dam.
D2-1	40.5	• Proposed rehabilitation	All runoff reports to existing sediment dam SD D2-1.
D3-1	25.6	• Proposed rehabilitation	All runoff reports to existing sediment dam SD D3-1.
Jews Creek			
J2-1	64.4	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD J2-1.
J2-2	45.3	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD J2-2.
J2-3	21.3	• Spoil Dump • Proposed rehabilitation	All runoff reports to proposed sediment dam SD J2-3.
J3-2	65.3	• Proposed rehabilitation • Haul road	All runoff reports to existing sediment dam SD J3-2.
J3-3	51.9	• Active mining area • Spoil dump	All runoff drains to sumps located in open cut pit then is pumped to MWD J6-2 for reuse.
J3-4	18.9	• Active mining area • Spoil dump • Haul Road	All runoff drains to sumps located in open cut pit then is pumped to MWD C4-2 for reuse. Clean water diversion installed upstream of haul road to divert undisturbed catchment located upstream.
J5-1	32.0	• Active mining area • Sand quarrying	All runoff drains to sumps located in open cut pit then is pumped to MWD J6-2 for reuse.
J5-2	10.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD J5-2.
J5-3	72.0	• Spoil dump • Proposed rehabilitation	All runoff reports to existing sediment dam SD J5-3.
J6-1	29.6	• Haul road • Proposed rehabilitation	All runoff reports to existing sediment dam SD J6-1, located on eastern side of haul road.
J6-2	16.9	• Rail siding • Coal stockpile • Haul road • Proposed rehabilitation	All runoff from rail siding catchment is collected in proposed MWD J6-2, located against the eastern face of the noise bund. Water from MWD J6-2 reused at Cullen Valley or pumped to MWD JC4-2 for reuse at East

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
J7-1	16.6	• Haul road • Proposed rehabilitation	Tyldesley. All runoff reports to existing sediment dam SD J7-1.

4.5 YEAR 20 MINE PLAN

Figure 4.4 shows the conceptual mine layout and surface water management plan for Year 20 of the Project. Proposed mining activities and surface water management structures and systems are described below.

4.5.1 Mining Operations

Mining operations in Year 20 can be summarised as follows:

- Mining activities are completed in mine subcatchment J5-1, J5-2 and J5-3. These subcatchments will be rehabilitated.
- Three separate open cut pits will be established on the western side of the Castlereagh Highway (mine subcatchment J3-3, J3-5 and J4-1. Previously mined areas in the vicinity will be rehabilitated. There is a spoil dump associated with each of the open cut pits.
- Mining in the area north-east of the Tyldesley CHPP will be completed. Areas previously disturbed by mining in these areas will be rehabilitated (mine subcatchments J2-1, J2-2, and J3-4). During rehabilitation works, the diversion drain to convey flows from the upstream undisturbed catchment will be maintained.
- A new open cut pit and associated spoil dump will be established in the East Tyldesley mining area to the north of the East Tyldesley CHPP, east of the Castlereagh Highway (subcatchment J3-6).
- Mining activities north of the Invincible Colliery will extend north-east along the haul road towards the East Tyldesley CHPP (northern most extent of mine subcatchment C3-6), and also north west towards Ben Bullen state forest (mine subcatchment J1-1). Mining will be completed in mine subcatchment J1-1 by Year 20, and the area will be rehabilitated.
- The remainder of the Invincible Colliery mining areas (with the exception of the Invincible CHPP) and fine rejects storage dams will be rehabilitated.
- Sand quarrying operations in Cullen Valley are completed.

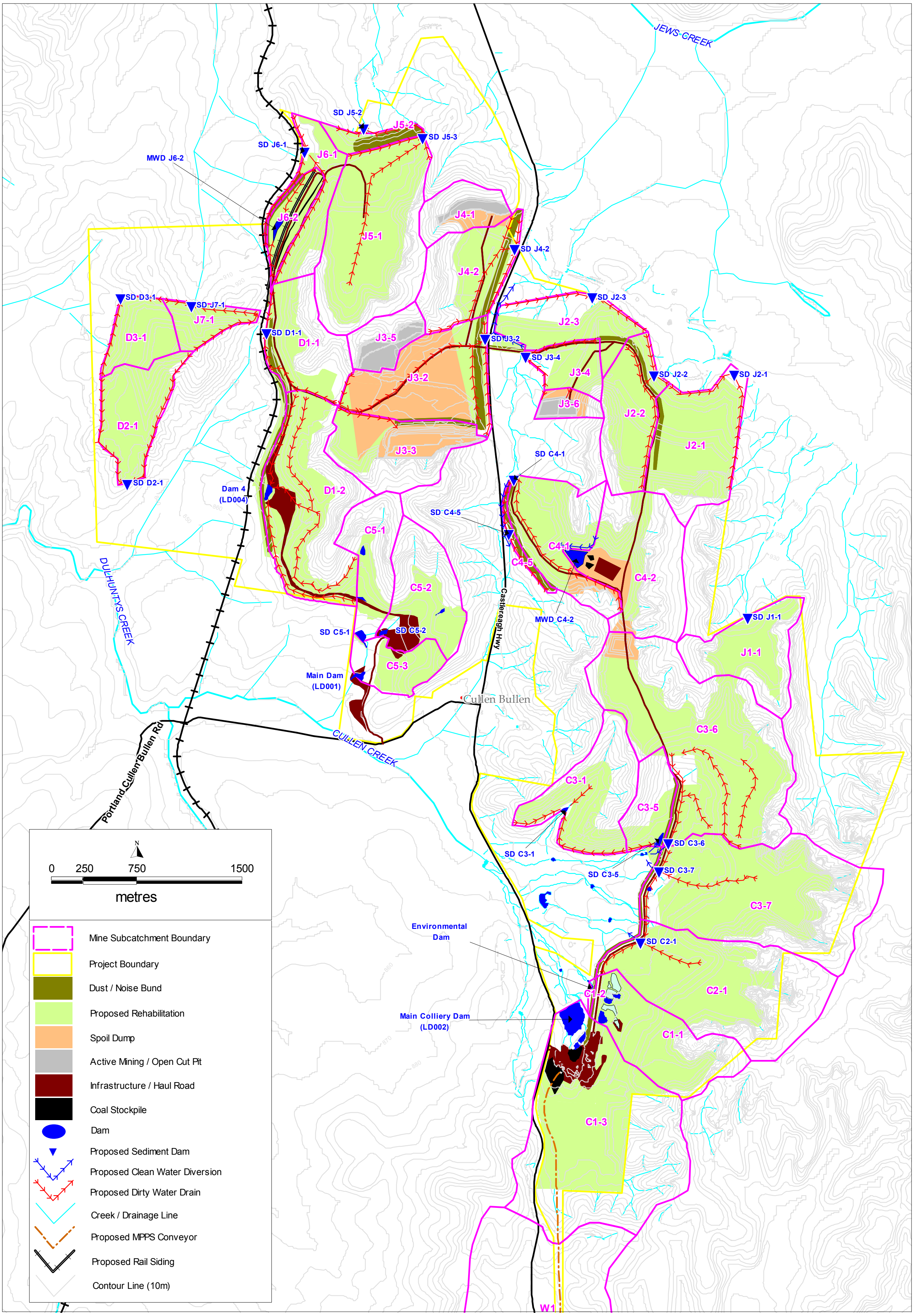

Figure 4.4 Conceptual Mine Layout and Surface Water Management Plan, Year 20

4.5.2 Surface Water Management

Table 4.4 lists the mine subcatchment areas disturbed by mining in Year 20, and indicates the type of stormwater management measure proposed for each catchment.

Table 4.4 Project Mine Subcatchments Affected by Disturbance, Year 20

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Cullen Creek			
C1-1	58.2	• Proposed rehabilitation • Fine Reject Storage Dams	Drains to Fine Reject Storage Area then infiltrates to Old Invincible underground. Inflows from upstream natural catchment reduced due to subsidence cracking.
C1-2	1.0	• Seepage from Fine Reject Storage Dams	Drains to Environmental Dam then pumped to Main Colliery Dam.
C1-3	170.1	• Mine infrastructure area • Coal processing plant • Proposed rehabilitation	Drains to Main Colliery Dam then reused.
C2-1	114.8	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C2-1.
C3-1	56.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-1.
C3-5	22.8	• Proposed rehabilitation • Spoil dump	All runoff reports to existing sediment dam SD C3-5. Dam to be enlarged for additional catchment area if necessary.
C3-6	159.1	• Spoil dump • Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-6.
C3-7	136.7	• Proposed rehabilitation	All runoff reports to existing sediment dam SD C3-7.
C4-1	54.6	• Spoil dump • Proposed rehabilitation	All runoff reports to existing sediment dam SD C4-1.
C4-2	72.5	• Mine Infrastructure • Coal processing plant • Proposed rehabilitation	All runoff reports to proposed MWD C4-2 for reuse at East Tyldesley CHPP.
C4-5	5.4	• Noise and dust bund • Proposed rehabilitation	All runoff reports to existing sediment dam SD C4-5.
C5-1	35.9	• Haul Road	Drains to SD C5-1, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.
C5-2	48.3	• Haul Road	Drains to SD C5-2, which in turn drains via gravity to Main Dam for reuse or transfer to Old Tyldesley underground.
C5-3	24.0	• Haul Road	Drains to Main Dam for reuse or transfer to Old Tyldesley Underground.

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
Dulhuntys Creek			
D1-1	45.3	• Proposed rehabilitation • Haul Road	All runoff reports to existing sediment dam SD D1-1.
D1-2	92.5	• Haul Road • Proposed rehabilitation	All runoff reports to Dam 4 for reuse or transfer to Old Tyldesley underground via Main Dam.
D2-1	40.5	• Proposed rehabilitation	All runoff reports to existing sediment dam SD D2-1.
D3-1	25.6	• Proposed rehabilitation	All runoff reports to existing sediment dam SD D3-1.
Jews Creek			
J1-1	46.7	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD J1-1.
J2-1	64.4	• Proposed rehabilitation • Haul Road	All runoff reports to existing sediment dam SD J2-1.
J2-2	45.3	• Proposed rehabilitation • Haul Road	All runoff reports to proposed sediment dam SD J2-2.
J2-3	38.1	• Proposed rehabilitation	All runoff reports to proposed sediment dam SD J2-3. SD J2-3 to be enlarged if required.
J3-2	66.3	• Spoil dumps • Proposed rehabilitation	All runoff reports to existing sediment dam SD J3-2.
J3-3	52.0	• Active mining area • Spoil dump • Proposed rehabilitation	All runoff drains to sumps located in open cut pit then is pumped to MWD J6-2 for reuse or allowed to infiltrate through pit floor.
J3-4	19.4	• Haul Road • Proposed rehabilitation	All runoff reports to proposed sediment dam SD J3-4.
J3-5	20.0	• Active mining area	All runoff drains to sumps located in open cut pit then is pumped to MWD J6-2 for reuse or allowed to infiltrate through pit floor.
J3-6	10.2	• Active mining area • Spoil Dump	All runoff drains to sumps located in open cut pit then is pumped to MWD C4-2 for reuse or allowed to infiltrate through pit floor.
J4-1	23.0	• Active mining area • Spoil dump	All runoff drains to sumps located in open cut pit then is pumped to MWD J6-2 for reuse or allowed to infiltrate through pit floor.
J4-2	48.7	• Spoil sump • Proposed rehabilitation	All runoff reports to proposed sediment dam SD J4-2.

Mine Subcatchment ID	Area (ha)	Disturbance Type	Stormwater Treatment Measure
J5-1	104.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD J5-3. SD J5-3 will be enlarged to accept the additional catchment area.
J5-2	10.0	• Proposed rehabilitation	All runoff reports to existing sediment dam SD J5-2.
J6-1	29.6	• Haul road • Proposed rehabilitation	All runoff reports to existing sediment dam SD J6-1.
J6-2	16.9	• Rail siding • Coal stockpile • Haul road • Proposed rehabilitation	All runoff from rail siding catchment is collected in proposed MWD J6-2, located against the eastern face of the noise bund. Water from MWD J6-2 reused at Cullen Valley or pumped to MWD JC4-2 for reuse at East Tyldesley.
J7-1	16.6	• Haul road • Proposed rehabilitation	All runoff reports to existing sediment dam SD J7-1.

5 IMPACT ASSESSMENT

5.1 POTENTIAL IMPACTS

The potential impacts of the proposed mining operations on surface water resources include:

- Potential shortfalls in meeting mine site water requirements affecting water available for coal processing, sand quarrying and dust suppression;
- Potential subsidence and loss of catchment area during highwall mining activities;
- Adverse impacts on the quality of surface runoff draining from the surrounding lands on site catchments to Cullen Creek, Dulhuntys Creek and Jews Creek;
- Adverse impacts on downstream water quality associated with possible overflows from the mine water dams affected by coal;
- Loss of catchment area draining to Cullen Creek, Dulhuntys Creek and Jews Creek due to the capture of runoff within on site storages and the Open Cut Pits within the Project Boundary. This could potentially reduce runoff volumes to the above watercourses.
- Potential flooding impacts from minor tributaries and watercourses draining the Project.

An assessment of each of these potential impacts of the Project is provided in the following sections.

5.2 MINE SITE WATER REQUIREMENTS

The maximum annual process water demand during the life of the Project, including water for coal processing and dust suppression, is about 926 ML per year. Table 5.1 lists a breakdown of process water demands for each stage of mining. It should be noted that mine site water requirements have been estimated for the four stages of Project life as described in Section 4.1. The total Project life is 21 years, although mine operations and water demands are expected to be generally unchanged between Year 20 and completion of operations in Year 21.

A detailed description of the estimated water requirements for coal processing, sand quarrying and dust suppression throughout the life of the Project is provided in Section 5.2.1, 5.2.2 and 5.2.3.

Details of the proposed mine water management system are provided in Section 6. Water balance modelling has been undertaken to demonstrate that the operation of the mine water management system will ensure that uncontrolled releases of mine water are limited, and that process water demands for the Project can be met. The methodology and results of the water balance modelling for the Project are also provided in Section 6.

Table 5.1 Predicted Mine Site Water Requirements, Existing and Future Mining Operations

Mining Stage	Total Sand Production (Mt/year)	Total ROM Coal Extraction (Mt/year)	Total Coal Production (Mt/year)	Mine Site Water Demands							
				Sand Quarrying Demand (ML/year)	Coal Processing Demand (ML/year)			Dust Suppression Demand (ML/year)			Total Process Water Demand (ML/year)
				Cullen Valley	Cullen Valley	Invincible	East Tyldesley	Cullen Valley	Invincible	East Tyldesley	
Year 0	0.0	2.4	2.2	0	5	144	0	100	130	0	379
Year 2	0.5	4.5	3.5	50	5	242	242	100	130	100	869
Year 8	0.5	4.5	3.5	50	0	55	491	100	130	100	926
Year 14	0.5	4.5	3.5	50	0	55	491	100	130	100	926
Year 20	0.0	4.5	3.5	0.0	0	55	491	100	130	100	876

5.2.1 Coal Processing Water Demand Estimate

A net coal processing demand of 120 L/ROM tonne of coal was adopted for the purposes of estimating process water demands for both the existing Invincible CHPP and the proposed East Tyldesley CHPP. The adopted coal handling and processing water demand was estimated based on current usage figures provided by Coalpac for the existing Invincible Colliery coal processing plant.

It should be noted that under existing conditions, the majority of coal extracted at Cullen Valley Mine does not require washing. Cullen Valley Mine product coal is generally only crushed prior to transportation to the MPPS. When the East Tyldesley CHPP becomes operational in Year 2, coal crushing operations at Cullen Valley will be significantly reduced, and the majority of product coal will be washed at the East Tyldesley CHPP and Invincible CHPP. By Year 8, the East Tyldesley CHPP is predicted to wash 90% of the total ROM coal, with the remaining 10% washed at the Invincible CHPP. CHPP demand for both Invincible and East Tyldesley has been assumed at 120L/ROM tonne.

5.2.2 Sand Quarrying Water Demand Estimate

The maximum projected sand production rate is 445,000 m^3/yr, equivalent to 1,068,000 t/yr (adopted sand density 2.4 t/m^3). The ROM sandstone is first dry screened, which will require no water input. The dry screening produces 30% over-size material (133,500 m^3/yr), 25% product sand (111,250 m^3/yr) and 45% fines material (200,250 m^3/yr) that requires wet-screening.

The wet screening process produces 55% product sand (110,137.5 m^3/yr or 264,330 t/yr) of product sand and 45% (90,112.5 m^3/yr) of wet silt material, which is discharged to silt cells for settling, prior to further dewatering via evaporation followed by capping.

A review of available data for similar sand quarrying operations elsewhere in New South Wales indicates that the water demand for the wet screening process is up to 5000 L/tonne of sand produced, and that approximately 95% of the wet screening water demand is met via water recycled from the silt cells. The remaining 5% is sourced externally from the wet screening water cycle. The water cycle for a typical wet screening process includes losses for oversized waste and dust suppression, which together make up 25% of the external water demand for the screening process. The following is of note with regards to the wet screening process proposed at the Project Site:

- No oversize waste will be generated by the wet screening process at Cullen Valley, as this material is removed by dry screening.
- Dust suppression water will not be sourced from sand mining operations at Cullen Valley, as dust suppression demands for the Project Site will be obtained from other storages throughout the Project Site.

Removing the oversize waste and dust suppression components from the wet screening water balance reduces the amount of external water required by 25%. Therefore the sand quarrying wet screening operation at the Project Site will have an external demand of 188 L/tonne of sand produced. This equates to an annual demand of about 50 ML/yr based on the maximum projected sand production rate. Sand quarrying operations will be completed in Year 14 of the Project life.

5.2.3 Dust Suppression Water Demand Estimate

Dust suppression demand for future operations at the Project Site were estimated from annual dust suppression water demands at Invincible Colliery and Cullen Valley mine as reported in 2008, 2009 and 2010 AEMR documents (Coalpac 2008a, 2008b, 2010a, 2010b, 2011a & 2011b), as well as the dust suppression demands outlined in the existing water management plans for both sites (Coalpac, 2009 and Lithgow Coal Company, 2006). The following dust suppression demands for future operations at the Project Site were adopted:

- Cullen Valley: 100 ML/yr;
- Invincible: 130ML/yr; and
- East Tyldesley 100ML/yr.

The adopted dust suppression demands are estimates only based on previous experience at the Project Site. Actual dust suppression usage will vary depending on annual rainfall and haul road development.

5.2.4 Sourcing of Water for Mine Site Water Requirements

The first priority source of water to satisfy mine site demands will be the dirty water stored in licensed discharge dams (Invincible Main Colliery Dam, Cullen Valley Main Dam, Cullen Valley Dam 4 and proposed MWD C4-2 and MWD J6-2). These dams are likely to contain the poorest quality water, as they receive runoff from coal stockpiles and processing areas, as well as pumped flows from open cut pit sumps. Water collected in sediment dams may also be used for dust suppression. By maximising the recycling of water on the site, the requirements for makeup water from external sources will be minimised.

