Department of Planning & Infrastructure

Watermark Coal Project: - EIS and Response to Submissions

Merit Review of Surface Water Issues

March 2014

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1 Introduction

1.1 Scope

This report provides a review of the merits of the surface water aspects of the proposed Watermark Coal Project in response to a request from the Department of Planning and Infrastructure to:

> *Review the appropriate documentation (in relation to the surface water assessment) including:*
>
> - *Environmental Impact Statement submitted for public exhibition including relevant specialist compendium reports that are part of the EA;*
> - *Relevant submissions and response to submissions related to surface water management and impacts;*
> - *Other material the Department deems relevant, e.g. Correspondence, PAC reports;*
>
> *Provide the Department written advice (in relation to the surface water assessment) on:*
>
> - *adequacy of response from Proponent*
> - *final assessment of the adequacy and/or suitability of the proposed mitigation and/or management and/or protection measures;*
> - *an assessment of the significance of the impacts of the proposal;*
> - *suggested conditions of approval (where appropriate).*

This review is based on the description and assessment of the proposed Watermark Coal Project as set out in the *Environmental Impact Statement* (February 2013) and the *Response to Submissions* (November 2013).

1.2 The Project

The proposed Watermark Coal Project will involve the following key elements that have a bearing on the management of surface water and potential impacts:

- The development of an open-cut mining operation extracting approximately 268 Mt of ROM coal from three mine pits to produce approximately 159 Mt of product coal within a 30-year period.
- Use of standard mining equipment fleet of excavators and shovels, supported by haul trucks, dozers, graders, drill rigs and water carts;
- The construction and operation of a CHPP with a capacity to process 10 Mtpa of ROM coal and utilisation of thickener and filter presses to produce semi-solid fine tailings;
- The co-disposal of tailings and coarse reject within the Overburden Emplacement Areas (OEA), predominantly within the footprint of the mine pits;
- Progressive rehabilitation of all disturbed areas leading to a final landform comprising relatively flat topped "hills" with steeper side batters and a final void on the western side of the disturbance area in which a permanent lake is expected to develop. The lake is predicted to remain a permanent sink for regional groundwater;
- Construction of a rail spur, rail loop and associated train load out facility to allow transport of product coal by rail via the Werris Creek to the Port of Newcastle for export;
- The construction and operation of surface and groundwater management and reticulation infrastructure including pipelines, pumping stations/bore field and associated infrastructure

for access to water from the groundwater aquifers in the vicinity of the Project, the Mooki River and private dams to the north-east of the Project Boundary.

1.3 Key Issues and Report Outline

Potential to surface water impacts of the Watermark Coal Project are linked to many aspects of the proposed project including the chemical characteristics of the soils and overburden, the landform and revegetation of the overburden dumps and the final void that will remain at the completion of the 30 year mining period.

For purposes of this report, a number of key themes arising from submissions by community groups and agencies have been identified. For each of these themes, this report provides an overview of the data, analysis and proposed mitigation works/activities described in the *EIS* and *RTS*; and provides an assessment of the merits of the project. The merit assessment takes account of the key aspects raised in submissions and opportunities for further mitigation of environmental risks. The key themes discussed in this report and the relevant section in which they are discussed are:

- Salinity and salt balance **Section 2**
- Flooding **Section 3**;
- Mine water requirements and water balance **Section 4**;
- Final void **Section 5**.

Section 6 includes a summary of the assessments and suggestions for matters to be included in any conditions of approval.

For simplicity, the main Environmental Impact Statement (Hansen Bailey, February 2013) is simply referred to as the *EIS* and the Response to Submissions as the *RTS*. All other references to specialist technical assessments that for appendices to the *EIS* are referred to in full, with the appropriate table, figure, page, etc.

Throughout this report, the term 'site' is intended to refer generally to the mine disturbance area unless it is more specifically defined by the particular context.

The *EIS* (Tables 23 and 24) identifies a range of environmental risks and provides an assessment of the change in risk as a result of the proposed mitigation and management measures as described in the *EIS*. Issues that relate to matters addressed in this report are set out in **Table 1.1**

Table 1.1: Identified Environmental Risks

Issue	Preliminary Risk Assessment	Revised Risk Assessment[1]
Surface water	Significant	Medium
Flooding	Significant	Medium
Groundwater	Significant	Medium
Soils and land capability	Low	Low
Geochemical	Low	Medium
Rehabilitation and final landform	Low	Medium

1. After accounting for proposed mitigation and management measures

It is interesting to note that, while most issues are rated lower because of the proposed mitigation and management measures, the risk rating for geochemical issues has increased from low to medium.

2 Salinity

Many submissions raise salinity as a key issue for the project, particularly in relation to salt exports from the disturbance area and the potential to lead to additional salt loads in the Mooki River or to salinization of adjacent land. Key considerations relate to the inherent characteristics of the soils on the site; the availability of salt derived from leaching and breakdown of the overburden and inter-burden; and the surface and sub-surface pathways by which salt from these sources could enter the environment.

2.1 Soil Characteristics

The *Soil Survey and Land Capability Impact Assessment* (Appendix Y to the *EIS*) defines:

- the 'disturbance area' - as the area that would be disturbed by mining activities (5,630 ha);
- the 'study area' - as the area within EL 7223 (encompassing disturbance area) in which detailed soil investigations were undertaken (9,500 ha).

The soil survey included test pits and collection of soil samples from all the main soil landscape units as mapped and described by Banks (1995). Laboratory analysis included soil salinity (as measured in a 1:5 soil:water solution) and exchangeable sodium percentage (ESP – a measure of sodicity). **Table 2.1** (derived from numerous tables in the *Soil Survey and Land Capability Impact Assessment*) summarises the characteristics of the main soil landscape units identified in the mine disturbance area, including the salinity and ESP characteristics and recommended soil stripping depths for re-use, based on limitations of the specific soil horizons. Note that the soil landscape units in **Table 2.1** are listed in descending order of the percentage of the mine disturbance area covered.

Table 2.1: Main Soil Landscape Units within the Mine Disturbance Area

Soil Landscape Unit	Soil Type	Area		Salinity		ESP		Stripping Depth (m)	
		ha	%	Topsoil	Subsoil	Topsoil	Subsoil	Topsoil	Subsoil
Fullwoods Road	Brown Sodosol	890	26%	Non	Highly	Non-Sodic	Marginal to Sodic	0.20	0.0
Watermark	Brown Sodosol	452	13%	Non	Non	Marginally Sodic	Non-Sodic	0.25	1.2
	Brown Kandosol	453	13%	Non	Non	Non-Sodic	Non-Sodic	0.55	1.2
Stafford Gap	Red Chromosol	417	12%	Non	Non	Marginally Sodic	Non-Sodic	0.30	1.2
Goscombes Road	Brown Sodosol	225	7%	Non	Slightly	Marginal to Sodic	Marginal to Sodic	0.25	1.2
	Brown Chromosol	225	7%	Non	Non	Non-Sodic	Non-Sodic	0.50	1.2
Boollcooroo	Sodic Brown Dermosol	212	6%	Highly	Highly	Marginal to Sodic	Marginal to Sodic	0.00	1.2
	Brown Vertosol	213	6%	Non	Slightly	Non-Sodic	Marginally Sodic	0.35	1.2
Carinya	Brown Vertosol	167	5%	Non	Moderately	Non-Sodic	Marginal to Sodic	0.25	1.2
Ponderosa	Red Ferrosol	107	3%	Non	Non	Non-Sodic	Non-Sodic	0.60	1.2

Sources: *Soil Survey and Land Capability Impact Assessment,* Tables 1, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31 and 41

The data in **Table 2.1** indicates that, while most of the soils are non-saline, the subsoil of the Fullwoods Road soil landscape unit (which covers 26% of the mine disturbance area) is highly saline and the *Soil Survey and Land Capability Assessment* recommends that this subsoil not be stripped for subsequent re-use in the mine rehabilitation. Similarly, the sodic brown dermosol within the Boollcooroo soil landscape unit has highly saline topsoil and is not recommended for re-use in the rehabilitation.

The occurrence of dry-land salinity has been a recognised problem in the upper Namoi Valley as a result of clearing of tree cover and there are numerous examples of locations where remedial action has been taken by re-introduction of deeper rooted trees on the hill crests and slopes and the planting of salt tolerant vegetation in salinised areas at the foot of the slope.

The proposed selective stripping to soils for re-use in the rehabilitation program can be expected to significantly assist in minimising the potential for salt exports in surface runoff from the overburden emplacements, provided the unsuitable soils are isolated within the overburden emplacements.

2.2 Overburden Runoff

Notwithstanding, the benefits of the proposed selective stripping to avoid saline, sodic and other unsuitable soils, there remains the potential for some salts to be exported in surface runoff which has not been adequately characterised in the *RTS*. The *RTS* (page 136) argues that:

> *"Sediment dams would only spill following extended periods of significant or extreme rainfall events."*

Subsequently the *RTS* (page 454) states that:

> *"Under most rainfall conditions, water accumulating in sediment dams will be pumped back into the mine water system for recycling to meet water demands for coal processing and dust suppression. However, during major rainfall events that exceed the capacity of the sediment dams (which are designed to a government-specified standard), some overflows from sediment dams may occur after a period of time to allow any suspended sediment to settle out of suspension."*

These statements do not seem to align with the water balance data presented in Table 29 of the *EIS* from which the source data for the first four data rows in **Table 2.2** has been extracted.

Table 2.2: Water Balance for Sediment Dams

	Year 2	Year 5	Year 10	Year 15	Year 21	Year 25	Year 30
Rainfall/runoff yield (ML/year)	239	331	309	471	830	486	508
Evaporation (ML/year)	23	17	31	62	106	48	99
Storage overflows (offsite) (ML/year)	55	61	56	111	307	145	224
Water Retained (onsite) (ML/year)	2	0	2	5	6	3	4
Transferred to mine water (ML/year)	159	253	220	293	411	290	181
Storage overflows (offsite) (% of runoff)	23%	18%	18%	24%	37%	30%	44%
Transferred to mine water (% of runoff)	67%	76%	71%	62%	50%	60%	36%

Source data: *EIS*, Table 23

The table assumes that the difference between the runoff generated and the losses from evaporation, overflows and retained, constitutes water transferred to the mine water management system. The second last row of the table shows that the overflow from the sediment dams is expected to constitute 18% to 44% (overall average 30%) of the average annual runoff from the overburden emplacements. The last row shows that water transferred to the mine water circuit is expected to comprise anywhere from 36% to 76% (overall average 57%) of the average annual runoff. In addition, the sediment dam volume and frequency of spillage from the water balance analysis appears to be inconsistent with the data presented in Table 7.15 of the *Surface Water Impact Assessment*. This issue is considered further in **Section 4.6.2** below.

The relatively significant proportion of water that is expected to overflow from the sediment basins (based on the water balance analysis) is not inconsistent with the data in Table 6.2 of *Managing Urban Stormwater: Soils and Construction- Volume 2E: Mines and Quarries* (DECC, 2008) which indicates that for a sediment dam designed and operated in accordance with the requirements for capture of runoff from a 90th percentile storm, an average of 2-4 overflow events per year can be expected.

The data in **Table 2.2** indicates that overflow from the sediment dams is likely to be greater than implied by the statement that the dams would "*only spill following extended periods of significant or extreme rainfall events.*"

A further factor that needs to be considered is that the data in Table 29 of the *EIS* only relates to average conditions for each nominated mine year, based on analysis using the full historic daily rainfall record. In practice, the actual runoff, and therefore the overflow, will depend on the actual rainfall during the particular year when that stage of mining occurs. In view of this, average annual runoff is not a very useful indicator of the performance of the water management system. Water balance for realistic lower and upper rainfall conditions (say 5th percentile [dry] and 95th percentile [wet] years) would provide an indication of the variability.

The *RTS* (pages 133 – 136) sets out the basis for the salt balance assessment for the site during mining operations. The salt load assessment for surface runoff is based on accounting for the volume and salinity of shallow sub-surface baseflow contribution as well as surface runoff reporting to the sediment basins. Although not explicitly stated, it appears that the partitioning between the base flow component and surface runoff is based on the partitioning implicit in the adopted surface runoff model (AWBM) described in the *Surface Water Impact Assessment* (WRM, 2013 – Appendix S to the EIS). AWBM model includes a 'base flow index' (BFI) which governs the proportion of rainfall excess that reports to the sub-surface, as opposed to running across the land surface. Table 7.11 of the *Surface Water Impact Assessment* lists the adopted BFI values as:

- Natural/undisturbed land 0.3;
- Un-rehabilitated spoil 0.2;
- Rehabilitated spoil 0.3.

The implication of adopting the listed BFI values for spoil is that shallow sub-surface flow is a significant process in the hydrology of mine spoil. However, once competed, typical overburden emplacements comprise mixed coarse rock overlain by a shallow layer of soil, as opposed to the natural soil profile that has a gradation from various soil horizons to weathered rock and competent rock. It is therefore likely that any rainfall excess passing through the soil layer on mine overburden emplacement would continue to drain towards the deeper groundwater rather than contribute to any shallow sub-surface flow that would eventually manifest itself in surface runoff. Accordingly, it is considered more likely that a BFI close to zero would more correctly represent the runoff characteristics of mine spoil.

It is acknowledged that the key reference for AWBM parameters for mine site (ACARP Report C07007, December 2001) lists BFI ranging up to 0.8 based on water level monitoring of mine voids. However, these BFI values reflect situations in which drainage through the overburden placed in the mine pit is a significant contributor to the water in the void and do not constitute a component of surface runoff that would report to a sediment basin.

2.3 Overburden Seepage

The *Groundwater Impact Assessment* predicts that the groundwater levels in the overburden dumps will be at a higher elevation than naturally occurs in the existing landscape. The potential for saline groundwater seepage from the overburden dumps is a function of:

- Relatively shallow soil profile compared to the existing natural soils, which would lead to a reduction is the water holding capacity of the soil profile and an increase in seepage below the bottom of the soil profile;
- Increased permeability of overburden compared to the in-situ rock;
- The geometry of the overburden dumps which, because of the bulking up effect, occupy a greater volume than the original materials. To accommodate the greater volume while maintaining ridge elevations similar to the existing landform, the overburden dumps typically comprise a flat upper plateau area with relatively steep batters down to the existing natural land levels.

