NEW HOPE
GROUP

G.4.5 Groundwater Numerical Modelling Report

New Acland Coal Mine Stage 3 Project
Environmental Impact Assessment

GROUNDWATER NUMERICAL MODELLING REPORT

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New Acland Revised Stage 3 Project Environmental Impact Statement

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1. Background

SKM was engaged by the New Hope Group in 2008 to develop a groundwater flow model of the New Acland mine to help estimate groundwater impacts as required by Environmental Impact Statement (EIS) in support of the planned Stage 3 mine expansion. Details of the model development and results are provided in the previous Stage 3 EIS and supporting documentation.

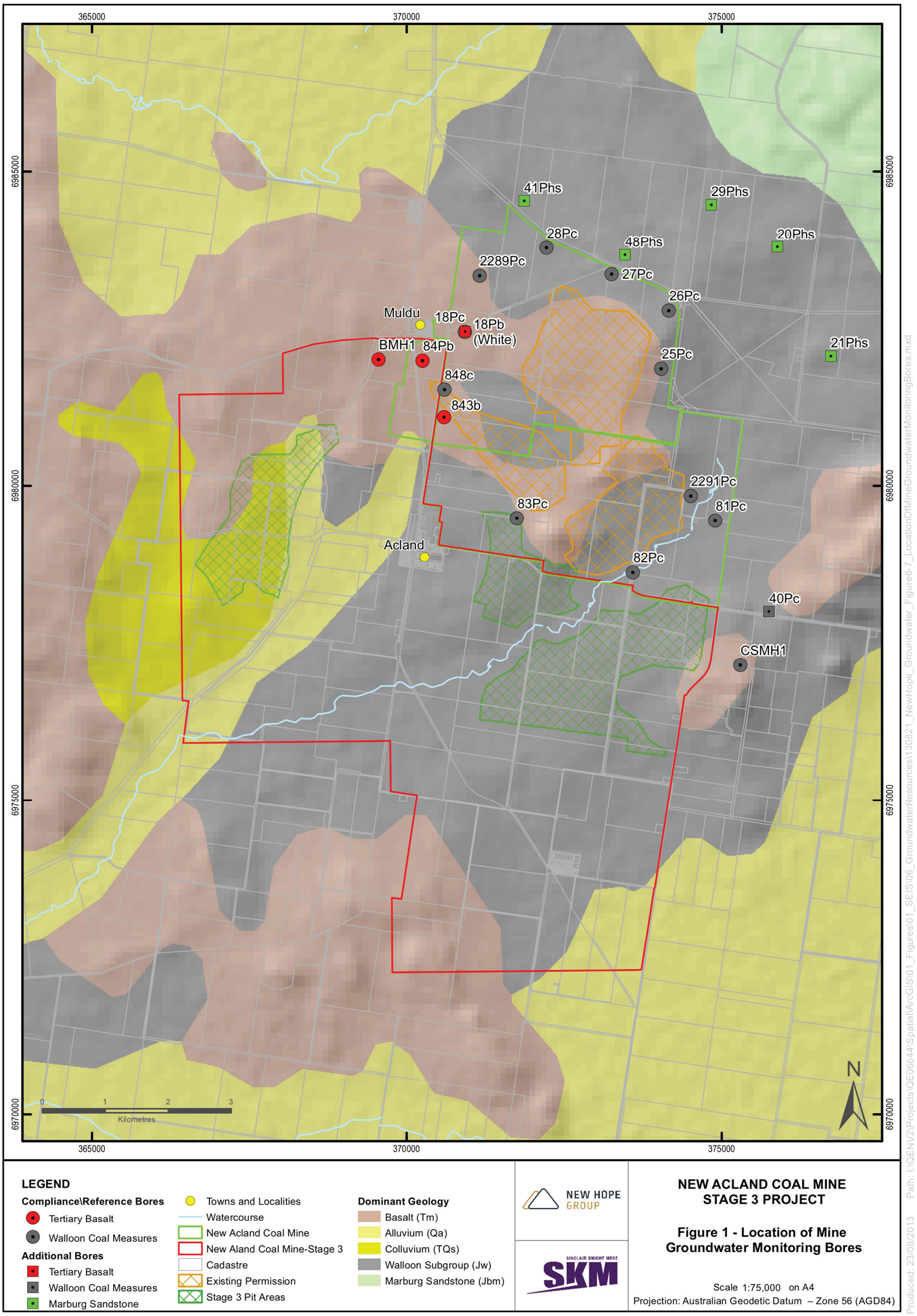
During 2012, the New Hope Group significantly modified the Stage 3 mine expansion to meet public and government expectations. As a result, a revised Project is now under evaluation as part of a new EIS. The proposed mining plans were changed as part of the revised Project, and therefore, the existing groundwater model has been revised and upgraded to provide estimates of potential groundwater impacts that may arise from operation of the revised Project.

The existing groundwater model was calibrated in steady state mode using information obtained prior to 2008. At this time, mining had not generated any observed drawdown impacts in the monitoring bore network. Recent observations of groundwater inflows to the mining pits and groundwater head responses to mining observed in monitoring bores provide an opportunity to undertake a transient calibration which has improved the confidence with which predictions can be made.

This report describes the upgrades made to the model as part of the revised Project, including the recalibration work that has been recently undertaken for the New Acland Mine. It also describes the use of the model in a predictive mode as an estimator of future pit inflows and the associated drawdown impacts that may be expected as mining progresses.

Figure 1 is a map showing the current mining leases, the surface geology and the existing Mine monitoring bore network (including bores located on neighbour's properties).

- **Figure 1 Location of mining pit and nearby observation bores**



2. Objectives

The objectives associated with the upgrade and revision of the groundwater model are:

1) to estimate groundwater inflows to revised Project; and
2) to estimate the potential groundwater impacts that may arise from dewatering by the revised Project.

3. Hydrogeological Conceptualisation

The revised Project site is situated in the western portion of the Clarence-Moreton Basin and is located approximately 15 km north of the township of Oakey in southeast Queensland. The Walloon Coal Measures within the Clarence-Moreton Basin underlie the revised Project site and regionally contain a coal resource of over 800 million tonnes.

The revised Project site is located in undulating terrain that spans three catchments. Runoff from the majority of the revised Project site drains to Lagoon Creek. Spring and Doctors Creeks receive minor runoff from the revised Project site. Lagoon Creek flows into Oakey Creek which is part of the larger Condamine River Catchment.

3.1 Hydrogeology

The geology of the revised Project site in relation to groundwater impacts from mining comprises four main formations, which are described below.

3.1.1 Quaternary Deposits

Quaternary deposits consist of recent alluvium (e.g. clay, silt, sand and gravel) deposited by creeks and rivers. Within the revised Project area, these deposits are likely to occur in association with Lagoon Creek. The nearest alluvial deposit with significant groundwater supplies is associated with Oakey Creek; approximately 15 km southeast of Acland township.

3.1.2 Tertiary Basalt

The Tertiary Basalt unconformably overlies the Walloon Coal Measures in several localities in the Acland area. Remnants of Tertiary age basalt flows from the hill tops in the Acland area occur as low lying horizontal continuous flows. The presence of weathered basalt below fresh basalt, in combination with relict soil profiles and sedimentary layers, indicate that there has been a succession of basalt flows in the Acland area.

The Tertiary Basalt aquifer consists of olivine basalts and where present varies in thickness from 1 m to 90 m. The Tertiary Basalt aquifer is interbedded with clay which has the potential to act as an aquitard. There is a minor outcrop of the Tertiary Basalt aquifer in the northern section of the revised Project site.

3.1.3 Walloon Coal Measures

The Walloon Coal Measures comprise shale, siltstone, carbonaceous mudstone, minor sandstone and coal layers. This geological unit outcrops over much of the revised Project site with the coal seams being the principal conduit for groundwater. Few wells that access the coal measures at the Mine and revised Project sites are able to deliver high yields of water. The mine reclaims some groundwater which has expressed to the mine pits from the Walloon Coal Measures for industrial purposes (e.g. coal washing, dust suppression). Neighbouring properties also use groundwater from the Walloon Coal Measures.

3.1.4 Marburg Sandstone

The Marburg Sandstone is up to 500 m thick and regionally dips to the southwest. The Marburg Sandstone is made up of poorly graded, coarse to medium-grained, feldspathic sandstone and fine-grained, well sorted quartzose sandstone. Minor carbonaceous siltstone, mudstone, coal and rare pebble conglomerate also occur within the Marburg Sandstone.

The Marburg Sandstone aquifer is a confined aquifer which occurs at a depth of approximately 150 m below ground level (bgl) within the revised Project site. Aquitards within and below the Walloon Coal Measures act as effective confining layers for the Marburg Sandstone aquifer.

3.2 Recharge

The aquifers are generally recharged by infiltration of rainfall where the aquifers outcrop. Average annual rainfall for the Oakey Bureau of Meteorology rainfall station amounts to 635 mm per year. Recharge rates differ for the various outcropping geological units in the revised Project site and its surrounds, with recharge rates typically being higher for more permeable formations (Quaternary Alluvium and Tertiary Basalt).

3.3 Discharge

The revised Project will consist of a series of mine pits and voids which will intersect the Quaternary Alluvial sediments and the Walloon Coal Measures. It is anticipated that these formations will be dewatered during mining to in-pit sumps.

The Quaternary Alluvial sediments are considered to be a minor aquifer within the revised Project Site and do not represent a significant groundwater resource. Due to its limited use and limited interaction with surface water, the risks associated with impacts to the Alluvial aquifer are minimal.

The Walloon Coal Measures are also considered to be limited in their capacity to store and transmit water. This observation is consistent with pumping tests carried out in the formation which have indicated transmissivities of between 7 and 40 m^2/d. However, it is recognised that most of the dewatering undertaken by the revised Project will occur in the coal measures and as such there are potential impacts associated with the Walloon Coal Measures aquifer. Also of interest is the potential for groundwater impacts to occur in the Tertiary Basalt and Marburg Sandstone aquifers, located above (where present) and below the coal measures respectively, as these may be in hydraulic connection to the Walloon Coal Measures aquifer that is directly impacted by the revised Project's mining activities.

4. Procedure

4.1 Calibration

A transient model calibration exercise was undertaken on the revised Project model to ensure that the model was able to replicate observed groundwater system behaviour, before being used to predict future mining impacts. The calibration aimed to demonstrate that the model is able to replicate the observed drawdown in observation bores and to replicate the inferred inflows to the pit (as detailed in the Waste Solutions Australia (2013) report).

Specific tasks undertaken were as follows.

1) Data collection. The New Hope Group provided SKM with updated mining data including:
   - pit floor elevation data for the current mine location and for the period 1 January 2011 to present;
   - estimated inflows to the pit;
   - pit outlines for the period since 1 January 2011 to present; and
   - pit floor elevations for the region of future mine expansion.
2) A transient calibration model was formulated with the updated model configuration and data.
3) Model parameters were initially manually revised to try to obtain an acceptable replication of observed drawdown and pit inflows.
4) The PEST software package was used to optimise the calibration.

The locations of monitoring bores used in calibration are presented in Figure 2.

4.2 Predictive scenario

The calibrated model was used to run a predictive scenario for the period of the revised Project's development and for 100 years following mine closure. The scenario assumes a mine progression as provided by the New Hope Group as shown in Figure 3. It also assumes no temporal variation in climatic stresses in the future. In this regard the model assumes average rainfall and evaporation in the future as estimated from historic climate observations.

A series of MODFLOW Drain cells (using the DRN Package) were assigned to the model to simulate the removal of water flowing into the mining pits throughout the life of the revised Project. These cells are activated and deactivated in a manner that replicates the mining schedule as illustrated in Figure 3. The drain elevations have been set to the base of the planned mining pits as determined from information provided by the New Hope Group and as shown in Figure 4.

For the post-closure period the final voids were represented as regions of high hydraulic conductivity and specific yield was set to 1.0 which are the appropriate settings for the simulation of a void in which water can accumulate. The voids can be seen in the final land form contours provided by New Hope Group (Figure 5). Rainfall and evaporation were assumed to be active in the final voids and these climatic stresses help to determine where the water level will form in each of the three voids.