Site water demand that cannot be supplied from recycled water on site will be sourced from the abandoned Invincible and Old Invincible underground workings via a new bore and pump. Limited make-up water will be extracted from the existing Old Tyldesley bore and pump. The estimated volume of water stored in the flooded underground workings exceeds 6000ML (AGE, 2011). It is estimated 706ML is held in the flooded Old Tyldesley underground workings, approximately 4790ML in the flooded Invincible underground, and approximately 747ML of water is stored in the Old Invincible underground workings. All flooded underground workings are hydraulically connected to the nearby Baal Bone underground, however there is no hydraulic connection between the Old Tyldesley underground workings and the Invincible and Old Invincible underground workings. The Invincible and Old Invincible underground workings are hydraulically connected.

Since the quantity of water available from on site sources will be dependent on rainfall, water balance modelling was undertaken to estimate the required volume of makeup water for a range of climatic conditions. Full details of the water balance modelling are provided in Section 6.

Table 5.2 shows the volumes of process water required for each stage of mining, and the volumes that the water balance model predicts are available from mine site storages that can be obtained from mine site storages. Table 5.2 also shows the predicted process water deficit which will be obtained from the abandoned Invincible and Old Invincible underground workings and the existing Old Tyldesley bore and pump. Results are provided for a median runoff year and a representative wet and dry year together with the driest runoff year over the 121 year simulation period. The following is of note:

- Water from the flooded underground workings will be required to supply a significant portion of the mine site water demands over the life of the Project.
- The mine site water supply deficit is greatest in Year 8 of Project Life.
- For a median runoff year in Year 8 of Project life, runoff captured in mine site storages can supply 76% of the annual mine site water requirements.
- For the driest runoff year over the simulation period, water from the flooded underground workings will be required to meet 55% of the Year 8 mine site water demand.
- Mine site water may account for a higher proportion of mine water demand if water from proposed sediment dams is used for dust suppression when available.
- In a typical wet year (20^{th} percentile rainfall year) captured mine site runoff satisfies the mine site water demand for the existing case (Year 0), however water from the flooded underground working is required for all other mine scenarios.

Table 5.2 Predicted Mine Site Water Demands and Supply Deficit

Water Supply Breakdown	Year 0 (Existing) (ML/yr)	Year 2 (ML/yr)	Year 8 (ML/yr)	Year 14 (ML/yr)	Year 20 (ML/yr)
Median Year					
Mine Site Storages	360	663	703	768	688
Deficit	19	206	223	158	188
Total	379	869	926	926	876
Wet Year (20th %ile)					
Mine Site Storages	379	800	840	896	831
Deficit	0	69	86	30	45
Total	379	869	926	926	876
Dry Year (80th %ile)					
Mine Site Storages	298	516	572	650	581
Deficit	81	353	354	276	295
Total	379	869	926	926	876
Driest Year on Record (99th %ile)					
Mine Site Storages	233	404	414	475	423
Deficit	146	465	512	451	453
Total	379	869	926	926	876

Table 5.3 compares the predicted process water deficit to be extracted from the flooded underground workings with the predicted volumes of water which will seep or be transferred into the underground workings at each stage of the Project life. Inflows to the underground workings from the Project Site consist of seepage from open cut pits and surface cracking at the Invincible Colliery and pumped transfers into the underground working from the Cullen Valley Main Dam. Results are provided for a median runoff year and a representative wet and dry year together with the driest runoff year over the 121 year simulation period. The following is of note:

- Throughout the majority of the Project life, extractions from the flooded underground workings exceed inflows.
- For a median runoff year, inflows to the flooded underground workings are predicted to exceed extractions for only the existing case (Year 0).
- For a median runoff year in Year 20 of Project life, extractions from the flooded underground workings are more than triple predicted inflows.
- For the driest runoff year over the simulation period, extractions from the flooded underground workings are between 10 and 20 times larger than inflows for all future stages of Project Life.
- Inflows are predicted to exceed extractions for all stages of Project life during a wet year.
- Inflows to the flooded underground workings depend mainly on the amount of open cut pits located above flooded underground workings. Hence inflows are greatest during periods of significant active mining in the Invincible Colliery area.
- It has been assumed that no runoff from rehabilitated areas will seep into the flooded underground workings, and for the purposes of estimating the impact of supplying the mine water deficit from the underground this is a conservative assumption. However in reality is likely that some runoff from rehabilitated areas does seep into the underground workings and provide some recharge to the volume of water stored there. No accurate data is available to quantify the volume of rehabilitation runoff which may be seeping into the underground workings.
- It is likely that significant inflows to the flooded underground workings beneath the Project Site occur from other sources including the up gradient Ivanhoe and Wallerawang collieries to the south of the Invincible Colliery. These external recharge sources have not been included in this study, which has focussed on quantifying the contribution of surface water runoff at the Project Site to the volume of water held in the flooded

underground, and comparing this to the volume of water that may potentially be exracted in order to satisfy process water demands at the Project Site.

Table 5.3 Predicted Extractions from and Inflows to Flooded Underground Workings

Flooded Underground Working Extractions and Inflows	Year 0 (Existing) (ML/yr)	Year 2 (ML/yr)	Year 8 (ML/yr)	Year 14 (ML/yr)	Year 20 (ML/yr)
Median Year					
Extractions	19	206	223	158	188
Total Inflows	321	72	88	129	57
Balance (Inflows – Extractions)	302	-134	-135	-28	-131
Wet Year (20th %ile)					
Extractions	0	69	86	30	45
Total Inflows	893	232	236	295	159
Balance (Inflows – Extractions)	893	163	151	265	113
Dry Year (80th %ile)					
Extractions	81	353	354	276	295
Total Inflows	237	62	75	101	38
Balance (Inflows – Extractions)	156	-291	-279	-175	-257
Driest Year on Record (99th %ile)					
Extractions	146	465	512	451	453
Total Inflows	94	28	32	41	22
Balance (Inflows – Extractions)	-53	-437	-480	-410	-431

5.2.5 Domestic Water Supply

Domestic water requirements for the Project Site will be continue to be obtained from the Fish River Water Supply Pipeline, which supplies potable water to the existing Invincible Colliery and Cullen Valley Mine operations.

The 2008, 2009 and 2010 AEMR documents for Cullen Valley Mine and Invincible Colliery (Coalpac 2008a, 2008b, 2010a, 2010b, 2011a & 2011b) indicate that existing potable water demands are of the order of 5 ML/year to 9ML/year, based on 101 employees and contractors on site. The maximum potable water demand for future operations is expected to range from 6 ML/year to 10.7ML/year, accounting for an increase in the total number of employees to 120 full time staff.

5.3 HIGHWALL MINING ACTIVITIES

Highwall mining activities will be carried out from benches within the open cut mining areas proposed for the Project, and may result in subsidence and loss of catchment impacts on drainage in upstream undisturbed areas. An assessment of highwall mining stability and subsidence at the Project by Geonet Consulting Group (Geonet, 2011) indicates that potential subsidence from highwall mining activities will be insignificant (less than 20mm) and it can therefore be assumed drainage in undisturbed catchments upstream of highwall mining areas will not be impacted. Runoff draining towards the highwall mining areas from such catchments will be diverted around and away from active mining and disturbed areas. If this is not possible, runoff from upstream areas within the open cut pits will be diverted around highwall working areas and collected in sumps for reuse.

5.4 SURFACE WATER QUALITY

5.4.1 Surface Water Management Strategy

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas, infrastructure areas and coal processing areas (pits, roads, coal stockpiles, etc.) may have increased concentrations of salts and other pollutants compared to natural runoff. The surface water generated on the mine site is categorised into four types, based on water quality:

- Clean – surface runoff from areas where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas and any areas where rehabilitation is established.
- Dirty – surface runoff water from areas that are disturbed by mining operations (including spoil dumps, unestablished rehabilitation and haul roads). This runoff may contain high sediment loads, but is not likely to contain contaminated material or high salt concentrations. This runoff must be managed to ensure that downstream water quality is within the adopted water quality compliance criteria;
- Mine water – surface water that has generally come in contact with coal such as in the pit, from the ROM coal stockpiles or infrastructure and CHPP areas. This water is likely to contain higher TDS above values that represent fresh water as defined by ANZECC & ARMCANZ (2000) and includes tailing seepage; and
- Contaminated – surface water from areas potentially containing chemicals of various types used in the mining operations. There are restrictions on the use and release of this water. Contaminated water areas include sumps, service bays and fuel storage areas. Rainfall and resulting runoff from these areas is also potentially contaminated and therefore must be managed to avoid discharge of potentially contaminated water into the natural watercourses or treated prior to reuse in the mine water management system.

By implementing an effective system of mine water management, the Project will ensure no adverse impact on receiving waters. Key elements of the proposed water management system include:

- Diversion of runoff from undisturbed catchments away from disturbed areas, wherever possible, using surface drains;
- Treatment of runoff from unestablished rehabilitation and spoil dumps through sedimentation dams prior to reuse in the mine water management system or discharge from the site. All sediment dams and water management systems will be designed in accordance with relevant standards (Landcom, 2004). The water quality of runoff will be regularly tested to ensure that it meets relevant standards prior to release from the site. If the quality of runoff from disturbed areas is not suitable for release, this water will be pumped into the mine water management system;
- Runoff from mining areas (pits and coal stockpiles), infrastructure and CHPP areas will be collected in open cut pit sumps and mine water dams for reuse on site;
- Sand quarrying activities in Cullen Valley will take place in areas where active coal mining is taking place, as shown in Figures 4.1 to 4.4, and as such, any overflow of water from the silt cells or wet screening water supply dam will be collected in stormwater sumps in the active mining area and enter the mine water management system. As such no additional sediment and erosion control measures beyond those of the proposed water management strategy are therefore required to manage sand quarrying activities;
- Runoff from vehicle sumps, service bays and fuel storage areas will drain to interception storages fitted with oil, grease and hydrocarbon separators. This runoff will be removed off site for treatment and disposal; and

- No runoff from disturbed areas will be discharged from the Project Boundary without treatment via a sediment dam or collection and reuse on site.

Release of surface water from the Project Boundary will occur only in the following ways:
- Clean runoff, occurring from areas undisturbed by mining activities;
- Overflows from sediment dams. Sediment dams will be designed in accordance with Landcom (2004) and will spill regularly. Spills from appropriately designed sediment dams are considered to be clean runoff; and
- Discharge of mine water from the existing licensed discharge points at Invincible Colliery and Cullen Valley Mine. Mine water storages will be managed to limit the discharge of mine water from the Project Boundary. No additional licensed discharge points are proposed as part of the Project. The two new proposed mine water dams, MWD C4-2 and MWD J6-2 will be designed as 'zero-release' storages, and hence will not require additional licensed discharge points.

5.4.2 Sediment Dam Discharges

Based on water quality monitoring undertaken for SD C3-5 at Invincible Colliery and Main Dam (LD001) at Cullen Valley Mine (See Section 3), runoff from areas disturbed rehabilitation and spoil dump areas is generally of suitable quality for release. As such, the ongoing treatment of runoff from unestablished rehabilitation and spoil dumps via appropriately designed sediment dams is considered suitable for the Project. The major contaminant of concern from such catchments is TSS, and this can be adequately addressed through the use of Type D sediment dams, designed in accordance with Landcom (2004).

Overflows from appropriately designed sediment dams are considered to be clean runoff, with no potential for impact on surface water quality downstream of the Project Site. It should be noted that surface water quality will be monitored at locations where discharges from sediment dams leave the Project Site. Details of the proposed monitoring program are provided in Section 7.

5.4.3 Future Discharges from Cullen Valley Licensed Discharge Points LD001 and LD004

The existing EPL 10341 discharge water quality criteria for the Cullen Valley Main Dam (LD001) and Cullen Valley Dam 4 (LD004) are shown in Table 3.12. No modification to the existing discharge water quality criteria is proposed for future mining operations, and it is envisaged that releases of water will continue to occur periodically during rainfall events at these discharge points. A comparison of the EPL 10341 discharge water quality criteria against background water data for nearby watercourses (see Section 2.3) indicates the following:
- Background pH values in the watercourses surrounding the Project Site are typically within the EPL 10341 discharge criteria (pH of 6.5 to 8.5).
- Background TSS concentrations in the watercourses draining the Project Site are very low. Median TSS values in the surrounding watercourses are typically up to 80% lower than the EPL 10341 discharge criteria of 50mg/L.
- There is no available background water quality data from nearby watercourses for Oil and Grease.

Analysis of available water quality data for LD001 and LD004 (see Section 3.2.6) indicates that water held in these storages is typically suitable for release, despite coal crushing and active mining occurring in the catchment of Dam 4 and Dam 1 over the water quality monitoring period. Statistical analysis of available data suggests that historically the EPL 10341 discharge criteria are exceeded in LD001 and LD004 less than 20% of the time, indicating that water quality in these storages is generally of acceptable quality. Water quality data indicates that when EPL discharge criteria are exceeded it is typically due to high TSS concentrations or low pH.

As demonstrated in Section 4, by Year 2 of Project life the catchment areas draining to LD001 and LD004 will consist of mainly rehabilitation areas under varying stages of establishment. Minor areas of disturbance in the form of haul roads and vehicle manoeuvring areas will remain throughout the Project, however no active mining or coal processing will occur in these catchments beyond Year 2 of the Project life. As such it is expected that water quality in LD001 and LD004 would improve over the life of the Project, particularly as the rehabilitation areas in each catchment become established and sediment transport is further minimised.

To reduce the potential for future releases which exceed the EPL 10341 discharge criteria water quality in LD001 and LD004 will be monitored regularly (Refer Section 7). If TSS concentrations exceed the EPL criteria, flocculants will be added to promote the settling of TSS and raise pH, allowing water from these storages to be released.

As such, it is expected that any future releases from these LD001 and LD004 would meet EPL 10341 release water quality criteria. Releases from these storages would be limited by transferring water into the Old Tyldesley Colliery underground workings, and reusing as much water from these storages as possible to satisfy process water demands.

5.4.4 Future Releases from Invincible Licensed Discharge Point LD002

The existing EPL 1095 discharge water quality criteria for the Invincible Main Colliery Dam (LD002) are shown in Table 3.3. No modification to the existing discharge water quality criteria is proposed for future mining operations, and it is envisaged that some releases of water may occur periodically from the Main Colliery Dam. A comparison of the EPL 1095 discharge water quality criteria against background water data for nearby watercourses (see Section 2.3) indicates the following:

- Background pH values in the watercourses surrounding the Project Site are typically within the EPL 1095 discharge criteria (pH of 6.5 to 8.5).
- Background TSS concentrations in the watercourses draining the Project Site are very low. Median TSS values in the surrounding watercourses are typically up to 66% lower than the EPL 1095 discharge criteria of 30mg/L.
- There is no available background water quality data from nearby watercourses for Oil and Grease.

Analysis of available water quality data for LD002 (see Section 3.1.6) indicates that water held in the Main Colliery Dam is generally suitable for release, despite coal handling activities occurring in the Main Colliery Dam catchment, and periodic transfers of low pH water from the Environmental Dam throughout the water quality monitoring period. Available data suggests that historically the EPL 1095 discharge criteria are exceeded in the Main Colliery Dam less than 20% of the time, and when EPL discharge criteria are exceeded in the Main Colliery Dam it is typically due to low pH, possibly as a result of transfer of water from the Environmental Dam. It is of note that the January 2011 discharge event from the Main Colliery Dam did not exceed EPL 1095 discharge criteria for TSS, pH or Oil & Grease. The January 2011 discharge event is the only release that has occurred from the Main Colliery Dam since Coalpac took over operations at the Project site in 1989.

As demonstrated in Section 4, between Year 2 and Year 8 of Project life, the catchment area draining to the Main Colliery Dam will be substantially reduced due to active mining upstream of the dam. It is likely that this reduction in catchment area will result in a significant decrease in releases from the Main Colliery Dam during this period, however coal handling and processing will continue to occur in the dam's catchment, and the dam will continue to receive pumped transfers from the Environmental Dam.

From Year 8 of the Project life onwards, the original catchment area of the dam will be reinstated as the upstream mining areas are rehabilitated. Water quality in the Main Colliery Dam during this period of the Project life is expected to be similar to existing conditions, although there is the possibility of increased TSS levels due to sediment transport occurring from freshly rehabilitated areas. This will be addressed by implementing appropriate sediment and erosion control in the upstream rehabilitation areas in order to limit the amount of sediment which will drain to the Main Colliery Dam.

As such, it is expected that any future releases from the Main Colliery Dam would meet EPL 1095 release water quality criteria. Releases would be limited by reusing as much water from the Main Colliery Dam as possible to satisfy process water demands. To reduce the potential for future releases exceeding the EPL 1095 discharge criteria water quality in LD002 will be monitored regularly (see Section 7). If TSS concentrations exceed the EPL criteria, flocculants could be added to promote the settling of TSS and raise pH, allowing water from these storages to be released.

To further limit the frequency of releases following the completion of active mining upstream of the dam, the open cut pit area in mine subcatchment C1-4 immediately upstream of the Invincible Colliery area (Refer Figure 4.1) could be retained and used as a buffer storage, with captured runoff from the upstream rehabilitation areas seeping into the abandoned underground workings. This option is not proposed at this stage as based on available water quality data, any future releases from the Main Colliery Dam are likely to be within the EPL 1095 discharge criteria. However, it may be considered in more detail following the results of water quality monitoring in LD002 during Year 2 to Year 8 of the Project life.

5.4.5 Volumetric Impact Assessment of Future Releases

An assessment of the potential volumetric impacts of potential future releases from the existing licensed discharge points was undertaken based on a comparison of watercourse catchments and licensed discharge point dam catchments. The following is of note:

- Cullen Creek has a catchment area of approximately 258ha at the location where releases from the Invincible Main Colliery Dam (LD002) enter the main creek channel. Of the 258ha catchment area approximately 170ha drains to the Invincible Main Colliery Dam, and the remaining 88ha is undisturbed catchment area.
- Due to the large volume of runoff captured by the Invincible Main Colliery Dam, it is likely to only release water during severe extended wet periods, coinciding with high volumes of runoff from the undisturbed catchment area, and providing significant dilution for any contaminants.
- The total catchment area of Cullen Creek at the location where releases from Cullen Valley Main Dam (LD001) enter the main creek channel is approximately 1542ha. The catchment area draining to Cullen Valley Main Dam (including upstream dam catchments) is approximately 108ha.
- Due to the small volume of Cullen Valley Main Dam, it is likely to release water regularly, however due to the large catchment area of Cullen Creek at this location, the volume of water released by Cullen Valley Main Dam would be minor when compared to flow volumes in Cullen Creek during release events. The volume of any potential releases will also be minimised by transferring water from the Cullen Valley Main Dam into the Old Tyldesley underground via the existing bore and pump.
- Releases from Cullen Valley Dam 4 (LD004) drain to Dulhunty's Creek downstream of the confluence with Cullen Creek. The total catchment area of Dulhunty's Creek at this location is approximately 4770ha. The catchment area draining to Cullen Valley Dam 4 is approximately 93ha. The volume of any releases from Cullen Valley Dam 4 would be insignificant in comparison to flow volumes occurring in Dulhunty's Creek.

