Appendix B – Modelling Technical Report

WINCHESTER SOUTH PROJECT

Groundwater Modelling Technical Report

Prepared for:

Whitehaven Coal Ltd

SLR Ref: 620.13245-R02
Version No: -v6.0
May 2021

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 2, 15 Astor Terrace
Spring Hill QLD 4000 Australia
(PO Box 26 Spring Hill QLD 4004)
T: +61 7 3858 4800
E: brisbane@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Whitehaven Coal Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.13245-R02-v6.0	20 May 2021	Arash Mohajeri	Brian Rask	Derwin Lyons
620.13245-R02-v5.0	9 October 2020	Michael Veen	Brian Rask	Derwin Lyons
620.13245-R02-v4.0	10 September 2020	Michael Veen	Brian Rask	Derwin Lyons
620.13245-R02-v3.0	19 August 2020	Michael Veen	Brian Rask	Derwin Lyons
620.13245-R02-v2.0	21 February 2020	Michael Veen	Brian Rask	Derwin Lyons

CONTENTS

CONTENTS

TABLES

CONTENTS

FIGURES

CONTENTS

APPENDICES

1 Introduction

SLR Consulting Pty Ltd (SLR) was engaged by Whitehaven Coal Limited (Whitehaven) to prepare a groundwater impact assessment as required for the Winchester South Project (the Project) Environmental Impact Statement (EIS). For this purpose, numerical groundwater modelling is being undertaken to predict impacts of the Project on the local groundwater regime. The overall objectives of this modelling are to:

- assess the groundwater inflow to the mine workings as a function of mine position and timing;
- simulate and predict the extent of dewatering due to the Project and the level and rate of drawdown at specific locations; and
- identify areas of potential risk where groundwater impact management measures may be necessary.

Conceptualisation of the groundwater regime and the calibration of the model against observed data are key to achieving a reliable numerical model. Conceptualisation is a simplified overview of the groundwater regime (i.e. the distribution and flow of groundwater) based on available data and experience. Consistency between numerical model results and the conceptual understanding of the groundwater regime increases the credibility of the numerical model predictions. The conceptual model for the Project has been provided in **Section 5.7** of the Groundwater Impact Assessment Baseline Report (SLR, 2021) prepared in accordance with the requirements of the EIS. Confidence in the numerical model is increased by calibration of numerical model results against observed data. A well calibrated model has demonstrated the ability to simulate groundwater levels that approximate observed levels at specific locations.

The numerical groundwater model for the Project builds on the groundwater model used in the groundwater impact assessments for the Moorvale South Project (SLR, 2019) and Olive Downs Project (HydroSimulations, 2018). The Moorvale South Project model adopted the Olive Downs Project model for the Olive Downs South and Willunga domains incorporating updates where necessary.

2 Model Construction and Development

2.1 Model Code

MODFLOW-USG Transport was used as the model code (Panday *et al.* 2013). MODFLOW-USG is the latest version of industry standard MODFLOW code and was determined to be the most suitable modelling code for accomplishing the model objectives. MODFLOW-USG optimises the model grid and increases numerical stability by using unstructured, variably sized cells. These cells take any polygonal shape, with variable size constraints allowing for refinement in areas of interest (i.e. geological or mining features).

Where previous MODFLOW versions restricted interlayer flow to vertical connectivity, MODFLOW-USG offers lateral connectivity between model layers. Lateral connectivity enables more accurate representations of hydrostratigraphic units, particularly those that pinch out, outcrop, or cross geological faults.

MODFLOW-USG is also able to simulate unsaturated conditions, allowing progressive mine dewatering and post closure rewetting to be represented by the model. For the Project model, vadose zone properties have been excluded, and the unsaturated zone was simulated using the upstream-weighting method.

Fortran code and a MODFLOW-USG edition of the Groundwater Data Utilities (Watermark Numerical Computing) were used to construct the MODFLOW-USG input files.

2.2 Model Extent and Mesh Design

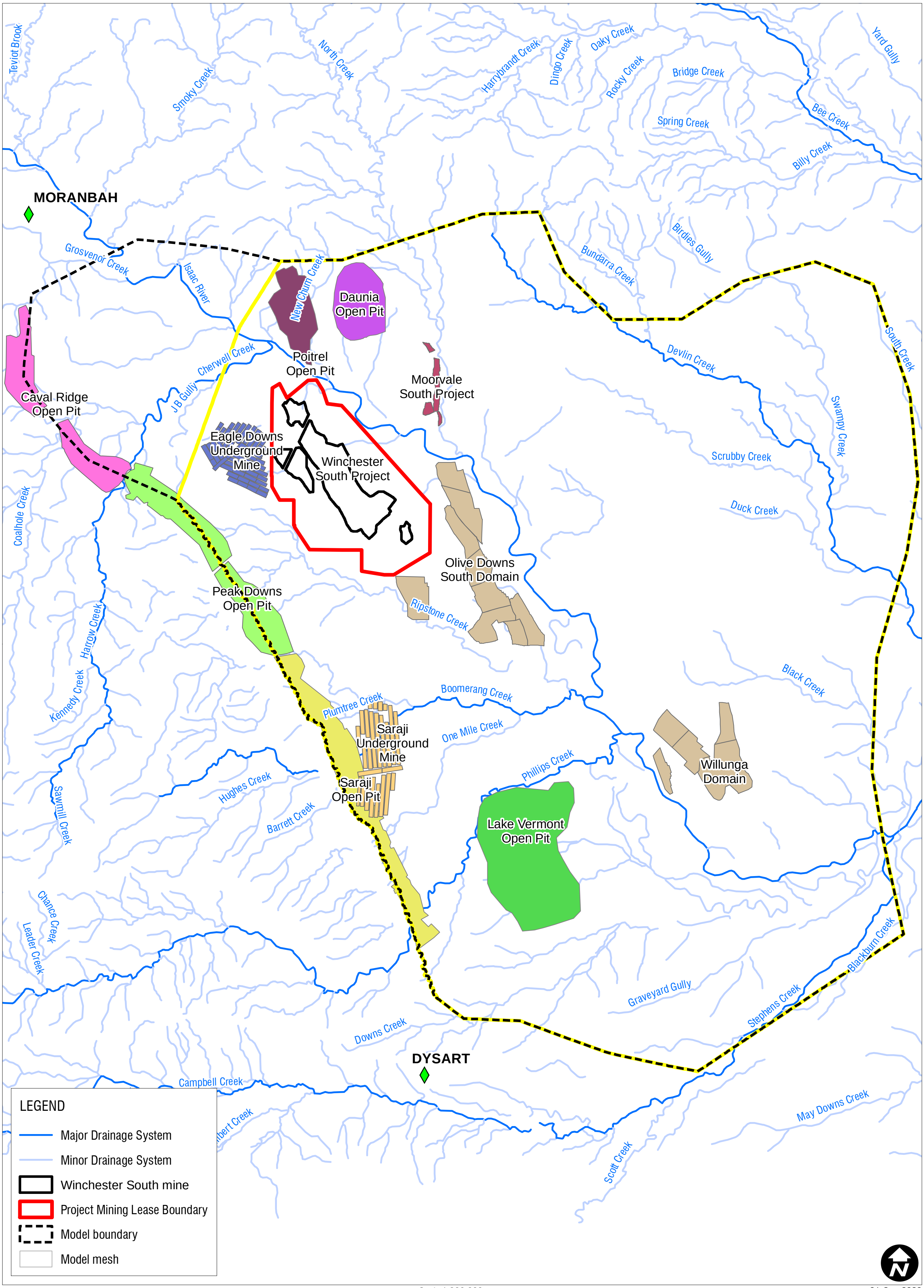
The model extent has been updated from the Moorvale South Project model for the Project through the expansion of the original model domain into the north-west (**Figure 2-1**). Herein, this report will use the term "north-west model expansion" to refer to the additional area now included in the model. The model domain was updated so that boundary conditions are sufficiently distant from the Project to not affect the modelling results (i.e. no edge effects). Elsewhere along the model perimeter, boundary locations are consistent with those of the Moorvale South Project model.

The model encompasses the Project and elongation is in the direction of geological strike (north-west to south-east). At its widest extents, the model is approximately 65 kilometres (km) x 70 km. The model domain was selected based on the following considerations:

- The western and eastern boundaries are represented by the outcrop of the Back Creek Group, which is considered the regional low permeability basement for the purpose of this modelling.
- The northern boundary contains the primary aquifers being mined by the Project and is at least 10 km away from the proposed pits.
- The southern boundary is at least 35 km from the mining lease and is expected to be far outside the range of predicted Project related drawdown.

The above boundaries include surrounding mines listed in **Section 2.5** for cumulative impact assessment.

The area occupied by the model is large, resulting in the need for an unstructured grid. The unstructured grid comprises varying cell sizes allowing for refinement in areas of interest, reducing the model cell count to an optimal size. AlgoMesh (Merrick & Merrick, 2015) was used to construct the model grid and is presented in **Figure 2-1.**



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\62013245 F2_1 Model domain.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 15 Kilometers

Model Domain

FIGURE 2-1

The following features have been included in the grid design:

- The Isaac River is represented in the model with a 50 metre (m) Voronoi cell size constraint.
- Open cut mining for the Project is represented with a 100 m cell size constraint.
- Open cut mine areas for the Olive Downs Project have a 100 m Voronoi cell size constraint.
- Open cut mining at all other sites (Lake Vermont, Poitrel, Daunia, Caval Ridge, Peak Downs, Saraji and the Moorvale South Project) have a maximum cell size of 200 m.
- Longwall mining at Eagle Downs Mine has an oriented regular grid of 350 m width squares to represent longwalls. Proposed mining at Saraji East is represented similarly by 400 m squares.
- Faults are represented using a 100 m Voronoi cell constraint.

The active cell count for a layer encompassing the entire model domain is 72,700, which would result in over 1,000,000 cells. However, over the 14 model layers, pinch-out areas (where a layer is not present) in Layers 3 to 14 bring the total active cell count of the model to 787,789.

2.3 Model Layers

Topography within the model domain has been defined using numerous sources of varying accuracy. Data extents of the sources used to construct model topography are shown in **Figure 2-2**. High resolution (1 m) Digital Elevation Model (DEM) data, provided by Whitehaven, was used to define local surface elevation within the Project area. The DEM data is centred over the Project, and at maximum extents, extends approximately 26 km north-south and 29 km east-west.

Outside the extents of the DEM dataset for the Project, LiDAR data from the Moorvale South Project and the Olive Downs Project were used to define surface elevation, where available. In areas where datasets overlap, priority was given to the LiDAR data from the Moorvale South Project. Public domain DEM data sourced from Geoscience Australia (with 3m subtracted for consistency between datasets) was used to define topography in the remainder of the model domain.

The model domain is discretised into 14 layers, as listed in **Table 2-1**. Model layer extents (lateral and vertical) have been defined using data from the following sources:

- Whitehaven – the Project site geological model (as of November 2019);
- Whitehaven – Exploration drill hole logs;
- Whitehaven –the Project TEM alluvial surveys and slope break analysis;
- Peabody – Moorvale South Project groundwater model (2019), includes:
    - Peabody – Moorvale South Project site geological model;
    - Pembroke – Olive Downs Project site geology model and numerical groundwater model;
- CSIRO Regolith depth survey;
- Queensland Globe bore hole logs; and
- Queensland surface geology and basement geological maps.

Table 2-1 Model Layers and Thicknesses

Model Layer	Formation	Unit	Average Thickness (m)	Max Thickness (m)
1	Surface cover	Alluvium, colluvium, Tertiary basalt	8.4	37.0
2	Regolith	Tertiary and minor Triassic Clematis, weathered Permian, Tertiary basalt	21.9	221.4
3	Rewan Group	Triassic	119.4	658.4
4	Rangal Coal Measures	Leichhardt overburden	45.3	269.2
5		Leichhardt seam	4.9	5.5
6		Interburden	40.0	139.1
7		Vermont seam	3.9	5.6
8		Vermont underburden	25.5	170.4
9	Fort Cooper Coal Measures	Fort Cooper overburden	73.2	180.5
10		Fort Cooper seams (combined)	73.2	
11		Fort Cooper underburden	73.1	
12	Moranbah Coal Measures	Moranbah overburden	46.9	211.2
13		Moranbah seams (combined)	46.9	
14		Moranbah underburden	46.9	

The geological layering in the model is generally consistent with the Moorvale South Project model. Layering was updated to include the Project site-specific geology model, data from surrounding exploration drill holes and the updated alluvium extents. In the north-west model expansion, layers were constructed using data from CSIRO regolith depth surveys, exploration drill logs, Queensland Globe bore logs and average thicknesses where data was unavailable.

Model Layer 1 is fully extensive across the model with an assumed depth of 3 m for colluvium. Model Layer 2 is also fully present across the model area with a minimum thickness of 1 m. Base of weathering elevation from the site-specific geology model was used to define the elevation for base of model Layer 2 at the Project. Elsewhere, the Moorvale South Project model was used to define the base of model Layer 2. In the north-west model expansion, the base of Layer 2 was interpreted from CSIRO regolith survey depths and Queensland Globe bore log lithology data.

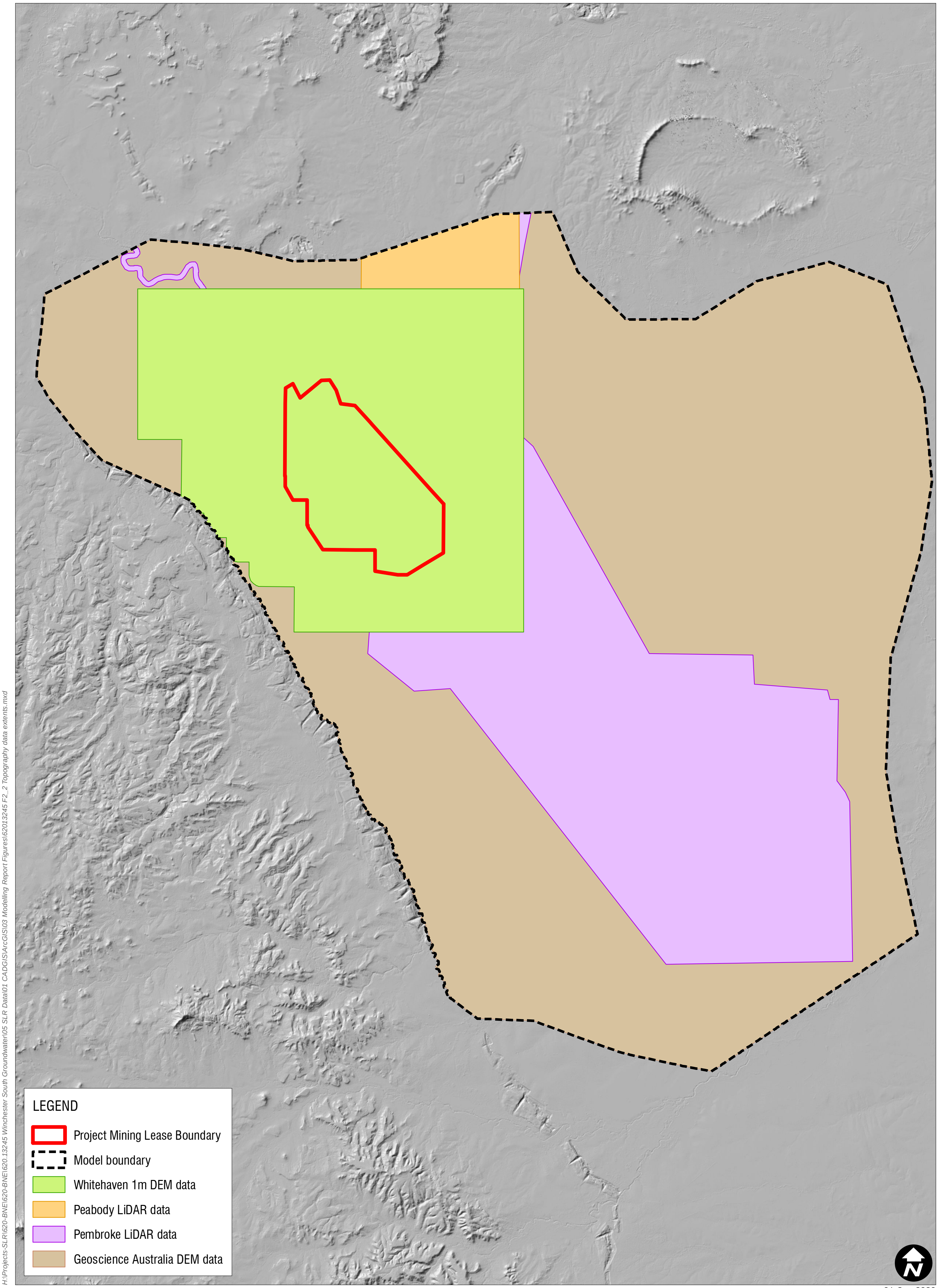
The underlying Triassic and Permian layers are present only to their outcrop extents, with some inference made for the presence of older units beneath the surface outcrop due to folding and faulting. The Back Creek Group is considered the regional low-permeability basement for the purpose of this modelling and defines the base of the model, and the western and eastern model boundaries.

It is not possible to represent every individual coal seam (typically <1 m thickness) in a regional groundwater model, therefore a “combined thickness” totalling the individual seam thicknesses for each relevant seam has been simulated. Site specific information for the Leichhardt and Vermont seams at the Project, Moorvale South Project and Olive Downs Project has been included in the model. Outside these sites, limited regional layer thicknesses information is available. The following values were used to define the combined seam thicknesses in the local geology at the Project:

- Leichhardt Seam thickness: 3.8 m
- Vermont Seam Thickness: 5.6 m

There is no additional data regarding thicknesses below the Rangal Coal Measures. As such, thicknesses from the Olive Downs Project model were used, with average thicknesses extrapolated out into the extended model area.

Model Layers 1 and 2 exist over the entire model extent. For other layers the minimum model layer thickness is 0.15 m. Model cells with thickness below this 0.15 m threshold are pinched out and removed from the model. **Table 2-1** presents the average and maximum thicknesses across the model domain for each layer.



Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 15 Kilometers

Topography Data Extents

FIGURE 2-2

2.3.1 Geological Faults

The modelling of faults has been updated from the Moorvale South Project model at the Project area through the inclusion of major regional and local scale faults, interpreted by SLR (2021) from the site-specific geology model. Mesh refinement (100 m) has been used along fault lines to allow for isolated changes of hydraulic properties along fault zones during calibration. Fault zones have been assigned to all model layers below model Layer 2 (base of regolith). **Figure 2-3** shows the locations of geological fault zones represented in the model.

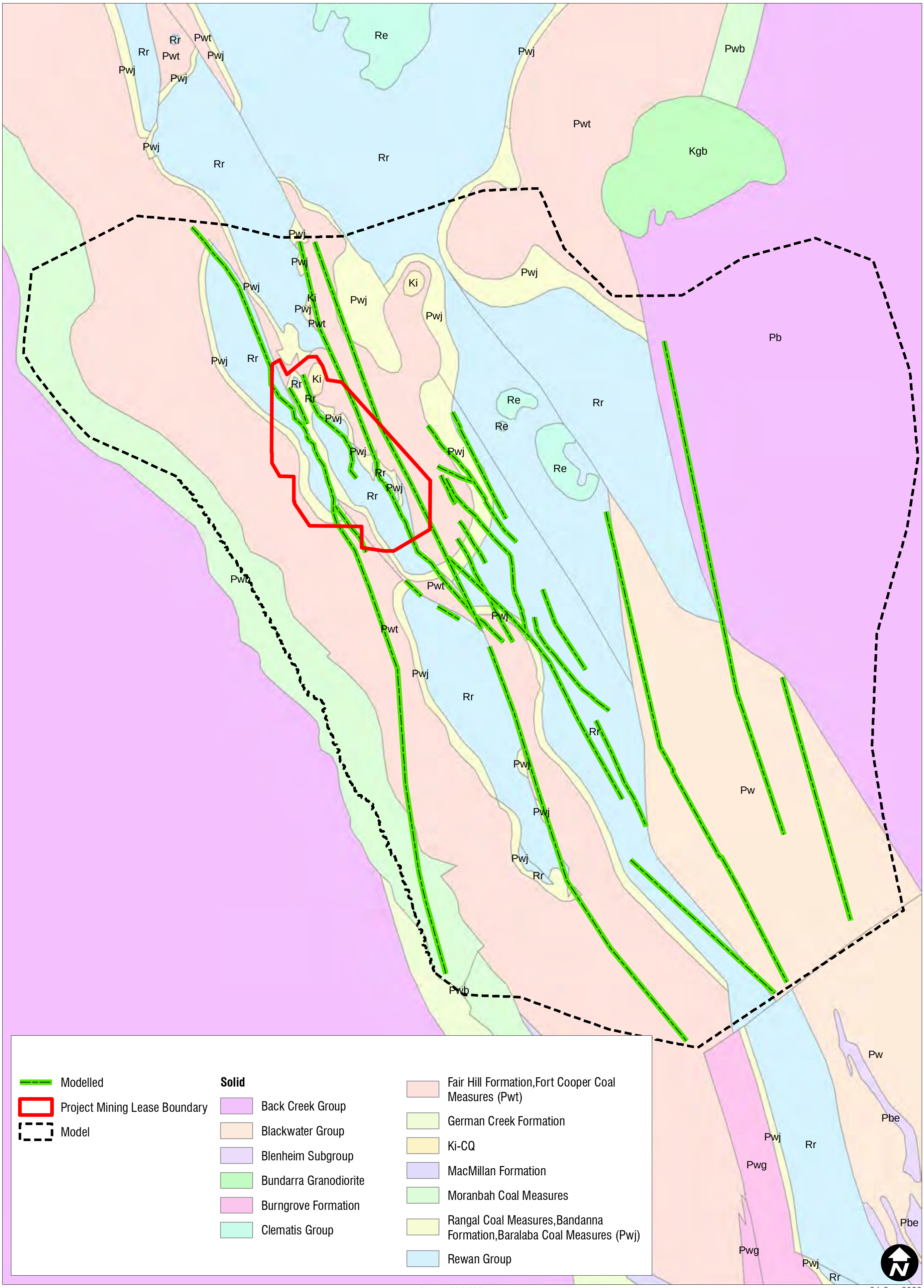
As discussed in Section 5.2.3 of the main Groundwater Impact Assessment report (SLR, 2021), faults in the vicinity of the Project are unlikely to act as conduits for flow given faulting in the Bowen Basin has been inactive for over 140 million years and drill core indicates that many fractures and faults have been “healed” with calcite and siderite.

Two drillholes that intersected faults in the Project area were redrilled for the purpose of packer testing to characterise hydraulic properties of the faults downhole. The packer test results are presented in Section 5.2.3 of the main Groundwater Impact Assessment report (SLR, 2021) and summarised as follows:

- Hydraulic conductivity results from bore WS3182 ranged from 9.48 x 10^{-4} to 1.02 x 10^{-3} m/day.
- Hydraulic conductivity results from bore WS3189 ranged from 6.93 x 10^{-5} to 2.07 x 10^{-3} m/day.

This hydraulic testwork aligns with the conceptualisation of faults in the vicinity of the Project. Notwithstanding, a broad range for hydraulic conductivity (1.00 x 10^{-6} m/day to 1.00 m/day) was conservatively used in the calibration process to allow the model to provide the best match to historical water level observations in the vicinity of the faults.

The calibrated hydraulic parameters for faults are discussed further in **Section 2.8**.



Scale:1:380,000
GDA 1994 MGA Zone 55

04-Sep-2020
620.13245

H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\62013245 F2_3 Modelled fault zones.mxd

Sheet Size : A4

0 5 10 15
Kilometers

SLR
www.slrconsultingaustralia.com

Modelled Fault Zones

FIGURE 2-3

2.4 Model Stresses and Boundary Conditions

2.4.1 Regional Groundwater Flow

General Head Boundary (GHB) have been specified along the northern, eastern and southern model boundaries. A drain boundary condition was used along the western model boundary. It is appropriate to use this condition due to the abundance of open cut mining along the western boundary.

The GHB boundary condition is used to represent the regional flow into and out of the model area and has been assigned using GHB cells in all layers. Groundwater will enter the model where the head set in the GHB is higher than the modelled head in the adjacent cell and will leave the model when the water level is lower in the GHB. GHB conductance is calculated using the hydraulic conductivity and the dimensions of each GHB cells and is therefore variable in this model due to variable cell-size.

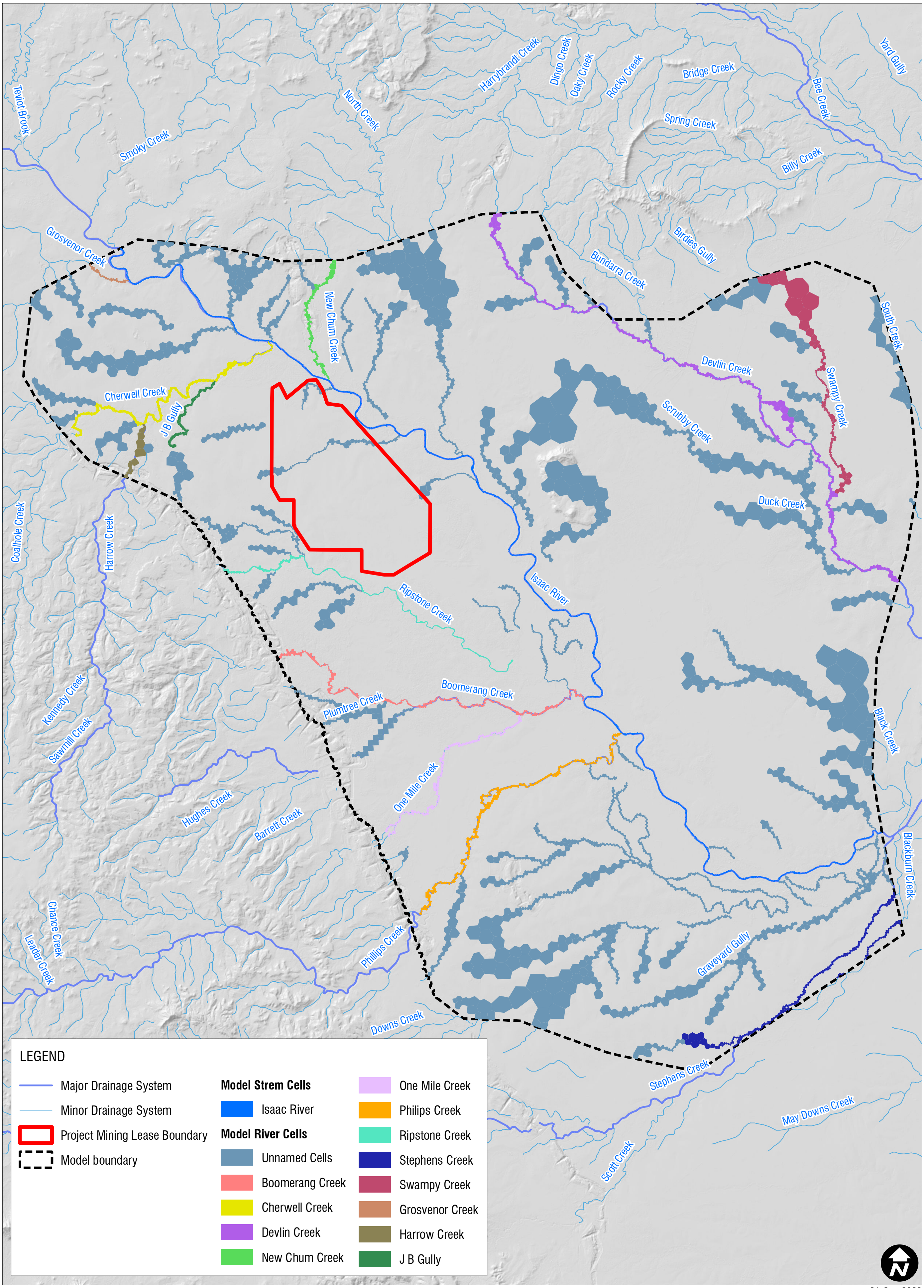
2.4.2 Watercourses

The Isaac River is the primary watercourse relevant to the Project. It is represented in the MODFLOW USG model using the Stream (STR) package. All other watercourses, as shown in **Figure 2-4**, are represented using the River (RIV) package. The rivers are set with the riverbed 1 to 11 m below the surrounding topography to represent the steep-banked incised channels.

Surveyed river stage data was available at several locations along the Isaac River. The closest gauging station to the site, located at Deveril, records monthly water levels which have been averaged for all available months and presented in **Table 2-2**, along with the annual average. These averages were extrapolated to provide continuous stage elevations used for the calibration and predictive model periods. Simulated stage heights are variable with time and fixed for each model stress period.

Table 2-2 Average Stage Heights (m) Used to Develop Transient Sequence

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Isaac at Deveril	0.90	1.13	0.89	0.65	0.53	0.43	0.35	0.27	0.24	0.24	0.41	0.65	0.56



Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 15 Kilometers

Stream and River Cells

FIGURE 2-4

2.4.3 Rainfall Recharge

Rainfall recharge was applied to the model using the MODFLOW-USG recharge (RCH) package. The model distributed the recharge in zones across the model domain according to outcropping geology. The model assigned a proportion of annual rainfall to each of these zones. The proportion of rainfall entering the model as recharge varied through the calibration process.

The calibrated recharge rates are discussed in **Section 2.10**.

2.4.4 Evapotranspiration

The MODFLOW Evapotranspiration (EVT) package was used to simulate evapotranspiration from the groundwater system. Extinction depths were set to 2 m below ground across the model domain. Maximum potential rates were set using actual evapotranspiration values (from the Bureau of Meteorology), with the average value (600 millimetres per year [mm/year]) used as the transient calibration evapotranspiration rate.

2.4.5 Groundwater Use

Private groundwater pumping bores have not been included in the model due to lack of information regarding abstraction rates. Due to low groundwater abstraction across the model area, it is likely that the bores have very localised drawdowns and will not significantly impact model results.

2.4.6 Mining

The MODFLOW Drain (DRN) package is used to simulate mine dewatering in the model for the Project and surrounding mines. Boundary conditions for drain cells allow one-way flow of water out of the model. When the computed head drops below the stage elevation of the drain, the drain cells become inactive. This is an effective way of theoretically representing removal of water seeping into a mine over time, with the actual removal of water being via pumping and evaporation.

To simulate open cut mines in the model, drain cells are applied to all active layers from the surface to the base of the lowermost mined seam. The longwall extraction at Eagle Downs Mine and Saraji East is represented as drain cells in model Layer 13 (combined Moranbah Coal Measures) and the fracture zone extended up to Layer 8. The drain cells representing the surrounding mines were interpolated from mine schedule information available from relevant approval documentation and changes in aerial imagery over time.

2.4.6.1 Variation in Hydraulic Properties due to mining

For open cut mining, Hawkins (1998) and Mackie (2009) indicate that spoil and waste rock are more permeable than the undisturbed strata. Completed open cut mining areas will be backfilled with waste overburden as the extraction proceeds. 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. In the transient calibration and prediction model, backfill properties are applied two years behind the mine face.

The hydraulic properties were varied with time using the Time-variant materials (TVM) package of MODFLOW-USG Transport. For the underground mines, the hydraulic properties were changed with time in the goaf and overlying fractured zone directly above each longwall panel.

2.5 Calibration Model Simulation Period and Temporal Discretisation

Both steady-state and transient calibration models have been developed to meet the model objectives. For steady-state conditions, the average of observed conditions prior to 2006 were used. The transient calibration model was based on temporal pre-mining data at quarterly intervals from the end of the steady-state calibration (January 2006) until December 2019.

The groundwater model has been calibrated against measurements from 177 bores (including VWPs) across the Study Area. The dataset of calibration observations comprises site specific data from the Project area, measurements from the Moorvale South Project transient calibration model, which includes the bores from the landholder bore census survey (October 2017), newly added Queensland Globe bore monitoring observations and data from the Eagle Downs Mine and Moorvale South Project. Together, the steady-state and transient calibrations comprise 57 stress periods. **Table 2-3** summarises the calibration model stress periods and simulated active mine timings.

Table 2-3 Calibration model stress period setup

Calibration Period	Interval	Stress Period	Date (from)	Date (to)	Winchester South (OC)	Moorvale South (OC)	Olive Downs (OC)	Caval Ridge (OC)	Peak Downs (OC)	Saraji (OC)	Saraji East (UG)	Lake Vermont (OC)	Eagle Downs Mine (UG)	Poitrel (OC)	Daunia (OC)
Steady-State		1	Steady-state					x	x	x					
Transient	Quarterly	2	01-01-2006	02-04-2006				x	x	x					
	Quarterly	3	02-04-2006	02-07-2006				x	x	x					
	Quarterly	4	02-07-2006	01-10-2006				x	x	x					
	Quarterly	5	01-10-2006	31-12-2006				x	x	x					
	Quarterly	6	01-01-2007	02-04-2007				x	x	x				x	
	Quarterly	7	02-04-2007	02-07-2007				x	x	x				x	
	Quarterly	8	02-07-2007	01-10-2007				x	x	x				x	
	Quarterly	9	02-10-2007	01-01-2008				x	x	x				x	
	Quarterly	10	01-01-2008	01-04-2008				x	x	x				x	
	Quarterly	11	01-04-2008	01-07-2008				x	x	x				x	
	Quarterly	12	02-07-2008	01-10-2008				x	x	x				x	
	Quarterly	13	01-10-2008	31-12-2008				x	x	x				x	
	Quarterly	14	31-12-2008	01-04-2009				x	x	x		x		x	
	Quarterly	15	02-04-2009	02-07-2009				x	x	x		x		x	
	Quarterly	16	02-07-2009	01-10-2009				x	x	x		x		x	
	Quarterly	17	01-10-2009	31-12-2009				x	x	x		x		x	
	Quarterly	18	01-01-2010	02-04-2010				x	x	x		x		x	
	Quarterly	19	02-04-2010	02-07-2010				x	x	x		x		x	
	Quarterly	20	02-07-2010	01-10-2010				x	x	x		x		x	
	Quarterly	21	01-10-2010	31-12-2010				x	x	x		x		x	
	Quarterly	22	01-01-2011	02-04-2011				x	x	x		x		x	
	Quarterly	23	02-04-2011	02-07-2011				x	x	x		x		x	
	Quarterly	24	02-07-2011	01-10-2011				x	x	x		x		x	
	Quarterly	25	02-10-2011	01-01-2012				x	x	x		x		x	
	Quarterly	26	01-01-2012	01-04-2012				x	x	x		x		x	
	Quarterly	27	01-04-2012	01-07-2012				x	x	x		x		x	
	Quarterly	28	02-07-2012	01-10-2012				x	x	x		x		x	
	Quarterly	29	01-10-2012	31-12-2012				x	x	x		x		x	
	Quarterly	30	31-12-2012	01-04-2013				x	x	x		x		x	
	Quarterly	31	02-04-2013	02-07-2013				x	x	x		x		x	x
	Quarterly	32	02-07-2013	01-10-2013				x	x	x		x		x	x
	Quarterly	33	01-10-2013	31-12-2013				x	x	x		x		x	x

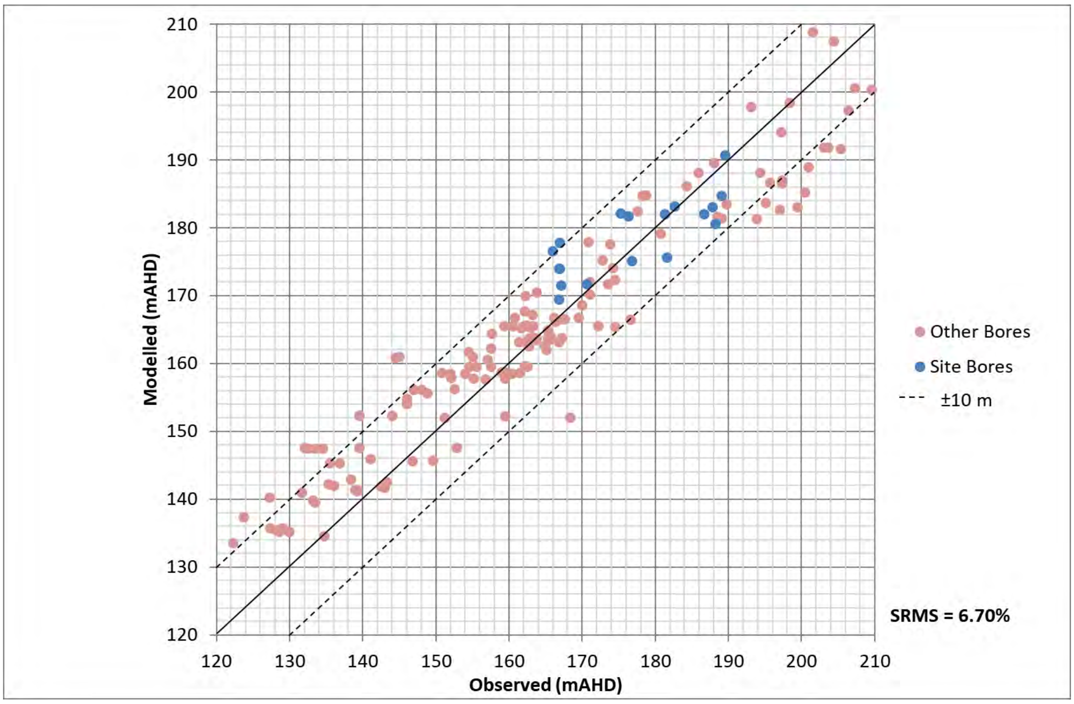
Calibration Period	Interval	Stress Period	Date (from)	Date (to)	Winchester South (OC)	Moorvale South (OC)	Olive Downs (OC)	Caval Ridge (OC)	Peak Downs (OC)	Saraji (OC)	Saraji East (UG)	Lake Vermont (OC)	Eagle Downs Mine (UG)	Poitrel (OC)	Daunia (OC)
	Quarterly	34	01-01-2014	02-04-2014				x	x	x		x		x	x
	Quarterly	35	02-04-2014	02-07-2014				x	x	x		x		x	x
	Quarterly	36	02-07-2014	01-10-2014				x	x	x		x		x	x
	Quarterly	37	01-10-2014	31-12-2014				x	x	x		x		x	x
	Quarterly	38	01-01-2015	02-04-2015				x	x			x		x	x
	Quarterly	39	02-04-2015	02-07-2015				x	x			x		x	x
	Quarterly	40	02-07-2015	01-10-2015				x	x			x		x	x
	Quarterly	41	02-10-2015	01-01-2016				x	x			x		x	x
	Quarterly	42	01-01-2016	01-04-2016				x	x			x		x	x
	Quarterly	43	01-04-2016	01-07-2016				x	x			x		x	x
	Quarterly	44	02-07-2016	01-10-2016				x	x			x		x	x
	Quarterly	45	01-10-2016	31-12-2016				x	x			x		x	x
	Quarterly	46	31-12-2016	01-04-2017				x	x			x		x	x
	Quarterly	47	02-04-2017	02-07-2017				x	x			x		x	x
	Quarterly	48	02-07-2017	01-10-2017				x	x			x		x	x
	Quarterly	49	01-10-2017	31-12-2017				x	x			x		x	x
	Quarterly	50	31-12-2017	01-04-2018				x	x			x		x	x
	Quarterly	51	01-04-2018	01-07-2018				x	x			x		x	x
	Quarterly	52	01-07-2018	30-09-2018				x	x			x		x	x
	Quarterly	53	01-10-2018	31-12-2018				x	x			x		x	x
	Quarterly	54	31-12-2018	01-04-2019				x	x			x		x	x
	Quarterly	55	01-04-2019	01-07-2019				x	x			x		x	x
	Quarterly	56	02-07-2019	01-10-2019				x	x			x		x	x
	Quarterly	57	01-10-2019	31-12-2019				x	x			x		x	x

2.6 Steady-state

Steady-state calibration was undertaken using the automated calibration utility PEST (Doherty, 2010) with 177 groundwater targets, including 18 site bores. Manual parameter adjustment was then undertaken to validate that the calibrated parameters were consistent with the conceptual understanding of the hydrogeological system. Hydraulic conductivity, recharge and river/stream conductance were adjusted to achieve the steady-state calibration. Manual adjustments to the Isaac River stream conductance were made to maintain consistency between modelled stream behavior (i.e. gaining/losing river) and the conceptual understanding of the Isaac River. Vertical hydraulic conductivity (K_v) was calibrated as a factor of horizontal conductivity (K_V/Kx). Reduced vertical hydraulic conductivity is typically observed due to sedimentary layering throughout the sequence, and by aggregation of strata in a numerical model.

2.6.1 Statistics

A scattergram of observed vs simulated groundwater levels for the steady-state calibration targets is presented in **Figure 2-5**.



mAHD = metres Australian Height Datum.

Figure 2-5 Steady-state Calibration – Modelled vs Observed Groundwater Levels

The industry standard method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS) error. A RMS error is expressed as:

$$\mathrm{RMS} = \left[1/n \sum (h_o - h_m)_i^{\,2}\right]^{0.5}$$

Where:

- n = number of measurements
- h_o = observed water level
- h_m = simulated water level

The RMS error is considered to be the best measure of error, if normally distributed. The RMS error for the calibrated steady-state model is 6.87 m.

When considering if this achieved RMS is acceptable, the RMS should be assessed in the context of the range of the observed head changes over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are only a small part of the overall model response. The total measured head change across the model domain is 102.57 m; therefore, the ratio of RMS error to the total head loss (i.e., the scaled root mean squared [SRMS] error) is 6.7%. This indicates a good calibration as it is within the Australian guidelines' indicator of 10% SRMS error (Middlemis *et al.*, 2001; Barnett *et al.*, 2012).

2.6.2 Water Balance

The water balance for the steady-state simulation is presented in **Table 2-4**.

Table 2-4 Steady-state Model Mass Balance

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Outflow (%)
Recharge (RCH)	4.74	50.61	-	-
ET (from GW) (EVT)	-	-	0.55	5.85
SW-GW Interaction Isaac River (STR)	1.91	20.43	6.83	72.90
SW-GW Interaction Minor Rivers (RIV)	-	-	0.61	6.50
Regional GW Flow (GHB)	2.71	28.97	1.33	14.17
Mines (DRN)	-	-	0.05	0.58
Storage	-	-	-	-
Total	9.37	100.00	9.37	100.00

ML/d = megalitres per day.

The water balance for the steady state calibration indicates that recharge is the largest inflow contributor to the groundwater system, providing 4.74 ML/d. Regional groundwater flow into the model domain is another net positive contributor of inflow to the groundwater system and contributes a net of 1.39 ML/d (i.e. difference between the regional groundwater inflow and outflow).

A net outflow of 4.92 ML/d from the model occurs due to baseflow seepage to the Isaac River (i.e. surface water and groundwater interaction in the Isaac River). This is the largest component of outflow from the model during steady state calibration. Other factors that contribute to outflow from the groundwater system are evapotranspiration (0.55 ML/d outflow), baseflow seepage to minor drainage systems (0.61 ML/d outflow) and groundwater take from mining activities (0.05 ML/d outflow). The mass balance error for the steady state calibration is within the 1% error threshold recommended by the *Australian Groundwater Modelling Guidelines* (Barnett *et al.*, 2012).

2.7 Transient Calibration

Automated calibration utility PEST and manual calibration were used to match the available transient water level data. In all, 18,981 target heads were established for 174 locations, including the 15 bore locations, comprising the Project monitoring network, and 159 other registered bores as identified through bore censuses, the QLD Globe database and surrounding mine monitoring networks. PEST was used to adjust horizontal and vertical hydraulic conductivity, specific storage (Ss), specific yield, recharge and river/stream conductance in order to match the observed and simulated water levels. To begin each transient model calibration run, a steady-state simulation was undertaken. The steady-state heads for each calibration scenario were transferred into the transient calibration model as initial groundwater levels. This approach confirmed that initial conditions (steady-state groundwater levels) for the transient run were derived from the corresponding parameter set being applied in the transient simulation. Discrepancies between these two parameter sets would disrupt groundwater flow budgets as the transient version of the model settles to pseudo steady-state conditions outside the mining areas throughout the simulation.

2.7.1 Statistics

Figure 2-6 presents the observed and simulated groundwater levels as a scattergram for the initial steady-state and transient calibration (beginning 2005 to end of 2019). The scattergram indicates site bores have been adequately represented by the calibration model (simulated water levels typically within 10 m of observed).

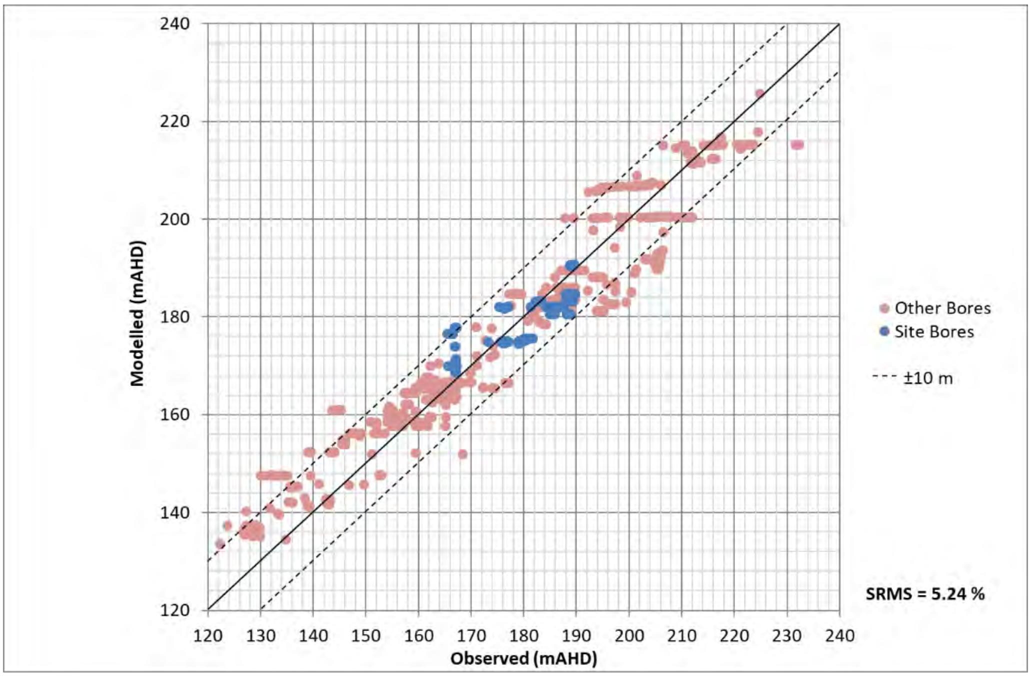


Figure 2-6 Transient Calibration – Modelled vs Observed Groundwater Levels

Calibration hydrographs, showing the fit between modelled and observed groundwater levels are presented in **Appendix A**. Seasonal water level fluctuations are to some extent replicated by the groundwater model. This can be seen in the hydrograph for bores such as 13040180, which intersects the Isaac River alluvium. For site bores R2008 and Winnet Bore, the hydrographs show the observed and simulated water levels generally align. R2008 and Winnet Bore are screened in the Vermont Seam and the Isaac River alluvium, respectively. Hydrographs at S series bores most notably S6, S8 and S10 show the model matches well the water levels in alluvial bores near the Olive Downs Project area. Average (arithmetic mean) residual for alluvial bores across the study area is -0.69 m. The average alluvial residual was calculated by taking the averaging the residual at each alluvial bore in the numerical groundwater model. This ensures all bores were weighted evenly, and the reported average was not skewed by bores with large numbers of observations. Observed measurements for Permian Coal Measure bores 162166 and 162172 in the north-west model expansion are closely matched by the simulated water levels, indicating strong calibration at these sites.

Resulting statistics for the transient simulation are shown in **Table 2-5** and average residuals in each layer are shown in **Table 2-6**. Residuals have been calculated as the observed water level minus the modelled water level. The model SRMS error across all observations is 5.24%, again considered a good fit using statistical targets suggested by Middlemis *et al*. (2001) and Barnett *et al.* (2012).

For bores within the Project Area, the residual errors range from -11.25 m to 8.17 m, with an average residual of -1.17 m. The average residual was calculated as the average of the average residuals at each bore. The model results show a tendency to overpredict groundwater levels within the Project Area, as indicated by the negative average residual. There is a high level of variability in observed water levels in the bores within the Project Area, which is considered to likely be a result of the complexity of the structural geology (i.e. faulting) in the vicinity of the Project. The residual error is resulting from the inability of the model to fully replicate this complexity. The model is a simplification of reality in this regard as the grid resolution will never be of the finite degree required to replicate all the structure.

The aim of the model calibration was to obtain a good fit to the regional spread of data, in order to replicate the regional groundwater gradients and to provide the best possible constraint to the model boundary conditions across the entire model domain. The calibration hydrographs and statistic indicate that a reasonable calibration has been achieved across the model domain, regardless of the discrepancies noted in the calibration for some of the bores within the Project Area.

The spatial distribution of residuals is shown in **Figure 2-7**. By examining the scatter distribution in **Figure 2-6**, the spatial distribution in **Figure 2-7** and the transient calibration summary in **Table 2-5**, the model is shown to demonstrate no significant tendency overall for over predicting or under predicting groundwater levels within the model domain. **Appendix B** contains a table of average, maximum and minimum residuals for each bore in the transient calibration.

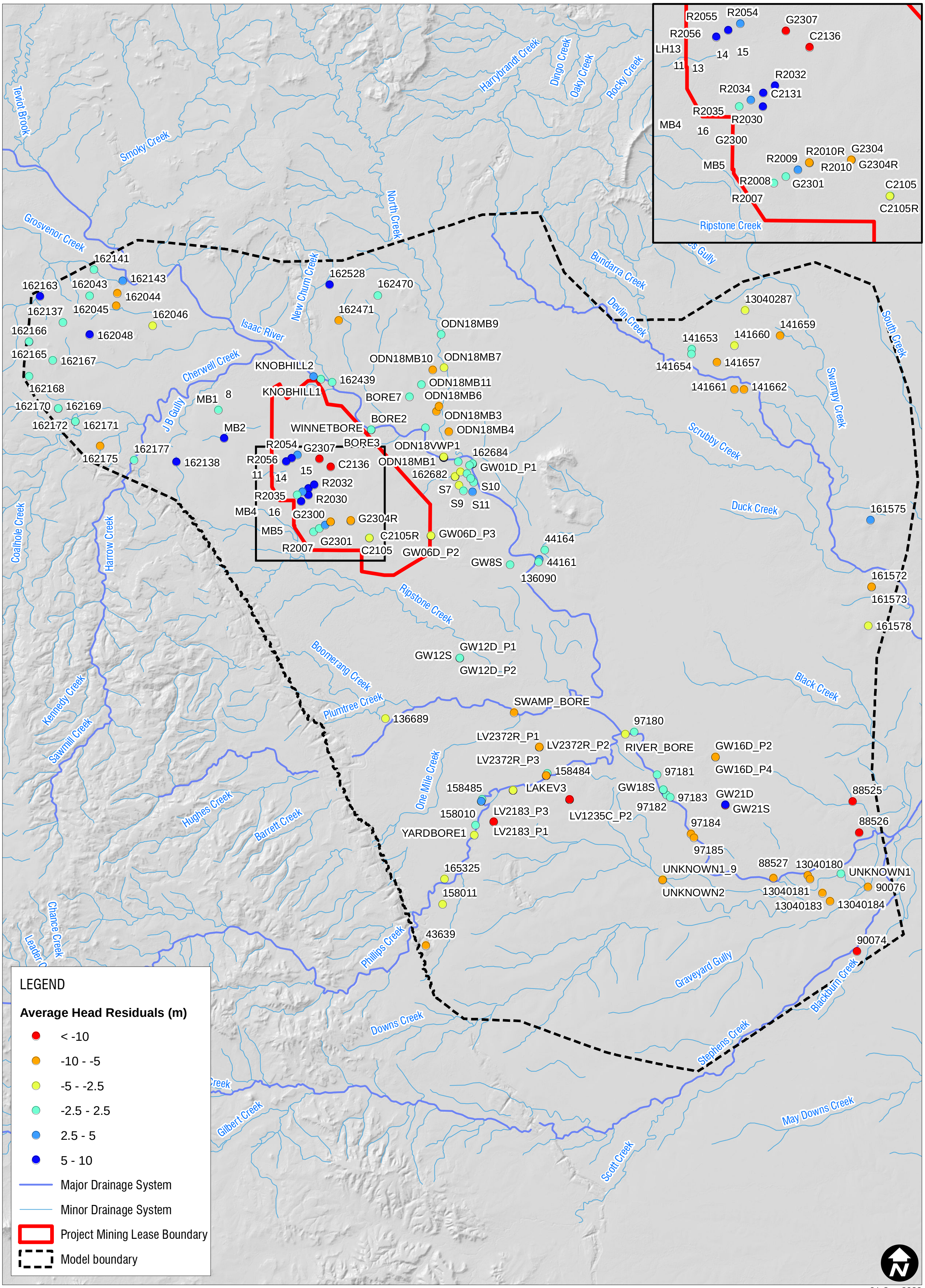
Table 2-5 Transient Calibration Statistics

Statistic	Value
Residual Mean (m)	0.26
RMS Error (m)	5.77
Minimum Residual (m)	-17.59
Maximum Residual (m)	17.08
Scaled RMS Error (%)	5.24
% Targets within ±2m	30.00
% Targets within ±5m	63.38

Table 2-6 Average Residual by Model Layer

Model Layer	Formation	Average Residual (m)	Number of Observation Targets
1	Alluvium, colluvium	0.97	4605
2	Regolith	4.16	114
3	Rewan Group	-1.80	32
4	Rangal Coal Measures	1.34	75
5		-1.72	4463
6		3.97	1924
7		-1.52	5442
8		3.77	1842
9	Fort Cooper Coal Measures	-6.29	47
10		1.16	22
11		9.28	11
12	Moranbah Coal Measures	0.55	45
13		4.31	356
14		-1.39	3

Note: Negative residuals indicate modelled heads are higher than observed, positive indicates modelled heads are lower than observed.



Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

SLR

www.slrconsultingaustralia.com

0 5 10 15 Kilometers

Transient Calibration
Average Head Residuals (m)

FIGURE 2-7

2.7.2 Water Balance

The water balance for the transient simulation averaged over the duration of the calibration period is presented in **Table 2-7**. The maximum absolute mass balance error across all timesteps in the transient calibration was 0.04%, with cumulative absolute error remaining below 0.01%. This level of error is well within the recommended 1% error (Barnett *et al*., 2012), indicating the model is stable and the numerical solution achieved is accurate.

Table 2-7 Transient Model Mass Balance

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Outflow (%)
Recharge (RCH)	5.62	16.54	-	-
ET (from GW) (EVT)	-	-	0.60	1.77
SW-GW Interaction Isaac River (STR)	15.49	45.56	15.90	46.78
SW-GW Interaction Minor Rivers (RIV)	-	-	0.65	1.92
Regional GW Flow (GHB)	2.72	8.00	1.63	4.81
Mines (DRN)	-	-	2.50	7.36
Storage	10.16	29.90	12.70	37.35
Total	33.99	100.00	33.99	100.00

The water balance for the transient calibration indicates that recharge was the largest net inflow contributor to the model, contributing an average of 5.62 ML/d to the groundwater system. Modelled net seepage outflow along the length of the Isaac River from the groundwater system is 0.42 ML/d. However, closer to the Project Area, the river is simulated as a losing system (net inflow during transient calibration equals 0.50 ML/d). Minor drainage systems contribute to a loss of approximately 0.65 ML/d from the groundwater system, and, 0.60 ML/d of groundwater is lost due to evapotranspiration. Additionally, surrounding mines remove 2.50 ML/d of groundwater. Over the total duration of the transient calibration, there was a simulated gain in storage of approximately 2.53 ML/d.

2.8 Calibrated Hydraulic Parameters

Table 2-8 provides a summary of the calibrated values for horizontal and vertical hydraulic conductivity used in the model. Hydraulic zone distribution maps are provided as **Appendix C**.

Table 2-8 Calibrated Hydraulic Parameters

Model Layer	Formation	Unit	Horizontal Hydraulic Conductivity (m/day)	Anisotropy Kv/Kx
1	Alluvium	Surface cover	10.0	2.9 x10^{-1}
1	Colluvium	Surface cover	1.0	2.5 x 10^{-1}
1 & 2	Tertiary Basalt	Tertiary basalt	1.5 x 10^{-1}	1.8 x10^{-1}
2	Regolith	Tertiary and minor Triassic Clematis	7.3 x 10^{-1} to 2.0	9.7 x 10^{-3} to 6.7 x 10^{-2}
3	Rewan Group	Triassic	1.0 x 10^{-3}	2.7 x10^{-2} to 1.0 x10^{-1}
4	Rangal Coal Measures	Leichhardt overburden	1.0 x 10^{-5} to 2.2 x 10^{-1}	4.2 x 10^{-3}
5		Leichhardt seam	1.0 x 10^{-4} to 6.0 x 10^{-1}	3.8 x 10^{-2}
6		Interburden	1.0 x 10^{-5} to 1.0 x 10^{-3}	1.3 x 10^{-2}
7		Vermont seam	1.0 x 10^{-4} to 2.0 x 10^{-2}	9.1 x10^{-2}
8		Vermont underburden	1.0 x 10^{-5} to 9.0 x 10^{-4}	8.0 x10^{-2}
9	Fort Cooper Coal Measures	Fort Cooper overburden	1.0 x 10^{-5} to 1.0 x 10^{-3}	8.0 x 10^{-3}
10		Fort Cooper seam	1.0 x 10^{-4} to 4.3 x 10^{-4}	1.0 x 10^{-1}
11		Fort Cooper underburden	1.0 x 10^{-5} to 8.6 x10^{-5}	1.0 x 10^{-1}
12	Moranbah Coal Measures	Moranbah overburden	1.0 x 10^{-5} to 9.6 x 10^{-5}	1.0 x10^{-2}
13		Moranbah (Goonyella) seam	1.0 x 10^{-4} to 3.4 x 10^{-3}	5.0 x10^{-2}
14		Moranbah underburden	1.0 x 10^{-5} to 9.4 x 10^{-4}	1.9 x10^{-2}
all	Undivided Intrusives	Igneous intrusion	1.0 x 10^{-3}	1.4 x10^{-2}
Below L02	Faults	All below Layer 2	5.0 x 10^{-5} to 8.3 x 10^{-3}	1.0 x 10^{-3} to 1.5 x10^{-1}
-	Waste Rock/Spoil	-	2.0 x 10^{-1}	2.0 x 10^{-2}

Note: * upper hydraulic conductivity derived from depth of 20 m below surface and using depth formula

The hydraulic conductivity of the Permian interburden material in the model reduces with depth in order to reflect field observations. As the decrease of horizontal hydraulic conductivity within the interburden rock units is driven by an increase in overburden pressure, the relationship between horizontal hydraulic conductivity and depth is different from that of coal seams. The hydraulic conductivity for the interburden material is capped at a minimum of 1.0 x 10^{-5} m/day and the hydraulic conductivity of the coal seams is capped at a minimum of 1.0 x 10^{-4} m/day. The hydraulic conductivity of the interburden/overburden and coal seam layers decreases with depth according to Equations 1 and 2 (exponential):

Coal: $HC = HC_0 \times e(-0.015\times depth)$ (Eq. 1)

Interburden: $HC = HC_0 \times e(-0.018\times depth)$ (Eq. 2)

Where:

- HC is horizontal hydraulic conductivity at specific depth;
- HC_0 is horizontal hydraulic conductivity at depth of 0 m (intercept of the curve);
- depth is depth of the floor of the layer (thickness of the cover material); and
- slope is a term representing slope of the formula (steepness of the curve).

HC_0 was estimated in the calibration. It varies for the coal seams and for the interburden and overburden units in the model. The slope function and coefficient of the coal and interburden depth dependence equations were calibrated. The horizontal hydraulic conductivity against depth relationships for the interburden/overburden are presented in **Figure 2-8**, while the calibrated relationships for coal units are presented in **Figure 2-9**. The figure also presents the Olive Downs Project data (2018), Coffey (2014) Bowen Basin data trends and the Isaac Plains groundwater calibrated model parameters (Hansen Bailey, 2016).

Figure 2-9 shows lower hydraulic conductivities in Fort Cooper and Moranbah coal measures. It was not possible to represent every individual coal seam in Fort Cooper and Moranbah coal measures in the model. Therefore, a “combined thickness” totalling the individual seam thicknesses for each relevant seam has been simulated.

Figure 2-10 illustrates the range in horizontal hydraulic conductivity obtained from site testing and publicly available data. The data are focused on the key site units, being the alluvium, regolith, Rewan Group and the coal and interburden sequences of the Rangal Coal Measures. The data are compared to the horizontal hydraulic conductivity values used in the model. A depth dependence equation for the Rangal Coal Measures was used in the numerical groundwater model and therefore the calibrated hydraulic conductivity values vary across the model domain. Accordingly, the average value for the Rangal Coal Measures at the Project is displayed. As shown in **Figure 2-10**, the modelled horizontal hydraulic conductivity values are all within the range of field data.

The range of calibrated hydraulic conductivity values (5.0 x 10^{-5} m/day to 8.3 x 10^{-3} m/day) used to represent faults in the model domain (**Table 2-8**) is consistent with the packer test hydraulic conductivity range obtained for Project Area drillholes WS3182 and WS3189, both of which are confirmed to be intersecting faults. Packer test ranges for hydraulic conductivities across these two sites were between 6.93 x 10^{-5} m/day and 2.07 x 10^{-3} m/day (Hydrogeologist, 2019).

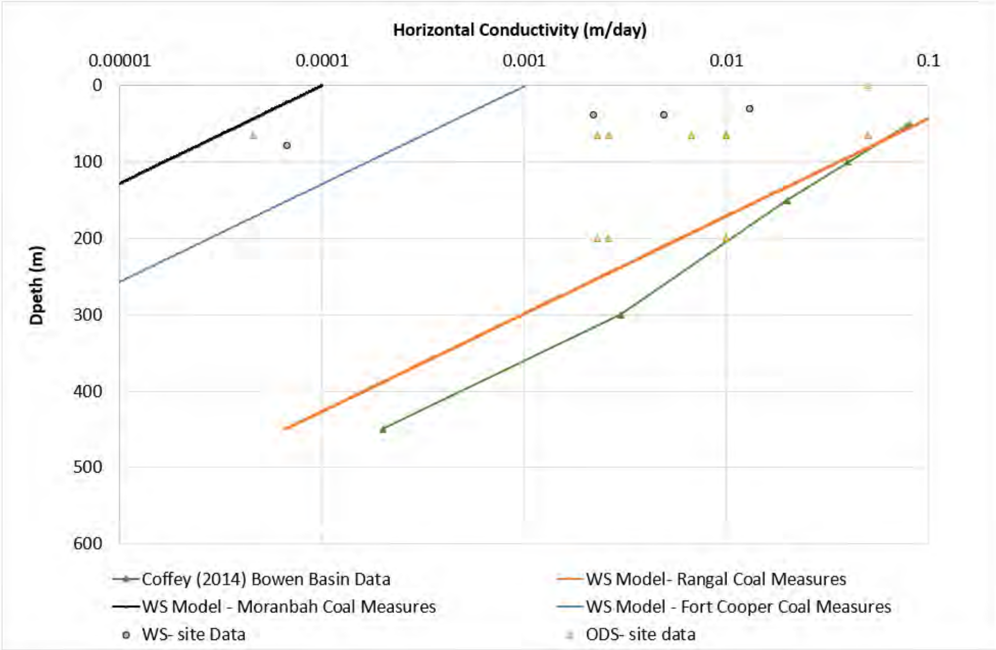


Figure 2-8 Hydraulic Conductivity vs Depth – Interburden/Overburden

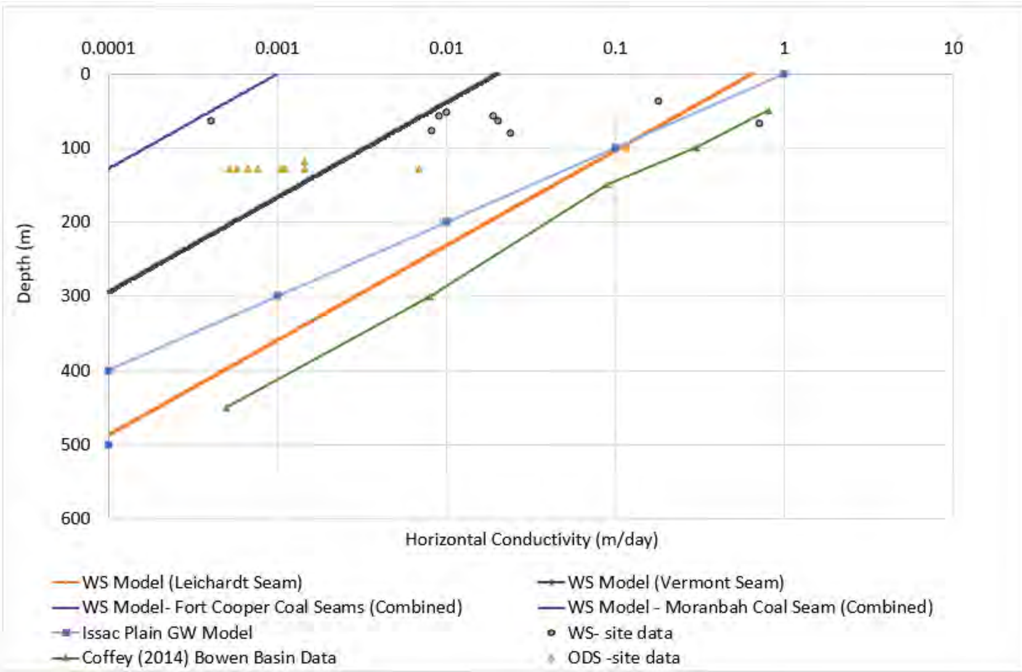


Figure 2-9 Hydraulic Conductivity vs Depth – Coal

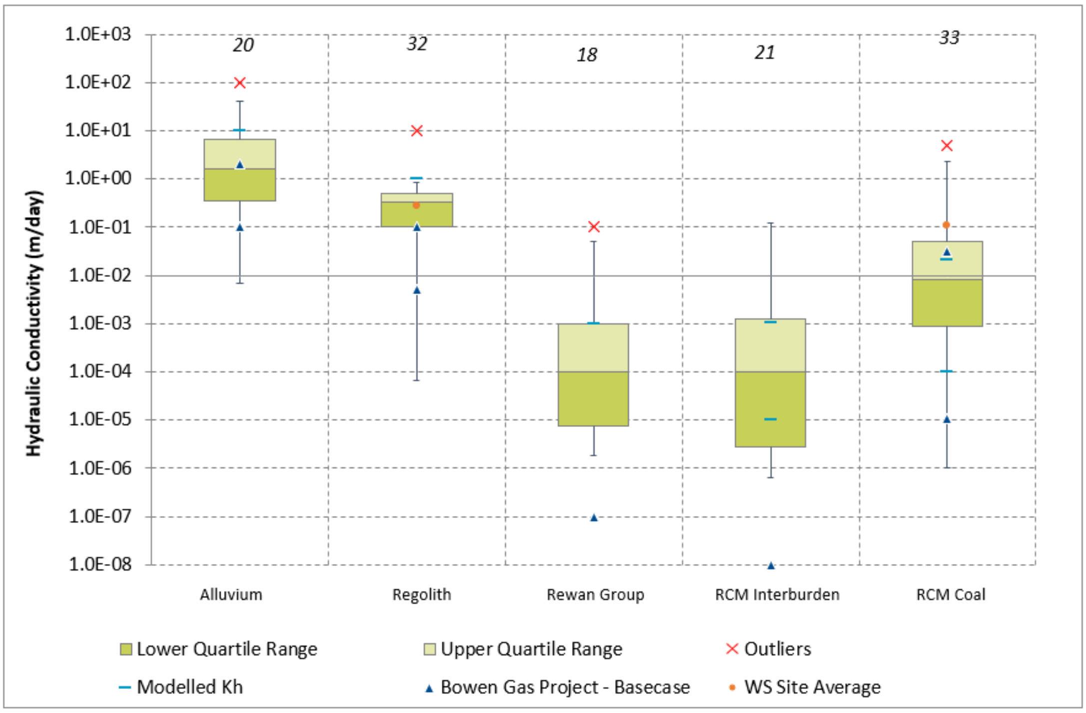


Figure 2-10 Hydraulic Parameters Estimates vs Calibrated Hydraulic Parameters

2.9 Calibrated Storage Properties

Table 2-9 summarises the calibrated values for specific storage and specific yield.

Table 2-9 Calibrated Storage Parameters

Model Layer	Formation	Unit	Specific Yield (SY) (%)	Specific Storage (SS) (m^{-1})
1	Alluvium	Surface cover	5.0	1.0×10^{-4}
	Colluvium	Surface cover	0.4	1.0×10^{-5}
1 & 2	Tertiary Basalt	Tertiary basalt	2.9	7.3×10^{-5}
2	Regolith	Tertiary and minor Triassic Clematis	0.1 to 2.0	1.1×10^{-5} to 1.5×10^{-5}
3	Rewan Group	Triassic	0.3 to 0.5	1.5×10^{-5} to 5.0×10^{-5}
4	Rangal Coal Measures	Leichhardt overburden	0.1	5.0×10^{-5}
5		Leichhardt Seam	0.2	3.8×10^{-6}
6		Interburden	0.2	1.8×10^{-6}
7		Vermont Seam	0.1	1.2×10^{-6}
8		Vermont underburden	0.4	1.3×10^{-6}
9	Fort Cooper Coal Measures	Fort Cooper overburden	0.2	1.4×10^{-5}
10		Fort Cooper seam	0.9	5.0×10^{-5}
11		Fort Cooper underburden	0.2	1.0×10^{-6}
12	Moranbah Coal Measures	Moranbah overburden	0.2	1.3×10^{-6}
13		Moranbah (Goonyella) Seam	0.4	1.3×10^{-6}
14		Moranbah underburden	0.1	1.0×10^{-6}
All	Undivided Intrusives	Intrusives	<0.1	1.0×10^{-6}
Below L02	Fault	All below Layer 2	0.1 to 1.0	1.0×10^{-6} to 1.00×10^{-5}
-	Waste Rock/Spoil	-	5.0	1.0×10^{-5}

2.10 Calibrated Recharge

Table 2-10 presents the calibrated (Base Case) recharge rates to each geological unit in the model, compared to the Bowen Gas Project (BGP) recharge rate range. These calibrated recharge rates have been adopted into the predictive model.

Figure 2-11 illustrates the range in recharge values for the model domain, as annual rainfall (mm/year). The recharge rates were calculated using the chloride mass balance (CMB) method for the various units. The CMB calculations were based on available water quality results (chloride concentrations) collected from site monitoring bores and landholder bores. The CMB calculation assumed average annual rainfall of 577 millimetres (mm) as modelled. The calculations also assumed a mean annual rainfall chloride flux of 3 milligrams per litre (mg/L). No site data is available for the low permeability Rewan Group. Outliers were excluded from the calculations, and were identified as readings more than four standard deviations above the mean (USEPA, 2009).

Table 2-10 Rainfall Recharge Ranges

	BGP Low		BGP High		Project Base Case		MVS/ODP Base Case	
	mm/year	% rain	mm/year	% rain	mm/year	% rain	mm/year	% rain
Stream Channel	3	0.48	26	4.35	3.19	0.55	2.8	0.45
Flood Plain Alluvium	2	0.32	17	2.90	1.44	0.25	5.1	0.82
Other Alluvium	1	0.16	9	1.45	1.44	0.25	3.1	0.49
Tertiary Sediments	0.3	0.05	3	0.48	0.1	0.02	0.15	0.02
Tertiary basalt	0.5	0.1	28	4.85	28.87	5.00	-	-
Rewan Group	0	0.00	0	0.00	0.06	0.01	0.01	<0.01
Outcropping Coal Measures	0.3	0.05	3	0.48	0.06	0.01	0.06	0.01

BGP = Arrow Energy Bowen Gas Project
MVS = Moorvale South Project model
ODP = Olive Downs Project model

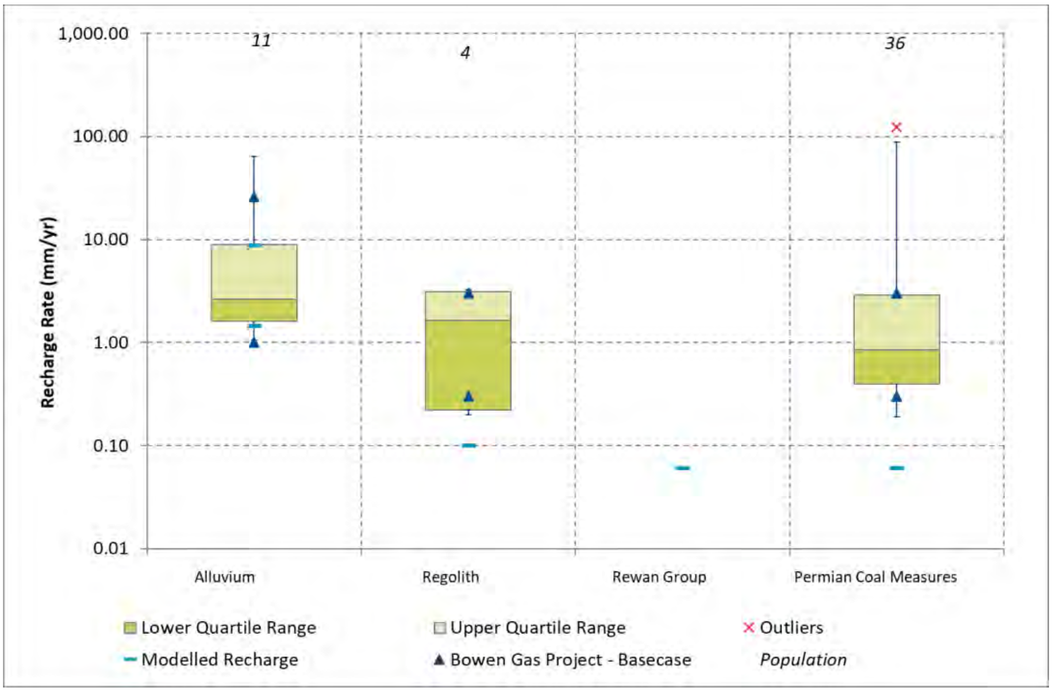


Figure 2-11 Site Recharge Estimates vs Modelled Recharge

This is consistent with the recharge applied in the BGP modelling and has been used as a guide to applicable recharge ranges for each outcropping geological unit. As per the conceptual model, higher recharge occurs through the alluvium and lower recharge in regolith and Permian outcrops. Increased recharge through the alluvium of the Isaac River channel has been used to simulate the potential for the Isaac River to provide rapid recharge to the alluvial groundwater system during rainfall events. For comparison, other nearby projects have used modelled recharge as a default value across the domain, with Lake Vermont simulating recharge equivalent of 2% mean annual rainfall, and Isaac Plains simulating 0.5% to alluvium and 0.25% elsewhere. These values indicate overall rainfall recharge to the groundwater system is limited. Recharge rates in regolith and outcropping coal measures are similar between the Moorvale South Project base case and the Project base case. Recharge rates to the stream channel is 3 times higher in the Project base case relative to Moorvale South Project base case and recharge to Rewan group is also 5 times higher in the Project base case. Conversely, flood plain alluvium and other alluvium recharge rates are more than 2 times higher in the Moorvale South Project base care relative to the Project base case.

3 Predictive Modelling

3.1 Timing and Mining

Transient predictive modelling was used to simulate the proposed mining at the Project as well as mining at other approved and foreseeable mines within the model domain. The predictive model comprises 45 stress periods, from 31 December 2019 until 30 December 2053. Mining cells progress either monthly or annually, depending on stress period duration. The predictive model stress period setup is detailed in **Table 3-1**, alongside simulated mine timings. The planned timing progression for coal seam mining at the Project is presented in **Figure 3-1**.

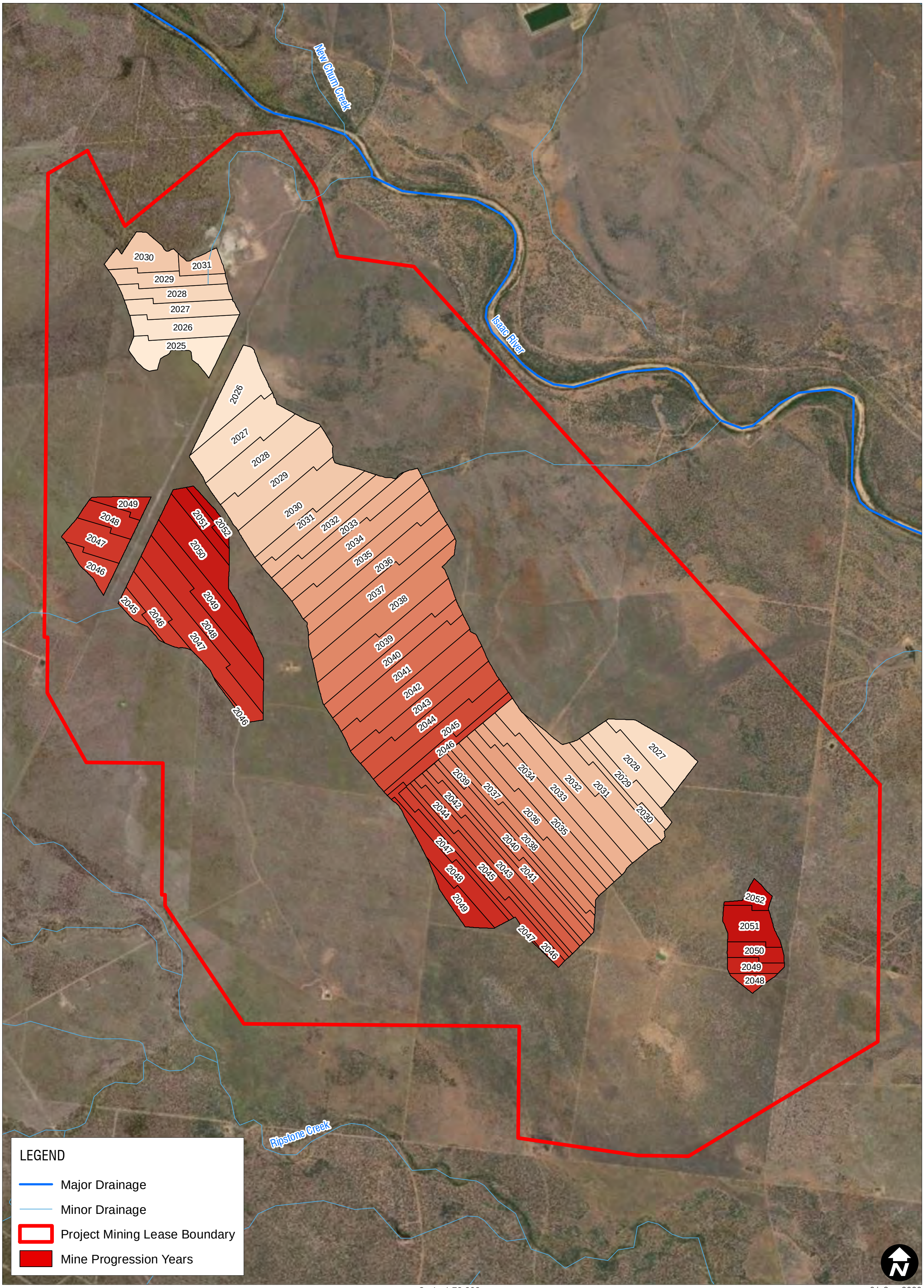
Timings of active drain cells at the Project were based on annual mine progression stage plans. Pre-stripping was simulated 1 year prior to active seam mining by applying drain cells down to the base of Rewan. Following pre-stripping, drain cells were projected down to the base of the lower most target coal seam (i.e. the Vermont seam). A two-year operational window was assumed for mine cells at the Project, after which time the drains were removed and the MODFLOW Time Varying Materials (TVM) package was used to assign spoil properties to the cells. **Table 3-1** details simulated mine timings for the Project and surrounding mines used in the predictive model. All mines included in the model were simulated using the MODFLOW Drain (DRN) package. A nominally high drain conductance of 100 square metres per day (m^2/day) was applied to drain cells to simulate rapid removal of water from the system.

Table 3-1 Predictive Model Stress Period Setup and Mining

Interval	Stress Period	Date (from)	Date (to)	Winchester South (OC)	Moorvale South (OC)	Olive Downs (OC)	Caval Ridge (OC)	Peak Downs (OC)	Saraji (OC)	Saraji East (UG)	Lake Vermont (OC)	Eagle Downs (UG)	Poitrel (OC)	Daunia (OC)
Monthly	1	31-12-2019	30-01-2020				x	x	x		x	x	x	x
Monthly	2	31-01-2020	01-03-2020				x	x	x		x	x	x	x
Monthly	3	02-03-2020	31-03-2020				x	x	x		x	x	x	x
Monthly	4	01-04-2020	01-05-2020				x	x	x		x	x	x	x
Monthly	5	02-05-2020	31-05-2020				x	x	x		x	x	x	x
Monthly	6	01-06-2020	30-06-2020				x	x	x		x	x	x	x
Monthly	7	01-07-2020	31-07-2020		x		x	x	x		x	x	x	x
Monthly	8	01-08-2020	30-08-2020		x		x	x	x		x	x	x	x
Monthly	9	31-08-2020	30-09-2020		x		x	x	x		x	x	x	x
Monthly	10	01-10-2020	30-10-2020		x		x	x	x		x	x	x	x
Monthly	11	31-10-2020	30-11-2020		x		x	x	x		x	x	x	x
Monthly	12	01-12-2020	30-12-2020		x	x	x	x	x		x	x	x	x
Annual	13	31-12-2020	30-12-2021		x	x	x	x	x		x	x	x	x
Annual	14	31-12-2021	31-12-2022		x	x	x	x	x		x	x	x	x
Annual	15	01-01-2023	31-12-2023		x	x	x	x	x		x	x	x	x
Annual	16	01-01-2024	30-12-2024	x	x	x	x	x	x		x	x	x	x
Annual	17	31-12-2024	30-12-2025	x	x	x	x	x	x		x	x	x	x

Interval	Stress Period	Date (from)	Date (to)	Winchester South (OC)	Moorvale South (OC)	Olive Downs (OC)	Caval Ridge (OC)	Peak Downs (OC)	Saraji (OC)	Saraji East (UG)	Lake Vermont (OC)	Eagle Downs (UG)	Poitrel (OC)	Daunia (OC)
Annual	18	31-12-2025	31-12-2026	x	x	x	x	x	x		x	x	x	x
Annual	19	01-01-2027	31-12-2027	x	x	x	x	x	x		x	x	x	x
Annual	20	01-01-2028	30-12-2028	x	x	x	x	x	x		x	x	x	x
Annual	21	31-12-2028	30-12-2029	x	x	x	x	x	x		x	x	x	x
Annual	22	31-12-2029	31-12-2030	x	x	x	x	x	x		x	x	x	x
Annual	23	01-01-2031	31-12-2031	x		x	x	x	x		x	x	x	x
Annual	24	01-01-2032	30-12-2032	x		x	x	x	x		x	x	x	x
Annual	25	31-12-2032	30-12-2033	x		x	x	x			x	x	x	x
Annual	26	31-12-2033	31-12-2034	x		x	x	x			x	x	x	x
Annual	27	01-01-2035	31-12-2035	x		x	x	x			x	x	x	x
Annual	28	01-01-2036	30-12-2036	x		x	x	x			x	x	x	x
Annual	29	31-12-2036	30-12-2037	x		x	x	x			x	x	x	x
Annual	30	31-12-2037	31-12-2038	x		x	x	x		x	x	x	x	x
Annual	31	01-01-2039	31-12-2039	x		x	x	x		x	x	x	x	x
Annual	32	01-01-2040	30-12-2040	x		x	x	x		x	x	x	x	x
Annual	33	31-12-2040	30-12-2041	x		x	x	x		x	x	x	x	x
Annual	34	31-12-2041	31-12-2042	x		x	x	x		x	x	x	x	x
Annual	35	01-01-2043	31-12-2043	x		x	x	x		x	x	x	x	x

Interval	Stress Period	Date (from)	Date (to)	Winchester South (OC)	Moorvale South (OC)	Olive Downs (OC)	Caval Ridge (OC)	Peak Downs (OC)	Saraji (OC)	Saraji East (UG)	Lake Vermont (OC)	Eagle Downs (UG)	Poitrel (OC)	Daunia (OC)
Annual	36	01-01-2044	30-12-2044	x		x	x	x		x	x	x	x	x
Annual	37	31-12-2044	30-12-2045	x		x	x	x		x	x	x	x	x
Annual	38	31-12-2045	31-12-2046	x		x	x	x		x	x	x	x	x
Annual	39	01-01-2047	31-12-2047	x		x	x	x		x	x	x	x	x
Annual	40	01-01-2048	30-12-2048	x		x	x	x		x	x	x	x	x
Annual	41	31-12-2048	30-12-2049	x		x	x	x		x	x	x	x	x
Annual	42	31-12-2049	31-12-2050	x		x	x	x		x	x	x		x
Annual	43	01-01-2051	31-12-2051	x		x	x	x		x	x	x		x
Annual	44	01-01-2052	30-12-2052	x		x	x	x		x	x	x		x
Annual	45	31-12-2052	30-12-2053	x		x	x			x	x	x		x



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\02 EIS Report Figures\SLR62013245_F3_1 Winchester South Mine Progression.mxd

Scale: 1:72,202
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 1 2 3 Kilometers

Project Mine Progression

FIGURE 3-1

3.2 Water Balance

Table 3-2 details average flow rates for water transfer into and out of the predictive model period (January 2020 to end of December 2053) for two scenarios:

- Scenario A (Approved Mining) which includes all approved and foreseeable surrounding mines in the Study Area; and
- Scenario B (Cumulative Mining) which includes the surrounding mines from Scenario A, with the addition of the Project.

In both scenarios, the largest inflow contributor to the groundwater system is rainfall recharge. Rainfall recharge contributes on average; 5.39 ML/d in Scenario A, and, 5.61 ML/d in Scenario B to the model groundwater system. Regional groundwater flow is the next largest contributor in both scenarios. For both Scenarios A and B, regional groundwater flow provides a net model inflow contribution of 3.27 ML/d. Net inflow of leakage from the Isaac River to the groundwater system is also consistent between the scenarios, at 1.74 ML/d.

Groundwater outflow from the model mostly occurs via drain cells, used to simulate open cut and underground mining activity in the model. Drain cell outflow is equal to 9.06 ML/d in Scenario B and 8.62 ML/d in Scenario A. See **Section 3.5** for a summary of the predicted inflows to the proposed open cut pits for the Project. In both scenarios, evapotranspiration and baseflow to minor river systems are responsible for average outflow rates of 0.93 ML/d and 0.61 ML/d, respectively.

Both scenarios maintained mass balance errors below 1% for all time steps as well as cumulatively throughout the simulations. The low error achieved indicates that the predictive model is stable, and the solution achieved is accurate (Barnett *et al*., 2012).

Table 3-2 Average Simulated Water Balance over the Prediction Period

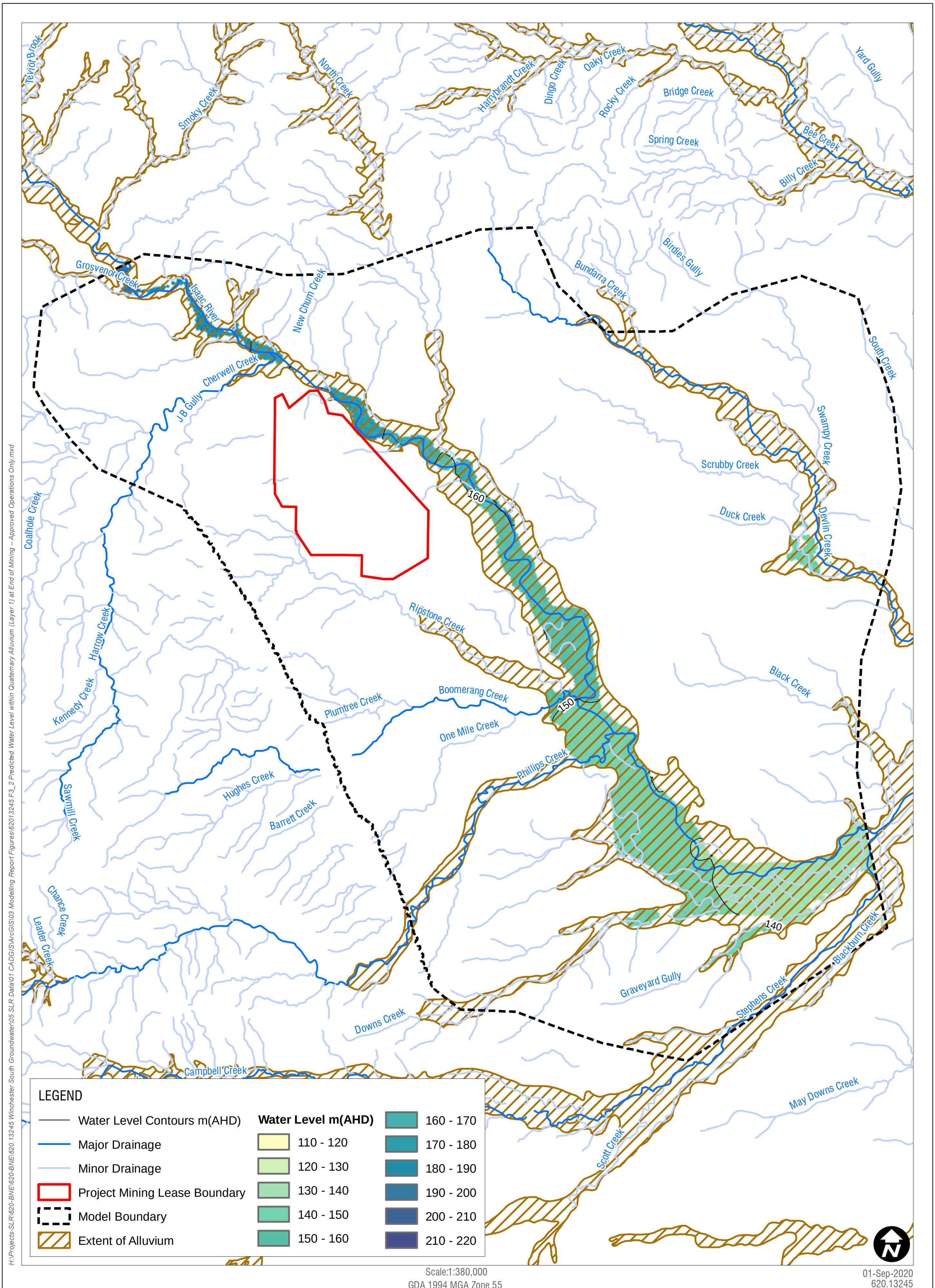
Component	Scenario A (Approved Mining)		Scenario B (Cumulative Mining)	
	Inflow (ML/d)	Outflow (ML/d)	Inflow (ML/d)	Outflow (ML/d)
Recharge (direct rainfall)	5.39	-	5.61	-
Evapotranspiration (ET)	-	0.93	-	0.93
SW/GW Interaction Isaac River (STR)	12.79	11.05	12.75	11.01
SW/GW Interaction Minor Rivers (RIV)	-	0.61	-	0.61
Regional GW flow (GHB)	4.29	1.02	4.29	1.02
Drains (Mine water removal)	-	8.62	-	9.06
Storage	15.70	15.94	16.33	16.35
Total	38.16	38.16	38.97	38.97

3.3 Predicted Groundwater Levels

Predicted groundwater levels at the end of mining operations for the two scenarios are provided in **Figure 3-2** through **Figure 3-7**. No data regions in the water level grids represent unsaturated areas, i.e. where the simulated water level elevation is below the base of cell.

Minimal changes to alluvial groundwater levels are observed between the Approved and Cumulative mining scenarios (**Figure 3-2** and **Figure 3-5**). **Figure 3-3** and **Figure 3-6** show predicted groundwater levels in the regolith at the end of mining for the two scenarios. Dewatering of the regolith caused by the proposed mining at the Project is evident by the larger desaturated zone within the Project Area for the Cumulative mining scenario(**Figure 3-6**), relative to the Approved mining scenario (**Figure 3-3**).

Figure 3-4 and **Figure 3-7** show the predicted water levels in the Fort Cooper Coal Measures overburden (Layer 9) at the end of mining for the Approved and Cumulative mining scenarios. This unit has been chosen to represent head levels in the Permian Coal Measures due to its regional extent. A regional south-easterly hydraulic gradient can be observed, reflecting the downstream flow gradient of the Isaac River. Zones of depressurisation at the Project and surrounding mines are shown to cause localised interruptions to the regional flow gradient. Discussion on groundwater drawdown within the Permian Coal Measures is included in **Section 3.4**.



Sheet Size : A4

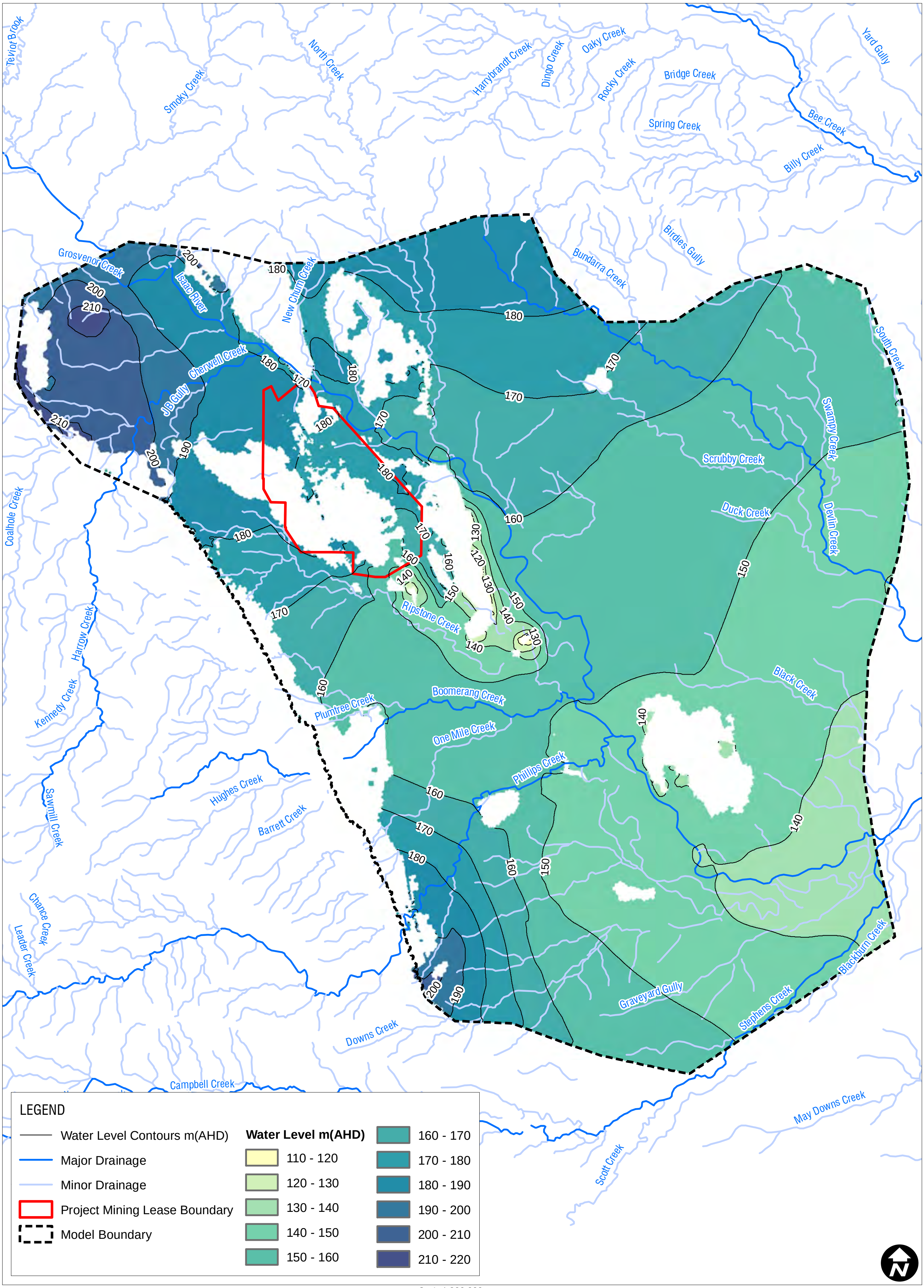
SLR

www.slrconsultingaustralia.com

0 5 10 Kilometers

Predicted Water Level within Quaternary Alluvium (Layer 1) at End of Mining – Approved Operations Only

FIGURE 3-2



Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\62013245 F3_3 Predicted Water Level within Regolith (Layer 2) at End of Mining – Approved Operations Only.mxd

Sheet Size : A4

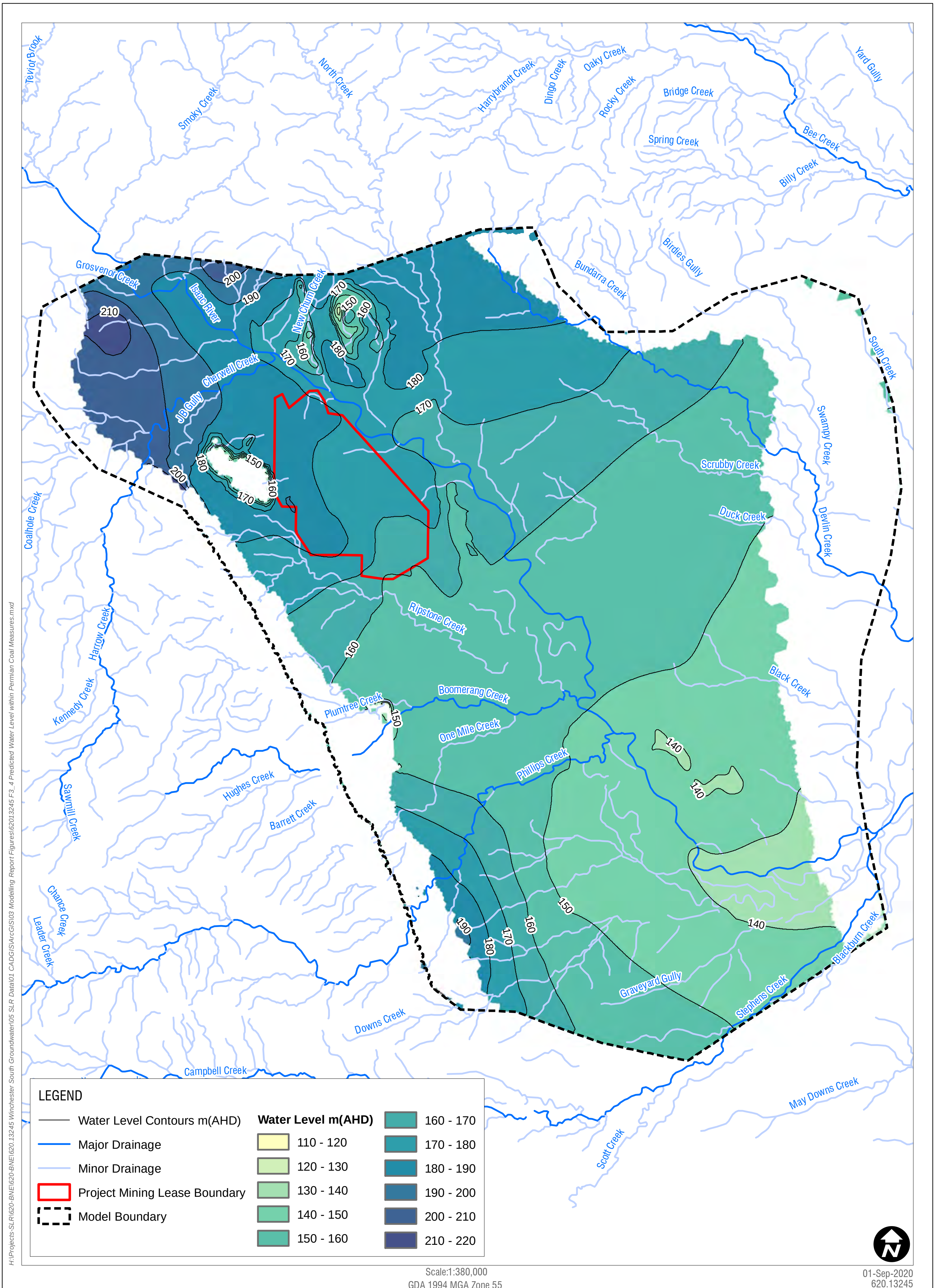
SLR

www.slrconsultingaustralia.com

0 5 10 Kilometers

Predicted Water Level within Regolith (Layer 2) at End of Mining – Approved Operations Only

FIGURE 3-3



Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

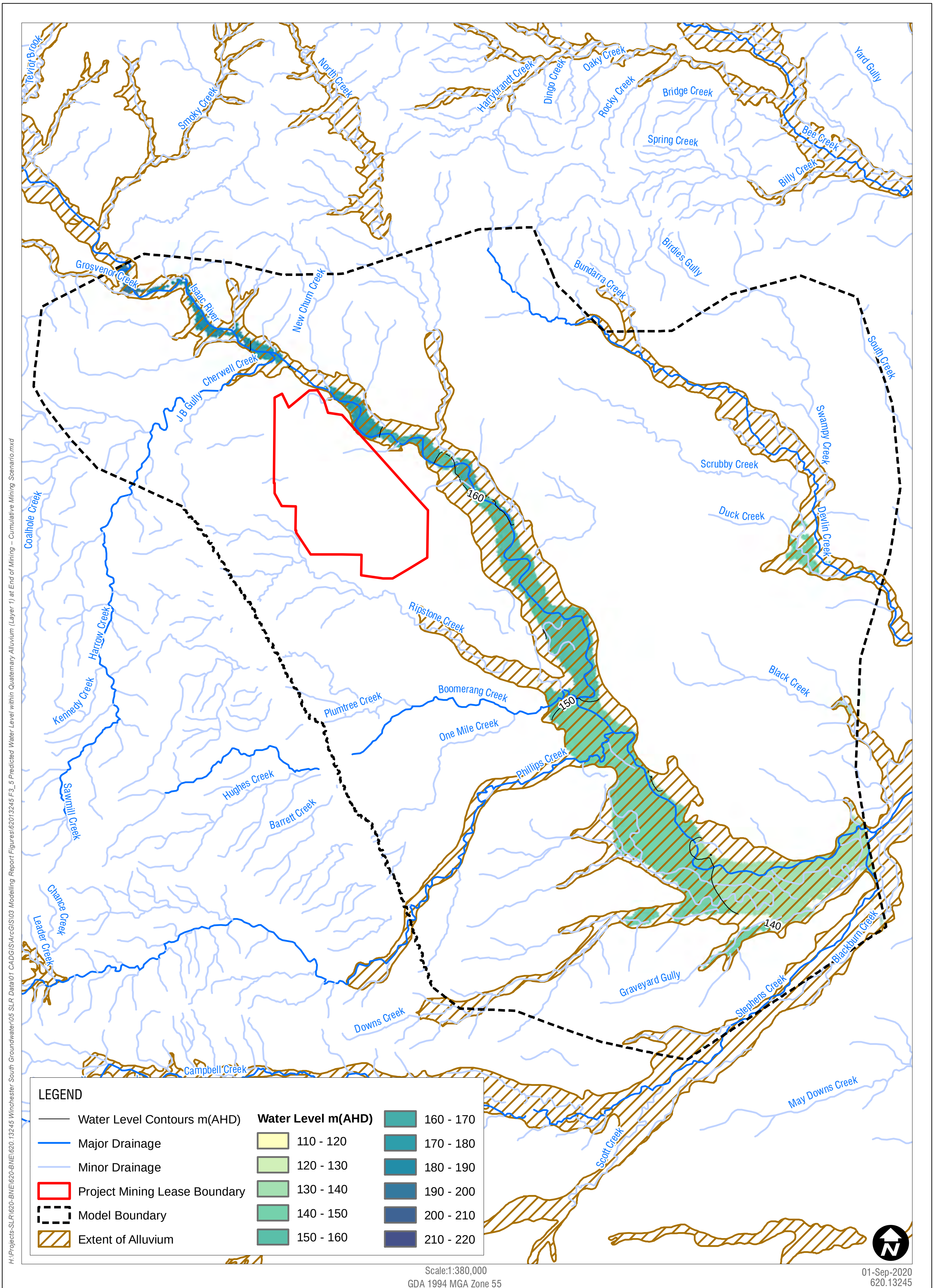
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Predicted Water Level within Permian Coal Measures (Layer 9) at End of Mining – Approved Operations Only

FIGURE 3-4



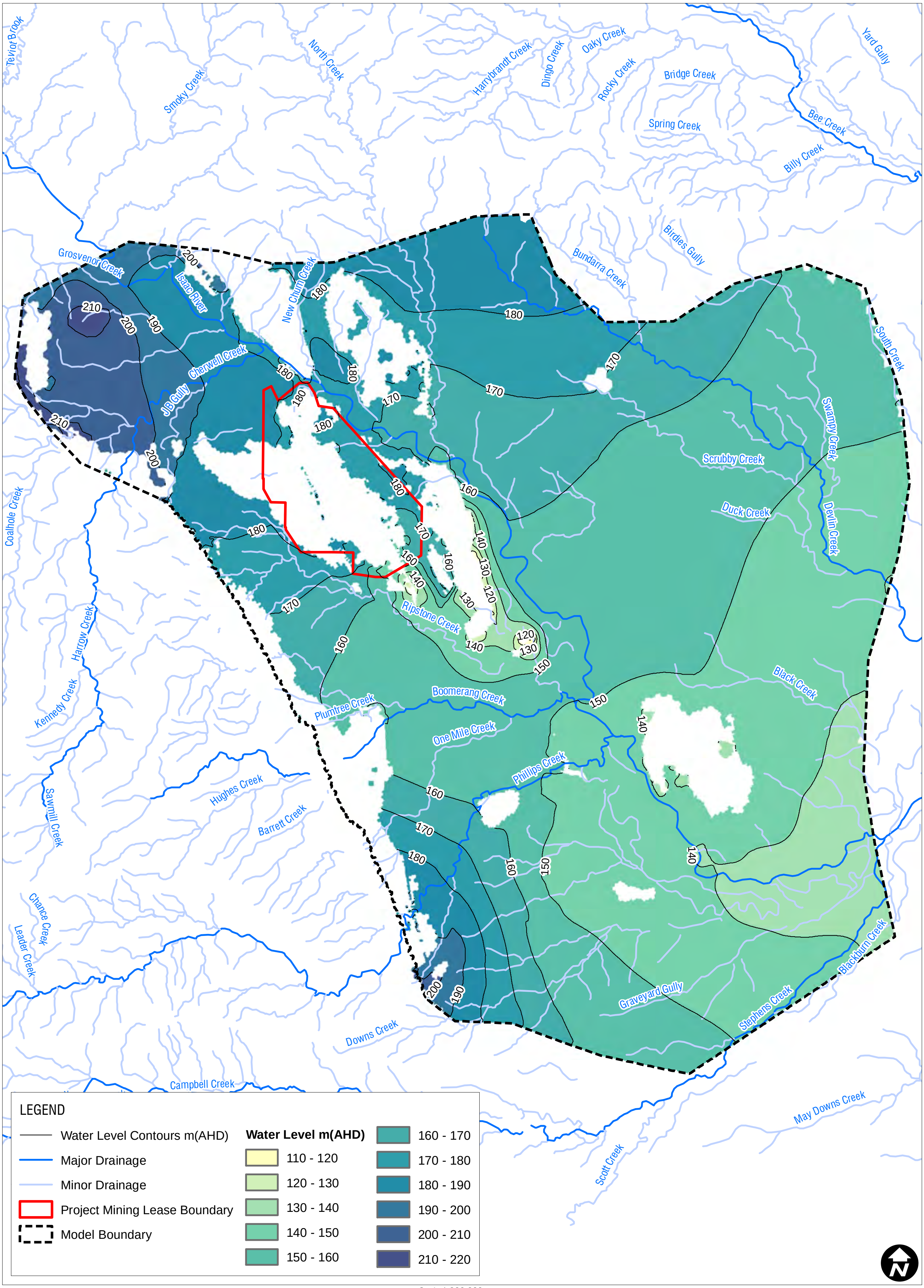
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Predicted Water Level within Quaternary Alluvium (Layer 1) at End of Mining – Cumulative Mining Scenario

FIGURE 3-5



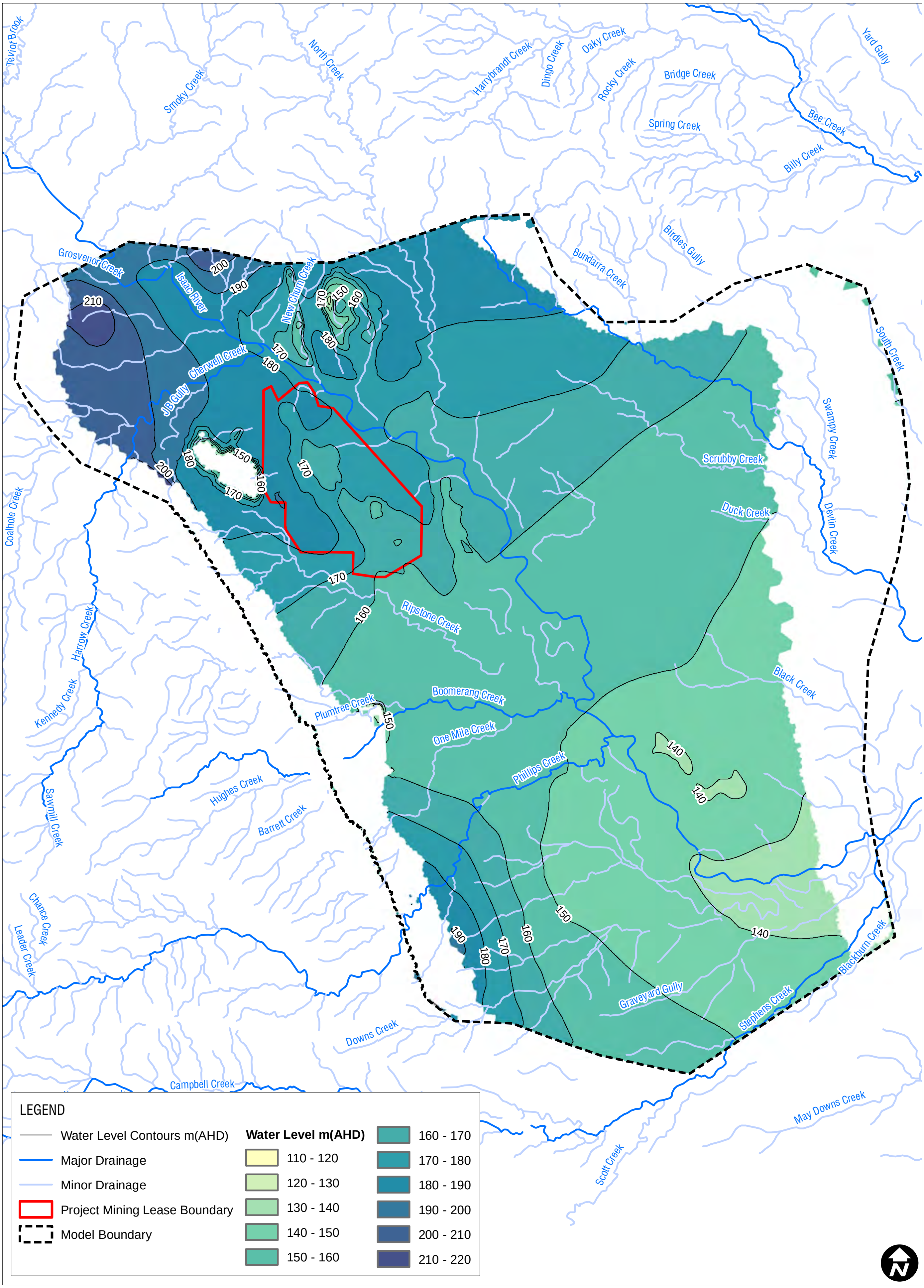
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Predicted Water Level within Regolith (Layer 2) at End of Mining – Cumulative Mining Scenario

FIGURE 3-6



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\6201324S F3_7 Predicted Water Level within Permian Coal Measures (Layer 9) at End of Mining – Cumulative Mine Plan.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Predicted Water Level within Permian Coal Measures (Layer 9) at End of Mining – Cumulative Mine Plan

FIGURE 3-7

3.4 Maximum Predicted Drawdowns

The process of mining directly removes water from the groundwater system and reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Aquifer drawdown is greatest at the working coal-face and decreases with distance from the mine.

Maximum incremental drawdown refers to the drawdown impact associated with the Project and is obtained by comparing the difference in predicted aquifer groundwater levels for the Approved model scenario and the Cumulative model scenario at matching times. The maximum drawdown represents the maximum drawdown values recorded at each model cell at any time over the predictive model duration. Predicted drawdown figures (**Figure 3-8** through **Figure 3-14**) show where maximum drawdown impacts are predicted to exceed 1 m. In areas within the 1 m drawdown contour, the unit is considered impacted by drawdown. Figures include the locations of known private bores intercepting the relevant layers. Note that no private bores are predicted to be impacted as a result of mining activities at the Project.

No incremental drawdown impacts are predicted for the Quaternary alluvium as a result of mining at the Project. For a discussion on the potential incidental water impacts on the Quaternary alluvium, see **Section 3.6.1**.

The maximum predicted incremental drawdowns associated with the Project within the regolith is shown in **Figure 3-8.** Lateral incremental drawdown extents within the regolith (Layer 2) is largely confined to the Project Area, and, is influenced by the distribution of predicted saturated zones in the regolith. At the northern end of the mining lease, 1 m drawdown influence is predicted to extend 1.9 km west of the MLA boundary. At the southern end of the MLA, predicted drawdown impacts extend 1.7 km south-east of the MLA boundary. Southward drawdown impacts are predicted to reach Pit 9 of the Olive Downs Project. Incremental drawdown impacts within regolith is not predicted to exceed 15 m.

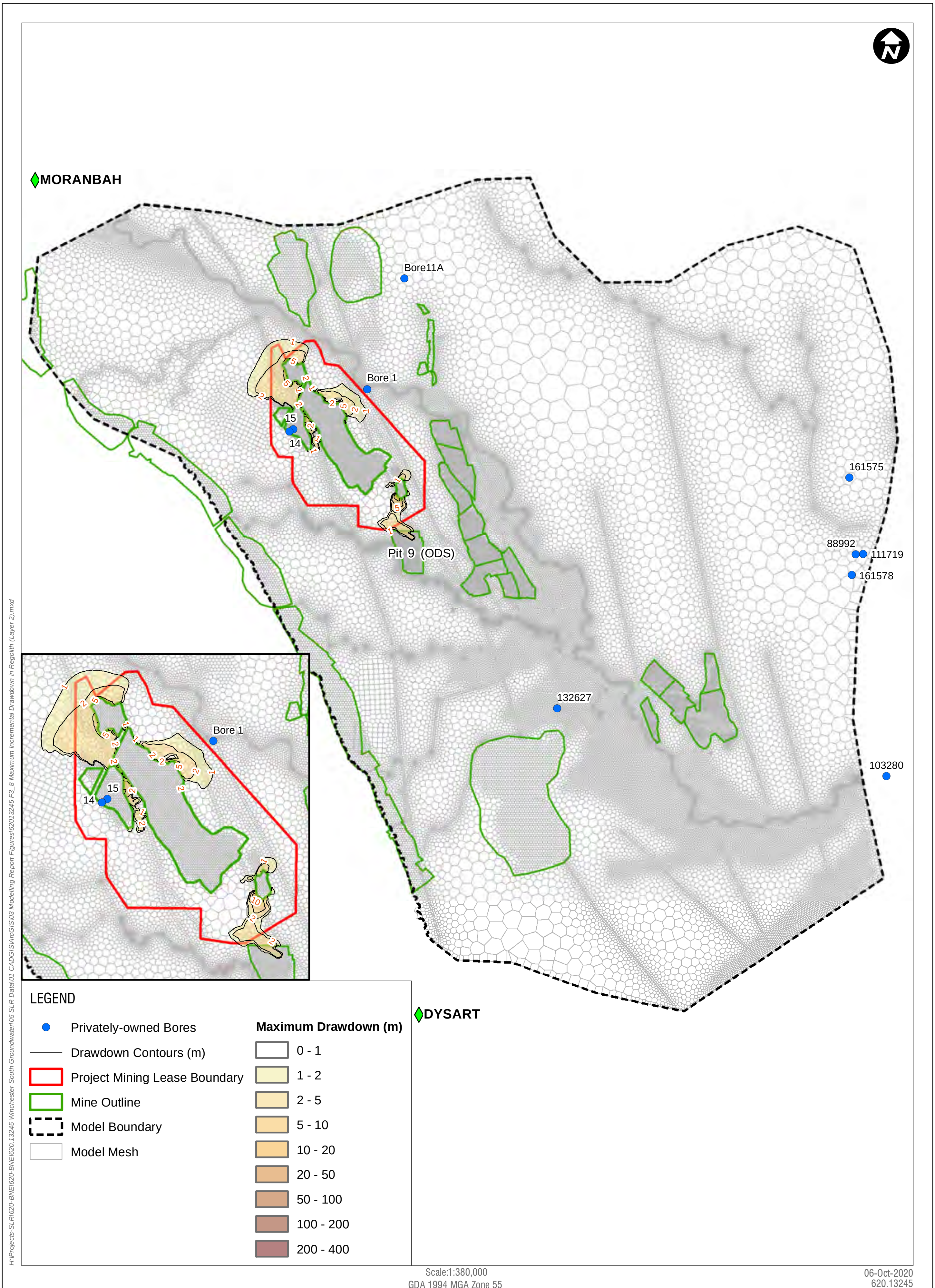
The Leichhardt and Vermont coal seams of the Rangal Coal Measures are the primary aquifers targeted by the Project, and, will experience drawdowns as a direct result of mining at the Project. Groundwater level drawdown within the mined coal seams is influenced by unit structure and is confined to unit extents. The direction of impact propagation in the coal seam aquifers is shown to align with the geologic strike of the Winchester South Syncline on which the Project is located (northwest – southeast). Project impacts are restricted in the east-west direction by the unit structure and are largely contained within the MLA (**Figure 3-9** and **Figure 3-10**).

Figure 3-9 shows the maximum predicted incremental drawdown for the Leichhardt seam (Layer 5). This unit is predicted to experience a maximum of 82 m drawdown at the working coal face. Impacts are predicted to extend up to 2 km north-west of the Project, and up to 2.1 km south-east of the Project.

Figure 3-10 shows the maximum predicted incremental drawdown for the Vermont seam (Layer 7). This unit is predicted to experience a maximum of 142 m drawdown at the working coal face. Impacts are predicted up to 1.6 km west of the Project MLA, and up to 1.2 km south-east of the Project. Drawdown impacts in both the Leichhardt and Vermont seams are predicted to reach mining at Pit 9 of the Olive Downs Project.

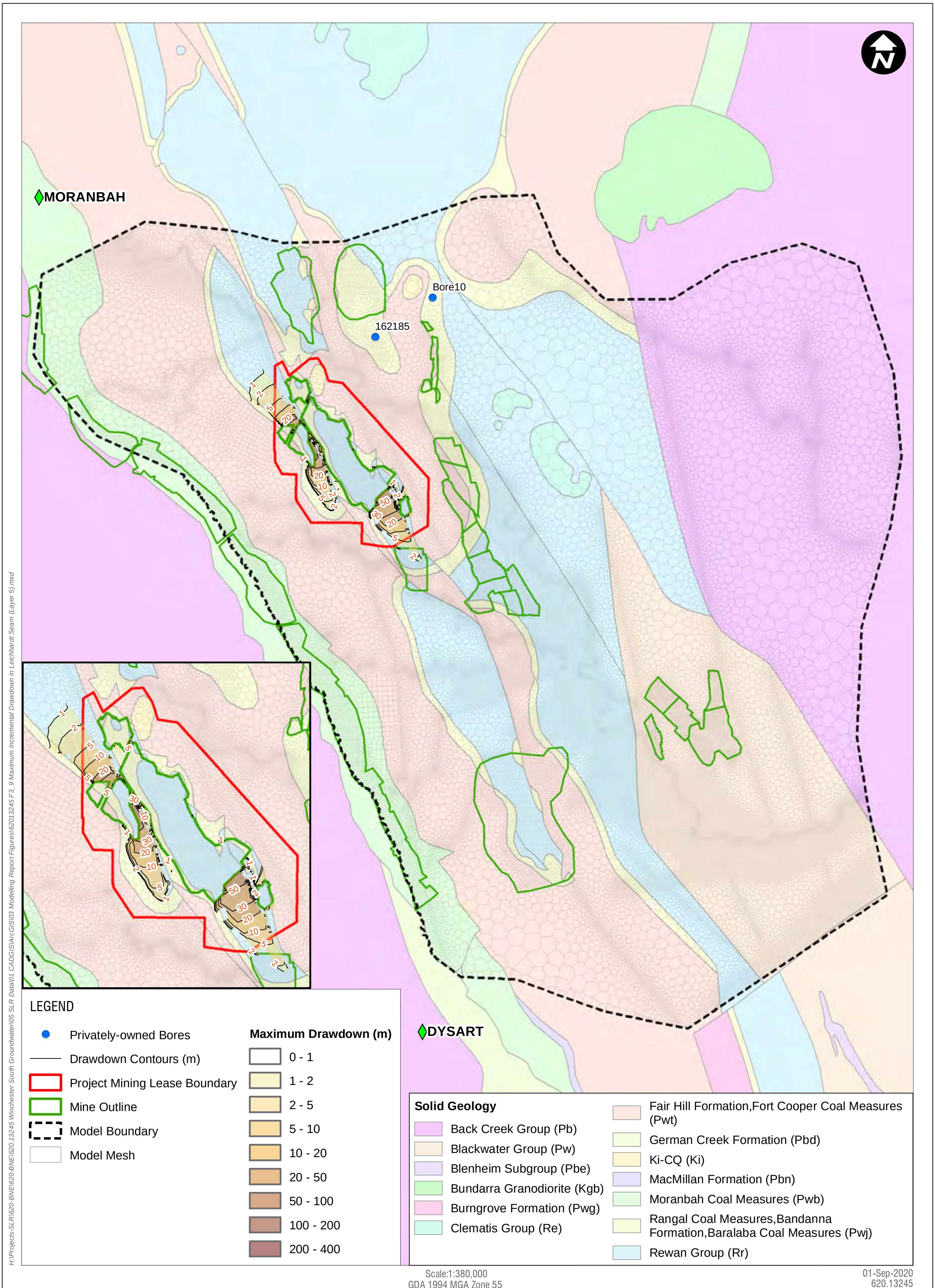
Cumulative drawdown impacts are shown in **Figure 3-11** through **Figure 3-14**. These drawdowns represent the total impact of mining to model groundwater levels by comparing the maximum difference in aquifer groundwater levels for the Cumulative model scenario with those in a theoretical "No Mining" scenario, for all times during the predictive model period.

Cumulative drawdown impacts are predicted within the extents of the Isaac River alluvium and occur north and east of the Project mining lease boundary (**Figure 3-11)**. Cumulative impacts within the regolith can be seen connecting the Project-related drawdown to the drawdown impacts at Olive Downs Project, south of the Project, as well as to Eagle Downs Mine and Peak Downs Mine impacts to the west (**Figure 3-12**). For the Leichhardt and Vermont coal seams, drawdown interaction is predicted between the Project and Olive Downs Project Pit 9 (**Figure 3-13** and **Figure 3-14**). For drawdowns at specific times over the life of mining, see **Appendix D**.



Maximum Incremental Drawdown in Regolith (Layer 2)

FIGURE 3-8



Sheet Size : A4

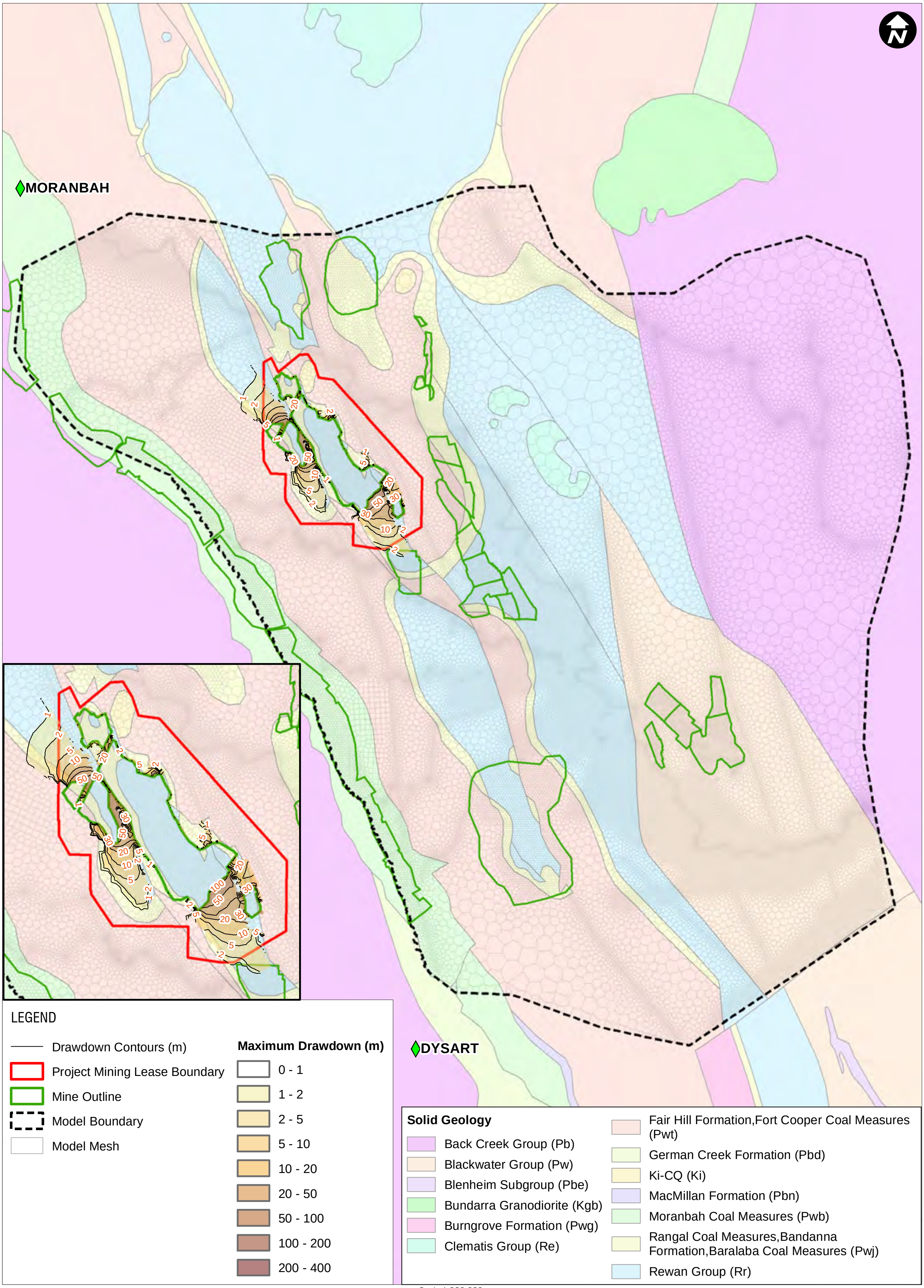
SLR

www.slrconsultingaustralia.com

0 5 10 Kilometers

Maximum Incremental Drawdown in Leichhardt Seam (Layer 5)

FIGURE 3-9



Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

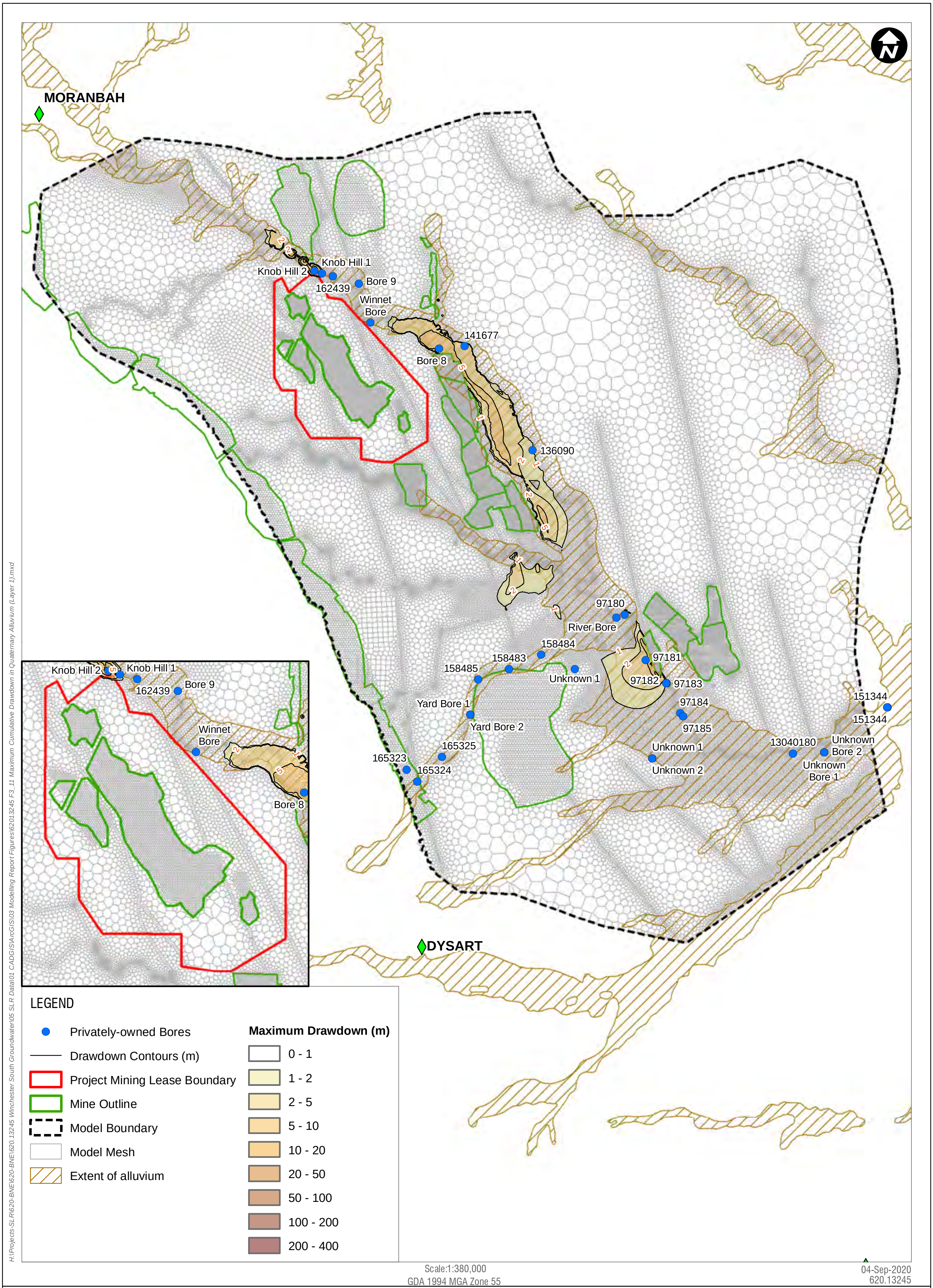
Sheet Size : A4

0 5 10 Kilometers

www.slrconsultingaustralia.com

Maximum Incremental Drawdown in Vermont Seam (Layer 7)

FIGURE 3-10



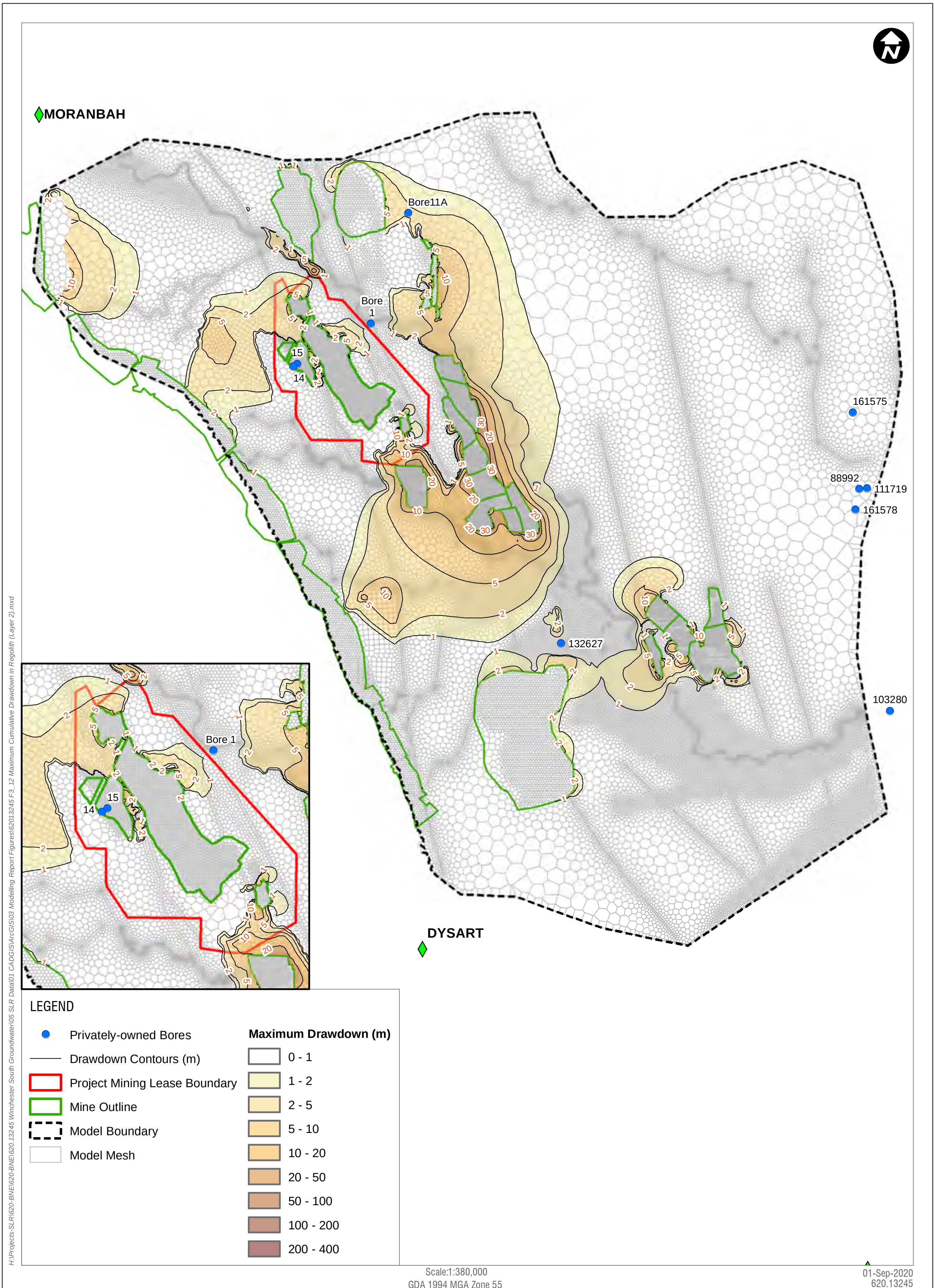
Sheet Size : A4

0 5 10 Kilometers

SLR www.slrconsultingaustralia.com

Maximum Cumulative Drawdown in Quaternary Alluvium (Layer 1)

FIGURE 3-11



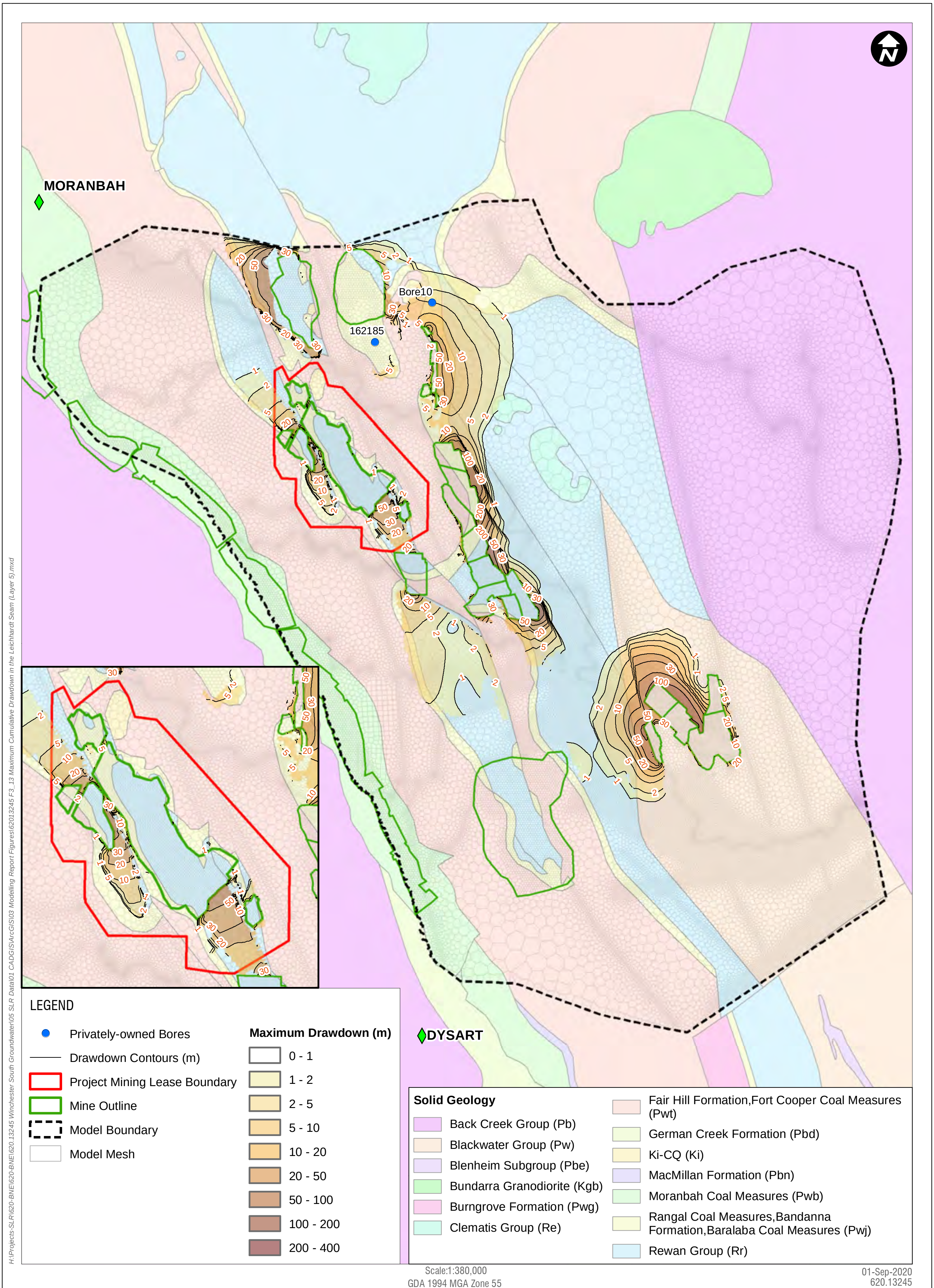
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Maximum Cumulative Drawdown in Regolith (Layer 2)

FIGURE 3-12



Sheet Size : A4

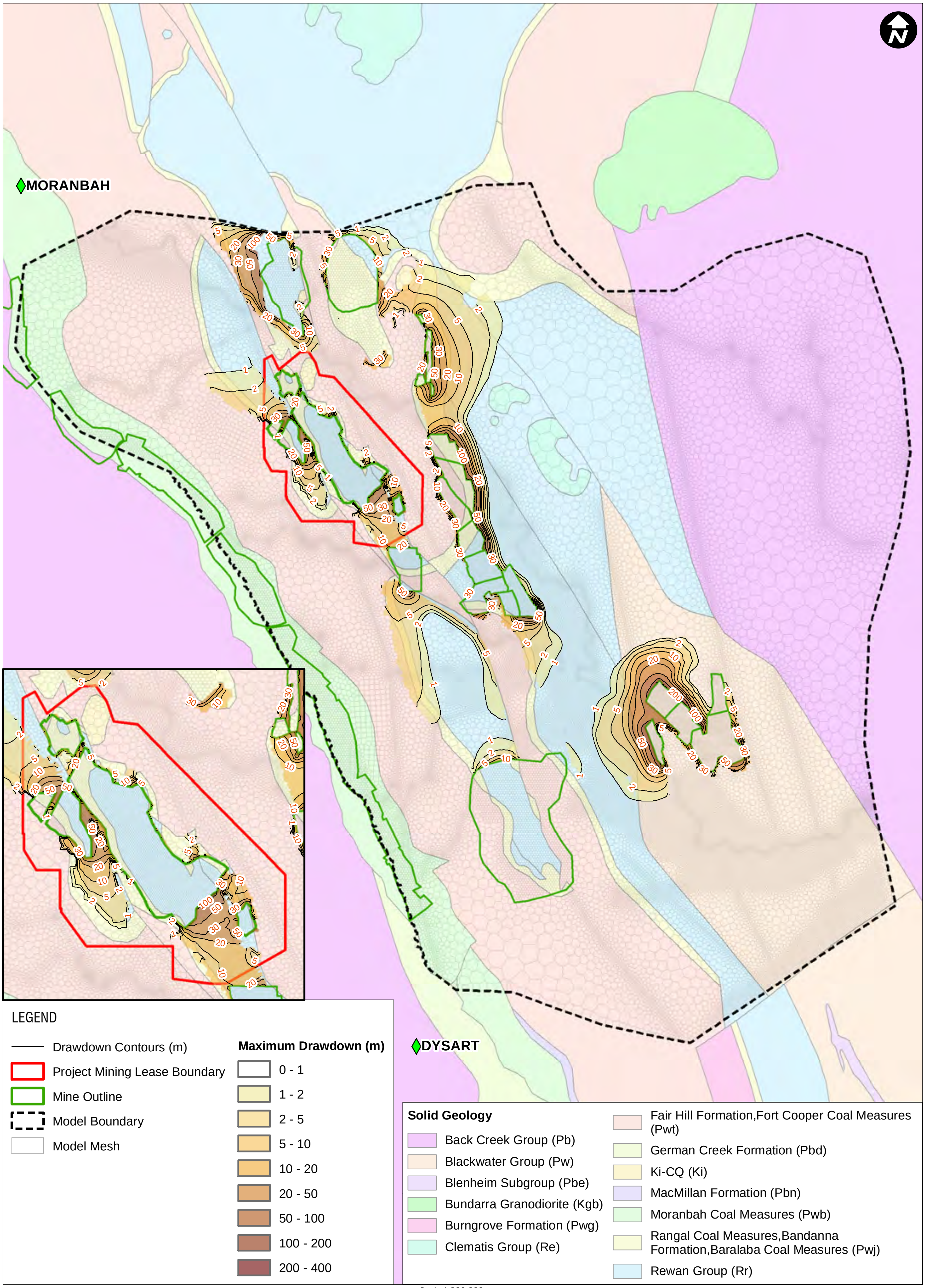
SLR

www.slrconsultingaustralia.com

0 5 10 Kilometers

Maximum Cumulative Drawdown in the Leichhardt Seam (Layer 5)

FIGURE 3-13



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\62013245 F3_14 Maximum Cumulative Drawdown in the Vermont Seam (Layer 7).mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

01-Sep-2020
620.13245

Sheet Size : A4

0 5 10 Kilometers

SLR
www.slrconsultingaustralia.com

Maximum Cumulative Drawdown in the Vermont Seam (Layer 7)

FIGURE 3-14

3.5 Predicted Groundwater Interception

Project mine pit inflow volumes have been calculated as time weighted averages of the outflow reported by ZoneBudget software for Project drain cells. Results are presented in **Figure 3-15**. As shown, inflows to the open cut operations is predicted to reach a maximum peak in year 2029, with 352 ML total inflow predicted for the year. Inflow rates decline before rising again from 2046, with the planned commencement of mining at South Pit, West Pit and North-west Pit. This later peak in 2049 is predicted to reach approximately 254 ML/year. The average inflow rate over the total duration of mining is calculated at 183 ML/year.

The Water Plan (Fitzroy Basin) 2011 groundwater area consists of the following:

- Groundwater Unit 1 (containing aquifers of the Quaternary alluvium); and
- Groundwater Unit 2 (sub-artesian aquifers).

Planned mining operations at the Project will not intercept Quaternary alluvium at any of the proposed pits. As such, all direct groundwater take predicted by the model is from Groundwater Unit 2.