Figure 2 Monitoring bores used in calibration

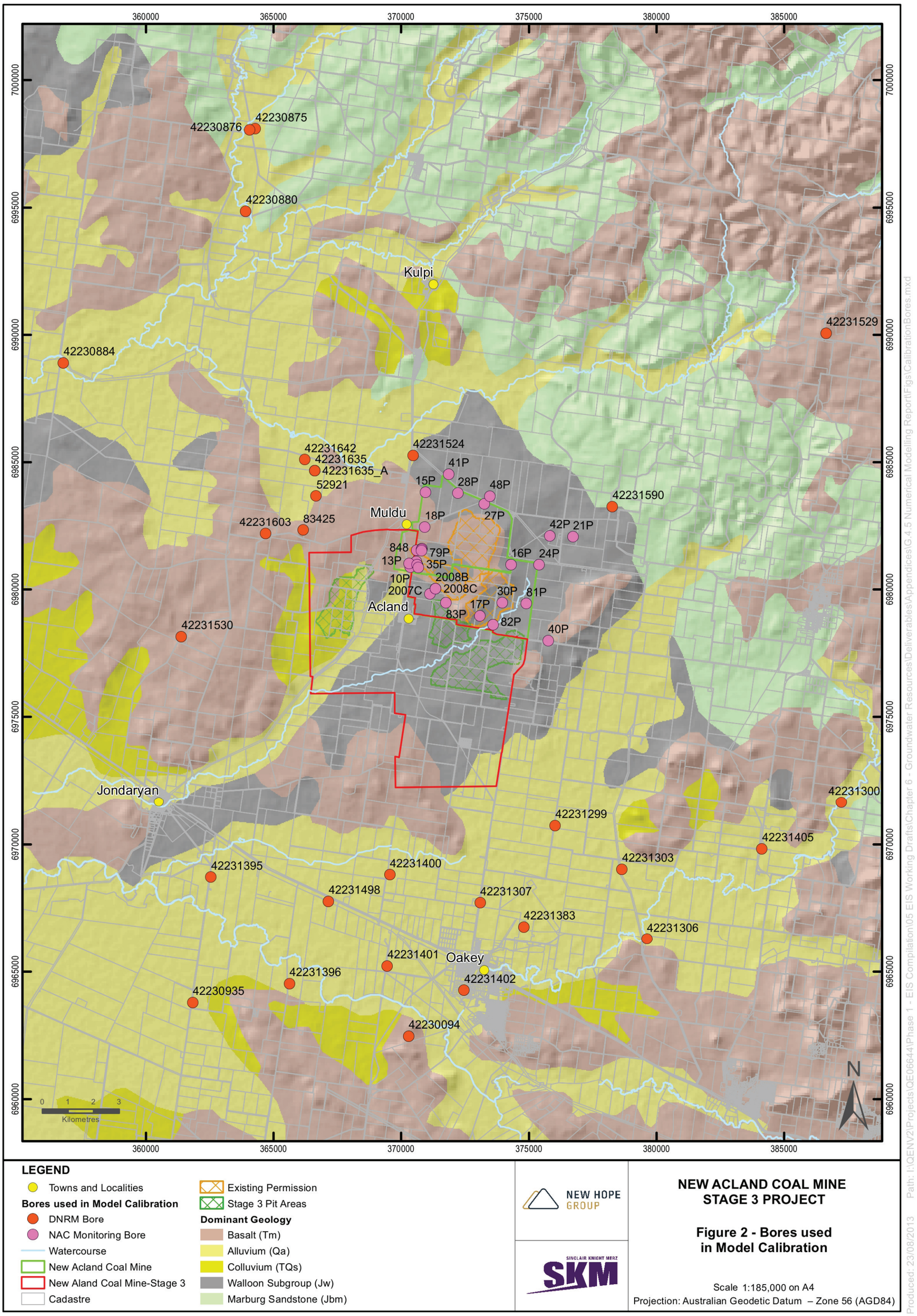


Figure 3 Planned mine progression for Stage 3

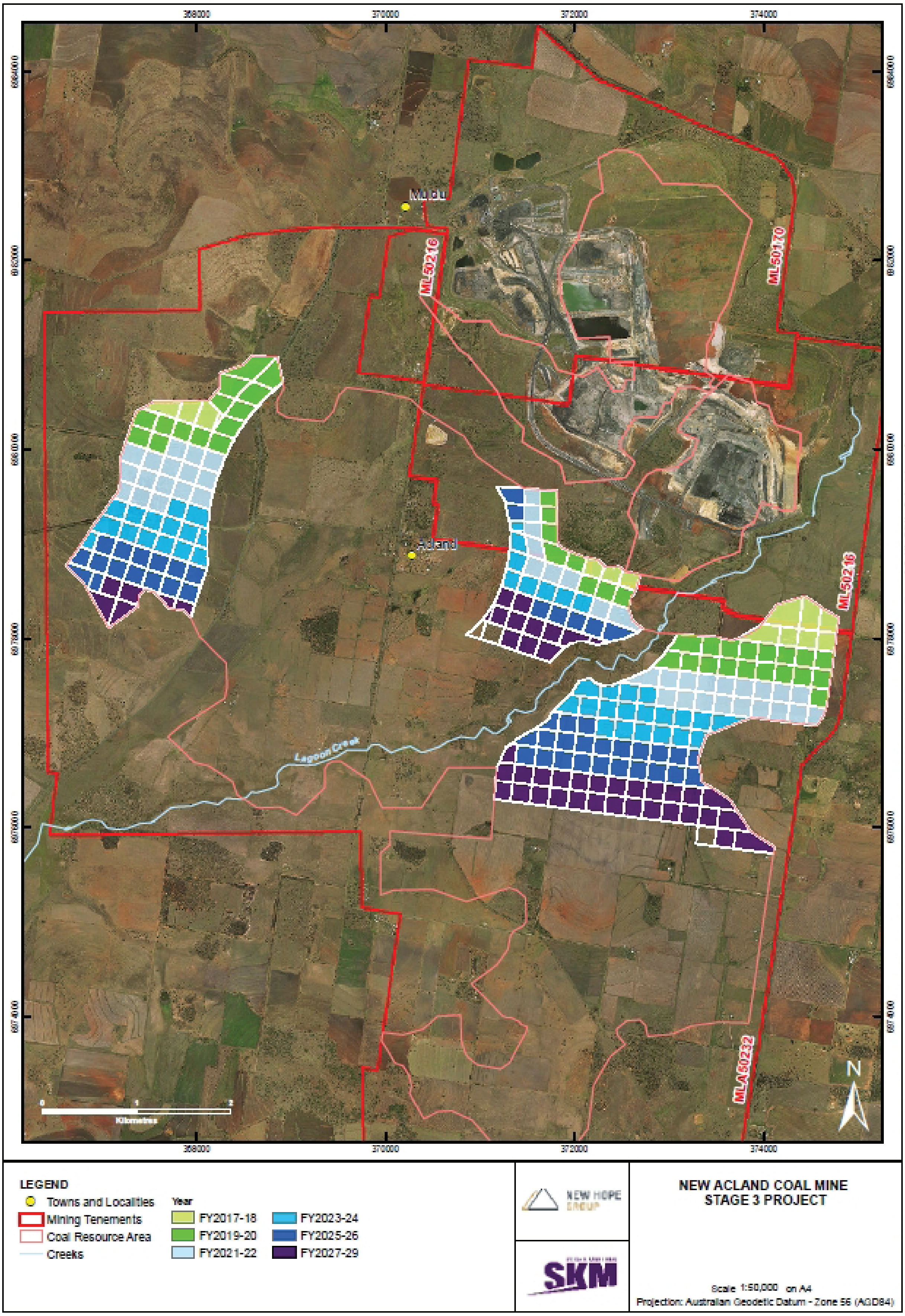


Figure 4 Pit floor mining horizons

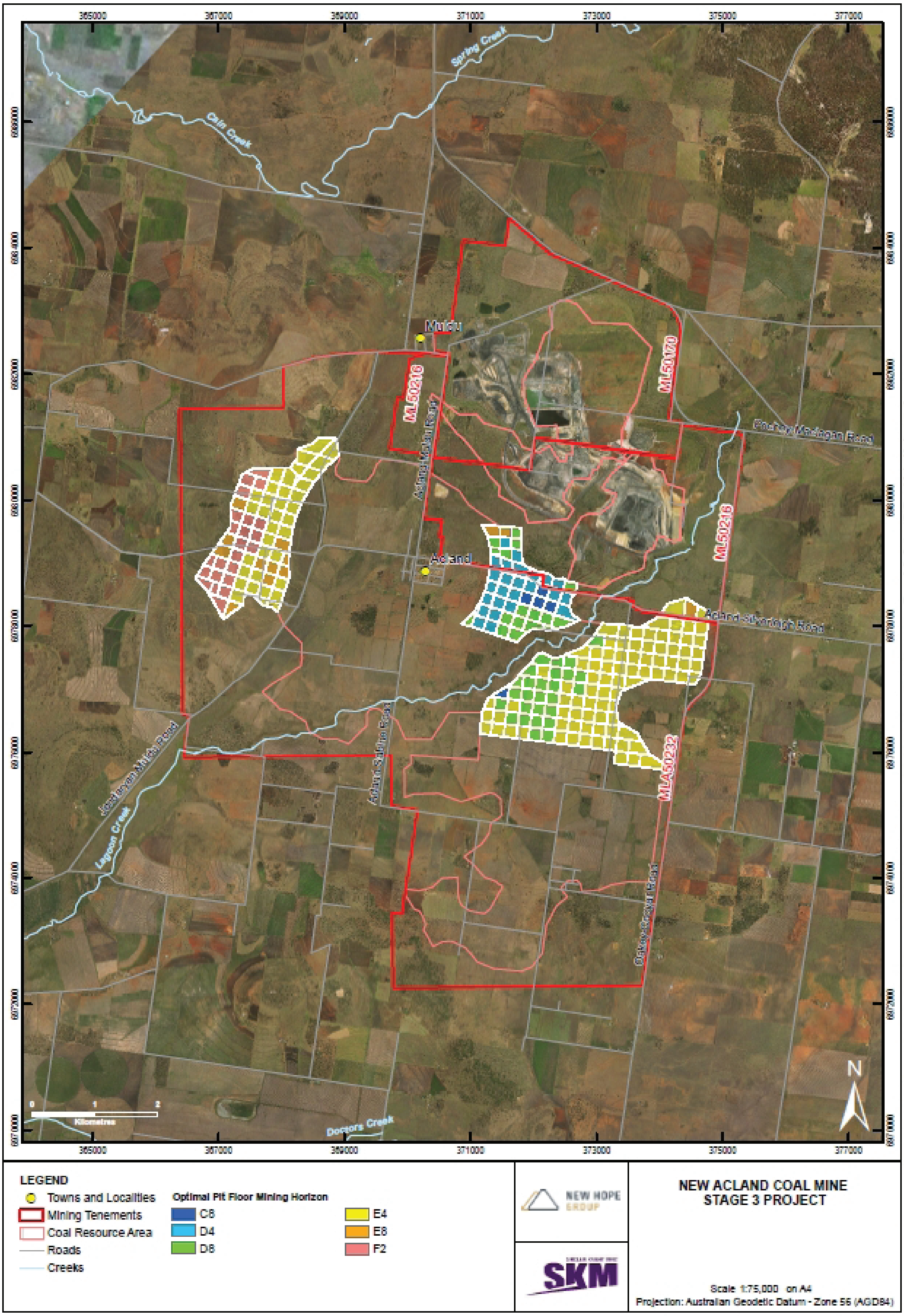
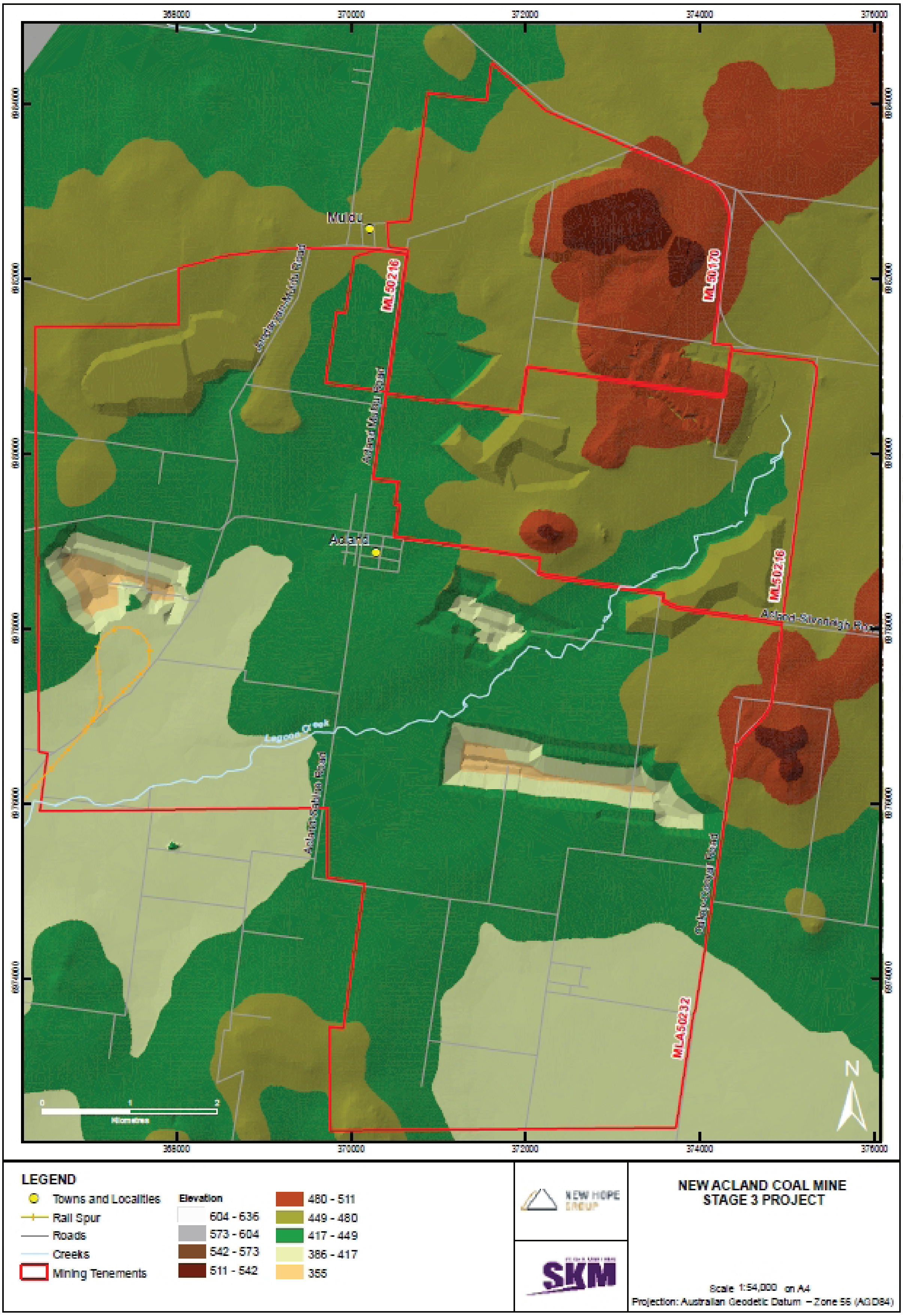


Figure 5 Location of final voids



5. Results

5.1 Calibration

Updated data collected for this investigation includes recent recordings of groundwater heads in observation bores located near the current mining pit (South Pit) and estimated constraints on pit inflows. Both data sets are included in Waste Solutions Australia (2013). Examples of the latest bore hydrographs measured in observation wells near the pit are illustrated in Figure 6 and estimated rates of water extracted by the Mine are shown in Figure 7.