5.4.6 Domestic Wastewater Management

All domestic wastewater is currently collected onsite and periodically pumped out be a licensed contractor, and disposed of at Lithgow Council wastewater treatment facilities. It is proposed that this approach will continue, and is considered viable based on the limited increases in full-time staff that will be onsite.

5.5 LOSS OF CATCHMENT AREA

5.5.1 During Active Mining Operations

During active mining operations, the mine water management system will capture and retain runoff from areas that would have previously flowed to Cullen, Dulhuntys and Jews creeks. The captured catchment area will change as the Project develops. This will occur where runoff from active mining areas and spoil dumps is drained to sumps located within open cut pit areas. The catchment areas draining to the existing Invincible Main Colliery Dam and the Cullen Valley Mine licensed dams (Main Dam and Dam 4) are also considered as being lost to the regional creek catchments, as runoff from these catchments will be collected and reused on site. Runoff draining to sediment dams is not considered to be lost to regional catchments, as all sediment dams will be designed to drain down over a number of days (in accordance with Landcom (2004)), and will only overflow during major storm events.

Table 5.4 shows the catchment area captured within the mine water management system for various stages of mine development. The potential maximum catchment area draining to the mine water management system is approximately 632ha during Year 14 operations, which represents about 8% of the catchment area of Dulhuntys Creek and 2% of the catchment area of Jews Creek upstream of the Turon River. The loss of catchment from the Turon River, which has a total catchment area of some 6500km^2, is negligible.

Table 5.4 Estimated Catchment Area Captured Within Mine Water Management System

Year	Captured Catchment (ha)			Proportion of Total Creek Catchment
	Open Cut Pit	Mine Water Dams	Total	
Cullen Creek				
0	407	277	684	39.7%
2	137	219	356	20.7%
8	43	351	394	22.9%
14	69	351	420	24.4%
20	0	351	351	20.4%
Dulhuntys Creek (includes Cullen Creek)				
0	459	392	851	12.9%
2	144	247	391	5.9%
8	43	443	486	7.4%
14	69	443	512	7.8%
20	0	443	443	6.7%
Jews Creek				
0	0	0	0	0.0%

Year	Captured Catchment (ha)			Proportion of Total Creek Catchment
	Open Cut Pit	Mine Water Dams	Total	
2	44	17	61	0.8%
8	81	17	98	1.3%
14	103	17	120	1.7%
20	105	17	122	1.7%

5.5.2 Final Landform

The drainage strategy for the proposed final landform the Project is shown in Figure 5.1. The final landform is configured such that the majority of the catchment area draining to Cullen, Dulhunty's and Jews creeks will be returned to pre mining conditions.

A number of key mine water and sediment dams within the Project boundary will remain in place, and be maintained, until the final landform rehabilitation is signed off on by the appropriate regulator. Once final sign off is received dams within the Project Boundary may be decommissioned or retained for ecological habitat, as required. Table 5.5 describes the final landform subcatchments and drainage strategy.

Table 5.5 Final Landform Project Subcatchments and Drainage Strategy

Final Landform Subcatchment ID	Area (ha)	Sediment Dam ID	Overflows
C1-2	12.8	Environmental Dam	Cullen Creek
C1-3	170.1	Main Colliery Dam	Cullen Creek
C2-1	156.2	SD C2-1	Cullen Creek
C3-1	53.7	SD C3-1	Cullen Creek
C3-5	178.7	SD C3-5	Cullen Creek
C3-7	136.3	SD C3-7	Cullen Creek
C4-1	54.6	SD C4-1	Cullen Creek
C4-2	72.5	MWD C4-2	SD C4-1 (Cullen Creek)
C4-5	5.4	SD C4-5	Cullen Creek
C5-1	35.8	SD C5-1	Main Dam (LD001) (Cullen Creek)
C5-2	48.3	SD C5-2	SD C5-1 (Cullen Creek)
C5-3	24.0	Main Dam (LD001)	Cullen Creek
J1-1	45.6	SD J1-1	Jews Creek
J2-1	64.4	SD J2-1	Jews Creek
J2-2	45.3	SD J2-2	Jews Creek
J2-3	38.1	SD J2-3	Jews Creek
J3-2	138.3	SD J3-2	Jews Creek
J3-4	29.7	SD J3-4	Jews Creek
J4-2	71.7	SD J4-2	Jews Creek
J5-1	104.0	SD J5-3	Jews Creek
J5-2	10.0	SD J5-2	Jews Creek
J6-1	29.6	SD J6-1	Jews Creek
J6-2	16.9	MWD J6-2	Jews Creek
J7-1	16.6	SD J7-1	Jews Creek
D1-1	45.3	SD D1-1	Dulhunty's Creek
D1-2	92.5	Dam 4 (LD004)	Dulhunty's Creek
D2-1	40.5	SD D2-1	Dulhunty's Creek
D3-1	25.6	SD D3-1	Dulhunty's Creek

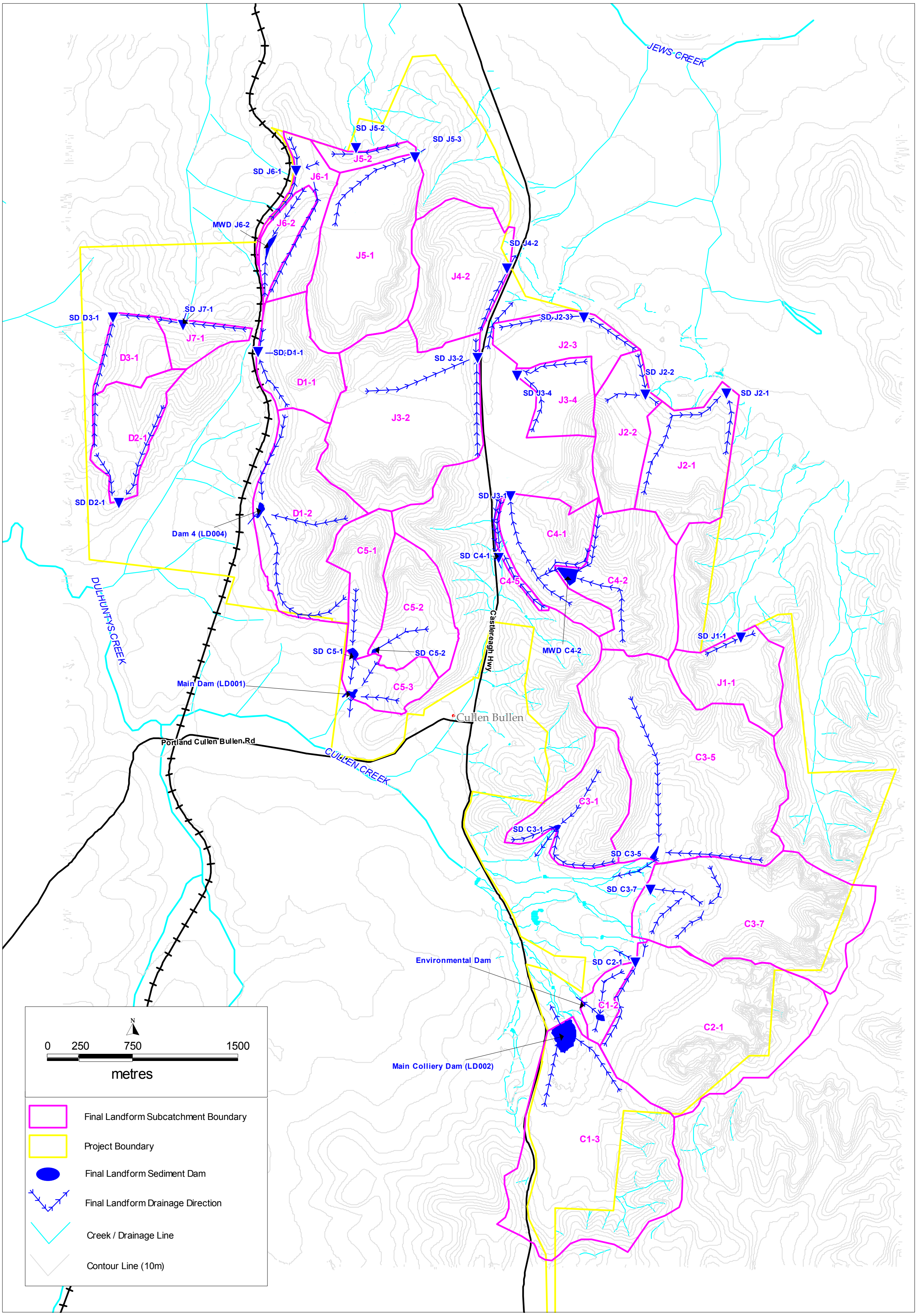

Figure 5.1 Proposed Final Landform Drainage Configuration

5.6 POTENTIAL IMPACT OF FLOODING ON PROJECT INFRASTRUCTURE

The potential for flooding of mine infrastructure from the regional watercourses in the vicinity of the Project Boundary is minimal. Ground levels adjacent to the upper reaches of Cullen Creek, on the western side of the Castlereagh Highway, are approximately 12m below the embankment level of the Invincible Main Colliery Dam. On this basis backwater flooding from Cullen Creek will not impact on infrastructure at Invincible Colliery. However it is of note that flooding from Cullen Creek may potentially inundate parts of the Castlereagh Highway south of Cullen Bullen as it is under existing conditions.

Similarly, ground levels adjacent to Cullen Creek south of Cullen Valley Mine are some 12m to 15m below the embankment level of Cullen Valley Main Dam. Flooding in Cullen Creek will not impact on infrastructure at Cullen Valley mine; however Portland-Cullen Bullen Road and Wallerawang Gwabegar Railway may be impacted by flooding from both Cullen and Dulhunty's creeks as it is under existing conditions.

Flooding from Jews and Dulhunty's creeks would not impact on any existing or proposed Project infrastructure, as all infrastructure is located well above the potential floodplains of both watercourses.

Flooding from the minor tributaries draining the Project Boundary is unlikely to impact on Project infrastructure due to the small size of upstream catchment areas and the steep nature of the topography within the Project Boundary. The proposed water management system will involve the capture and storage of runoff draining to these minor tributaries, allowing for effective management of flooding. All diversion drains within the Project Boundary will be designed in accordance with DECC (2008) guidelines.

6 MINE WATER BALANCE

6.1 OVERVIEW

An AWBM (Boughton, 2003) rainfall runoff model was developed to determine runoff volumes from pit, stockpile, rehabilitation and natural catchment areas for the Project. The Goldsim (Goldsim Technology Group, 2010) model was then used to determine the behaviour of the proposed Project storages for the following stages of mine operations:

- Year 0;
- Year 2;
- Year 8;
- Year 14; and
- Year 20.

The models were run over the 121 year (from 1st January 1889 to 1st January 2011) period of daily rainfall data obtained from the Bureau of Meteorology's SILO Data Drill (Jeffrey *et al*, 2001). The use of such a long period of continuous data provides a good indication of the behaviour of the system over extended dry and wet periods.

6.2 SIMULATION METHODOLOGY

To assess the performance of the water management system throughout the life of the mine, water balance modelling was undertaken for each of the five stages described above using the 121 year daily SILO Data Drill climate data set.

The water balance model was configured to represent the changing characteristics of the conceptual water management system over the 20 year mine life, including the addition of new storages and changes in contributing catchment areas and catchment types, as represented in the mine stage plans given in Figure 4.1 to 4.4.

The models were configured to represent the inflows to and outflows from the mine water management system shown in Table 6.1, as well as transfers of water between mine site storages. Details of the model configuration, input data and results are provided in the following sections.

The model was configured to provide salient information on the following key points of the mine water management system for each stage of mining:

- The volume of water likely to report to open cut pits;
- The ability of the mine water management system to supply process water demands;
- The volume of makeup water required from the Invincible and Old Invincible Colliery underground workings;
- The volume of water transferred to the Old Tyldesley Colliery underground via Cullen Valley Main Dam;

- The volume of surface water runoff from the Invincible Colliery that may drain or seep into the Invincible and Old Invincible underground workings via pit seepage and subsidence cracking; and
- The size and frequency of any spill events from the Invincible Main Colliery Dam, Cullen Valley licensed discharge dams and the proposed MWD C4-2 and MWD J6-2.

Table 6.1 Simulated Inflows and Outflows to Mine Water Management System

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Direct rainfall into pits and active mining areas	CHPP demands
Makeup water supply from underground workings	Dust suppression demands
Catchment runoff from natural and disturbed catchments entering storages	Sand quarrying demands
Catchment runoff from natural and disturbed catchments entering pits and active mining areas	Pumped transfers to Old Tyldesley underground
Groundwater seepage into open cut pits and storages. Likely to be negligible (AGE, 2011).	Off site spills from storages
	Runoff entering Invincible and Old Invincible underground workings.

6.3 STORAGES

Table 6.2 shows the indicative sizes of mine site storages adopted in the site water balance model. The locations of the various storages are shown in Figure 4.1 to 4.4. The existing Environmental Dam and all proposed sediment dams were not included in the water balance model due to the small size of these storages. Existing sediment dams have been included in the Year 0 (existing case) model as they are of reasonable size and play a role in providing process water at both Cullen Valley Mine and Invincible Colliery. Open cut pits in each mine region (Cullen Valley, Invincible and East Tyldesley) were modelled as combined storages with a nominal storage volume and surface area. It should be noted that the two new proposed mine water dams (MWD C4-2 and MWD J6-2) have been designed and sized as no spill storages, although emergency spillways will be provided in both dams.

Table 6.2 Adopted Storage Details, Water Balance Model

Storage	Capacity (ML)	Maximum Surface Area (ha)	Spills To
Main Colliery Dam	115	3.4	Off site (Inv LD002)
SD C3-1	10	0.5	Off site
SD C3-5	60	3.0	Off site
SD C5-2	5	0.2	SD C5-3
SD C5-3	30	0.5	CV Main Dam
CV Main Dam	7	0.4	Off site (CV LD001)
CV Dam 4	38	0.5	Off site (CV LD004)
MWD C4-2	250	3.0	NA
MWD J6-2	75	1.5	NA

6.4 MODEL CONFIGURATION AND ASSUMPTIONS

Figure 6.1 shows the conceptualisation of the Year 0 (existing case) mine water management system adopted for the water balance model. Figures 6.2, 6.3 and 6.4 show the conceptual water balance model configuration for Year 2 to Year 20 of Project life. The conceptual water balance model configuration is identical for Year 8 and Year 14 (ie. demands and water management system are the same, but catchment areas differ based on the concept mine layouts). Note that the coal process and sand quarrying water circuits were not explicitly modelled. However, the estimated net water demand from the Invincible CHPP and East Tyldesley CHPP (from Year 2), and water demand for coal crushing and sand quarrying at Cullen Valley was included in the model. Key water balance modelling assumptions are as follows:

- Runoff that reports to open cut pits or storages that are located above the Invincible and Old Invincible underground workings will infiltrate to the workings and is lost to the water management system. This assumption is based on operational observations made by Coalpac staff at the Invincible Colliery. It is of note that all pits in the Invincible Colliery area of operations are located above abandoned underground workings;
- There is 100% reliability for makeup water supply from the Invincible and Old Invincible undergrounds;
- All runoff from catchment areas located in and upstream of underground mining subsidence affected areas reports directly to the underground via sinkholes and no overland runoff will occur from these catchment areas. This assumption is based on operational observations made by Coalpac staff at the Invincible Colliery;
- On site pumps for transfer of water between open cut pit sumps and mine water storages have a capacity of 7ML/day (approximately 80L/s); and
- Groundwater seepage into pits and mine site storages is negligible (AGE, 2011).

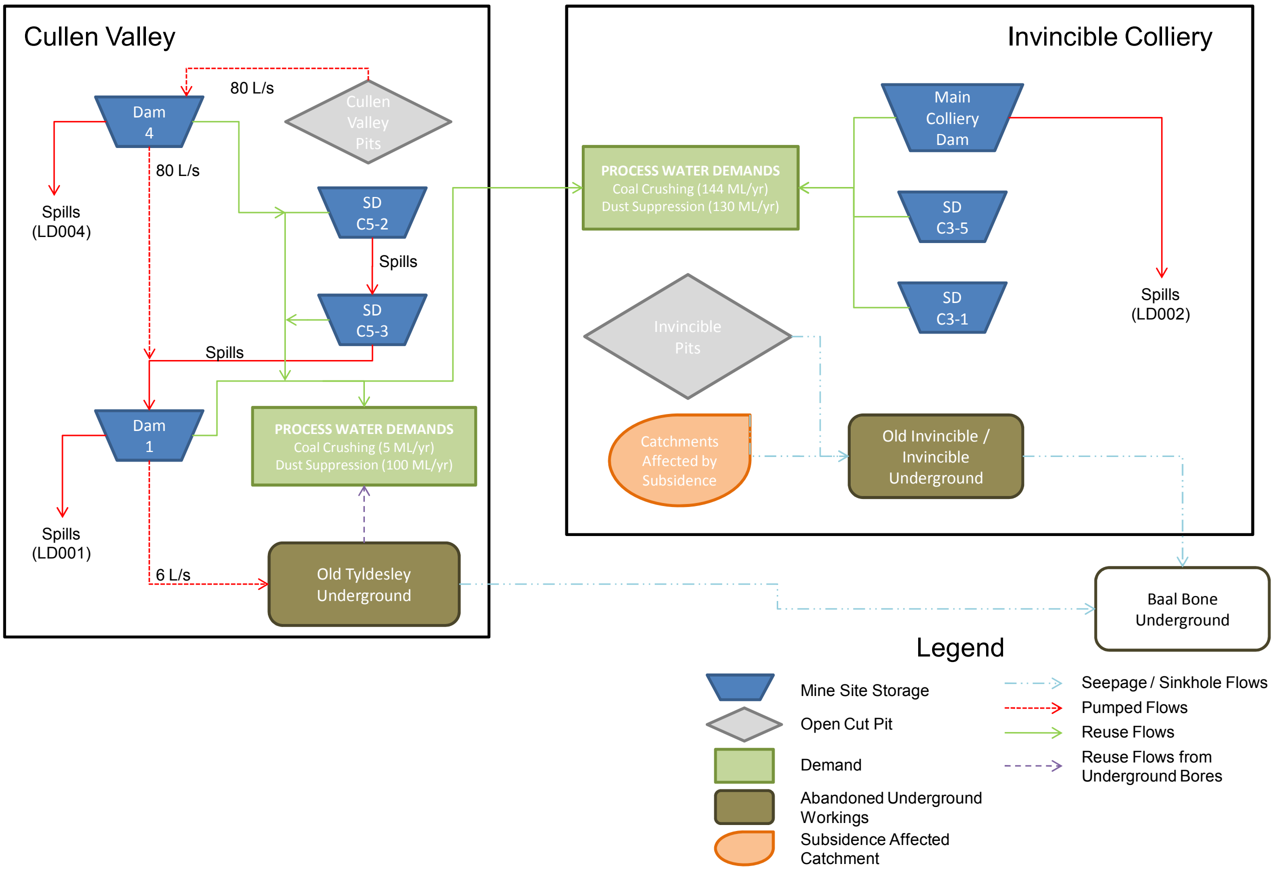

Figure 6.1 Conceptual Water Balance Model Configuration, Year 0 (Existing Case)

