Enclosure 1

Assessment of Final Landform Alternatives

WINCHESTER SOUTH PROJECT

Environmental Impact Statement

Additional Information

WHITEHAVEN COAL

Resource Strategies

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1 OVERVIEW

Request for Additional Information

The Winchester South Project (the Project) is located approximately 30 kilometres south-east of Moranbah, in the Isaac Regional Council Local Government Area, within the Bowen Basin Coalfield, in Queensland.

The Project involves the development of an open cut metallurgical coal mine in an existing mining precinct. Products would include metallurgical coal for the steel industry and thermal coal for energy production.

Whitehaven WS Pty Ltd (Whitehaven WS) is the proponent for the Project, and is a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven). In 2021, Whitehaven WS submitted the *Winchester South Project Environmental Impact Statement* (the Draft EIS) for assessment under the *State Development and Public Works Organisation Act 1971* (SDPWO Act).

The Draft EIS was placed on public notification by the Office of the Coordinator-General (OCG) from 4 August 2021 until 15 September 2021. During and following this period, government advisory agencies, organisations and members of the public provided submissions on the Draft EIS to the OCG.

On 3 December 2021, the Coordinator-General requested additional information on environmental effects of the Project and other matters the Coordinator-General considered was relevant to the Project in accordance with section 34A of the SDPWO Act. Specifically, the Coordinator-General requested:

- *justification for the proposed final landform, including presenting and assessing project alternatives that fully consider residual void rehabilitation scenarios that include backfilling of all four residual voids; partial backfilling above the groundwater level; partial backfilling above the coal seam; best environmental management practice; and maximising the area of post-mining land uses*

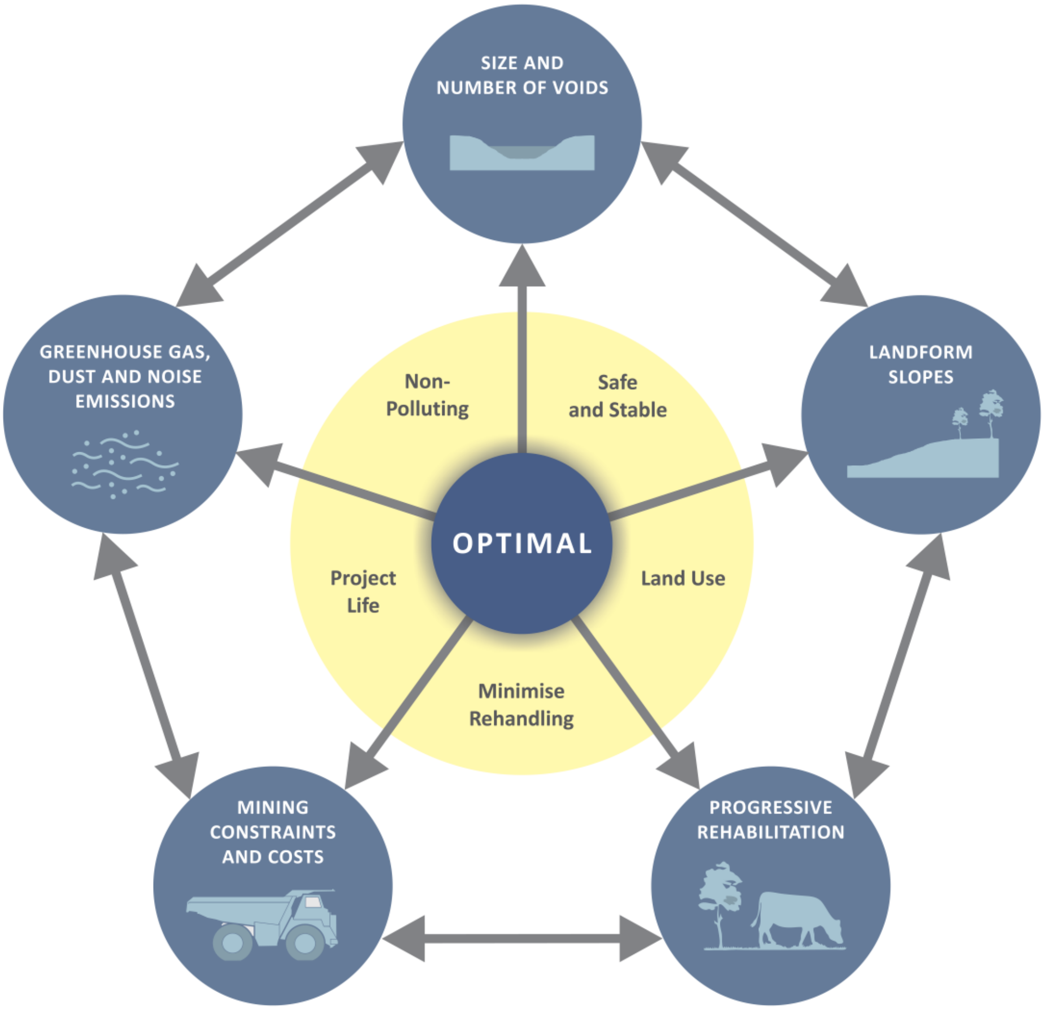
This document provides an assessment of the requested Project final landform alternatives, including backfilling all residual voids, partial backfilling above the pre-mining groundwater level and covering of the exposed coal seams.

Optimised Project Final Landform

As part of developing the Project description, rehabilitation schedule and the final landform for the Draft EIS, Whitehaven WS invested significant effort to design the Project responsibly and have regard to a range of competing priorities. These included, for example, limiting the size and number of residual voids, optimising the location of residual voids (i.e. ensuring they were outside the floodplain[1]), landform slopes, mining costs, land disturbance area and associated mine rehabilitation outcomes (Figure 1).

1 The *Voids in Flood Plains Information Sheet* (Department of Environment and Science, 2020) defines "floodplain" as the 0.1% Annual Exceedance Probability extent under the *Australian Rainfall and Runoff: A Guide to Flood Estimation* (Ball et al., 2019).

Figure 1
Final Landform Optimisation Context



In response to feedback from regulatory and community stakeholders, Whitehaven WS has further reviewed the Project mine plan and sequence with the aim of further reducing the number of residual voids in the final landform and the impacts of the Project on threatened species habitat. In particular, Whitehaven WS has reduced the disturbance footprint of the Project as well as re-designed the Project final landform to backfill South Pit mine void and to minimise slopes to approximately 10 degrees (°) or lower in the final landform. Additional analysis and water modelling has also been undertaken to confirm that the residual void water bodies (previously non-use management areas [NUMAs]) are forecast to have a post-mining land use (PMLU). More detail on these benefits is provided in Section 3.

The benefits associated with the backfill of South Pit mine void (mainly additional employment opportunities), result from additional years of backfilling activities, which extend the Project life and result in unavoidable consequential amenity impacts (noise and dust emissions), additional greenhouse gas emissions (associated with the additional diesel use for the extended operation of the Project fleet life) and additional rehabilitation costs. Rehabilitation costs to Whitehaven WS associated with the backfilling of South Pit mine void are $63 million Australian Dollars (AUD) (in net present value [NPV] terms) (Attachment 16 of the Additional Information) (Deloitte Access Economics, 2022).

Notwithstanding the impacts associated with the environmental benefits, feedback received during public notification of the Draft EIS in 2021 indicates that the backfilling of the South Pit mine void optimises the Project.

It is noted that during the period since the Draft EIS was publicly notified, Whitehaven WS has obtained further information about the resource, and has included the results of that information in its analysis of the Project mine plan. This includes new geological data, coal quality data and the outcomes of processing trials, which results in an additional 43 million tonnes (Mt) of run-of-mine (ROM) coal being extracted by the optimised mine plan compared to the Draft EIS mine plan, which affects the economic outcomes of the Project. (e.g. the forecast royalties and economic benefits of the Project have improved).

This document, as previously stated, presents an assessment of the optimised final landform against the three requested alternative landforms.

Approach to Consideration of Alternatives

The Queensland Government's position taken from the *Queensland resources industry development plan* (State of Queensland, 2022) is that "*Coal projects in Queensland will continue to be supported as long as they stack up economically, environmentally, and socially*". Each project must proceed on its own merits, based on demand and economic viability, and meet the highest environmental and community standards (State of Queensland, 2021).

Assessment of the final landform alternatives has considered the social, environmental and economic merits, in terms of:

- residual void location;
- number and size of the residual voids;
- ensuring the landform is safe, stable and non-polluting;
- rehabilitation outcomes (establishment of rehabilitation and PMLUs);
- environmental effects (e.g. greenhouse gas emissions);
- viability to Whitehaven WS (cost of backfilling and rehabilitation); and
- benefit to the Queensland community.

The assessment also includes consideration to the strategic merits of each alternative, in accordance with the *Mined Land Rehabilitation Policy* (State of Queensland, 2017). The Cost-benefit Analysis of each alternative adopted a conservative estimate of costs. It has been assumed that the costs will be entirely incurred after coal extraction operations end (Year 30 and onwards) (Attachment 16 of the Additional Information) (Deloitte Access Economics, 2022). As a result, the costs have been heavily discounted (i.e. 7% discount rate) (as they are incurred in the late future).

Summary of Consideration of Alternatives

The result of the assessment of the alternative final landforms is that a clearly optimal final landform has been identified, which increases benefits to the Queensland community, responsibly balances environmental impacts and results in a sustainable, safe, non-polluting final landform that supports a use post-mining. The optimised final landform is discussed in more detail below in Section 3. A summary of the consideration of the requested final landform alternatives is below. A complete analysis is provided in Section 4.

Full Backfill of All Proposed Residual Voids

Completely backfilling the residual voids would:

1. Render the Project uneconomic due to the increased cost associated with the rehandling of at least 300 million bank cubic metres (Mbcm) of waste rock of approximately $1.7 billion AUD (in undiscounted terms).
2. Increase the area of land that could be restored to low intensity cattle grazing.
3. Increase greenhouse gas emissions from consumption of additional diesel fuel required to rehandle the waste rock.
4. Residual voids would no longer be groundwater sinks (i.e. groundwater sources).
5. Increase or prolong various environmental impacts (e.g. water, noise and air quality impacts).
6. Reduce the net economic benefits to the Queensland community by $882 million AUD (in NPV terms) as the Project would be rendered uneconomic (Deloitte Access Economics, 2022).

On balance, this alternative final landform would reduce the benefits to the Queensland community compared to the optimised final landform. <u>It is therefore considered to not be in the public interest</u>.

Partial Backfill Above the Pre-mining Groundwater Level

Partially backfilling the proposed residual voids above the pre-mining groundwater extent would:

1. Require rehandling of at least 130 Mbcm of waste rock over three years, increasing associated rehabilitation and mine closure costs by around $691 million AUD (in undiscounted terms).
2. Increase greenhouse gas emissions from consumption of additional diesel fuel required to rehandle the waste rock.
3. Increase or prolong various environmental impacts (e.g. water, noise and air quality impacts).
4. Result in no benefits in perpetuity to the behaviour of the water within the final landform (e.g. predicted to behave as a groundwater source) or quality of water in the residual voids (e.g. water is predicted to be higher in salinity compared to the residual void water bodies for the optimised final landform).
5. Reduce the net economic benefits to the Queensland community by $11 million AUD (in NPV terms) (Deloitte Access Economics, 2022).

On balance, this alternative final landform would reduce the benefits to the Queensland community compared to the optimised final landform. <u>It is therefore considered to not be in the public interest</u>.

Covering of Exposed Coal Seams

Covering exposed coal seams within the proposed residual voids would:

1. Require rehandling of at least 6 Mbcm of waste rock over two years, increasing associated rehabilitation and mine closure costs by around $38 million AUD (in undiscounted terms).
2. Increase greenhouse gas emissions from consumption of additional diesel fuel required to rehandle the waste rock.
3. Increase or prolong various environmental impacts (e.g. water, noise and air quality impacts).
4. Result in no discernible in perpetuity benefits to the quality of water in the proposed residual voids.
5. Reduce the net economic benefits to the Queensland community by $1 million AUD (in NPV terms) (Deloitte Access Economics, 2022) for no discernible positive change in strategic, environmental, social or economic outcomes associated with the optimised final landform.

On balance, this alternative final landform would reduce the benefits to the Queensland community in comparison to the optimised final landform. It is therefore considered to not be in the public interest.

2 DRAFT EIS (2021) PROJECT FINAL LANDFORM

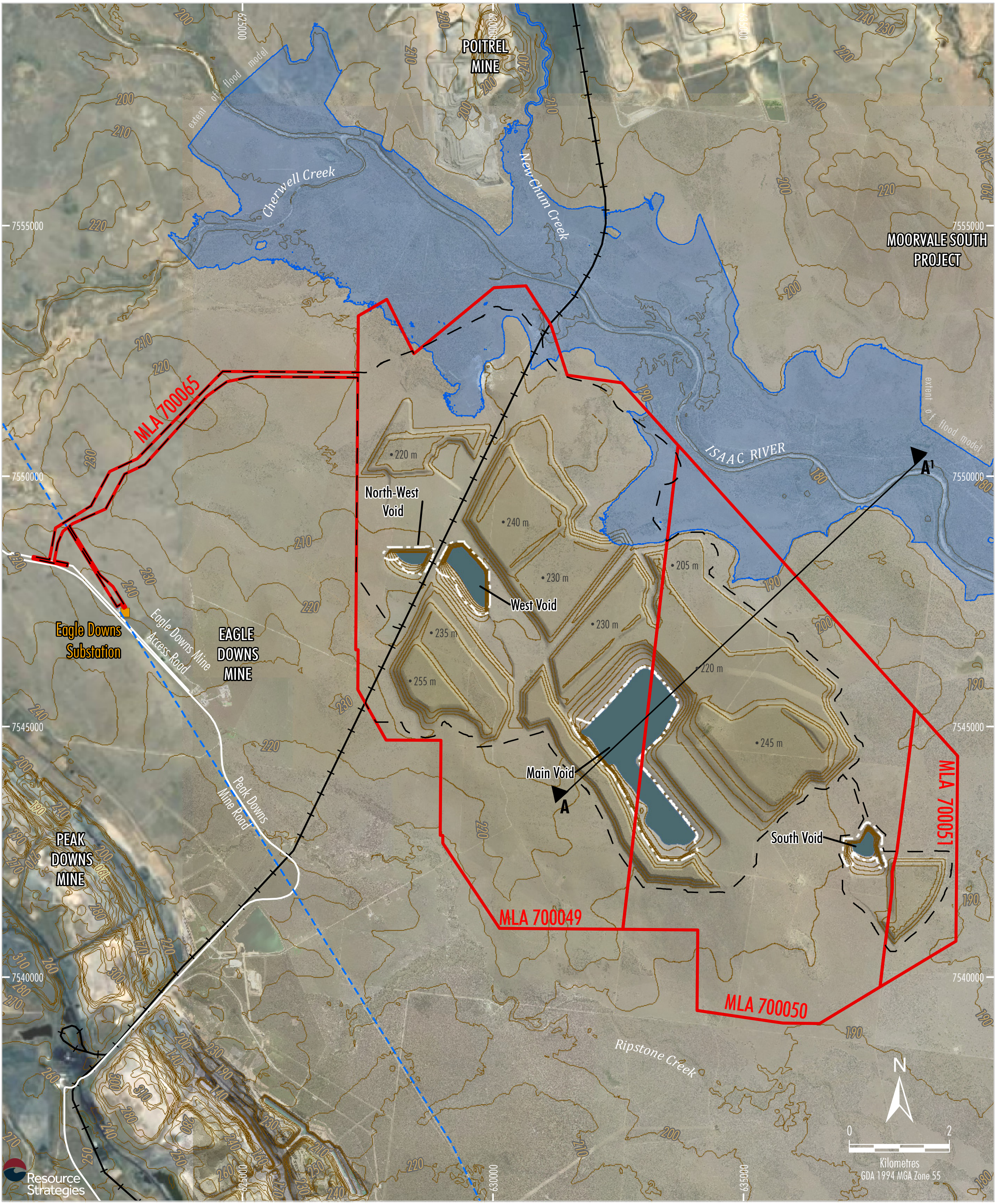
As part of developing the Project description, rehabilitation scheduling and final landform, Whitehaven WS invested significant effort into considering a range of competing priorities. These included, for example, the size and number of residual voids, location of residual voids (i.e. ensuring they were outside the floodplain), landform slopes, mining costs, land disturbance area and associated mine rehabilitation outcomes (Figure 2).

The 2021 Draft EIS final landform was also a reflection of the mine plan and sequence which were refined during the EIS process, compared to that presented in the Initial Advice Statement. These refinements were included to:

- avoid disturbance to any Brigalow *(Acacia harpophylla dominant and co-dominant)* threatened ecological community;
- reduce impacts to threatened species habitat (Ornamental Snake [*Denisonia maculata*]) by minimising the extent of out-of-pit waste rock emplacements and therefore the overall extent of disturbance;
- co-locating the mine access road, electricity transmission line and water pipeline within a single infrastructure corridor (where located within Mining Lease Application [MLA] 700065);
- avoid creek crossings/waterways for the infrastructure corridor;
- avoid palustrine wetlands on the boundary of MLA 700049 and MLA 700050 and establishing a 50 metre buffer from the two wetlands; and
- progressive rehabilitation of land as it becomes available and where practicable.

The 2021 Draft EIS final landform was also designed to:

1. be safe, geotechnically stable and non-polluting (residual voids would be groundwater sinks in perpetuity, preventing the migration of saline water into adjacent aquifers);
2. ensure no residual voids were located within the floodplain (Figure 2 and Appendix A); and
3. backfill Railway Pit mine void.



LEGEND

- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Substation
- Indicative Surface Disturbance Extent
- Isaac River 0.1% AEP Flood Extent (Pre-mining)
- Indicative Extent of Non-Use Management Area
- Indicative Residual Void Waterbody

Source: The State of Queensland (2018 - 2020); Whitehaven (2022); WRM (2021)
Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

2021 Draft EIS Conceptual Final Landform

Figure 2

3 OPTIMISED (2022) PROJECT FINAL LANDFORM

In response to feedback from regulatory and community stakeholders, Whitehaven WS has reviewed the Project mine plan and sequence with the aim of reducing the number of residual voids in the final landform; reducing the impacts of the Project on threatened species habitat and investigating uses for the residual void water bodies. The optimised Project final landform achieves these by (Figures 3a and 3b):

1. Backfilling an additional void, the South Pit mine void.
2. Providing a PMLU for all remaining proposed residual voids (i.e. no non-use management areas).
3. Reducing the overall surface disturbance extent by approximately 179 ha, with further minimised out-of-pit waste rock emplacements to reduce impacts to habitat for:
    a. the Koala (*Phascolarctos cinereus*) by approximately 145.7 ha (approximately 46% reduction);
    b. Greater Glider (*Petauroides volans*) by approximately 34.3 ha (approximately 20% reduction); and
    c. Squatter Pigeon (southern subspecies) (*Geophaps scripta scripta*) by approximately 145.7 ha (approximately 56% reduction).
4. Smoothing low-walls to minimise slopes to approximately 10° or lower.
5. Providing water supply to stock.
6. Re-establishing a post-mining surface water drainage that is sympathetic with the natural drainage lines.
7. Reinstating excised portions of the northern waterway in the final landform.

In comparison to the 2021 Draft EIS final landform, the optimised final landform results in additional rehabilitation costs to Whitehaven WS in the order of $63 million AUD (in NPV terms), i.e. in addition to the $40 million AUD (in NPV terms) rehabilitation cost associated with the Draft EIS final landform. The optimised final landform also (unavoidably) adds an extra year to the Project life (Attachment 16 of the Additional Information).

It is noted that during the period since the Draft EIS was publicly notified, Whitehaven WS has obtained further information about the resource, and has included the results of that information in its analysis of the Project mine plan. This includes new geological data, coal quality data and the outcomes of processing trials, which results in an additional 43 Mt of ROM coal being extracted by the optimised mine plan compared to the Draft EIS mine plan, which affects the economic outcomes of the Project. For example, the forecast royalties and economic benefits of the Project have improved.

Additional modelling and analysis was undertaken by SLR Consulting Australia Pty Ltd (SLR) (2022a) and Water and Environment Pty Ltd (WRM) (2022a) to provide an assessment of the environmental merits of the optimised final landform (Attachments 5 and 6 of the Additional Information, respectively).

Table 1 presents a tabulated assessment of the optimised mine plan and final landform against the 2021 Draft EIS mine plan and final landform, in consideration of strategic, environmental, social and economic merits. The comparison is focused on the benefits to the Queensland community.

The environmental, social and economic merits considered in Table 1 are consistent with the Queensland Government's position taken from the *Queensland resources industry development plan* (State of Queensland, 2022), that "*Coal projects in Queensland will continue to be supported as long as they stack up economically, environmentally, and socially*", and consider concerns raised by government agencies, non-government organisations and the public during the public notification of the Draft EIS. The strategic merits provided are also consistent with the core requirements of a final landform as provided in the *Mined Land Rehabilitation Policy* (State of Queensland, 2017).

Table 1
Consideration of Strategic, Environmental, Social and Economic Merits – Optimised Mine Plan and Final Landform

CONSIDERATION	DESCRIPTION (RELATIVE TO THE DRAFT EIS)	BENEFIT TO QLD EXPECTED (RELATIVE TO THE DRAFT EIS)[1]
Final Landform Strategic Merits		
Residual voids outside of floodplain extent	• Consistent with the 2021 Draft EIS final landform, there would be no residual voids within the floodplain (Figures 2, 3a and 3b and Appendix A).	–
Safe, stable and non-polluting	• Consistent with the 2021 Draft EIS final landform, the final landform would be geotechnically stable and safe. • Residual voids would continue to act as groundwater sinks.	–
Extent of NUMA	• Number of residual voids further reduced as South Pit mine void is backfilled. • Additional analysis has identified an opportunity for beneficial use of the residual void water bodies and therefore no NUMAs are proposed. The residual voids are expected to contain water with water quality sufficient for a PMLU (e.g. water for cattle consumption). • The optimised final landform has no NUMAs.	✓
Progressive rehabilitation and closure	• Consistent with the 2021 Draft EIS, disturbed land when available and practical to do so, would be progressively rehabilitated.	✓

Table 1 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits –
Optimised Mine Plan and Final Landform