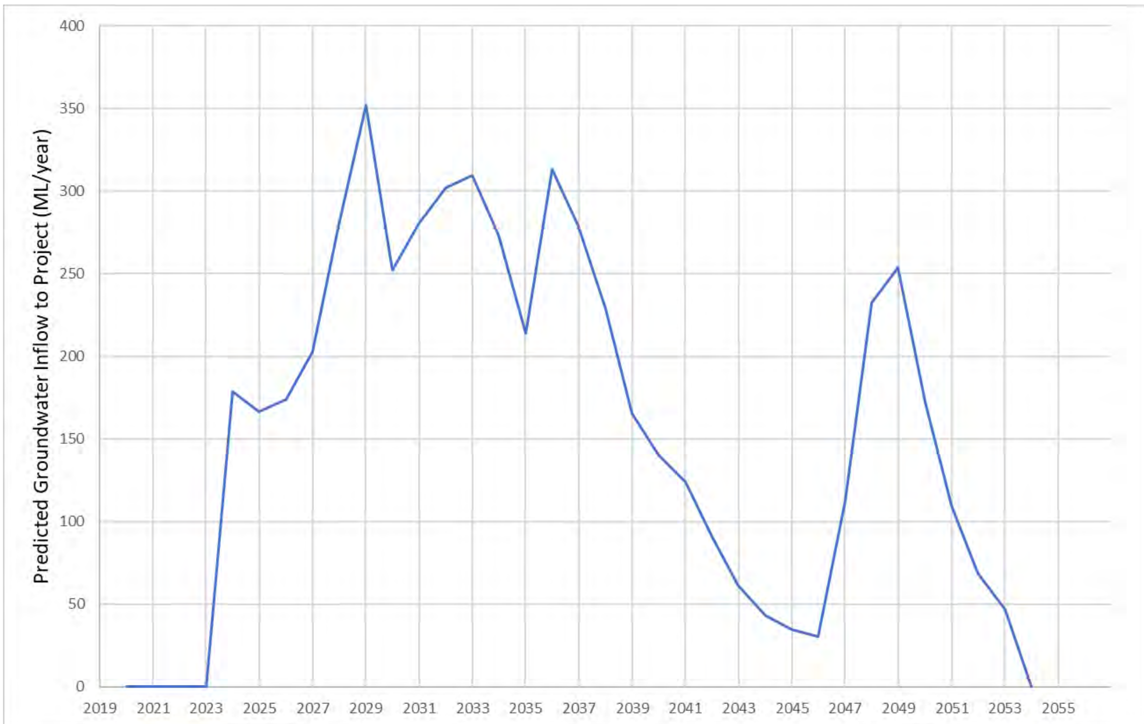


Figure 3-15 Predicted Project Mine Inflows

3.6 Incidental Water Impacts

3.6.1 Influence on Alluvium

Interference of the alluvial groundwater can occur due to increased leakage to the underlying Permian coal measures that are depressurised as a result of mining activities. Over the extent of Quaternary alluvium, there is no predicted loss of water from the alluvium as a result of exercising the underground water rights for the Project. Uncertainty analysis was performed on this metric and it was shown that 91% of the realisations run showed zero (0.0 ML) take from the alluvium over the life of the Project. Outcomes of the uncertainty analysis show only the 95th percentile indicated any take from alluvium (4.38 ML total over the life of the Project). See **Section 5.3.2** for further uncertainty analysis surrounding this metric.

3.6.2 Groundwater – Surface Water Interaction

The predicted change in water levels induced by mining could increase the hydraulic gradient between the Isaac River and the alluvium. The model predicts that over the life of mine, the change in the average rate of seepage from the river to the alluvium is insignificant and considered within the error threshold of predictions (less than 3.65 ML/year)[1]. On average, when the Isaac River flows, 161,863 ML/year of surface water is discharged downstream. An estimate of less than 0.01% increased seepage from the Isaac River to the alluvium as a result of mining at the Project, therefore, represents an insignificant potential for flow rate reduction. The number of days that the Isaac River runs dry is not predicted to increase with the addition of the Project.

[1] Note that the incidental water impacts, reported above, have been obtained using a model version that does not simulate mining at Poitrel.

4 Recovery Model

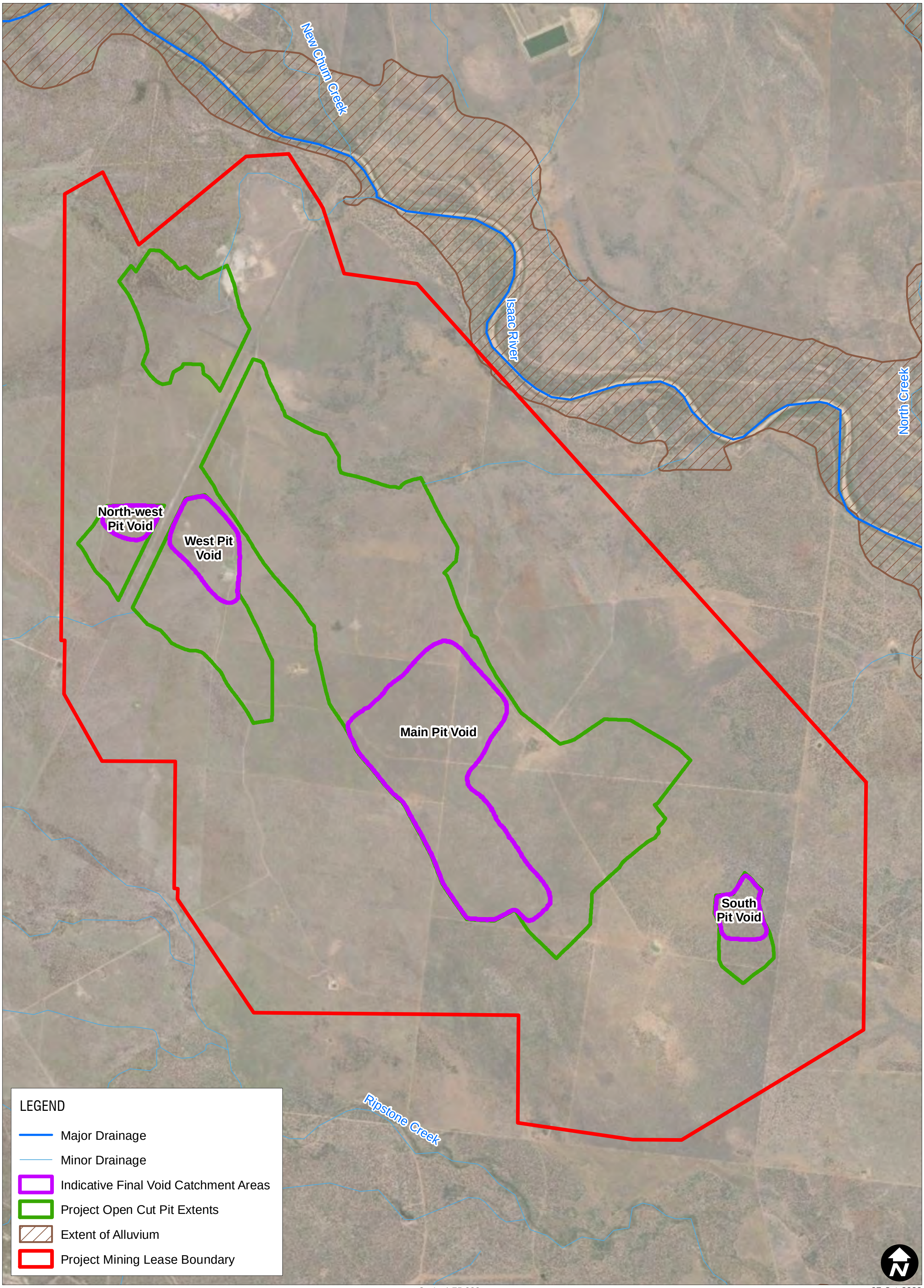
The potential post-mining impacts of the Project were investigated with a recovery model, commencing at the end of mining at the Project and run for 250 years. A transient model was created to ascertain post-mining inflows, with all predictive model drain cells removed. All drain cells in the Study Area were removed at the start of the recovery period to allow groundwater levels to equilibrate. At the end of mining at the Project, the properties of the final void cells were converted to values representative of a void. The void cells were assigned high horizontal and vertical hydraulic conductivities (1000 m/day) and storage parameters based on the compressibility of water (specific yield of 1.0, storage coefficient of 5.0 x 10^{-5} m^{-1}), to simulate free water movement within the final void. This approach is often referred to as a 'high-K' lake. The location of final voids at the Project is provided in **Figure 4-1**.

Groundwater inflows to the four final voids during recovery were incorporated in the site water balance model for the Surface Water Assessment (WRM Water & Environment [WRM], 2021). The pit lake recovery levels and timings were predicted by the surface water consultants. These elevations and recovery timings derived from the surface water modelling were replicated within the numerical groundwater model using the time variant constant head boundary condition. This recovery model was then re-run for 250 years to maintain consistency with the Surface Water and Flooding Assessment prepared for the Project. Predictions from the re-run recovery model are presented within the main report. Hydrographs for pit water levels are provided as **Figure 4-2**.

The average predicted equilibrated final void water levels were:

- 160 mAHD within North-west Pit Void;
- 124 mAHD within West Pit Void;
- 157 mAHD within Main Pit Void; and
- 140 mAHD within South Pit Void.

The peak predicted equilibrated final void water levels (including the predicted final void water levels following a Q1000 event) are presented in the Surface Water and Flooding Assessment prepared by WRM (2021).



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\02 EIS Report Figures\SLR62013245_F4_1 Final Void Locations.mxd

Scale: 1:75,000
GDA 1994 MGA Zone 55

07-Oct-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 1 2 Kilometers

Final Void Locations

FIGURE 4-1

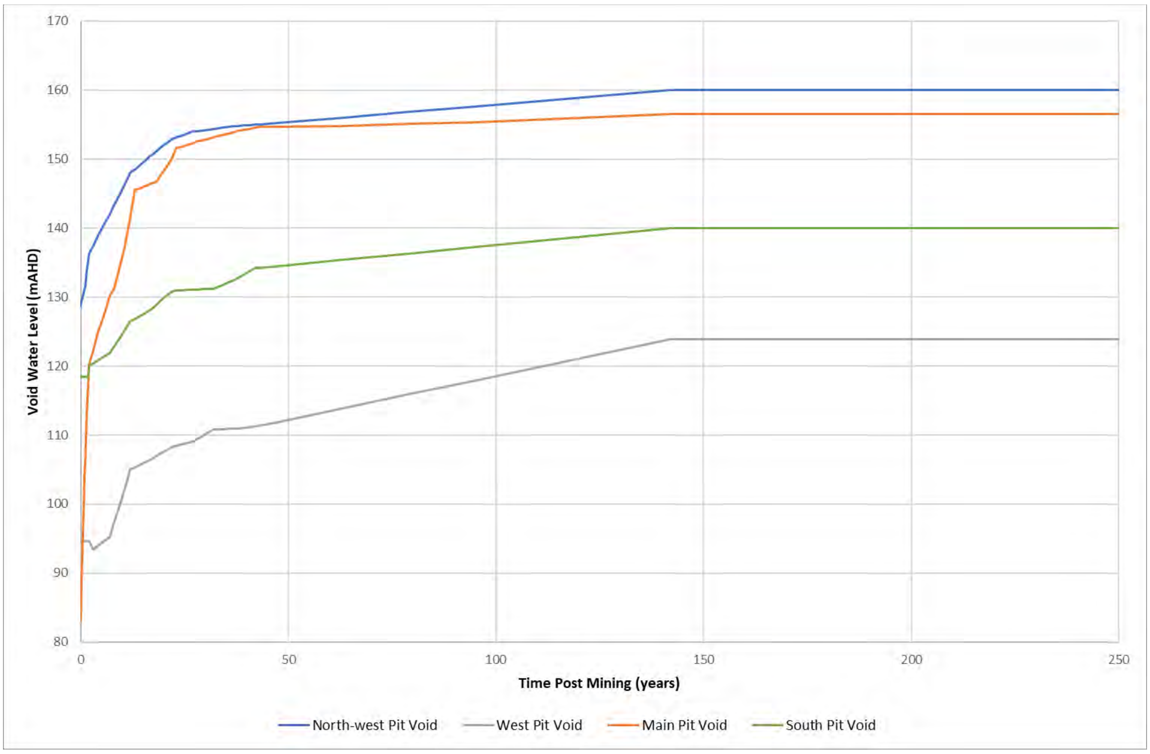


Figure 4-2 Final Void Recovery

5 Sensitivity and Uncertainty Analysis

A Type 3 Monte Carlo uncertainty analysis (Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development [IESC], 2018) was undertaken to estimate the uncertainty in the future impacts predicted by the model. This method operates by generating numerous alternative sets of input parameters to the deterministic groundwater flow model (realisations), executing the model independently for each realisation, and then aggregating the results for statistical analysis.

The first step in Monte Carlo analysis is to define the parameter distribution and range. For the Project, the parameters are assumed to be log-normally distributed around the mean derived value with assumed standard deviations variable for different parameters (0.5 or 1 order of magnitude). The distribution for each parameter were checked and constrained such that upper or lower ranges do not go beyond ranges in literature for physical constraints. 1400 model realisations were generated, each having differing values of key parameters. The realisations were run and calibration quality was assessed. In this case, models were considered to have an acceptable calibration if they achieved an SRMS value less than 6%. The calibration cut-off criterion of 6% SRMS is 15% higher than the achieved SRMS of the best calibrated model (i.e. the base case model), while being 24% below the SRMS of the foundational ODP model and 29% below that of the MVS model. Of the 1400 model runs, 257 model runs were found to be sufficiently calibrated. These were used in all model scenarios (calibration, cumulative mining, approved mining and no mining) and statistically analysed for uncertainty analysis.

5.1 Parameter Distribution

Table 5-1 through **Table 5-4** show the parameter ranges explored during the sensitivity and uncertainty analysis simulation. Parameters were assumed to possess a log-Normal distribution. The parameter distribution for the converged and calibrated model runs are provided as **Appendix E**.

Table 5-1 Uncertainty Parameter Range for Horizontal Hydraulic Conductivity.

Zone	Layer - Unit	Horizontal Hydraulic Conductivity (m/day)	
		Mean (Log10)	Constraint
1	Layer 1 - Alluvium	1.0	No constraint
2	Layer 1 - Colluvium	0.0	< Kh_Alluvium
3	Layer 2 - Regolith (< 65 mbgl)	0.3	< Kh_Alluvium
4	Layer 2 - Regolith (> 65 mbgl)	-0.1	< Kh_Alluvium
5	Layer 1 & 2 - Tertiary basalt	-0.8	No constraint
6	Layer 3 - Rewan Group (< 65 mbgl)	-3.0	< Kh_Alluvium
7	Layer 3 - Rewan Group (> 65 mbgl)	-3.0	< Kh_Alluvium
8	Layer 3 - Rewan Group Fault	-3.0	< Kh_Alluvium
9	Layer 4 - RCM O/B	-0.7	< Kh_Alluvium
10	Layer 4 - RCM O/B Fault	-2.3	< Kh_Alluvium
11	Layer 5 - Leichhardt Seam	-0.2	< Kh_Alluvium
12	Layer 5 - Leichhardt Seam Fault	-2.6	< Kh_Alluvium
13	Layer 6 - RCM I/B	-2.9	< Kh_Alluvium
14	Layer 6 - RCM I/B Fault	-4.6	< Kh_Alluvium

Zone	Layer - Unit	Horizontal Hydraulic Conductivity (m/day)	
		Mean (Log10)	Constraint
15	Layer 7 - Vermont Seam	-1.6	< Kh_Alluvium
16	Layer 7 - Vermont Seam Fault	-2.0	< Kh_Alluvium
17	Layer 8 - RCM U/B	-3.0	< Kh_Alluvium
18	Layer 8 - RCM U/B Fault	-3.4	< Kh_Alluvium
19	Layer 9 - FCCM O/B	-3.0	< Kh_Alluvium
20	Layer 9 - FCCM O/B Fault	-4.4	< Kh_Alluvium
21	Layer 10 - FCCM Seam	-3.3	< Kh_Alluvium
22	Layer 10 - FCCM Seam Fault	-2.3	< Kh_Alluvium
23	Layer 11 - FCCM U/B	-4.0	< Kh_Alluvium
24	Layer 11 - FCCM U/B Fault	-3.5	< Kh_Alluvium
25	Layer 12 - MCM O/B	-4.0	< Kh_Alluvium
26	Layer 12 - MCM O/B Fault	-4.6	< Kh_Alluvium
27	Layer 13 - MCM Seam	-2.4	< Kh_Alluvium
28	Layer 13 - MCM Seam Fault	-2.3	< Kh_Alluvium
29	Layer 14 - MCM U/B	-3.0	< Kh_Alluvium
30	Layer 14 - MCM U/B Fault	-2.3	< Kh_Alluvium
31	All - Intrusives	-3.0	< Kh_Alluvium

Standard deviation = 1 order of magnitude for all units.
O/B = Overburden.
I/B = Interburden.
U/B = Underburden.
RCM = Rangal Coal Measures.
FCCM = Fort Cooper Coal Measures.
MCM = Moranbah Coal Measures.

Table 5-2 Uncertainty Parameter Range for Anisotropy

Layer - Unit	Anisotropy (Kv/Kx) (Log10)	
	Mean	Constraint
Layer 1 - Alluvium	-0.53	< 0.5
Layer 1 - Colluvium	-0.61	< 0.5
Layer 2 - Regolith (< 65 mbgl)	-2.01	< 0.5
Layer 2 - Regolith (> 65 mbgl)	-1.18	< 0.5
Layer 1 & 2 - Tertiary basalt	-0.75	< 0.5
Layer 3 - Rewan Group (< 65 mbgl)	-1.57	< 0.5
Layer 3 - Rewan Group (> 65 mbgl)	-1.0	< 0.5
Layer 3 - Rewan Group Fault	-2.25	< 0.5
Layer 4 - RCM O/B	-2.38	< 0.5
Layer 4 - RCM O/B Fault	-2.13	No constraint
Layer 5 - Leichhardt Seam	-1.42	< 0.5
Layer 5 - Leichhardt Seam Fault	-1.8	No constraint
Layer 6 - RCM I/B	-1.89	< 0.5
Layer 6 - RCM I/B Fault	-3.0	No constraint
Layer 7 - Vermont Seam	-1.04	< 0.5
Layer 7 - Vermont Seam Fault	-2.3	No constraint
Layer 8 - RCM U/B	-1.1	< 0.5
Layer 8 - RCM U/B Fault	-1.97	No constraint
Layer 9 - FCCM O/B	-2.09	< 0.5
Layer 9 - FCCM O/B Fault	-2.64	No constraint
Layer 10 - FCCM Seam	-1.0	< 0.5
Layer 10 - FCCM Seam Fault	-2.2	No constraint
Layer 11 - FCCM U/B	-1.0	< 0.5
Layer 11 - FCCM U/B Fault	-0.83	No constraint
Layer 12 - MCM O/B	-1.98	< 0.5
Layer 12 - MCM O/B Fault	-2.69	No constraint
Layer 13 - MCM Seam	-1.3	< 0.5
Layer 13 - MCM Seam Fault	-1.19	No constraint
Layer 14 - MCM U/B	-0.73	< 0.5
Layer 14 - MCM U/B Fault	-0.97	No constraint
All - Intrusives	-1.86	< 0.5

Standard deviation = 0.5 orders of magnitude for all units.
mbgl = metres below ground level.

Table 5-3 Uncertainty Parameter Range for Specific Yield

Layer - Unit	Specific Yield (Log10)	
	Mean	Constraint
Layer 1 - Alluvium	-1.3	No constraint
Layer 1 - Colluvium	-2.43	< Sy_Alluvium; < 0.05
Layer 2 - Regolith (< 65 mbgl)	-1.72	< Sy_Alluvium; < 0.15
Layer 2 - Regolith (> 65 mbgl)	-3.0	< Sy_Alluvium; < 0.3
Layer 1 & 2 - Tertiary basalt	-1.53	< 0.1
Layer 3 - Rewan Group (< 65 mbgl)	-2.61	< Sy_Alluvium; < 0.1
Layer 3 - Rewan Group (> 65 mbgl)	-2.33	< Sy_Alluvium; < 0.1
Layer 3 - Rewan Group Fault	-2.74	< Sy_Alluvium; < 0.1
Layer 4 - RCM O/B	-2.9	< Sy_Alluvium; < 0.1
Layer 4 - RCM O/B Fault	-2.53	< Sy_Alluvium; < 0.05
Layer 5 - Leichhardt Seam	-2.77	< Sy_Alluvium; < 0.05
Layer 5 - Leichhardt Seam Fault	-2.82	< Sy_Alluvium; < 0.05
Layer 6 - RCM I/B	-2.8	< Sy_Alluvium; < 0.05
Layer 6 - RCM I/B Fault	-2.41	< Sy_Alluvium; < 0.05
Layer 7 - Vermont Seam	-2.94	< Sy_Alluvium; < 0.05
Layer 7 - Vermont Seam Fault	-2.02	< Sy_Alluvium; < 0.05
Layer 8 - RCM U/B	-2.42	< Sy_Alluvium; < 0.05
Layer 8 - RCM U/B Fault	-2.94	< Sy_Alluvium; < 0.05
Layer 9 - FCCM O/B	-2.77	< Sy_Alluvium; < 0.05
Layer 9 - FCCM O/B Fault	-2.86	< Sy_Alluvium; < 0.05
Layer 10 - FCCM Seam	-2.06	< Sy_Alluvium; < 0.05
Layer 10 - FCCM Seam Fault	-2.25	< Sy_Alluvium; < 0.05
Layer 11 - FCCM U/B	-2.64	< Sy_Alluvium; < 0.05
Layer 11 - FCCM U/B Fault	-2.13	< Sy_Alluvium; < 0.05
Layer 12 - MCM O/B	-2.8	< Sy_Alluvium; < 0.05
Layer 12 - MCM O/B Fault	-2.07	< Sy_Alluvium; < 0.05
Layer 13 - MCM Seam	-2.75	< Sy_Alluvium; < 0.05
Layer 13 - MCM Seam Fault	-2.41	< Sy_Alluvium; < 0.05
Layer 14 - MCM U/B	-2.95	< Sy_Alluvium; < 0.05
Layer 14 - MCM U/B Fault	-2.88	< Sy_Alluvium; < 0.05
All - Intrusives	-4.0	< Sy_Alluvium; < 0.001

Standard deviation = 0.5 orders of magnitude for all units.

Table 5-4 Uncertainty Ranges for Recharge Factor

	Mean (Log10)	Constraints
Unit	**% of rainfall**	
Stream Channel	0.55	>RCH_Rewan_Group; >RCH_Outcropping_Coal_Measures
Flood Plain Alluvium	0.25	>RCH_Rewan_Group; >RCH_Outcropping_Coal_Measures
Other Alluvium	0.25	>RCH_Rewan_Group; >RCH_Outcropping_Coal_Measures
Tertiary Sediments	0.02	No constraint
Tertiary Basalt	5.01	>RCH_Rewan_Group; >RCH_Outcropping_Coal_Measures
Rewan Group	0.01	No constraint
Outcropping Coal Measures	0.01	No constraint

Standard deviation = 0.5 orders of magnitude for all units.
RCH = Recharge.

5.2 Sensitivity Analysis

5.2.1 Calibrations Identifiability and Sensitivity Analysis

Identifiability describes a parameters capability to be constrained by the model calibration. Identifiability values range from zero to one. As identifiability approaches one, the parameter is increasingly able to be constrained. Likewise, as values approach zero the parameter is increasingly unable to be constrained by the calibration and uncertainty of model results is not reduced through calibration.

The PEST utility GENLINPRED was used to provide an estimate of parameter identifiability for each of the model parameters. Estimated identifiability values for the calibrated parameters horizontal hydraulic conductivity, Anisotropy, Specific yield and recharge are summarised in **Figure 5-1** through **Figure 5-4**.

Figure 5-1 indicates that that the horizontal hydraulic conductivity of faults generally has not been able to be constrained well during calibration, relative to their surrounding unit. The exception to this is the Fort Cooper Coal Measures coal seam fault zone, which has been constrained much better than the seam in which it is located. Notably, the colluvium, Rewan Group, Vermont Seam and Fort Cooper Coal Measures units are less constrained by calibration. While all other units have high identifiability values (equal to or above 0.90, with the exception of Moranbah Coal Measures underburden).

Identifiability of hydraulic conductivity anisotropy for model zones is presented in **Figure 5-2**. Anisotropy in the Rangal Coal Measures interburden, Fort Cooper Coal Measures overburden and Moranbah Coal Measures overburden have high identifiability values indicating these are able to be constrained, and contribute to reducing model uncertainty. All other zones feature low values (equal to and below 0.40) and are less constrained by calibration.

Specific yield shows high identifiability for the alluvium (**Figure 5-3**). Alluvium is a sensitive receptor within the model domain, and so, the high value is desirable, as it indicates calibration has constrained this variable and gives confidence to model predictions for how mining impacts the unit (i.e. drawdown, baseflow changes and indirect take predictions). Specific yield of other zones in the model domain has low identifiability.

The recharge zones for Tertiary sediments, alluvium (excluding stream channel alluvium) and Tertiary basalt are prevalent across the model domain and are highly constrained by the calibration. The other zones have low identifiability (**Figure 5-4**). Note that the stream channel alluvium represents a narrow zone along the Isaac River, with a small area relative to the other recharge zones. It is, therefore, considered less impactful to model predictions.

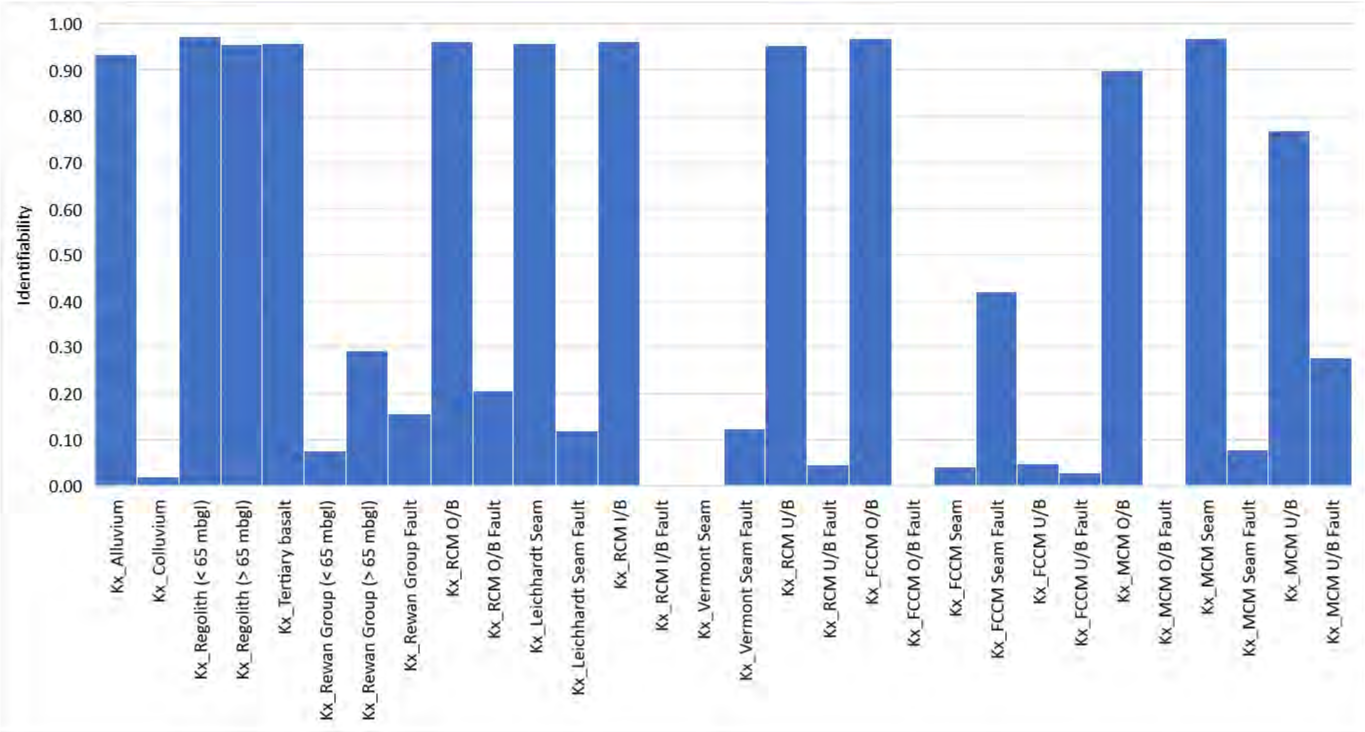


Figure 5-1 Identifiability – Horizontal Hydraulic Conductivity (Kh)

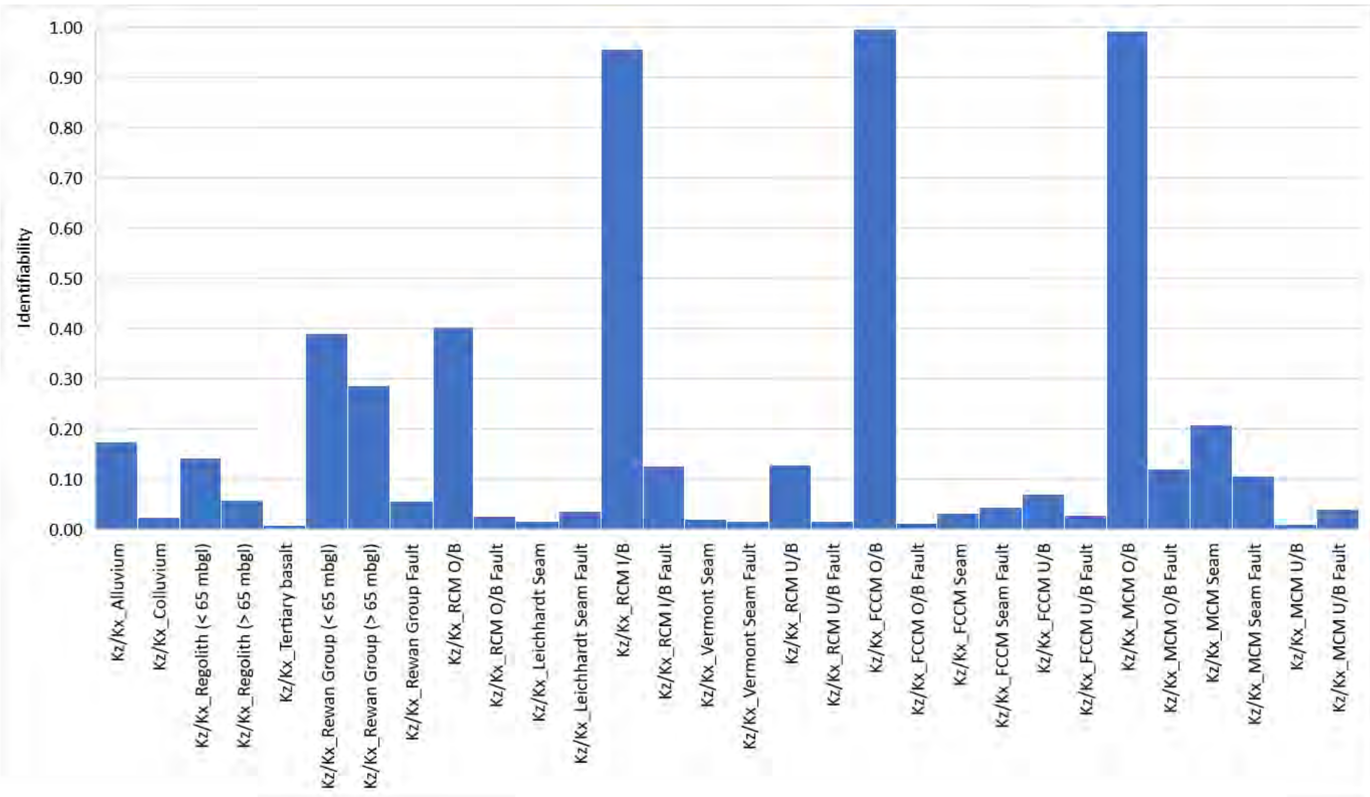


Figure 5-2 Identifiability – Anisotropy (Kv/Kx)

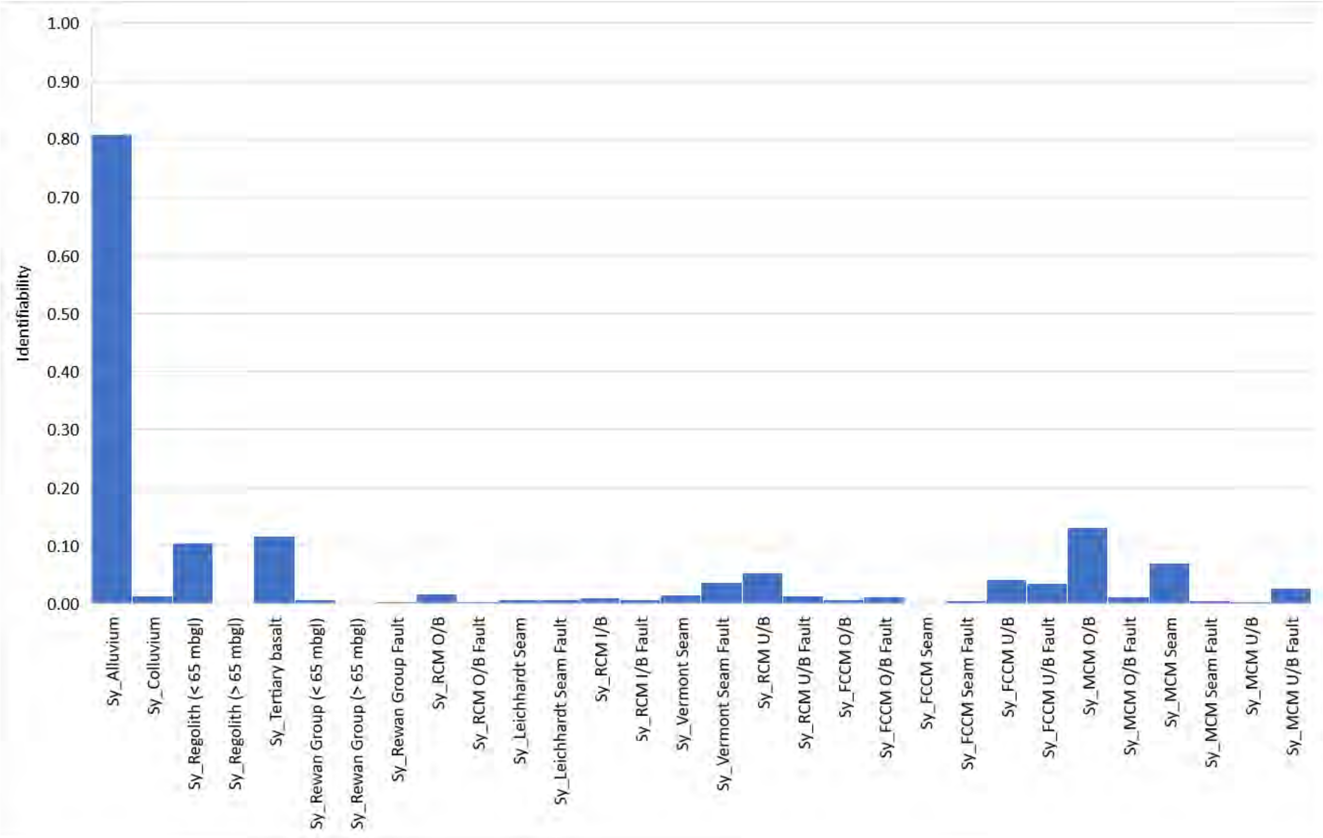


Figure 5-3 Identifiability – Specific Yield (Sy)

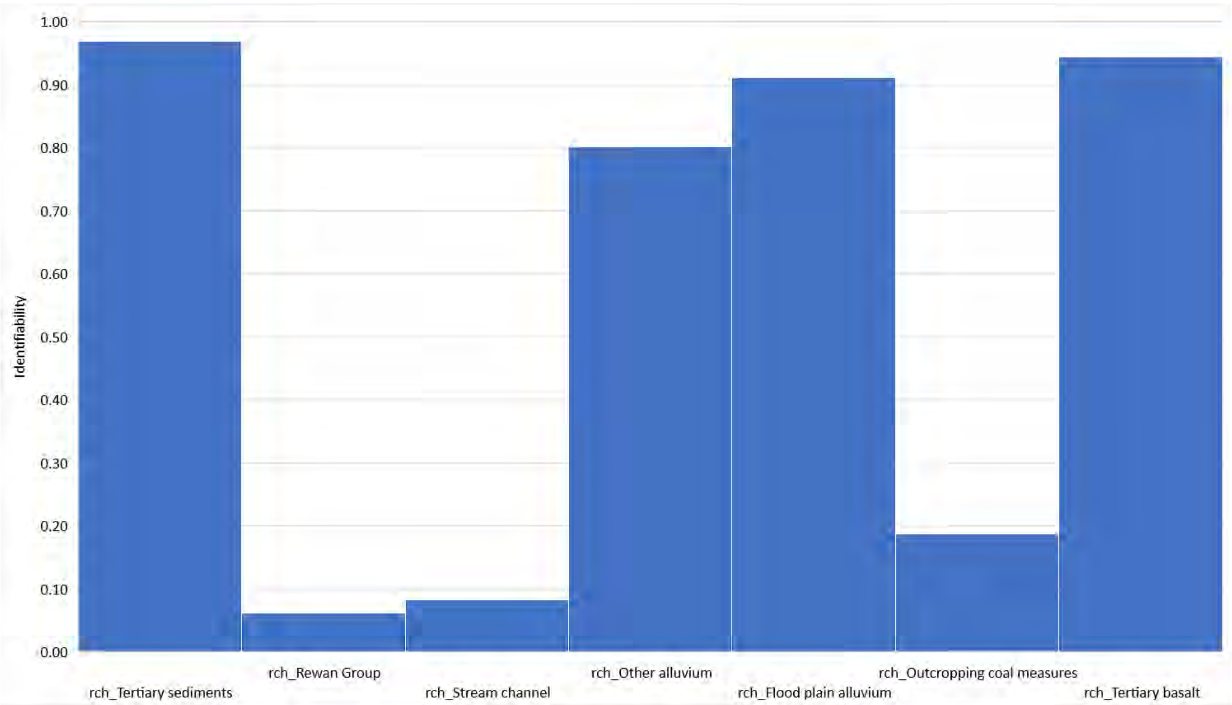


Figure 5-4 Identifiability – Recharge

5.2.2 Predictive Sensitivity Analysis

Graphs showing sensitivity derivatives for model parameters are included in **Appendix F**. "In strict mathematical terms, a sensitivity measures how fast one quantity changes when another changes. A sensitivity is the derivative, or slope, of a function" (Barnett et al, 2012). For the purposes of assessing parameter predictive sensitivity, SLR has calculated the sensitivity derivative of each parameter to mine inflows, alluvial drawdown magnitude and extent, and coal seam drawdown extent. Parameter and predicted values were standardized as standard deviation from the mean prior to calculating the derivatives. The derivative was calculated as the slope of the linear regression line through the predicted standardized values (y values) and the parameter standardized values (x values). The sensitivity to model parameters for the following has been investigated:

- maximum drawdown impacted area extents for alluvium/colluvium;
- maximum drawdown impacted area extents for the Vermont Seam;
- Project open cut pit inflows; and
- maximum drawdown to the alluvium has been investigated.

Drawdown impact area of the alluvium/colluvium is shown to be most sensitive to the horizontal hydraulic conductivity of the colluvium. For the Vermont Seam, impact area is most sensitive to horizontal hydraulic conductivity of the Vermont Seam. The Project open cut pit inflows are most sensitive to the specific yield of the Rangal Coal Measures interburden. Maximum drawdown in the alluvium appears to be most sensitive to the recharge to Tertiary sediments.

5.3 Uncertainty Results

5.3.1 Uncertainty of Mine Inflows

Figure 5-5 presents the uncertainty of groundwater inflow rates to the Project from 2020 to 2055. The figure presents the inflow to the proposed open pit mine for the reported base case model, along with the 5th, 50th and 95th inflow percentiles. The base case model falls below the 50th percentile inflow value for most times over the life of Project, i.e. the majority of the 257 model realisations had inflows consistently above those reported in **Section 3.5**. The maximum mine inflow rate predicted by the uncertainty analysis is 2,228 ML/year (6.1 ML/day) and occurs in 2028. Total inflows for the base case model and the different percentiles are provided in **Table 5-5**.

A convergence graph, as indicated by the percent change in the 95th precent confidence interval of the mean for pit inflows is shown in **Figure 5-6**. The stabilisation of the percent change in the confidence interval, indicates that the number of realisations used for the uncertainty analysis was sufficient for calculating pit inflows uncertainty, and additional realisations will not reduce uncertainty further than what has been achieved.

In addition, **Figure 5-6** also shows the 95% confidence interval for inflow predictions. The uncertainty analysis, therefore, indicates a 95% confidence that the total inflow to the Project over the life of the Project will be within 317 ML of the mean total inflow (5,740 ML) calculated across the 257 realisations.

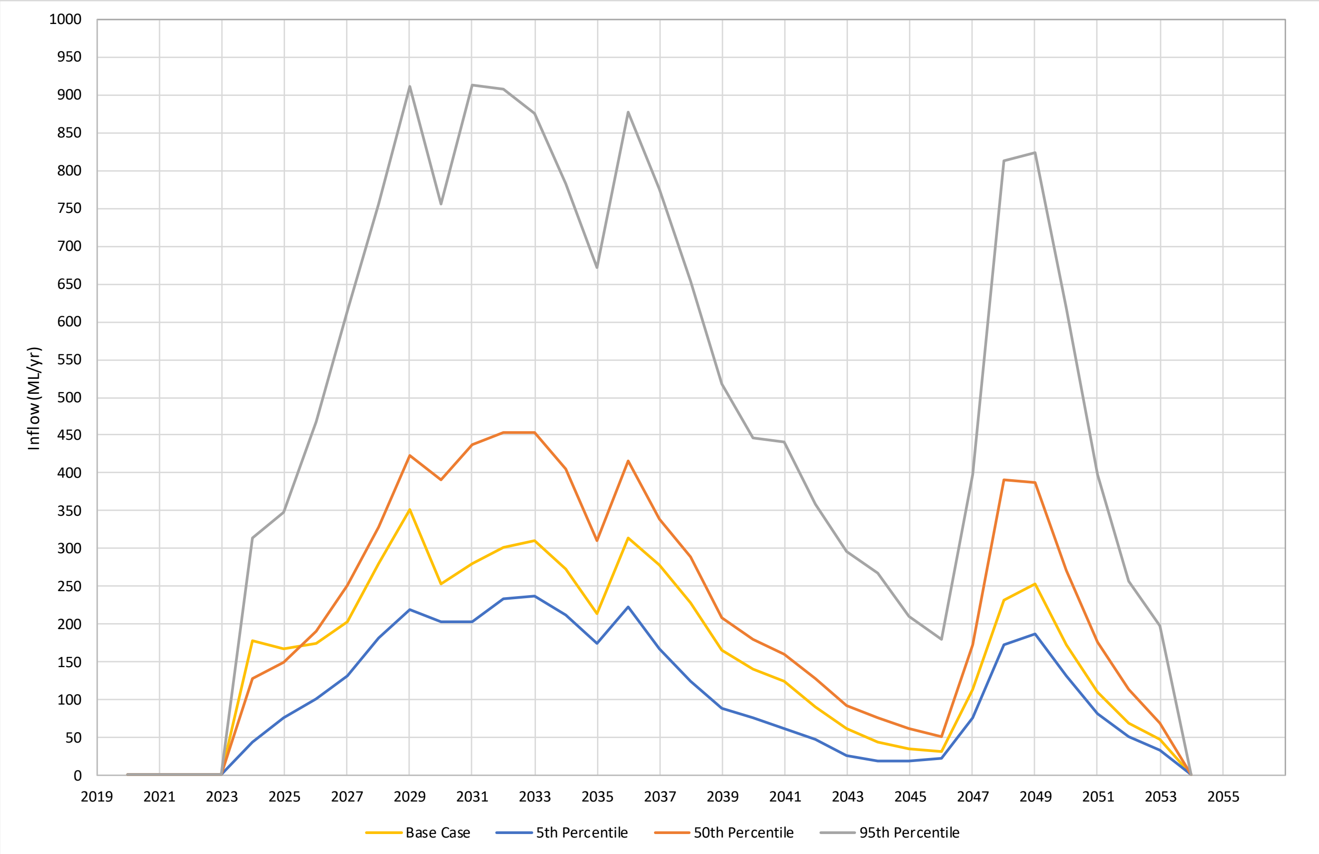


Figure 5-5 Uncertainty Analysis – Predicted Project Mine Inflows

Table 5-5 Total Predicted Inflows Over Life of the Project

	Base Case	5th Percentile	50th Percentile	95th Percentile
Total Inflow (ML)	5,490 ML	3,616 ML	7,502 ML	16,867 ML

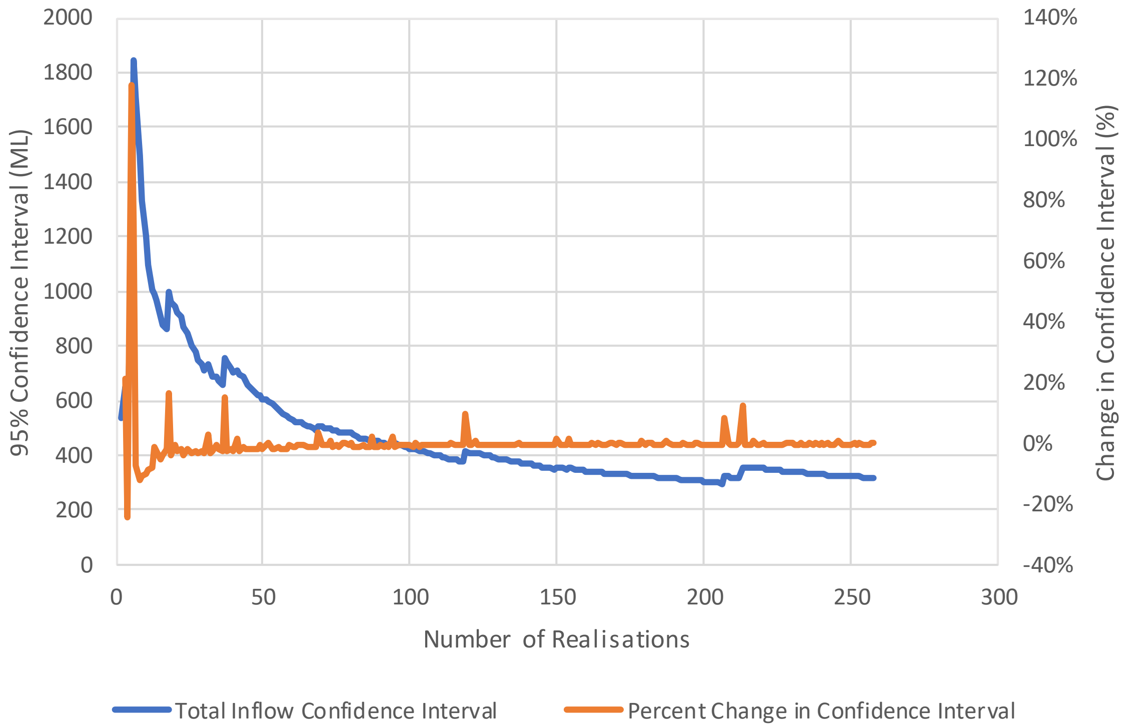


Figure 5-6 Uncertainty Analysis Convergence – Predicted Project Mine Inflows

5.3.2 Uncertainty of Influence on Alluvium

Uncertainty analysis surrounding the Project's influence on alluvium via take from 2020 to 2055 was carried out using the 257 available model realisations. Note that any predicted take is indirect, as mined areas are outside the Pit extents of the Project. 91% of realisations (235 of 257 realisations) showed zero loss from alluvium. The 5th, 50th and 95th percentiles were calculated for total alluvial take volume over the life of the project. Of these, only the 95th percentile indicated any take from alluvium over the life of the Project (4.38ML). The convergence graph for alluvial take is shown in **Figure 5-7**. The mean total alluvial take volume across the 257 realisations is 2.8 ML. From **Figure 5-7,** the 95% confidence interval for total alluvial take is, therefore, 2.8 ML +/- 2.7 ML. The stabilisation of the percent change in confidence interval observed, indicates that the number of realisations used for uncertainty analysis was sufficient for calculating total alluvial take uncertainty, and additional realisations will not reduce uncertainty further than what has been achieved.

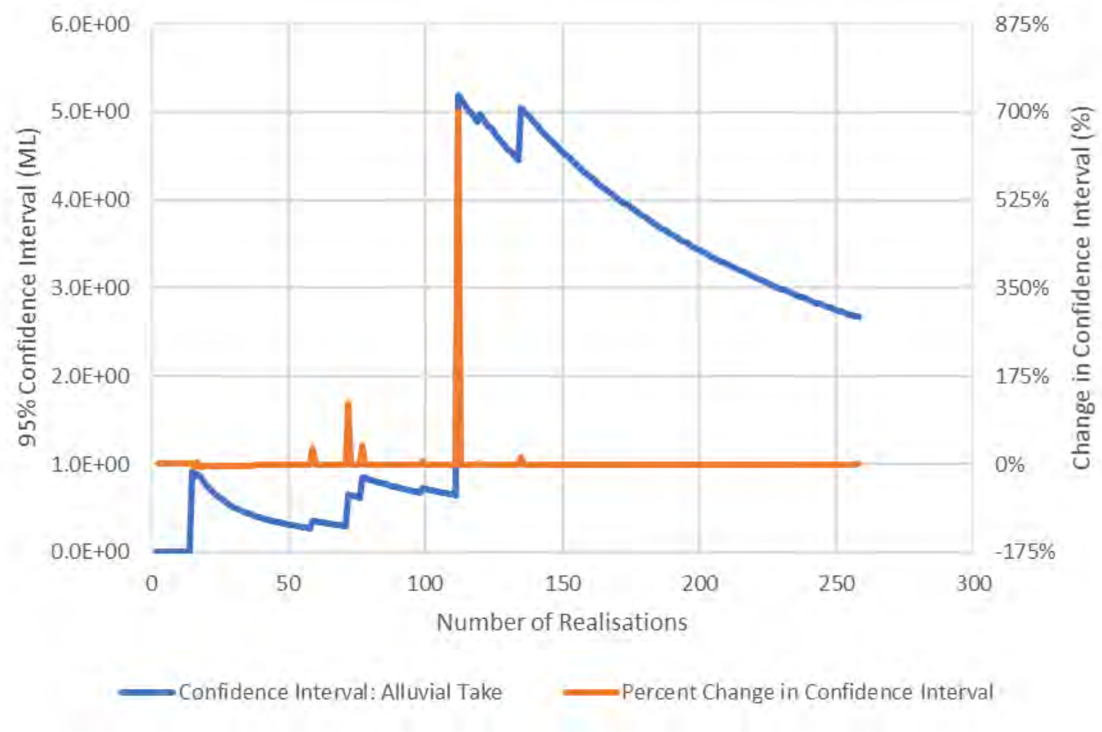


Figure 5-7 Uncertainty Analysis Convergence –Alluvial Take

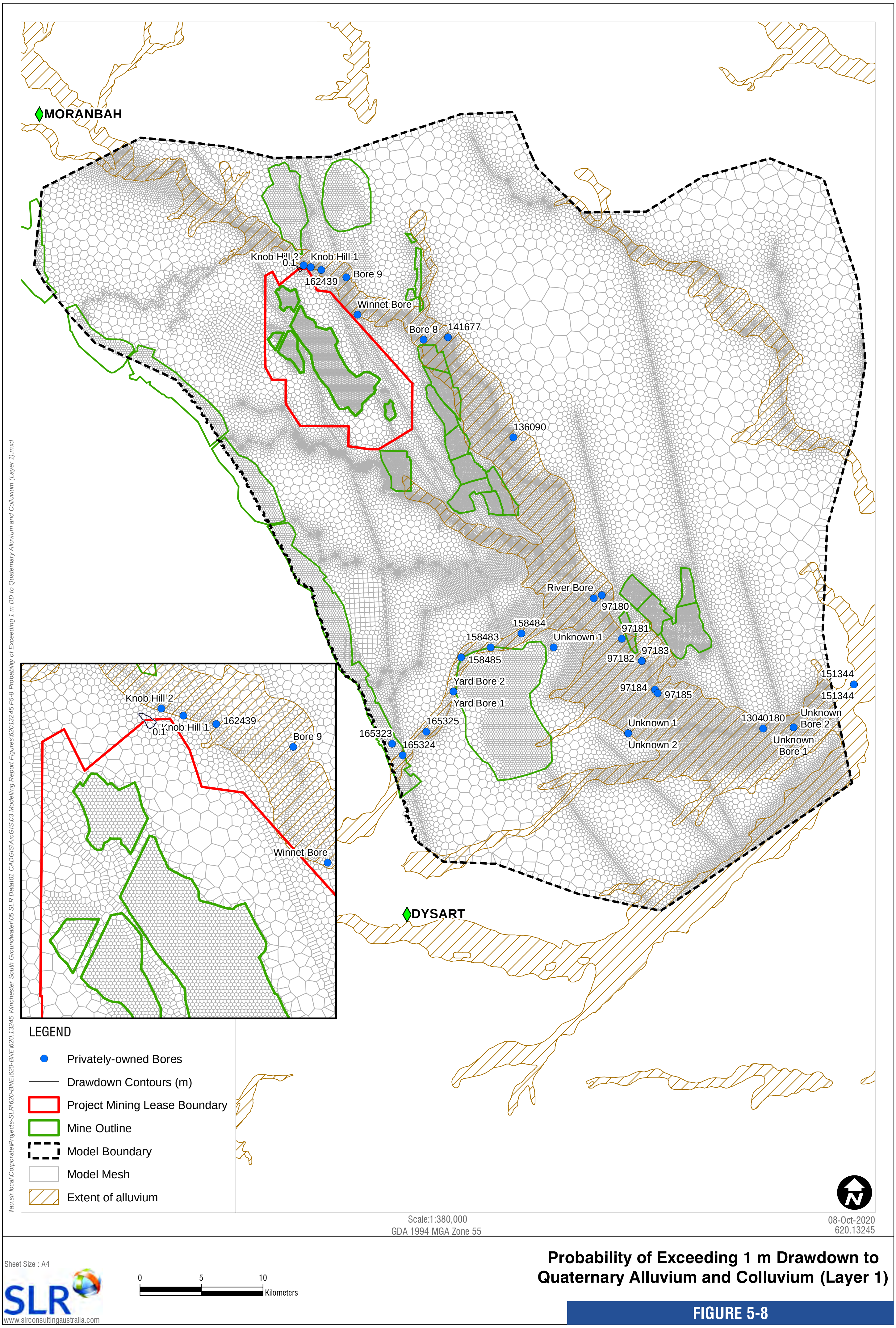
5.3.3 Groundwater Drawdowns

5.3.3.1 Groundwater Probability Drawdown Extents

To illustrate the level of uncertainty in the extent of predicted incremental drawdown, maximum drawdown probability contour maps were generated for incremental drawdown to Layer 1 (colluvium and Quaternary alluvium) and Layer 7 (Vermont seam). These contours represent the probability of maximum aquifer drawdown at any location exceeding 1 m, as a result of mining at the Project. Probability maps are based on the 257 available model realisations.

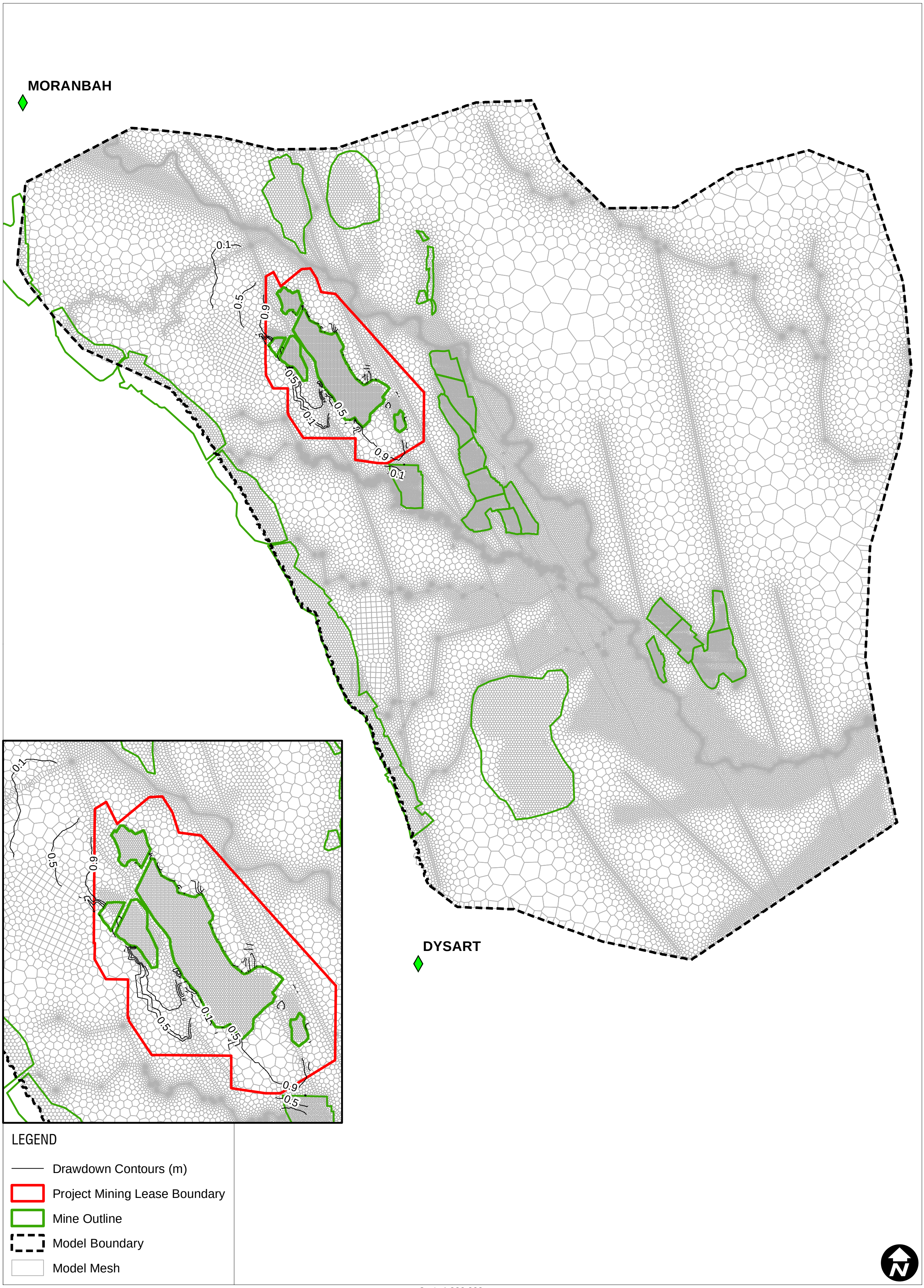
Layer 1 drawdown probability contours are shown in **Figure 5-8**. This shows a small zone of potential drawdown to the colluvium, on the northern boundary of MDL183. This zone represents a 10 % drawdown probability and is 510 m across, at its widest extent. It is located approximately 25 m from the edge of the mapped Quaternary alluvium. No private landholder bores, intersecting the alluvium or colluvium, are known to occur within this zone.

Vermont Seam drawdown probability contours are shown in **Figure 5-9** for the 10%, 50% and 90% probability drawdown impact zones. Model structure influences probability contour distribution, with greater distance between contours occurring to the north, where drawdown is able to propagate. The general contour distribution is similar to what was observed in **Figure 3-10** for the base case maximum incremental drawdown map. No private landholder bores, intersecting the Vermont seam, are known to occur within the zone covered by the drawdown probability map.



Probability of Exceeding 1 m Drawdown to Quaternary Alluvium and Colluvium (Layer 1)

FIGURE 5-8



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Probability of Exceeding 1m Incremental Drawdown to Vermont Seam (Layer 7)

FIGURE 5-9

5.3.3.2 Drawdown Impact Convergence

Of the 257 model realisations, 4 feature incremental drawdown greater than 1 m to the Quaternary alluvium. The maximum incremental alluvial drawdown for each realisation was averaged across the 257 realisation and found to be 0.32 m. The 95% confidence interval for this metric is 0.32 m +/- 0.03 m. Convergence of this metric was achieved, as demonstrated by the confidence interval convergence stabilisation at 0% change shown in **Figure 5-10**.

Convergence of maximum impacted drawdowns area was investigated for Layers 1 and 7. This area represents the area of all model cells where drawdown exceeds 1 m. For Layer 1, the 95% confidence interval for the total impacted area is 2.91 x 10^4 m^2 +/- 8.31 x 10^3 m^2. For Layer 7, this 95% confidence interval is 3.19 x 10^6 m^2 +/- 1.60 x 10^6 m^2. The stabilisation of the percent change in confidence interval for these metrics indicates that additional realisations would not reduce the level of uncertainty achieved. Convergence is shown graphically in **Figure 5-11** for Layer 1 (Quaternary alluvium and colluvium impacted area) and in **Figure 5-12** for Layer 7 (Vermont seam impacted area).

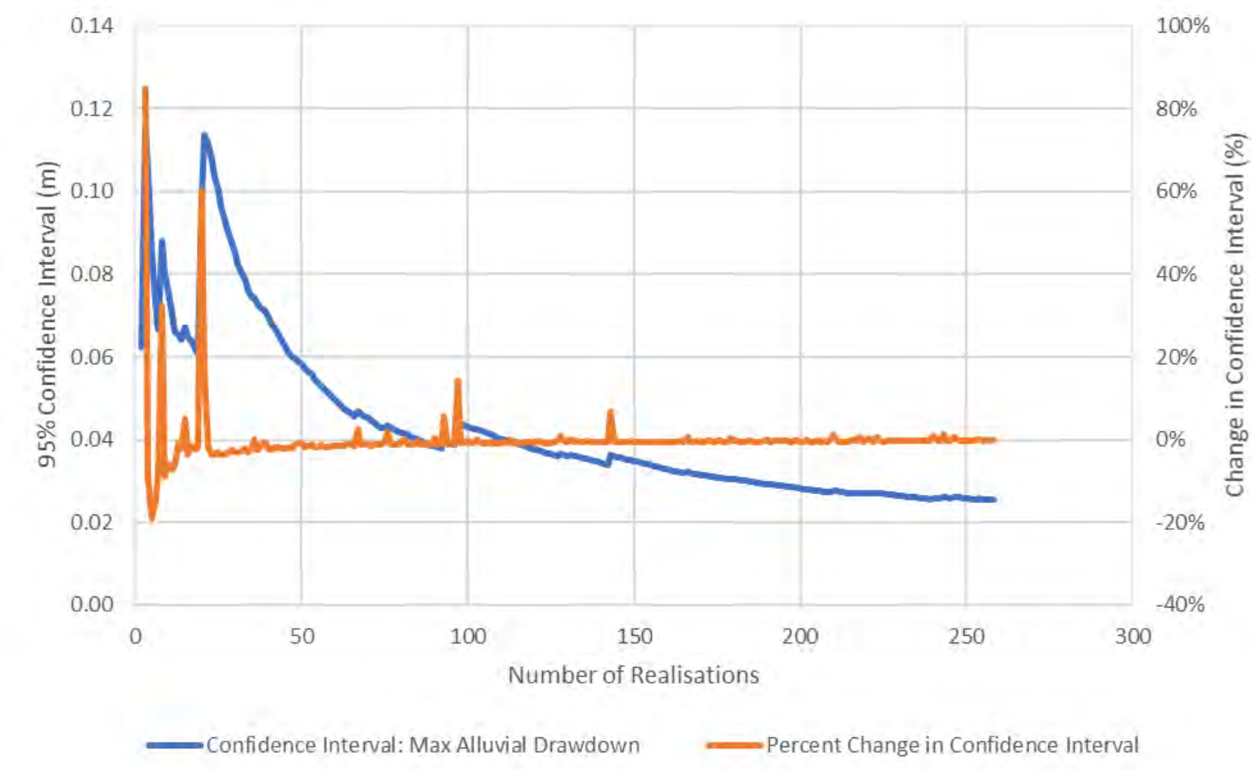


Figure 5-10 Uncertainty Analysis Convergence – Maximum Alluvial Drawdown

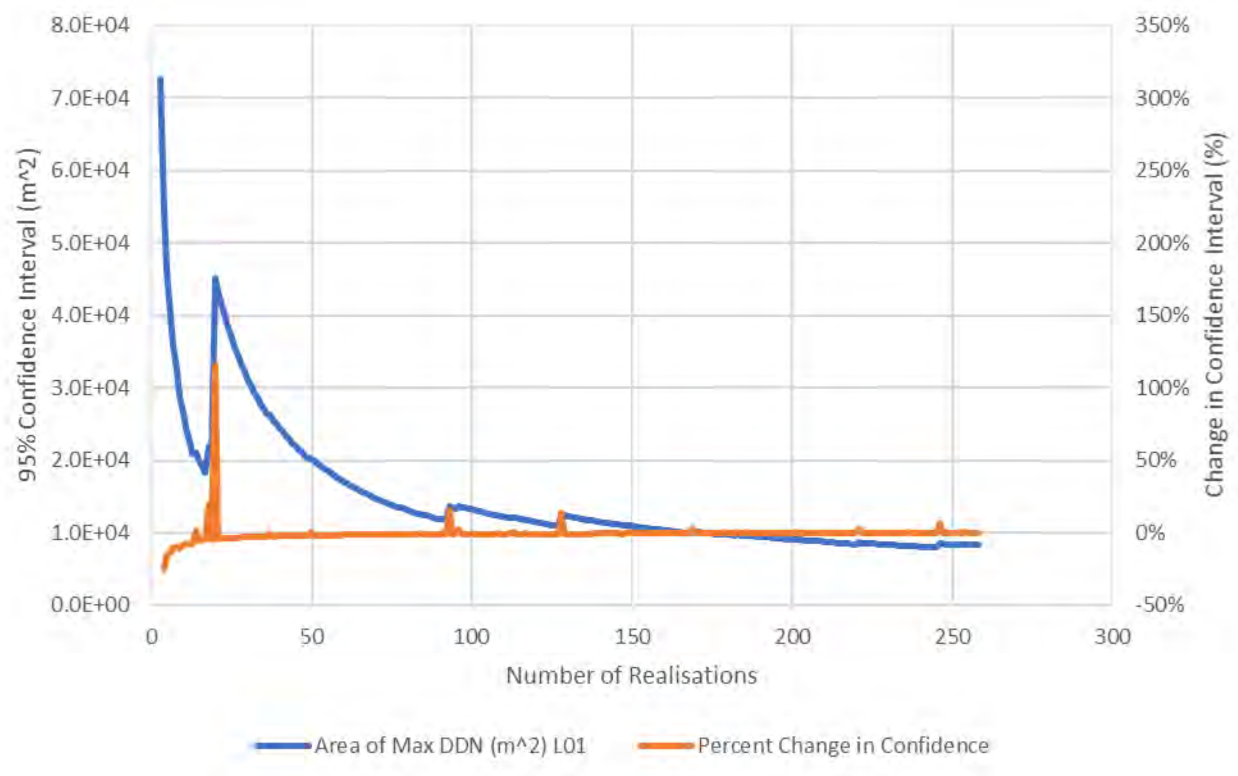


Figure 5-11 Uncertainty Analysis Convergence – Area of Drawdown Impact (>1 m) Layer 1

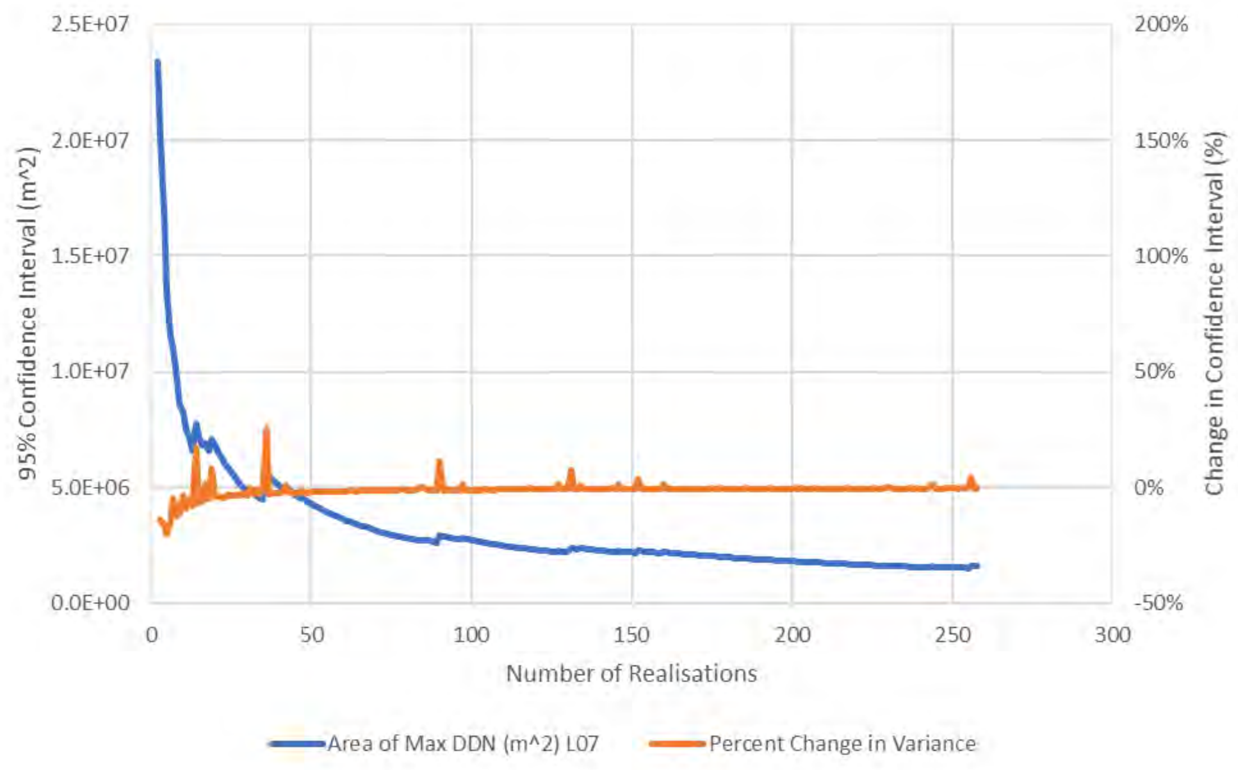


Figure 5-12 Uncertainty Analysis Convergence – Area of Drawdown Impact (>1 m) Layer 7

6 Limitations and Recommendations

Site geological models were available for the Project Area as well as for Moorvale South and Olive Downs Project sites. Model geology at these locations is, therefore, reliable. However, elsewhere within the model domain, geology has been interpolated and estimated from publicly available data; including regional scale mapping (e.g. Qld Government mapping and EIS documentation [including the BGP]). Consequently, the depths, thickness and extents of the model layers away from the mentioned site geological models (the Project, Moorvale South Project and the Olive Downs Project) may not closely replicate reality. This limitation is important to note as inaccurate geology at surrounding mines may result in over or under prediction of impacts when considering the cumulative impacts of mining in the Study Area.

Additionally, the timings and active extents of surrounding mines in the model (excluding Moorvale South and Olive Downs Projects where mine plans were available) have been largely inferred from publicly available data. Therefore, the simulation of these mines is unlikely to be entirely accurate, and potential over- or under-estimation of impacts, or timing of impacts may result due to this. It is recommended that the timings and extents of surrounding mines simulated in the model be updated as new information on these sites becomes available.

The inaccuracies involved in the modelling of surrounding mines, as noted above, combined with the large scale and complexity of the groundwater model has resulted in some model inaccuracies, which manifested as isolated targeted drawdowns at Poitrel seemingly caused by the incremental impacts at the Project. However, the lateral separation of the isolated drawdowns at Poitrel from the drawdowns at the Project indicated that these were not true impacts. The model was subjected to thorough quality control processing and the conclusion was made that the drawdowns at Poitrel likely resulted from inaccuracies surrounding how the mining and geology at Poitrel has been simulated. The decision was, therefore, to exclude Poitrel mining activities from the calibration and predictive simulation periods, for the impact assessment results relating to the direct impacts of the Project (i.e. incremental drawdowns, pit inflows, indirect alluvial take and changes in baseflow).

The coal seams of the Fort Cooper Coal Measures and Moranbah Coal Measures are simplified to single seams with aggregated seam thickness; as mining is applied conservatively to the base of this simplified seam, the simulated depths of the surrounding mines targeting these units may not be accurate, and the model stresses exaggerated. As these seams are not intercepted by planned mining operations at the Project, this simplification of the geology is considered appropriate for the purpose of assessing potential impacts caused by the Project.

Limited site-specific information on hydraulic conductivities and storage parameters were available during calibration. As more site-specific hydraulic data becomes available, new data should be compared with the calibrated parameters achieved and the validity of the model calibration should be assessed. Additional site specific data is expected to "tighten" uncertainty bounds for model prediction results.

Future revisions of the model should feature simplified hydraulic zone distributions. Currently, multiple zones are used to simulate Isaac River alluvium. This is a redundancy carried forward from the foundational model. Reducing the number of zones will improve the efficiency of stochastic runs during sensitivity and uncertainty analysis.

Predictive sensitivity indicates that mine inflows are most sensitive to the specific yield values of the Rewan Group, Rangal Coal Measures interburden and the Vermont Seam. However, calibration sensitivity to these parameters is relatively low. Future work should consider opportunities to further constrain values of these parameters.

Mine cells at the Project assume a two-year operational window and have been based on annual stage plans provided to SLR by Whitehaven Coal in February 2020. Any variation to the simulated mine plan should be addressed in coming model iterations, to ensure mine impacts are captured to the best approximation.

7 Conclusions

The numerical groundwater model developed for the Project successfully achieved the modelling objectives, as outlined in **Section 1**. Model calibration statistics are within suggested guidelines (Middlemis *et al*., 2001) and mass balance errors remain low, through the model calibration and predictive modelling. Model construction considers all available data, including the current site mine plan and site geological model for the Project Area. Reported inflows are expected to be about 25% below those likely to occur, as discussed within **Section 5.3.1**. Uncertainty analysis has demonstrated a low likelihood for the Project to impact on alluvial water levels, with drawdown to layers mostly contained within the Project Area. The model serves as a suitable representation of possible transient groundwater conditions within the Study Area, over the life of the Project, however, the uncertainty in predictions should be acknowledged.

8 References

Barnett, B., Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A., 2012. Australian Groundwater Modelling Guidelines. Waterlines Report Series No. 82, June 2012.

Coffey 2014, Supplementary Groundwater Assessment - Arrow Energy Bowen Gas Project. Supplementary Report to the EIS, Document ENAUBRIS107043AC, April 2014.

Doherty, J., 2010. PEST - Model Independent Parameter Estimation. User Manual 5th Edition. Watermark Numerical Computing.

Groundwater Imaging Pty Ltd (Allen, D), 2018. Moorvale South AgTEM survey for Groundwater Investigation, near Coppabella, Bowen Basin, QLD. Report for Peabody Energy. 2018.

Hansen Bailey, 2016. *Isaac Plains East Project – Appendix IV Numerical Groundwater Modelling Report*. Prepared by Klohn Crippen Berger, October 2016.

Hawkins, J.W., 1998. Hydrogeologic characteristics of surface-mine spoil. In Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania, ed. Brady, Smithy and Schueck. Harrisburg, Pennsylvania. Available at: http://www.techtransfer.osmre.gov/nttmainsite/Library/pub/cmdpppp/chapter3.pdf.

HydroAlgorithmics, 2018. AlgoCompute web site, https://www.algocompute.com/. Accessed 8 May, 2018.

Hydrogeologist.com.au, 2019. *Hydrogeological Drilling Report Winchester South Project*. Report for Whitehaven Coal Ltd, November 2019.

HydroSimulations, 2018. Olive Downs South and Willunga. Appendix B. Modelling Appendix. Report for Pembroke Resources Pty Ltd. 2018.

Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development, 2018. Information guidelines for proponents preparing coal seam gas and large coal mining development proposals. May 2018.

Mackie, C.D., 2009. Hydrogeological characterisation of Coal Measures and overview of impacts of coal mining on groundwater systems in the upper Hunter Valley of NSW. PhD thesis at University of Technology, Sydney.

Merrick, D. and Merrick, N., 2015. AlgoMesh: A new software tool for building unstructured grid models. In Proc. MODFLOW and More, Golden, Colorado.

Merrick, D., 2017. AlgoCompute: Large-scale calibration and uncertainty analysis made easy in the cloud. In Proc. MODFLOW and More, Golden, Colorado.

Middlemis, H., Merrick, N., and Ross, J., 2001. Murray-Darling Basin Commission – Groundwater Flow Modelling Guideline. Report for Murray-Darling Basin Commission. January 2001.

USEPA, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance, EPA 530-R-09-007, Washington, DC: Office of Resource Conservation and Recovery, Program Implementation and Information Division, United States Environmental Protection Agency.

Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D., 2013., MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: USGS Techniques and Methods 6-A45.

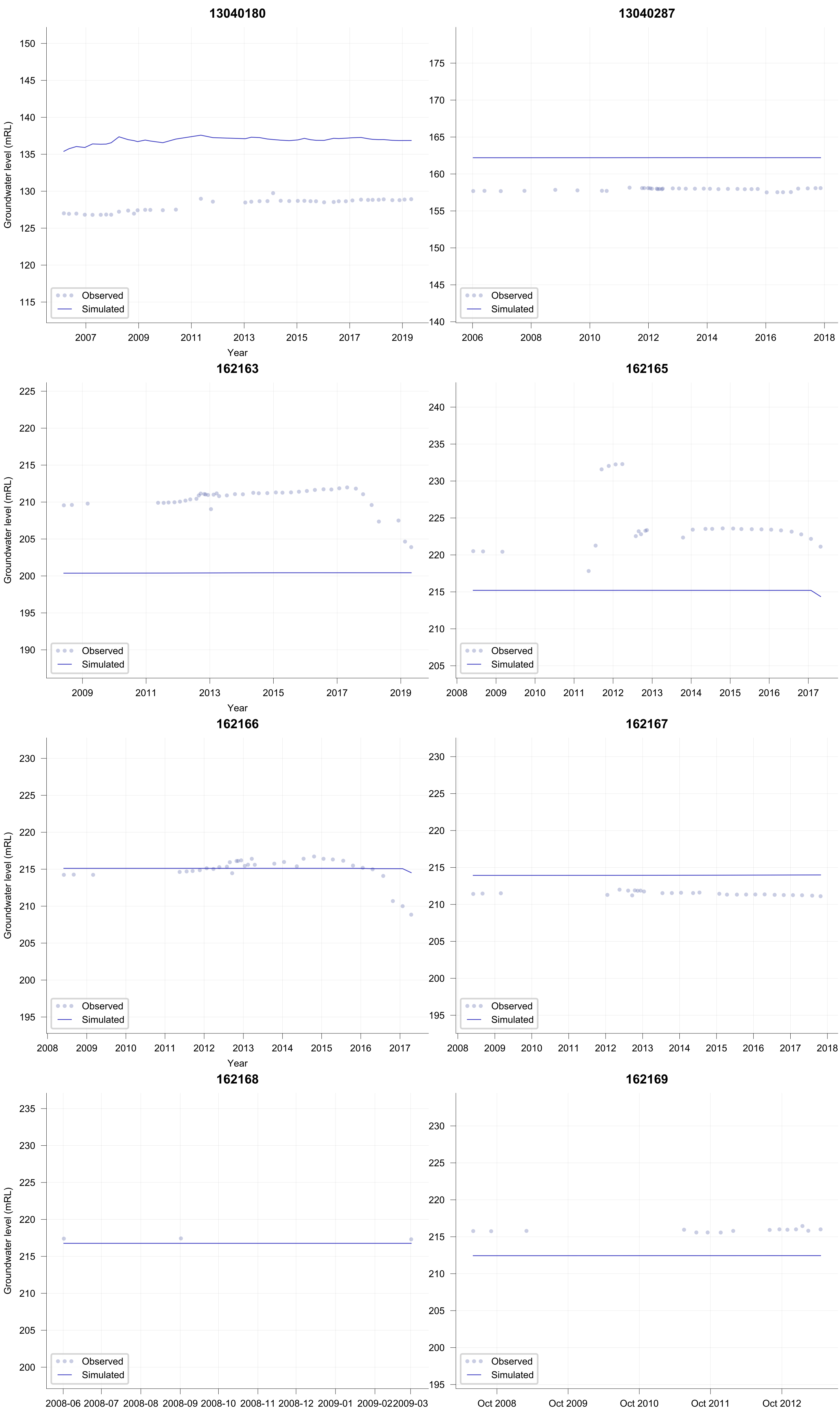
SLR, 2019. Moorvale South Groundwater Assessment. Appendix B1 Groundwater Modelling Technical Appendix. Report for Peabody Energy. 2019.

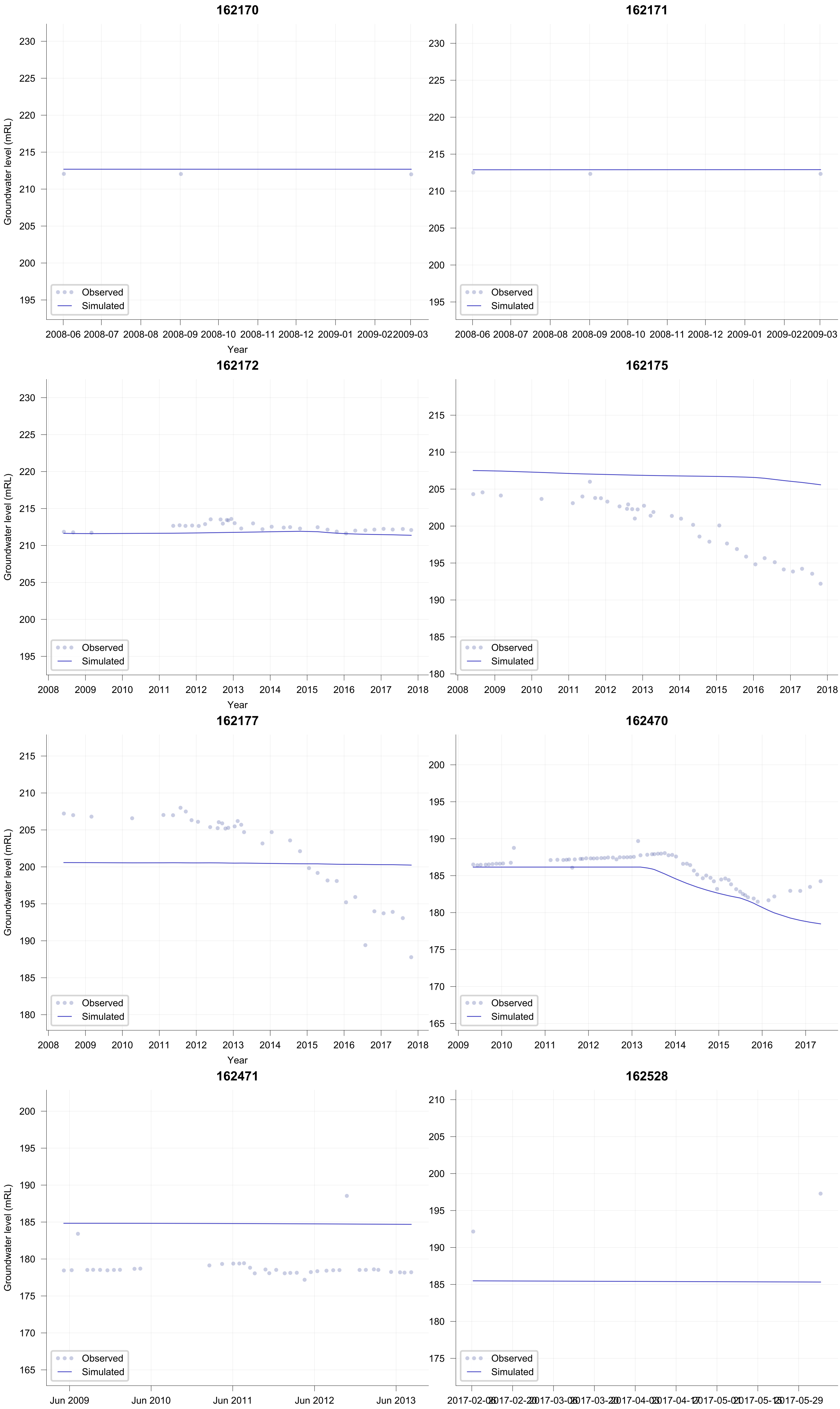
SLR, 2021. Winchester South Project EIS Groundwater Impact Assessment. Report for Whitehaven Coal.

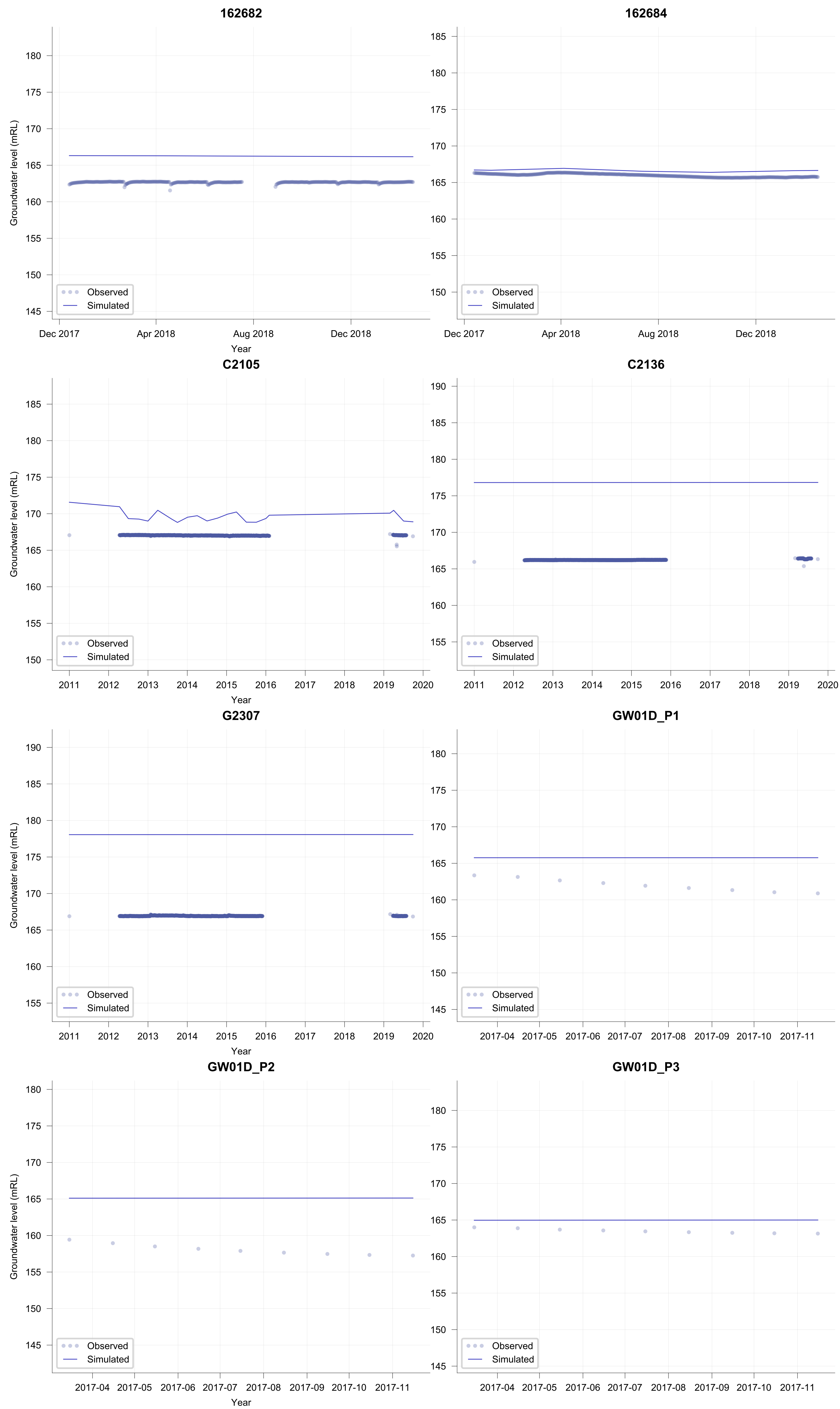
WRM Water & Environment, 2021. Winchester South Project - Surface Water and Flooding Assessment. Report for Whitehaven Coal Limited.

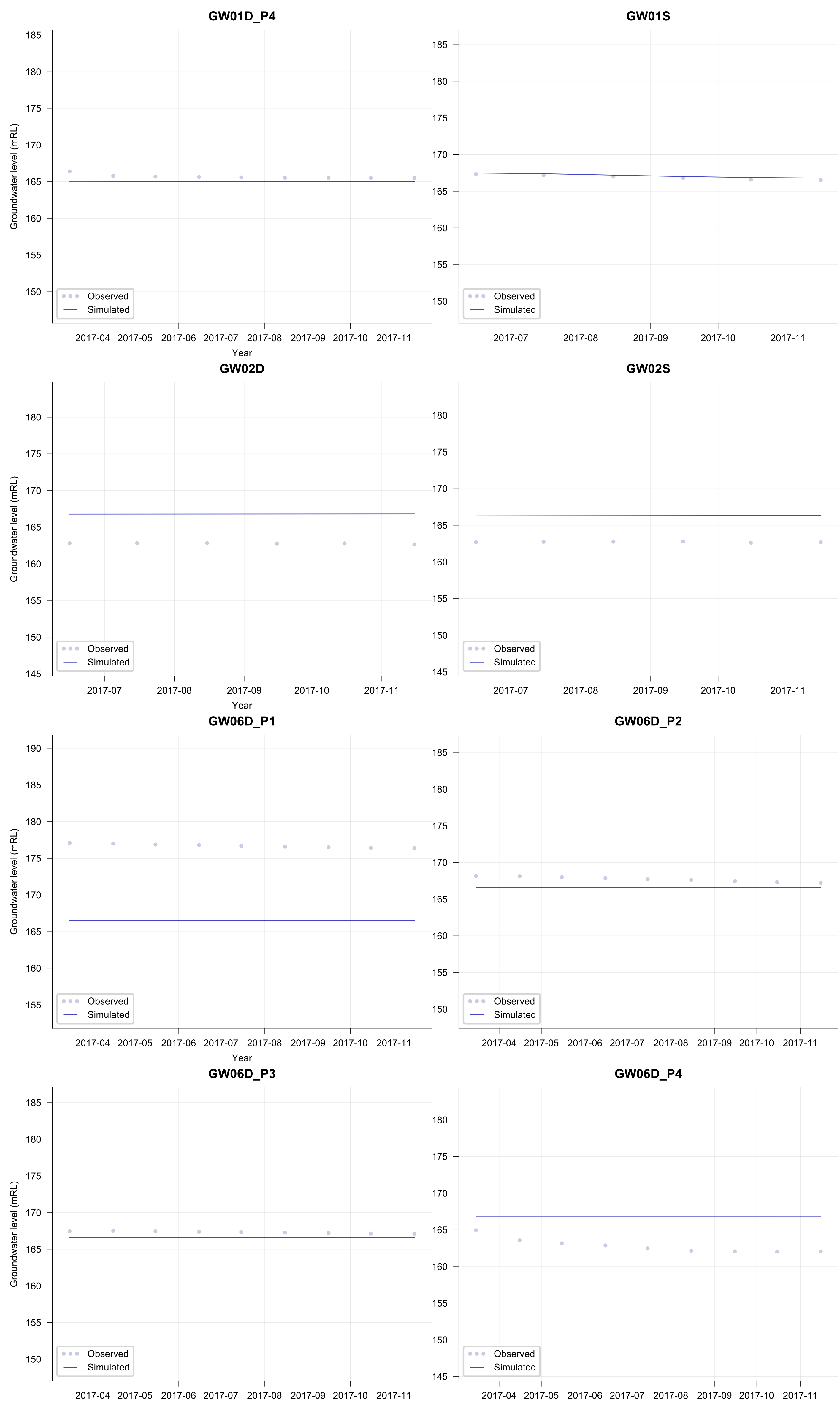
APPENDIX A

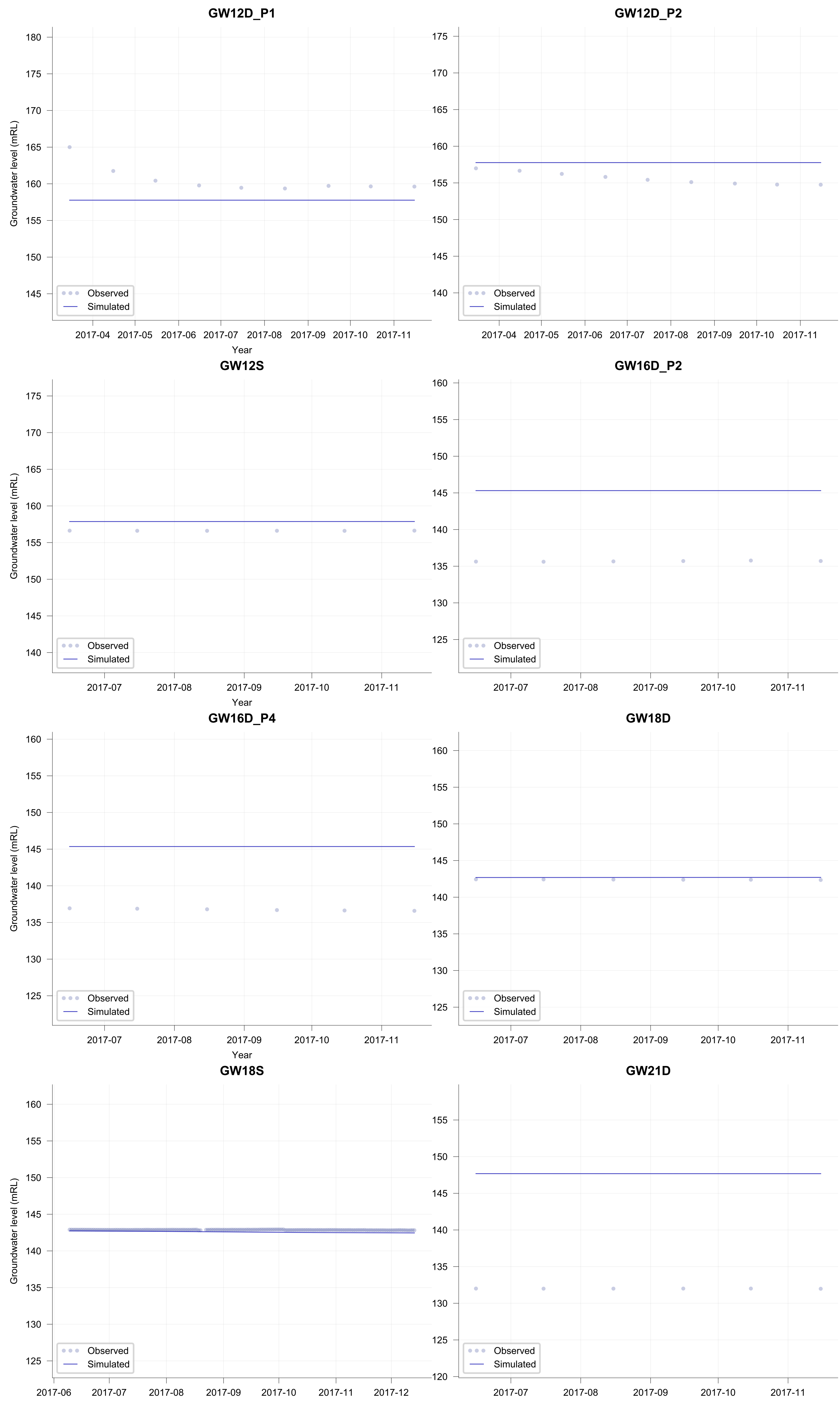
Calibration Bore Hydrographs

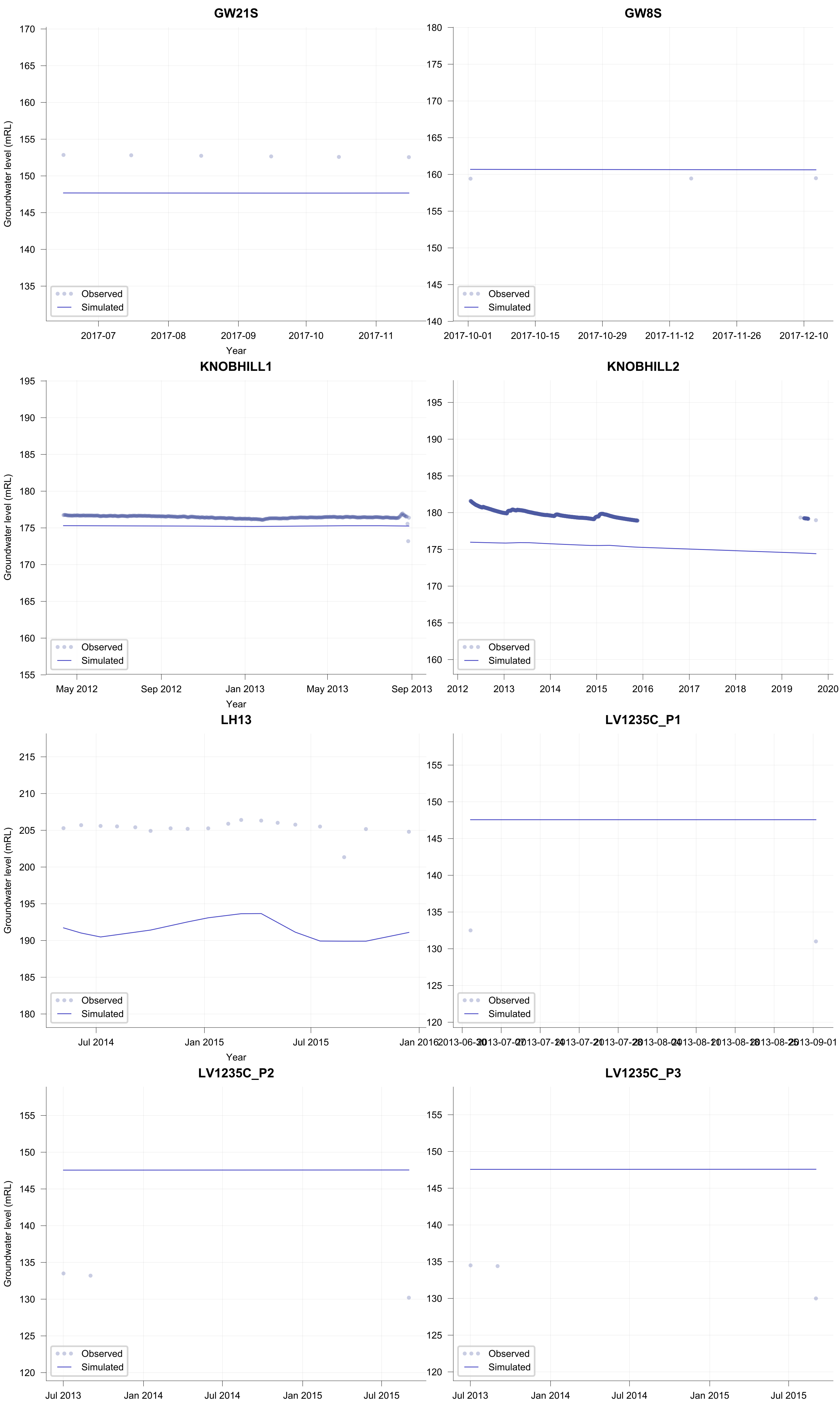

13040180
13040287
162163
162165
162166
162167
162168
162169
Groundwater level (mRL)
Year
Observed
Simulated
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2008-06
2008-07
2008-08
2008-09
2008-10
2008-11
2008-12
2009-01
2009-02
2009-03
Oct 2008
Oct 2009
Oct 2010
Oct 2011
Oct 2012
115
120
125
130
135
140
145
150
155
160
165
170
175
190
195
200
205
210
215
220
225
230
235
240

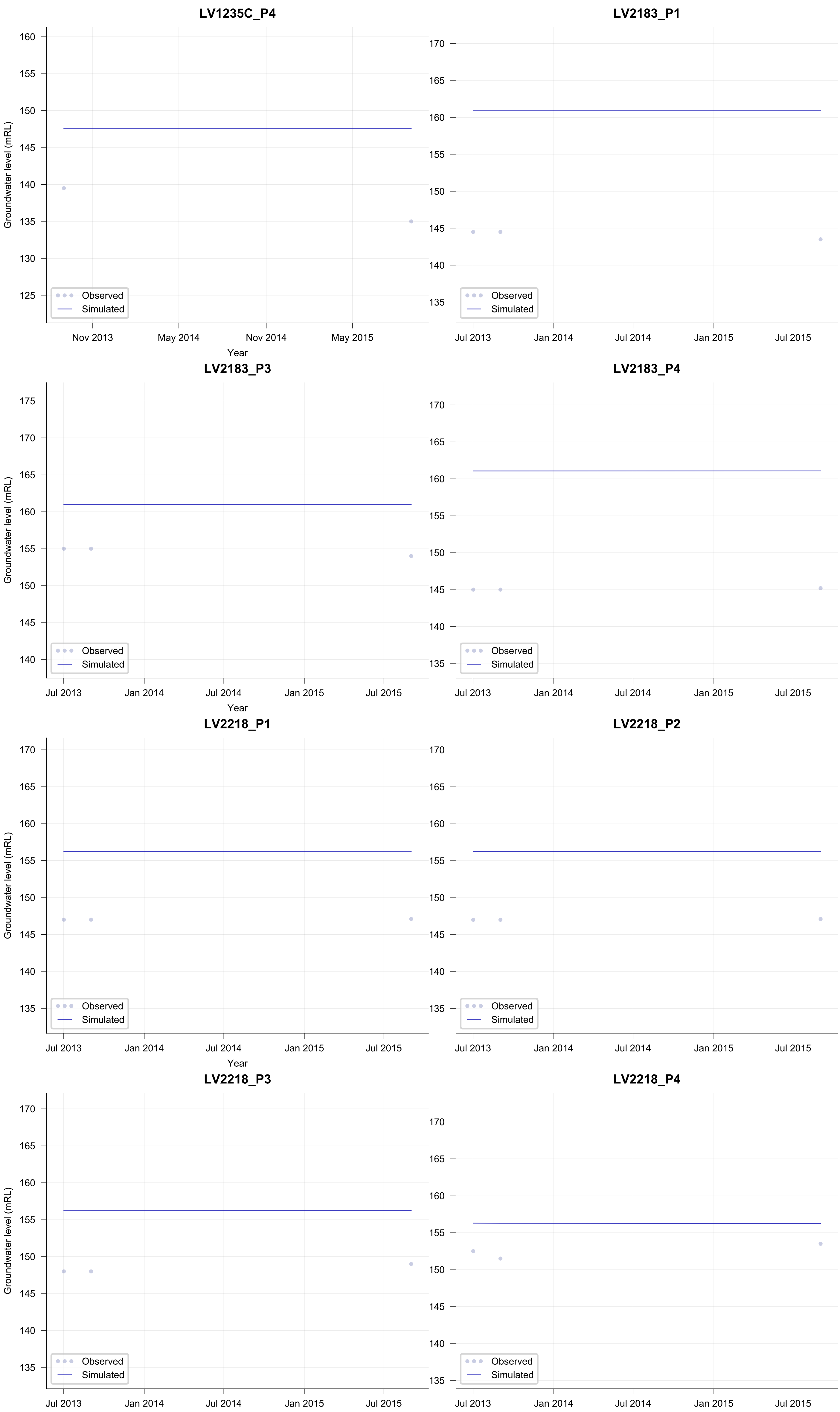

162170
162171
162172
162175
162177
162470
162471
162528
Groundwater level (mRL)
Year
Observed
Simulated
2008-06
2008-07
2008-08
2008-09
2008-10
2008-11
2008-12
2009-01
2009-02
2009-03
Jun 2009
Jun 2010
Jun 2011
Jun 2012
Jun 2013
2017-02-20
2017-03-06
2017-03-20
2017-04-03
2017-04-17
2017-05-01
2017-05-15
2017-05-29

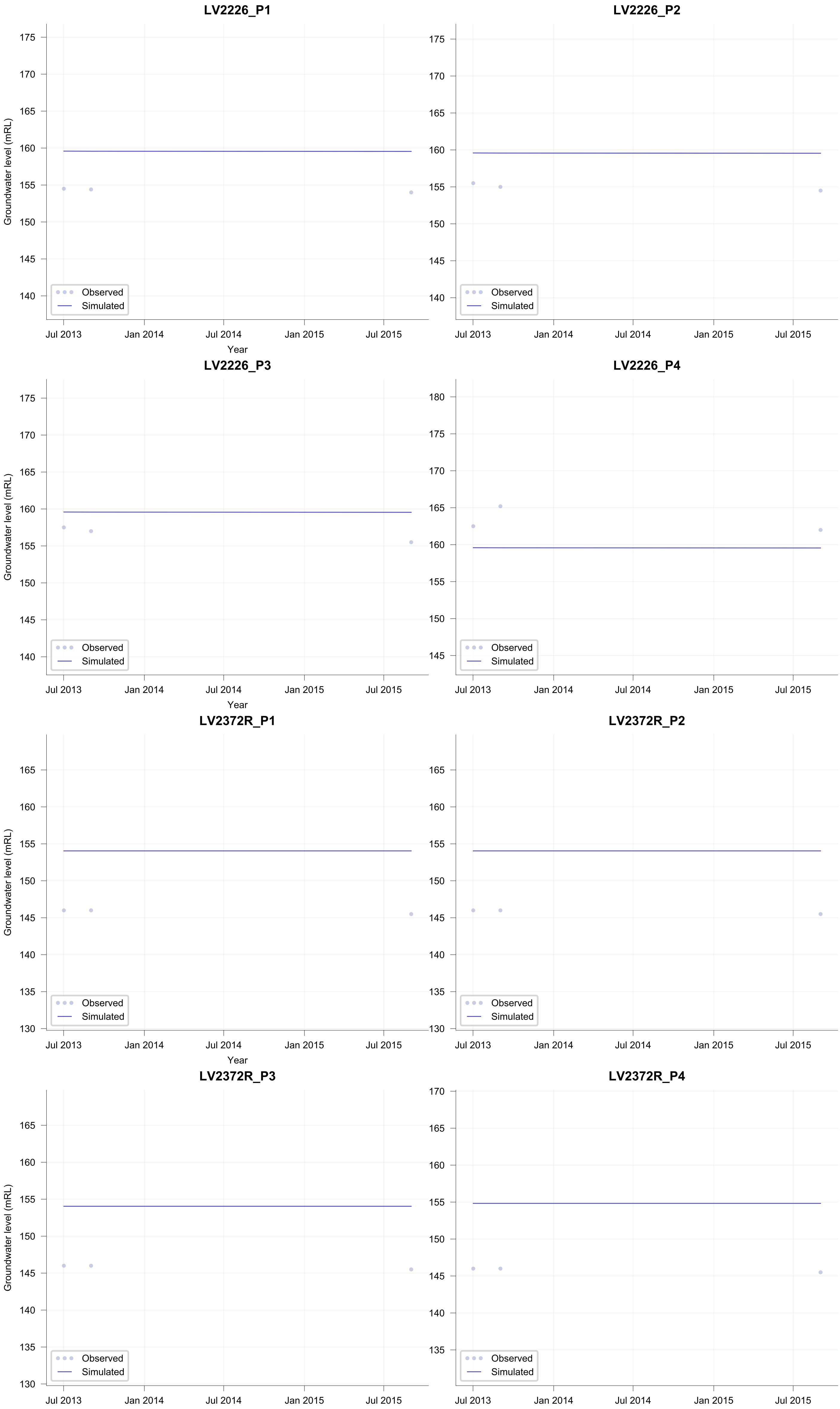

162682
162684
C2105
C2136
G2307
GW01D_P1
GW01D_P2
GW01D_P3
Groundwater level (mRL)
Year
Observed
Simulated
Dec 2017
Apr 2018
Aug 2018
Dec 2018
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2017-04
2017-05
2017-06
2017-07
2017-08
2017-09
2017-10
2017-11

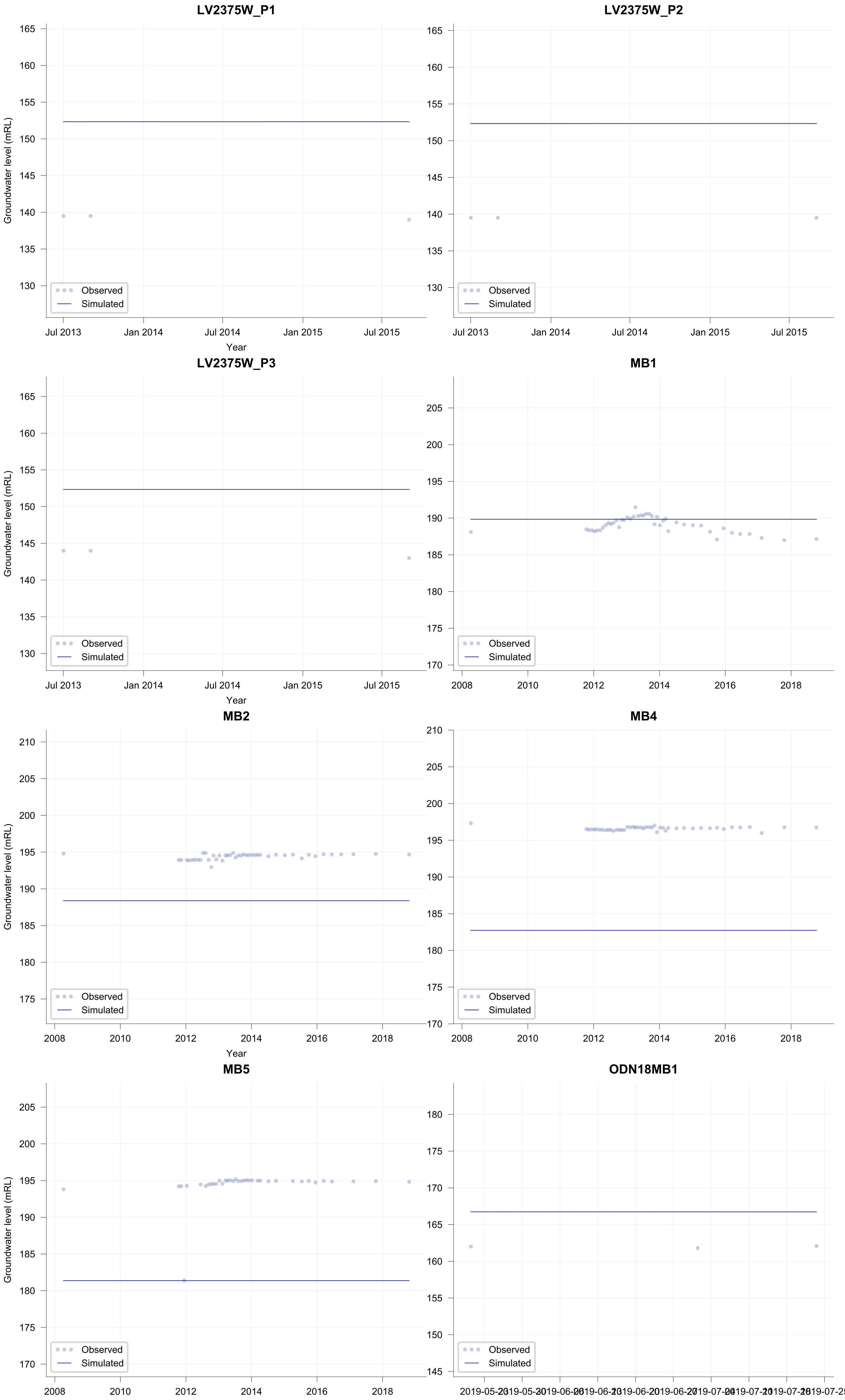

GW01D_P4
GW01S
GW02D
GW02S
GW06D_P1
GW06D_P2
GW06D_P3
GW06D_P4
Groundwater level (mRL)
Year
Observed
Simulated
2017-04
2017-05
2017-06
2017-07
2017-08
2017-09
2017-10
2017-11
145
150
155
160
165
170
175
180
185
190

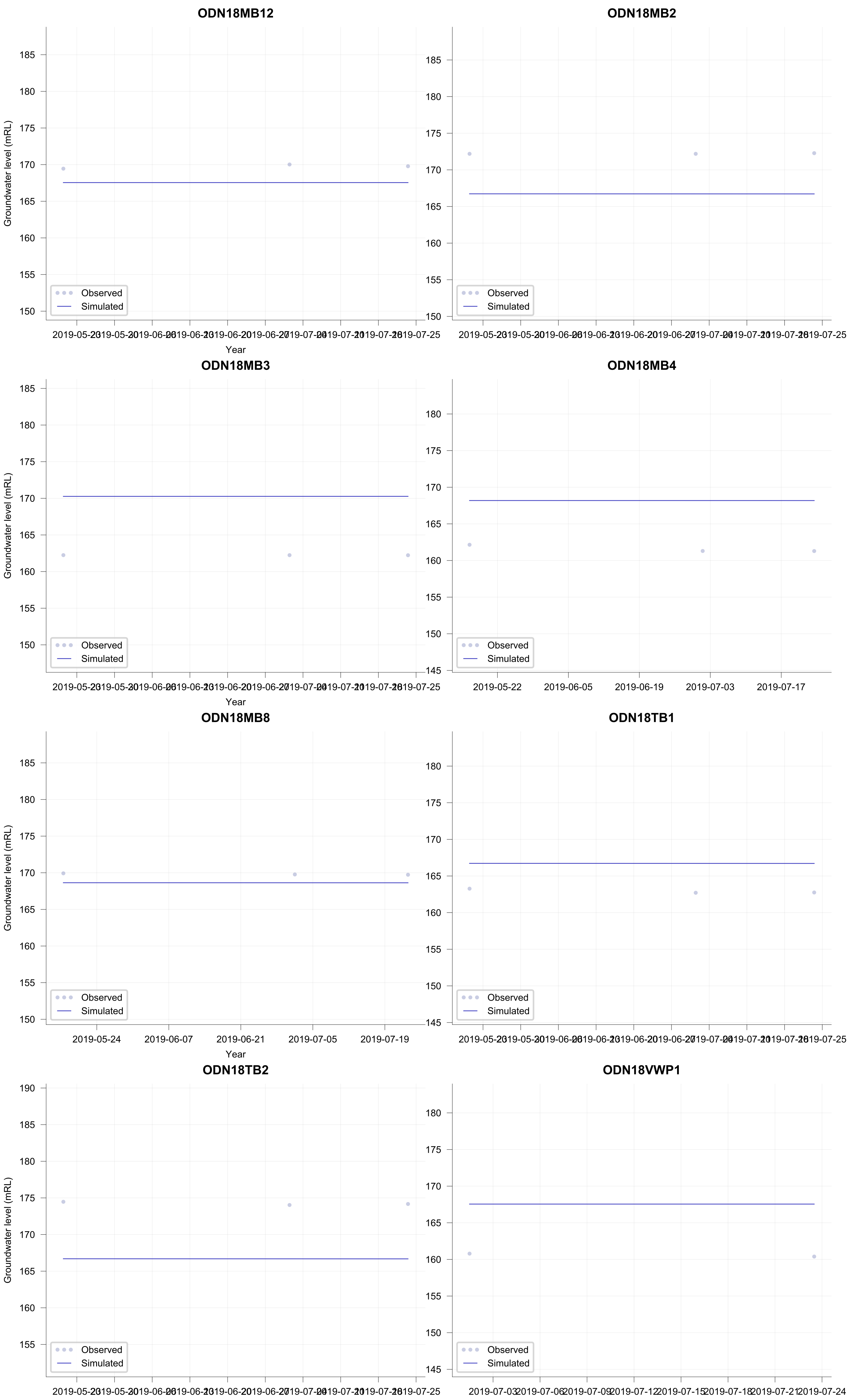

GW12D_P1
GW12D_P2
GW12S
GW16D_P2
GW16D_P4
GW18D
GW18S
GW21D
Groundwater level (mRL)
Year
Observed
Simulated
2017-04
2017-05
2017-06
2017-07
2017-08
2017-09
2017-10
2017-11
2017-12
120
125
130
135
140
145
150
155
160
165
170
175
180

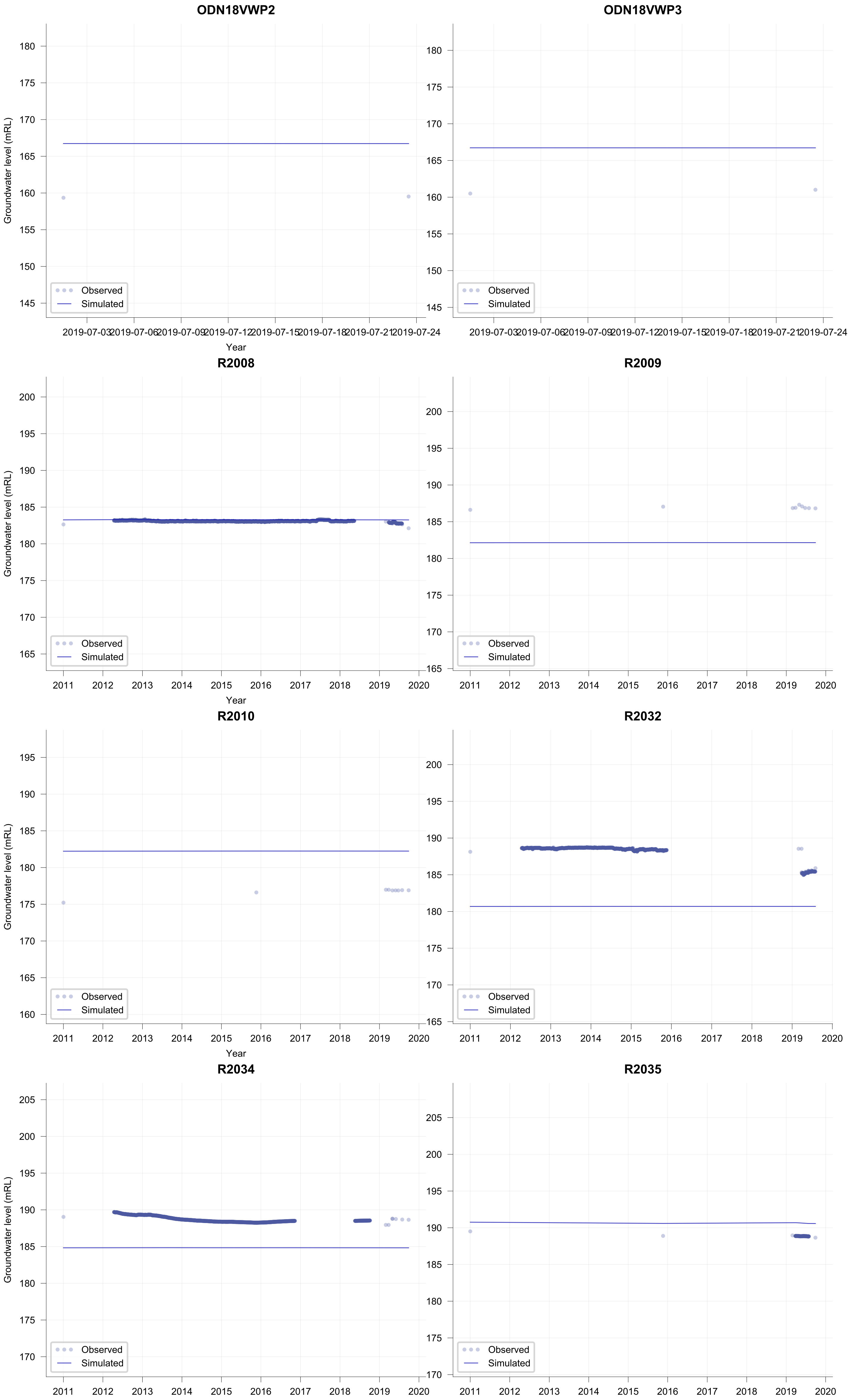

GW21S
170
165
160
155
150
145
140
135
Groundwater level (mRL)
Observed
Simulated
2017-07
2017-08
2017-09
2017-10
2017-11
Year
GW8S
180
175
170
165
160
155
150
145
140
Observed
Simulated
2017-10-01
2017-10-15
2017-10-29
2017-11-12
2017-11-26
2017-12-10
KNOBHILL1
195
190
185
180
175
170
165
160
155
Groundwater level (mRL)
Observed
Simulated
May 2012
Sep 2012
Jan 2013
May 2013
Sep 2013
Year
KNOBHILL2
195
190
185
180
175
170
165
160
Observed
Simulated
2012
2013
2014
2015
2016
2017
2018
2019
2020
LH13
215
210
205
200
195
190
185
180
Groundwater level (mRL)
Observed
Simulated
Jul 2014
Jan 2015
Jul 2015
Jan 2016
Year
LV1235C_P1
155
150
145
140
135
130
125
120
Observed
Simulated
2013-06-30
2013-07-07
2013-07-14
2013-07-21
2013-07-28
2013-08-04
2013-08-11
2013-08-18
2013-08-25
2013-09-01
LV1235C_P2
155
150
145
140
135
130
125
120
Groundwater level (mRL)
Observed
Simulated
Jul 2013
Jan 2014
Jul 2014
Jan 2015
Jul 2015
Year
LV1235C_P3
155
150
145
140
135
130
125
120
Observed
Simulated
Jul 2013
Jan 2014
Jul 2014
Jan 2015
Jul 2015

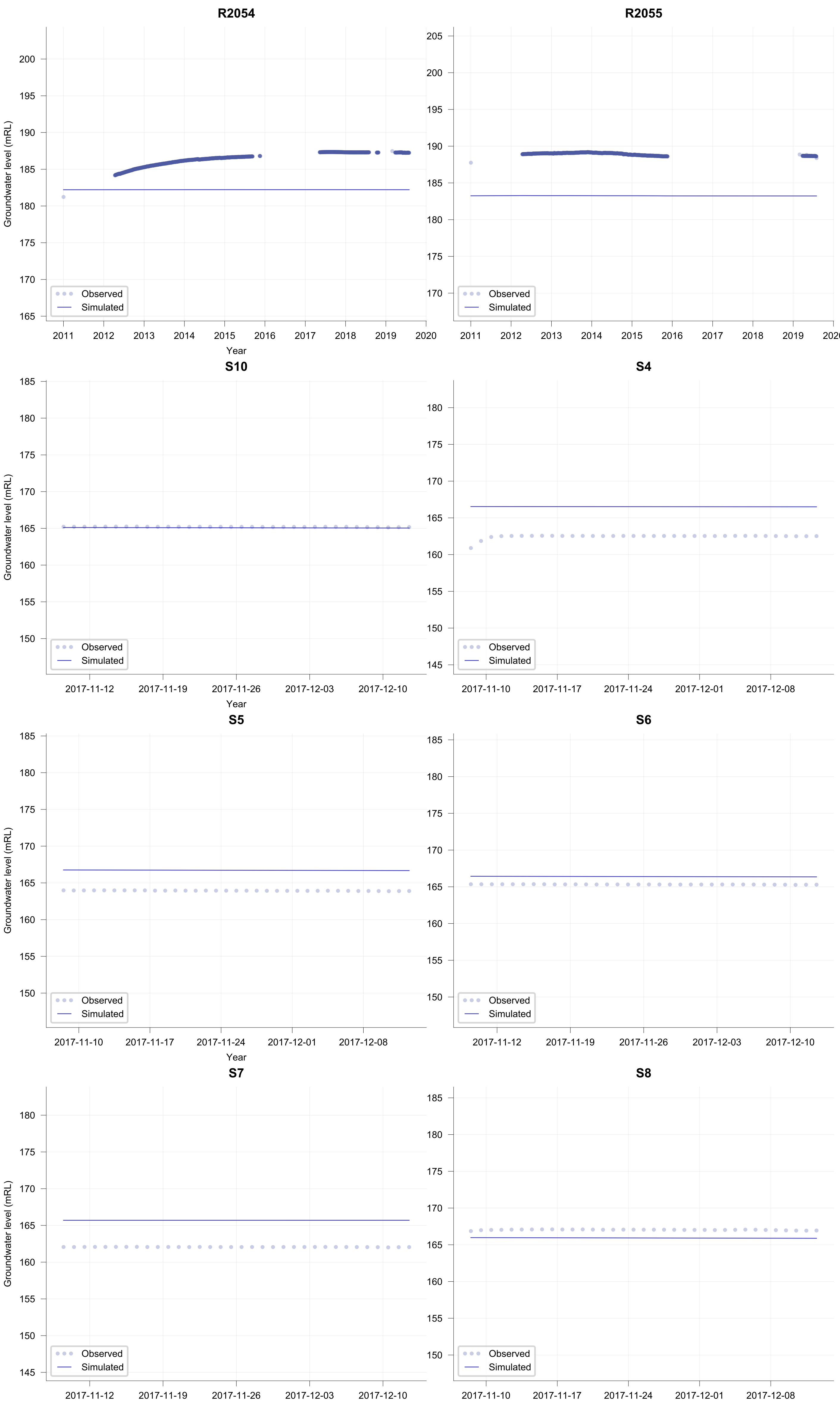

LV1235C_P4
LV2183_P1
LV2183_P3
LV2183_P4
LV2218_P1
LV2218_P2
LV2218_P3
LV2218_P4
Groundwater level (mRL)
Year
Observed
Simulated
Nov 2013
May 2014
Nov 2014
May 2015
Jul 2013
Jan 2014
Jul 2014
Jan 2015
Jul 2015


LV2226_P1
LV2226_P2
LV2226_P3
LV2226_P4
LV2372R_P1
LV2372R_P2
LV2372R_P3
LV2372R_P4
Groundwater level (mRL)
Year
Jul 2013
Jan 2014
Jul 2014
Jan 2015
Jul 2015
Observed
Simulated


LV2375W_P1
LV2375W_P2
LV2375W_P3
MB1
MB2
MB4
MB5
ODN18MB1
Groundwater level (mRL)
Year
Observed
Simulated
Jul 2013
Jan 2014
Jul 2014
Jan 2015
Jul 2015
2008
2010
2012
2014
2016
2018
2019-07-25


ODN18MB12
ODN18MB2
ODN18MB3
ODN18MB4
ODN18MB8
ODN18TB1
ODN18TB2
ODN18VWP1
Groundwater level (mRL)
Year
Observed
Simulated
2019-05-22
2019-06-05
2019-06-19
2019-07-03
2019-07-17
2019-05-24
2019-06-07
2019-06-21
2019-07-05
2019-07-19
2019-07-25
2019-07-24


ODN18VWP2
ODN18VWP3
R2008
R2009
R2010
R2032
R2034
R2035
Groundwater level (mRL)
Year
Observed
Simulated



R2054
R2055
S10
S4
S5
S6
S7
S8
Groundwater level (mRL)
Year
Observed
Simulated
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2017-11-10
2017-11-12
2017-11-17
2017-11-19
2017-11-24
2017-11-26
2017-12-01
2017-12-03
2017-12-08
2017-12-10

APPENDIX B

Calibration Residuals

ID	Easting	Northing	Layer	Average Residual	Min	Max
8	623797	7552173	1	12.0	12.0	12.0
11	627210	7546907	2	11.1	11.1	11.1
13	627200	7546952	2	11.7	11.7	11.7
14	628767	7546686	2	10.2	10.2	10.2
15	629120	7546795	8	11.4	11.4	11.4
16	628258	7544098	12	15.2	15.2	15.2
43639	638939	7511033	14	-6.1	-6.1	-6.1
44161	647509	7540289	1	2.8	2.8	2.8
44164	647938	7540971	2	0.2	0.2	0.2
88525	671221	7521945	12	-13.7	-13.7	-13.7
88526	671710	7519574	12	-11.3	-11.3	-11.3
88527	665212	7516134	1	-6.7	-6.7	-6.7
90074	671554	7510596	12	-13.1	-13.1	-13.1
90076	672380	7515478	12	-6.9	-6.9	-6.9
97180	654694	7527196	1	1.2	1.2	1.2
97181	656434	7523988	1	0.7	0.7	0.7
97182	657151	7522448	1	-2.2	-2.2	-2.2
97183	657419	7522279	1	-2.0	-2.0	-2.0
97184	658993	7519473	1	-6.7	-6.7	-6.7
97185	659218	7519203	1	-6.1	-6.1	-6.1
136090	647465	7540053	2	1.8	1.8	1.8
136689	635868	7528234	2	-4.6	-4.6	-4.6
141653	659045	7556157	2	0.1	0.1	0.1
141654	659021	7555813	2	-1.8	-1.8	-1.8
141657	660949	7555175	2	-7.3	-7.3	-7.3
141659	665723	7557183	2	-7.8	-7.8	-7.8
141660	662270	7556435	2	-3.5	-3.5	-3.5
141661	662270	7553121	2	-6.5	-6.5	-6.5
141662	662988	7553121	2	-5.9	-5.9	-5.9
158010	642695	7520136	9	0.3	0.3	0.3
158011	640219	7514147	12	-4.9	-4.9	-4.9
158484	648127	7524068	2	-0.8	-0.8	-0.8
158485	643179	7522108	9	2.4	2.4	2.4
161572	672635	7538180	14	-6.9	-6.9	-6.9
161573	672635	7538180	12	-6.0	-6.0	-6.0
161575	672566	7543230	13	3.8	3.8	3.8

ID	Easting	Northing	Layer	Average Residual	Min	Max
161578	672387	7535241	14	-4.6	-4.6	-4.6
162043	613496	7560208	2	-0.9	-0.9	-0.9
162044	615613	7560397	2	-7.4	-7.4	-7.4
162045	615524	7559448	9	-8.6	-8.6	-8.6
162046	618281	7557938	10	-4.7	-4.7	-4.7
162048	613513	7557249	2	6.6	6.6	6.6
162137	611503	7558187	13	-2.4	-2.4	-2.4
162138	620084	7547613	12	9.1	9.1	9.1
162141	613846	7562175	1	-0.1	-0.1	-0.1
162143	616018	7561336	2	3.1	3.1	3.1
162163	609752	7560149	13	9.9	3.5	11.6
162165	608920	7556710	2	8.6	2.6	17.1
162166	608920	7556710	13	-0.2	-5.7	1.6
162167	610730	7555327	13	-2.4	-2.8	-1.9
162168	608929	7554114	2	0.6	0.5	0.7
162169	611129	7551675	2	3.5	3.2	4.1
162170	611129	7551675	13	-0.6	-0.6	-0.6
162171	612441	7550671	1	-0.5	-0.5	-0.3
162172	612441	7550671	13	0.9	0.1	1.9
162175	614317	7548834	13	-6.6	-13.4	-1.0
162177	616863	7547756	12	1.7	-12.5	7.4
162439	631855	7553648	1	2.0	2.0	2.0
162470	635300	7560237	4	1.5	-1.9	5.8
162471	632332	7558326	6	-5.9	-7.5	3.9
162528	631660	7561036	9	9.8	6.7	12.0
162682	641152	7546517	1	-2.9	-4.1	-2.7
162684	642471	7547492	1	-0.1	-0.3	0.1
165325	640350	7516070	12	-3.8	-3.8	-3.8
13040180	667824	7516333	1	-8.7	-10.1	-6.6
13040181	667995	7516067	1	-5.3	-5.3	-5.3
13040183	668911	7514985	9	-7.2	-7.2	-7.2
13040184	669488	7514387	9	-8.4	-8.4	-8.4
13040287	663069	7559093	1	-4.3	-4.7	-4.1
BORE2	634799	7550042	1	0.8	0.8	0.8
BORE3	634799	7550042	10	-1.0	-1.0	-1.0
BORE7	637704	7552565	9	1.8	1.8	1.8

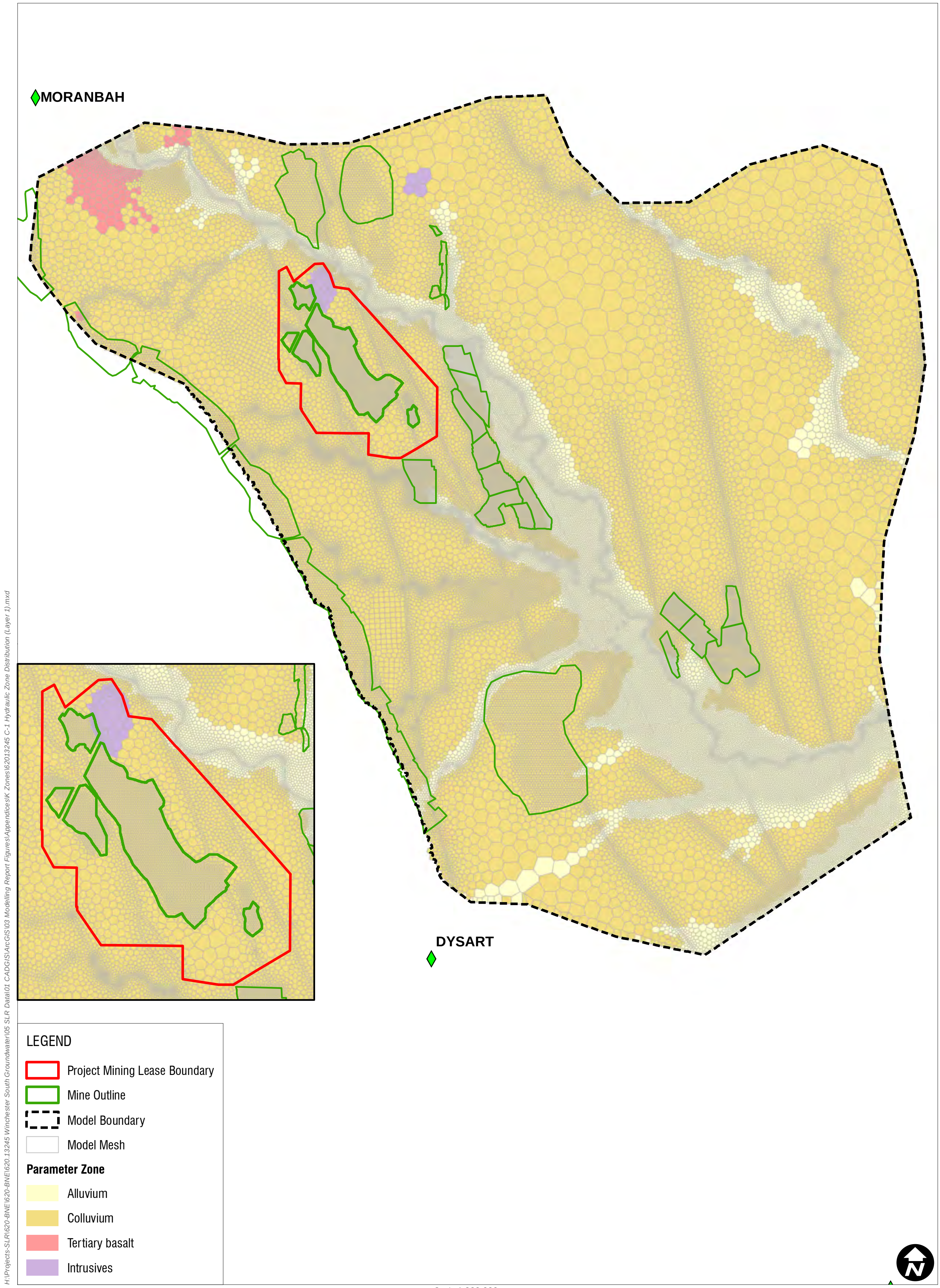
ID	Easting	Northing	Layer	Average Residual	Min	Max
C2105	634668	7541868	5	-2.4	-4.5	-1.7
C2105R	634650	7541857	5	-2.6	-2.6	-2.6
C2131	630066	7545593	6	7.6	7.6	7.6
C2136	631742	7547243	5	-10.4	-11.2	-10.2
G2300	629491	7544600	6	6.2	6.2	6.2
G2301	630967	7542324	6	16.3	16.3	16.3
G2304	633262	7543161	7	-7.3	-7.3	-7.3
G2304R	633245	7543171	7	-7.1	-7.1	-7.1
G2307	630881	7547844	7	-10.9	-11.0	-10.7
GW01D_P1	642475	7547489	7	-3.3	-4.4	-1.9
GW01D_P2	642475	7547489	5	-6.5	-7.3	-5.1
GW01D_P3	642475	7547489	3	-0.9	-1.3	-0.4
GW01D_P4	642475	7547489	3	1.3	1.0	2.0
GW01S	642471	7547492	1	0.6	0.1	3.4
GW02D	641148	7546512	7	-3.3	-3.6	-2.4
GW02S	641152	7546517	1	-2.7	-3.1	-1.0
GW06D_P1	639334	7542009	11	10.2	9.9	10.6
GW06D_P2	639334	7542009	10	1.1	0.6	1.6
GW06D_P3	639334	7542009	10	0.7	0.5	0.9
GW06D_P4	639334	7542009	9	-3.6	-4.7	-0.7
GW12D_P1	641492	7532790	5	2.6	1.6	7.2
GW12D_P2	641492	7532790	5	-2.2	-3.0	-0.8
GW12S	641498	7532791	2	-1.2	-1.3	-1.0
GW16D_P2	660834	7525288	5	-9.7	-9.8	-9.5
GW16D_P4	660834	7525288	3	-8.6	-8.8	-8.4
GW18D	656891	7522809	7	-0.2	-0.4	0.5
GW18S	656885	7522810	1	0.3	0.1	1.2
GW21D	661580	7521648	8	-15.7	-15.7	-15.6
GW21S	661580	7521653	2	5.0	4.9	5.2
GW8S	645324	7539847	1	-0.7	-1.3	0.6
KNOBHILL1	631005	7553874	1	1.5	-1.7	2.1
KNOBHILL2	630431	7554061	1	4.6	4.0	6.0
LAKEV3	648037	7523878	2	7.1	7.1	7.1
LH13	627200	7546952	2	13.7	11.5	15.6
LV1235C_P1	649799	7522054	8	-15.6	-16.6	-15.0
LV1235C_P2	649799	7522054	8	-15.0	-17.4	-14.0

ID	Easting	Northing	Layer	Average Residual	Min	Max
LV1235C_P3	649799	7522054	8	-14.2	-17.6	-13.0
LV1235C_P4	649799	7522054	2	-10.3	-12.6	-8.0
LV2183_P1	644068	7520358	7	-16.6	-17.4	-16.4
LV2183_P3	644068	7520358	6	-6.2	-7.0	-6.0
LV2183_P4	644068	7520358	2	-16.0	-16.1	-15.9
LV2218_P1	645526	7522753	7	-9.2	-9.2	-9.1
LV2218_P2	645526	7522753	6	-9.2	-9.3	-9.1
LV2218_P3	645526	7522753	6	-8.0	-8.3	-7.2
LV2218_P4	645526	7522753	3	-3.8	-4.8	-2.8
LV2226_P1	643129	7521950	7	-5.2	-5.6	-5.0
LV2226_P2	643129	7521950	6	-4.4	-5.1	-4.0
LV2226_P3	643129	7521950	6	-2.7	-4.1	-2.0
LV2226_P4	643129	7521950	2	3.5	2.4	5.6
LV2370W	648127	7524068	2	16.3	16.3	16.3
LV2372R_P1	647515	7526007	9	-8.2	-8.5	-8.0
LV2372R_P2	647515	7526007	9	-8.2	-8.5	-8.0
LV2372R_P3	647515	7526007	9	-8.2	-8.5	-8.0
LV2372R_P4	647515	7526007	2	-9.0	-9.3	-8.8
LV2375W_P1	648040	7523865	9	-13.0	-13.3	-12.8
LV2375W_P2	648040	7523865	9	-12.8	-12.8	-12.8
LV2375W_P3	648040	7523865	9	-8.6	-9.3	-8.3
MB1	623254	7551541	13	-0.5	-2.6	1.9
MB2	623684	7549391	13	6.2	4.8	6.7
MB4	626507	7544152	13	14.0	13.3	14.7
MB5	628491	7542693	13	13.1	0.1	13.9
ODN18MB1	640275	7547943	5	-3.6	-3.8	-3.5
ODN18MB10	639451	7554580	9	-7.1	-7.1	-7.1
ODN18MB11	638599	7553465	9	0.0	0.0	0.0
ODN18MB12	640277	7547944	7	3.0	2.7	3.3
ODN18MB2	640263	7547944	1	6.7	6.6	6.7
ODN18MB3	639751	7551426	5	-7.8	-7.8	-7.8
ODN18MB4	640684	7549869	1	-6.1	-6.4	-5.5
ODN18MB6	639944	7551802	5	-6.8	-6.8	-6.8
ODN18MB7	640310	7554734	1	-2.5	-2.5	-2.5
ODN18MB8	638921	7550183	1	1.2	1.1	1.3
ODN18MB9	640089	7557236	5	1.6	1.6	1.6

ID	Easting	Northing	Layer	Average Residual	Min	Max
ODN18TB1	640318	7547935	5	-2.7	-2.9	-2.3
ODN18TB2	640303	7547935	1	8.7	8.6	9.0
ODN18VWP1	640295	7547985	7	-6.1	-6.3	-5.9
ODN18VWP2	640295	7547985	5	-6.1	-6.2	-6.0
ODN18VWP3	640295	7547985	4	-4.8	-5.1	-4.5
R2007	630448	7542330	7	-2.3	-2.3	-2.3
R2008	630879	7542573	7	-0.1	-1.1	0.1
R2009	631317	7542810	6	4.9	4.6	5.3
R2010	631743	7543062	7	-5.4	-6.9	-5.2
R2010R	631730	7543070	5	-5.4	-5.4	-5.4
R2030	630055	7545089	6	6.8	6.8	6.8
R2032	630495	7545853	5	7.7	4.4	8.2
R2034	629614	7545329	8	3.9	3.2	4.9
R2035	629190	7545103	7	-1.7	-1.9	-1.2
R2054	629240	7548107	6	4.3	-0.8	5.4
R2055	628798	7547863	7	5.8	4.6	6.1
R2056	628364	7547623	8	9.0	9.0	9.0
RIVER_BORE	654027	7526987	3	-5.0	-5.0	-5.0
S10	642552	7546035	1	0.4	0.3	2.1
S11	642455	7545332	1	3.0	3.0	3.0
S2	641386	7547617	1	1.7	1.7	1.7
S4	641567	7546845	1	-3.3	-5.0	0.1
S5	642239	7547332	1	-2.1	-2.2	1.5
S6	642054	7546721	1	-0.6	-0.7	2.0
S7	641443	7545828	1	-3.2	-3.3	-0.9
S8	642340	7546343	1	1.5	1.2	3.6
S9	641767	7545426	1	-1.8	-1.9	0.1
SWAMP_BORE	645609	7528626	9	-6.8	-6.8	-6.8
UNKNOWN1	670340	7516415	1	0.1	0.1	0.1
UNKNOWN1_9	656877	7515985	9	-2.6	-2.6	-2.6
UNKNOWN2	656850	7515962	2	-9.4	-9.4	-9.4
WINNETBORE	634791	7550023	1	-0.3	-1.2	0.1
YARDBORE1	642611	7519351	11	-4.0	-4.0	-4.0

APPENDIX C

Hydraulic Zone Distributions



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

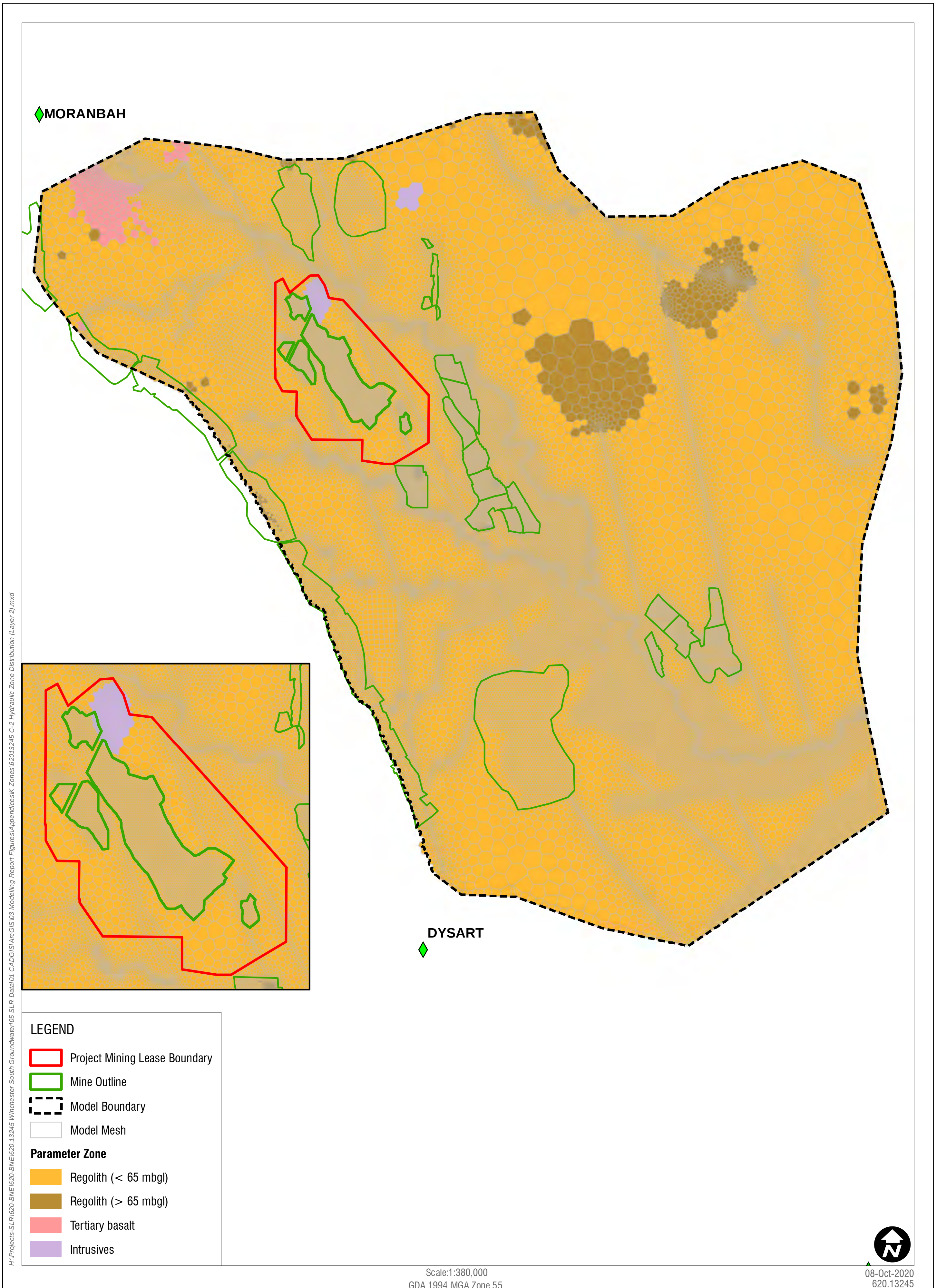
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Hydraulic Parameter Zone Distribution Layer 1