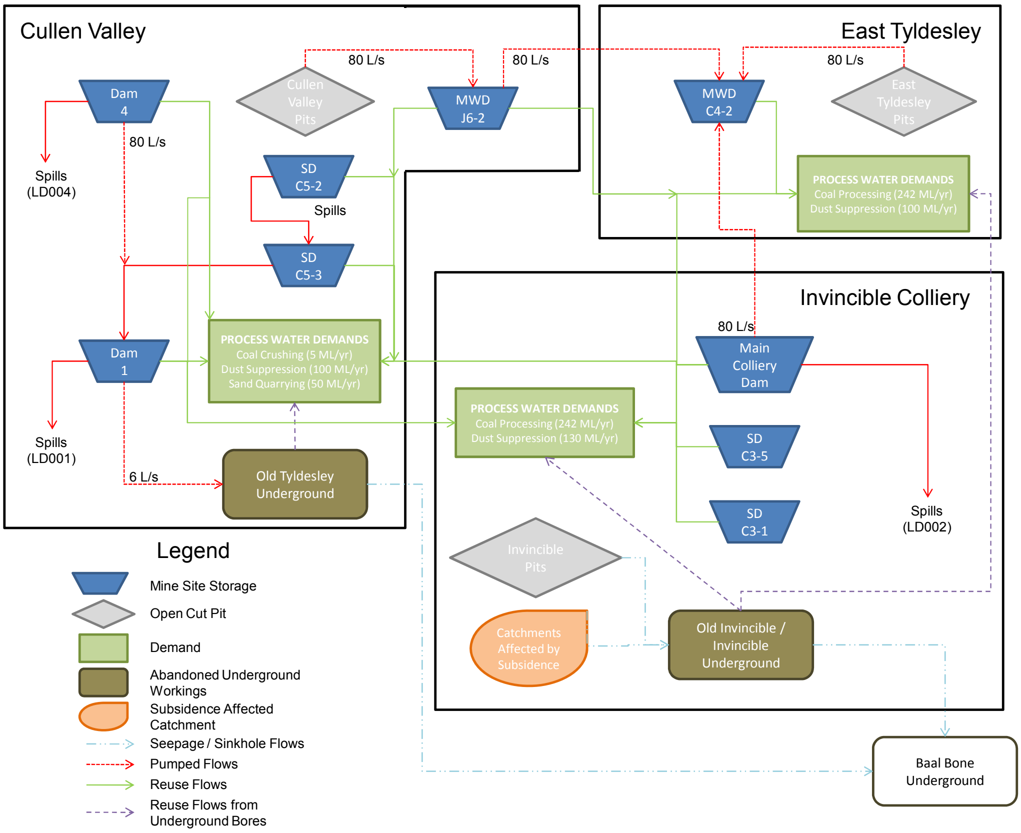

Figure 6.2 Conceptual Water Balance Model Configuration, Year 2 Project Life

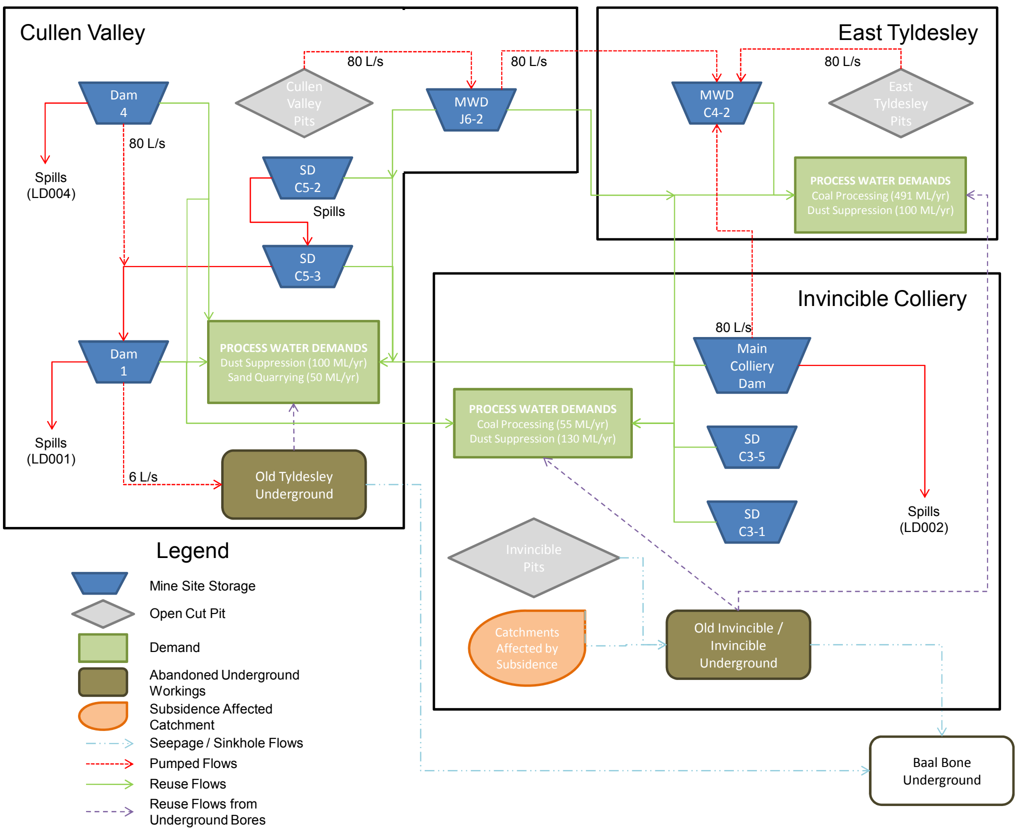

Figure 6.3 Conceptual Water Balance Model Configuration, Year 8 & Year 14 Project Life

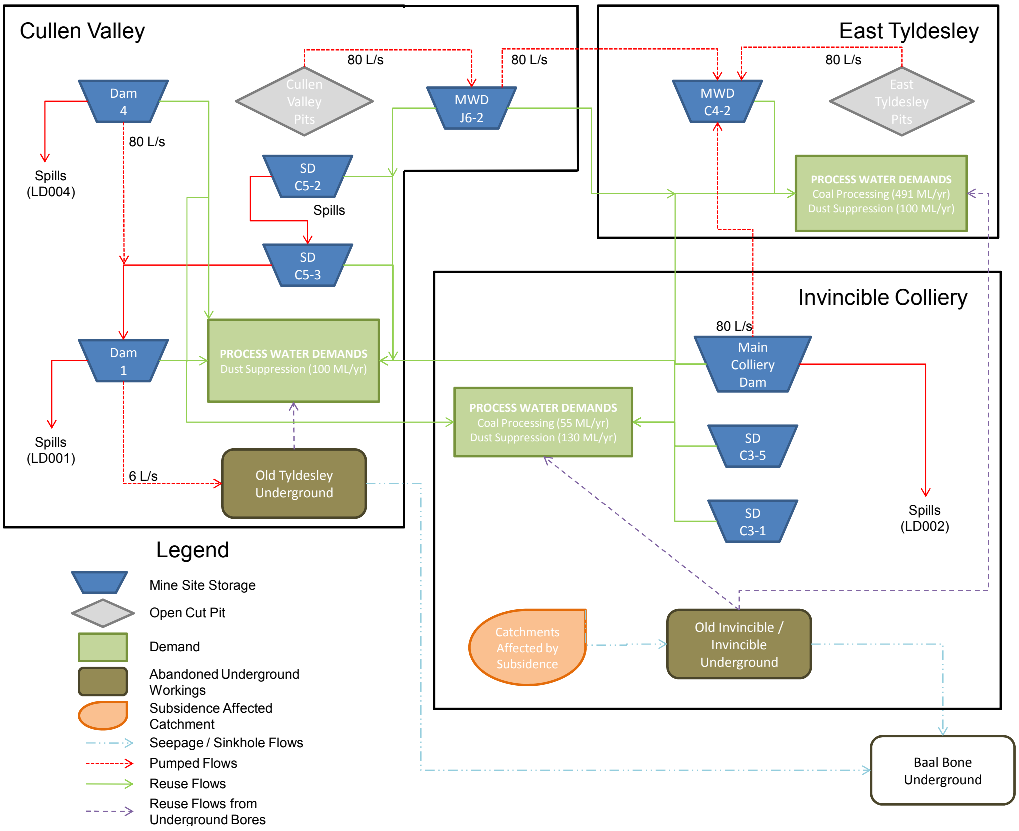

Figure 6.4 Conceptual Water Balance Model Configuration, Year 20 Project Life

6.5 PROCESS WATER DEMANDS

The process demands given in Table 5.1 for each stage of mining operations were incorporated into the water balance model. Potable water demands were excluded from the water balance model.

6.6 OPERATING RULES

The operational strategy for the mine's water management system is represented in the water balance model as a set of pumping rules that describe the interactions between the various water storages. The adopted pumping rules are described as follows:

- The primary sources of water for all process water demands are the existing licensed discharge dams (Main Colliery Dam (Inv LD002), Main Dam (CV LD001), Dam 4 (CV LD004), the proposed East Tyldesley mine water dam (MWD C4-2) and the proposed rail siding mine water dam (MWD J6-2);
- If the process water demands cannot be met from the licensed discharge dams and proposed mine water dams, the remaining demand is allocated to the existing sediment dams;
- If process water demands cannot be met from water stored in the dams described above, it will be sourced from the abandoned underground workings, via the new bore to the abandoned Invincible and Old Invincible underground. If necessary bore licences will be secured for any new supplies. Limited quantities of water will be extracted from the existing bore and pump connected to the Old Tyldesley underground workings.

- Prior to the construction of the East Tyldesley CHPP and MWD C4-2, dust suppression demands for East Tyldesley operations will be sourced primarily from the Invincible Main Colliery Dam and existing sediment dams, with the remainder obtained from Cullen Valley storages and abandoned underground workings;
- Water accumulating in the open cut pits is pumped to the mine water dams. Pumping ceases when the volume of water held in the receiving dam encroaches on the flood storage component of the mine water dam. This rule also applies to pumped transfers between storages (i.e. MWD J6-2 to MWD C4-2);
- The adopted pump stop volumes for each of the key storages are:
- Proposed MWD J6-2 35ML (Total Dam Volume: 75ML);
- Proposed MWD C4-2 130ML (Total Dam Volume: 250ML); and
- Water is transferred from the Cullen Valley licensed discharge dams (Main Dam and Dam 4) into the Old Tyldesley underground workings to limit releases of water from these storages.

6.7 CLIMATE DATA

6.7.1 Open Water Evaporation

Table 6.3 shows Morton's shallow lake evaporation estimates (Morton, 1983) for the area of interest which was adopted for the water balance model. Morton's method is regarded as suitable for the estimation of lake evaporation in non-arid areas (Mulder, 1997). The estimated total annual lake evaporation is 1,206 mm which is about 17% lower than the point potential evapotranspiration given in Section 2.

The values shown in Table 6.3 were adopted to estimate evaporation from all of the water storages for the Project, including open cut pits.

Table 6.3 Mean Monthly Evaporation Depths from Storages

Month	Morton's Lake Evaporation, Mean Monthly (mm)
Jan	170
Feb	136
Mar	118
Apr	77
May	48
Jun	32
Jul	38
Aug	58
Sep	86
Oct	124
Nov	147
Dec	172
Total	1,206

6.7.2 Site Rainfall

A representative long-term rainfall sequence for the Project was obtained from the Bureau of Meteorology's SILO Data Drill for the period 1st January 1889 to 17th February 2011. These data are derived by interpolation of recorded rainfall data between stations as described by Jeffreys *et al* (2001). Rainfall data from the SILO Data Drill is available from the late 1800s and is corrected for missing data and accumulated totals. Hence, this data is more reliable and easier to use for computer modelling than raw recorded rainfall data. Figure 6.5 shows a comparison of mean monthly rainfall recorded at the Portland (Jamieson St) rainfall station from 1904 to 2010 and the corresponding SILO Data Drill rainfalls. The comparison indicates that the SILO data provides a good representation of recorded rainfall data for the Project Boundary. The mean annual rainfall from the SILO data (690 mm) matches the mean annual rainfall from the Portland (Jamieson St) station (690 mm) over this period.

6.8 CATCHMENT RUNOFF

6.8.1 Adopted Rainfall-Runoff Model

The AWBM model (Boughton 2003) was used to estimate runoff volumes from on site catchments, based on available rainfall and evaporation data. AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow groundwater store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area. The various parameters of the AWBM model are shown in Table 6.4.

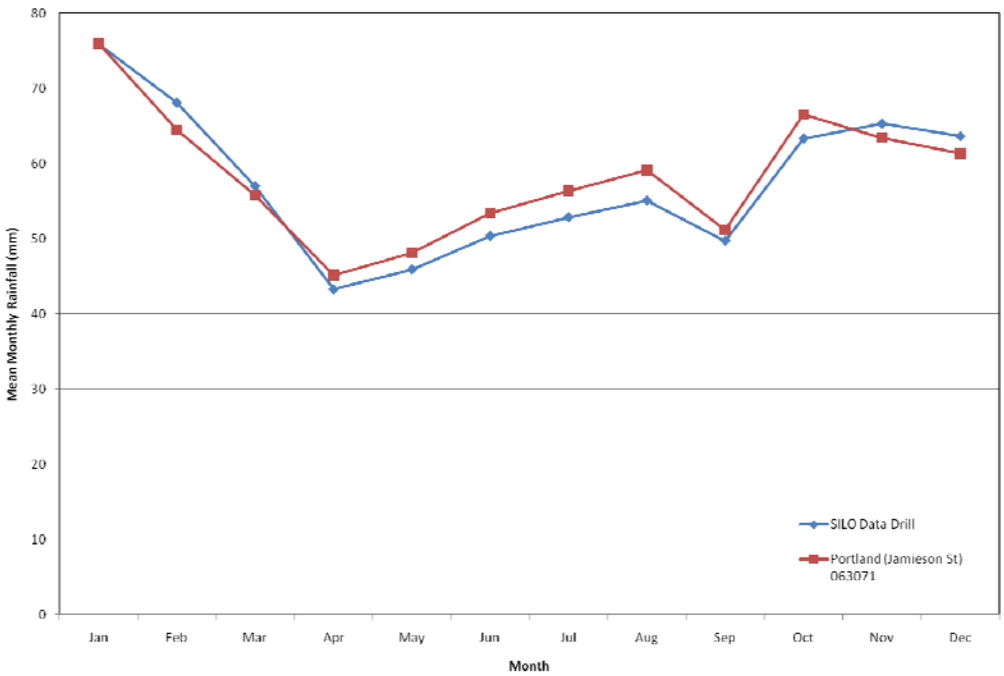

Figure 6.5 Comparison of Mean Monthly Rainfalls from SILO Data Drill and Portland (Jamieson St) (063071), 1904 to 2010

Table 6.4 Summary of AWBM Model Parameters

Parameter Specification	Description
Partial Area Fractions	Parameters A1, A2 & A3. Fraction of catchment area represented by surface storages No. 1, 2 & 3.
Soil Store Capacities	Parameter C1, C2 & C3. Soil moisture storage capacities for smallest store (No. 1), middle store (No. 2) and largest store (No. 3).

Parameter Specification	Description
Base Flow Index	Parameter BFI. Proportion of runoff directed to baseflow store.
Daily Baseflow Recession Constant	Parameter K. Rate at which water discharges from baseflow store.

To estimate catchment runoff inflows to the mine water management system, separate AWBM model parameters were developed for the following catchment types:

- Natural (undisturbed catchments and established rehabilitation);
- Moderately Disturbed (unestablished rehabilitation); and
- Disturbed / Compacted (haul roads, spoil dumps, pit floor, mine infrastructure);

The AWBM models for natural, moderately disturbed and disturbed catchments were used to generate long term runoff profiles for each catchment type, based on the SILO Data Drill rainfall series described in Section 6.7.1.

Details of the available data for calibration of the AWBM model and the adopted model parameters for each catchment type are provided in Section 6.8.2.

6.8.2 AWBM Model Calibration

Streamflow data has been recorded at a gauging station on Neubecks Creek upstream of Wallerawang Colliery (GS 212055) since 1991. The Neubecks Creek gauging station is located 3.5km south of the Project Boundary, and although the Project is not located within the catchment of Neubecks Creek, the catchment area (19.9km^2) draining to the gauging station is considered to be representative of the undisturbed catchments evident within the Project Boundary. The location of the Neubecks Creek gauging station is shown in Figure 1.1.

A flood study undertaken by WRM for the Pine Dale Coal Mine (WRM, 2005) indicated that the NSW Office of Water (NOW) rating curve for the Neubecks Creek gauge was inaccurate at discharges above 2m^3/s, with the NOW rating curve overestimating discharges by 75%. This was confirmed with a NOW hydrographer, and a new rating curve was developed as part of the flood study. The revised WRM (2005) rating curve was used to generate a daily peak runoff series for the gauging station for use in calibration of the AWBM model.

The Neubecks Creek AWBM model was calibrated by adjusting the surface storage capacities until the recorded and simulated flow duration curves were in agreement, and the runoff simulated by the AWBM model matched the mean and total runoff recorded at the gauge site over the calibration period. The calibrated Neubecks Creek AWBM model has an annual volumetric runoff coefficient (AVRC) of 0.13 and was adopted to represent natural catchment within the Project Boundary.

The AWBM model for disturbed / compacted catchments (spoil dumps, haul roads, pit areas, mine infrastructure) were developed by adjusting the natural catchment AWBM model parameters to achieve an AVRC of 0.4, in accordance with previous water balance studies undertaken for the Invincible Colliery as part of the approved water management plan (Coalpac, 2009).

Similarly the AWBM model for moderately disturbed catchments (unestablished rehabilitation) was developed by developed by adjusting the natural catchment AWBM model parameters to achieve an AVRC of 0.25. The adopted runoff coefficient for slightly disturbed catchments is 92% greater than that adopted for the natural catchment.

The adopted AWBM model parameters and volumetric runoff coefficients for the three catchment types are shown in Table 6.5.

Table 6.5 Adopted AWBM Parameters

AWBM Model Parameter		Natural	Slightly Disturbed	Disturbed
Partial Areas	A1	0.134	0.134	0.134
	A2	0.433	0.433	0.433
Base flow index	BFI	0.360	0.150	0.150
Surface Store Depth (mm)	C 1	4.5	1.4	0.1
	C 2	60	18.9	5.2
	C 3	101.8	44.4	17.0
Base flow recession constant	Kb	0.803	0.480	0.48
Volumetric Runoff coefficient for period 1889 - 2011	RC	12.9%	24.8%	40.3%

6.8.3 Catchment Areas

Table 6.6 shows the adopted catchment areas draining to the various mine site storages represented in the water balance model. Catchment types are represented as follows:

- **Natural.** Undisturbed or fully rehabilitated areas;
- **Moderately Disturbed.** Unestablished rehabilitation areas;
- **Disturbed / Compacted.** Pit floor, spoil dumps, roads, coal stockpiles and mine infrastructure areas.