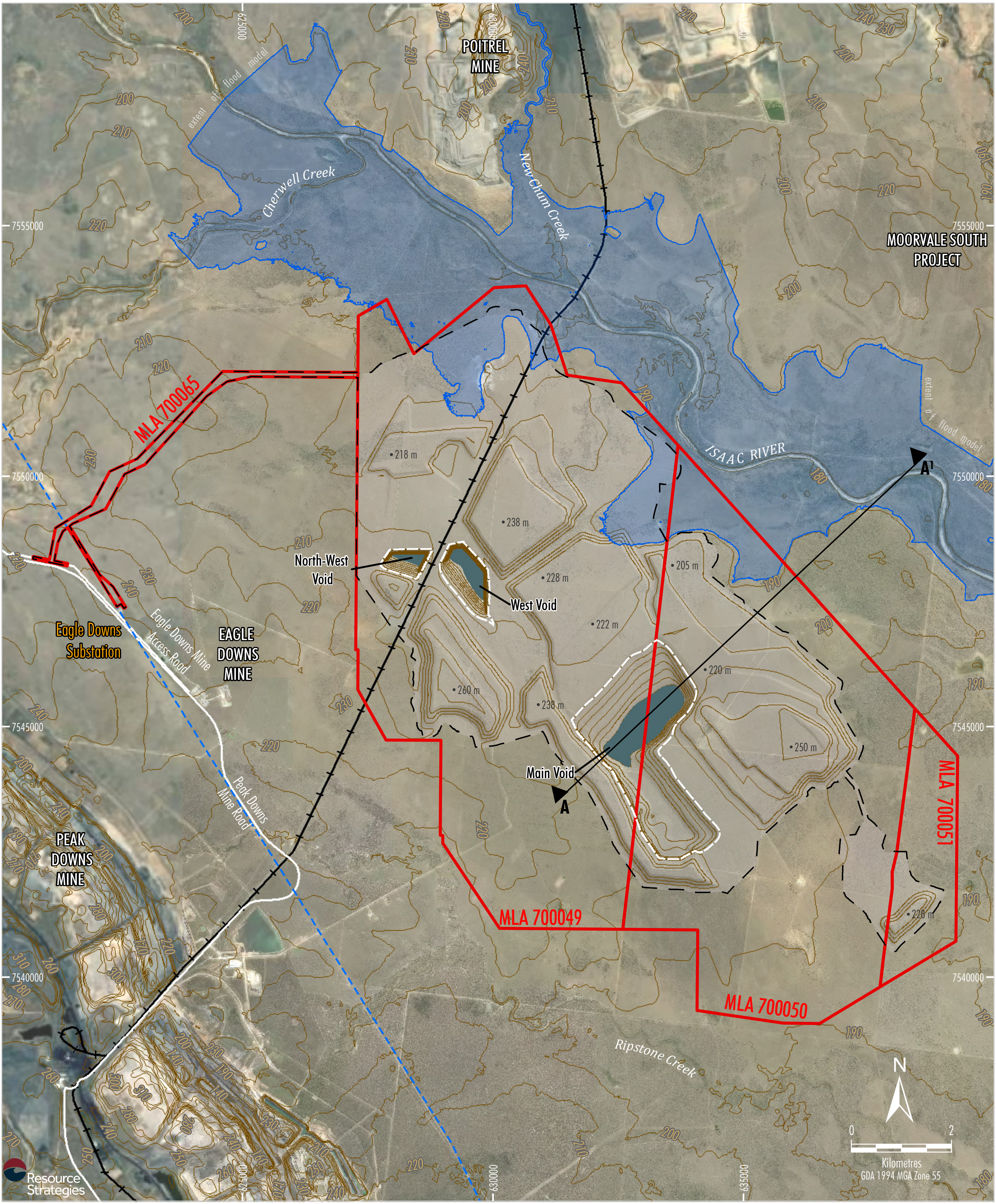
CONSIDERATION	DESCRIPTION (RELATIVE TO THE DRAFT EIS)	BENEFIT TO QLD EXPECTED (RELATIVE TO THE DRAFT EIS)[1]
Environmental Merits		
Surface water losses (post-mining)	• Consistent with the 2021 Draft EIS, the loss of catchment flows to the Isaac River would be indiscernible. • Reduced loss of catchment flows associated with backfilling South Pit mine void.	✓
Greenhouse gas emissions	• Slightly increased greenhouse gas emissions from the increase in ROM coal removed and an unavoidable increase associated with prolonged operation of the diesel-powered fleet to backfill South Pit mine void. • Notwithstanding the above point, overall total Scope 1 and 2 greenhouse gas emissions associated with the Project have reduced due to commitment to purchase carbon neutral electricity (abatement of Scope 2 emissions).	✓
Dust emissions	• The optimised mine plan and final landform would result in no additional air quality exceedances, compared to the 2021 Draft EIS. • Rehandling of waste rock to backfill the South Pit mine void would result in unavoidable continued emissions of PM_{10} and $PM_{2.5}$ for an additional two years.	X
Noise emissions	• Overall, the noise impact outcomes of the optimised mine plan and final landform are very similar to those in the 2021 Draft EIS. • Increased duration of waste haulage and operation of excavators and dozers (associated with backfilling South Pit mine void) would result in an additional two years of noise emissions.	X
Disturbance of native flora and fauna	• Significant reduction in disturbance to native vegetation and fauna habitat compared to the Draft EIS e.g: – Koala habitat - reduced by 145.7 ha (approximate 46% reduction). – Great Glider habitat - reduced by 34.3 ha (approximate 20% reduction). – Squatter Pigeon (southern subspecies) habitat - reduced by 145.7 ha (approximate 56% reduction). • Backfilled South Pit mine void would provide additional land that could be returned to low intensity cattle grazing and/or flora and fauna habitat.	✓
Agricultural production	• Backfilled South Pit mine void would provide additional land that could support agricultural production (low intensity grazing). • The residual void water bodies could be beneficially re-used for agricultural or other purposes (e.g. water for cattle consumption).	✓

Table 1 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits –
Optimised Mine Plan and Final Landform

CONSIDERATION	DESCRIPTION (RELATIVE TO THE DRAFT EIS)	BENEFIT TO QLD EXPECTED (RELATIVE TO THE DRAFT EIS)[1]
Social Merits		
Employment opportunities	• Increased duration of employment for a proportion of the workforce associated with additional backfilling activities.	✓
Local community views	• No change – no landowner or local[2] submissions received regarding either the extent of disturbance of the Project or the number and use of residual voids.	–
Perceived benefit of fewer residual voids	• Improved public perception of final landform amongst some stakeholders due to the backfill of South Pit mine void (noting no local submissions regarding the final landform were received).	✓
Amenity	• Additional amenity (air and noise emissions) impacts associated with backfilling South Pit mine void.	X
Water quality	• Consistent with the 2021 Draft EIS, residual voids would act as groundwater sinks, however additional analysis undertaken has identified water quality would be significantly improved within the residual voids.	✓
Economic Merits		
Externalities	• Slightly increased cost associated with greenhouse gas emissions and other environmental externalities.	X
Agricultural production	• Consistent with the 2021 Draft EIS, loss of agricultural production land associated with the residual voids would be immaterial (in NPV terms). • The residual void water bodies could be beneficially re-used for agricultural or other purposes (e.g. water for cattle consumption).	✓
Indirect and flow-on economic benefits	• Increased flow-on economic benefits, due to increased duration of wage payments and expenditure with local suppliers (noting indirect and flow-on economic benefits are conservatively excluded from the Economic Assessment).	✓

1 Green shading indicates potential positive change to Queensland relative to the Project, pink shading indicates potential negative change.

2 'Local' is defined as the townships of Moranbah, Dysart and Coppabella, consistent with the Social Impact Assessment (SIA).



LEGEND
- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Indicative Surface Disturbance Extent
- Isaac River 0.1% AEP Flood Extent (Pre-mining)
- Indicative Residual Void Waterbody
- Indicative Extent of Water Storage
- Post-mining Land Use

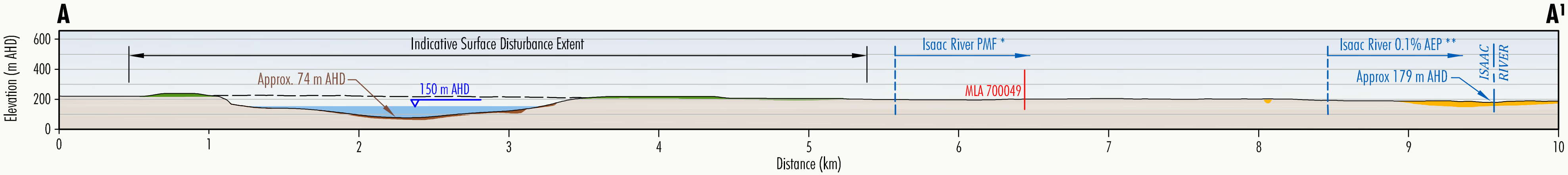
Source: The State of Queensland (2018 - 2020); Whitehaven (2022); Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

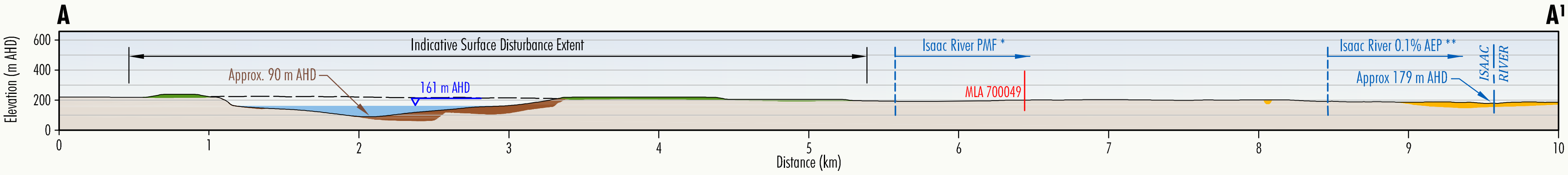
WINCHESTER SOUTH PROJECT

Optimised Final Landform (May 2022)

Figure 3a



Optimised Final Landform (Refer to Figure 3a)



2021 Draft EIS Final Landform (Refer to Figure 2)

* Isaac River Probable Maximum Flood Extent (PMF) (Pre-mining and During Operations)

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LEGEND

- Pre-mining Topography
- Indicative Final Landform Surface
- Isaac River Alluvium Extent
- In-pit Waste Rock Emplacement
- Out-of-pit Waste Rock Emplacement
- Residual Void Maximum Water Level

Scale 1 Horizontal : 1 Vertical

* Isaac River Probable Maximum Flood Extent (PMF) (Pre-mining)

** Isaac River 0.1% AEP Flood Extent (Pre-mining)

Source: The State of Queensland (2022); Whitehaven (2022)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Indicative 2021 Draft EIS Final Landform and Optimised Final Landform Profiles Cross Section A - A1

Figure 3b

4 ASSESSMENT OF REQUESTED FINAL LANDFORM ALTERNATIVES

As described in Section 1, the three alternate landforms requested to be assessed include:

- Full backfill of all residual voids.
- Partial backfill of all residual voids above the pre-mining groundwater level.
- Covering of the exposed coal seams in the walls of all residual voids.

To support an assessment of the environmental merits of each of the requested final landform alternatives, additional modelling and analysis was undertaken by various specialists, for example Deloitte Access Economics (2022) (Attachment 16 of the Additional Information), Katestone Environmental Pty Ltd (Katestone) (2022) (Attachment 13 of the Additional Information), SLR (2022b) (Appendix B of this document) and WRM (2022b) (Appendix C of this document). The results from these specialists' analyses are summarised in Sections 4.1 to 4.4.

4.1 FULL BACKFILL

The 'full backfill' alternative considers backfilling all proposed residual voids to the surrounding land surface to create a free draining landform. The indicative final landform for the full backfill alternative is shown on Figure 4.

To fully backfill all residual voids, an additional six years is required after cessation of ROM coal extraction to rehandle already emplaced waste rock. This rehandling results in an additional rehabilitation cost to Whitehaven WS in the order of $1.7 billion AUD in undiscounted terms ($178 million AUD in NPV terms) compared to the optimised final landform (Deloitte Access Economics, 2022). These costs are in addition to the $389 million AUD in undiscounted terms ($103 million AUD in NPV terms) already committed for the rehabilitation of the optimised Project (including the backfill of the Railway Pit and South Pit mine voids).

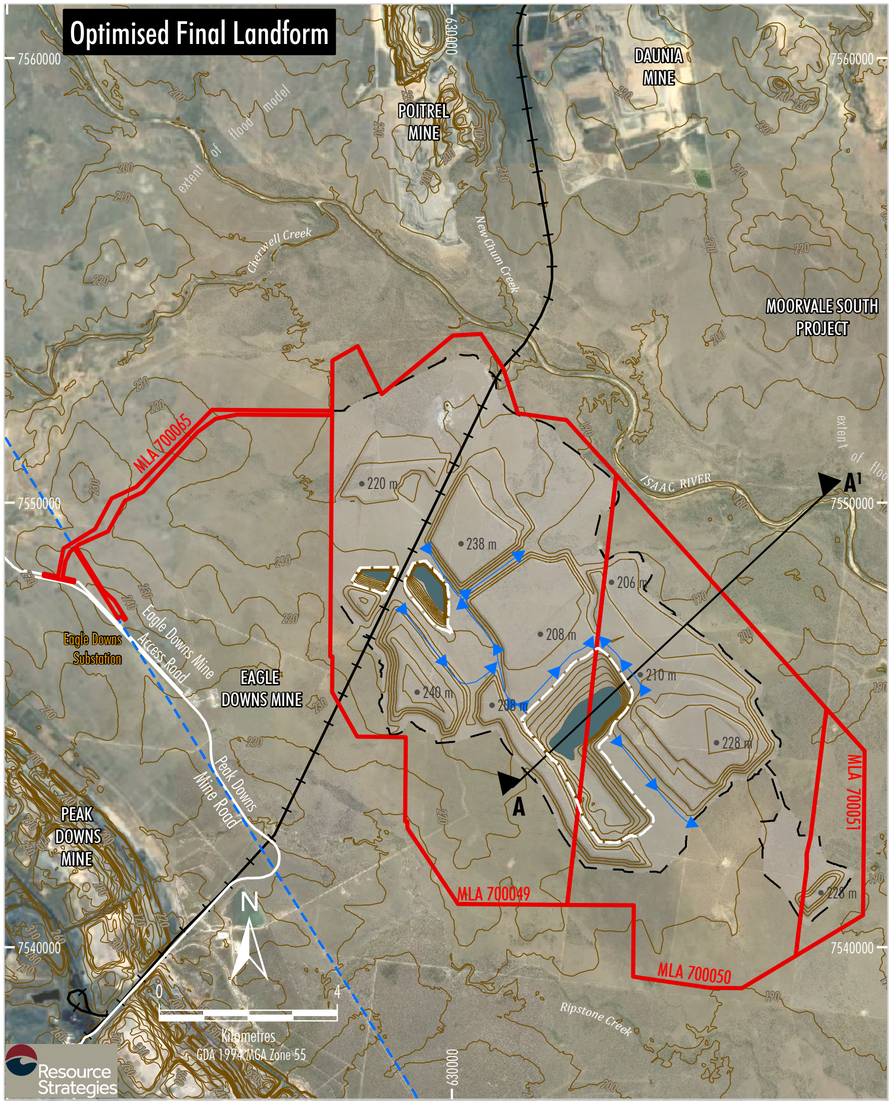
Completely backfilling all proposed residual voids would increase the area of rehabilitated land in the final landform. However, the additional six years associated with rehandling waste rock would:

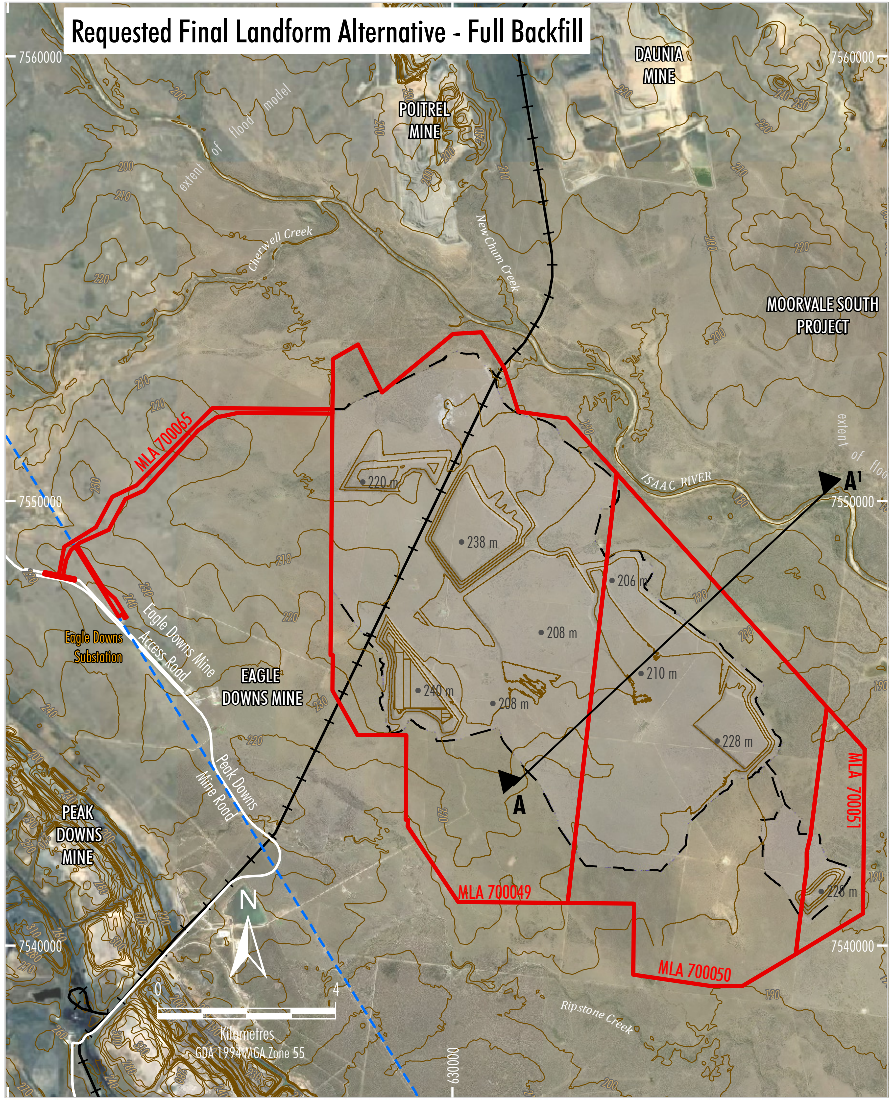
- increase greenhouse gas emissions associated with the Project by approximately 1 Mt of carbon dioxide equivalent (CO_2-e) from consumption of additional diesel fuel (increase of around 7%) (Katestone, 2022);
- increase or prolong various environmental impacts (e.g. water, noise and air quality impacts); and
- reduce the net economic benefits to the Queensland community by $25 million AUD in NPV terms (Deloitte Access Economics, 2022).

An assessment of this alternative against the optimised final landform, in consideration of strategic, environmental, social and economic merits, is provided in Table 2.

On balance, the full backfill alternative final landform would result in less benefits to the Queensland community in comparison to the optimised final landform and is therefore considered to not be in the public interest.

In addition, this alternative would increase rehabilitation and mine closure costs by around $1.7 billion AUD (in undiscounted terms), which in all likelihood would render the Project financially unviable. If this results in the Project not proceeding, the Queensland community would forgo $882 million AUD in net benefits generated by the Project (NPV terms) (Deloitte Access Economics, 2022).





LEGEND
- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Indicative Surface Disturbance Extent
- Indicative Residual Void Waterbody
- Indicative Extent of Water Storage
- Post-mining Land Use
- Indicative Surface Water Drain

Source: The State of Queensland (2018 - 2020); Whitehaven (2022); Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Requested Final Landform Alternative - Full Backfill

Figure 4

Table 2
Consideration of Strategic, Environmental, Social and Economic Merits – Full Backfill

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Final Landform Strategic Merits		
Residual voids outside of floodplain extent	• Consistent with the optimised final landform, there would be no residual voids within the floodplain (Figure 4).	–
Safe, stable and non-polluting	• Groundwater movement is predicted from the final landform towards the Isaac River alluvium and to the south-east off-site due to there being limited hydraulic gradient towards the backfilled residual voids. • In-pit (e.g. backfilled spoil) and out-of-pit waste rock emplacements are predicted to behave as groundwater sources (not groundwater sinks). • Consistent with the optimised final landform, the final landform would be geotechnically stable and safe.	X
Extent of NUMA	• Consistent with the optimised final landform, there would be no NUMAs.	–
Progressive rehabilitation and closure	• Rehandling of at least 300 Mbcm of waste rock, resulting in: 1. Material delays to rehabilitation and/or disturbance of established rehabilitation. 2. Delay of final rehabilitation and mine closure by approximately six years. • Additional rehabilitation and decommissioning costs of $1.7 billion AUD (undiscounted). • Extended storage of topsoil, potentially reducing its viability for rehabilitation.	X^
Environmental Merits		
Surface water losses (post-mining)	• No catchment excision as final landform would be free-draining (noting catchment excision of the Isaac River for the optimised final landform would be indiscernible in consideration of the overall catchment).	✓
Greenhouse gas emissions	• Increased greenhouse gas emissions by approximately 1 Mt CO_2-e (increase of 7%) from the prolonged operation of the diesel-powered fleet. • Increase duration of greenhouse gas emissions by approximately six years.	X
Dust emissions	• Rehandling of waste rock to backfill the residual voids would result in continued emissions of PM_{10} and $PM_{2.5}$ for an additional six years.	X
Noise emissions	• Increased duration of waste haulage and operation of excavators and dozers would result in continued noise emissions for an additional six years.	X
Disturbance of native flora and fauna	• No change to the disturbance footprint of the Project.	–

Table 2 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits – Full Backfill

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Agricultural production	• Backfilled residual voids would provide additional land for grazing as opposed to agricultural water supply storage.	–
Social Merits		
Employment opportunities	• Increased duration of employment for a proportion of the workforce.	✓
Local community views	• No change, no landowner or local[2] submissions were received regarding the number and use of residual voids.	–
Perceived benefit of fewer residual voids	• Improved perception of final landform for some stakeholders.	✓
Amenity	• Increased amenity impacts (e.g. noise, air quality, greenhouse gas emissions).	X
Water quality	• Potential increased community concerns relating to increased risk of groundwater migrating off-site.	X
Economic Merits		
Net producer surplus	• Overall decreased net producer surplus attributed to Queensland due to increased rehabilitation costs (value to Queensland Whitehaven shareholders) (reduction of $23 million AUD in NPV terms) (Deloitte Access Economics, 2022). • Continued payroll tax payments due to ongoing employment (increase of $3 million AUD in NPV terms) (Deloitte Access Economics, 2022). • Continued local government rate payments for at least six years (increase of $0.1 million AUD in NPV terms) (Deloitte Access Economics, 2022).	X
Royalties	• No change.	–
Company income tax	• No change.	–
Externalities	• Increased cost to Queensland associated with greenhouse gas emissions (increase of $2 million AUD in NPV terms or $28 million AUD undiscounted) (Deloitte Access Economics, 2022) and other environmental externalities (not quantified).	X
Agricultural production	• Backfilled voids would provide additional land for grazing as opposed to agricultural water supply storage (immaterial in NPV terms).	–

Table 2 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits – Full Backfill

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Indirect and flow-on economic benefits	• Increased flow-on economic benefits, due to increased duration of wage payments and expenditure with local suppliers (noting indirect and flow-on economic benefits are conservatively excluded from the Economic Assessment).	✓
Net economic benefit to Qld community	• Decreased net benefit to the Queensland community (reduction of $25 million AUD in NPV terms).	X

1 Green shading indicates potential positive change to Queensland relative to the Project, pink shading indicates potential negative change.

2 'Local' is defined as the townships of Moranbah, Dysart and Coppabella, consistent with the SIA.

^ Dark red shading indicates the change from the optimised final landform associated with this final landform alternative would result in a material risk to the viability of the Project.

4.2 PARTIAL BACKFILL ABOVE THE PRE-MINING GROUNDWATER LEVEL

This alternative considers partial backfilling of the remaining residual voids (agricultural water storage) above the pre-mining groundwater level. As the optimised final landform includes full backfill of the Railway Pit and South Pit mine voids, this alternative is focused on partial backfill of the Main Pit, West Pit and North-West Pit mine voids. The indicative final landform associated with this alternative is shown on Figure 5.

To partially backfill the remaining mine voids above the pre-mining groundwater level, an additional three years is required after cessation of ROM coal extraction to rehandle already emplaced waste rock and place into the mine voids. This rehandling results in an additional rehabilitation cost to Whitehaven WS in the order of $691 million AUD in undiscounted terms ($80 million AUD in NPV terms) compared to the optimised final landform (Deloitte Access Economics, 2022). These costs are in addition to the $389 million AUD in undiscounted terms ($103 million AUD in NPV terms) already committed for the rehabilitation of the optimised Project (including the backfill of the Railway Pit and South Pit mine voids).

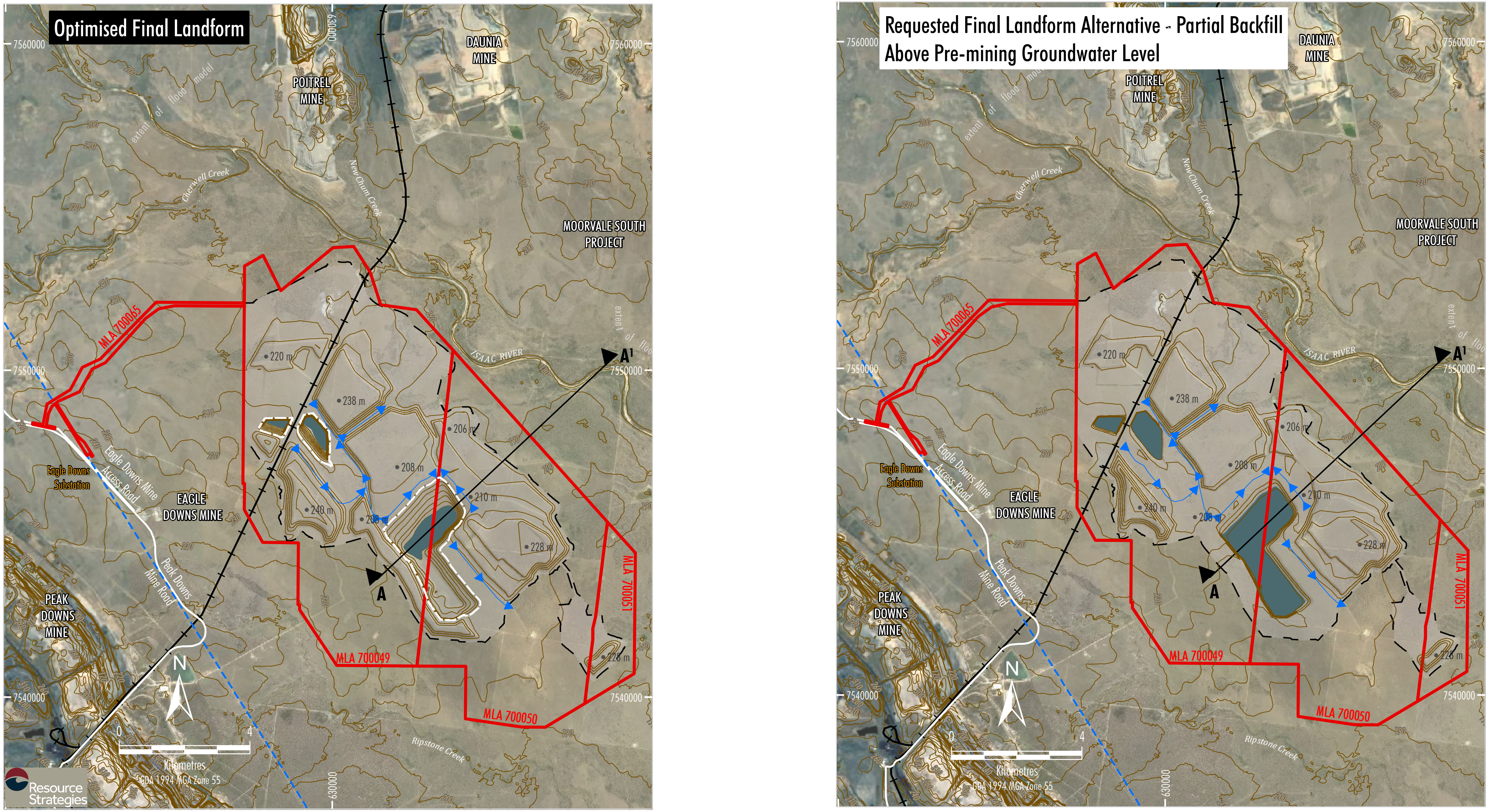
Partially backfilling the remaining residual voids to above the pre-mining groundwater extent would require rehandling of at least 130 Mbcm of waste rock over three years and would:

- increase greenhouse gas emissions associated with the Project by around 0.5 Mt CO_2-e from consumption of additional diesel fuel (increase of around 3%) (Katestone, 2022);
- increase or prolong various environmental impacts (e.g. water, noise and air quality impacts); and
- reduce the net economic benefits to the Queensland community by $11 million AUD in NPV terms (Deloitte Access Economics, 2022).