Figure 6 Groundwater head observations near the mining pit

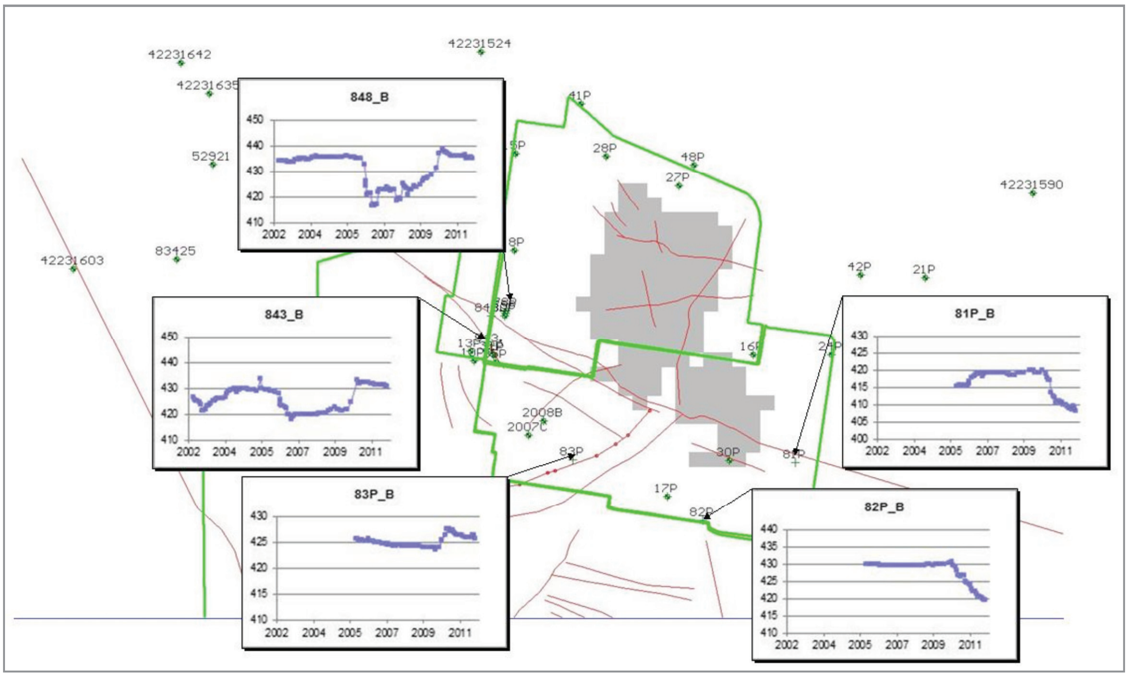
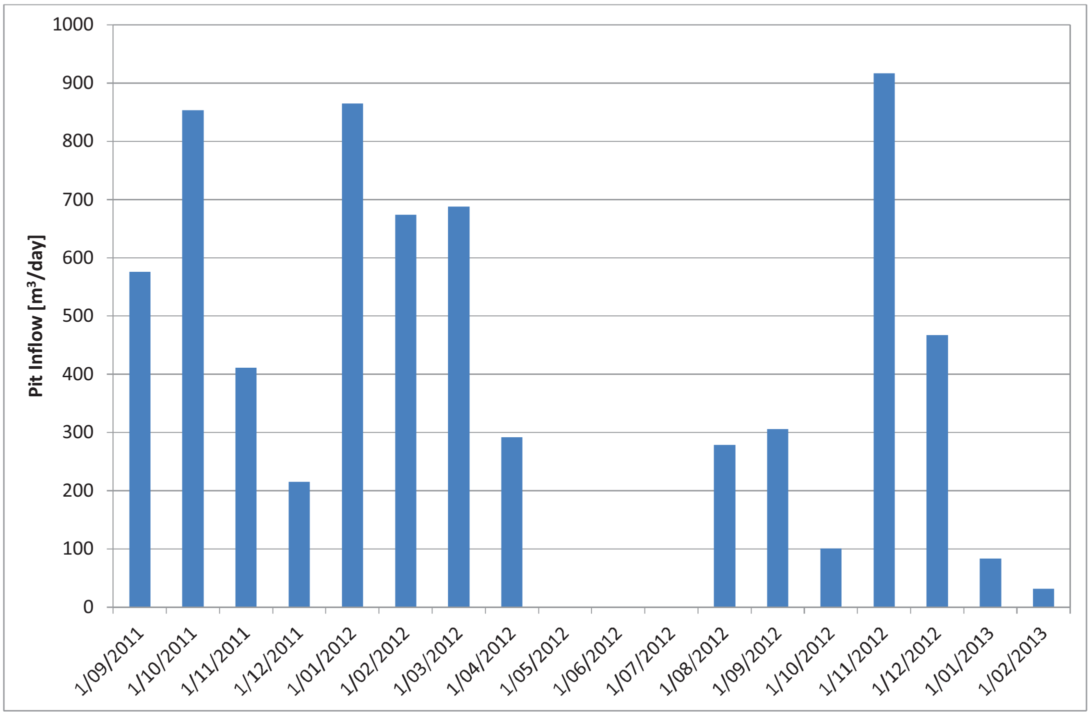


Figure 7 Estimated rates of water extracted from the mining pit



Initial runs of the revised model indicated that a minor response to mining was predicted. Modifications to the hydrogeological parameters controlling the formations' ability to transmit and store water were made in an effort to improve the model's ability to replicate the observed responses. Manual trial and error calibration runs were followed by PEST automated calibration. The following constraints were placed on the calibration procedure:

- Calibration was attempted without changing the hydrogeological zonation as defined by the interpreted distribution of the principal hydrogeological units present at the site.
- Calibration was attained through refinement of the following model parameters and features:
    - hydraulic conductivity in the horizontal and vertical dimensions;
    - anisotropy between the principal components of horizontal hydraulic conductivity (i.e. the kx/ky ratio);
    - specific yield;
    - recharge;
    - hydraulic conductivity assigned to the Modflow Walls used to replicate the influence of faults; and
    - conductance assigned to the Drain cells that define the flux of water into the mining pit.

The results of recalibration are illustrated by the hydrographs showing the model match to observed groundwater responses in the region of the pit. These results are presented in Figure 8. The calibration to observed heads can be quantified through estimation of the scaled RMS error for the goodness of fit (in this case 8%). The scatter plot and estimates of goodness of fit are shown in Figure 9. The model predicted inflows to the pit are presented in Figure 10 together with the calculated rate at which water has been removed from the pit. Note that the observed rate of water removal from the pit includes rainfall and runoff accumulation in the pit and hence should be greater than the actual groundwater inflow to the revised Project.

Figure 8 Calibration hydrographs

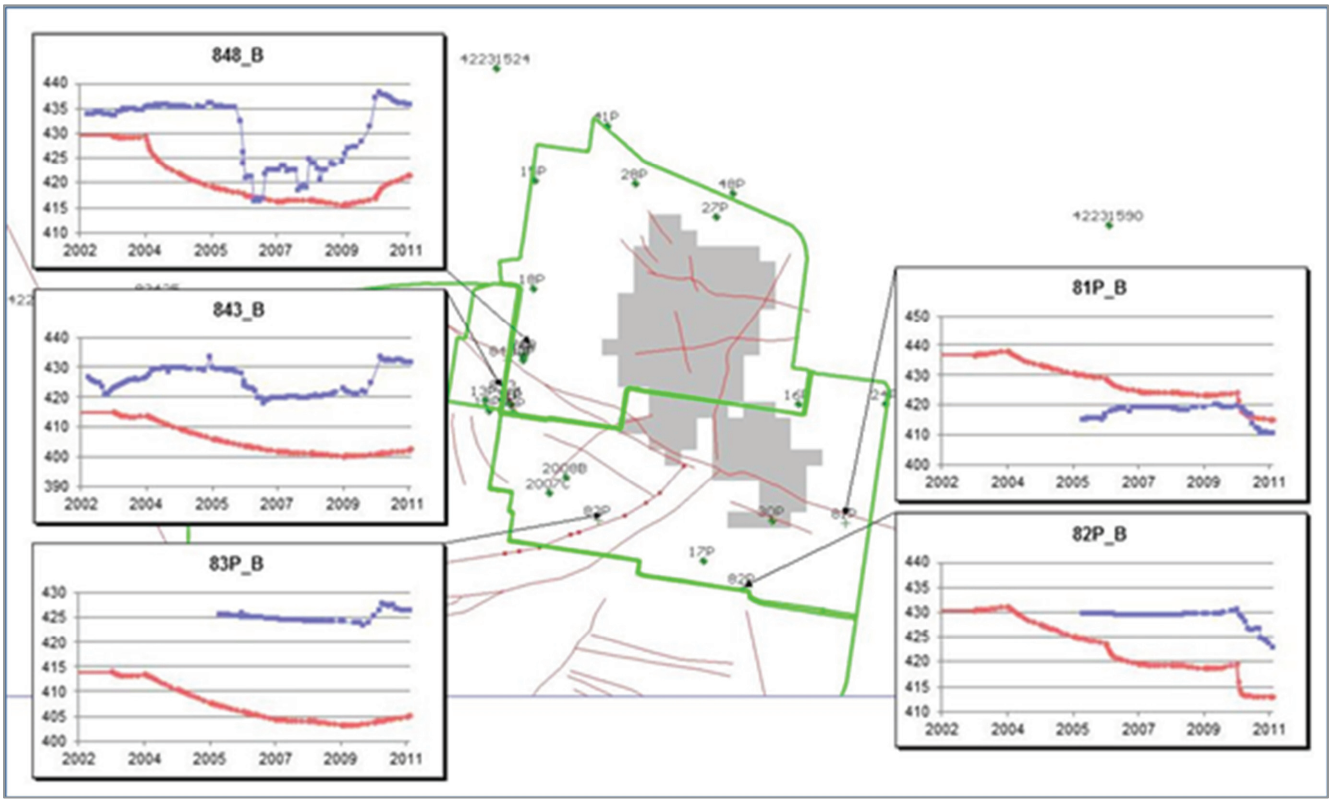


Figure 9 Calibration scatter plot

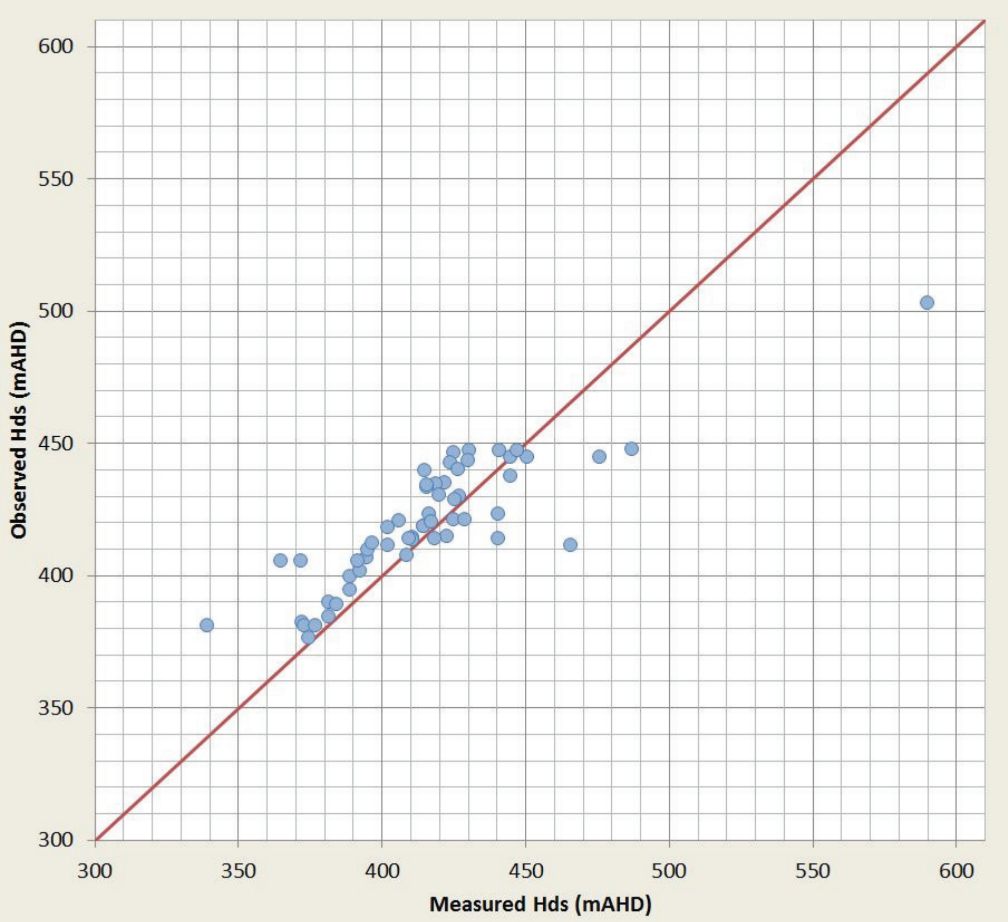
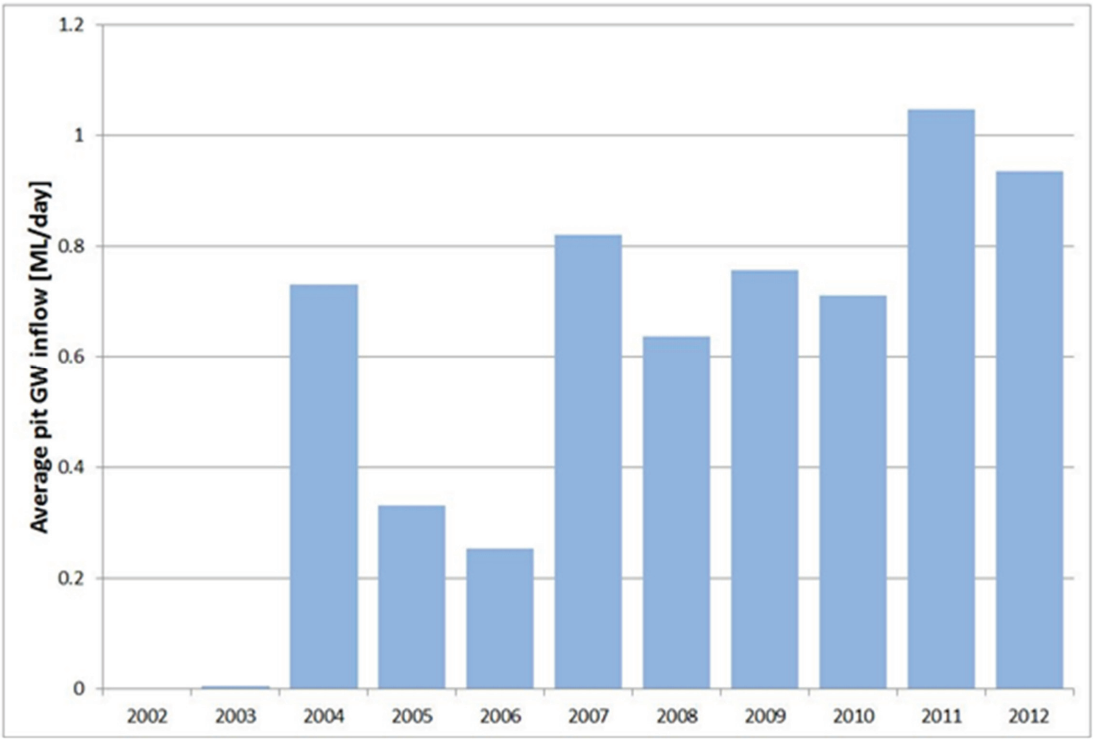


Figure 10 Predicted inflows to the pit



5.2 Description of the calibrated model

5.2.1 Domain and Grid

A fully transient three dimensional finite difference groundwater flow model of the revised Project and its surroundings has been developed in the MODFLOW2000 code using the Groundwater Vistas Version 6 Graphical User Interface. The model covers an area of 1,908 km^2 extending 36 km in the east-west direction and 53 km in the north-south. It is centred on the mine and has grid cells of 200 m by 200 m near the revised Project and 400 m by 400 m in outer areas. The model domain is shown in Figure 11.