Table 6.6 Adopted Catchment Areas

Storage	Contributing Catchment (ha)			
	Natural	Moderately Disturbed	Disturbed / Compacted	Total
Year 0 (2011)				
Main Colliery Dam (LD002)	28.9	0.0	12.6	41.5
Main Dam (LD001)	8.1	14.3	0.0	22.4
Dam 4 (LD004)	36.0	52.8	26.3	115.1
SD C3-1	20.2	2.4	8.3	30.9
SD C3-5	15.0	7.5	3.1	25.6
SD C5-1	25.4	9.6	0.5	35.5
SD C5-2	22.2	18.8	7.1	48.1
Cullen Valley Pits	18.7	0.0	33.7	52.4
Invincible Pits*	325.8	17.3	10.0	353.1
Invincible Subsidence Affected Catchments*	190.0	0.0	7.7	197.7
Year 2				
Main Colliery Dam (LD002)	21.7	7.9	14.1	43.7
Main Dam (LD001)	6.9	15.8	0.8	23.5
Dam 4 (LD004)	28.5	54.8	9.4	92.7
SD C3-1	25.4	30.4	0.0	55.8
SD C3-5	13.3	9.2	0.0	22.5
SD C5-1	24.9	10.1	0.5	35.5
SD C5-2	21.5	19.5	7.1	48.1
Cullen Valley Pits	33.4	0.0	17.5	50.9
Invincible Pits*	2.3	0.0	6.1	8.4

Storage	Contributing Catchment (ha)			
	Natural	Moderately Disturbed	Disturbed / Compacted	Total
Invincible Subsidence Affected Catchments*	135.1	0.0	0.0	135.1
East Tyldesley Pits	7.8	0.0	4.7	12.5
MWD C4-2	54.9	0.0	9.8	64.7
MWD J6-2	0.0	10.4	6.5	16.9
Year 8				
Main Colliery Dam (LD002)	6.3	69.8	14.1	90.2
Main Dam (LD001)	6.9	15.8	0.8	23.5
Dam 4 (LD004)	28.5	54.8	9.4	92.7
SD C3-1	25.4	30.4	0.0	55.8
SD C3-5	13.3	9.2	0.0	22.5
SD C5-1	35.0	0.0	0.5	35.5
SD C5-2	41.0	0.0	7.1	48.1
Cullen Valley Pits	16.6	0.0	36.6	53.2
Invincible Pits*	26.8	0.0	16.0	42.8
Invincible Subsidence Affected Catchments*	77.5	0.0	0.0	77.5
East Tyldesley Pits	7.6	1.7	18.9	28.2
MWD C4-2	42.3	18.7	11.8	72.8
MWD J6-2	0.0	10.4	6.5	16.9
Year 14				
Main Colliery Dam (LD002)	6.3	69.8	14.1	90.2
Main Dam (LD001)	6.9	15.8	0.8	23.5
Dam 4 (LD004)	28.5	54.8	9.4	92.7
SD C3-1	25.4	30.4	0.0	55.8
SD C3-5	13.3	9.2	0.0	22.5
SD C5-1	24.9	10.1	0.5	35.5
SD C5-2	21.5	19.5	7.1	48.1
Cullen Valley Pits	32.0	0.0	52.0	84.0
Invincible Pits*	29.9	17.4	22.1	69.4
Invincible Subsidence Affected Catchments*	77.5	0.0	0.0	77.5
East Tyldesley Pits	4.9	0.0	14.0	18.9
MWD C4-2	42.3	18.7	11.8	72.8
MWD J6-2	0.0	10.4	6.5	16.9
Year 20				
Main Colliery Dam (LD002)	6.3	69.8	14.1	90.2
Main Dam (LD001)	6.9	15.8	0.8	23.5
Dam 4 (LD004)	28.5	54.8	9.4	92.7
SD C3-1	25.4	30.4	0.0	55.8
SD C3-5	13.3	9.2	0.0	22.5
SD C5-1	24.9	10.1	0.5	35.5
SD C5-2	21.5	19.5	7.1	48.1
Cullen Valley Pits	38.1	9.9	47.0	95.0
Invincible Pits*	0.0	0.0	0.0	0.0
Invincible Subsidence Affected Catchments*	77.5	0.0	0.0	77.5
East Tyldesley Pits	1.7	0.0	8.6	10.3
MWD C4-2	40.9	18.7	13.2	72.8
MWD J6-2	0.0	10.4	6.5	16.9

*Connected to underground workings via seepage and subsidence

6.9 WATER BALANCE MODEL RESULTS

6.9.1 Year 0 (Existing Case)

Table 6.7 presents the results of the water balance model for Year 0 mining operations. These results provide an indication of the behaviour of mine site storages under existing mine operations over a 121 year continuous simulation period. The water balance results indicate the following:

- The Invincible Main Colliery Dam is not predicted to spill during the 121 year simulation period;
- The existing Invincible sediment dams (SD C3-1 and SD C3-5) are predicted to spill periodically;
- The model predicts that an average of 1.6ML/day of surface water would drain to the abandoned Invincible and Old Invincible underground workings. An average of 1.0ML/day is predicted to seep into the underground from the active Invincible Pit areas, and the remaining 0.6ML/day is due to surface water runoff from subsidence affected catchments entering sinkholes and subsidence cracking;
- The model predicts that the Invincible CHPP and dust suppression demands are met 46% of the time from water stored in the Main Colliery Dam, SD C3-1 and SD C3-5. The model indicates that there is 85% reliability to source makeup water from the Cullen Valley Mine storages to satisfy the Invincible Colliery demands. An average of 0.11ML/day of bore water from the Old Tyldesley underground would be required to supply the remaining Invincible CHPP demand deficit;
- All existing storages at Cullen Valley Mine are predicted to spill regularly. Operational management of pit dewatering (storing water in pit sumps for short periods of time) may reduce spill frequencies and volumes from the Cullen Valley Mine storages.
- The model predicts that on average 0.1ML/day is transferred from the Cullen Valley Mine Main Dam into the abandoned Old Tyldesley underground workings.
- The model indicates that the Cullen Valley Mine dust suppression and coal crushing demands can be sourced from the Cullen Valley Mine storages 98% of the time. An average of 0.01ML/day of bore water from the Old Tyldesley underground would be required to supply the remaining Cullen Valley Mine demand deficit.

Table 6.7 Water Balance Model Results, Year 0 (Existing Case)

Storage	Average Volume (ML)	Max. Volume (ML)	20th %ile Volume (ML)	80th %ile Volume (ML)	Number Spill Years	Max Annual Spill Volume (ML)	Average Spill Volume / Spill Year (ML)
Invincible							
Main Colliery Dam (LD002)	2.6	109.6	1.1	0.0	0	0	NA
SD C3-1	2.6	10.0	6.8	0.0	79	174.2	26.9
SD C3-5	7.0	60.0	8.8	0.0	9	101.3	30.8
Cullen Valley							
Main Dam (LD001)*	4.9	7.0	6.0	4.8	118	527.4	95.5
Dam 4 (LD004)	23.8	38.0	35.8	0.6	113	668.5	119.7
SD C5-1	26.0	30.0	30.0	25.8	113	491.4	104.2
SD C5-2	4.8	5.0	5.0	4.9	121	297.8	70.1
Active Pits	63.4	523.9	103.6	0.0	0	0	NA

* Spills from SD C5-1 and SD C5-2 discharge into the Main Dam (LD001)

The following comments are of note with regards to the Year 0 (existing case) water balance modelling results:

Invincible Colliery

- The 2008 (Coalpac, 2008), 2009 (Coalpac, 2010) and 2010 (Coalpac, 2011) AEMR documents for the Invincible Colliery state that there were no releases from any of the onsite storages during these reporting periods. The water balance model results support these statements;
- The Invincible Colliery AEMRs also state that water was sourced from the Cullen Valley Mine during these periods in order to satisfy process water demands. This is also supported by the results of the water balance model;
- The AGE Consulting groundwater study (AGE, 2011), indicates that the flooded Old Invincible and Invincible underground workings (and the flooded Old Tyldesley Colliery) are hydraulically linked to the adjacent Baal Bone underground workings, however there is no hydraulic connection between the Old Tyldelsey Colliery and the Invincible and Old Invincible undergrounds. The Invincible and Old Invincible undergrounds are hydraulically connected.
- The AGE (2011) study suggests that between 0.3ML/day and 1.0ML/day of water could seep from the flooded underground workings into the Baal Bone Colliery underground. The Year 0 (existing case) water balance suggests that surface water inflows to the flooded Invincible workings are approximately 1.6ML/day. This is in the order of seepage flows predicted by the AGE study, although it is higher than the maximum predicted seepage rate of 1.0ML/day in the AGE (2011) study;
- The correlation between the AGE (2011) modelling and the Year 0 surface water balance model is considered acceptable. The differences between the two models area likely due to the runoff coefficients adopted for use in modelling surface water runoff volumes, and the coarse nature of the assumptions regarding the proportion of surface water runoff which reports directly to the flooded underground via seepage and surface cracking;
- It is likely that the use of site specific data (ie. recorded dam levels) to calibrate predicted surface runoff volumes at the Project site would improve the correlation between the AGE (2011) groundwater study and the Year 0 surface water balance model. Unfortunately no site specific data suitable for calibration was available for use at the time of reporting;
- A sensitivity analysis was also undertaken using the Year 0 water balance model to investigate the impact of the assumption that all surface water runoff from subsidence affected catchments would report to the flooded underground workings. The sensitivity analysis used the assumption that runoff events less than or equal to the median daily runoff event would drain directly to the underground, however any runoff events greater than the median would generate overland flow which reported to the bottom of the catchment;
- The results of the sensitivity analysis indicated that the average daily inflow of surface water to the flooded underground would be reduced to 1.3ML/day assuming that only runoff from events less than or equal to the median would drain directly to sinkholes and subsidence cracking; and
- The sensitivity analysis also predicted a small spill would have occurred from the Main Colliery Dam (due to more runoff reporting to the dam from the subsidence affected upstream catchment) during the 2008 and 2009 AEMR reporting periods (this was not reported in the AEMR documents).

Cullen Valley Mine

- The 2008 (Coalpac, 2008a), 2009 (Coalpac, 2010a) and 2010 (Coalpac 2011a) AEMR documents for the Cullen Valley Mine state that there was a single release from the Main Dam (LD001) in December 2010. The water balance model predicts frequent large volume spills from both the Main Dam (LD001) and Dam 4 (LD004) over these periods; and
- Further, the Cullen Valley Mine AEMRs indicate that there was a shortfall of water at the site during the reporting periods, and that makeup water for the Invincible Colliery

demands was sourced from the bore connected to the Old Tyldesley underground. The water balance model suggests there would be an excess of surface water stored at Cullen Valley over this period, which would be more than enough to supply the Cullen Valley demands as well as any makeup water required for the Invincible Colliery.

The discrepancies between the Cullen Valley AEMRs and the water balance model results are likely due to the conservatively high runoff coefficients adopted for the mine site catchments. This would also explain the overestimation of surface water flows entering the flooded Invincible and Old Invincible underground workings. Runoff coefficients of 0.4 for spoil dumps and pit areas, and 0.25 for unestablished rehabilitation are likely causing the water balance model to substantially over-predict the volumes of runoff for the Project. However in the absence of detailed calibration data for mine site storages, the conservative runoff coefficients are considered acceptable. If detailed water level information becomes available for mine site storages, the adopted runoff coefficients could be adjusted to improve the estimation of runoff.

6.9.2 Year 2

Table 6.8 presents the results of the water balance model for Year 2 mining operations. These results provide an indication of the behaviour of mine site storages under Year 2 mine operations over a 121 year continuous simulation period. The water balance results indicate the following:

Predicted Releases from Project Storages

- The Invincible Main Colliery Dam is not predicted to spill for the 121 year simulation period;
- The existing Invincible sediment dams (SD C3-1 and SD C3-5) are predicted to spill between once every second year and once every thirtieth year;
- The proposed rail siding area and associated MWD J6-2 will be operational at the Cullen Valley Mine area by Year 2. Runoff accumulating in the Cullen Valley open cut pit sumps will be pumped to MWD J6-2. Water stored in MWD J6-2 is to be transferred to MWD C4-2 for reuse at East Tyldesley CHPP. The water balance model does not predict any spills from MWD J6-2 during the 121 simulation period;
- All existing storages at Cullen Valley Mine are predicted to spill regularly, with spill frequencies ranging from yearly to once every three years. It should be noted that the catchments of the Cullen Valley Mine Main Dam, Dam4, SD C5-1 and SD C5-2 consist almost entirely of established rehabilitation in Year 2 and as such, the water quality of releases from these storages is expected to be acceptable (See Section 5.4.3); and
- The East Tyldesley CHPP and associated MWD C4-2 would be operational in Year 2. The model does not predict any spills from MWD C4-2 during the 121 year simulation period.

Mine Site Process Water Supply

- The model predicts that the Invincible CHPP and dust demands are met 30% of the time from water stored in the Main Colliery Dam, SD C3-1 and SD C3-5. The model indicates that there is 67% reliability to source makeup water from the Cullen Valley storages to satisfy the Invincible Colliery demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the Invincible process water demand deficit is 78ML/yr, equivalent to approximately 20% of the annual Year 2 Invincible process water demand.
- The model indicates that the Cullen Valley Mine dust suppression, coal crushing and sand quarrying demands can be sourced from the Cullen Valley Mine Main Dam, Dam4, SD C5-1 and SD C5-2 storages 90% of the time. In a median runoff year no water is extracted from the Old Tyldesley Colliery underground workings.

- The model predicts that the East Tyldesley CHPP and dust suppression demands are met 66% of the time from water stored in MWD C4-2. The model indicates that there is 71% reliability to source makeup water from storages at Invincible Colliery and Cullen Valley mine to satisfy the East Tyldesley demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the East Tyldesley process water demand deficit is 125ML/yr, equivalent to approximately 37% of the annual Year 2 East Tyldesley process water demand.

Inflows to Underground Workings & Predicted Pit and Storage Transfers

- The model predicts that an average of 0.4ML/day of surface water would drain to the abandoned Invincible and Old Invincible underground workings. An average of 0.1ML/day is predicted to seep into the underground from the active Invincible pit areas, and the remaining 0.3ML/day is due to surface water runoff from subsidence affected catchments entering sinkholes and subsidence cracking. In a median runoff year 65ML/year of runoff is predicted to enter the flooded underground workings via pit areas and subsidence cracking at the Invincible Colliery.
- The model predicts that on average 0.1ML/day is transferred from the Cullen Valley Mine Main Dam into the abandoned Old Tyldesley Colliery underground workings. In a median runoff year 6ML/year of captured runoff is predicted to be transferred to the flooded Old Tyldesley workings via the transfer pump in Cullen Valley Main Dam.
- Table 6.9 summarises the predicted annual inflow volumes to the active mining pits in each part of the Project area. Results are provided for a median runoff year and a representative wet and dry year together with the wettest runoff year over the 121 year simulation period.
- Table 6.10 summarises the predicted annual volumes of water that will be transferred between active mining pits and dams, and between dams at the Project site during the Year 2 scenario. Results are provided based on total annual transfer volumes, and percentiles do not directly correspond to climatic conditions (ie. little water may be transferred during a very wet year as all storages are close to full, but if the following year is dry large volumes of water will be transferred).
- Note no water is transferred from Invincible pits to the Invincible Main Colliery Dam, as it is assumed that all water that is captured by these pits will seep into the flooded Invincible underground workings, and hence not require dewatering.

Table 6.8 Water Balance Model Results, Year 2 Project Life

Storage	Average Volume (ML)	Max. Volume (ML)	20th %ile Volume (ML)	80th %ile Volume (ML)	Number Spill Years	Max Annual Spill Volume (ML)	Average Spill Volume / Spill Year (ML)
Invincible							
Main Colliery Dam (LD002)	1.2	107.2	0.0	0.0	0	0	NA
SD C3-1	1.7	10.0	2.9	0.0	96	298.0	40.9
SD C3-5	3.2	60.0	1.6	0.0	4	37.0	22.2
Cullen Valley							
Main Dam (LD001)*	3.3	7.0	6.0	0.0	112	539.6	77.8
Dam 4 (LD004)	7.8	38.0	18.9	0.0	69	474.9	72.8
SD C5-1	15.6	30.0	30.0	0.0	94	493.9	90.0
SD C5-2	3.4	5.0	5.0	0.0	120	299.3	61.8
Active Pits	6.8	228.5	0.2	0.0	0	0	NA
MWD J6-2	4.8	64.5	1.1	0.0	0	0	NA
East Tyldesley							
Active Pits	4.2	70.2	0.3	0.0	0	0	NA
MWD C4-2	46.1	248.7	115.3	0.0	0	0	NA

* Spills from SD C5-1 and SD C5-2 discharge into the Main Dam (LD001)

Table 6.9 Predicted Inflows to Active Pit Areas, Year 2 Project Life

Pit Area	Median Year (ML/yr)	Wet Year (20th %ile) (ML/yr)	Dry Year (80th %ile) (ML/yr)	Wettest Year (1st %ile) (ML/yr)
Invincible Pits				
External Catchment Runoff	0.9	3.1	0.7	11.0
Direct Rainfall on Disturbed Area	14.2	20.5	11.3	52.8
Total	15.1	23.6	12.0	63.8
Cullen Valley Pits				
External Catchment Runoff	12.4	45.1	9.9	159.6
Direct Rainfall on Disturbed Area	41.3	59.5	32.9	164.9
Total	53.7	104.6	42.8	324.5
East Tyldesley Pits				
External Catchment Runoff	2.9	10.5	2.3	37.3
Direct Rainfall on Disturbed Area	11.1	16.8	8.9	48.4
Total	14.0	27.3	11.2	85.7

Table 6.10 Predicted Storage and Pit Transfers, Year 2 Project Life

Transfer	80th %ile Transfer Volume (ML/yr)	Median Transfer Volume (ML/yr)	20th %ile Transfer Volume (ML/yr)	1st %ile Transfer Volume (ML/yr)
Invincible Main Colliery Dam (LD002) to East Tyldesley MWD C4-2	28.4	46.2	65.2	90.1
East Tyldesley Pits to East Tyldesley MWD C4-2	9.2	15.6	25.8	63.1
Cullen Valley Pits to Rail Siding MWD J6-2	40.8	66.0	106.9	212.7
Rail Siding MWD J6-2 to East Tyldesley MWD C4-2	55.9	89.3	138.0	201.4
Cullen Valley Dam 4 (LD004) to Cullen Valley Main Dam (LD001)	36.4	50.1	60.6	77.0

6.9.3 Year 8

Table 6.11 presents the results of the water balance model for Year 8 mining operations. These results provide an indication of the behaviour of mine site storages under Year 8 mining operations over a 121 year continuous simulation period. The water balance results indicate the following:

Predicted Releases from Project Storages

- For the Year 8 scenario the Invincible Main Colliery Dam is predicted to spill for 15 years out of the 121 year simulation period. This increase of spills is caused by the decrease in coal processing demands at the Invincible Colliery and the restoration of a large catchment area to the dam, which was previously affected by subsidence (this area will be rehabilitated in Year 8, restoring significant surface water drainage from the upstream catchment);
- During Year 8 of Project life spill frequency and volume from the existing Invincible Colliery sediment dams (SD C3-1 and SD C3-5) will increase due to reduced demands on the Invincible Colliery storages;
- Spill frequency and volume from Cullen Valley Mine Main Dam, Dam4, SD C5-1 and SD C5-2 are generally unchanged from Year 2;
- For the Year 8 scenario MWD J6-2 is not predicted to spill during the 121 year simulation period.