FIGURE C-1

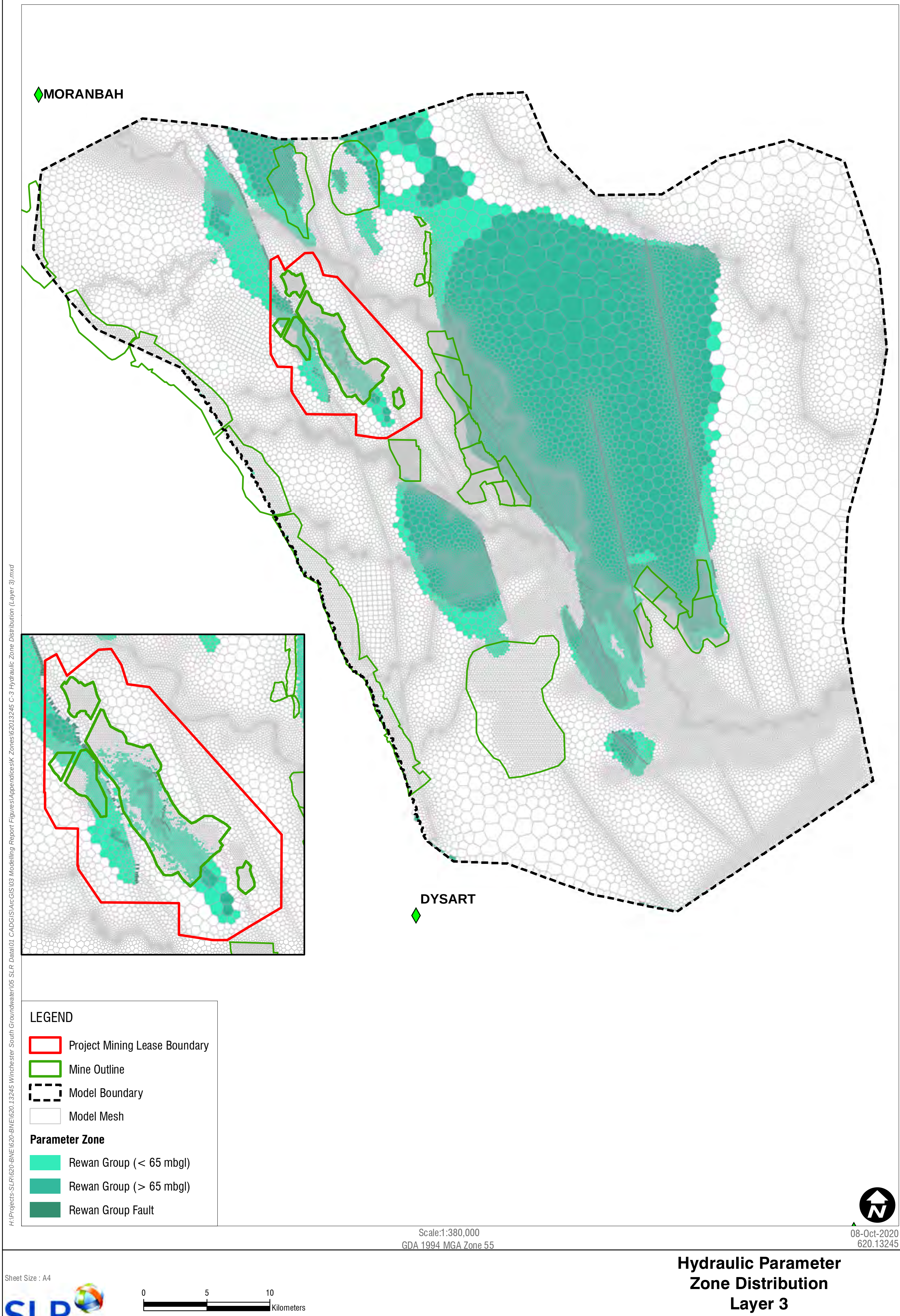


Sheet Size : A4

www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 2

FIGURE C-2



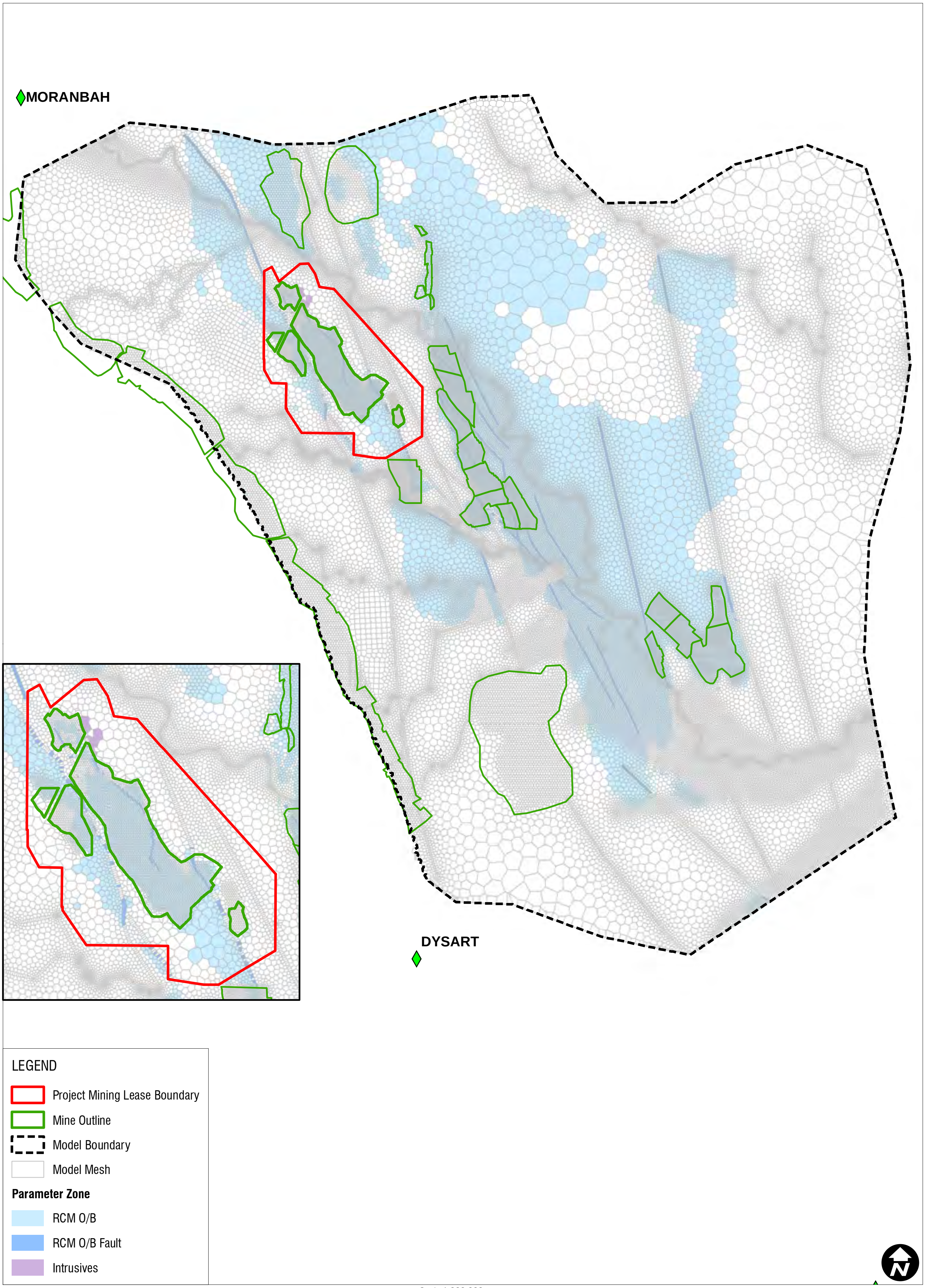
H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-3 Hydraulic Zone Distribution (Layer 3).mxd

Sheet Size : A4

www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 3

FIGURE C-3



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-4 Hydraulic Zone Distribution (Layer 4).mxd

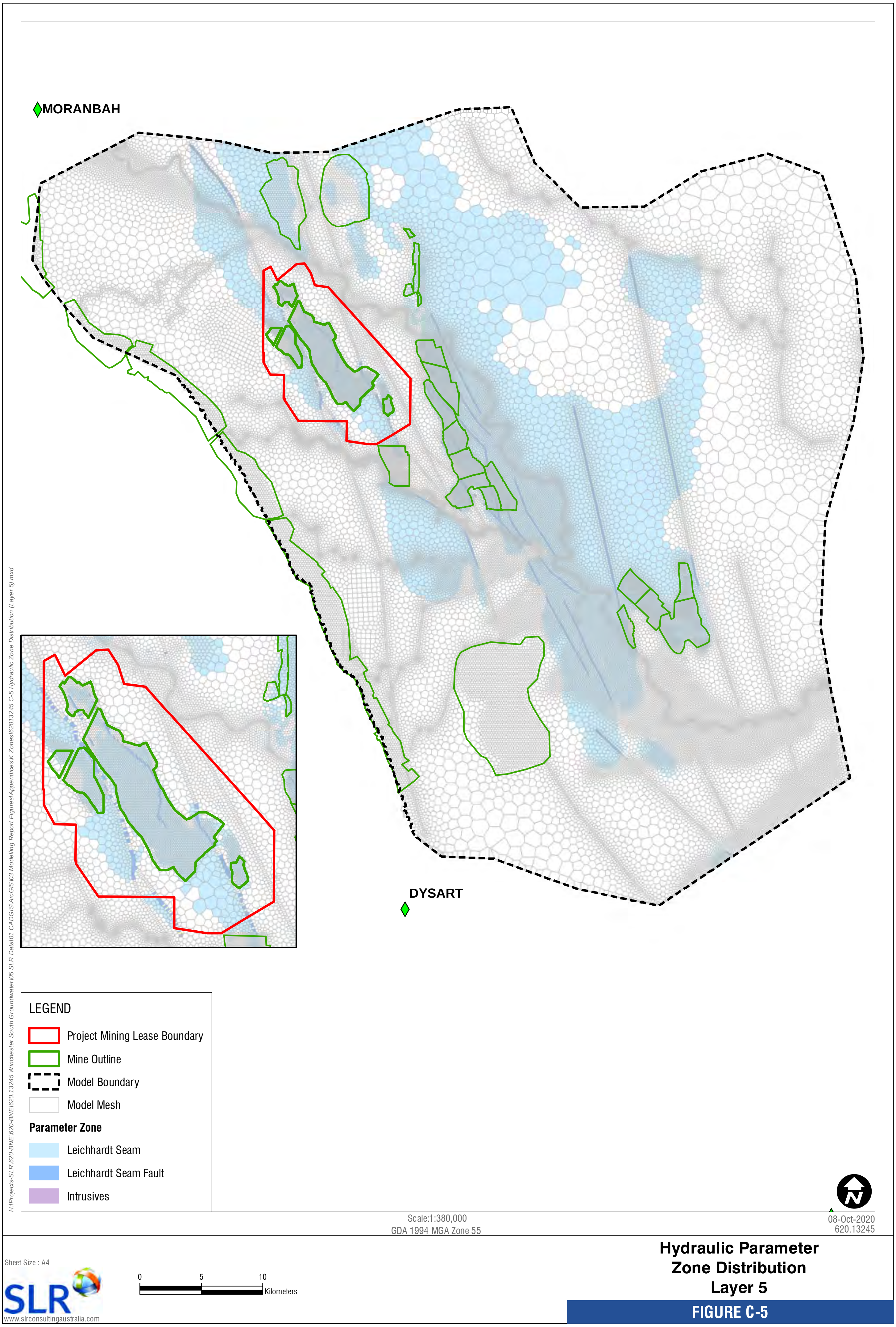
Sheet Size : A4

0 5 10 Kilometers

SLR
www.slrconsultingaustralia.com

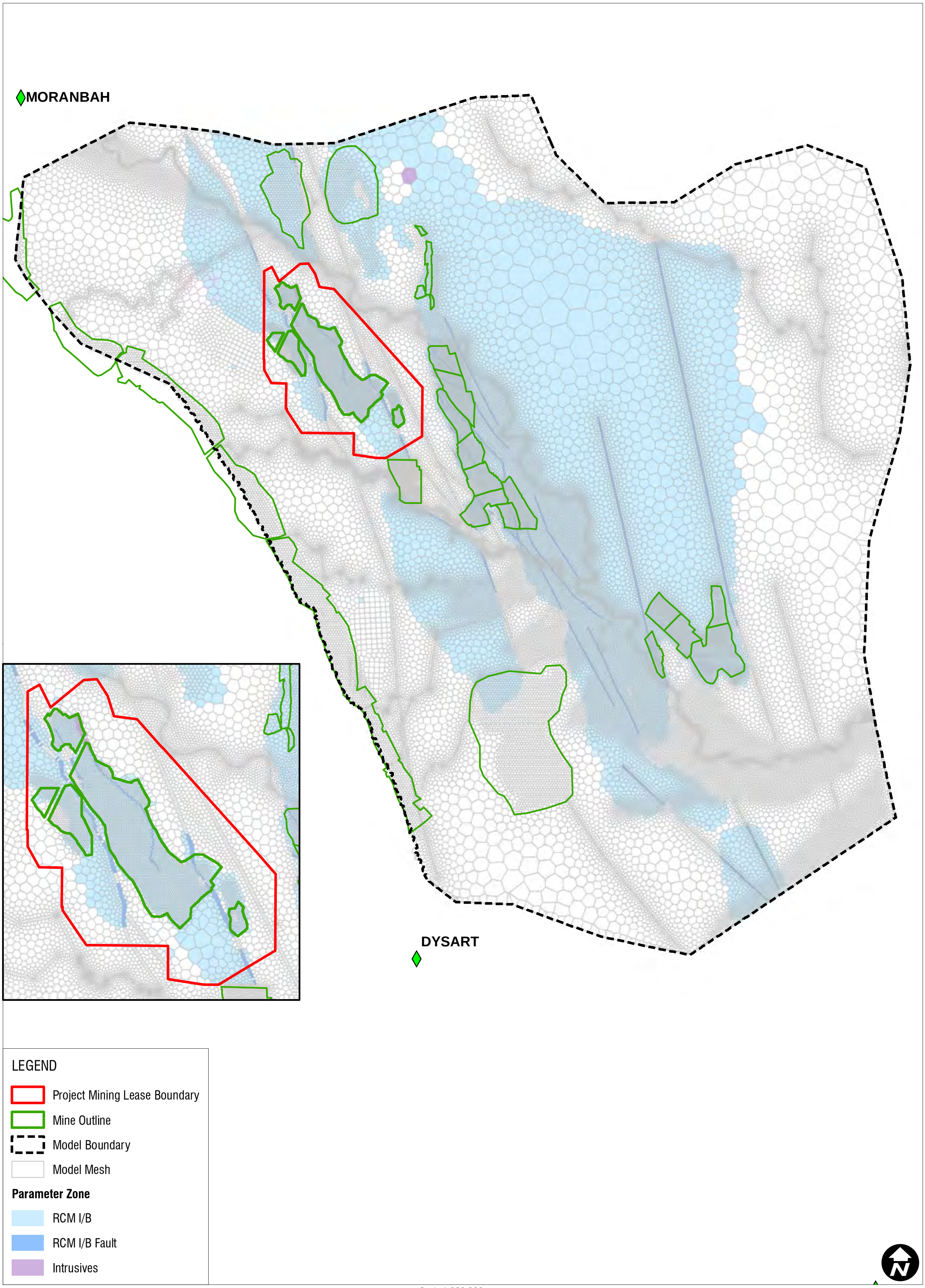
Hydraulic Parameter Zone Distribution Layer 4

FIGURE C-4



Hydraulic Parameter Zone Distribution Layer 5

FIGURE C-5



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-6 Hydraulic Zone Distribution (Layer 6).mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

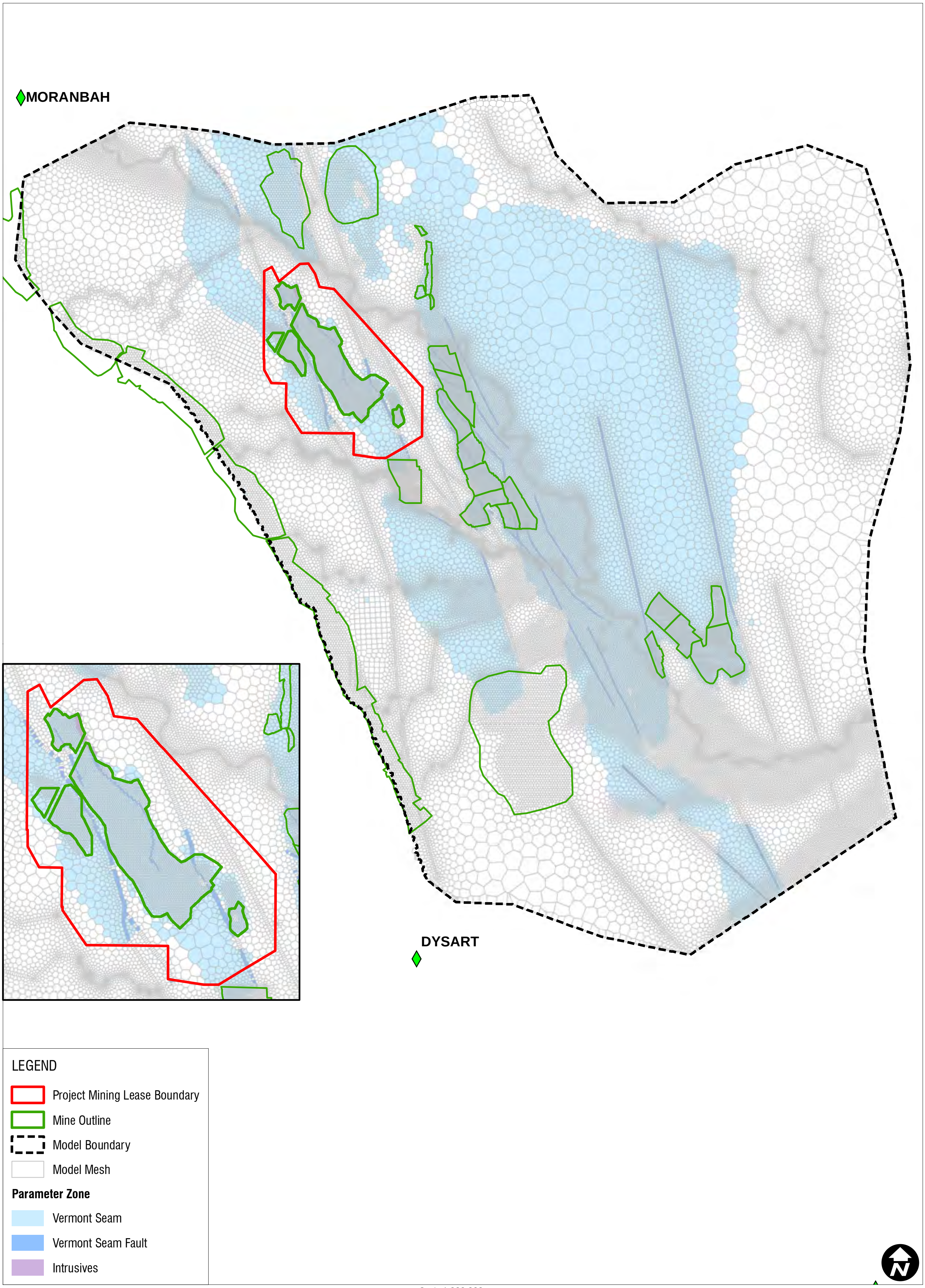
Sheet Size : A4

0 5 10 Kilometers

www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 6

FIGURE C-6



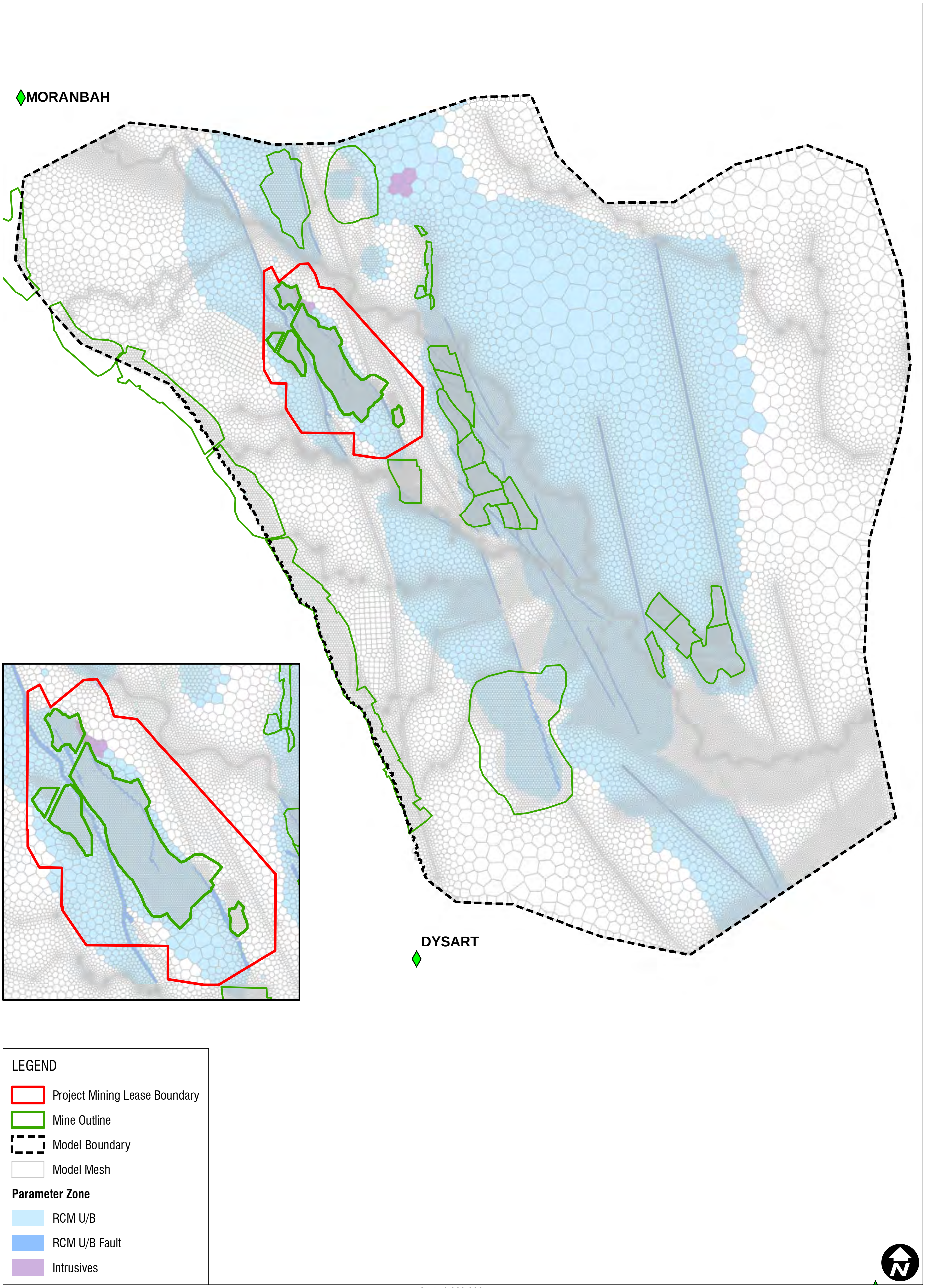
H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-7 Hydraulic Zone Distribution (Layer 7).mxd

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 7

FIGURE C-7



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-8 Hydraulic Zone Distribution (Layer 8).mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

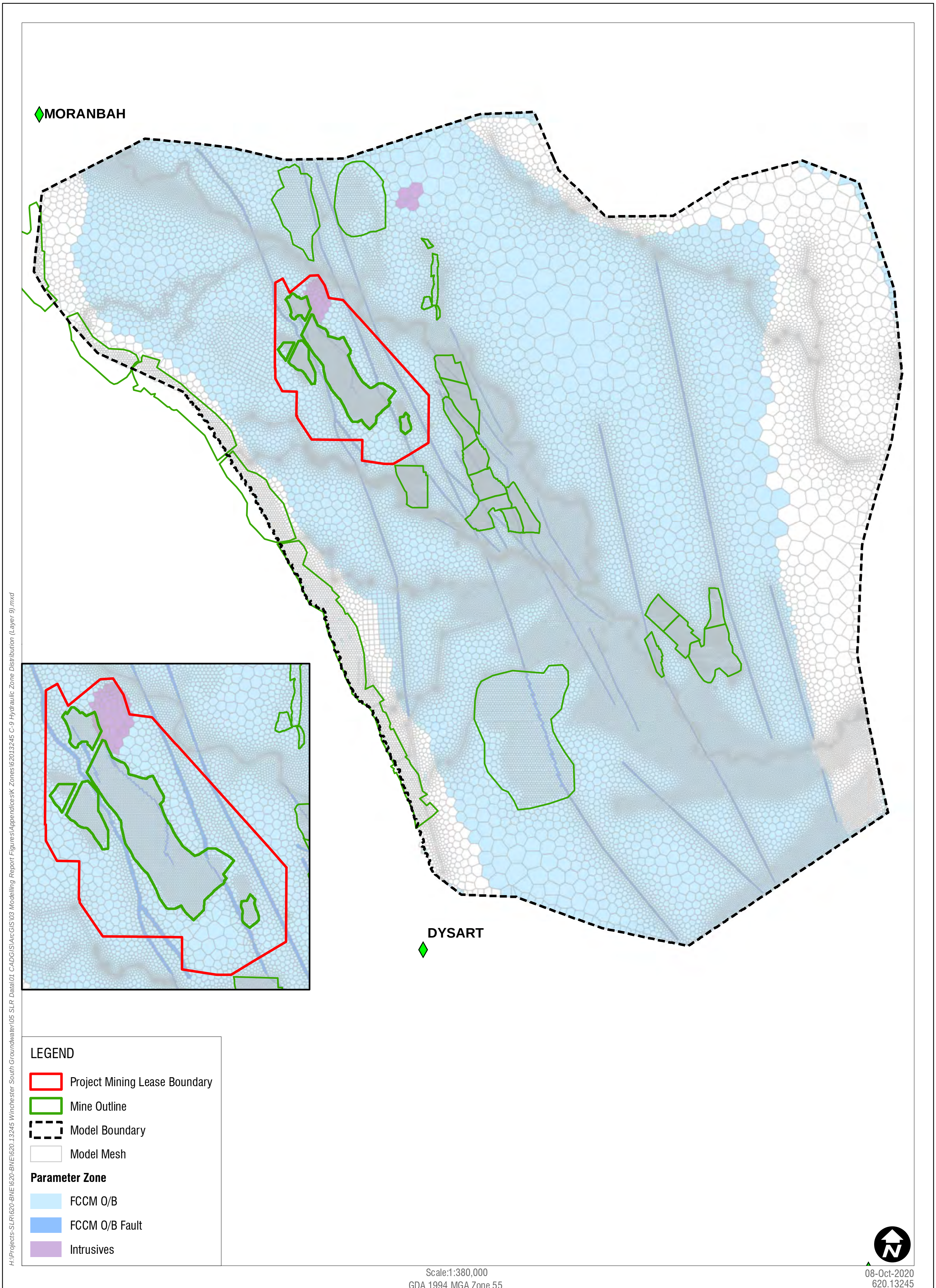
Sheet Size : A4

0 5 10 Kilometers

SLR
www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 8

FIGURE C-8

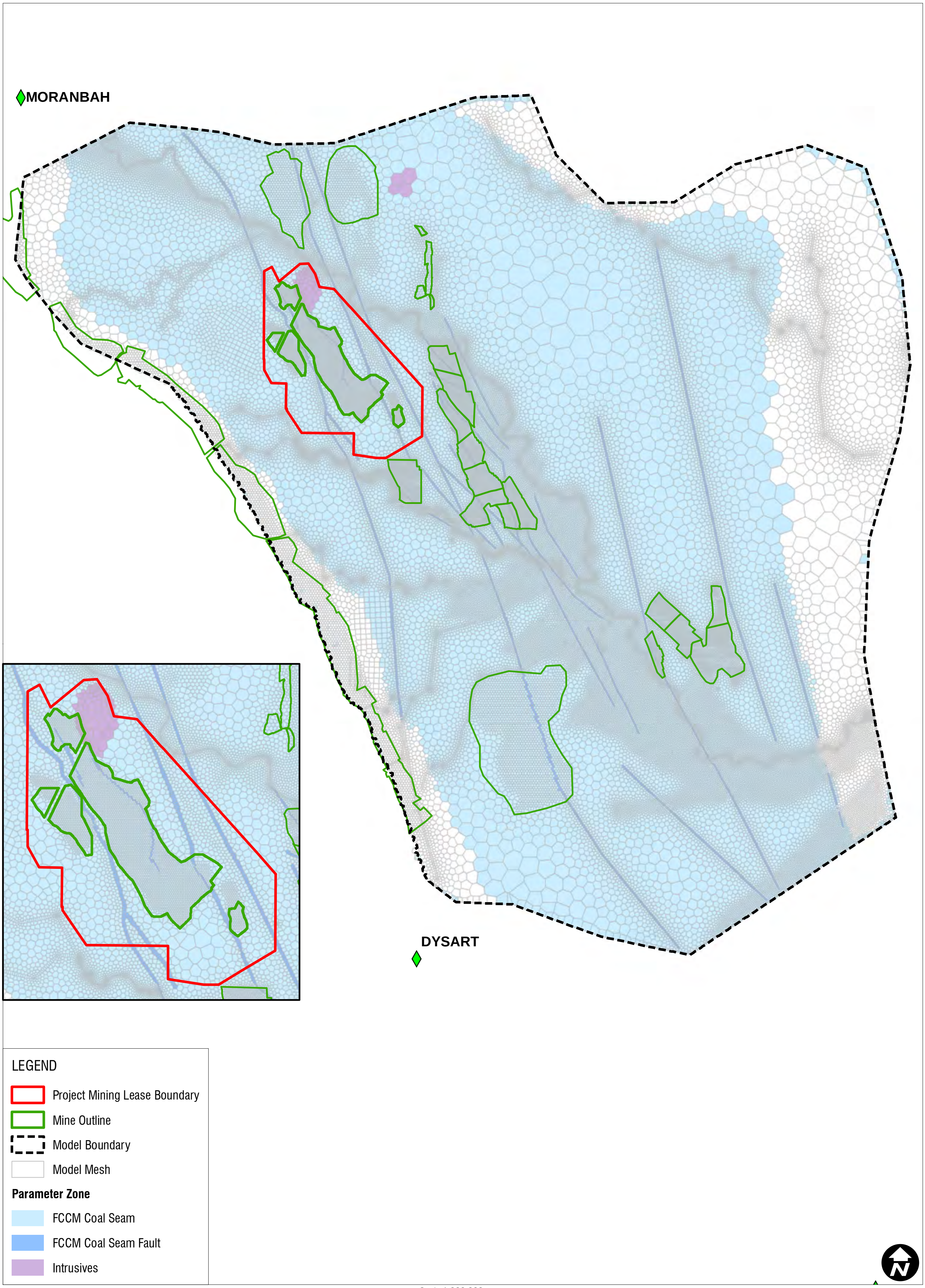


Sheet Size : A4

SLR
www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 9

FIGURE C-9



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\6201323245 C-10 Hydraulic Zone Distribution (Layer 10).mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

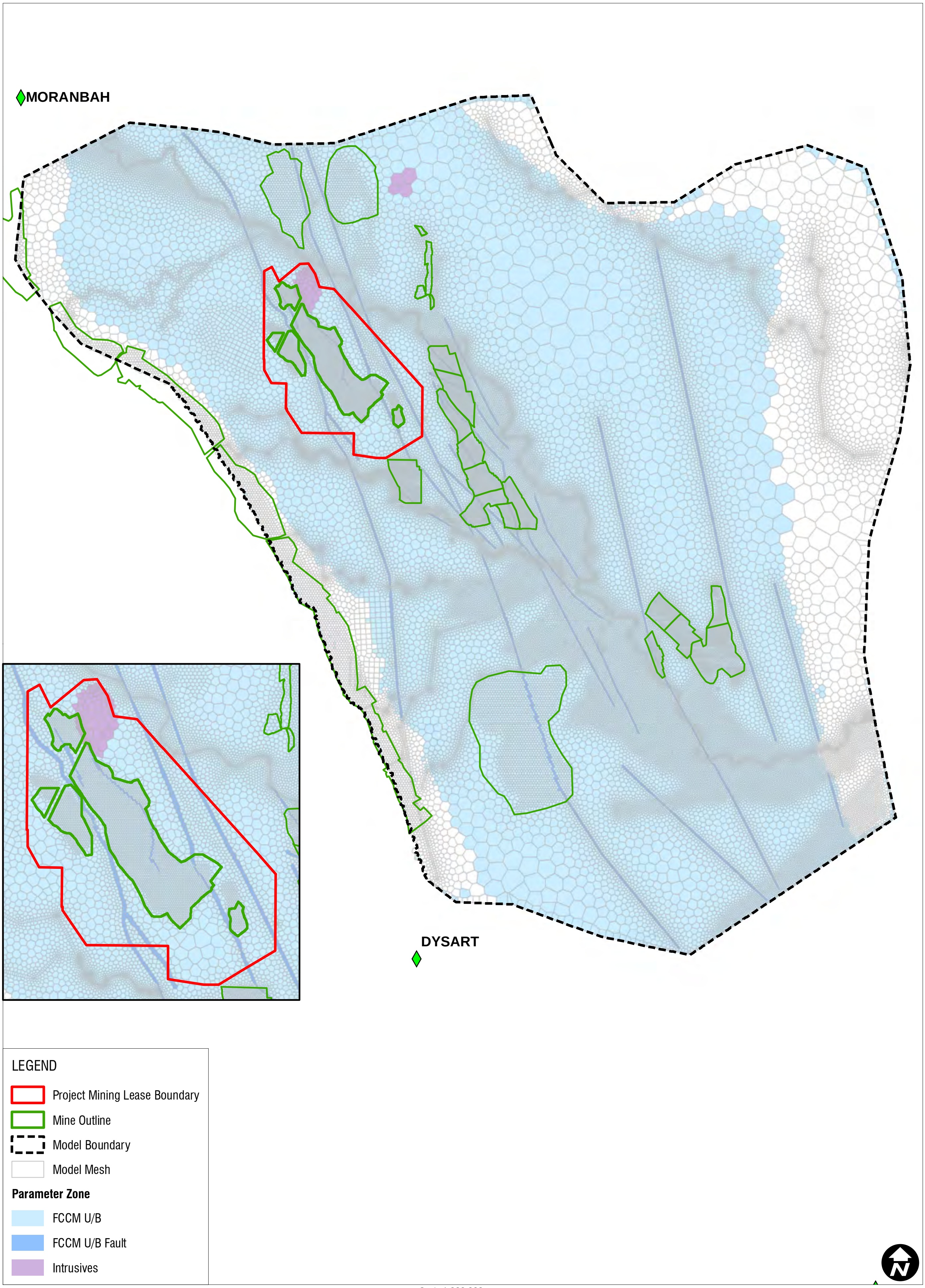
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Hydraulic Parameter Zone Distribution Layer 10

FIGURE C-10



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-11 Hydraulic Zone Distribution (Layer 11).mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

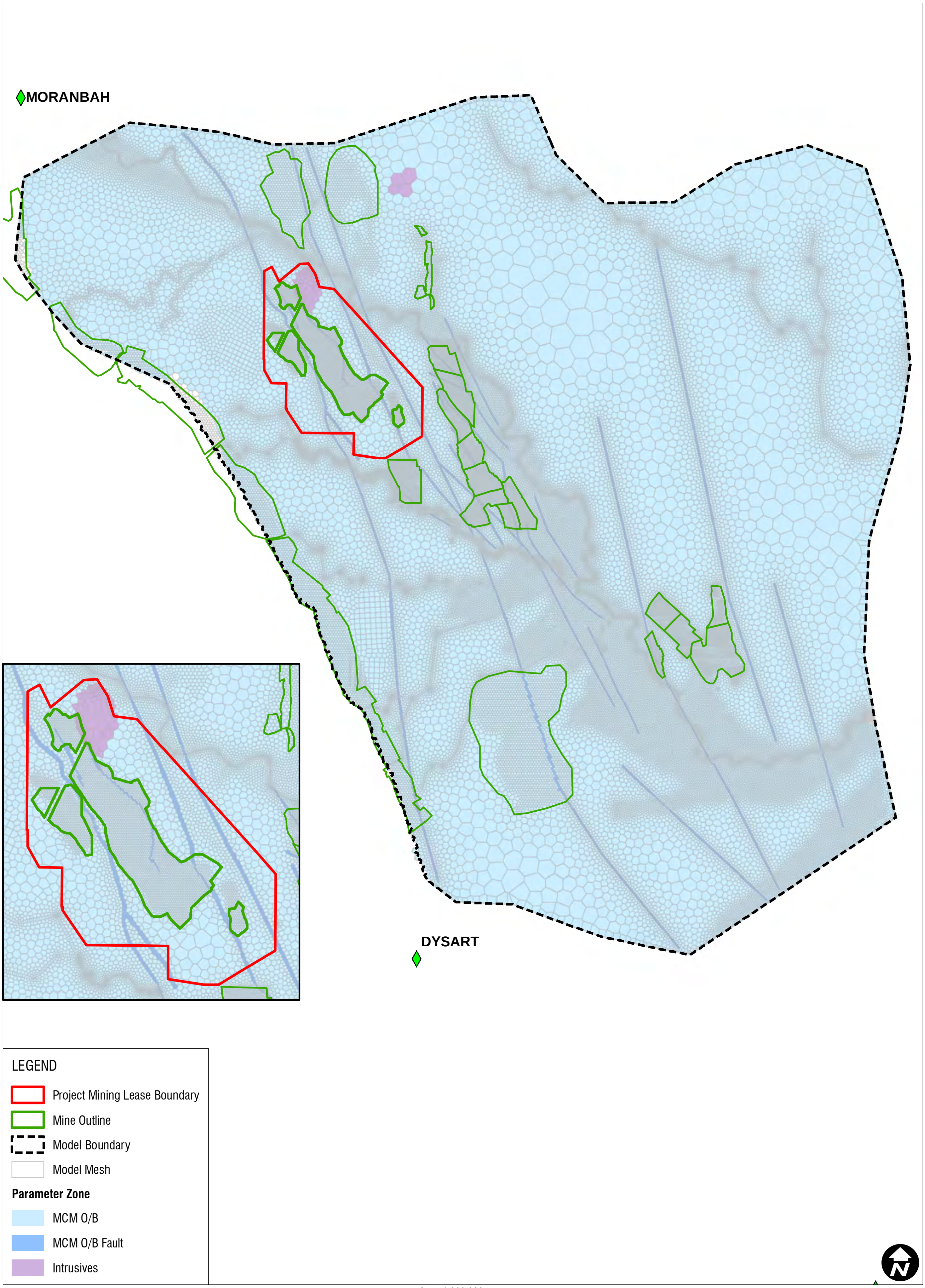
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Hydraulic Parameter Zone Distribution Layer 11

FIGURE C-11



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\620013245 C-12 Hydraulic Zone Distribution (Layer 12).mxd

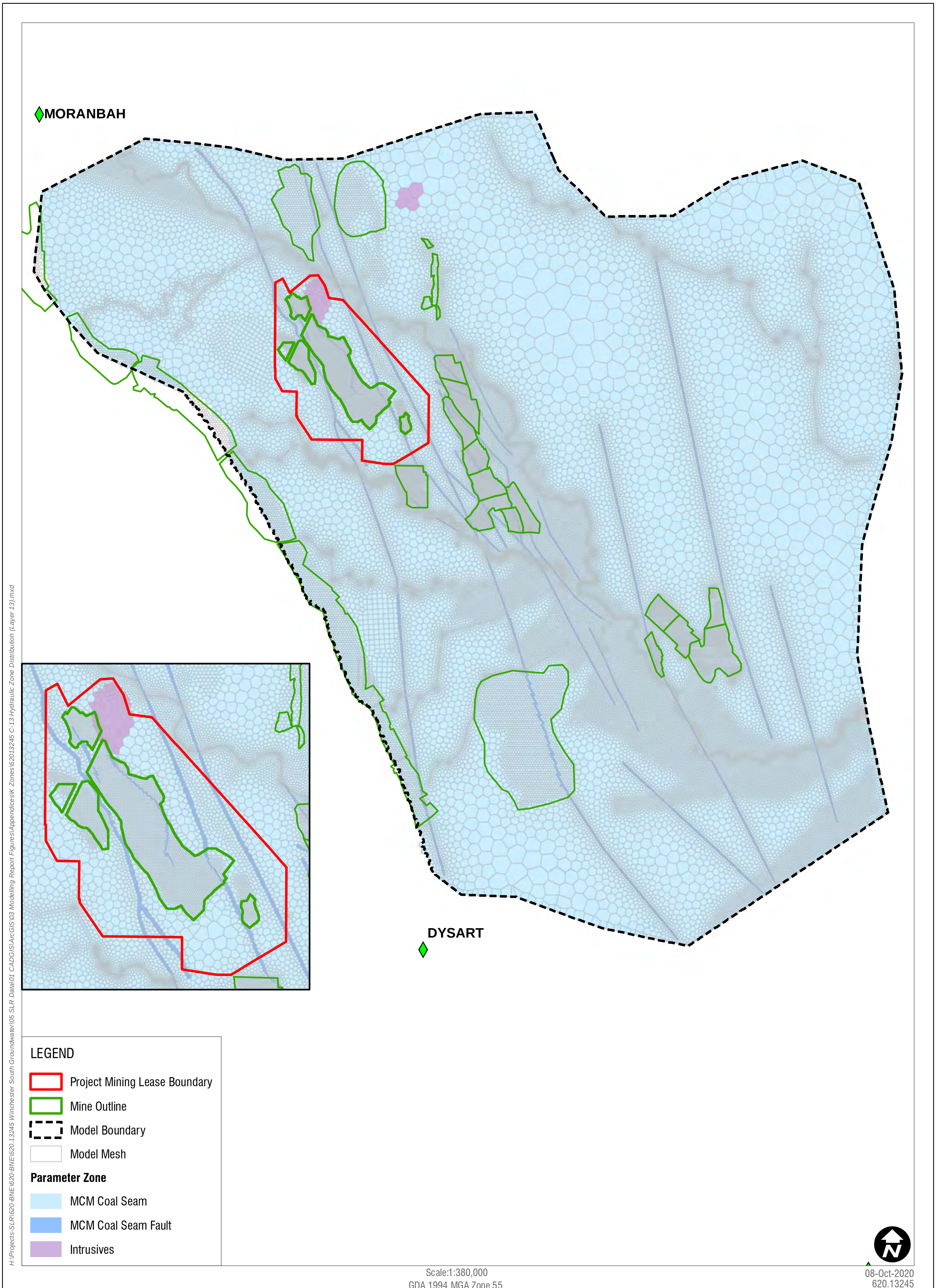
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Hydraulic Parameter Zone Distribution Layer 12

FIGURE C-12



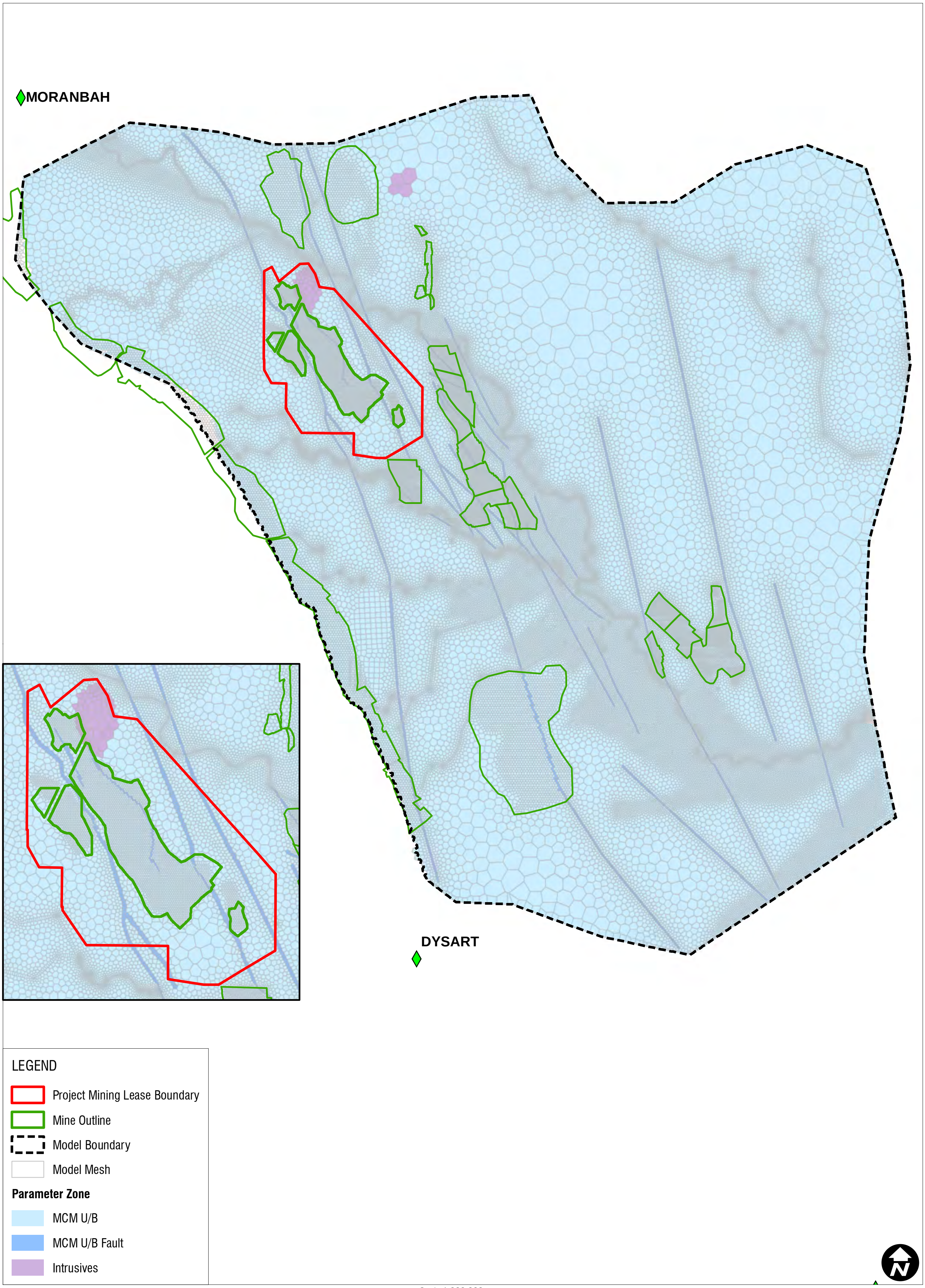
H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-13 Hydraulic Zone Distribution (Layer 13).mxd

Sheet Size : A4

www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 13

FIGURE C-13



H:\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\K Zones\62013245 C-14 Hydraulic Zone Distribution (Layer 14).mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

Sheet Size : A4

0 5 10 Kilometers

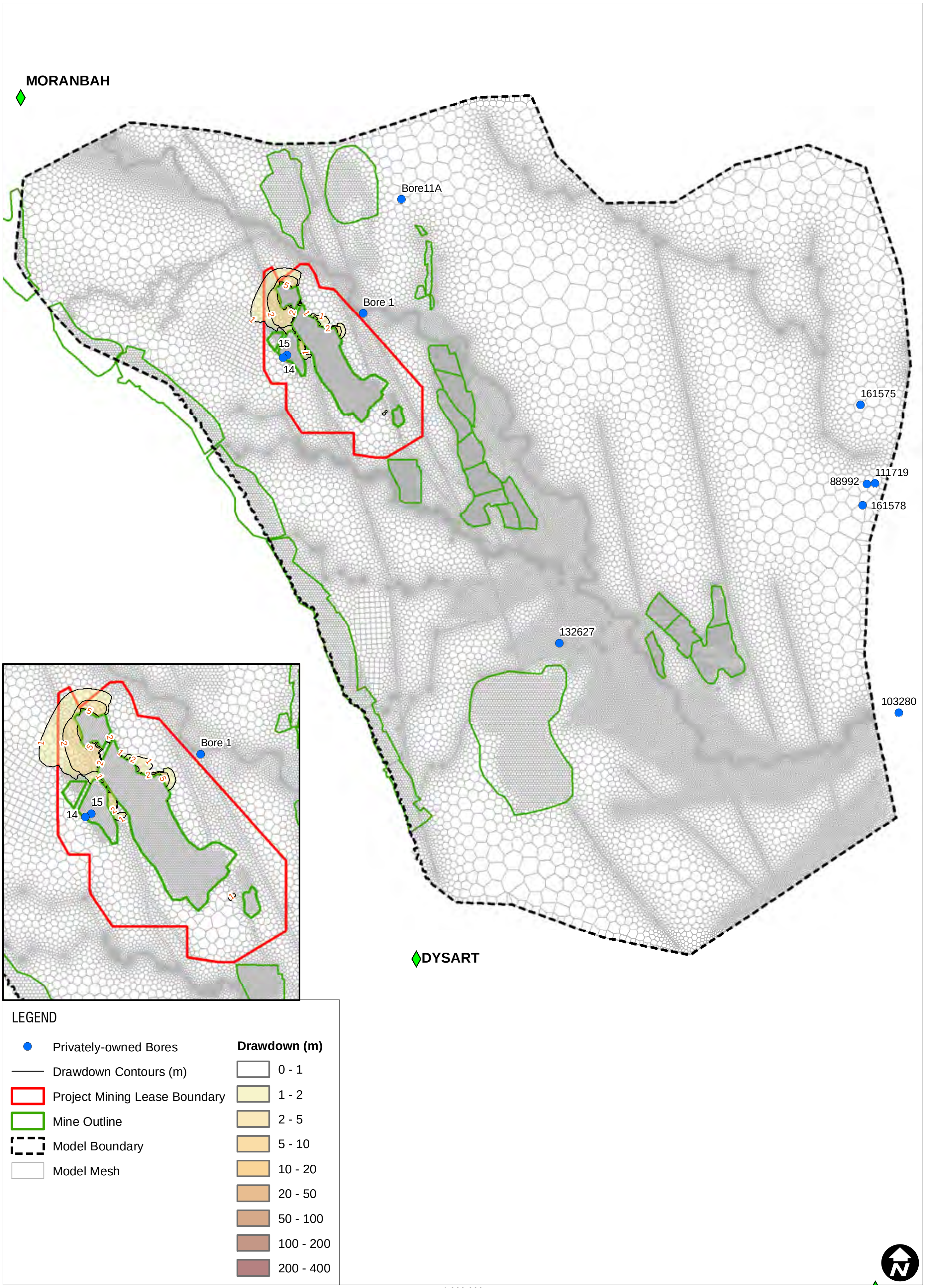
SLR
www.slrconsultingaustralia.com

Hydraulic Parameter Zone Distribution Layer 14

FIGURE C-14

APPENDIX D

Drawdown Progression over Life of the Project



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-1 Incremental Drawdown in Regolith (Layer 2) 2033.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

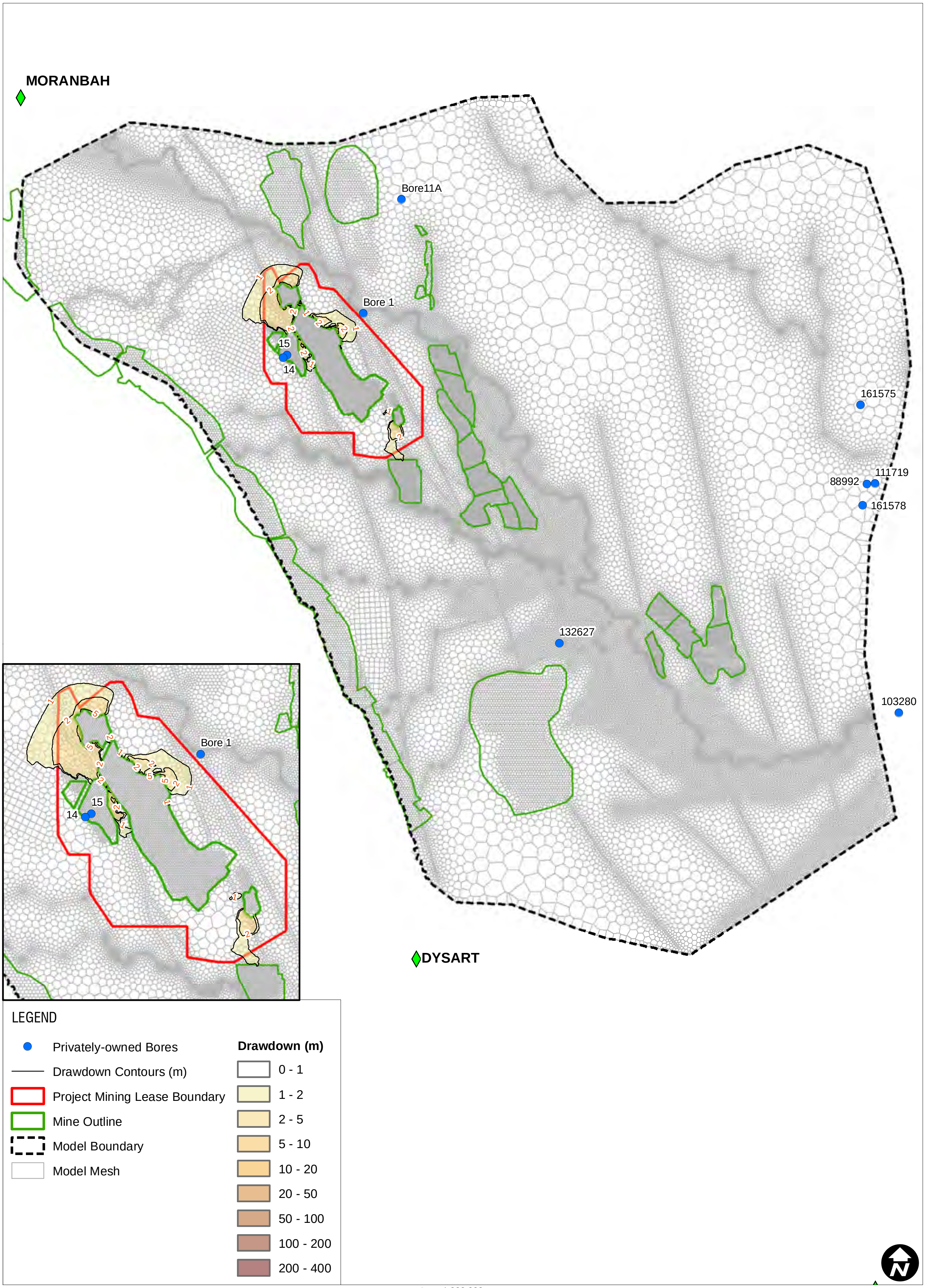
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Incremental Drawdown in Regolith (Layer 2) 2033

FIGURE D-1



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-2 Incremental Drawdown in Regolith (Layer 2) 2043.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

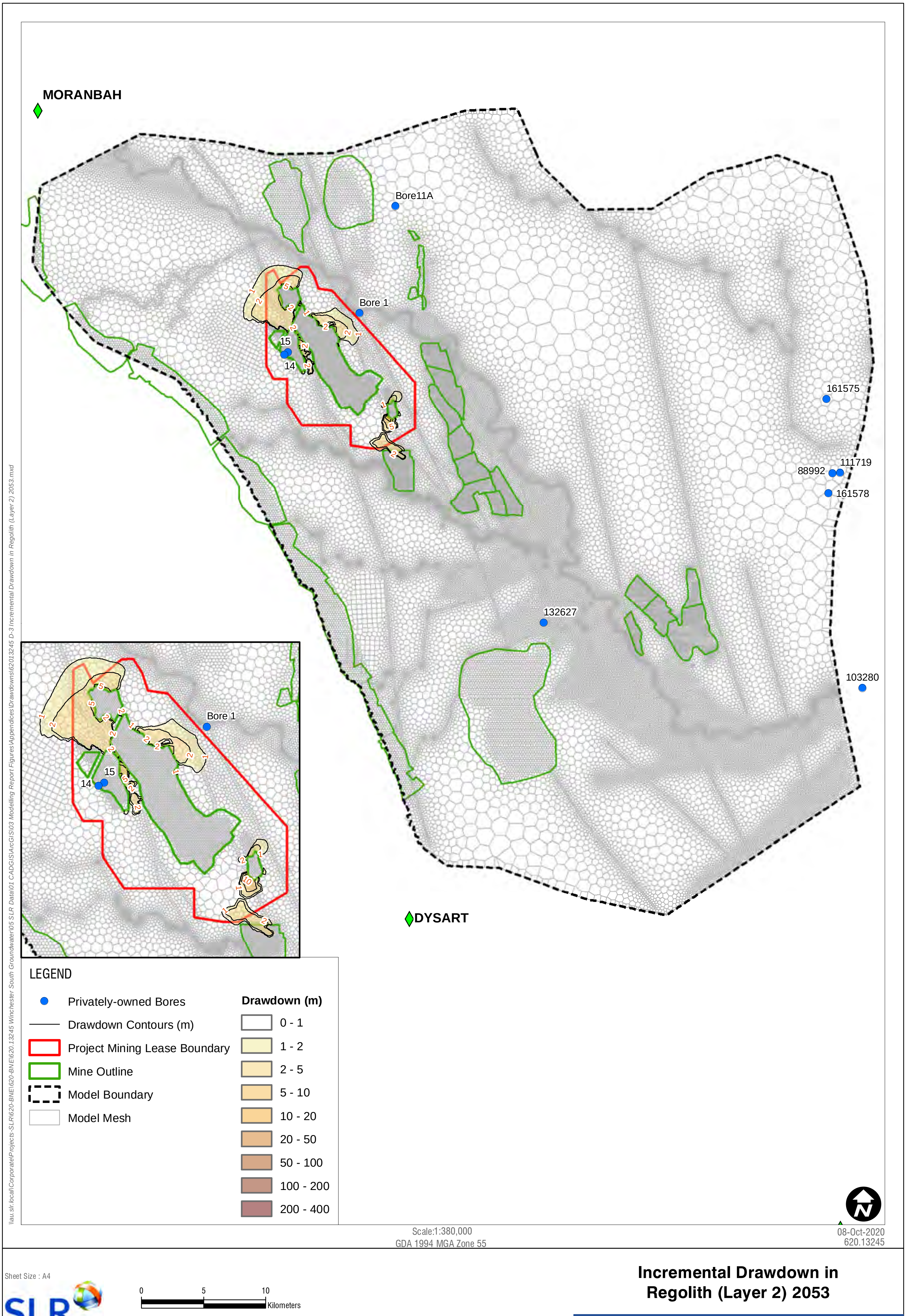
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10
Kilometers

Incremental Drawdown in Regolith (Layer 2) 2043

FIGURE D-2

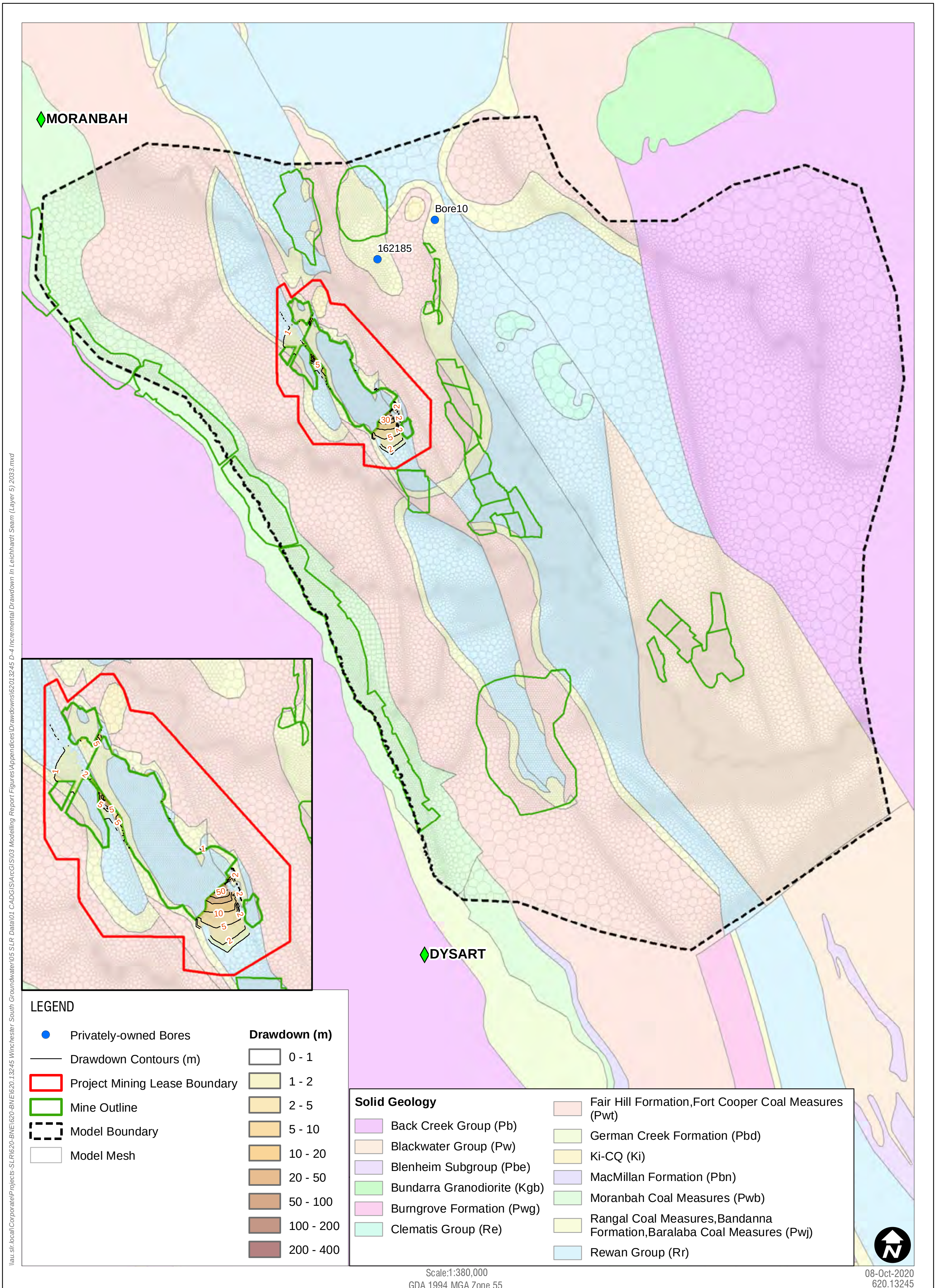


Sheet Size : A4

www.slrconsultingaustralia.com

Incremental Drawdown in Regolith (Layer 2) 2053

FIGURE D-3



Sheet Size : A4

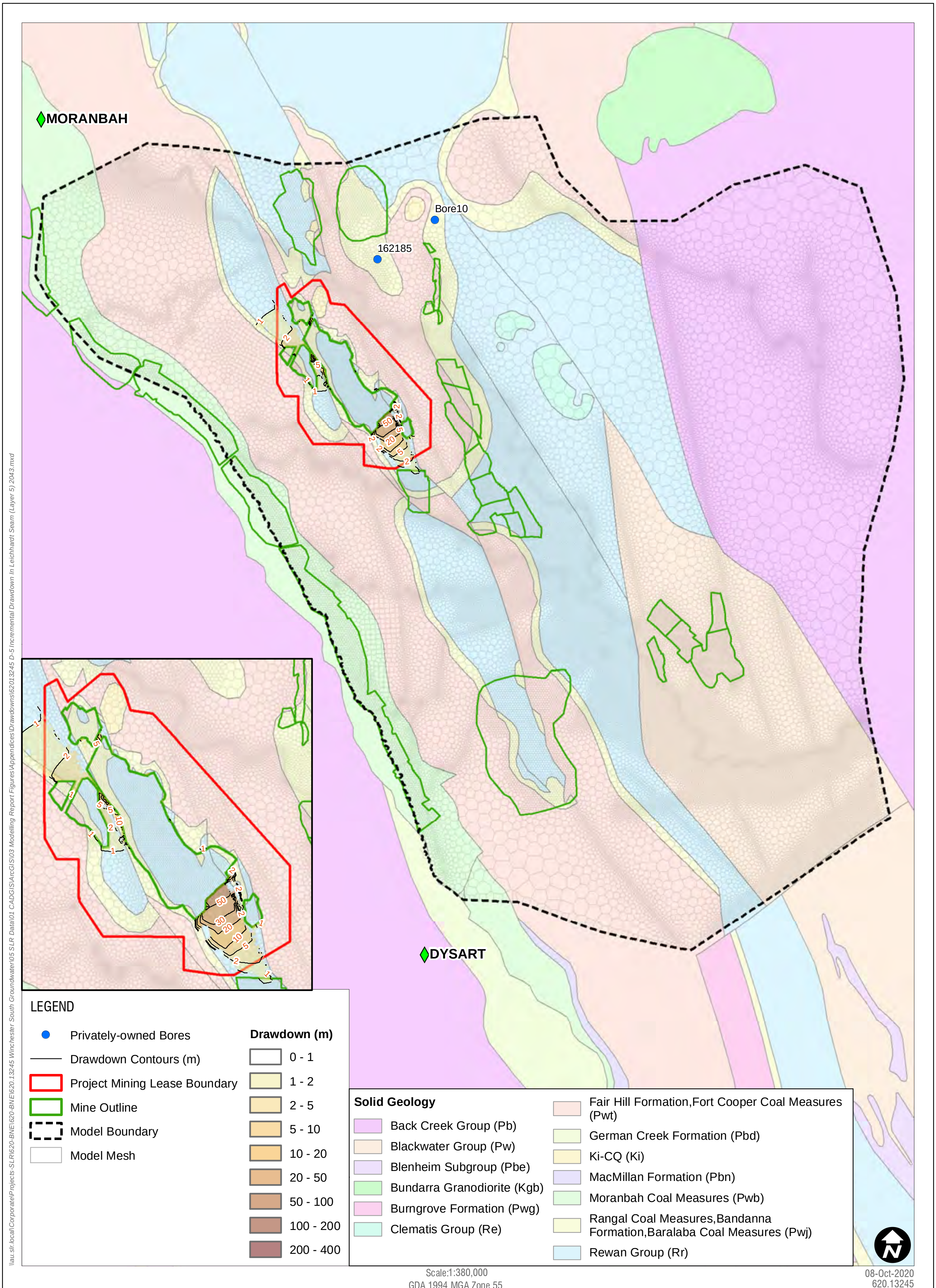
0 5 10 Kilometers

SLR

www.slrconsultingaustralia.com

Incremental Drawdown in Leichhardt Seam (Layer 5) 2033

FIGURE D-4

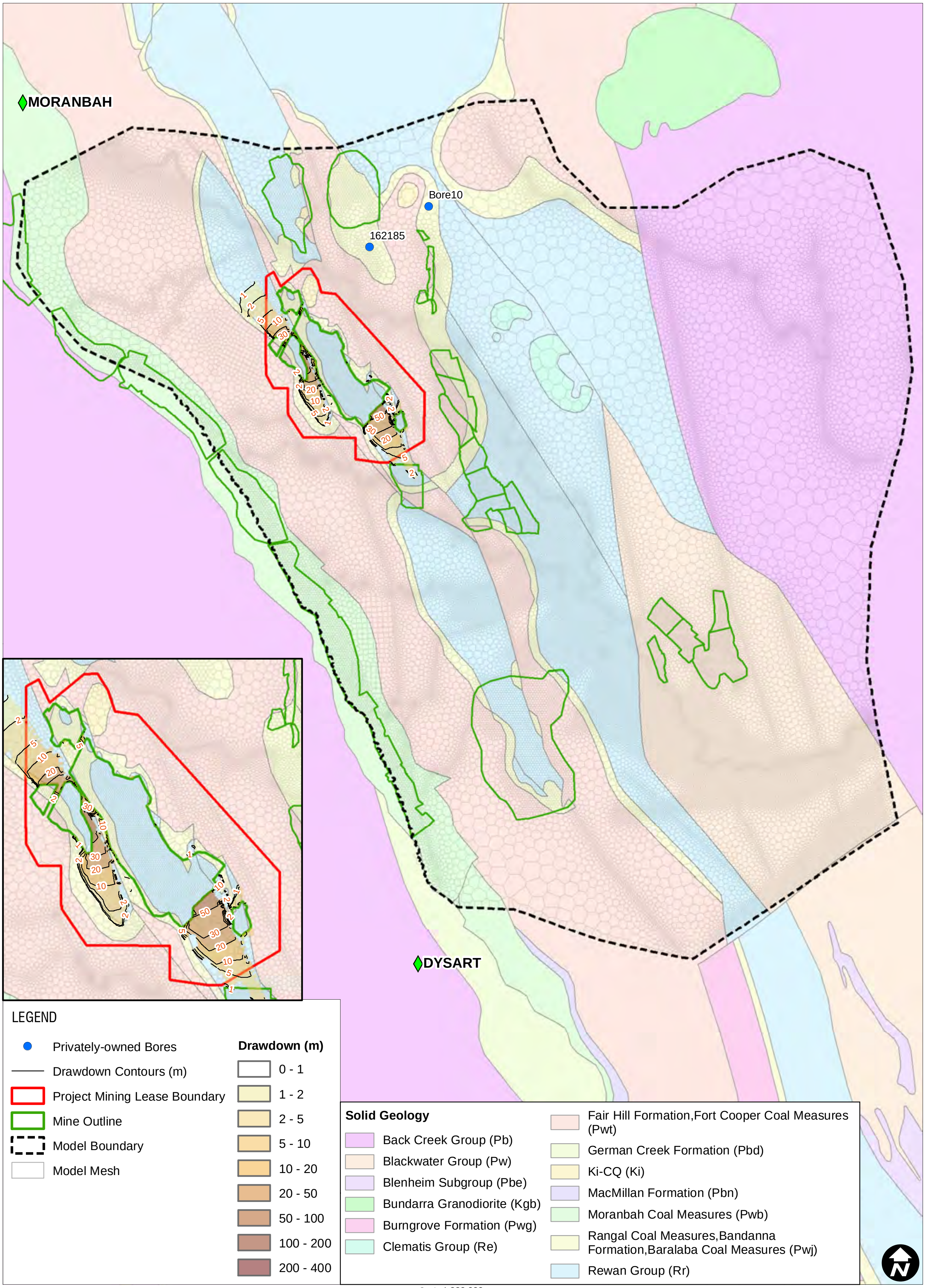


Sheet Size : A4

SLR
www.slrconsultingaustralia.com

Incremental Drawdown in Leichhardt Seam (Layer 5) 2043

FIGURE D-5



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-6 Incremental Drawdown in Leichhardt Seam (Layer 5) 2053.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

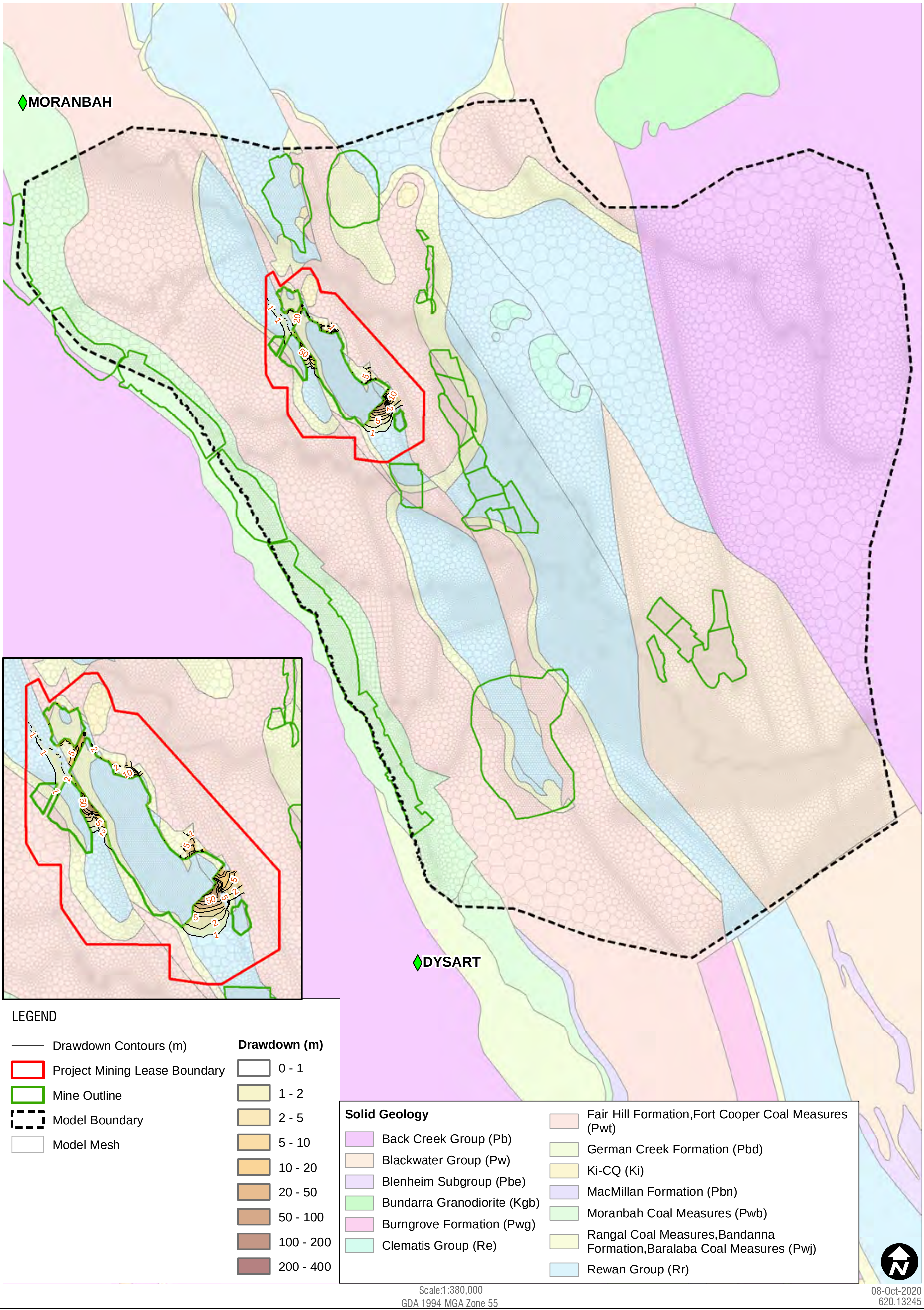
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10
Kilometers

Incremental Drawdown in Leichhardt Seam (Layer 5) 2053

FIGURE D-6



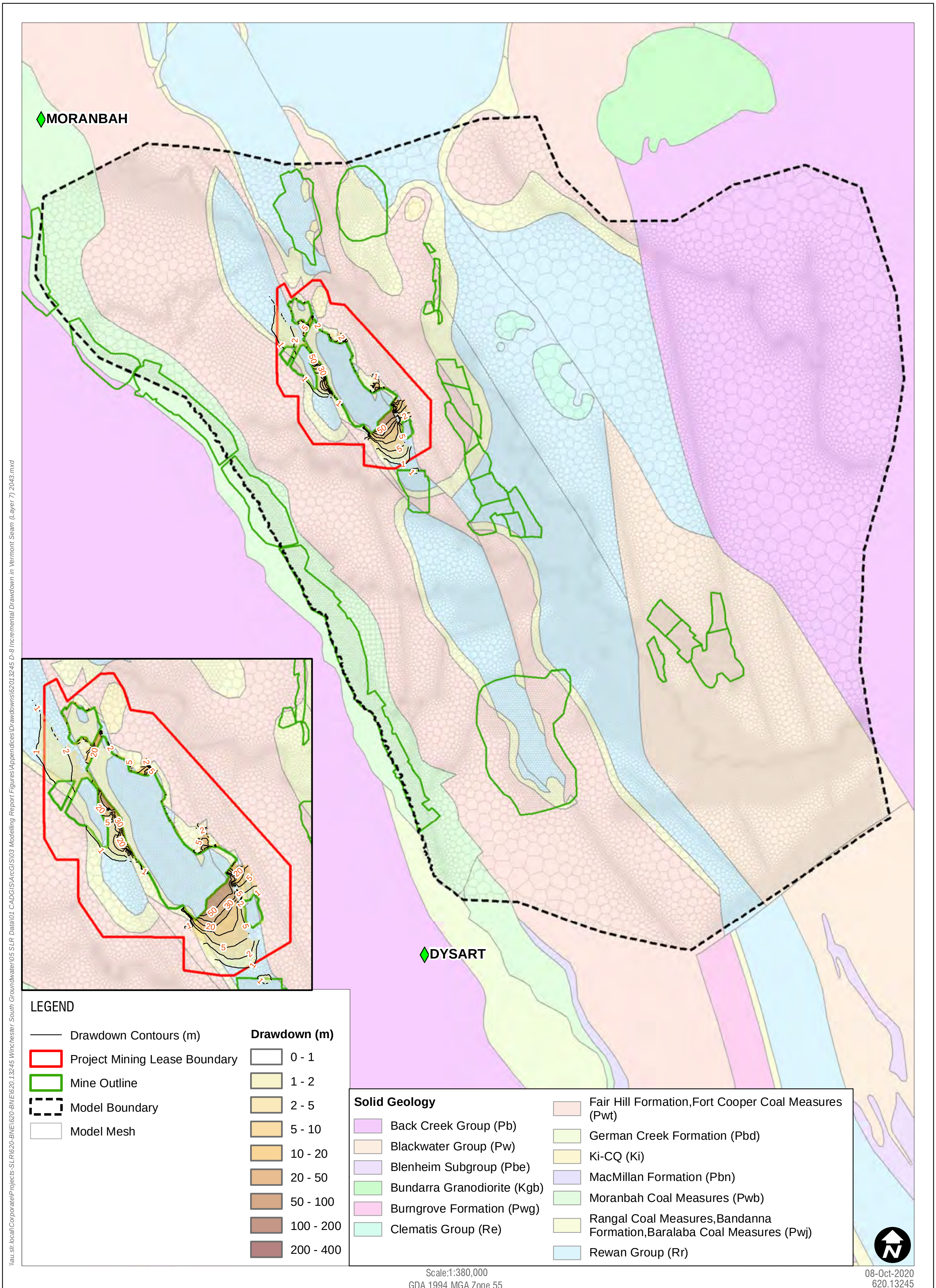
08-Oct-2020
620.13245

Sheet Size : A4

SLR
www.slrconsultingaustralia.com

Incremental Drawdown in Vermont Seam (Layer 7) 2033

FIGURE D-7

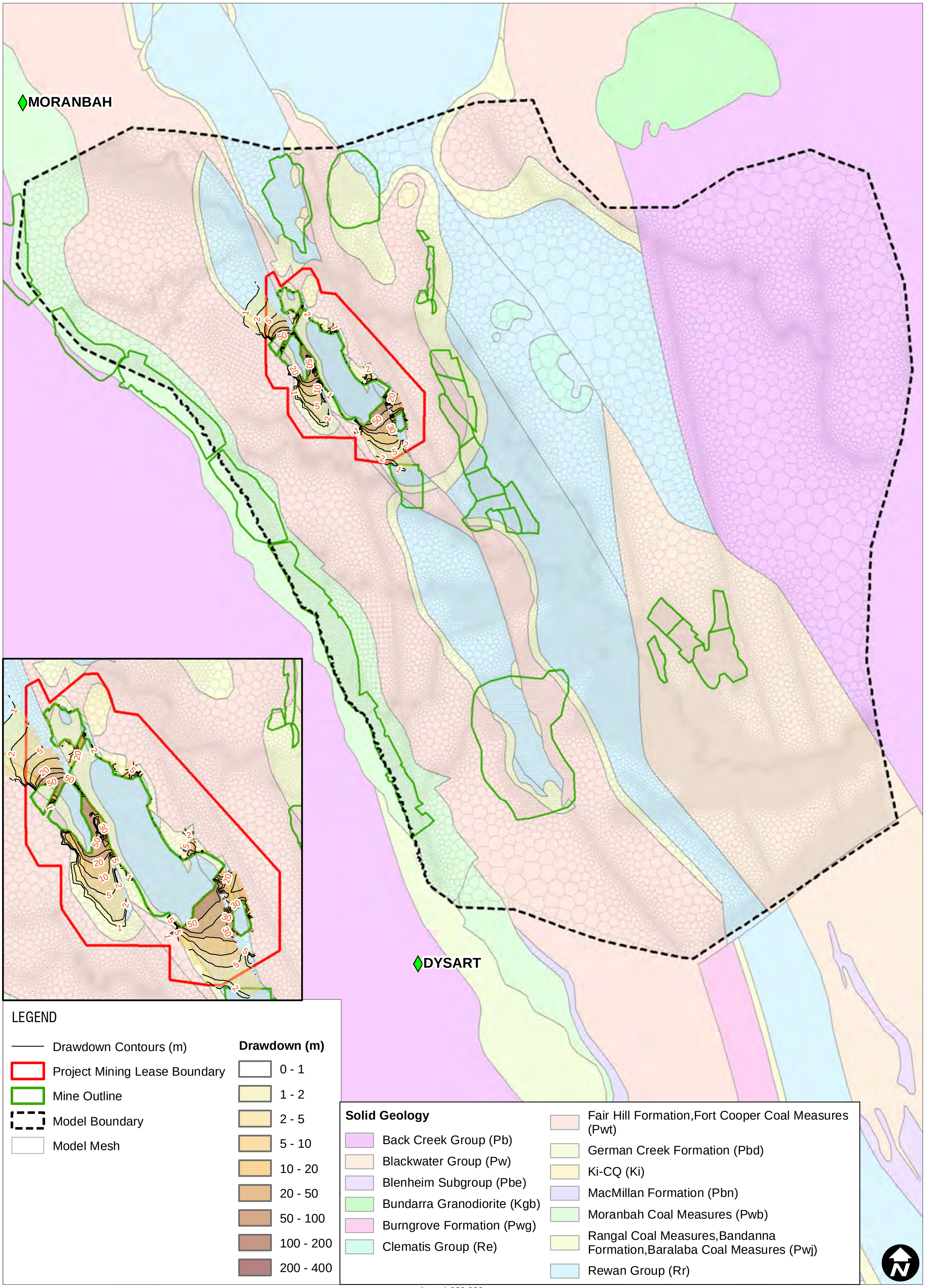


Sheet Size : A4

SLR
www.slrconsultingaustralia.com

Incremental Drawdown in Vermont Seam (Layer 7) 2043

FIGURE D-8



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-9 Incremental Drawdown in Vermont Seam (Layer 7) 2053.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

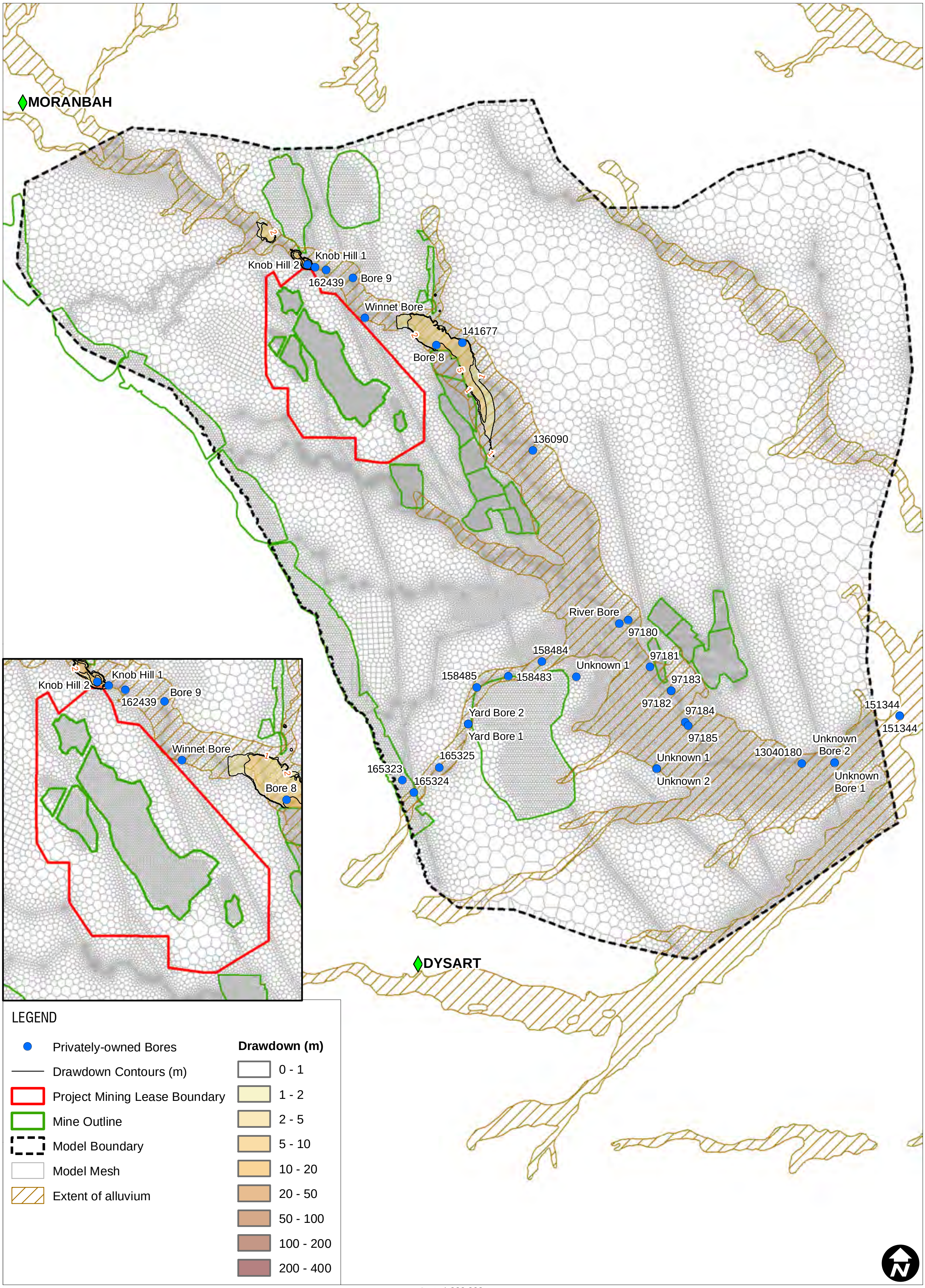
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Incremental Drawdown in Vermont Seam (Layer 7) 2053

FIGURE D-9



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-10 Cumulative Drawdown in Quaternary Alluvium (Layer 1) 2033.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

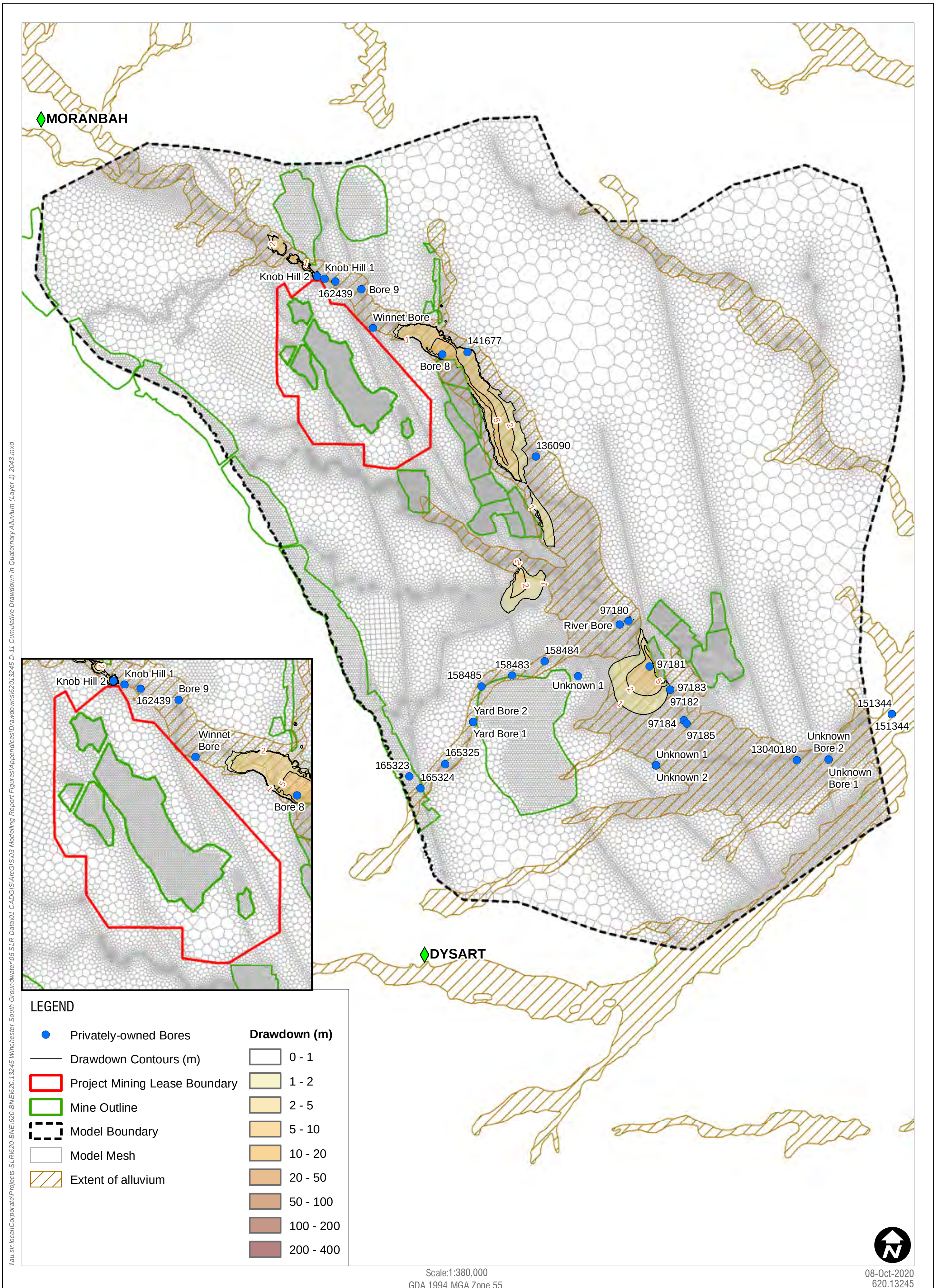
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Cumulative Drawdown in Quaternary Alluvium (Layer 1) 2033

FIGURE D-10



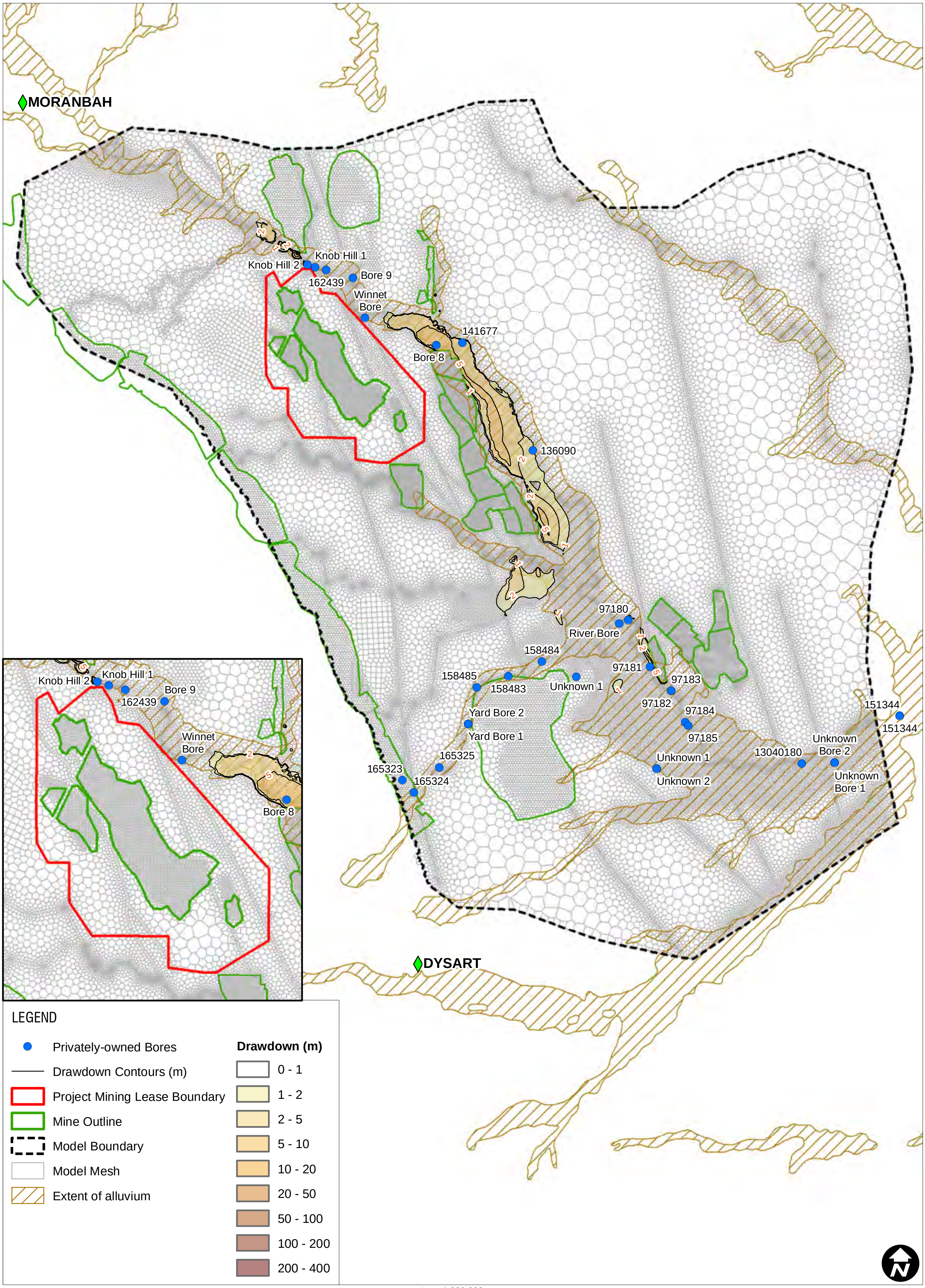
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Cumulative Drawdown in Quaternary Alluvium (Layer 1) 2043

FIGURE D-11



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-12 Cumulative Drawdown in Quaternary Alluvium (Layer 1) 2053.mxd

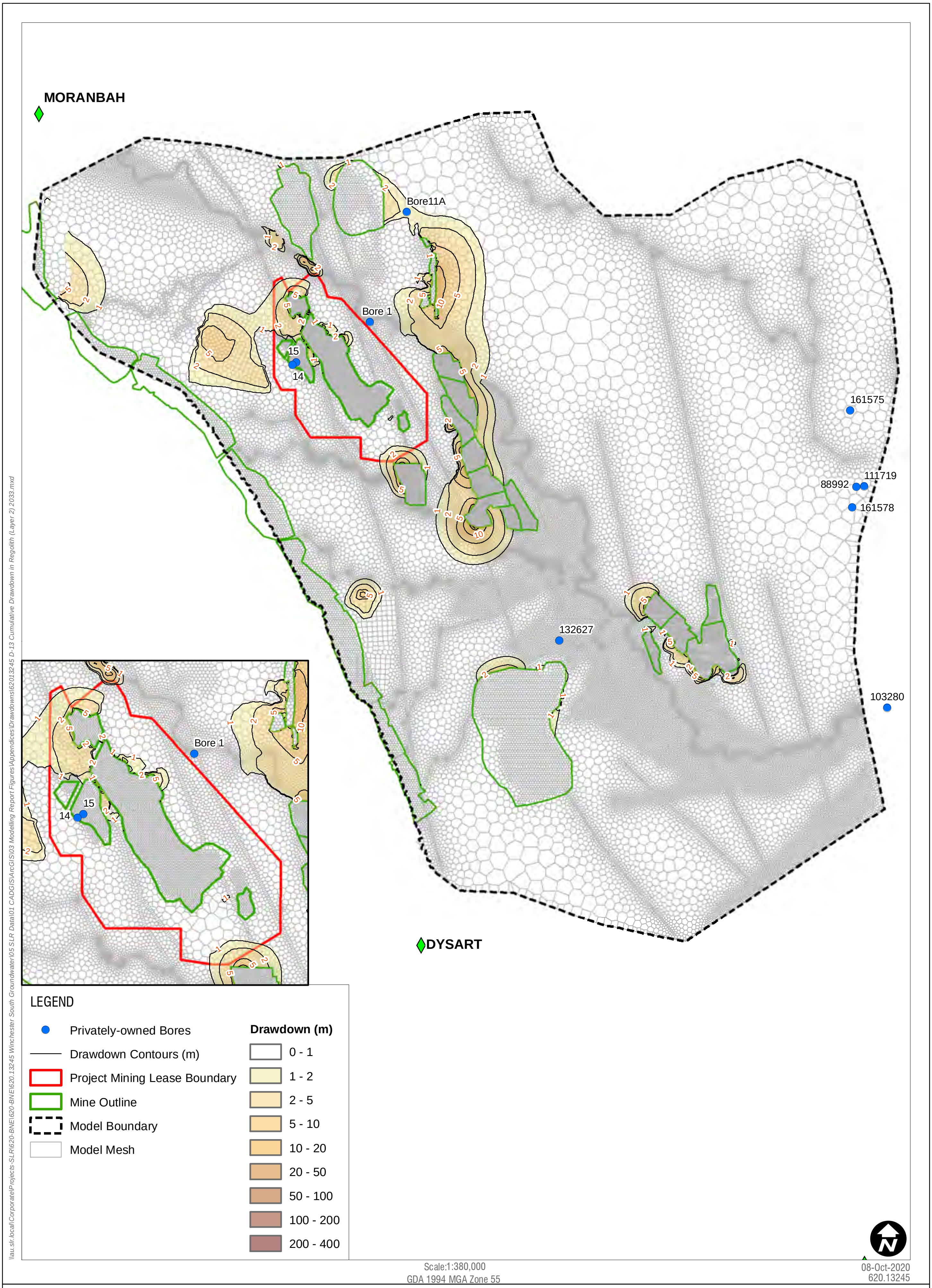
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

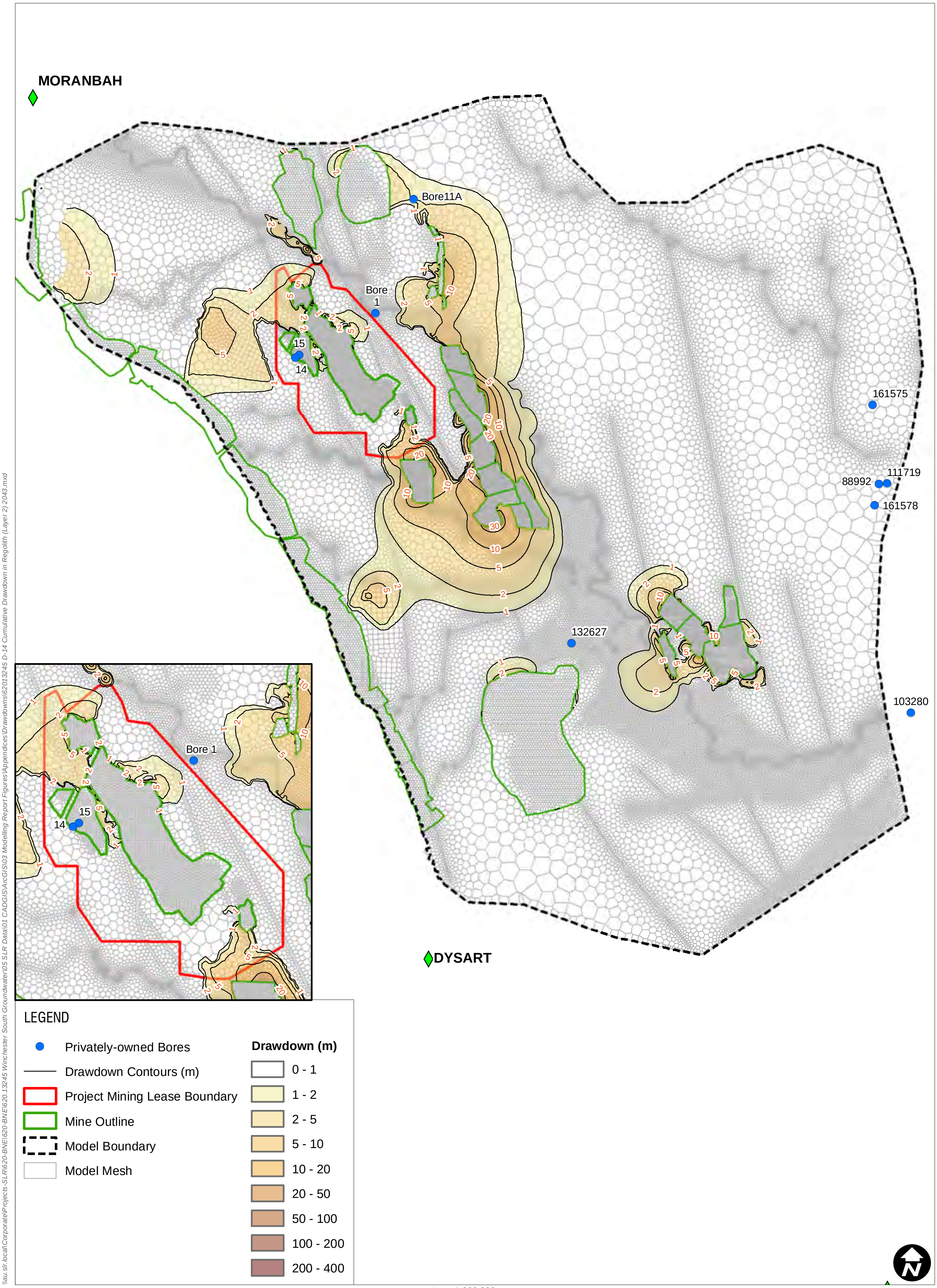
Cumulative Drawdown in Quaternary Alluvium (Layer 1) 2053

FIGURE D-12



Cumulative Drawdown in Regolith (Layer 2) 2033

FIGURE D-13



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

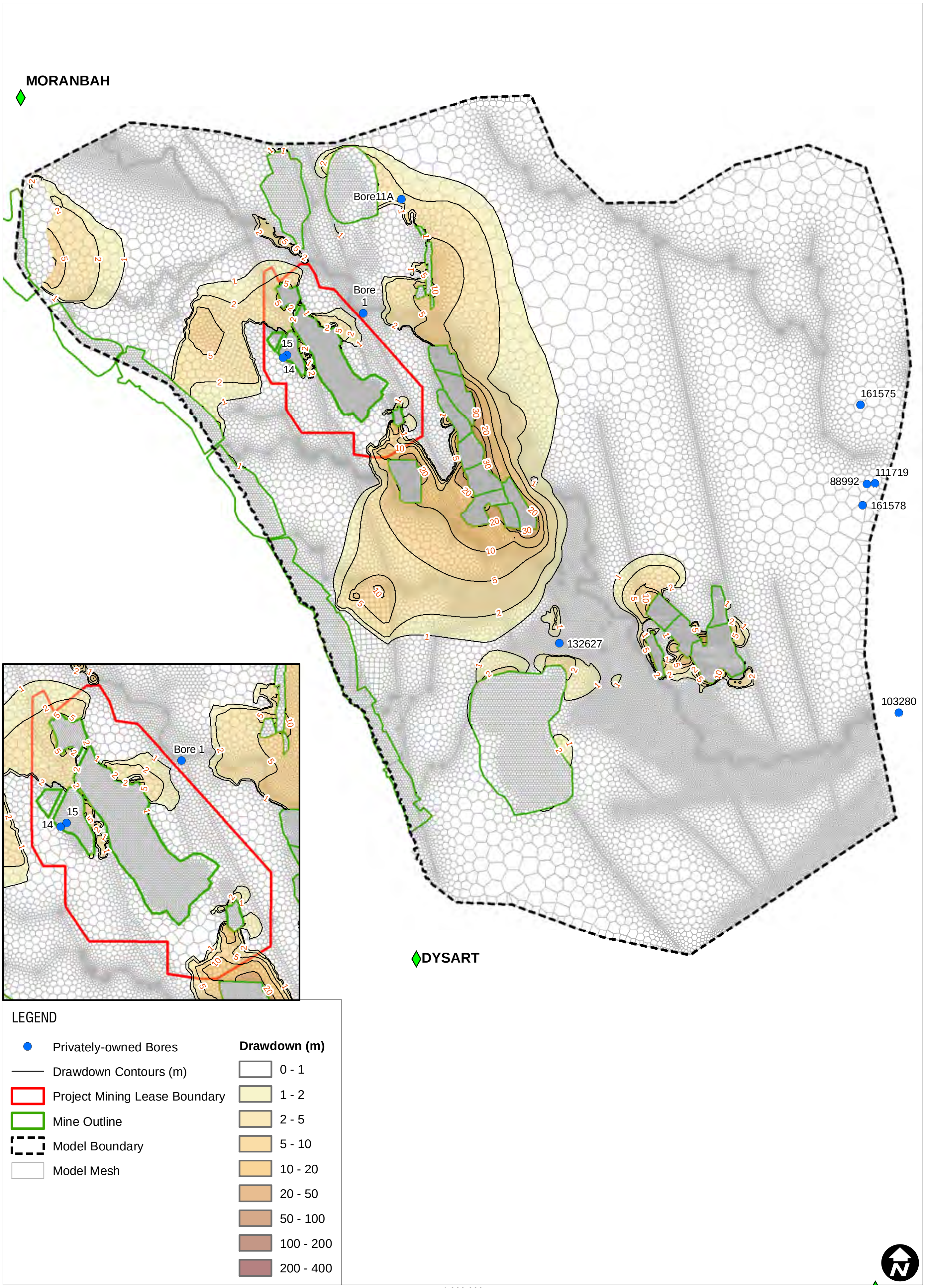
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10
Kilometers

Cumulative Drawdown in Regolith (Layer 2) 2043

FIGURE D-14



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-15 Cumulative Drawdown in Regolith (Layer 2) 2053.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

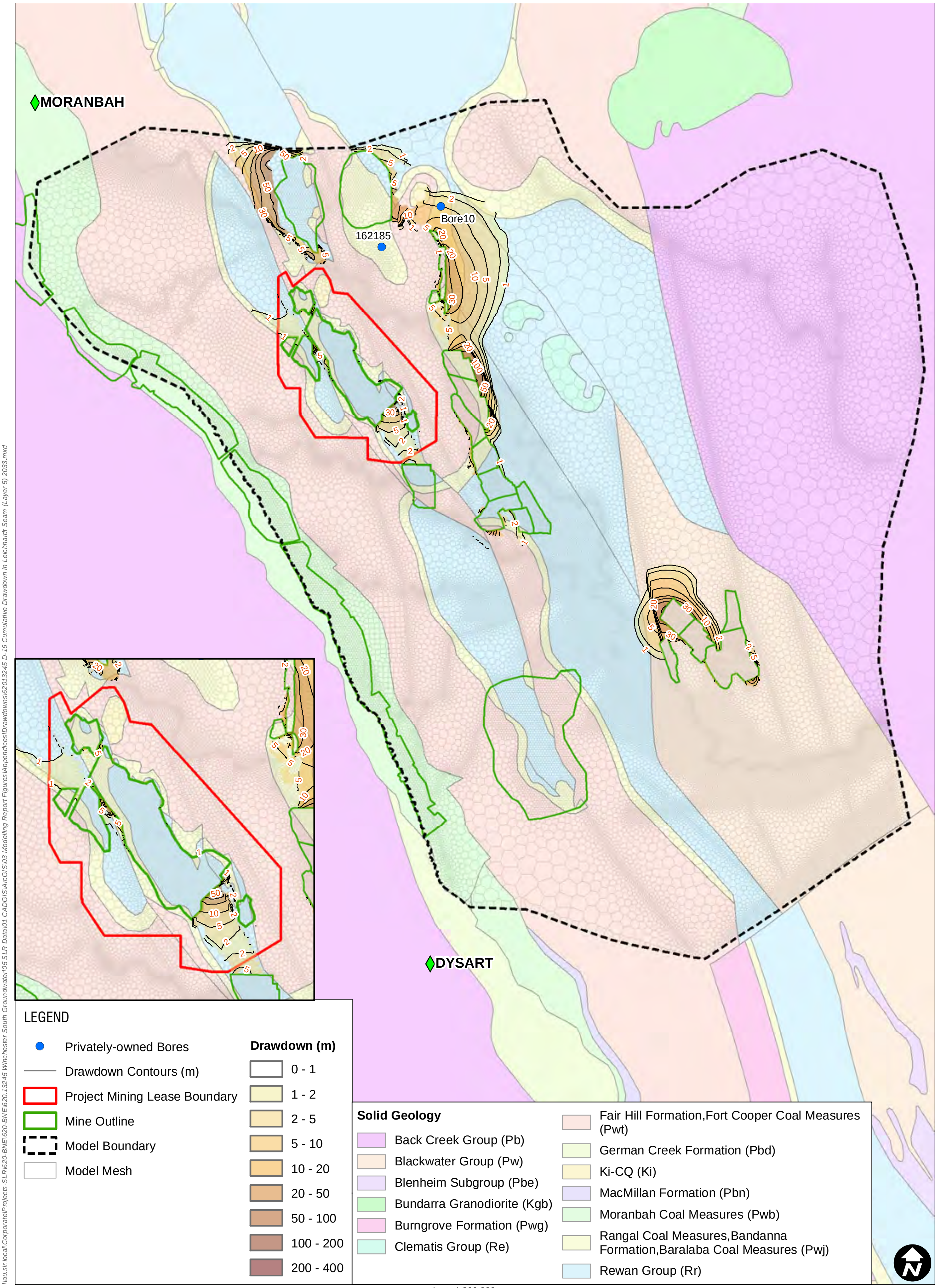
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Cumulative Drawdown in Regolith (Layer 2) 2053

FIGURE D-15



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

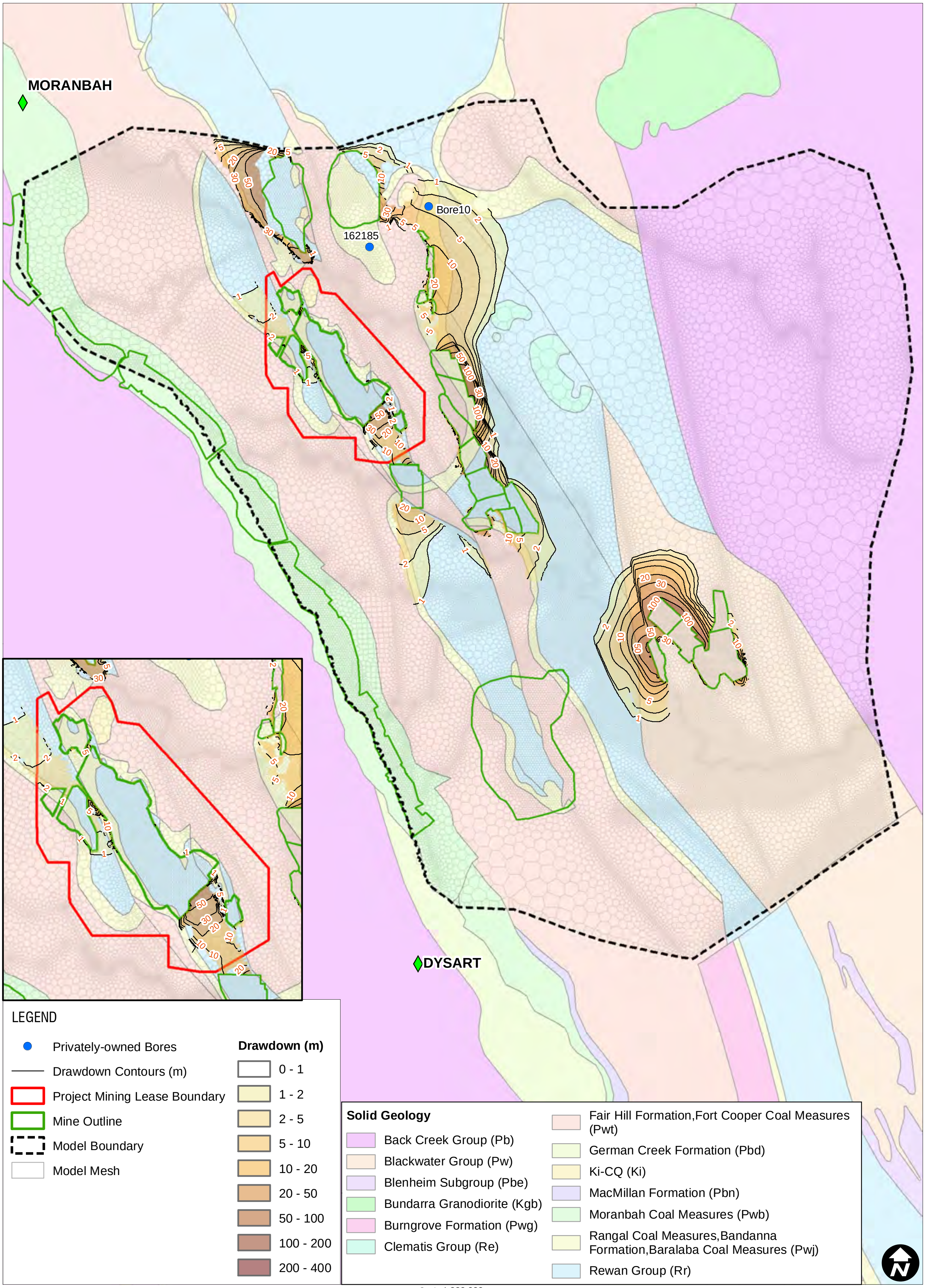
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Cumulative Drawdown in Leichhardt Seam (Layer 5) 2033

FIGURE D-16



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

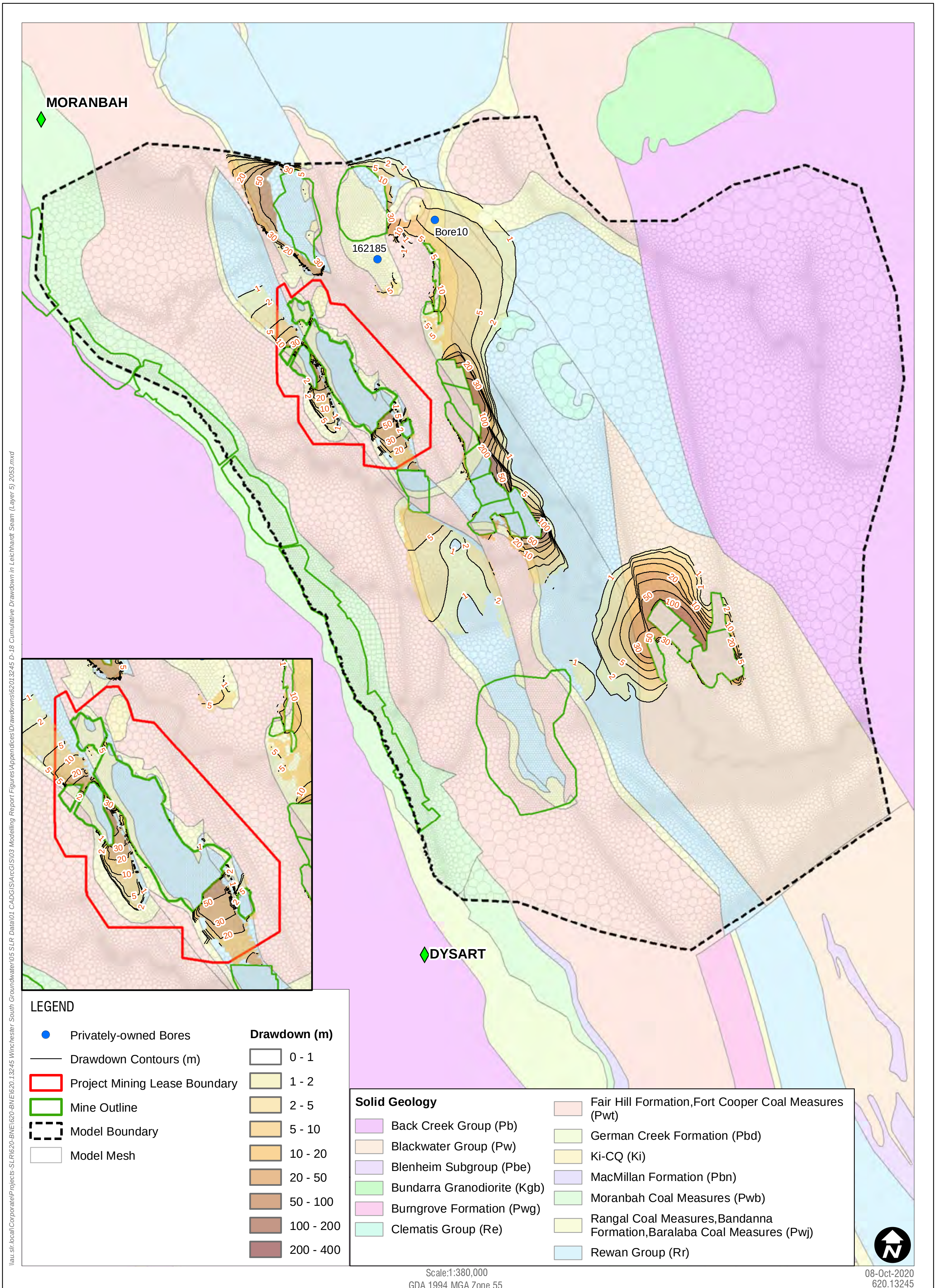
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10
Kilometers

Cumulative Drawdown in Leichhardt Seam (Layer 5) 2043

FIGURE D-17



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

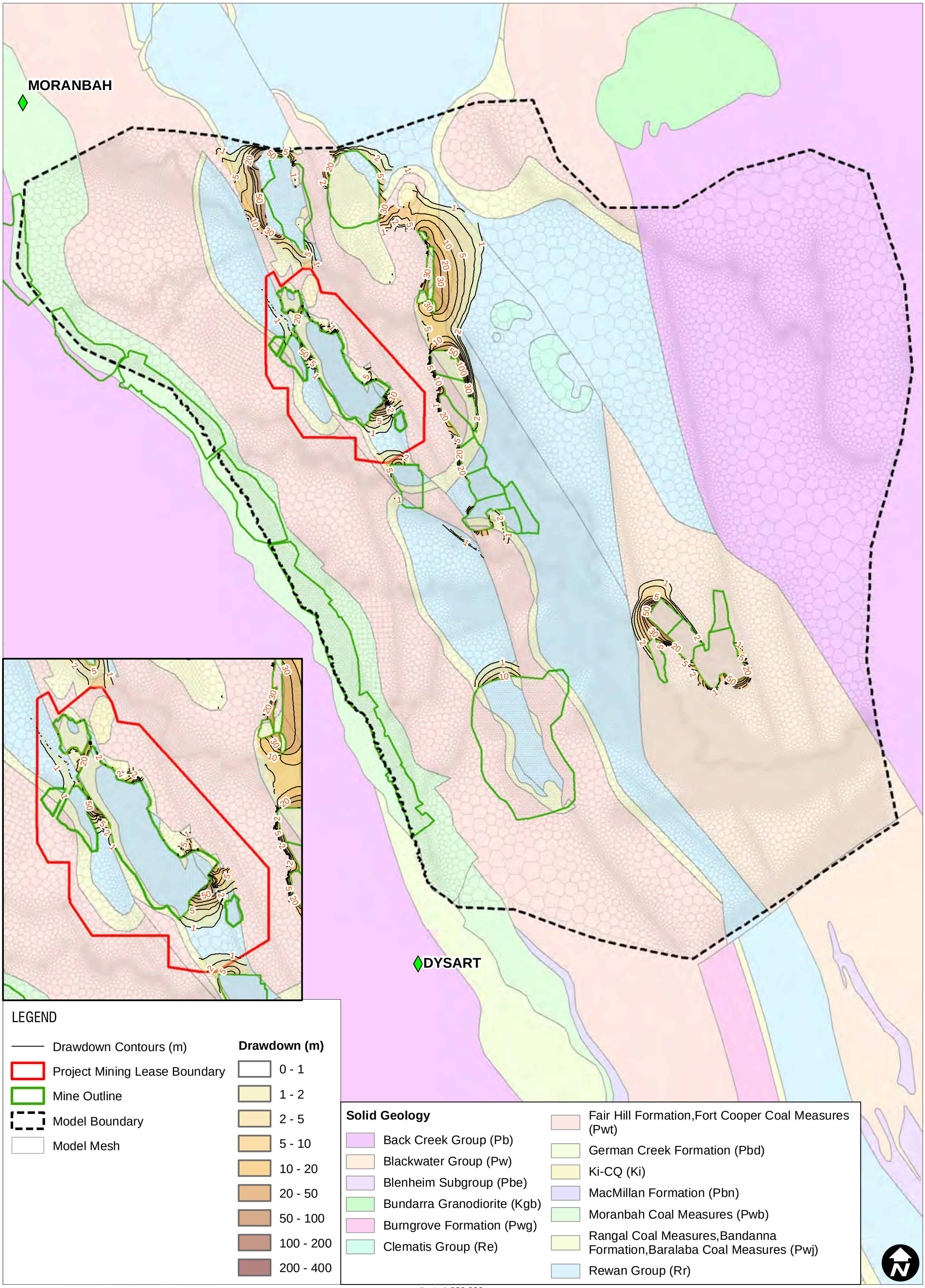
Sheet Size : A4

0 5 10
Kilometers

www.slrconsultingaustralia.com

Cumulative Drawdown in Leichhardt Seam (Layer 5) 2053

FIGURE D-18



Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-19 Cumulative Drawdown in Vermont Seam (Layer 7) 2033.mxd

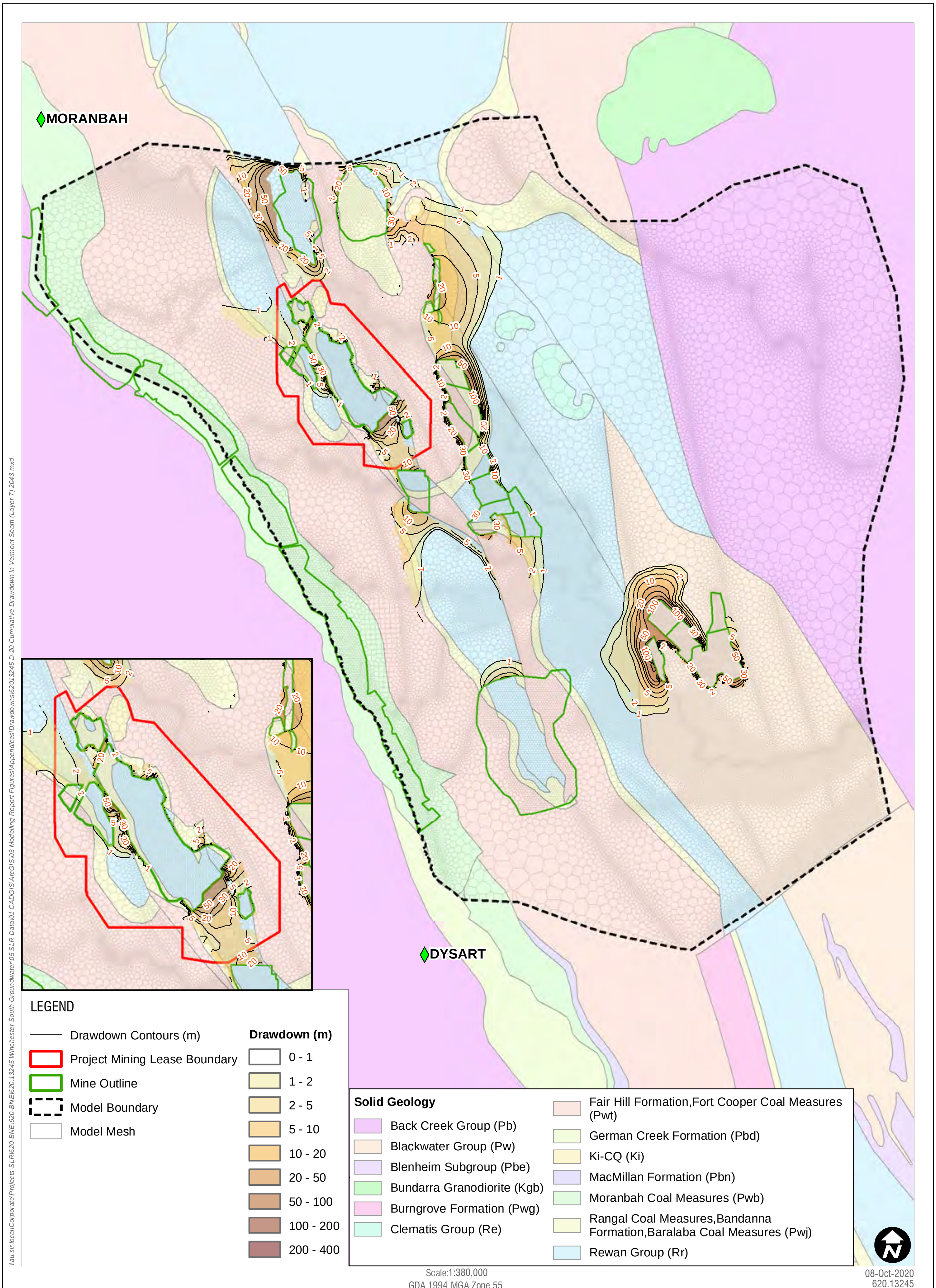
Sheet Size : A4

SLR
www.slrconsultingaustralia.com

0 5 10 Kilometers

Cumulative Drawdown in Vermont Seam (Layer 7) 2033

FIGURE D-19

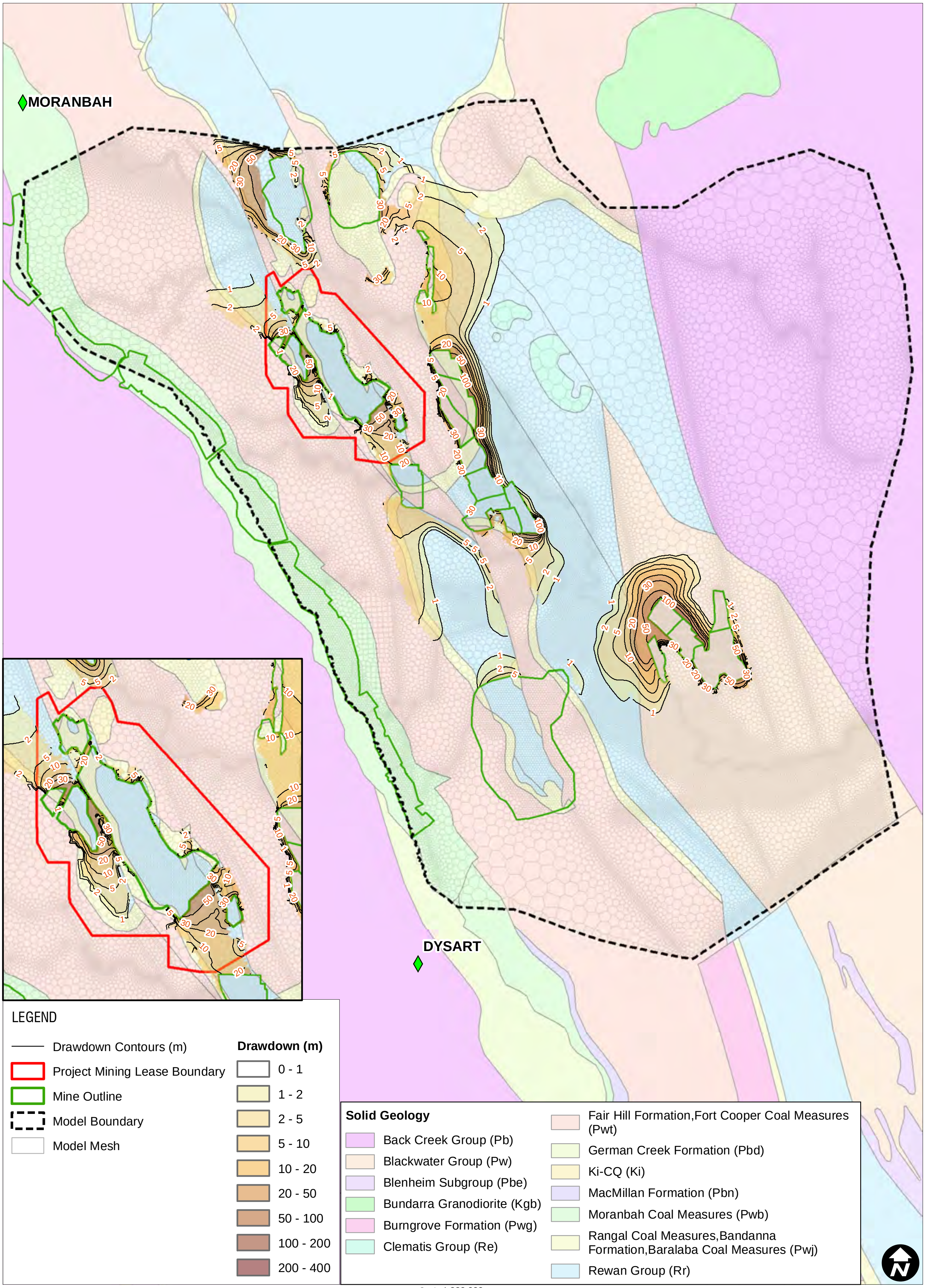


Sheet Size : A4

SLR
www.slrconsultingaustralia.com

Cumulative Drawdown in Vermont Seam (Layer 7) 2043

FIGURE D-20



\\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.13245 Winchester South Groundwater\05 SLR Data\01 CADGIS\ArcGIS\03 Modelling Report Figures\Appendices\Drawdowns\62013245 D-21 Cumulative Drawdown in Vermont Seam (Layer 7) 2053.mxd

Scale:1:380,000
GDA 1994 MGA Zone 55

08-Oct-2020
620.13245

Sheet Size : A4

0 5 10 Kilometers

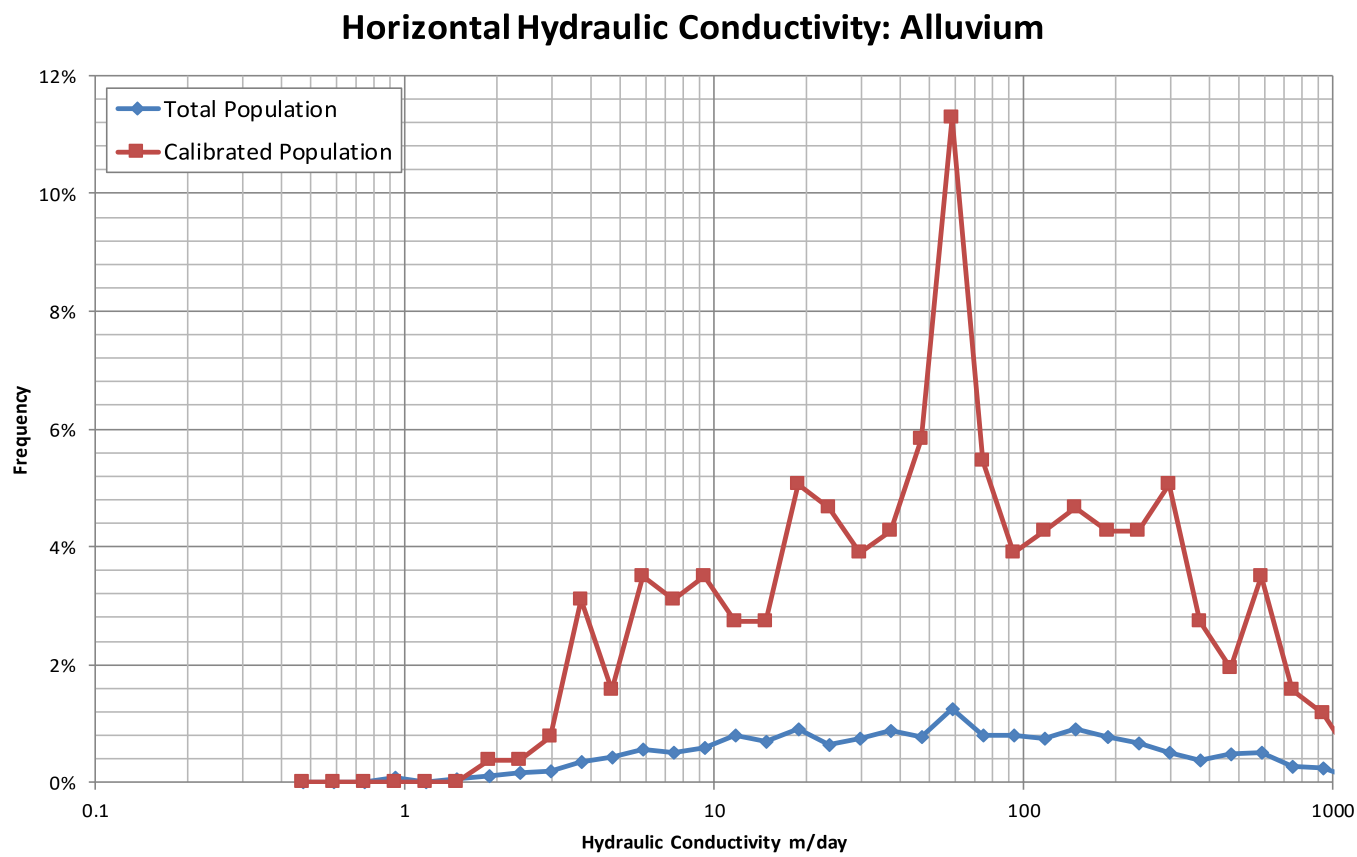
SLR
www.slrconsultingaustralia.com

Cumulative Drawdown in Vermont Seam (Layer 7) 2053

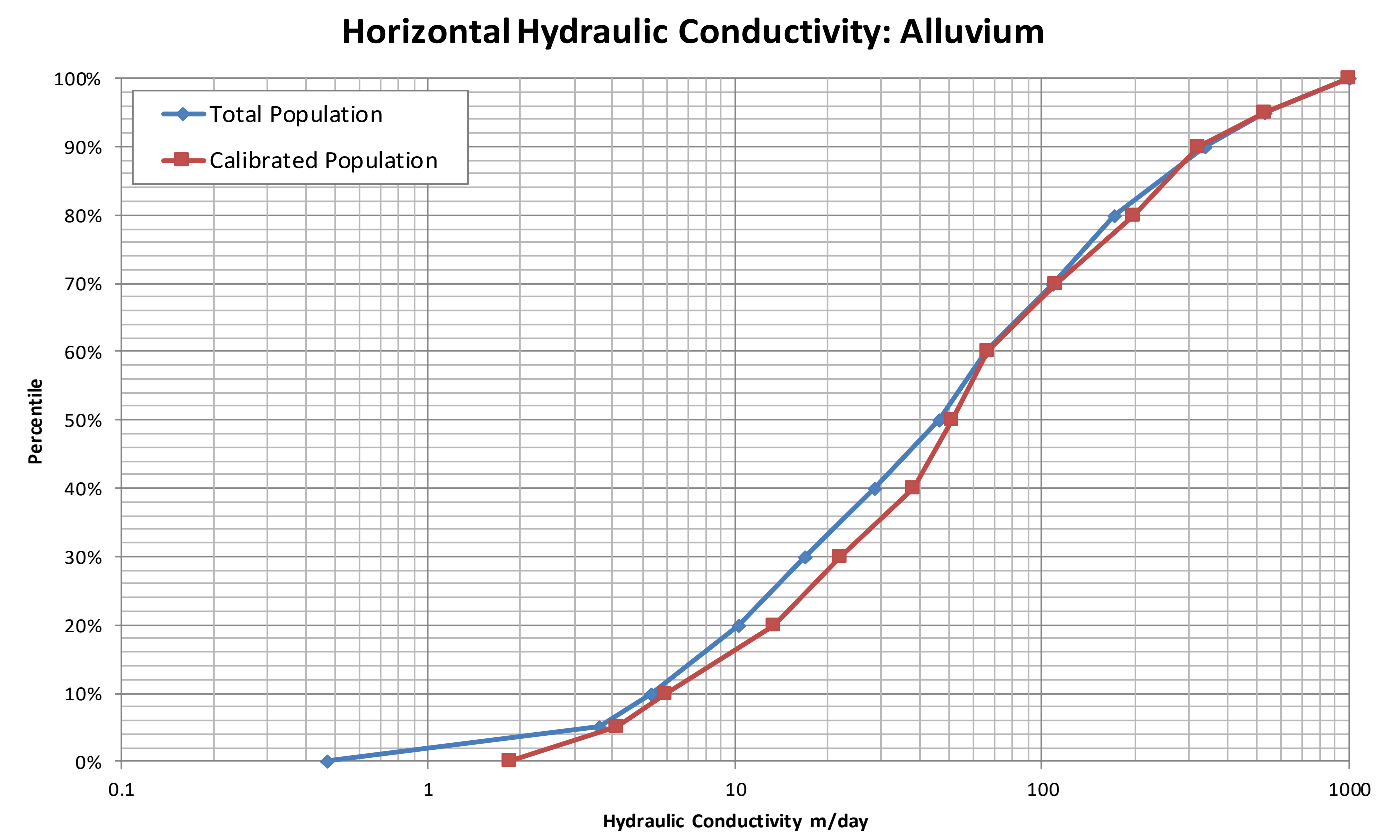
FIGURE D-21

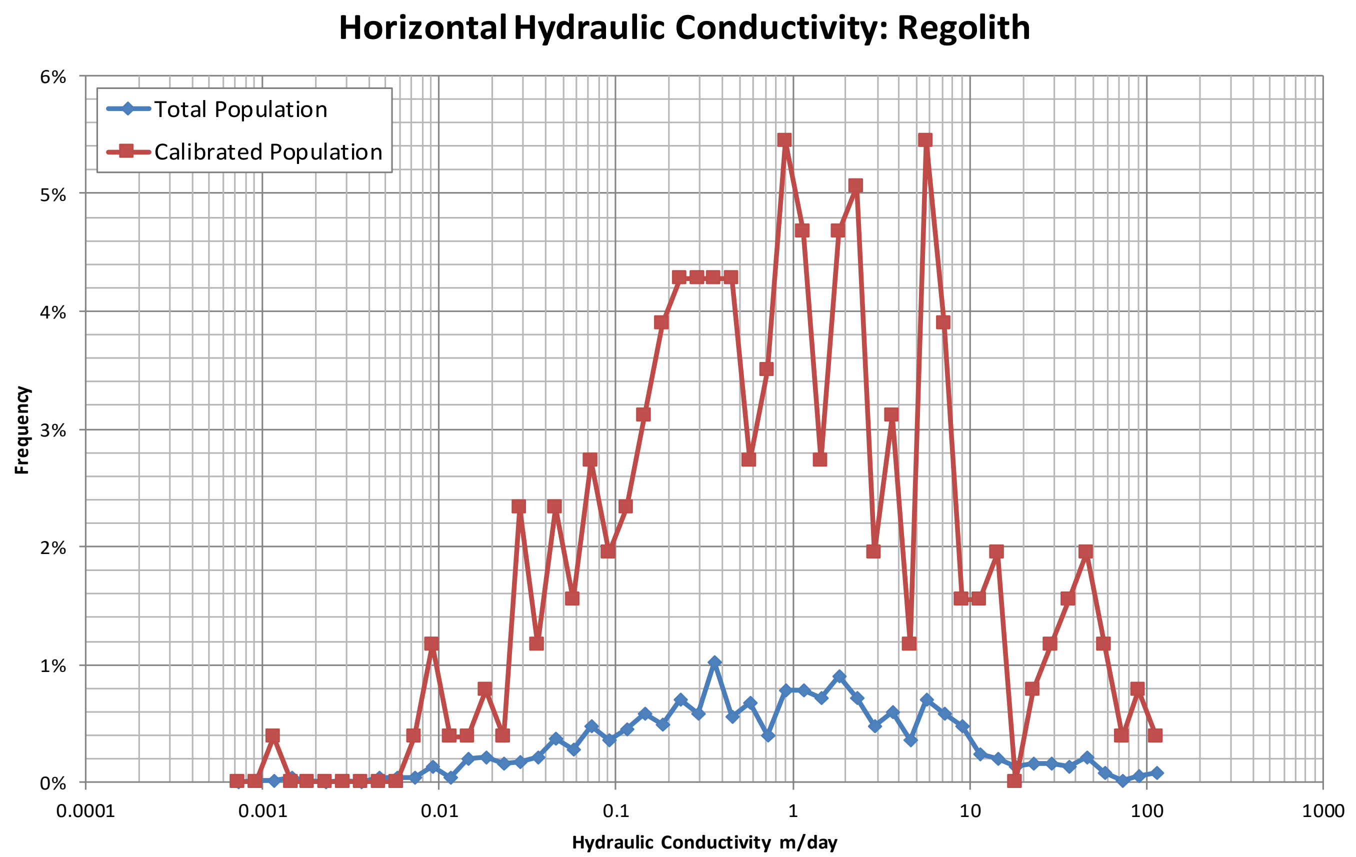
APPENDIX E

Parameter Distributions

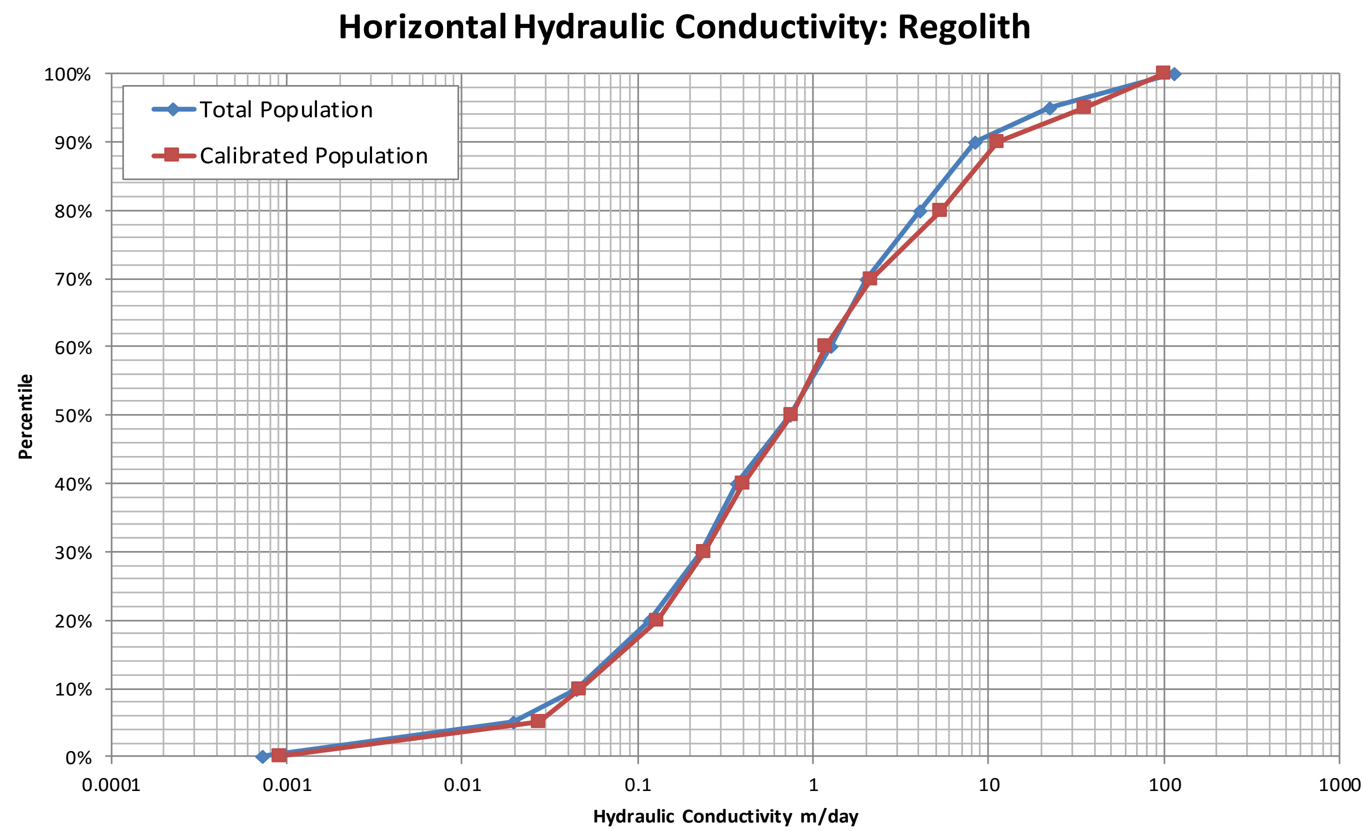


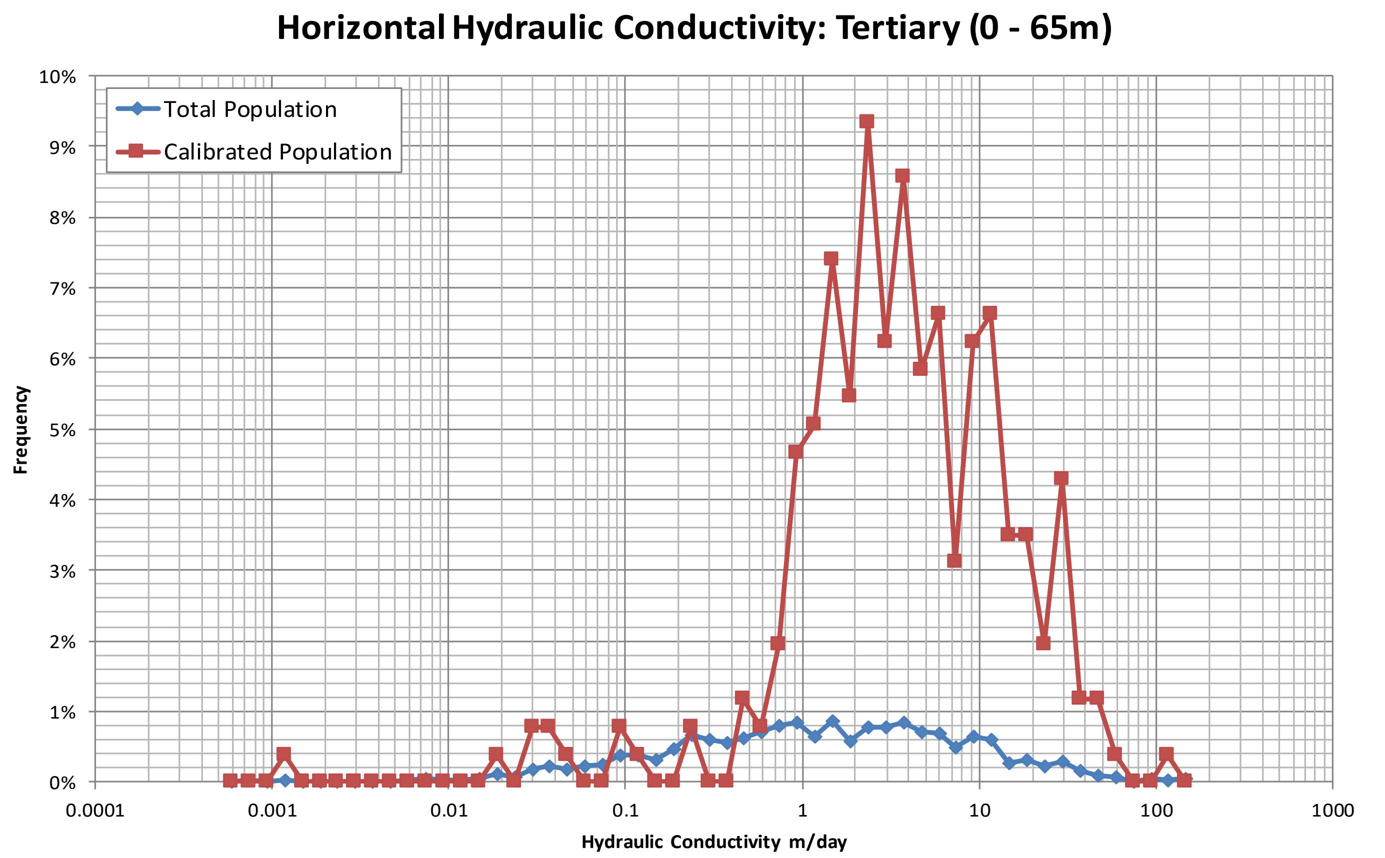
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