The model consists of four layers with depth intervals that correspond to mapped or interpreted contacts between geological units and to the geometry of the mining pit. The layering structure is defined in Table 1. Note that individual layers include a number of different hydrogeological units. The distributions of hydrogeological units in each model layer are shown in Figure 12.

Table 1 Definition of model layers

Model layer	Elevation range	Hydrogeological units present
1	Ground surface to base of pits	Walloon Coal Measures, Tertiary Basalts, Quaternary Alluvium
2	Base of pits to base of the Basalt	Walloon Coal Measures, Tertiary Basalts, Quaternary Alluvium, Marburg Sandstone
3	45 m thickness	Lower part of the Walloon Coal Measures, Quaternary Alluvium, Marburg Sandstone
4	250 m thickness	Marburg Sandstone

5.2.2 Boundary conditions

The model provides for exchange of water with surrounding aquifers through the inclusion of Constant Head Boundary Conditions assigned to all external model boundaries.

Faulting is known to have occurred from mapping of underground mines in the Acland area and has also been interpreted from drilling results. Faulting is developed along two main trends, northeast-southwest and northwest-southeast. Folding has been interpreted from photogeological mapping, regional drilling and geological interpretation of the drilling results elsewhere in the Moreton Basin. Model calibration highlighted the fact that there are significant head differences measured in neighbouring groundwater wells suggesting localised areas of low permeability and associated compartmentalisation of the aquifers in the region of the revised Project.

In the model the Modflow Horizontal Flow Barrier Package was implemented in order to represent the compartmental nature of the groundwater system. This package simulates thin, vertical low-permeability geologic features that impede the horizontal flow of groundwater. Faults are approximated as a series of horizontal-flow barriers (or "walls") conceptually situated on the boundaries between pairs of adjacent cells in the finite-difference grid. Wall settings were adopted to represent the faulting present at the revised Project. The locations, alignment and permeability of the flow walls were derived from faults mapped by New Acland Coal Pty Ltd at the site and during the model calibration process. The walls were defined through Layer 1 to Layer 4. Figure 11 shows the location of the faulting (represented as green lines) assumed in the model.

Myall Creek is included as a Modflow Drain Boundary Condition which is a head dependent boundary condition that allows water to exit the model only. In other words it is modelled as a gaining creek and groundwater recharge through the creek beds is not allowed for in the model. This representation is consistent with the fact that it is an ephemeral water course that is not a consistent source of groundwater recharge throughout the year. Oakey Creek has been included in the model as a Modflow River Boundary Condition that allows groundwater to enter or exit the model depending on the predicted groundwater heads and those specified as the river stage. In this case the river stage is assumed to be 5 m below the ground surface and the river bottom 6 m below ground surface (i.e. the water in the river is 1 m deep).

Inflows to the mining pit are modelled as time varying Drain Boundary Conditions that drain each pit to the elevation of the pit floor. The locations of Drain Boundary Conditions are also shown in Figure 11.

Figure 11 Model Domain and Boundary Conditions

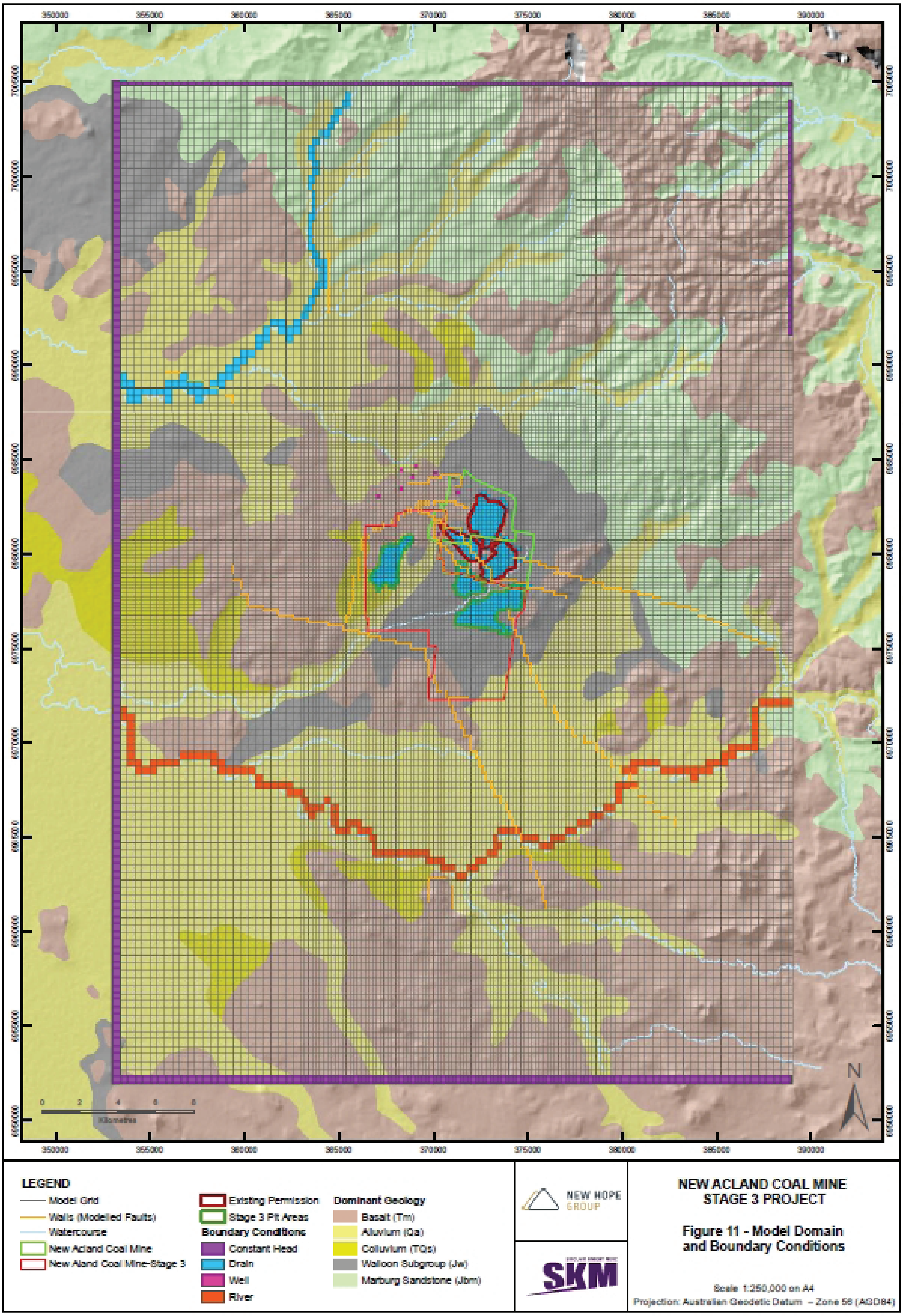
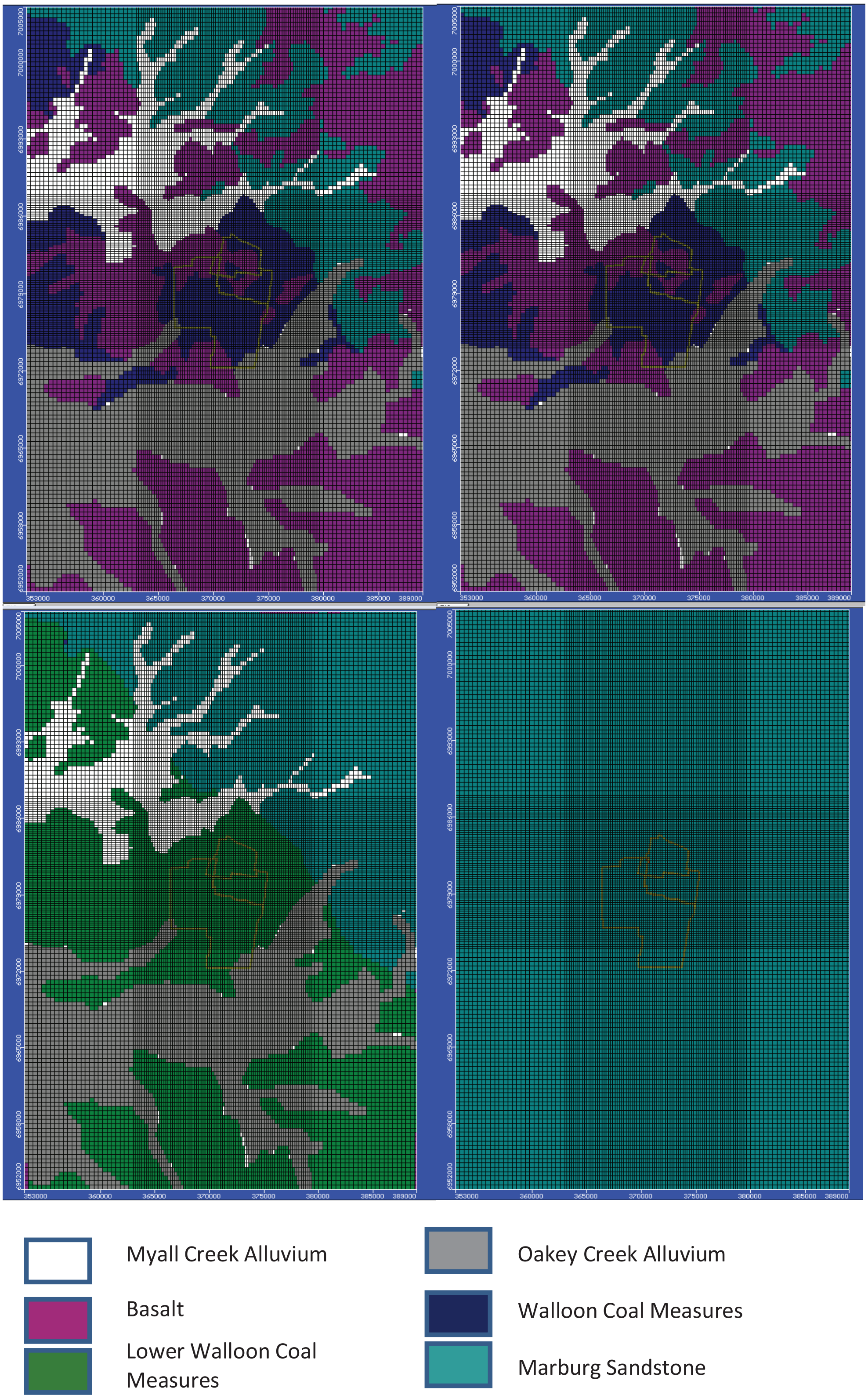


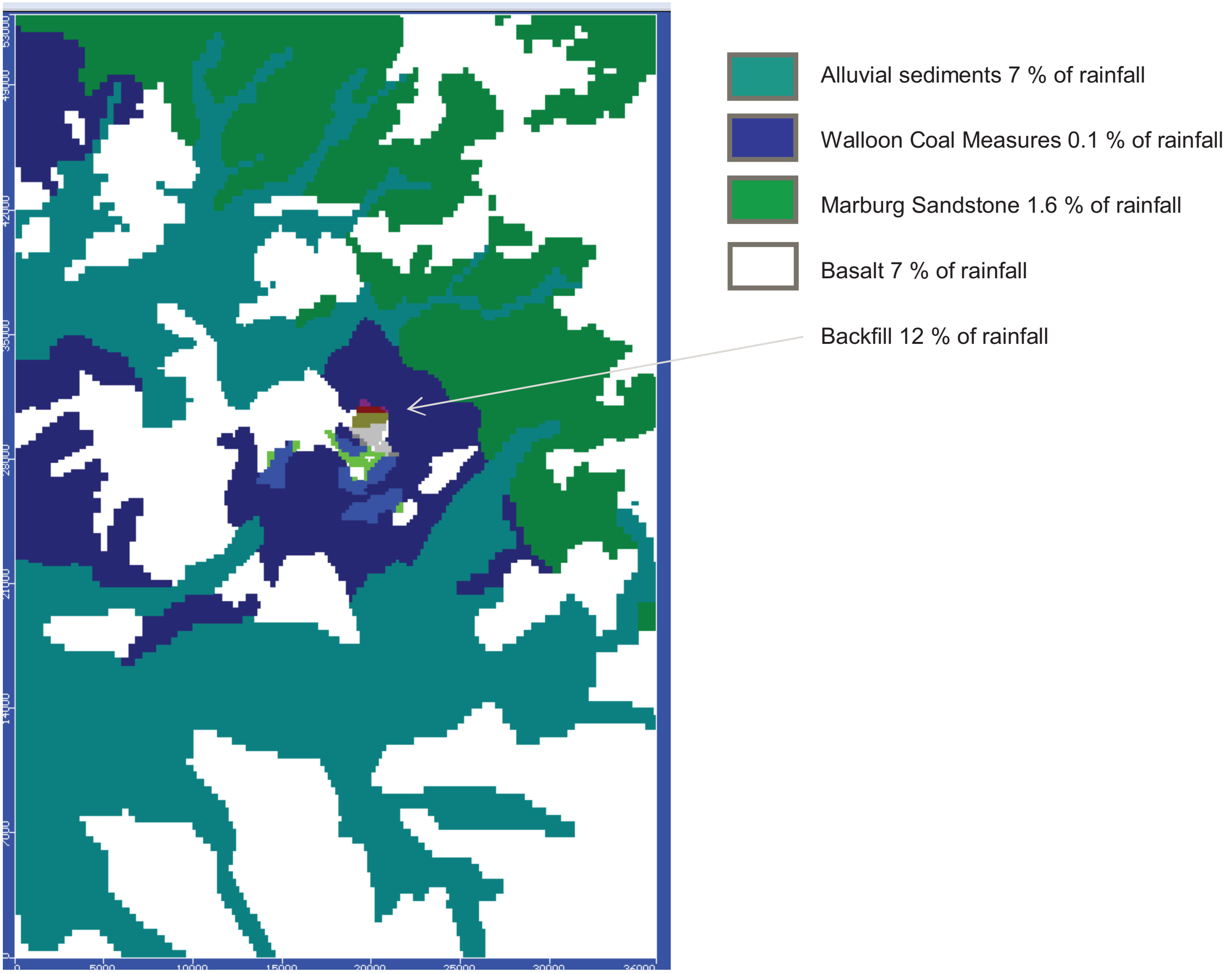
Figure 12 Hydrogeological units in model layers



5.2.3 Recharge

A nominal level of rainfall recharge has been applied across the top surface of the model. Initial estimates of recharge were set at a fixed percentage of rainfall measured in gauges located within and near the model domain. The assumed distribution of recharge is shown in Figure 13. The figure shows that the model is subdivided into a number of recharge zones according to the permeability of the outcropping hydrogeological units. Zone 1 (coded as areas of white in Figure 13) represents the Tertiary Basalts. Zone 2 (shown in dark blue) represents the Walloon Coal Measures outcrop, Zone 3 is the Marburg Sandstone (shown in green in Figure 13) and zone 4 (with various colours) is the pit backfill region. Each backfill colour represents five years of backfilling.