- For Year 8 operations, MWD C4-2 is not predicted to spill during the 121 year simulation period.

Mine Site Process Water Supply

- The model predicts that the Invincible Colliery CHPP and dust suppression demands are met 56% of the time from water stored in the Main Colliery Dam, SD C3-1 and SD C3-5. The model indicates that there is 75% reliability to source makeup water from the Cullen Valley Mine storages to satisfy the Invincible Colliery demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the Invincible process water demand deficit is 13ML/yr, equivalent to 7% of the annual Year 8 Invincible process water demand.
- The model indicates that the Cullen Valley Mine dust suppression and sand quarrying demands can be sourced from the Cullen Valley Mine storages 84% of the time. In a median runoff year the volume of water extracted from the flooded Old Tyldesley underground workings to satisfy the Cullen Valley process water demand deficit is 11ML/yr, equivalent to 7% of the annual Year 8 Cullen Valley process water demand.
- The water balance model predicts that the East Tyldesley CHPP and dust suppression demands are met 67% of the time from water stored in MWD C4-2. The model indicates that there is 71% reliability to source makeup water from storages at Invincible Colliery and Cullen Valley Mine to satisfy the East Tyldesley demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the East Tyldesley process water demand deficit is 199ML/yr, equivalent to 37% of the annual Year 8 East Tyldesley process water demand.

Inflows to Underground Workings & Predicted Pit and Storage Transfers

- Total inflows of surface water to the abandoned Invincible Colliery underground workings are generally unchanged between Year 2 and Year 8 (0.4ML/day), with an average of 0.2ML/day from both active pits and subsidence affected catchments entering the underground. In a median runoff year 80ML/year of runoff is predicted to enter the flooded underground workings via pit areas and subsidence cracking at the Invincible Colliery.
- The model predicts that on average 0.12ML/day is transferred from the Cullen Valley Mine Main Dam into the abandoned Old Tyldesley underground workings. In a median runoff year 8ML/year of captured runoff is predicted to be transferred to the flooded Old Tyldesley workings via the transfer pump in Cullen Valley Main Dam.
- Table 6.12 summarises the predicted annual inflow volumes to the active mining pits in each part of the Project area. Results are provided for a median runoff year and a representative wet and dry year together with the wettest runoff year over the 121 year simulation period.
- Table 6.13 summarises the predicted annual volumes of water that will be transferred between active mining pits and dams, and between dams at the Project site during the Year 2 scenario. Results are provided based on total annual transfer volumes, and percentiles do not directly correspond to climatic conditions (ie. little water may be transferred during a very wet year as all storages are close to full, but if the following year is dry large volumes of water will be transferred).
- Note no water is transferred from Invincible pits to the Invincible Main Colliery Dam, as it is assumed that all water that is captured by these pits will seep into the flooded Invincible underground workings, and hence not require dewatering.

Table 6.11 Water Balance Model Results, Year 8 Project Life

Storage	Average Volume (ML)	Max. Volume (ML)	20th %ile Volume (ML)	80th %ile Volume (ML)	Number Spill Years	Max Annual Spill Volume (ML)	Average Spill Volume / Spill Year (ML)
Invincible							
Main Colliery Dam (LD002)	10.3	115.0	4.5	0.0	15	279.1	72.0
SD C3-1	3.6	10.0	9.8	0.0	102	320.4	52.0
SD C3-5	9.9	60.0	18.5	0.0	11	81.3	33.4
Cullen Valley							
Main Dam (LD001)*	4.0	7.0	6.0	0.0	115	542.7	84.0
Dam 4 (LD004)	12.6	38.0	29.8	0.0	74	478.7	82.2
SD C5-1	18.4	30.0	30.0	0.1	101	493.9	92.4
SD C5-2	3.8	5.0	5.0	1.0	120	299.3	64.5
Active Pits	9.5	297.8	0.6	0.0	0	0	NA
MWD J6-3	6.4	63.1	8.0	0.0	0	0	NA
East Tyldesley							
Active Pits	16.8	211.9	14.3	0.0	0	0	NA
MWD C4-2	54.8	242.4	128.3	0.0	0	0	NA

* Spills from SD C5-1 and SD C5-2 discharge into the Main Dam (LD001)

Table 6.12 Predicted Inflows to Active Pit Areas, Year 8 Project Life

Pit Area	Median Year (ML/yr)	Wet Year (20th %ile) (ML/yr)	Dry Year (80th %ile) (ML/yr)	Wettest Year (1st %ile) (ML/yr)
Invincible Pits				
External Catchment Runoff	14.0	43.6	11.1	152.9
Direct Rainfall on Disturbed Area	37.4	53.7	29.6	138.4
Total	51.4	97.3	40.7	291.3
Cullen Valley Pits				
External Catchment Runoff	6.2	22.4	4.9	79.3
Direct Rainfall on Disturbed Area	86.0	124.3	68.4	334.6
Total	92.2	146.7	73.3	413.9
East Tyldesley Pits				
External Catchment Runoff	4.7	13.8	3.8	48.0
Direct Rainfall on Disturbed Area	44.5	66.1	35.5	177.2
Total	49.2	79.9	39.3	225.2

Table 6.13 Predicted Storage and Pit Transfers, Year 8 Project Life

Transfer	80th %ile Transfer Volume (ML/yr)	Median Transfer Volume (ML/yr)	20th %ile Transfer Volume (ML/yr)	1st %ile Transfer Volume (ML/yr)
Invincible Main Colliery Dam (LD002) to East Tyldesley MWD C4-2	76.5	118.6	76.5	194.1
East Tyldesley Pits to East Tyldesley MWD C4-2	32.3	50.2	75.6	209.0
Cullen Valley Pits to Rail Siding MWD J6-2	66.8	106.0	156.2	265.2
Rail Siding MWD J6-2 to East Tyldesley MWD C4-2	80.6	128.9	177.6	272.3
Cullen Valley Dam 4 (LD004) to Cullen Valley Main Dam (LD001)	26.7	35.2	44.7	59.8

6.9.4 Year 14

Table 6.14 presents the results of the water balance model for Year 14 mining operations. These results provide an indication of the behaviour of mine site storages under Year 14 mine operations over a 121 year continuous simulation period. The water balance results indicate the following:

Predicted Releases from Project Storages

- Spills from the Invincible Colliery Main Colliery Dam are generally the same between Year 8 and Year 14;
- Spill frequency and volume from the existing Invincible Colliery sediment dams (SD C3-1 and SD C3-5) will increase due to reduced demands on the Invincible Colliery storages.
- Spill frequency and volume from Cullen Valley Mine Main Dam, Dam4, SD C5-1 and SD C5-2 are generally unchanged from Year 8;
- For Year 14 operations MWD J6-2 is not predicted to spill during the 121 year simulation period; and
- For Year 14 operations, MWD C4-2 is not predicted to spill during the 121 year simulation period.

Mine Site Process Water Supply

- The model predicts that the Invincible Colliery CHPP and dust suppression demands are met 77% of the time from water stored in the Main Colliery Dam, SD C3-1 and SD C3-5. The model indicates that there is 86% reliability to source makeup water from the Cullen Valley Mine storages to satisfy the Invincible Colliery demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the Invincible process water demand deficit is 9ML/yr, equivalent to 5% of the annual Year 14 Invincible process water demand.
- The model indicates that the Cullen Valley Mine dust suppression and sand quarrying demands can be sourced from the Cullen Valley storages 86% of the time. In a median runoff year the volume of water extracted from the flooded Old Tyldesley underground workings to satisfy the Cullen Valley process water demand deficit is 7ML/yr, equivalent to 5% of the annual Year 14 Cullen Valley process water demand.
- The water balance model predicts that the East Tyldesley CHPP and dust suppression demands are met 69% of the time from water stored in MWD C4-2. The model indicates that there is 76% reliability to source makeup water from storages at Invincible Colliery and Cullen Valley mine to satisfy the East Tyldesley demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the East Tyldesley process water demand deficit is 142ML/yr, equivalent to 24% of the annual Year 14 East Tyldesley process water demand.

Inflows to Underground Workings & Predicted Pit and Storage Transfers

- Surface water flows entering the abandoned Invincible Colliery underground workings will increase to 0.5ML/year by Year 14, as the catchment areas of Invincible Colliery pits increase. In a median runoff year 111ML/year of runoff is predicted to enter the flooded underground workings via pit areas and subsidence cracking at the Invincible Colliery.
- The model predicts that on average 0.13ML/day is transferred from the Cullen Valley Mine Main Dam into the abandoned Old Tyldesley underground workings. In a median runoff year 18ML/year of captured runoff is predicted to be transferred to the flooded Old Tyldesley workings via the transfer pump in Cullen Valley Main Dam.
- Table 6.15 summarises the predicted annual inflow volumes to the active mining pits in each part of the Project area. Results are provided for a median runoff year and a representative wet and dry year together with the wettest runoff year over the 121 year simulation period.

- Table 6.16 summarises the predicted annual volumes of water that will be transferred between active mining pits and dams, and between dams at the Project site during the Year 2 scenario. Results are provided based on total annual transfer volumes, and percentiles do not directly correspond to climatic conditions (ie. little water may be transferred during a very wet year as all storages are close to full, but if the following year is dry large volumes of water will be transferred).
- Note no water is transferred from Invincible pits to the Invincible Main Colliery Dam, as it is assumed that all water that is captured by these pits will seep into the flooded Invincible underground workings, and hence not require dewatering.

Table 6.14 Water Balance Model Results, Year 14 Project Life

Storage	Average Volume (ML)	Max. Volume (ML)	20th %ile Volume (ML)	80th %ile Volume (ML)	Number Spill Years	Max Annual Spill Volume (ML)	Average Spill Volume / Spill Year (ML)
Invincible							
Main Colliery Dam (LD002)	16.2	115.0	26.4	0.0	17	345.6	103.9
SD C3-1	5.6	10.0	9.9	0.0	108	329.1	58.3
SD C3-5	27.3	60.0	58.7	0.0	64	413.4	89.3
Cullen Valley							
Main Dam (LD001)*	4.2	7.0	6.0	0.0	117	543.0	86.1
Dam 4 (LD004)	14.0	38.0	30.4	0.0	76	486.2	83.3
SD C5-1	19.9	30.0	30.0	1.0	105	493.9	93.6
SD C5-2	4.0	5.0	5.0	3.2	120	299.3	65.8
Active Pits	20.0	438.3	1.5	0.0	0	0	NA
MWD J6-3	6.6	62.0	8.7	0.0	0	0	NA
East Tyldesley							
Active Pits	13.8	203.5	14.6	0.0	0	0	NA
MWD C4-2	59.2	242.4	128.3	0.0	0	0	NA

* Spills from SD C5-1 and SD C5-2 discharge into the Main Dam (LD001)

Table 6.15 Predicted Inflows to Active Pit Areas, Year 14 Project Life

Pit Area	Median Year (ML/yr)	Wet Year (20th %ile) (ML/yr)	Dry Year (80th %ile) (ML/yr)	Wettest Year (1st %ile) (ML/yr)
Invincible Pits				
External Catchment Runoff	30.6	76.4	24.4	262.8
Direct Rainfall on Disturbed Area	51.6	74.2	40.8	191.2
Total	82.2	150.6	65.2	454.0
Cullen Valley Pits				
External Catchment Runoff	12.1	43.9	9.6	155.3
Direct Rainfall on Disturbed Area	121.0	174.9	96.0	471.3
Total	133.1	218.8	105.6	626.6
East Tyldesley Pits				
External Catchment Runoff	1.8	6.6	1.4	23.4
Direct Rainfall on Disturbed Area	33.0	49.7	26.3	132.0
Total	34.8	56.3	27.7	155.4

Table 6.16 Predicted Storage and Pit Transfers, Year 14 Project Life

Transfer	80th %ile Transfer Volume (ML/yr)	Median Transfer Volume (ML/yr)	20th %ile Transfer Volume (ML/yr)	1st %ile Transfer Volume (ML/yr)
Invincible Main Colliery Dam (LD002) to East Tyldesley MWD C4-2	59.5	103.5	134.4	180.3
East Tyldesley Pits to East Tyldesley MWD C4-2	21.4	35.2	51.4	136.4
Cullen Valley Pits to Rail Siding MWD J6-2	99.0	155.9	236.6	383.8
Rail Siding MWD J6-2 to East Tyldesley MWD C4-2	110.5	179.6	248.5	391.6
Cullen Valley Dam 4 (LD004) to Cullen Valley Main Dam (LD001)	25.1	29.2	37.9	54.8

6.9.5 Year 20

Table 6.17 presents the results of the water balance model for Year 20 mining operations. These results provide an indication of the behaviour of mine site storages under Year 20 mining operations over a 121 year continuous simulation period. The water balance results indicate the following:

Predicted Releases from Project Storages

- Spills from the Invincible Colliery Main Colliery Dam, SD C3-1 and SD C3-5 are reduced between Year 14 and Year 20, as more makeup water is required to satisfy the process water supply deficit at East Tyldesley;
- Spill frequency and volume from Cullen Valley Mine Main Dam, Dam4, SD C5-1 and SD C5-2 increase slightly from Year 14 due to the completion of sand quarrying operations;
- For Year 20 operations MWD J6-2 is not predicted to spill during the 121 year simulation period.
- For Year 20 operations, MWD C4-2 is not predicted to spill during the 121 year simulation period.

Mine Site Process Water Supply

- The model predicts that the Invincible Colliery CHPP and dust suppression demands are met 57% of the time from water stored in the Main Colliery Dam, SD C3-1 and SD C3-5. The model indicates that there is 86% reliability to source makeup water from the Cullen Valley Mine storages to satisfy the Invincible Colliery demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the Invincible process water demand deficit is 8ML/yr, equivalent to 4% of the annual Year 20 Invincible process water demand.
- The model indicates that the Cullen Valley Mine dust suppression demands can be sourced from the Cullen Valley storages 87% of the time. In a median runoff year the volume of water extracted from the flooded Old Tyldesley underground workings to satisfy the Cullen Valley process water demand deficit is 4ML/yr, equivalent to 4% of the annual Year 20 Cullen Valley process water demand.
- The water balance model predicts that the East Tyldesley CHPP and dust suppression demands are met 70% of the time from water stored in MWD C4-2. The model indicates that there is 74% reliability to source makeup water from storages at Invincible Colliery and Cullen Valley mine to satisfy the East Tyldesley demands. In a median runoff year the volume of water extracted from the flooded Invincible underground workings to satisfy the East Tyldesley process water demand deficit is 176ML/yr, equivalent to 30% of the annual Year 20 East Tyldesley process water demand.

Inflows to Underground Workings & Predicted Pit and Storage Transfers

- Surface water flows entering the abandoned Invincible Colliery underground workings are reduced to 0.2ML/day via subsidence affected catchments, as there are no active pit areas located above the abandoned underground workings during Year 20 operations. In a median runoff year 29ML/year of runoff is predicted to enter the flooded underground workings via pre-existing subsidence cracking at the Invincible Colliery.
- The model predicts that on average 0.12ML/day is transferred from the Cullen Valley Mine Main Dam into the abandoned Old Tyldesley underground workings. In a median runoff year 28ML/year of captured runoff is predicted to be transferred to the flooded Old Tyldesley workings via the transfer pump in Cullen Valley Main Dam.
- Table 6.18 summarises the predicted annual inflow volumes to the active mining pits in each part of the Project area. Results are provided for a median runoff year and a representative wet and dry year together with the wettest runoff year over the 121 year simulation period. There are no active mining pits in the Invincible Colliery during Year 20 operations.
- Table 6.19 summarises the predicted annual volumes of water that will be transferred between active mining pits and dams, and between dams at the Project site during the Year 2 scenario. Results are provided based on total annual transfer volumes, and percentiles do not directly correspond to climatic conditions (ie. little water may be transferred during a very wet year as all storages are close to full, but if the following year is dry large volumes of water will be transferred).

Table 6.17 Water Balance Model Results, Year 20 Project Life

Storage	Average Volume (ML)	Max. Volume (ML)	20th %ile Volume (ML)	80th %ile Volume (ML)	Number Spill Years	Max Annual Spill Volume (ML)	Average Spill Volume / Spill Year (ML)
Invincible							
Main Colliery Dam (LD002)	10.9	115.0	6.7	0.0	11	284.4	76.0
SD C3-1	3.8	10.0	9.9	0.0	102	320.4	53.1
SD C3-5	10.2	60.0	19.9	0.0	11	81.3	34.6
Cullen Valley							
Main Dam (LD001)*	4.2	7.0	6.0	0.0	118	542.3	85.7
Dam 4 (LD004)	15.5	38.0	33.4	0.0	80	512.7	90.3
SD C5-1	20.0	30.0	30.0	1.2	103	493.9	95.5
SD C5-2	4.1	5.0	5.0	3.7	120	299.3	66.1
Active Pits	36.7	560.4	28.8	0.0	0	0	NA
MWD J6-3	10.1	70.5	33.2	0.0	0	0	NA
East Tyldesley							
Active Pits	11.2	140.9	13.2	0.0	0	0	NA
MWD C4-2	61.2	241.7	128.3	0.0	0	0	NA

* Spills from SD C5-1 and SD C5-2 discharge into the Main Dam (LD001)

Table 6.18 Predicted Inflows to Active Pit Areas, Year 20 Project Life

Pit Area	Median Year (ML/yr)	Wet Year (20th %ile) (ML/yr)	Dry Year (80th %ile) (ML/yr)	Wettest Year (1st %ile) (ML/yr)
Invincible Pits				
External Catchment Runoff	0.0	0.0	0.0	0.0
Direct Rainfall on Disturbed Area	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0
Cullen Valley Pits				
External Catchment Runoff	25.2	71.9	20.1	250.3
Direct Rainfall on Disturbed Area	110.4	161.1	87.7	438.0
Total	135.6	233.0	107.8	688.3
East Tyldesley Pits				
External Catchment Runoff	0.6	2.3	0.5	8.1
Direct Rainfall on Disturbed Area	20.3	31.2	16.2	82.6
Total	20.9	33.5	16.7	90.7

Table 6.19 Predicted Storage and Pit Transfers, Year 20 Project Life

Transfer	80th %ile Transfer Volume (ML/yr)	Median Transfer Volume (ML/yr)	20th %ile Transfer Volume (ML/yr)	1st %ile Transfer Volume (ML/yr)
Invincible Main Colliery Dam (LD002) to East Tyldesley MWD C4-2	74.0	115.0	145.3	192.2
East Tyldesley Pits to East Tyldesley MWD C4-2	11.7	20.5	29.0	88.9
Cullen Valley Pits to Rail Siding MWD J6-2	107.1	161.6	233.9	407.8
Rail Siding MWD J6-2 to East Tyldesley MWD C4-2	118.1	185.2	252.1	401.9
Cullen Valley Dam 4 (LD004) to Cullen Valley Main Dam (LD001)	29.6	36.7	46.4	61.1

6.10 WATER BALANCE MODEL SUMMARY

6.10.1 Minesite Releases

The water balance modelling undertaken indicates that releases of water from the Project are likely to vary over the life of the mine. Figure 6.6, Figure 6.7 and Figure 6.8 show the predicted annual releases from the existing licensed discharge points (LD001, LD002 and LD004), and the proposed new mine water storages (MWD J6-2 and MWD C4-2) for a median runoff year, wet runoff year (20th percentile), and the wettest year on record. The following is of note with regards to the predicted releases:

- Annual releases from Cullen Valley Main Dam (LD001) and Cullen Valley Dam 4 (LD004) during median and wet years are predicted to decrease for all future stages of mining when compared to existing conditions. A slight increase in releases is predicted form Cullen Valley Main Dam during the wettest year on record.
- The Invincible Main Colliery Dam (LD002) is not predicted to release water during median or wet runoff years; however releases are predicted to occur during the wettest runoff year on record for Years 8, 14 and 20 of the Project life.
- The two new proposed mine water dams, MWD J6-2 and MWD C4-2 are not predicted to release water at any stage of the Project life, for any climatic conditions.