Figure 22 in the *RTS* (reproduced as **Figure 2.1** below) shows the proposed final landform together with the two proposed vegetation zones (agriculture and Box Gum woodland). The figure also shows the locations of areas identified in the backfilled Southern Mining Area and Eastern Mining Area in which the *Groundwater Impact Assessment* predicts that groundwater seepage would occur as a result of groundwater levels recovering to above pre-mining levels. A number of submissions have expresses concern about the prospect of salt from these seepage areas being conveyed down-slope towards Native Dog Gully.

Table 2.3 summarises the predicted seepage areas and associated and salt loads quoted in the *EIS* (page 133), based on an assumed salinity concentration in the groundwater seepage of 5,000 mg/L. The *RTS* (pages 80 – 81) argues that any seepage would be lost by evaporation (or evapotranspiration):

> *"The groundwater model predicts the maximum flows from these seepages around the toe of the Southern and Eastern Mining areas to be 0.08 ML/day. This is equivalent to a discharge rate of 0.03 mm/day over the 280 ha area where the potential outbreaks are predicted by the model.*
>
> *Pan evaporation ranges from 2 mm/day in the winter months up to 8 mm/day in summer, and therefore will readily evaporate the seepage if it reaches the ground surface."*

Notwithstanding the potential for the seepage to be lost by evaporation, the salt load (about 20 t/ha/year in the Southern Mining Area) can be expected to progressively accumulate unless it is lost by means of vegetation uptake or loss in off-site surface runoff.

Table 2.3: Predicted Groundwater Seepage Areas and Salt loads

Location	Affected Area	Salt Load	
	(ha)	(kg/ha/day)	(t/year)
South-eastern corner of the Eastern Mining Area	214	<1	84
North-eastern edge of Eastern Mining Area	16		
South-eastern edge of Southern Mining Area	53	5.6	108

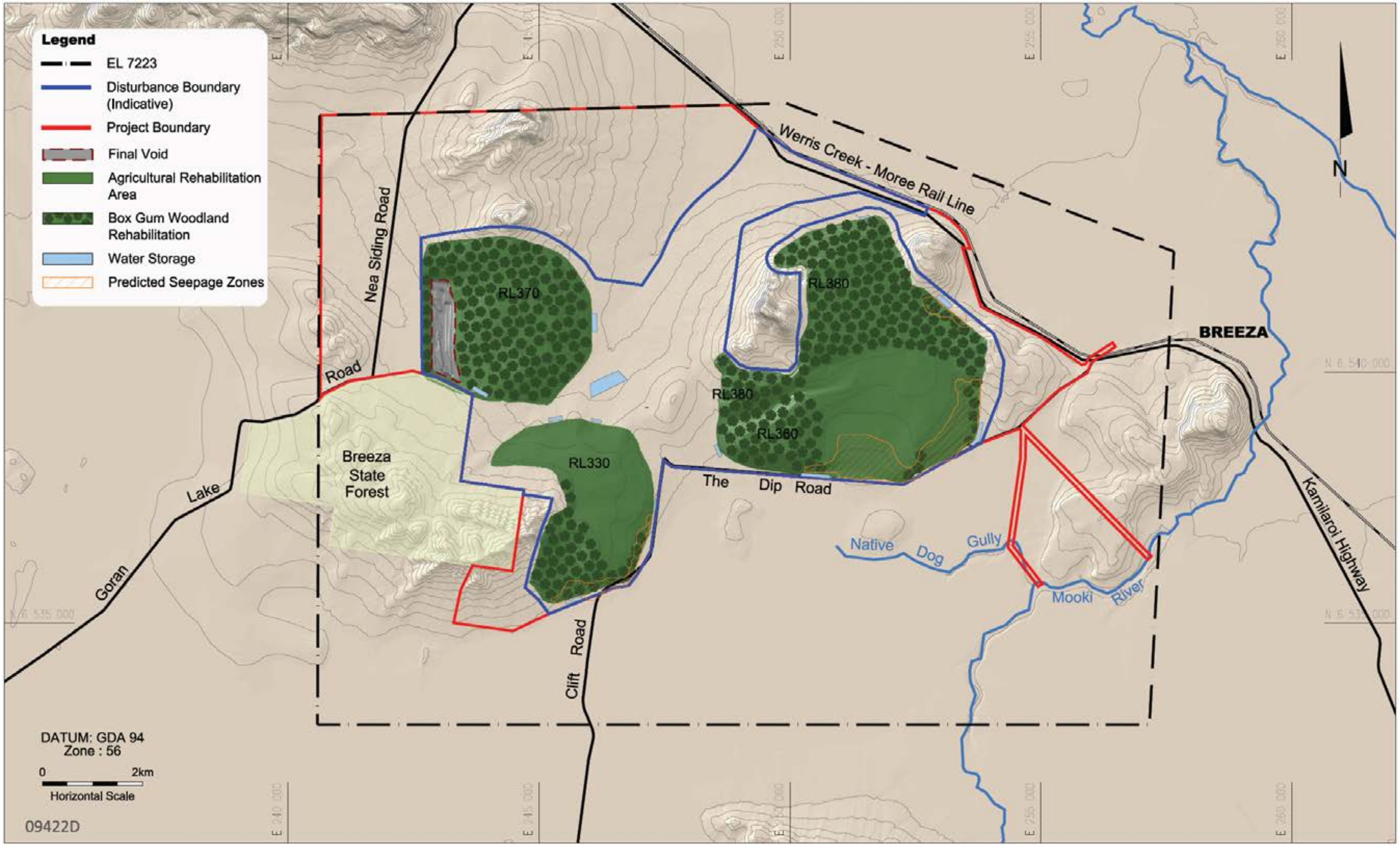

Figure 2.1:
Final Landform, Rehabilitation Zones and Predicted Seepage Zones Post Mining
Source: *Response to Submissions*, Figure 22

It should be noted that the *Seepage Water Quality Assessment* (Terrenus, 2013 – Appendix 6 to the *Groundwater Impact Assessment*) quotes estimated salt loads from the Eastern Mining Area of 164 t/year, or about 2 kg/ha/year. The *Seepage Water Quality Assessment* also points out that seepage is not expected to occur until about 30 years after completion of mining. Any efforts to further mitigate potential impacts would, therefore, need to rely on measures to limit groundwater recharge into the overburden emplacements such as geometry, surface soils and vegetation embedded into the final landform, rather than any direct management action at the time that seepage became apparent.

Notwithstanding the salt loads identified in **Table 2.3**, the *RTS* goes on to argue

> *"There is no reason to indicate the salinity of the seepage zones will contribute any additional salt load to Native Dog Gully or the Mooki River than already occurs from the existing soil landscapes. The results of the geochemical testing (provided in Appendix W of the EIS and summarised in the Groundwater Impact Assessment) concluded that 'leachate from mixed overburden emplacement materials, comprising fine- to coarse-grained overburden and interburden and a small proportion of coal rejects, is conservatively estimated to have an initial salt concentration of up to 5,000 mg/L. The concentration of seepage /leachate / run-off is expected to decrease over time (as readily available salt is flushed during the early years)'.*

2.4 Salt Sources and Sinks within the Mine Operations Area

Table 13 of the *RTS* presents an assessment of the overall daily average salt balance for each of the nominated mine years (5, 15, 25 and 30) based on the schematic diagram in Figure 38. A key feature of the analysis is that it correctly reflects the principle underlying the mine water management system; namely, that all mine water that has come into contact with coal will be retained on site and will not be discharged. However, terminology used in Table 13 differs from that in the text and Figure 38. In particular, the distinction is not evident between the '*Dirty water system*' and the '*Active mining areas*' (the same terms as used in the average water balance set out in Table 29 of the *EIS*). Notwithstanding, Table 13 of the *RTS* indicates that for most of the mine life runoff from all sources contributing to the mine water management system would be from surface runoff.

Table 13 of the *RTS* indicates that up to Year 15 (while mining occurs in the Eastern Mining Area) the salt loads for groundwater inflow to the pit are expected to be minor (<5%), reflecting the predicted relatively low seepage rate into the active mine pit (about 0.2 ML/day in Year 15). In later years, when the Southern or Western Mine Areas are active, the salt contribution from groundwater seepage is greater (up to 33% corresponding to seepage of about 0.85 ML/day in Year 25). However, the mine years selected for presentation in Table 13 are somewhat misleading because they do not include the years with maximum predicted seepage rates. Based on the groundwater 'take' data in Table 10.5 in the *Groundwater Impact Assessment*, and assuming similar salinities at each stage of mining (e.g. similar seepage salinity in Year 24 to Year 25), **Table 2.4** shows that the salt loads in Years 13, 24 and 29 are likely to be significantly higher that the loads quoted in Table 13 for Years 15, 25 and 30 respectively. In particular, **Table 2.4** indicates that the peak daily salt load from groundwater seepage in Year 24 (estimated 7.6 t/day) would be more than double the salt load for Year 25 quoted in Table 13 (3.0 t/day).

Table 2.4: Predicted Groundwater Seepage and Salt Loads

Mine Year	Groundwater Seepage[1] (ML/day)	Salt Load[2] (t/day)
5	0.26	0.1
13	0.53	*0.8*
15	0.2	0.3
24	2.14	*7.6*
25	0.85	3.0
29	1.24	*1.6*
30	0.84	1.1

Sources: 1 – *Groundwater Impact Assessment*, Table 10.5 2 – based on *RTS*, Table 13

Table 13 of the *RTS* indicates that up to Year 25, the major 'sink' for salt is expected to be the water retained in the tailings or the product coal. Because the tailings are to be buried within the overburden emplacements, (below natural ground level?), the associated salt would be effectively retained on site. Any salt in the product coal will be transported off site and would not pose any threat to the environment surrounding the mine. The second largest 'sink' for salt is predicted to be the water used for dust suppression on haul roads. While much of this salt is likely to be retained and subsumed into the overburden as the emplacements are constructed, there is the possibility that a proportion of this salt load could report to the sediment dams, from which a significant proportion could be lost in overflow (see **Section 2.2**). This does not appear to have been accounted for the analysis presented in Table 13 in the *RTS*.

Notwithstanding the uncertainty regarding the fate of a proportion of the salt applied in water used for dust suppression, it is clear from the analysis that the intention of the mine water system is to retain all salt within the operating mine area. Although any additional salt loads reaching the sediment dams from haul road runoff are unlikely to significantly affect the total salt loads leaving the site, monitoring of sediment dam discharge should be undertaken to verify this and remedial action taken if necessary (see **Section 2.5** below and **Section 4.6.2**).

2.5 Drainage to External Catchments

Table 14 of the *RTS* (copied as **Table 2.5**) sets out the changes in salt loads draining to external catchments (expressed as a long-term average daily value for each of the nominated mine Years (5, 15, 25 and 30). The changes in salt load reflect both changes in the contributing catchment area as well as the assumed increase in salt load associated with surface runoff from the overburden emplacements (see **Section 2.2**).

The most significant predicted change in salt load occurs in Watermark Gully for Year 30 (total of 0.9 t/day) with the majority of this (0.8 t/day) attributable to overflow from sediment basins. However, as noted in **Section 2.2**, it appears that the contribution from sediment basin discharge in Year 30 may have been overestimated as a result of the way the AWBM model treats the runoff process from overburden and the conservative assumption of average salinity in runoff (800 mg/L).

Not only are the estimated increases in salt load draining to external catchments from the sediment dams likely to be conservative, in practice, any increase is unlikely to be detectable from the background variation. In addition, if operational monitoring showed that salt loads discharging from the sediment basins were of concern, modifications to the size and operating regime for the sediment basins would allow an increased percentage of runoff to be transferred back to the mine water management system and thereby reduce the actual exported salt loads .

Table 2.5: Long Term Average Surface Water Salt Loads Draining to External Catchments

Average Annual Salt Load (t/day)					
	Existing	**Year 5**	**Year 15**	**Year 25**	**Year 30**
Watermark Gully Salt Load					
Catchment Runoff	*2.4*	*2.2*	*2.3*	*2.2*	*2.5*
Sediment Dam Overflows	*0.0*	*0.1*	*0.1*	*0.4*	*0.8*
Total	2.4	2.3	2.4	2.6	3.3
Native Dog Gully Salt Load					
Catchment Runoff	*3.0*	*2.7*	*2.4*	*2.9*	*2.9*
Sediment Dam Overflows	*0.0*	*0.2*	*0.4*	*0.3*	*0.2*
Total	3.0	2.9	2.7	3.2	3.1
Lake Goran Salt Load					
Catchment Runoff	*59.9*	*59.9*	*59.9*	*59.8*	*59.6*
Sediment Dam Overflows	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Total	59.9	59.9	59.9	59.8	59.6
Gross Salt Inputs	**65.2**	**65.1**	**65.0**	**65.5**	**66.0**

Source: RTS, Table 14

2.6 Salt Balance

The *RTS* (pages 133 – 136) sets out the basis for the salt balance assessment for the site during mining operations. Table 13 of the *RTS* presents the average daily salt balance for mine years 5, 15, 25 and 30. (The table is somewhat confusing, because it quotes the annual averages in tonnes of salt per day.) It is assumed that the intent of the words 'average annual' are that they refer to the daily values (calculated on the basis of the long term climate record) expressed as the average for each particular mine year.

2.6.1 Surface Sources

The *RTS* (pages 133 and 134) lists the following assumptions regarding the salt loads attributable to surface runoff:

- Surface water baseflow for newly rehabilitated overburden 5,000 mg/L;
- Surface water baseflow for rehabilitated overburden 2,500 mg/L;
- Surface runoff 800 mg/L.

These concentrations are all claimed to be based on the upper limits of values derived from the *Geochemical Assessment of Overburden/Interburden and Coal Rejects Materials* (RGS Environmental – Appendix W to the EIS).