An assessment of this alternative against the optimised finalised landform, in consideration of strategic, environmental, social and economic merits, is provided in Table 3.

On balance, the partial backfill above the pre-mining groundwater level alternative final landform would result in less benefits to the Queensland community in comparison to the optimised final landform, with the same or slightly worse environmental outcomes, and is therefore considered to not be in the public interest.

In addition, this alternative would increase rehabilitation and mine closure costs by around $691 million AUD (in undiscounted terms), which would reduce the financial viability and likelihood of the Project proceeding. This results in the Project not proceeding, the Queensland community would forgo $882 million AUD in net benefits generated by the Project (NPV terms) (Deloitte Access Economics, 2022).



LEGEND

- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Indicative Surface Disturbance Extent
- Indicative Residual Void Waterbody
- Indicative Extent of Water Storage
- Post-mining Land Use
- Indicative Surface Water Drain

Source: The State of Queensland (2018 - 2020); Whitehaven (2022);
Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Requested Final Landform Alternative - Partial Backfill Above the Pre-mining Groundwater Level

Figure 5

Table 3
Consideration of Strategic, Environmental, Social and Economic Merits – Partial Backfill Above the Pre-mining Groundwater Levels

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Final Landform Strategic Merits		
Residual voids outside of floodplain extent	• Consistent with the optimised final landform, there would be no residual voids within the floodplain (Figure 5).	–
Safe, stable and non-polluting	• Groundwater movement is predicted from the final landform (in-pit and out-of-pit waste rock emplacements) towards the Isaac River alluvium and to the south-east off-site due to the reduced hydraulic gradient towards the partially backfilled residual voids (Appendix B). • In-pit (e.g. backfilled spoil) and out-of-pit waste rock emplacements are predicted to behave as groundwater sources (not groundwater sinks). • Consistent with the optimised final landform, the final landform would be geotechnically stable and safe.	**X**
Extent of NUMA	• The salinity of the residual void water bodies is predicted to oscillate as the water body undergoes wetting and drying cycles, and is predicted to become highly saline (i.e. up to 510,000 microSiemens per centimetre [the maximum solubility of salt in water at 25 degrees Celsius]). Due to the highly concentrated salinity, the water bodies would not sustain a use post-mining. • The residual void pit lakes would also not be suitable for providing a reliable source of water for beneficial use purposes due to times where the water body would go dry.	**X**
Progressive rehabilitation and closure	• Rehandling of at least 130 Mbcm of waste rock, resulting in: – Disturbance of established rehabilitation. – Delay of final rehabilitation and mine closure by approximately three years. • Additional rehabilitation and decommissioning costs of $691 million AUD (undiscounted). • Extended storage of topsoil, potentially reducing its viability for rehabilitation.	**X^**

Table 3 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits – Partial Backfill Above the Pre-mining Groundwater Levels

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Environmental Merits		
Surface water losses (post-mining)	• Limited reduction in catchment excision in comparison to optimised final landform (noting catchment excision of the Isaac River for the optimised final landform would be indiscernible in consideration of the overall catchment).	✓
Greenhouse gas emissions	• Slightly increased greenhouse gas emissions from the prolonged operation of the diesel-powered fleet. • Increase duration of greenhouse gas emissions by approximately three years.	X
Dust emissions	• Rehandling of waste rock to backfill the residual voids would result in continued emissions of PM_{10} and $PM_{2.5}$ for an additional three years.	X
Noise emissions	• Increased duration of waste haulage and operation of excavators and dozers would result in continued noise emissions for an additional three years.	X
Disturbance of native flora and fauna	• No change to the disturbance footprint of the Project.	–
Agricultural production	• The highly concentrated salinity of the residual void water bodies would result in the water bodies not being suitable for agricultural use.	X
Social Merits		
Employment opportunities	• Increased duration of employment for a proportion of the workforce.	✓
Local community views	• No change, no landowner or local[2] submissions were received regarding the number and use of residual voids.	–
Perceived benefit of fewer residual voids	• No change, consistent with the optimised final landform there would be three residual voids, albeit with lower capacities.	–
Amenity	• Increased amenity impacts (e.g. noise, air quality, greenhouse gas emissions).	X
Water quality	• Potential increased community concerns relating to increased risk of groundwater migrating off-site.	X

Table 3 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits –
Partial Backfill Above the Pre-mining Groundwater Levels

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]	BENEFIT TO QLD EXPECTED CHANGE (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Economic Merits		
Net producer surplus	• Overall decreased net producer surplus attributed to Queensland (value to Queensland Whitehaven shareholders) (reduction of $11 million AUD in NPV terms) (Deloitte Access Economics, 2022). • Continued payroll tax payments due to ongoing employment (increase of $2 million AUD in NPV terms) (Deloitte Access Economics, 2022). • Continued local government rate payments ($0.1 million in NPV terms) (Deloitte Access Economics, 2022).	X
Royalties	• No change.	–
Company income tax	• No change.	–
Externalities	• Slight increased cost associated with greenhouse gas emissions (increase of $1 million AUD in NPV terms) (Deloitte Access Economics, 2022) and other environmental externalities (not quantified).	X
Agricultural production	• Consistent with the optimised final landform, there would be a loss of agricultural production land associated with the residual voids (immaterial in NPV terms).	–
Indirect and flow-on economic benefits	• Slight increased flow-on economic benefits, due to increased duration of wage payments and expenditure with local suppliers (noting indirect and flow-on economic benefits are conservatively excluded from the Economic Assessment).	✓
Net economic benefit to Qld community	• Decreased net benefit to the Queensland community (reduction of $11 million AUD in NPV terms) (Deloitte Access Economics, 2022).	X

[1] Green shading indicates potential positive change to Queensland relative to the Project, pink shading indicates potential negative change.

[2] 'Local' is defined as the townships of Moranbah, Dysart and Coppabella, consistent with the SIA.

^ Dark red shading indicates the change from the optimised final landform associated with this final landform alternative would result in a material risk to the viability of the Project.

4.3 COVERING OF EXPOSED COAL SEAMS

This alternative considers partial backfilling all of the residual voids to cover the exposed coal seams (as requested to limit inflows from the coal seam aquifers). The indicative final landform for the covering of exposed coal seams alternative is shown on Figure 6.

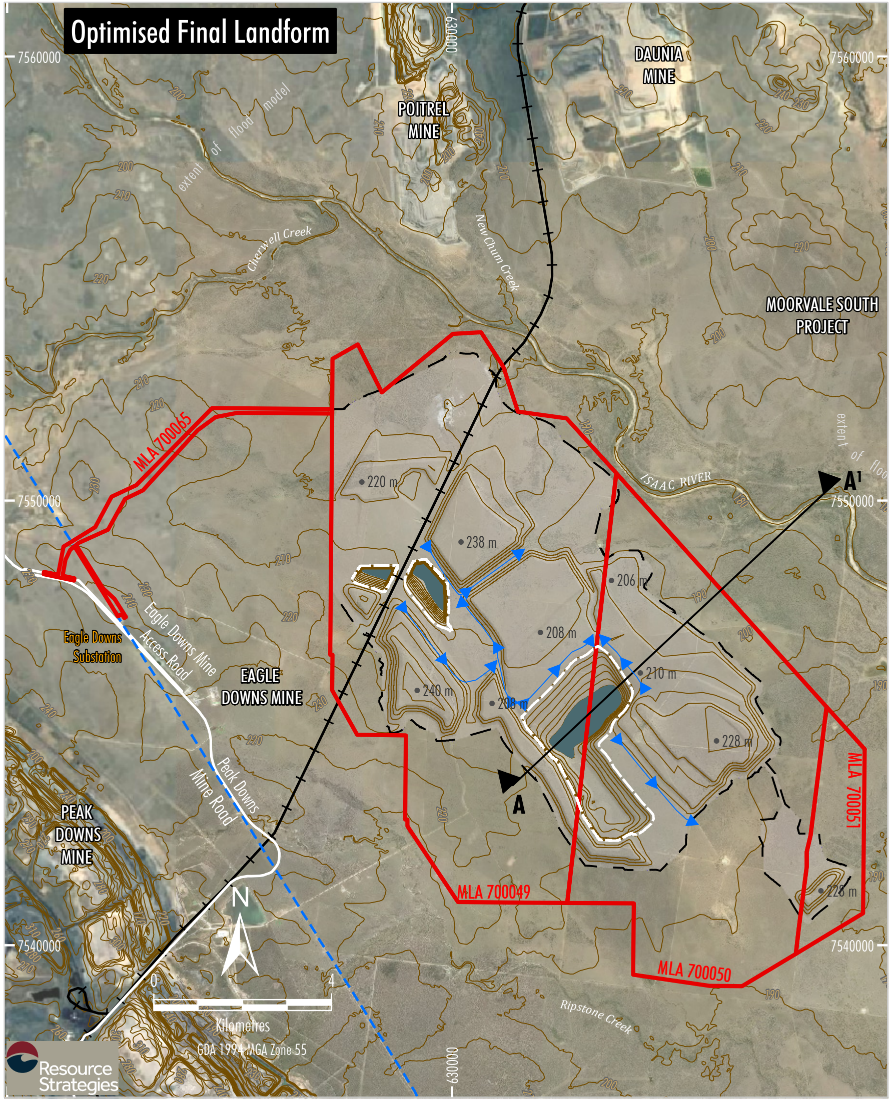
To cover the exposed coal seams in the residual voids with waste rock, an additional two years is required after cessation of ROM coal extraction to rehandle already emplaced waste rock. This rehandling results in an additional rehabilitation cost to Whitehaven WS in the order of $38 million AUD in undiscounted terms ($5 million AUD in NPV terms) compared to the optimised final landform (Deloitte Access Economics, 2022). These costs are in addition to the $389 million in undiscounted terms ($103 million AUD in NPV terms) already committed to the rehabilitation of the optimised Project (including the backfill of the Railway Pit and South Pit mine voids).

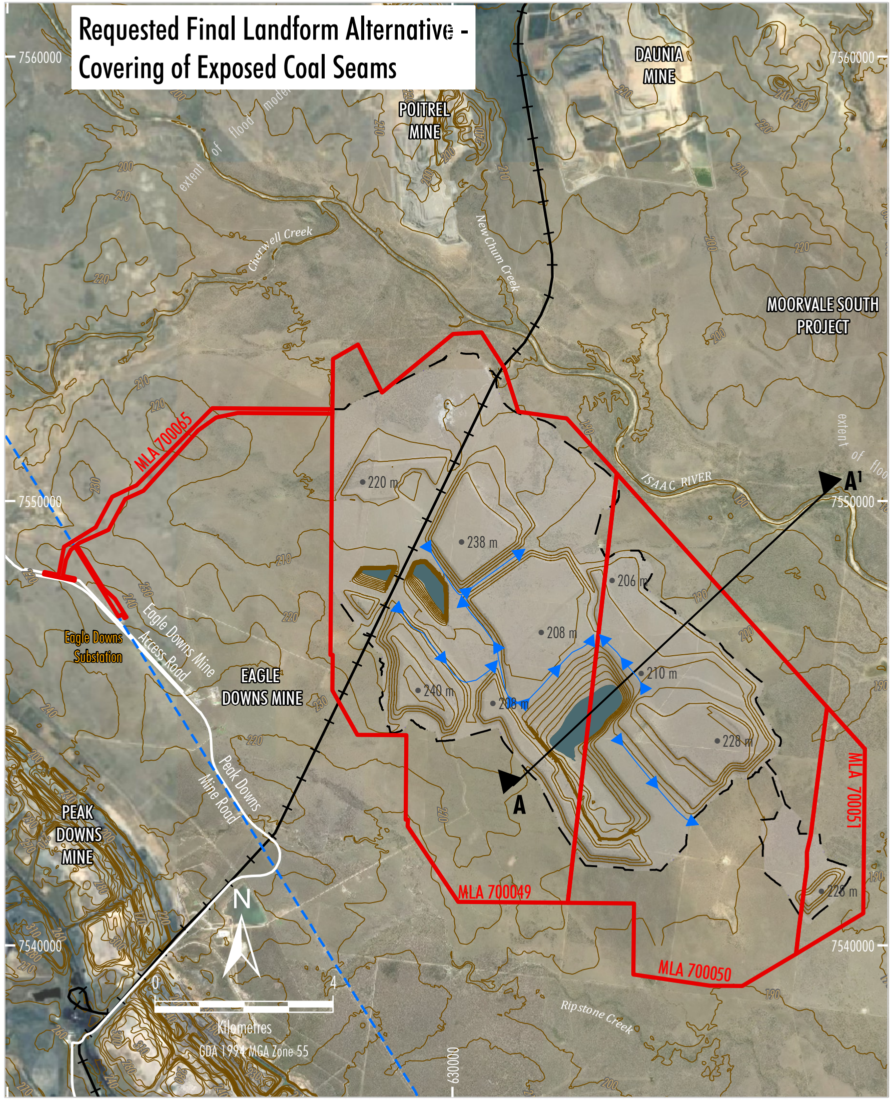
Covering the exposed coal seams within the proposed residual voids would require rehandling of at least 6 Mbcm of waste rock over two years, and would:

- increase greenhouse gas emissions associated with the Project by 0.02 Mt CO_2-e from consumption of additional diesel fuel (increase of 0.1%) (Katestone, 2022);
- increase or prolong various environmental impacts (e.g. water, noise and air quality impacts); and
- reduce the net economic benefits to the Queensland community by $1 million AUD in NPV terms (Deloitte Access Economics, 2022) for no discernible positive change in strategic, environmental, social or economic outcomes associated with the optimised final landform (Table 4).

An assessment of this alternative against the optimised final landform, in consideration of strategic, environmental, social and economic merits, is provided in Table 4.

On balance, the covering of exposed coal seams alternative final landform would result in $1 million AUD (in NPV terms) less economic benefits to the Queensland community in comparison to the optimised final landform, with the same environmental outcomes, and is therefore considered to not be in the public interest.





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Resource Strategies

LEGEND

- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Indicative Surface Disturbance Extent
- Indicative Residual Void Waterbody
- Indicative Extent of Water Storage
- Post-mining Land Use
- Indicative Surface Water Drain

Source: The State of Queensland (2018 - 2020); Whitehaven (2022); Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Requested Final Landform Alternative - Covering of Exposed Coal Seams

Figure 6

Table 4
Consideration of Strategic, Environmental, Social and Economic Merits – Covering of Exposed Coal Seams

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Final Landform Strategic Merits		
Residual voids outside of floodplain extent	• Consistent with the optimised final landform, there would be no residual voids within the Isaac River floodplain (Figure 6).	–
Safe, stable and non-polluting	• Consistent with the optimised final landform, the final landform would behave as a groundwater sink. • Consistent with the optimised final landform, the final landform would be geotechnically stable and safe.	–
Extent of NUMA	• Consistent with the optimised final landform, there would be no NUMAs and the residual voids is expected to contain water with water quality sufficient for a PMLU (e.g. water for cattle consumption).	–
Progressive rehabilitation and closure	• Rehandling of at least 6 Mbcm of waste rock, resulting in: – Disturbance of established rehabilitation. – Delay of final rehabilitation and mine closure by approximately two years. • Additional rehabilitation and decommissioning costs of $38 million AUD (undiscounted). • Extended storage of topsoil, potentially reducing its viability for rehabilitation.	**X**
Environmental Merits		
Surface water losses (post-mining)	• Negligible reduction in catchment excision (noting catchment excision of the Isaac River for the optimised final landform would be indiscernible in consideration of the overall catchment).	–
Greenhouse gas emissions	• Slightly increased greenhouse gas emissions from the prolonged operation of the diesel-powered fleet. • Increase duration of greenhouse gas emissions by approximately two years.	**X**
Dust emissions	• Rehandling of waste rock to backfill the residual voids would result in continued emissions of PM_{10} and $PM_{2.5}$ for an additional two years.	**X**
Noise emissions	• Increased duration of waste haulage and operation of excavators and dozers would result in continued noise emissions for an additional two years.	**X**
Disturbance of native flora and fauna	• No change to the disturbance footprint of the Project. • Consistent with the optimised final landform, the backfilled South Pit mine void would provide additional land that could be returned to low intensity cattle grazing and/or flora and fauna habitat.	–

Table 4 (Continued)
Consideration of Strategic, Environmental, Social and Economic Merits – Covering of Exposed Coal Seams

CONSIDERATION	DESCRIPTION (RELATIVE TO THE OPTIMISED FINAL LANDFORM)	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]
Environmental Merits (Continued)		
Agricultural production	• Consistent with the optimised final landform, the residual voids water bodies could be beneficially re-used for agricultural or other purposes (e.g. water for cattle consumption).	–
Social Merits		
Employment opportunities	• Increased duration of employment for a proportion of the workforce.	✓
Local community views	• No change, no landowner or local[2] submissions were received regarding the number and use of residual voids.	–
Perceived benefit of fewer residual voids	• No change, consistent with the optimised final landform there would be three residual voids, albeit with lower capacities.	–
Amenity	• Increased amenity impacts (e.g. noise, air quality, greenhouse gas emissions).	X
Water quality	• No change.	–
Economic Merits		
Net producer surplus	• Overall decreased net producer surplus attributed to Queensland (value to Queensland Whitehaven shareholders) (reduction of $1 million AUD in NPV terms) (Deloitte Access Economics, 2022) .	X
Royalties	• No change.	–
Company income tax	• No change.	–
Externalities	• Slight increased cost to Queensland associated with greenhouse gas emissions (Deloitte Access Economics, 2022) and other environmental externalities (not quantified).	X
Agricultural production	• Consistent with the optimised final landform, there would be a loss of agricultural production land associated with the residual voids (immaterial in NPV terms).	–
Indirect and flow-on economic benefits	• Slight increased flow-on economic benefits, due to increased duration of wage payments and expenditure with local suppliers (noting indirect and flow-on economic benefits are conservatively excluded from the Economic Assessment).	✓
Net economic benefit to Qld community	• Decreased net benefit to the Queensland community (reduction of $1 million AUD in NPV terms) (Deloitte Access Economics, 2022).	x

1 Green shading indicates potential positive change to Queensland relative to the Project, pink shading indicates potential negative change.

2 'Local' is defined as the townships of Moranbah, Dysart and Coppabella, consistent with the SIA.

4.4 SUMMARY OF FINAL LANDFORM ALTERNATIVE ASSESSMENT

A summary of the strategic, environmental, social and economic merits of the optimised final landform (relative to the Draft EIS) and the requested alternative final landforms in comparison to the optimised final landform is provided in Table 5.

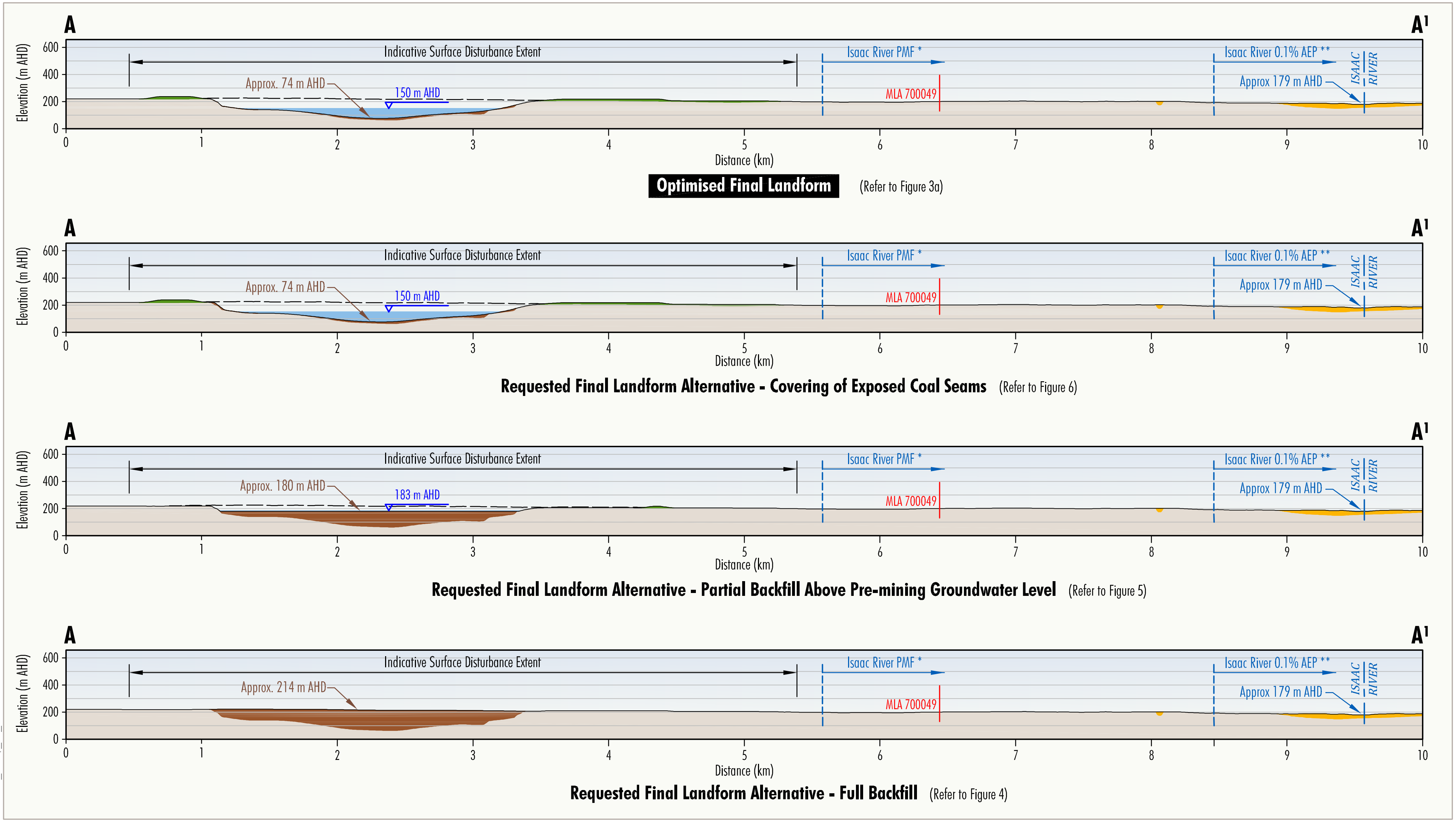
Figure 7 shows a comparison of cross-sections through the Main Void for the optimised final landform and requested alternative final landforms.

Table 5
Summary of Assessed Merits of the Optimised Final Landform and Requested Final Landform Scenarios

CONSIDERATION	BENEFIT TO QLD EXPECTED (RELATIVE TO THE DRAFT EIS)[1]	BENEFIT TO QLD EXPECTED (RELATIVE TO THE OPTIMISED FINAL LANDFORM)[1]		
	OPTIMISED FINAL LANDFORM	FULL BACKFILL	PARTIAL BACKFILL ABOVE THE PRE-MINING GROUNDWATER LEVEL	COVERING OF EXPOSED COAL SEAMS
Final Landform Strategic Merits				
Residual voids outside of floodplain extent	–	–	–	–
Safe, stable and non-polluting	–	x	x	–
Extent of NUMA	✓	–	x	–
Progressive rehabilitation and closure	✓	x^	x^	x
Environmental Merits				
Surface water losses (post-mining)	✓	✓	✓	–
Greenhouse gas emissions	✓	x	x	x
Dust emissions	x	x	x	x
Noise emissions	x	x	x	x
Disturbance of native flora and fauna	✓	–	–	–
Agricultural production	✓	–	x	–
Social Merits				
Employment opportunities	✓	✓	✓	✓
Local community views	–	–	–	–
Perceived benefit of fewer residual voids	✓	✓	–	–
Amenity	x	x	x	x
Water quality	✓	x	x	–
Economic Merits				
Net producer surplus	✓	x	x	x
Royalties	✓	–	–	–
Company income tax	✓	–	–	–
Externalities	x	x	x	x
Agricultural production	✓	–	–	–
Indirect and flow-on economic benefits	✓	✓	✓	✓
Net economic benefit to Qld community	✓	x	x	x

[1] Green shading indicates potential positive change to Queensland relative to the Project, pink shading indicates potential negative change.