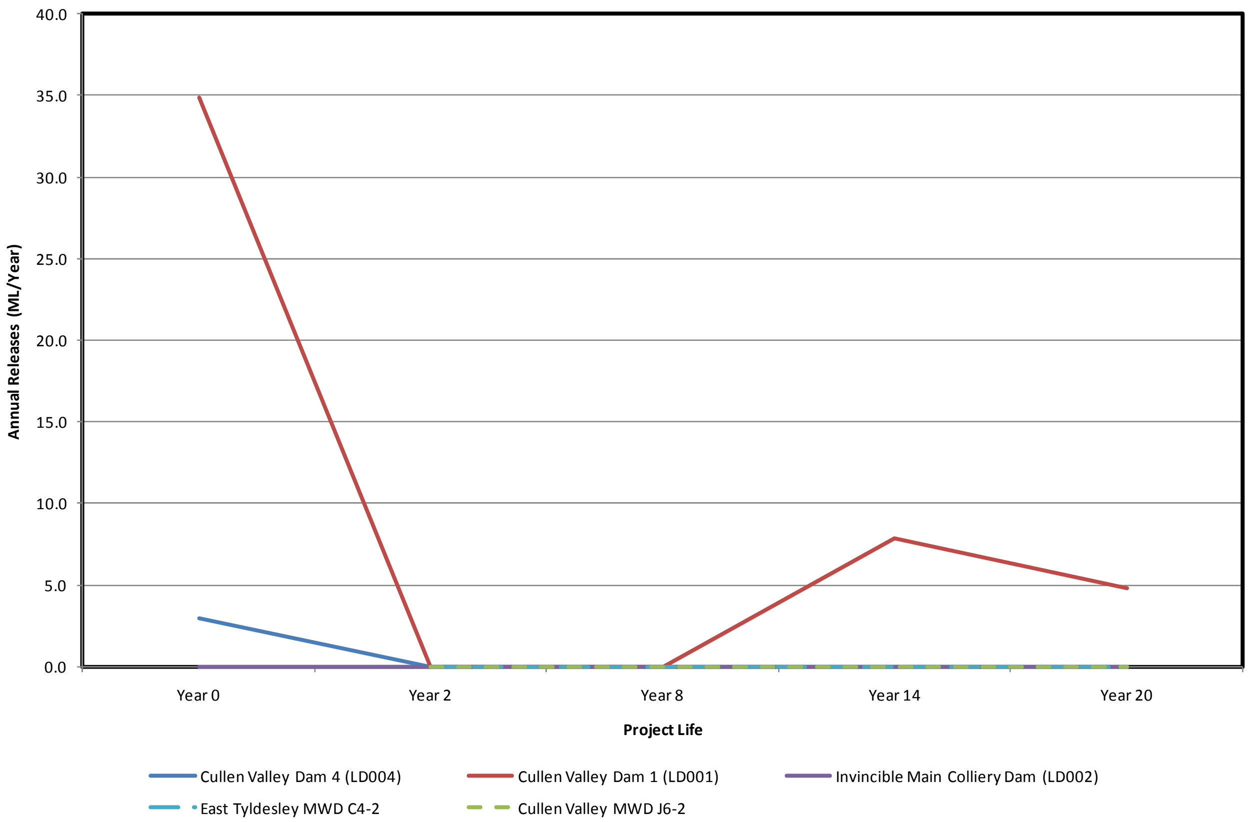

Figure 6.6 Predicted Releases from Existing Licensed Discharge Points and Proposed Mine Water Dams, Median Runoff Year

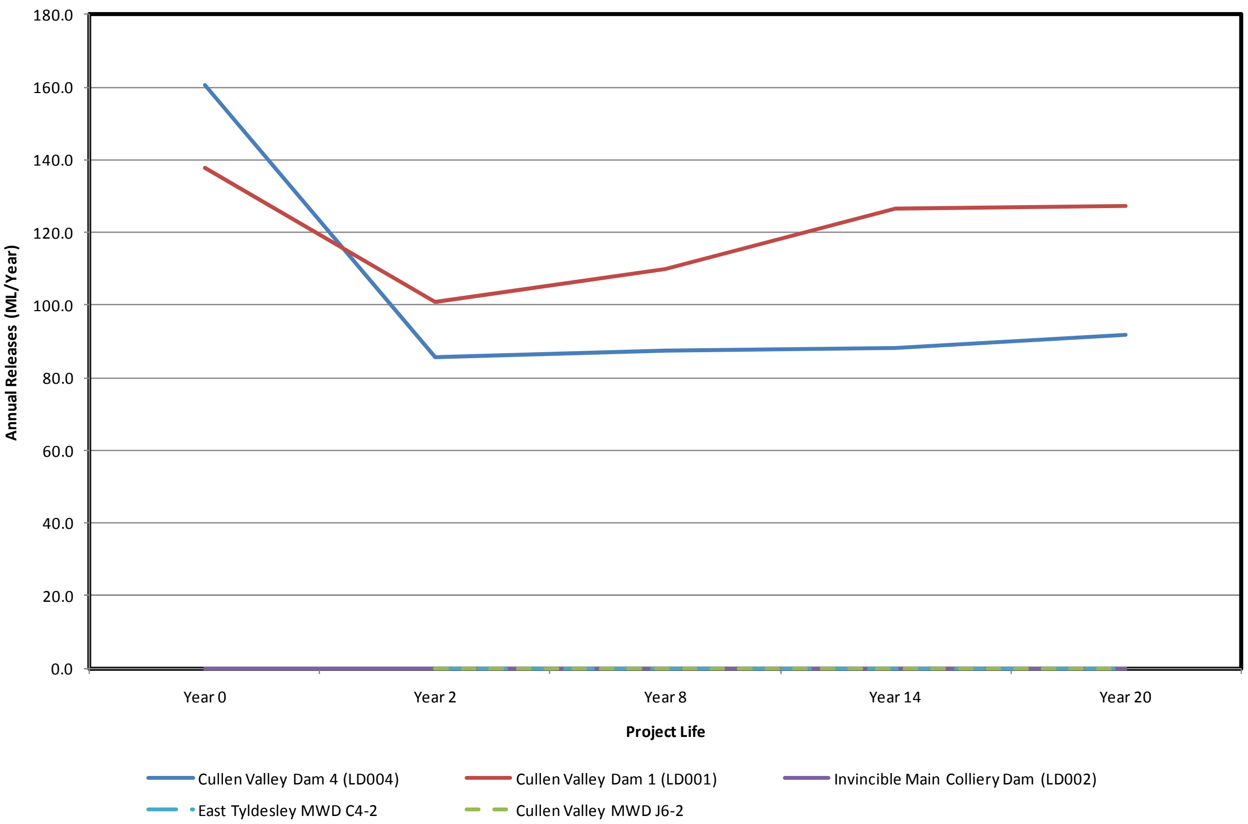

Figure 6.7 Predicted Releases from Existing Licensed Discharge Points and Proposed Mine Water Dams, Wet Runoff Year (20th %ile Runoff)

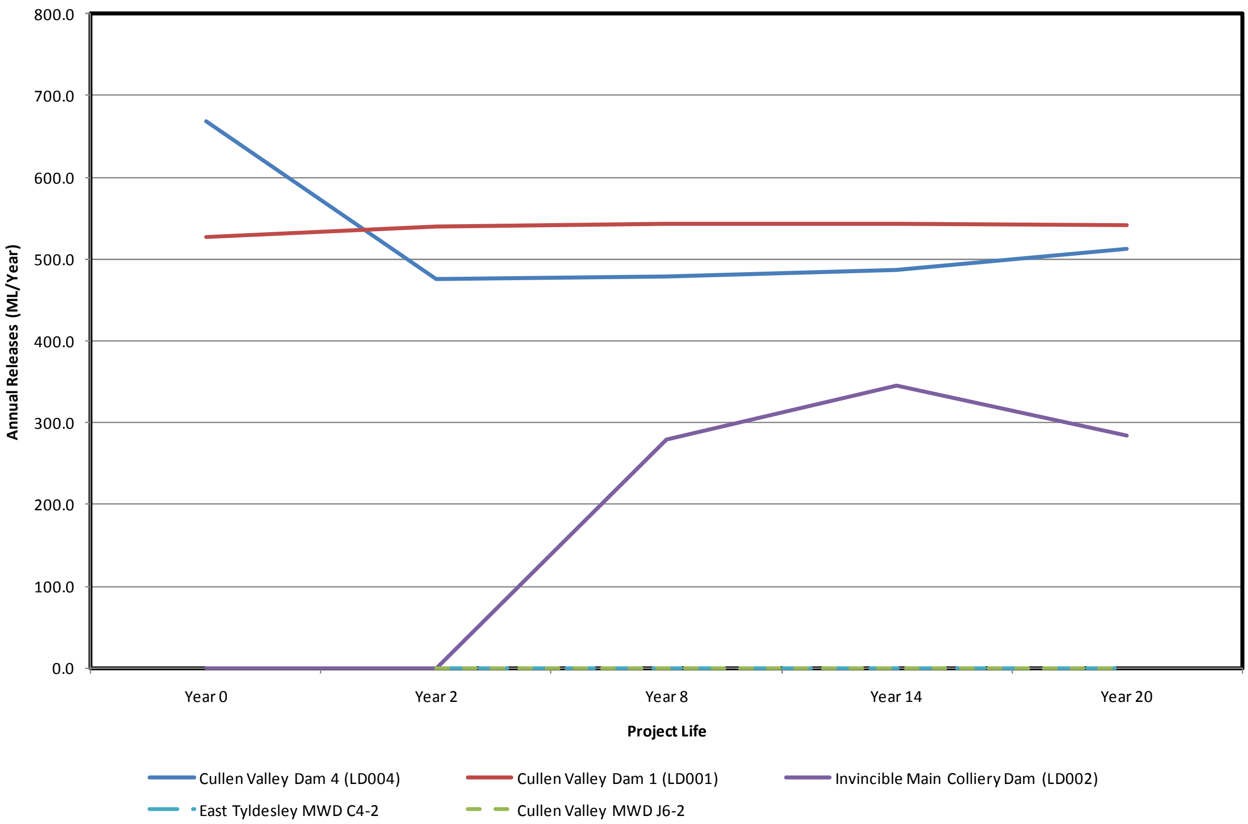

Figure 6.8 Predicted Releases from Existing Licensed Discharge Points and Proposed Mine Water Dams, Wettest Runoff Year on Record

The two new proposed mine water dams have been sized to prevent spills occurring, except during severe extended wet periods. Long term water balance modelling indicates that discharges from these dams are unlikely to occur provided the following management strategies are implemented:

- Pumping of mine water from active mining areas and open cut pits into MWD J6-2 ceases when the volume of water stored in MWD J6-2 exceeds 35ML (total proposed dam volume is 75ML).
- Pumping of mine water from active mining areas and open cut pits into MWD C4-2 ceases when the volume of water stored in MWD J6-2 exceeds 130ML (total proposed dam volume is 250ML).
- Excess mine water will be stored in open cut sumps until capacity is available in MWD J6-2 and MWD C4-2 for transfer. The transfer limit volume for each storage outlined above were adopted based on the water balance modelling described in Section 6, which has identified the amount of freeboard required to prevent discharge from these storages, based on 121 years of climate data.
- In emergency situations, water may be pumped from MWD J6-2 to Cullen Valley Mine Dam 4 (LD004) and from MWD C4-2 to the Invincible Main Colliery Dam (LD002) for discharge, provided it meets the appropriate EPL water quality limits.

6.10.2 Predicted Inflows and Extractions from Underground Workings

Figure 6.9 shows the modelled inflows and extractions from the abandoned underground workings which underlie the Project Boundary for median, dry and wet runoff years. The estimated volume of water stored in the flooded underground workings exceeds 6000ML (AGE, 2011). It is estimated 706ML is held in the flooded Old Tyldesley underground workings, approximately 4790ML in the flooded Invincible underground, and approximately 747ML of water is stored in the Old Invincible underground workings. All flooded underground workings are hydraulically connected to the nearby Baal Bone underground, however there is no hydraulic connection between the Old Tyldesley underground workings and the Invincible and Old Invincible underground workings. The Invincible and Old Invincible underground workings are hydraulically connected.

Figure 6.9 indicates that extractions of water from the flooded underground workings to satisfy process water demands will exceed inflows for all stages of Project life, except under existing conditions. It is of note that even in a dry runoff year, the total volume of water extracted from the underground to satisfy process water demands is less than 10% of the total volume of water held in the underground workings. Based on the predicted extractions for a median runoff year the Project would potentially extract up to 4000ML from the flooded underground workings over the life of the Project, while inflows over this period would total approximately 1850ML. As such, if the Project experiences median climatic conditions over its 21 year life, approximately one third of the water currently stored in the flooded underground workings would be consumed to satisfy process water demands, assuming there are no other inflows to the flooded underground besides surface water seepage and pumped transfers from the Project site.

It should be noted that the above summary of extractions from and inflows to the flooded underground workings at the Project Site assumes that no runoff from rehabilitated areas will seep into the flooded underground workings, and for the purposes of estimating the impact of supplying the mine water deficit from the underground this is a conservative assumption. However in reality is likely that some runoff from rehabilitated areas does seep into the underground workings and provide some recharge to the volume of water stored there. No accurate data is available to quantify the volume of rehabilitation runoff which may be seeping into the underground workings.

Further, it is likely that significant inflows to the flooded underground workings beneath the Project Site occur from other sources including the up gradient Ivanhoe and Wallerawang collieries to the south of the Invincible Colliery. These external recharge sources have not been included in this study, which has focussed on quantifying the contribution of surface water runoff at the Project Site to the volume of water held in the flooded underground, and comparing this to the volume of water that may potentially be exracted in order to satisfy process water demands at the Project Site.

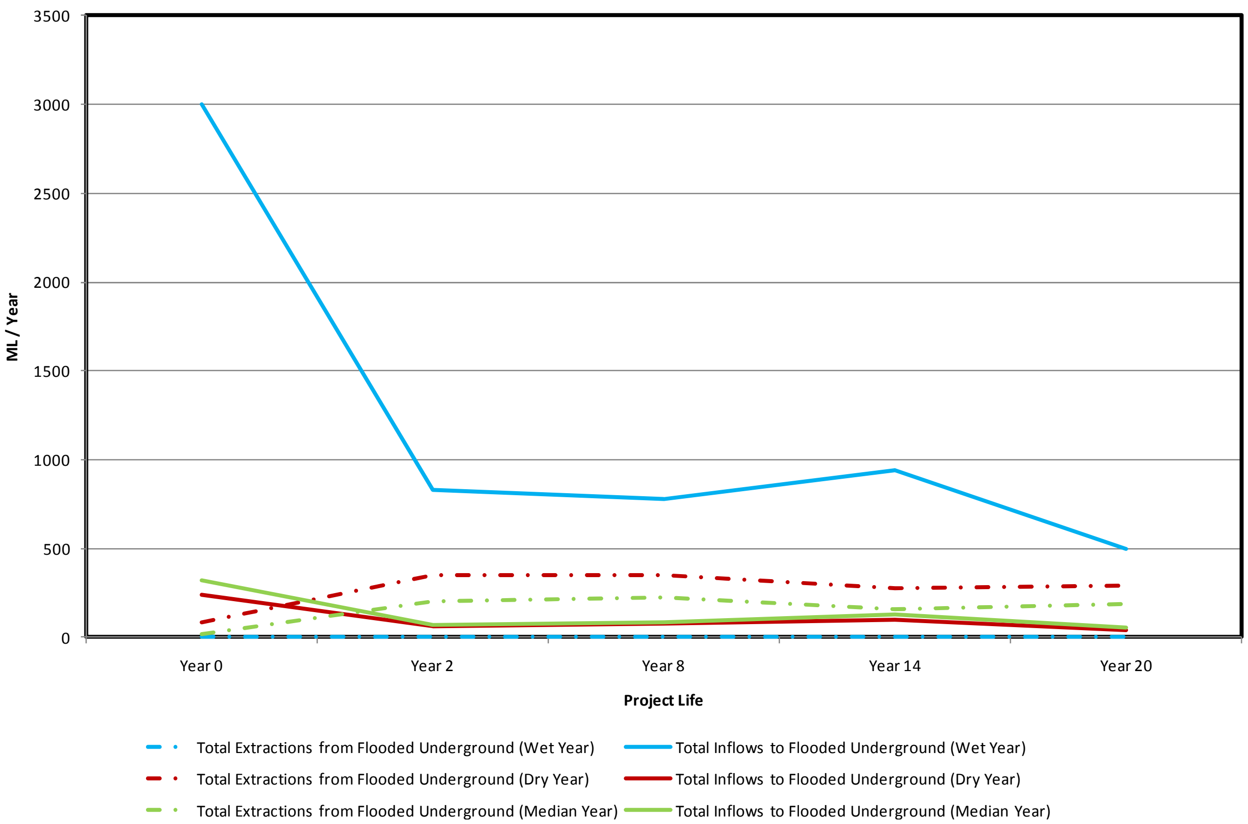

Figure 6.9 Predicted Inflow and Extractions from Underground Workings

7 MITIGATION AND MANAGEMENT MEASURES

7.1 OVERVIEW

The impacts of the Project on surface water resources will be mitigated through the implementation of the following measures:

- An integrated **mine site water management system**, to control the flow and storage of water of different qualities across the site;
- A consolidated **sediment control plan** to reduce sediment loads from disturbed area runoff; and
- A consolidated **surface water monitoring program** to ensure that the site water management system is meeting its objectives of no adverse impact on receiving waters.

An overview of each of these management measures are provided in the following sections.