The consequence of the adoption of the BFI values listed in **Section 2.2**, is that 20-30% of the rainfall excess is assumed to have salinity between 2,500 mg/L and 5,000 mg/L. This is likely to lead to an over estimation of the salt loads reaching the sediment dams, as illustrated by the data in **Table 2.6** which has been derived as follows:

- Data taken direct from Table 13 of the *RTS*;
- Salt load calculated by multiplying the overburden runoff volume from Table 23 in the *EIS* by the adopted salinity (800 mg/L).

Table 2.6: Estimated Salt Loads in Overburden Runoff Derived by Different Sources

Source		Year 5	Year 15	Year 25	Year 30
Table 13 *RTS*, (page 135)					
	Rainfall/runoff yield (t/day)	1.8	1.7	2.1	1.9
	Storage overflows (offsite) (t/day)	0.3	0.4	0.7	0.9
Calculated from Water Balance					
	Rainfall/runoff yield (t/day)	0.7	1.0	1.1	1.1
	Storage overflows (offsite) (t/day)	0.1	0.2	0.3	0.5

This analysis suggests that, notwithstanding the inherent conservative assumptions underlying the surface runoff salinity of 800 mg/L from overburden, the salt loads set out in Table 13 of the *RTS* are likely to be over estimates by an average of about 50%.

2.6.2 Groundwater Sources

The analysis presented in the *Groundwater Impact Assessment* and its various appendices indicates that any groundwater seepage in the areas identified in **Figure 2.1** is likely to occur once the groundwater levels in the overburden have risen above pre-development levels about 30 years after completion of mining.

The prediction of the groundwater levels within the overburden is dependent on the assumptions regarding infiltration through the rehabilitated soil and the porosity of the overburden following any settlement. **Table 2.7** below summarises the hydraulic properties of overburden, inter-burden and spoil from Table 9.2 (p 150) and Table 10.1 (p 216) of the *Groundwater Impact Assessment*. The table shows that, as expected, the spoil would have much higher conductivity, specific yield and specific storage that the in-situ rock that it will replace. Accordingly, any water that drains below the base of the covering soil layer of the overburden emplacements can be expected to drain downwards at a relatively rapid rate. Nevertheless, as outlined above, because of the volume of the East and South mine pits below natural ground level, the *Groundwater Impact Assessment* predicts that it would take 30 years before the groundwater level in these pits would be at an elevation that would cause seepage. Any management actions deemed necessary to manage or mitigate the predicted seepage would, however, need to be undertaken during the mining and rehabilitation process.

Table 2.7: Hydraulic Parameters of Spoil, Overburden and Interburden

Parameter	Spoil	Overburden and Interburden	
		Minimum	Maximum
Horizontal Hydraulic Conductivity kh (m/day)	1	1×10^{-4}	6.5×10^{-1}
Vertical Hydraulic Conductivity kv (m/day)	0.1	1×10^{-5}	1.9×10^{-1}
Specific Yield Sy	0.1	1×10^{-3}	1.5×10^{-3}
Specific Storage Ss (m^{-1})	1×10^{-3}	1×10^{-5}	5×10^{-4}

Source: *Groundwater Impact Assessment*, Table 9.2 and Table 10.1

2.7 Impact Assessment and Management Issues

The proposed selective stripping of soils to avoid the re-use of any soils that pose a salinity or sodicity risk represents good management practice, provided the unsuitable soils are placed within the overburden in a location where they will not contribute to the quality of the predicted long-term groundwater seepage.

The analysis on which the runoff salt loads appear to have been assessed is likely to over-estimate the actual loads discharged from the sediment basins. If operational monitoring showed that salt loads discharging from the sediment basins were of concern, modifications to the size and operating regime for the sediment basins would allow an increased percentage of runoff to be transferred back to the mine water management system and thereby reduce the actual exported salt loads.

The *Seepage Water Quality Assessment* points out that groundwater seepage from various identified areas at the foot of the overburden emplacements is expected to start about 30 years after completion of mining. Accordingly, any efforts to further mitigate potential impacts would need to rely on measures to limit groundwater recharge into the overburden emplacements such as geometry, surface soils and vegetation embedded into the final landform, rather than any direct management action once seepage has commenced.

The assessment of the likely rates of seepage and the associated salt load are highly dependent on the assumptions regarding the recharge rate into the overburden dumps and the salinity of the groundwater. As part of any approval, the Proponent should be required to establish a monitoring program to characterise the actual groundwater recharge characteristics of the overburden, periodically re-assess the groundwater predictions (say every 5 years) and the implications for the estimated groundwater seepage and salt loads. In the light of this reassessment, further consideration should be given to the geometry of the overburden emplacements and the location of deeper-rooted trees on the landscape in order to minimise groundwater recharge. Consideration should also be given to planting of salt tolerant vegetation in areas where seepage is predicted (using the same principle as has been successfully employed to combat dry-land salinity elsewhere in the Mooki River catchment).

3 Flooding

3.1 Watermark Gully

For the *RTS*, the flood conditions along Watermark Gully have been reassessed using a more sophisticated two-dimensional program (compared to the one-dimensional analysis adopted for the *EIS*) The two-dimensional analysis provides a better representation of flow conditions across the broad flat floodplain where flow from Watermark Gully crosses the Kamilaroi Highway.

As a result of the changed landform associated with the project, the catchment draining to Watermark Gully is predicted to increase by 3.3 km^2 to a total of 43 km^2 following completion of mining. The effect of this increase is that the estimated peak flows for nominated 'design' storms increase slightly. Flood flow estimates have been derived using RAFTS, which is a widely used and recognised model for estimating the runoff hydrograph and peak runoff for nominated 'design' storms. Table 8.5 in the *Surface Water Impact Assessment* provides estimated peak flow rates for storms of 2, 5, 10, 20, 50 and 100-year average recurrence intervals (ARI) and for the probable maximum flood (PMF) under existing catchment conditions. The hydraulic analysis (in both the *Surface Water Impact Assessment* and the *RTS*) examines flood conditions along Watermark Gully for representative frequent and rare floods (2 year and 100 year ARI respectively). This is considered to provide an adequate basis for assessing the range of impacts on flooding across the Kamilaroi Highway.

The analysis presented in the *RTS* indicates that, as a result of the increase in the contributing catchment, the peak flow, flood depth and duration of flooding across the highway are likely to increase as set out in **Table 3.1**.

Table 3.1: Design Flood Conditions at the Kamilaroi Highway from Watermark Gully Flooding

Flood ARI (years)	Flood Characteristic	Existing	Post Mine
2	Peak Flow (m^3/s)	15.3	16.3
	Peak depth (m)	0.2	0.2
	Length of flooded road (m)	600	600
	Estimated peak velocity (m/s)	0.13	0.14
	Estimated Depth x Velocity	0.026	0.029
	Duration of flooding > 0.3 m (h)	0	0
100	Peak Flow (m^3/s)	125	136
	Peak depth (m)	1.45	1.5
	Length of flooded road (m)	1,650	1,650
	Estimated peak velocity (m/s)	0.05	0.05
		0.073	0.075
	Duration of flooding > 0.3 m (h)	10.5	11.0

Sources: *Surface Water Impact Assessment*, Table 8.5 and the *RTS*, Figures 32, 33, 34, 36 and 36

For purposes of assessing the duration of flooding the analysis has adopted a depth of 0.3 m as a depth at which light traffic might be stopped because of the risk of floating. This depth is less than the depth of 0.35 m for stability in standing water as shown in Figure L2 of the *NSW Floodplain Development Manual* (April 2005) and provides a reasonable estimate to allow for the relatively low velocity of flow. As part of the update of *Australian Rainfall & Runoff* (Engineers Australia -

http://www.ncwe.org.au/arr/p10.html, accessed 13/12/2013) draft stability criteria for passenger vehicles and lager 4WDs have been published. The proposed stability criteria include depth x velocity of 0.3 (D x V ≤ 0.3). The draft guidelines in the updated version of *Australian Rainfall & Runoff* also specify a limiting depth of 0.3 m before there is a risk of light vehicles floating. As shown in **Table 3.1**, for all situations listed, the flood conditions on the Kamilaroi Highway as a result of flooding from Watermark Gully are significantly less than either of the stability criteria.

Accordingly, the small increase in peak flood flow attributable to an increase in the catchment area of Watermark Gully would not significantly affect vehicle movement along the Highway.

Notwithstanding the limited impact, the Proponent (*RTS* page 129) has committed:

> "*Shenhua Watermark will ensure that the Watermark Gully diversion will return the catchment to pre-mine development flood flow rates and velocities. This will be detailed in the Water Management Plan to be prepared for the Project.*"

3.2 Mooki River Flood Assessment

A RAFTS model of the Mooki River catchment was used to estimate design flood discharges and a 2D TUFLOW hydraulic model was used to model flood levels and extents. Calibration was undertaken against the 1984, 1998 and 2000 events using historic streamflow and flood level records. Lake Goran was included in the model. The TUFLOW model contains a 2D section between 5 km downstream of Breeza and Lake Goran covering Native Dog Gully, the Mooki River and various creek inflows, and a 1D component north of the 2D section on the Mooki River.

Flood frequency analysis was also undertaken to determine discharges at Caroona and Breeza, however the adopted RAFTS design discharges used in the modelling were substantially lower than the flood frequency results and it is not immediately clear why this is so.

The *Surface Water Impact Assessment* includes flood extents for the historical 1998 and 2000 events, as well as for the 100-year ARI and PMF events. The flood assessment identifies a small area of the Eastern Mining Area (adjacent to The Dip Road) would experience up to 1.7 m depth of flooding a 100 year ARI flood event. The volume of floodwater held within this area in a 100-year ARI flood was assessed to be 235 ML, which constitutes only 2% of the floodplain storage to the north of Native Dog Gully and a trivial fraction of the whole Mooki River floodplain.

The mine plans (Figures 11 - 17 of the *EIS*) indicate this area would be mined between Years 10 and 15, with the mine pit immediately adjacent to The Dip Road. The *Surface Water Impact Assessment* indicates that a levee embankment is likely to be constructed within the disturbance boundary (i.e. to the north of The Dip Road) to prevent floodwaters from potentially entering the mine pit. Flood modelling indicated that, with the site filled to the disturbance boundary (simulating the impacts of a levee or the final landform), the increase in flood levels on the adjacent floodplain was less than 5 mm.

From a flood impact perspective, this impact is considered to have no consequence.

3.3 Floodplain Definition

Exploration Licence 7223 for the Watermark project specifies a range of conditions including:

> "*48. Any development approval sought by the licence holder within the initial term of the licence or during any extensions or renewals of the licence shall not include any of the following activities in the area covered by the licence:*

- *Long wall mining underneath the "deep alluvial irrigation aquifers";*
- *Long wall mining underneath the "floodplain";*
- *Open cut mining anywhere on the "floodplain"."*

The *RTS* notes that EL conditions do not define *"floodplain"*. However, in October 2013, the Minister for Resources and Energy advised the following definition of the term *"floodplain"*:

> *"A floodplain is an area of low-lying, nearly flat plain adjacent to a river, formed mainly of river sediments and subject to regular flooding."*

As noted in **Section 3.2** the flood modelling for the EIS indicated a small area in the Eastern Mining Area would experience flooding during a 100-year ARI flood event.

3.3.1 Matters for Consideration

A number of submissions question the validity of mining in the area that would be flooded in a 100 year ARI flood event on account of the fact that it would constitute mining on the "*floodplain*". The *RTS* asserts that this land does not meet the recent definition of "*floodplain*" in terms of the relevant criteria for purposes of EL 7223. The sections below quote the relevant text from the *RTS* and provide comment on the validity of the case presented.

1) Land Slope

Whilst this area (referred to as The Dip Road land below) is low-lying (less than 2% average gradient), the slope in the area has been drastically modified by contour banks and dams and is not indicative of a natural or residual floodplain."

Comment

The average slope of the land is in the range of 0.5% – 1.5%. However, the northern floodplain of Native Dog Gully has an average lateral slope of only 0.4% and the main Mooki River floodplain has an average slope of less than 0.1%. Based on this comparison, the slopes on the area of the site in question are not considered to be "*low lying*". However, the argument that the landform has been drastically modified by contour banks and dams is not considered a relevant consideration in this instance.

2) Proximity to a River

The Dip Road land is clearly not located adjacent to a river. The Mooki River is approximately 4 km to the east of The Dip Road land.

Comment

There seems to be some confusion about the distance of the land from the Mooki River. The text of the *RTS* (page 12) quotes the distance as "*approximately 4 km to the east*" while Figure 2 of the *RTS* indicates "*Approx 3 km to the Mooki River*". The 1:25,000 topographic map shows that land is actually 3.5 km from the Mooki River at its nearest point. Notwithstanding these discrepancies, the land is not considered to be "*adjacent*" to the Mooki River.

3) Flooding

"The flood modelling for the EIS indicated a small area in the Eastern Mining Area (adjacent to The Dip Road) may experience flood inundation during a 1 in 100 year flood event (see Figure 2)."

"In addition, the flood modelling in the EIS clearly demonstrates that the land is not "often" flooded by the Mooki River "at high water or when the channel reaches capacity".

Comment

Figures 9.23 and 9.25 of the *Surface Water Impact Assessment* show the modelled extent (using the calibrated TUFLOW hydraulic model) of flooding from historic floods in 1998 and 2000. Both these figures show minor incursion of floodwater onto the Eastern Mining Area. **Table 3.2** below summarises the flood flows and levels at the Breeza gauging station (419027) taken from various tables and figures in the *Surface Water Impact Assessment*. The table shows that the 1998 and 2000 floods had ARIs of 23 and 21 years respectively and reached peak levels at Breeza of 290 m AHD.

Based on the TUFLOW modelling, the 100-year ARI flood is predicted to be approximately 1 m higher than these historic floods. (This is slightly different to the 1.2 m difference quoted in the text of the *Surface Water Impact Assessment* [page 174] which compares the recorded historic flood level to the modelled 100-year ARI flood). Notwithstanding, based on the topography depicted in Figure 2 of the *RTS*, these flood levels indicate that a 20 year ARI flood (assumed to be 1 lower than the 100 year ARI flood) would only have a minor incursion onto the land in question. As a 20-year ARI flood does not constitute "*regular flooding*", the land does not fit this aspect of the definition of "*floodplain*" for purposes of EL 7223.