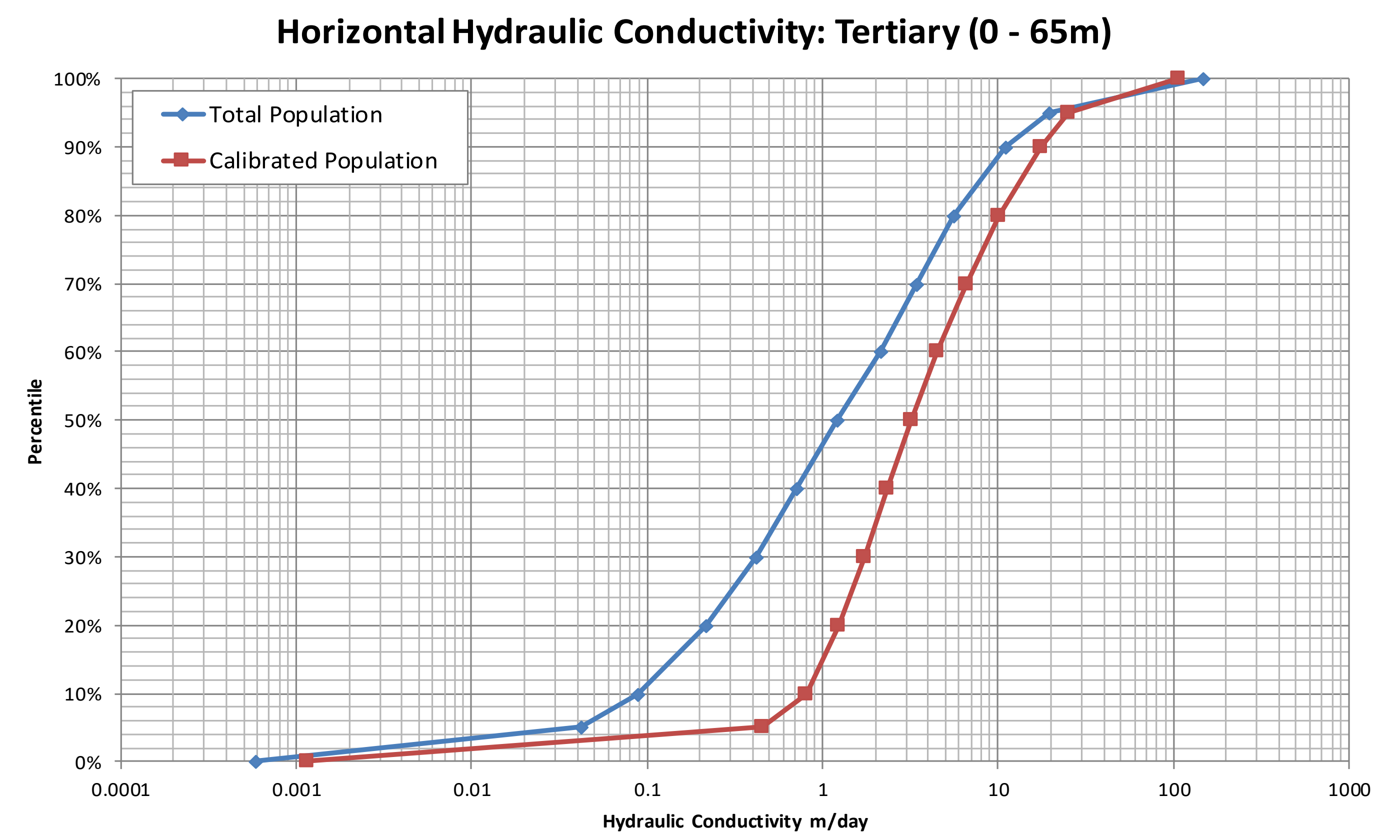


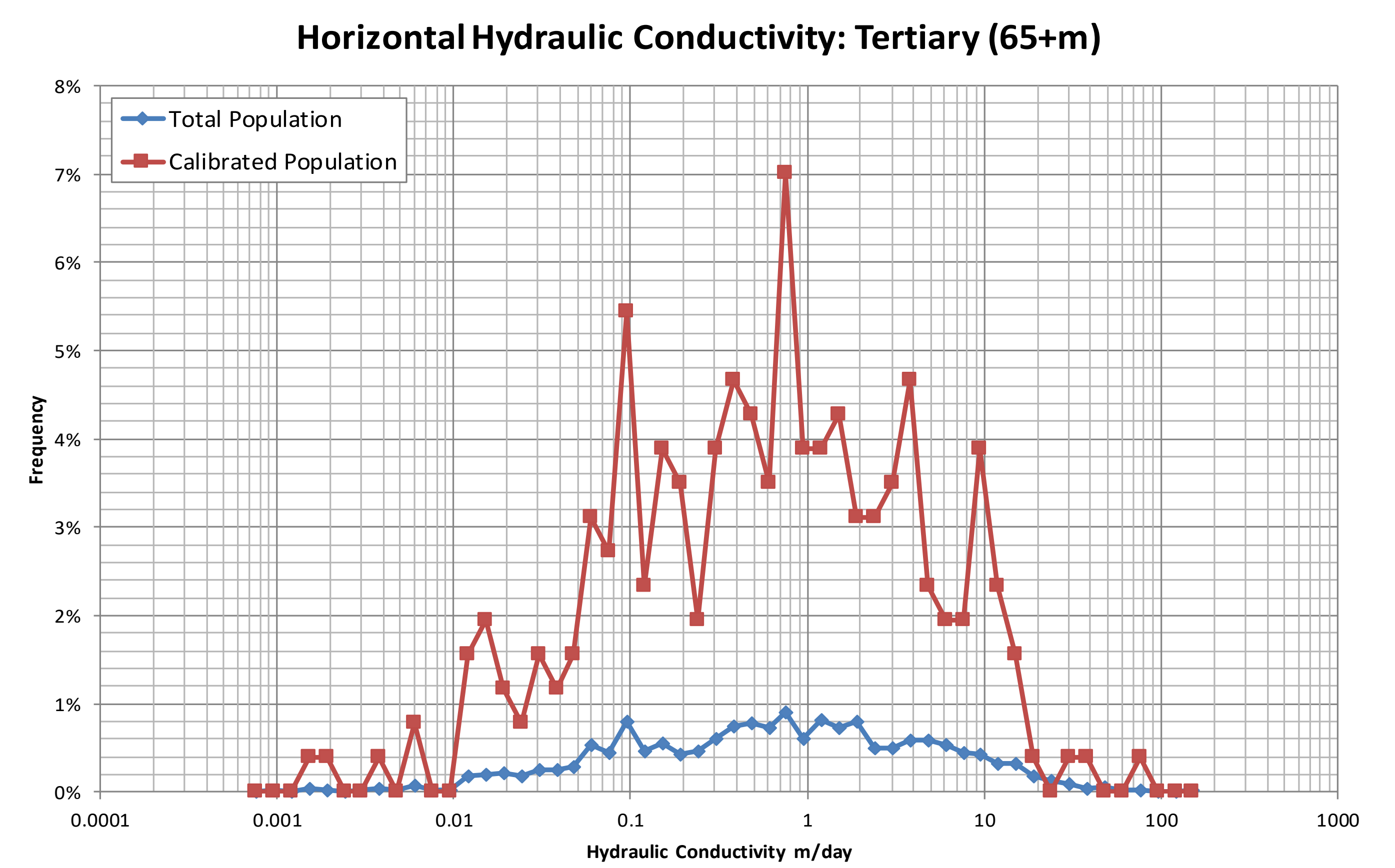
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



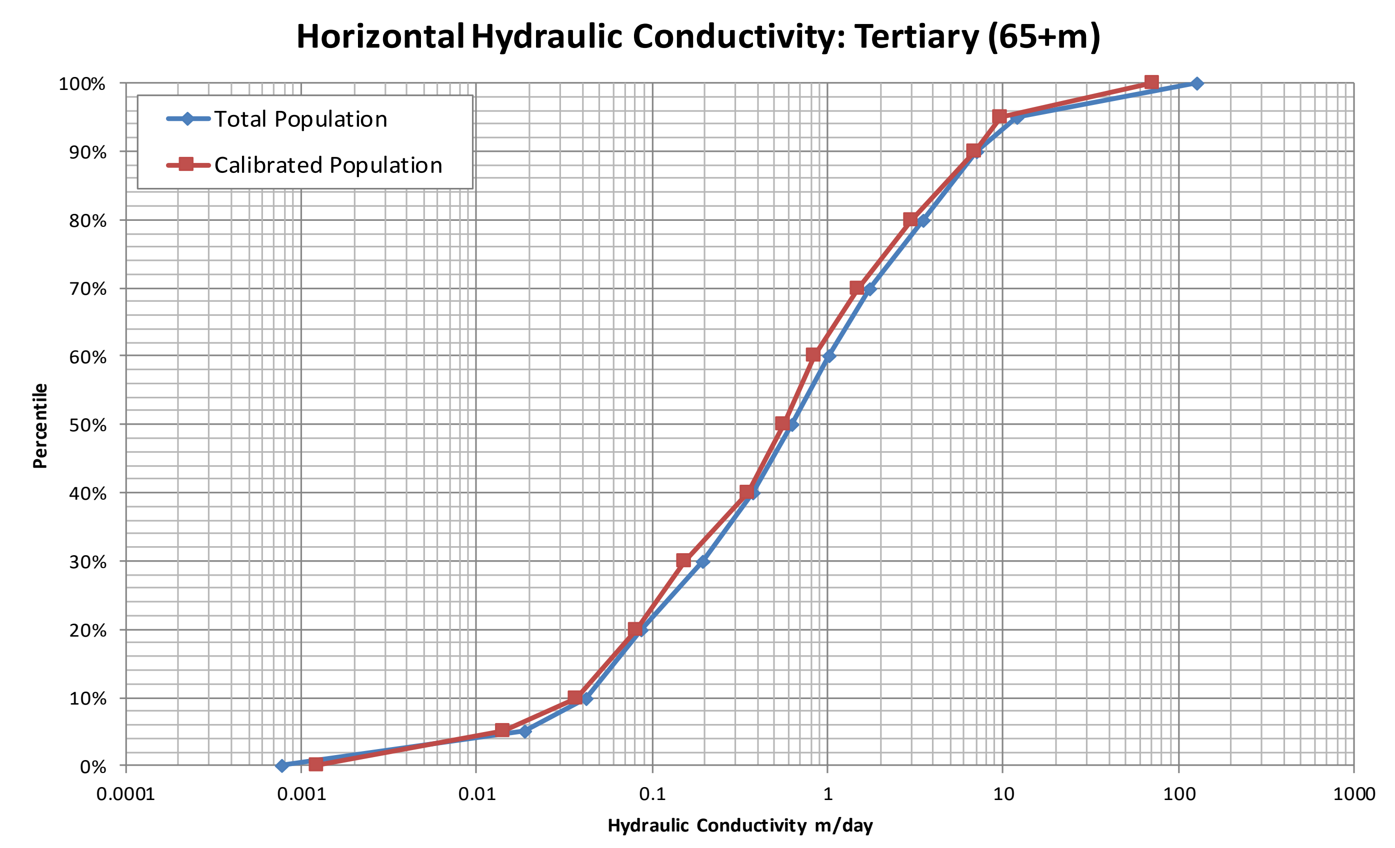


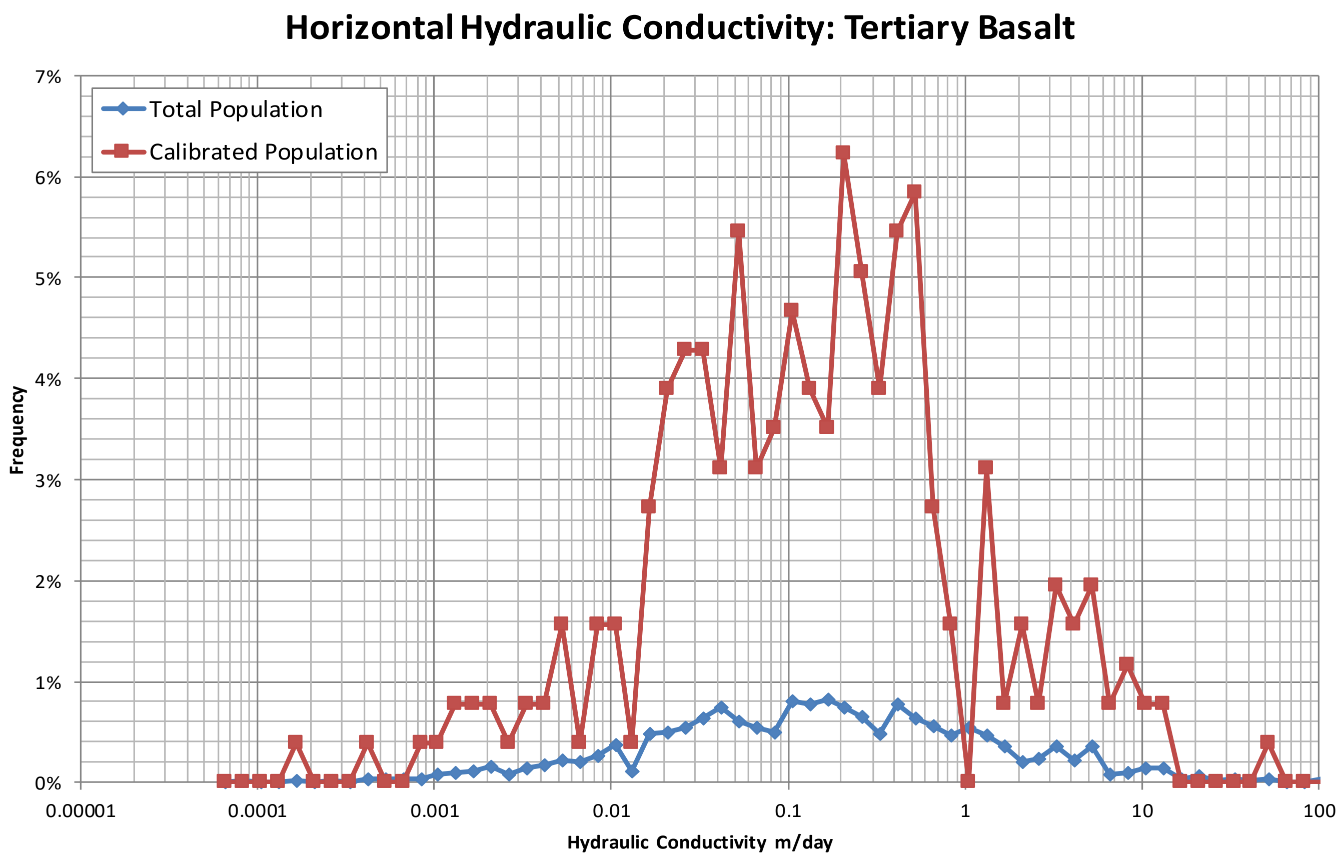
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



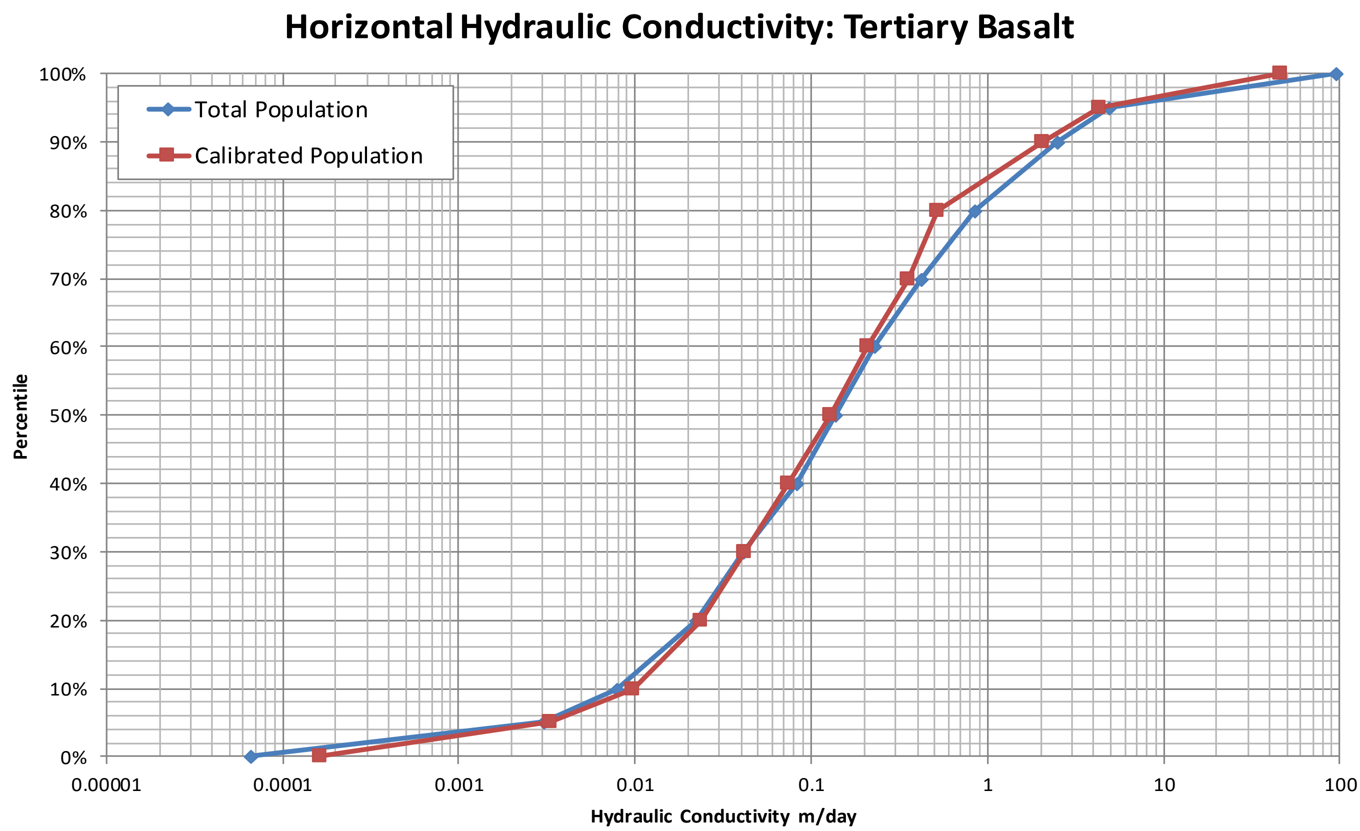


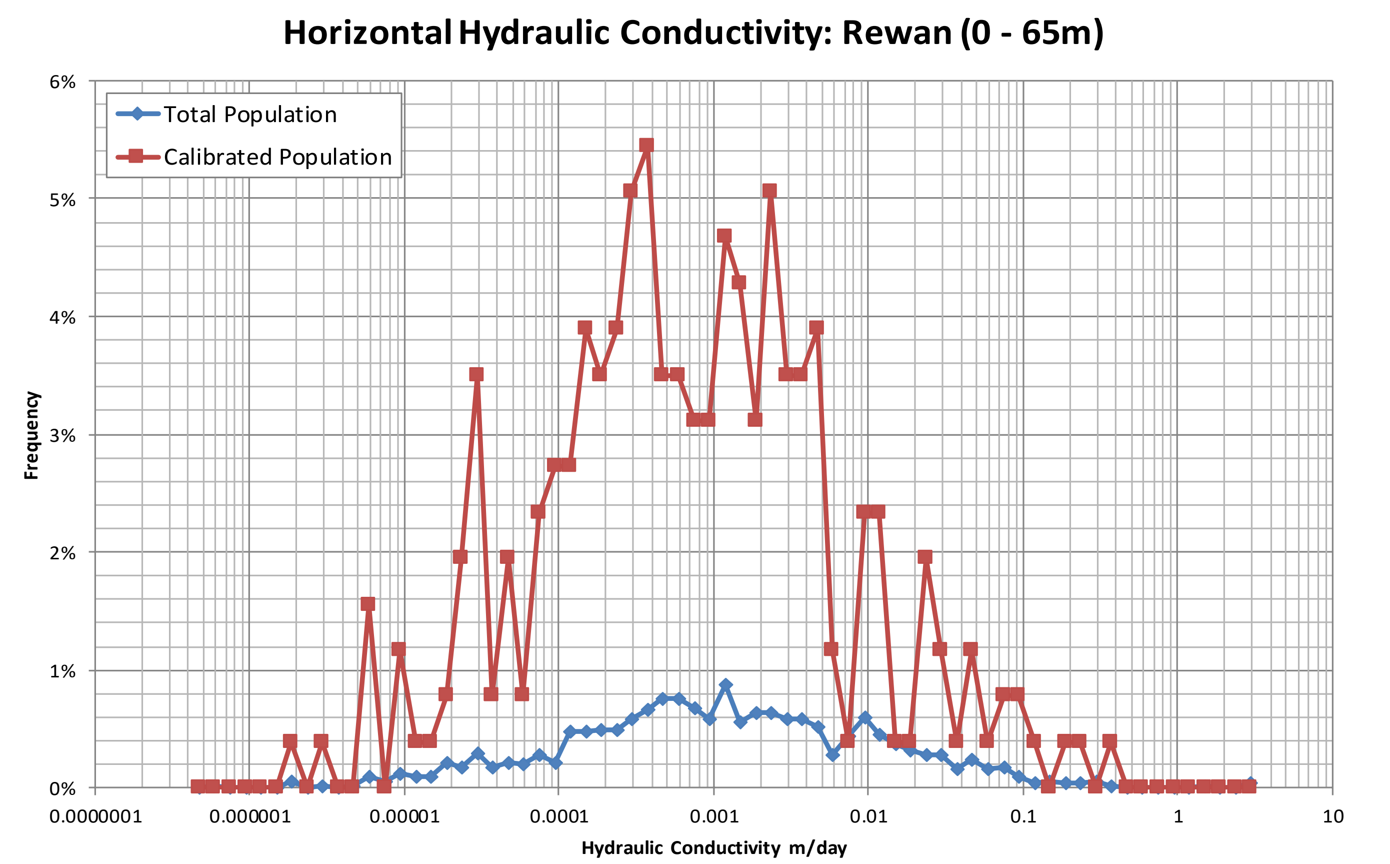
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



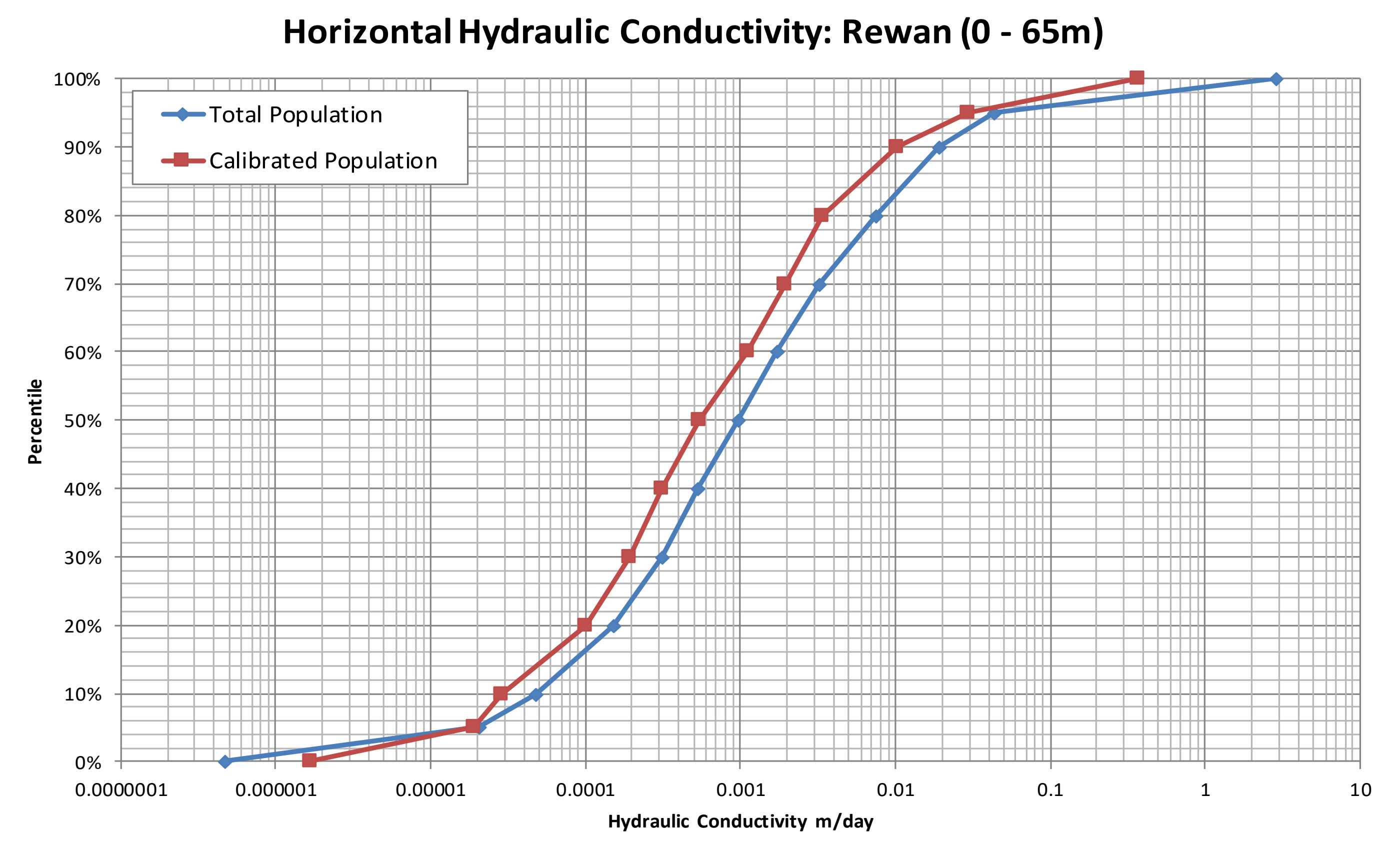


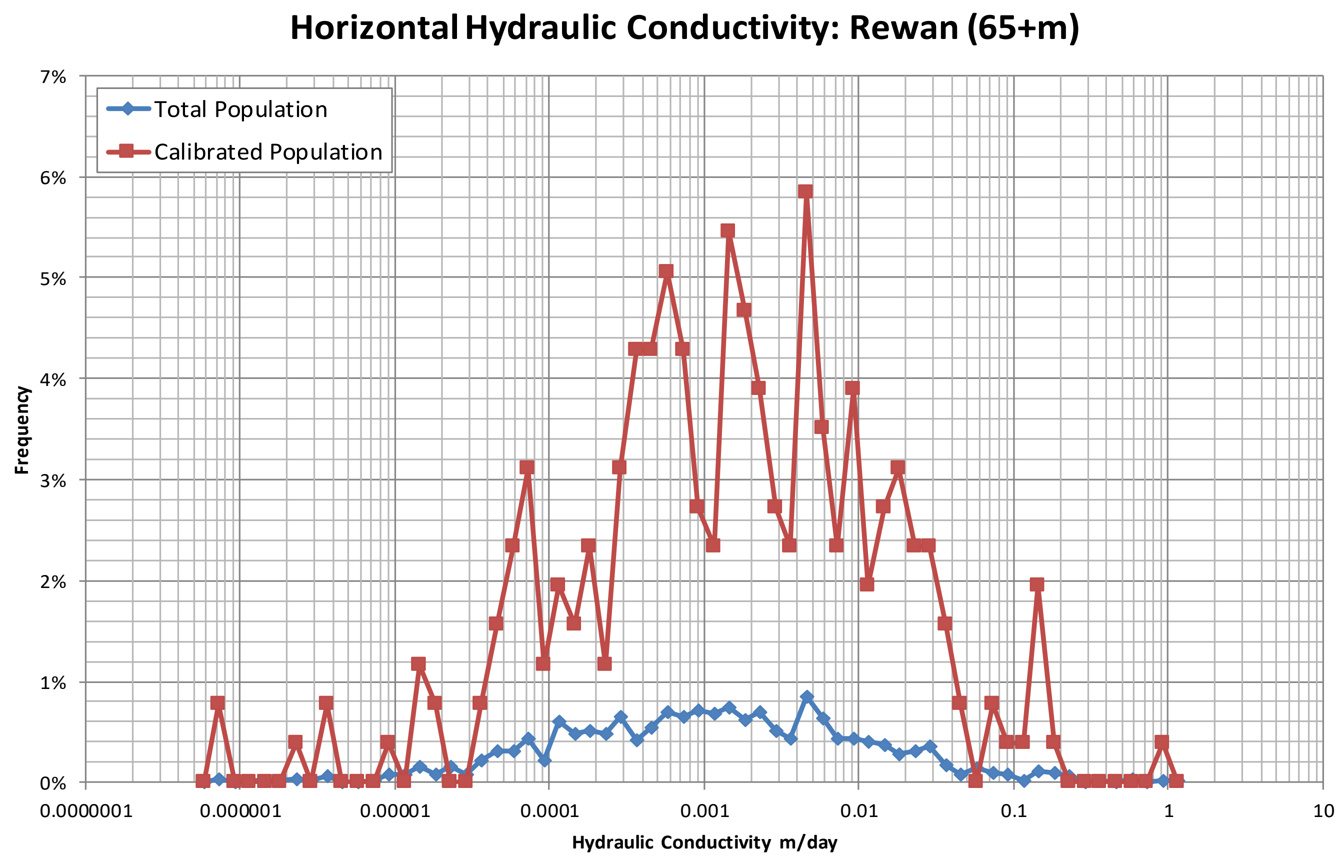
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



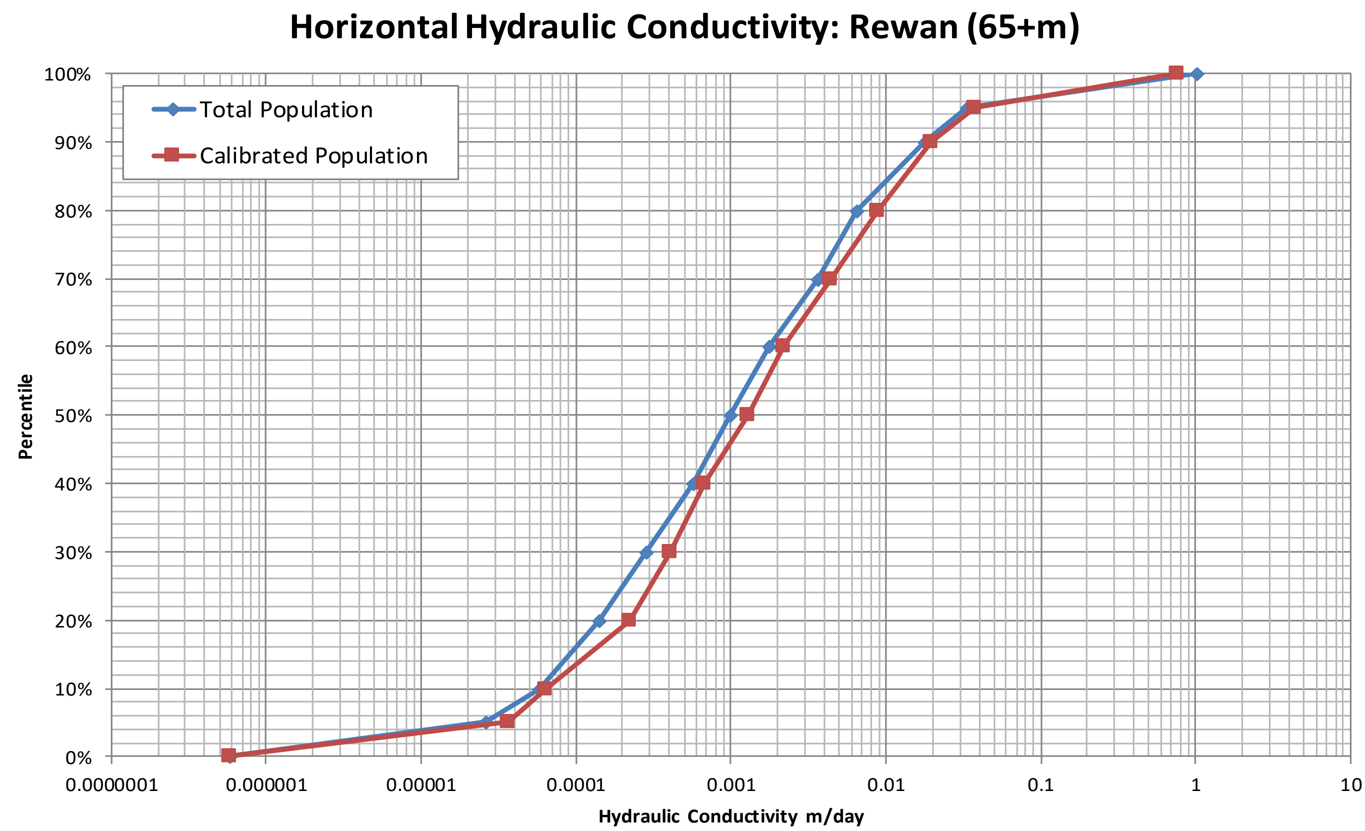


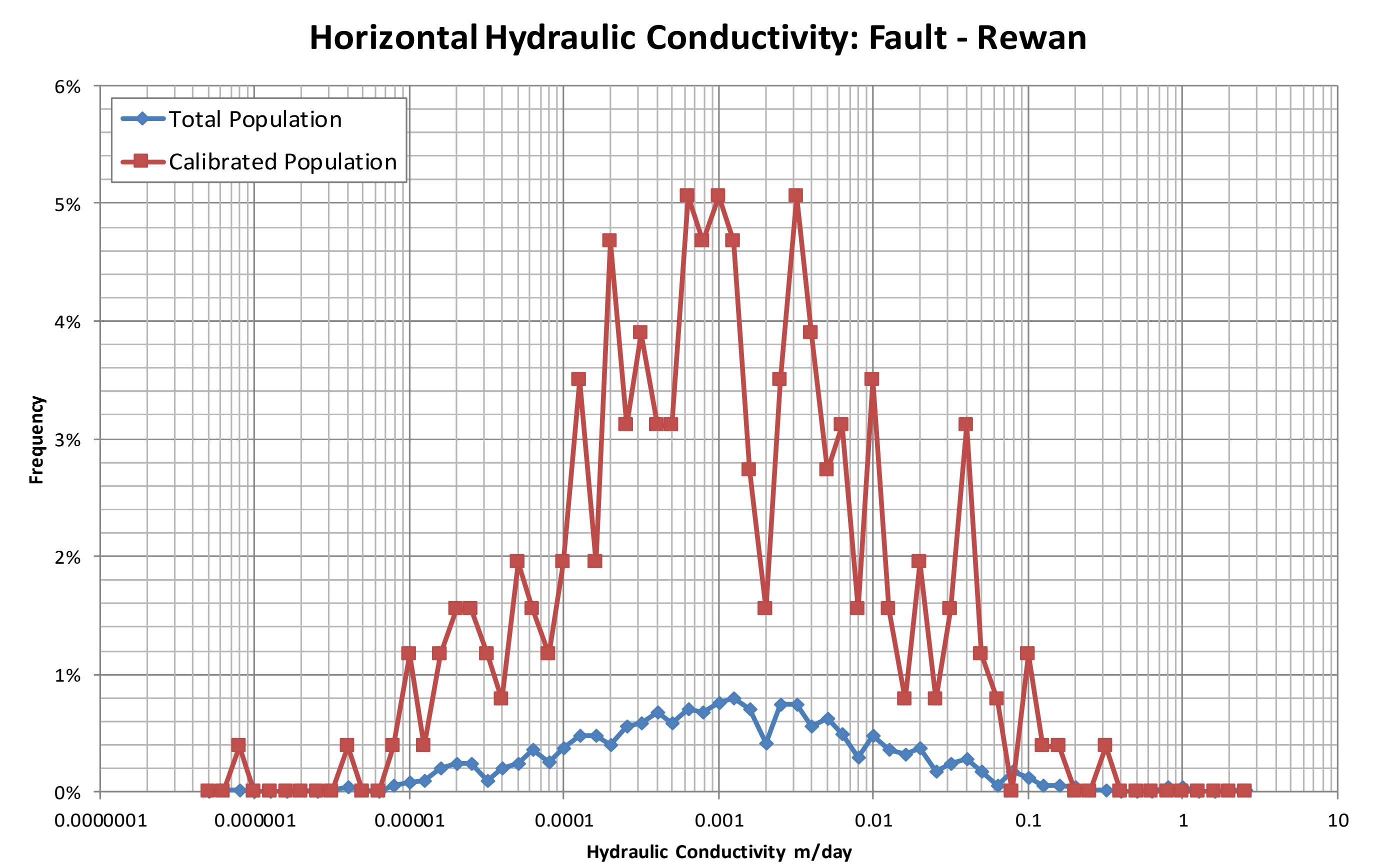
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



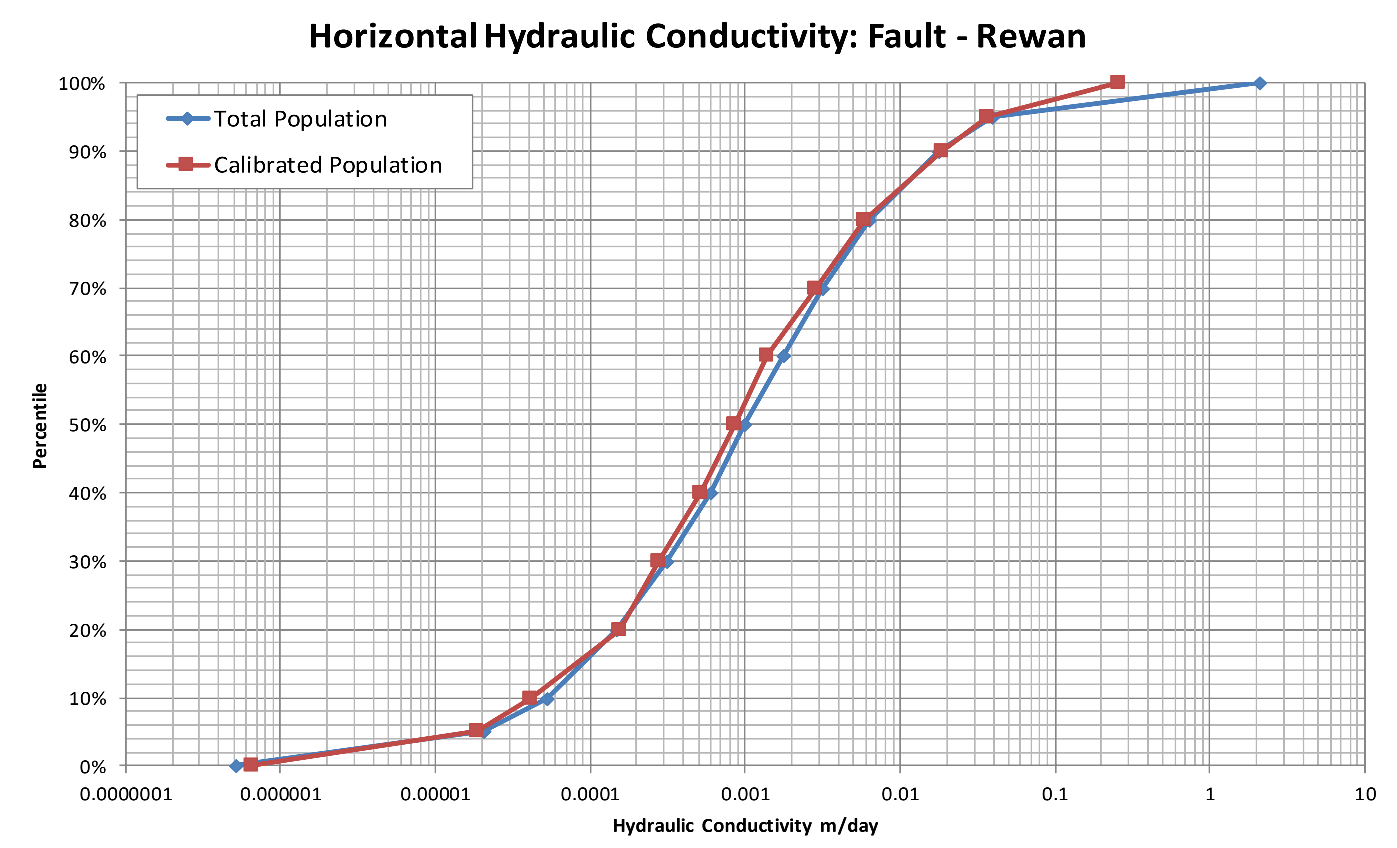


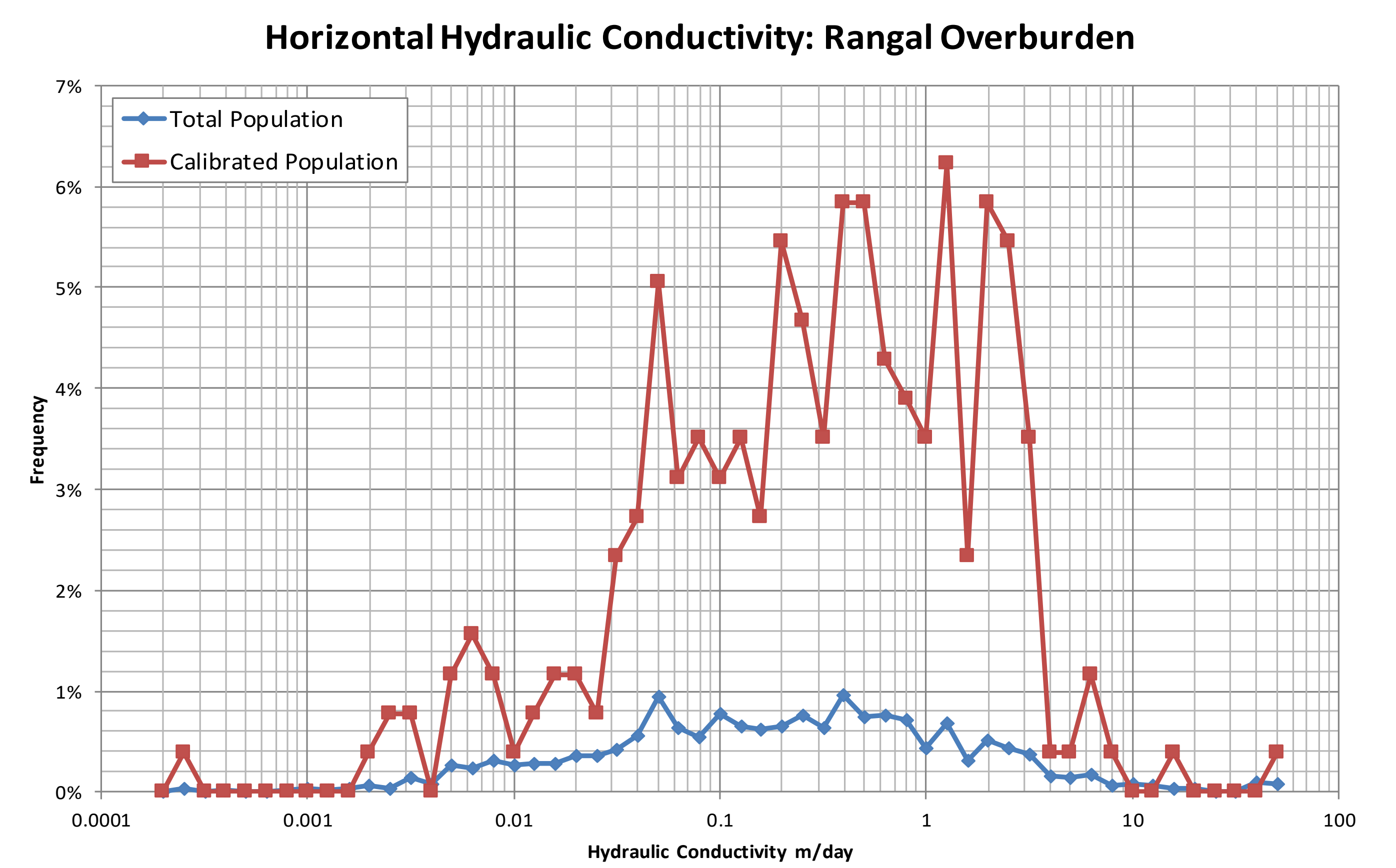
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



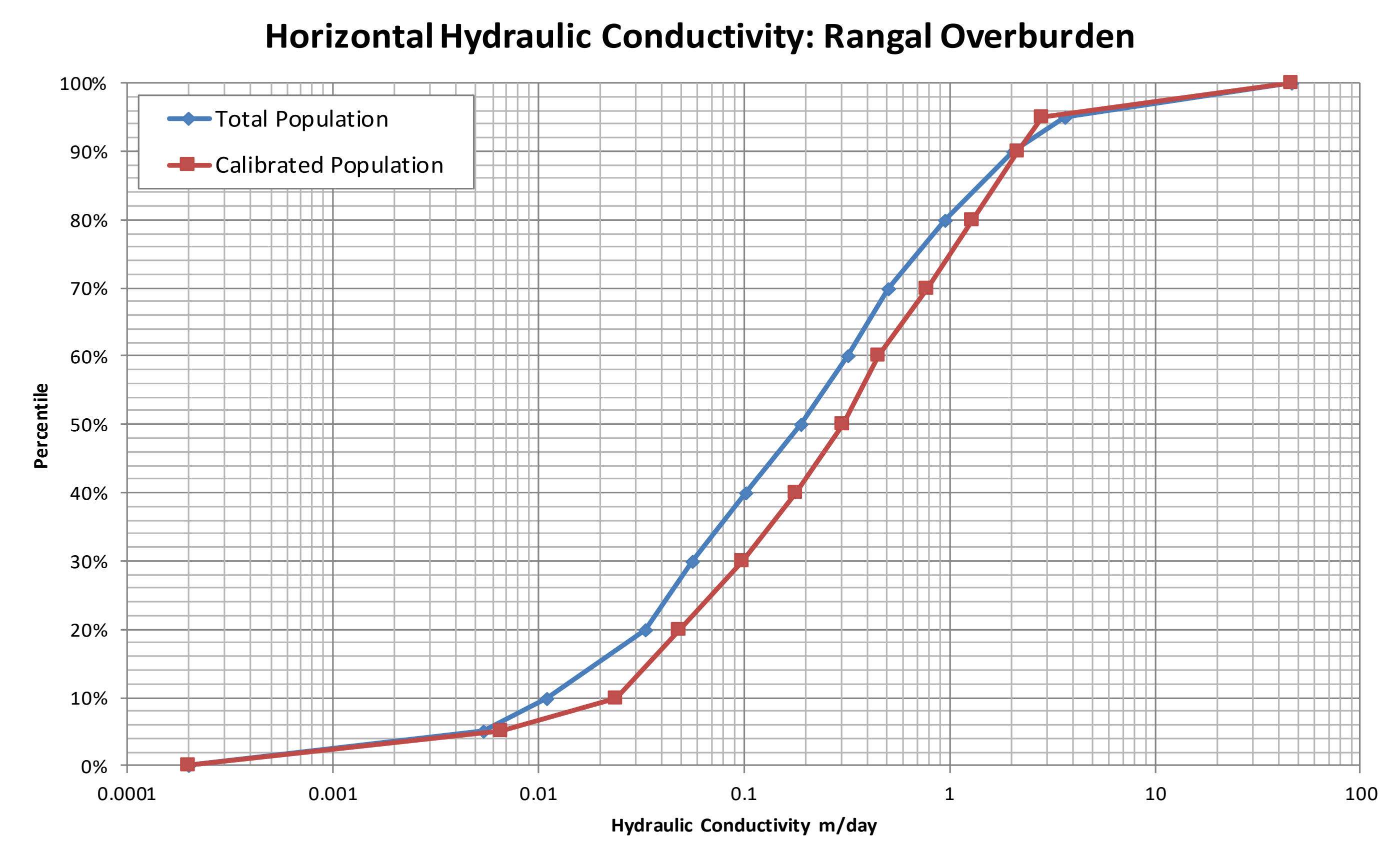


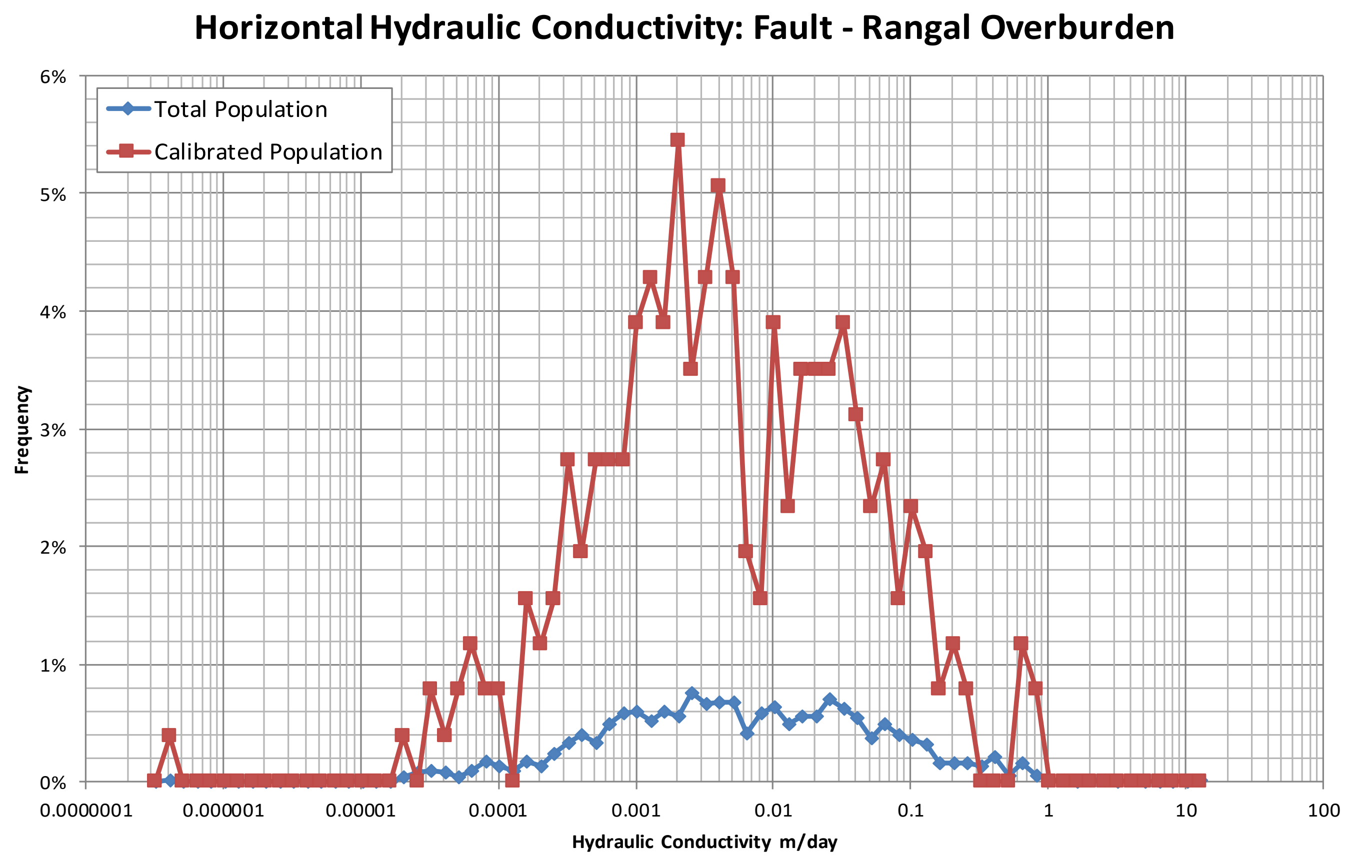
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



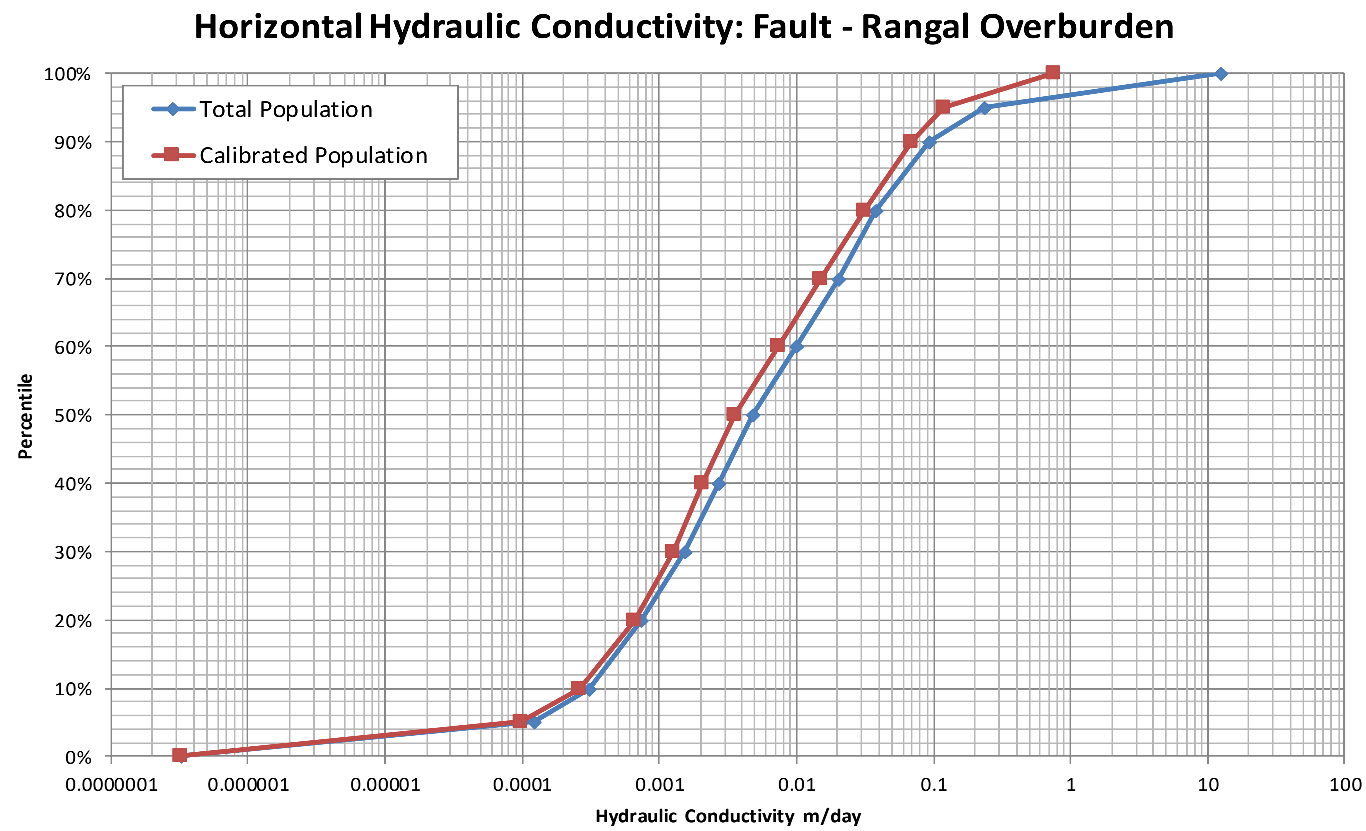


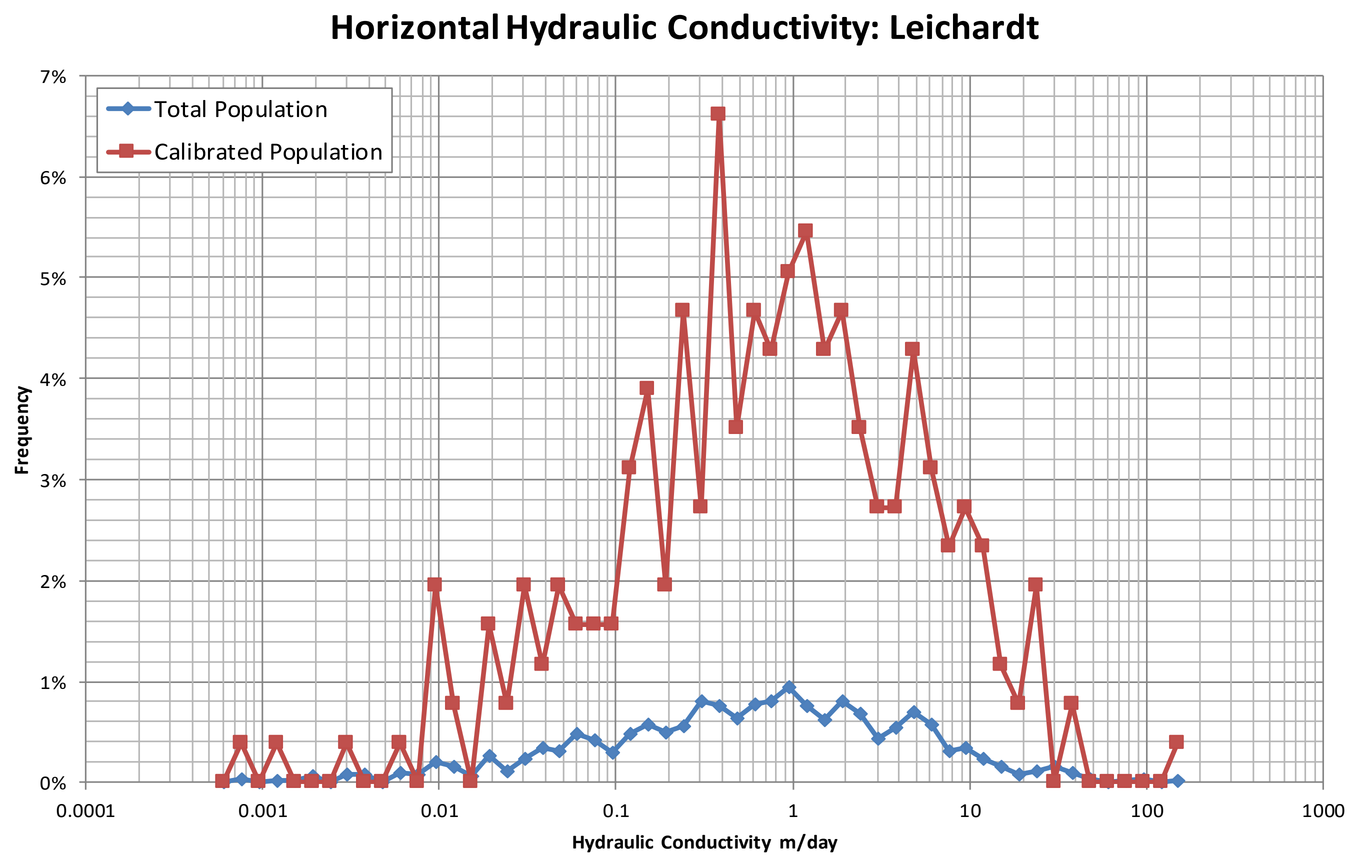
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



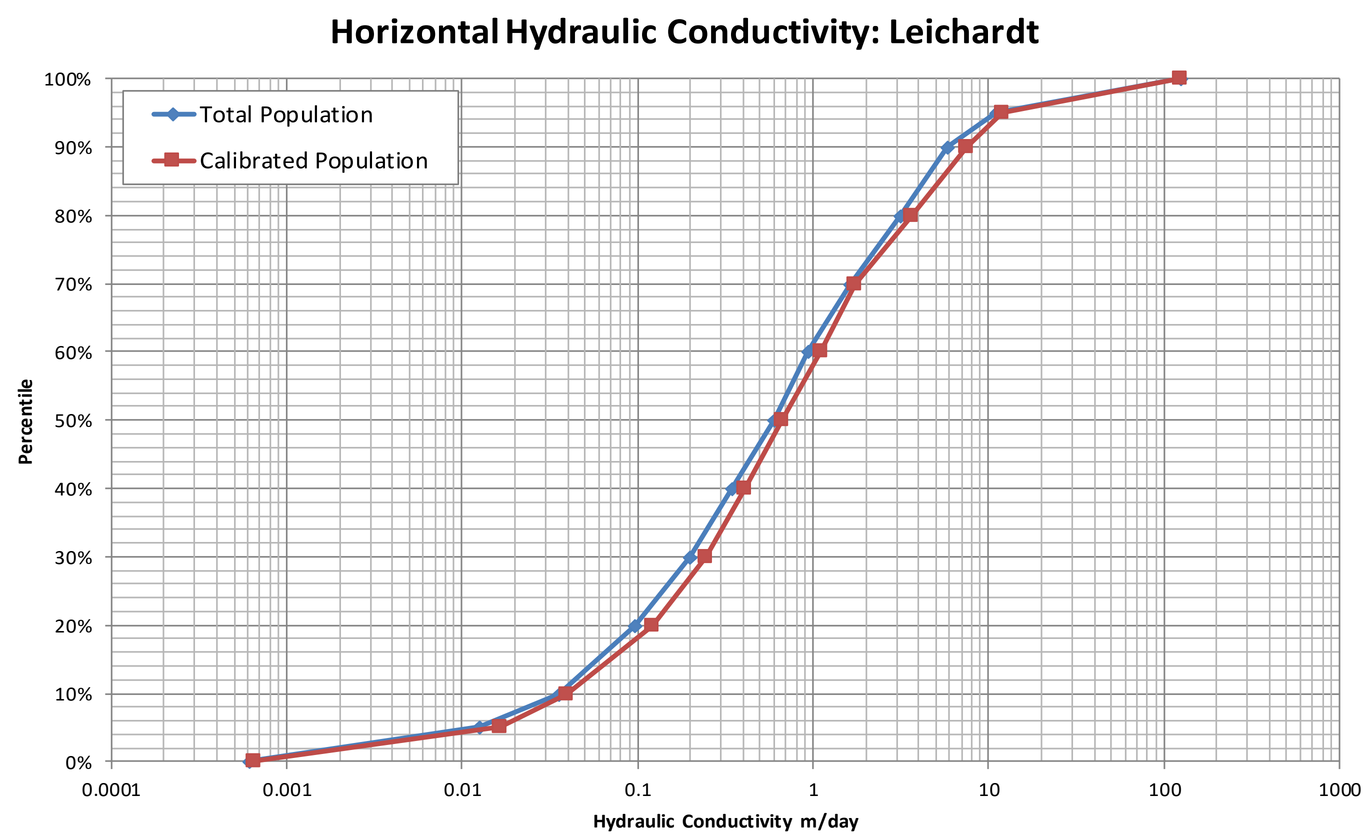


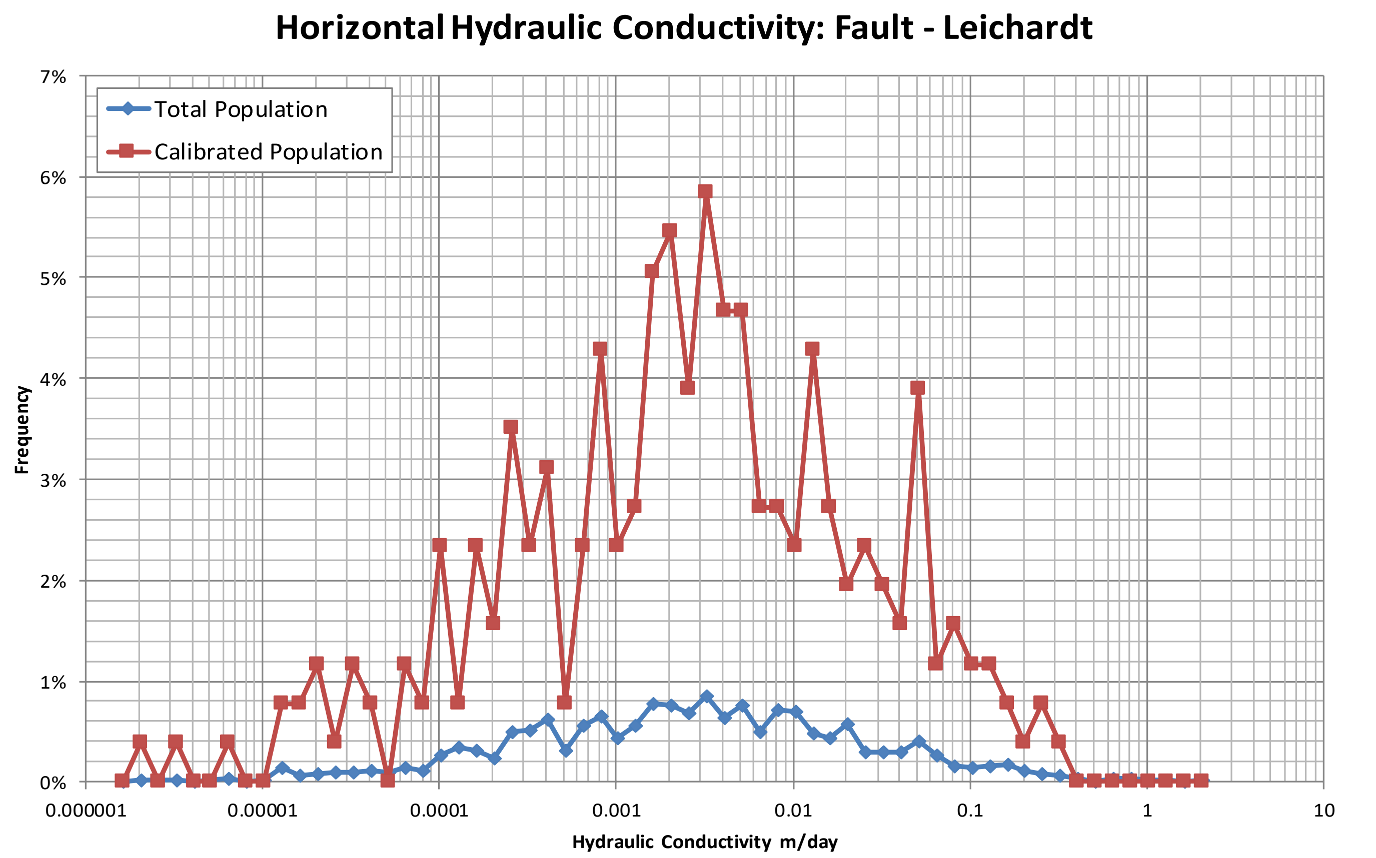
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



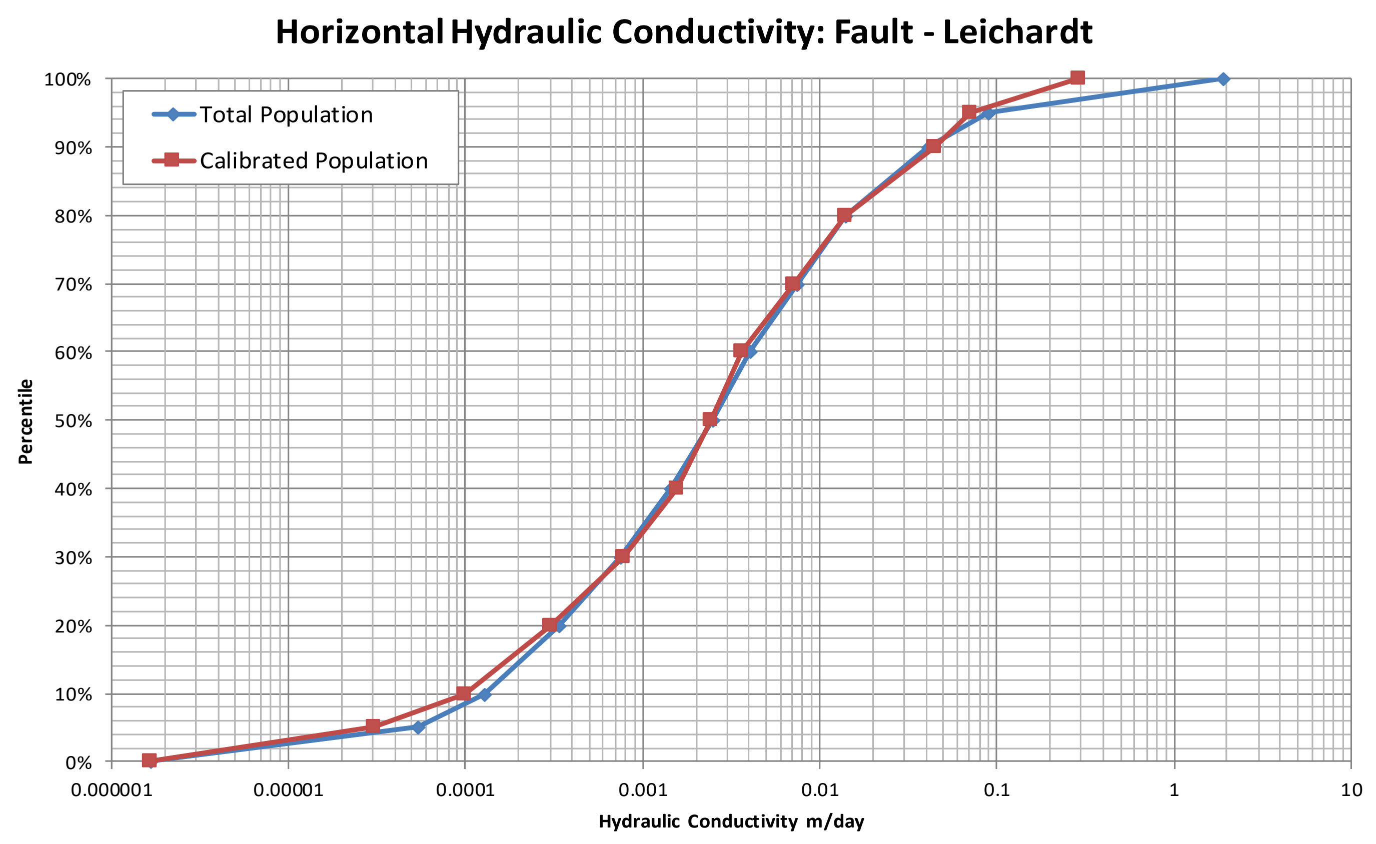


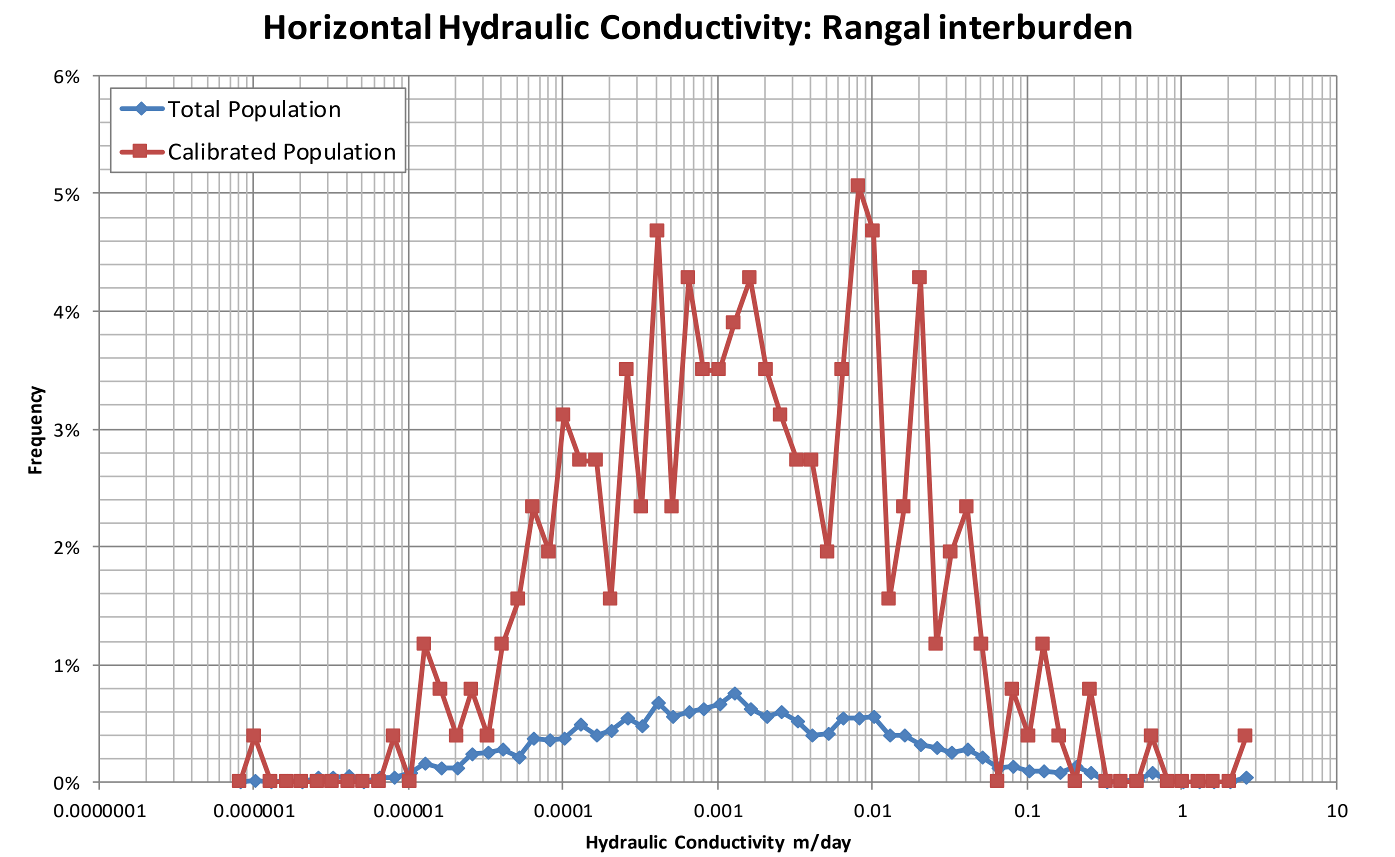
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



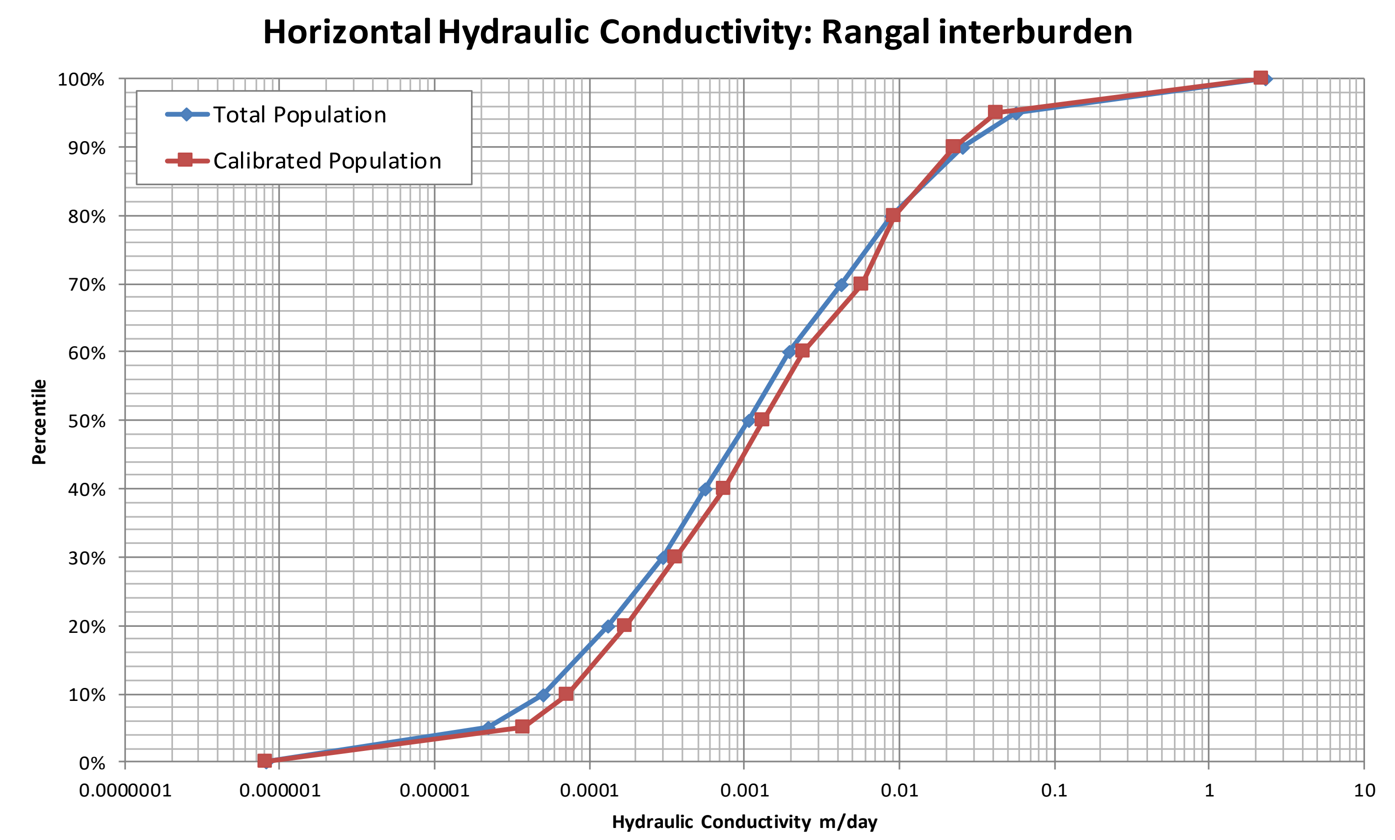


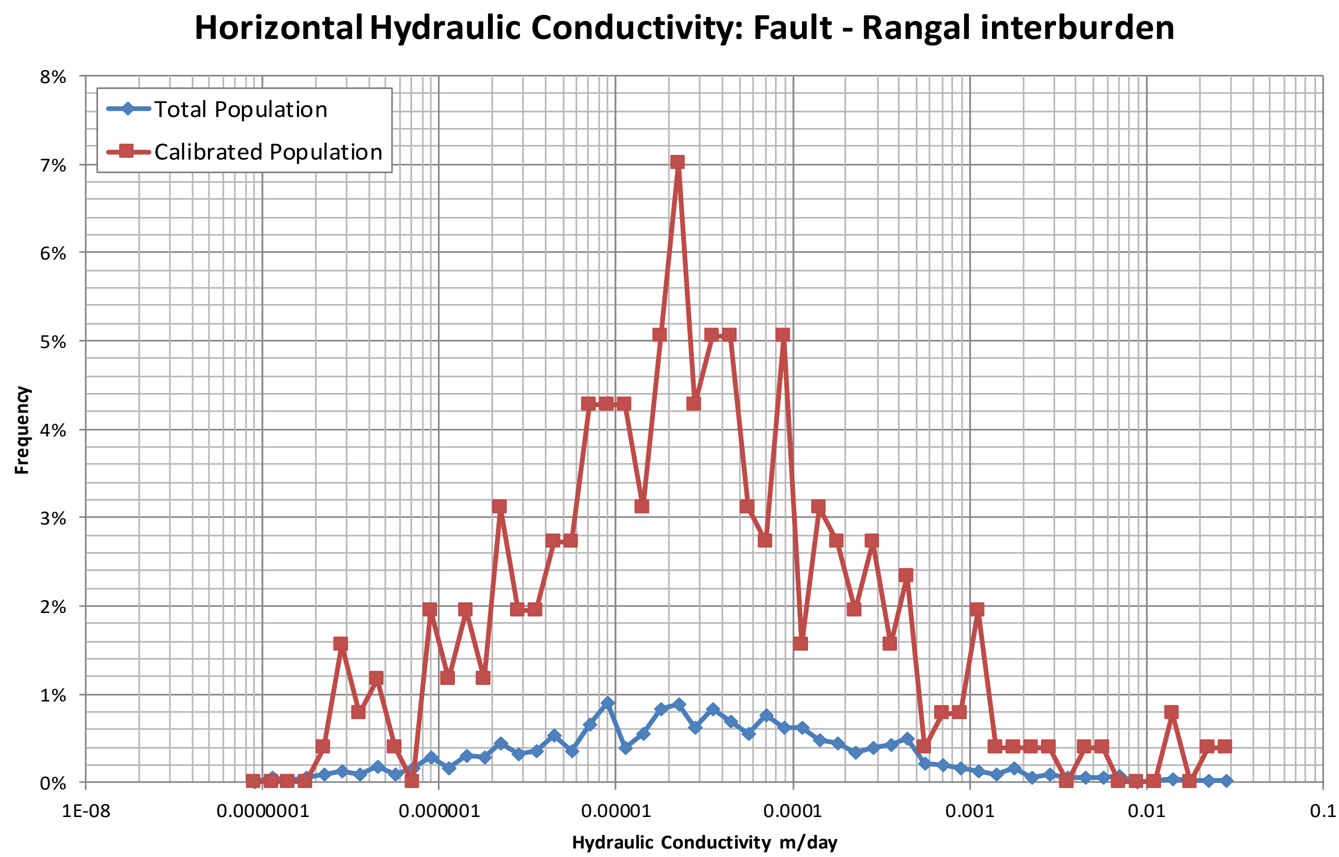
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



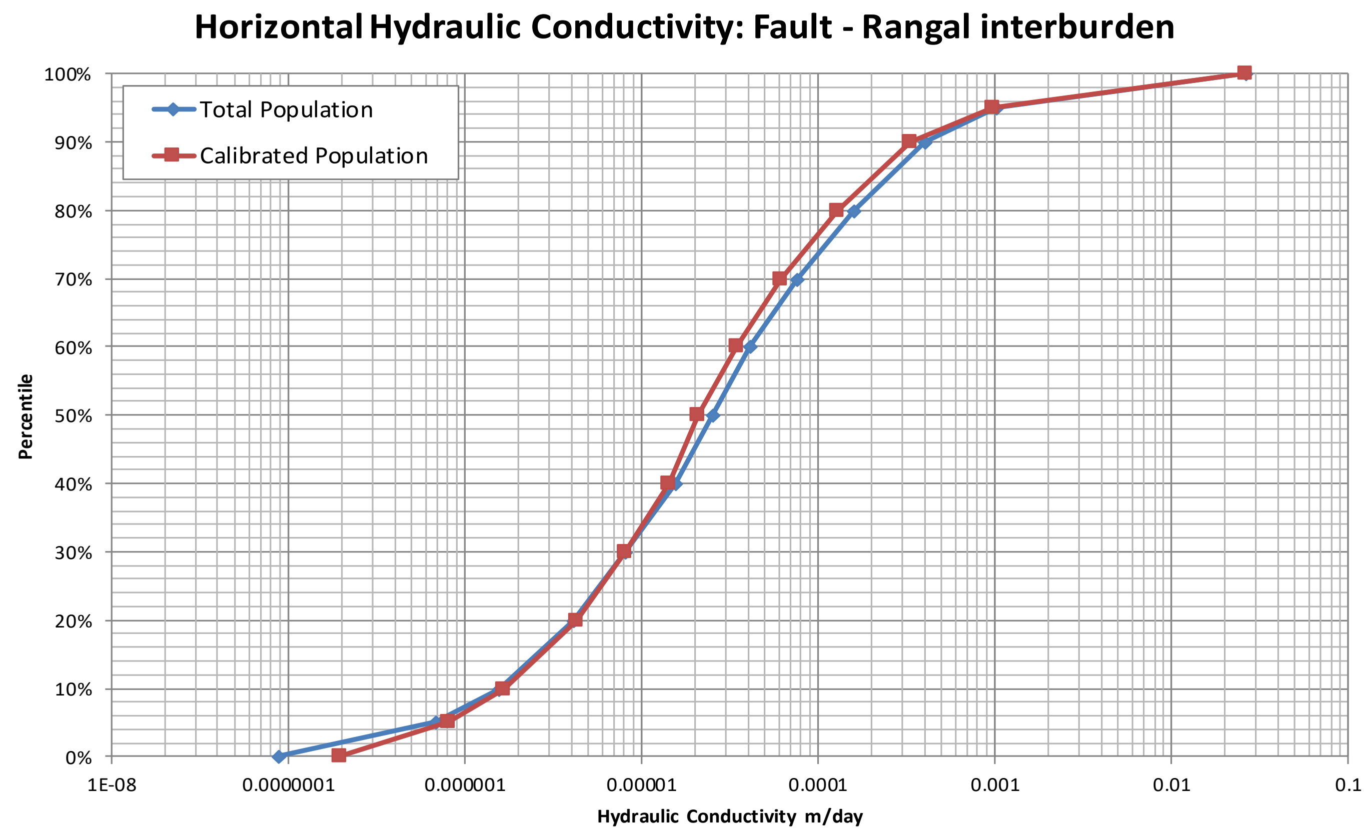


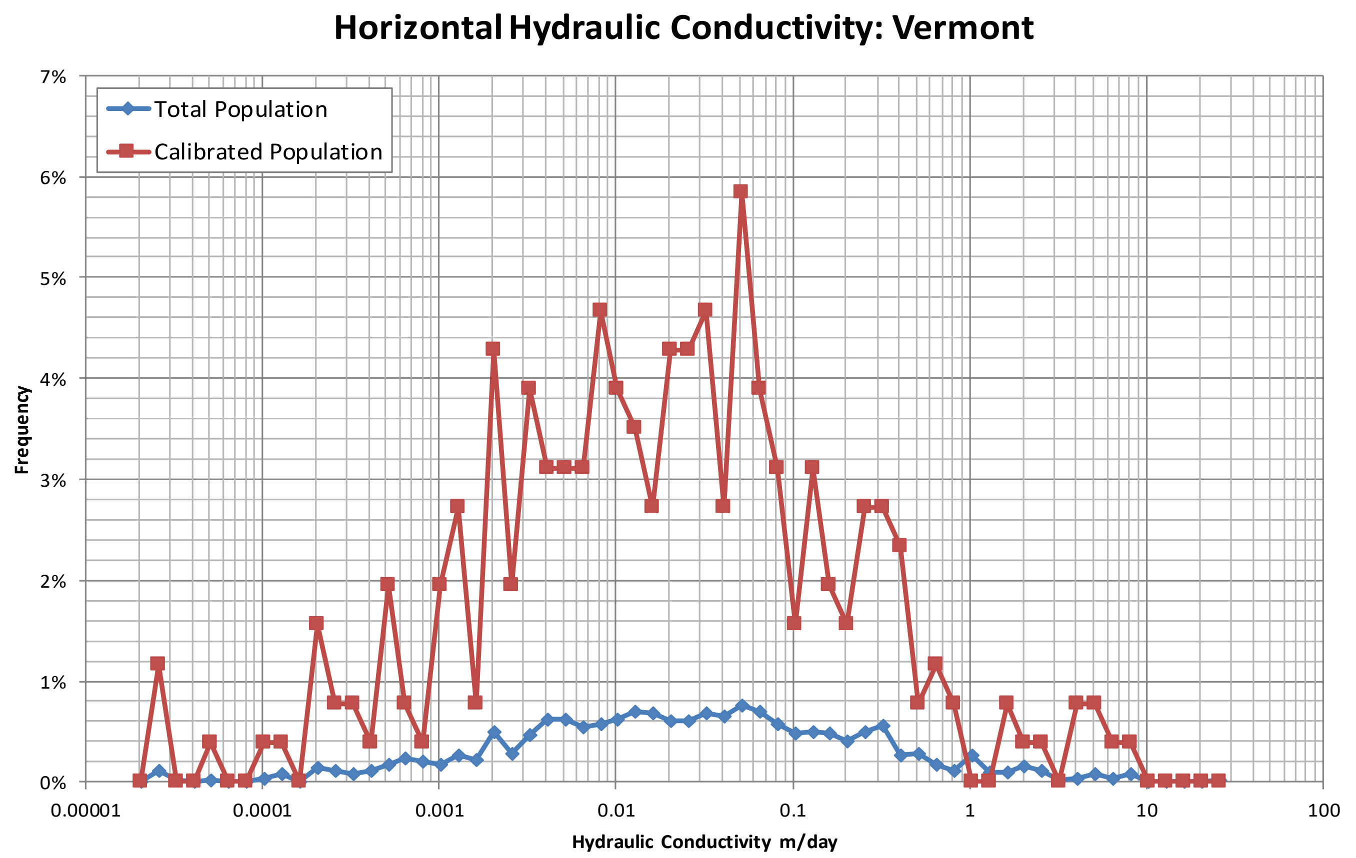
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



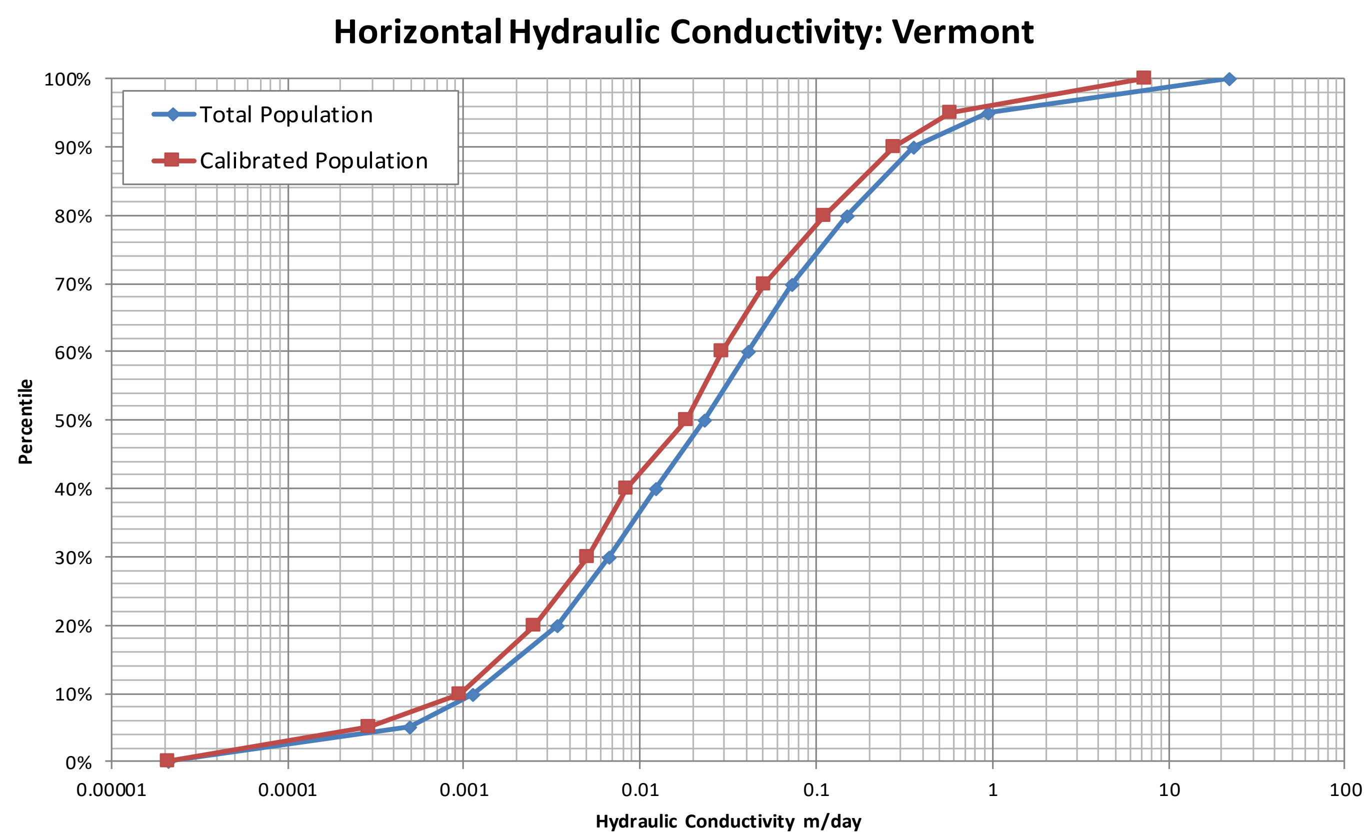


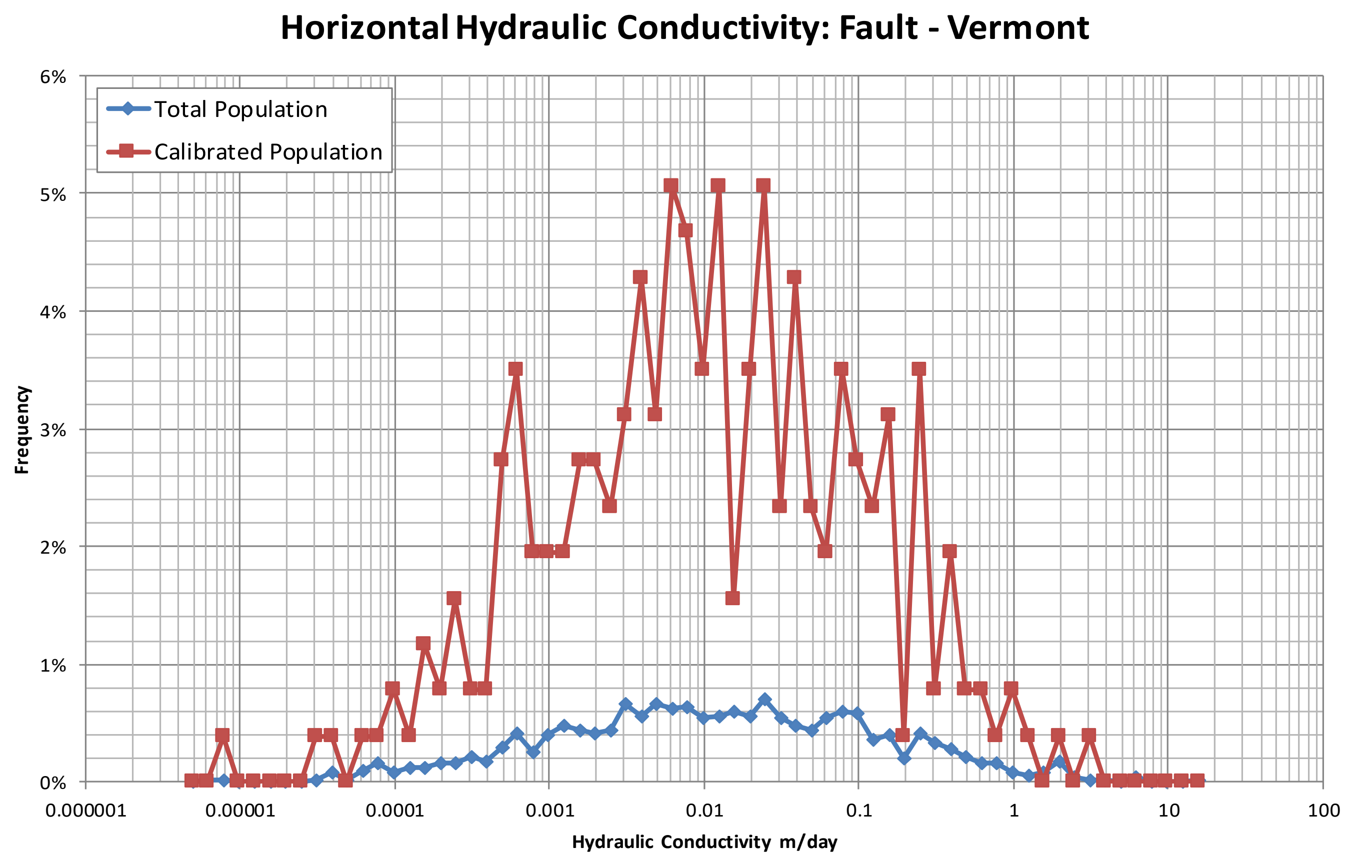
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



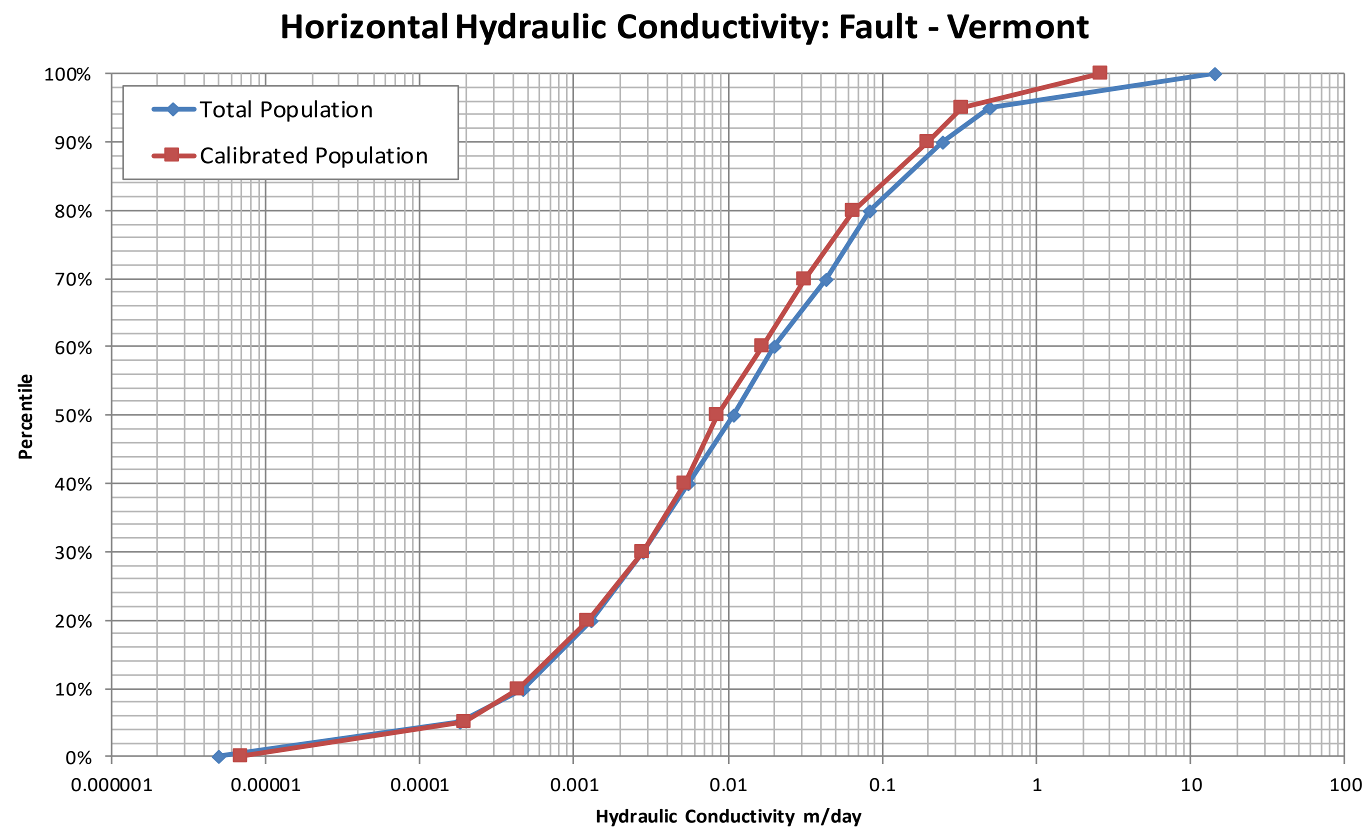


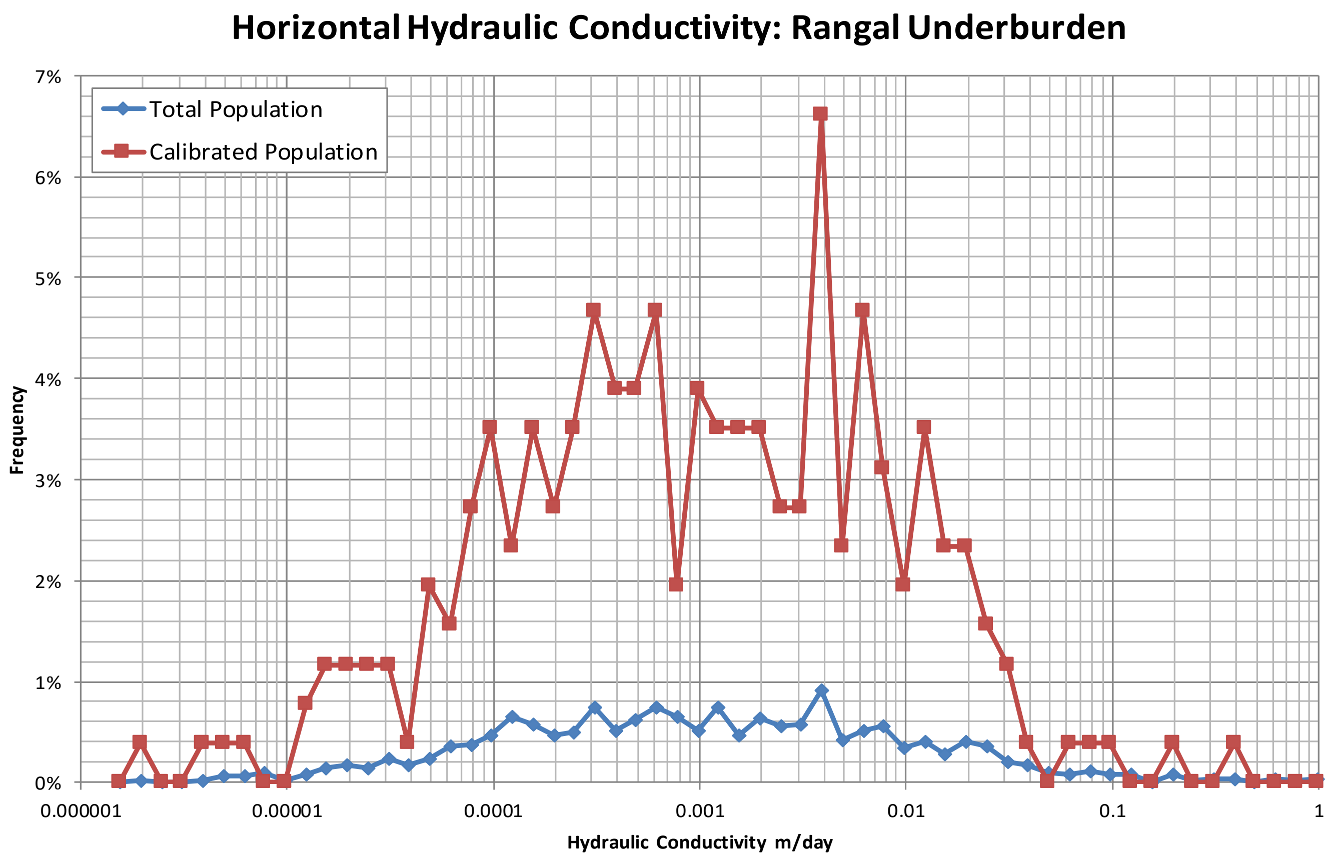
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



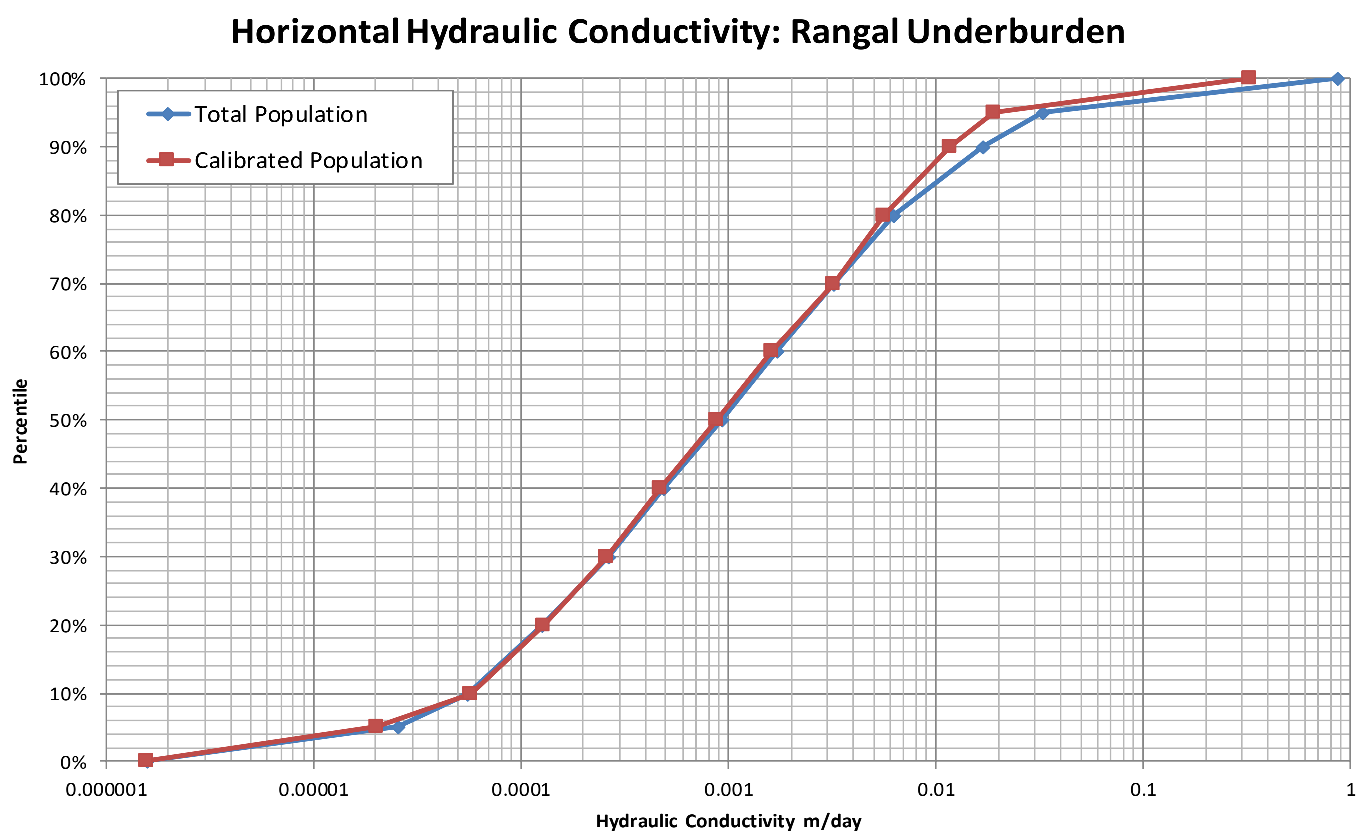


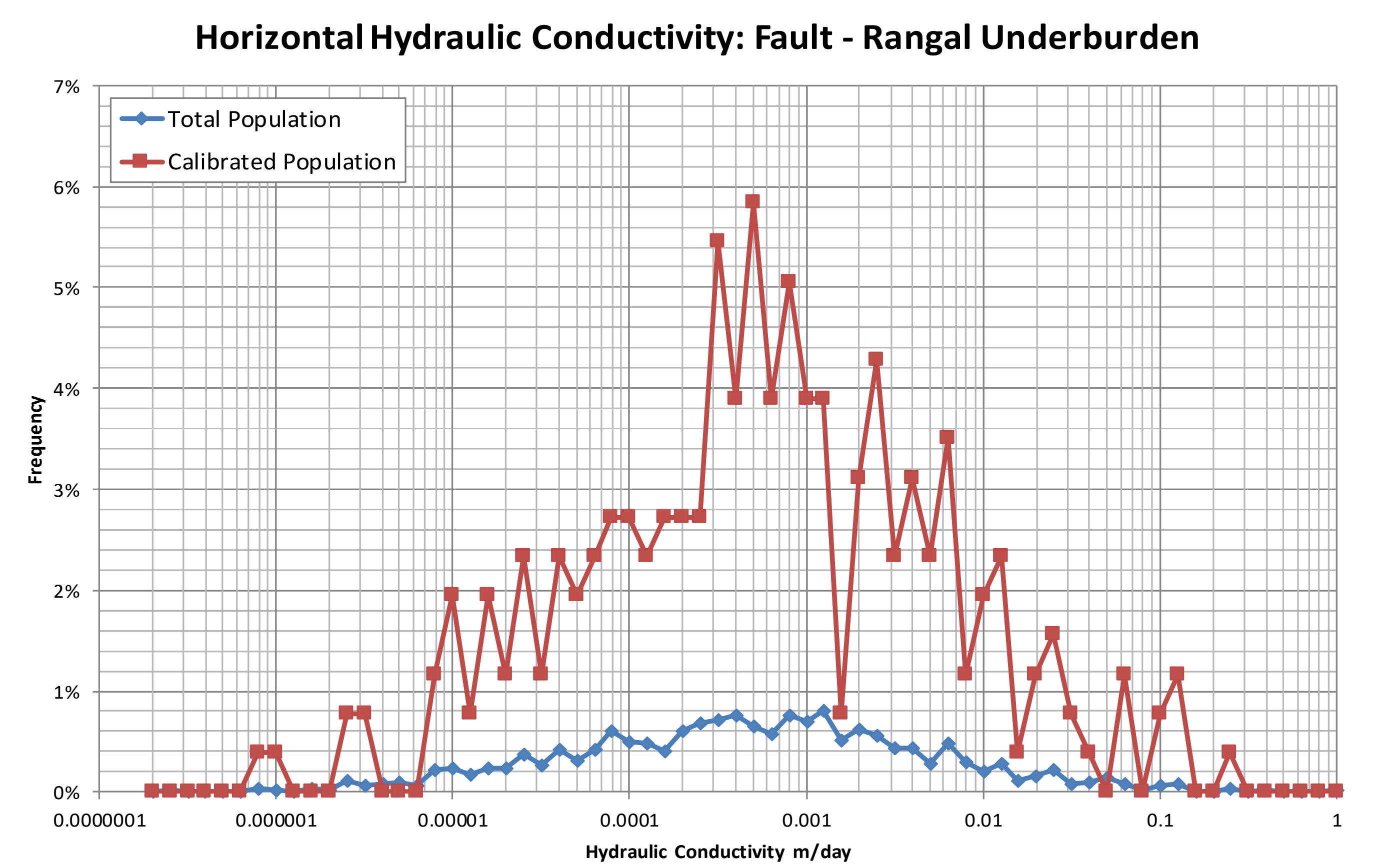
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



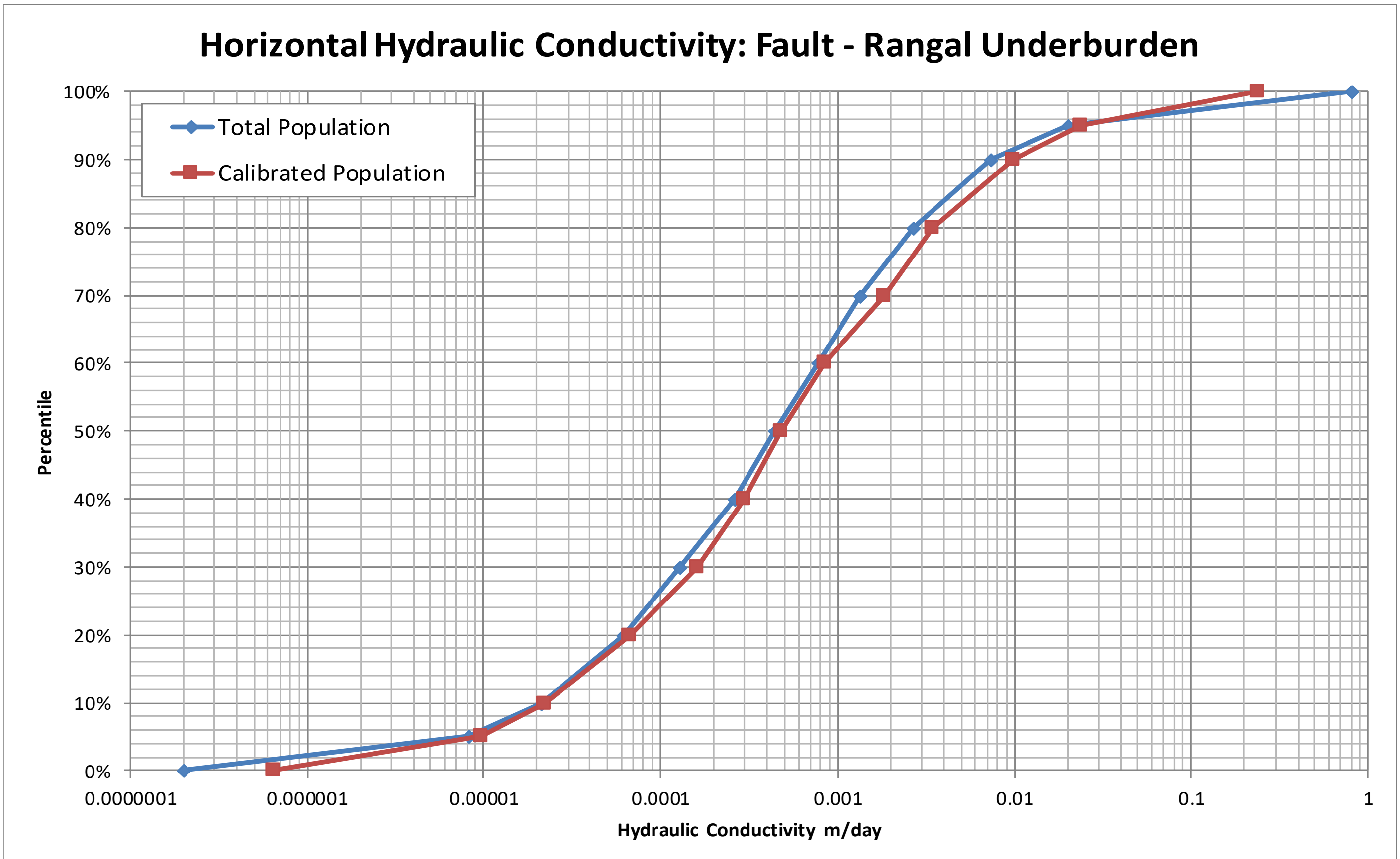


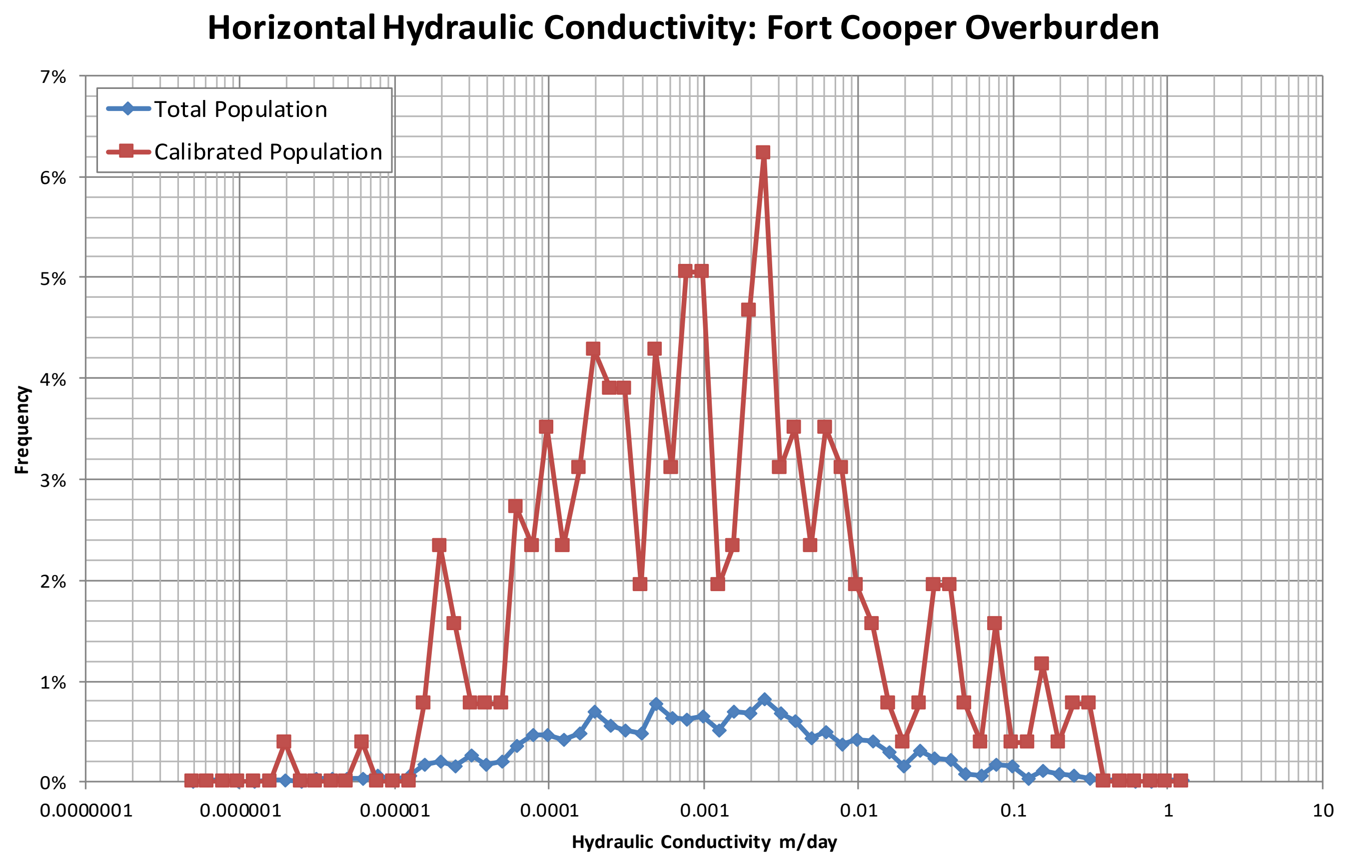
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



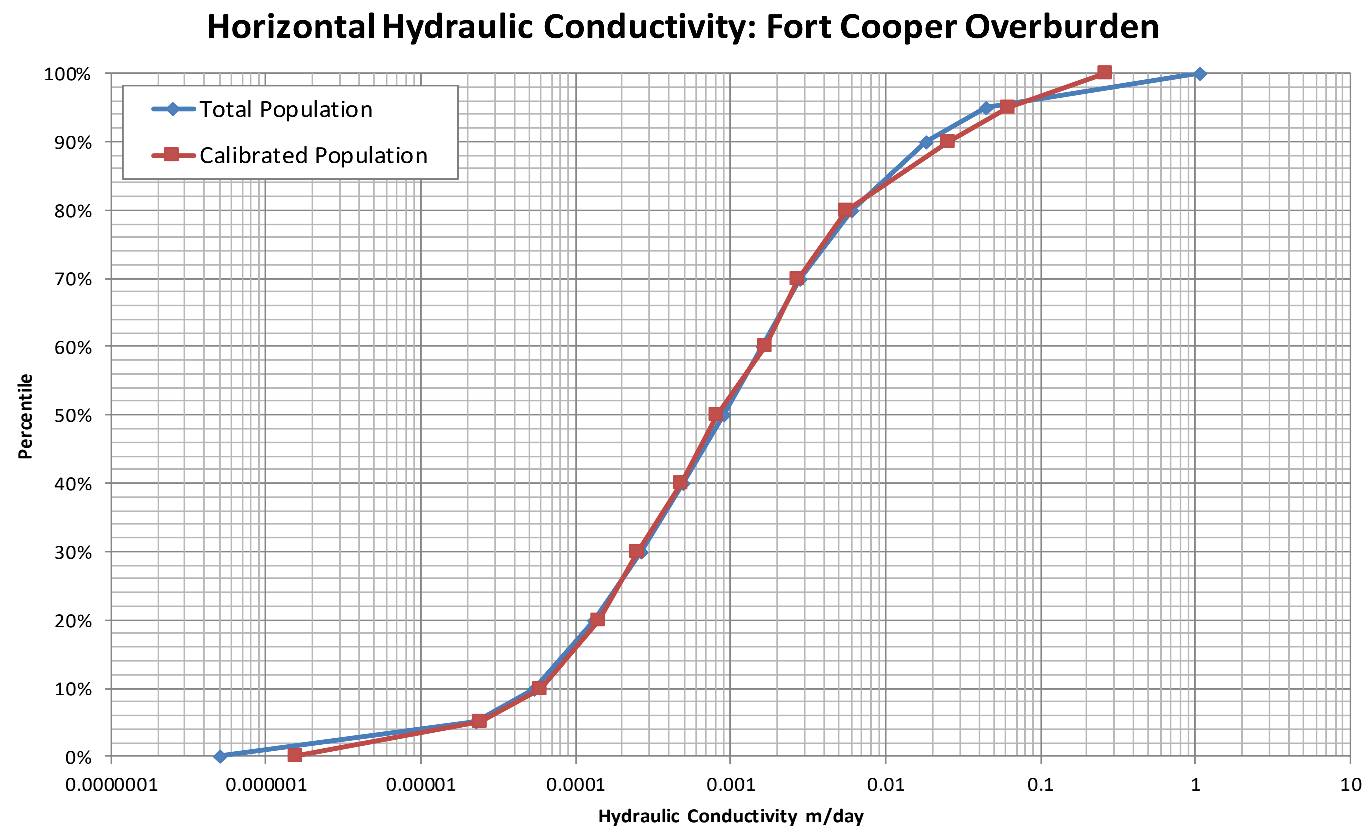


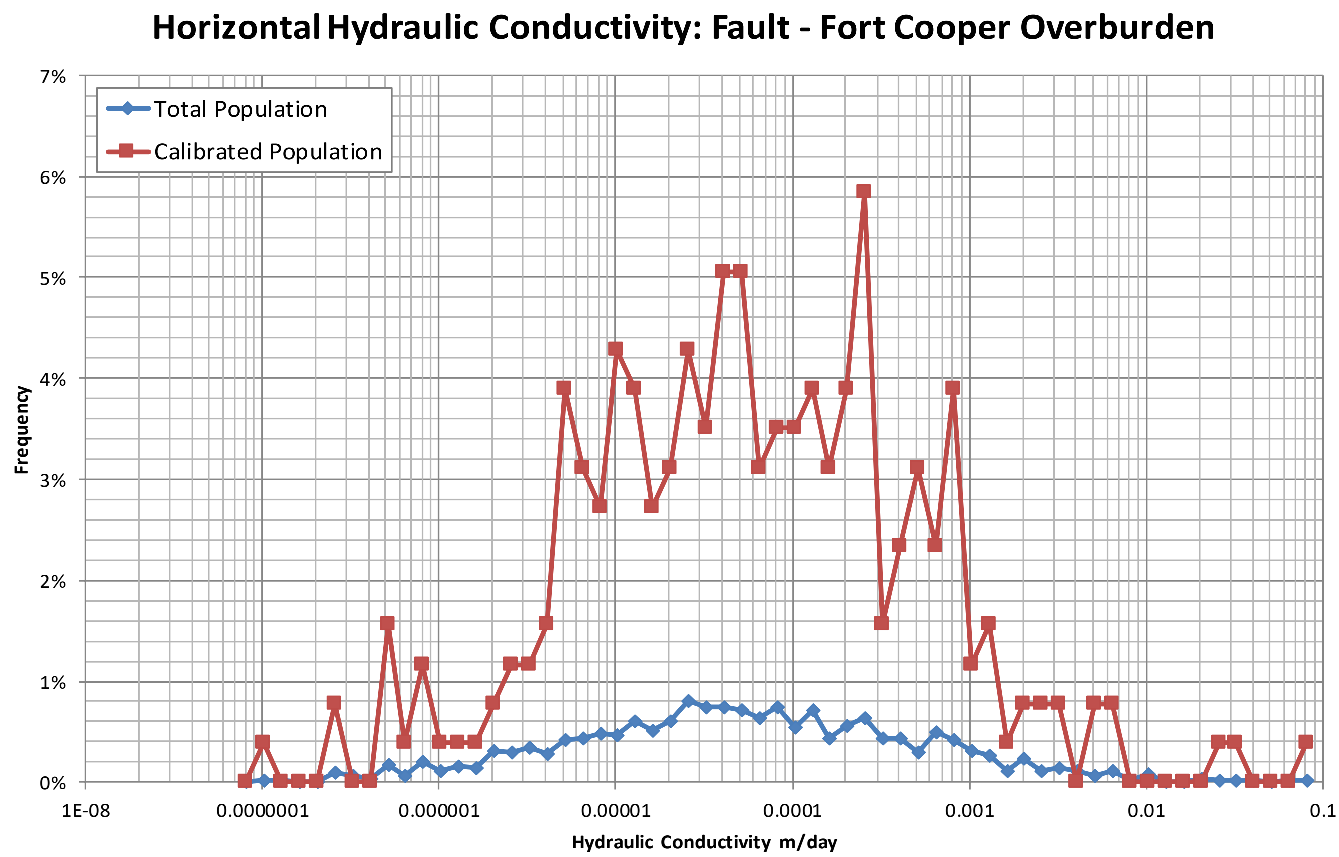
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



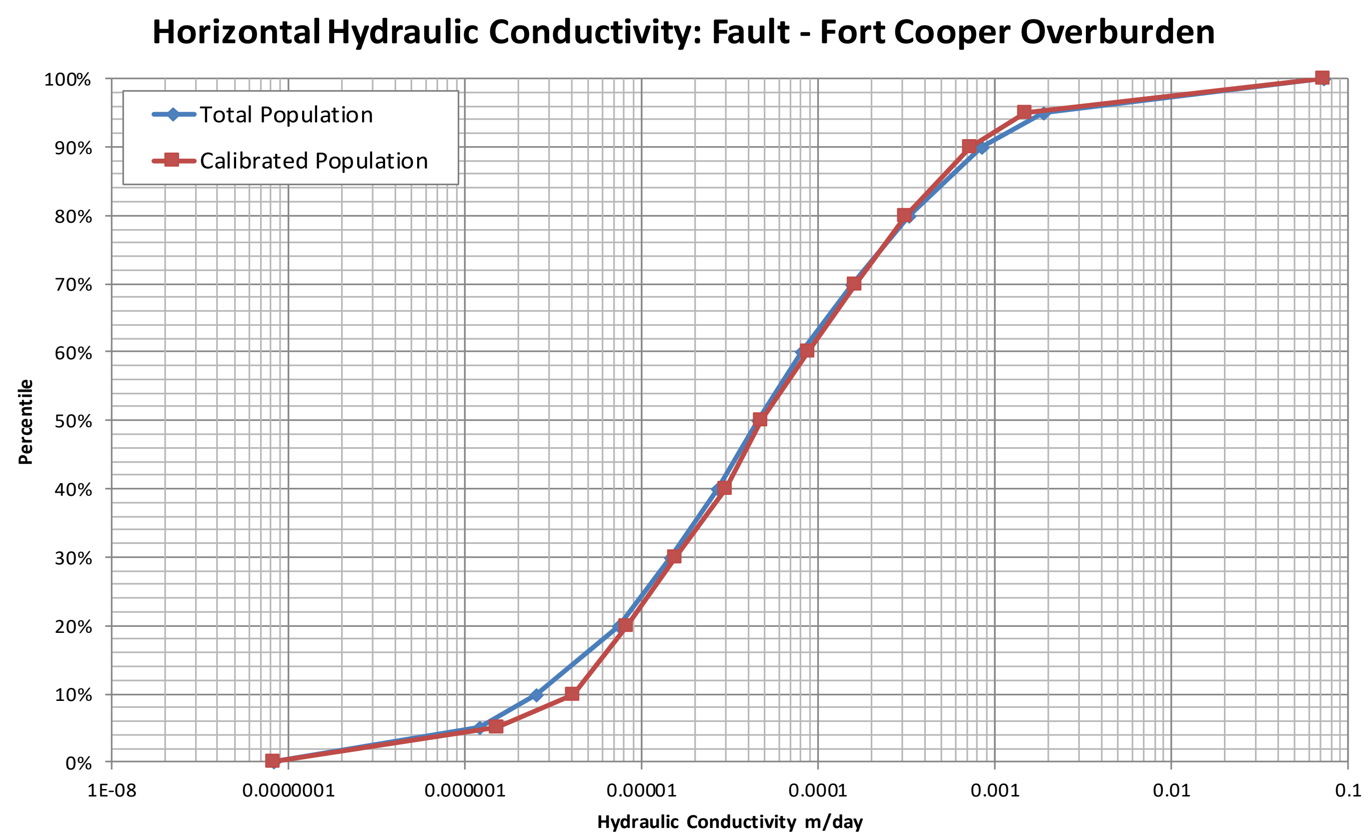


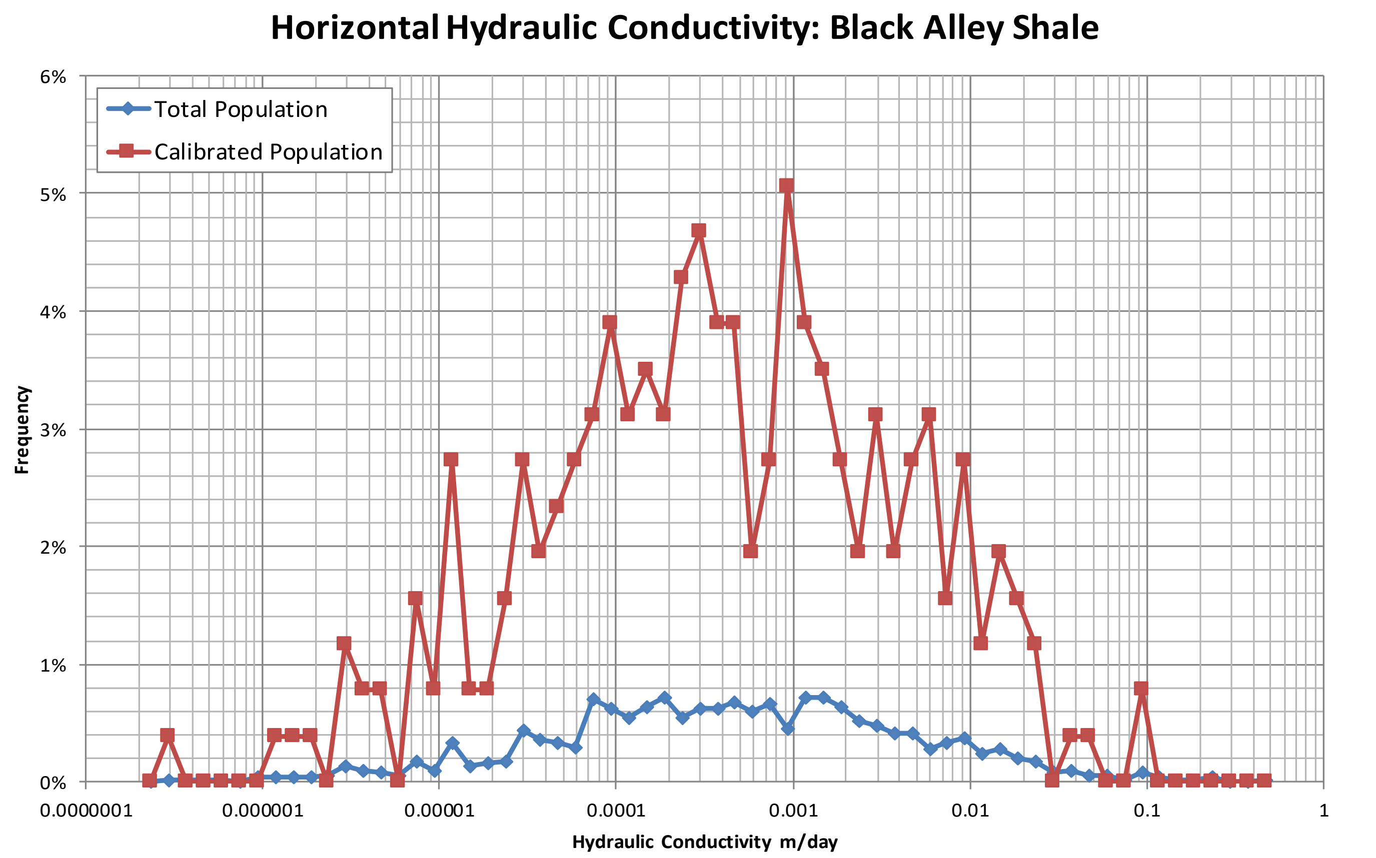
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



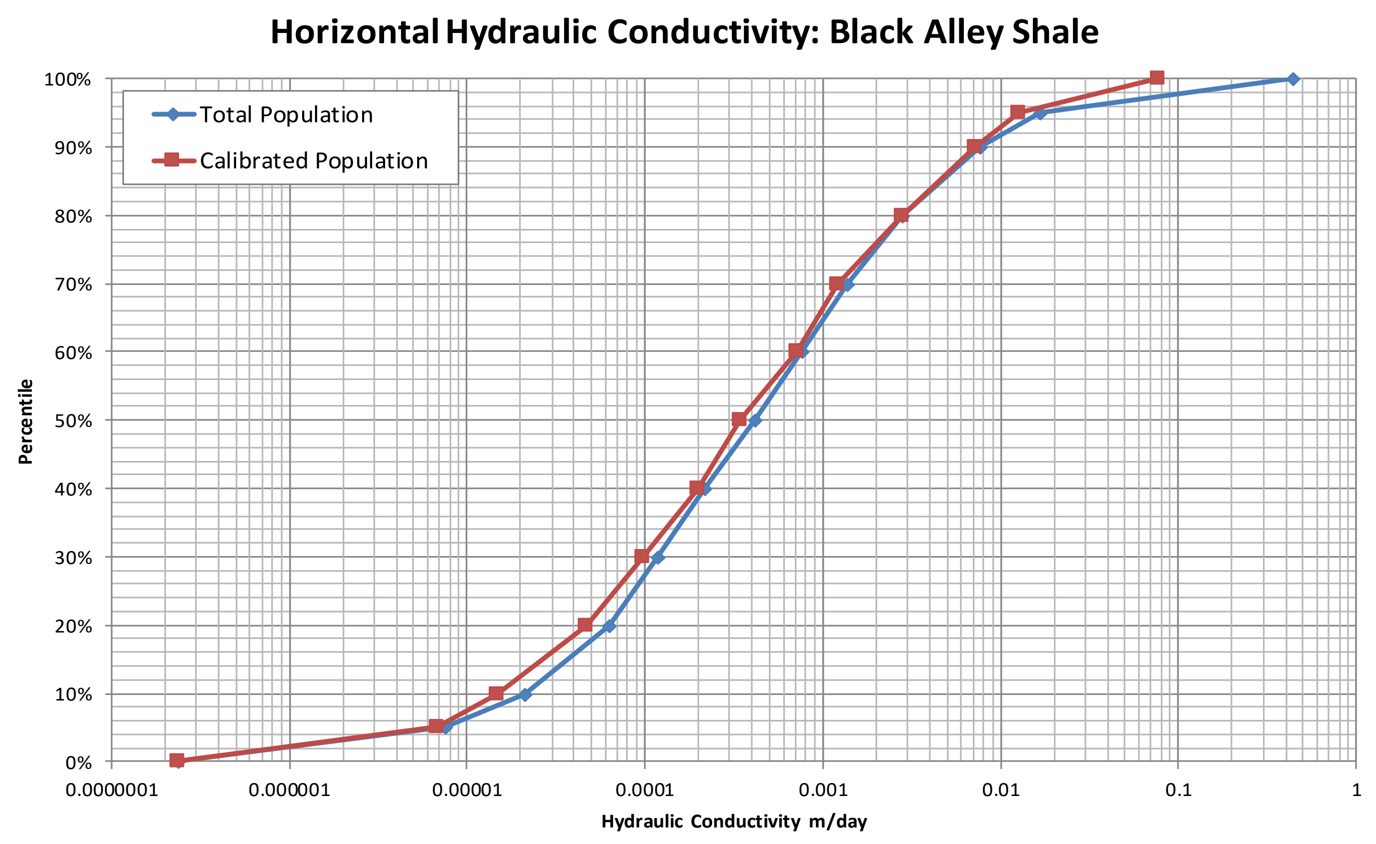


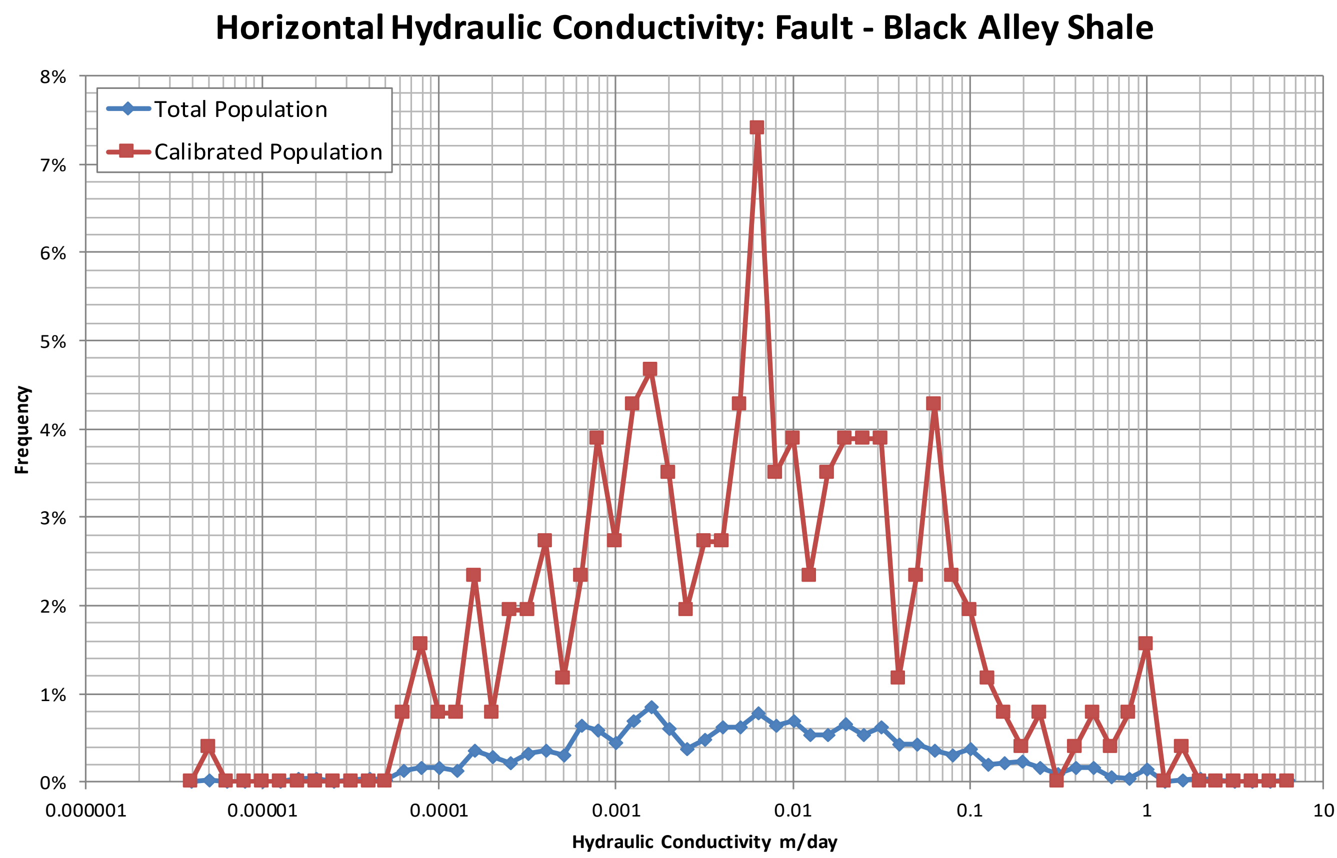
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



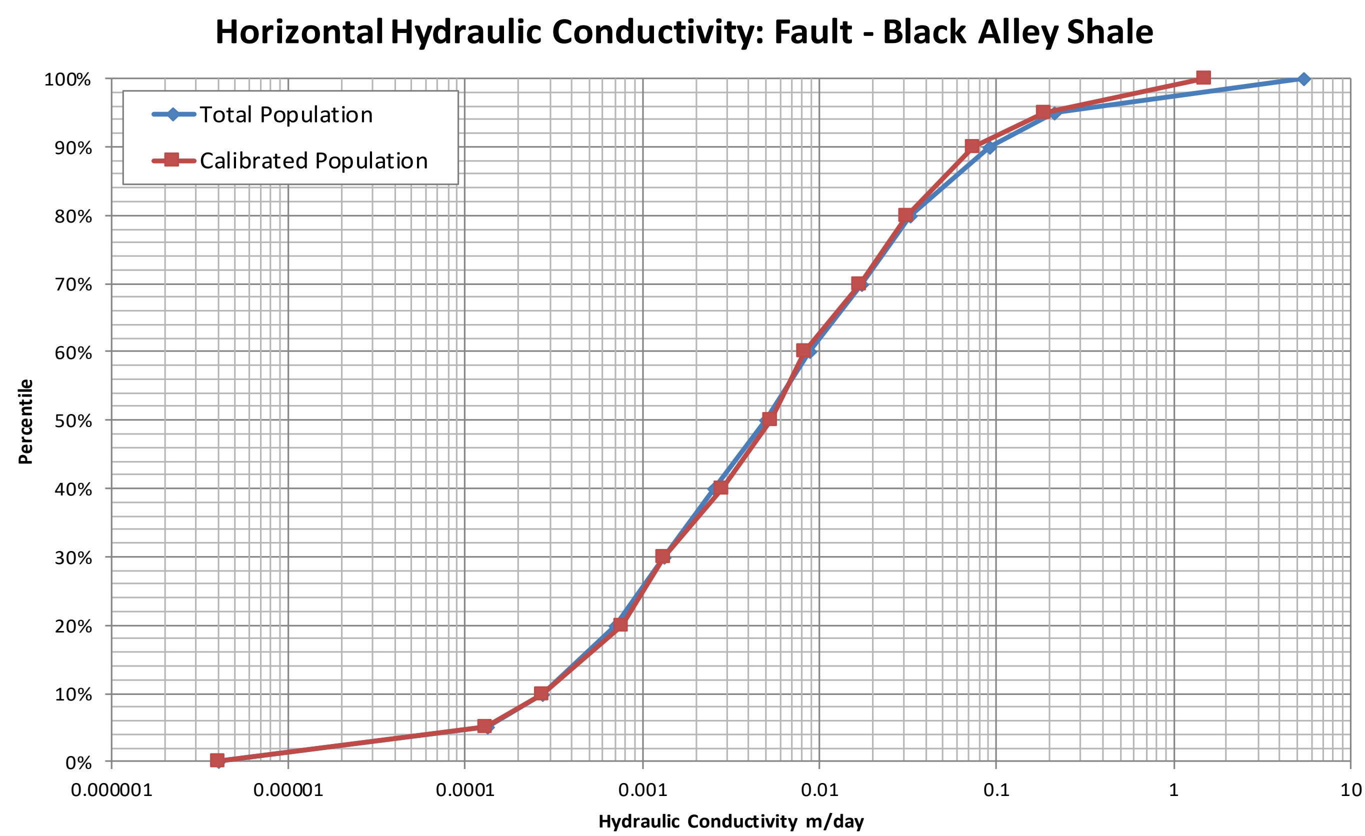


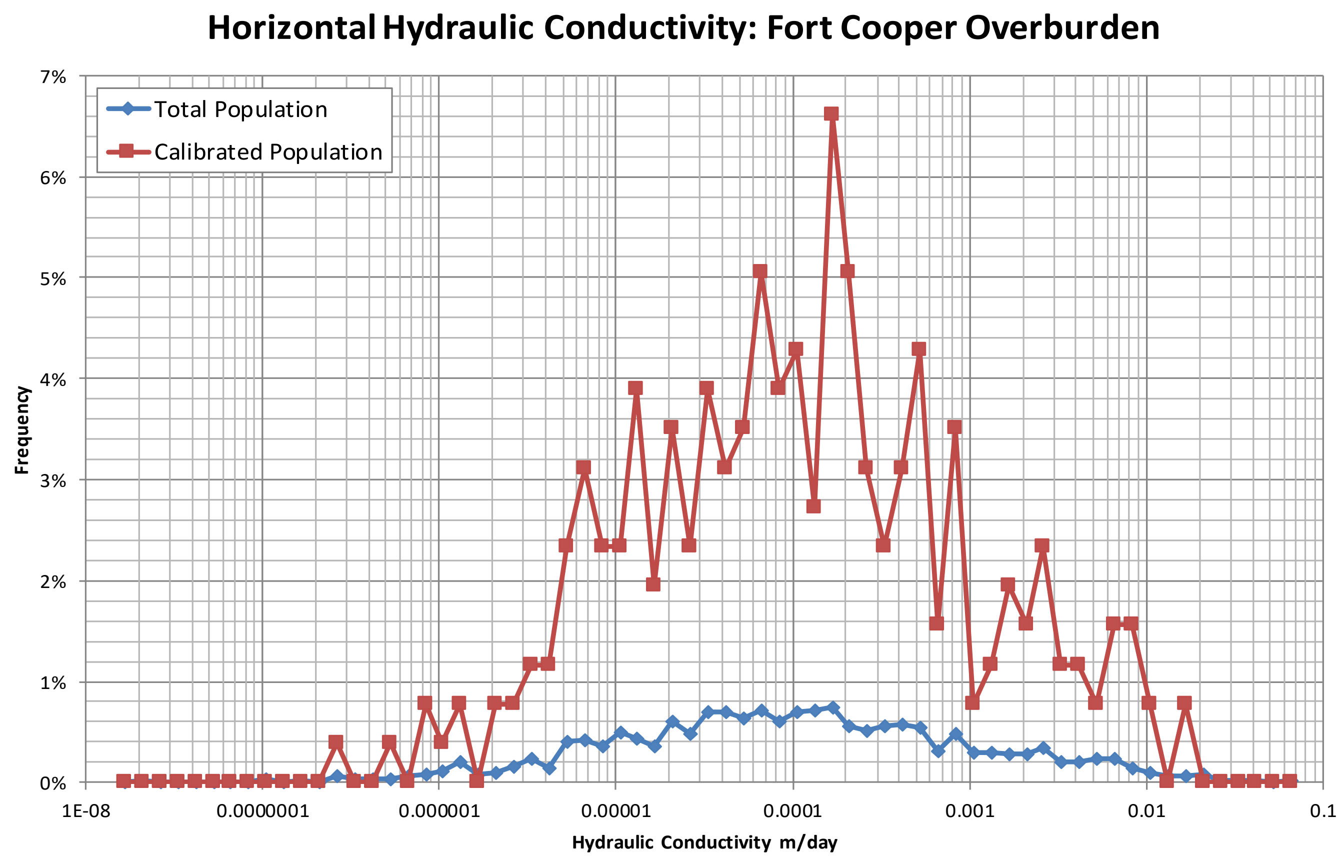
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