Figure 13 Recharge zonation



5.2.4 Aquifer Properties

Hydraulic conductivity and storage parameters included in the model as refined during the calibration procedure are presented in Table 2. Values of hydraulic conductivity are slightly lower than those indicated by pumping tests carried out in the Walloon Coal Measures as part of the revised Project EIS suggesting that on a regional scale the Walloon Coal Measures form a less significant aquifer than available individual bore tests might suggest. Similarly, the Marburg Sandstone hydraulic conductivity included in the model is higher than indicated by pumping tests associated with the Stage 2 Project EIS, suggesting the Marburg Sandstone forms a more prolific regional aquifer than available individual bore tests suggest. Parameter values included in the model provide a reasonable level of calibration and are consistent with observations from the Mine and from the general recognition that the Marburg Sandstone is an important regional aquifer while the Walloon Coal Measures does not yield substantial quantities of water.

Calibration has resulted in very low values of vertical hydraulic conductivity in most hydrogeological units. This has been necessary to maintain strong vertical gradients and to maintain heads in that shallow model layers at levels close to those observed. When this parameter is increased the heads in the shallow model layers decline to level that are well below those observed in monitoring bores.

The hydrogeological parameters and recharge assigned to each layer are also listed in Table 2.

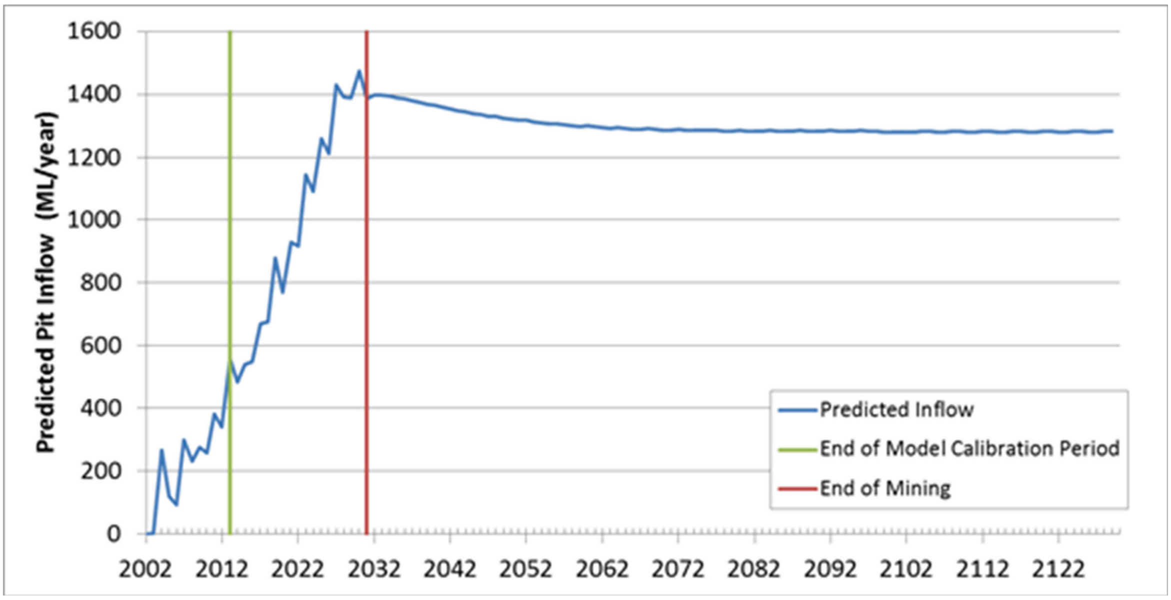
Table 2 Calibrated model parameters

Unit	Kx (m/d)	Kz (m/d)	Sy	SS	Recharge (% of rainfall)
Myall Creek Alluvials	10	0.1	0.01	n/a	7.0
Oakey Creek Alluvials	10	0.1	0.01	n/a	7.0
Tertiary Basalt	3.0	0.004	0.007	5.0e-6	7.0
Walloon Coal Measures	0.5	0.0003	0.002	5.0e-6	0.1
Lower Walloon Coal Measures	0.2	0.0001	0.0004	5.0e-6	NA
Marburg Sandstone	1.0	0.0003	0.0004	5.0e-6	1.6

5.3 Predictive scenario

The predicted total inflows to the pits are presented in Figure 14. Inflows are expected to peak immediately prior to the completion of the mining phase (2030) at approximately 1,480 ML/year (4 ML/day). Inflow rates decline slightly after mine closure. At this time it is assumed that there is no pumping of water from the revised Project and the inflows in the long term are balanced by the net evaporation rate for the pit lakes (i.e. the excess of evaporation over rainfall on the pit lake).

Figure 14 Predicted inflows to the mining pits.



Inflows of groundwater to the mining pits over the duration of mining will cause drawdown in the rocks and sediments surrounding the revised Project. Drawdown in the water table aquifers (Walloon Coal Measures and Tertiary Basalts) at 2015, 2017, 2021 and 2030 are shown in

Figure 15, Figure 16, Figure 17, and Figure 18 respectively. In this case drawdown has been estimated as the difference in heads predicted in the mining scenario and those predicted in an equivalent non-mining scenario. At all times the drawdown in the Marburg Sandstone has been predicted to be much lower than that in the coal measures and basalts (less than 3 m). Figure 19 illustrates the predicted drawdown in the Marburg Sandstone at 2030.

The drawdown cone arising from mining is predicted to extend to the west of the revised Project at later times of mining and reflects the fact that the drawdown is predicted to propagate through a large region of basalt located to the west of the revised Project. The predicted levels of drawdown depend on the depth to which the mine pit will be excavated. The greatest drawdown in the water table is expected to occur at the end of mining (2030) as shown in Figure 18.

Time series water balances for the period of mining are presented in Figure 20. Differences between the time series water balance fluxes predicted for the mining and non-mining models illustrates potential impacts associated with the revised Project's mining operations. These differences are shown in Figure 21. In Figure 20 and Figure 21 the water balance component described as "Drains" refers to the water that is predicted to flow into the revised Project (through the Modflow Drain Boundary Condition) and represents the water that is pumped from the revised Project to maintain a dry working environment. In these figures the "Storage" component of the mass balance refers to that volume of water released from or gained into storage through the rise and fall of groundwater heads. The storage flux into the model therefore indicates the change in water stored in the aquifer due to drawdown in the region immediately surrounding the revised Project. Figure 21 illustrates that mining causes a reduction in evapotranspiration (ET) and a substantial change in storage.

Figure 22 shows the predicted change in groundwater flow into the River and Drain boundary conditions that represent Oakey and Myall Creeks respectively. It can be seen that the maximum predicted loss of flow is about 0.35 ML/year and about 0.2 ML/day respectively.

5.4 Modelling the final void

The predictive model scenario continued through to 100 years post mine closure. Because the revised Project's mining activities result in excavations to below the regional water table level, the model predicts the formation of pit lakes in the final voids once mining and water removal from the voids ceases. During this period the model assumes specific hydrogeological conditions in the final mining voids, the locations of which are shown in Figure 23. These conditions are as follows:

- Hydraulic conductivity of 1,000 m/d, which represents very high conductivity consistent with a void filled with water. The assumption ensures that there are no substantial head gradients within the void.
- Specific storage is assumed to equal 1.0. This assumption causes the void to release or gain 1.0 m^3 of water for every 1 m rise or fall in water level in the void per square metre of void area, i.e. consistent with a void filled with water.
- Rainfall is assumed to accumulate in the void at a rate equivalent to 100% of the mean annual rainfall.
- Evaporation takes water from the void at a rate equal to the mean annual evaporation rate.

Figure 23 shows the predicted changes in water level in the pit lakes with time after mine closure. Water levels are expected to equilibrate by about 2070 at levels between 15 and 45 m below the undisturbed groundwater level. The residual drawdown predicted to occur during the closure phase of the revised Project is maintained by the level of evaporation in excess of rainfall on the open voids.

Drawdown in the water table aquifers (Walloon Coal Measures and Tertiary Basalts) at 50 and 100 years post mining are illustrated in Figure 24 and Figure 25 respectively. Outside the revised Project lease, drawdown is predicted in the long term to remain close to levels seen at the end of mining. No additional drawdown is expected post mining.