Table 3.2: Flood Flows and Levels at Breeza

Flood Event	Estimated ARI (years)	Peak Discharge at (m^3/s)	Peak Level (m AHD)
July 1998	23[1]	1,831[1]	≈ 290[3]
November 2000	21[1]	1,738[1]	≈ 290[4]
100 Year Design	100	3,880[2]	290.97[5]

Sources from *Surface Water Impact Assessment:*

1. Table 9.26
2. Table 9.24
3. Figure 9.22
4. Figure 9.24
5. Page 174

4) Alluvial Soils

"The Soils Survey and Land Capability Impact Assessment for the Project (Appendix Y of the EIS) demonstrate that The Dip Road land is not predominately comprised of river sediments."

Comment

Figure 2 of the *RTS* shows that approximately 40% of the land that would be flooded in a 100-year ARI flood has been classed as "*alluvial soils*". Given that any area which was subject to "*regular flooding*", would be a very minor proportion of the area flooded in a 100-year flood, the proportion of the land that meets the criteria for "*alluvial soils*" and "*regular flooding*" would be very small.

3.3.2 Assessment

On the basis of the assessment set out above, the lower lying area of land within the Eastern Mining Area is not considered to constitute "*floodplain*" for purposes of the EL 7223.

3.4 Impact Assessment and Management Issues

3.4.1 Watermark Gully

The flood analysis for Watermark Gully shows that the small increase in peak flood flow attributable to an increase in the catchment area of Watermark Gully would not significantly impact on vehicle movement along the Highway.

Notwithstanding the limited impact, the Proponent (*RTS* page 129) has committed:

> *"Shenhua Watermark will ensure that the Watermark Gully diversion will return the catchment to pre-mine development flood flow rates and velocities. This will be detailed in the Water Management Plan to be prepared for the Project."*

3.4.2 Mooki River Flooding

The mine plans indicate that a small area of the Eastern Mining Area adjacent to The Dip Road would be flooded in a 100-year ARI flood. Flood modelling shows that exclusion of this area from flooding (either by means of a levee during mining or the final overburden emplacement bordering the disturbance boundary) the increase in flood levels on the adjacent floodplain was less than 5 mm. From a flood impact perspective, this is considered to have no consequence.

3.4.3 Definition of "Floodplain"

The lower lying area of land within the Eastern Mining Area which is subject to flooding in floods greater that about 20 years is not considered to constitute "*floodplain*" for purposes of the EL 7223.

4 Water Management and Water Balance

All open-cut coal mines face the need to balance:

- Variable inflows to the mine water management system over the life of the mine attributable to changing groundwater inflow to the pit as the mine progresses (usually deeper), variation in the areas of pit and overburden that drain to the pit, and climate variation;
- Variable water demands over the life of the mine principally attributable to variation in water demand for dust suppression, with a 'base demand' for any coal processing activities.

On-site water storage is used to balance these variations while maintaining the principle of zero or minimal discharge to the environment (subject water quality limits).

The water management strategy for the Watermark Coal Project is based on the primary principle of maintaining separation of water from three different sources in terms of water quality.

- **Clean water:** surface runoff from areas where water quality is unaffected by mining operations including runoff from undisturbed areas and any fully rehabilitated areas. The proposed strategy will involve diverting this water around disturbed areas;
- **Sediment-laden water**: surface runoff water from areas that are disturbed by mining operations, principally the overburden emplacement areas. This runoff may contain high sediment loads but does not come into contact with coal or other carbonaceous material and therefore does not contain contaminated material or high salt concentrations. This runoff is directed into sediment dams and may be suitable for release offsite subject to meeting adopted water quality criteria. Alternatively, water from the sediment dams can be directed into the mine water system; and
- **Mine water**: water that has generally come in contact with coal such as groundwater seepage and surface runoff to the open cut mining area or runoff from the CHPP and the coal stockpiles. This water may contain elevated concentrations of salt and other contaminants and, in the case of the Watermark Coal Project, is proposed to only be retained on site and used for operational purposes.

The maintenance of strict separate management of these three sources represents current good practice in the mining industry and is capable of providing acceptable environmental outcomes.

Figure 34 in the *EIS* (copied as **Figure 4.1** below) is a highly schematic diagram of the conceptual water management system for the project. The adopted colour coding and the inclusion of a link showing 'spill' from the Main Dam has led to some confusion about the proposed operation of the water management system and the possibility of some mine water being discharged to the environment. This forms the basis of a number of submissions. Three aspects of the figure should be noted (and are clarified in the *RTS*):

- East Dam 1-2, East Dam 3-5, South Dam 1-2, South Dam 3-4, West Dam 1 and West Dam 2 represent the sediment dams that would receive runoff from the overburden emplacements. The schematic diagram shows water being pumped from these dams to the Main Dam from which water is drawn for mine operating purposes (solid line in the figure). This route for water represents water that is pumped to the Main Dam because water is required to supplement mine water supply from other sources or because it does not meet water quality criteria for discharge to the environment. A second (dotted line) from these dams is simply labelled "spill". This label does not accurately reflect the intended operation of sediment dams which are intended to capture and retain runoff from the nominated 'design' storm. The retention volume of the sediment dam is then to be restored within 5 days of the end of the rainfall period that led to runoff. Restoration of the retention volume may be achieved either by controlled release from the dam to the environment (subject to complying with water quality criteria) or directed to the mine water management system. Any discharge from the sediment dams in this manner should more correctly be referred to as a 'controlled release' rather that 'spill'. 'Spill' may however occur in circumstances where a storm leads to a larger volume of runoff that that from the nominated 'design' storm. However, as indicated in Table 6.2 of *Managing Urban Stormwater: Soils and Construction – Volume 2E: Mines and Quarries* (DECC, 2006) on average basins designed an operated in accordance with the requirements for a 90th percentile storm can be expected to experience uncontrolled overflow (i.e. 'spill') 2-4 events per year.

- The Main Dam will receive runoff and groundwater seepage from the mine operating area as well as water transferred from the sediment dams and backup supply from external sources via the Turkeys Nest Dam. **Figure 4.1** shows a dashed line labelled 'spill' running from the Main Dam to Watermark Gully. It is clear from the *RTS* that this line does not represent the intended operation of the Main Dam. In the event of there being any excess water that cannot be held in the Man Dam, water will be retained in one of the pits.

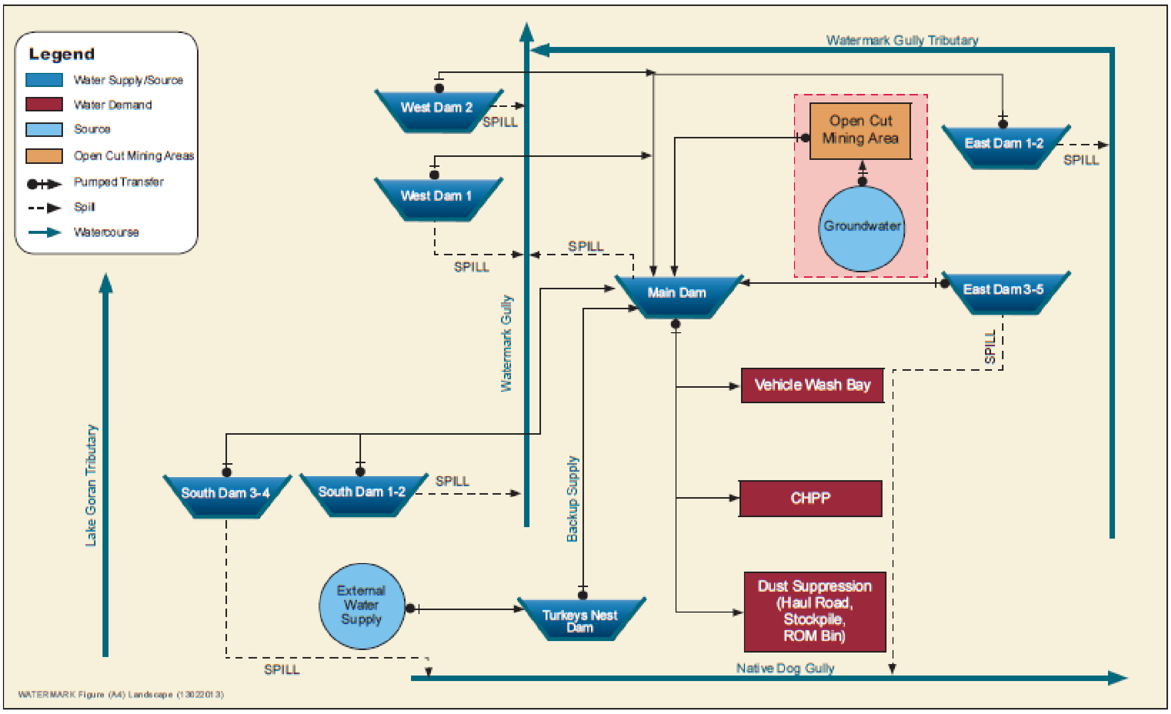

Figure 4.1: Conceptual Water Management System
(Source: EIS, Figure 34)

To avoid some of the confusion about the intended manner of operation of the mine water management system arising from Figure 34 of the *EIS*, the figure would have benefitted from colour coding and labelling in to clearly differentiate:

- Sediment dams (referred to in Table 27 of the *EIS* as "Sediment Dam East 1", etc.);
- The main mine water management system comprising the open-cut mining area, the Main Dam and the use of water for the CHPP, dust suppression and other operational activities;
- Supplementary supply from external sources.

The key to the successful operation of the mine water management system is the provision of sufficient on-site water storage capacity to balance variations in supply and demand while maintaining the principle of zero discharge (or minimal discharge to the environment, subject water quality limits).

4.1 Operational Water Requirements

Typically, the main uses of water in coal mine operations comprise dust suppression and operation of the CHPP (if one is included in the project). In the case of the Watermark Coal Project, the average annual water balance analysis (Table 29 in the *EIS*) indicates that the main water uses and losses are expected to be of the order of:

• Evaporation from storages	33%
• CHPP water usage	42%
• Haul road dust suppression (including effect of chemicals)	12%
• Other minor uses (other dust suppression and vehicle washdown)	5%

Although a significant proportion of the total water budget, evaporation loss is directly related to monitored climate data and appears to have been correctly accounted for in the water balance analysis. The sections below provide an assessment of the magnitude and variability of the CHPP water usage and dust suppression water requirements included in the water balance analysis.

4.1.1 Coal Processing

Section 7.6.5 of the *Surface Water Impact Assessment* quotes the adopted net CHPP demand rate is 76 L/ROM tonne, based on estimates for a coal processing facility using belt press filters provided by CPG Resources (Appendix B to the *Surface Water Impact Assessment*). Table 7.8 of the *Surface Water Impact Assessment* shows water demand varying in the range of 745 – 760 ML/year for the majority of the mining operation when ROM production of about 10 Mtpa is predicted.

While it is recognised that the water requirements for CHPP operation depend on the percentage of fine tailings in the ROM coal and the process used for disposal (slurry or mechanical thickening), the quoted water demand for the Watermark Coal Project compares with an estimated demand for the Cobbora Coal Project of 625 ML/year in the event that belt filter presses were used (Cobbora Coal Project, *Response to Recommendations of the Planning Assessment Commission Review Incorporating a Revised Preferred Project Report*, Appendix B: *Tailings Management Review*, August 2013).

The Cobbora Coal Project proposes to produce about 20 Mtpa of ROM coal from which 10-12 Mtpa of product is expected, with fine tailings comprising an average of 4.5% of ROM (dry weight). Table 6 in the *EIS* (reproduced as **Table 4.1** below) provides an indicative production schedule. However, because the mass of product, coarse rejects and tailings total more than the ROM, it appears that these tonnages are on a wet weight basis. Therefore, the proportion of tailing cannot be directly compared on the basis of the data in **Table 4.1.**

Table 4.1: Indicative Production Schedule

Year	Overburden (Mbcm)	ROM Coal (Mt)*	Product Coal (Mt)	Coarse Reject (Mt)	Tailings (Mt)	Rehabilitation (ha)
1	9.70	0.1	0.05	0.04	0.01	0
2	27.34	2.7	1.6	0.94	0.39	10
5	43.36	10.0	6.3	3.06	1.44	159
10	68.24	10.0	6.0	3.23	1.44	167
15	67.98	9.8	5.3	2.97	1.44	202
21	68.21	9.9	5.6	3.60	1.44	670
25	63.52	10.0	5.6	3.25	1.44	1,136
30	6.90	1.9	1.1	0.65	0.27	815
Total	1,629	268.3	159.4	70.12	38.67	3,348

** Minor discrepancies due to rounding*

Source: *EIS*, Table 6

Based on the data in Figure 3 of Appendix B to the *Surface Water Impact Assessment*, it appears that the following average moisture contents (on a dry weight basis) have been adopted for purposes of assessing the CHPP water make-up requirements for the Watermark Coal Project:

- ROM 5.5%
- Product Coal 8.7%
- Coarse rejects and tailings (combined) 20.4%

Based on these data, the total figures for the life of the mine and assuming that the moisture content of the coarse tailings is similar to the washed coal product, the inferred average proportion of tailings is 8.9% on a dry weight basis, which is approximately double that for the Cobbora Coal Project.

On the assumption that the water requirements for tailings disposal are proportional to the percentage of tailings, and allowing for the differences in proposed ROM throughput and tailings percentage, the estimated water requirements for CHPP makeup for Watermark Coal Project (738 ML/year) appear comparable to those quoted for the Cobbora Coal Project (625 ML/year) if belt filter press were used.

However, as noted in Appendix B to the *Surface Water Impact Assessment*, water balance calculations undertaken for the finest, lowest yielding coal (leading to maximum water usage) indicate that about 1,160 ML of process make-up water would be required, based on 10 Mtpa ROM processing. After allowing for other water usage around the CHPP area, a total CHPP water usage of 1,195 ML/year would be required (a 60% increase). This range of water usage does not feature in the water balance analysis, which is based on average use only.