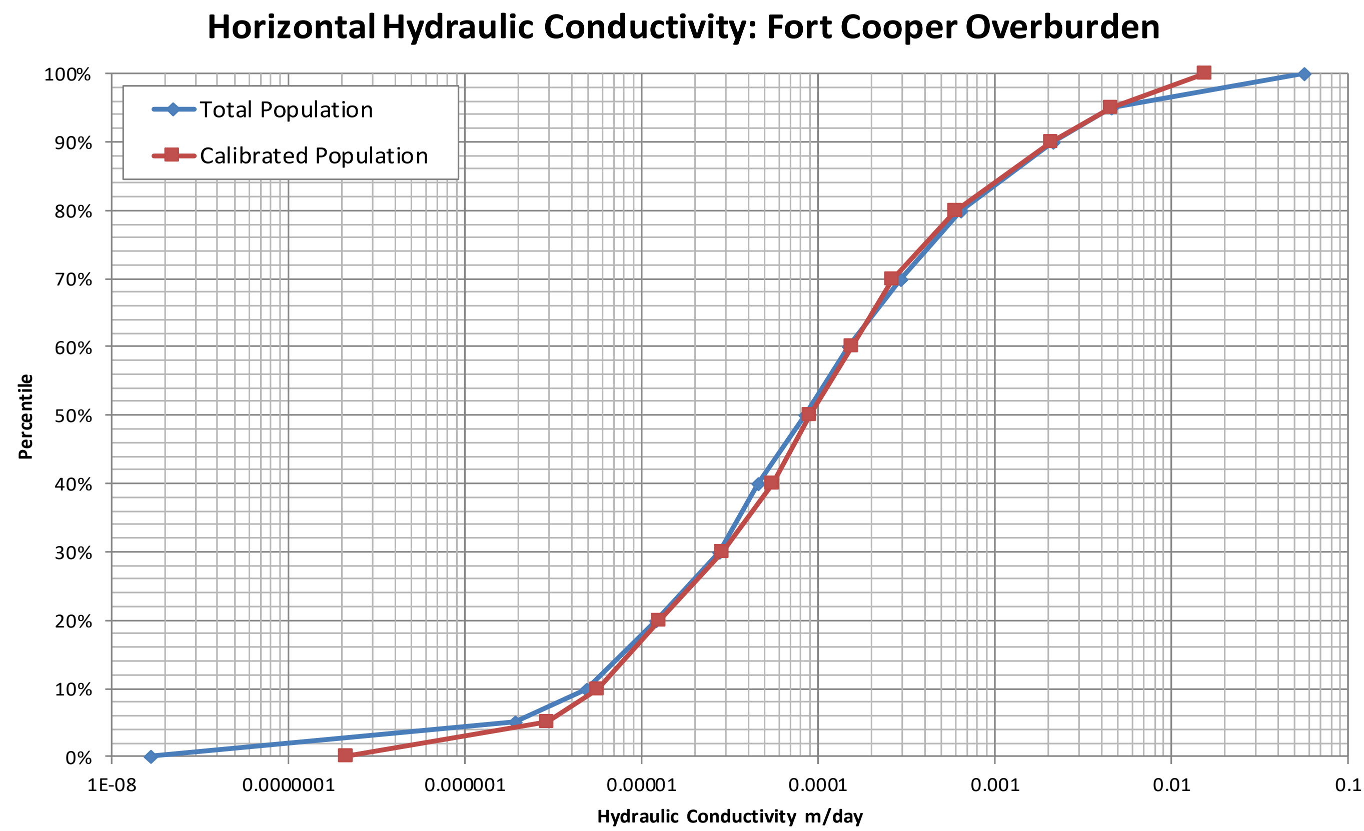


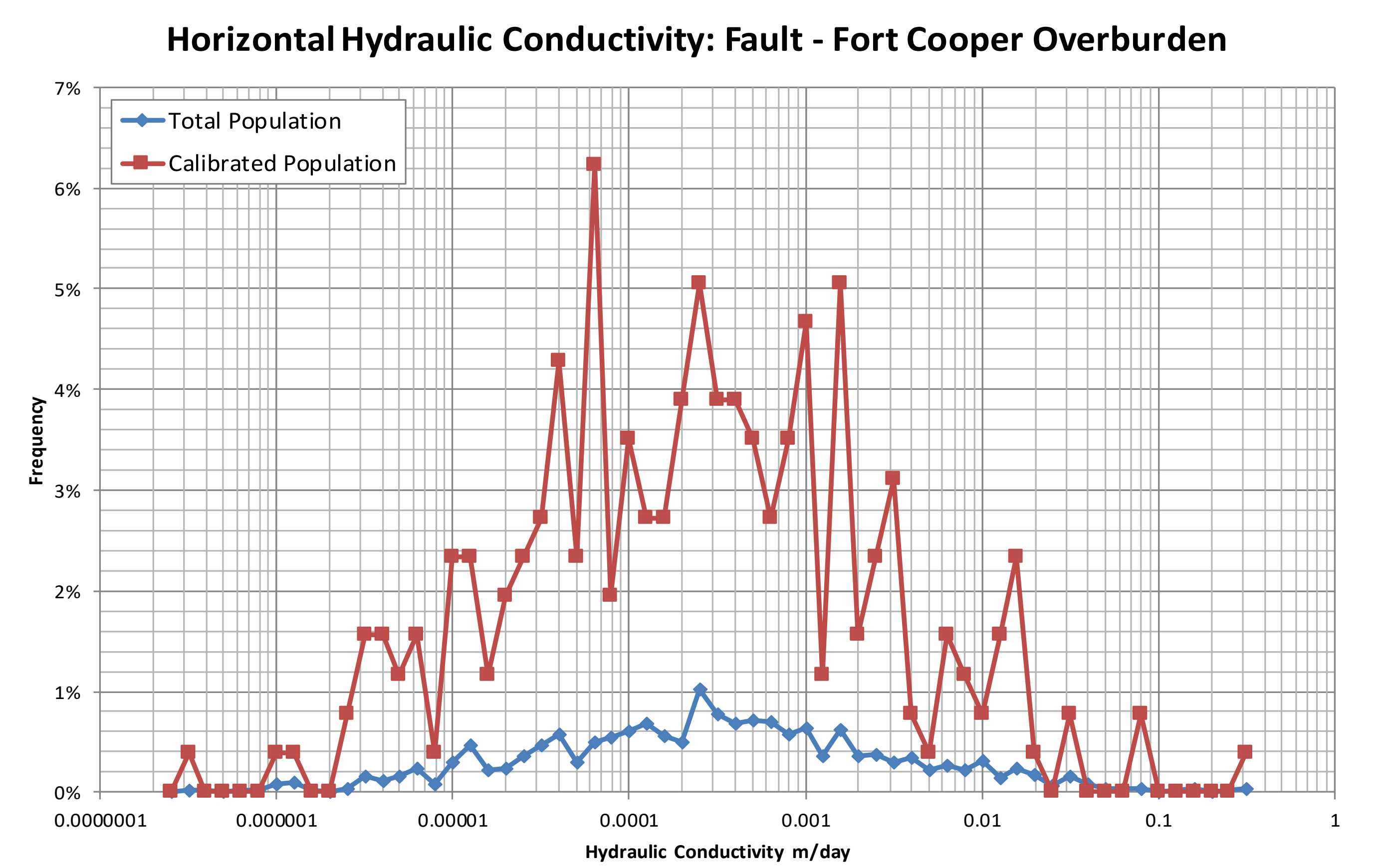
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



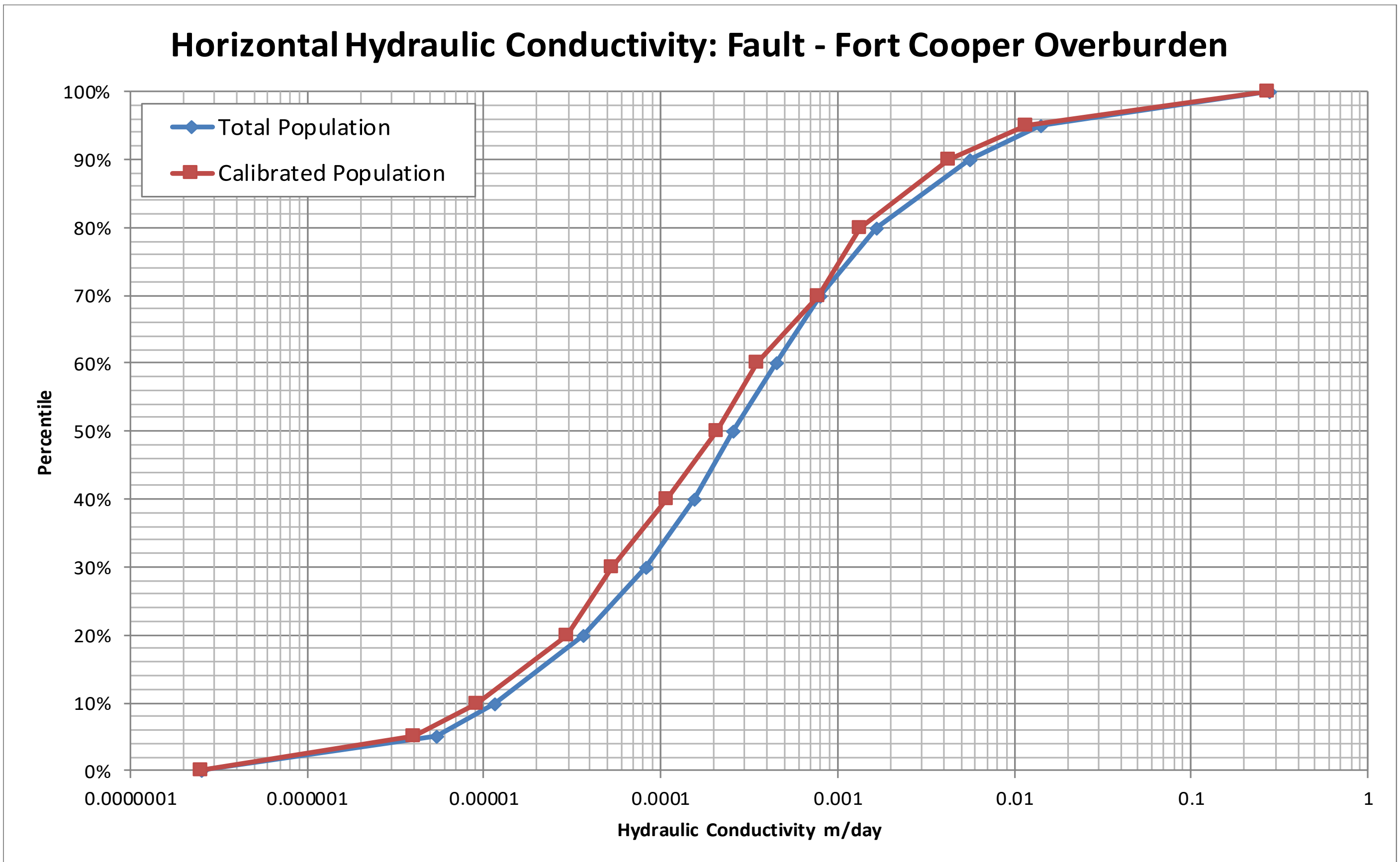


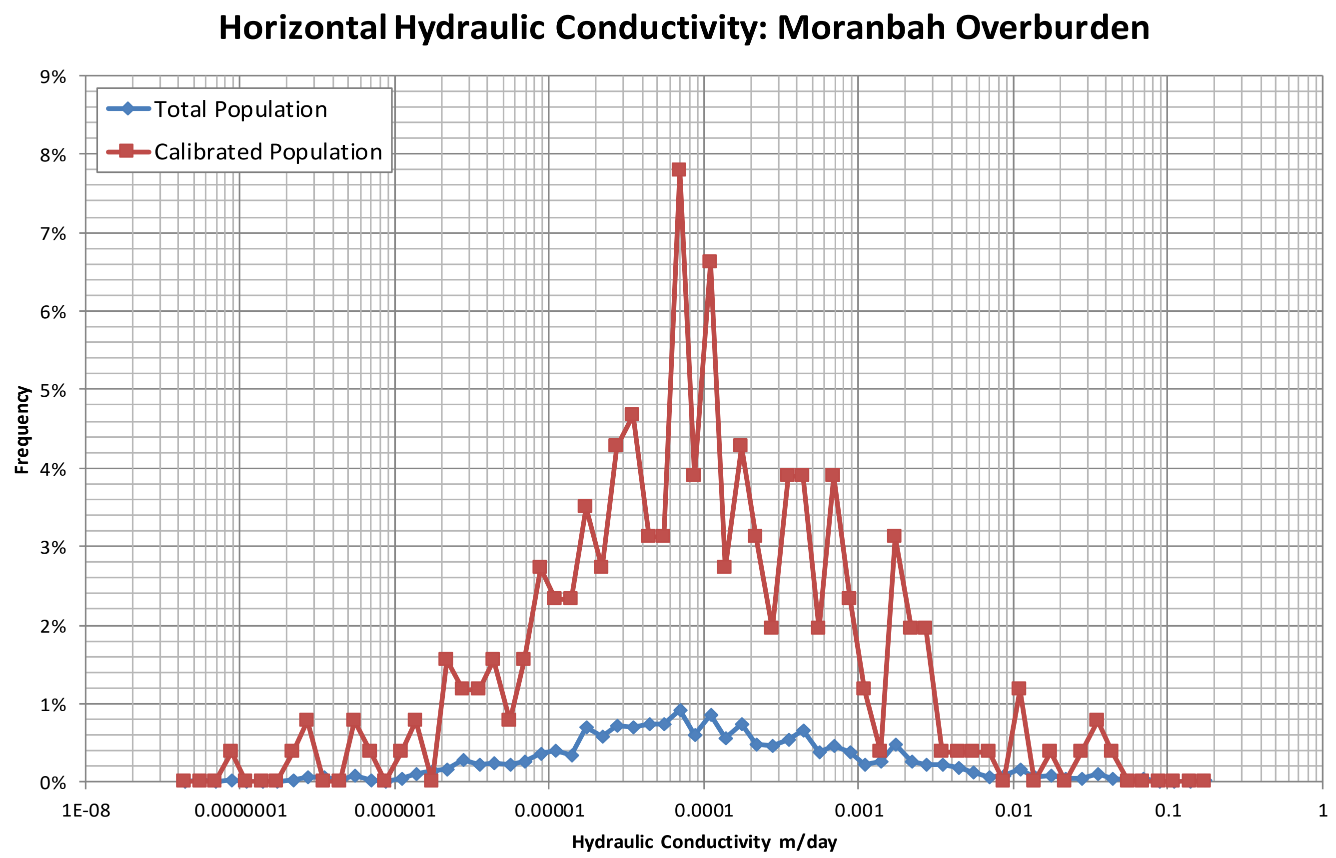
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



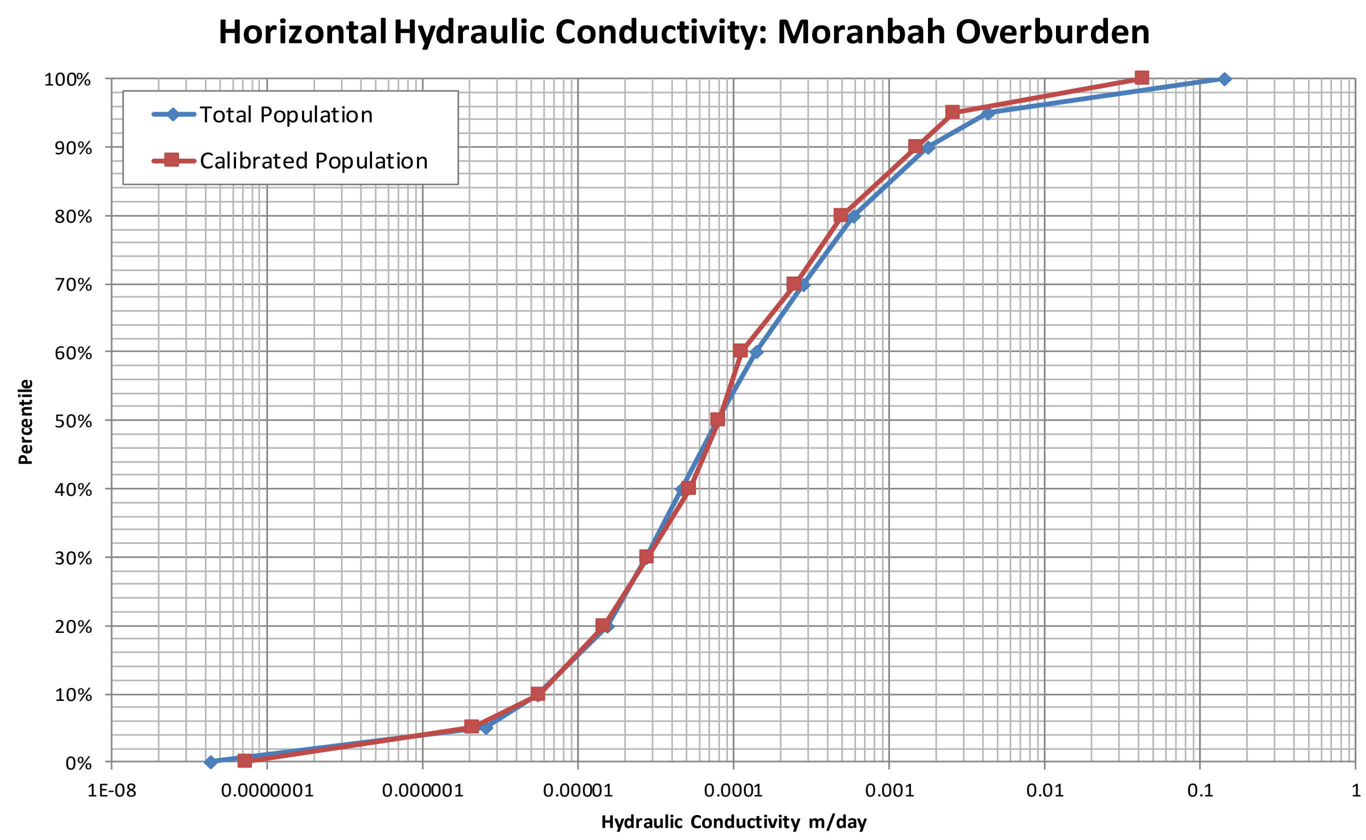


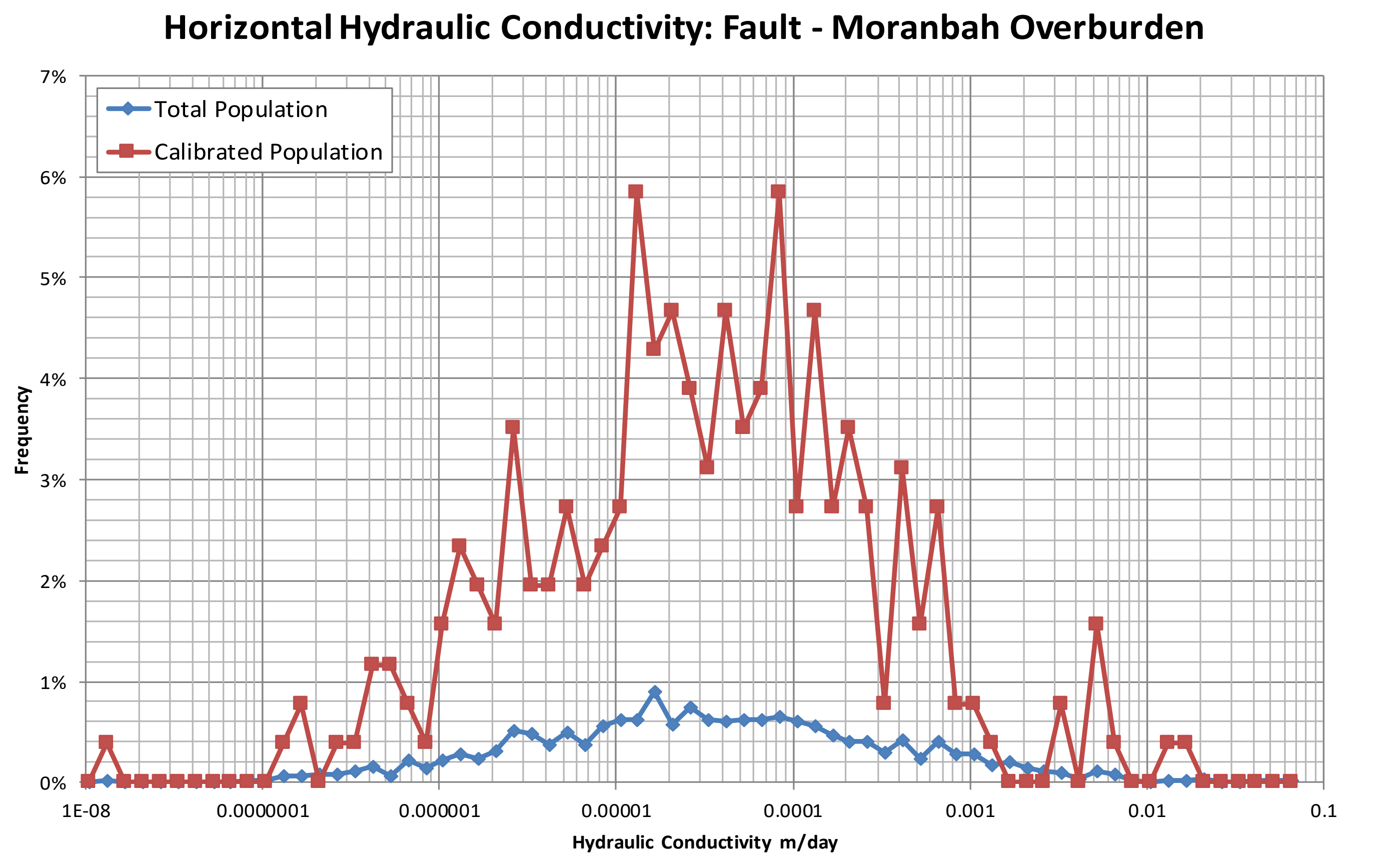
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



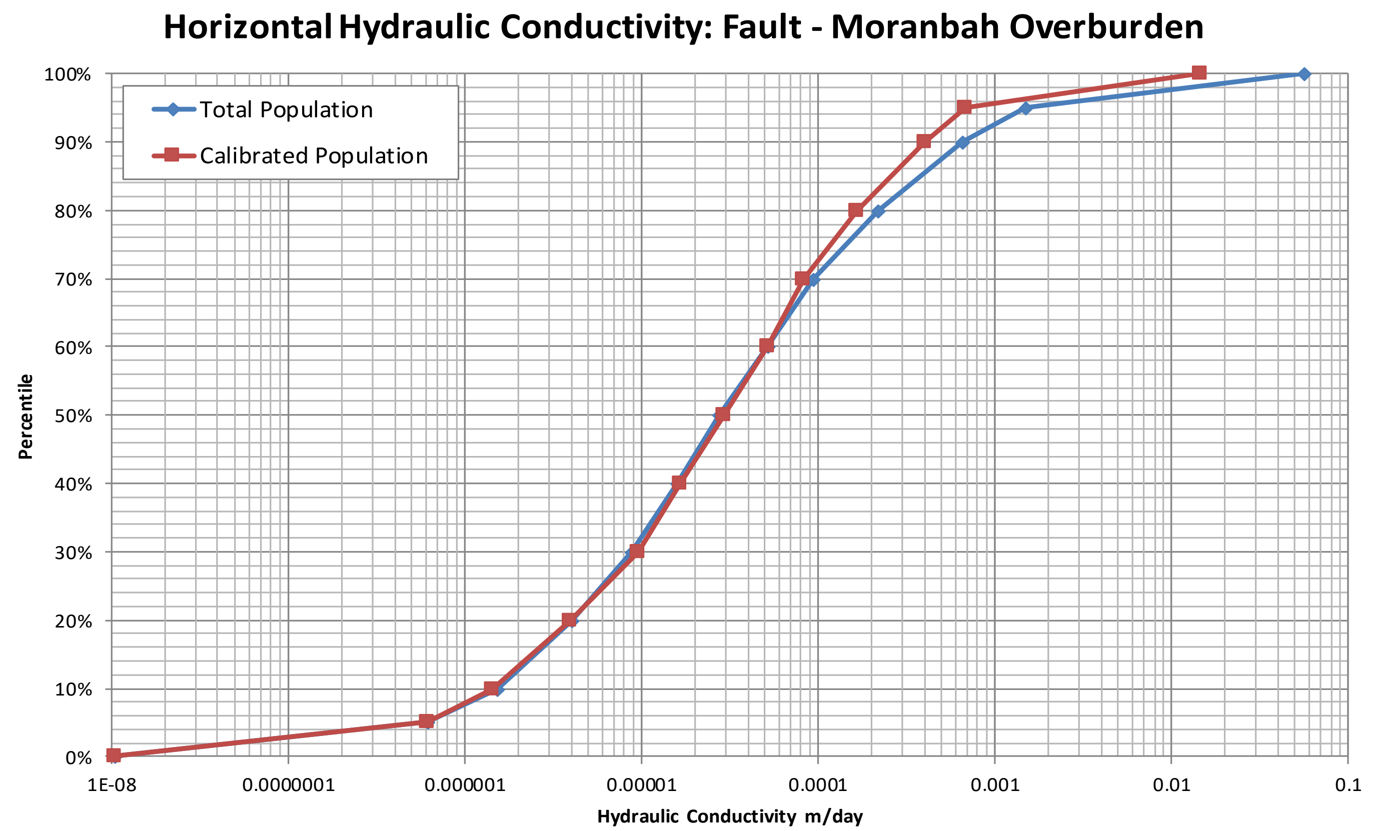


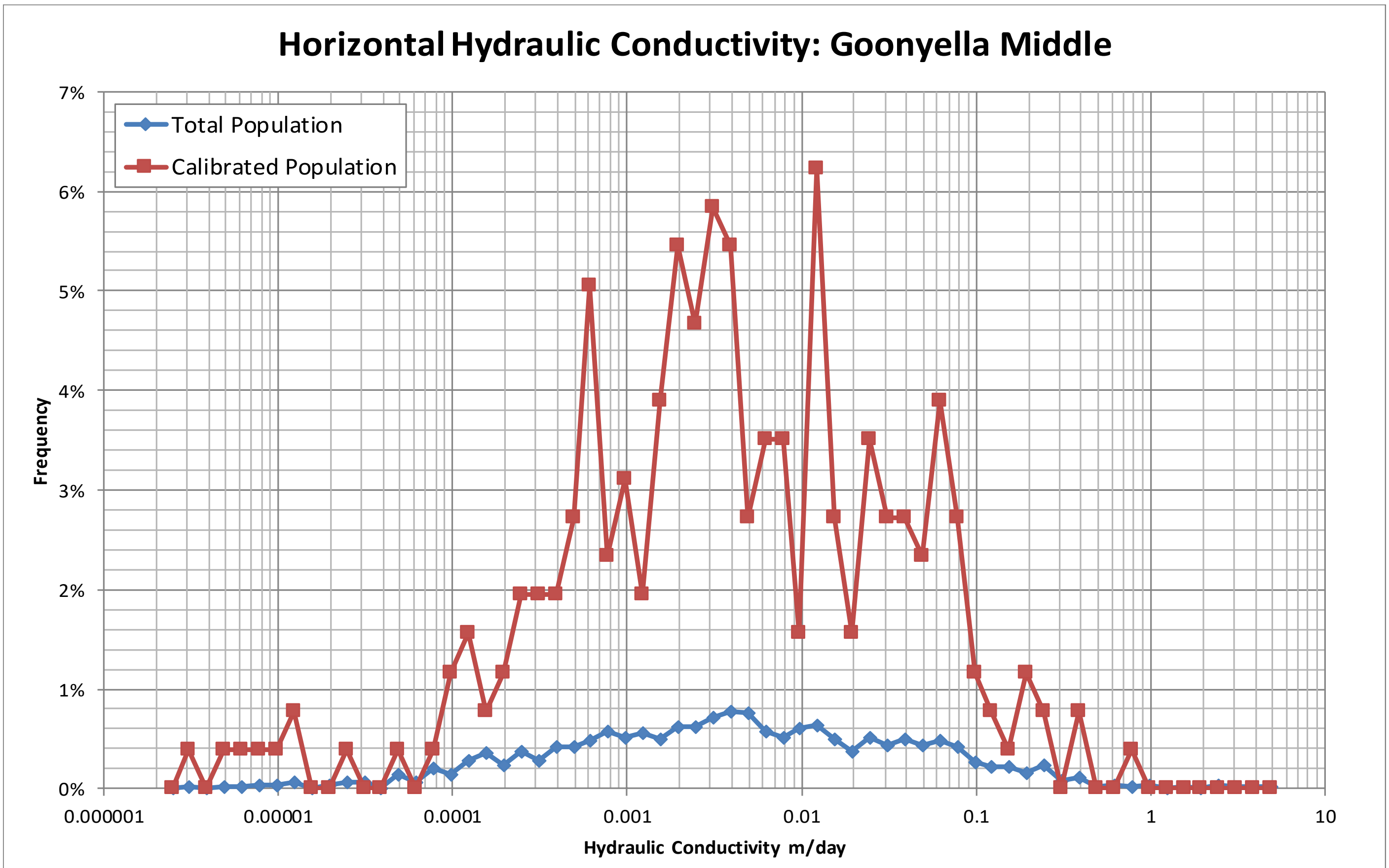
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



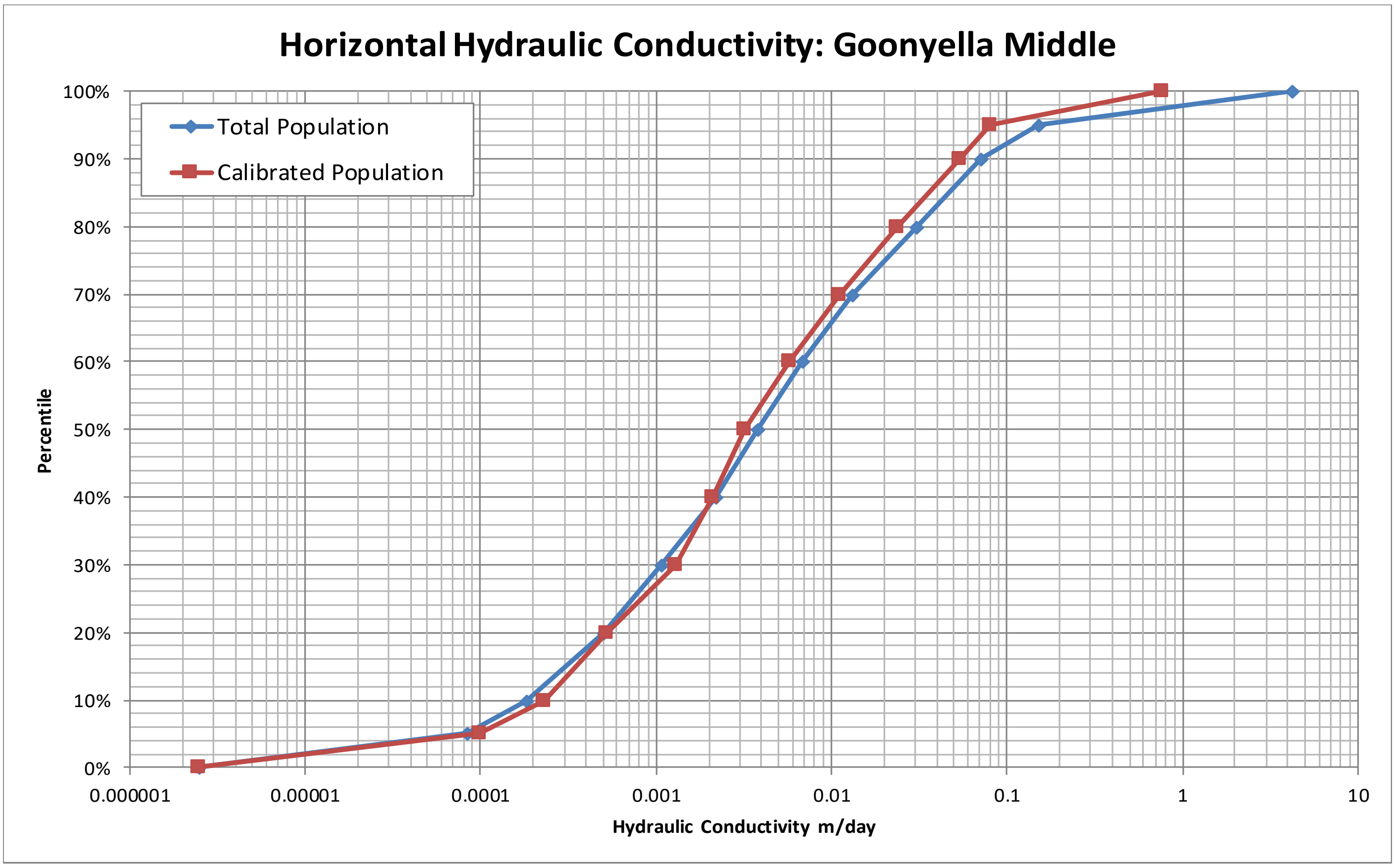


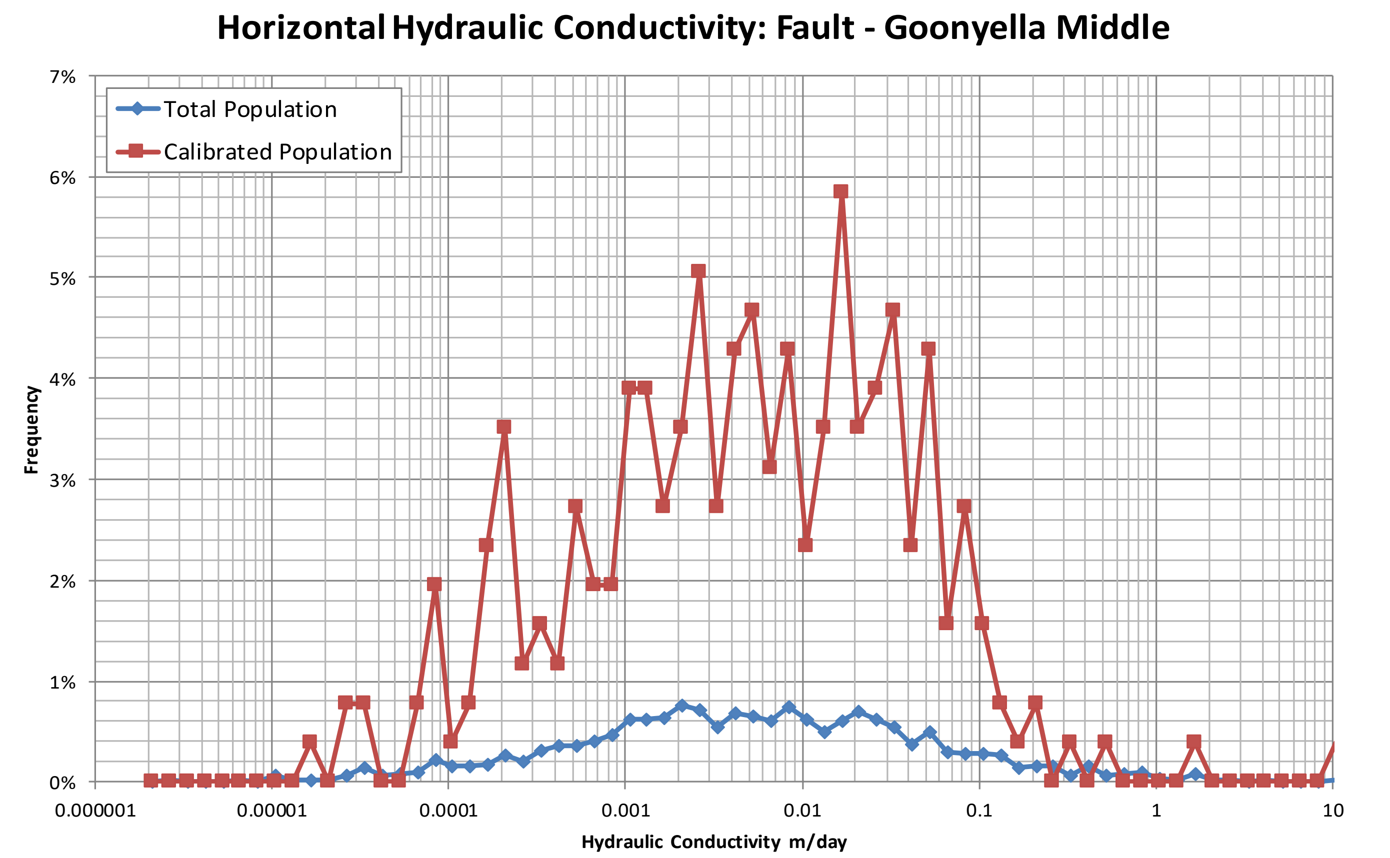
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



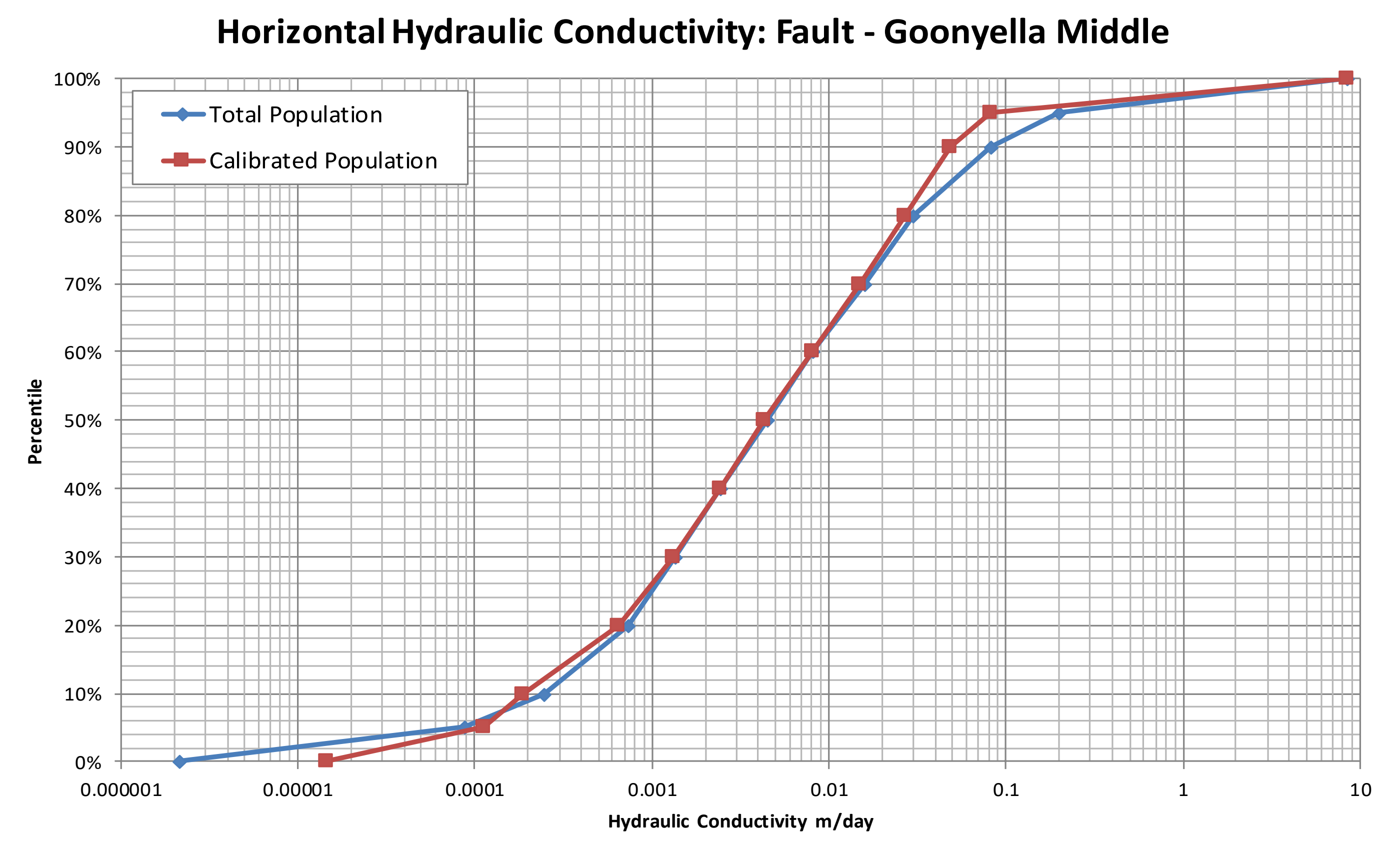


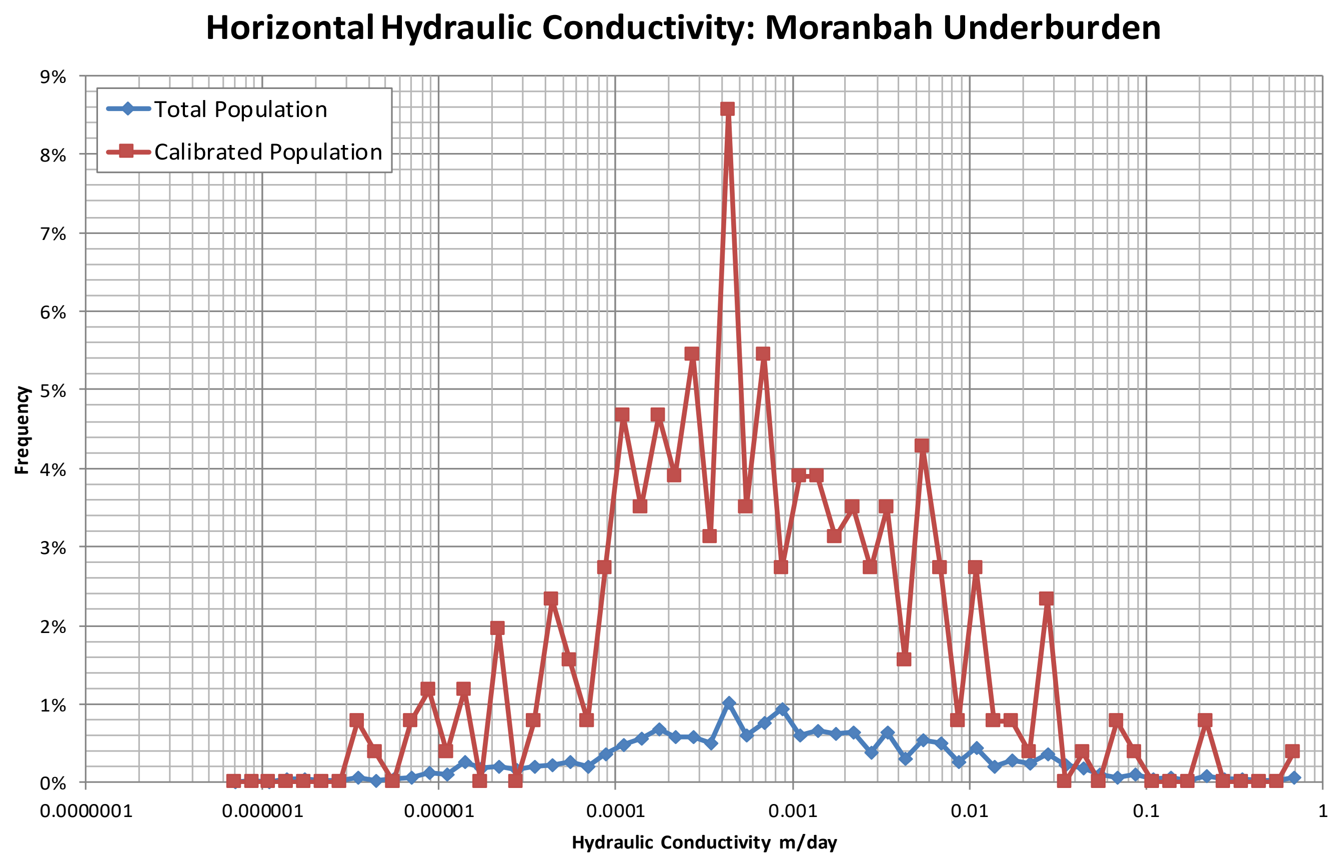
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



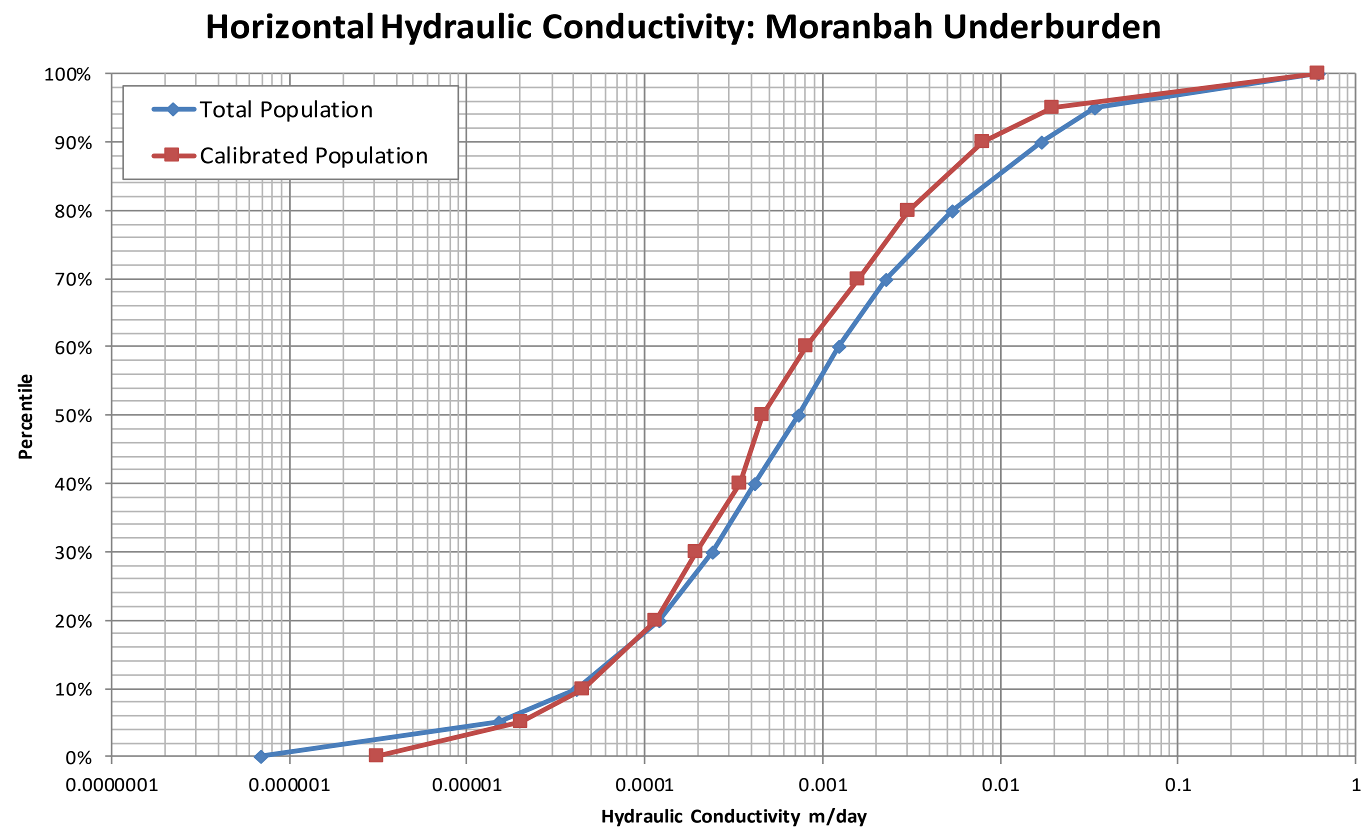


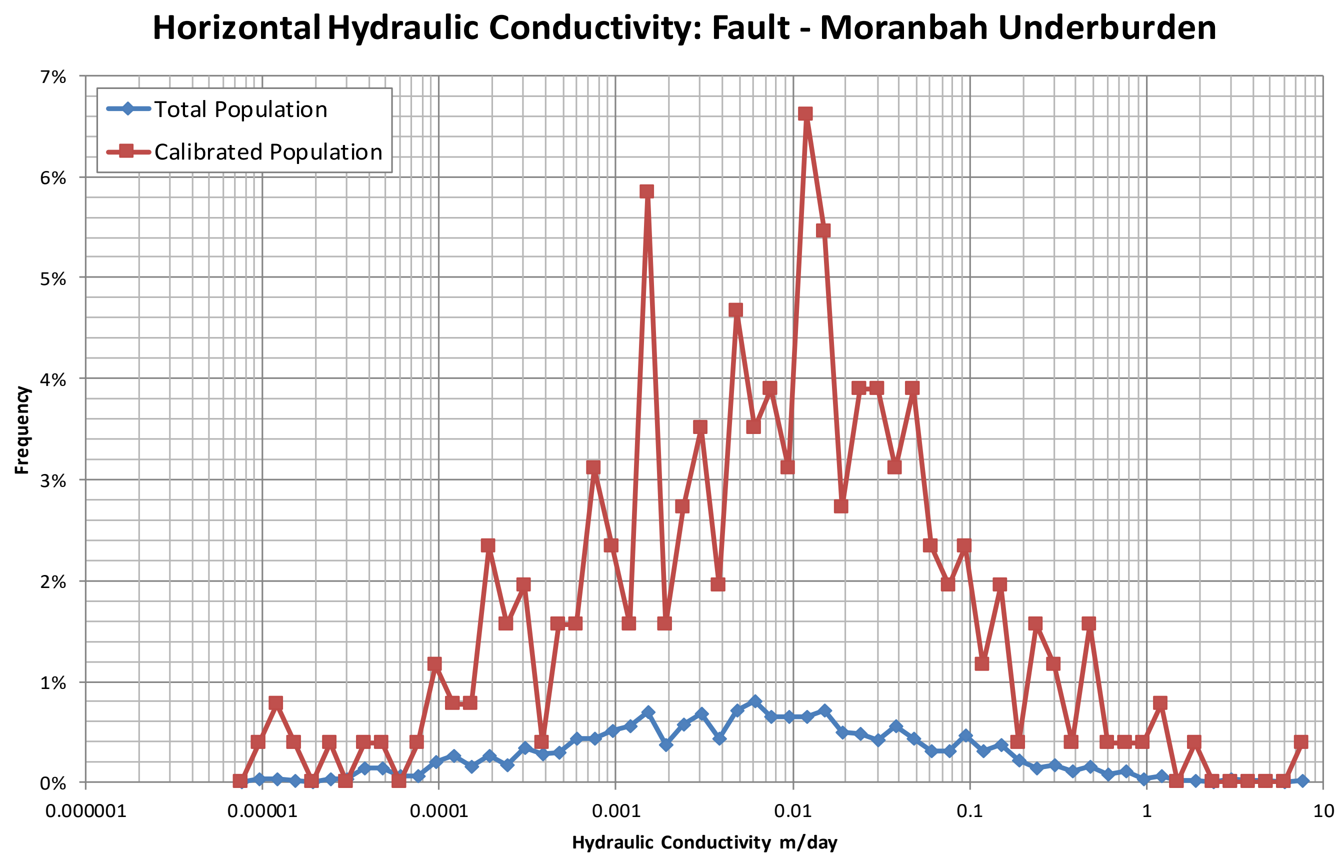
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



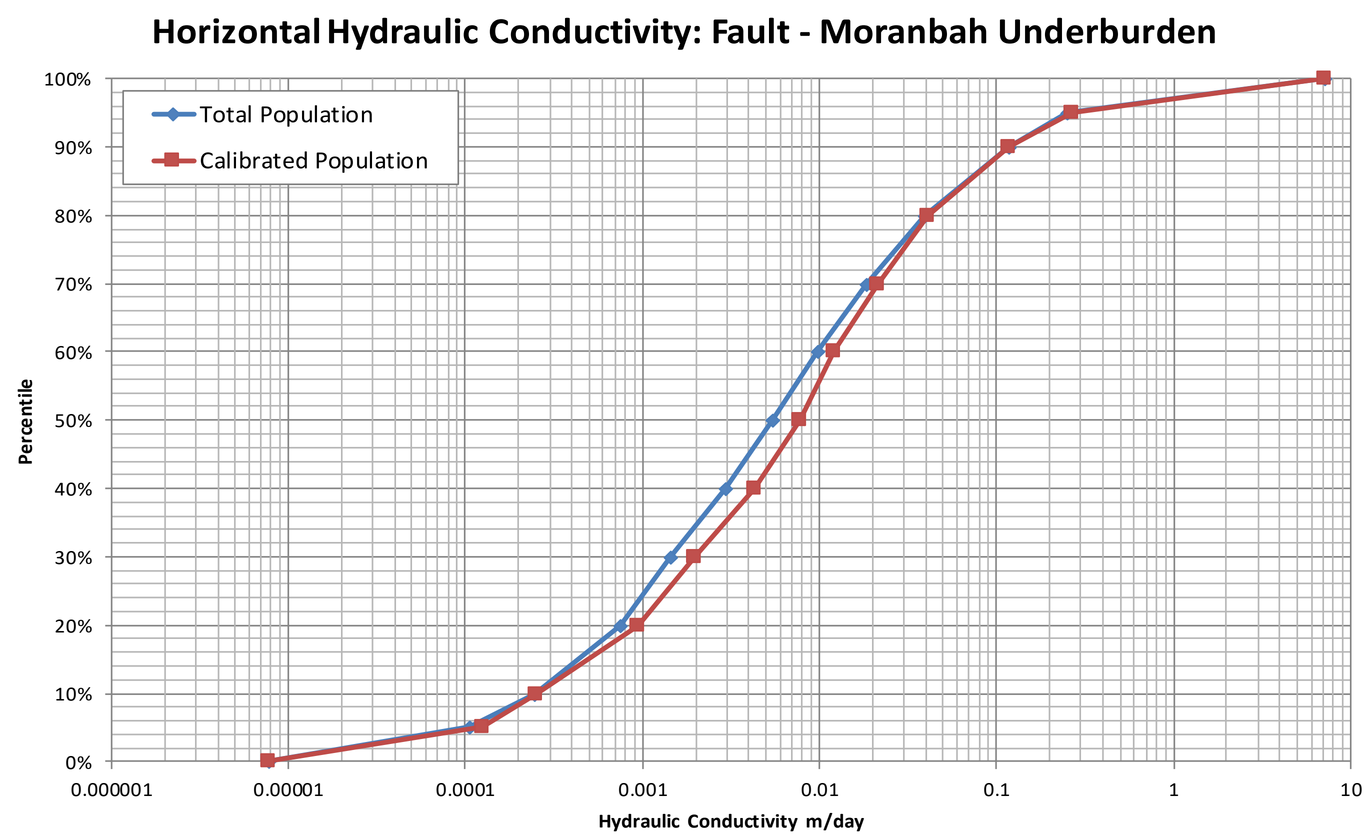


Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

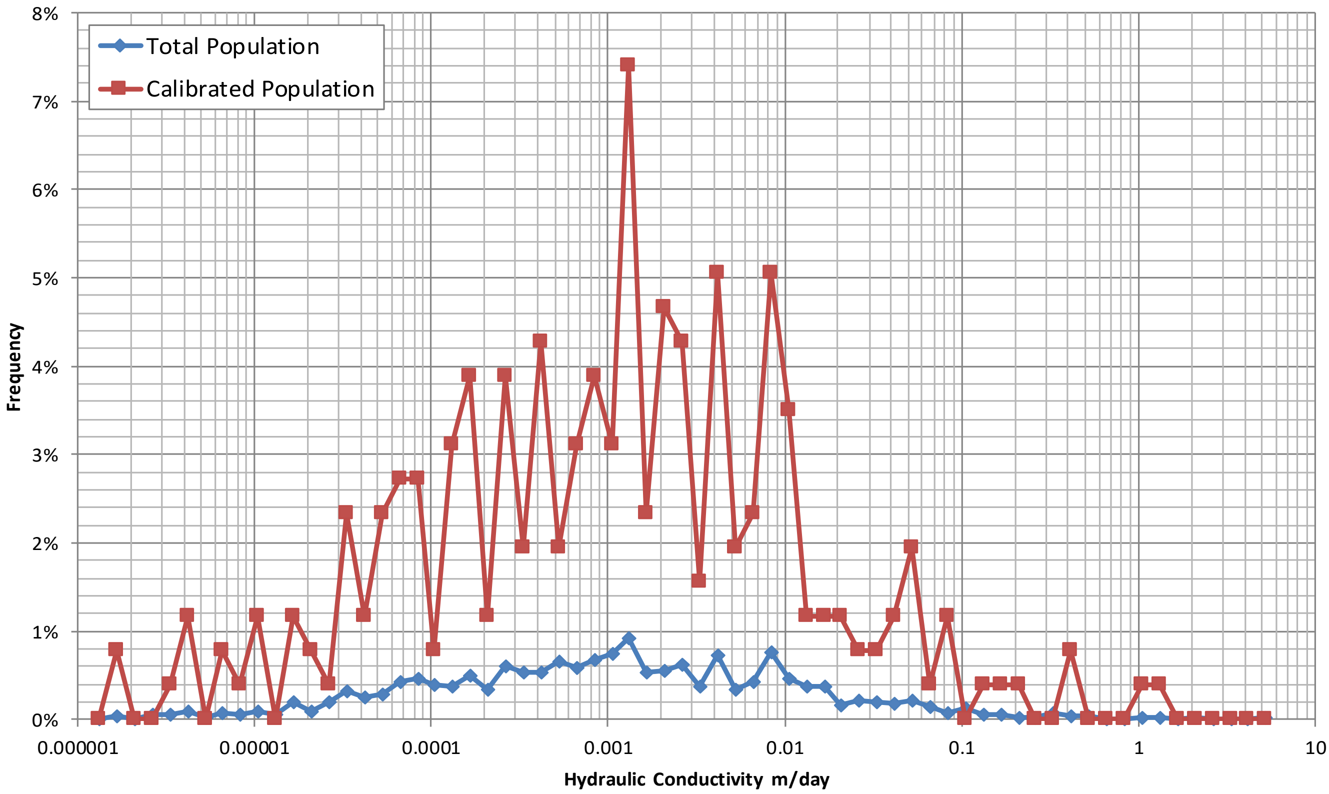




Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

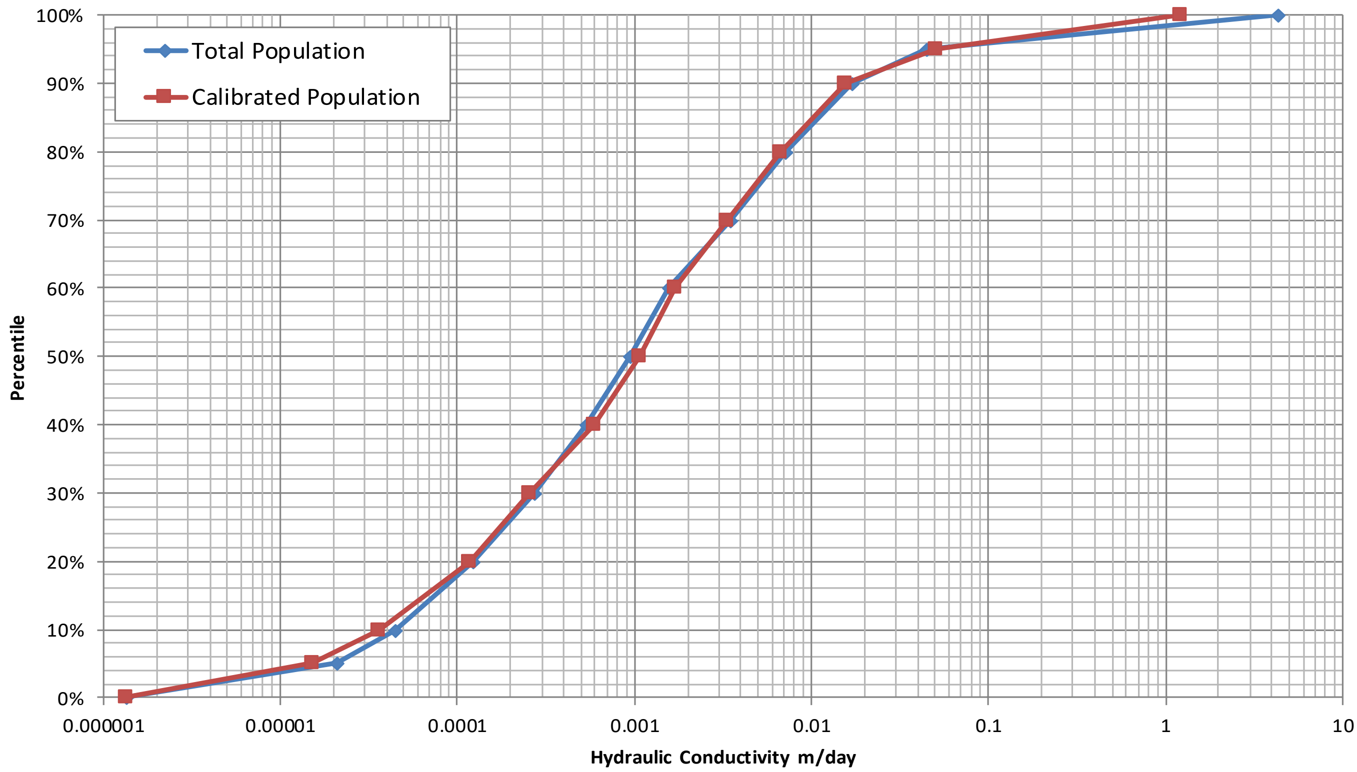


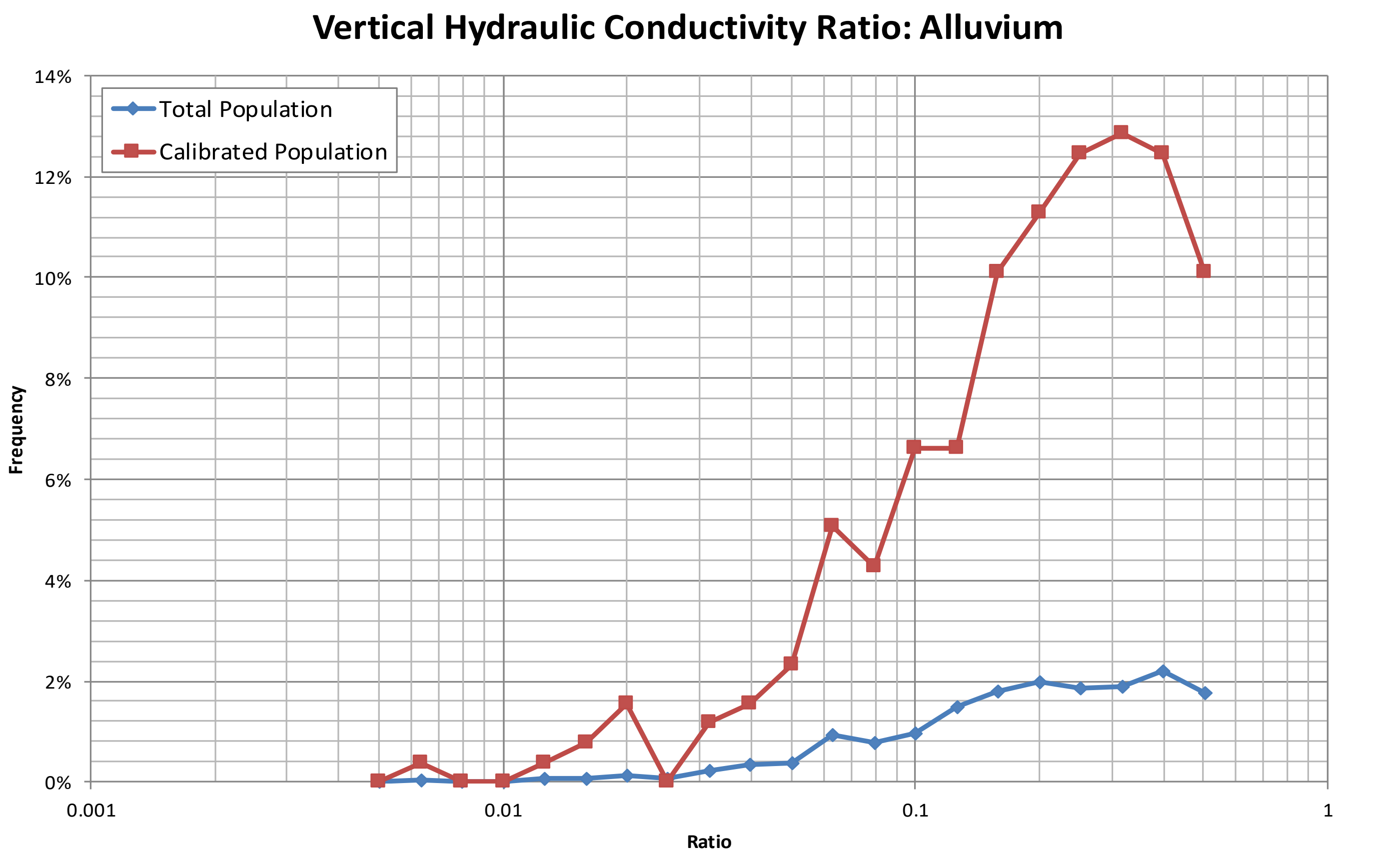
Horizontal Hydraulic Conductivity: Undivided Intrusives



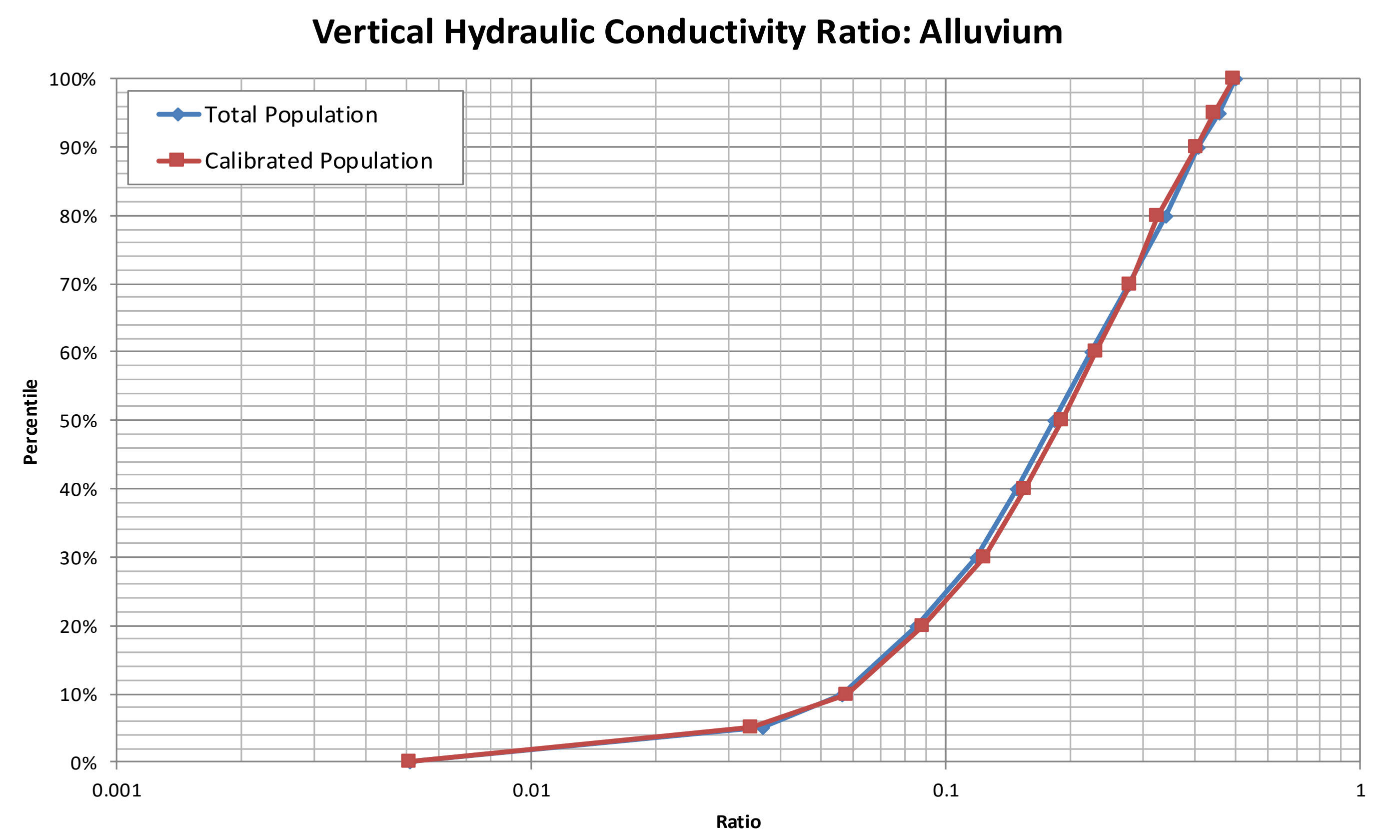
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

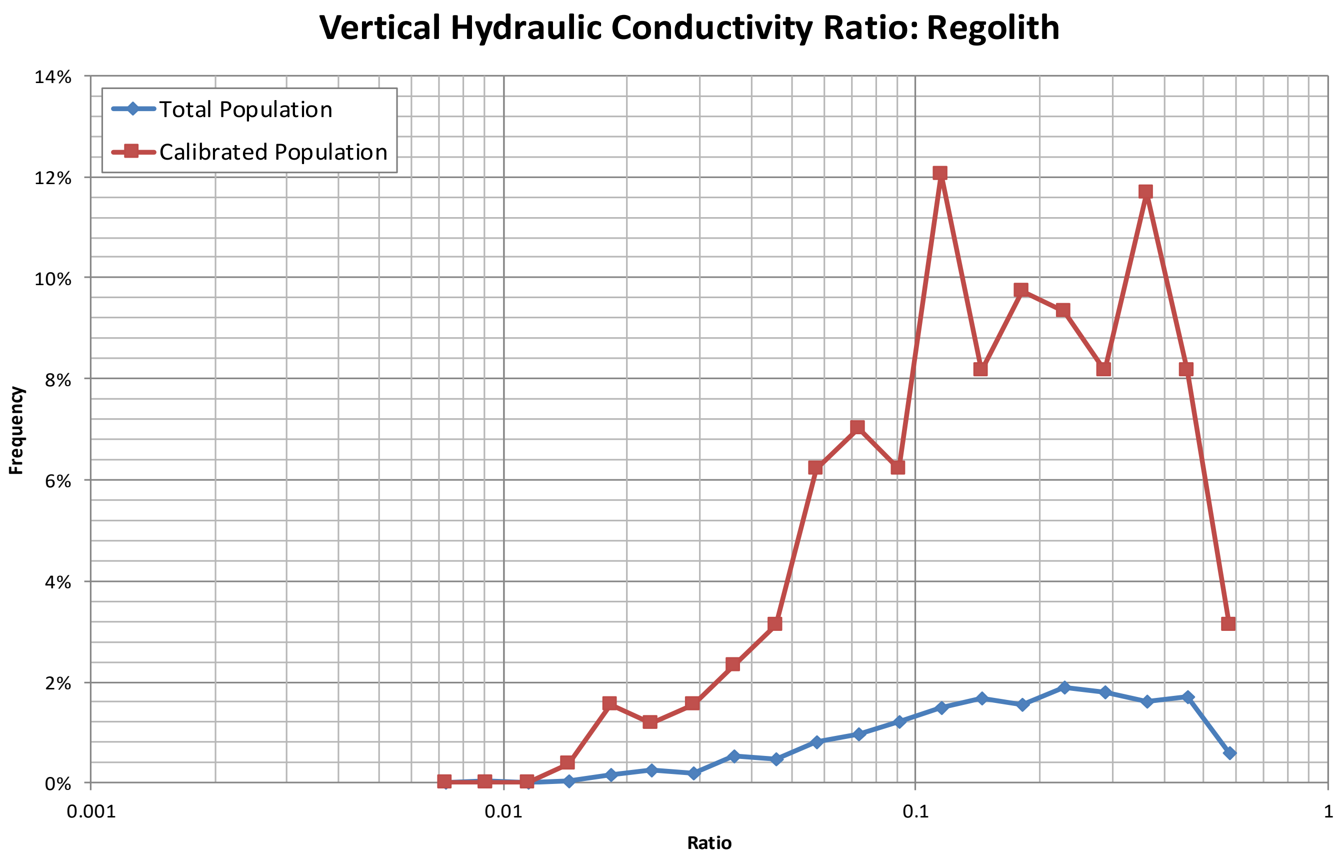
Horizontal Hydraulic Conductivity: Undivided Intrusives



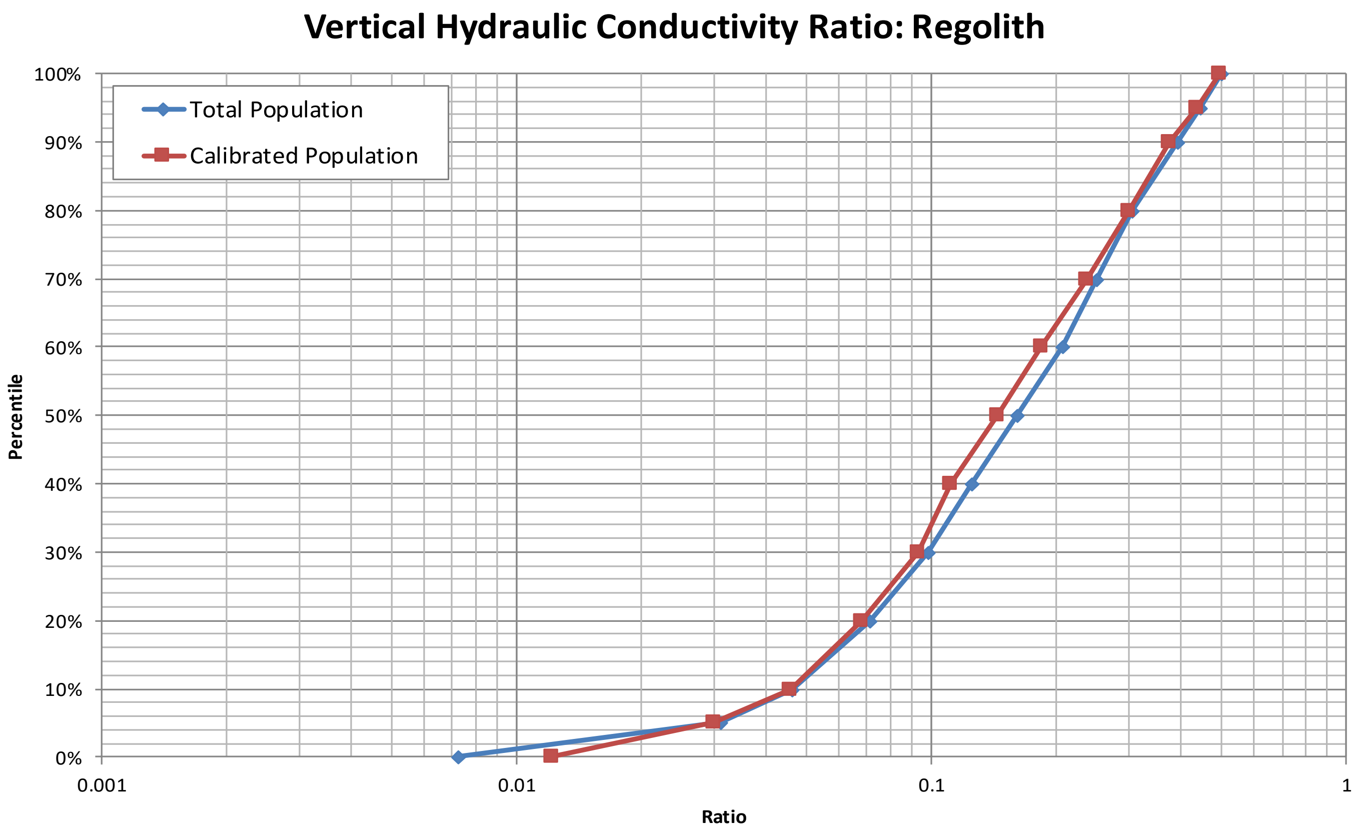


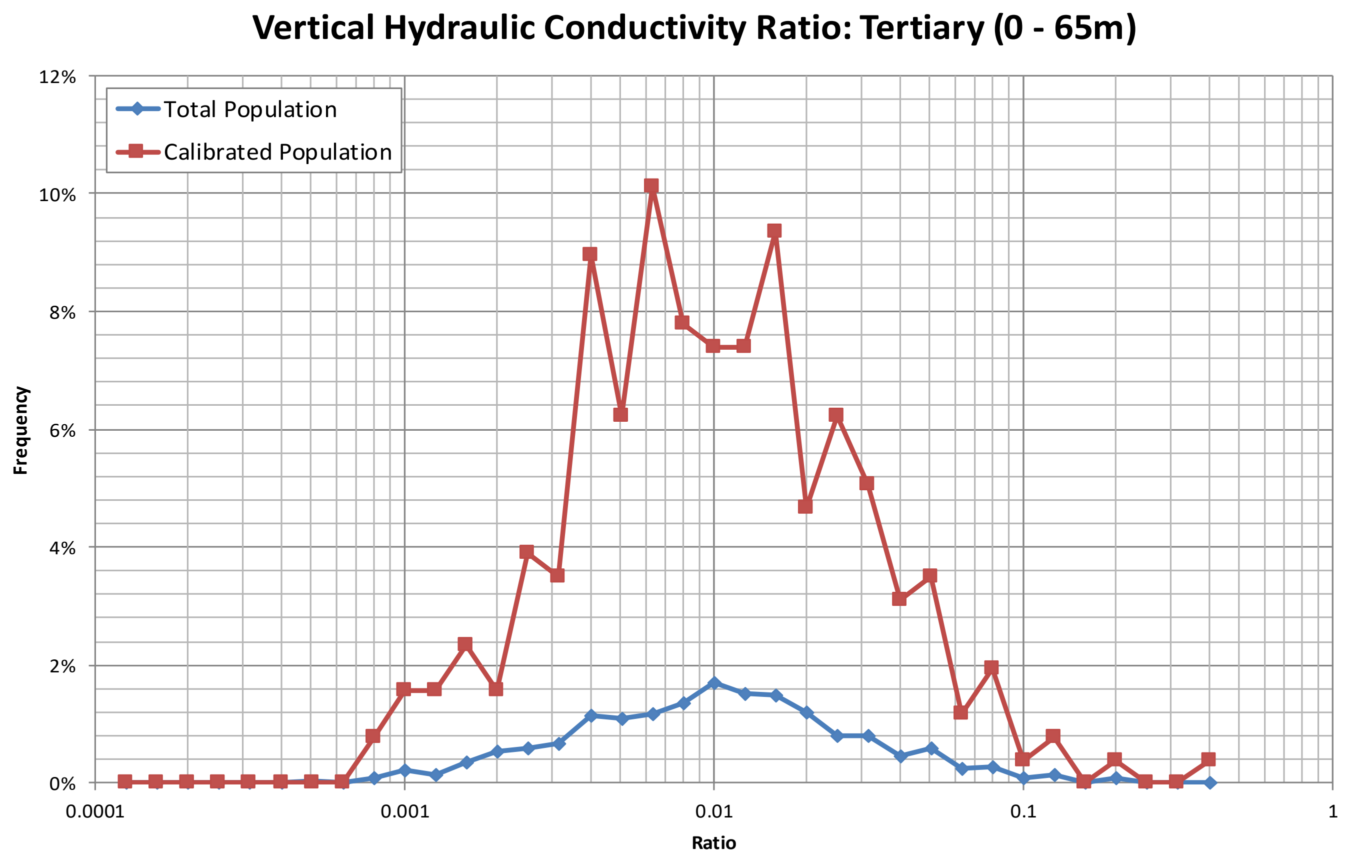
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



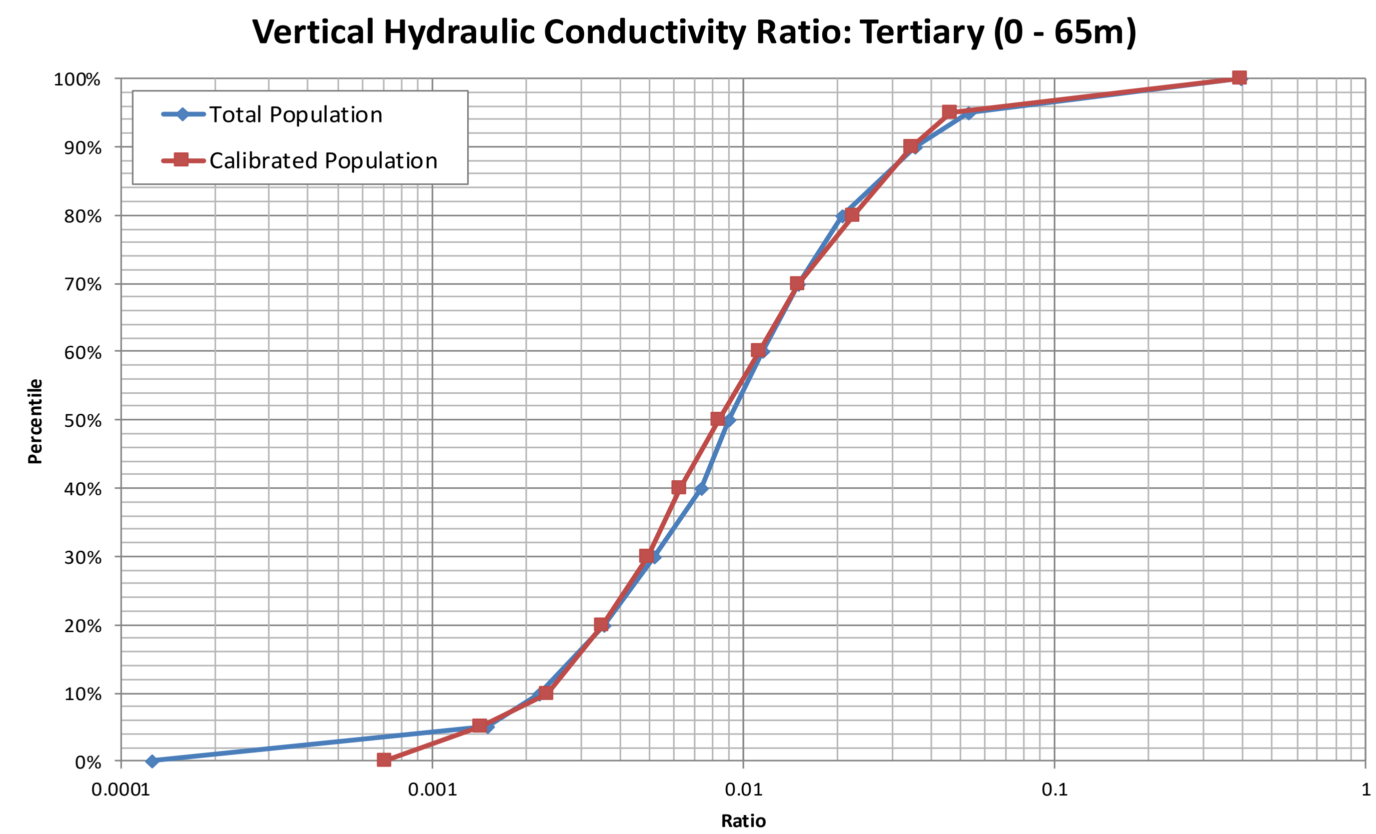


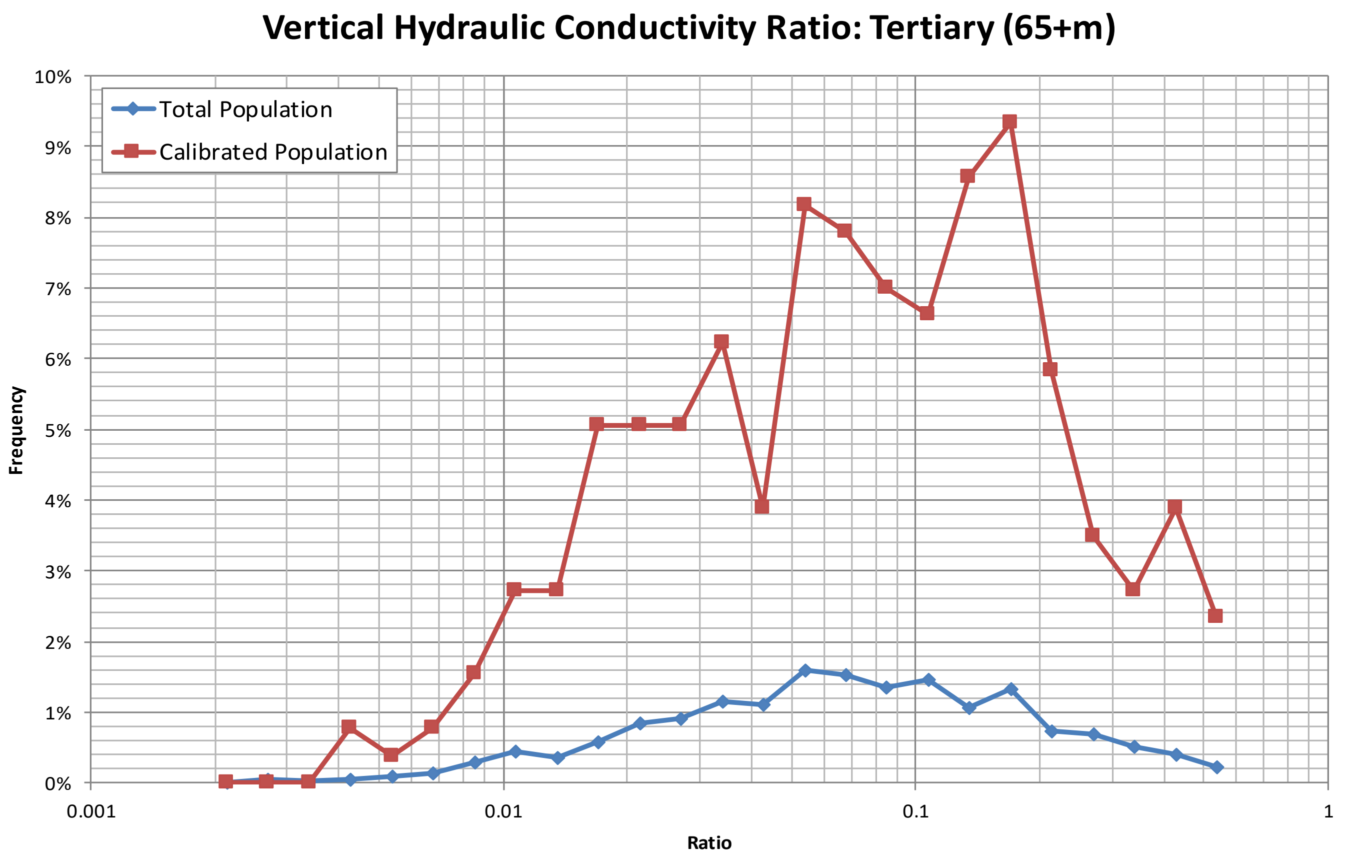
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



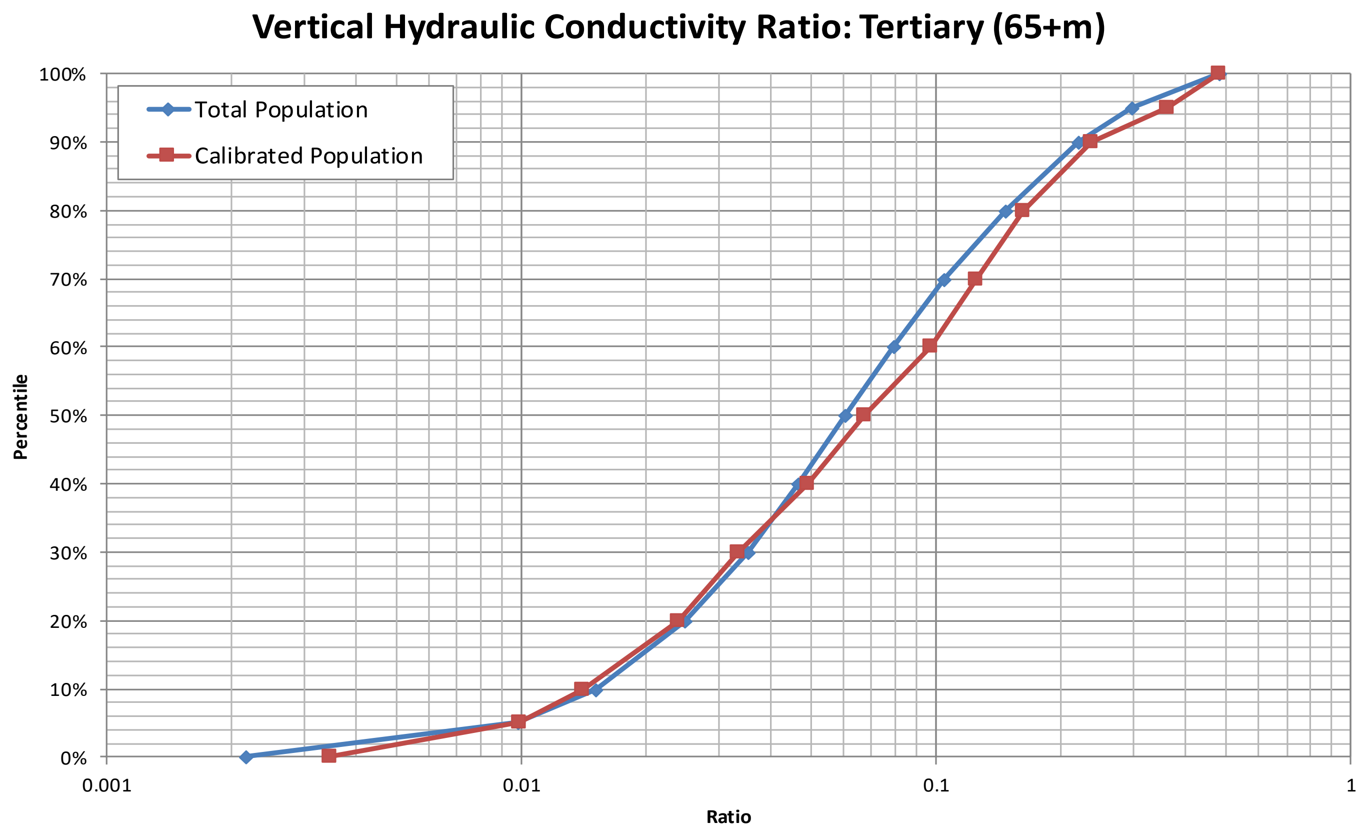


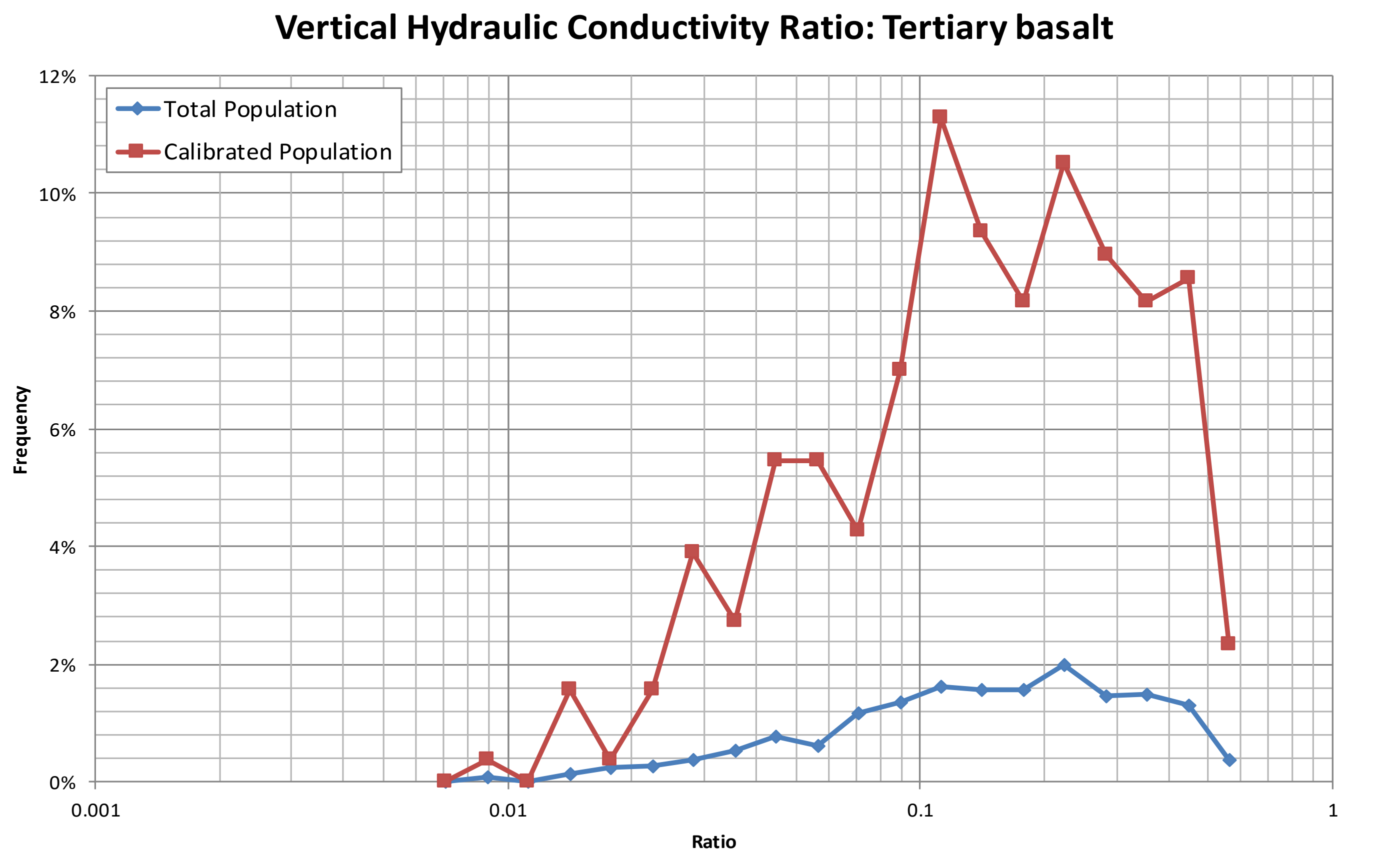
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



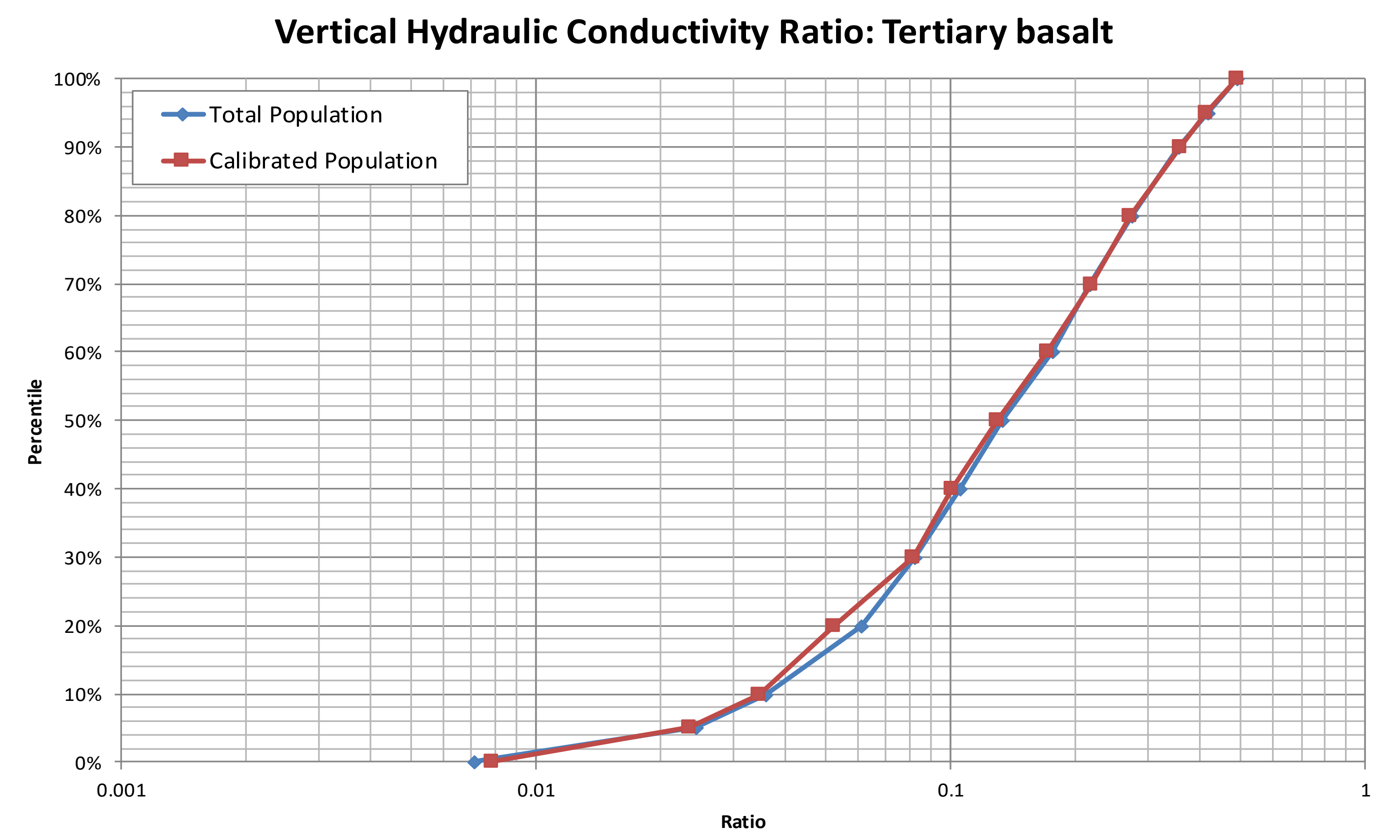


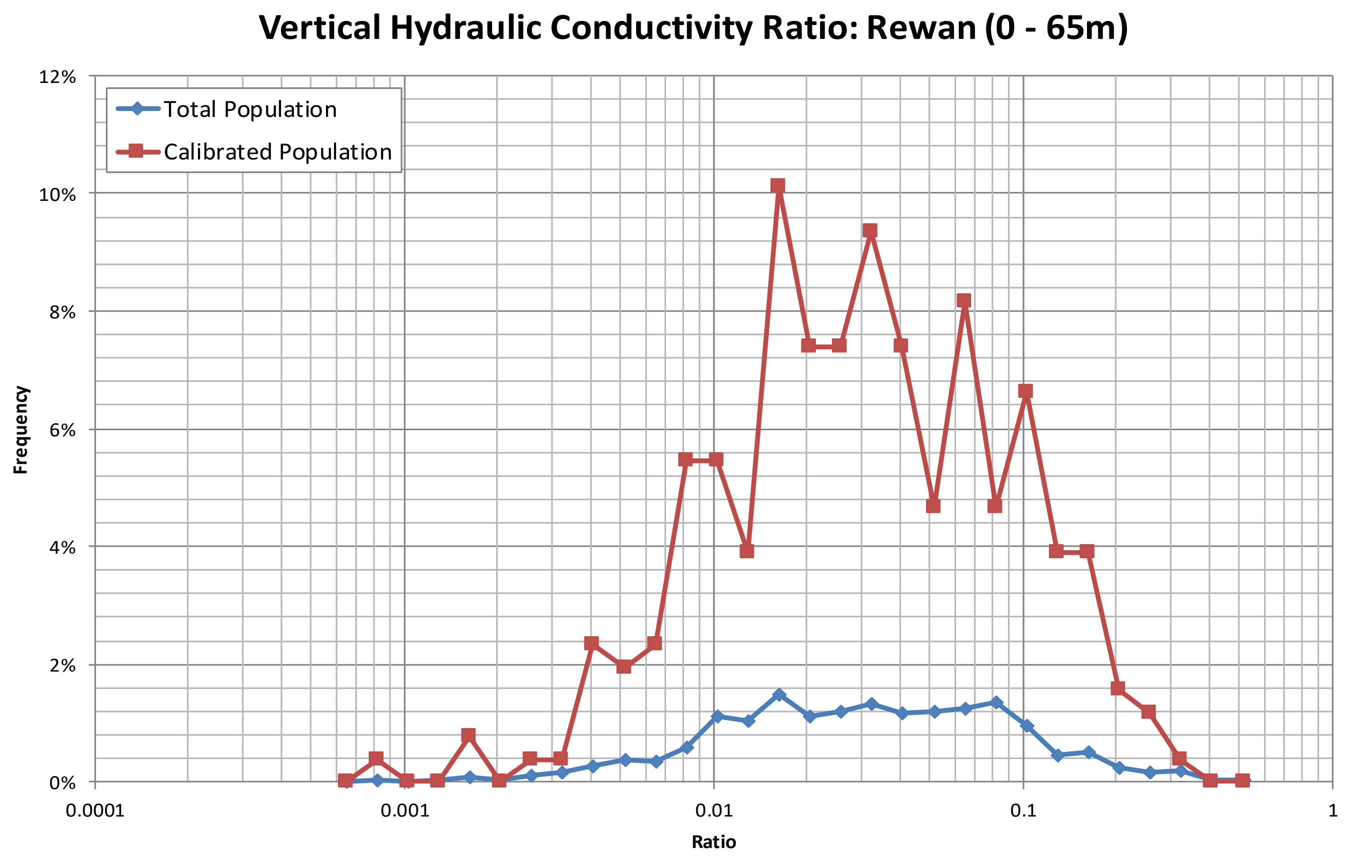
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



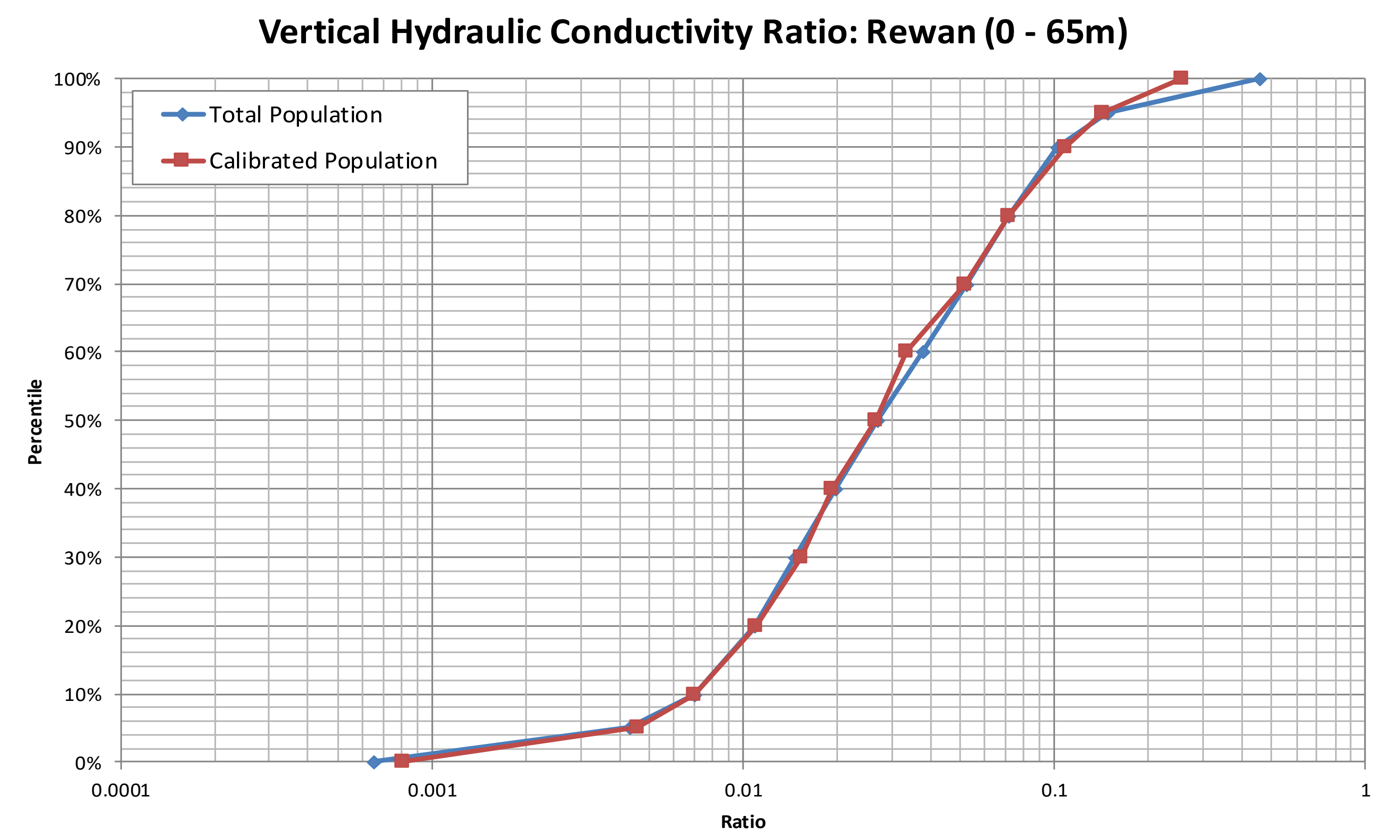


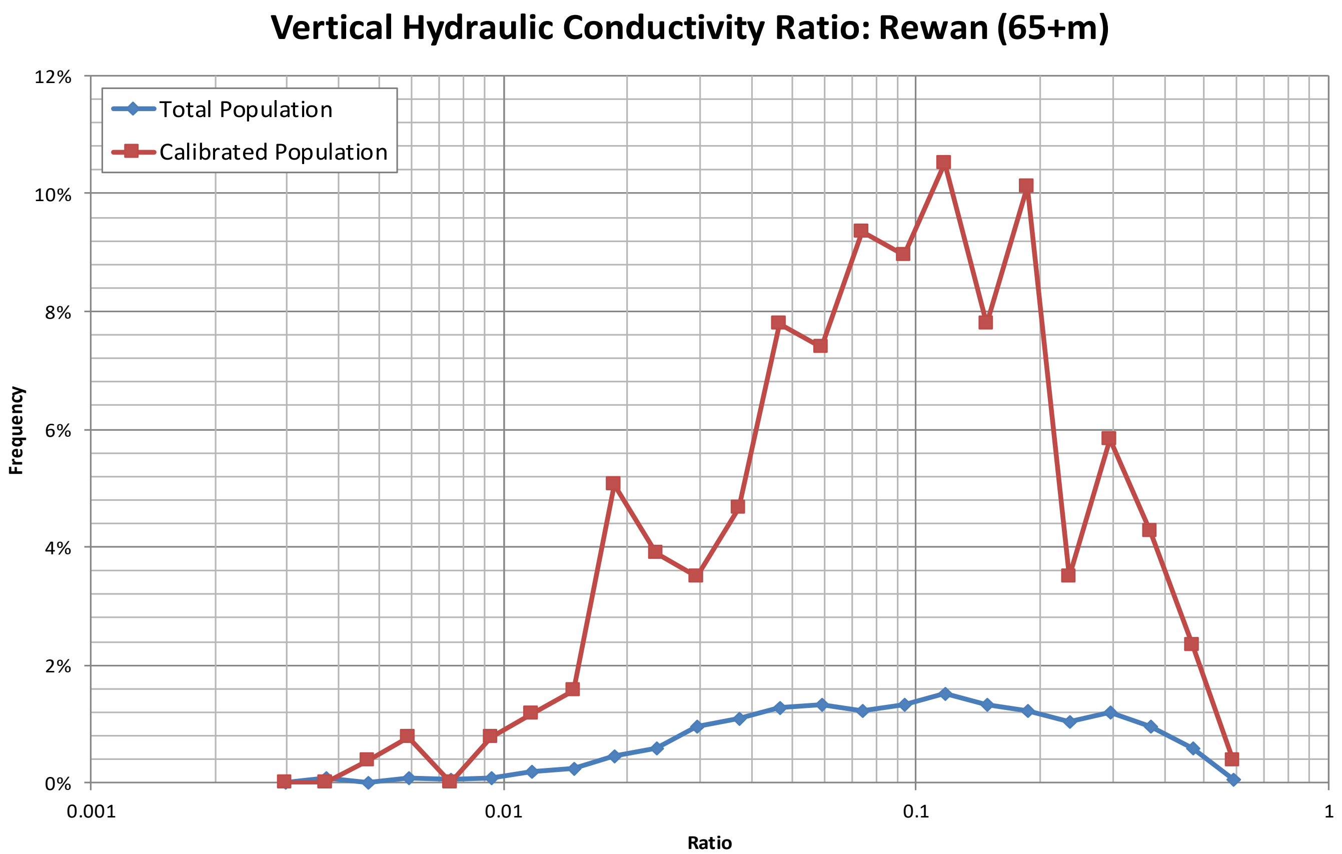
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



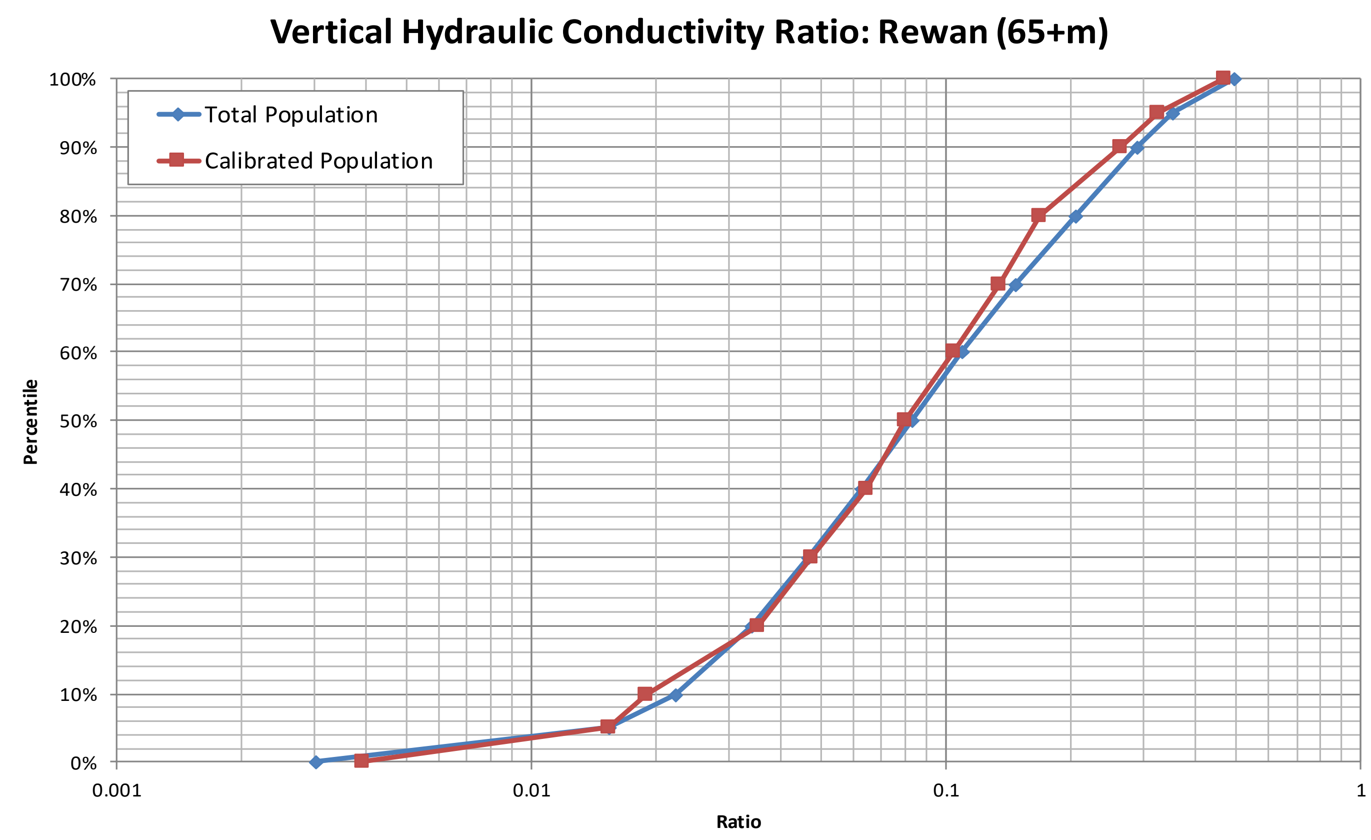


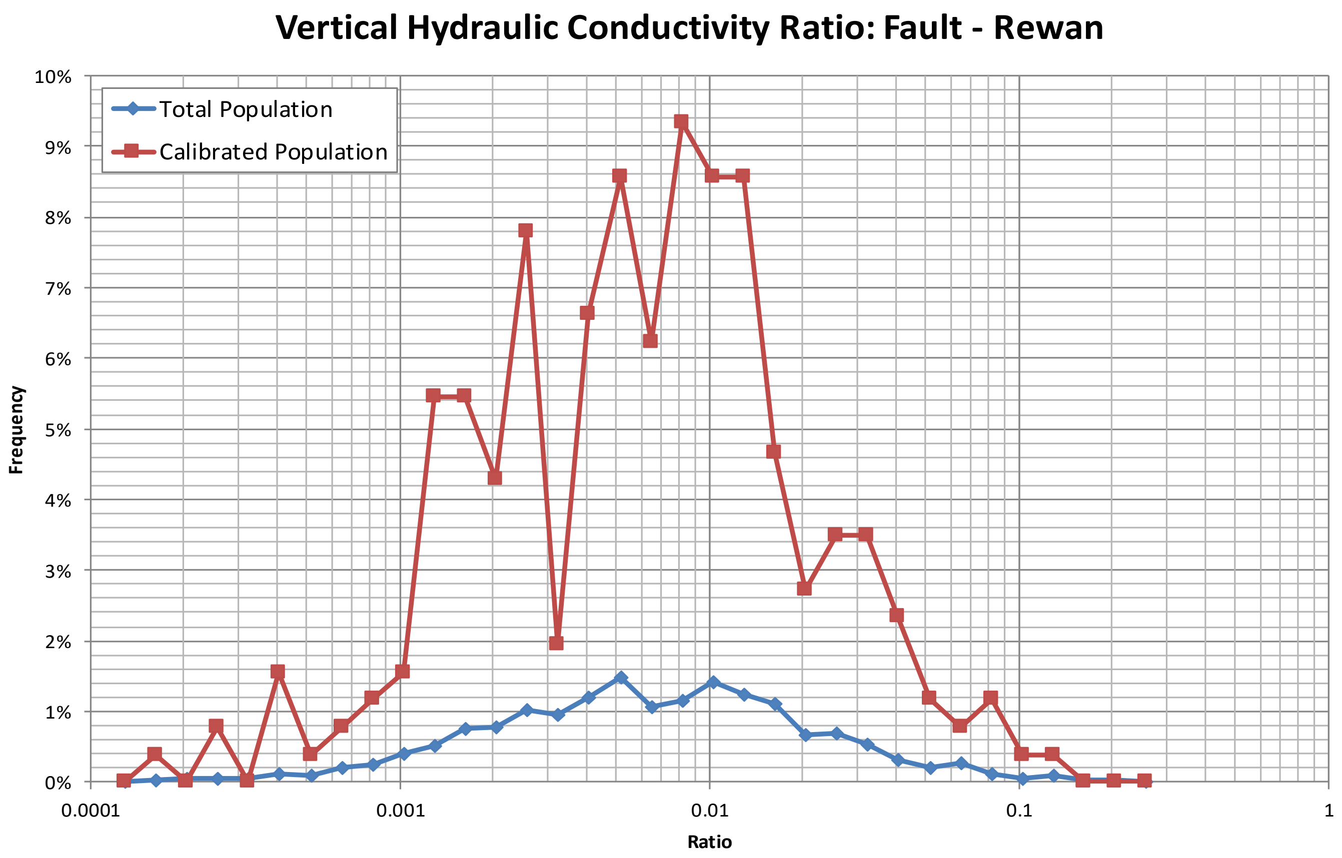
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



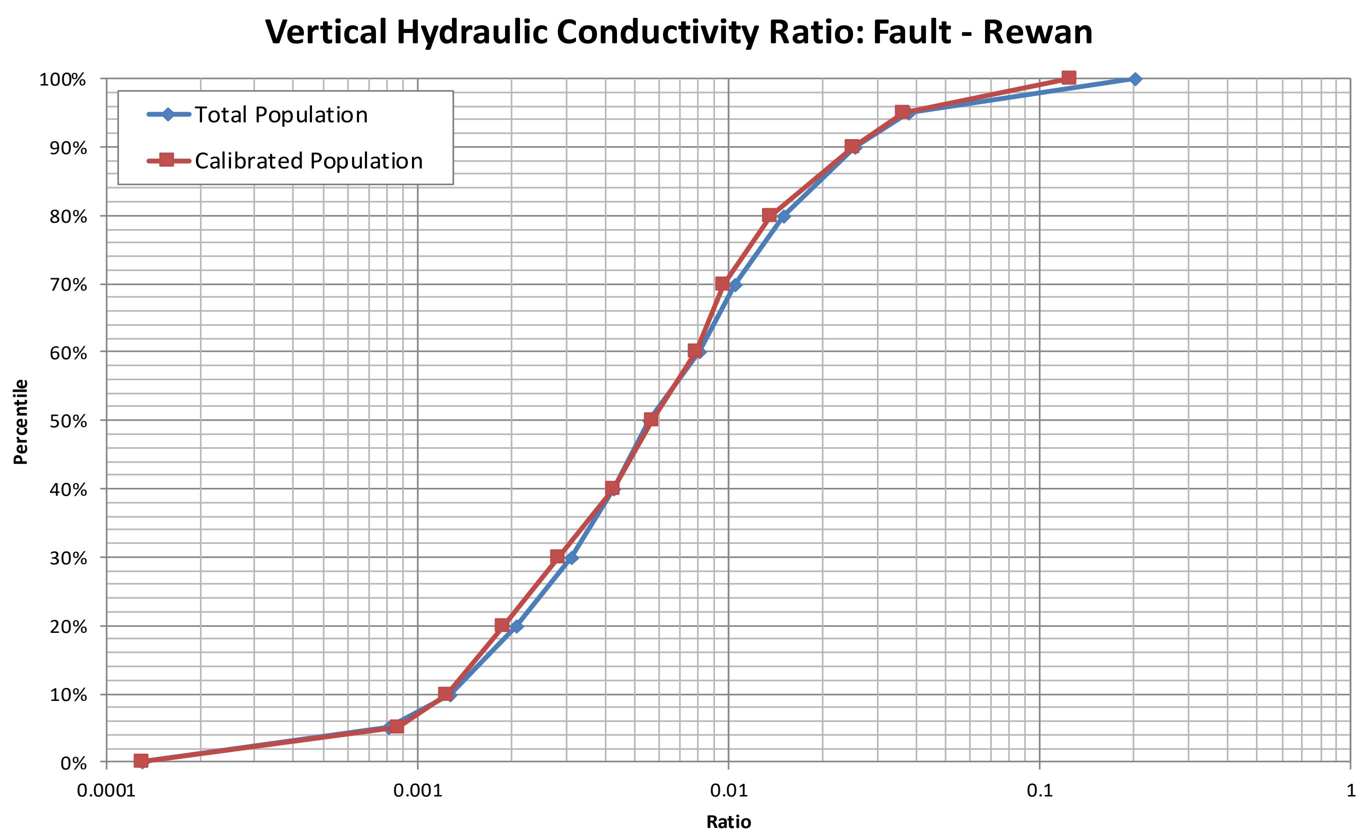


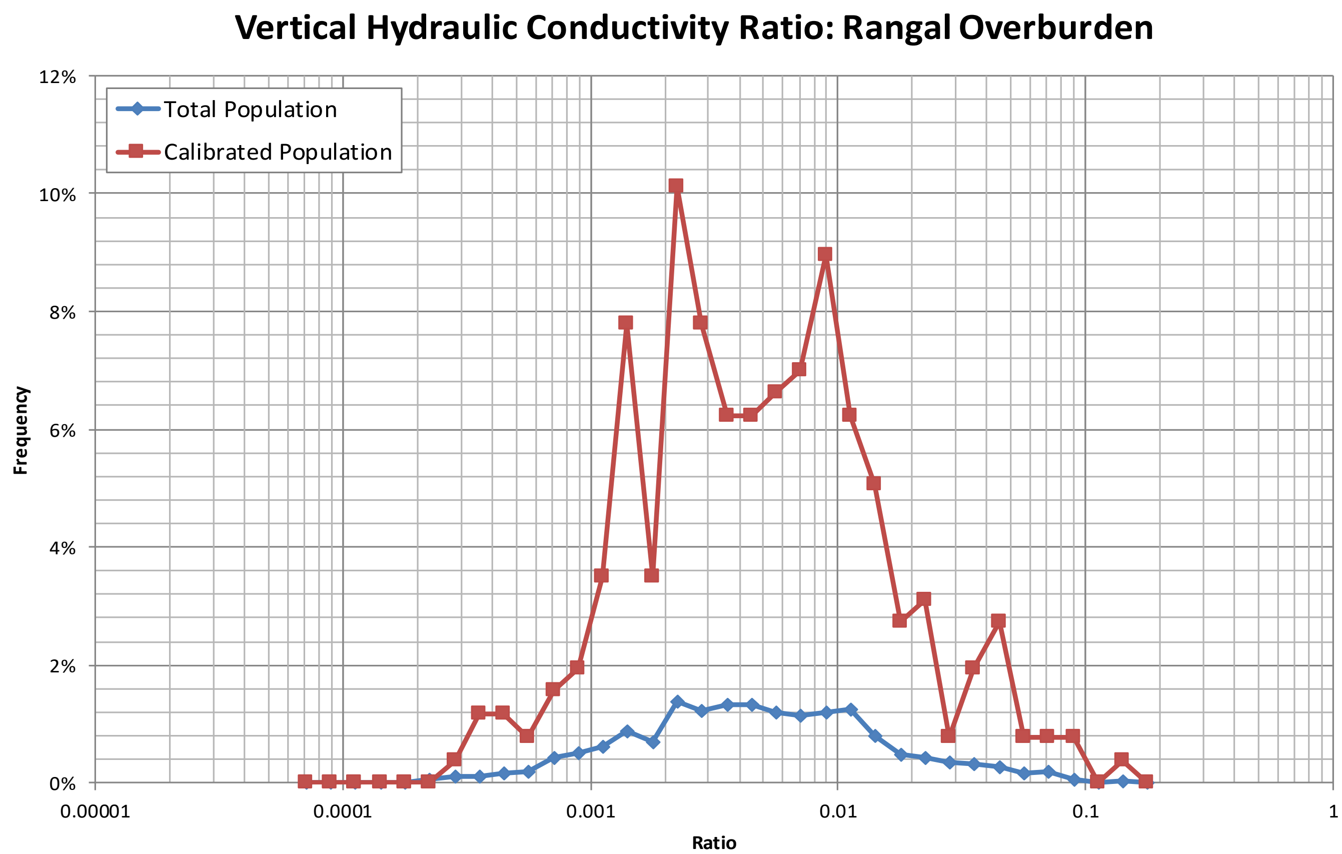
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



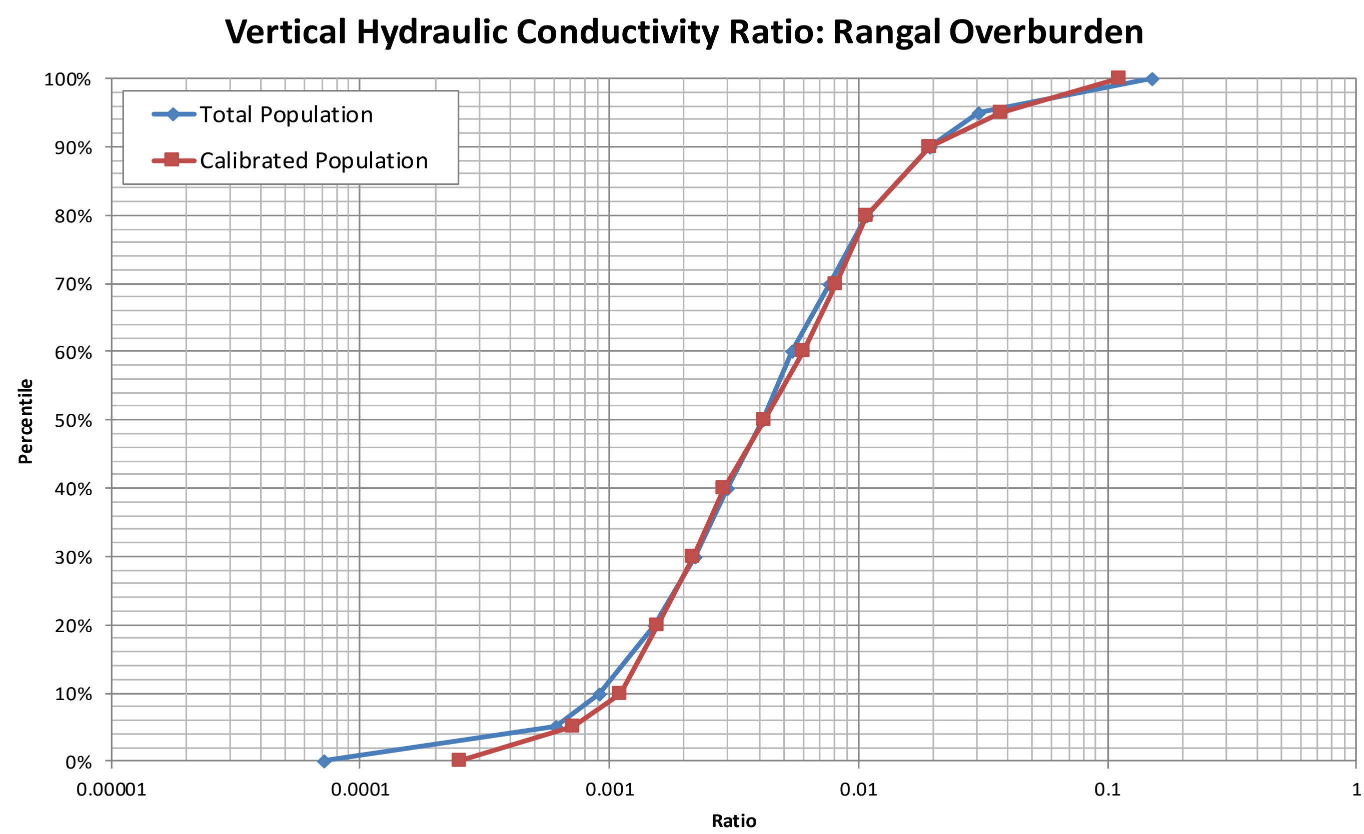


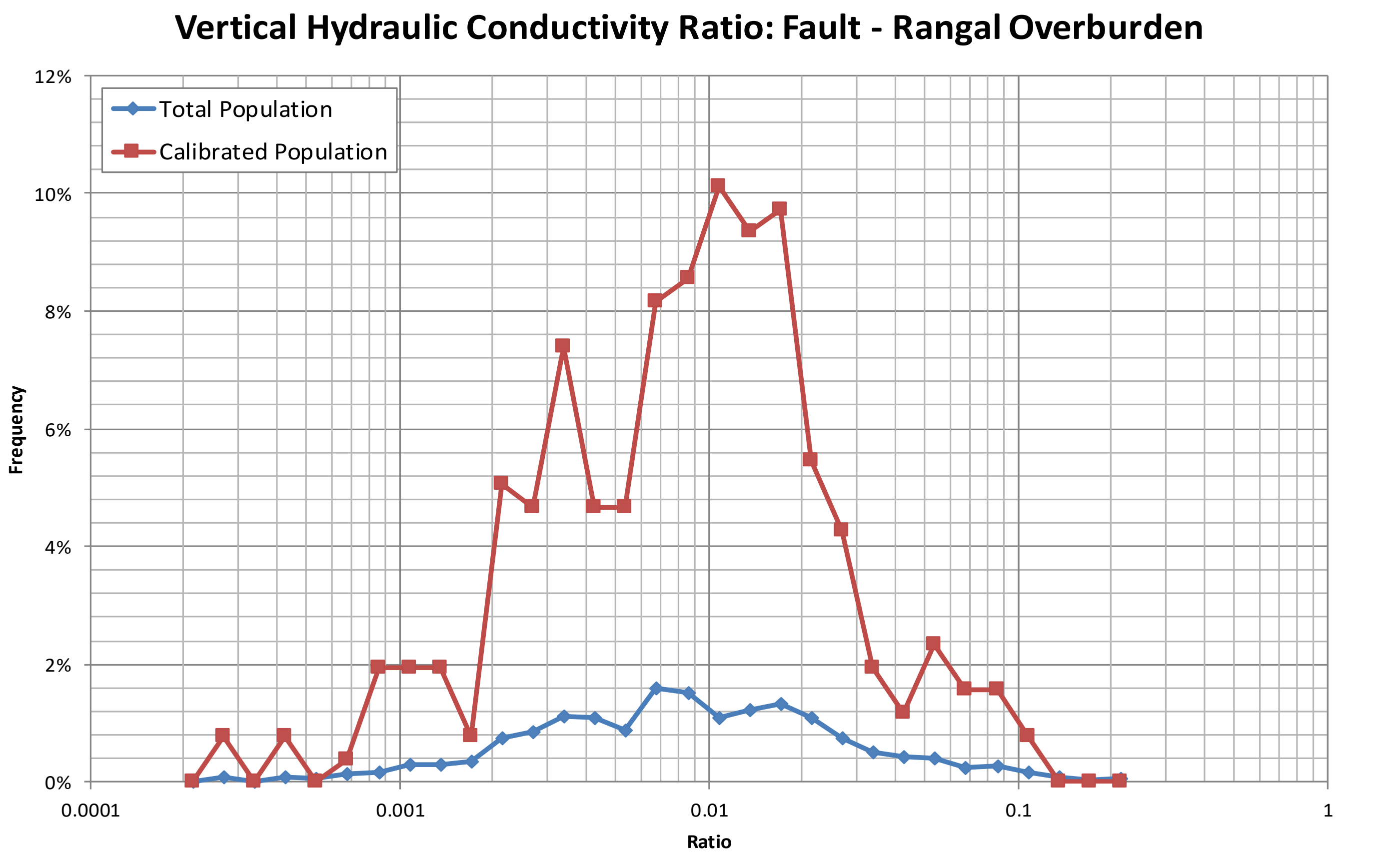
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



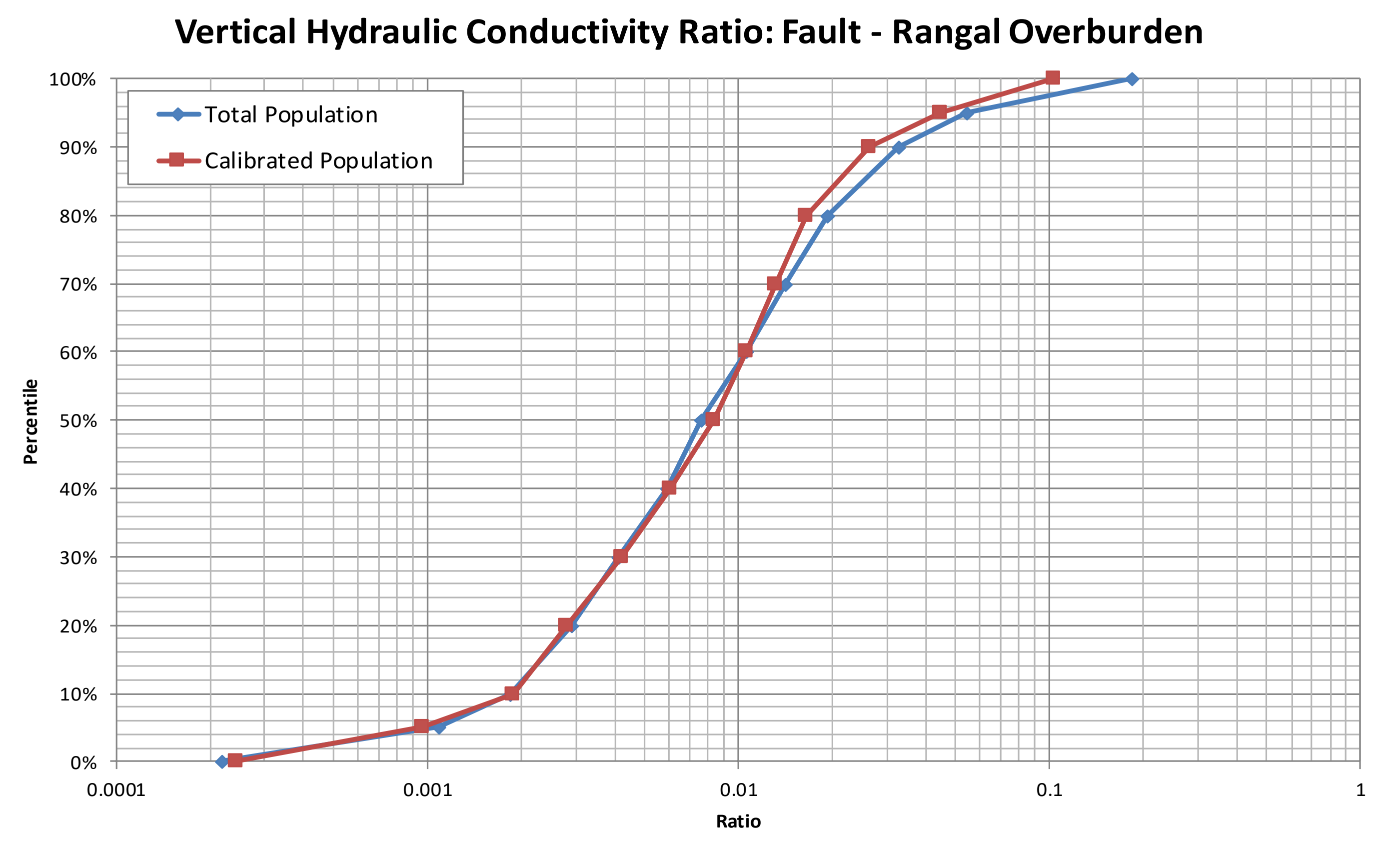


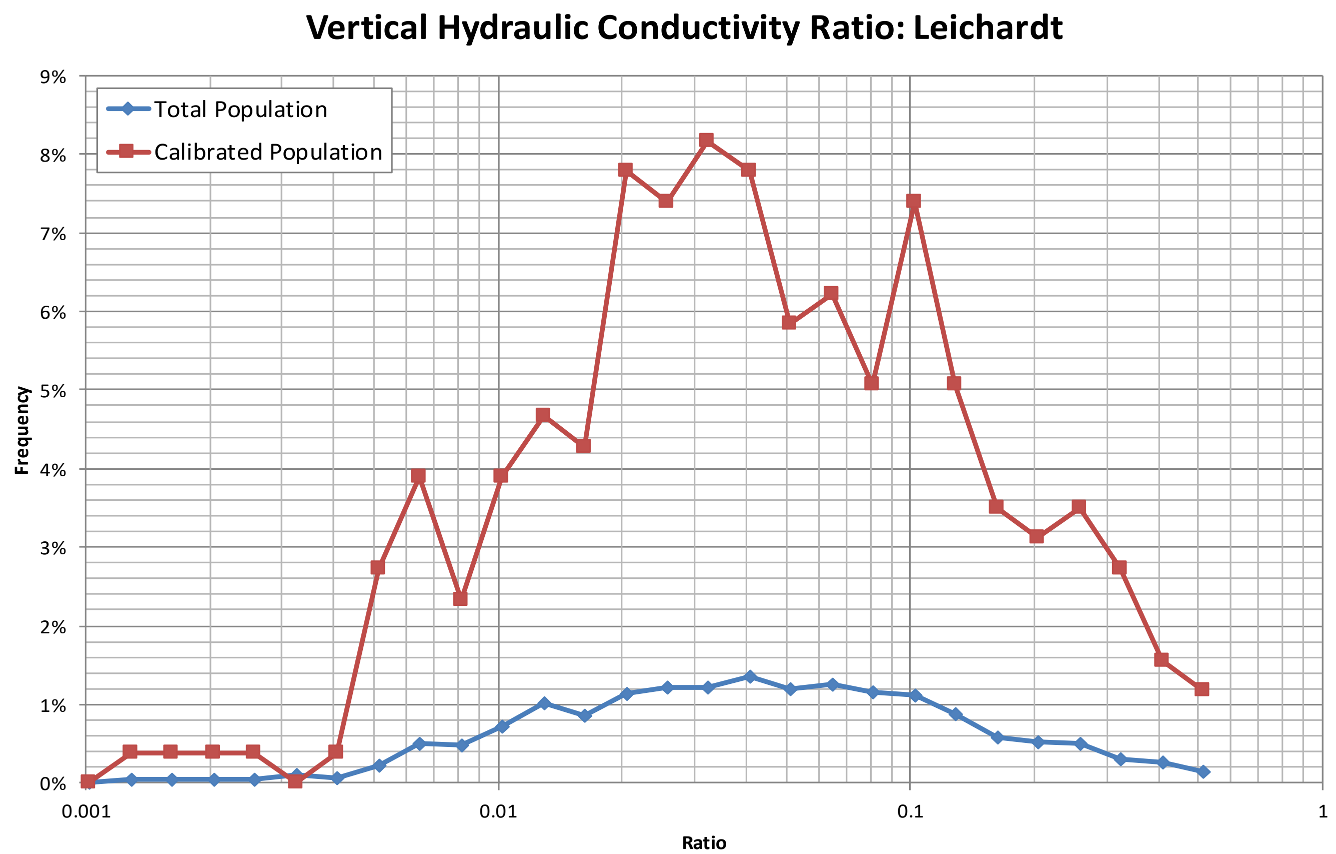
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



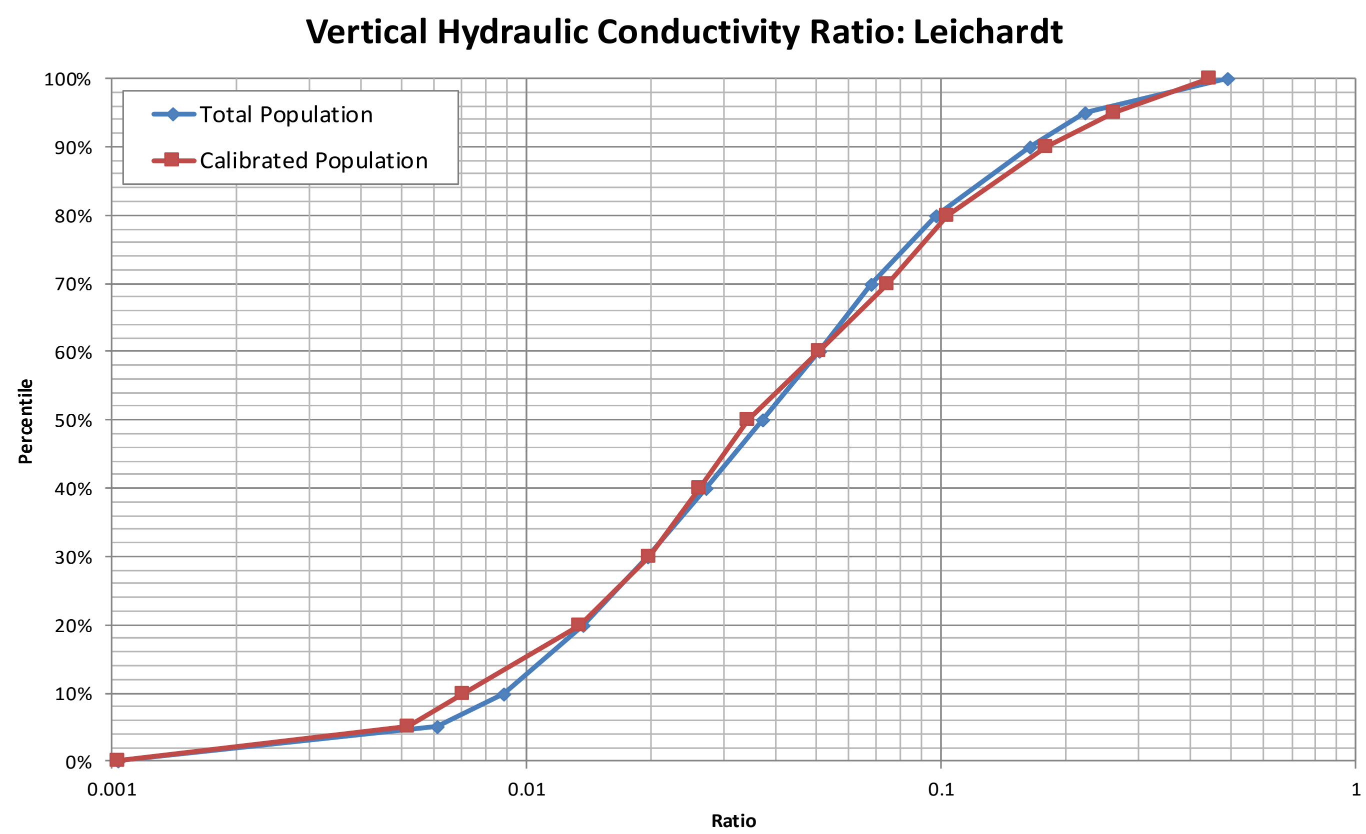


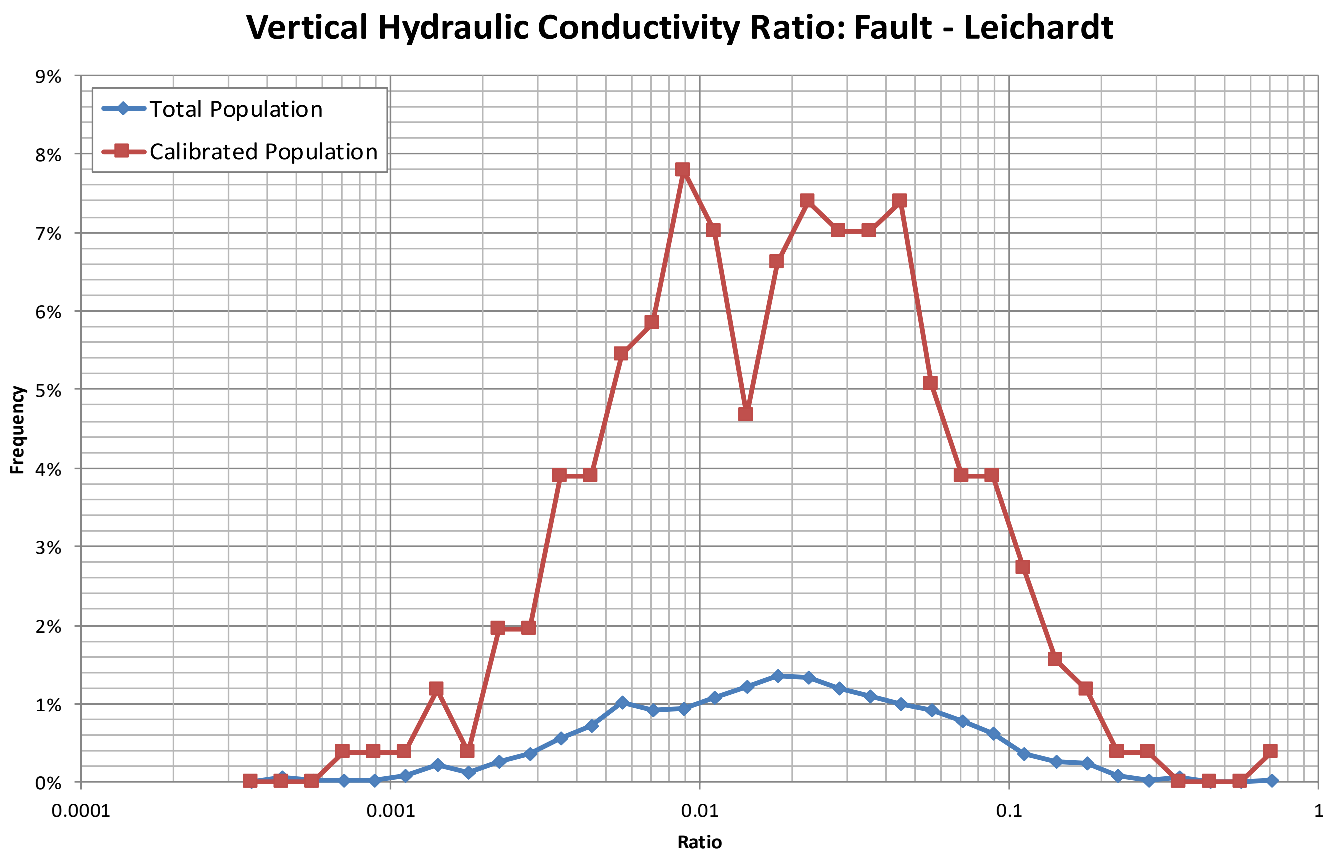
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