Figure 15 Drawdown [m] predicted at 2015

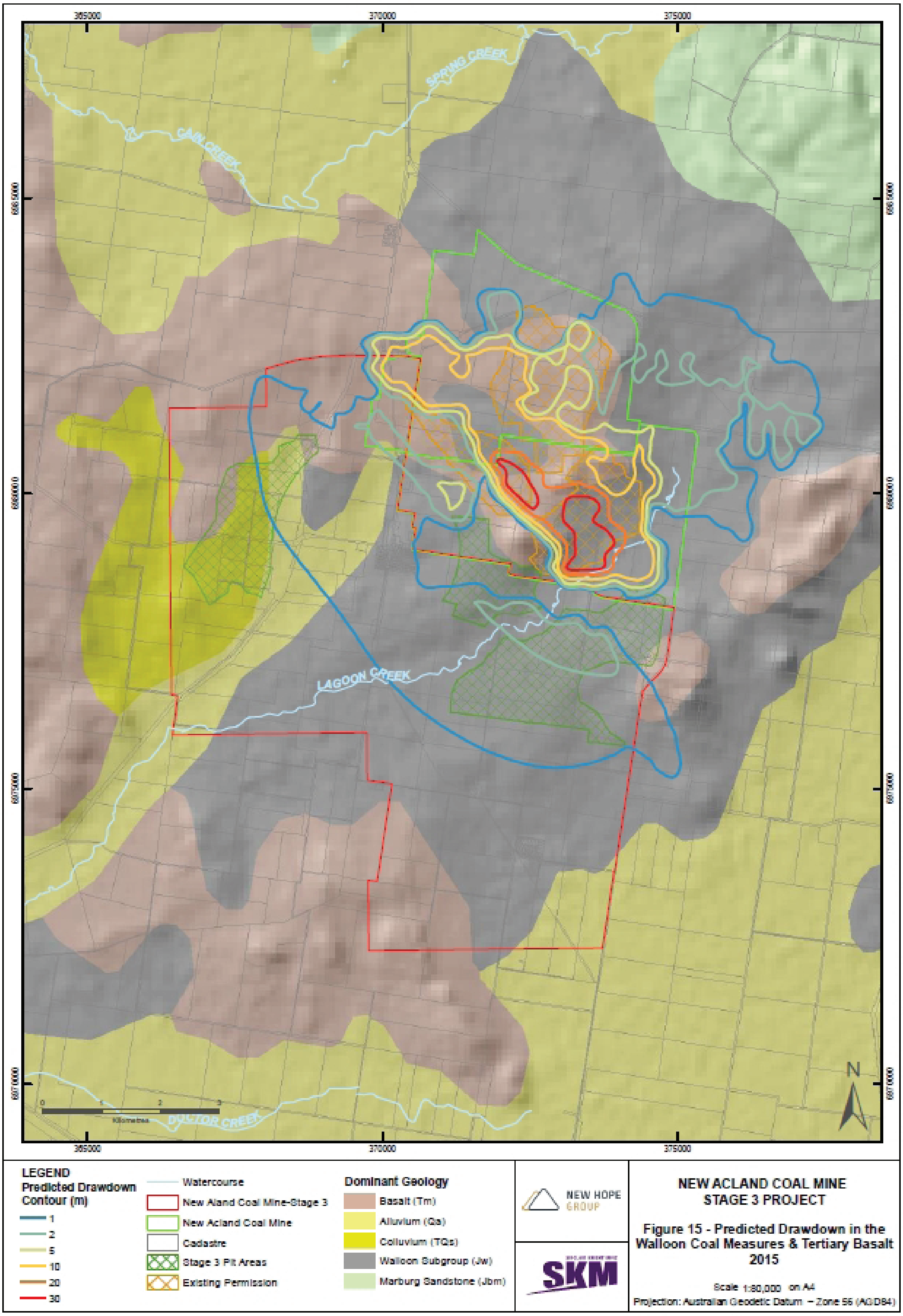


Figure 16 Water table drawdown [m] predicted at 2017

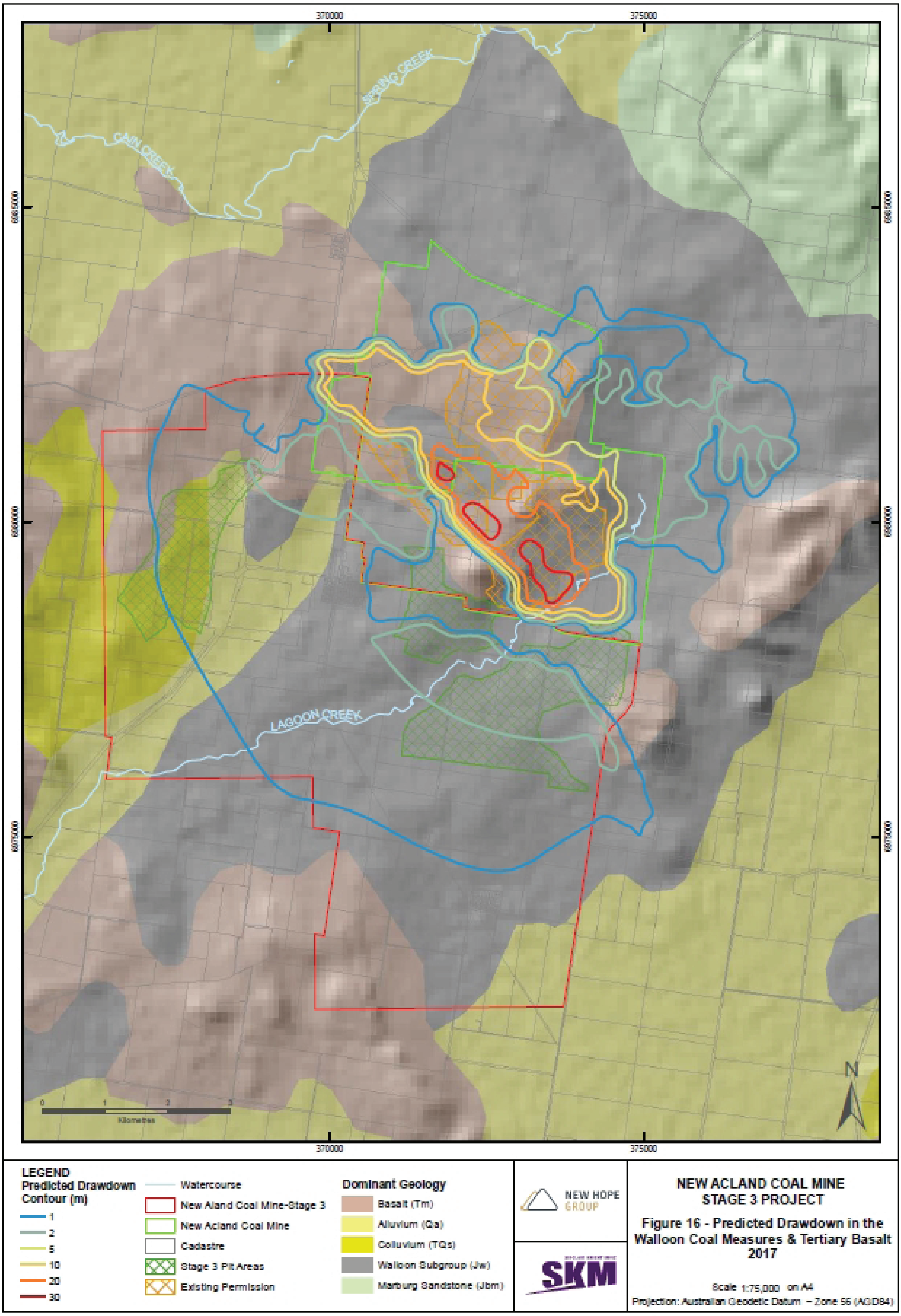


Figure 17 Water table drawdown [m] predicted at 2021

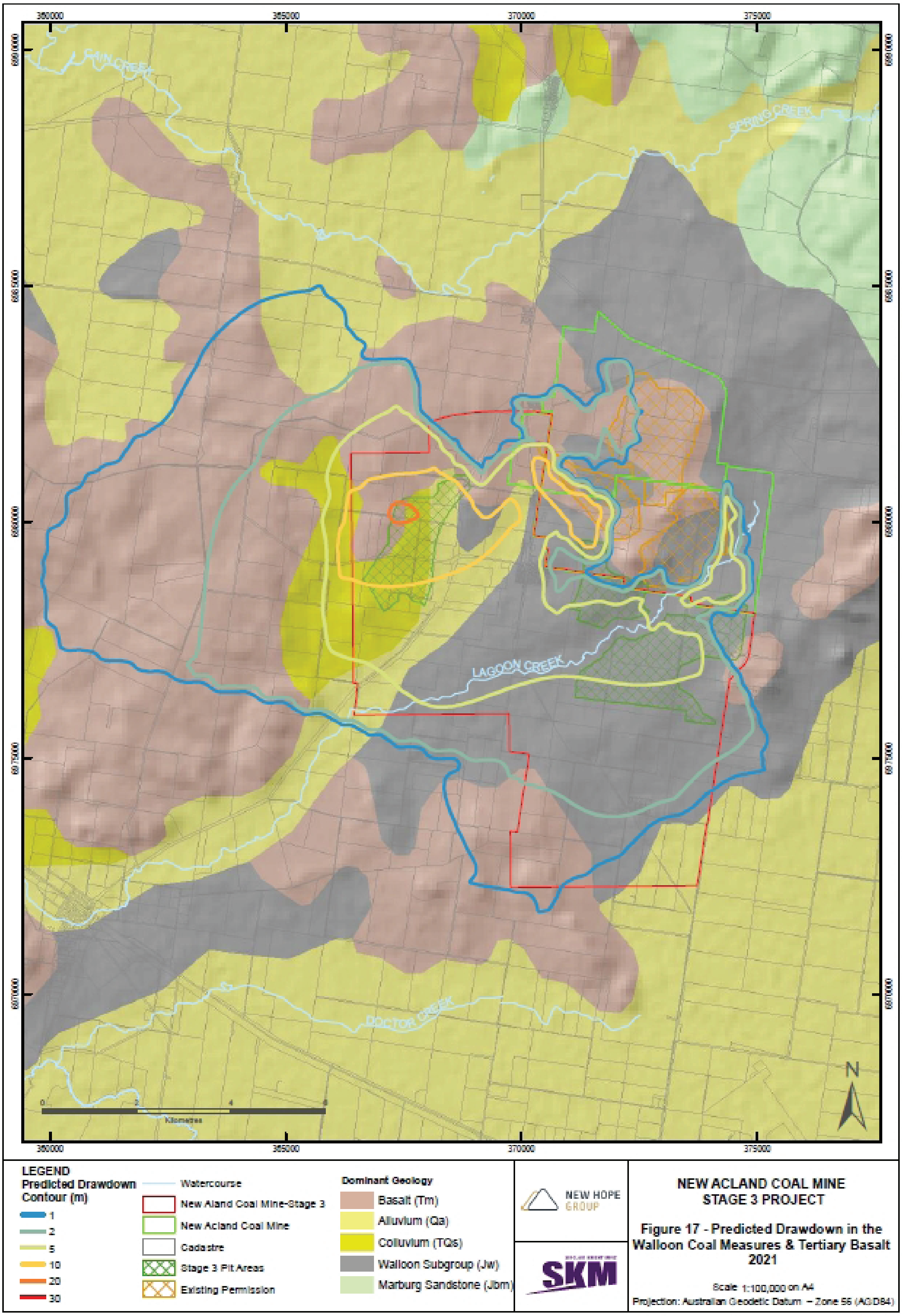


Figure 18 Water table drawdown [m] predicted at 2030

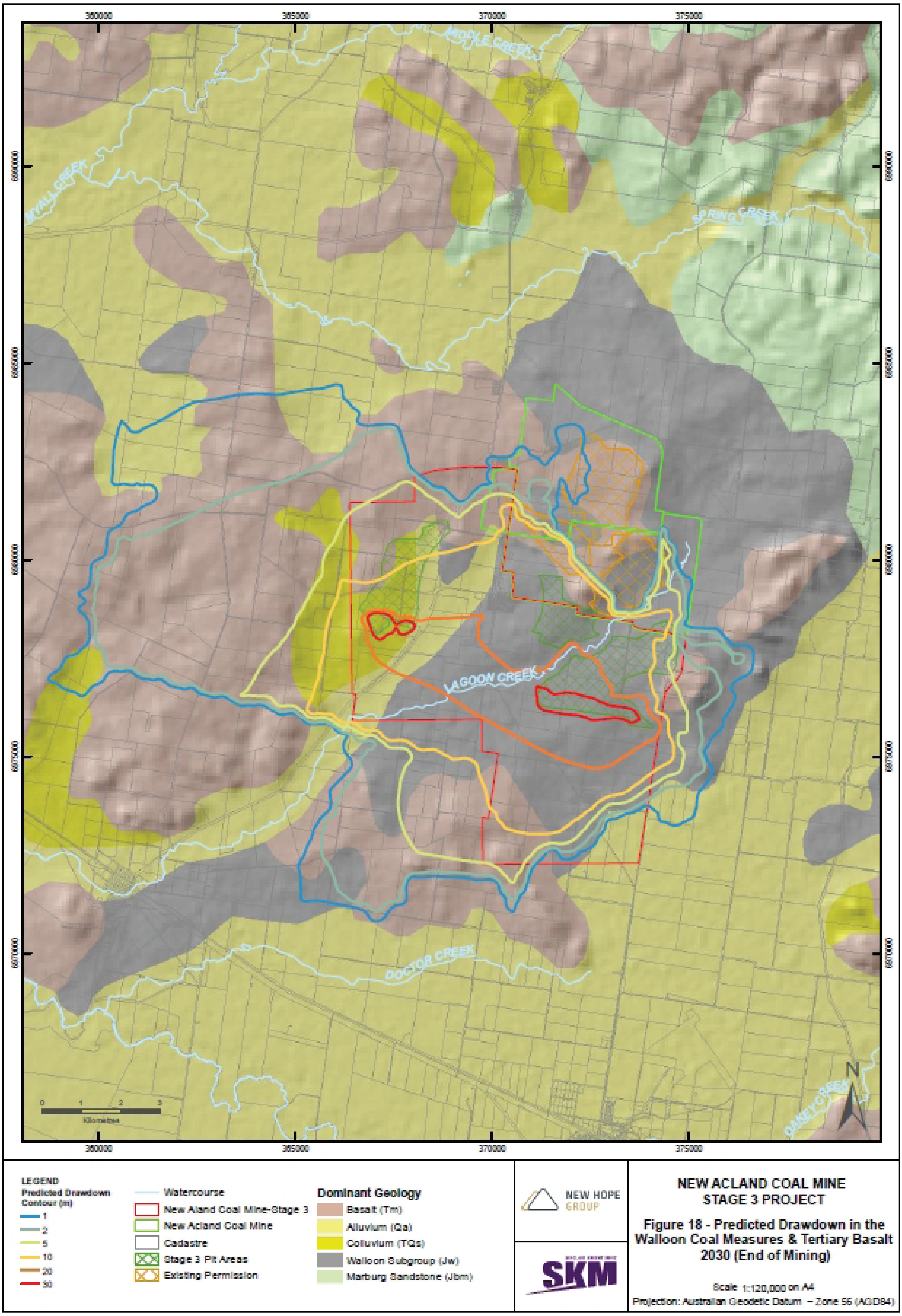


Figure 19 Drawdown [m] predicted in the Marburg Sandstone in 2030