4.1.2 Dust Suppression

The *RTS* (pages 226 - 231) reiterates the Proponent's commitment to implementing a range of best practice dust management measures to minimise potential air quality impacts and provides an overview of the applicable best practice management measures recommended by the EPA and those to be implemented for the Project (Table 36). Apart from the use of water carts/trucks supplemented if necessary with surfactants to control emissions from haul roads, the main management measures include control of the speed of trucks and use of water for of trafficked areas for bulldozing.

For purposes of this assessment, the key issue relates to the adequacy of supply of water and the efficacy of the use of chemical dust suppressants. The adopted strategy is largely driven by the predicted availability of groundwater seepage into the pit (see **Section 4.2.2** below). In essence, the predicted groundwater inflow between Years 3 and 20 averages 90 ML/year (with a range of 11-194 ML/year). After accounting for evaporation loses at the seepage face in the pit, the availability of water for mine operations is expected to be severely constrained in those years. Accordingly, the proponent proposes to use chemical dust suppressants during those years. Based on the data presented in the site water balance (reproduced as **Table 4.5** below), it appears that it has been assumed that the use of chemical suppressants in years of water supply constraint would allow water usage for dust suppression to be halved, compared to years in which only water was used for dust suppression. The basis for this assumption is not clear.

The assessment of water requirements for dust suppression (without the use of chemical suppressants) is based on an average evapotranspiration rate of 4 mm/day which is justified on the basis that this reflects the average water usage for mines in the Hunter Valley. The analysis assumes that:

- on days on which the rainfall depth is greater than 5 mm/day, no dust suppression will be required;
- when daily rainfall is less than 5 mm/day, the rate of 4 mm/day is interpolated linearly with rainfall; and
- when there is no daily rainfall, a dust suppression watering rate of 4 mm/day is applied.

However, these assumptions will actually lead to an average of less than 4 mm/day throughout the year because the full water application rate is only applied on dry days (292 days per year based on the long term climate record). On the days with rainfall less than 5 mm/day (40 days per year) the application rate is scaled pro-rata and on days with more than 5 mm/day (33 days per year) no water is applied. The overall effect of these assumptions is that the water requirements have been analysed on the basis of 1,250 mm/year rather than 1,460 mm/year (equivalent to an average of 4 mm/day).

Table 6 of the *RTS* seeks to justify the proposed water usage on the basis of comparison with reported water usage at other mines in the Hunter Valley and Gunnedah Basin (expressed as ML/year). However, because the table does not include the length or area of active haul road in each case, the comparisons have little value. In addition, as noted in the submission from the EPA, the quoted examples do not state the adequacy of the water application in achieving the required level of dust suppression.

Although the assumptions regarding water use for dust suppression seek to take account of day-to-day weather, the maximum water application used in the water balance analysis is limited to 4 mm/day, which does not take account of variation in seasonal evaporation or the effect of very high evaporation on hot windy days. For purposes of benchmarking, an analysis has been carried out using the rainfall and pan evaporation data for Gunnedah (1948 – 2011). This indicative analysis is based on the work by Thompson and Visser (2001) which relates water requirements for dust suppression to climate data and includes factors that account for the albedo of bare earth surfaces and the effect of wheel spray on water loss. The results of that analysis are shown in **Figure 4.2** which indicate that dust suppression water requirements are not a function of annual rainfall, but can vary significantly from year to year.

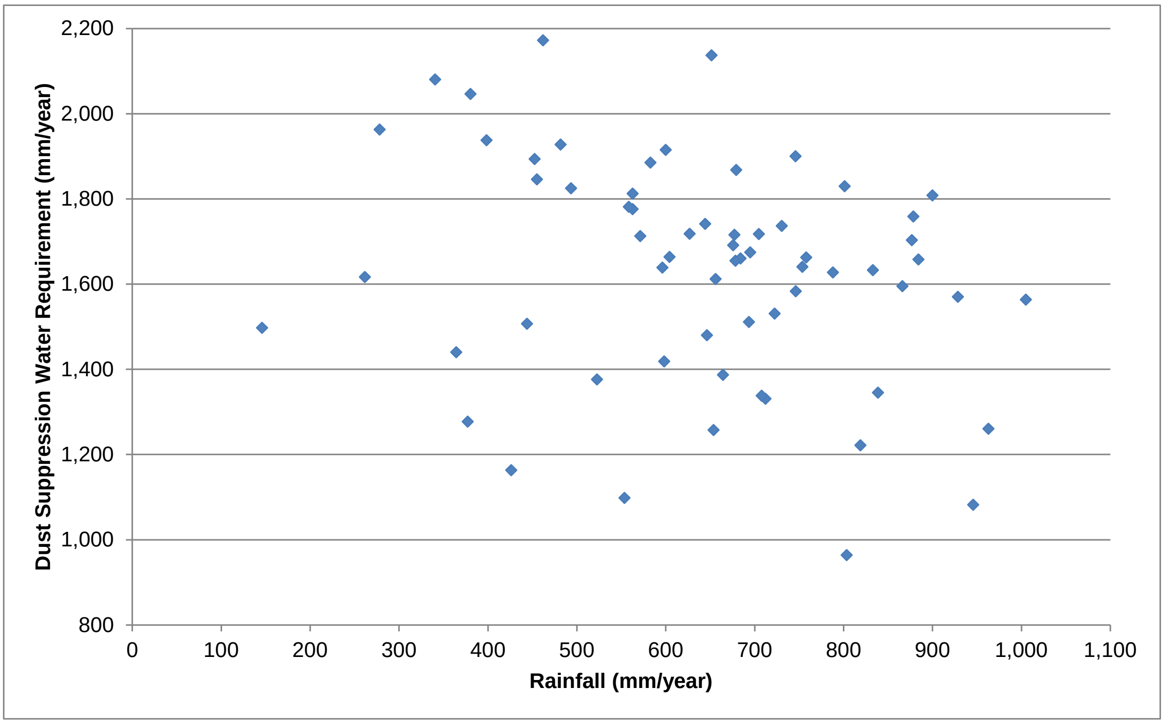

Figure 4.2: Indicative Dust Suppression Water Requirements
(based on Thompson & Visser, 2002)

Summary statistics for the data depicted in **Figure 4.2** are set out in **Table 4.2**.

Table 4.2: Summary Statics for Dust Suppression Water Requirements

Statistic	Estimated Water Requirement (mm/year)
Average	1,632
Min	964
10th percentile	1,266
90th percentile	1,924
Max	2,173

The main aspect of this indicative analysis is that it illustrates the fact that, by accounting for hot dry days when more than 4 mm of water is likely to be required, the average annual requirement (1,632 mm) is likely to be about 30% greater than actually allowed for in the water balance modelling. Although water for dust suppression only accounts for 12% of the water balance over the life of the project (after taking account of the use of chemical suppressants for about the first 20 years of the project), the under-estimation of water requirements for dust suppression is likely to place additional demand on water from external sources.

4.2 Water Sources

In addition to the variability in water requirements for coal processing and dust suppression, the water balance analysis needs to account for variation in the groundwater seepage to the pit, changes in the contributing catchment areas and variation in climate form year-to-year. The average annual water balance analysis (Table 29 in the *EIS*) indicates that the main sources are expected to be of the order of:

- Runoff from the mine operation area 31%
- Runoff from the active mine area 32%
- Runoff from overburden emplacement 28%
- Groundwater seepage (after allowing for evaporation) 8%

The sections below review the basis for the estimates of contributions from these sources.

4.2.1 Rainfall Runoff from Different Surfaces

For purposes of the water balance analysis, runoff from different surfaces has been generated using AWBM which is a well-developed and recognised model for estimating the depth of runoff from different types of land surface. This model is appropriate for estimation of mine site runoff.

The main issue with the use of AWBM on mine sites it the paucity of data with which to estimate the required model parameters to represent the characteristics of different surfaces. The main reference is work published by the Australian Coal Association Research Program (2001) which monitored runoff at 20 locations at eight mines in Queensland and the Hunter Valley. The variation in runoff estimated by the range of parameters for the same type of surface is quite wide (up to ± 40% of the average). Nevertheless, this data is the best available and appropriate average parameters have been adopted for the Watermark Coal Project. However, the water balance analysis lacks any assessment of the sensitivity of the modelling results to different assumed parameters.

4.2.2 Incidental Groundwater Make

Table 10.5 (page 258) of *Groundwater Impact Assessment* lists the estimated 'take' of groundwater from the porous rock aquifers to the mine pit. **Figure 4.3** shows the data graphically.

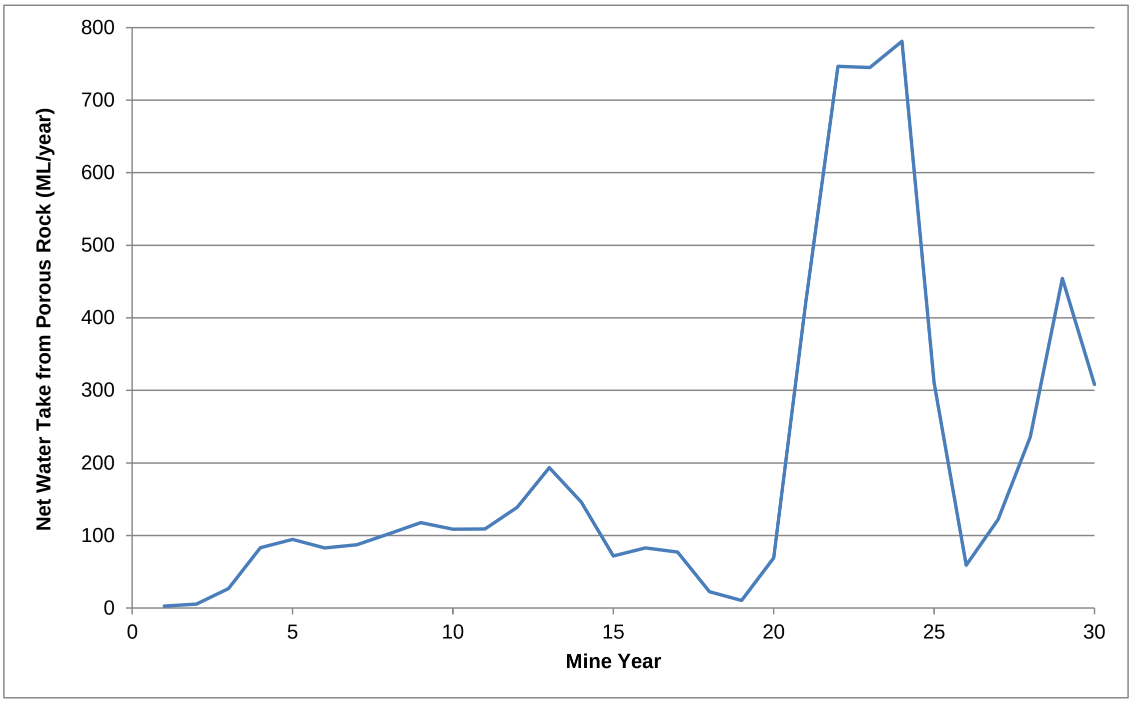

Figure 4.3:
Net Groundwater Take from Porous Rock Groundwater Zones
Source: *Groundwater Impact Assessment*, Table 10.5

The main features of note in **Figure 4.3** are that the net water 'take' from the porous rock aquifers show three distinct time periods corresponding to mining in the three mine areas:

- Years 1 - 21 Eastern Mine Area;
- Years 22 - 25 Southern Mine Area;
- Years 26 -30 Western Mine Area.

As noted previously the relatively low groundwater seepage predicted up to Year 21 has led to the proposed use of chemical dust suppressants for dust suppression in order to limit the mine operational water requirements.

The actual volume of groundwater seepage available for transfer to the mine water management system assumes a steady 5 mm/day evaporation loss from the water bearing units on active face of the pit. However, it is not clear exactly how the "active face" has been defined. While the assumed 5 mm/day loss does not take account of days on which rainfall offsets the evaporative loss, the assumption appears reasonable.

Table 7.10 of the *Surface Water Impact Assessment* lists the pumpable groundwater inflows for selected mine years. **Table 4.3** compares the data from this table with the data from which **Figure 4.3** was derived for the mine years selected for the water balance analysis. Apart from start-up years and Year 25 (which is anomalous) the data shows that for the majority of the mine operating period, the mine expects to be able to pump 40% - 60% of the seepage water that leaves the hard rock aquifers.

Table 4.3: Groundwater Loss and Pumpable Groundwater Volume in Selects Mine Years

Mine Year	Groundwater Loss (ML/year)	Pumpable Volume	
		(ML/year)	(%)
2	6	0	0%
5	95	14	15%
10	109	57	52%
15	72	43	60%
21	422	175	41%
25	311	371	119%
30	308	132	43%

4.2.3 Supplementary Supply

The *EIS* and *RTS* acknowledge that the project is likely to require supplementary supply at some stage, depending on the climate at the time. The *EIS* describes the proposed supplementary supply in the following terms:

> *"One or more electric pump stations (or possibly a licensed bore field) and an associated water pipeline will be constructed on Shenhua Watermark owned land to transfer water from Groundwater Management Zones or unregulated surface water sources to the Main Dam."*

The option of gaining supplementary supply from surface water sources is unlikely to provide sufficient volume of water because of the pumping restrictions for the Mooki River Water Source under the *Water Sharing Plan for Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources*.

The *RTS* (page 115) acknowledges that:

> *"The investigation into potential sources of offsite water supply (detailed in the following sections) shows that very little of the offsite water requirement can be obtained from the Mooki River, due to the Mooki River generally being dry at the times when offsite water is required. A hydrogeological assessment by GHD (GHD, 2013) indicates that the maximum external make-up water supply (600 ML/annum or 19 L/s) could be obtained from an existing irrigation bore on Shenhua Watermark owned land, or other existing or proposed bores, subject to appropriate water licensing."*

Whilst the option of obtaining supplementary supply from groundwater may be technically feasible, the main issue will be the availability of a suitable licence.