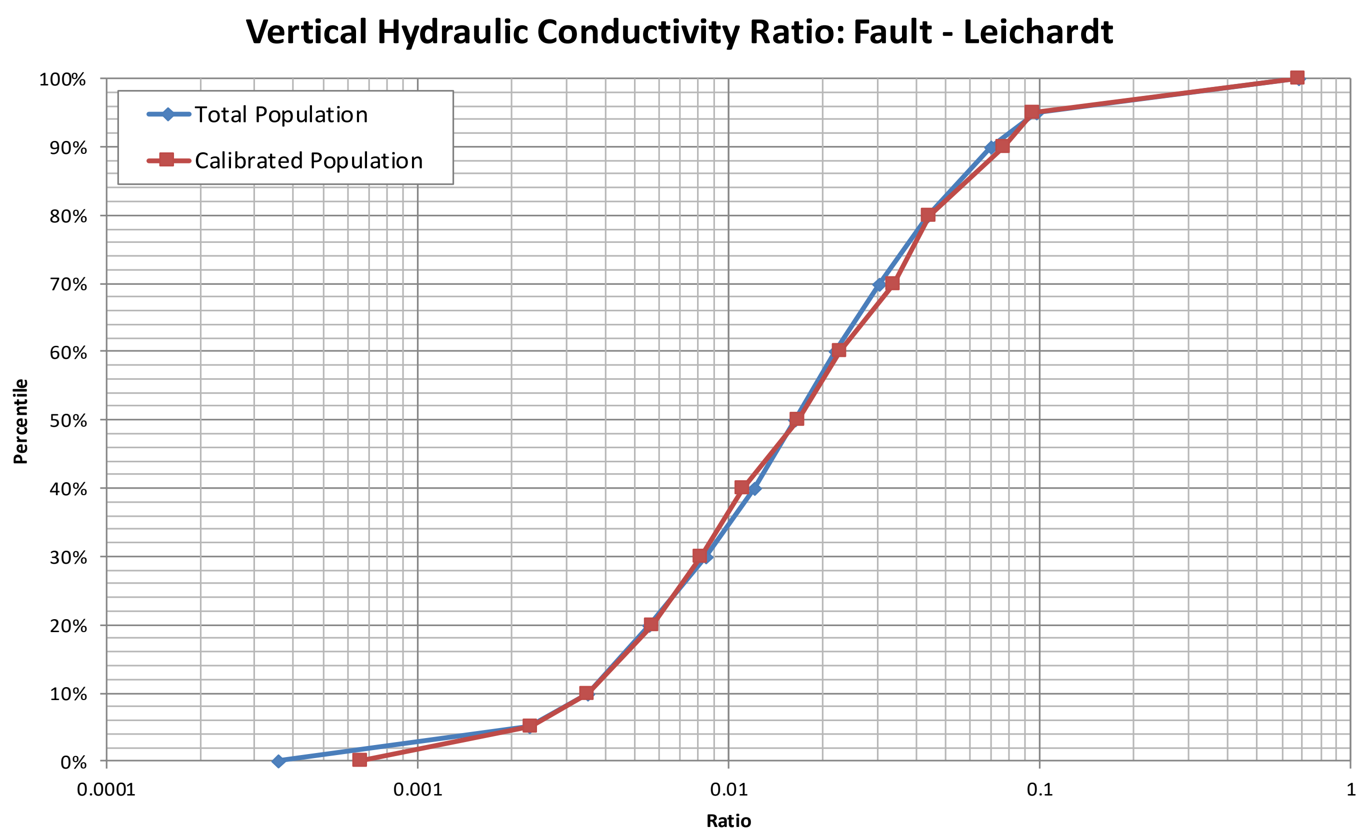


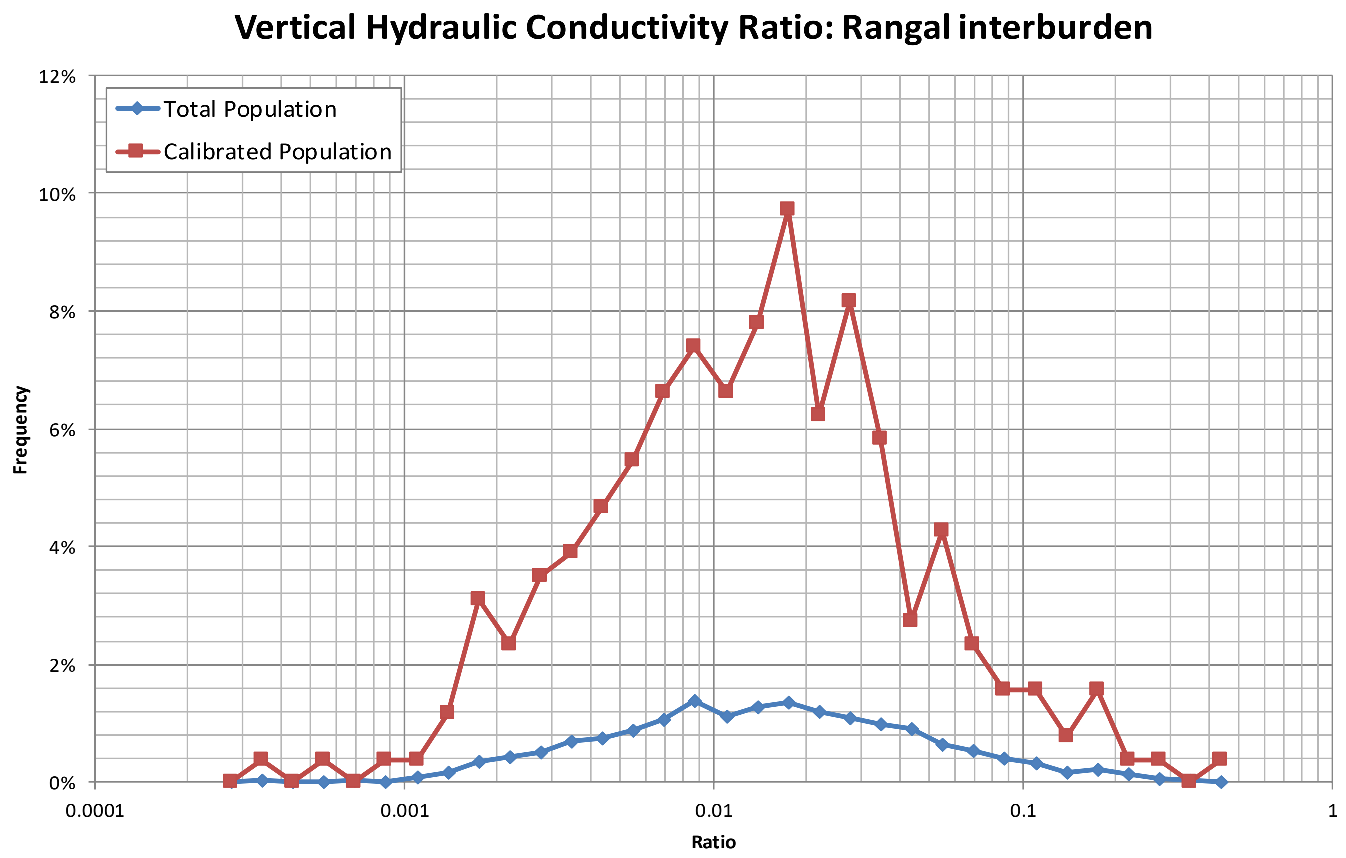
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



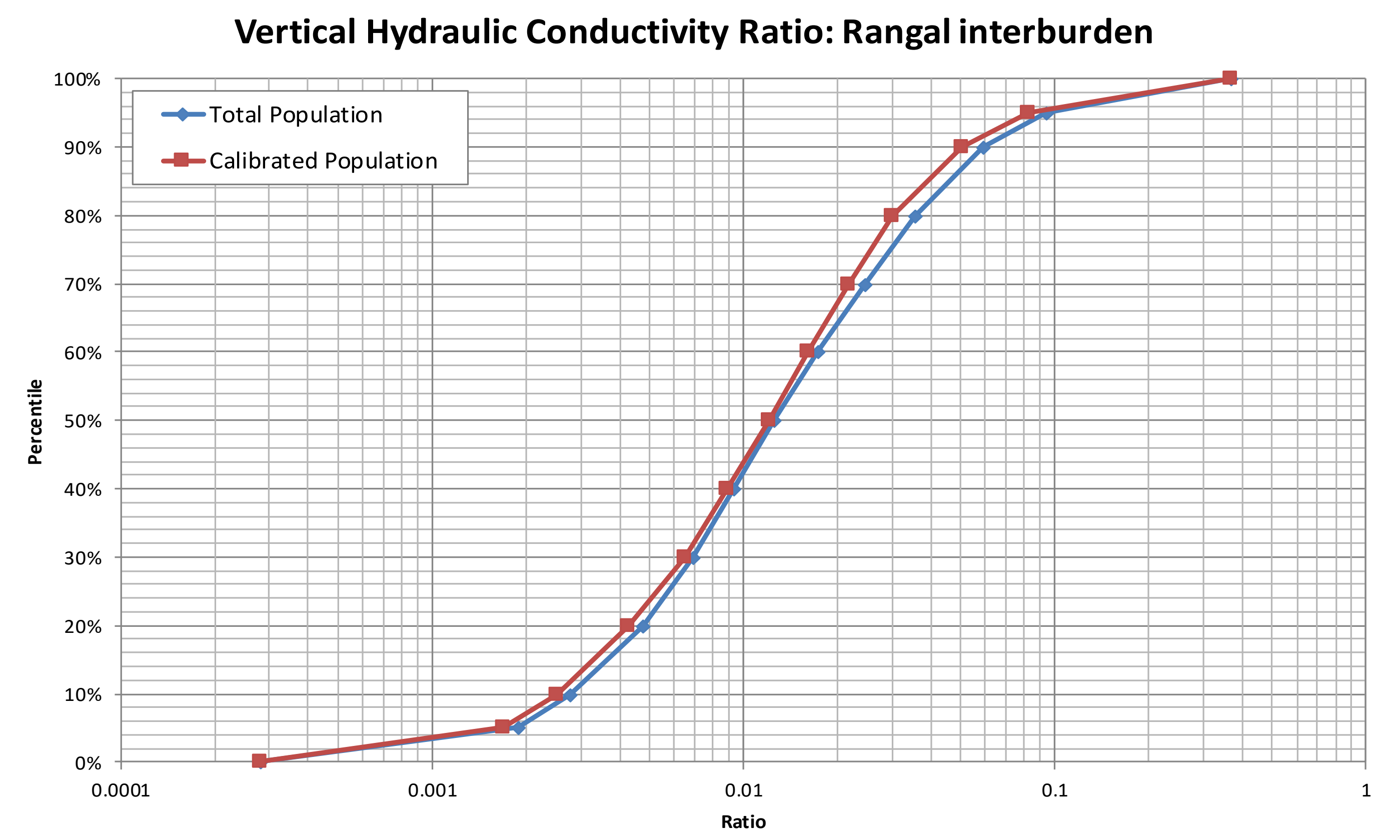


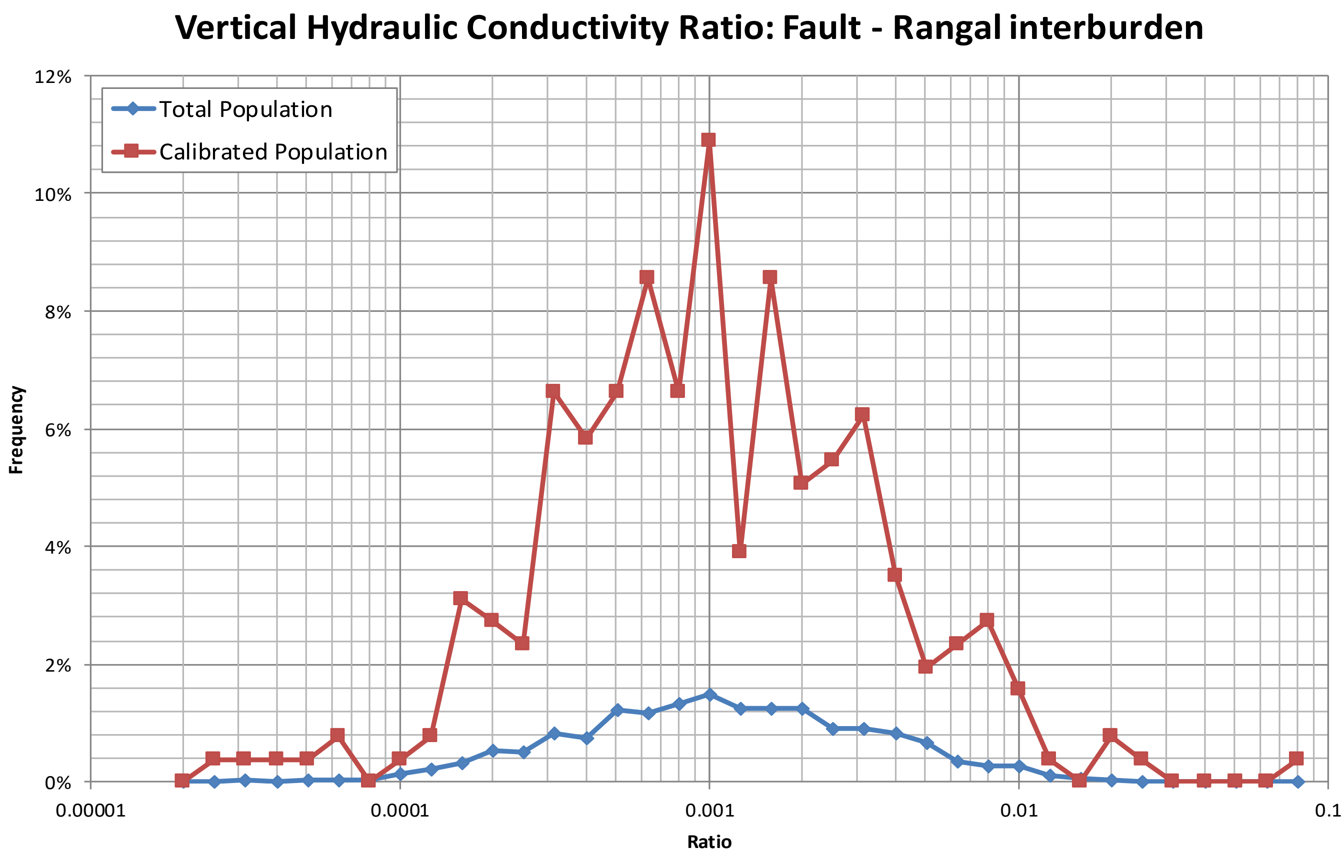
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



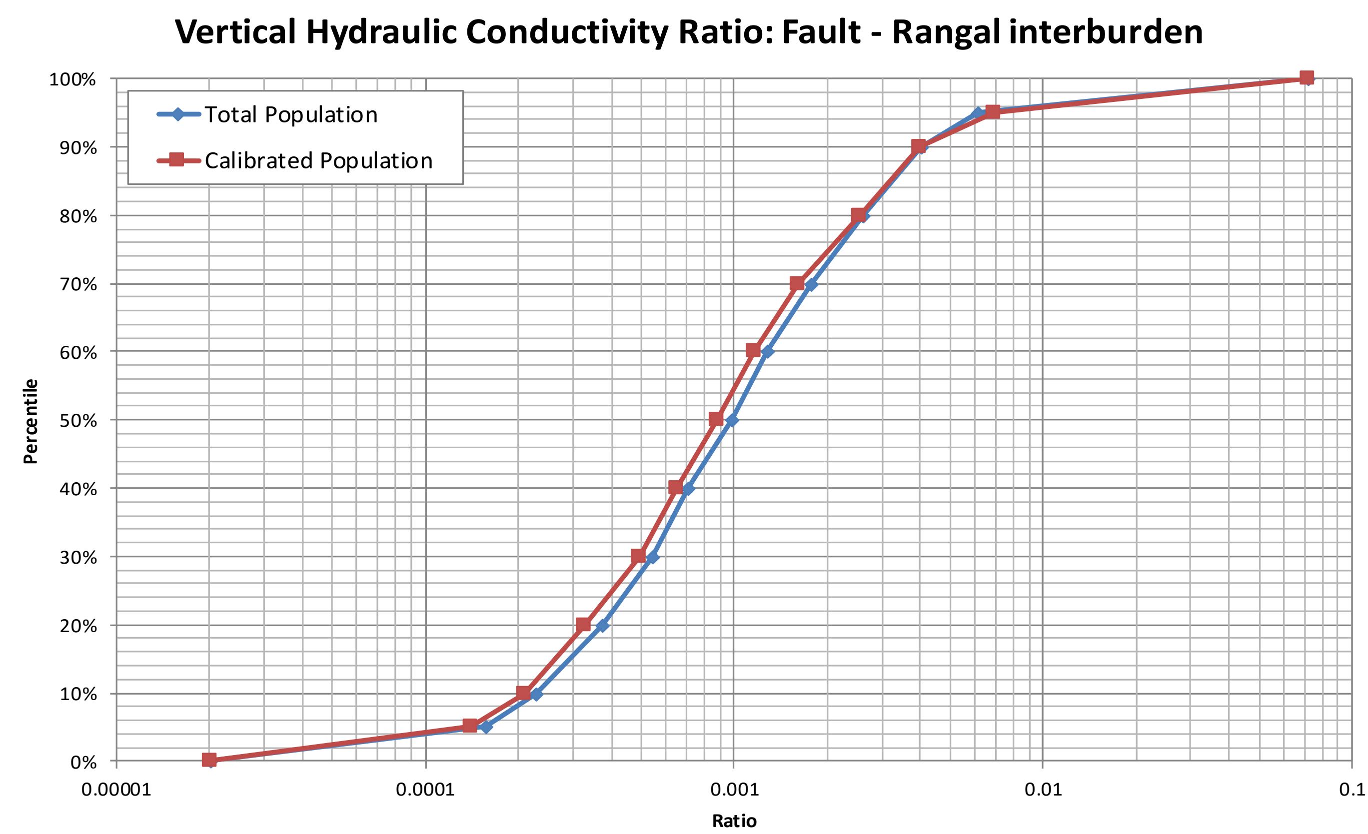


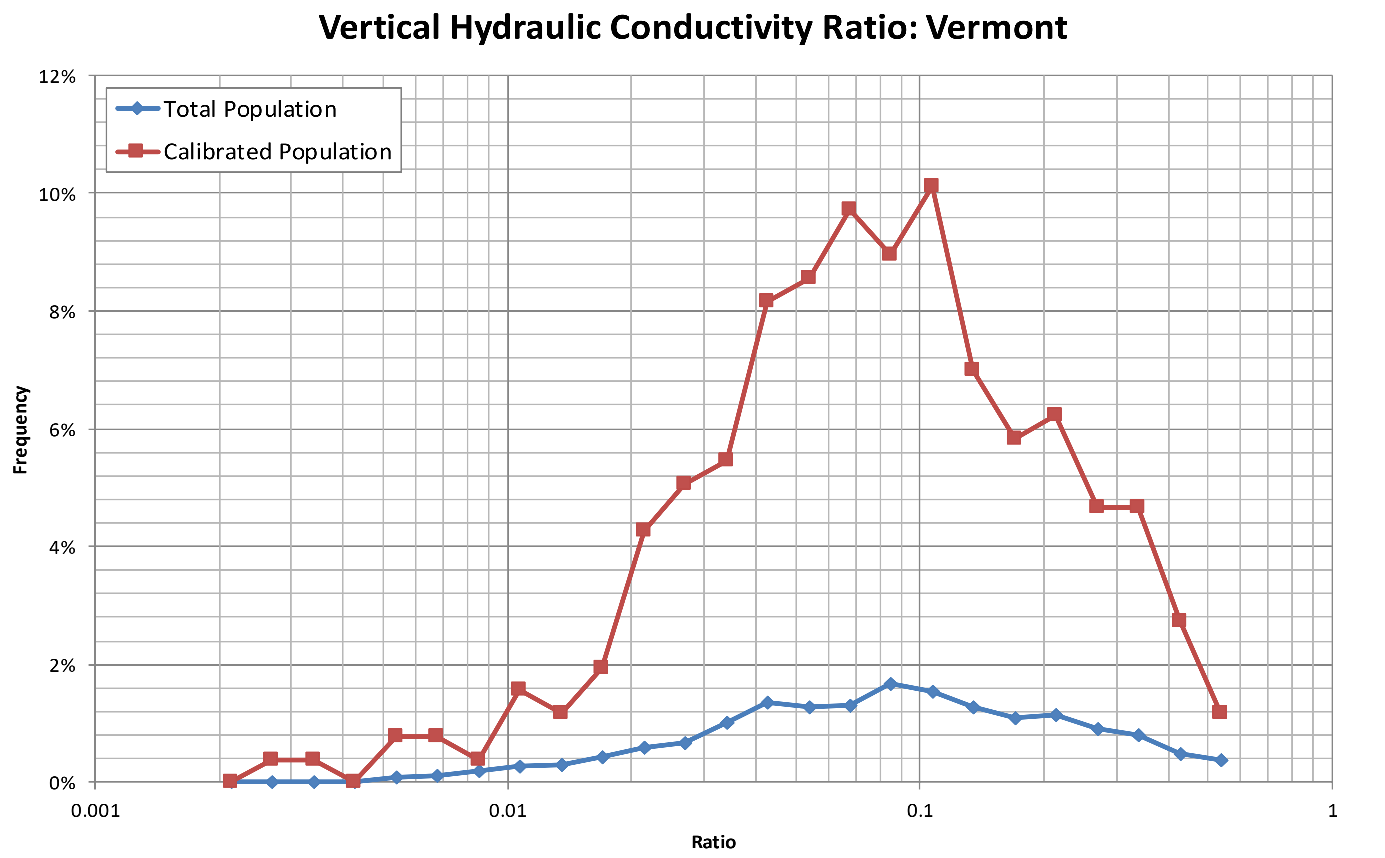
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



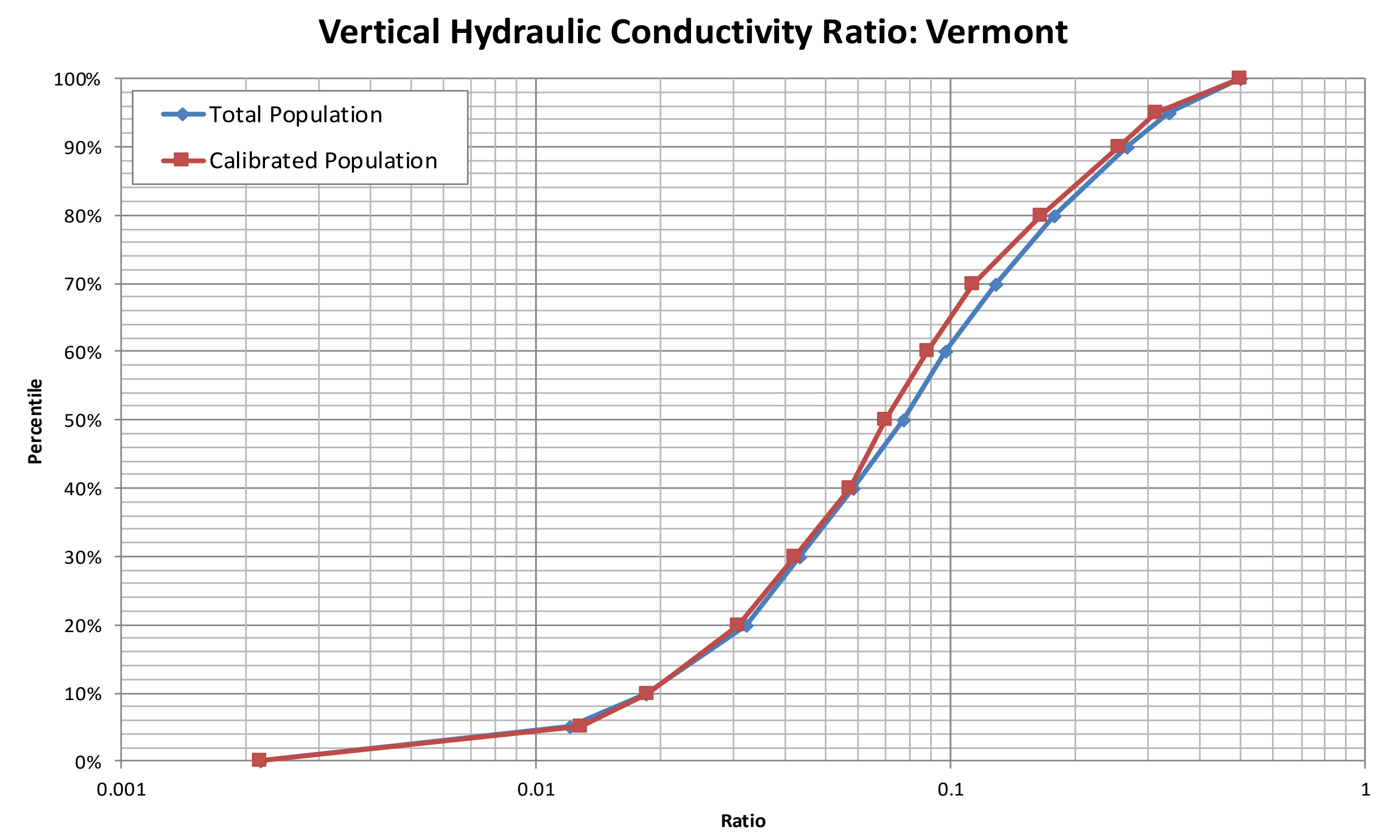


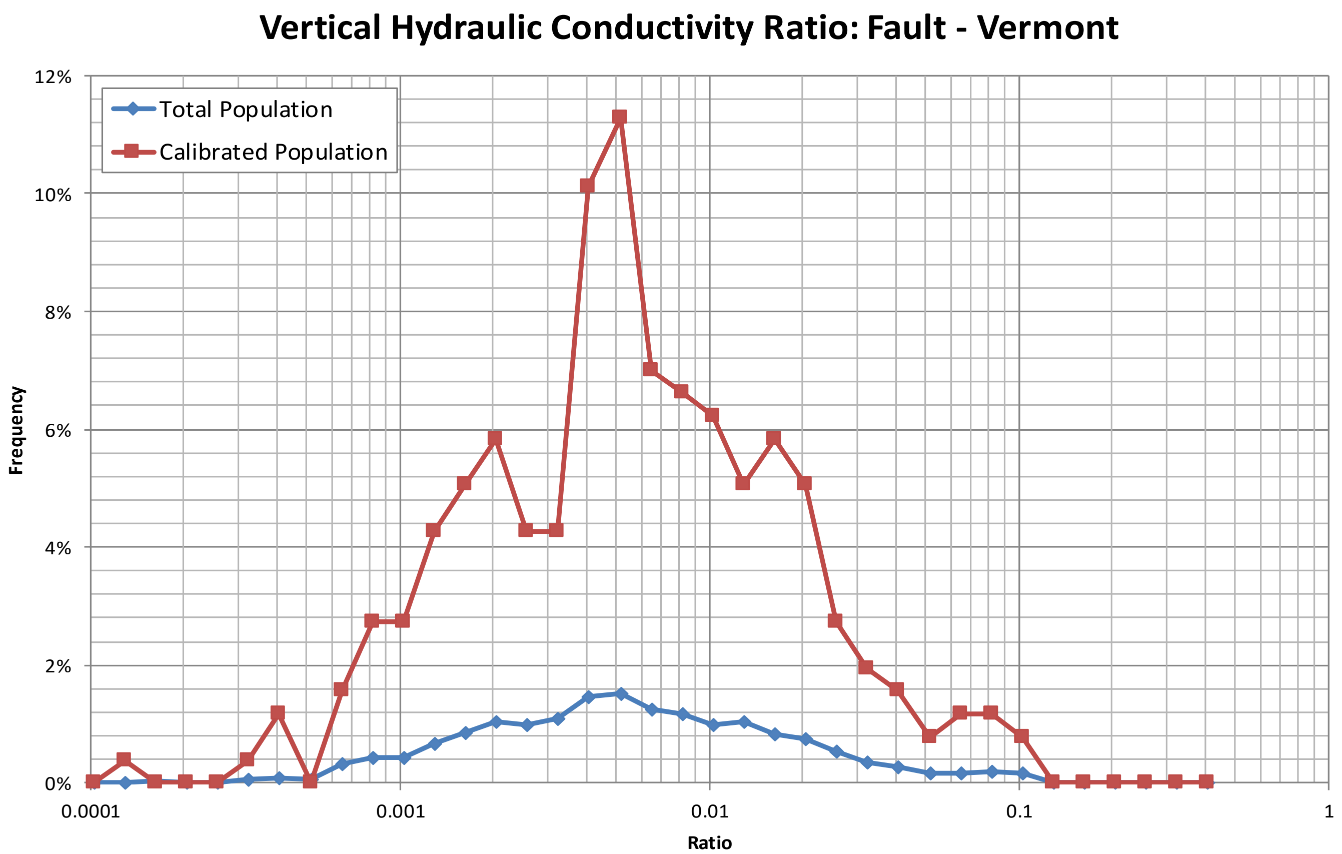
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



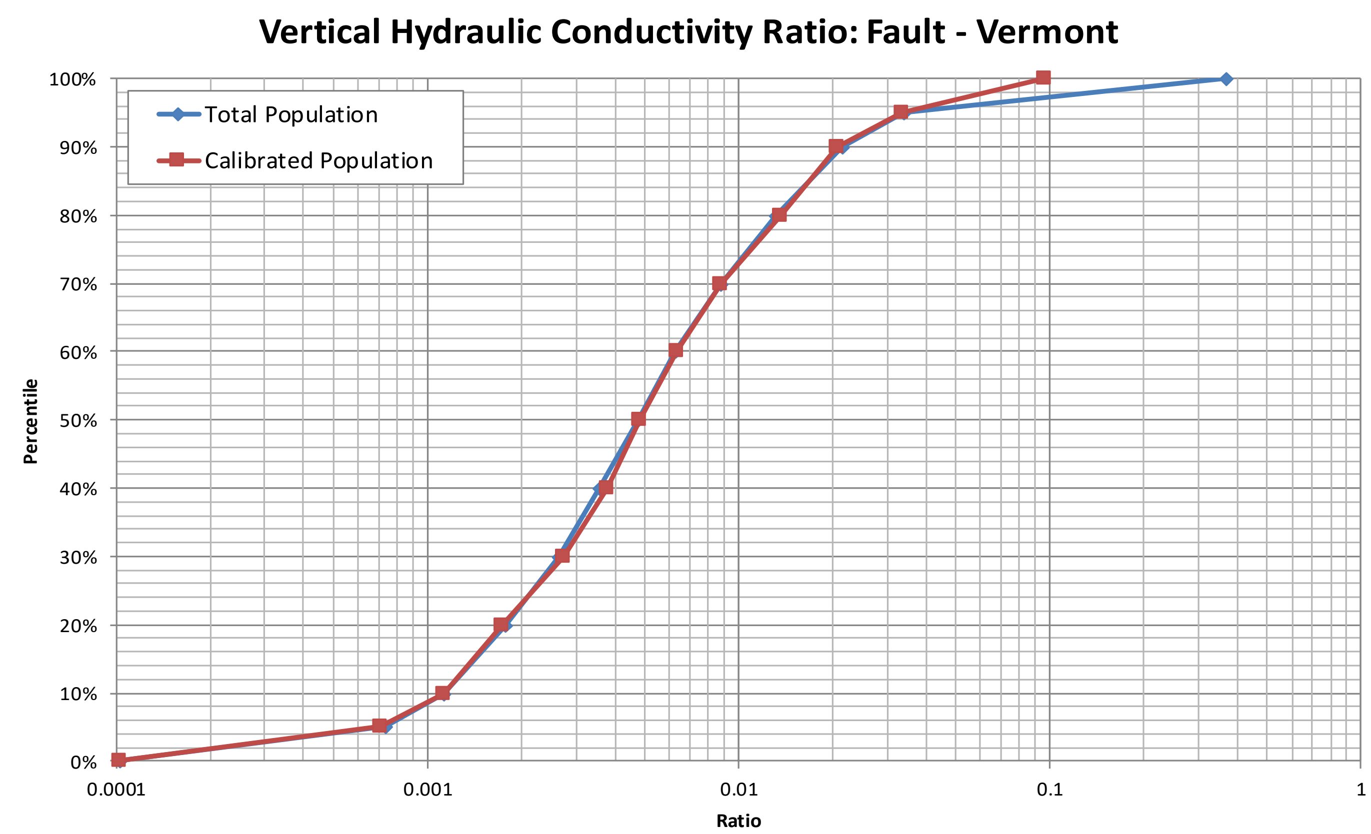


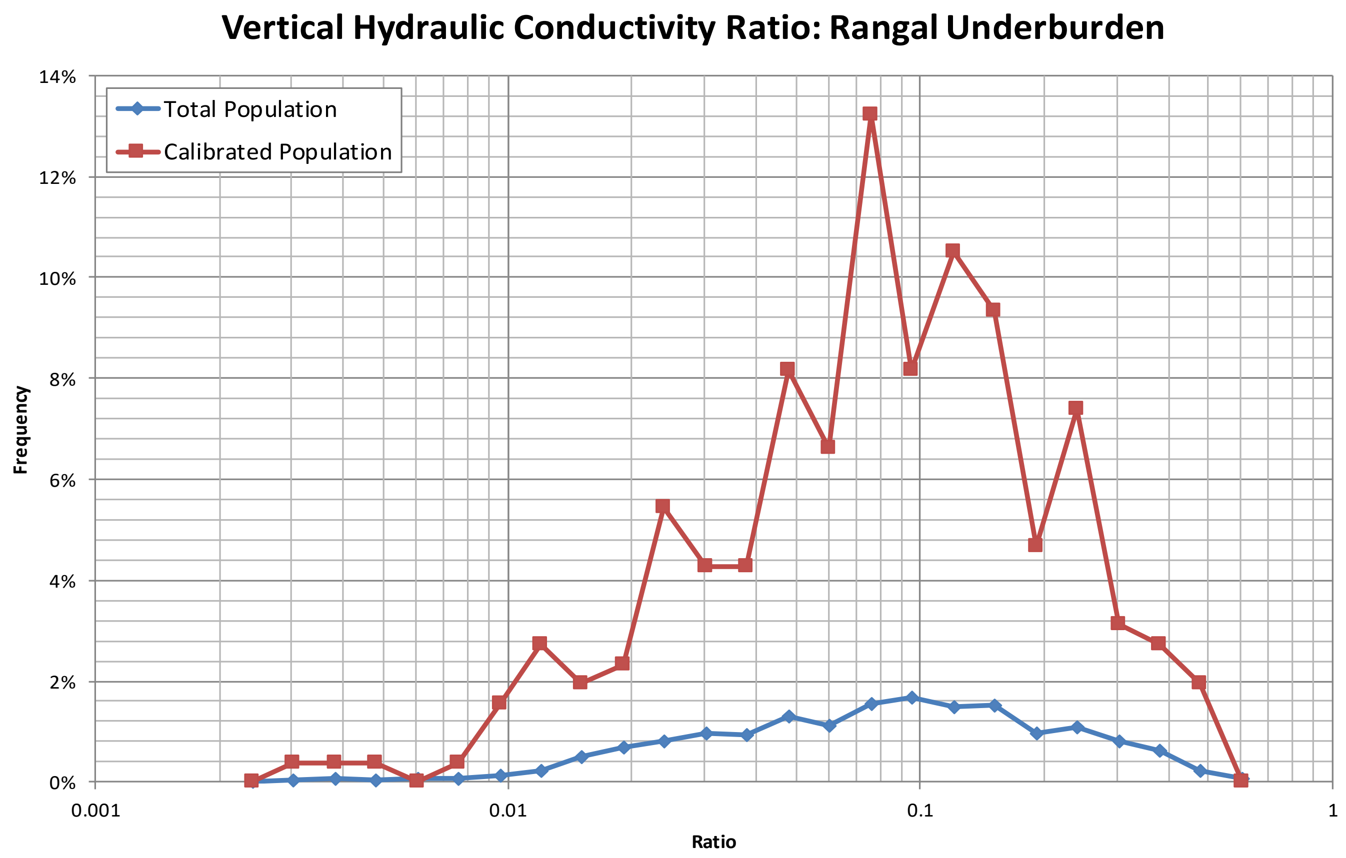
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



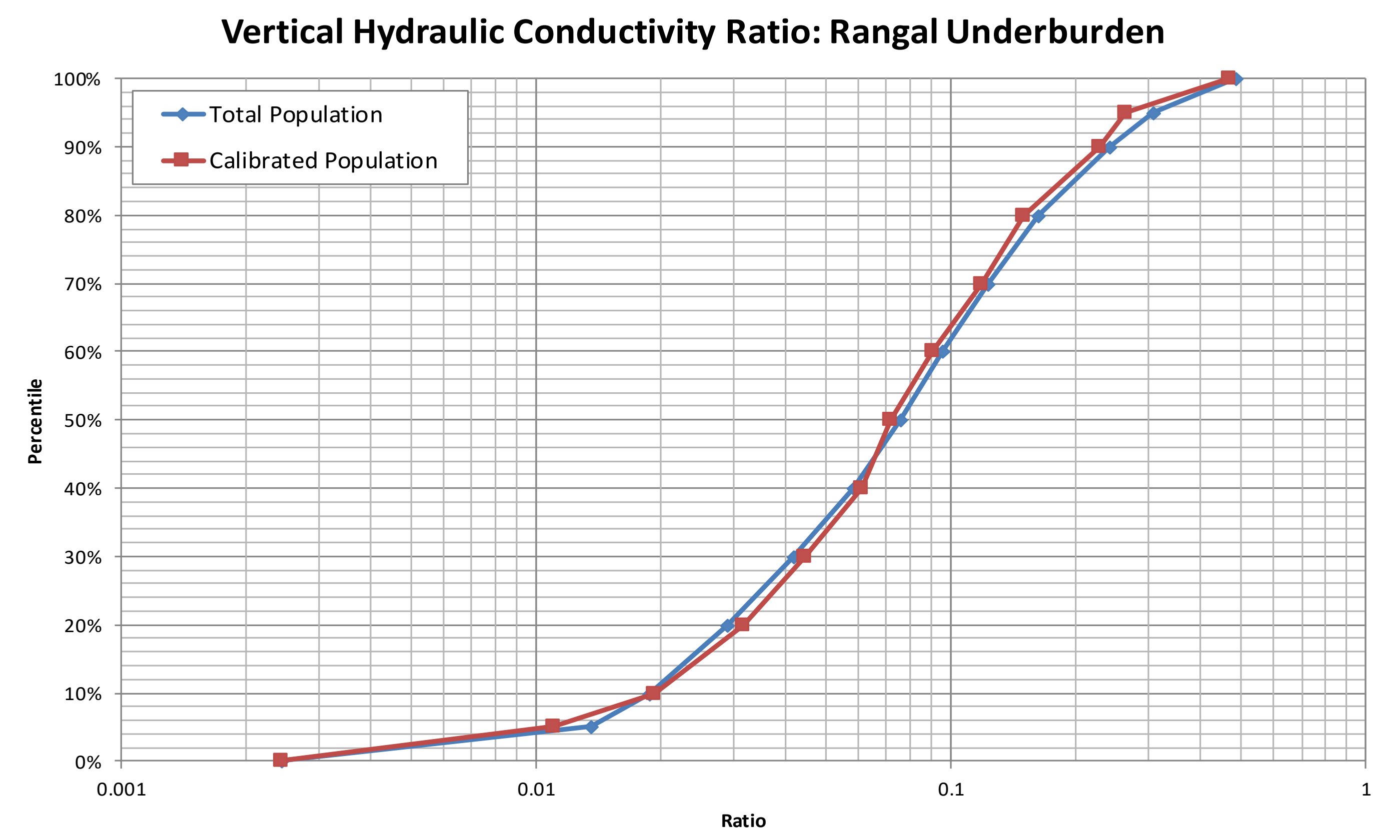


Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

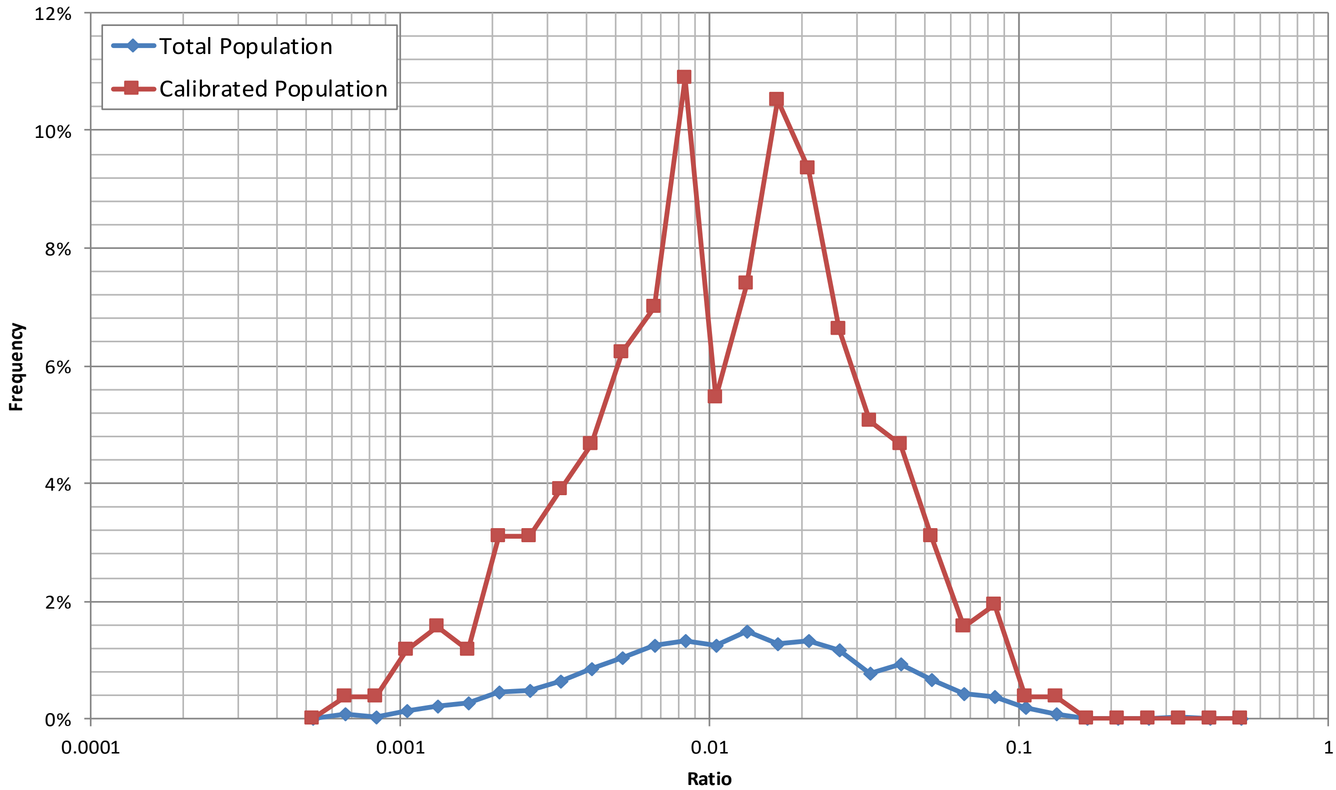




Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

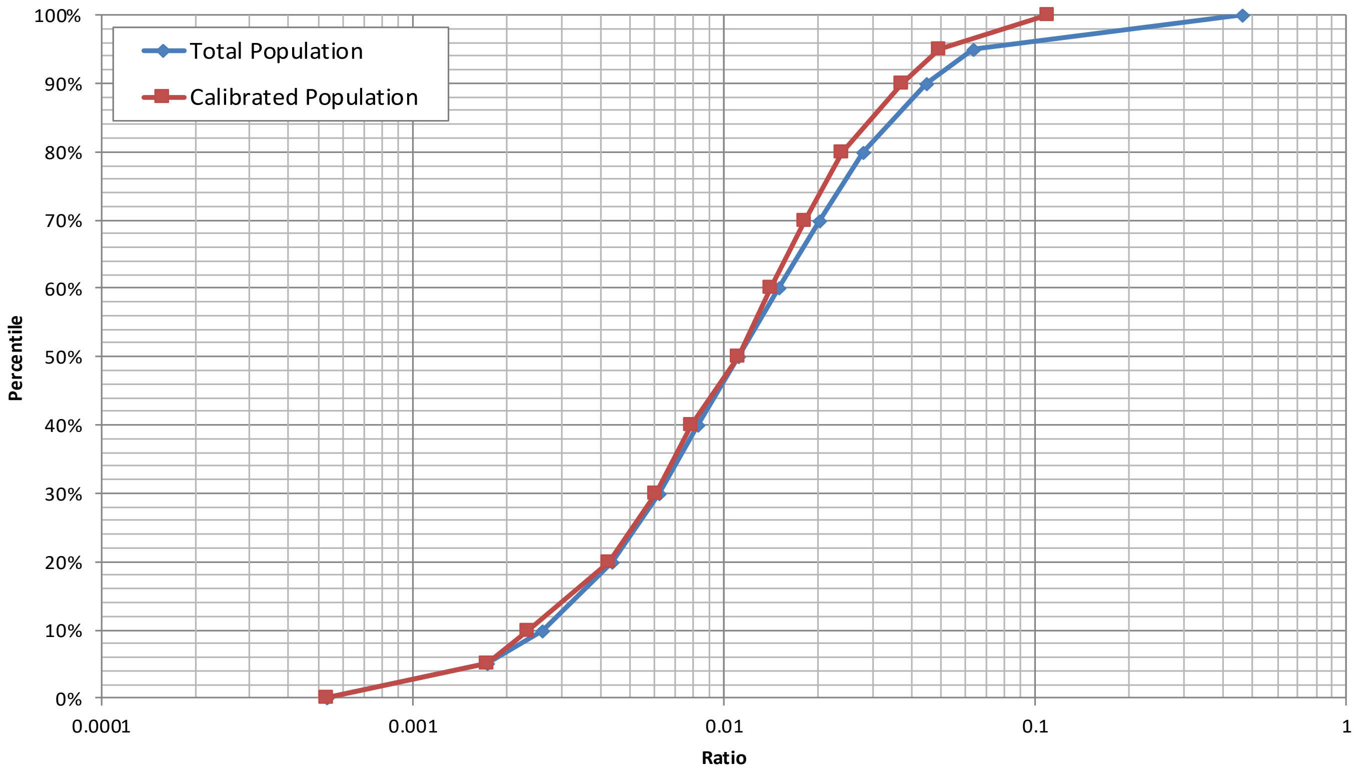


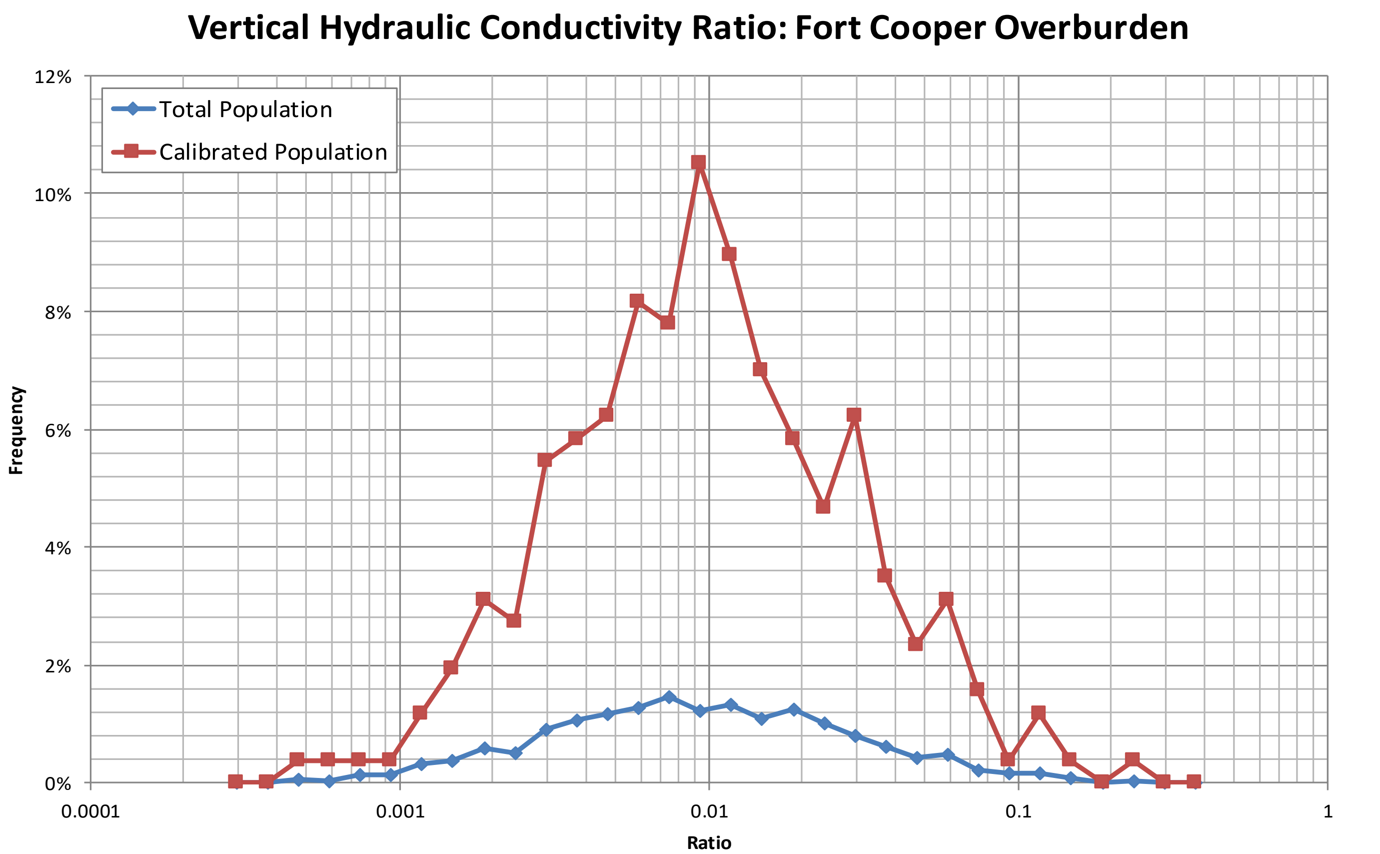
Vertical Hydraulic Conductivity Ratio: Fault - Rangal Underburden



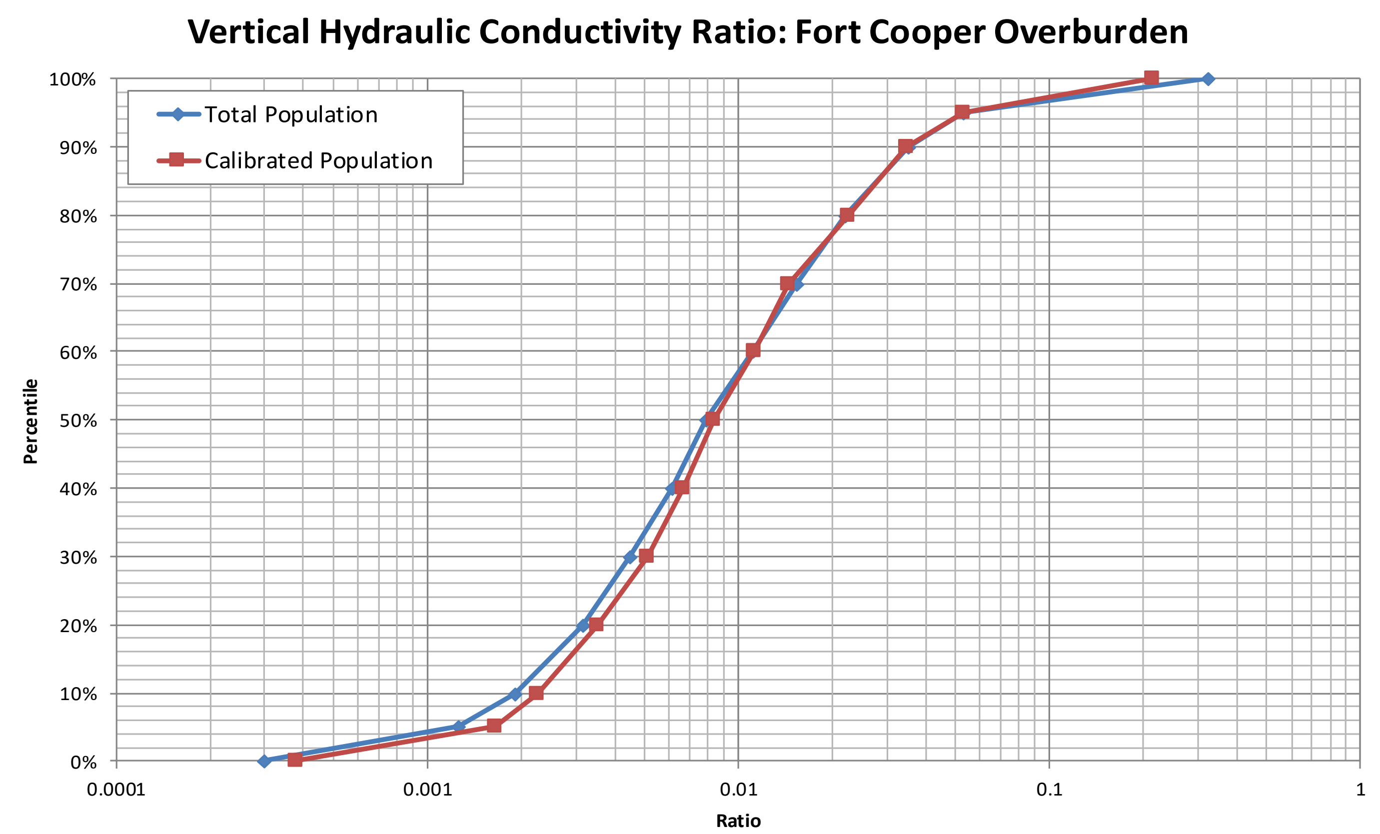
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

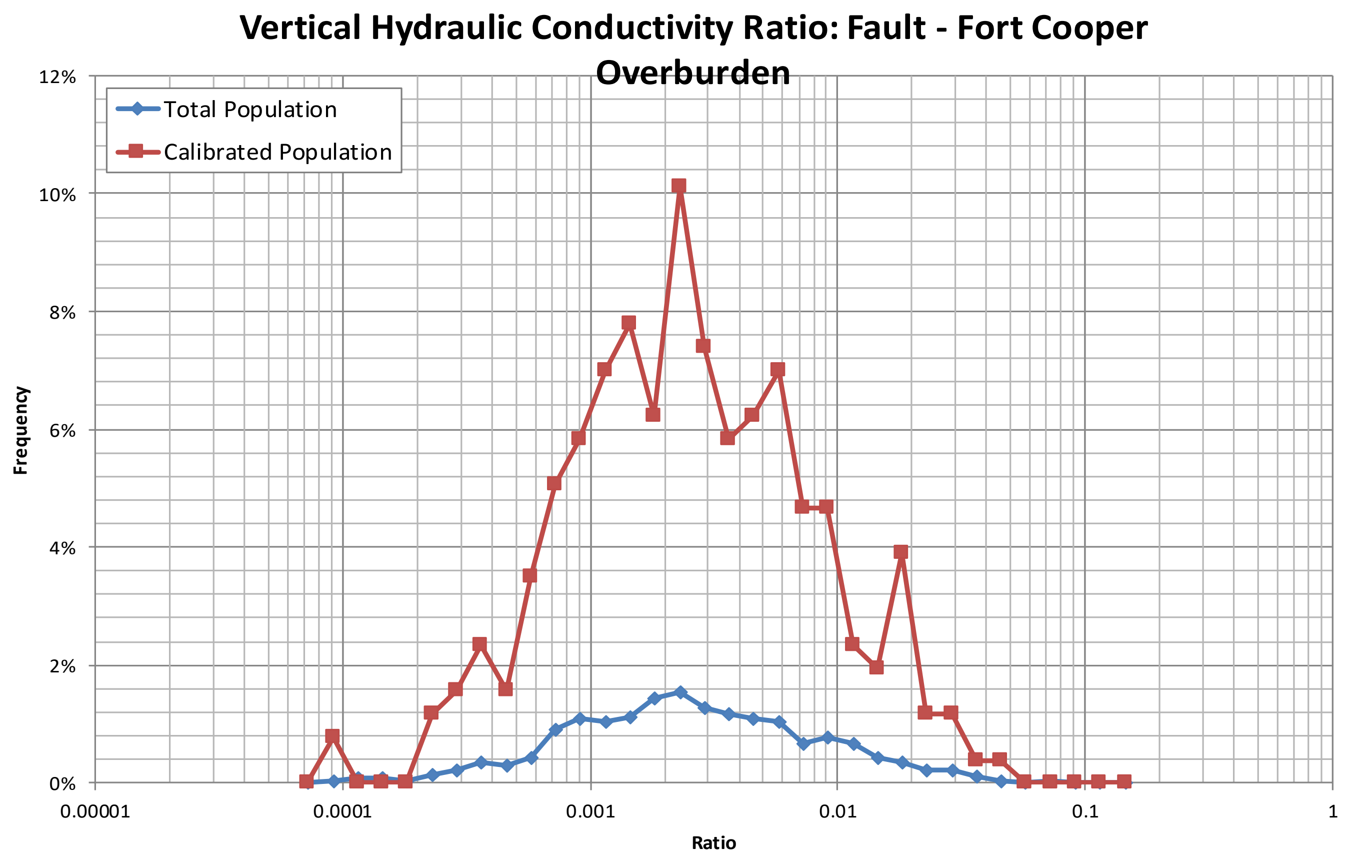
Vertical Hydraulic Conductivity Ratio: Fault - Rangal Underburden



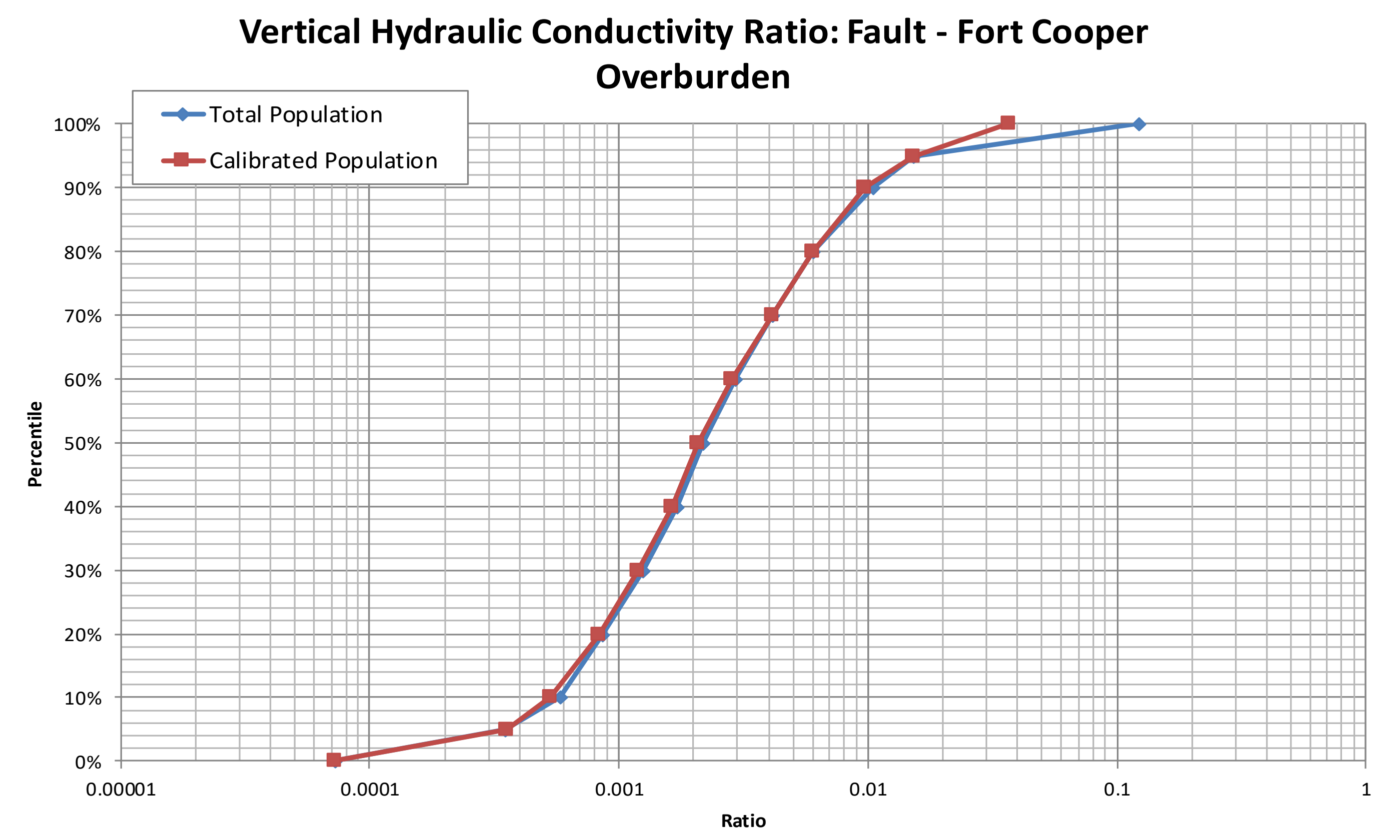


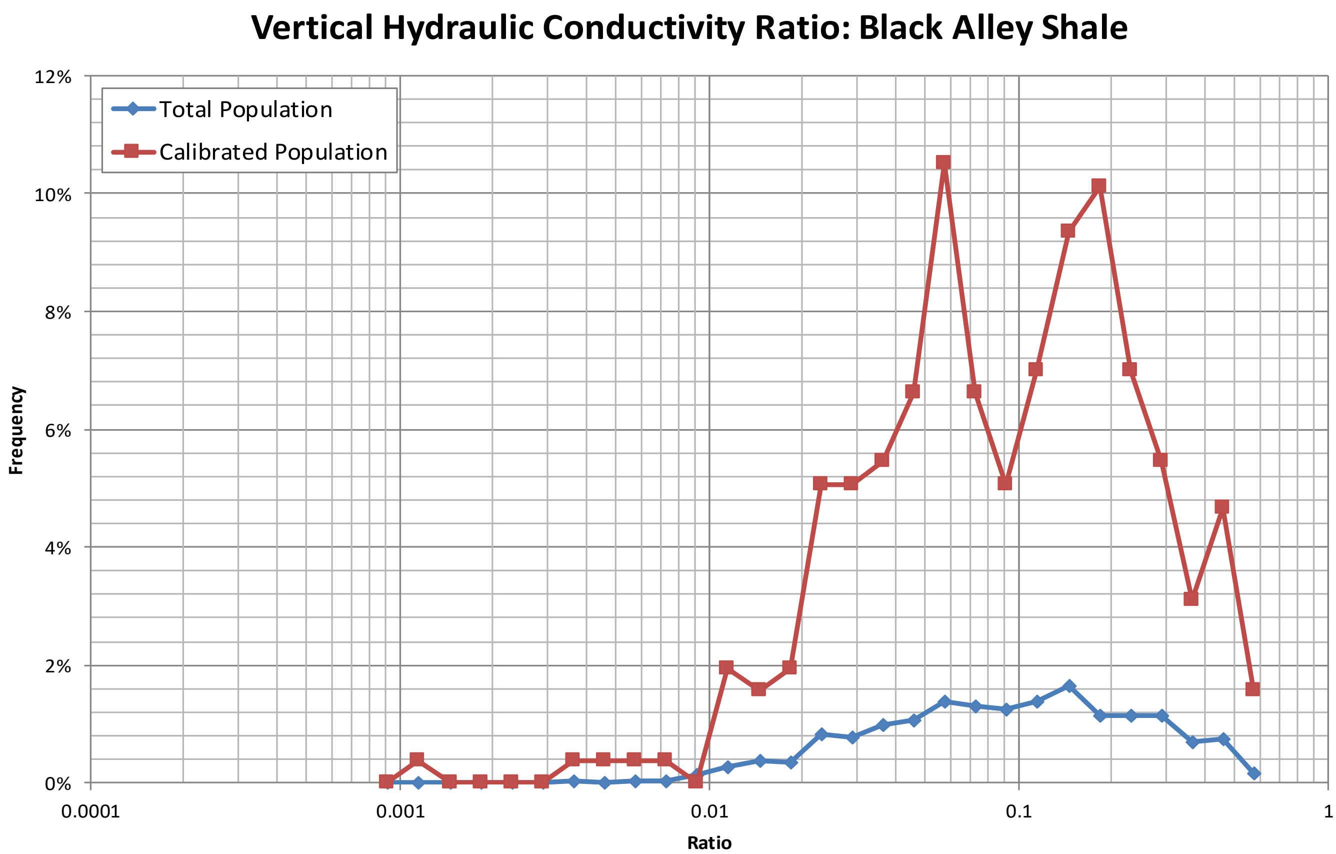
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



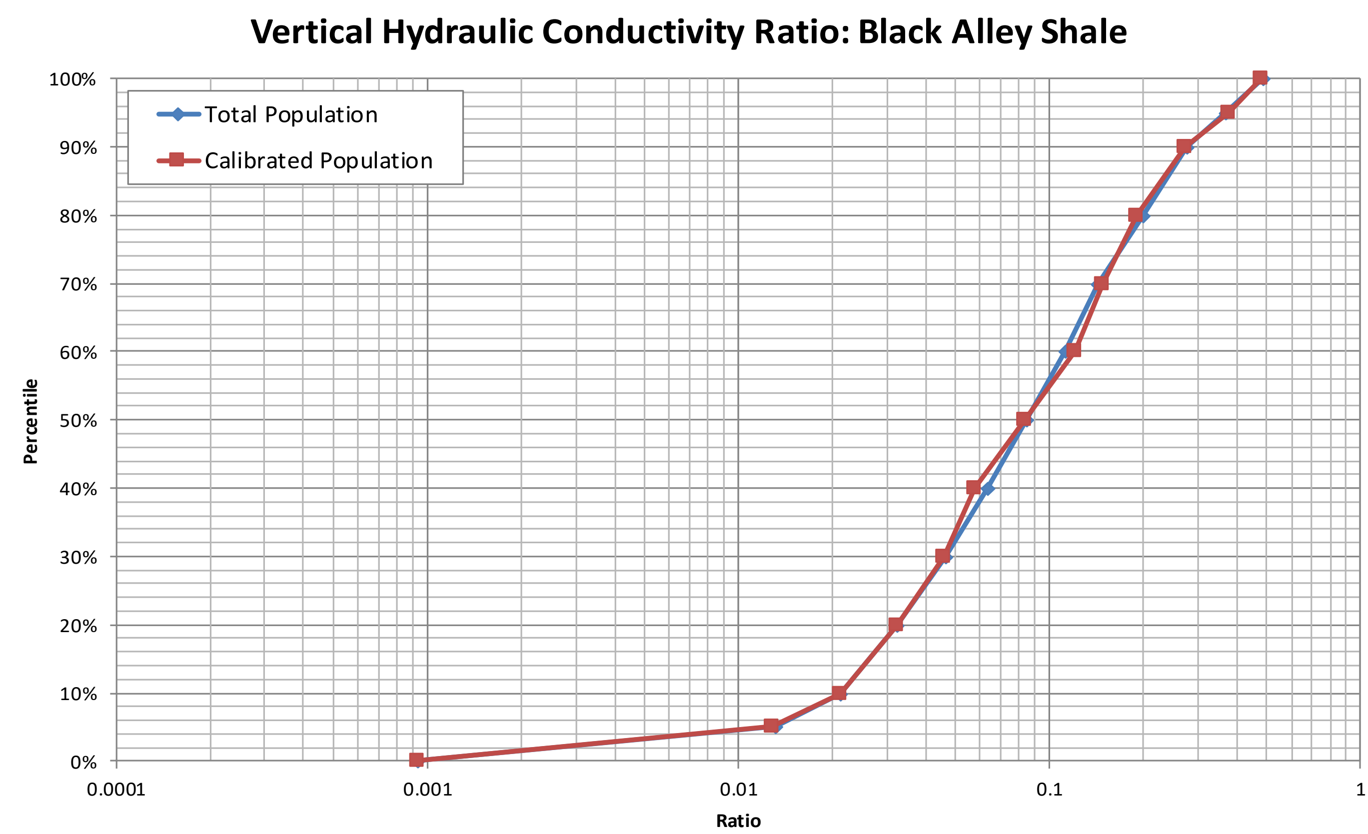


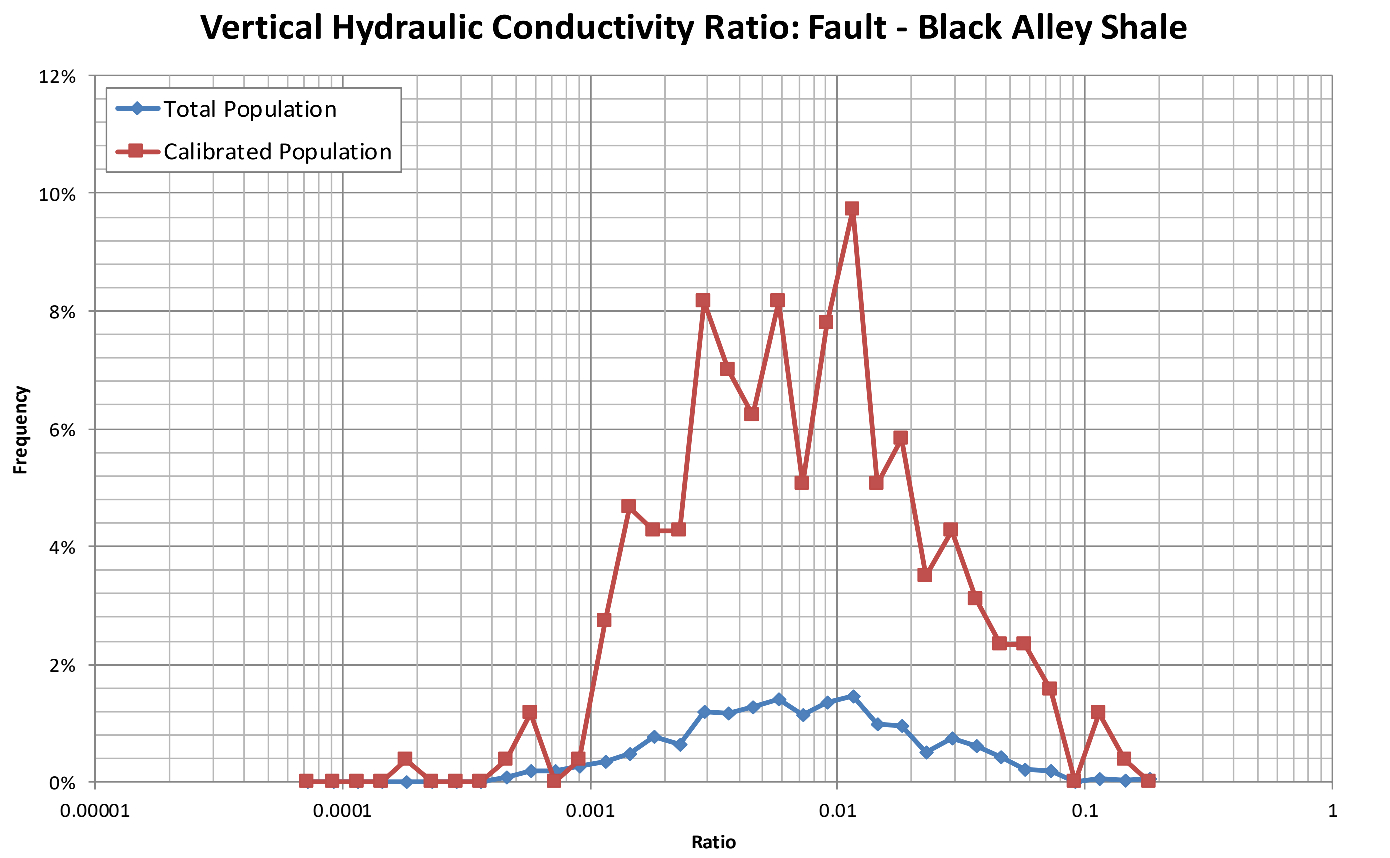
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



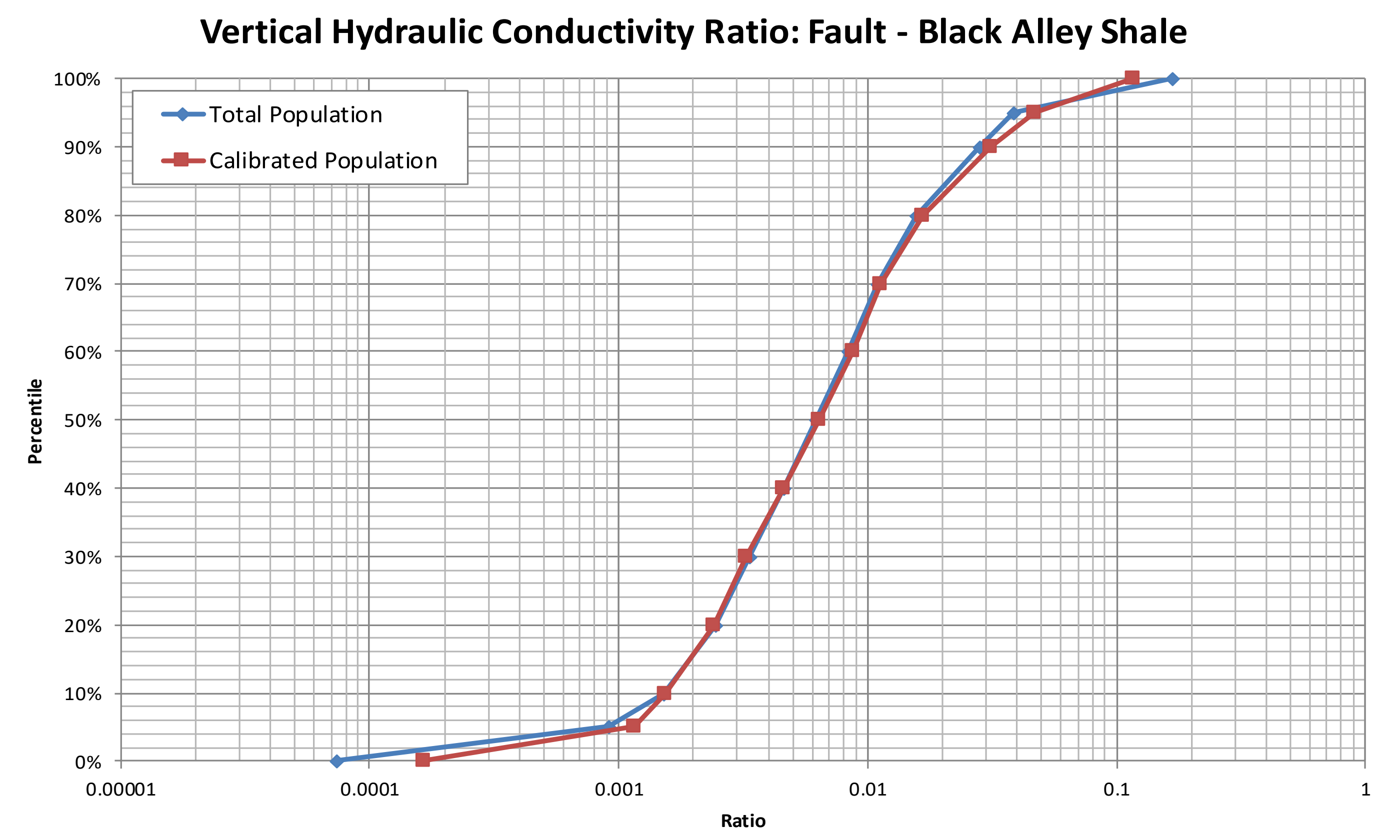


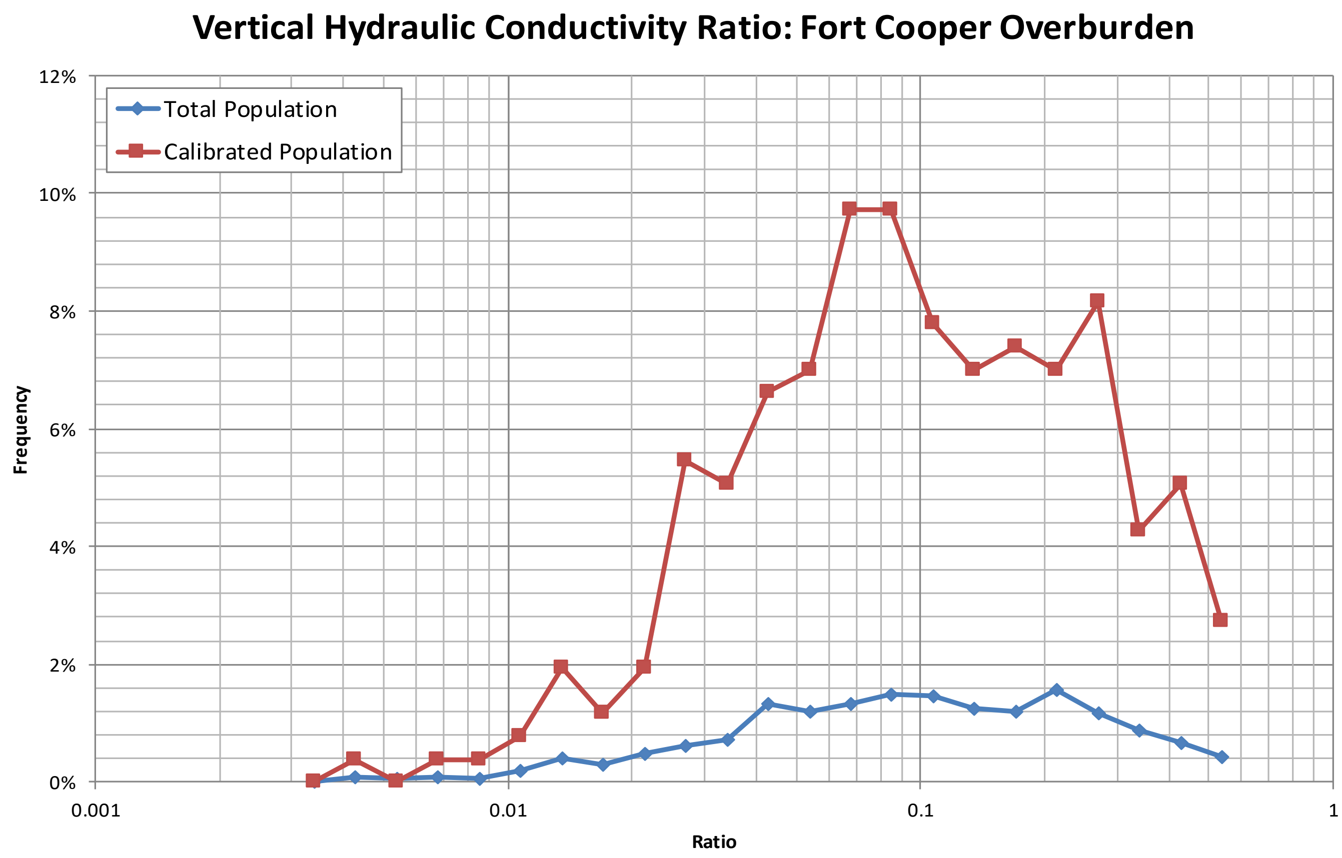
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



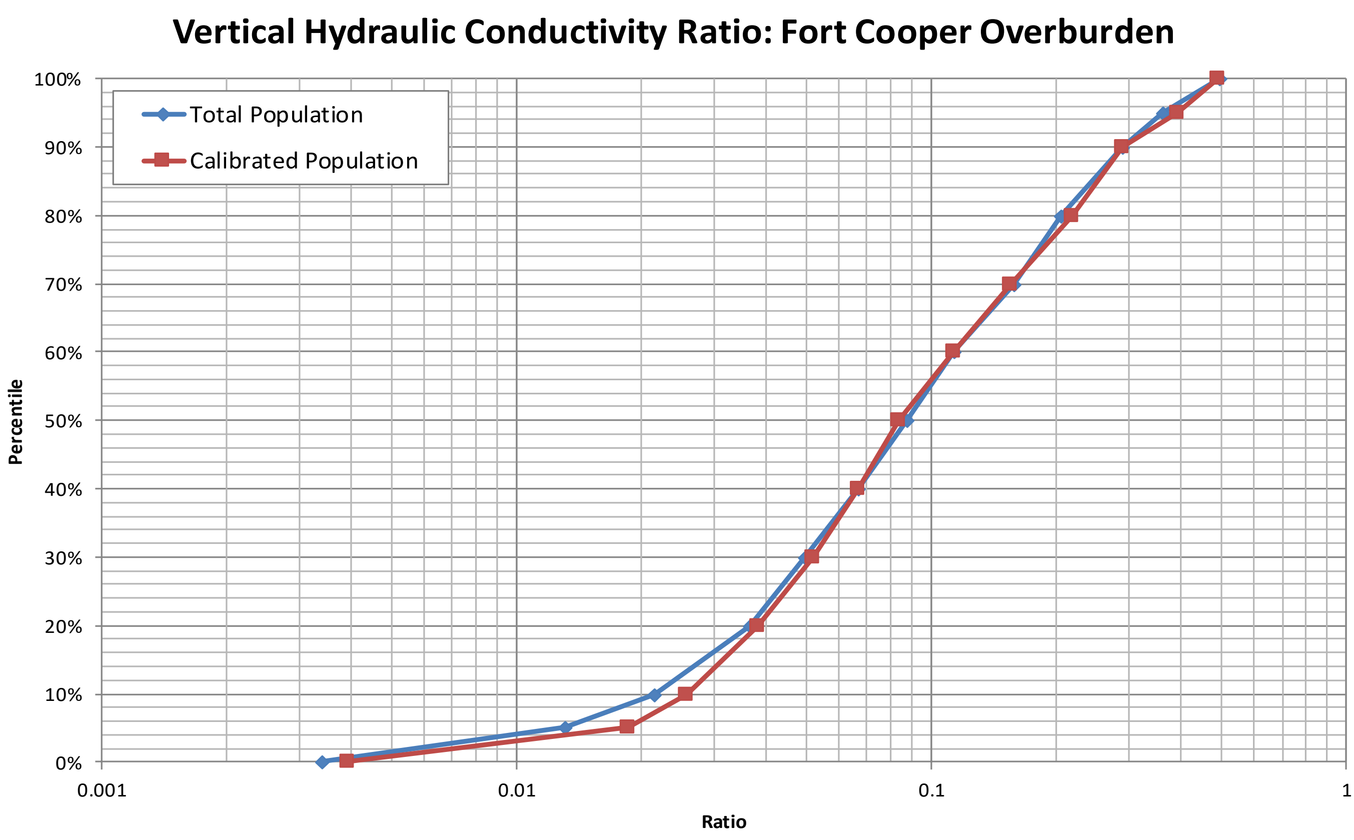


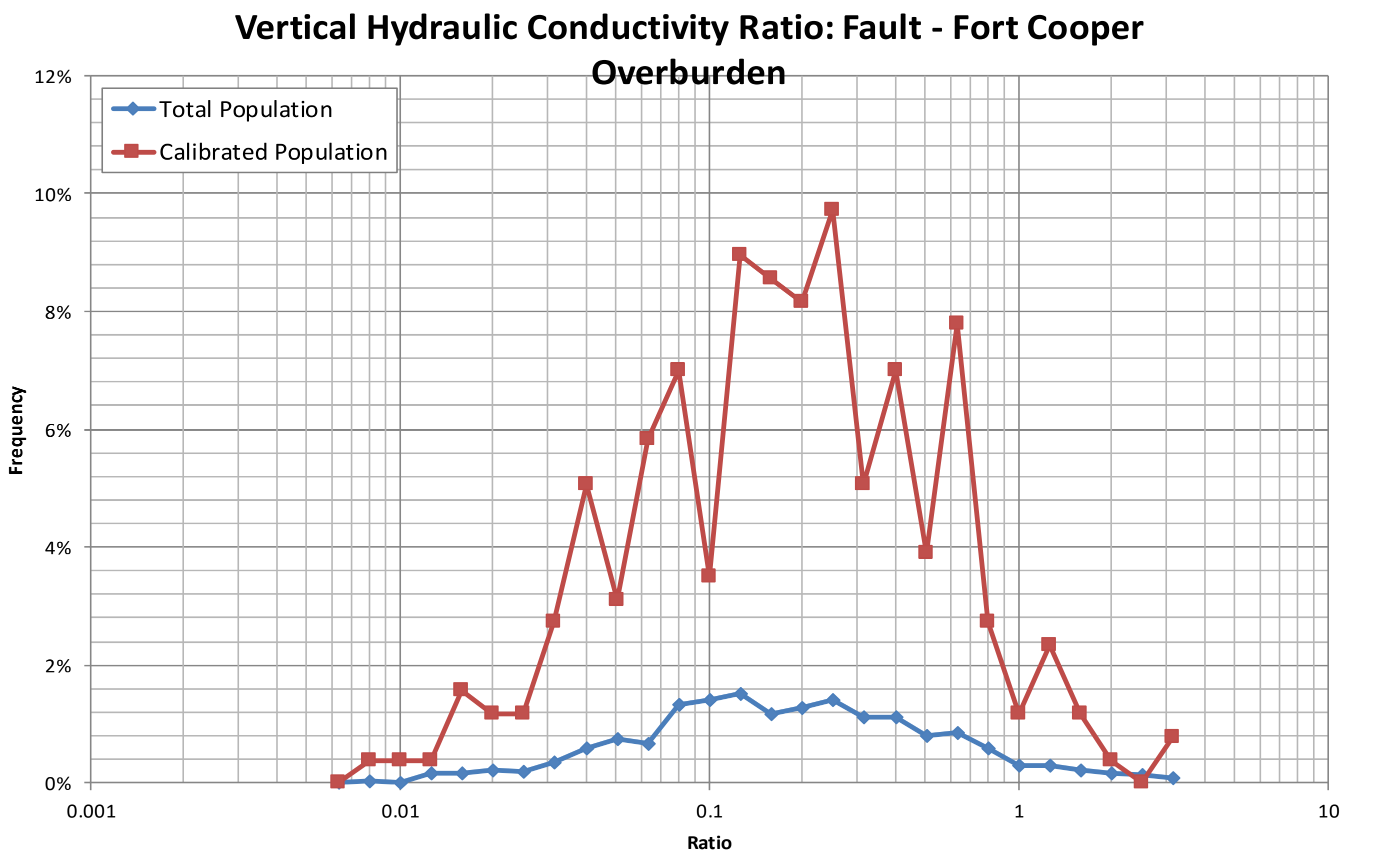
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



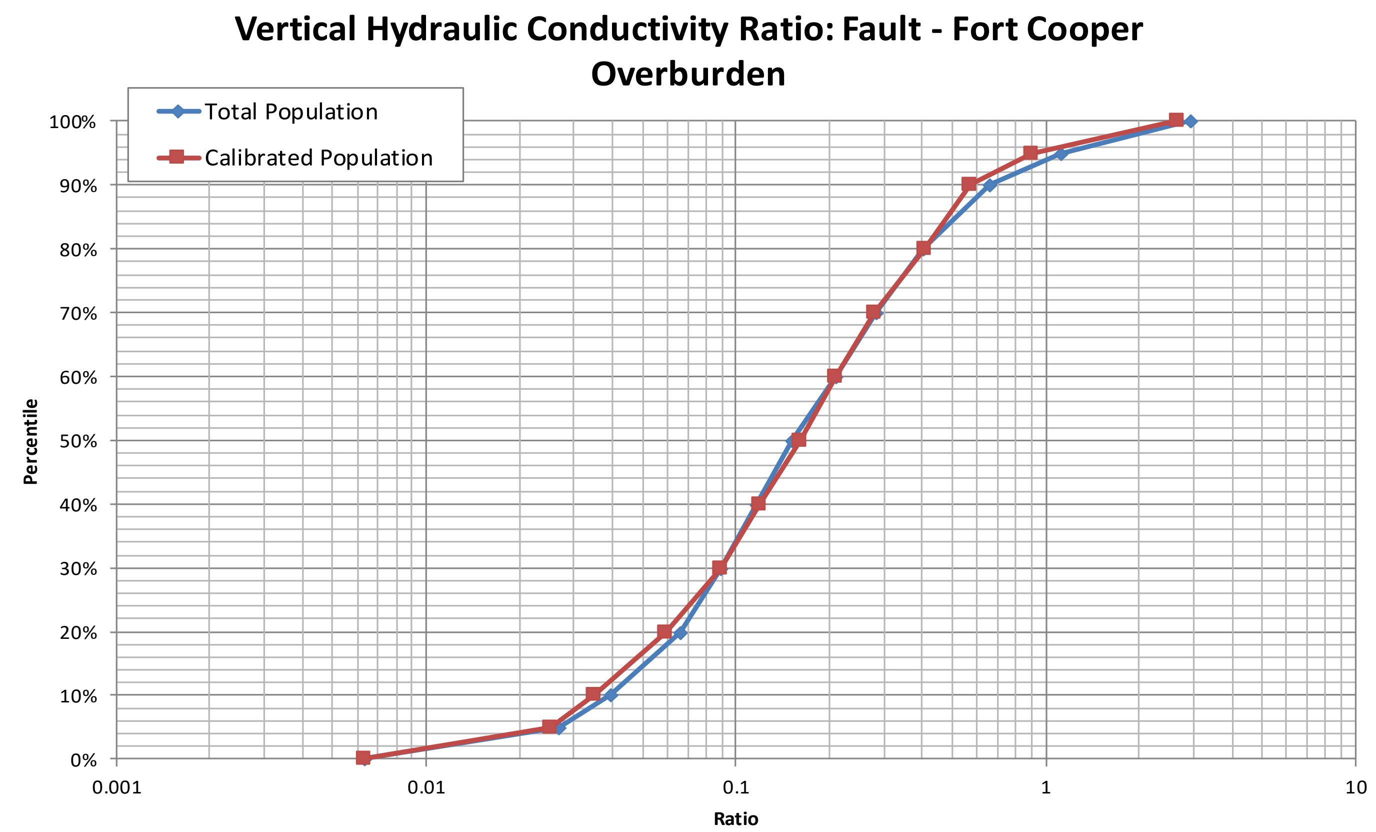


Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

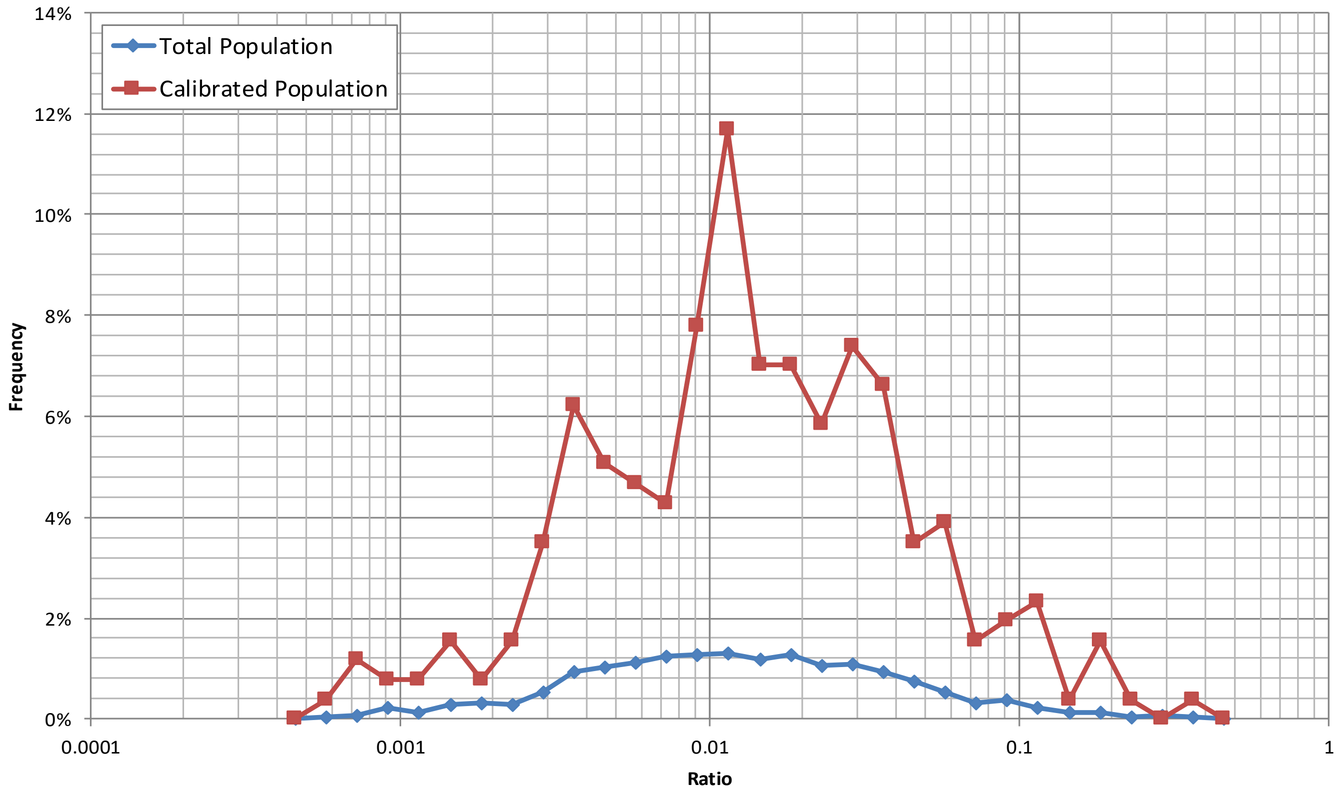




Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

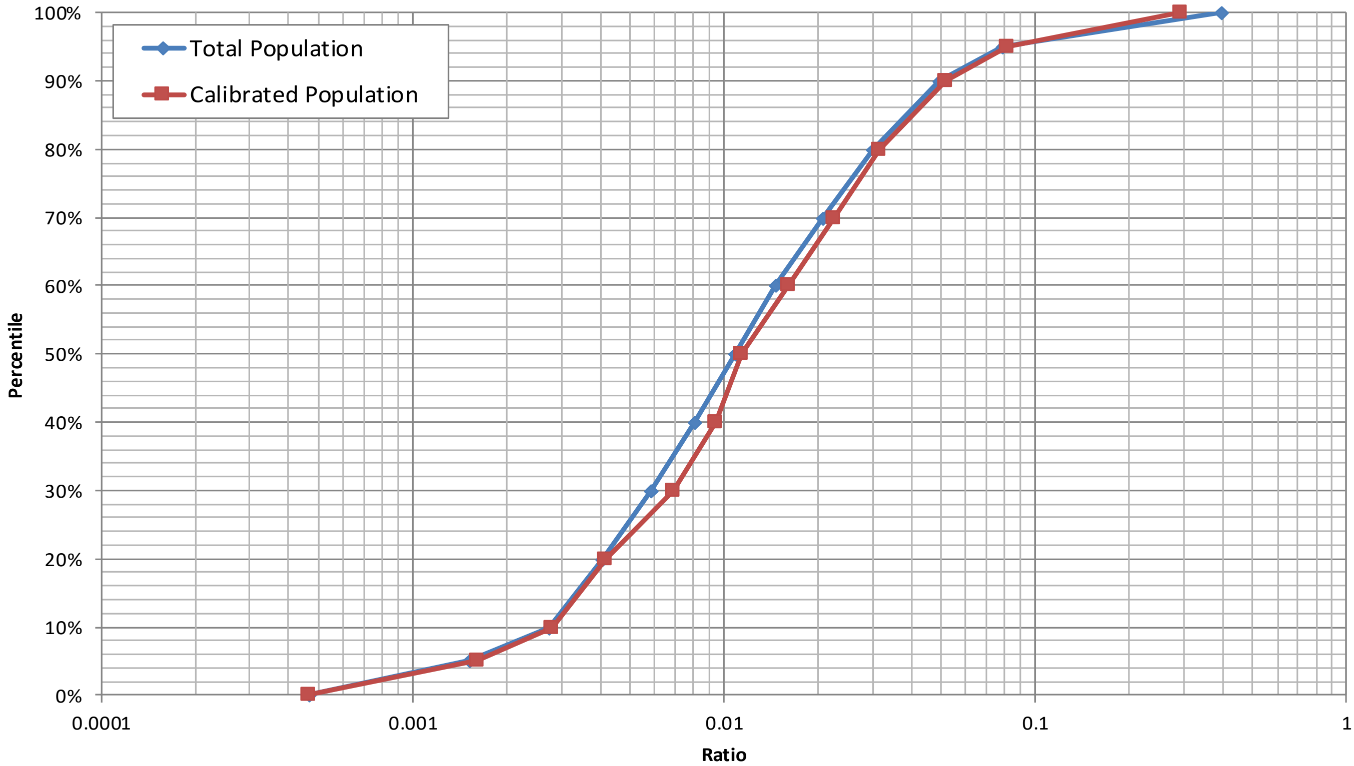


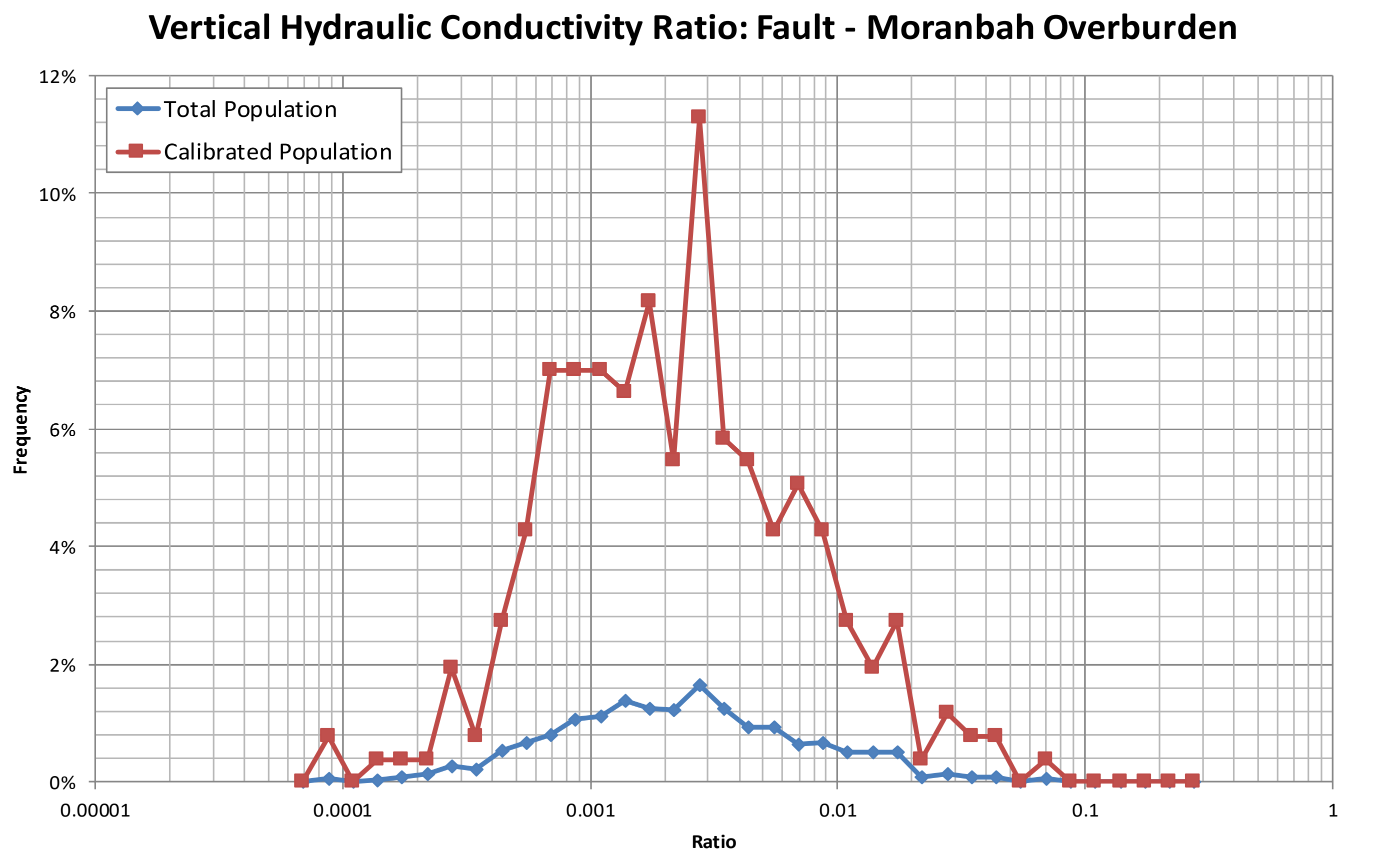
Vertical Hydraulic Conductivity Ratio: Moranbah Overburden



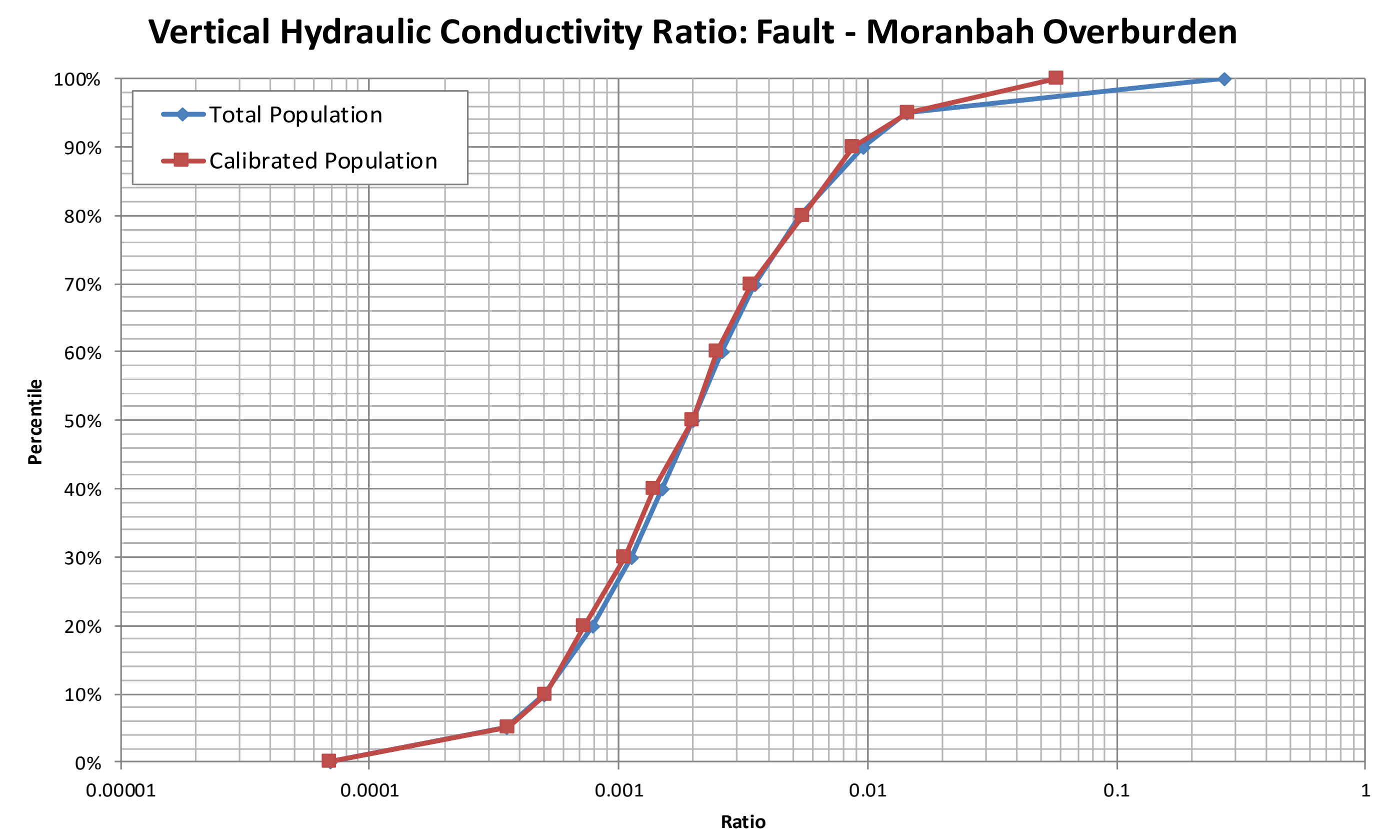
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

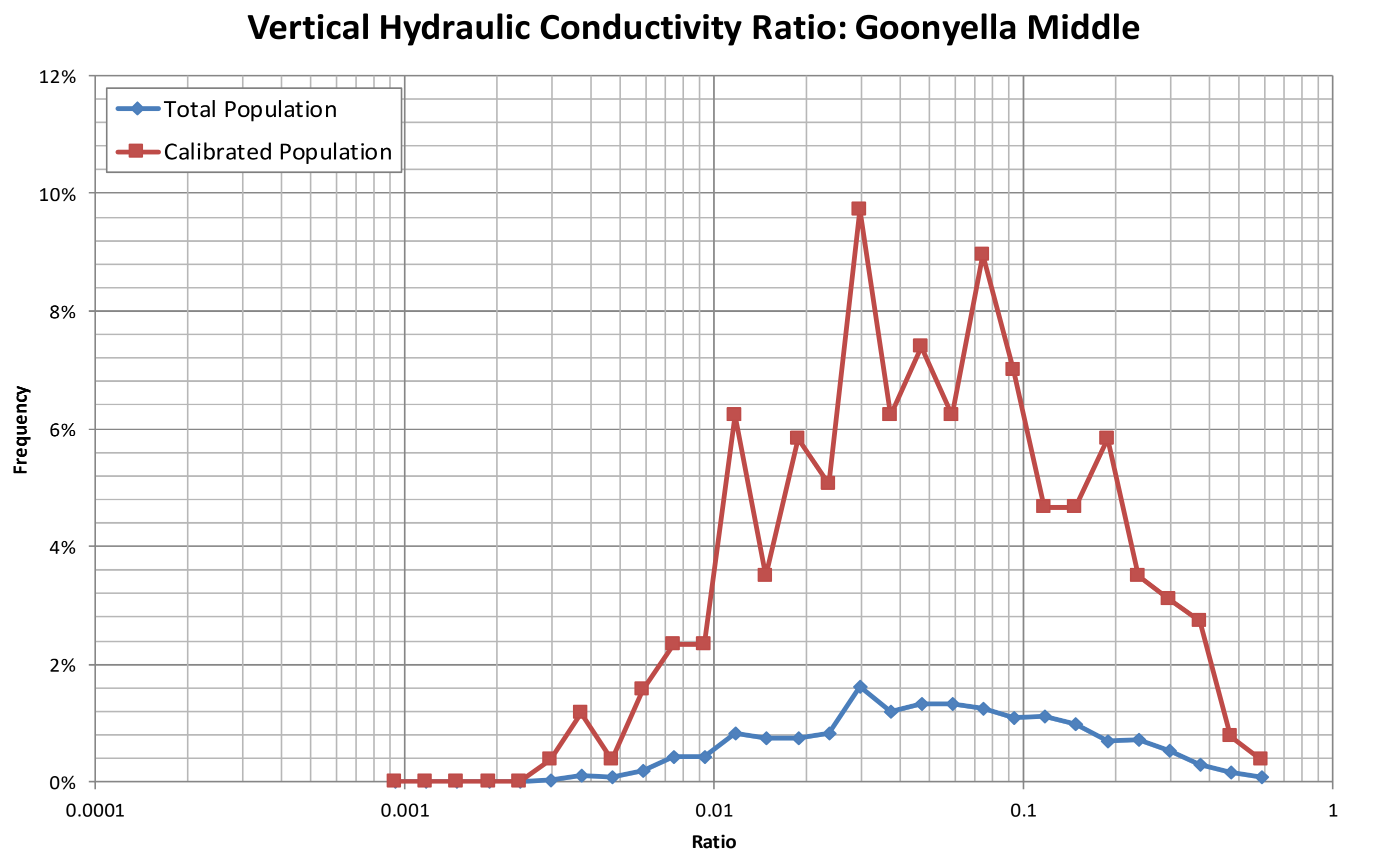
Vertical Hydraulic Conductivity Ratio: Moranbah Overburden



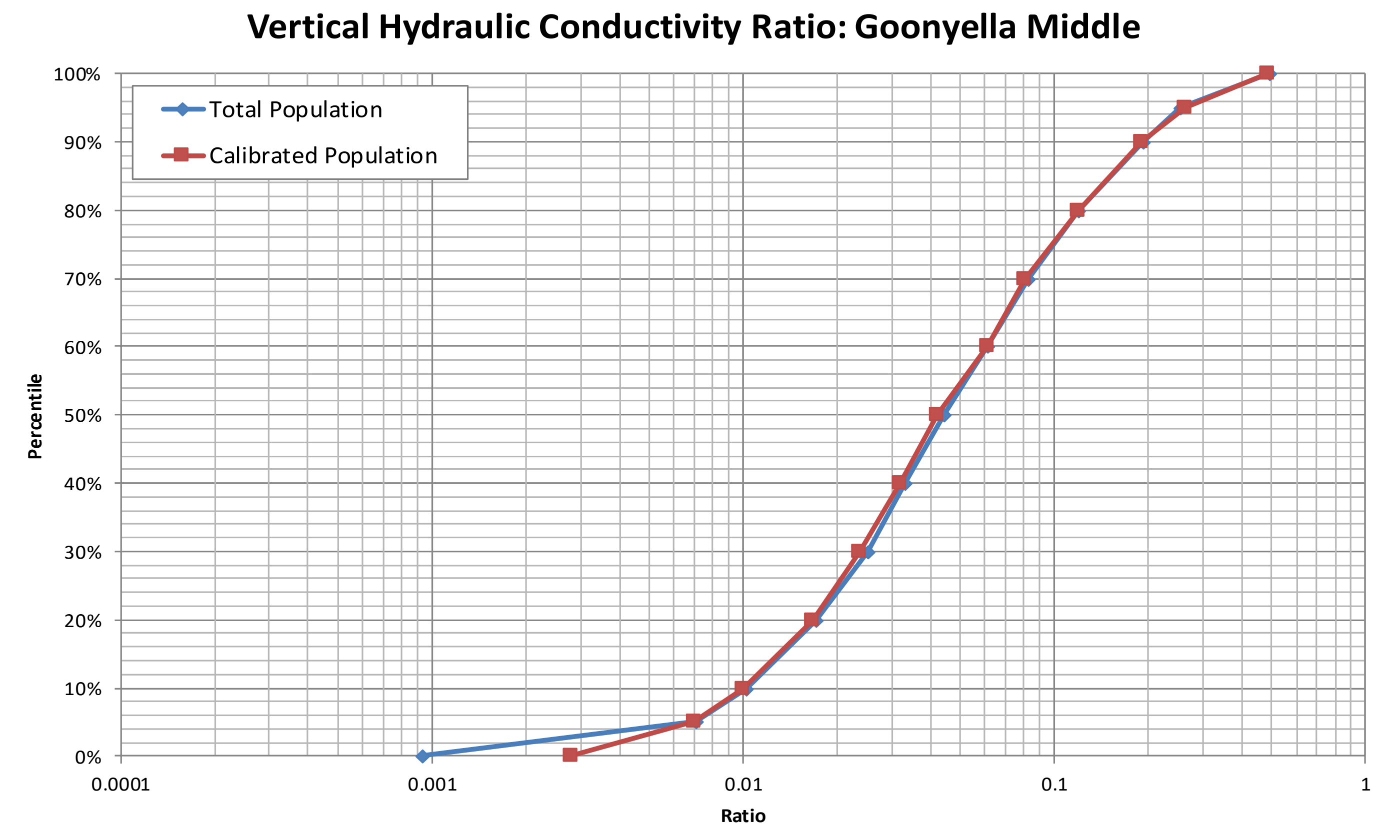


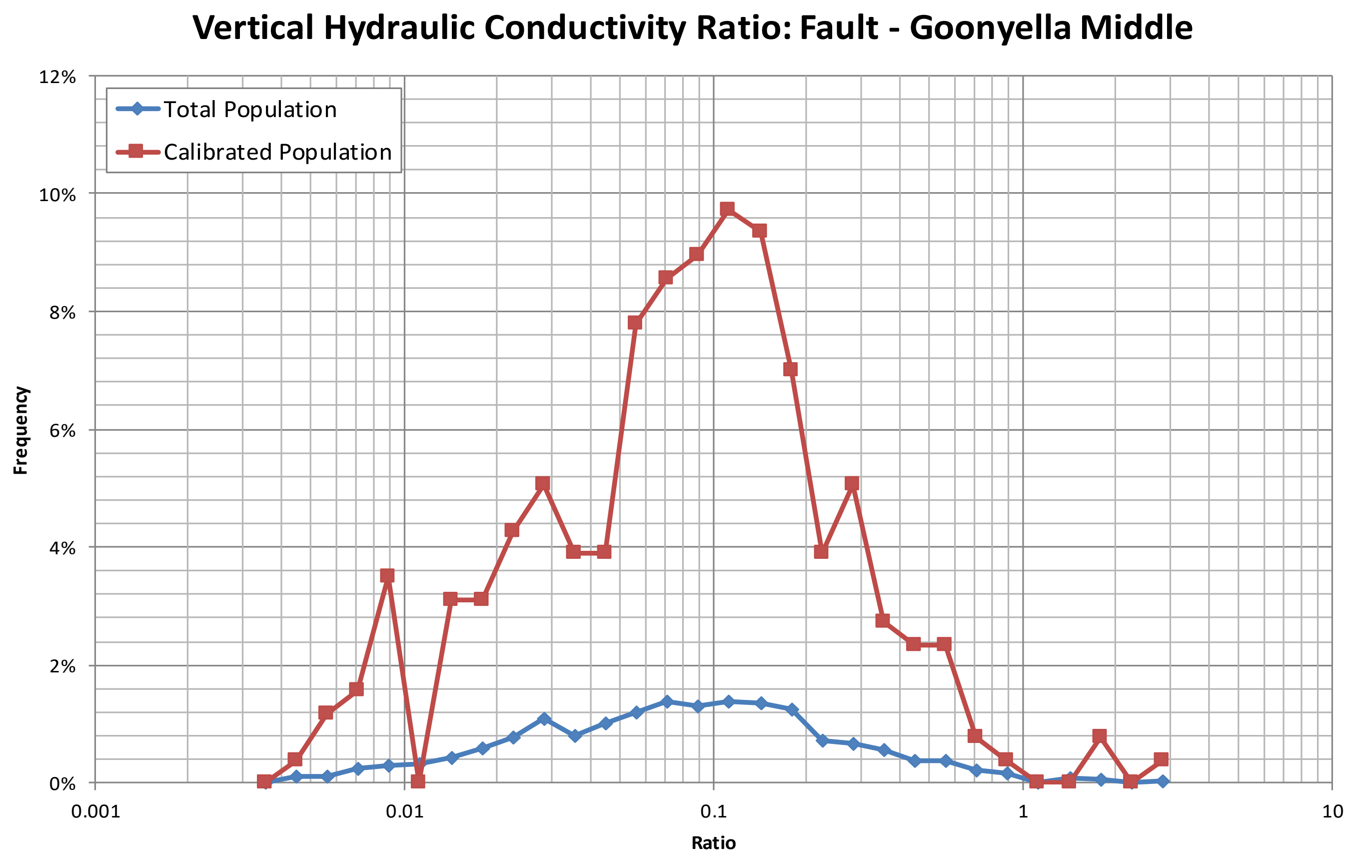
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



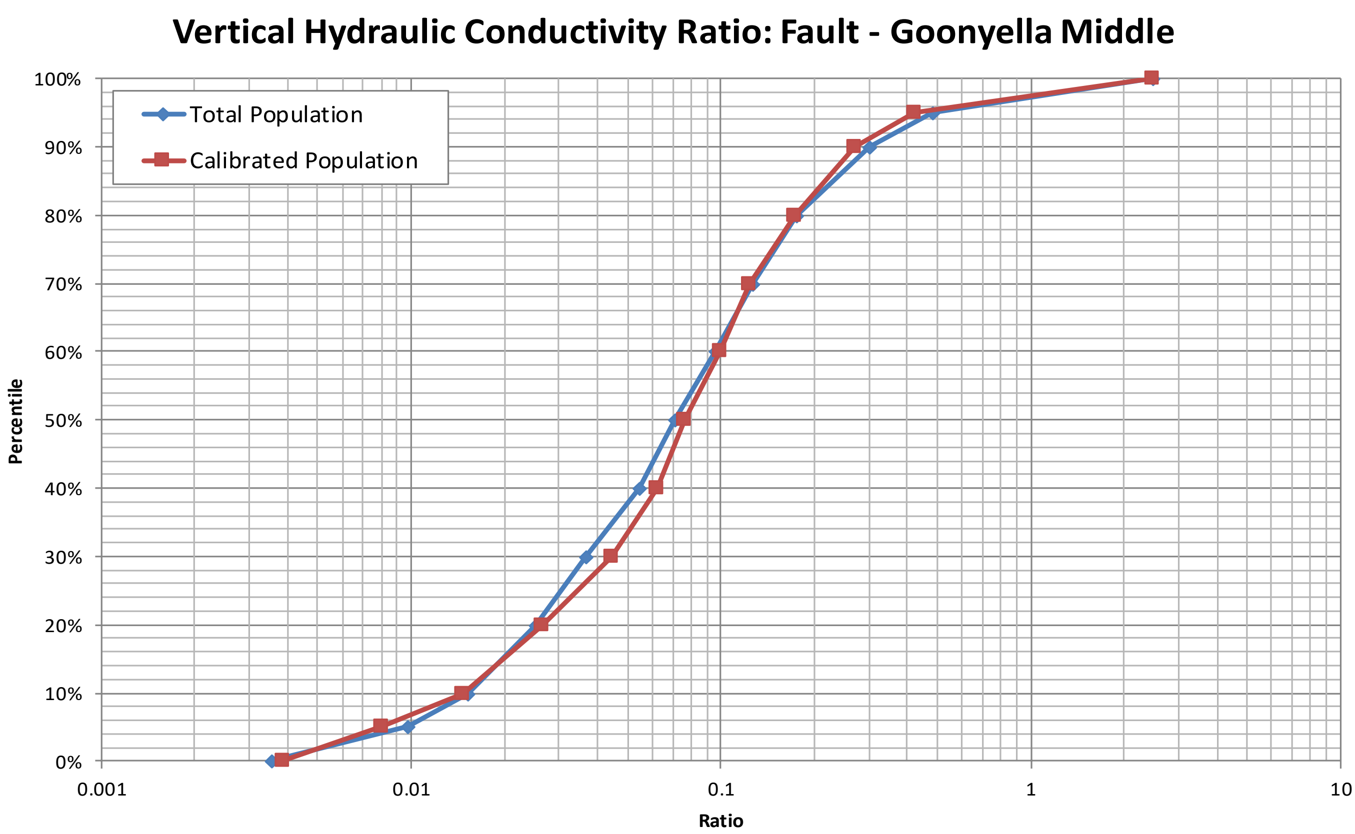


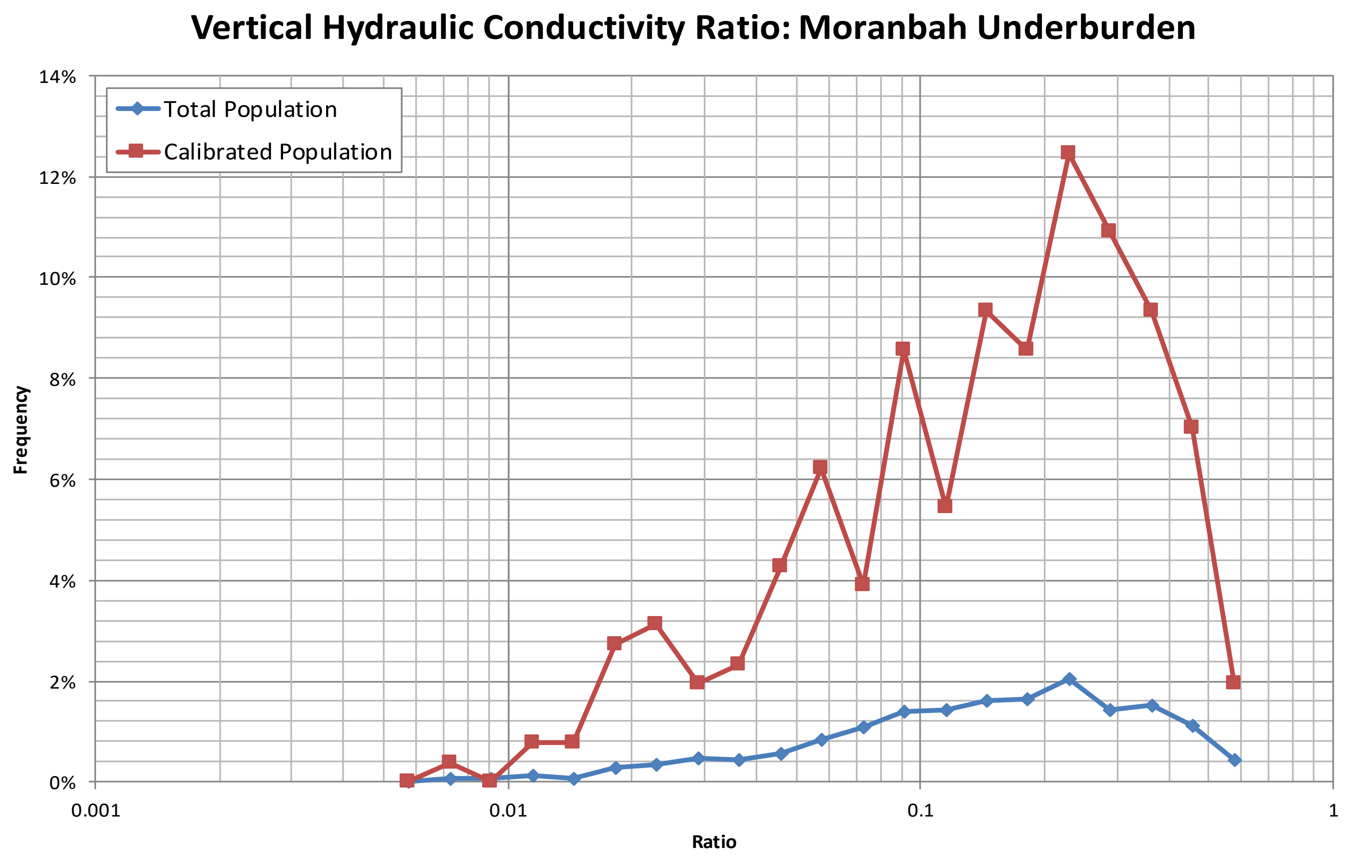
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



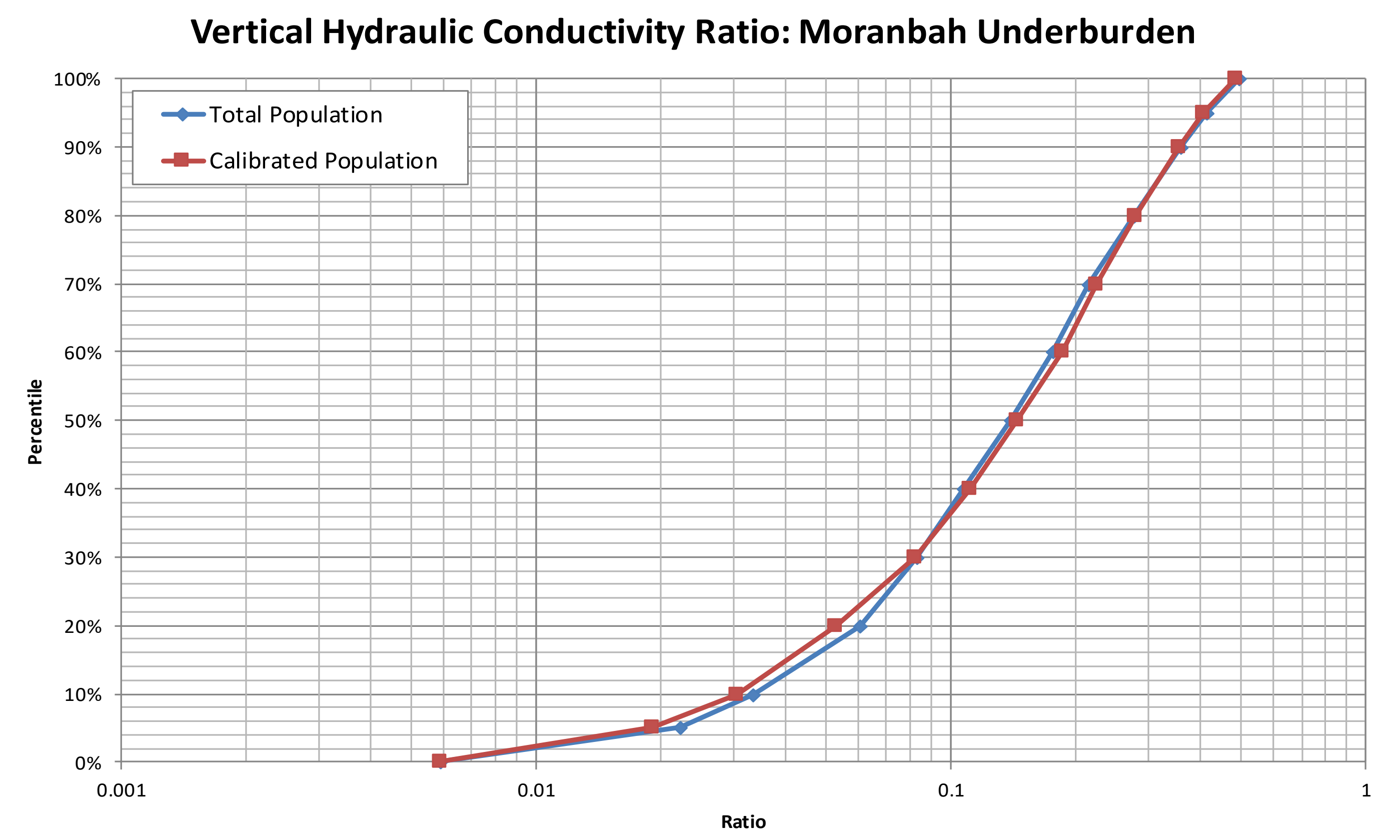


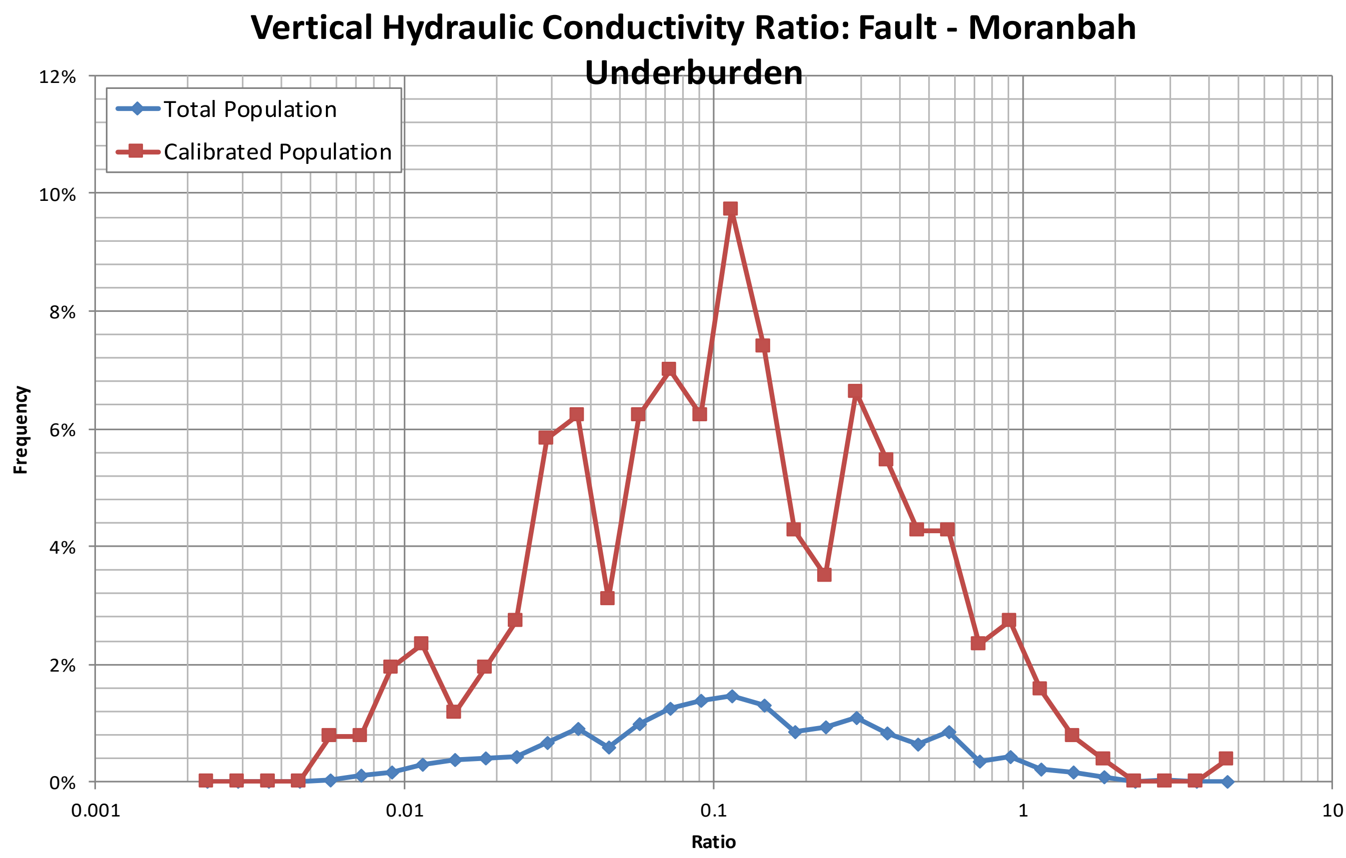
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



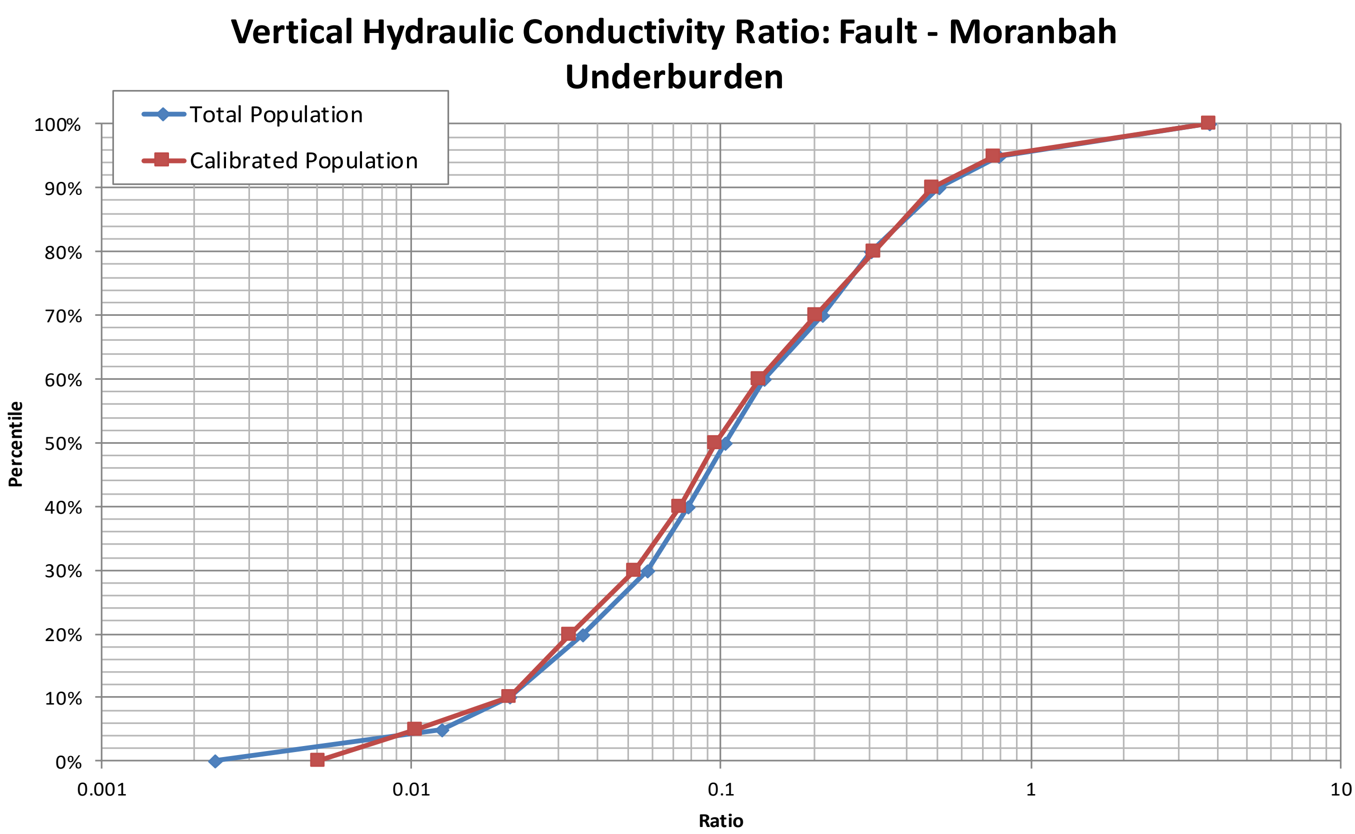


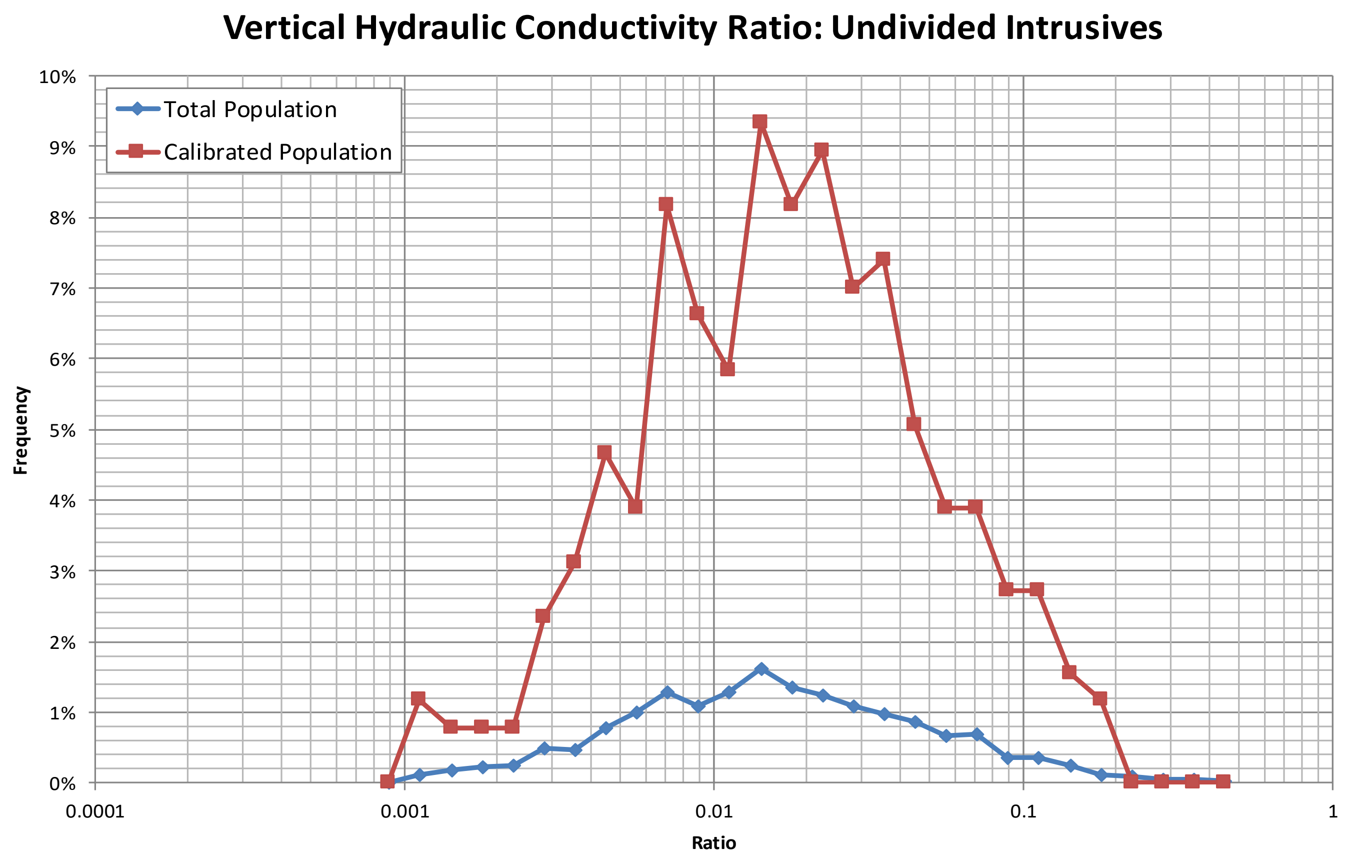
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



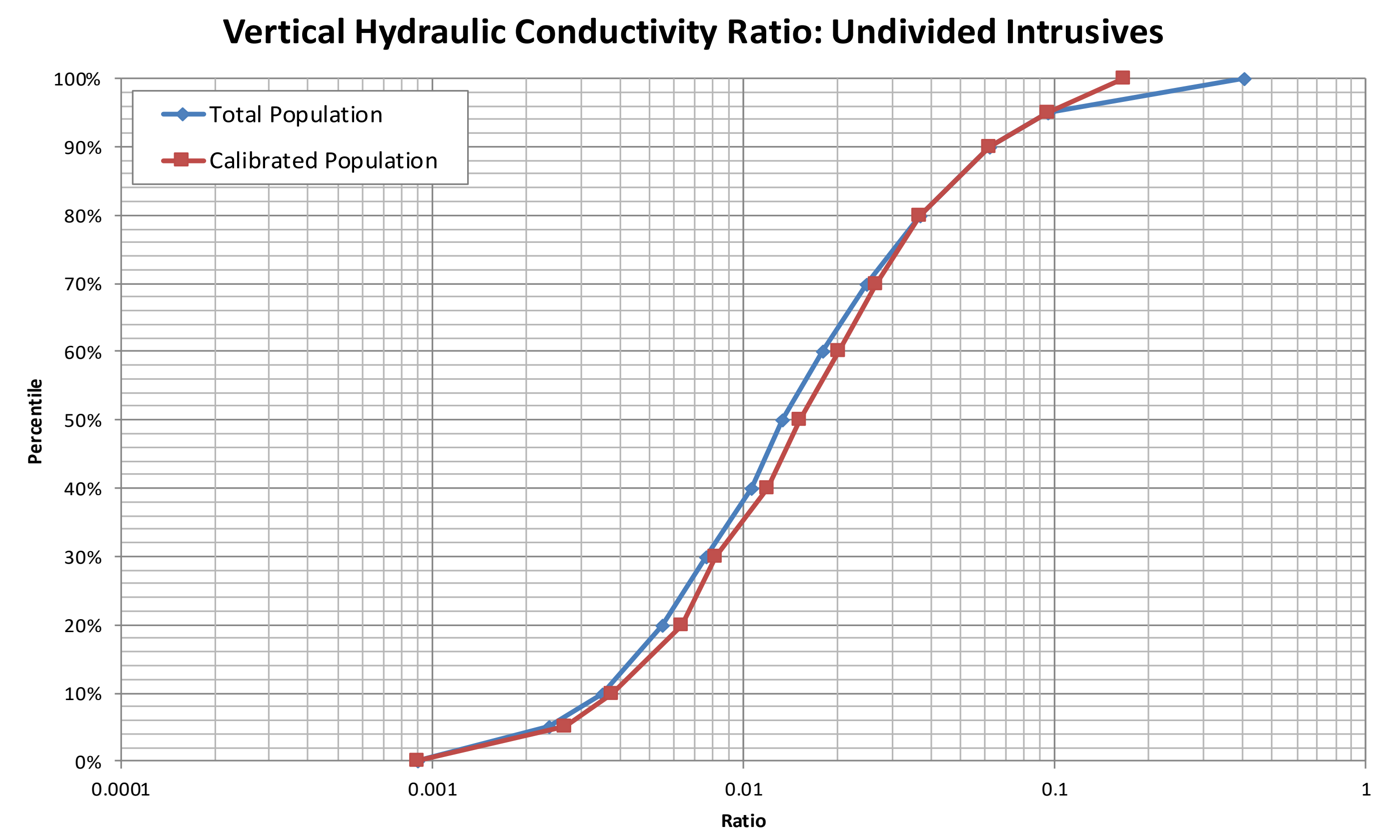


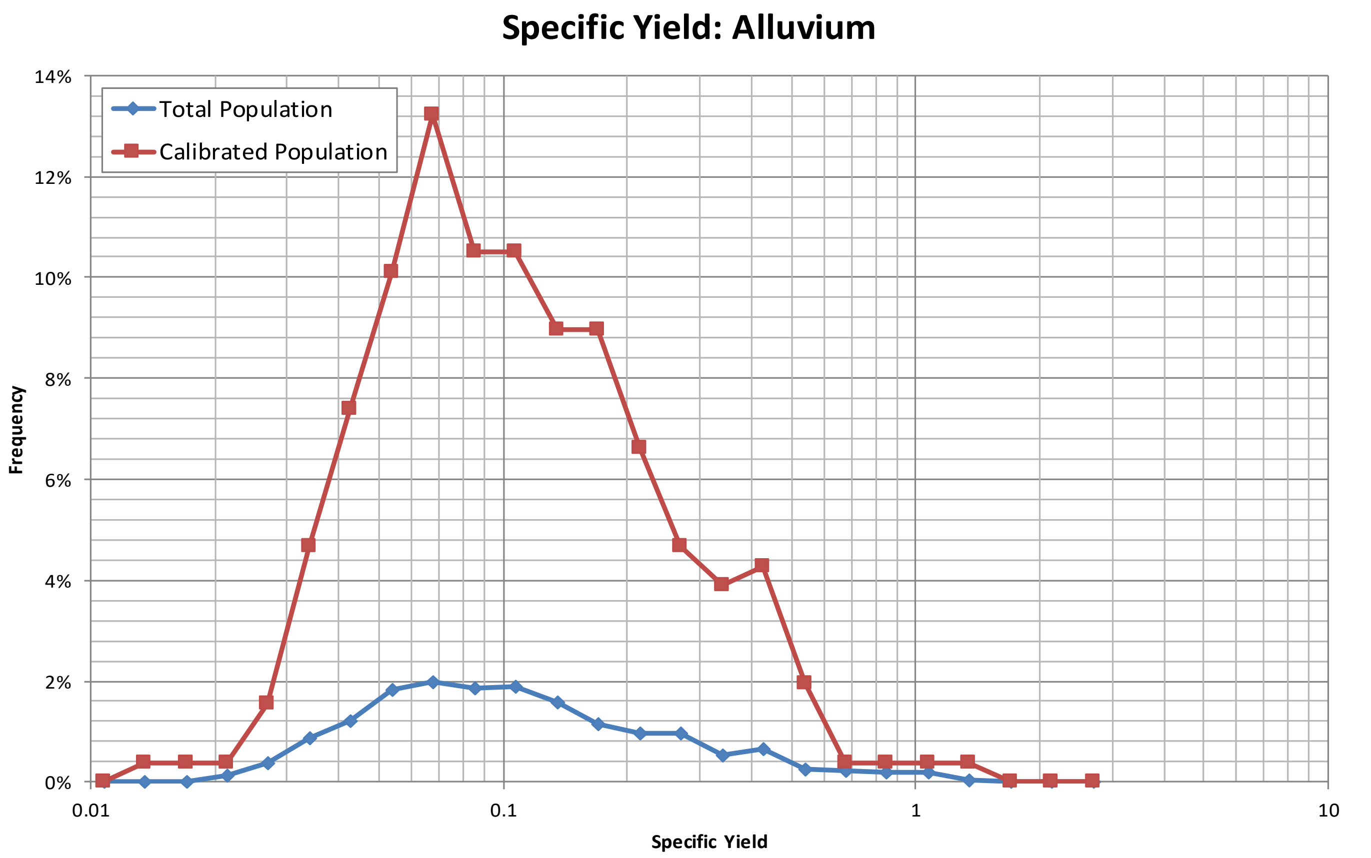
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