^ Dark red shading indicates the change from the optimised final landform associated with this final landform alternative would result in a material risk to the viability of the Project.



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LEGEND

- Pre-mining Topography
- Indicative Final Landform Surface
- Isaac River Alluvium Extent
- In-pit Waste Rock Emplacement
- Out-of-pit Waste Rock Emplacement
- Residual Void Maximum Water Level

Scale 1 Horizontal : 1 Vertical

* Isaac River Probable Maximum Flood Extent (PMF) (Pre-mining)

** Isaac River 0.1% AEP Flood Extent (Pre-mining)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Comparison of Alternate Indicative Final Landform Profiles Cross Section A - A¹

Figure 7

Source: The State of Queensland (2022); Whitehaven (2022)

5 CONCLUSION

In response to feedback from Government and community stakeholders, Whitehaven WS has conducted a comprehensive analysis of a range of alternative final landform options. The results from this comprehensive analysis are clear. The optimised landform will reduce the number of residual voids, increase benefits to the Queensland community and present a more usable and sustainable site post-mining.

The alternatives would reduce the net economic benefits to the Queensland community associated with the Project for similar or increased environmental outcomes when compared with the optimised final landform.

Additionally, the increased rehabilitation and mine closure costs associated with the full backfill and partial backfill above the pre-mining groundwater level alternatives would reduce the financial viability and likelihood of the Project proceeding.

6 REFERENCES

Ball, J., Babister, M., Nathan, R., Weeks, W., Weinmann, E., Retallick, M. and Testoni, I. (2019) *Australian Rainfall and Runoff: A Guide to Flood Estimation*.

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Department of Environment and Science (2020) *Voids in Flood Plains Information Sheet*. Version 1.00. March 2020.

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SLR Consulting Australia Pty Ltd (2022a) Winchester South Project – Groundwater Assessment.

SLR Consulting Australia Pty Ltd (2022b) Winchester South Project – Final Landform Alternatives Groundwater Analysis Memo.

State of Queensland (2017) *Mined Land Rehabilitation Policy*.

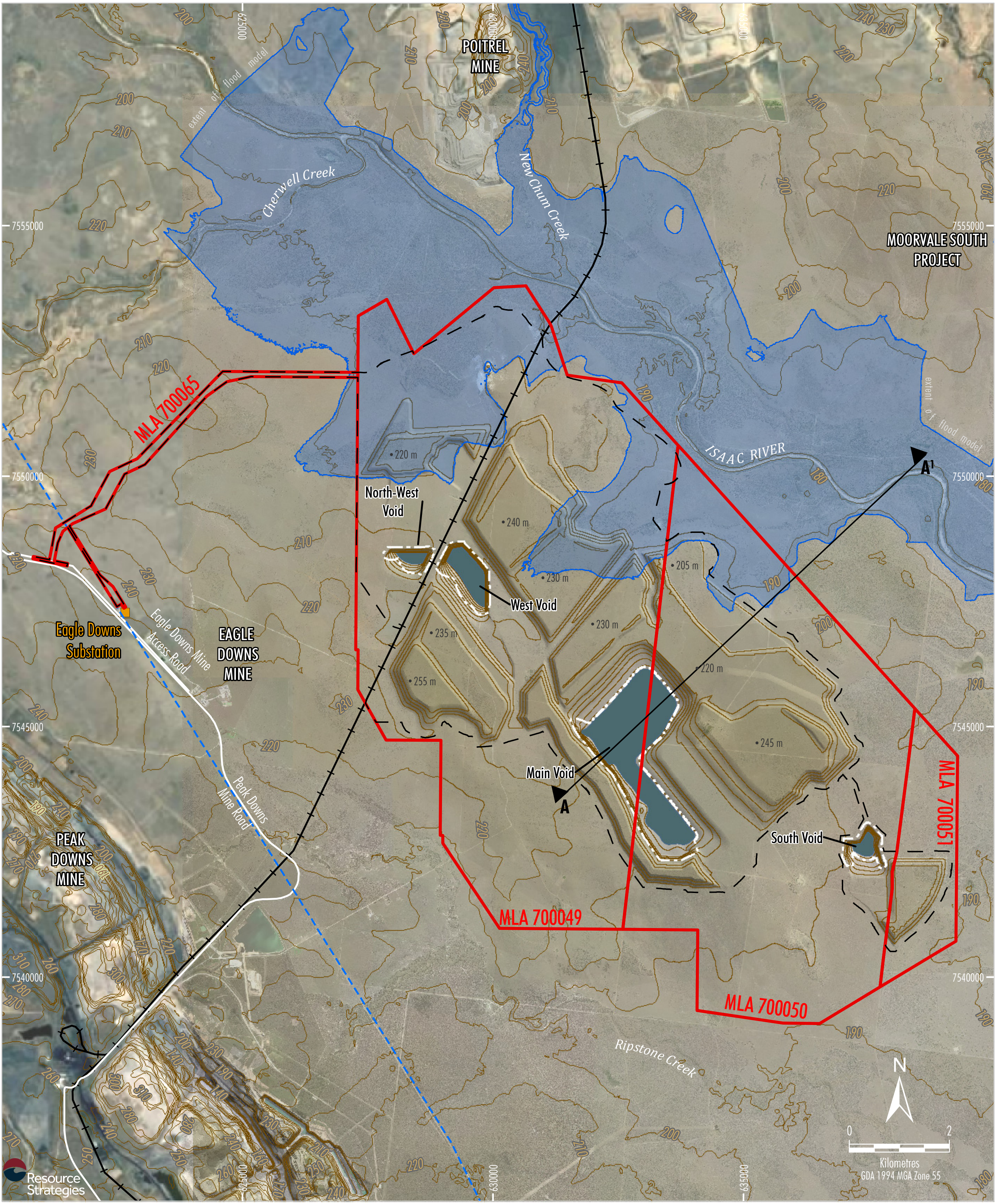
State of Queensland (2022) *Queensland resources industry development plan*.

WRM Water & Environment Pty Ltd (2022a) Winchester South Project – Surface Water Assessment.

WRM Water & Environment Pty Ltd (2022b) Winchester South Project – Final Landform Alternatives Water Balance Analysis.

Appendix A

Location of Residual Voids in Relation to the Probable Maximum Flood Extent



LEGEND

- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Substation
- Indicative Surface Disturbance Extent
- Isaac River Probable Maximum Flood (PMF) Extent (Pre-mining)*
- Indicative Extent of Non-Use Management Area
- Indicative Residual Void Waterbody

*Note: * Consistent with the Voids in the Flood Plains - Information Sheet (Department of Environment and Science, 2020), artificial features associated with the mine landform have been excluded for the flood plain modelling (e.g. PMF extent)*

Source: The State of Queensland (2018 - 2020); Whitehaven (2022); WRM (2021)
Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Probable Maximum Flood (Pre-mining) Extent in Relation to 2021 Draft EIS Conceptual Final Landform

Figure A-1

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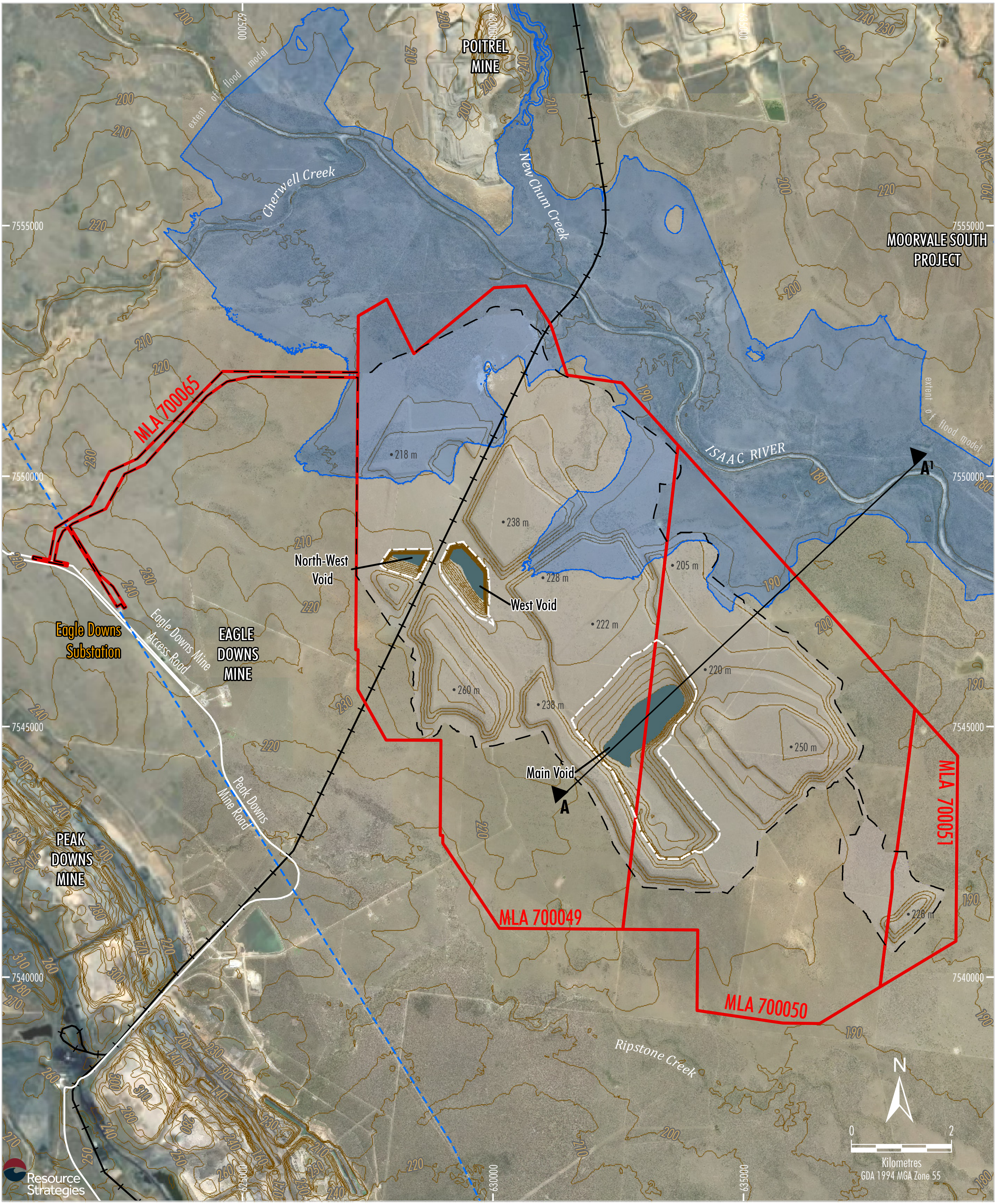


LEGEND

- Mining Lease Application Boundary
- Railway
- Eungella Water Pipeline Southern Extension
- Indicative Surface Disturbance Extent
- Isaac River Probable Maximum Flood (PMF) Extent (Pre-mining)*
- Indicative Residual Void Waterbody
- Indicative Extent of Water Storage
- Post-mining Land Use

*Note: * Consistent with the Voids in the Flood Plains - Information Sheet (Department of Environment and Science, 2020), artificial features associated with the mine landform have been excluded for the flood plain modelling (e.g. PMF extent)*

Source: The State of Queensland (2018 - 2020); Whitehaven (2022); Orthophoto: Google Image (2019); Whitehaven (2017)

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Probable Maximum Flood (Pre-mining) Extent in Relation to Optimised Final Landform (May 2022)

Figure A-2

Appendix B

Final Landform Alternatives Groundwater Analysis Memo

Memorandum

To:	Brendan Dillon	**At:**	Whitehaven WS Pty Ltd
From:	Dariarne Edwards / Vahid Shapoori	**At:**	SLR Consulting Australia Pty Ltd
Date:	29 June 2022	**Ref:**	620.13245.00008-M01-v4.0-20220616.docx
Subject:	Winchester South Project – Final Landform Scenario Groundwater Analysis Memo		

1 Introduction

The Winchester South Project (the Project) is located approximately 30 kilometres (km) south east of Moranbah, in the Isaac Regional Council Local Government Area (LGA), within the Bowen Basin Coalfield, in Queensland. The Project involves the development of an open cut metallurgical coal mine in an existing mining precinct. Products would include metallurgical coal for the steel industry and thermal coal for energy production.

Whitehaven WS Pty Ltd (Whitehaven WS) is the proponent for the Project, and is a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven). In 2021, Whitehaven WS submitted the Winchester South Project Environmental Impact Statement (the Draft EIS) for assessment under the *State Development and Public Works Organisation Act 1971* (SDPWO Act). The Draft EIS was placed on public notification by the Office of the Coordinator General (OCG) from 4 August 2021 until 15 September 2021. During and following this period, government advisory agencies, organisations and members of the public provided submissions on the Draft EIS to the OCG.

Subsequent to the public notification of the Draft EIS, Whitehaven WS reviewed the mine plan and mine schedule with the aim of reducing environmental impacts of the Project and changing the Project final landform in response to comments raised in submissions. This review also considered new geological data, coal quality data and the outcomes of processing trials to further refine the mine plan. On 3 December 2021, the Coordinator General formally requested (in accordance with section 34A of the SDPWO Act) Additional Information on the environmental effects of the Project and other matters relating to the Project. This Assessment forms part of the Additional Information and provides an assessment of the optimised mine plan and mine schedule and responses to issues raised in submissions.

It should be noted that, in response to feedback from regulatory and community stakeholders, Whitehaven WS has reviewed the Project mine plan and sequence with the aim of reducing the number of residual voids in the final landform, which includes backfilling of the South Pit Void for the optimised final landform.

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Whitehaven WS to evaluate alternative final landform scenarios requested by regulatory and community stakeholders in their submissions. The aim of this analysis is to characterise the potential implications for each of the alternative final landform scenarios to the residual void water levels and associated risk to the surrounding groundwater systems as requested by regulatory stakeholders.

This work is informed by the numerical groundwater model developed by SLR as part of the Groundwater Assessment for the Draft EIS for the Project (SLR, 2022). The specific scope of the assessment is to:

- Develop a numerical groundwater model based on the following final landform scenarios as requested by government agencies:
  - Scenario 1: Full backfill of the open cut pits to pre-mining levels.
  - Scenario 2: Final landform with partial backfill of the open cut pits to 5 m above pre mining groundwater levels.
  - Scenario 3: Final landform with covering of exposed coal seams.
- Revise the model packages for the three final landforms scenarios and run the models accordingly; and
- Present the model outputs in terms of water levels within each residual void and the groundwater flow paths to/from each residual void.

It should be noted the purpose of this analysis was to evaluate the final landforms scenarios and analyse any additional risk of water migrating off-site relative to the optimised final landform assessed in the Groundwater Assessment (SLR, 2022), and this memo does not assess the downstream impacts of any potential outflow of water from the alternative final landforms (e.g. from the backfilled voids or out-of-pit waste emplacements).

2 Model Predictions

2.1 Model Setup

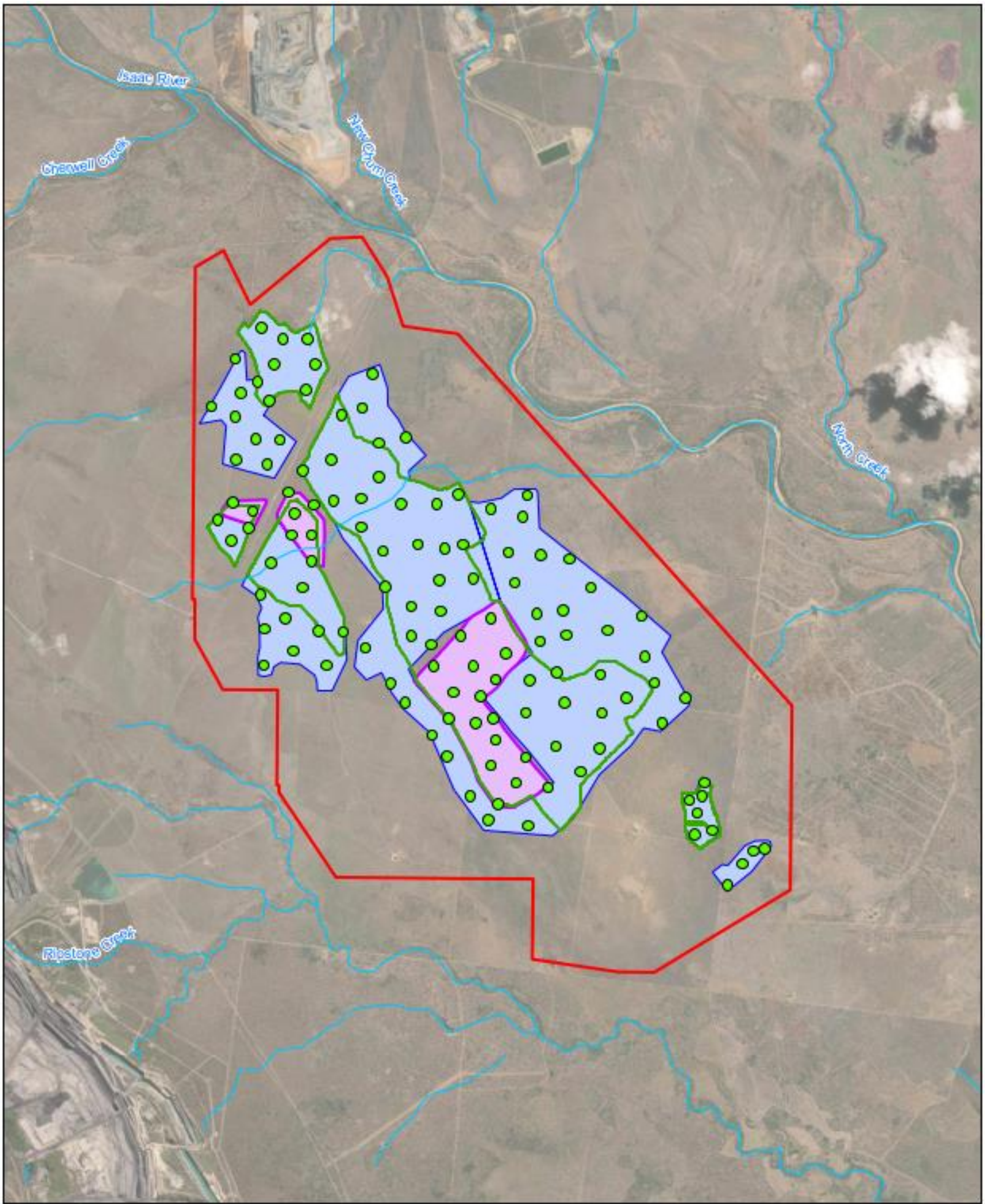
Whitehaven WS provided final landform surfaces for the three scenarios. SLR incorporated the final landforms into the numerical groundwater model and then imported them into the updated recovery model. Changes were also made to the recovery model to replicate the spoil and residual voids for each final landform scenario. The changes are as follows:

- Changes to the hydraulic properties of materials to spoil properties when the backfilling occurs within the open cut pits. Backfill was given uniform hydraulic conductivity of 0.2 metres per day (m/day), specific yield (Sy) of 0.05 and rainfall recharge set to 1 % of average rainfall consistent with the recovery model for the Draft EIS.
- Update the evapotranspiration (EVT) surface so that the EVT surface follows the out-of-pit waste rock emplacement and backfill levels within the open cut pits.
- Changes to the hydraulic properties of the materials within the residual void to values representative of a residual void where relevant. The void cells were assigned high horizontal and vertical hydraulic conductivities (1,000 m/day) and storage parameters based on the compressibility of water (Sy of 1.0, specific storage of 5.0×10^{-6} m^{-1}), to simulate free water movement within the residual void.
- Predicted groundwater inflows to the residual voids/backfilled open cut pits during recovery were incorporated in the site water balance model by WRM Water & Environment Pty Ltd (WRM) (WRM, 2022) for each of the final landform scenarios. The residual void recovery levels and timings were modelled by WRM and applied in the groundwater model as a constant head boundary condition (CHD) to replicate residual void pit lake recovery levels over time. Constant heads were not applied for Scenario 1 given the complete backfilling of the open cut pits for this final landform scenario.

The model uses the end of mining groundwater levels from the Draft EIS prediction model as the starting heads and runs for 2,000 years. Given that the groundwater recovery is a slow process with rates of recovery declining as it approaches the equilibrium state, a steady-state simulation was then run following the 2,000 year simulation, to ensure that the groundwater system has reached an equilibrium and hence the predictions are representative of long-term average conditions.

2.2 Groundwater Fate Modelling

To investigate the water movement within the residual voids and spoil during the recovery, an assessment was undertaken to simulate the fate and movement of water particles through the groundwater system. To achieve this, a number of particles were placed within the voids in the model and the Mod-PATH3DU code (S.S. Papadopulos & Associates, Inc., 2018) was used to simulate particle pathways along the groundwater flow field during recovery (i.e. 2,000 years). To run the Mod-Path3DU code, the groundwater flow model was first simulated, and the transient head outputs from the groundwater flow model were used by Mod-PATH3DU to simulate particle flowpath lines. **Figure 2-1** shows the location of particles placed within residual voids and out-of-pit waste rock emplacements. The particles were released from the start of recovery and the movement of particles was recorded during the recovery simulation.



Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.13245
Date:	09-Jun-2022
Drawn by:	JG

WINCHESTER SOUTH
FINAL LANDFORM MODELLING

Starting Location of Mod-Path3DU Particles

FIGURE 2-1

2.3 Scenario 1 Modelling Results

2.3.1 Water Level Simulation

Scenario 1 provides a scenario where the open cut pits for the final landform would be completely backfilled (e.g. no residual voids). **Figure 2-2** shows the predicted groundwater levels beneath the fully backfilled open cut pits over time for Scenario 1. **Figure 2-3** shows the predicted groundwater level contours at the end of recovery for Scenario 1. It should be noted that the lowering of the groundwater table at the end of the steady-state simulation to the south-east of the Project is largely driven by the residual voids at the Olive Downs Project. As Scenario 1 requires full backfilling of all pits, no controlled heads were applied during the recovery simulation. The water levels appear to recover gradually following the mining and reach a long-term equilibrium after approximately 1,000 years. The time to recover to 90% of the final levels is approximately 270 years at the backfilled West pit, 440 years at the backfilled North-west Pit, and 450 years at the backfilled Main Pit. **Table 2-1** shows the final predicted water levels within the backfilled open cut pits for the alternative final landform scenario.