4.3 Water Storage

The key to balancing the differences in timing and variation of supply and demand in any water management system is a function of the available storage capacity. Table 27 of the *EIS* (reproduced as **Table 4.4** below) shows the water storage volumes used for purposes of water balance modelling. Of the storages listed, all the sediment dams are only peripheral to the operation of the water management system for which the Main Dam is the critical element. Notwithstanding the volume of the Main Dam being listed as having a storage capacity of 2,000 ML, Table 7.14 of the surface water impact assessment lists the maximum operating volume as ranging from 1,550 ML to 1,600 ML except for 1,200 ML in Year 30. The reasons for this apparent discrepancy are not apparent.

Table 4.4: Indicative Water Storages Used for Water Balance Modelling

Storage	Capacity (ML)	Maximum Catchment Area (ha)
Main Dam	2,000	N/A
Turkeys Nest Dam	50	N/A
Sediment Dam East 1	43	120
Sediment Dam East 2	167	450
Sediment Dam East 3	212	580
Sediment Dam East 4	179	490
Sediment Dam East 5	83	230
Sediment Dam South 1	87	240
Sediment Dam South 2	51	140
Sediment Dam South 3	37	100
Sediment Dam South 4	130	350
Sediment Dam West 1	146	400
Sediment Dam West 2	176	480
Total	2,471	3,580

Source: *EIS*, Table 27

The proposed water management scheme relies on the following safeguards:

- Supply from a supplementary supply during extended dry periods;
- Retention of water in a mine pit the event of an extended wet period, in order to avoid any discharge of mine water from the site.

4.4 Water Balance

Table 29 of the *EIS* (reproduced as **Table 4.5** below) presents the "*Long Term Daily Average Water Balance*". This term, and the data in the table, are understood to represent the results of daily water balance modelling using the full historic climate sequence (122 years) for the seven selected mine years. This is referred to as a 'static' simulation. For each mine year, the status of the mine (catchment areas, pit area, groundwater seepage, ROM production, etc.) is constant and the water balance model is operated on a daily basis. The data quoted in **Table 4.5** represent the long term annual averages for each of the selected mine years.

Table 4.5: Long Term Average Water Balance (Daily Modelling)

Source	Source / Use Description	Volume (ML/year)						
		Year 2	Year 5	Year 10	Year 15	Year 21	Year 25	Year 30
Water Inputs								
Rainfall/Runoff Yield								
	Dirty water system	552	511	529	544	562	558	587
	Active mining area	378	485	634	629	399	606	359
	Turkeys nest dam	16	16	16	16	16	16	16
	Sediment dams	239	331	309	471	830	486	508
Total rainfall/runoff yield		1,185	1,342	1,487	1,660	1,807	1,666	1,470
Groundwater inflow to mining areas		0	14	57	43	175	371	132
Gross Water Inputs		1,185	1,356	1,544	1,703	1,982	2,037	1,602
Water Outputs								
Evaporation								
	Dirty water system	472	361	404	444	486	476	554
	Active mining area	39	21	75	101	70	113	209
	Turkeys nest dam	37	37	37	37	37	37	36
	Sediment dams	23	17	31	62	106	48	99
Total evaporation		570	436	548	643	699	674	898
Storage overflows (offsite)								
	Dirty water system	0	0	0	0	0	0	0
	Active mining area	0	0	0	0	0	0	0
	Turkeys nest dam	0	0	0	0	0	0	0
	Sediment dams	55	61	56	111	307	145	224
Total overflows		55	61	56	111	307	145	224
Net loss from CHPP		205	760	760	745	760	760	224
Vehicle wash down		5	5	5	5	5	5	5
ROM bin dust suppression		15	55	55	54	55	55	11
Stockpile dust suppression		10	37	37	37	37	37	7
Haul road dust suppression		342	150	189	174	156	393	266
Gross Water Outputs		1,203	1,504	1,650	1,769	2,020	2,069	1,555
Water Retained (onsite)								
Net inventory								
	Dirty water system	13	13	14	14	13	12	11
	Active mining area	9	1	7	12	4	21	52
	Turkeys nest dam	0	0	0	0	0	0	0
	Sediment dams	2	0	2	5	6	3	4
Gross Water Retained (onsite)		25	14	23	31	23	37	67
External Water Required (gross water deficit)		43	162	128	98	61	68	21

Source: *EIS*, Table 29

In the context of understanding the behaviour of the water management system under wetter or drier sequences of years comparable tables for at least 10th percentile, median and 90th percentile, would significantly assist in understanding the performance of the system and the probability of needing supplementary supply or needing to retain water in a mine pit.

Further water balance modelling was undertaken using 'forecast simulation' which allows the model configuration to change over the modelled 30 year mine life, reflecting changes in the water management system over time. For this analysis the catchments, ROM coal production, groundwater seepage and operational rules for the representative stages of mine life (as listed in **Table 4.5**) were applied to a range of years and are then linked in the model. The analysis was then run with a series of 92 'realisations' of possible 30 year climate sequences reflected in the historic record. This analysis is considered superior to the 'static' simulation because it provides a better reflection of the range of possible interactions between changes in the mine layout and climate variability. In this instance, however, the analysis only appears to include a series of seven 'step changes' in mine configuration rather than continuous progression. For example, the mine configuration for Year 2 is applied for the first three years of the analysis which then changes to the mine configuration for Year 7 which is applied to the next 4 years.

Figures 7.3, 7.4 and 7.5 in the *Surface Water Impact Assessment* provide probability graphs of out-of-pit water storage, mine water (also referred to as 'dirty water') and in-pit water storage over the life of the mine. The most instructive figures are:

- Figure 7.8 (copied as **Figure 4.4** below) which shows the maximum inundation over the mine life expressed as a percentage of realisations;
- Figure 7.9 (copied as **Figure 4.5** below) which shows the requirement for 'raw water' (external supply).

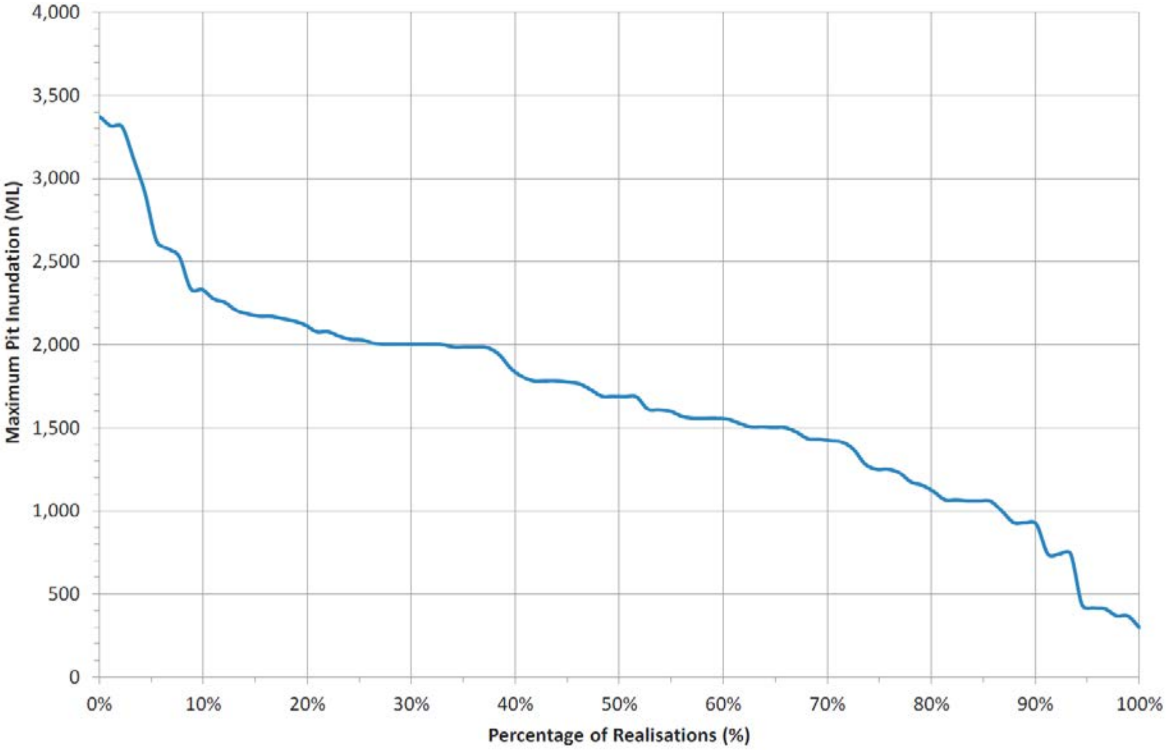

Figure 4.4:
Maximum Mine Pit Inundation
Source: Surface Water Impact Assessment, Figure 7.8

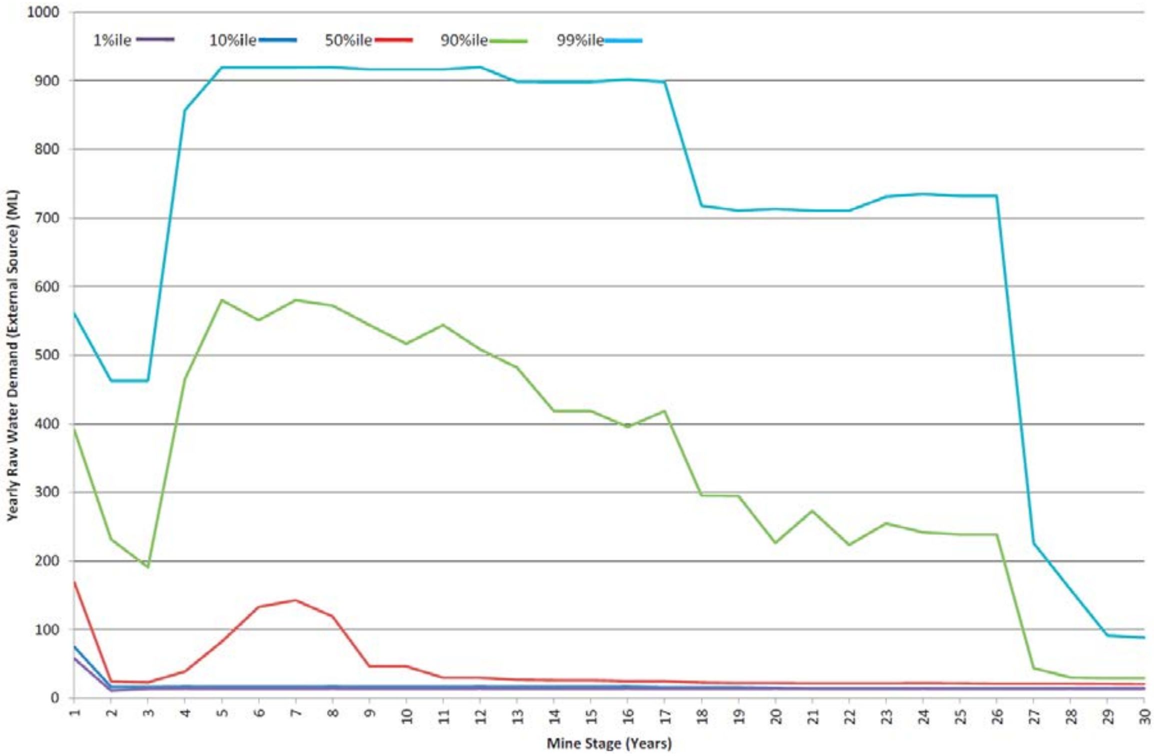

Figure 4.5:
Forecast Yearly Raw Water Demand
Source: Surface Water Impact Assessment, Figure 7.9

The main aspects to be drawn from the analysis depicted in **Figure 4.4** and **Figure 4.5** are summarised in **Table 4.6.**

Table 4.6: Summary of Water Management System Performance

Percentile	Maximum Pit Inundation (ML at any stage of mining)	Maximum External Supply (ML in any one year)
1%	3,300	±900
10%	2,330	580
50%	1,690	170
90%	920	<35[1]
99%	350	<35[1]

Note 1: offsite supplies required in order to maintain a minimum volume available in the Turkeys Nest Dam.

The water balance modelling has been undertaken on the basis that no mine ('dirty') water would be released from the site. Any water that cannot be retained in on-site storages would be retained in the mine pit. The data in **Table 4.6** indicates there is a high likelihood that some water may need to be stored in the pit at some stage of mining.

The water balance analysis also assumes that external supply will be available as, and when, required. (This assumption precludes reliance on surface water sources.) The modelled requirements for external supply indicate relatively modest median requirement (170 ML) and a requirement for 580 ML in 10% of years. It must be noted that the volumes of supplementary water required to maintain operations are highly dependent on the assumed water demands. As noted in **Section 4.1.1** and **Section 4.1.2**:

- The water demand for CHPP water use is assumed to be 738 ML/year for ROM production of 10 Mtpa. However, Appendix B to the *Surface Water Impact Assessment* indicates that the requirement could be as much 1,195 ML/year (a 60% increase) for the finest, lowest yielding coal (leading to maximum water usage). Although it is acknowledged that fine, low yielding ROM is unlikely to be mined for a whole year, the possibility of some variation in CHPP water requirement has not been factored into the analysis
- Water demand for dust suppression is based on a simple maximum daily requirement of 4 mm onto the area of haul roads. Indicative analysis undertaken for this review (**Section 4.1.2**) shows that by accounting for hot dry days when more than 4 mm of water is likely to be required, the average annual requirement (1,632 mm) is likely to be about 30% greater than actually allowed for in the water balance modelling. In addition, the water balance modelling does not allow for the year-to year variation in demand which can be expected to be in the range of ±20-25% of the average.

4.5 Climate Change

In response to submissions regarding climate change, the *RTS* outlines the results of re analysis of the mine water balance analysis using the CSIRO projections for the medium emissions scenario for 2030 (approximately mid-way through the proposed mine life). Two scenarios were assessed for the 10th and 90th percentile projections for rainfall and evaporation. Key results of the modelling were:

10th Percentile (10% drier conditions):

- No spills from the Dirty Water System;
- Significantly reduced risk of water accumulating in the active mining area;
- Increased risk of requiring off-site water in order to supplement the reduced volumes of water available on-site;
- Reduced risk of sediment dam spillage.