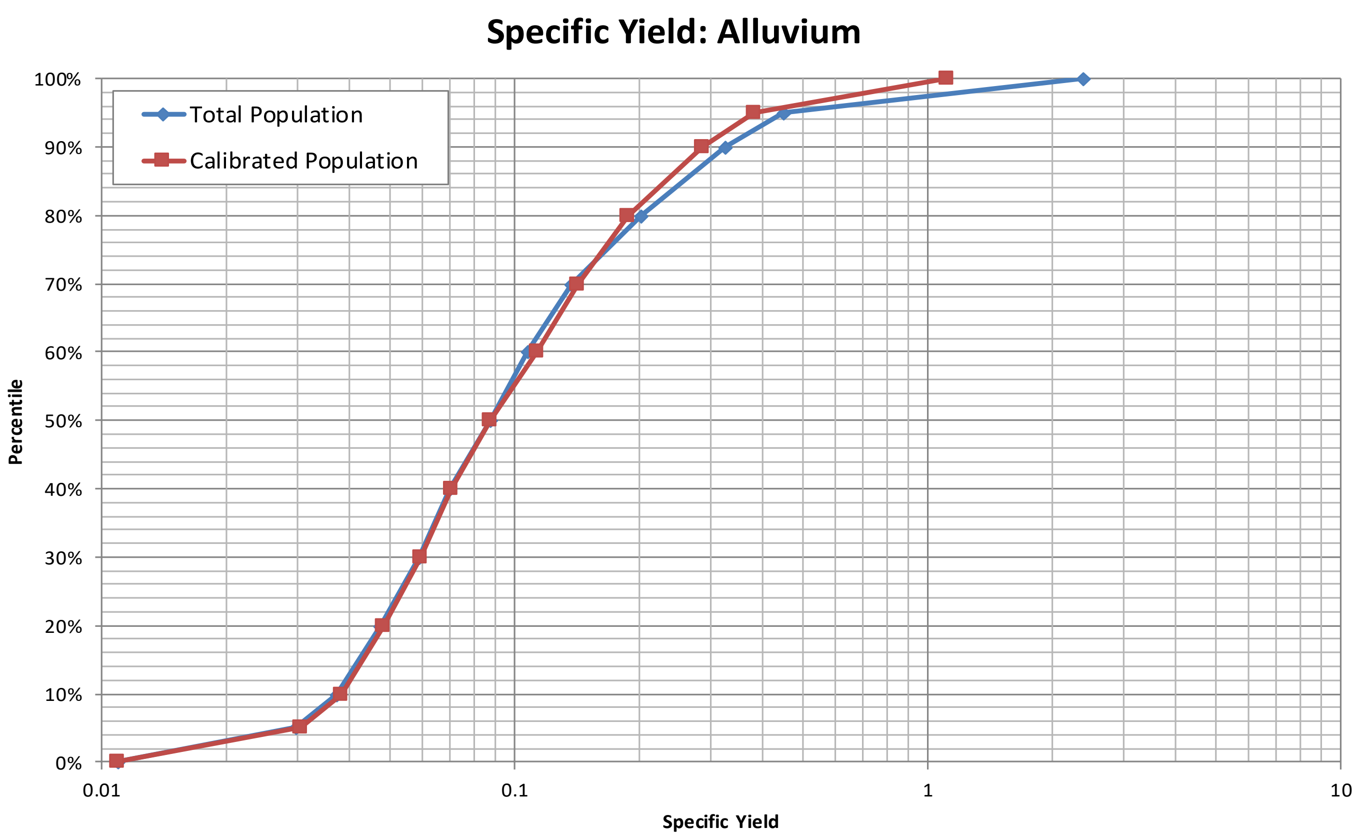


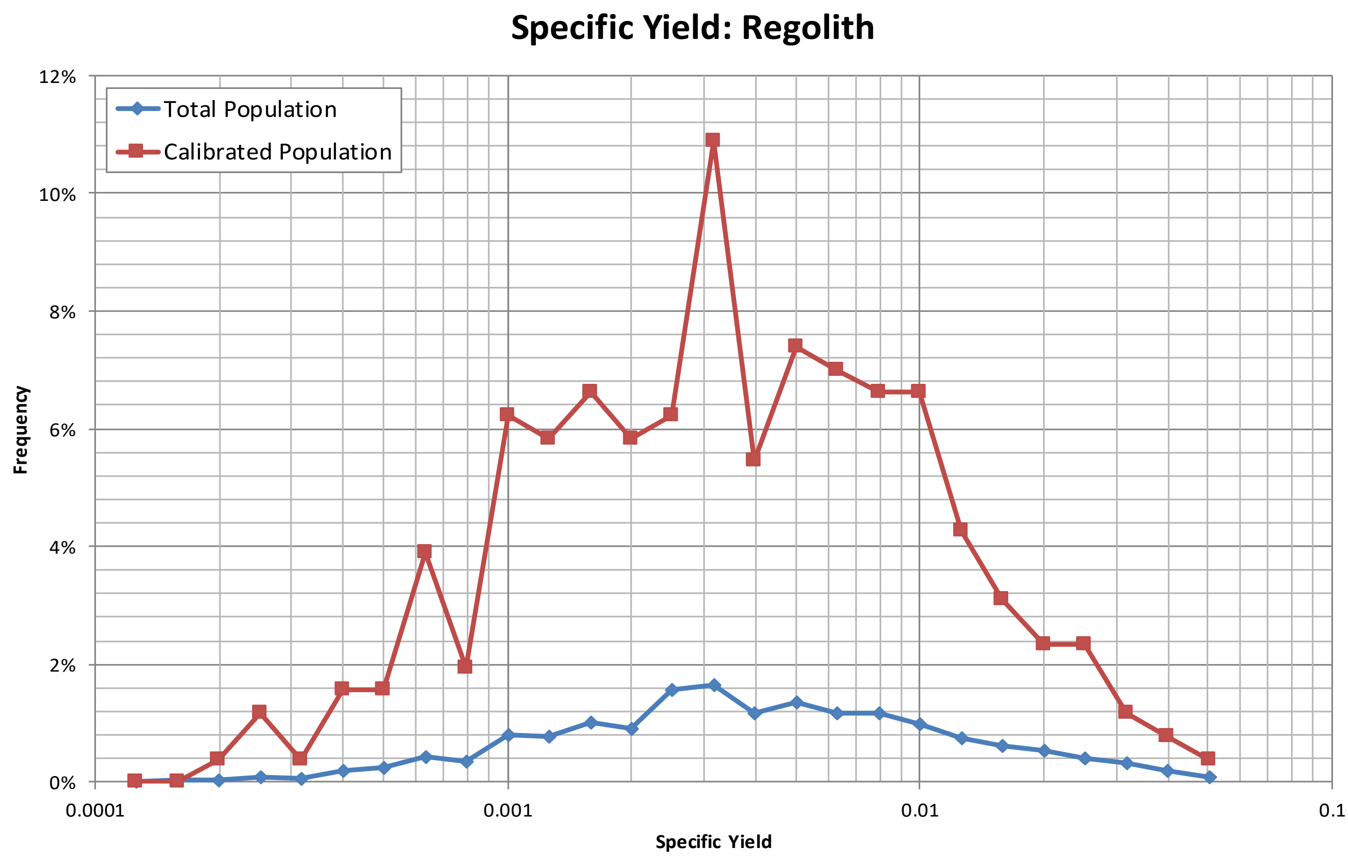
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



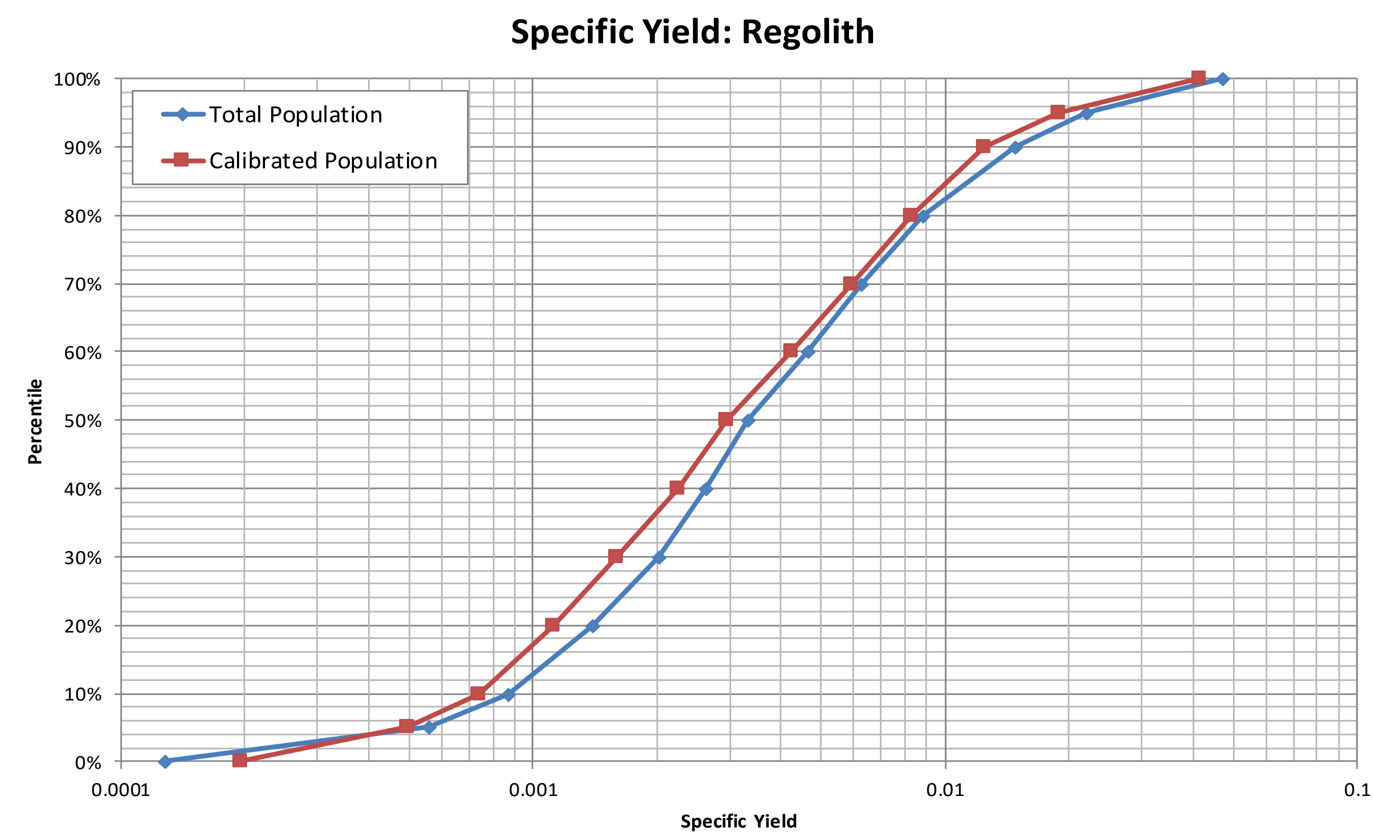


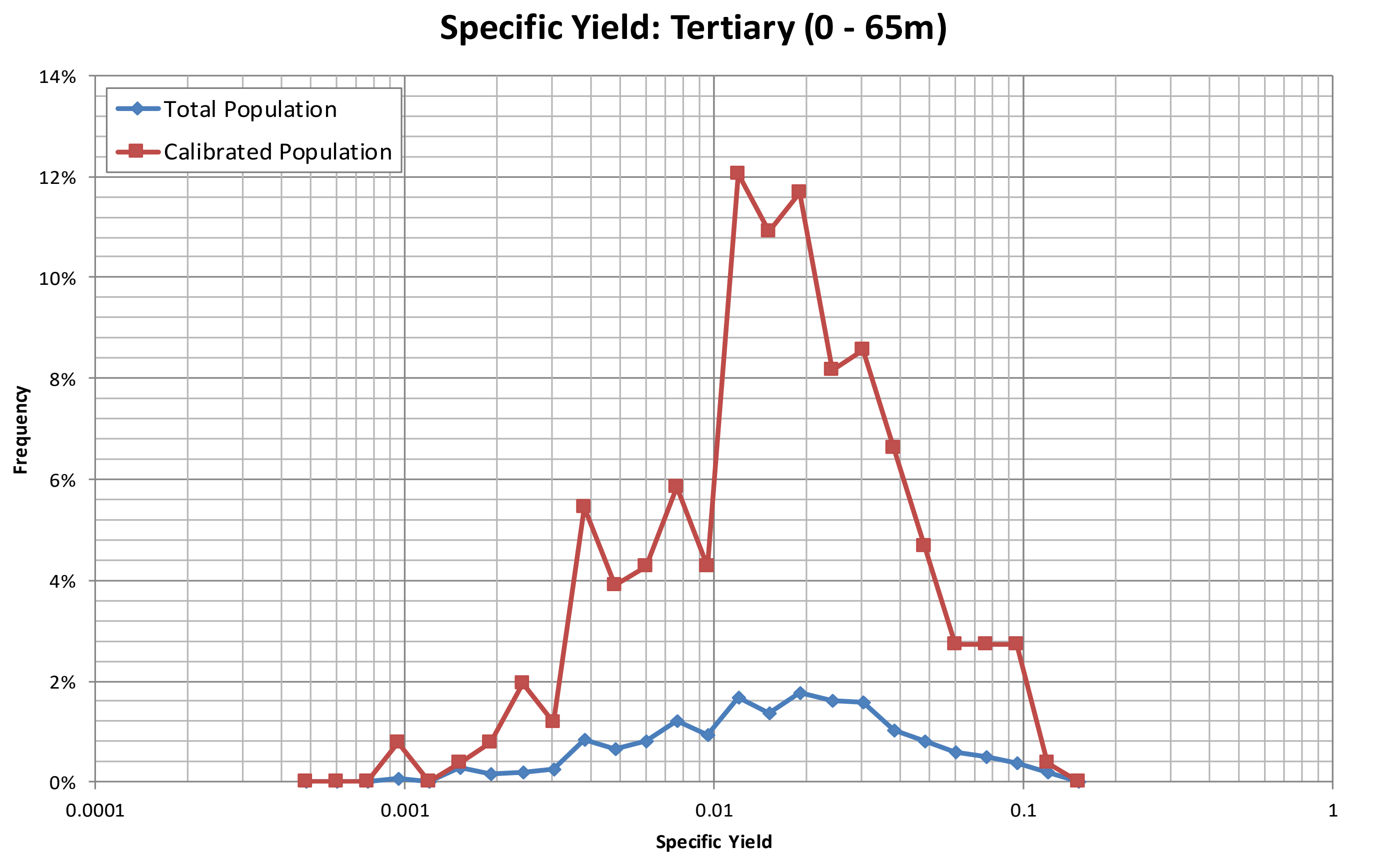
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



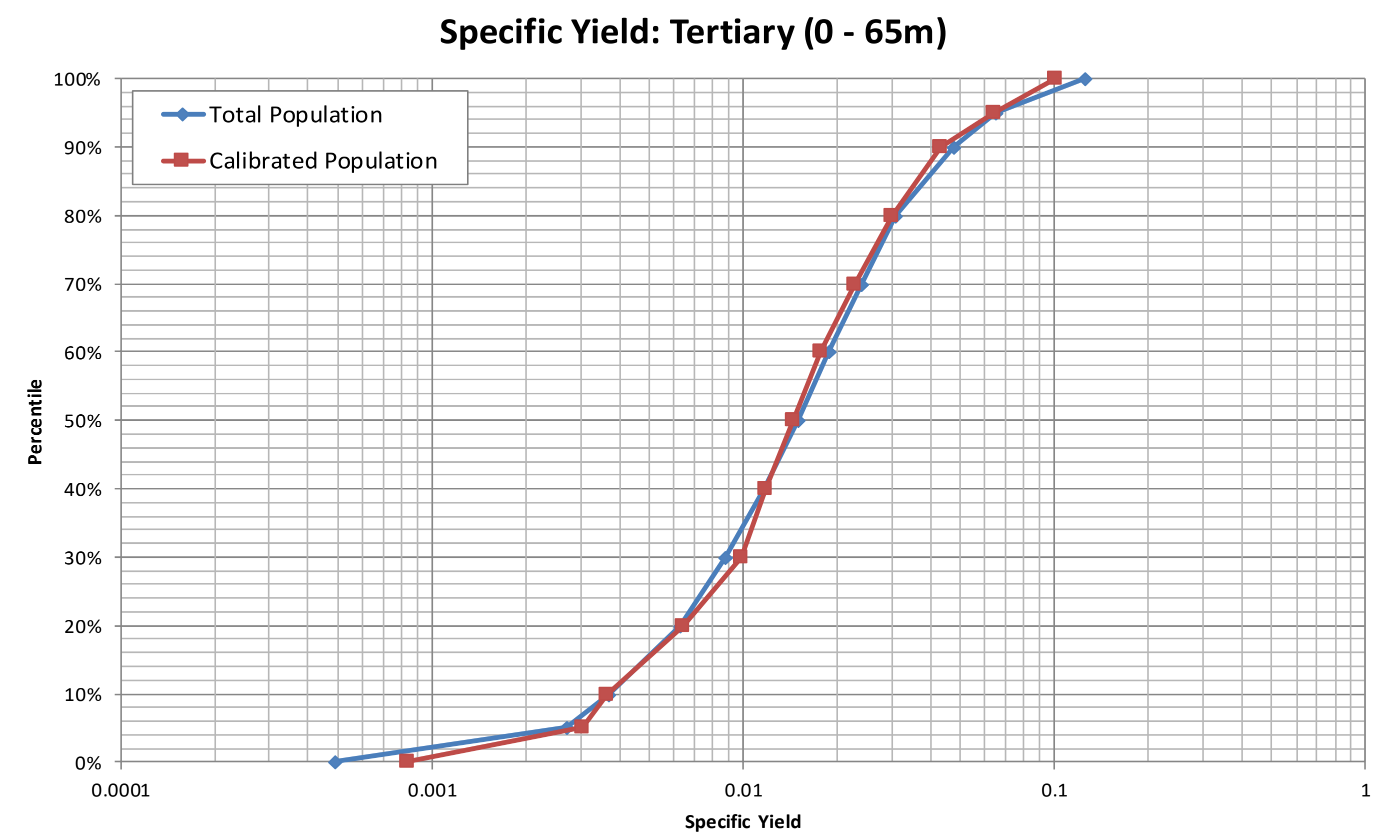


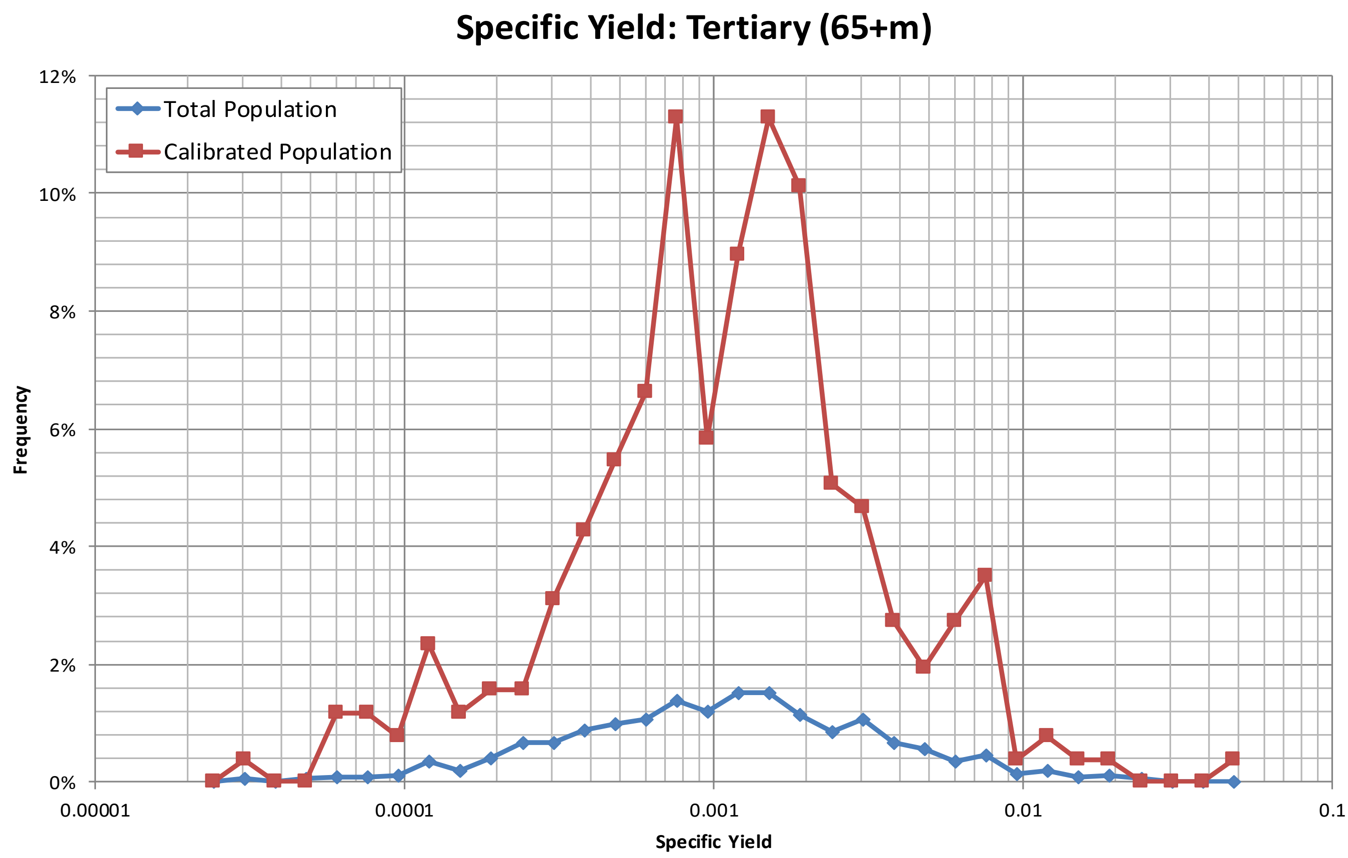
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



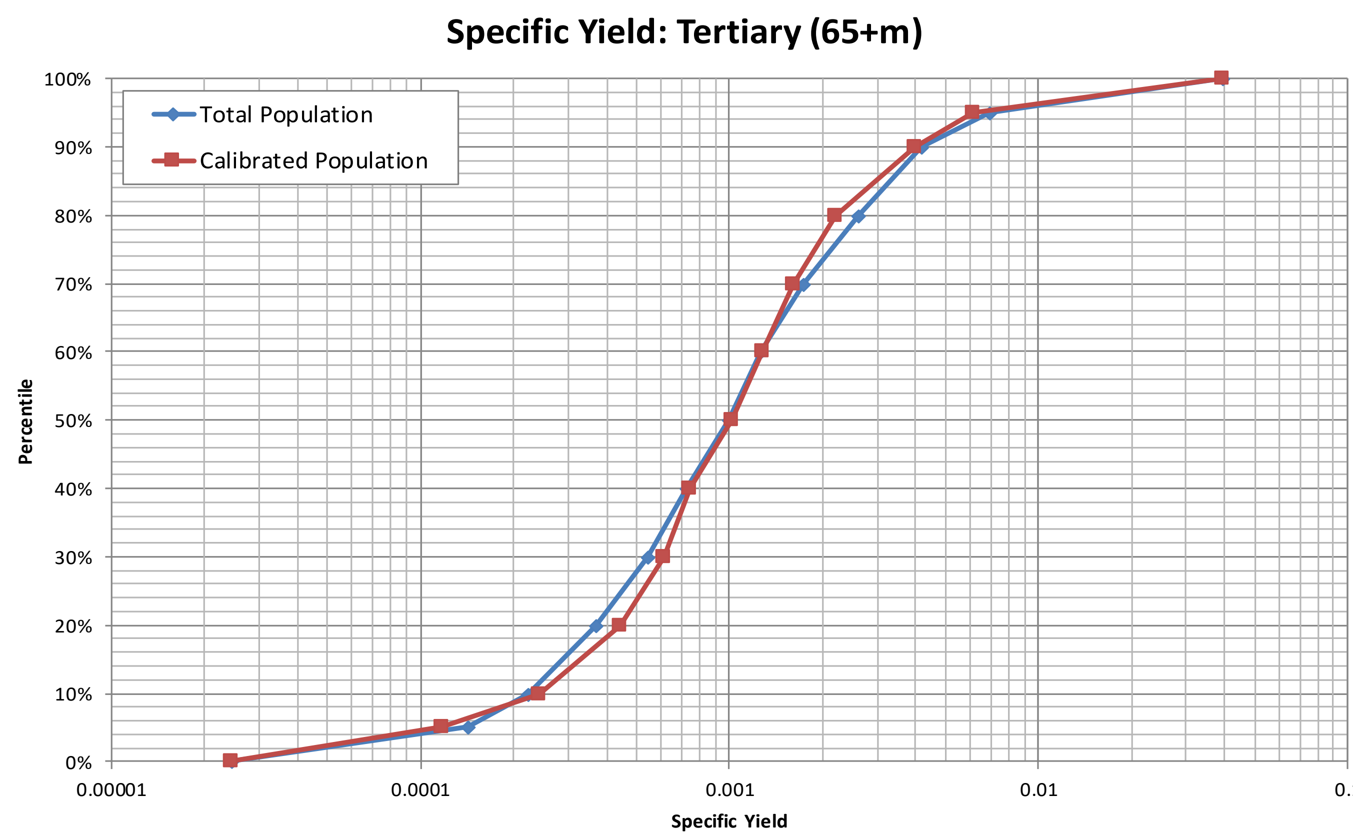


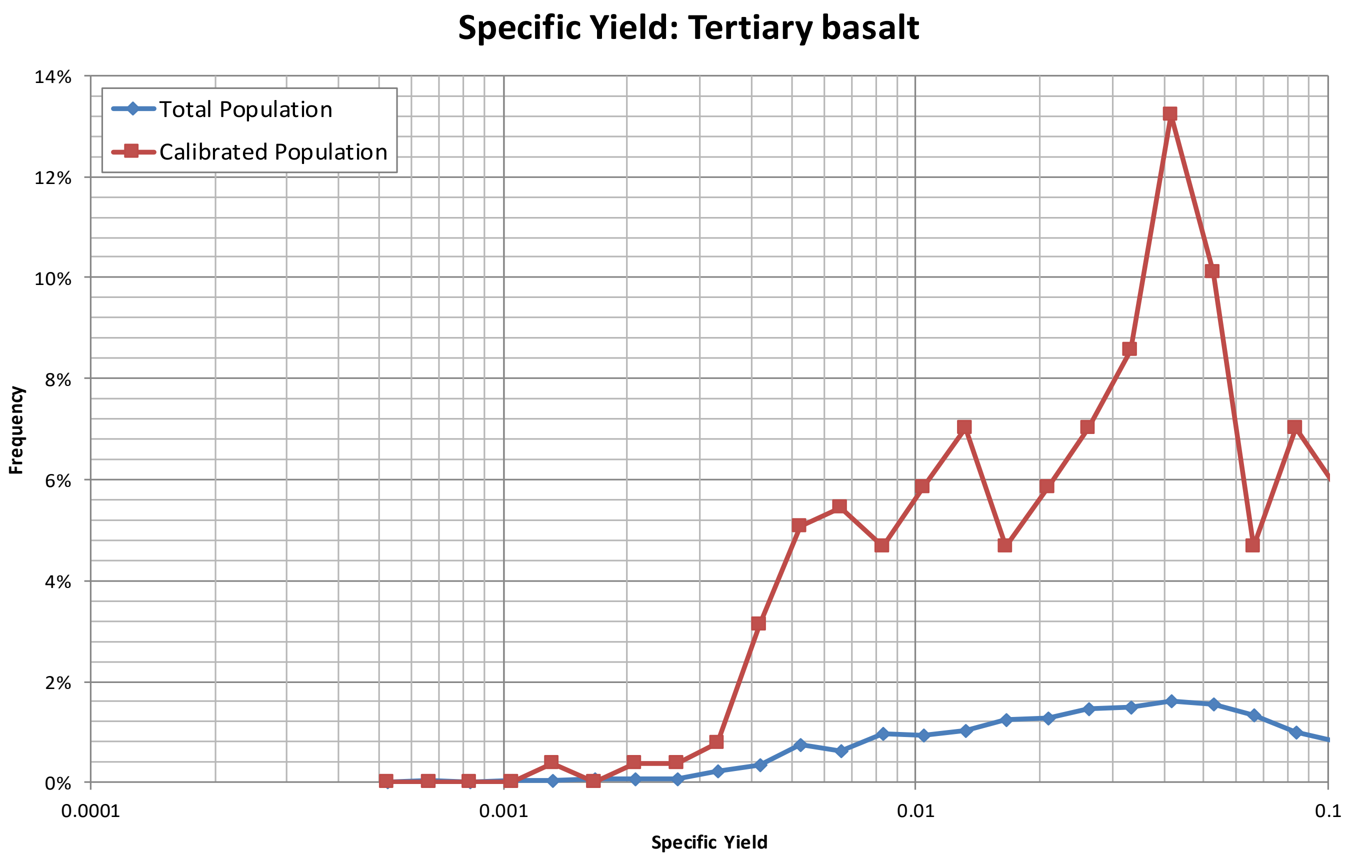
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



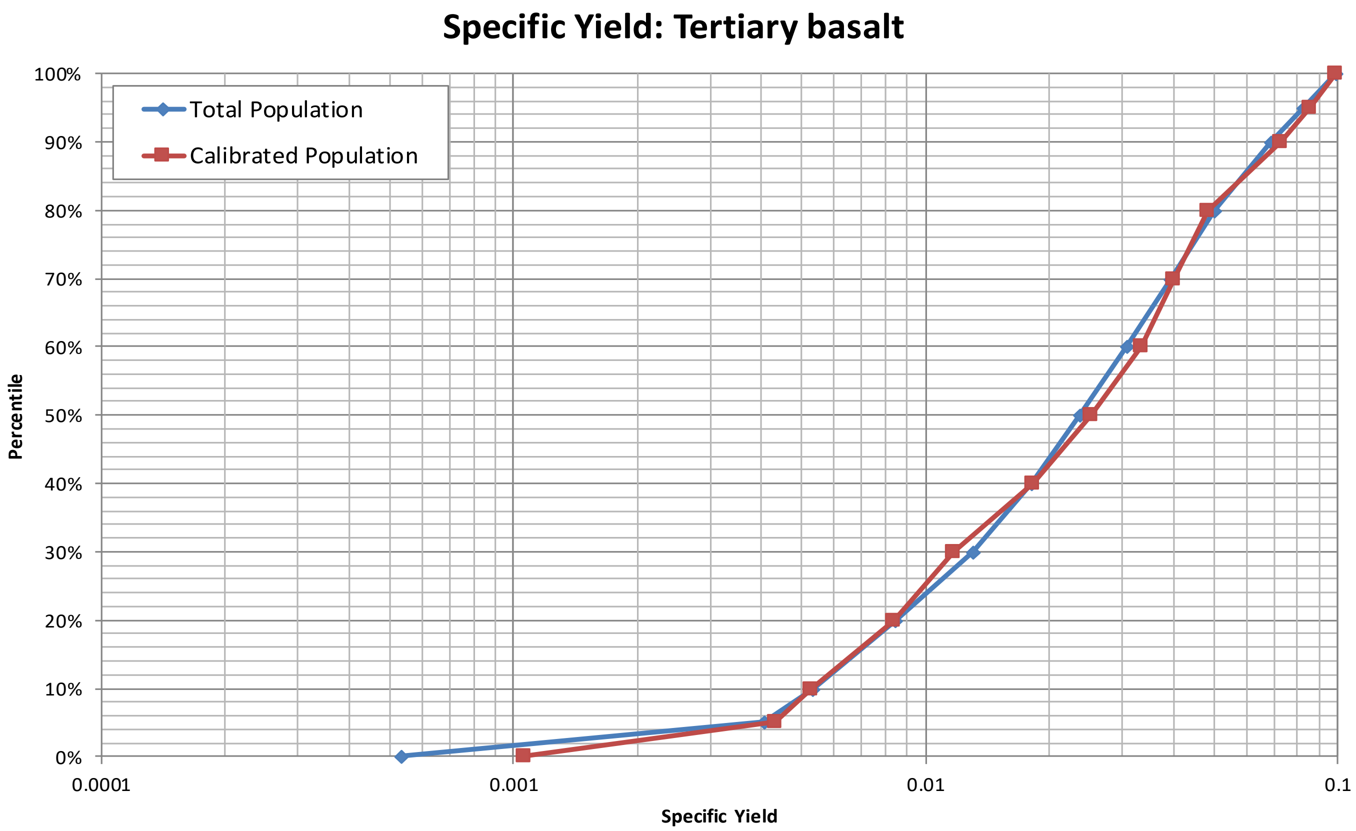


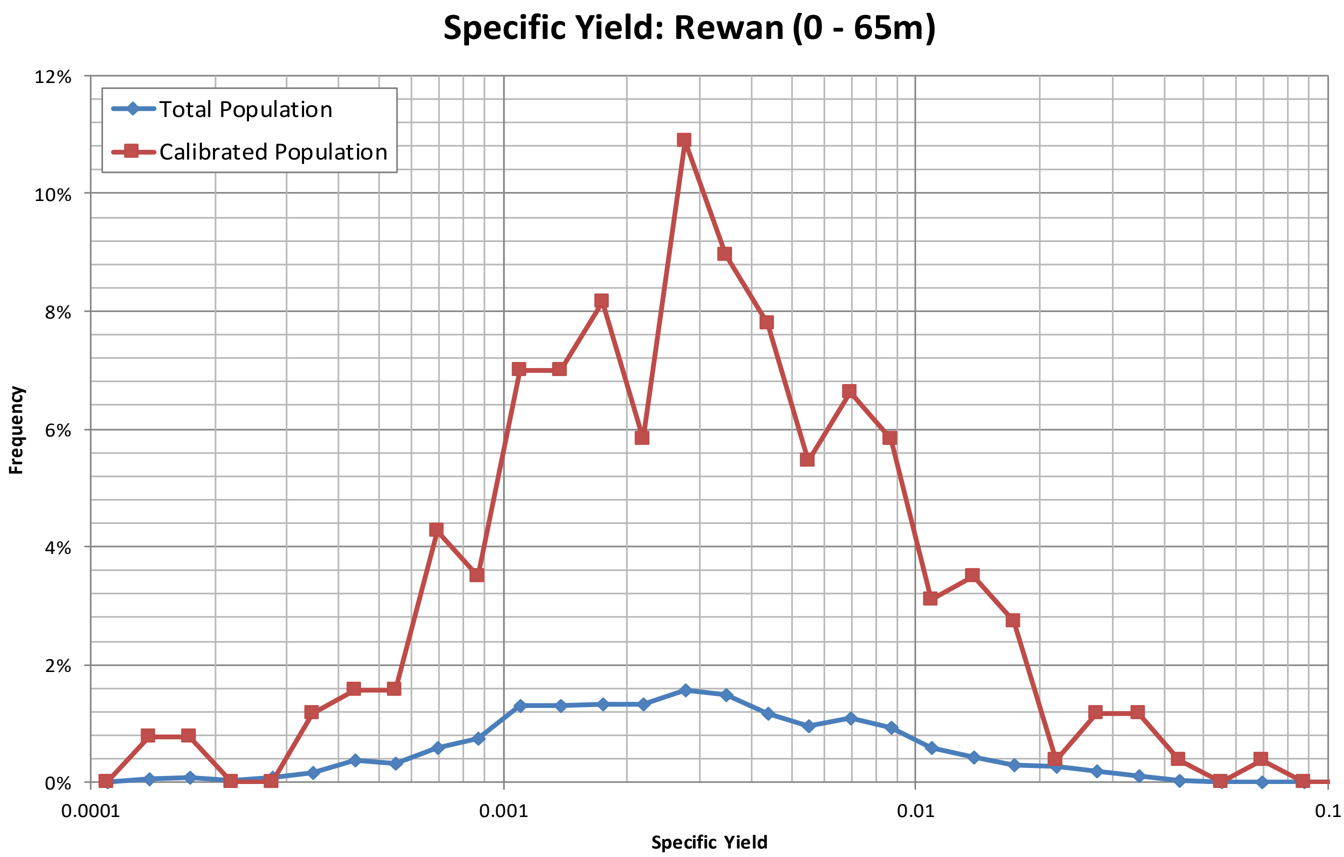
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



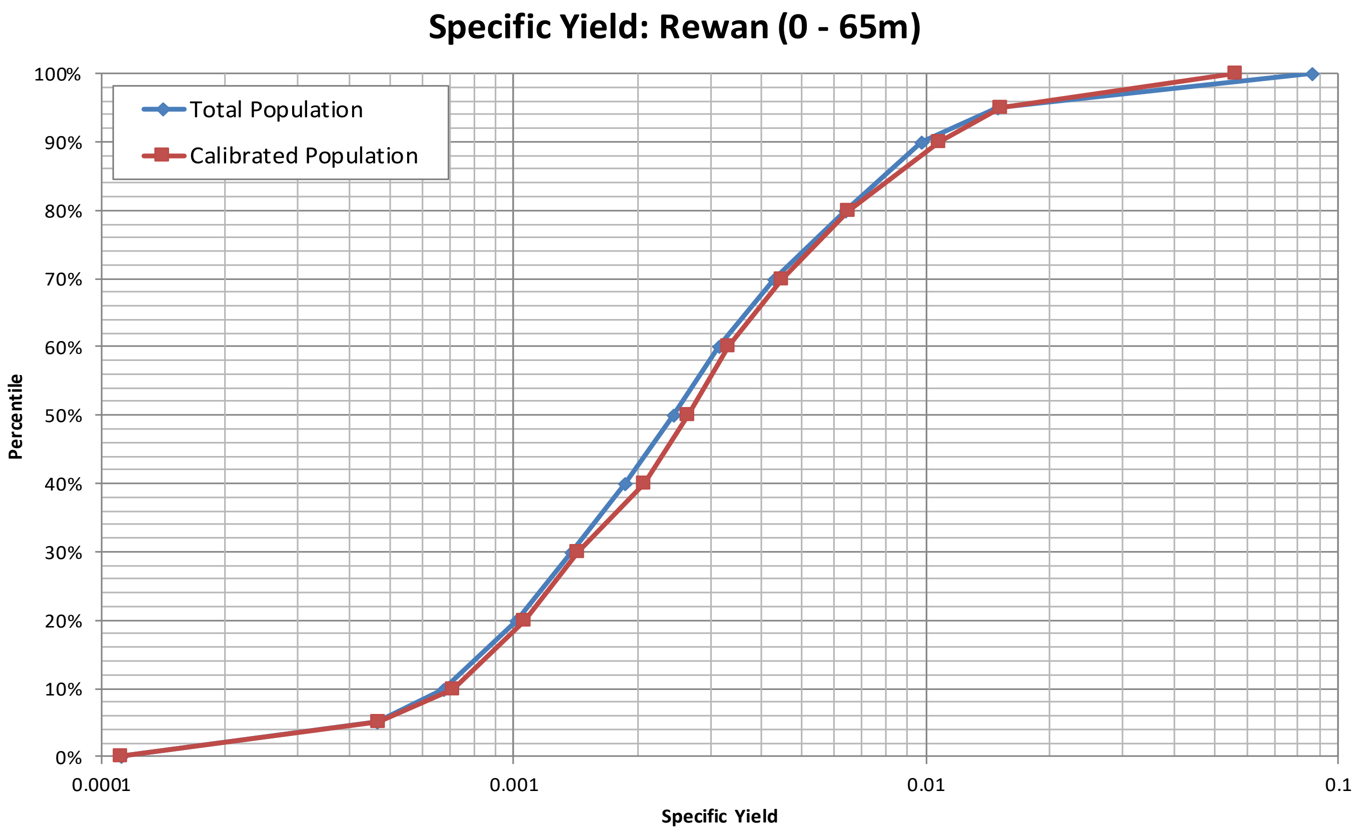


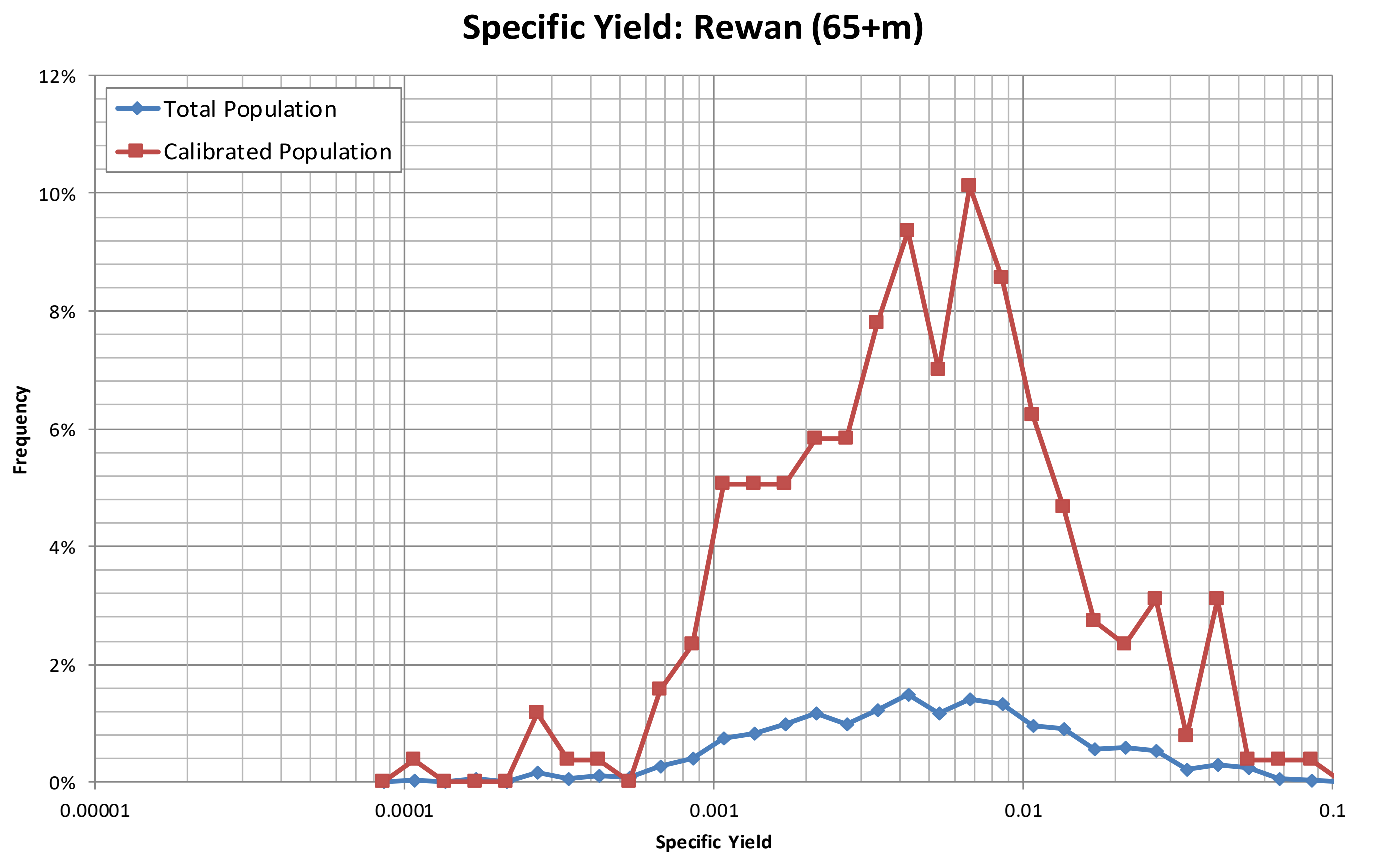
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



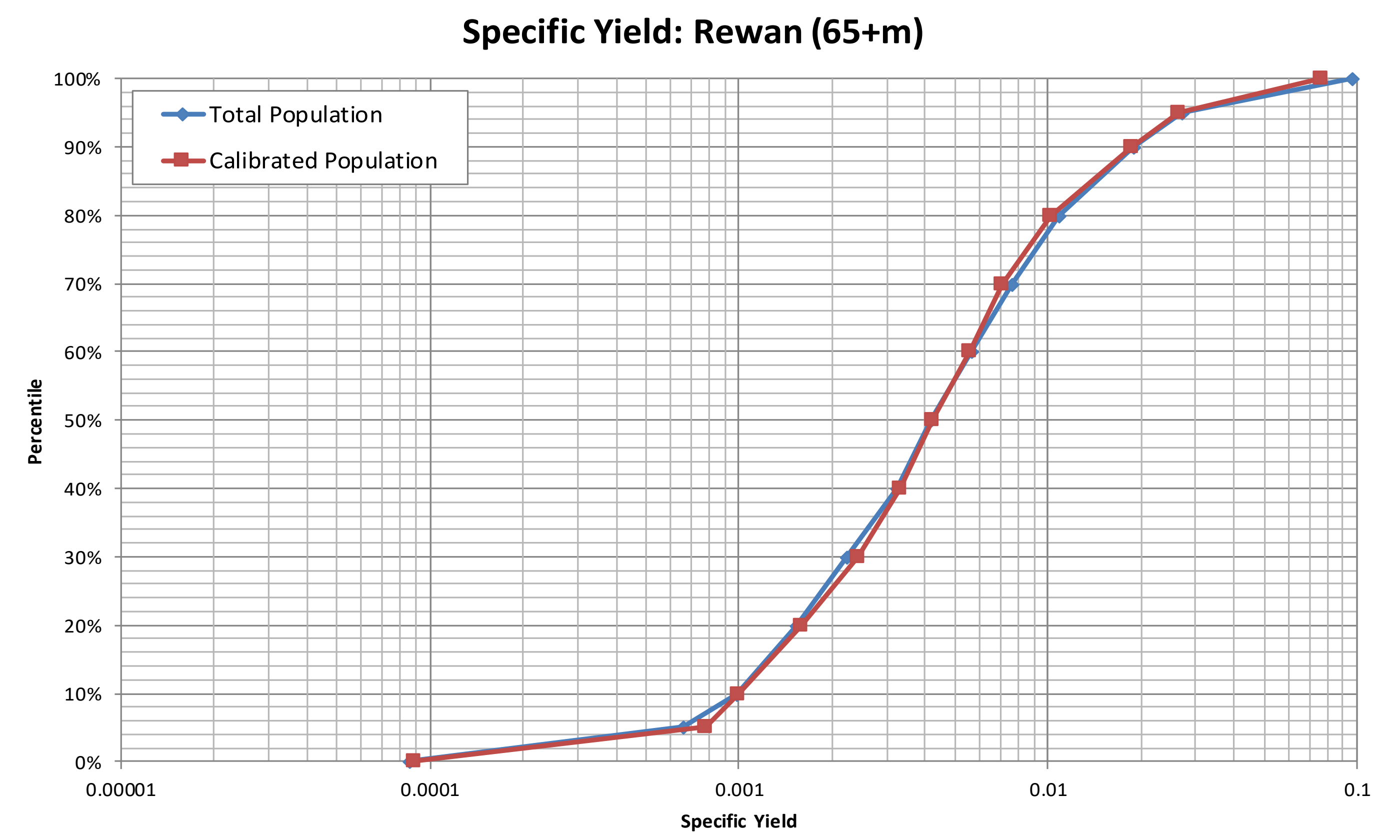


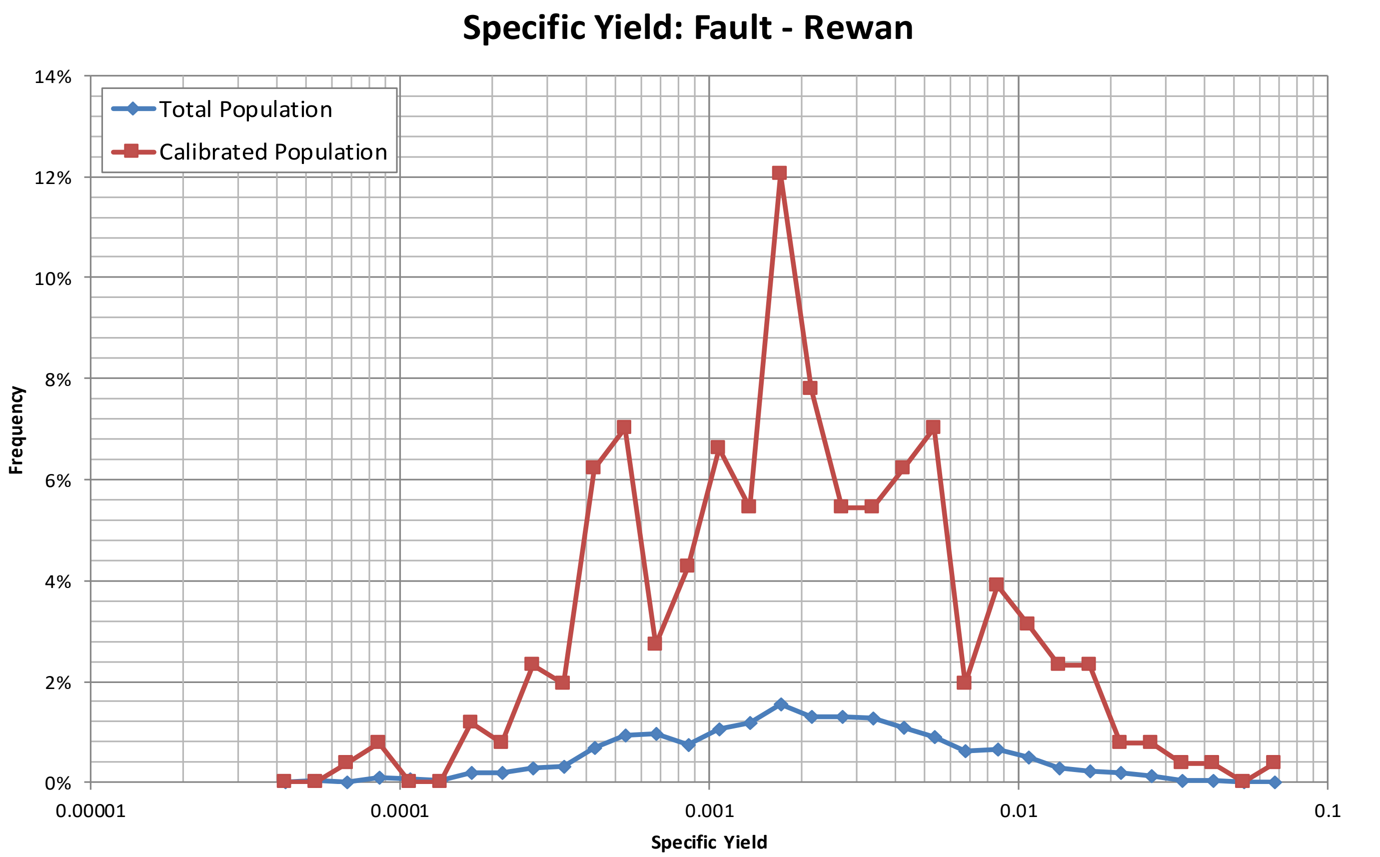
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



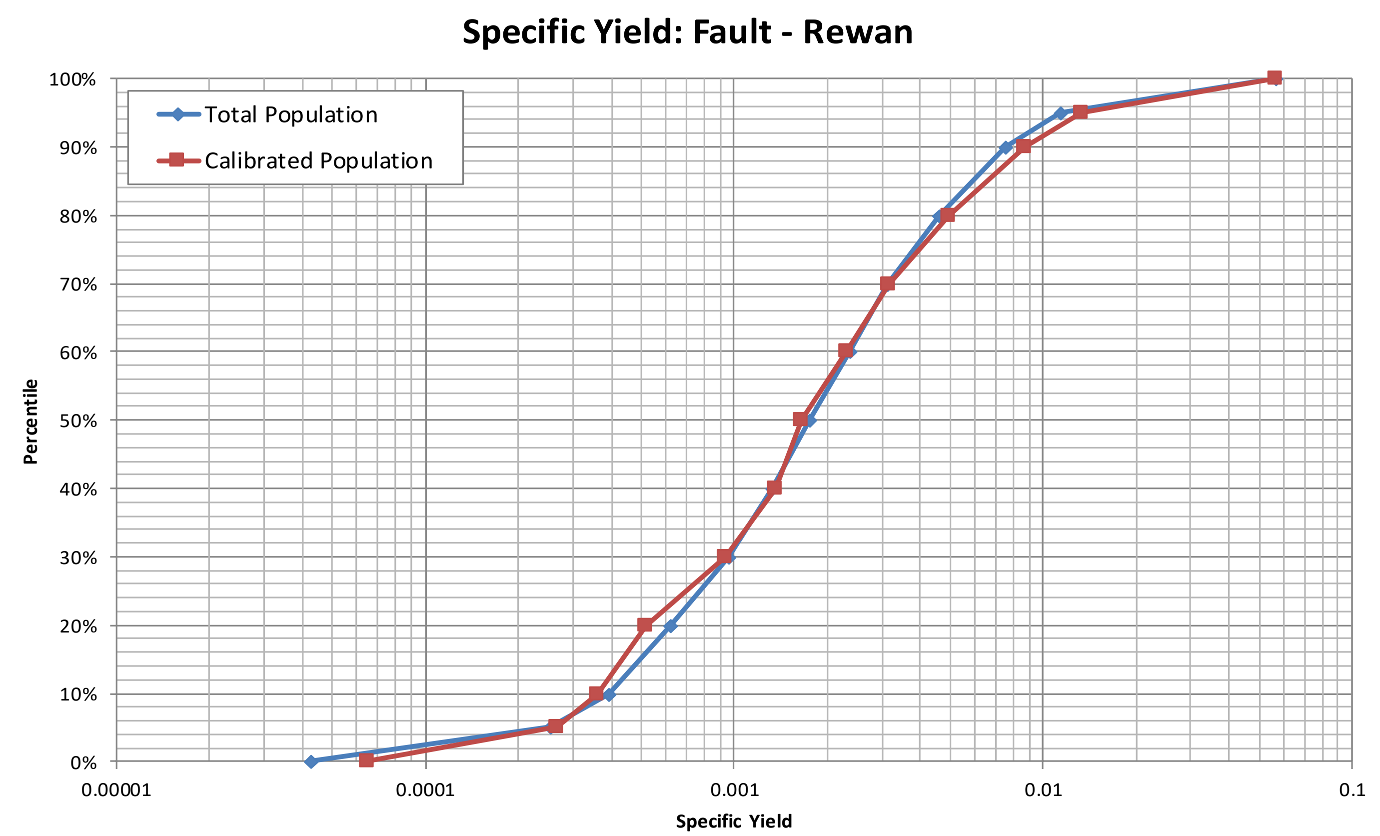


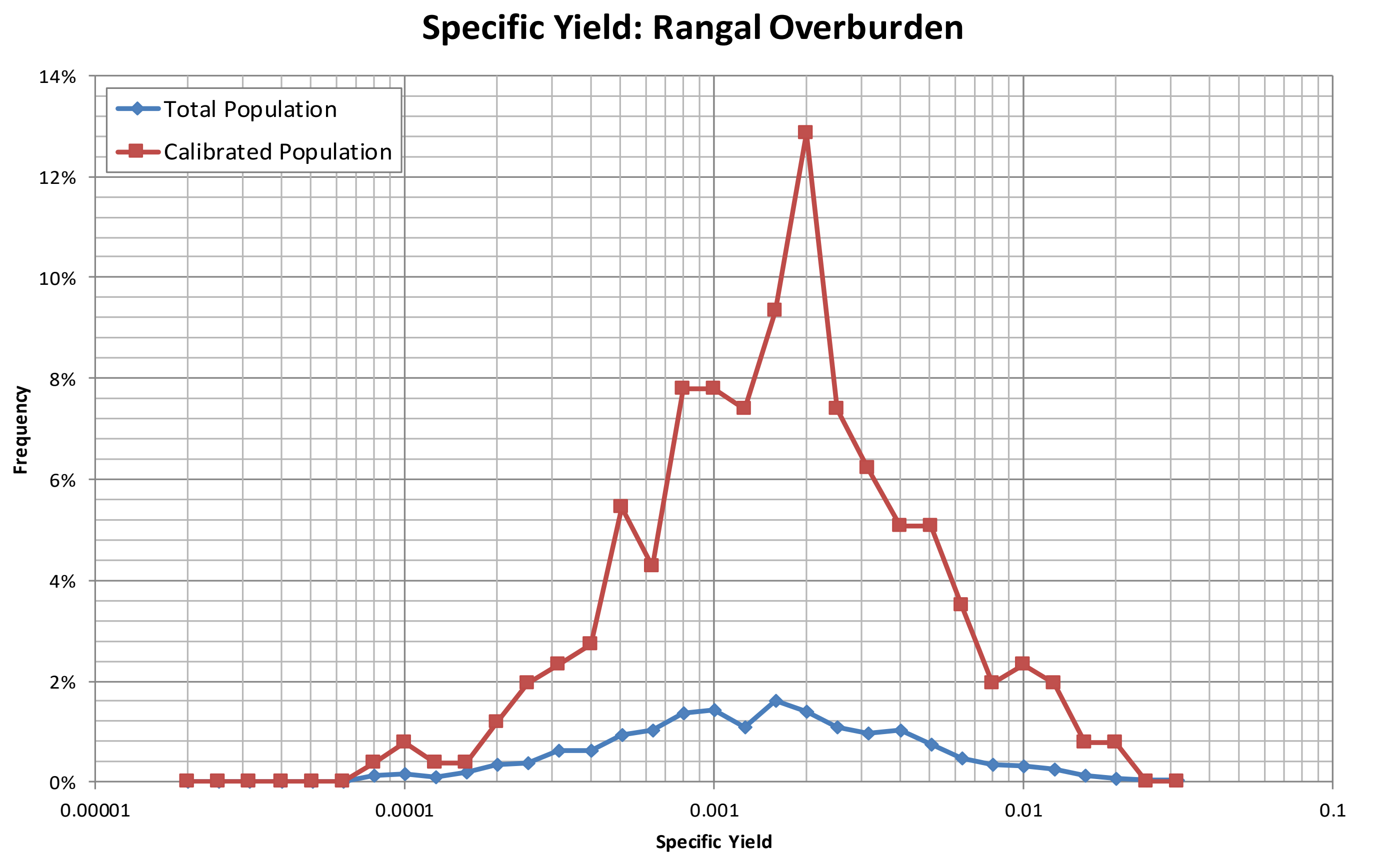
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



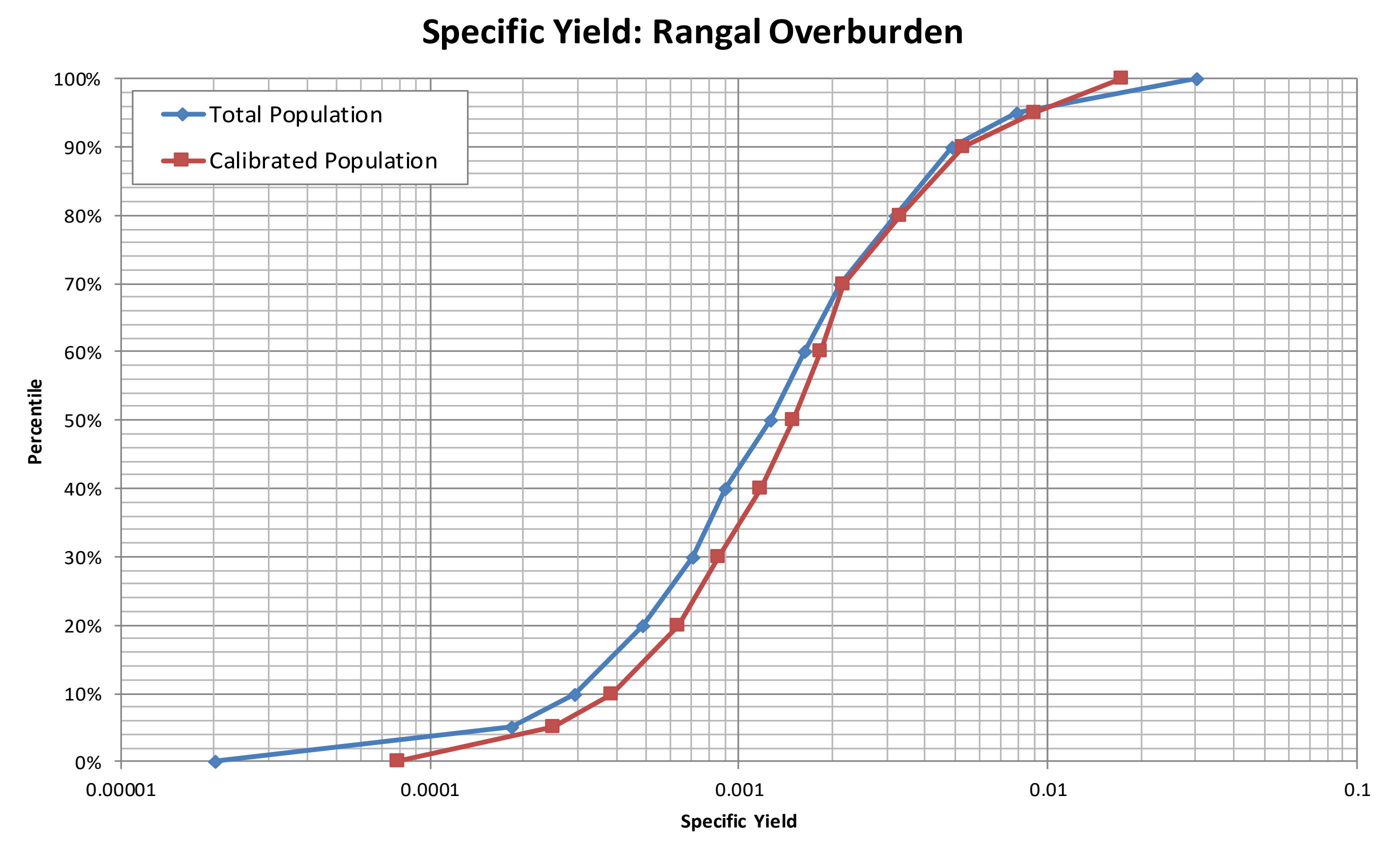


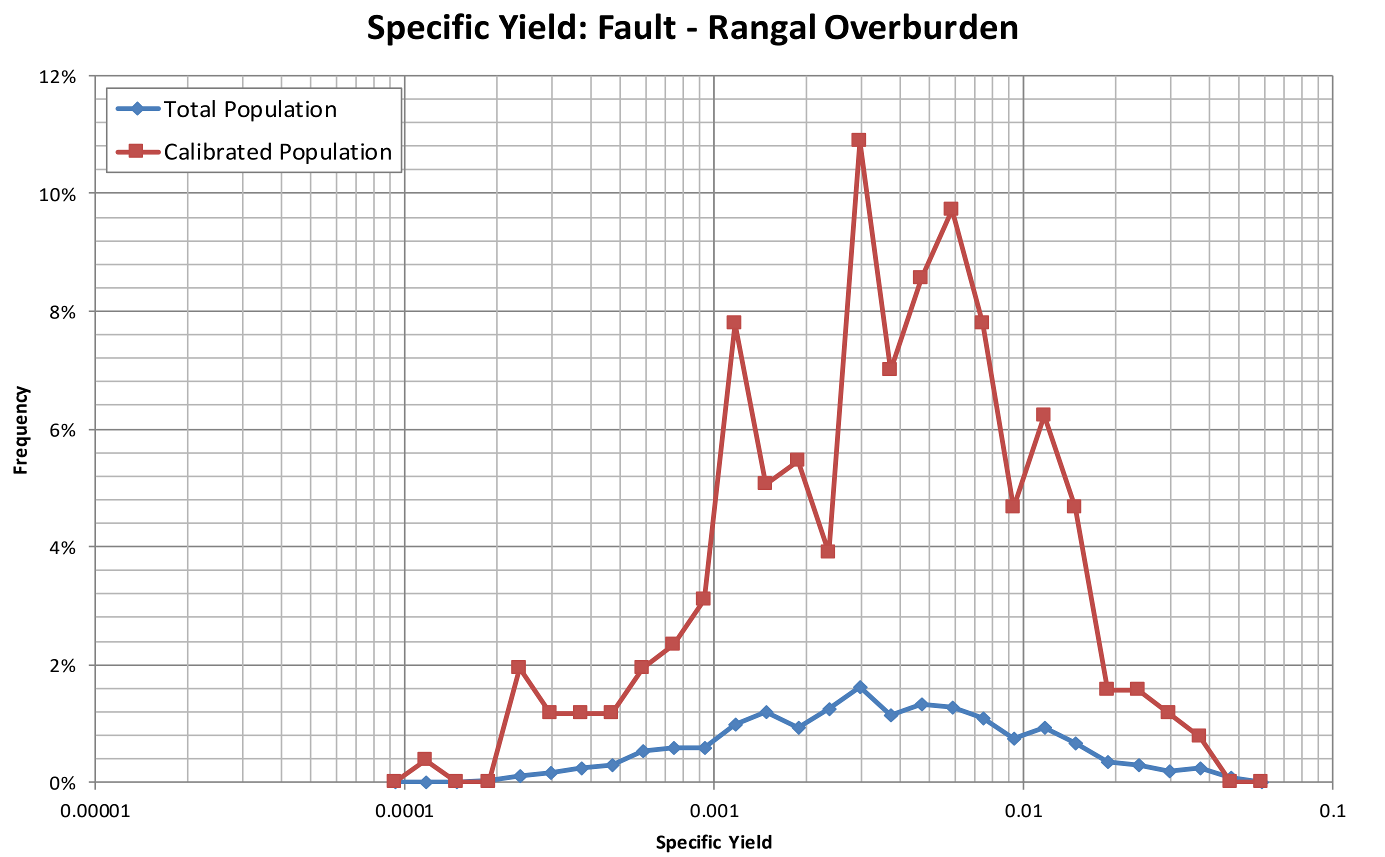
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



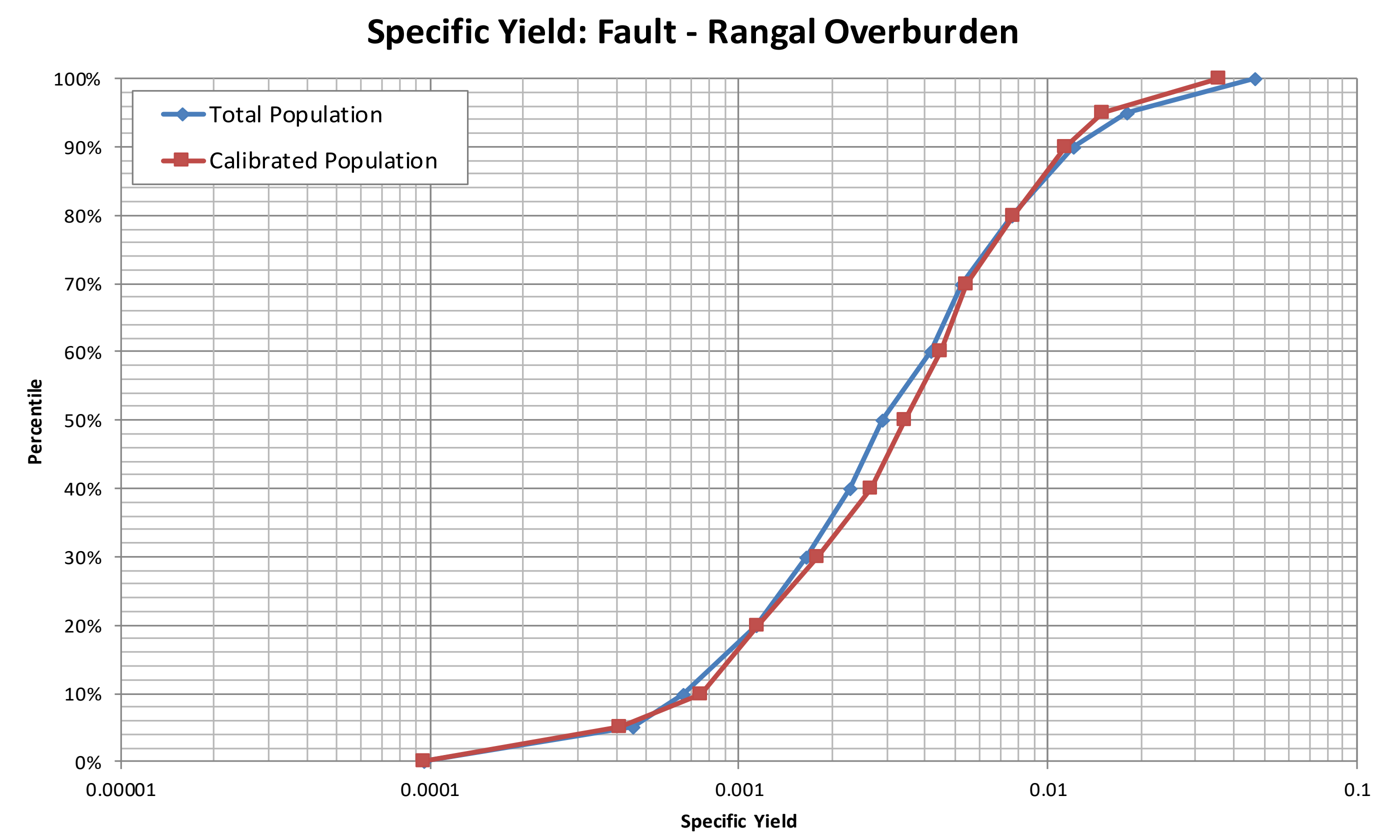


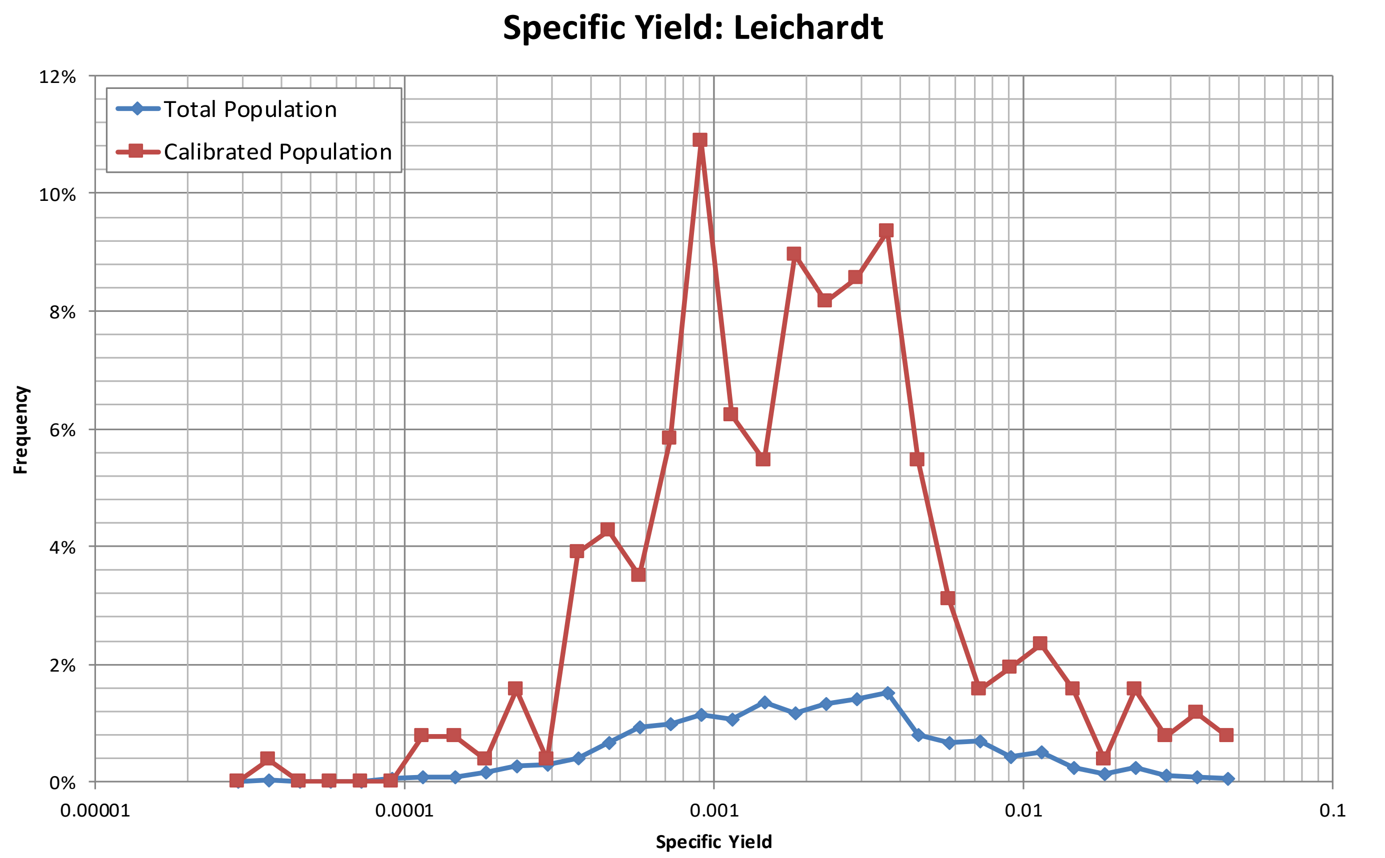
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



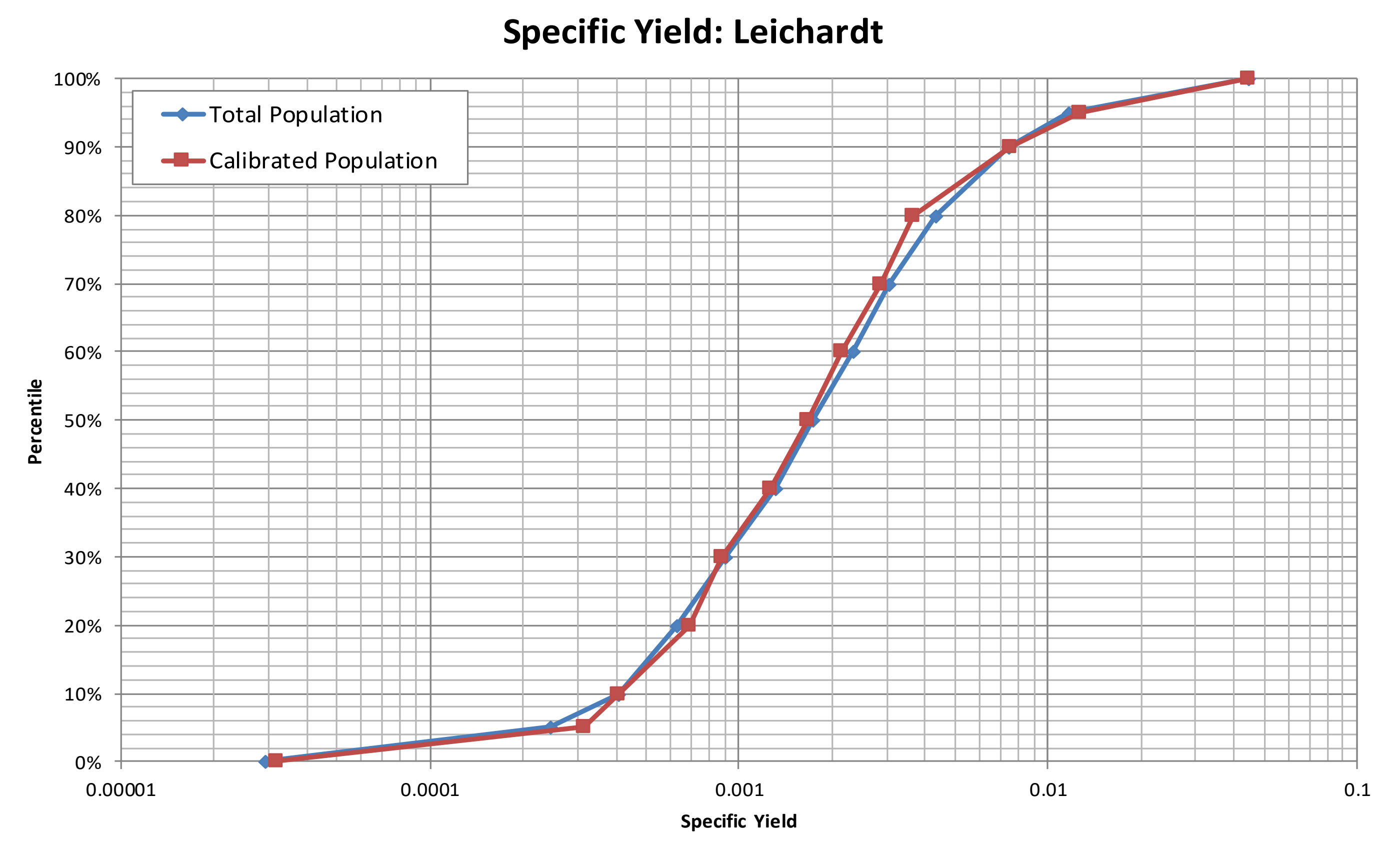


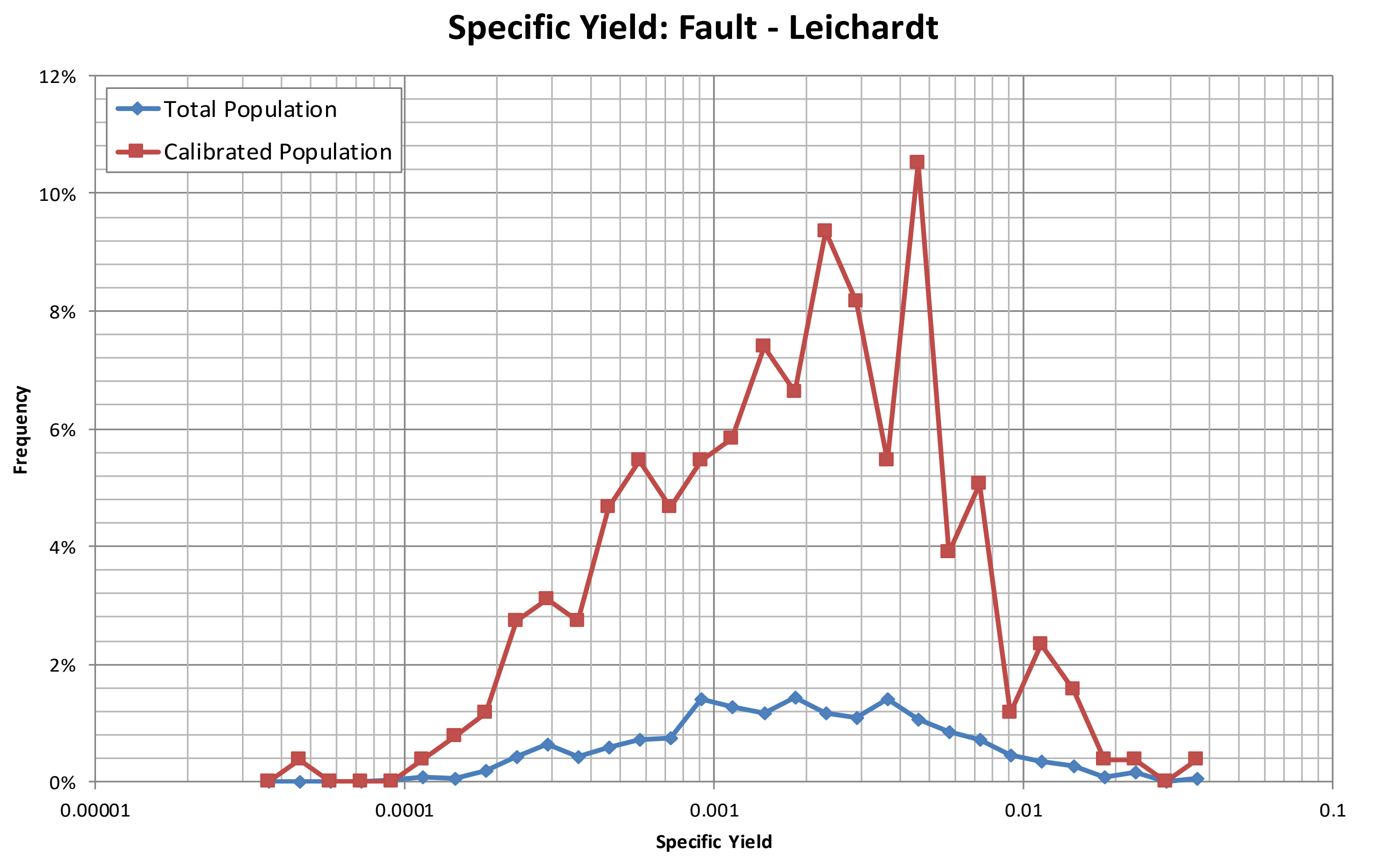
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



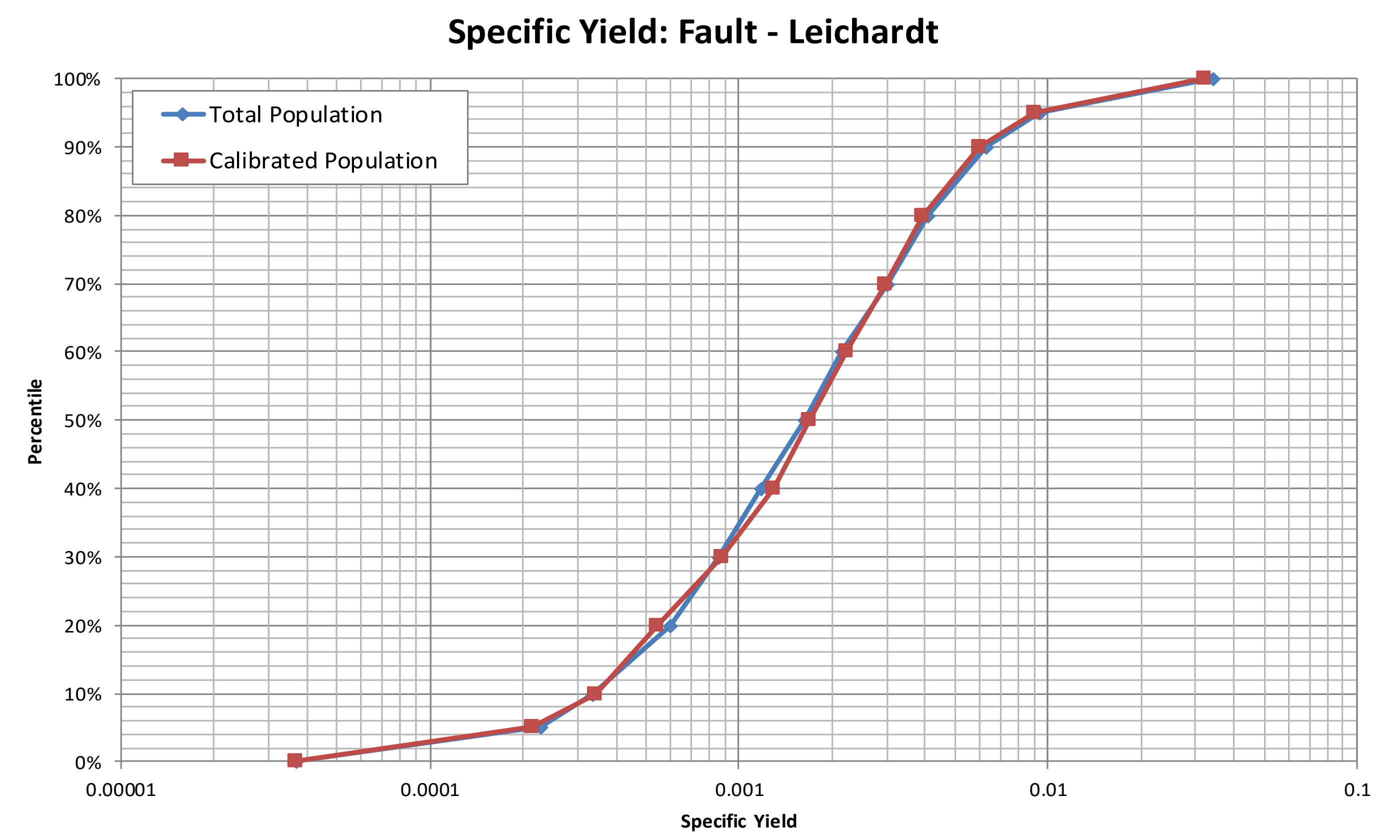


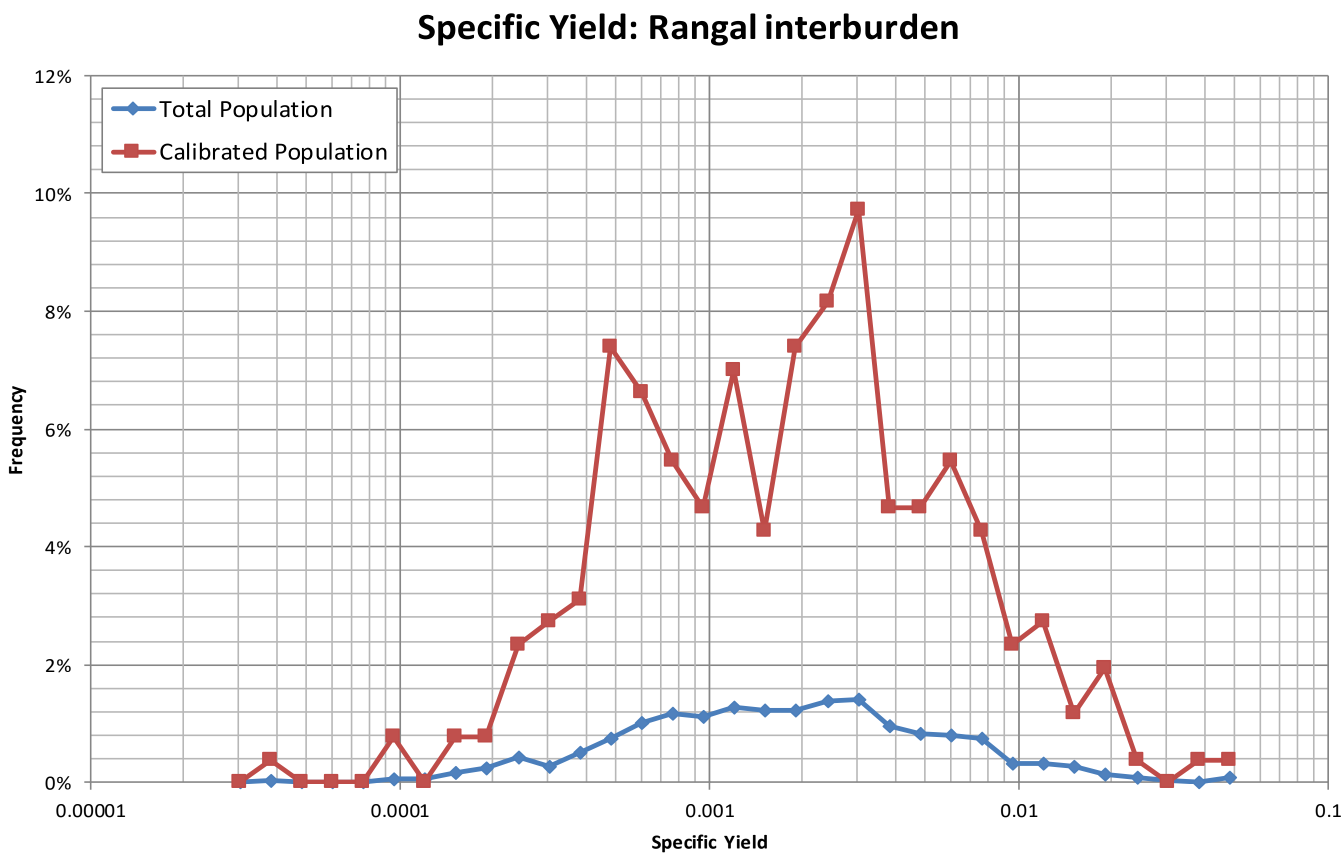
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



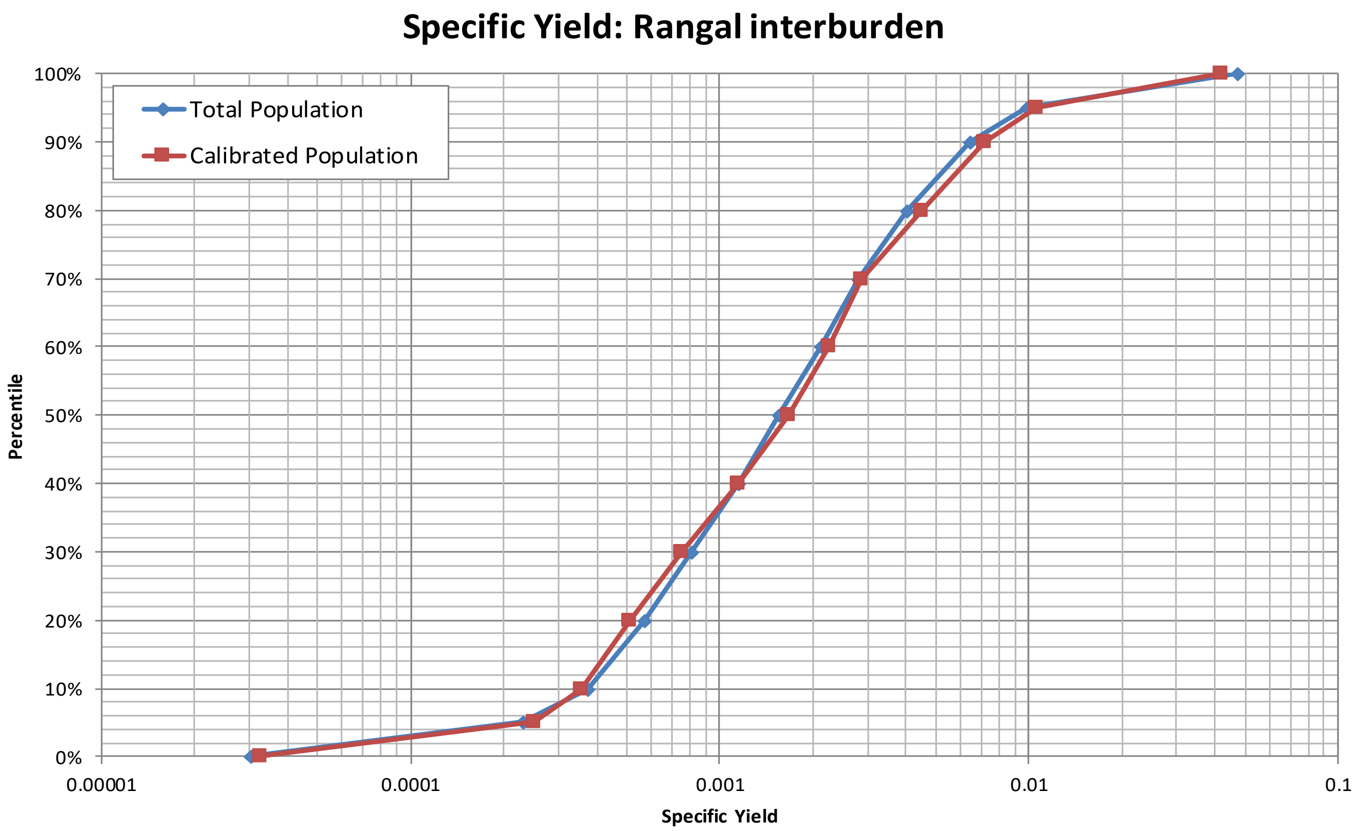


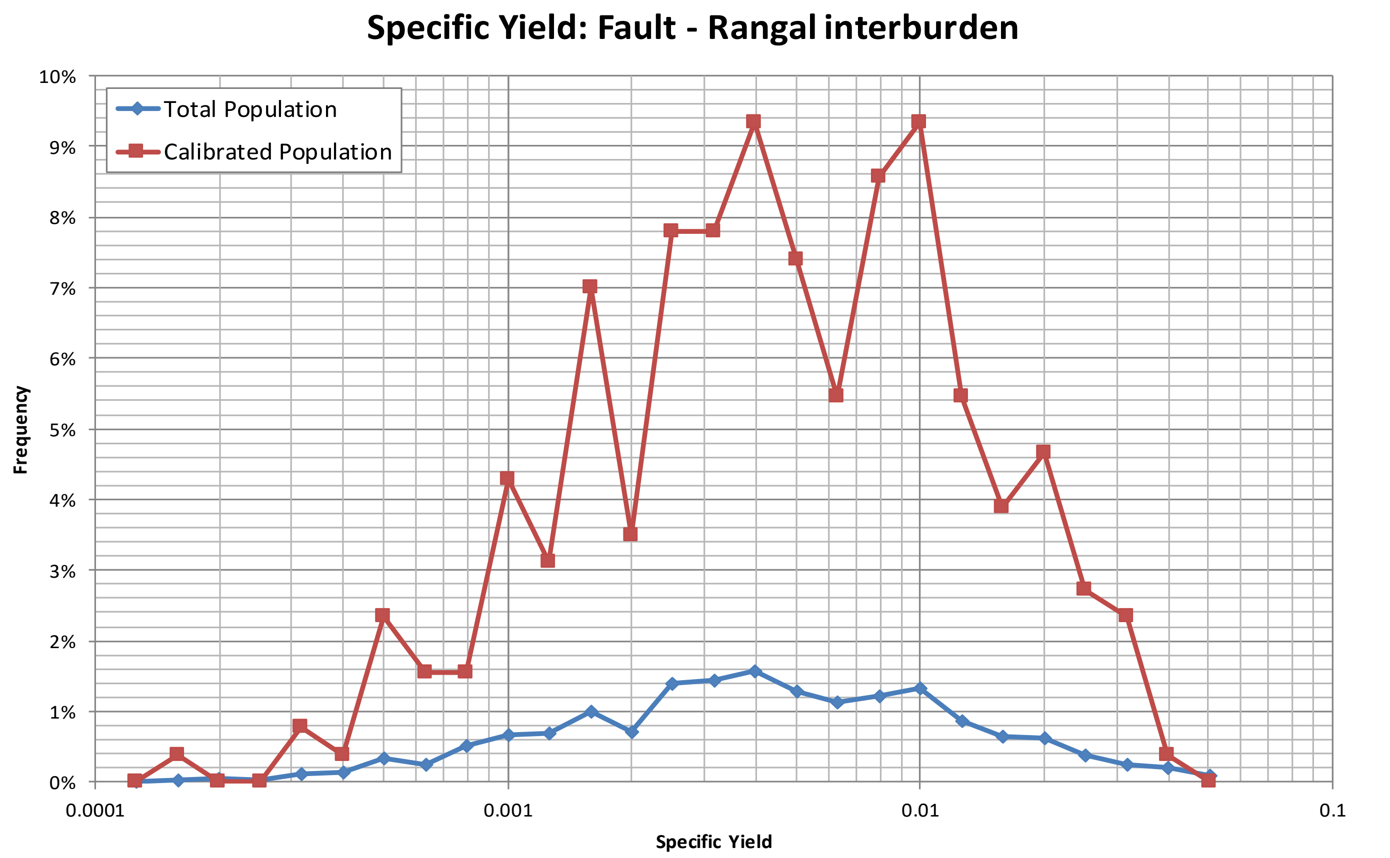
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



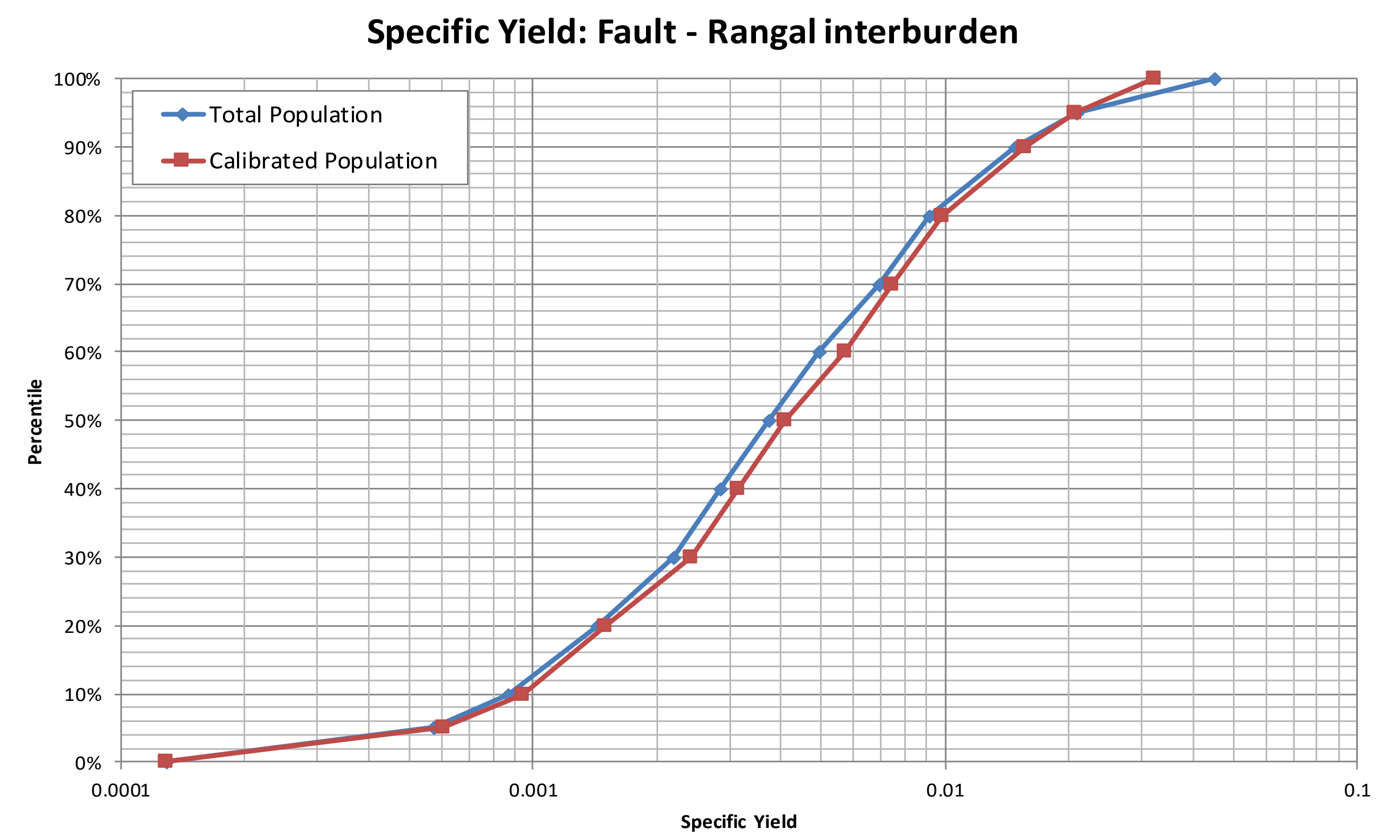


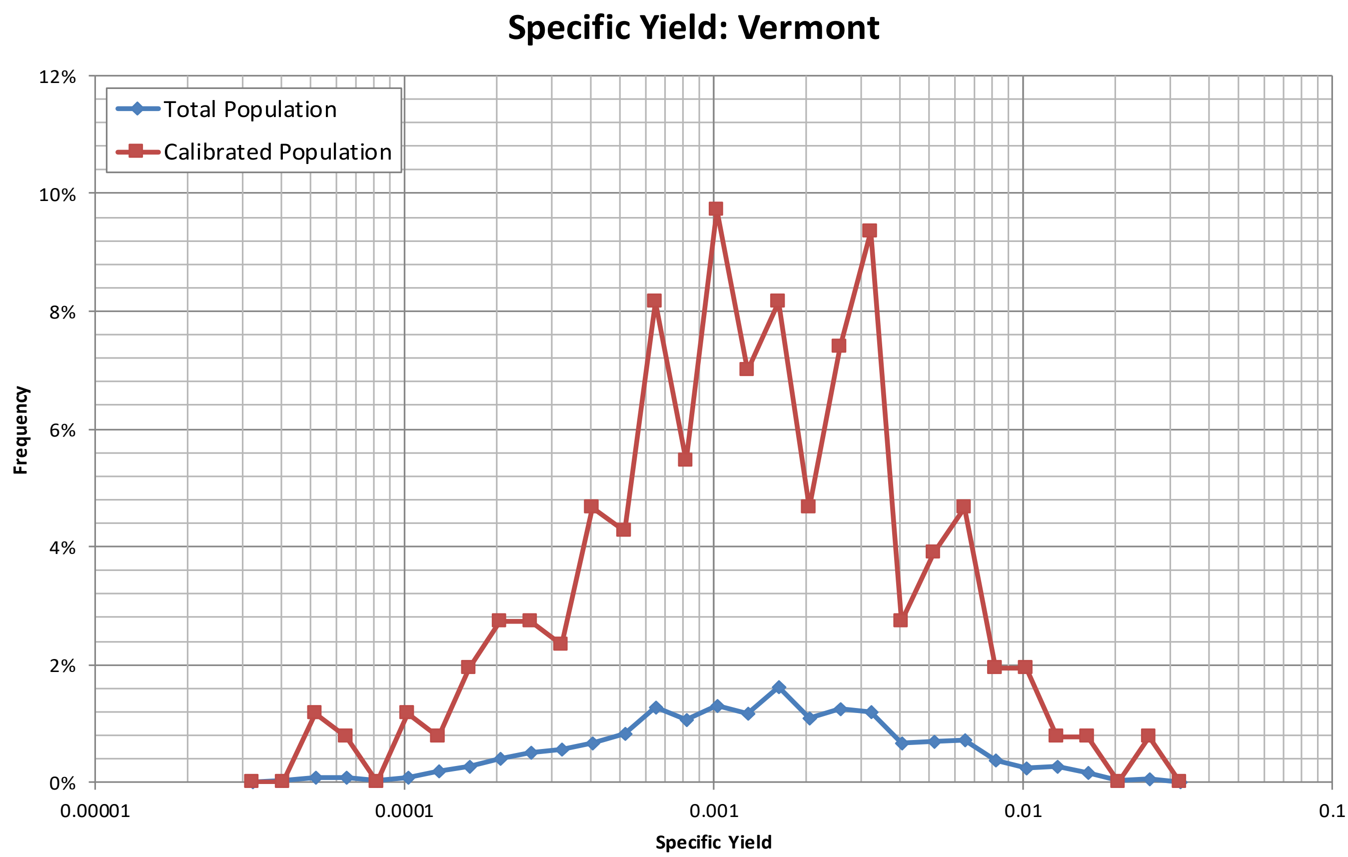
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



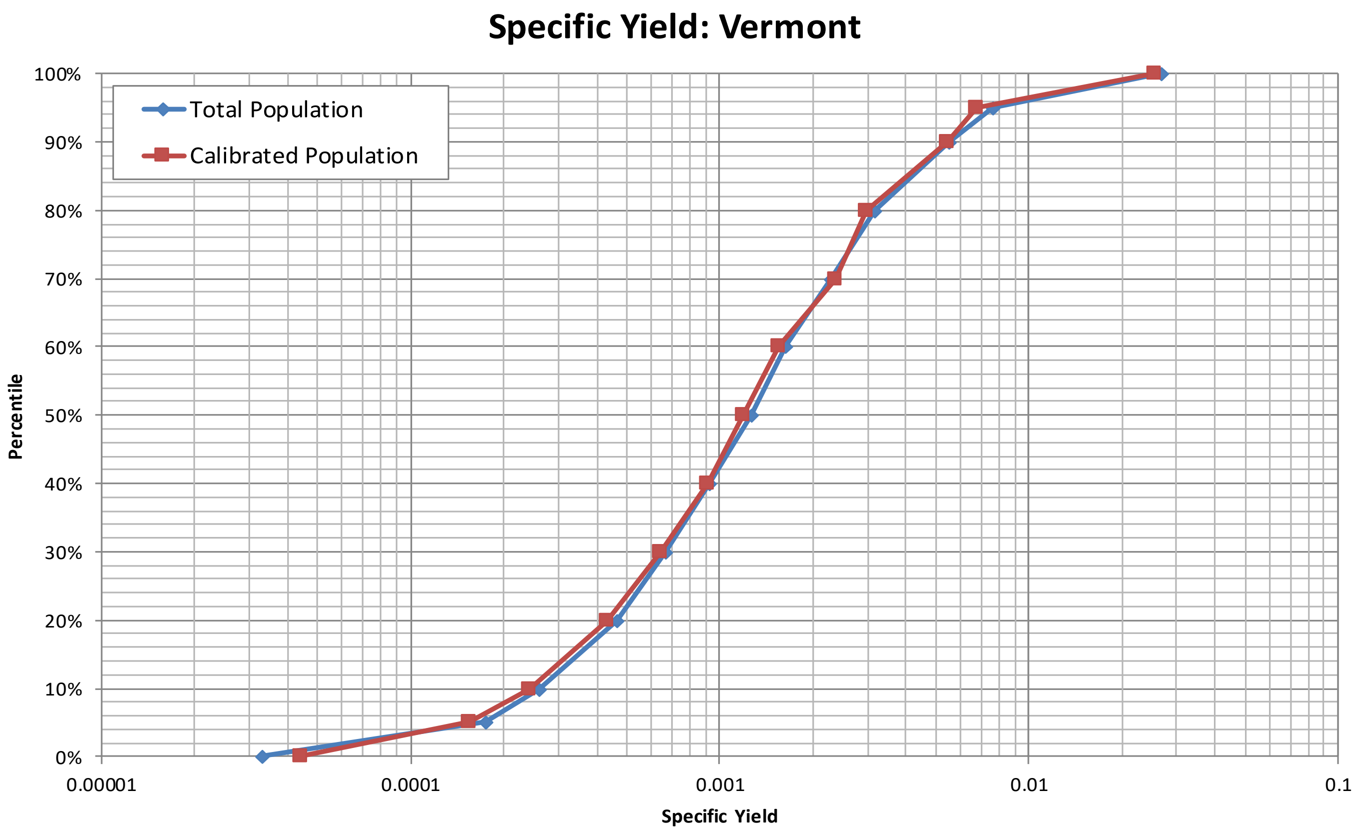


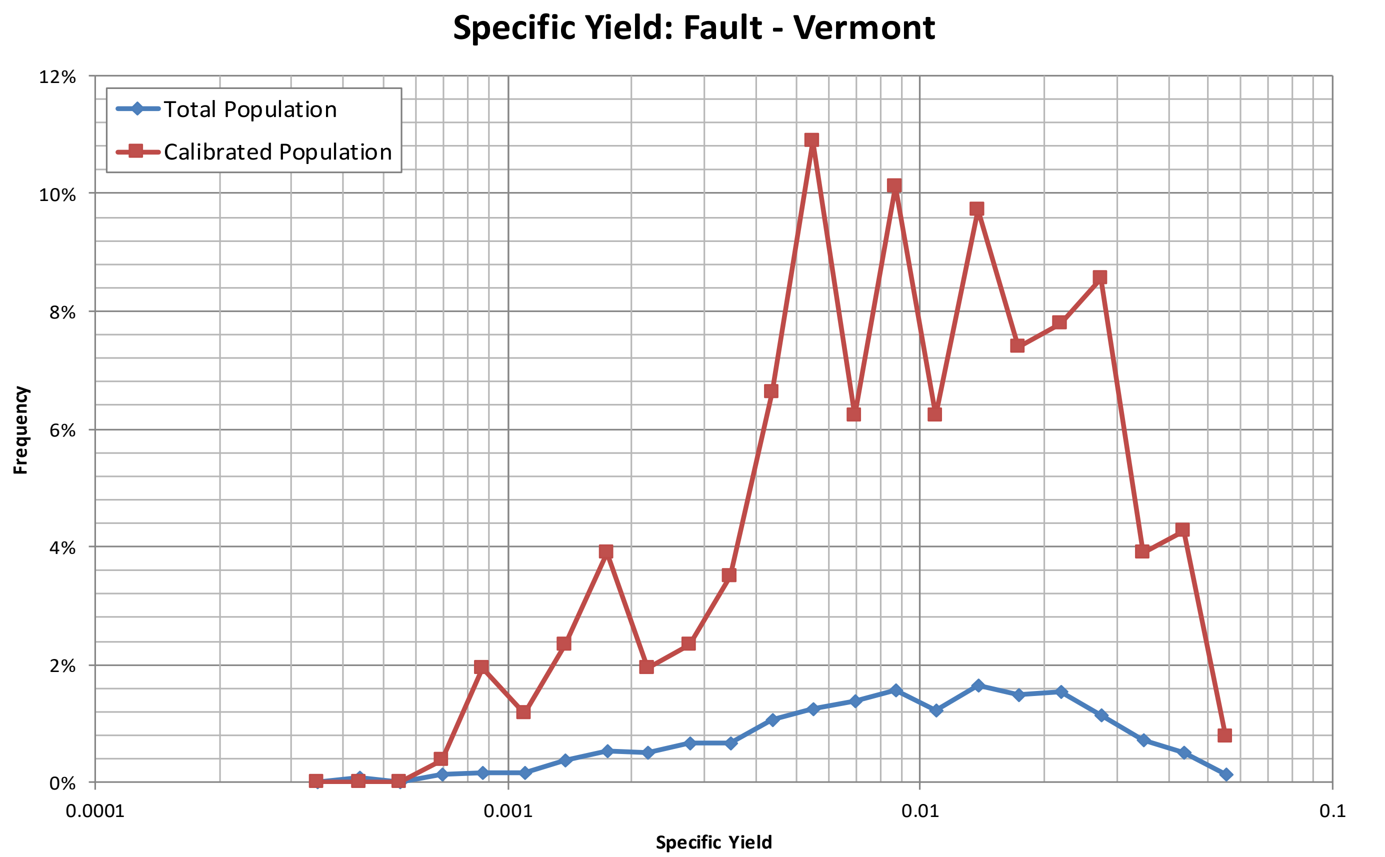
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



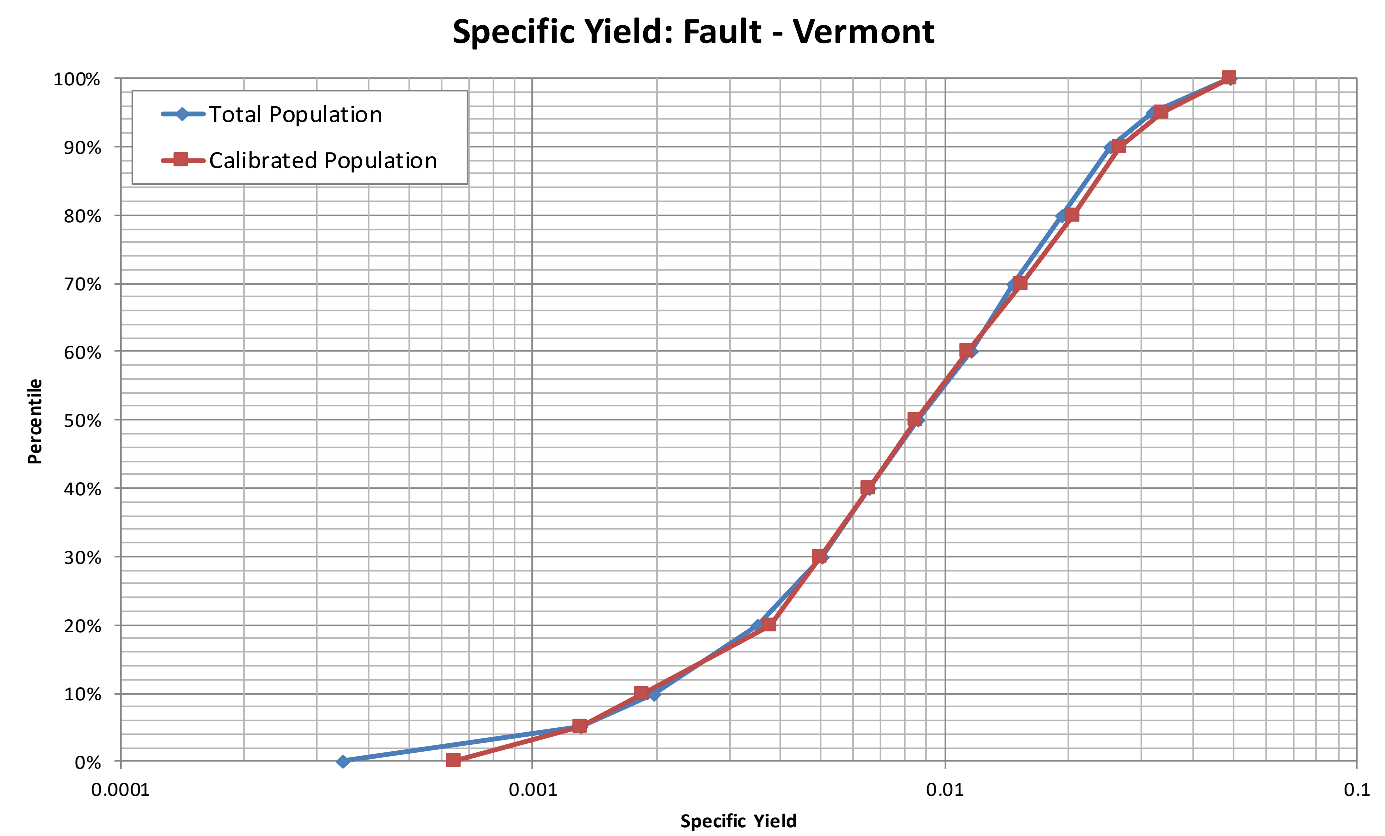


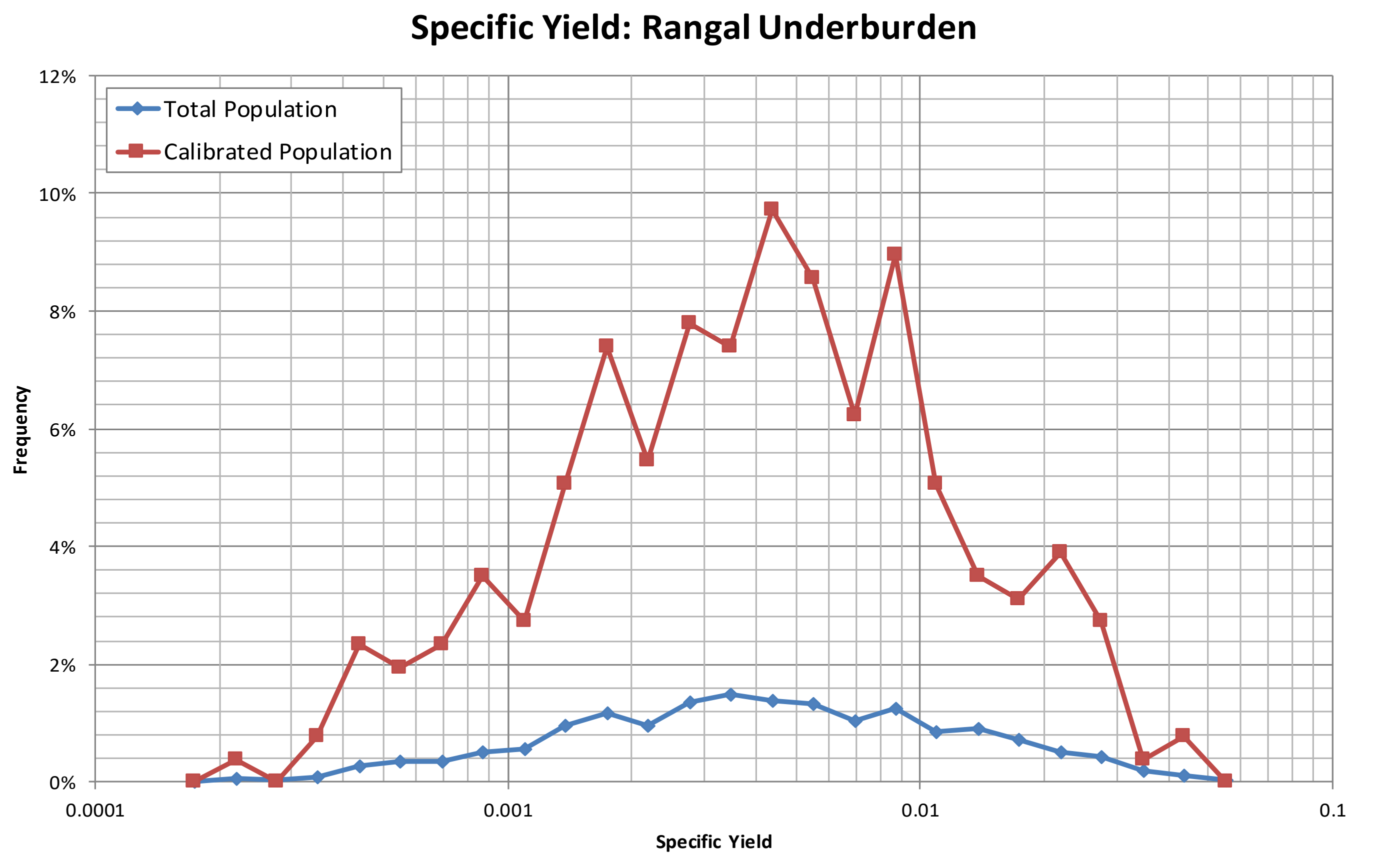
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



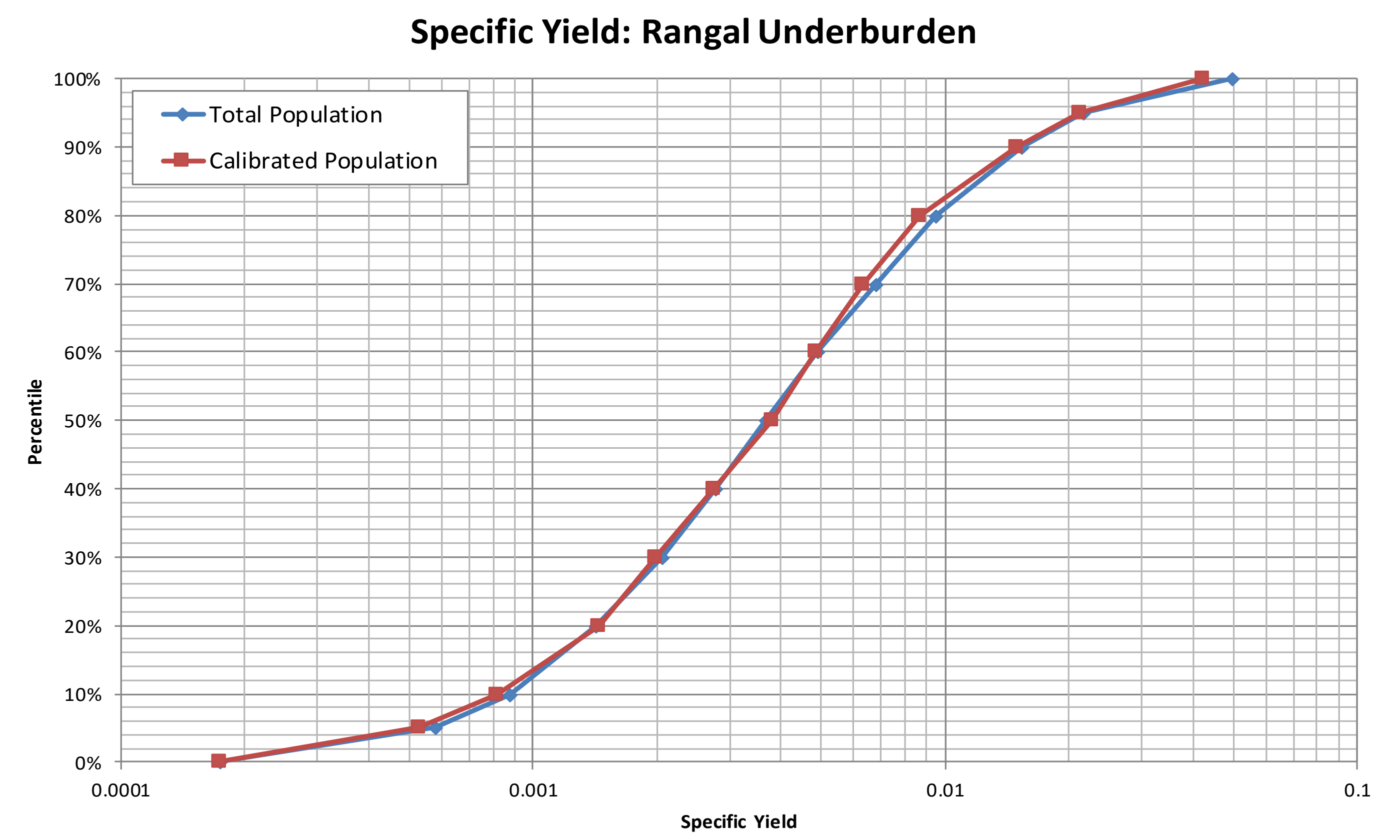


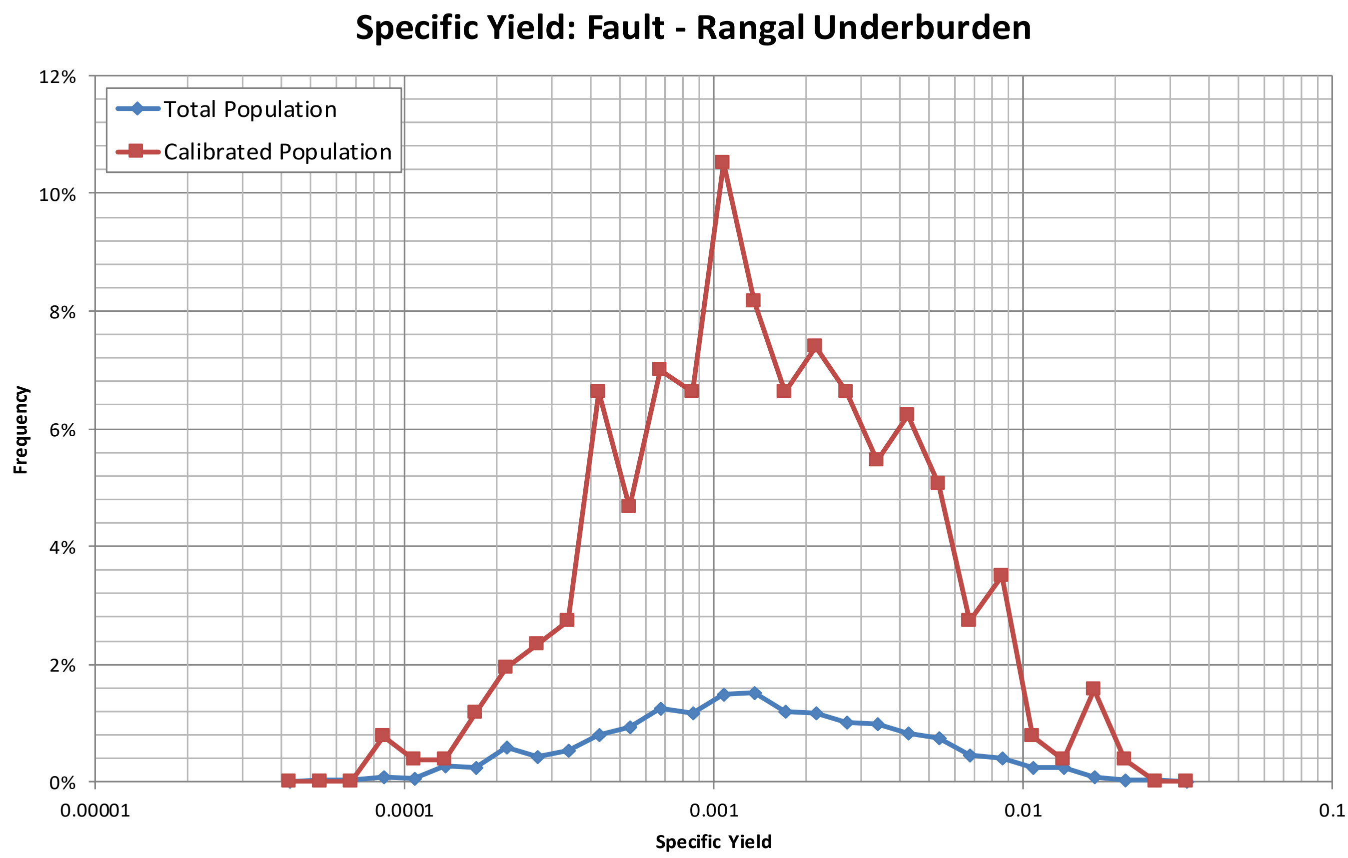
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



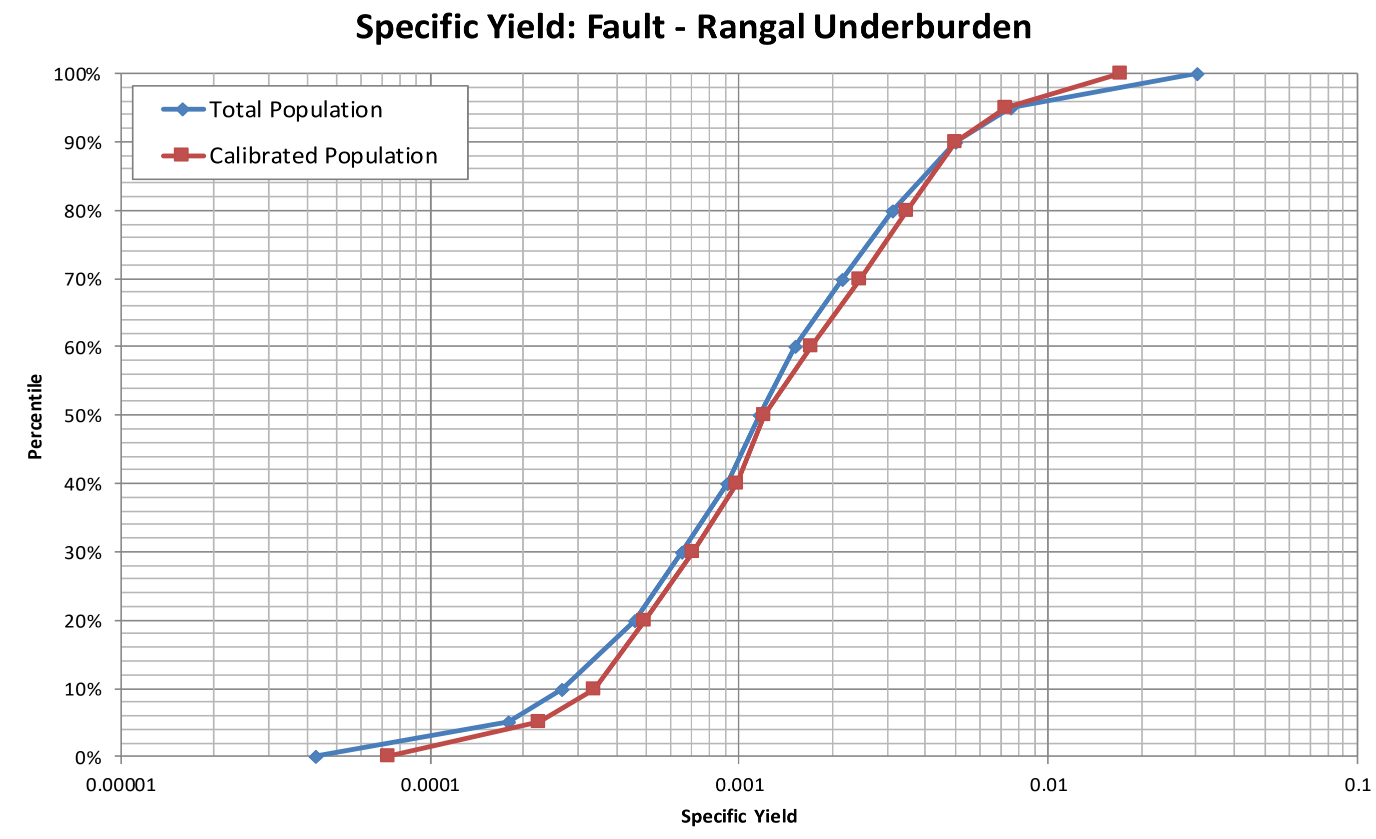


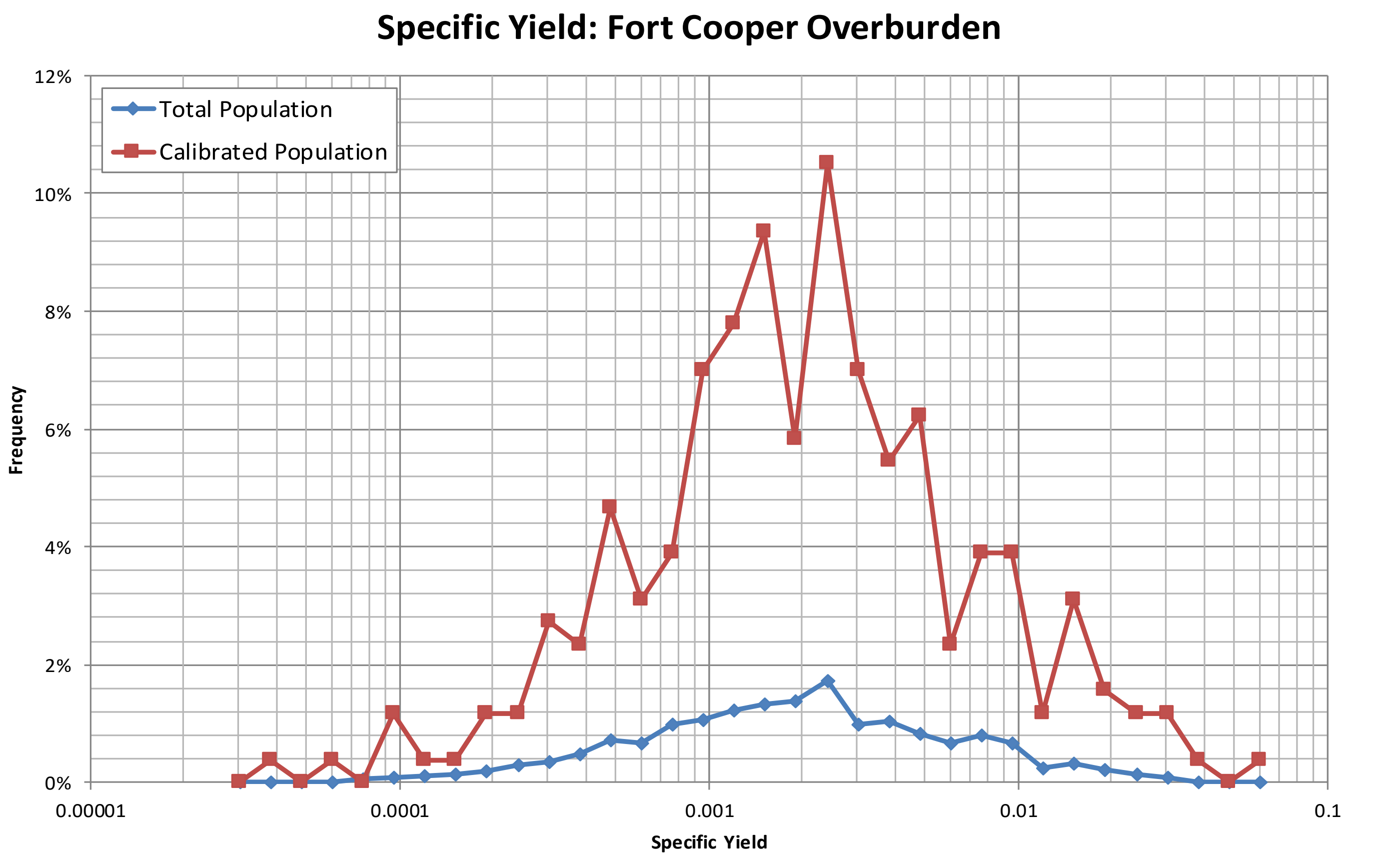
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



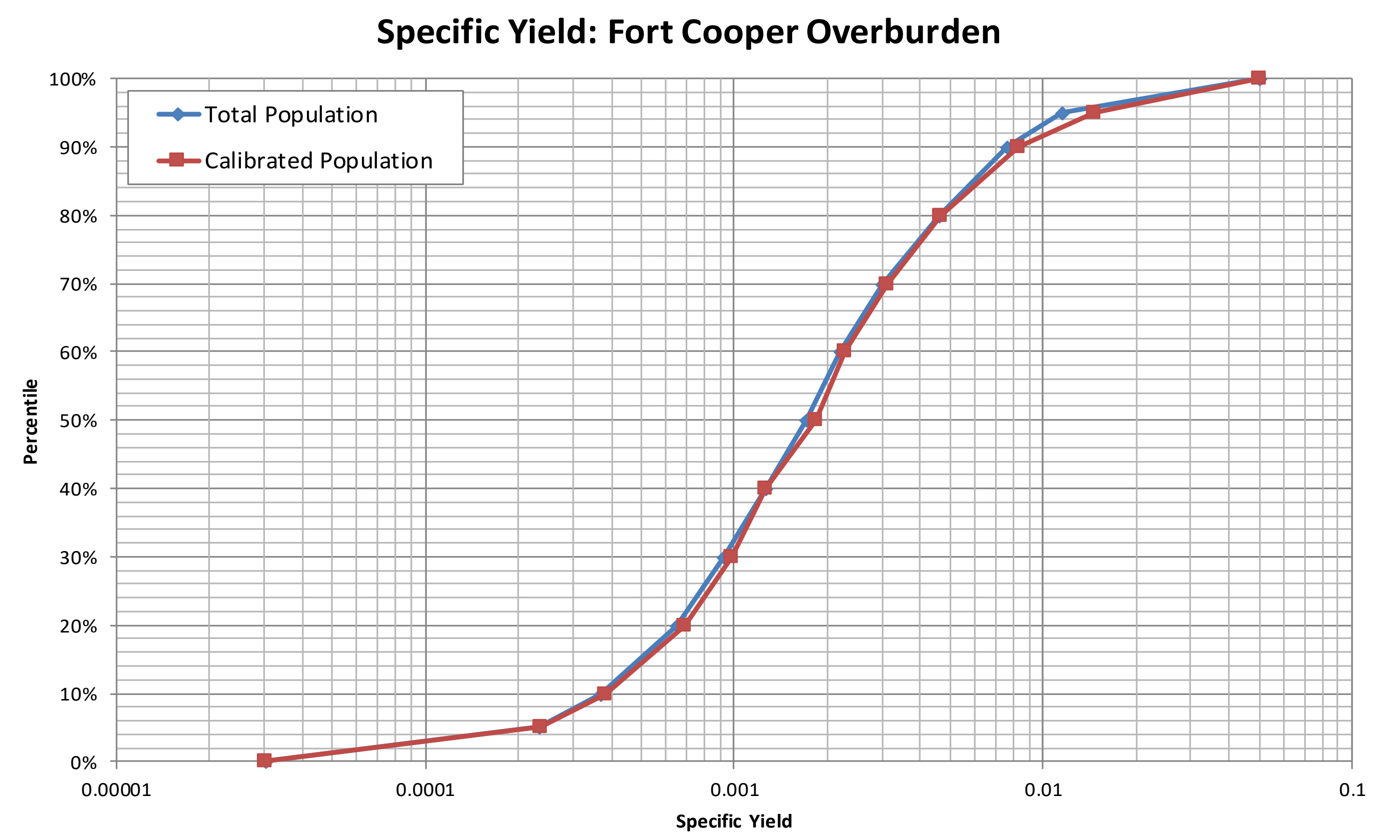


Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

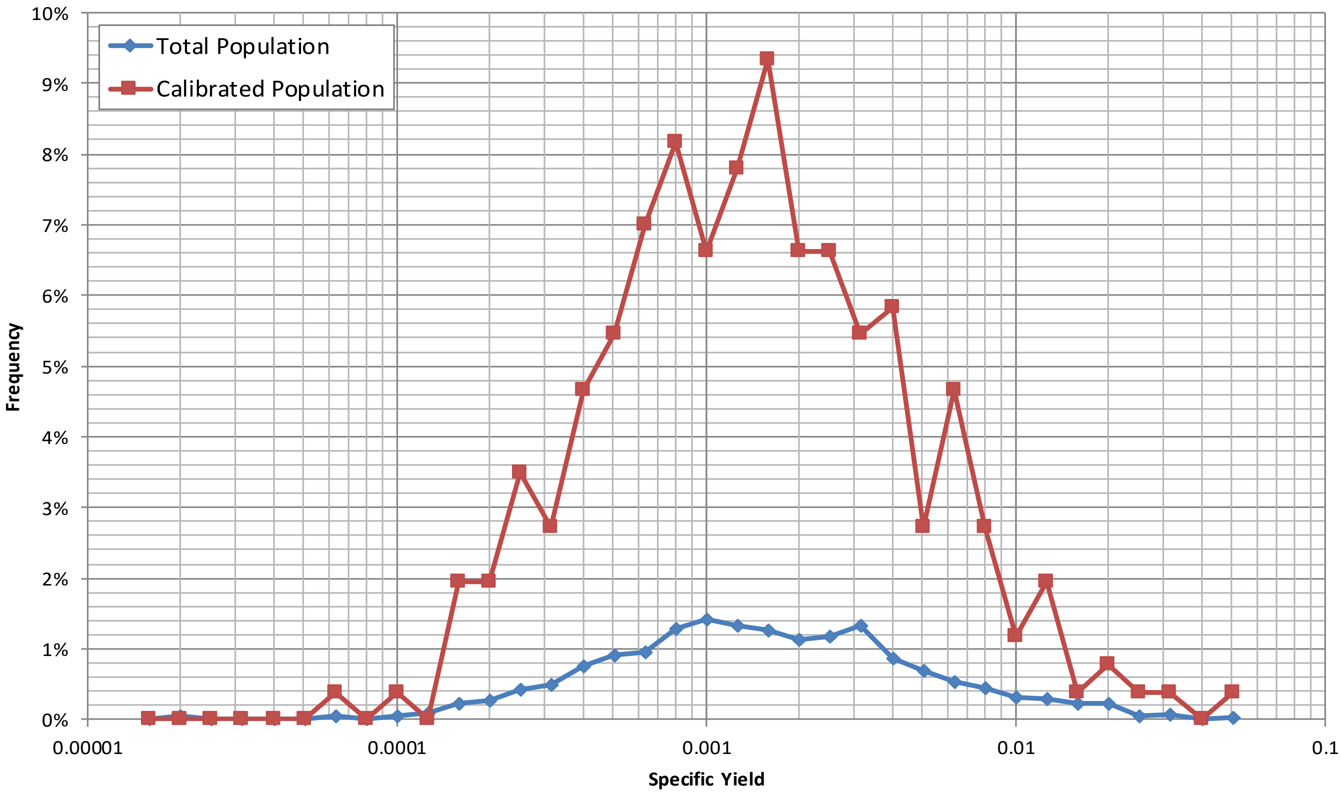




Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

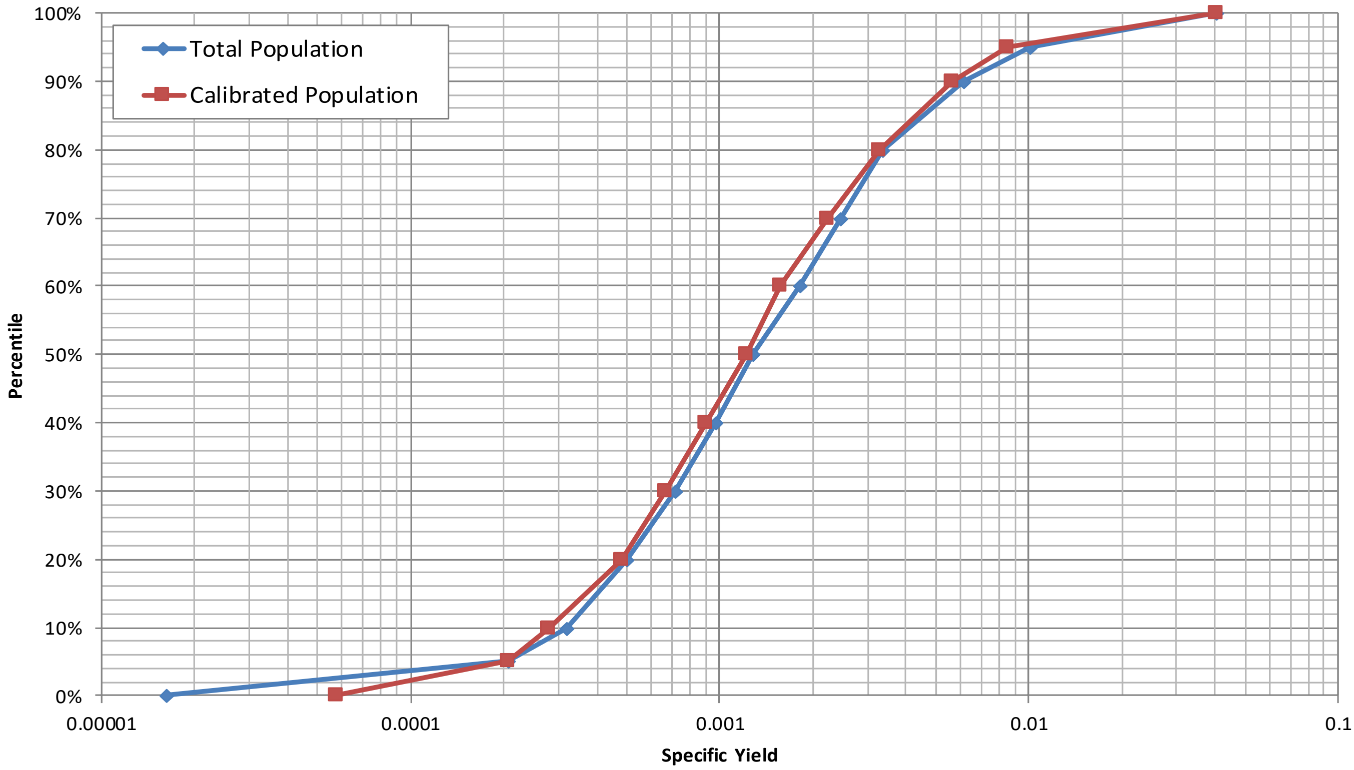


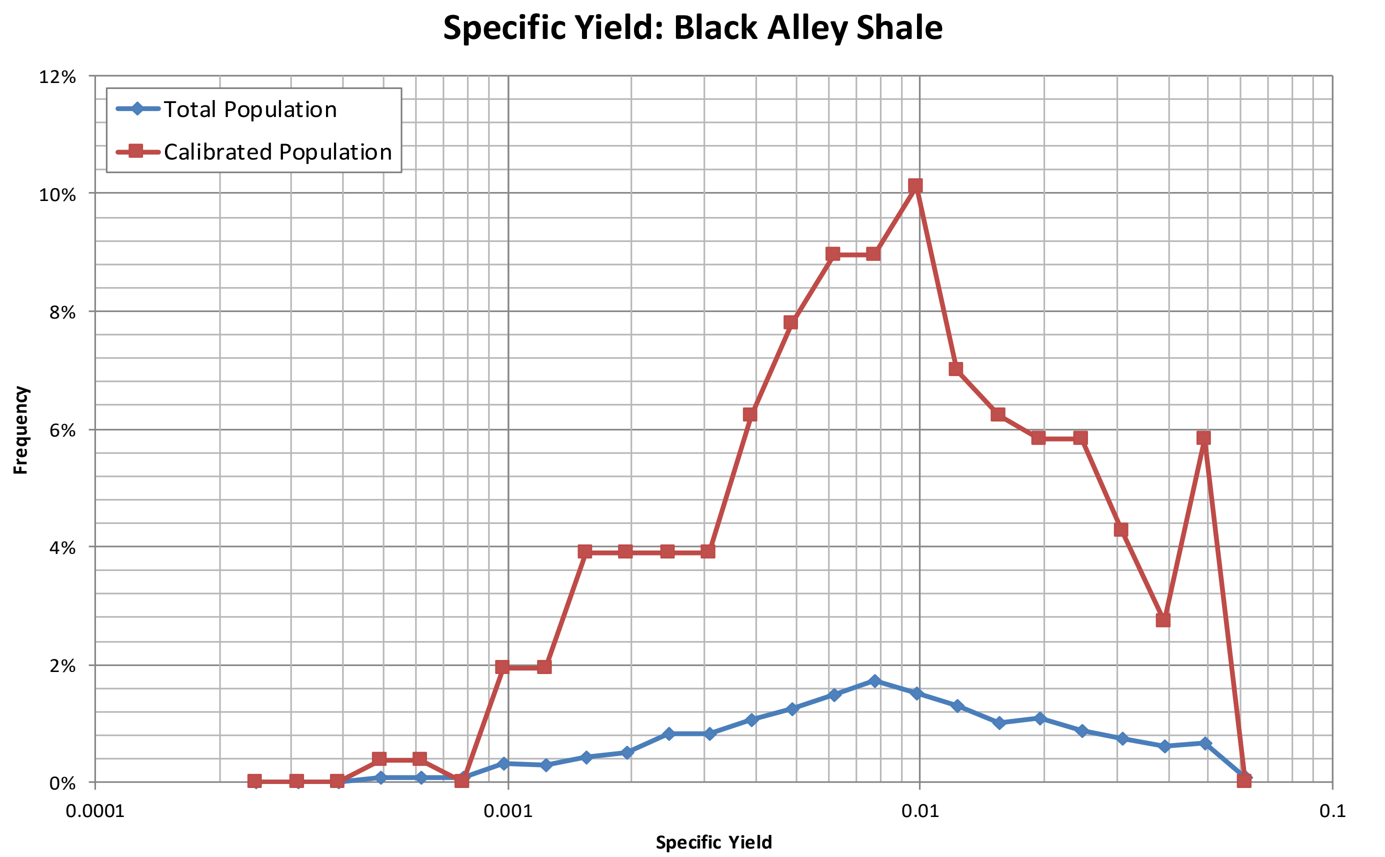
Specific Yield: Fault - Fort Cooper Overburden



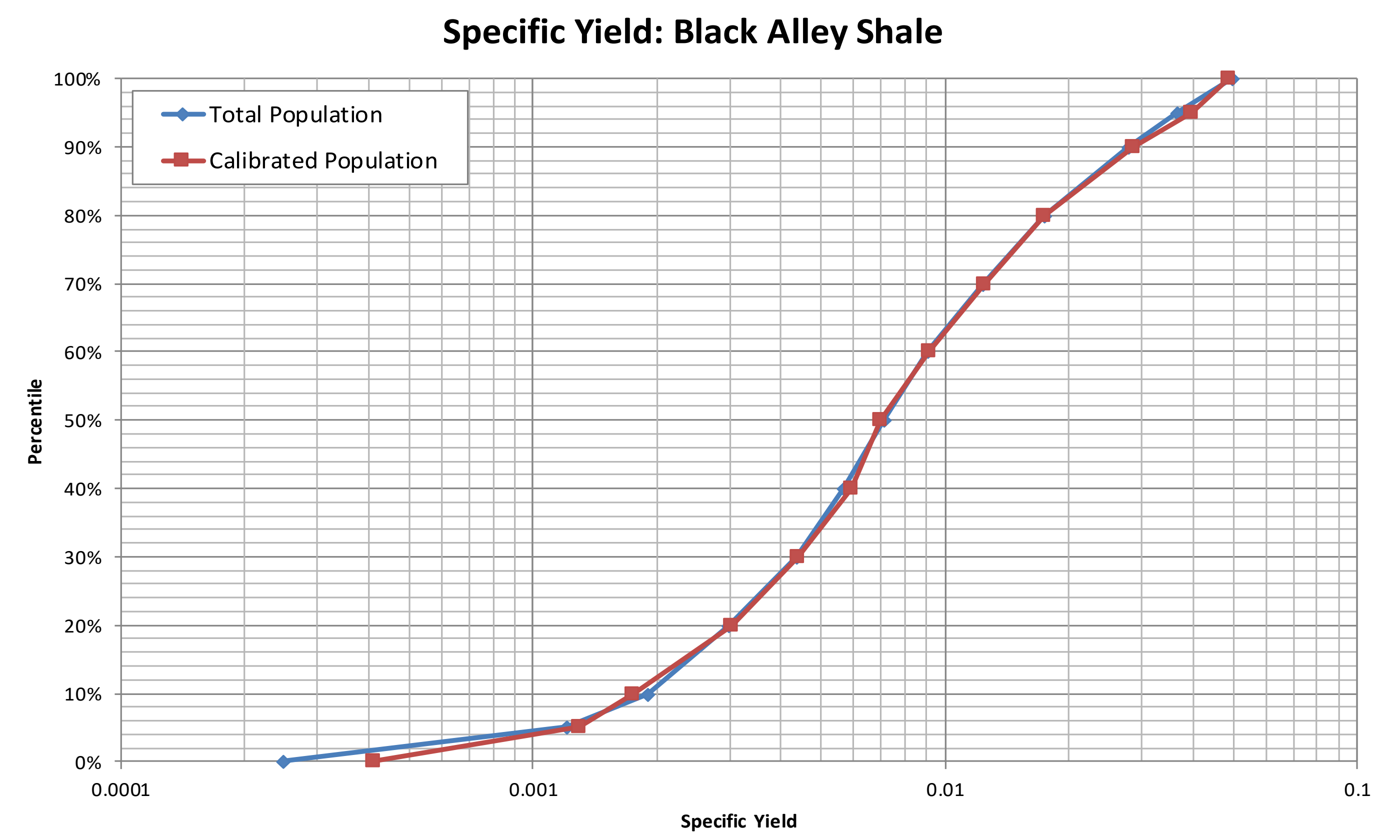
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.