Table 2-1 Predicted Water Levels within Backfilled Open Cut Pits (Scenario 1)

Backfilled Pit	Landform surface level (mAHD)		Water level (mAHD)
	Minimum	Maximum	
Backfilled North-west Pit	207.1	216.1	191.5
Backfilled West Pit	197.1	242.6	190.5
Backfilled Main Pit	191.8	245.9	188.8

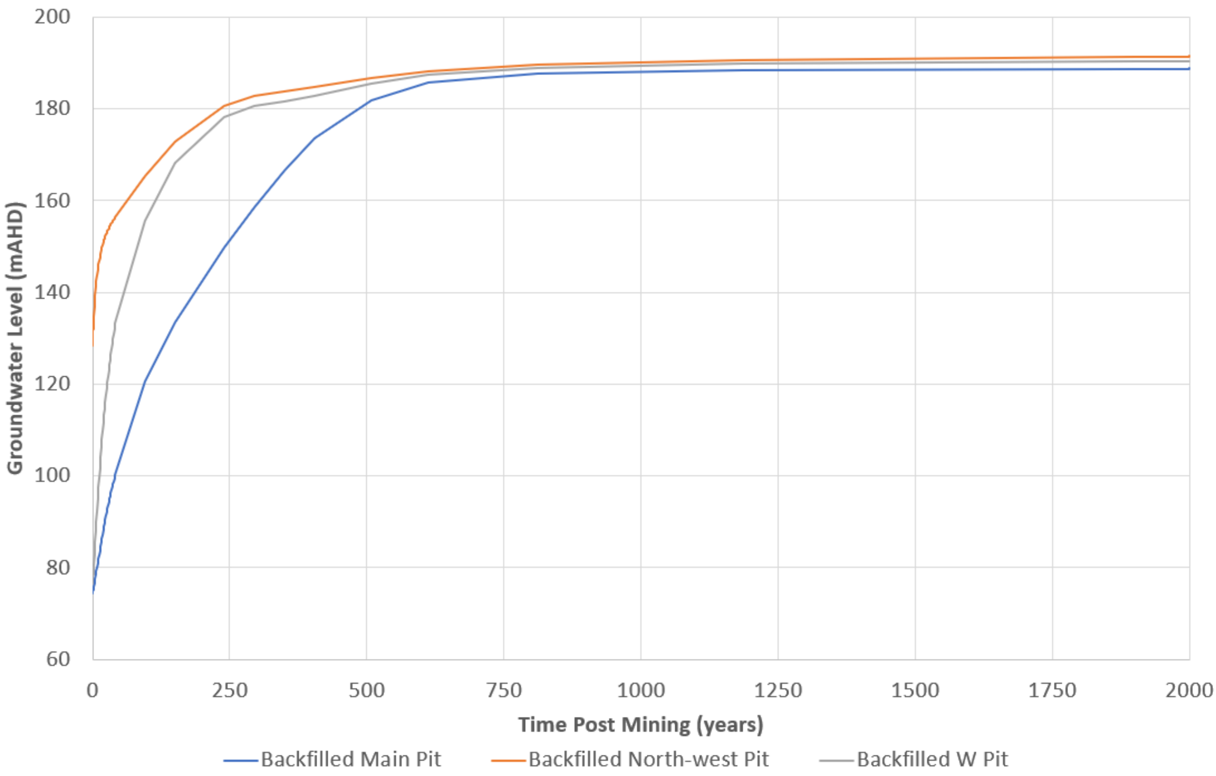
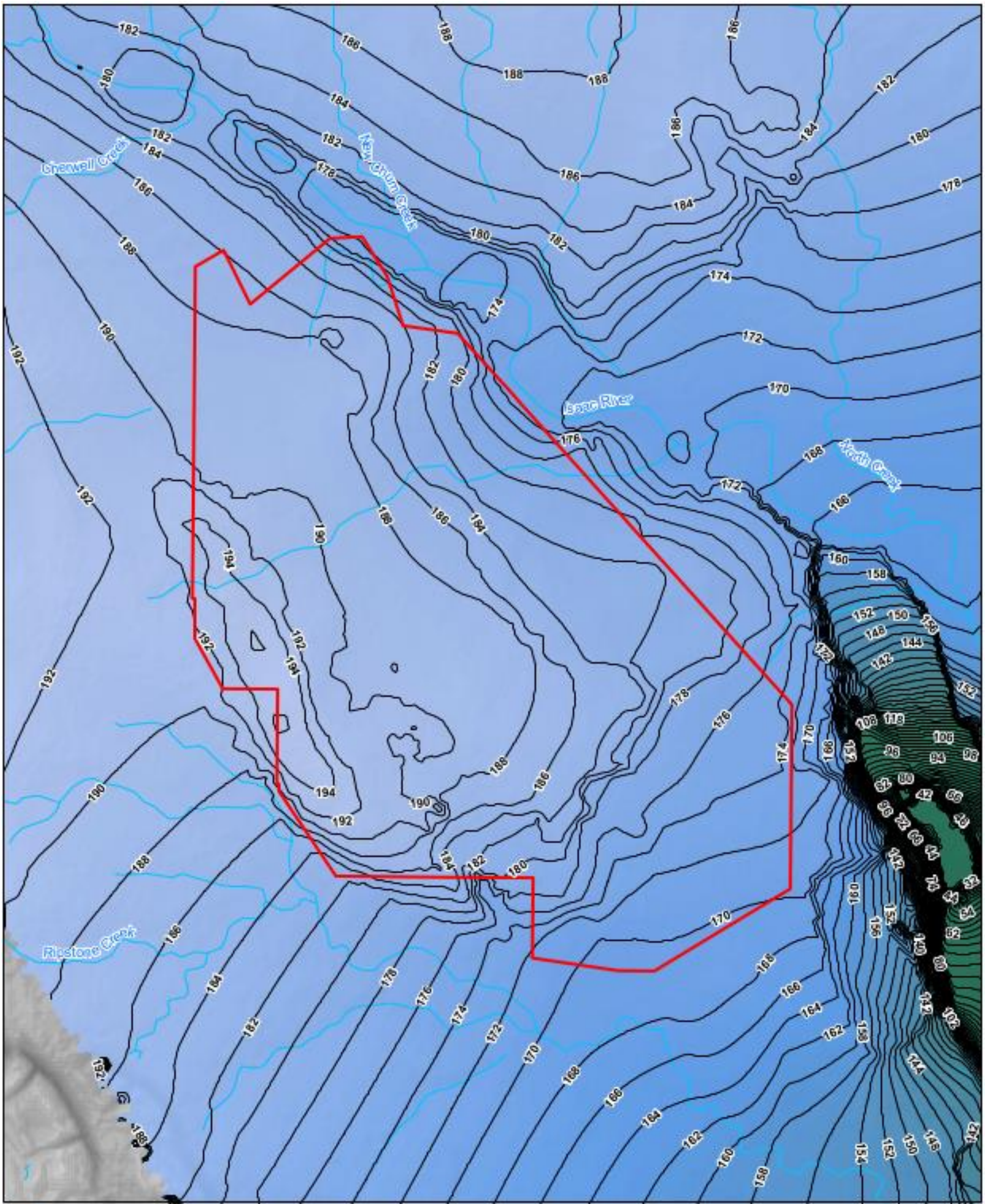


Figure 2-2 Predicted Water Levels at the Rehabilitated Pits (Scenario 1)



Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.13245
Date:	16-Jun-2022
Drawn by:	JG

SLR

Water Table Contours (mAHD)
Watercourses
Winchester South Mining Lease
Water Table (mAHD)
253.73
-22.72

WINCHESTER SOUTH
FINAL LANDFORM MODELLING

Water Table at the end of steady-state stage following 2000 years recovery simulation (Scenario 1)

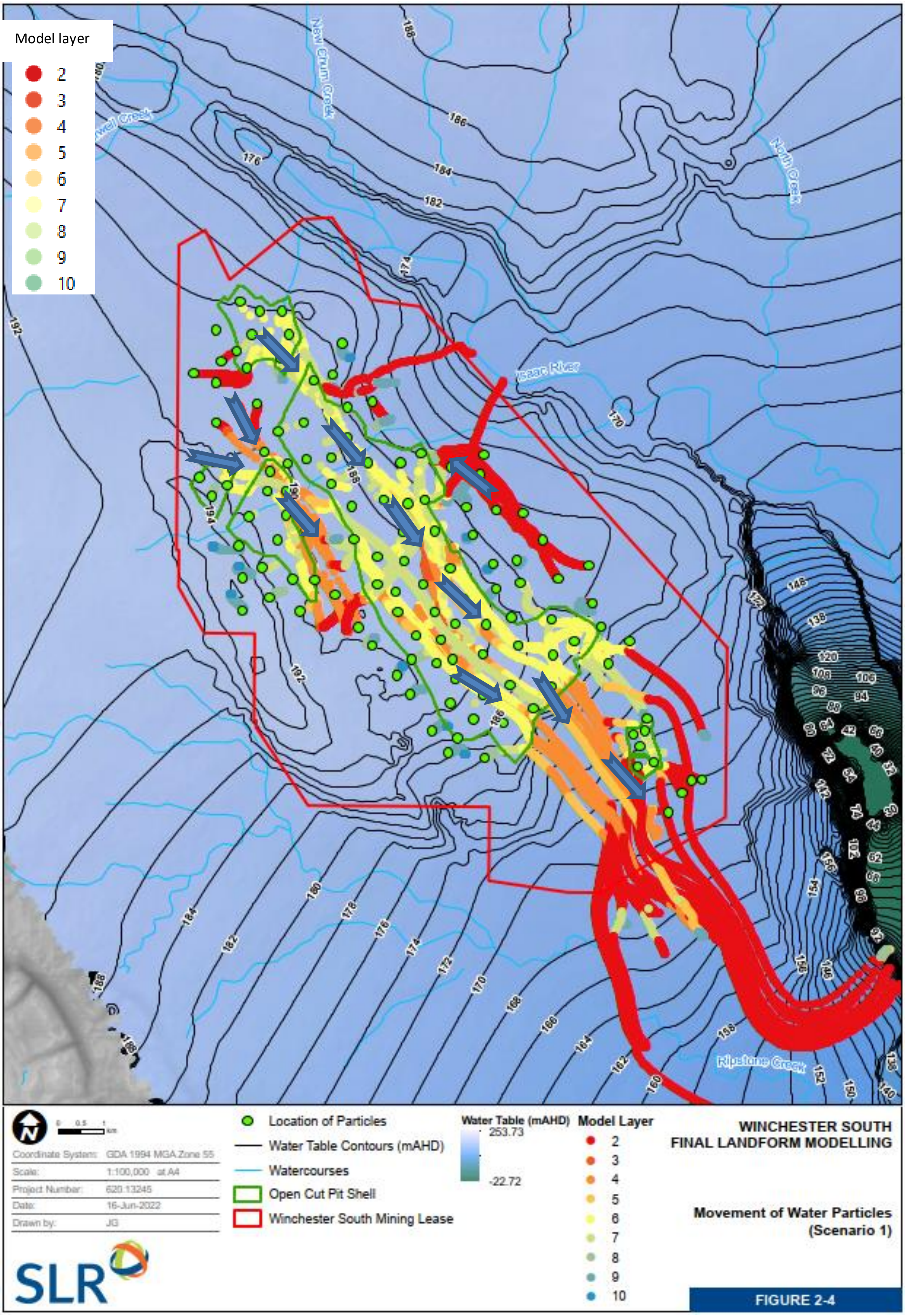
FIGURE 2-3

2.3.2 Flow Path Simulation

Figure 2-4 shows the predicted movement of water particles in the recovery simulation for the full backfill final landform scenario. The groundwater flow path analysis indicates the particles generally flow from the backfilled pits and waste rock emplacements to the Isaac River alluvium and residual voids at the Olive Downs Project, indicating that the full backfill final landform scenario would act as a groundwater source to the surrounding groundwater systems.

The majority of particles within the backfilled Main Pit would move towards residual voids associated with the Olive Downs Project, located south-east of the Project. The colour changes along the path also indicate that particles in the deeper layers (e.g. Layers 5 and 7 for Leichhardt and Vermont coal seams) travel progressively to the shallower units (e.g. Layer 2) to the south-east, ultimately moving to the residual voids at the Olive Downs Project. Groundwater from the full backfilled final landform would also travel north-west into the shallow layers within the Isaac River alluvium.

In consideration of the flow path simulation for the completely backfilled final landform scenario (e.g. no residual voids), the final landform would begin to behave as a groundwater source (i.e. not a groundwater sink), allowing water from the final landform to migrate into the surrounding groundwater systems.


Model layer
2
3
4
5
6
7
8
9
10
New Chum Creek
North Creek
Isaac River
Ripstone Creek
Location of Particles
Water Table Contours (mAHD)
Watercourses
Open Cut Pit Shell
Winchester South Mining Lease
Water Table (mAHD)
253.73
-22.72
Model Layer
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.13245
Date: 16-Jun-2022
Drawn by: JG
WINCHESTER SOUTH
FINAL LANDFORM MODELLING
Movement of Water Particles
(Scenario 1)
FIGURE 2-4

2.4 Scenario 2 Modelling Results

2.4.1 Water Level Simulation

Scenario 2 provides a scenario where the open cut pits would be partially backfilled with spoil above the pre-mining groundwater level plus 5 m. **Figure 2-5** shows the simulated pit lake water levels within the residual voids and partially backfilled pits over time based on the WRM (2022) water balance model results, noting that groundwater levels are not shown in **Figure 2-5**. **Table 2-2** shows the simulated recovered water levels based on the WRM (2022) water balance model results. The heads at the residual voids for Scenario 2 are significantly higher than the heads for Scenario 3. This is expected given that the pits in Scenario 2 are backfilled above pre-mining groundwater levels, and potentially due to the reduced storage volume in the voids, allowing for greater recovery of groundwater post-mining.

Table 2-2 Simulated Final Void Water Levels (Scenario 2)

Residual Void	Landform surface level (mAHD)		Water level (mAHD)
	Minimum	Maximum	
North-west Void	187.7	208.0	188.3
West Void	185.5	193.5	186.4
Main Void	170.6	202.0	180.4

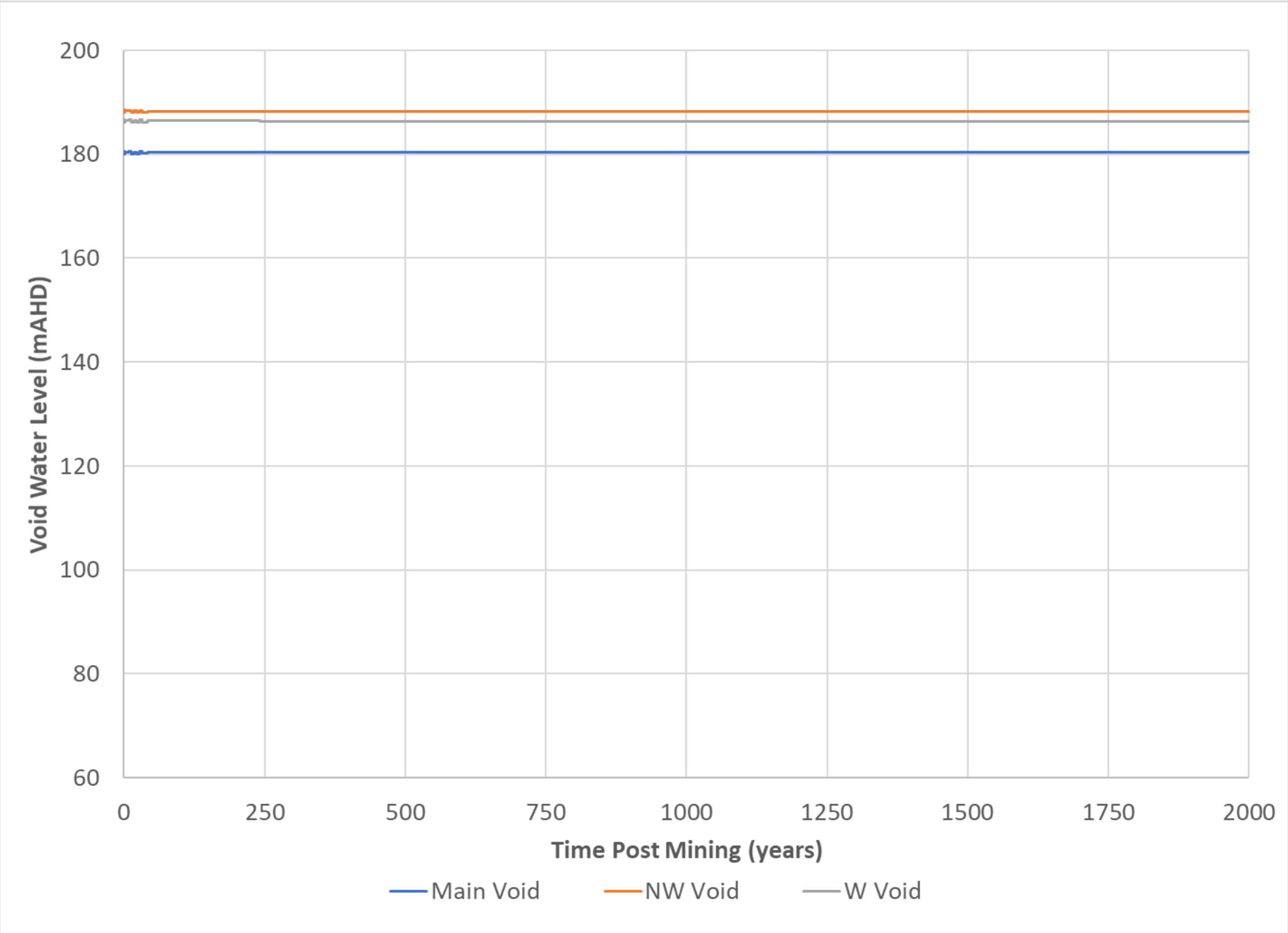
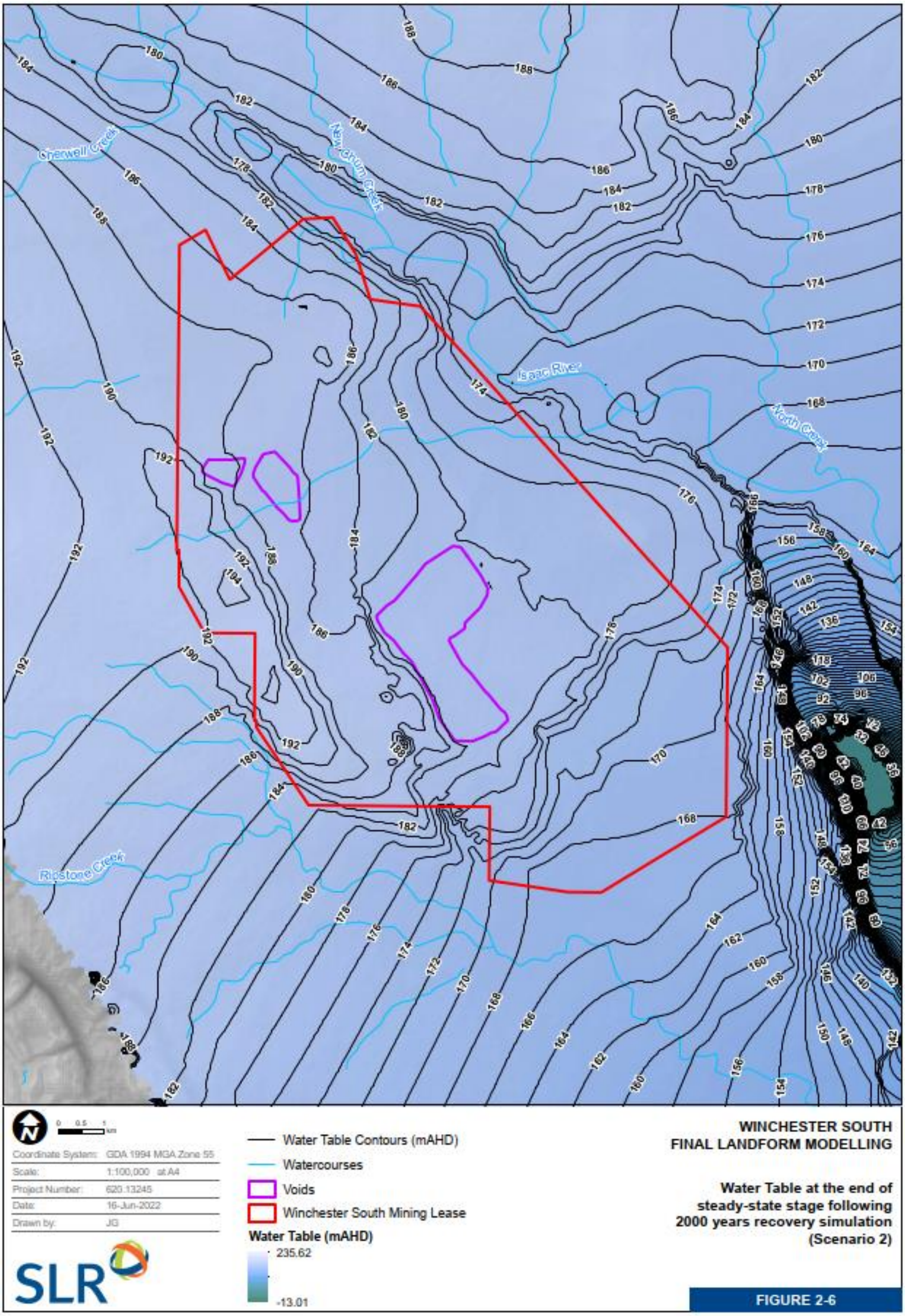


Figure 2-5 Simulated Water Levels at Each Void (Scenario 2)

Figure 2-6 shows the predicted groundwater level contours at the end of recovery for Scenario 2. It indicates that there is a general head gradient from 190 mAHD in the northwest to 170 mAHD in the east and south-east predicted by the recovery model. The West and Main Voids remain mild groundwater sinks, retaining a very shallow (approximately 1 m) hydraulic gradient towards the backfilled pits. It should be noted that the lowering of the groundwater table at the end of the steady-state simulation to the south-east of the Project is largely driven by the residual voids at the Olive Downs Project.

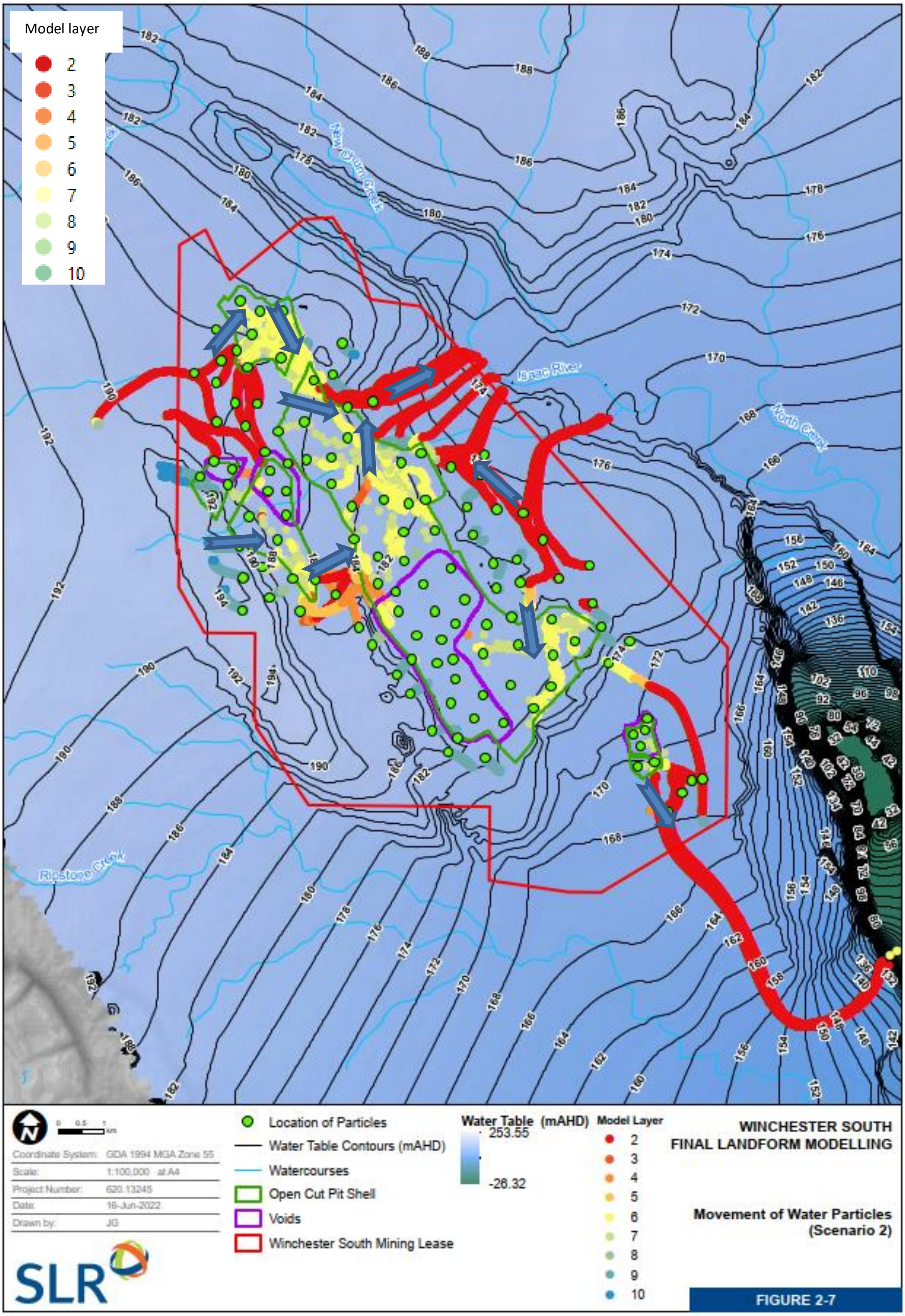

Cherwell Creek
New Chum Creek
Isaac River
North Creek
Ripstone Creek
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.13245
Date: 16-Jun-2022
Drawn by: JG
Water Table Contours (mAHD)
Watercourses
Voids
Winchester South Mining Lease
Water Table (mAHD)
235.62
-13.01
WINCHESTER SOUTH
FINAL LANDFORM MODELLING
Water Table at the end of steady-state stage following 2000 years recovery simulation (Scenario 2)
FIGURE 2-6

2.4.2 Flow Path Simulation

Figure 2-7 shows the movement of water particles for Scenario 2. Given that CHD boundaries have been applied within the partially backfilled residual voids, the particles within the partially backfilled residual voids are generally being controlled by the CHD and hence, there is limited particle movement within the partially backfilled residual voids. However, it appears that the two particles within the North-west Void move to the north and east. Particles along the eastern edge of the out-of-pit waste rock emplacements gradually move into the shallow layers toward the north-east and ultimately reach the Isaac River alluvium (e.g. Layers 1 and 2). Due to the reduction in hydraulic gradient towards the residual voids, specifically partial backfilling of the Main Void, the particles placed in the out-of-pit waste rock emplacement near the South Pit are predicted to move 6 km towards residual voids at the Olive Downs Project (e.g. the Scenario 2 landform is acting as a groundwater source rather than a sink). However, the simulation shows that the residual voids at the Olive Downs Project are acting as groundwater sinks and capture the water from the out-of-pit waste rock emplacement near the South Pit. The movement of these outer particles away from the open cut pits is expected given the predicted head gradients shown in **Figure 2-6**.