90th Percentile (5% wetter conditions):

- No spills from the Dirty Water System (implied);
- Increased risk of water accumulating in the active mining area;
- Decreased risk of requiring off-site supplementary supply;
- Slightly increased risk of sediment dam spillage;

These results indicate that any effects of climate change during the life of the mine is likely to be within the range of climate sequences represented in the historic record.

4.6 Off Site Discharge

4.6.1 Dirty Water System

Despite some confusion caused by a dashed line showing “spill” from the Main Dam in Figure 34 of the *EIS* (reproduced as **Figure 4.1** above), it is clear from the text and the modelling results in the *EIS* and the *RTS* that the mine water management system (containing water exposed to coal) is intended to have <u>no off-site discharge</u>. Any water that cannot be accommodated in the Main Dam will be held in a mine pit until such time as it can be re-used.

4.6.2 Sediment Dams

Table 7.15 of the *Surface Water Impact Assessment* shows the predicted annual spill volume and spill events from the sediment dams (referred to in the text as the "mine affected water storages") over the 30 year period for 10th, 50th and 90th percentile probabilities. Because the different sediment dams are in operation for different, and overlapping, period of time, it is not possible to directly compare the results in Table 7.15 with the results presented in Table 29 of the *EIS* (reproduced as **Table 4.5** above). In attempt to understand the overall volume and frequency of spillage from the sediment dams, the following manipulations have been carried out to the data in Table 7.15 of the *Surface Water Impact Assessment* in order to derive the overall indicative performance of the sediment basins presented in **Table 4.7**:

- The total spill volume over the life of the mine was calculated by multiplying the average annual spill volume for each basin by the life of the basin;
- The total spill volume over the life of the mine for all basins corresponding to each probability (10th percentile, etc.) was summed;
- The average annual volume corresponding to each probability was calculated by dividing by the life of the mine (30 years);
- Similar calculations were undertaken for the number of days of spill;
- The average number of basins active at any one time was calculated as the sum of the lifetime of each basin divided by 30;
- The average annual number of spill days per year was calculated by dividing the average annual spill days for all basins by the average number of active basins.

Table 4.7: Summary of Spillage from Sediment Dams

		10%ile	50%ile	90%ile
Spill Volume	Mine Life Total Spill (ML)	9,398	2,552	9
	Average Annual Spill (ML)	313	85	0
Spill Days	Mine Life Total Spill Days	3,839	1,284	1
	Average Annual Spill Days for all Basins	128	43	0
	Average Annual Spill Days per Basin	30	10	0

Two aspects of note are:

1) The median spill volume derived from this analysis is 85 ML/year. This compares with an average of 141 ML/year derived from **Table 4.5** (after allowing for the number of years represented by each mine stage). While it is acknowledged that an average cannot be directly compared with a median, there appears to be some discrepancy between the data in Tables 7.13 and 7.15 of the *Surface Water Impact Assessment.*

2) The median number of spill days per year in **Table 4.7** is 10. This compares with the average annual number of spill events of 2 – 4 as listed in Table 6.2 of *Managing Urban Stormwater: Soils and Construction- Volume 2E: Mines and Quarries* (DECC, 2008). Again, these data are not strictly comparable, but suggest that the operation of sediment basins, as represented in the modelling, does not accurately reflect the operational requirements set out in *Managing Urban Stormwater: Soils and Construction- Volume 2E: Mines and Quarries.*

Notwithstanding these apparent discrepancies, as a condition of approval for the project, the proponent is likely to be required to prepare a *Surface Water Management Plan* that includes design and operational requirements for the sediment dams in accordance with *Managing Urban Stormwater: Soils and Construction- Volume 2E: Mines and Quarries.*

4.7 Impact Assessment and Management Issues

The key issues arising in relation to management of water on the site are:

- It appears likely that the water requirements for mine operation have been underestimated. Accordingly the mine may require access to additional 'external' sources of supply than the proposed groundwater bore. Notwithstanding, as a condition of approval for the project, the proponent will be required to prepare a *Surface Water Management Plan* and gain sufficient water access licences to meet its obligations for suppression of dust. Any uncertainty regarding access to licenced external source(s) of supply is capable of resolution following any project approval.
- It is clear from the text and the modelling results in the *EIS* and the *RTS* that the mine water management system (containing water exposed to coal) is intended to have no off-site discharge. Any water that cannot be accommodated in the Main Dam would be held in the mine pit until such time as it can be reused. A condition of approval reflecting this would be appropriate.
- Although there is some uncertainty regarding the operational performance of the sediment basins, as a condition of approval for the project, the proponent should be required to prepare a *Surface Water Management Plan* that includes design and operational requirements for the sediment dams in accordance with *Managing Urban Stormwater: Soils and Construction- Volume 2E: Mines and Quarries.* In particular, the sediment basins should be required to have sufficient capacity to meet the requirements set out in Tables 6.1 and 6.2 of *Volume 2E: Mines and Quarries*.

5 Final Void

At the completion of mining, the landform of the Western Mining Area will be configured with a diversion drain along the eastern side of the mine pit to direct surface runoff from the rehabilitated overburden emplacement towards the headwaters of Watermark Gully. The general layout is shown in Figure 7.11 of the *Surface Water Impact Assessment* (copy provided as **Figure 5.1**). **Figure 5.2** is an artist's impression of the landscape and the lake that will form in the final void.

The final void will have a contributing catchment area of about 108 ha and a volume of 51,000 ML. The equilibrium water level in the lake will be governed by a balance between:

Inputs:

- Surface runoff from the small surrounding catchment area;
- Groundwater inflow from the regional hard rock aquifer;
- Groundwater inflow from the groundwater in the adjacent overburden emplacement (see **Figure 5.1**);
- Rainfall onto the surface of the lake.

Losses:

- Evaporation from the lake surface.

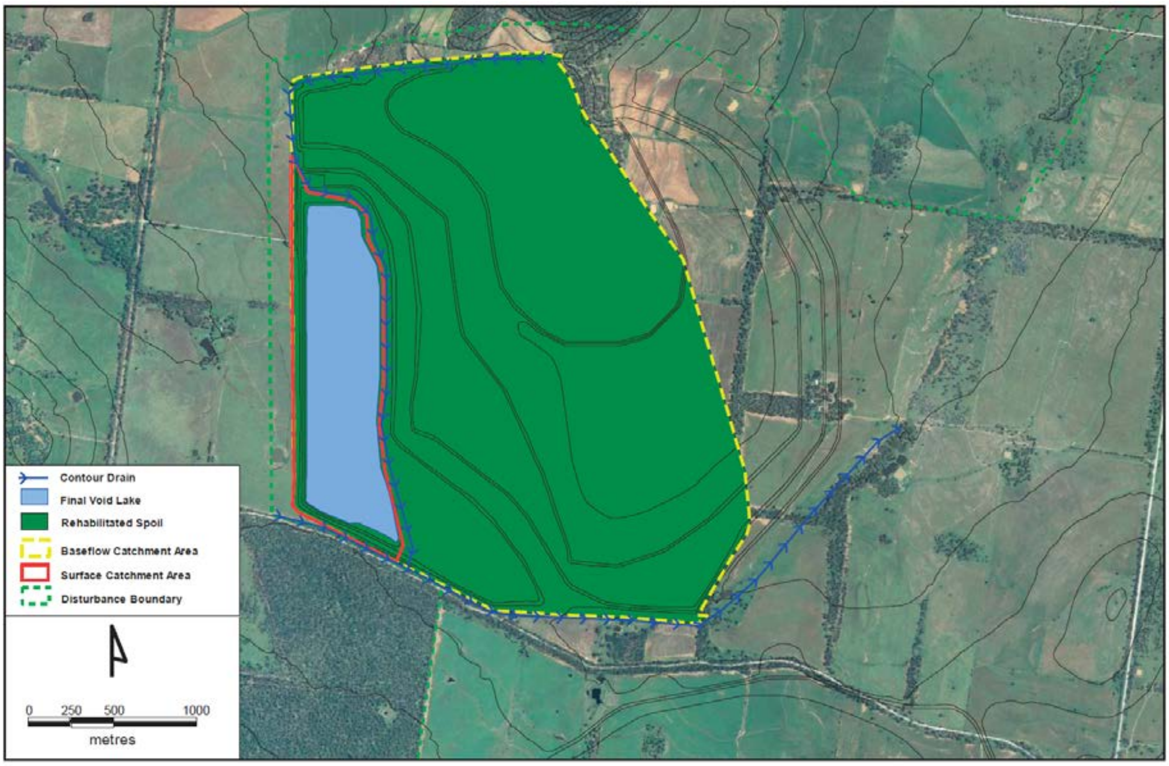

Figure 5.1:
Final Void Layout Plan
Source: *Surface Water Impact Assessment*, Figure 7.11

Figure 5.2:
Artist Impression of Project Final Void (View East from Nea Siding Road)
Source: *RTS*, Plate 5

5.1 Water Balance Analysis

The water balance analysis for the final void uses the same basic modelling assumptions and methodology as that used for the mine site water balance analysis, with appropriate characterisation of the geometry of the void and the surface and groundwater inflows.

For the *EIS*, differences in the assumptions in the surface water modelling and groundwater modelling led to differences in the estimated recovery rate and final lake level. Further analysis was undertaken for the *RTS* to reconcile these differences.

The key adopted parameters for the updated surface water (OPSIM) model and groundwater (MODFLOW) model are listed in **Table 5.1**. It is unclear however, why significant differences remain between the two models.

Table 5.1: Water Inflows and Outflows to the Final Lake Void

Model	Rainfall Recharge ML/day	Evaporation ML/day	Groundwater Inflow ML/day
OPSIM (EIS)	1.1	1.3	0.4
MODFLOW updated	1.6	1.9	0.4

Source: *RTS*, Table 16

Table 5.2 is a copy of Table 18 from the *RTS* which sets out the main components of the long term surface water balance for the final void, while **Figure 5.3** shows the modelled water level recovery derived from the surface water and groundwater models. The figure shows that, on the basis of the surface water modelling, the final lake level is expected to reach an equilibrium level of about 280 m AHD (about 40 m below the overflow level) after about 100 years.

Table 5.2: Final Void Water Balance from OPSIM Surface Water Model

Water Balance Component		kL/day
Inflows	Direct Rainfall	856
	Catchment Inflow	201
	Groundwater (below 280.4 m AHD)	312
Outflows	Evaporation	1,338
	Groundwater (above 280.4 m AHD)	31
Net Inflow / Outflow		0

Source: RTS, Table 18

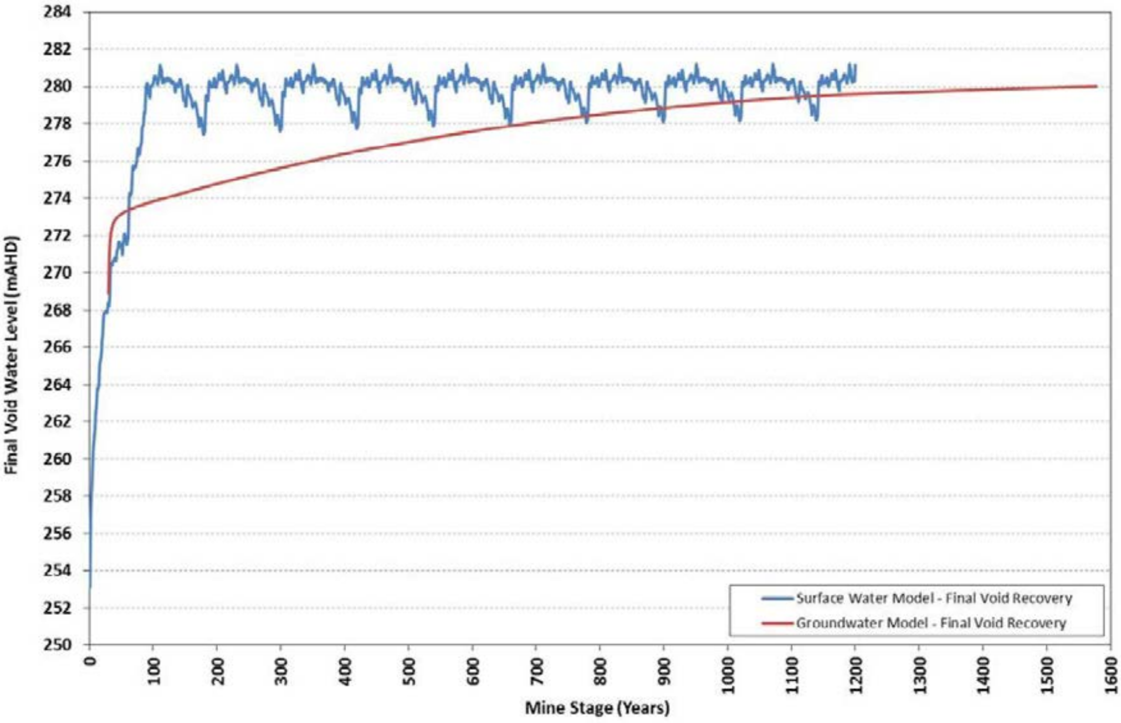

Figure 5.3:
Simulated Final Void Water Level from Surface and Groundwater Models
Source: *RTS*, Figure 44

5.2 Evaporation and Climate Change Effects

For the *Surface Water Impact Assessment*, assessments were undertaken of the potential impacts of:

- Assumptions regarding evaporation from the lake surface;
- Climate change.

Studies of remnant void lakes on coal mines in Queensland and the Hunter Valley indicate that, while the water level is low in the void, evaporation is considerably reduced compared to an open water surface at ground level. This reduction occurs because of the limited exposure to sunlight and protection from the wind. The original water balance analysis tested the effect of assuming different 'pan factors' (used to represent the different thermal and exposure conditions experienced by a large water body compared to a standard evaporation pan):

- Pan factor of 0.5 while the lake level is low;
- Pan factor of 0.7 when the lake level is near equilibrium.

The adopted pan factor of 0.7 for conditions in which the lake level is near equilibrium is low compared to the factor quoted in the review by McMahon et al (2103) for Tamworth Airport (0.86) and is a possible source of variation in the model outcomes.