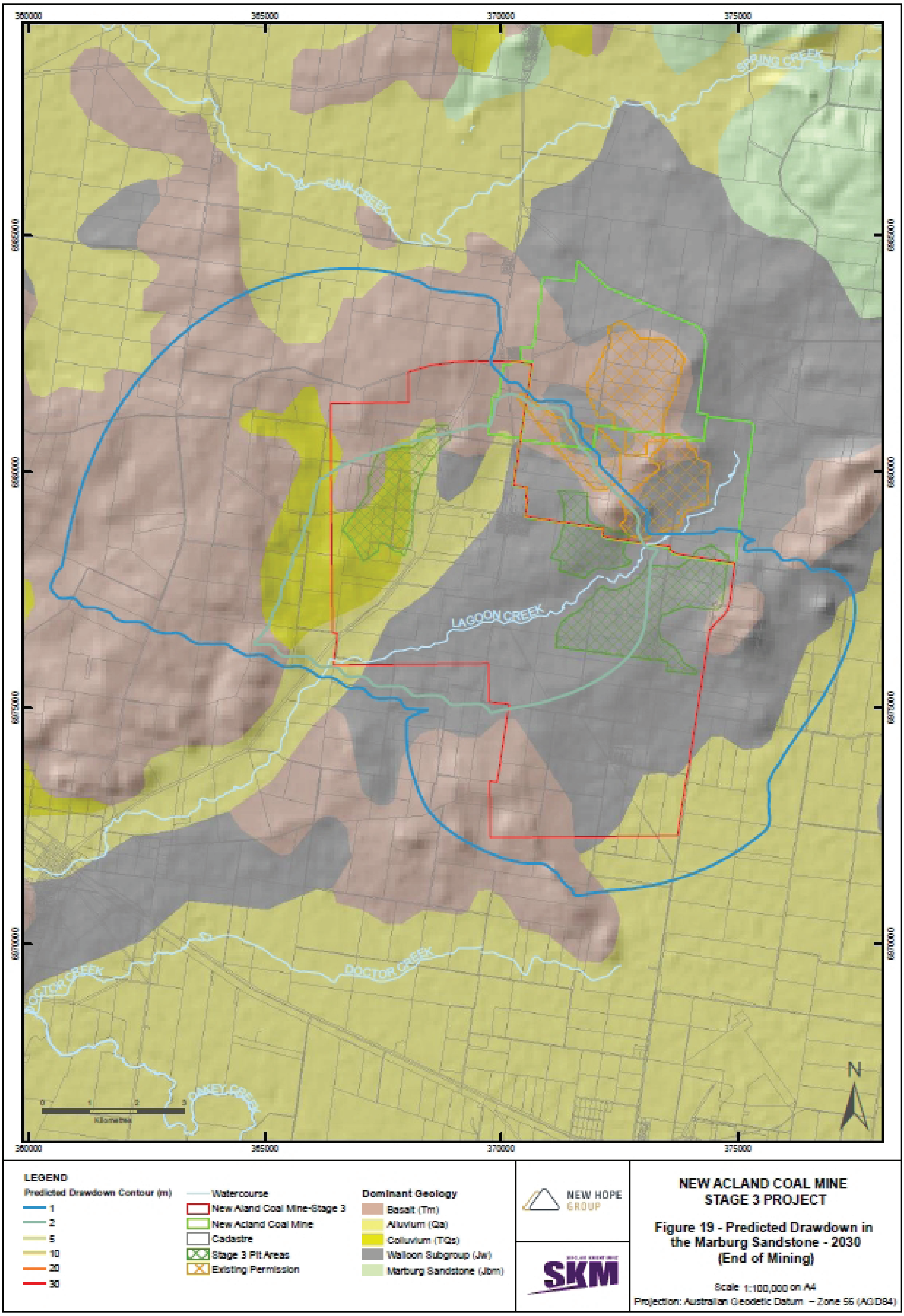
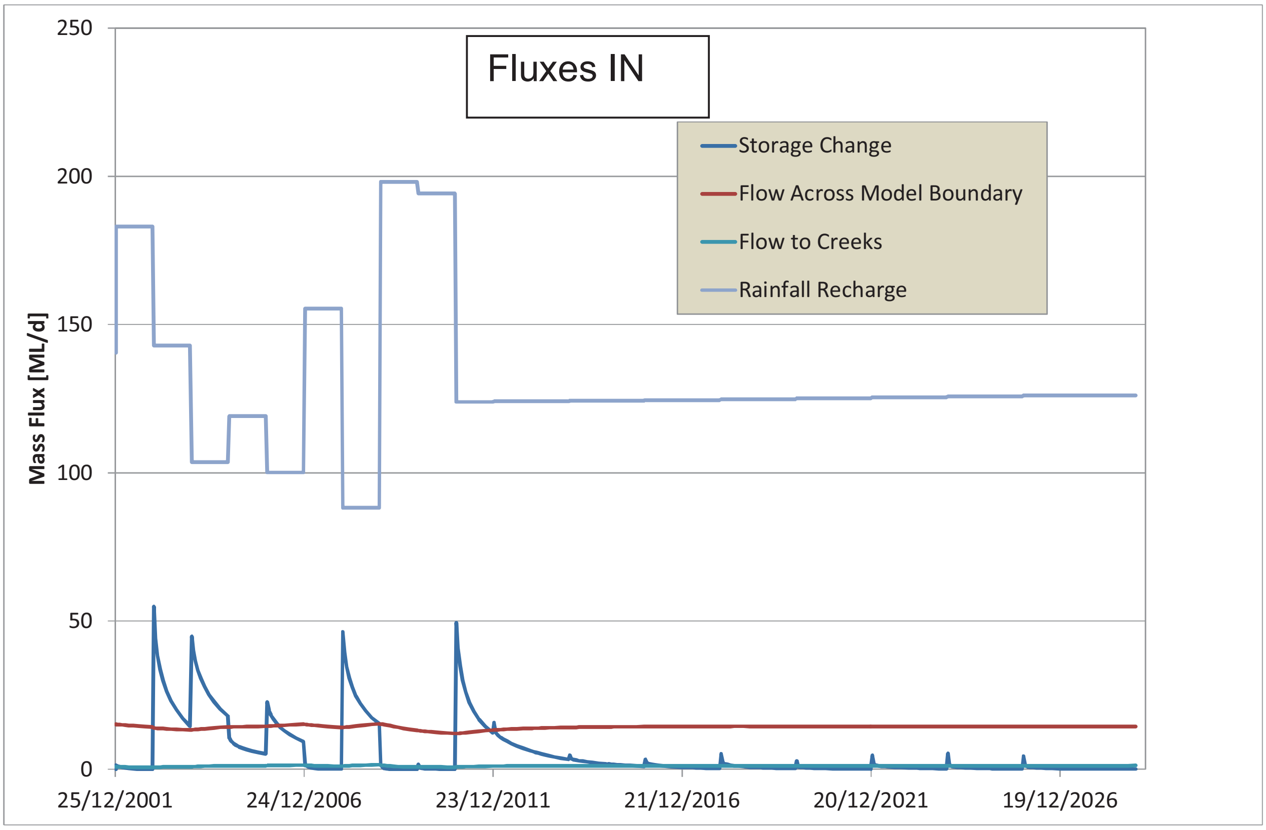
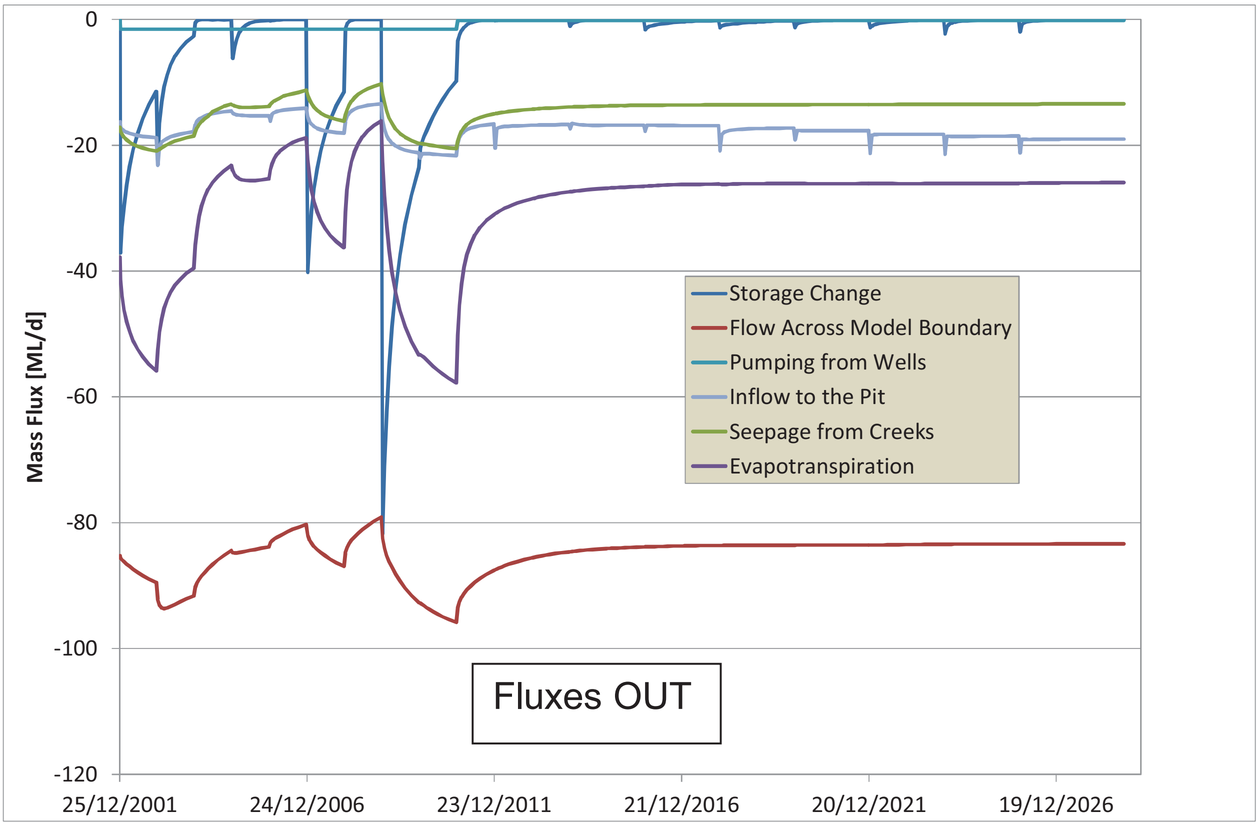


Figure 20 Time series of water balance components for period of mining





- **Figure 21 Changes in water balance caused by mining**

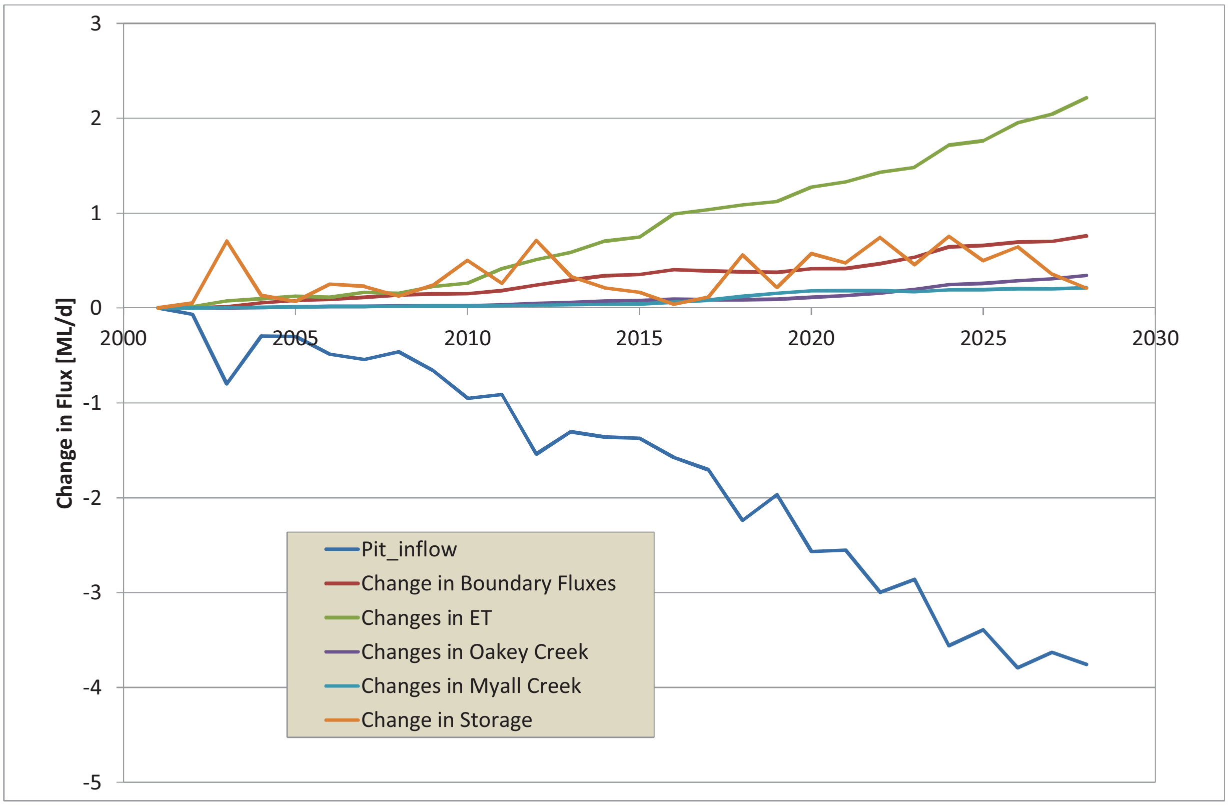


Figure 22 Predicted reduction in baseflow in Oakey and Myall Creeks

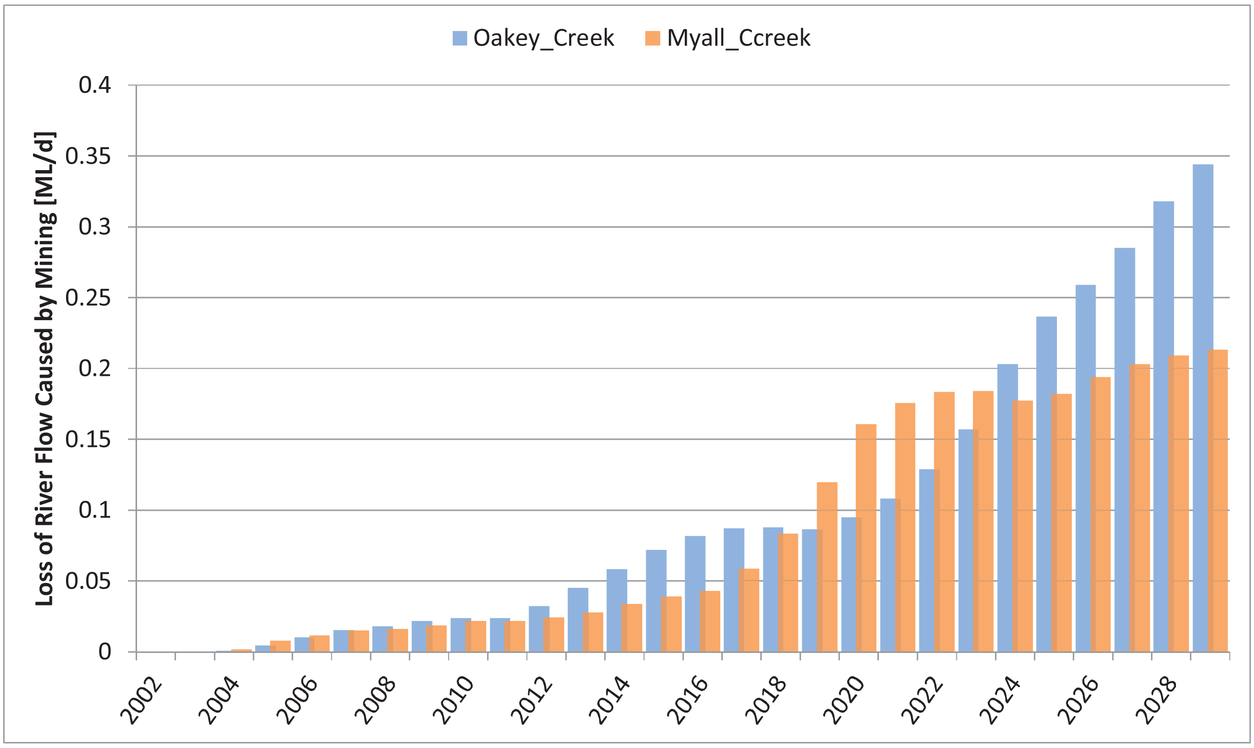


Figure 23. Residual lake level evolution.