The colour change along the groundwater paths indicates that particles move away from the partially backfilled residual voids and final landform and move towards the shallower units (i.e. Regolith), reaching Layer 1 at the Isaac River, while some particles in backfill spoil remain in Layers 5 to 7.

In consideration of the flow path simulation for the partial backfilled open cut pits above the pre-mining groundwater level scenario, the residual voids would largely remain as shallow groundwater sinks (i.e. groundwater would not flow from the residual voids off-site). However, the reduction in hydraulic gradient would result in water from out-of-pit waste rock emplacements to migrate into the surrounding groundwater systems.


Model layer
2
3
4
5
6
7
8
9
10
New Chum Creek
Isaac River
North Creek
Ripstone Creek
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.13245
Date: 16-Jun-2022
Drawn by: JG
Location of Particles
Water Table Contours (mAHD)
Watercourses
Open Cut Pit Shell
Voids
Winchester South Mining Lease
Water Table (mAHD)
253.55
-26.32
Model Layer
2
3
4
5
6
7
8
9
10
WINCHESTER SOUTH
FINAL LANDFORM MODELLING
Movement of Water Particles
(Scenario 2)
FIGURE 2-7

2.5 Scenario 3 Modelling Results

2.5.1 Water Level Simulation

Scenario 3 provides a scenario where the coal seams (Leichhardt and Vermont seams) would be covered by backfilled spoil within the residual voids. Scenario 3 is similar to the optimised final landform proposed in the Additional Information, however the coal seams along the highwalls in the residual voids would be covered with backfilled spoil resulting in varying depths of backfill (e.g. highwalls only covered with spoil). **Figure 2-8** shows the simulated pit lake water levels within the residual voids over time based on the WRM (2022) water balance model results, noting that groundwater levels are not shown in **Figure 2-8**. The residual void water levels recover following mining and approach equilibrium after approximately 250 years. **Table 2-3** shows the long-term equilibrium predicted water levels at each residual void based on the WRM (2022) water balance model results.

Table 2-3 Simulated Residual Void Water Levels (Scenario 3)

Residual Void	Landform surface level (mAHD)		Water level (mAHD)
	Minimum	Maximum	
North-west Void	116.4	205.0	130.5
West Void	74.2	189.0	107.2
Main Void	73.8	208.0	140.9

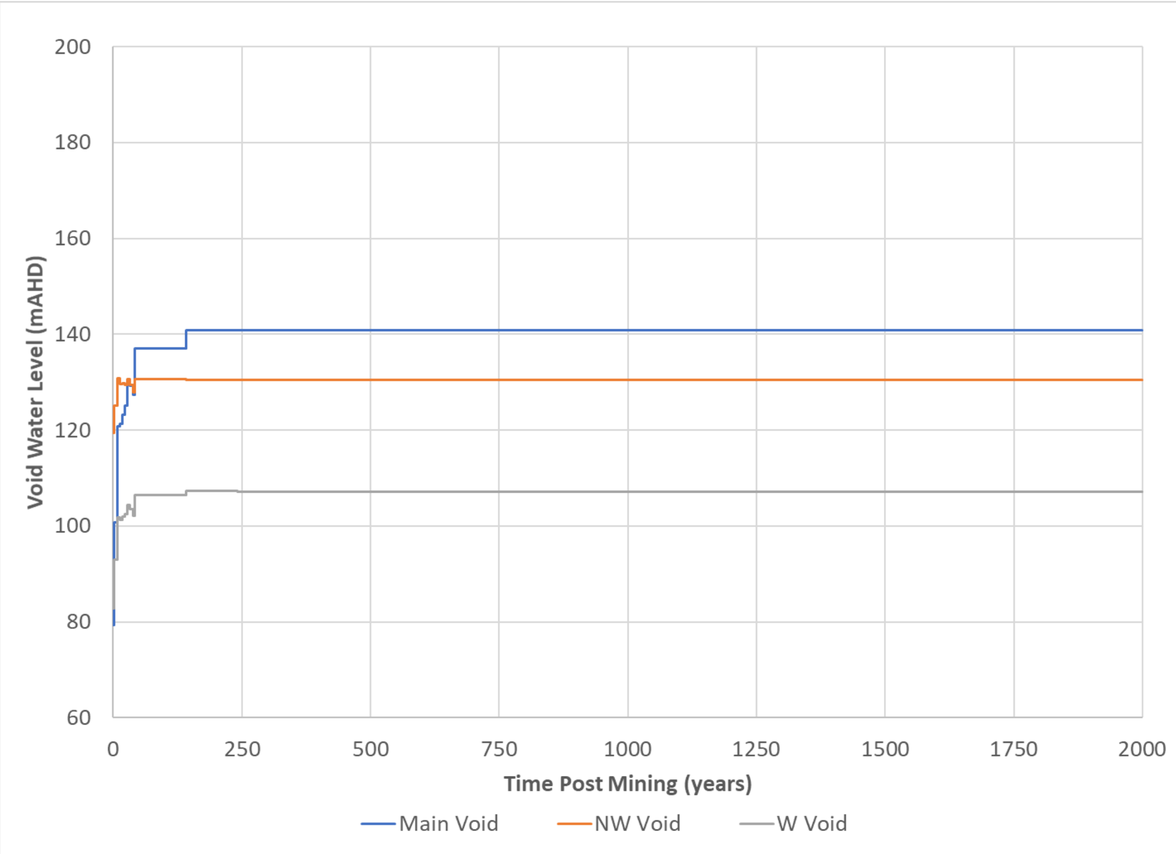


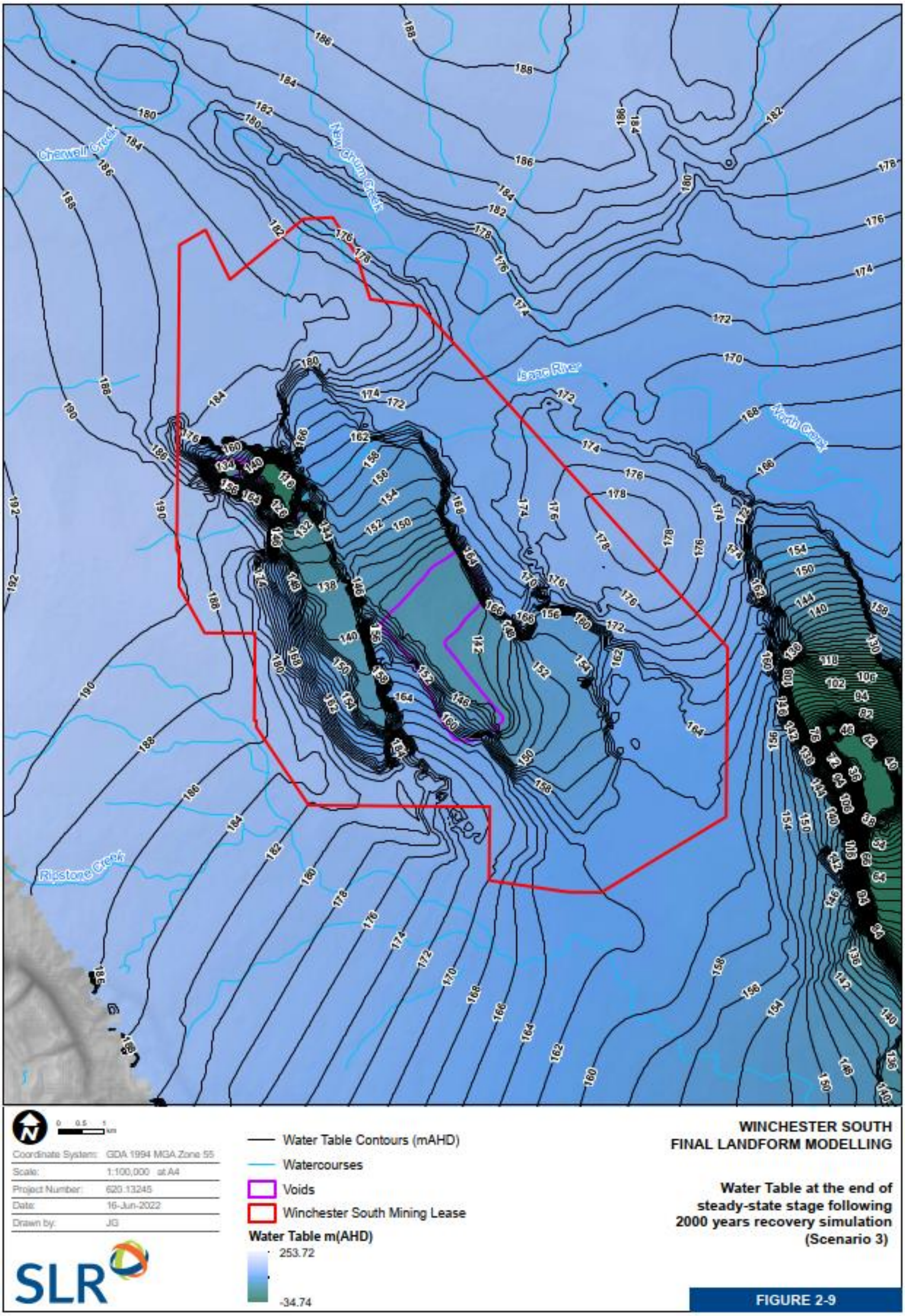
Figure 2-8 Simulated Water Levels at Each Backfilled Void (Scenario 3)

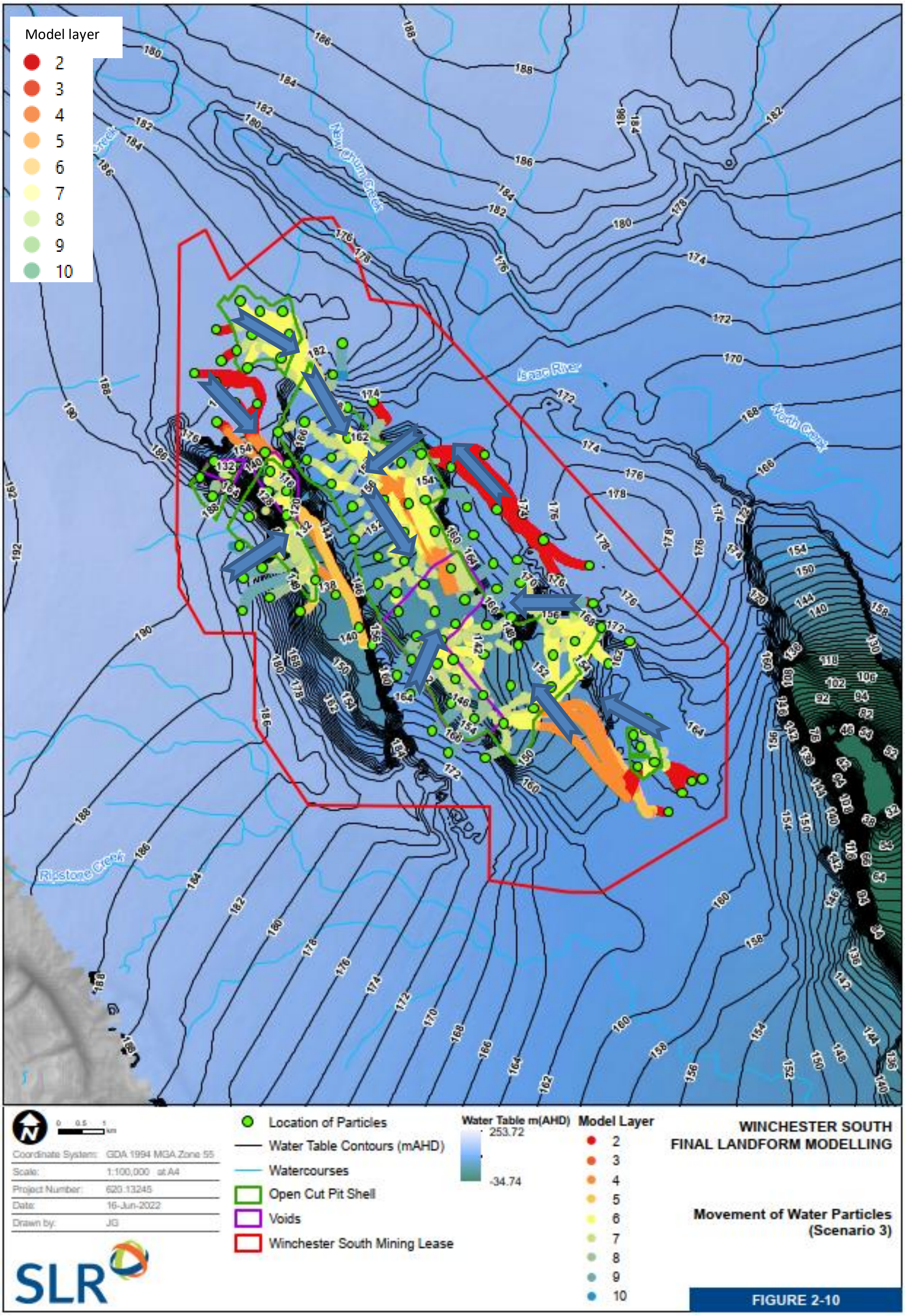
Figure 2-9 shows the predicted groundwater level contours at the end of recovery following 2,000 years recovery simulation. **Figure 2-9** indicates that the groundwater head gradient at the end of the steady-state simulation is generally from west to south-east. It should be noted that the lowering of the groundwater table at the end of the steady-state simulation to the south-east of the Project is largely driven by the residual voids at the Olive Downs Project. The contouring around the residual voids shows groundwater has recovered to around 140 mAHD at the Main and North-west Voids, while the water table at the West Void has recovered to about 110 mAHD after 2,000 years of recovery. The extent to which groundwater recovers in each of the residual voids is largely controlled by the void lake levels defined in the CHD package.

2.5.2 Flow Path Simulation

Figure 2-10 shows the predicted movement of water particles in the recovery simulation. The colours along the path show the model layer number. The colour ranges from red to green, representing Layer 2 (e.g. Regolith) to deeper units such as Rangal Coal Measures underburden (Layers 8 to 10). The light orange and light yellow colour represent Leichhardt and Vermont coal seam respectively (Layers 5 and 7). The blue arrows in the figure show the general direction of groundwater particle movement. The flow path analysis shows the particles generally move toward the residual voids, including particles placed in the out-of-pit waste rock emplacement to the south of the Main Pit, indicating all residual voids are acting as groundwater sinks, and therefore water is unlikely to migrate away from the Scenario 3 final landform. The colour change (e.g. from orange to green) along the paths indicates that particles in the shallower layers to the north-east and north-west move toward the deeper layers.

Given that the particle pathlines are simulated from the start of recovery, they generally follow head gradients. However, the particle directions at times appear to be in opposition to the head contours/gradients shown in **Figure 2-10**. It should be noted that the contours shown in **Figure 2-10** only represent the final head pattern when the aquifer has reached an equilibrium and hence does not necessarily show the transient head changes occurring during the 2,000 years recovery simulation. For example, the residual voids are generally dry at the start of the recovery when the head gradient is towards residual voids, which generally reduces as the backfilled spoil and residual void reach saturation.


Cherwell Creek
New Chum Creek
Isaac River
Ripstone Creek
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.13245
Date: 16-Jun-2022
Drawn by: JG
Water Table Contours (mAHD)
Watercourses
Voids
Winchester South Mining Lease
Water Table m(AHD)
253.72
-34.74
WINCHESTER SOUTH
FINAL LANDFORM MODELLING
Water Table at the end of steady-state stage following 2000 years recovery simulation (Scenario 3)
FIGURE 2-9


Model layer
2
3
4
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Isaac River
New Chum Creek
North Creek
Ripstone Creek
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.13245
Date: 16-Jun-2022
Drawn by: JG
Location of Particles
Water Table Contours (mAHD)
Watercourses
Open Cut Pit Shell
Voids
Winchester South Mining Lease
Water Table m(AHD)
253.72
-34.74
Model Layer
WINCHESTER SOUTH
FINAL LANDFORM MODELLING
Movement of Water Particles
(Scenario 3)
FIGURE 2-10

3 Conclusion

The recovery modelling results indicate that Scenario 1 (full backfill) does not limit groundwater movement, and groundwater would migrate off-site from the backfilled final landform from deeper groundwater layers into the shallower units (e.g. Isaac River alluvium and the residual voids at the Olive Downs Project).

Similarly, for Scenario 2 (partial backfill to above the pre-mining groundwater level plus 5 m), the results indicate that there would be groundwater movement from the partially backfilled final landform to the Isaac River alluvium, as well as towards the residual voids at the Olive Downs Project.

Scenario 3 (covering the coal seams) limits groundwater movement to within the Project area.

If one of the alternative final landform scenarios is adopted for Project, it is recommended that further analysis of the downstream impacts associated with the outflow of saline water from the final landform to the environment is undertaken by Whitehaven WS.

4 Closing

We trust the information contained within this memorandum meets your requirements. Please do not hesitate to contact Derwin Lyons with any further queries.

Checked/
Authorised by: BMR/DL

5 References

SLR, 2022. Winchester South Project Groundwater Impact Assessment. Prepared for Whitehaven Coal Ltd by SLR Consulting Australia Pty Ltd. 620.13245.10000-R01-v4.1, June 2022.

S. S. Papadopulos & Associates, Inc., 2018. mod-PATH3DU, version 2.1.2. Rockville, Maryland.

WRM, 2022. Winchester South Project Final Landform Alternatives Water Balance Analysis.

Appendix C

Final Landform Alternatives Surface Water Analysis

Winchester South Project

Final Landform Alternatives Water Balance Analysis

Whitehaven WS Pty Limited

0869-02-F4, 29 June 2022

Report Title	Winchester South Project, Final Landform Alternatives Water Balance Analysis
Client	Whitehaven WS Pty Limited
Report Number	0869-02-F4

Revision Number	Report Date	Report Author	Reviewer
4	29 June 2022	MGB	AMC

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Matthew Briody

Principal Engineer

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1 Introduction

The Winchester South Project (the Project) is located approximately 30 kilometres (km) south-east of Moranbah, in the Isaac Regional Council Local Government Area (LGA), within the Bowen Basin Coalfield, in Queensland. The Project involves the development of an open cut metallurgical coal mine in an existing mining precinct. Products would include metallurgical coal for the steel industry and thermal coal for energy production.

Whitehaven WS Pty Ltd (Whitehaven WS) is the proponent for the Project, and is a wholly owned subsidiary of Whitehaven Coal Limited. In 2021, Whitehaven WS submitted the Winchester South Project Environmental Impact Statement (the Draft EIS) for assessment under the *State Development and Public Works Organisation Act 1971* (SDPWO Act). The Draft EIS was placed on public notification by the Office of the Coordinator General (OCG) from 4 August 2021 until 15 September 2021. During and following this period, government advisory agencies, organisations and members of the public provided submissions on the Draft EIS to the OCG.

Subsequent to the public notification of the Draft EIS, Whitehaven WS reviewed the mine plan and mine schedule with the aim of reducing environmental impacts of the Project and challenging the Project final landform in response to comments raised in submissions. This review also considered new geological data, coal quality data and the outcomes of processing trials to further refine the mine plan.

On 3 December 2021, the Coordinator General formally requested (in accordance with section 34A of the SDPWO Act) Additional Information on the environmental effects of the Project and other matters relating to the Project. This analysis forms part of the Additional Information and provides responses to issues raised in submissions.

It should be noted that, in response to feedback from regulatory and community stakeholders, Whitehaven WS has reviewed the Project mine plan and sequence with the aim of reducing the number of residual voids in the final landform, which includes backfilling of the South Pit Void for the optimised final landform.

WRM Water & Environment Pty Ltd (WRM) has been engaged by Whitehaven WS to evaluate alternative final landform scenarios requested by regulatory and community stakeholders in their submissions. Three alternative final landform configurations have been considered in this analysis, in addition to the optimised final landform presented in Section 8 of the revised Surface Water and Flooding Assessment (WRM, 2022). The three alternative final landform scenarios are as follows:

- Scenario 1: Full backfill of the open cut pits to pre-mining levels.
- Scenario 2: Final landform with partial backfill of the open cut pits to 5 m above pre-mining groundwater levels.
- Scenario 3: Final landform with covering of exposed coal seams.

This analysis describes the methodology and modelling results for the alternative final landform scenarios.

2 Model setup and methodology

2.1 METHODOLOGY

The methodology for the modelling of the alternative final landform scenarios is consistent with the approach for the optimised final landform (outlined in WRM [2022] and was previously peer reviewed). A GoldSIM water balance model was used to simulate the residual void storage volumes and water levels. The residual void water volume is calculated at a daily time step as the sum of the direct rainfall to the pit lake surface, catchment runoff and groundwater inflows, less evaporation, groundwater outflows and, if applicable, beneficial use (e.g. pumped extraction).

2.2 ALTERNATIVE FINAL LANDFORM CONFIGURATIONS

Three alternative final landform configurations were considered, including:

- Scenario 1: The residual voids are completely backfilled to be free draining and there would be no residual void pit lakes under this scenario, however, an analysis of the water within the backfilled spoil for this final landform scenario (and potential to interact with the surrounding environment) is considered in SLR (2022).
- Scenario 2: The residual voids are partially backfilled to a level approximately 5 m above the pre-mining groundwater level at each residual void. This alternative configuration results in a significant reduction in the capacity of each residual void, and therefore significant changes to the overall residual void geometries.
- Scenario 3: The exposed coal seams within the residual voids are covered with waste rock/spoil, resulting in the highwall and end walls covered with a spoil buttress. This alternative configuration results in only minor changes to the geometry of the residual voids in comparison to the optimised final landform.

The alternative final landform surfaces for each alternative configuration are presented in Figure 2.1, Figure 2.2 and Figure 2.3.

2.3 CLIMATE INPUTS AND RAINFALL RUNOFF PARAMETERS

The climate inputs (rainfall and evaporation sequences) and rainfall runoff (Australian Water Balance Model [AWBM]) parameters are consistent with the simulation undertaken for the preferred optimised final landform (WRM, 2022).