Figure 5.4 shows the results of the sensitivity analysis for the different assumptions designated on the figure and demonstrates that the rate of recovery and the equilibrium lake level are quite sensitive to the model assumptions regarding evaporation.

To test the possible long term effects climate change, further modelling was undertaken for the *Surface Water Impact Assessment* with the following assumptions:

- Increase in average annual evaporation of up to 20%;
- Increase in average annual runoff of up to 5%;
- Increase in average annual rainfall of up to 10%.

The analysis showed that the final void water level would establish at a lower level with smaller water surface area to balance evaporation against the net inflows.

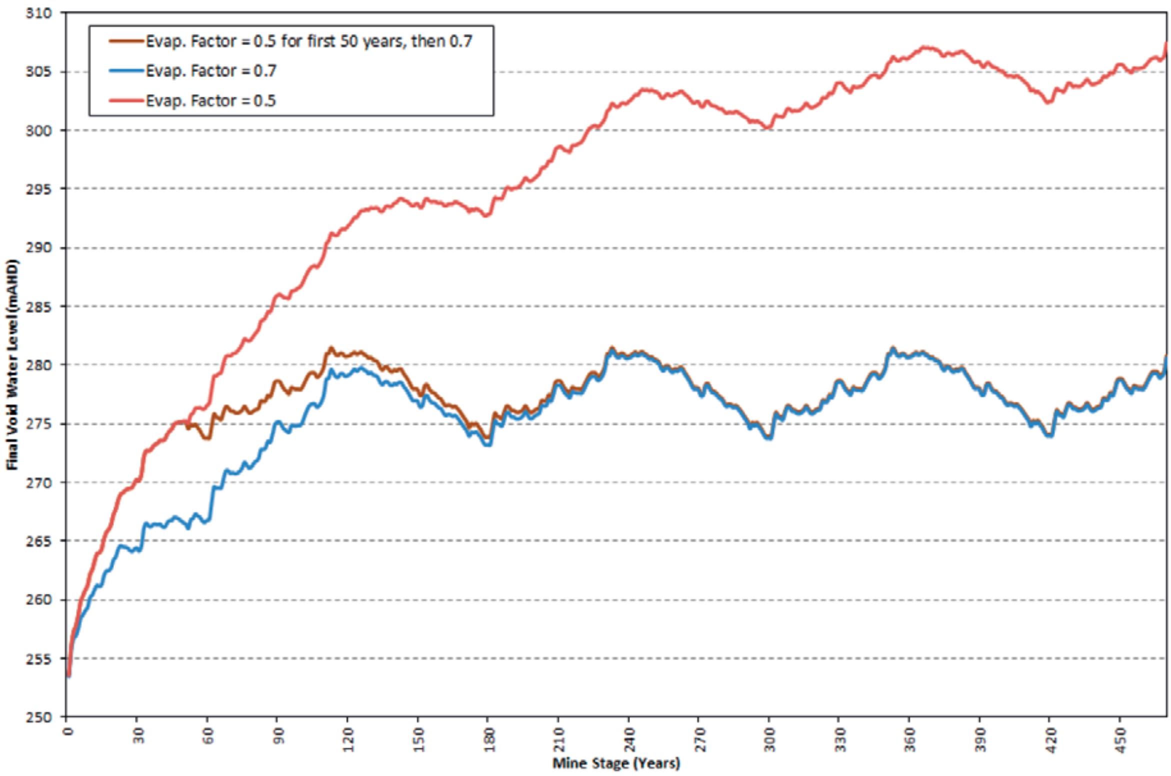

Figure 5.4:
Final Void Water levels for Different Evaporation Assumptions
Source: *Surface Water Impact Assessment*, Figure 7.13

5.3 Salt Balance Analysis

Salt balance analysis has been undertaken which accounts for the differing salinity of inflows from surface water and groundwater sources. The basis of the analysis is that salt enters the lake from surface runoff and groundwater sources, but none leaves the lake. Accordingly, as the lake is continuously losing water by evaporation, the lake will become more saline over time.

Figure 5.5 shows the projected increase in salinity for the final void with the lake projected to reach salinity comparable with seawater after about 400 years. The salinity can be expected to continue to increase progressively until the lake becomes hyper-saline which would suppress the evaporation rate and lead to a slightly higher equilibrium water level.

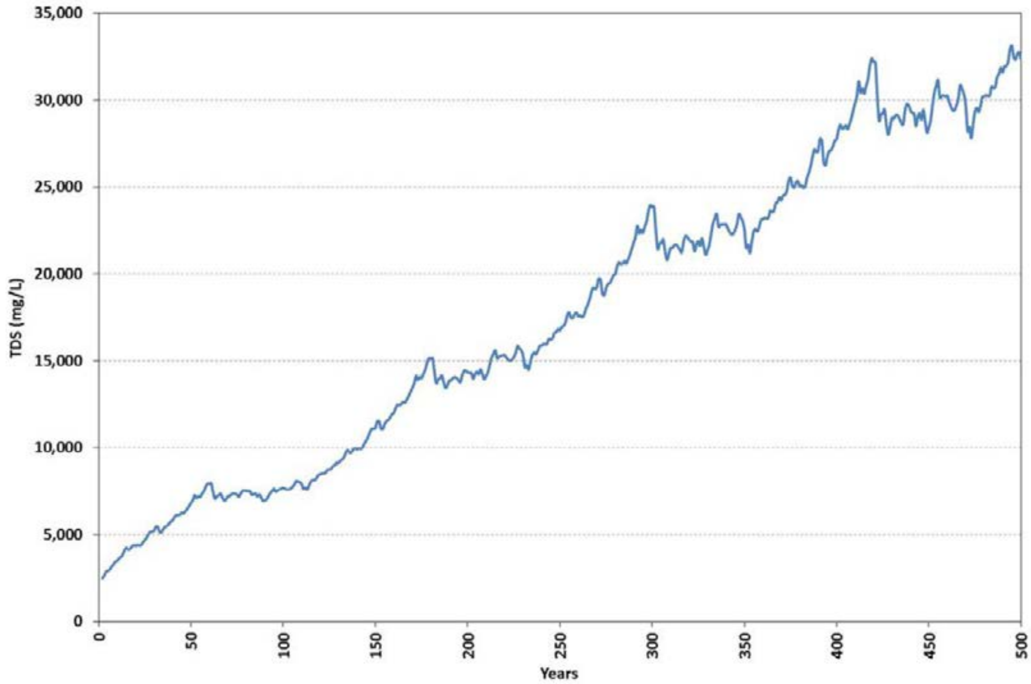

Figure 5.5:
Final Void Total Dissolved Solids Concentrations (Evaporation Factor of 0.7)

Source: *RTS*, Figure 45

5.4 Impact Assessment and Management Issues

The analysis of the equilibrium water level and salinity of the final void rests on a number of assumptions, principally the rate of evaporation from the surface. The assumption of a 'pan factor' of 0.7 adopted for the analysis reported in the *Surface Water Impact Assessment* is considered lower than could be justified from the latest published information (McMahon et al, 2013). However, by adopting a 'pan factor' of 0.86, the equilibrium lake level could be up to 10 m lower than predicted.

Conversely, once the lake becomes hyper-saline (likely to be in more than 1,000 years), the evaporation rate would reduce and the equilibrium level would be slightly higher.

Whatever the actual evaporation rate, the final void lake level is likely to reach equilibrium at a level substantially below the overflow level. In addition, the groundwater analysis indicates that, in the long term, the lake will remain a sink for regional groundwater. Accordingly, the lake would not pose a threat to the surrounding environment.

6 Summary Assessment and Recommendations

6.1 Compliance with Requirements

There are two sets of requirements that apply to the EIS for the Watermark Coal Project:

- The *Director General's Environmental Assessment Requirements* (DGRs) issued by the NSW Department of Planning and Infrastructure (April 2012);
- The *Requirements for Environmental Assessment* issued by the Department of the Sustainability, Environment, Water, Population and Communities (undated).

The *Surface Water Impact Assessment* generally addresses the relevant requirements in these two documents with the exceptions of some uncertainty regarding the requirement to provide:

– *Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP) or water source embargo* (DGRs, Key Issues, Water Resources).

The water balance analysis in the *Surface Water Impact Assessment* demonstrates that external sources of supply will be required on occasions to maintain operations. Figure 7.9 in the *Surface Water Impact Assessment* indicates that there is a 90% probability that the external demand will be less than about 600 ML/year. This review concludes that the requirements for CHPP operation and dust suppression have probably been underestimated, although the magnitude of the underestimation is difficult to quantify precisely. Notwithstanding, the *RTS* notes that:

> "*A hydrogeological assessment by GHD (GHD, 2013) indicates that the maximum external make-up water supply (600 ML/annum or 19 L/s) could be obtained from an existing irrigation bore on Shenhua Watermark owned land, or other existing or proposed bores, subject to appropriate water licensing*."

It is unclear from this statement whether the existing irrigation bore on Shenhua Watermark owned land is currently licensed or whether '*subject to appropriate water licensing*' refers to this proposed source of external supply.

6.2 Definition of "Floodplain"

The lower lying area of land within the Eastern Mining Area which is subject to flooding in floods greater that about 20 years is not considered to constitute "*floodplain*" for purposes of the EL 7223.

6.3 Suggested Matters to be Addressed in any Conditions of Approval

6.3.1 Salinity

The *Surface Water Impact Assessment* (Table 3.6) quotes the following median salinities in the Mooki River:

- Caroona (about 17 km upstream of Breeza) 888 µS/cm;
- Ruvigne (about 28 km downstream of Breeza) 688 µS/cm.

Although the median salinity in the Mooki River is within the ANZECC default range for irrigation, salinity is a key issue that has been raised in a number of submissions. The main potential sources of salt exports from the mine site are:

- Runoff from the overburden dumps and haul roads via overflow or controlled discharge from the sediment basins during the mining and rehabilitation process or direct discharge following completion of rehabilitation;
- Seepage from the small areas of the Eastern and Southern mining areas following backfilling of the mine pits. In both instances the seepage is predicted to occur as a result of the groundwater level in the overburden reaching the existing ground level at the toe of the overburden. Seepage is not expected to occur until, about 30 years after completion of mining.

Suggested matters that should be included in any conditions of approval include:

- Inclusion of a salinity limit for any overflow or controlled discharge from the sediment basins. The value of the salinity limit could be established and justified in the course of the preparation of a site Water Management Plan;
- Routine monitoring of water in overflow or controlled discharge from the sediment basins to determine salinity levels (as well as suspended sediment concentrations);
- In the event that the salinity levels regularly exceed the adopted limit, either:
  - Modify the operational rules for the sediment dams to direct a greater proportion of runoff to the mine water management system;
  - Increase the size of sediment dams to provide a longer period for water to be transferred to the mine water management system (see also the suggested condition below regarding reduction in the predicted volume and frequency of overflow from the sediment dams);
- Annual reporting of the site salt balance and periodic re-assessment (say every five years) of any need to revise the design or operation of sediment dams.
- Monitoring of the deep drainage past the root zone in the overburden capping, particularly on the plateaux areas with a view to:
  - Undertake monitoring to re-assess the groundwater recharge characteristics of the overburden;
  - Periodically re-assess the overburden groundwater recovery predictions (say every 5 years) and timeframe for seepage to occur at the toe of the overburden in the Eastern and Southern mine areas;
  - Reassess and the predicted long term seepage rate at the toe of the Eastern and Southern overburden emplacements;
  - Reviewing the design of the capping with a view to further reducing the deep drainage rate through the capping, particularly on plateaux areas that are proposed for agriculture;
  - Refining the final landform (less ‘flat’ land) and land use (more deep rooted trees) with a view to minimising deep drainage below the capping on the overburden emplacements;
- Monitoring of salinity in the groundwater within the overburden with a view to providing greater certainty regarding the salt loads associated with long term seepage;
- In the event that long term seepage cannot be prevented by actions taken during the rehabilitation process, development of a robust post mining vegetation management plan for

the predicted areas of saline seepage with a view to planting of salt tolerant vegetation in areas where seepage is predicted (using the same principle as has been successfully employed to combat dry-land salinity elsewhere in the Mooki River catchment).

6.3.2 Site Discharge

The *Surface Water Impact Assessment* provides inconsistent evidence in relation to the predicted volume and frequency of discharge from the sediment basins. In the course of developing a Water Management Plan for the project, the proponent should be required to review the sizing of the sediment basins with a view to reducing the predicted volume and frequency of overflow from the sediment dams. In this regard, the proponent should be encouraged to consider alternative design storm durations (as set out in Table 6.3b of *Managing Urban Stormwater: Soil and Construction*) and to demonstrate by means of the water balance model that the proposed design and mode of operation of the sediment basins comply with the overflow frequency performance criteria set out in Table 6.2 of *Volume 2E – Mines and Quarries*.

It is clear from the text and the modelling results in the *EIS* and the *RTS* that the mine water management system (containing water exposed to coal) is intended to have no off-site discharge. Any water that cannot be accommodated in the Main Dam would be held in the mine pit until such time as it can be reused. A condition of approval reflecting this would be appropriate.

6.3.3 Water Balance

The water balance analysis provided in the *Surface Water Impact Assessment* and the *Response to Submissions* demonstrates that the project has the potential to operate under conditions of significant water stress at times. In addition, the analysis does not provide adequate assessment of the likely impacts of CHPP process requirements in the event of a higher than average proportion of fine tailings and/or dust suppression water requirements exceeding those assumed.

As conditions of any approval it is suggested that the proponent be required to:

- As part of the preparation of a *Water Management Plan*:
    - Re-assess the sensitivity of the site water balance to conservative assumptions about the various water demands;
    - Propose realistic mitigation options that could be undertaken to further reduce water demand in the event of water stress;
    - Revise the anticipated demand for external water supply;
    - Demonstrate that sufficient supply can be provided from an '*appropriately authorised and reliable supply*'.
- Report the site water balance on an annual basis;
- Review, and as necessary update, the site water balance model, say every 5 years, based on monitoring data. In particular the site water balance should update estimates of the proportion of rainfall falling on the overburden that:
    - Contributes runoff to the sediment basins;
    - Contributes to deep drainage below the root zone of the capping on the overburden emplacements.

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