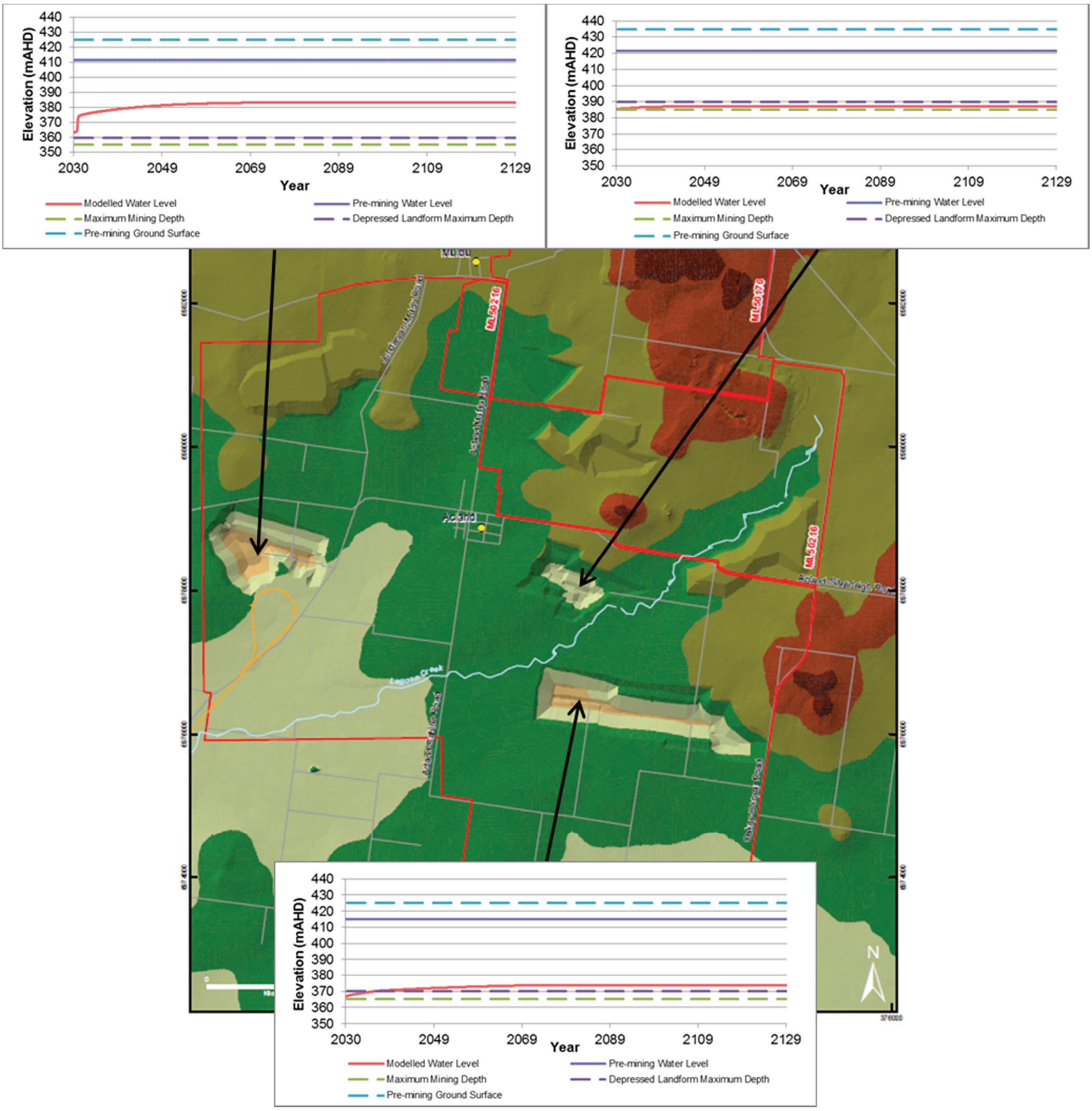


Figure 24 Water table drawdown [m] predicted at 2080

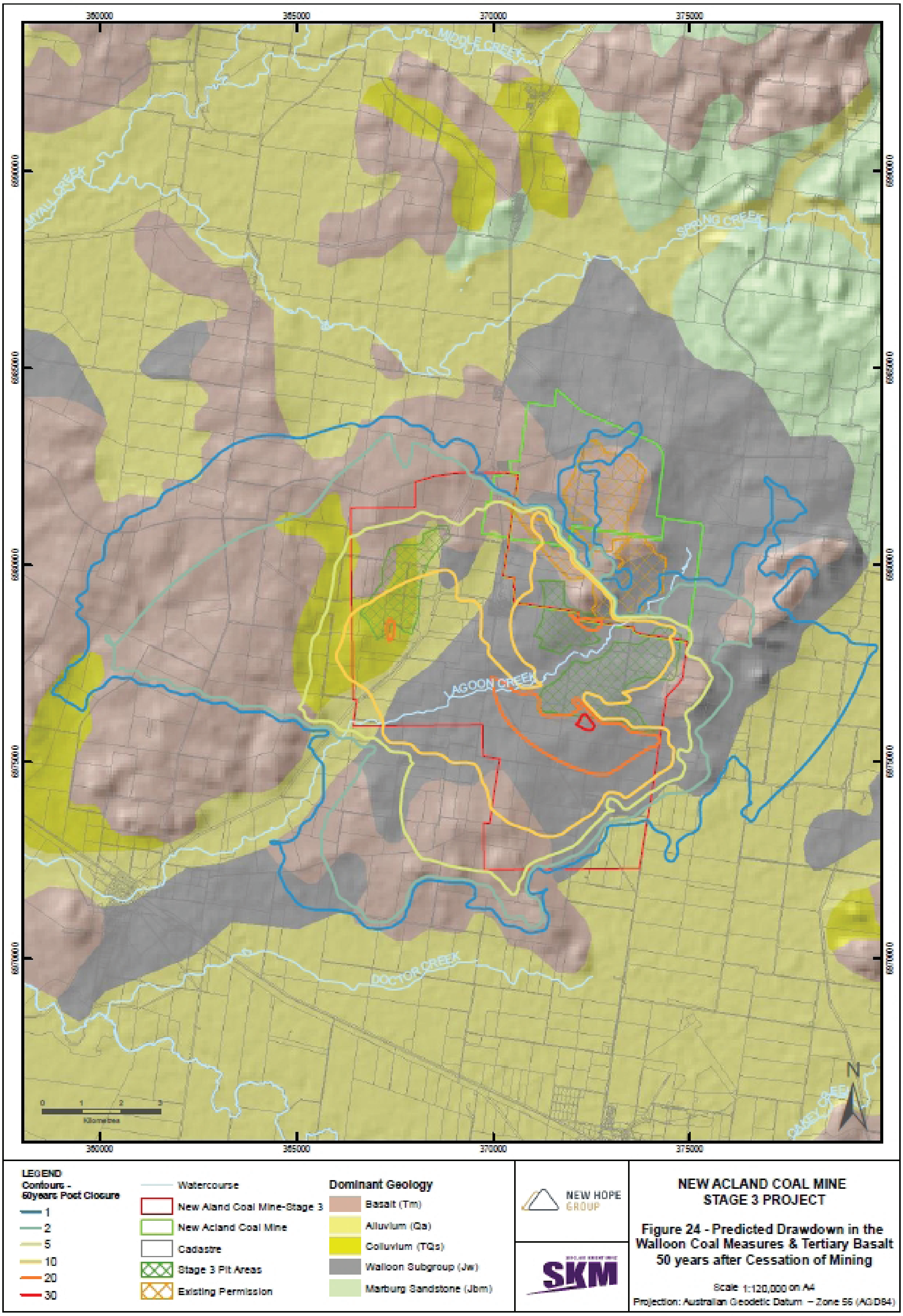
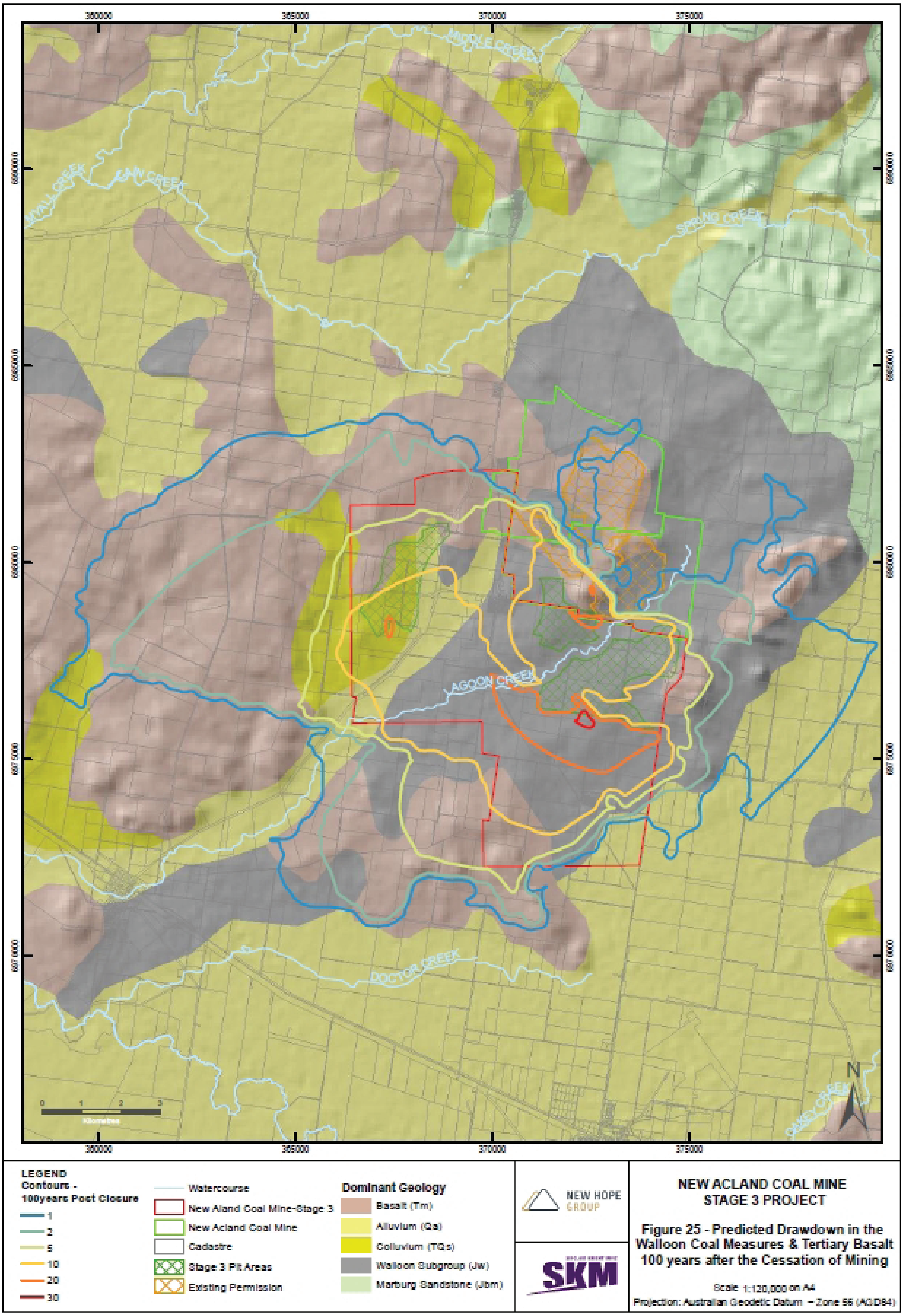


Figure 25 Water table drawdown [m] predicted at 2130



6. Confidence Level Classification

The Australian Groundwater Modelling Guidelines (Barnett et al. 2012) define the Confidence Level Classification for groundwater models. The classification provides an indication as to the relative confidence with which a particular groundwater model can be used in predictive analyses. The classification relies on assessment against a number of criteria related to the available data from which the model has been conceptualised and calibrated, the method of calibration and calibration outcomes, and the manner in which the predictive scenarios are formulated. The model described in this report has the characteristics that are typical of a Class 2 model which means that it is suitable for assessing mine dewatering characteristics, and for estimating impacts in medium value aquifers and to medium value environmental assets. It is considered suitable for the on-going modelling objectives required for the revised Project's EIS. The calibration work described in this report has been instrumental in upgrading the model Confidence Level Classification by incorporating a transient calibration in the model development and by calibrating to fluxes as well as heads measured in and around the Mine.

7. Predictive Uncertainty

Groundwater flow models are always subject to uncertainties arising from the fact that models are generally unable to incorporate the full complexity of the natural environment. In particular, groundwater models are unable to capture all of the salient features of the natural environment that influence groundwater behaviour. Predictive uncertainty also arises from the fact that groundwater models are founded on data that contains inherent inaccuracies, errors and simplifications. While it is generally not possible to eliminate measurement error and inaccuracies, or to map and include all of the spatial complexity of the aquifer being modelled, it is necessary to acknowledge predictive uncertainty and to try to quantify and deal with such uncertainties.

For the revised Project a conservative approach has been adopted with the aim that the predictive outcomes described are the worst likely outcomes from an environmental viewpoint. The conservatism is largely included in the hydraulic conductivity, storage and recharge parameters assigned to the Walloon Coal Measures and Tertiary Basalts, and the representation of the hydraulic connection between the two units. Although it is noted that these parameters have been obtained through the calibration procedure, the final values assigned to the model and used for subsequent prediction conservatively allow complete hydraulic connection between the two units, and this has led to the propagation of drawdown through the coal measures and adjacent basalts at the latter stages of mining.

8. Conclusions

Groundwater modelling results suggest that the mining planned to be undertaken as part of the revised Project's operations will cause drawdown in and immediately surrounding the mining pit predominantly in the Walloon Coal Measure aquifer. A drawdown cone is predicted to propagate to the west of the revised Project through the Tertiary Basalt and Walloon Coal Measures aquifers. Recent transient calibration investigations indicate that the connection between the Walloon Coal Measures aquifer and underlying Marburg Sandstone aquifer is not strong, and as a result, only minor drawdown impacts are expected in the Marburg Sandstone aquifer.

The model predicts inflow rates to the active mine pits vary from about 0.5 to 4.0 ML/day with the highest inflows expected when the planned mining pits are at their deepest in 2029. Consideration of the water balance predicted during mining suggests that inflows to the pits will cause changes in storage (associated with the predicted drawdown) and minor reduction in evapotranspiration within the water table drawdown cone.

9. References

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A 2012. *Australian Groundwater Modelling Guidelines*. Waterlines report #82, National Water Commission, Canberra

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