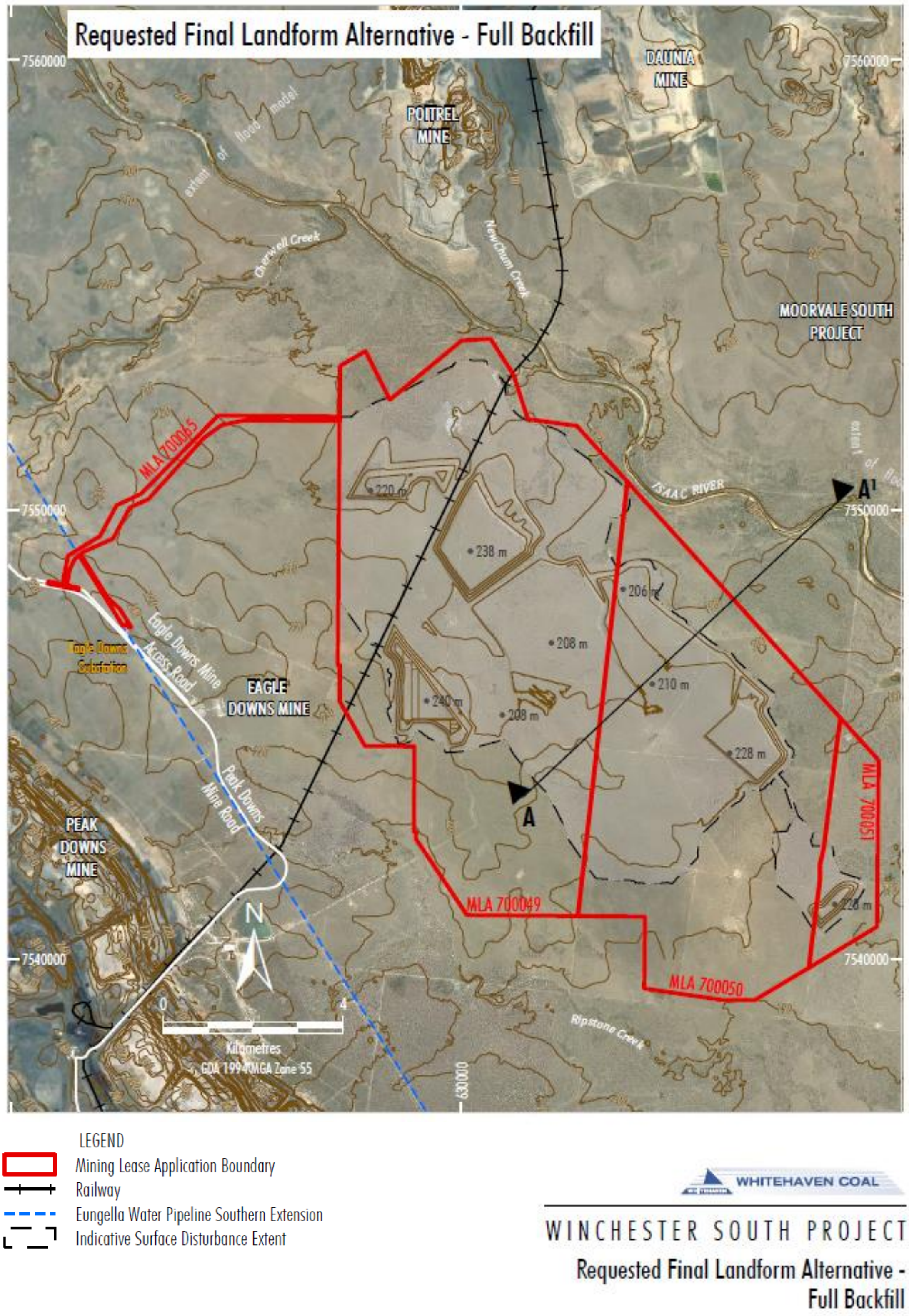

Figure 2.1 – Final landform configuration – Scenario 1

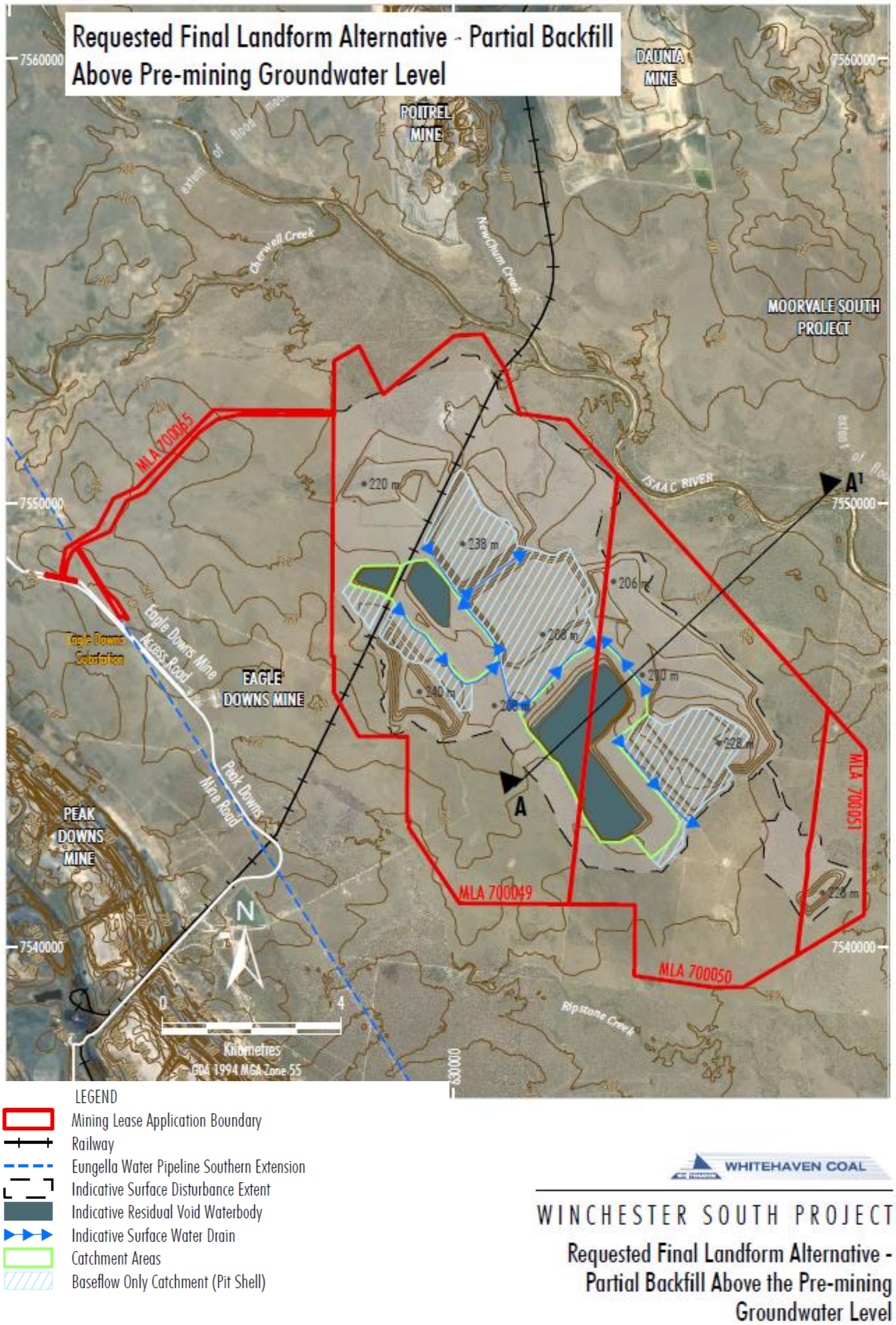

Figure 2.2 – Final landform configuration – Scenario 2

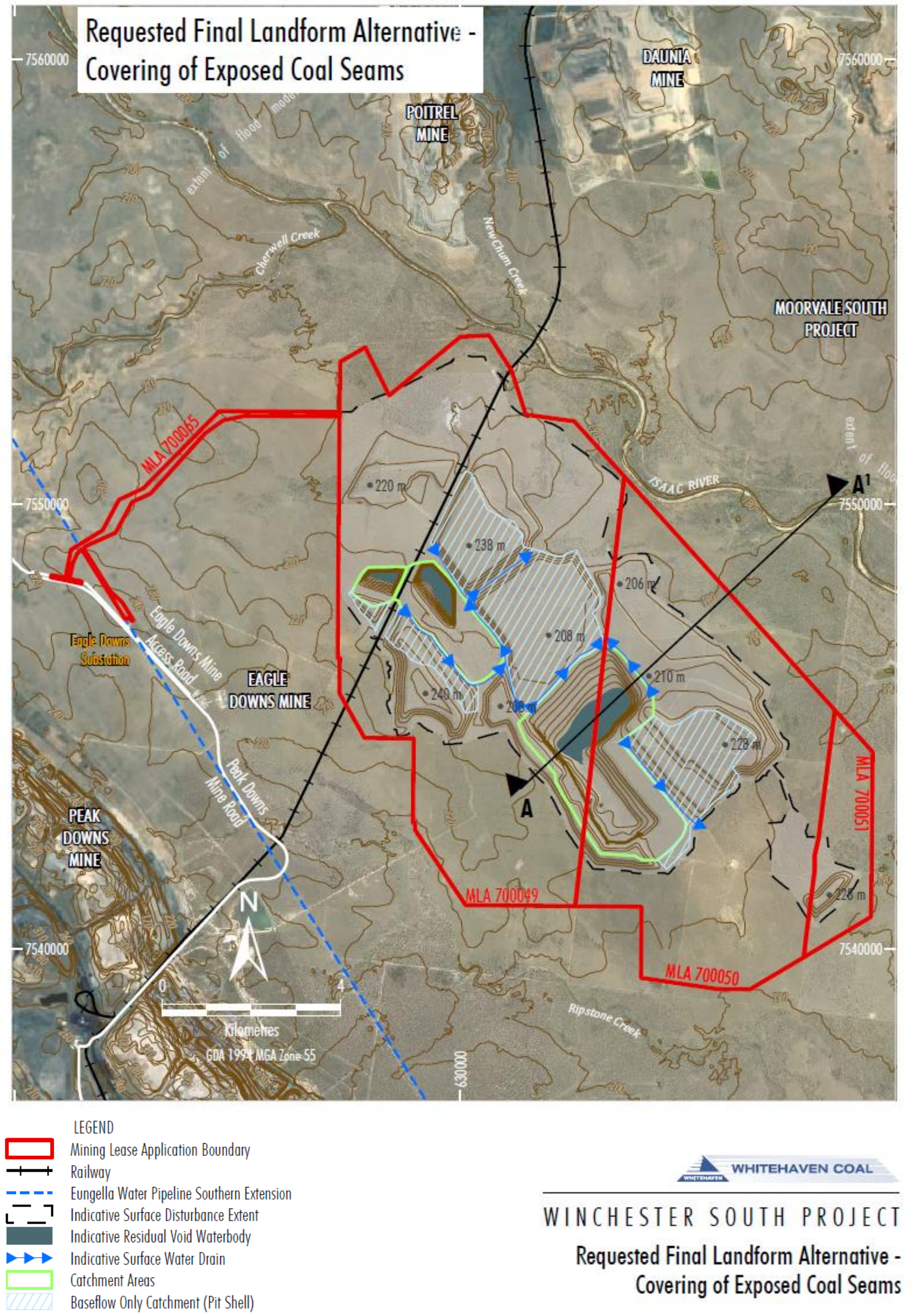

Figure 2.3 – Final landform configuration – Scenario 3

2.4 CATCHMENT AREAS

There are some slight differences to the adopted catchment areas for each alternative scenario, in comparison to preferred optimised final landform presented in the Additional Information due to the changes in the final landform surfaces. Table 2.1 outlines the catchment areas for the each of the final landform alternative scenarios, including the baseflow catchments. Scenario 1 has no catchment areas as the residual voids are completely backfilled and the final landform would be free-draining.

Table 2.1 – Catchment areas for EIS and alternative final landform scenarios

		Contributing surface catchment (ha)			Contributing baseflow catchment (ha)
Scenario	Residual Void	Spoil	Rehab	Total	Rehab
Optimised Final Landform	North-west Void	10.4	56.5	**66.9**	35.7
	West Void	35.2	278.6	**313.8**	156.9
	Main Void	233.5	748.8	**982.3**	1,435
Full Backfill	North-west Void	-	-	**-**	-
	West Void	-	-	**-**	-
	Main Void	-	-	**-**	-
Partial Backfill Above Groundwater Table	North-west Void	30.1	23.2	**53.3**	49.7
	West Void	86.0	237.9	**323.9**	148.6
	Main Void	457.3	401.9	**859.2**	1,435
Covering Coal Seams	North-west Void	9.3	67.2	**76.5**	26.3
	West Void	34.3	289.6	**323.9**	148.6
	Main Void	233.4	754.5	**987.9**	1,435

2.5 GROUNDWATER INFLOWS

Groundwater inputs into the water balance model were based upon information provided by SLR Consulting Pty Ltd (SLR). SLR provided a time series of groundwater inflow volumes for each of the residual voids, for each of the alternative final landform scenarios.

The groundwater inflows were split into the following components:

- Flow from the spoil adjacent to the residual voids; and
- Flows from the in-situ coal seams to the residual voids (e.g. via the highwalls and end walls).

2.6 WATER QUALITY INPUTS

Groundwater salinity has been applied to each of the groundwater inputs as follows:

- Inflows from the backfilled spoil: 1,012 microSiemens per centimetre (µS/cm) (based on the 90^{th} concentration from the geochemistry assessment for spoil) for all residual voids.
- Inflows from the rest of the pit (North-west Void and West Void): 8,400 µS/cm (based on the 50th percentile concentration from groundwater bore sampling data that targeted the coal seams and interburden near the North-west Void and West Void).
- Inflows from the rest of the pit (Main Void): 13,230 µS/cm (based on the median electrical conductivity (EC) of coal seam targeted groundwater samples between 2019 and 2020).

Assumed EC values for runoff from each sub-catchment type are outlined in Table 2.4. Note that for the pit floor, it was assumed that the coal basement is covered with a thick layer of spoil material.

Table 2.2 – Adopted EC values for sub-catchment types

Parameter	Spoil	Rehabilitated	Rehabilitated (baseflow)
EC (µS/cm)	520	300	300

2.7 BENEFICIAL USE

Initial modelling results indicate that the water quality in the residual voids for the optimised final landform (presented in the Draft EIS) and Scenario 3 (covered exposed coal seams) may be suitable for a beneficial use (e.g. cattle production).

For Scenario 1 (full backfill) the final landform does not provide for a water body. For Scenario 2 (partial backfill), the water quality would be highly saline and not be suitable for beneficial use, nor would it provide a reliable supply of water. Therefore, no beneficial use extraction was applied to Scenario 1 or Scenario 2.

Consistent with the preferred optimised final landform scenario, an annual extraction rate of 70 ML/year was applied across the residual voids for Scenario 3, at the following proportions:

- North-west Void – 15%
- West Void – 40%
- Main Void – 45%

3 Modelling results

3.1 SCENARIO 1 - FULL BACKFILL TO PRE-MINING LEVELS

As the open cut pits are fully backfilled under this scenario, pit lakes would not form and no residual void modelling is required. An analysis of the water within the backfilled spoil for this final landform scenario (and potential to interact with the surrounding environment) is considered in SLR (2022).

3.2 SCENARIO 2 - PARTIAL BACKFILL TO 5 M ABOVE PRE-MINING GROUNDWATER LEVELS

The residual void volumes and water levels in Scenario 2 for North-west Void, West Void and Main Void are presented in Figure 3.1, Figure 3.2 and Figure 3.3. Key model outcomes are as follows:

- All three residual voids form semi-permanent water bodies, with stored volumes fluctuating depending on the climatic conditions.
- North-west Void:
  - The residual void pit lake cycles between 188 metre Australian height Datum (mAHD) (empty) and 190.1 mAHD (250 megalitres [ML]) over the 500 year simulation, and does not reach a permanent pit lake equilibrium as water flows from the North-west Void to the West Void via the intervening strata.
- West Void:
  - The residual void pit lake cycles between 186 mAHD (empty) and 188.7 mAHD (1,150 ML) over the 500 year simulation, and does not reach an permanent pit lake equilibrium.
- Main Void:
  - The residual void pit lake cycles between 180 mAHD (empty) and 182.5 mAHD (5,150 ML) over the 500 year simulation, and does not reach an permanent pit lake equilibrium.
- The development of the pit lakes in the West Void and Main Void are delayed whilst the groundwater level in the surrounding spoil rises post-mining (i.e. water that flows into these residual voids initially percolates into the underlying spoil until it is saturated).

The residual void salt concentration and salt load for North-west Void, West Void and Main Void are presented in Figure 3.4, Figure 3.5 and Figure 3.6. Key model outcomes are as follows:

- The salinity of the pit lake for the North-west Void fluctuates between 380 µS/cm and up to 32,000 µS/cm, with salt lost due to groundwater outflows to the other residual voids.
- Once the West Void and Main Void begin to fill with water, the salinity of these residual voids fluctuates up to 510,000 µS/cm (the maximum solubility of salt in water at 25 degrees) as they undergo periodic wetting and drying cycles.