7.2 MINE SITE WATER MANAGEMENT SYSTEM

A key objective of the integrated mine water management system for the Project will be to minimise the risk of uncontrolled discharges from mine water storages. To achieve this objective, operation of the Project water management system will continue to be based on the following principles:

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Collection of dirty water runoff in sediment dams for control of suspended sediment prior to discharge from site or reuse in the mine water management system;
- Transfer of mine water (groundwater inflows and surface runoff) from within the open cut mining areas to the Mine Water Dam for reuse as a water supply;
- Collection of contaminated water from industrial areas for treatment in an oil and grease separator prior to recycling in the mine water management system;
- Minimisation of fresh water usage by recycling water from the mine water system before taking additional water from the abandoned underground workings of Old Tyldesley Colliery; and
- Release of runoff from rehabilitated catchments once rehabilitation is fully established.

The proposed water management infrastructure for the Project is shown in Figures 4.1 to 4.4. Details of the operation of the proposed mine water management systems are provided in Section 4.

7.3 STRATEGIES FOR MINMISING POTENTIAL FOR RELEASES FROM EXISTING DISCHARGE POINTS

7.3.1 Cullen Valley LD001 and LD004

Future releases from the Cullen Valley Main Dam and Cullen Valley Dam 4 could be minimised by increasing the capacity of the existing bore and pump connecting the Main Dam to the flooded Old Tyldesley Colliery. However, due to the relatively small size of these dams compared to the contributing catchment areas, such a measure is unlikely to impact on major releases from these dams following significant runoff events. Despite the possibility of future release, is expected that during future stages of Project life water quality in these storages would likely meet the existing EPL water quality criteria (see Section 5.4.3).

7.3.2 Invincible LD002

The first strategy for minimising any future releases from the Invincible Main Colliery Dam is to obtain approval for, and put in place equipment to allow the transfer of water from the Main Colliery Dam into the flooded Invincible and Old Invincible workings.

The second strategy for addressing future releases from the Main Colliery Dam is the construction of a second storage upstream of the dam, following the completion of active mining in this area between Years 2 and 8 of Project life. The open cut pit area in mine subcatchment C1-4 immediately upstream of the Invincible Colliery area (Refer Figure 4.1) could be retained and used as a buffer storage, with captured runoff from the upstream rehabilitation areas seeping into the abandoned underground workings.

Both of the above strategies would ensure that the potential for future releases from the dam is minimised, while also improving the reliability of the flooded underground workings as a source for makeup process water demands, by maximising the amount of surface water entering the flooded workings.

7.4 SEDIMENT CONTROL PLAN

The design of sediment control measures for the Project will be based on existing management measures and the principle of ensuring that runoff from disturbed areas is separated from clean area runoff and collected in sediment dams for treatment.
Design of proposed erosion and sediment control measures will be based on the recommended design standards in the following guidelines:

- *Managing Urban Stormwater, Soils and Construction*, (Landcom, 2004); and
- *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries* (DECC, 2008).

Figures 4.1 to 4.5 show the proposed sediment control measures for the site. A number of sediment dams, dirty water drains and clean water diversions are required at each stage of mining. The sizing of proposed sediment control structures will be undertaken during detailed design, and will be in accordance with Landcom (2004).

The proposed sediment dams should be dewatered within 5 days after the conclusion of a runoff event to provide storage and settling capacity for further runoff. Where TSS concentration in sediment dams after a runoff event is less than the selected water quality objective, sediment dams may be dewatered to receiving waters. Where TSS exceeds the water quality objective, water in basins must be either:

- Flocculated to reduce TSS to less than the water quality objective;
- Pumped to another water storage with available capacity; or
- Pumped in to the mine water management system.

Based on available water quality data collected within the Project Boundary, water quality within proposed sediment dams is likely to be of a standard suitable for release off site.

7.5 SURFACE WATER MONITORING PROGRAM

Monitoring of surface water quality both immediately adjacent and within the Project Boundary will form a key component of the surface water management system. Monitoring of on site, upstream and downstream water quality will assist in demonstrating that the site water management system is effective in meeting its objective of no adverse impact on receiving water quality.

Figure 7.1 shows proposed stream monitoring locations and the currently approved licensed discharge points to be retained for the Project. Details of the proposed monitoring locations, including sample collection frequency and key water quality parameters to be monitored are shown in Table 7.1. Table 7.1 also shows the proposed water quality monitoring program for water storages on site. All samples should be collected in a manner consistent with the *Approved Method for Sampling and Analysis of Water Pollutants in NSW* (DEC, 2004). The following is of note with regards to the proposed surface water monitoring program:

- Water quality will be monitored at locations where releases from proposed sediment dams drain across the Project boundary in order to identify locations where further sediment control measures may be required. Monitoring at these locations will only be undertaken during runoff events (>20mm rainfall in 24 hours), as most of these drainage lines are ephemeral and only flow in the period immediately following a rainfall event.
- Monitoring of discharge points in sediment dam catchments will only be required once the catchment has been disturbed.
- Sediment dam catchments that do not contain any disturbed areas, (ie. all rehabilitation areas within the catchment have been signed off against the agreed rehabilitation criteria) will not require water quality monitoring.
- The water quality monitoring program for Cullen and Dulhunty's creeks established in October 2011 will be continued to gather background data on downstream water quality and allow the impact of any releases from existing licensed discharge points to be quantified.
- Water quality monitoring will continue on a monthly basis (and during release events) for the existing licensed discharge points (LD001, LD002 and LD004) and in the Invincible Environmental Dam.
- Water quality will also be monitored in the two new proposed mine water dams (MWD J6-2 and MWD C4-2) on a monthly basis. These dams will be operated such that no releases occur from during the Project life, however in the extremely unlikely case of a release occurring from either storage, water quality during the release event will be monitored.
- All existing and proposed monitoring locations will monitor the following water quality parameters:
  - pH;
  - Total Suspended Solids (TSS);
  - Total Dissolved Salts (TDS);

– Turbidity;
– Oil & Grease; and
– Electrical Conductivity (EC);

- Some of the above parameters (TDS, Turbidity, EC) do not currently have water quality criteria in the existing EPL conditions for the licensed discharge points. However they represent water quality parameters which may be affected by mining operations at the Project Site, and should be monitored to ensure any potential environmental impact in the watercourses draining the project site is minimised.

Table 7.1 Surface Water Quality Monitoring Program

Location	ID	Parameters	Frequency
Cullen Creek upstream of Invincible	Cullen01	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Quarterly and following flow events (>20mm rainfall in 24 hours)
Dulhunty's Creek upstream of Cullen Valley	Dulhunty01	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Quarterly and following flow events (>20mm rainfall in 24 hours)
Dulhunty's Creek downstream of Cullen Valley	Dulhunty02	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Quarterly and following flow events (>20mm rainfall in 24 hours)
Invincible Main Colliery Dam (LD002)	INV MCD	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Monthly / Daily during releases
Invincible Environmental Dam	INV ED	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Monthly / Daily during releases
East Tyldesley Mine Water Dam	MWD C4-2	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Monthly / Daily during releases
Cullen Valley Main Dam (LD001)	CV MD	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Monthly / Daily during releases
Cullen Valley Dam 4 (LD004)	CV D4	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Monthly / Daily during releases
Catchment C1 Project Boundary	C1	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment C2 Project Boundary	C2	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment C3 Project Boundary	C3	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment C4 Project Boundary	C4	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment C5 Project Boundary	C5	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment D2 Project Boundary	D2-1	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment D3 Project Boundary	D3	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events

Location	ID	Parameters	Frequency
Catchment J1 Project Boundary – D/S SD J1-1	J1-1	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J2 Project Boundary – D/S SD J2-2	J2-2	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J2 Project Boundary – D/S SD J2-3	J2-3	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J2 Project Boundary – D/S SD J2-3	J2-3	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J4 Project Boundary – D/S SD J4-2 and J3-2	J4	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J5 Project Boundary	J5	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J6 Project Boundary – D/S SD J6-1 and MWD J6-3	J6-1	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J6 Project Boundary – D/S SD J6-2	J6-2	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events
Catchment J7 Project Boundary	J7	pH, TSS, TDS, Turbidity, Oil & Grease, EC	Daily during runoff events

Suite 1 = pH, EC, TSS, TDS, Turbidity

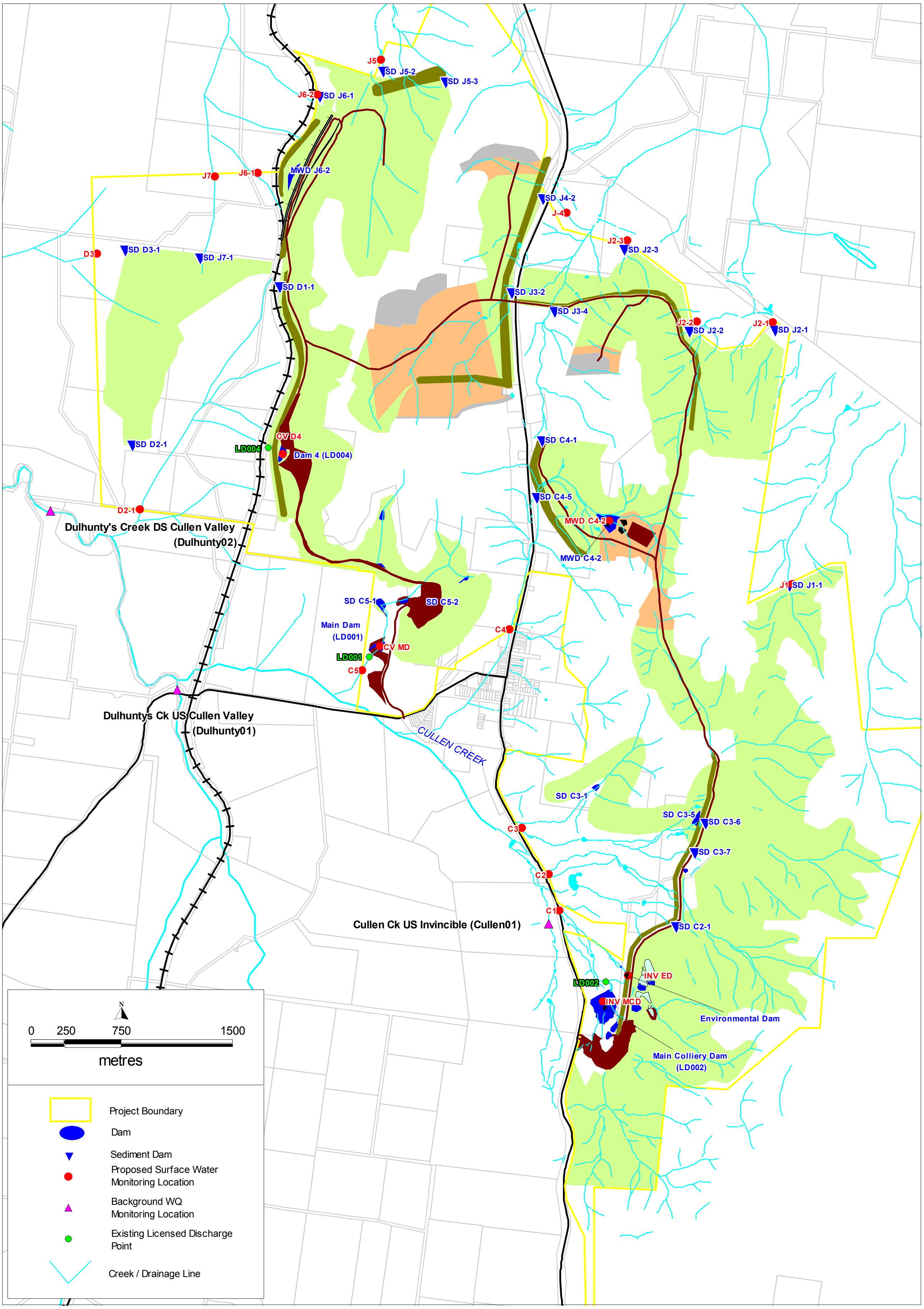

Figure 7.1 Proposed Surface Water Monitoring Locations

8 SUMMARY OF FINDINGS

The findings of the assessment of surface water impacts for the proposed Coalpac Consolidation Project may be summarised as follows:

- The integrated water management system proposed will ensure the separation of clean water, dirty water and mine water on site;
- Additional sediment dams are proposed to treat sediment laden runoff originating from unestablished rehabilitation and exposed spoil dumps;
- Surface water that has come in contact with coal such as in the pit, from the ROM coal stockpiles or infrastructure and CHPP areas (mine water) will be captured in open cut pit sumps and mine water dams. This water will be reused to supply mine water process demands;
- Two new mine water dams (MWD J6-2 and MWD C4-2) are proposed for the Project, located at the proposed rail siding within the Cullen Valley mining area, and at the location of the proposed East Tyldesley CHPP. Long term water balance modelling has been undertaken to size the new mine water dams such that no releases of water are predicted to occur from them over the life of the Project.

To prevent uncontrolled releases from mine water storages, pit dewatering operations will be managed to ensure a suitable freeboard is maintained in the receiving storage. Management procedures to limit discharge from the proposed mine water dams are as follows:

- Pumping of mine water from active mining areas and open cut pits into MWD J6-2 ceases when the volume of water stored in MWD J6-2 exceeds 35ML (total proposed dam volume is 75ML).
- Pumping of mine water from active mining areas and open cut pits into MWD C4-2 ceases when the volume of water stored in MWD C4-2 exceeds 130ML (total proposed dam volume is 250ML).
- In emergency situations water may be transferred from MWD J6-2 to Cullen Valley Mine Dam 4 (LD004) and from MWD C4-2 to the Invincible Main Colliery Dam (LD002) for discharge, provided it meets the appropriate EPL water quality limits.

Potential surface water impacts from the Project include:

- Potential shortfalls in meeting mine site water requirements affecting water available for dust suppression;
- Potential subsidence and loss of catchment area during highwall mining activities;
- Adverse impacts on the quality of surface runoff draining from the surrounding lands on site catchments to Cullen Creek, Dulhuntys Creek and Jews Creek;
- Adverse impacts on downstream water quality associated with possible overflows from the mine water dams affected by coal;
- Loss of catchment area draining to Cullen Creek, Dulhuntys Creek and Jews Creek due to the capture of runoff within on site storages and the Open Cut Pits within the Project Boundary. This could potentially reduce runoff volumes to the above watercourses.
- Potential flooding impacts from minor tributaries and watercourses draining the Project.

The following is of note with regards to the above potential surface water quality impacts:

- Net water demand for the operation of the Project can be met through reuse of dirty water and mine water captured on site, combined with extraction of water stored in the flooded underground workings beneath the Project Boundary. A licence may be required for the extraction of water stored in the Invincible Colliery underground workings.
- Impacts from highwall mining subsidence are unlikely to impact on surface water drainage within or outside of the Project Boundary.
- Water quality impacts on Cullen Creek, Dulhuntys Creek and Jews Creek will be mitigated through the rigorous separation of clean, dirty and mine water runoff within the Project Boundary, and the treatment of all sediment laden runoff prior to release. Coal affected water (mine water) will be reused on site.
- Based on available water quality data and projected disturbance areas, it is expected that any future releases of water from the existing licensed discharge points at the Project site will meet the existing EPL release criteria.
- A surface water monitoring program for the Project has been developed, to assist in demonstrating that the site water management system is effective in meeting its objective of no adverse impact on receiving water quality.
- The potential impacts from loss of catchment are minimal, and in fact, during the proposed 20 years of mine operations Project, will restore catchment areas draining to Cullen and Dulhuntys creeks. The total loss of catchment draining to Jews Creek is approximately 2%, and the loss of catchment draining to the Turon River is less than 0.1%.
- Under existing mine operating conditions, surface water runoff from the Invincible Colliery drains to the abandoned workings beneath the site via, pit floor seepage and subsidence cracking / sinkholes. The amount of surface water draining to the abandoned underground workings will decline over time, as the Invincible Colliery open cut mining areas for the Project are rehabilitated and mining in this area is concluded; and
- Flooding from minor tributaries draining the Project Boundary and regional watercourses will not impact on Project infrastructure.

9 REFERENCES

ACARP, 2001	*ACARP Project No. 7007 Water Quality and Discharge Predictions to Final Void and Spoil Catchments*, PPK Environment & Infrastructure, December 2001.
AGE, 2011	*Coalpac Consolidation Project Groundwater Impact Assessment*, Australasian Groundwater & Environmental Consultants, November 2011.
ANZECC & ARMCANZ, 2000	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment Control Council and Agricultural and Resource Management Council of Australia and New Zealand, Australia.
Boughton & Chiew, 2003	*Calibrations of the AWBM for Use on Ungauged Catchments*, Technical Report 03/15, Cooperative Research Centre for Catchment Hydrology, December 2003.
Coalpac, 2008	*Annual Environmental Management Report for the Invincible Colliery Open Cut Mine 8 October 2007 to 7 October 2008,* Report prepared by R.W. Corkery & Co Pty Ltd on behalf of Coalpac Pty Ltd
Coalpac, 2008a	*Annual Environmental Management Report for the Cullen Valley Mine 2008,* Report prepared by Hansen Bailey on behalf of Coalpac Pty Ltd
Coalpac, 2009	*Water Management Plan for the Invincible Coal Mine Extensions,* Report prepared by Coalpac Pty Ltd, June 2009
Coalpac, 2010	*2009 Annual Environmental Management Report for the Invincible Colliery,* Report prepared by Coalpac Pty Ltd, February 2010
Coalpac, 2010a	*2009 Annual Environmental Management Report for the Cullen Valley Mine,* Report prepared by Coalpac Pty Ltd, February 2010
Coalpac, 2011	*2010 Annual Environmental Management Report for the Invincible Colliery,* Report prepared by Coalpac Pty Ltd, February 2011
Coalpac, 2011a	*2010 Annual Environmental Management Report for the Cullen Valley Mine,* Report prepared by Coalpac Pty Ltd, February 2011
DEC, 2004	*Approved Method for Sampling and Analysis of Water Pollutants in NSW*. Published by the Department of Environment and Conservation, March 2004.
DECC, 2008	*Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries*, June 2008.

Geonet, 2011	*Assessment Of Stability and Subsidence SHM Highwall Mining Coalpac Consolidation Project*, report prepared by Geonet Consulting Group on behalf of Coalpac Pty Ltd, January 2011
IEAust, 1998	*Australian Rainfall & Runoff - A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT, 1998
Jeffrey *et al*, 2001	Jeffrey, S.J., Carter, J.O., Moodie, K.M and Beswick, A.R, 'Using spatial interpolation to construct a comprehensive archive of Australian climate data', *Environmental Modelling and Software,* Vol 16/4, pp 309-330, 2001.
Landcom, 2004	*Managing Urban Stormwater: Soils and Construction, Volume 1*, 4th Edition, Landcom, 2004.
Morton, 1983	Morton, F.I., 1983, 'Operational estimates of areal evapotranspiration and their significance to the science and practice of hydrology', *Journal of Hydrology*, Vol. 66, No. 1-4, pp. 1-76.
WRM, 2005	*Pine Dale Coal Mine – Neubecks Creek and Coxs River Flood Study,* Report prepared on behalf of Enhance Pty Ltd, December 2005