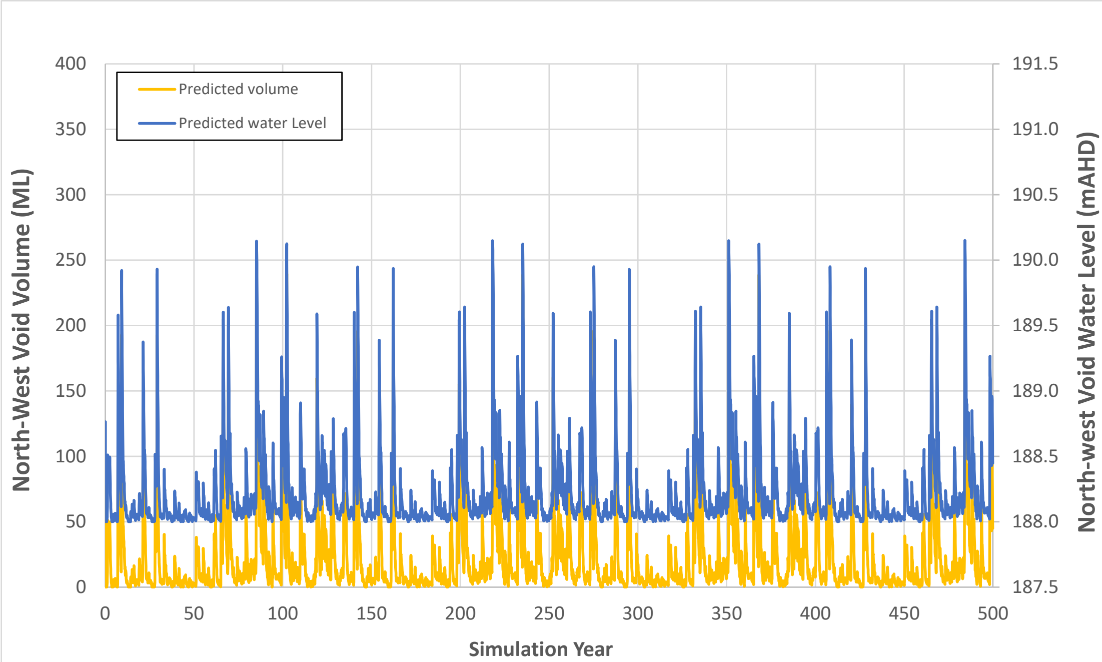

Figure 3.1 - Scenario 2 - Void volume and water level - North-west Void

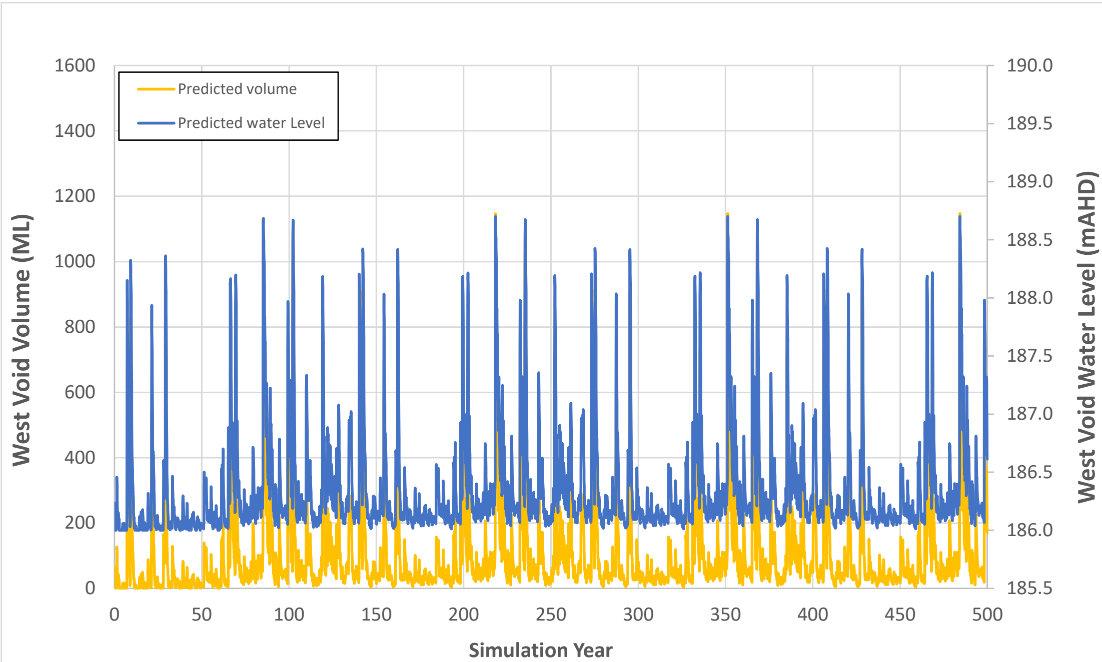

Figure 3.2 - Scenario 2 - Void volume and water level - West Void

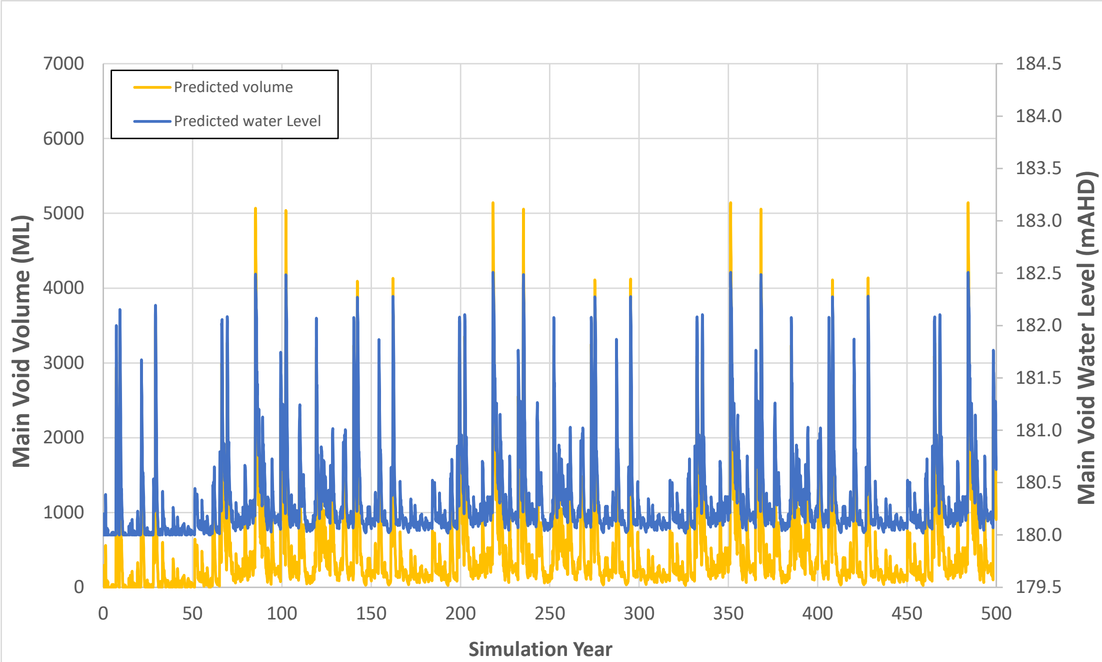

Figure 3.3 - Scenario 2 - Void volume and water level - Main Void

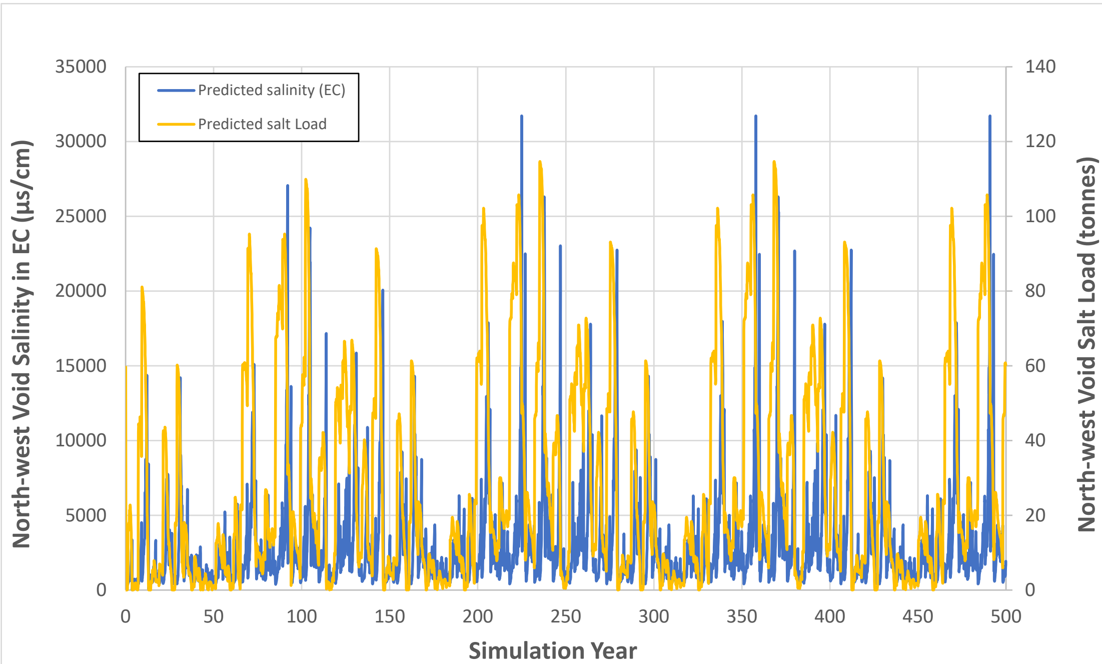

Figure 3.4 - Scenario 2 - Salt concentration and salt load - North-west Void

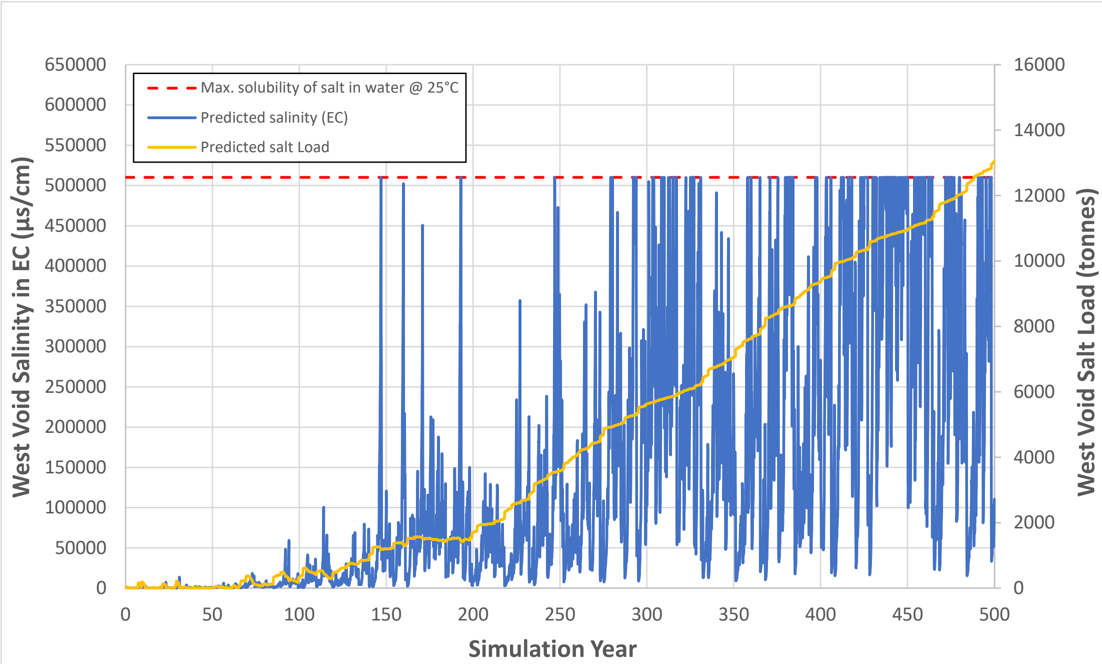

Figure 3.5 - Scenario 2 - Salt concentration and salt load - West Void

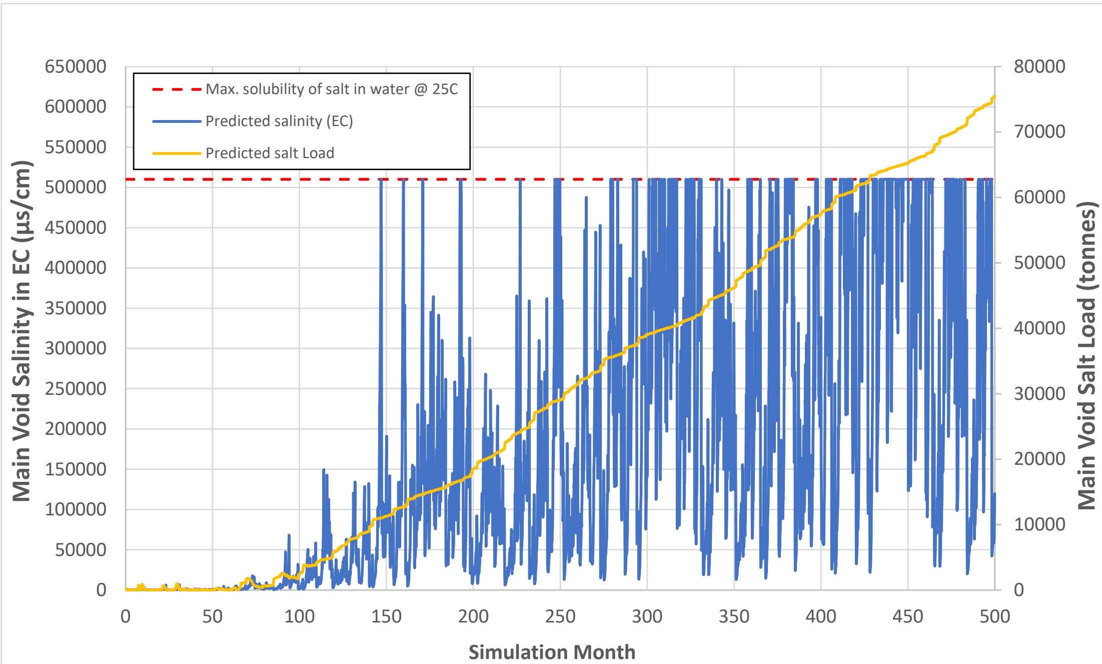

Figure 3.6 - Scenario 2 - Salt concentration and salt load - Main Void

3.3 SCENARIO 3 - COVERING OF EXPOSED COAL SEAMS

The residual void volumes and water levels in Scenario 3 for North-west Void, West Void and Main Void are presented in Figure 3.7, Figure 3.8 and Figure 3.9. Key model outcomes are as follows:

- North-west Void:
  - The residual void pit lake reaches equilibrium after the first 130 year climatic cycle, reaching an equilibrium level of between 120 mAHD (24 ML) and 135 mAHD (700 ML).
  - The residual void pit lake is able to provide 15% of the 70 megalitres per year (ML/year) beneficial use demand.
  - There is no outflow of water or salt into the surrounding groundwater, however salt is predicted to be lost through the beneficial use of the residual void water body.
- West Void:
  - The residual void pit lake reaches equilibrium after the first 130 year climatic cycle, reaching an equilibrium level of between 95 mAHD (920 ML) and 111 mAHD (4,160 ML).
  - The residual void pit lake is able to provide at least 40% of the 70 ML/year beneficial use demand.
  - There is no outflow of water or salt into the surrounding groundwater, however salt is predicted to be lost through the beneficial use of the residual void water body.
- Main Void:
  - The residual void pit lake reaches equilibrium after the first 130 year climatic cycle, reaching an equilibrium level of between 130 mAHD (14,800 ML) and 148 mAHD (29,700 ML).
  - The residual void pit lake is able to provide at least 45% of the 70 ML/year beneficial use demand.
  - There is no outflow of water or salt into the surrounding groundwater, however salt is predicted to be lost through the beneficial use of the residual void water body.

The residual void salt concentration and salt load for North-west Void, West Void and Main Void are presented in Figure 3.10, Figure 3.11 and Figure 3.12. Key model outcomes are as follows:

- North-west Void:
  - The salinity of the pit lake fluctuates significantly between wetter climatic conditions (around 2,000 to 6,000 µS/cm) and drier climatic conditions (up to 15,000 µS/cm).
  - The salt load in the pit lake reaches a peak load of around 1,100 tonnes during the 500 year simulation. The salt load decrease during periods when salt removal from the beneficial use demand exceeds the salt input from groundwater and runoff inputs.
  - In the long-term, the residual void acts as a perpetual sink and does not contribute water or salinity to the surrounding groundwater system.
- West Void:
  - The salinity of the pit lake fluctuates significantly between wetter climatic conditions (around 2,000 to 5,000 µS/cm) and drier climatic conditions (up to 12,500 µS/cm).
  - The salt load in the pit lake generally accumulates over time, reaching a peak load of around 10,000 tonnes during the 500 year simulation. The salt load does decrease at times when the salt removal from the beneficial use demand exceeds the salt input from groundwater and runoff inputs.
  - In the long-term, the void acts as a perpetual sink and does not contribute water or salinity to the surrounding groundwater system.

- Main Void:
  - The salinity of the residual void pit lake generally increases over time, fluctuating significantly between wetter climatic conditions (around 1,000 to 4,500 µS/cm) and drier climatic conditions (up to 6,400 µS/cm).
  - The salt load in the residual void pit lake generally accumulates over time, reaching a peak load of around 69,000 tonnes during the 500 year simulation. The salt load does stabilise at times when the salt removal from the beneficial use demand exceeds the salt input from groundwater and runoff inputs.
  - In the long-term, the residual void acts as a perpetual sink and does not contribute water or salinity to the surrounding groundwater system.

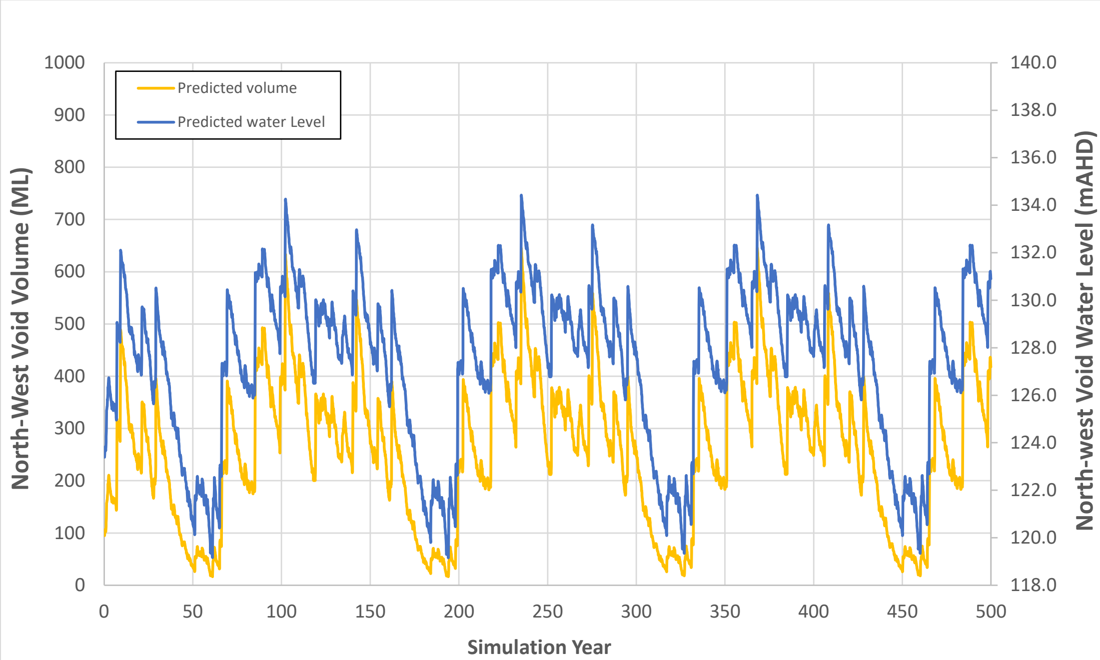

Figure 3.7 - Scenario 3 - Void volume and water level - North-west Void

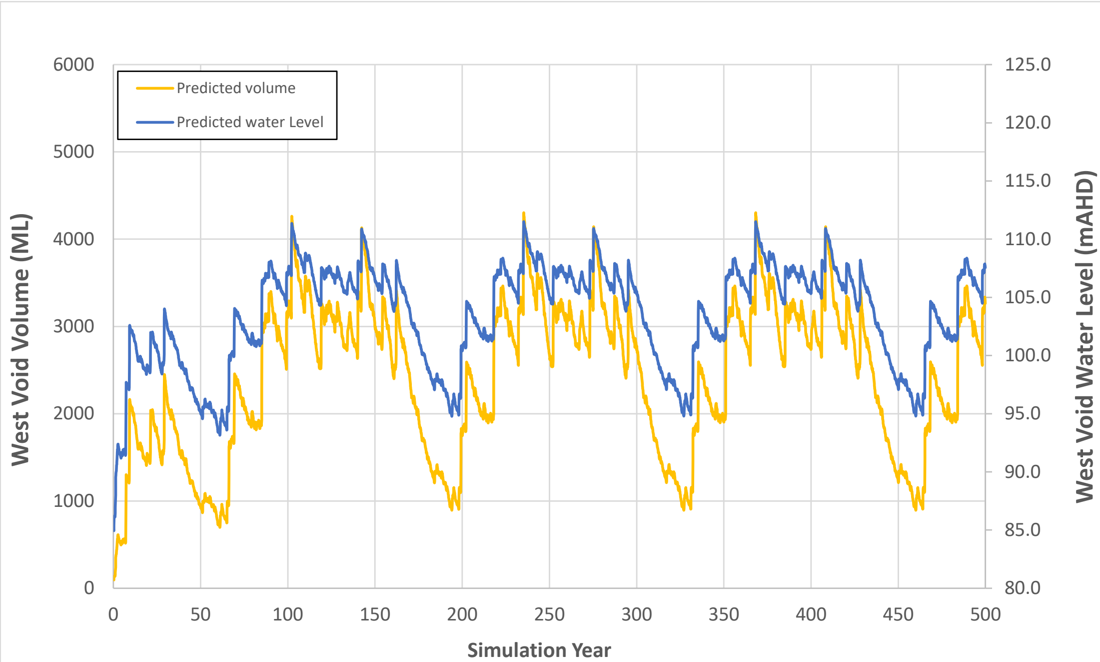

Figure 3.8 - Scenario 3 - Void volume and water level - West Void

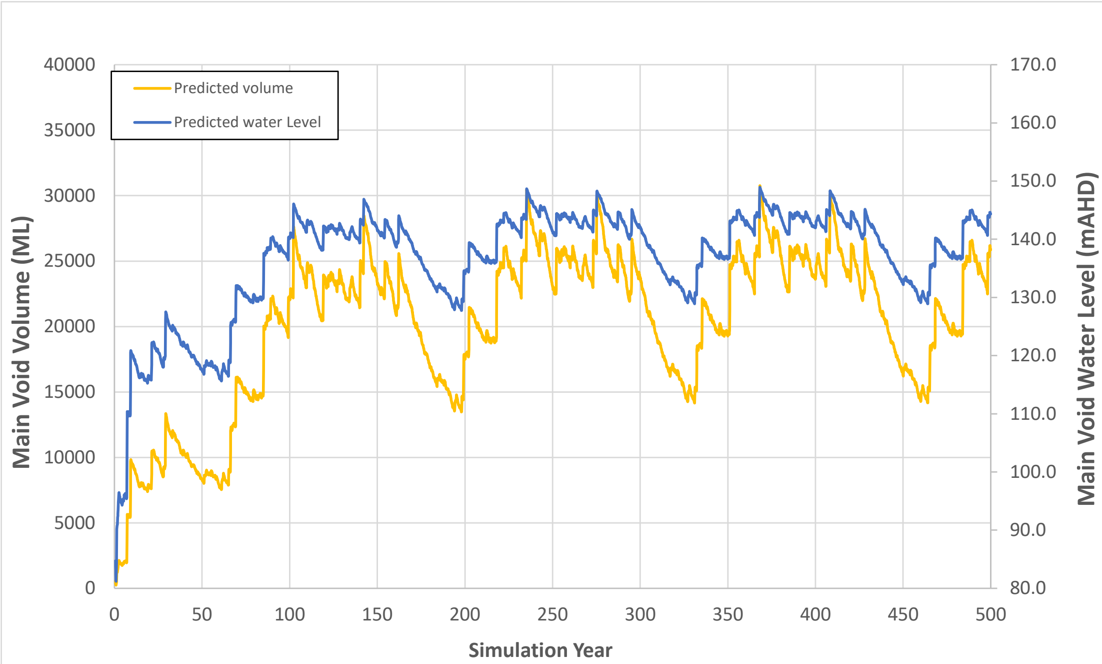

Figure 3.9 - Scenario 3 - Void volume and water level - Main Void

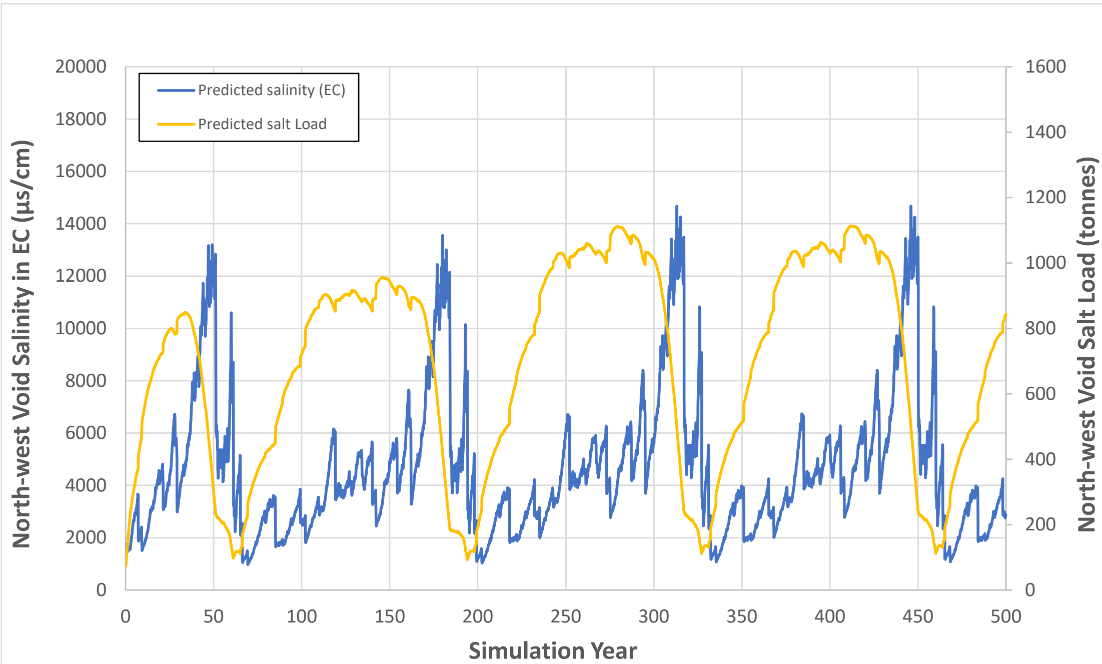

Figure 3.10 - Scenario 3 - Salt concentration and salt load - North-west Void

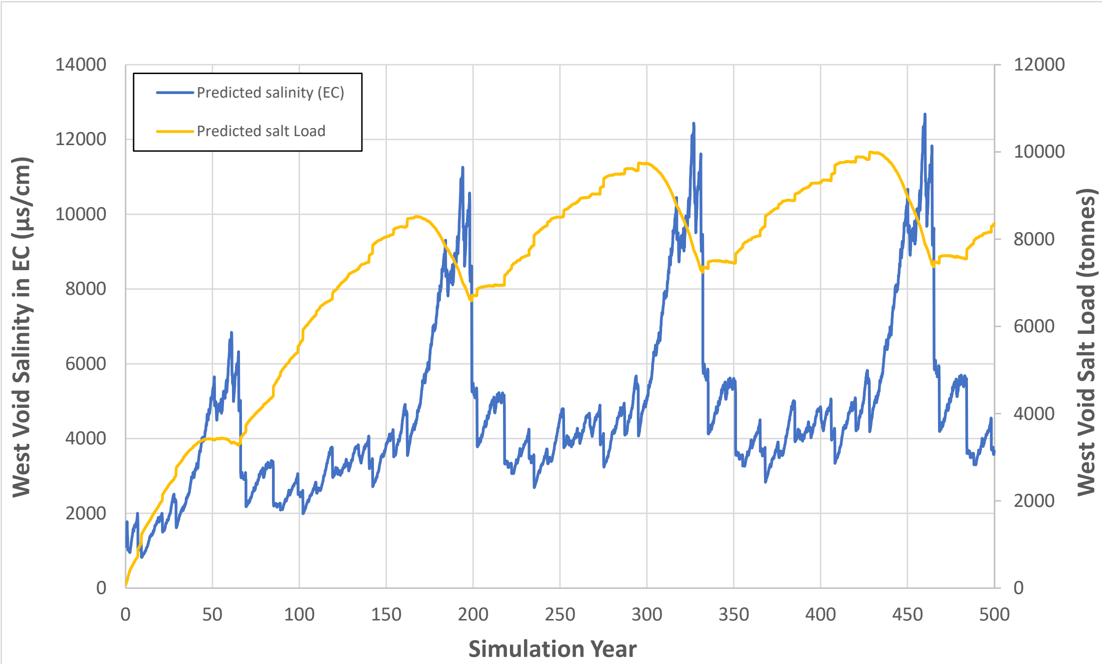

Figure 3.11 - Scenario 3 - Salt concentration and salt load - West Void

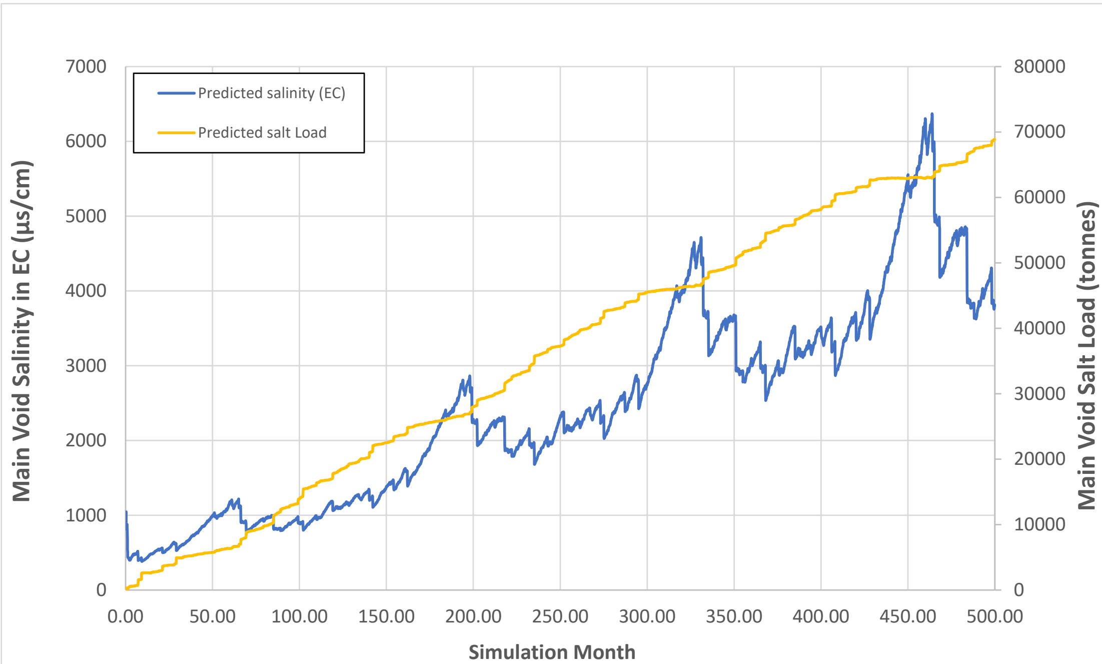

Figure 3.12 - Scenario 3 - Salt concentration and salt load - Main Void

4 Impact of alternative final landforms on stream flows

At the completion of mining, permanent drainage of waste rock emplacement areas would be installed to minimise capture of surface runoff into the residual voids in general accordance with the configuration for each scenario shown in Figure 2.1, Figure 2.2 and Figure 2.3. The final landform would be rehabilitated and allowed to drain back to the Isaac River and Ripstone Creek.

For the optimised final landform proposed in the Additional Information, a residual area of approximately 13.7 square kilometres (km^2) is predicted to drain to the residual voids, resulting in the following impacts on downstream waterway catchment area:

- The catchment draining to the Isaac River (to the Isaac River/Ripstone Creek confluence) would reduce by around 13.7 km^2 (compared to pre-mining conditions), a decrease of less than 0.3%.
- The catchment draining to Ripstone Creek would reduce by around 4.3 km^2 (compared to pre-mining conditions), a decrease of around 1.5%.
- The loss of catchment flows in the Isaac River and Ripstone Creek would be indiscernible, and as such the potential impact on water quantity in Isaac River and Ripstone Creek due to the optimised final landform is considered negligible.

The residual catchment draining to the residual voids for the alternative final landform scenarios is summarised in Table 4.1.

Table 4.1 – Post-mining landform - captured catchment area for alternative scenarios

Receiving waters	Pre-mining named watercourse catchment area (km^2)	Catchment area captured by final landform (km^2)	Reduction in named watercourse catchment area (%)
Scenario 1			
Isaac River	5,166	-	0%
Ripstone Creek	286	-	0%
Scenario 2			
Isaac River	5,166	8.9	0.2%
Ripstone Creek	286	3.5	1.2%
Scenario 3			
Isaac River	5,166	9.5	0.2%
Ripstone Creek	286	4.4	1.5%

In comparison to the optimised final landform as presented in the Additional Information:

- Scenario 1 – the fully backfilled and free-draining final landform alternative is predicted to result in no loss of catchment area to the Isaac River and Ripstone Creek in perpetuity.
- Scenario 2 – The reduction in catchment area for both Isaac River and Ripstone Creek is predicted to be slightly less than the optimised final landform in perpetuity, at 0.2% and 1.2%, respectively (a difference of 0.1% and 0.3%, respectively).
- Scenario 3 - The reduction in catchment area for both Isaac River and Ripstone Creek is predicted to be similar to the optimised final landform in perpetuity, at 0.2% and 1.5%, respectively (a difference of 0.1% and 0%, respectively).

In conclusion, the captured catchment areas for the scenarios would be slightly reduced in comparison to the optimised final landform, but the potential changes in impact to stream flows in the Isaac River and Ripstone Creek would most likely be indistinguishable, especially in consideration of the overall catchments for these water sources.

5 References

SLR, 2022 — ‘*Winchester South Project – Winchester South Project – Final Landform Alternatives Groundwater Analysis Memo*, June 2022.

WRM, 2022 — ‘*Winchester South Project - Surface Water and Flooding Assessment*’, WRM Water & Environment, June 2022