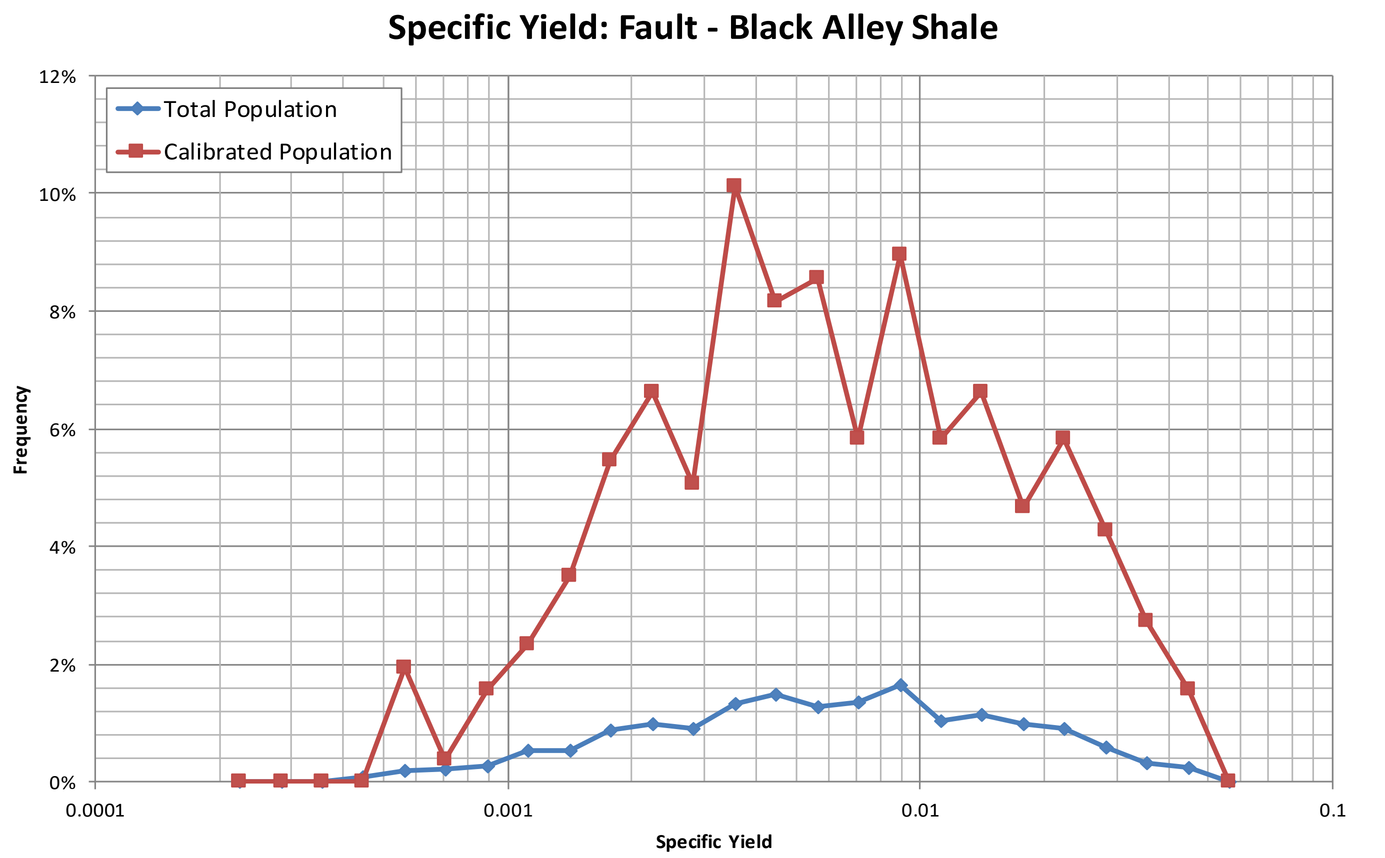
Specific Yield: Fault - Fort Cooper Overburden



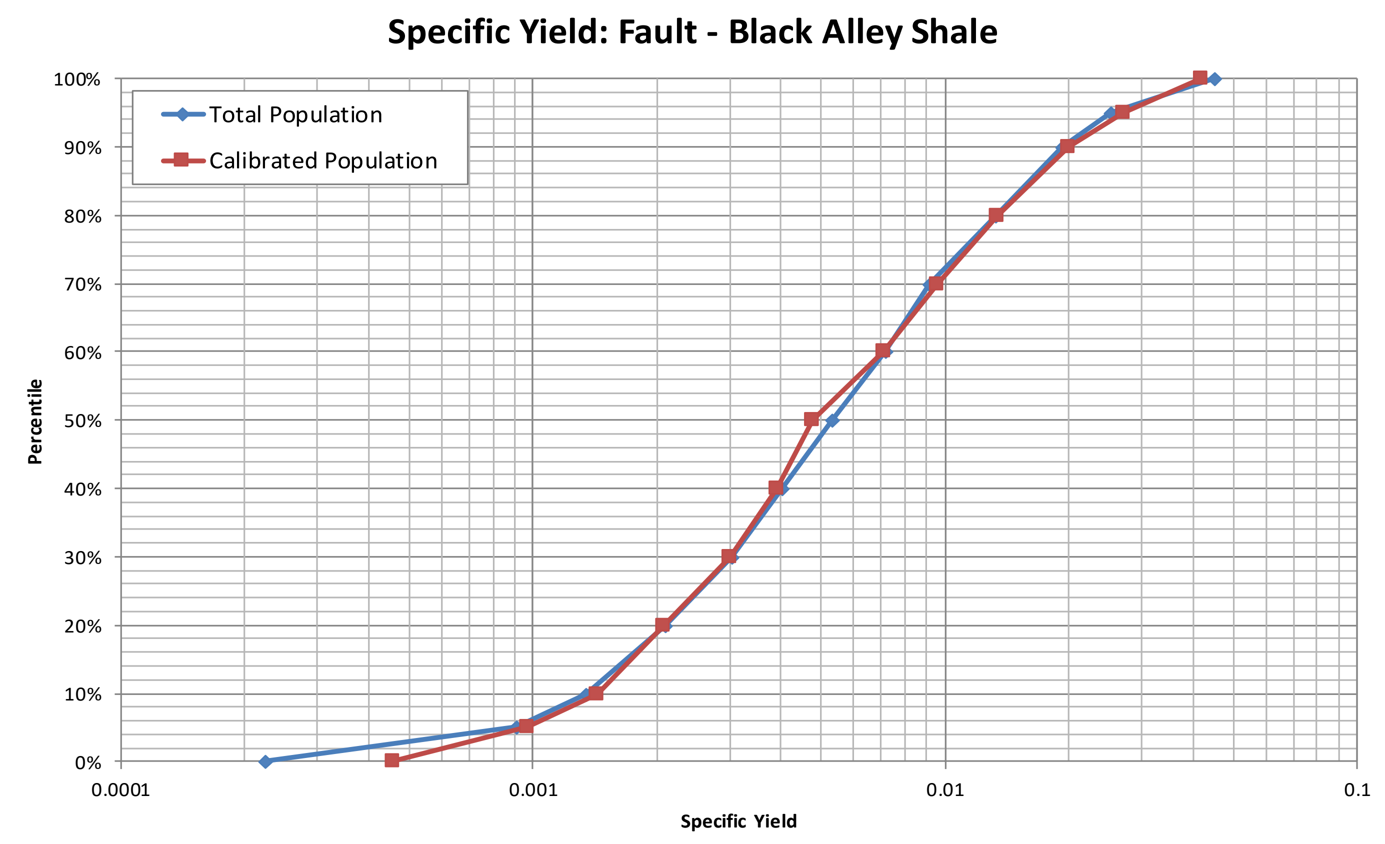


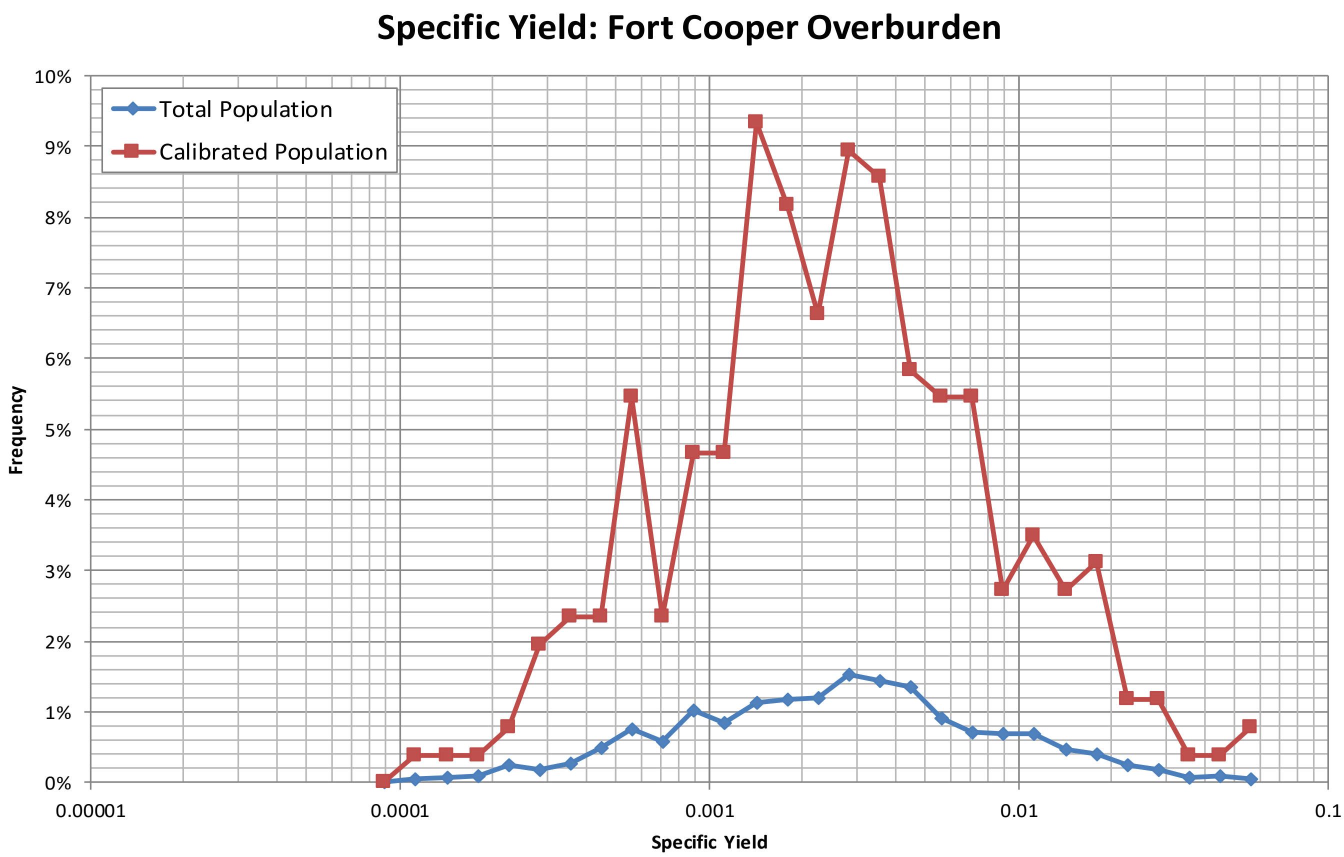
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



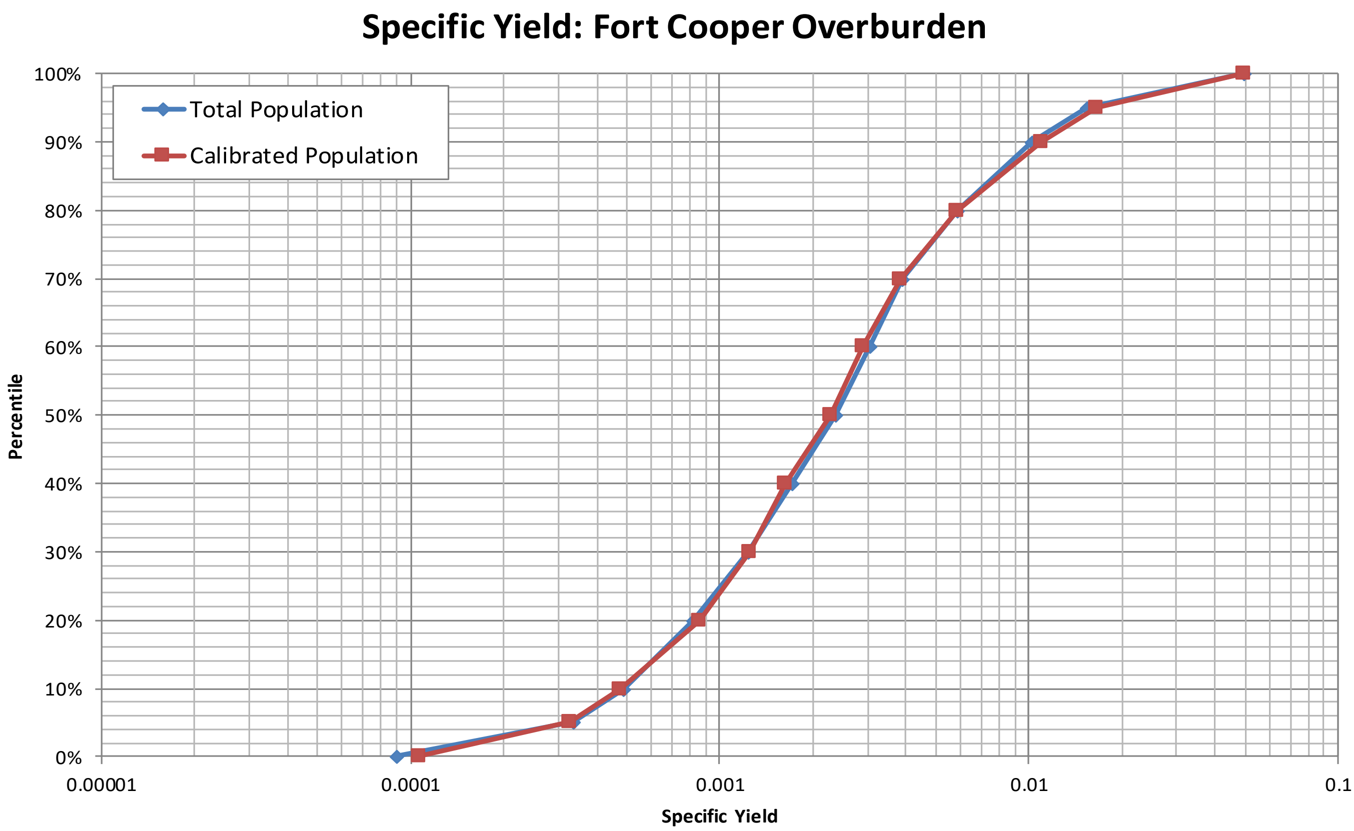


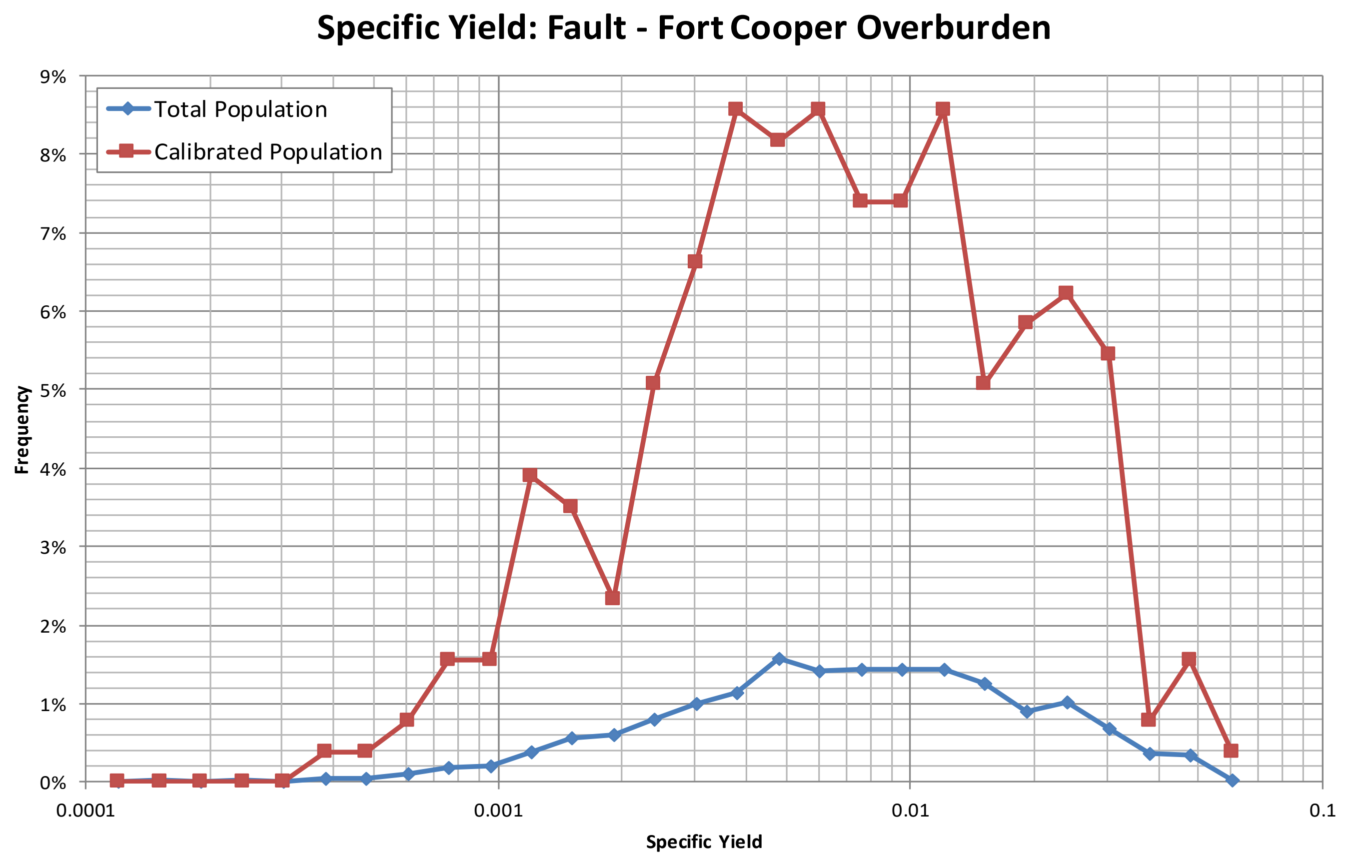
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



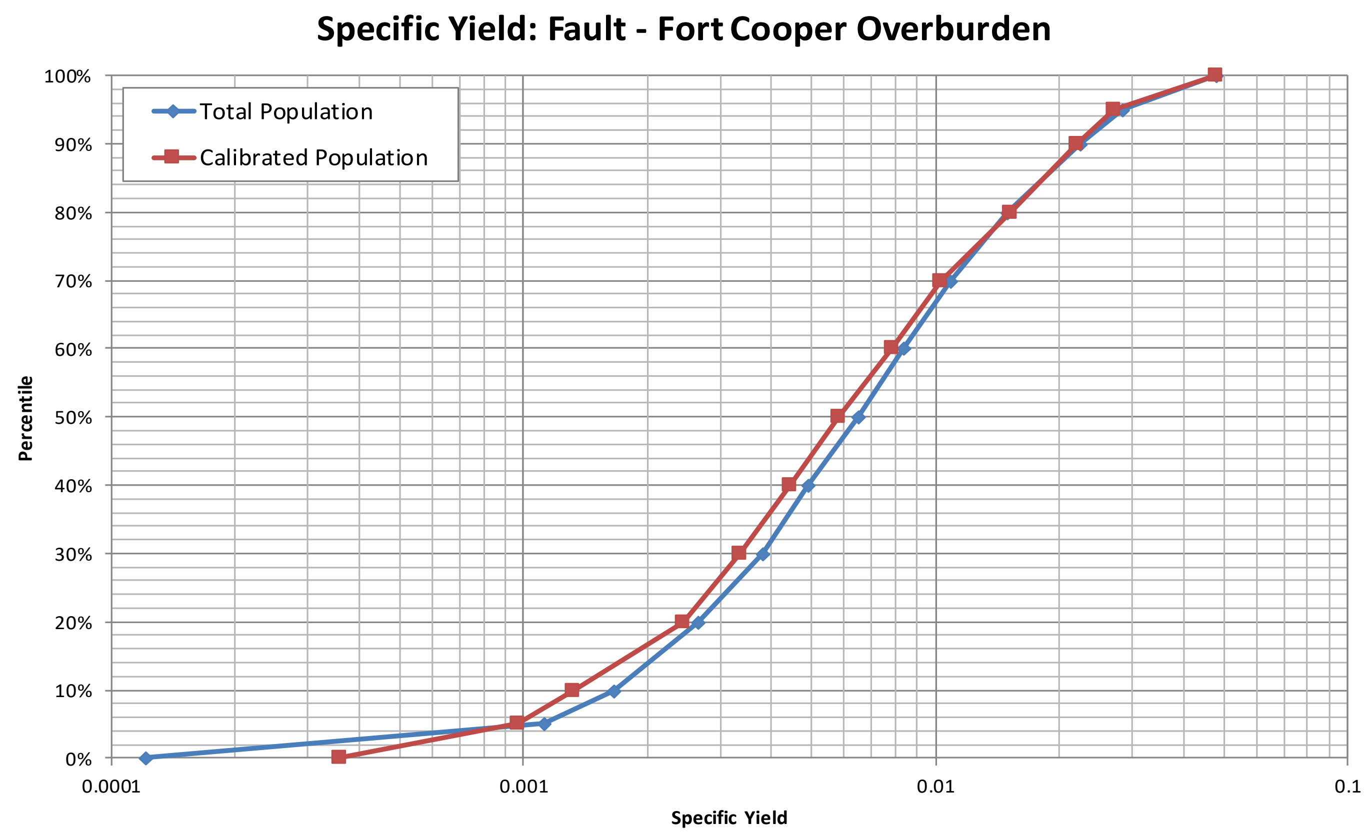


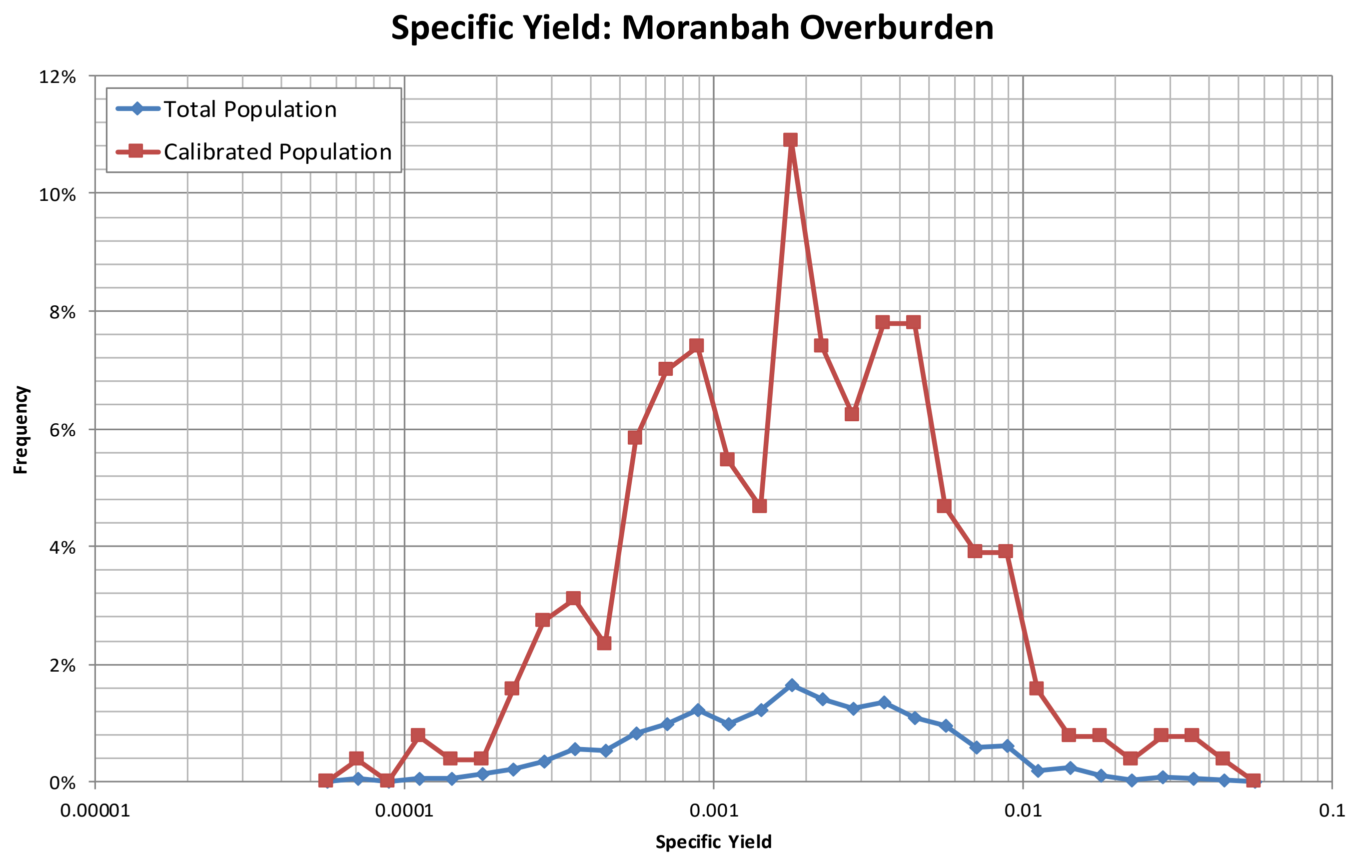
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



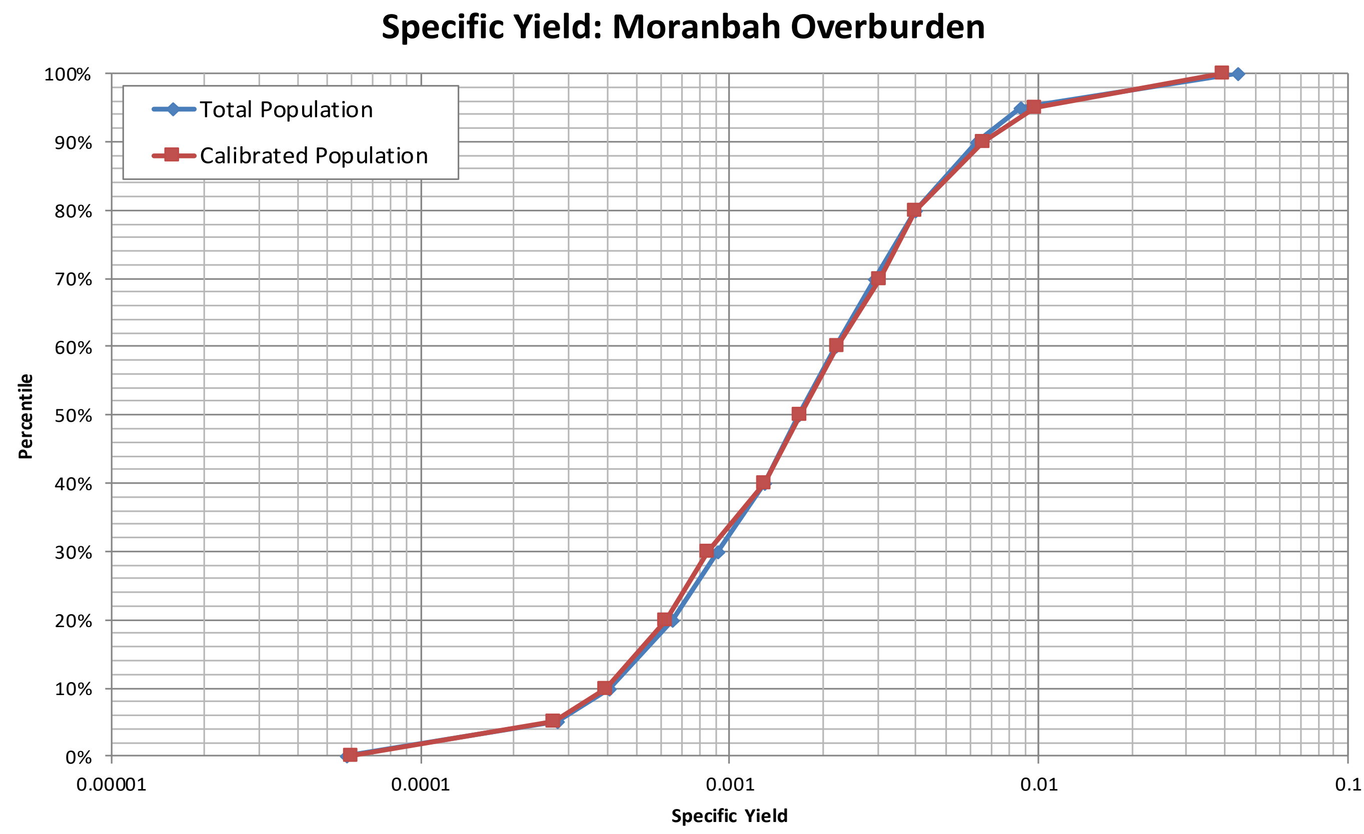


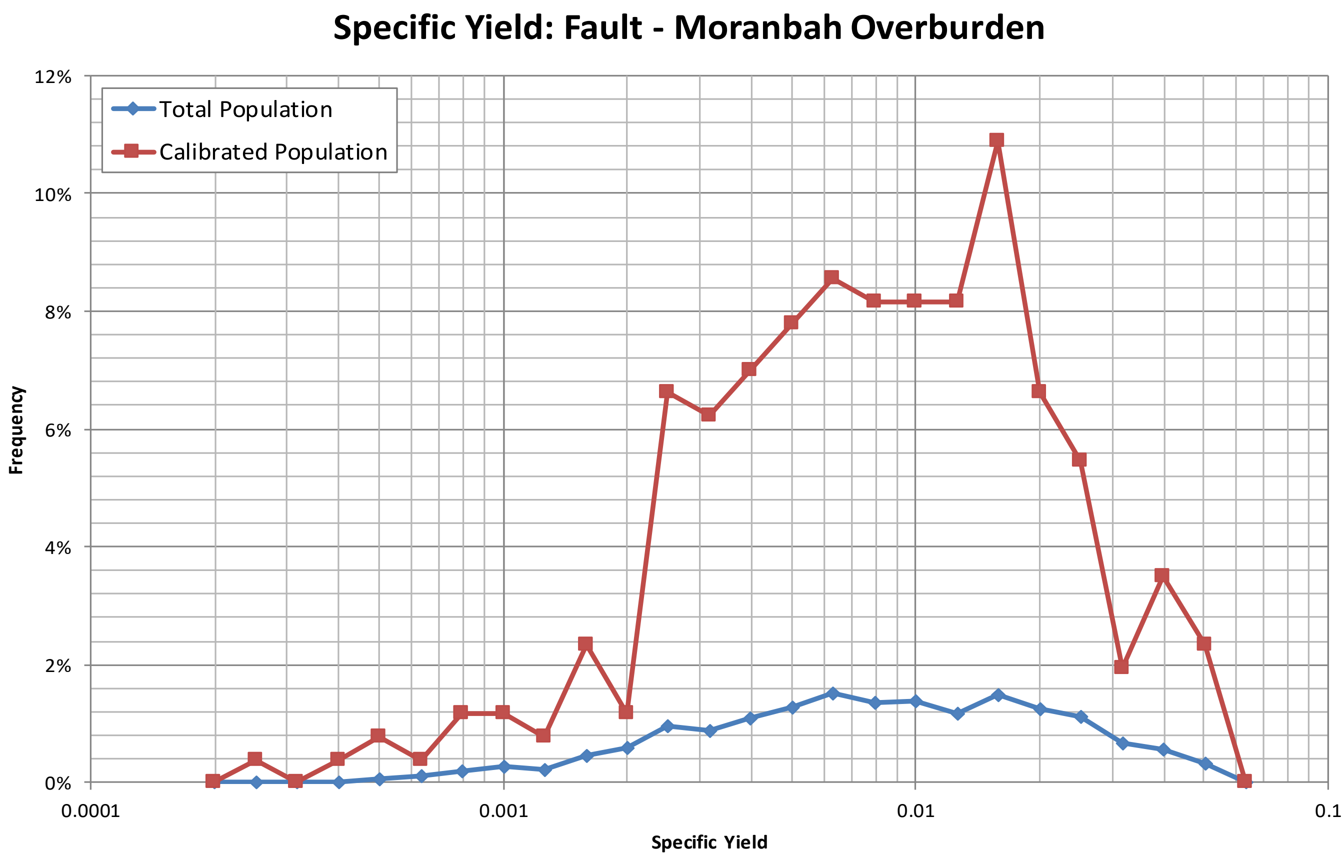
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



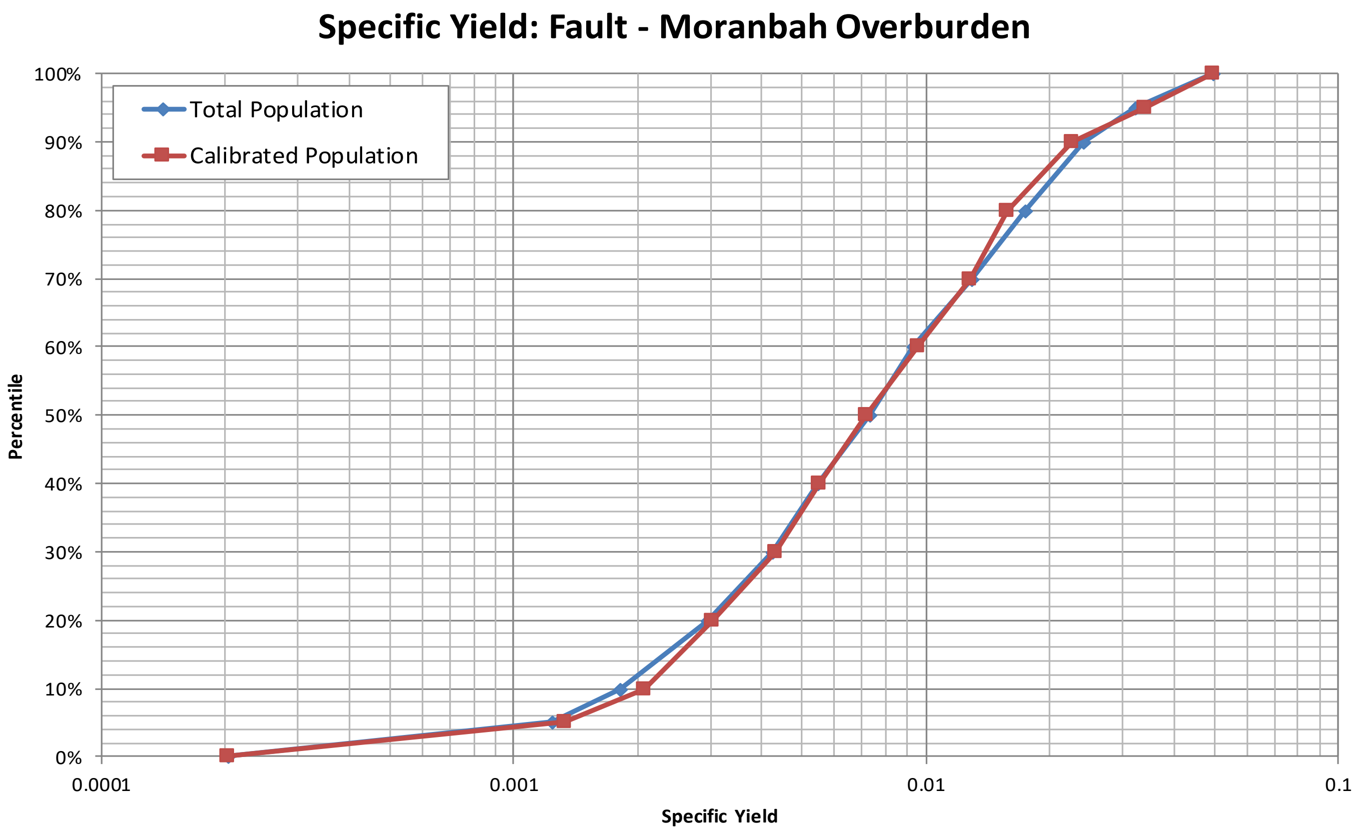


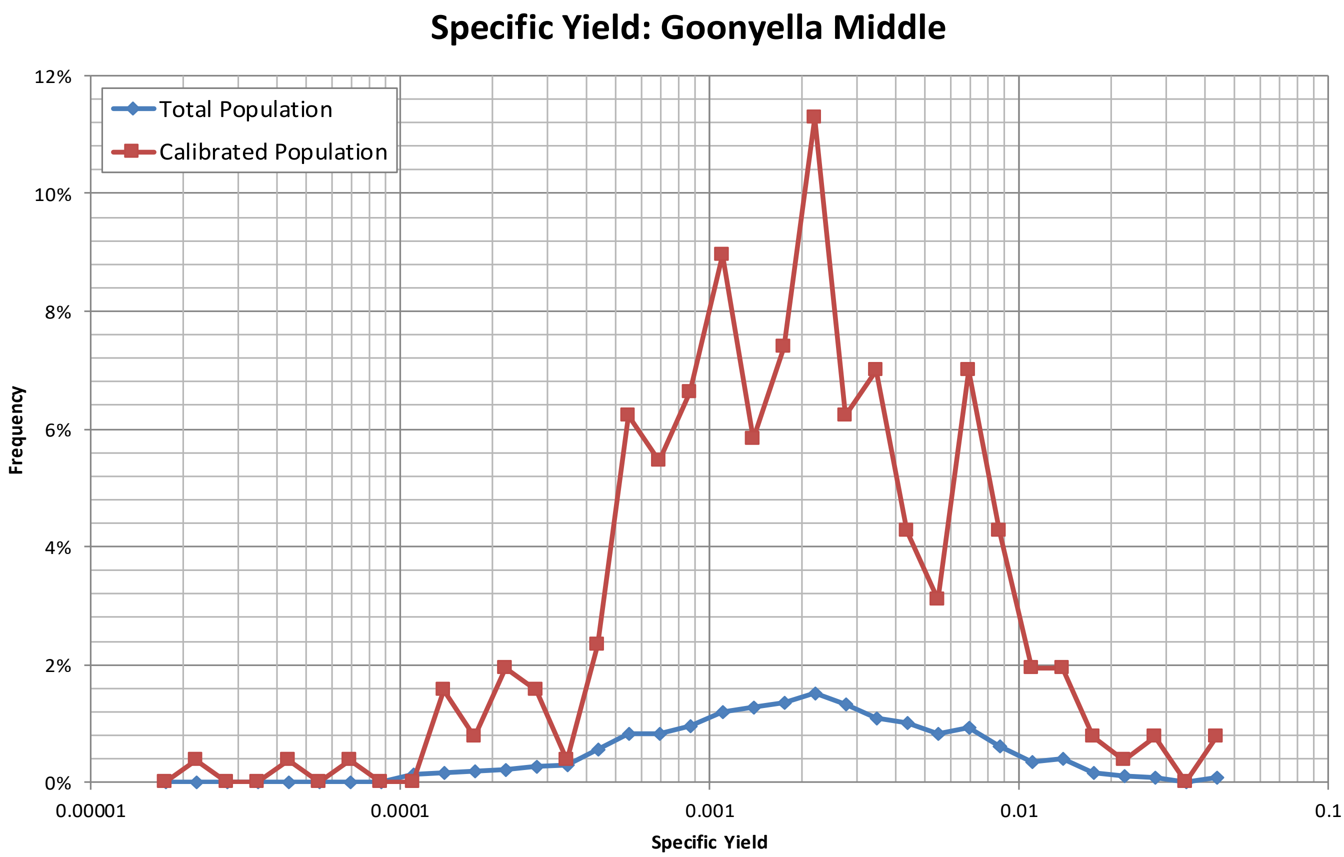
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



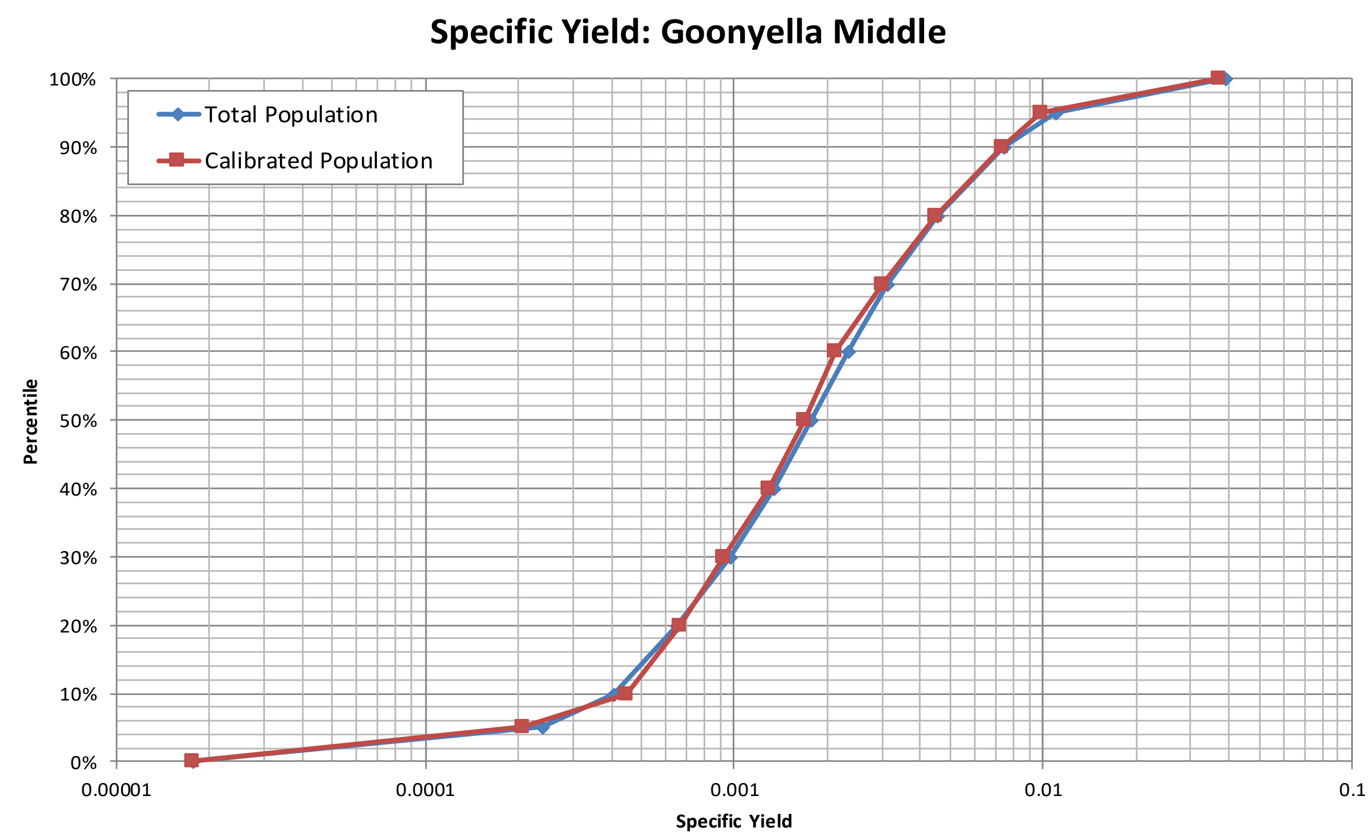


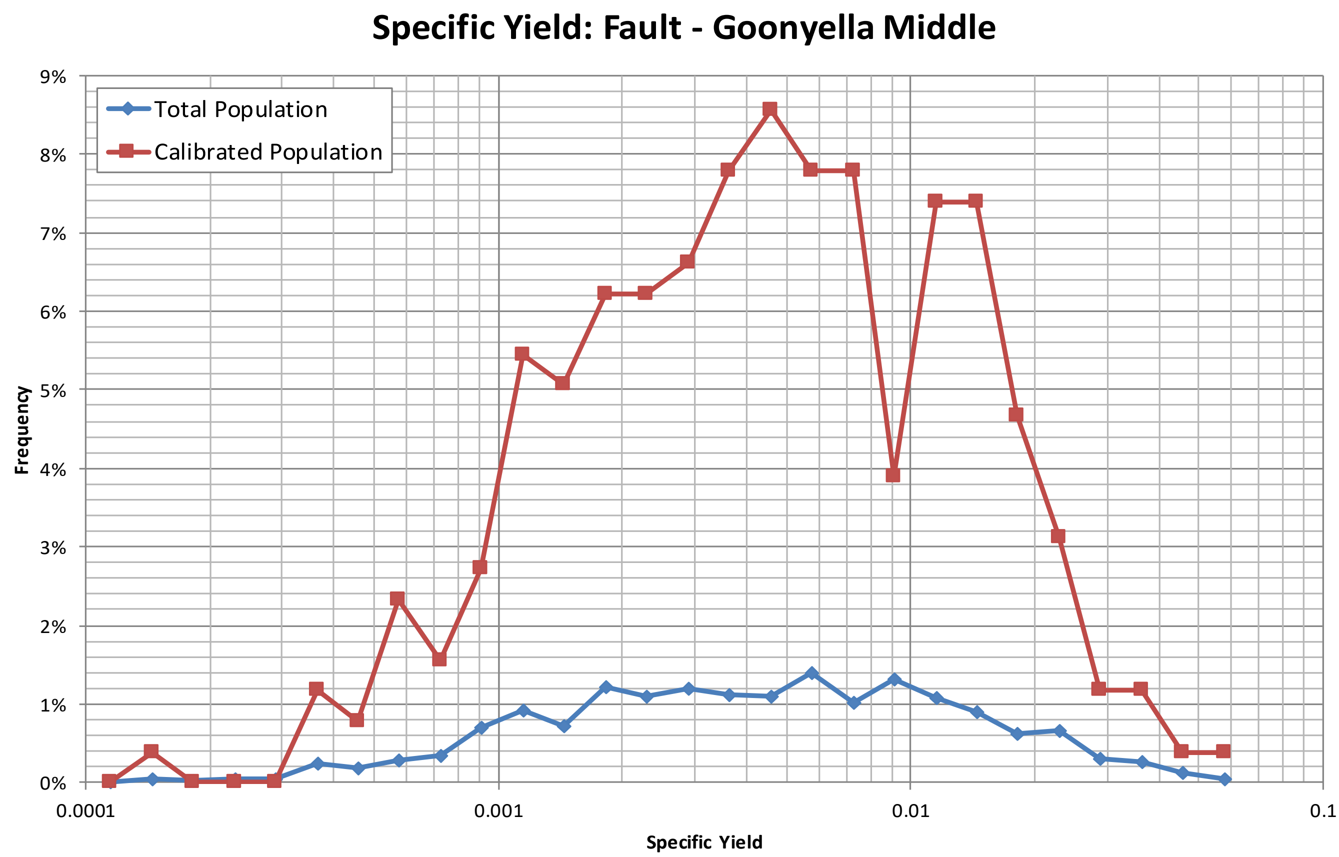
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



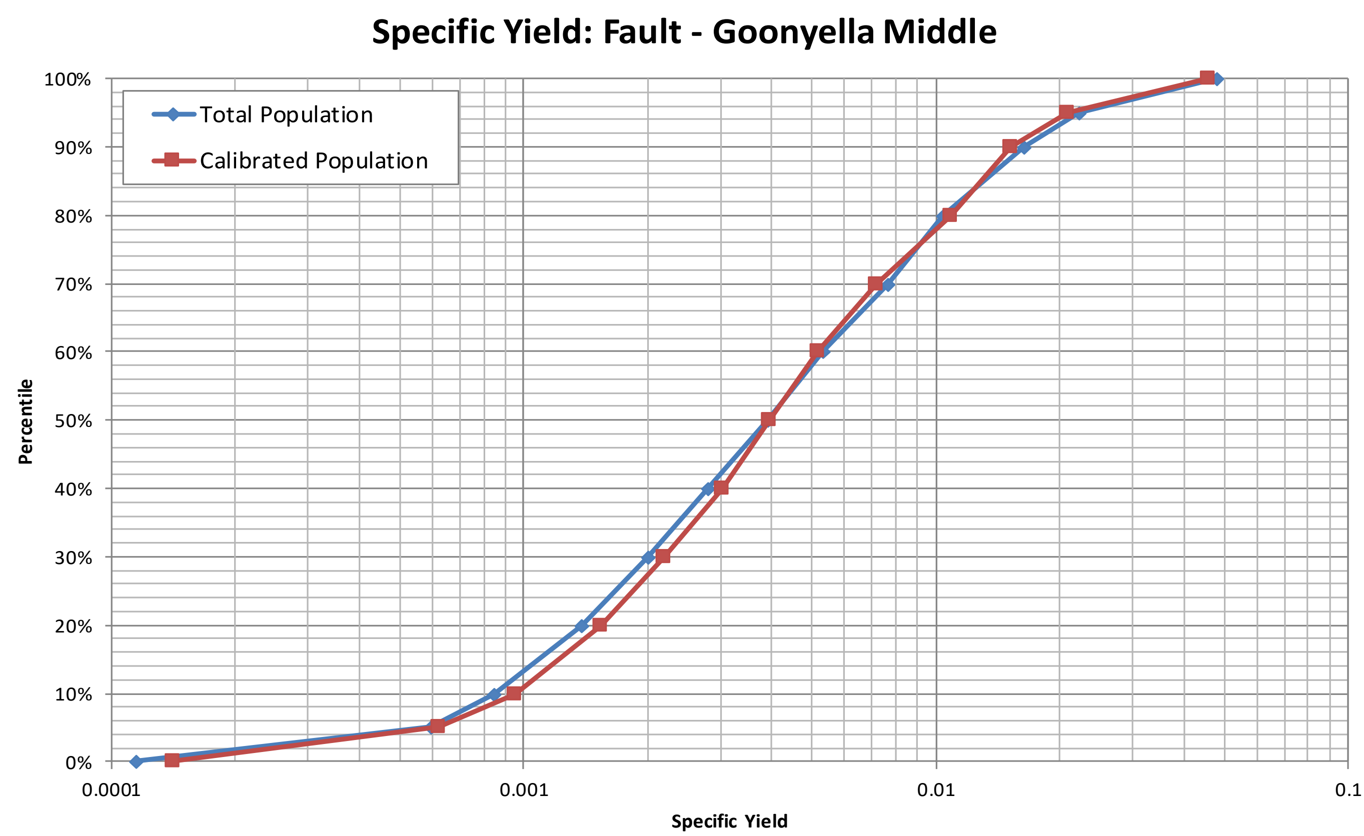


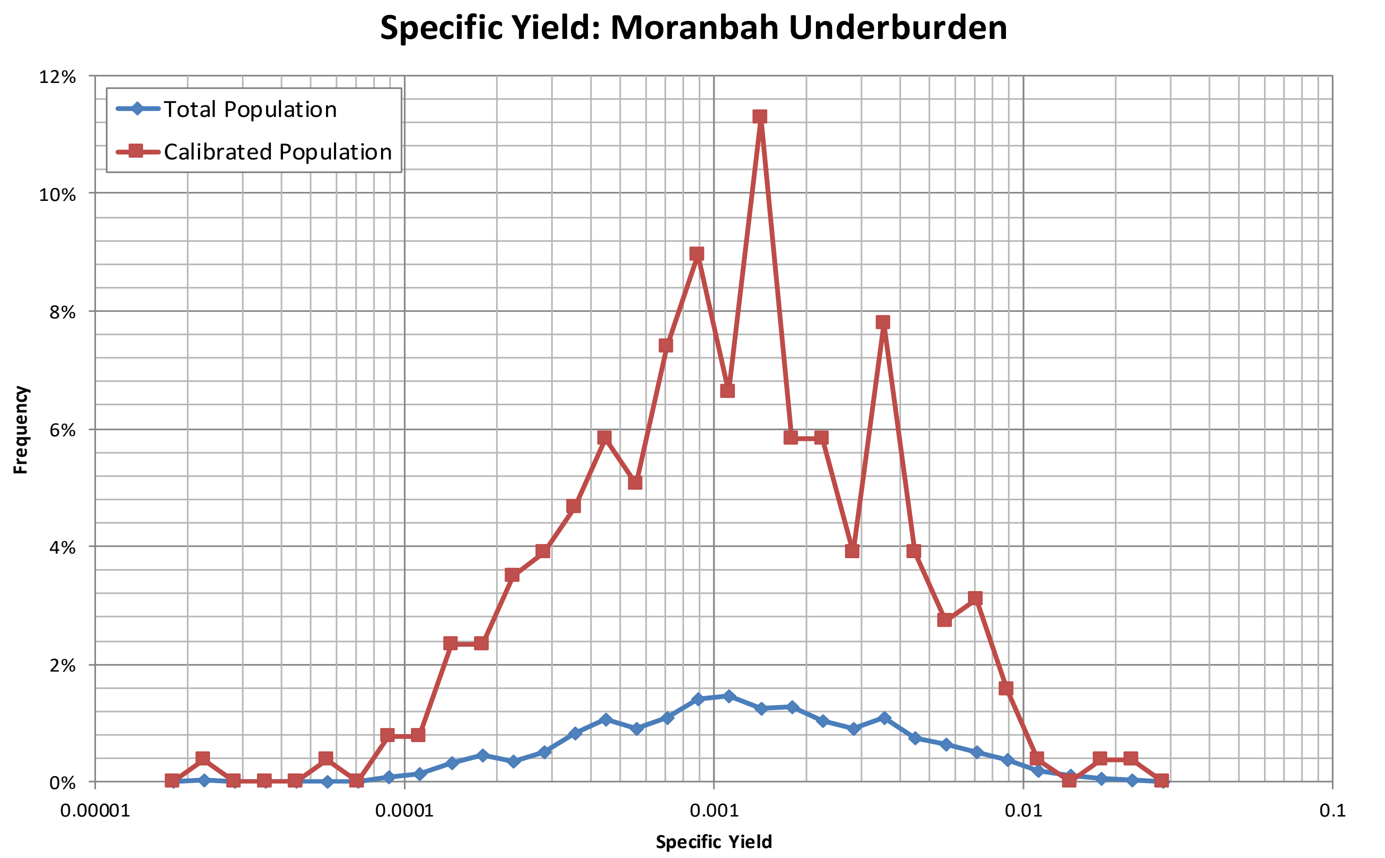
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



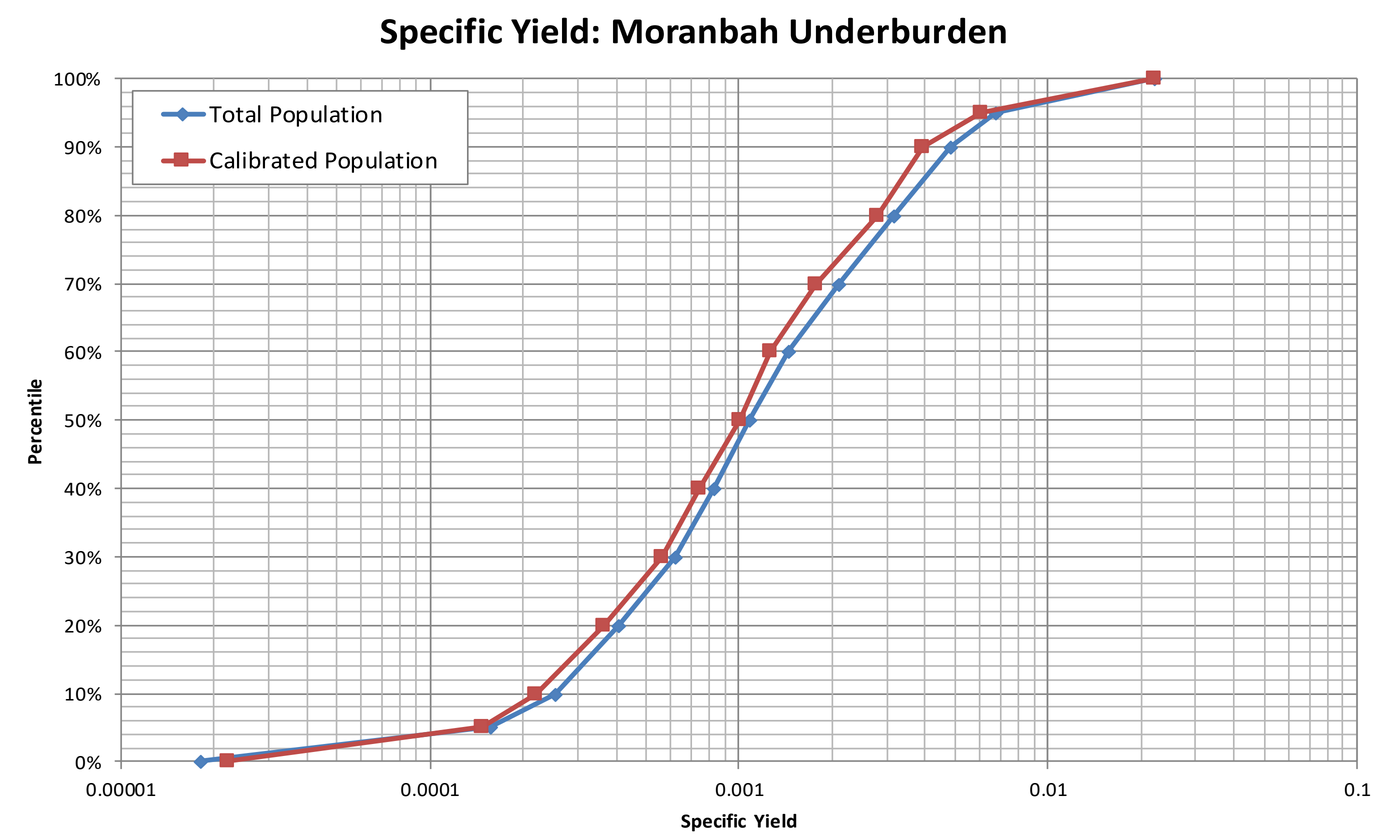


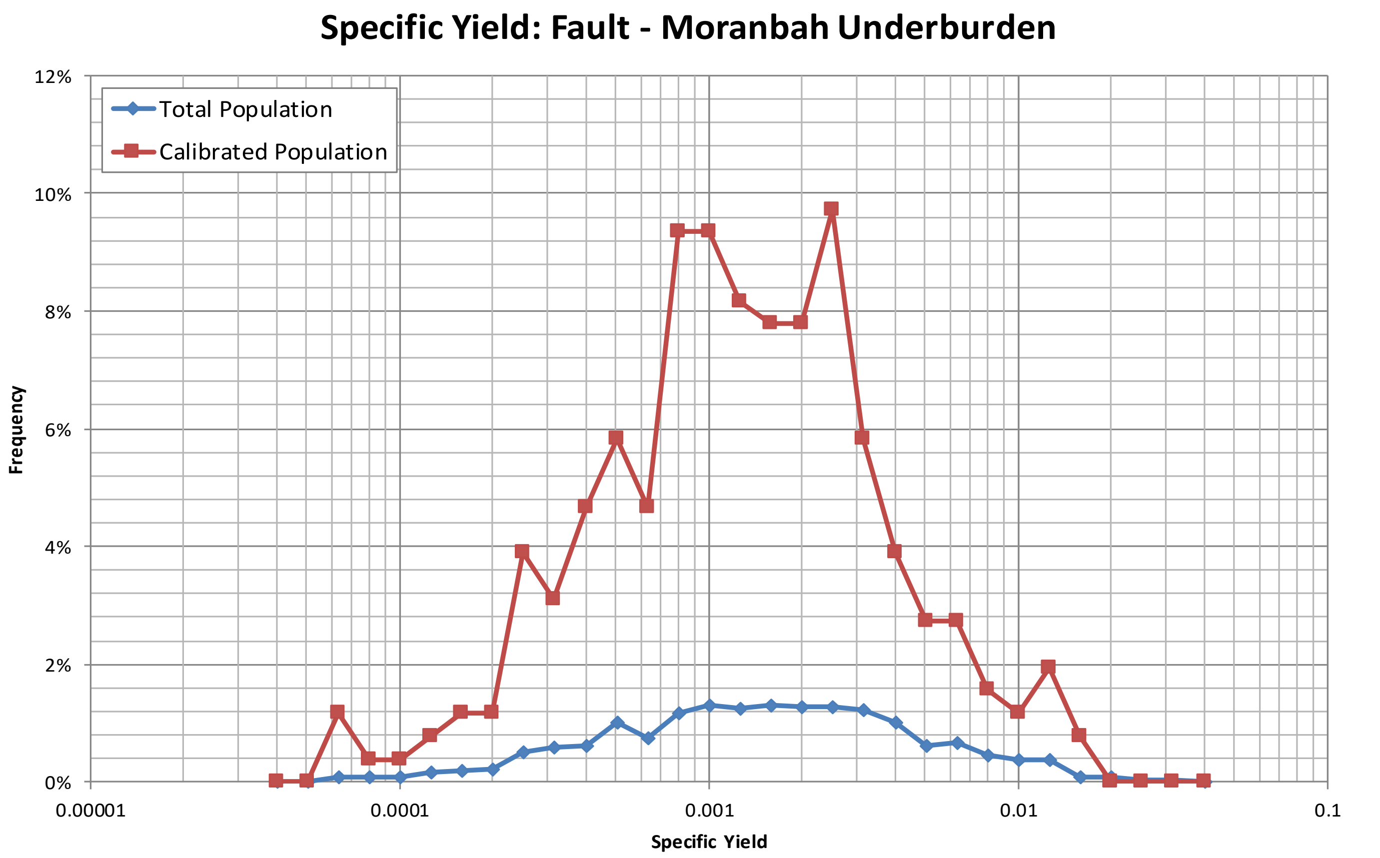
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



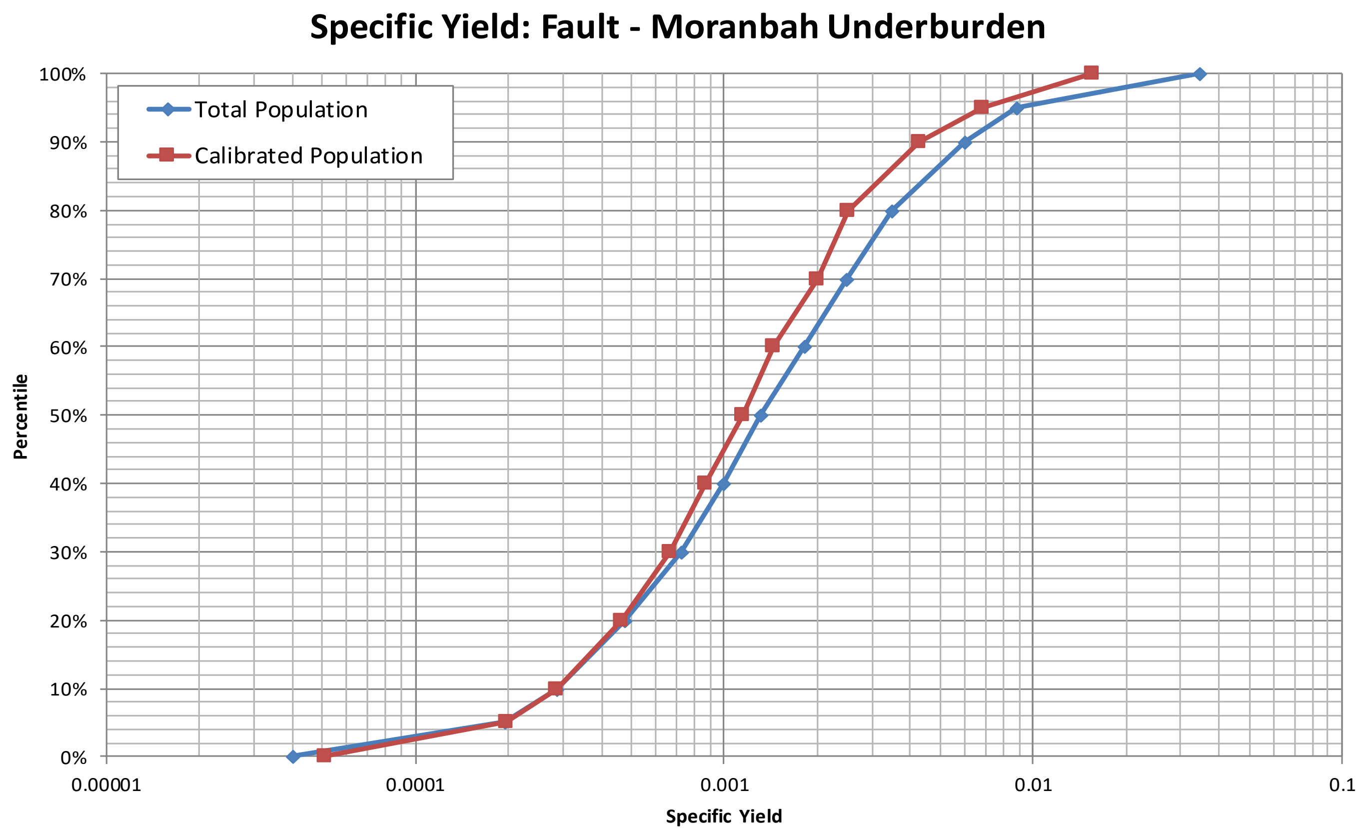


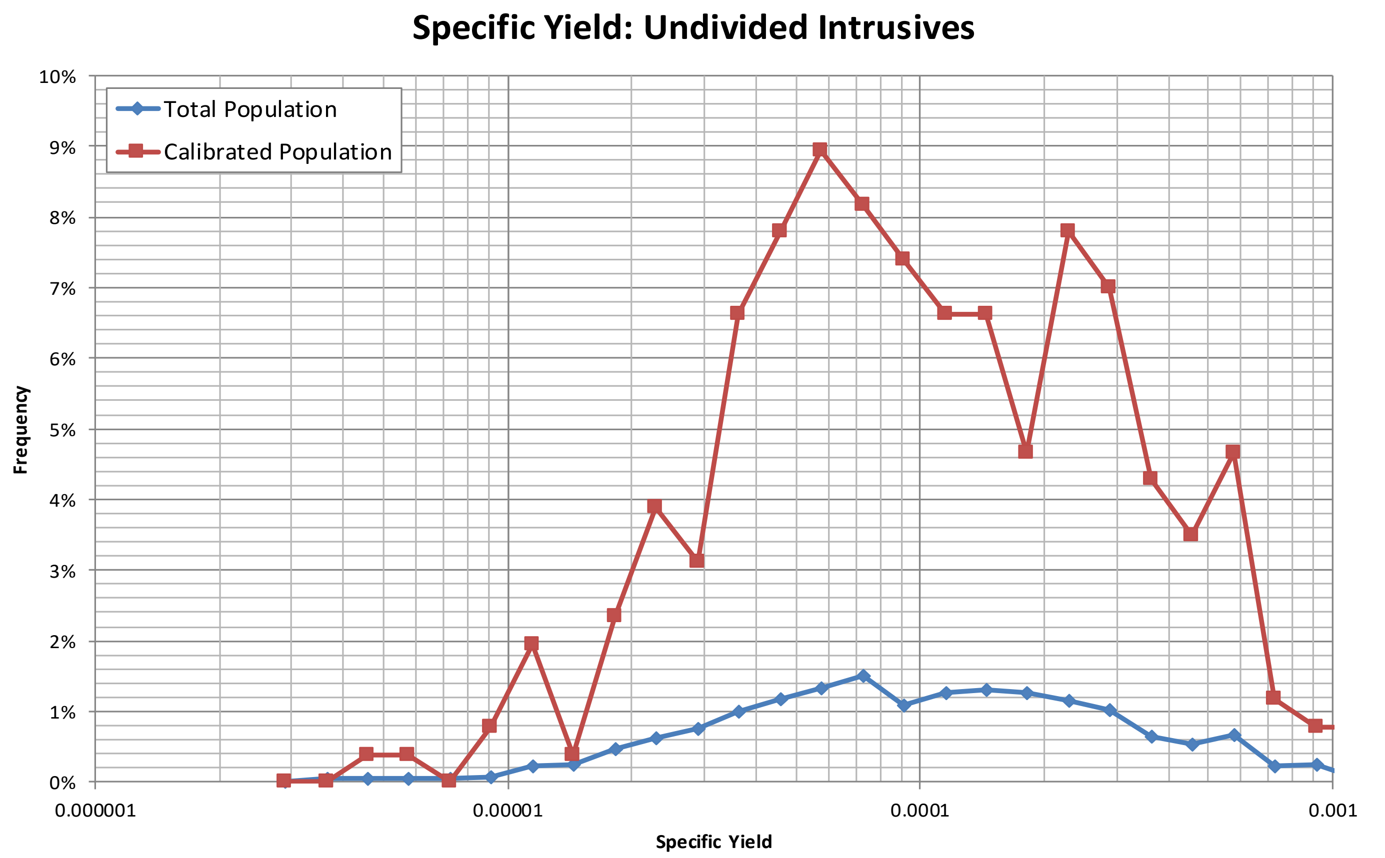
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



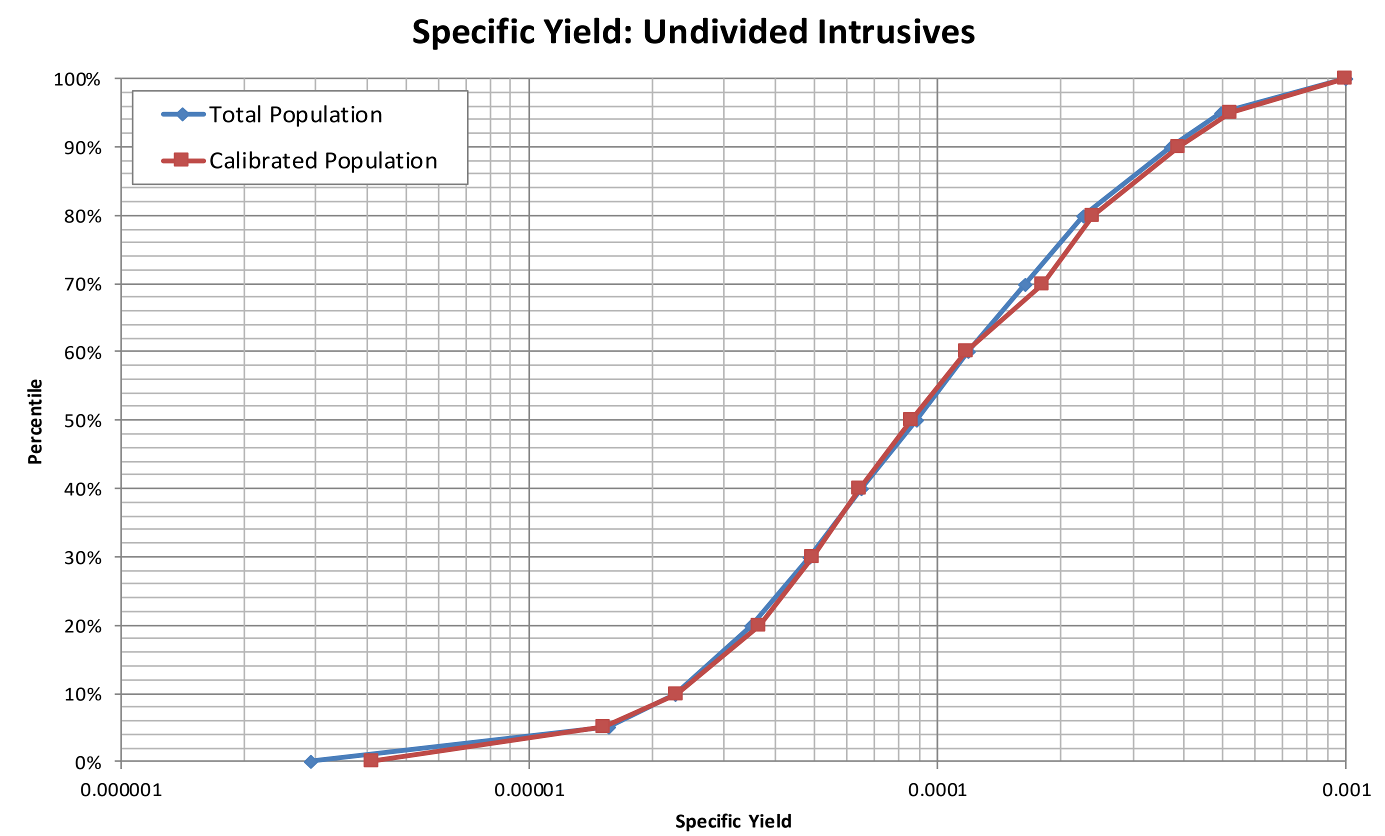


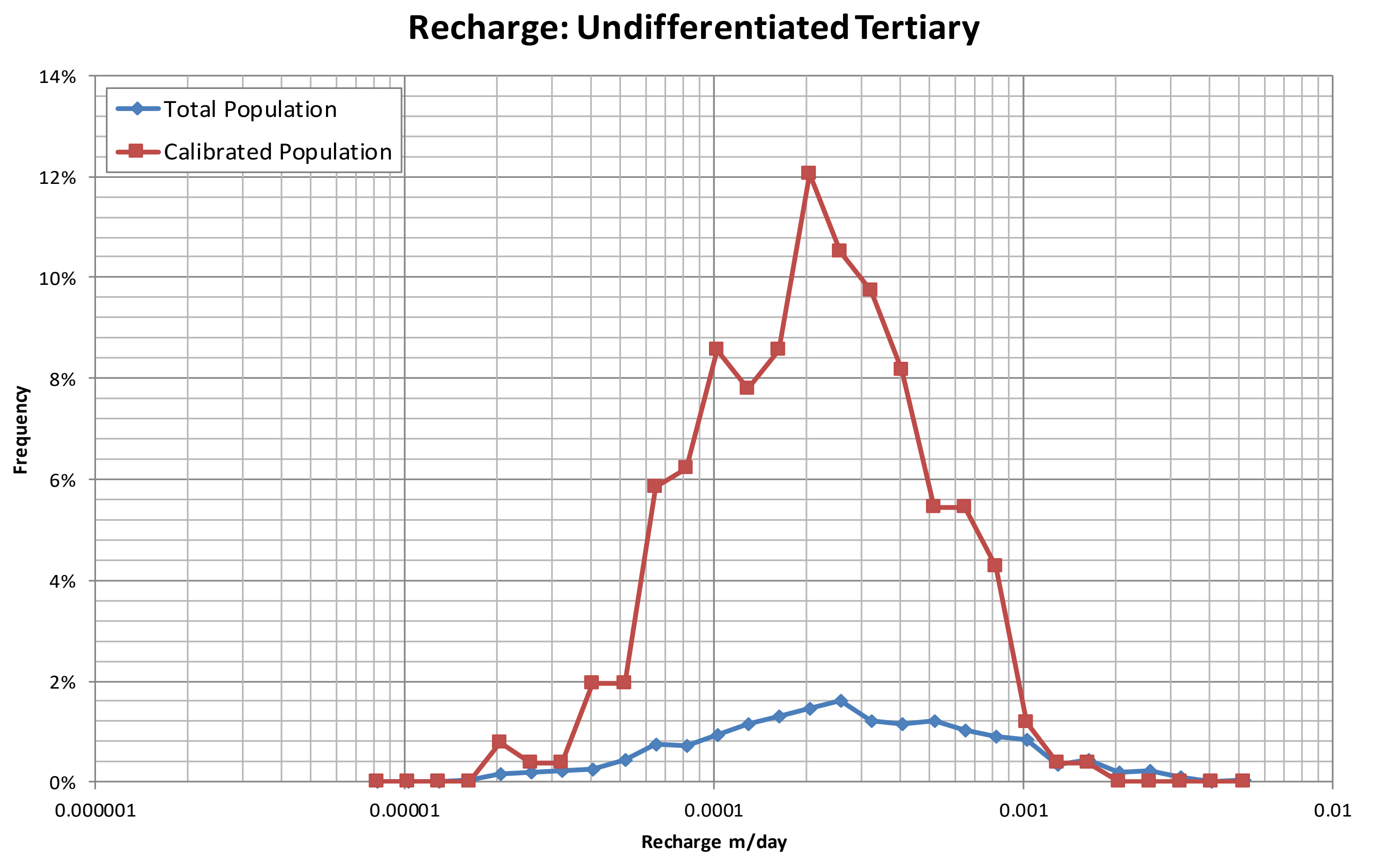
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



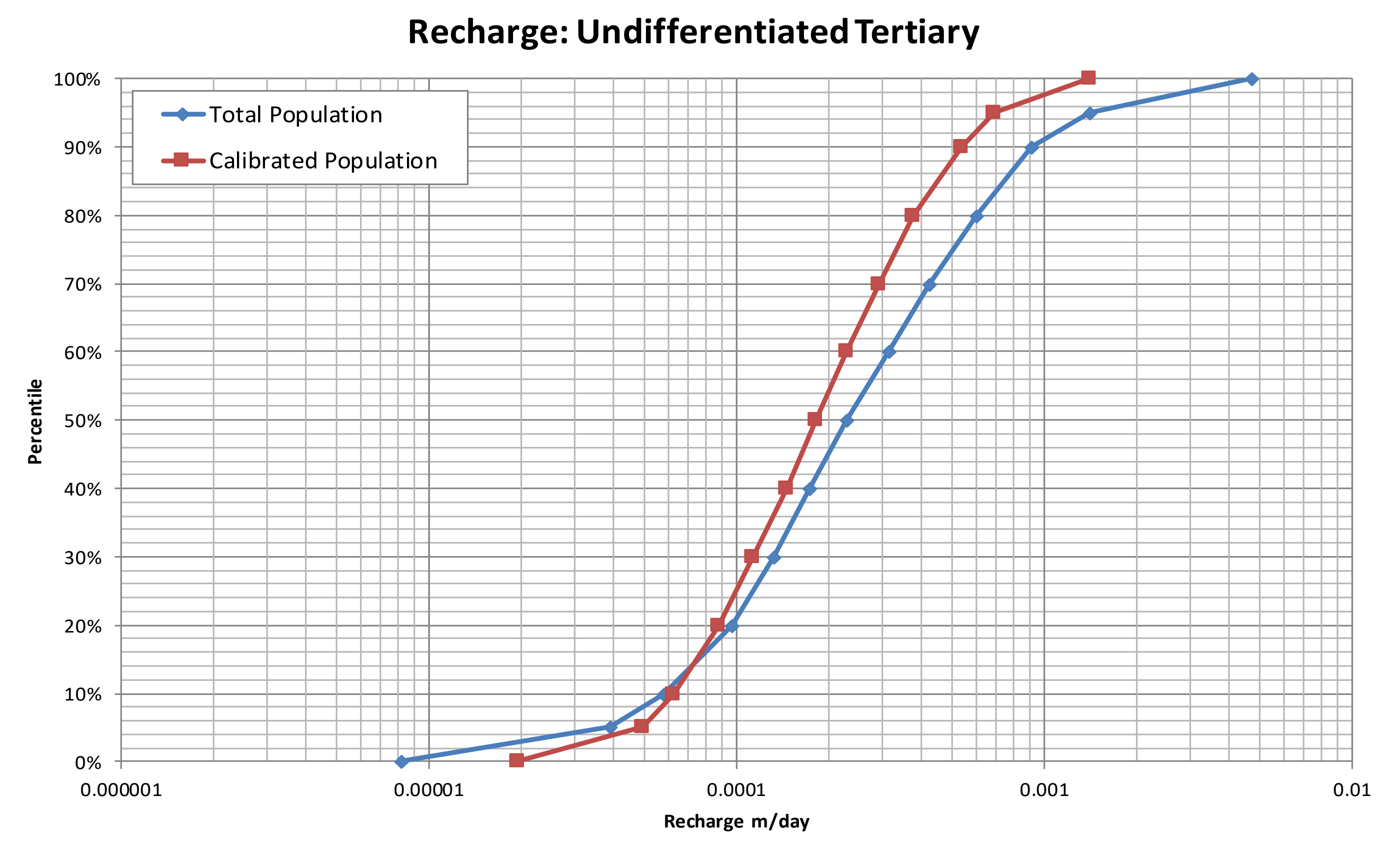


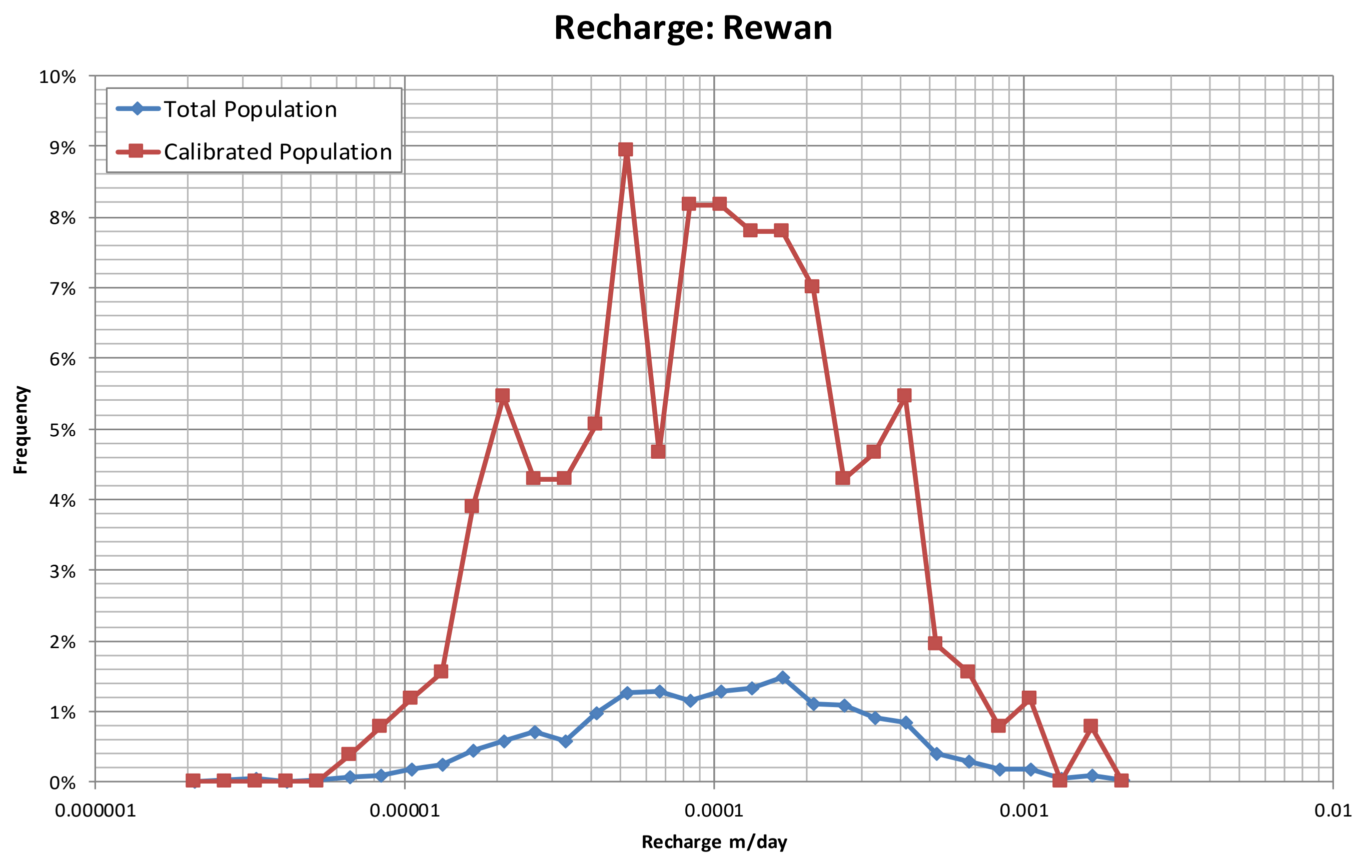
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



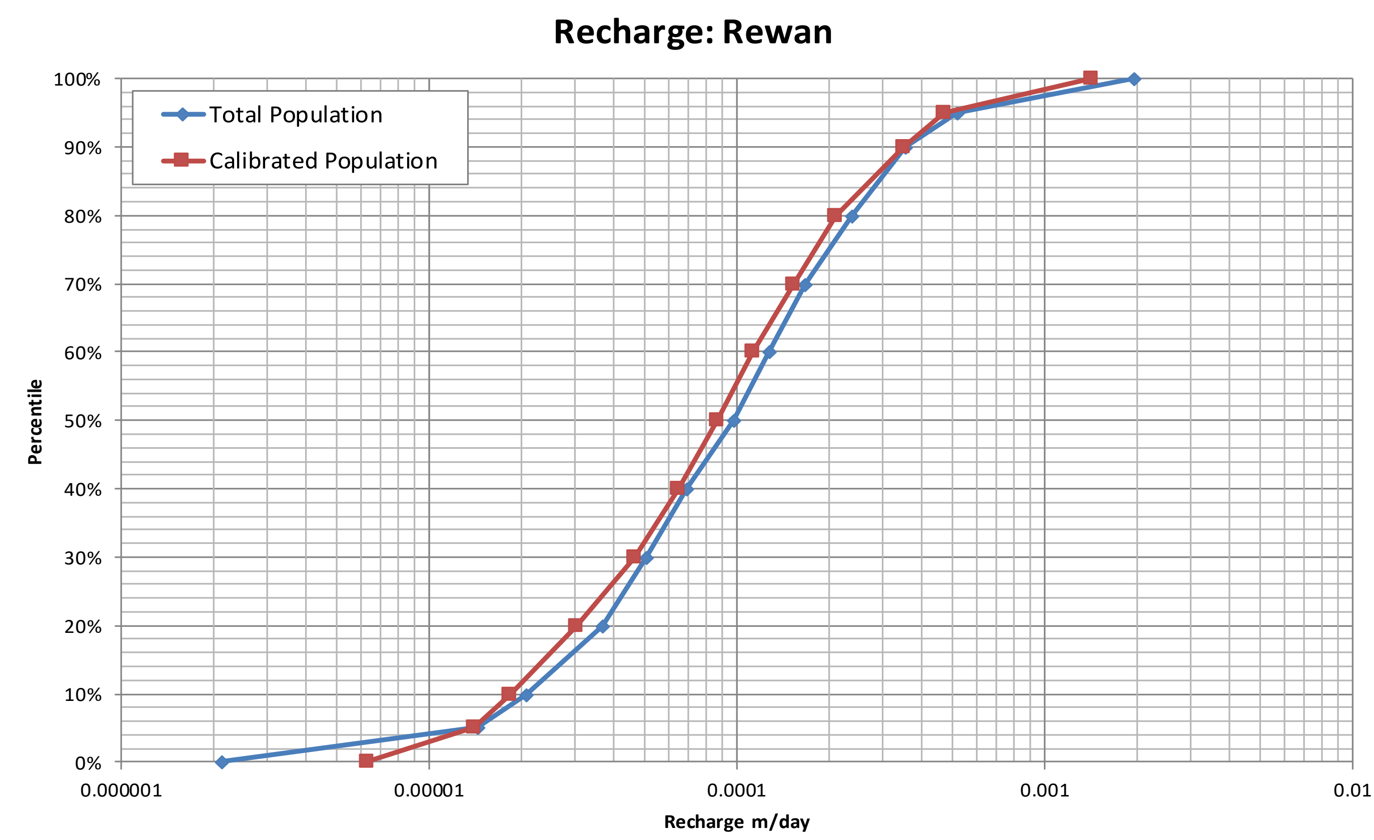


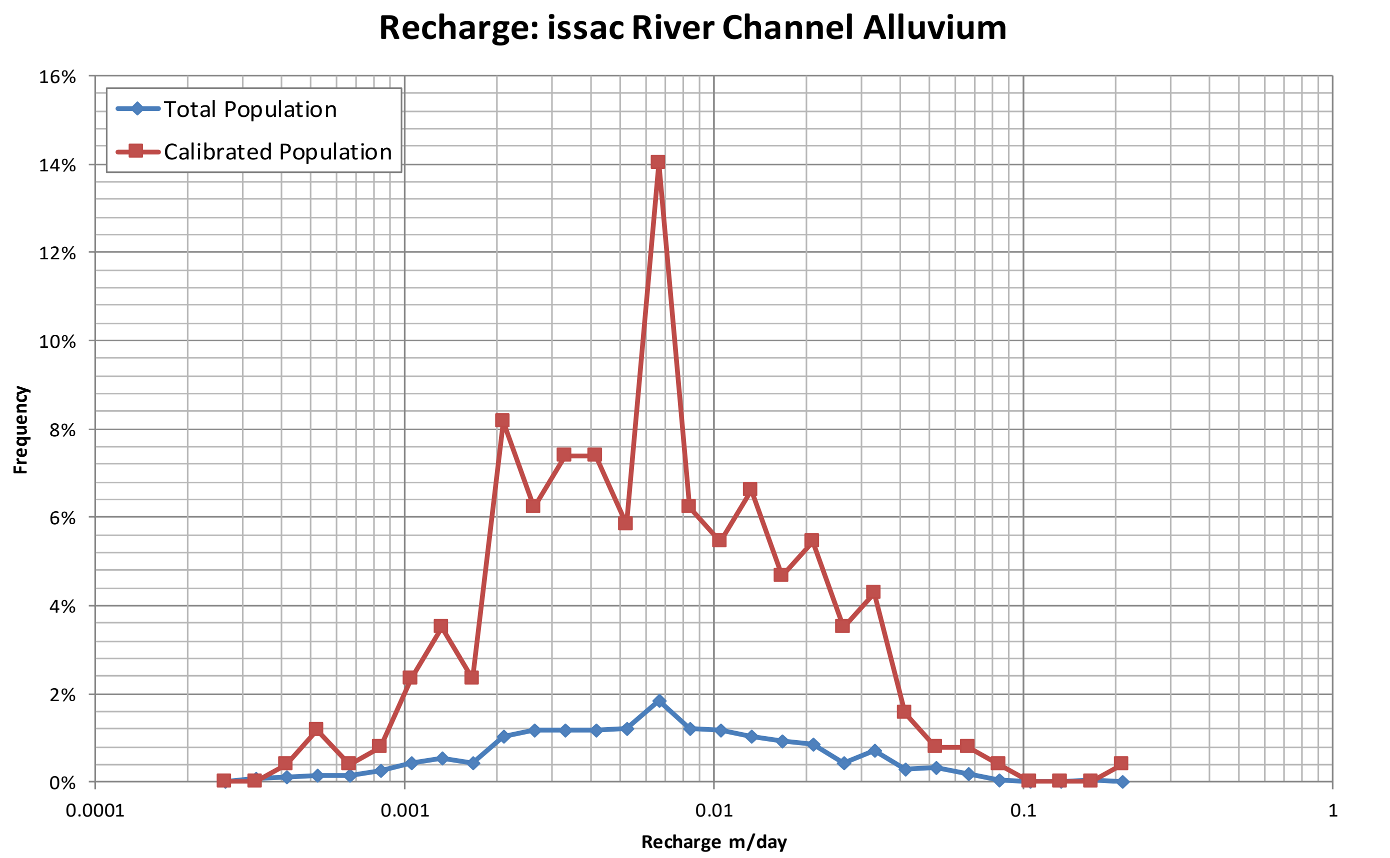
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



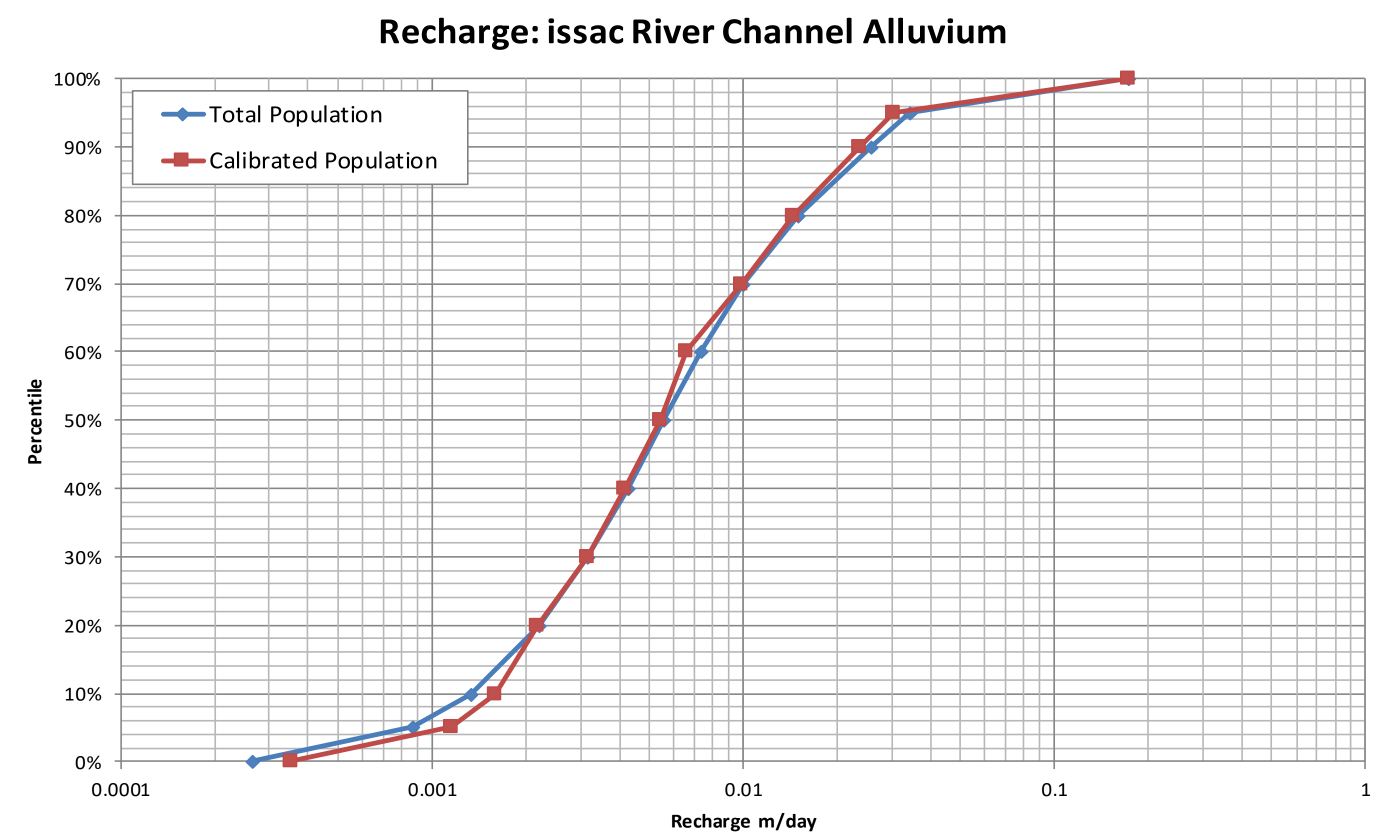


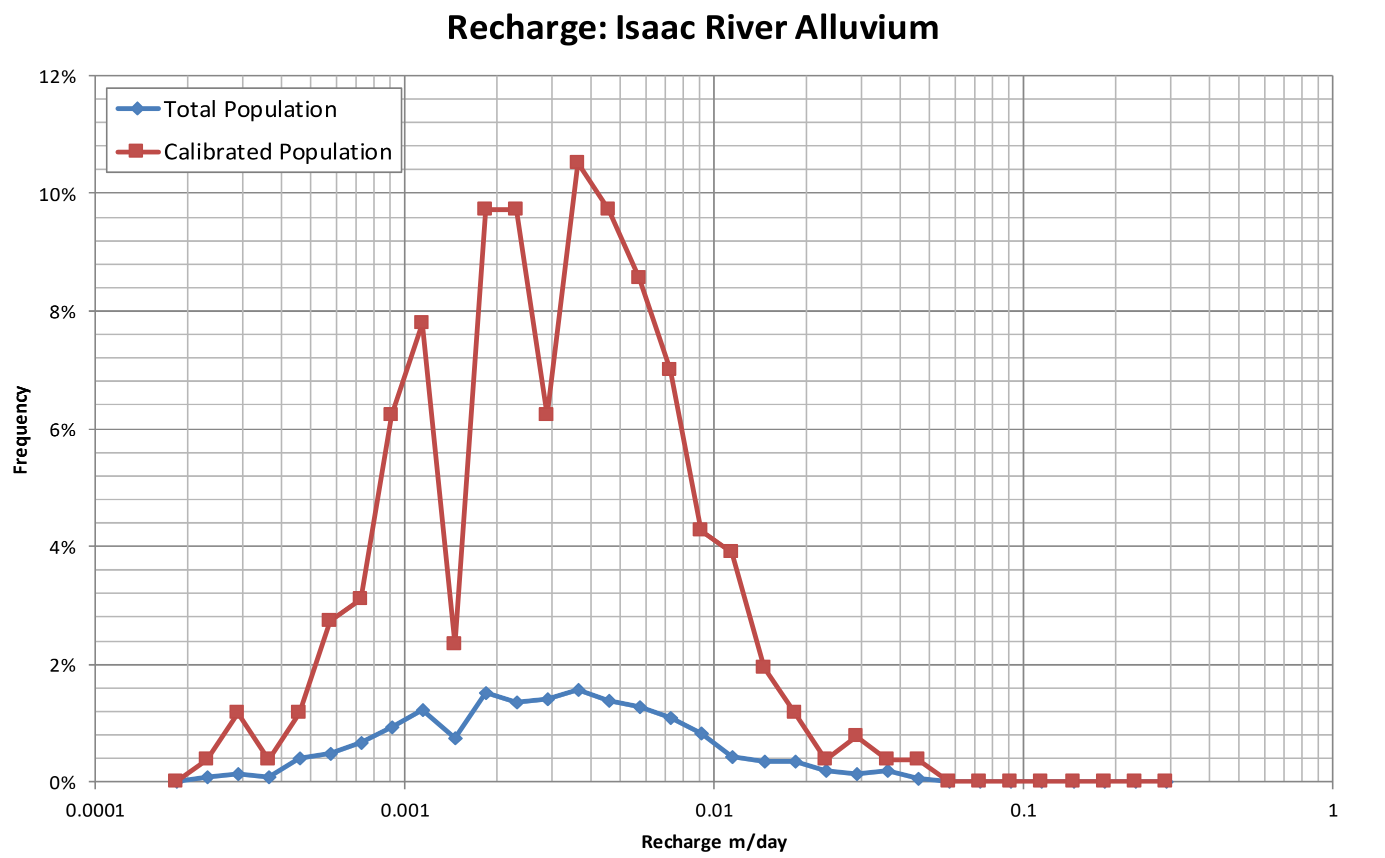
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



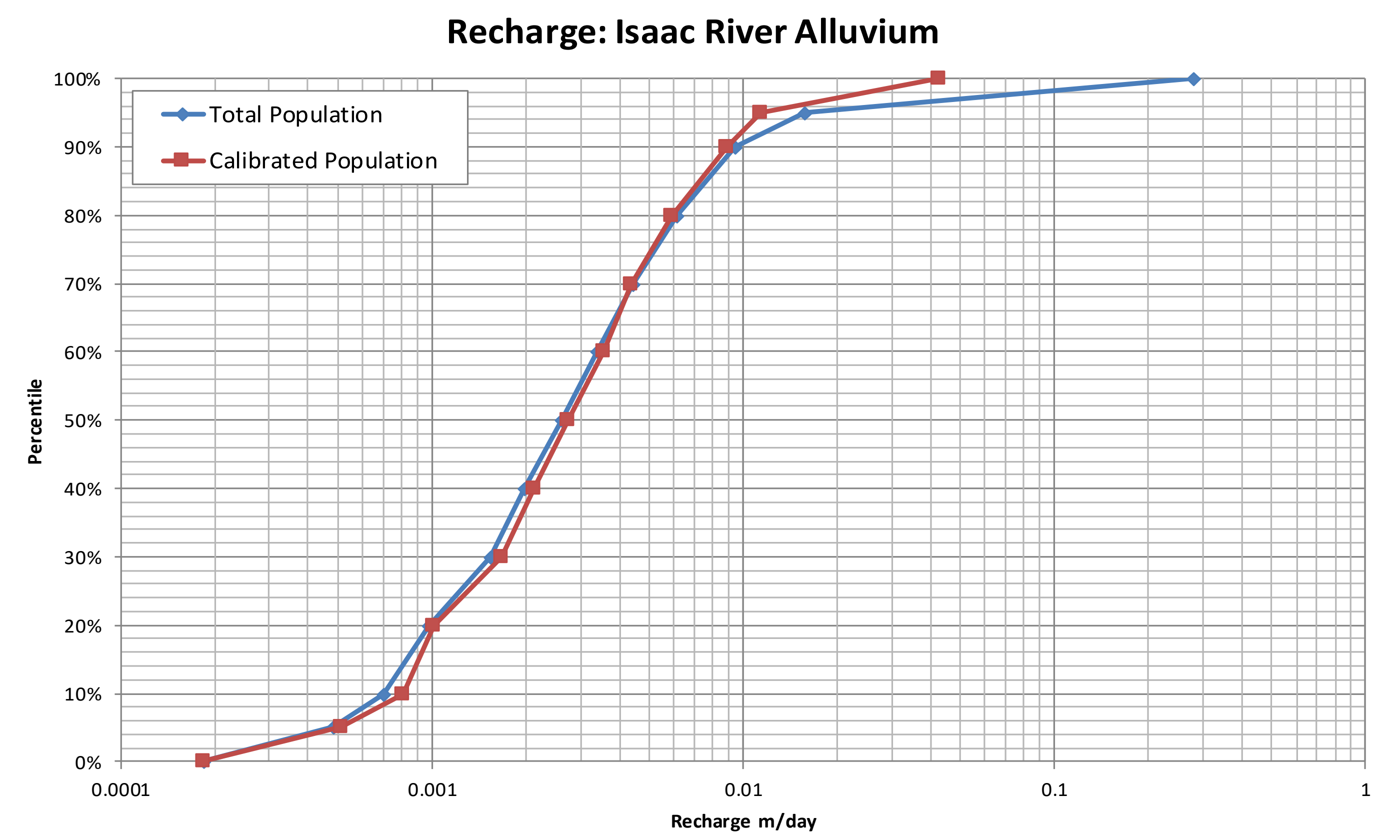


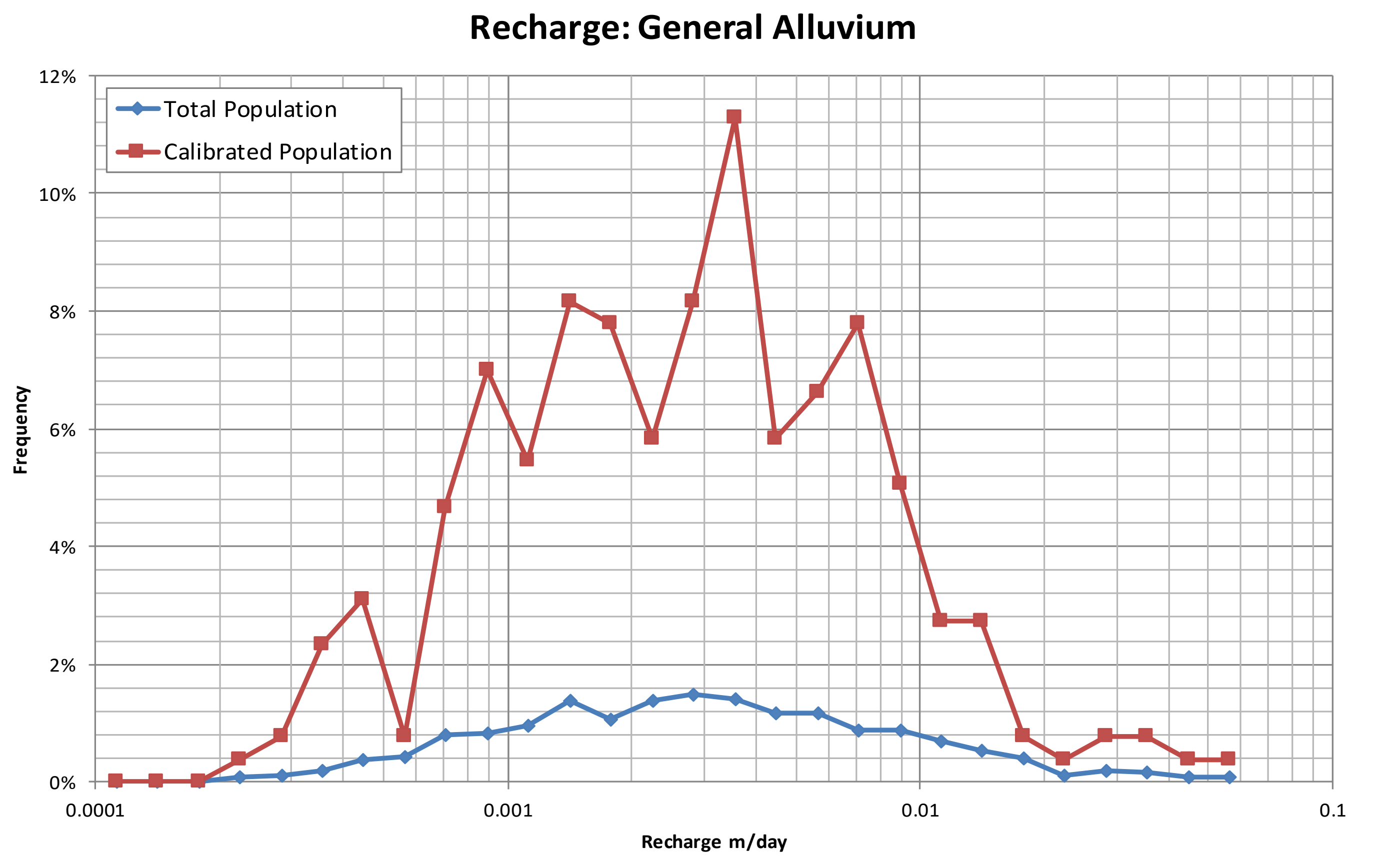
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



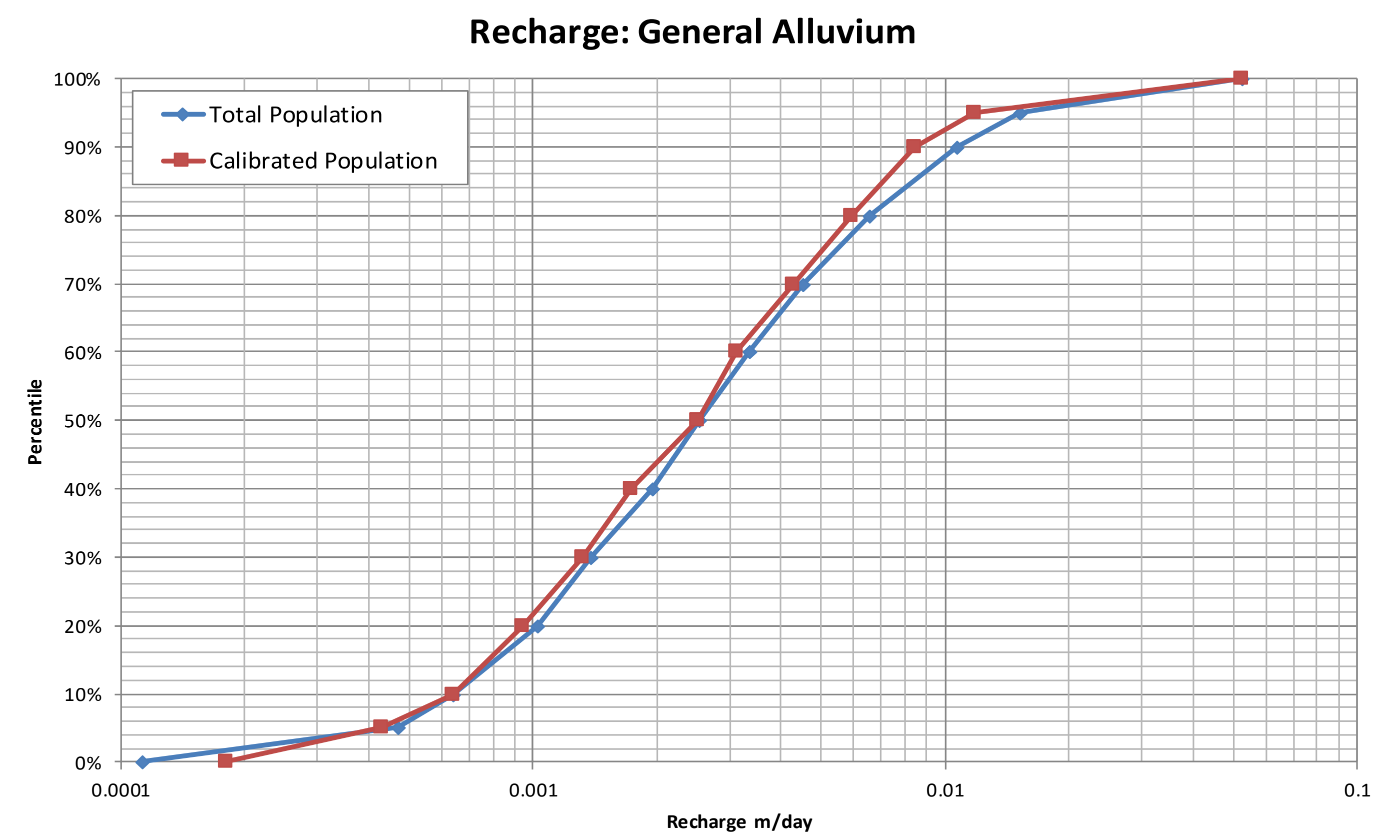


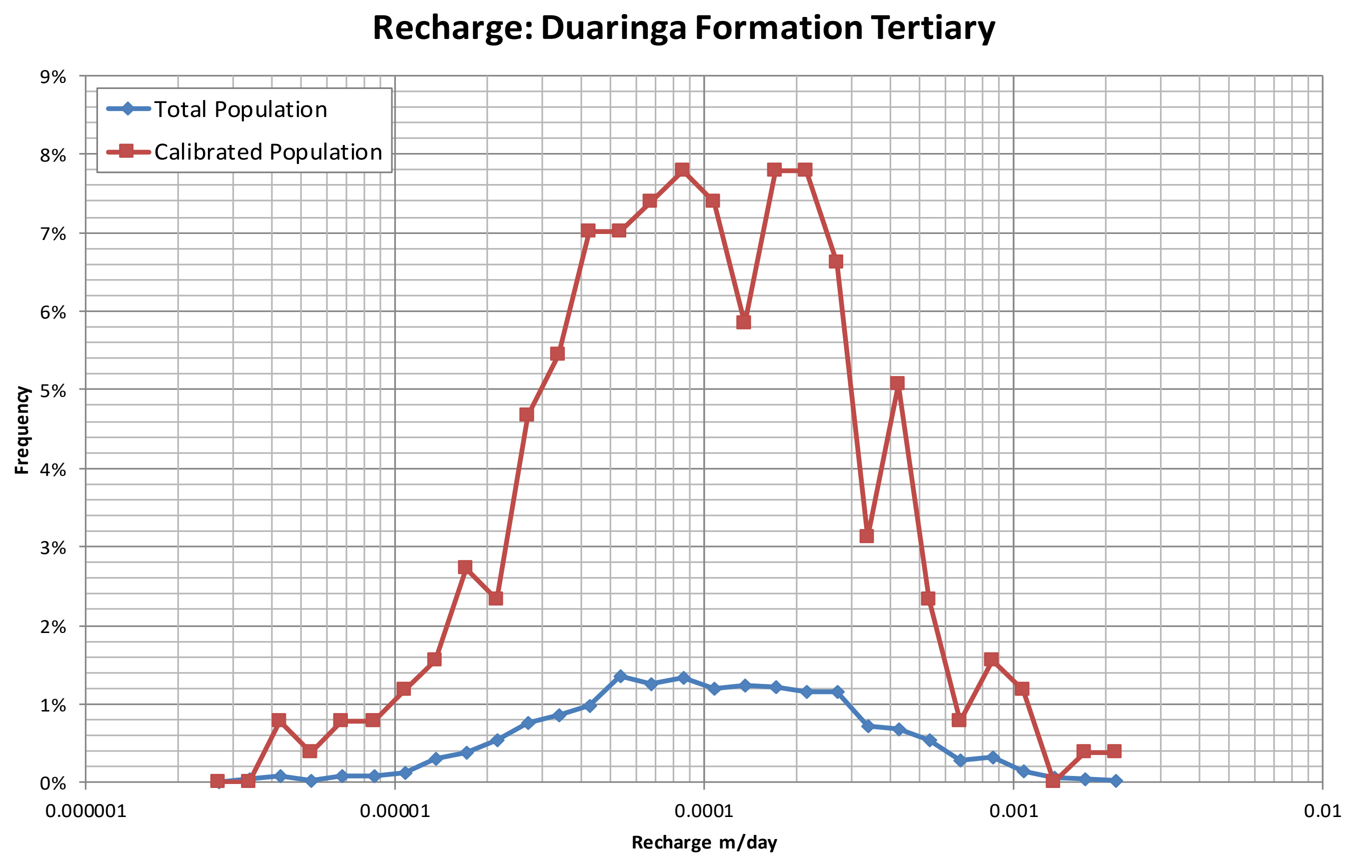
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



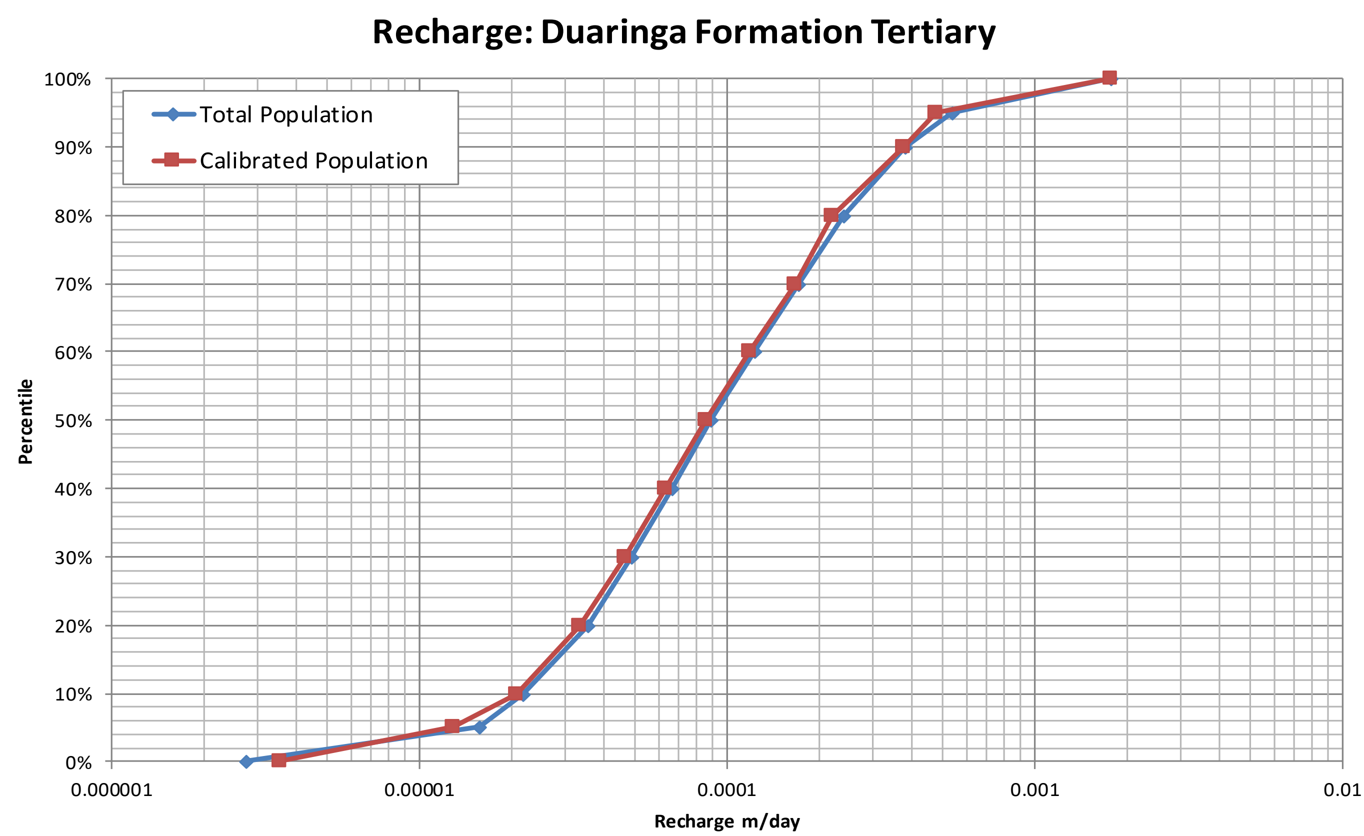


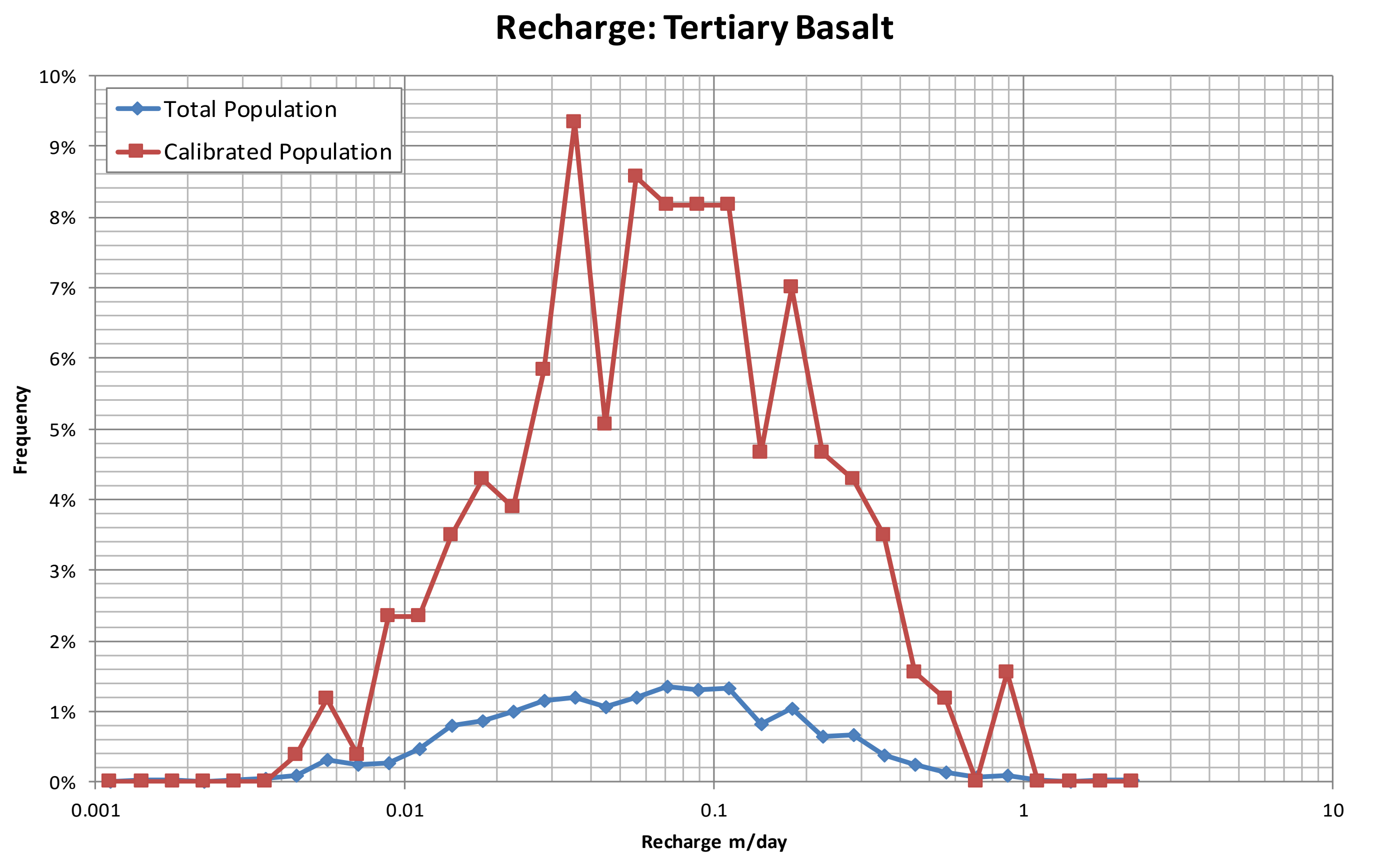
Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



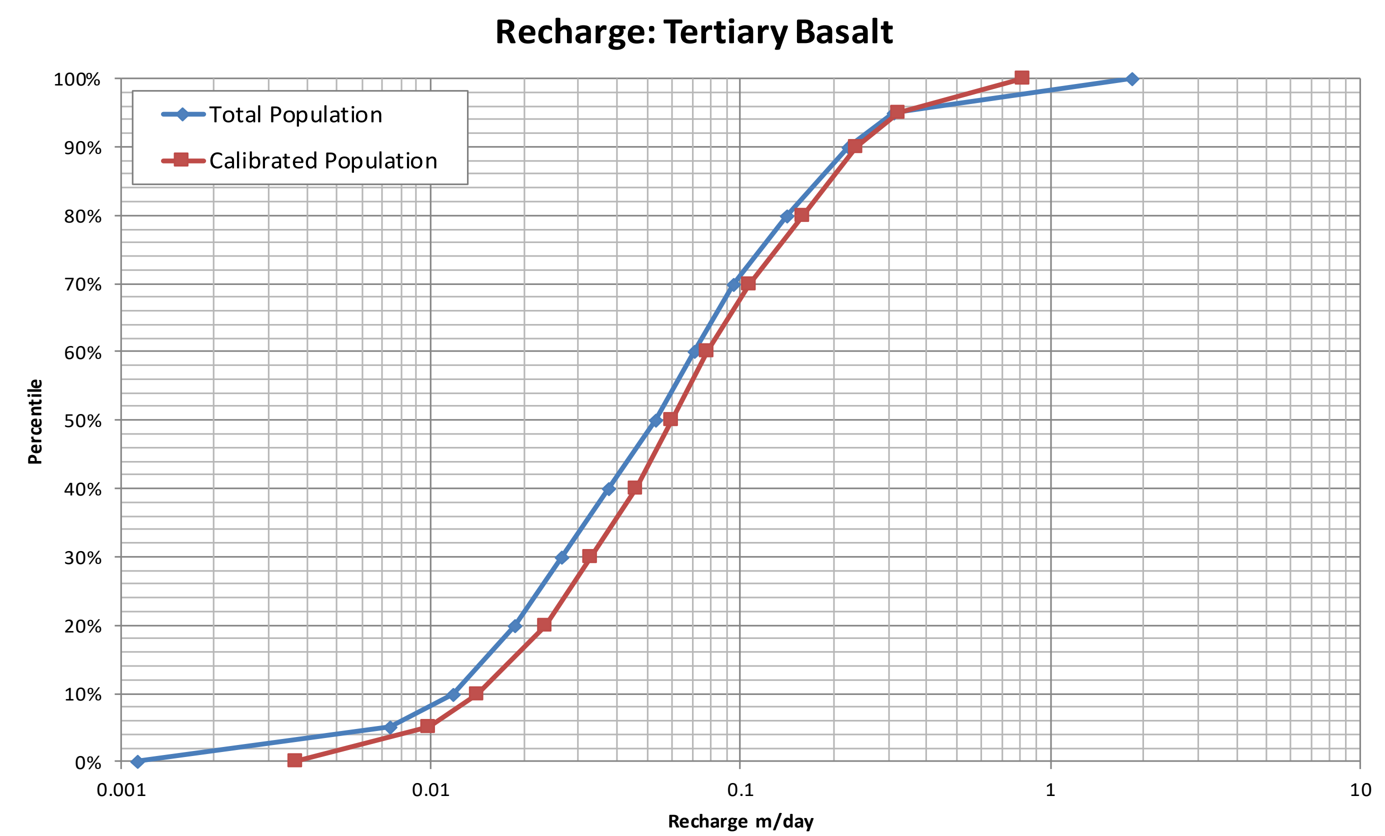


Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.





Note: The "Total Population" (blue line) frequency is calculated by dividing the total number of models simulated (converged) within the above parameter ranges by the total number of models simulated (converged). For the "Calibrated Population" (red line) the frequency is calculated by dividing the number of models simulated (converged) within the above parameter ranges that meet calibration criteria, by the total number of models simulated (converged) that meet calibration criteria.



APPENDIX F

Sensitivity Derivatives

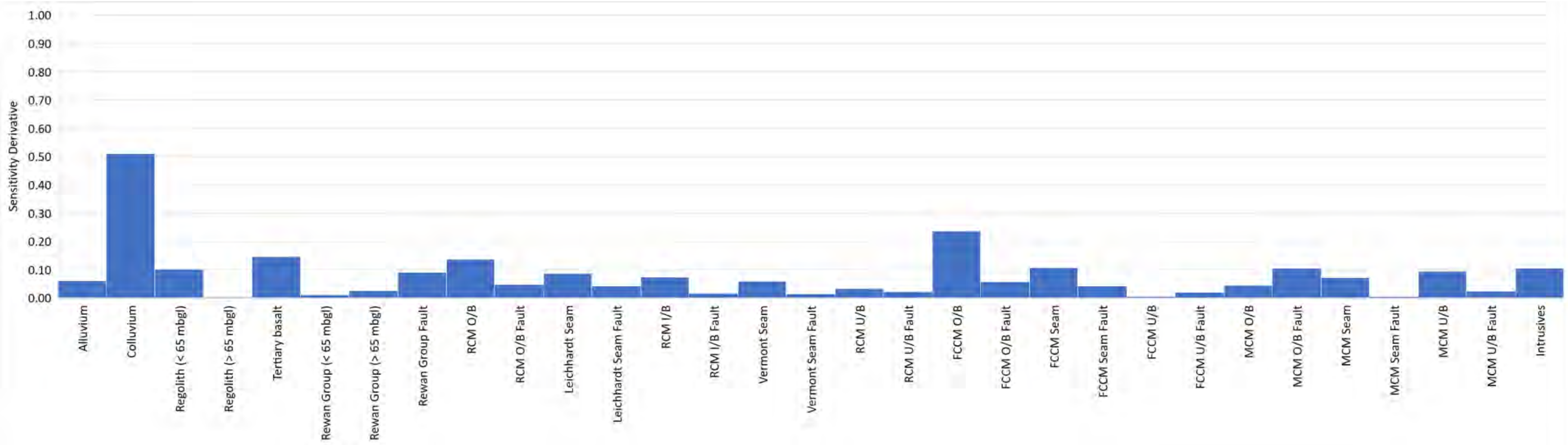


Figure F-1 Impacted Alluvium / Colluvium Drawdown Area (Layer 1) Sensitivity Derivatives – Horizontal Hydraulic Conductivity

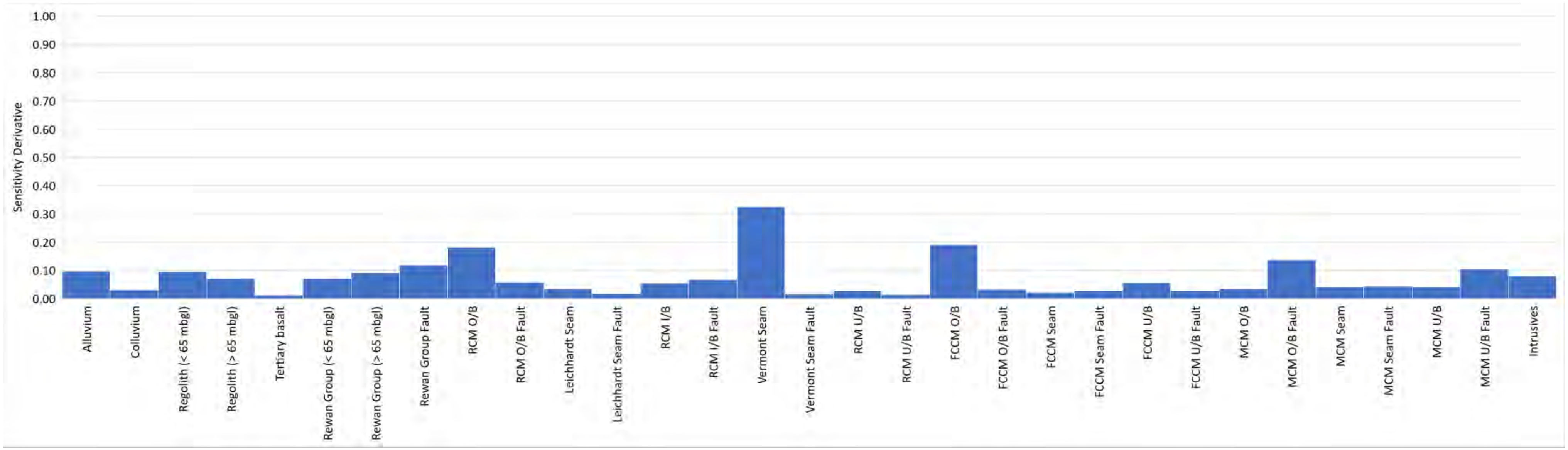


Figure F-2 Impacted Coal Seam Drawdown Area (Layer 7) Sensitivity Derivatives – Horizontal Hydraulic Conductivity

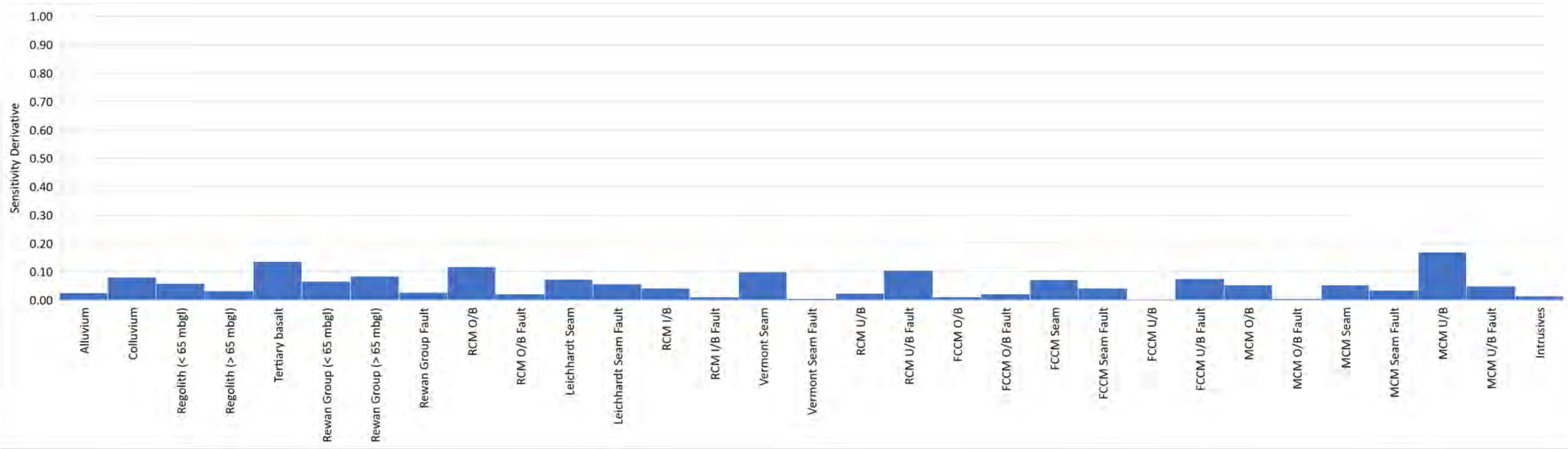


Figure F-3 Project Inflow Sensitivity Derivatives – Horizontal Hydraulic Conductivity

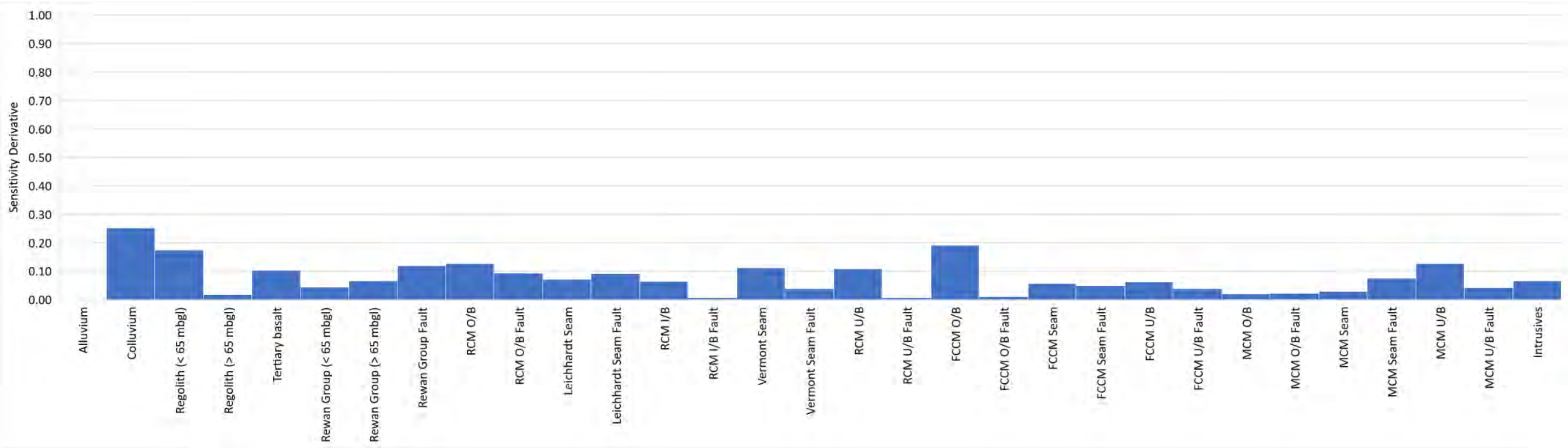


Figure F-4 Alluvial Drawdown Magnitude Sensitivity Derivatives – Horizontal Hydraulic Conductivity

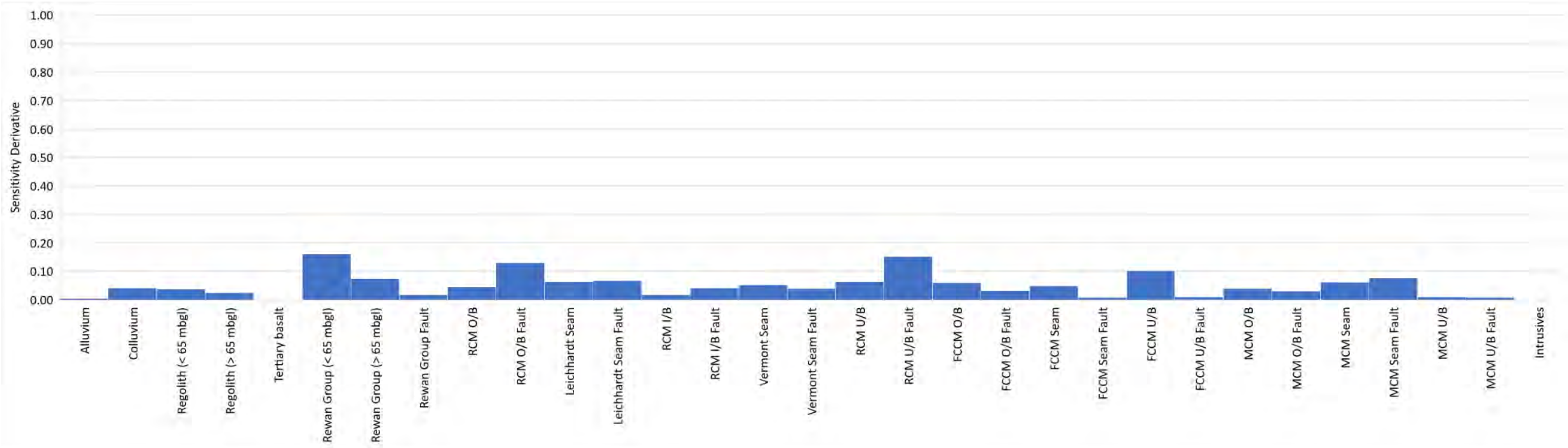


Figure F-5 Impacted Alluvium / Colluvium Drawdown Area (Layer 1) Sensitivity Derivatives – Anisotropy (Kv/Kx)

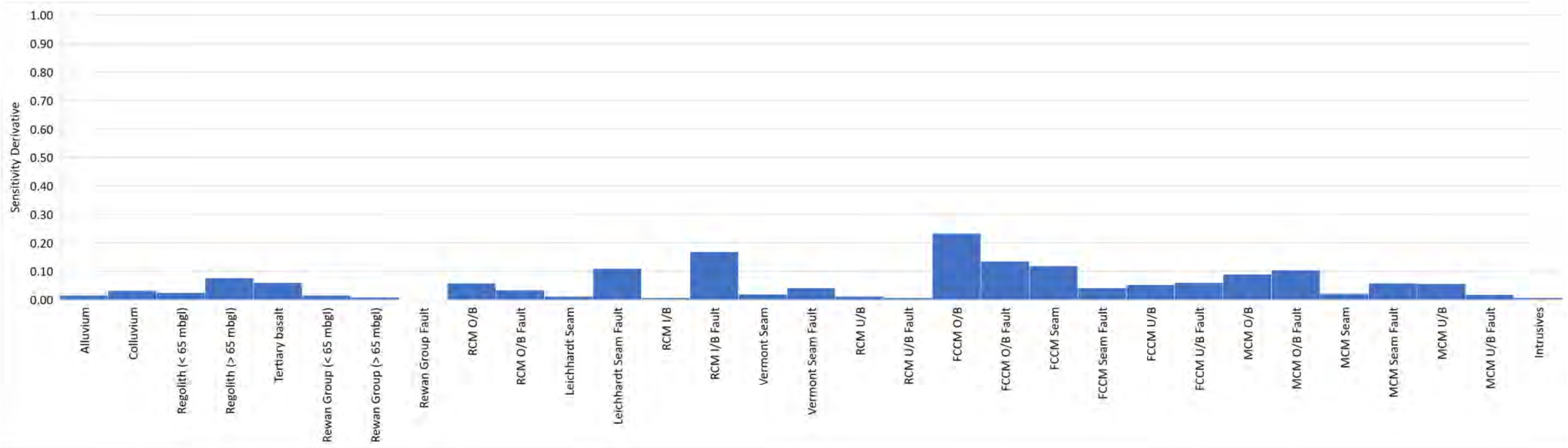


Figure F-6 Impacted Coal Seam Drawdown Area (Layer 7) Sensitivity Derivatives – Anisotropy (Kv/Kx)

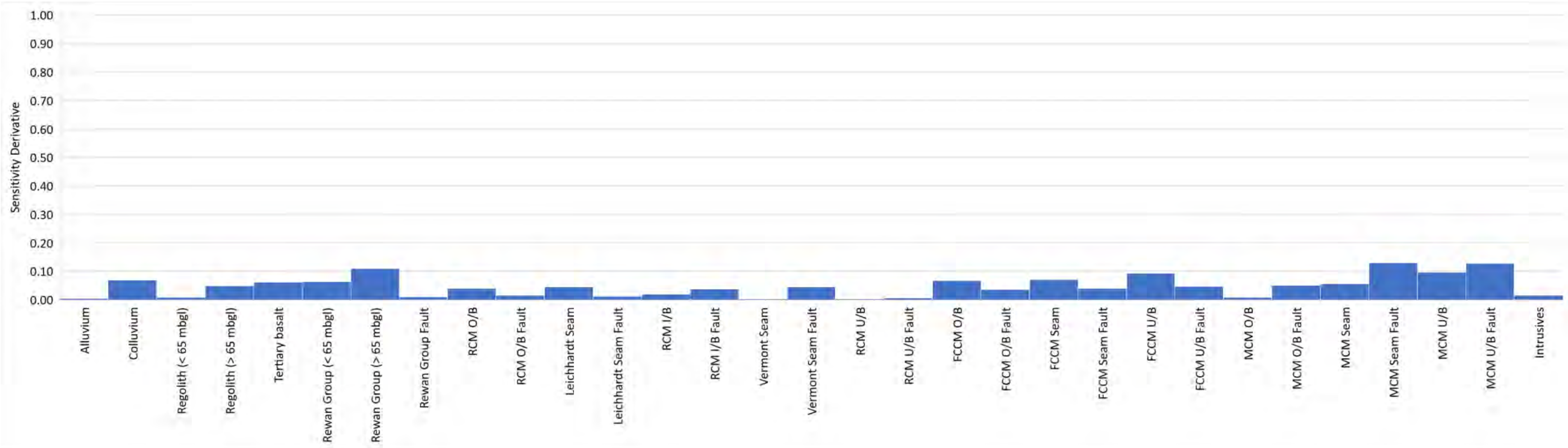


Figure F-7 Project Inflow Sensitivity Derivatives – Anisotropy (Kv/Kx)

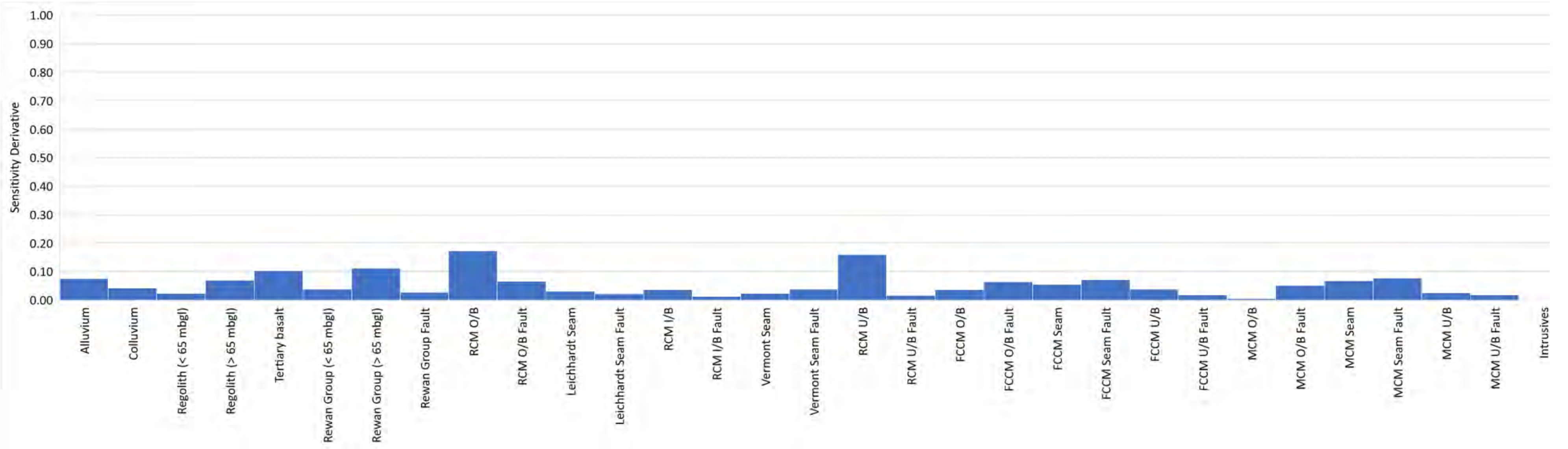


Figure F-8 Alluvial Drawdown Magnitude Sensitivity Derivatives – Anisotropy (Kv/Kx)

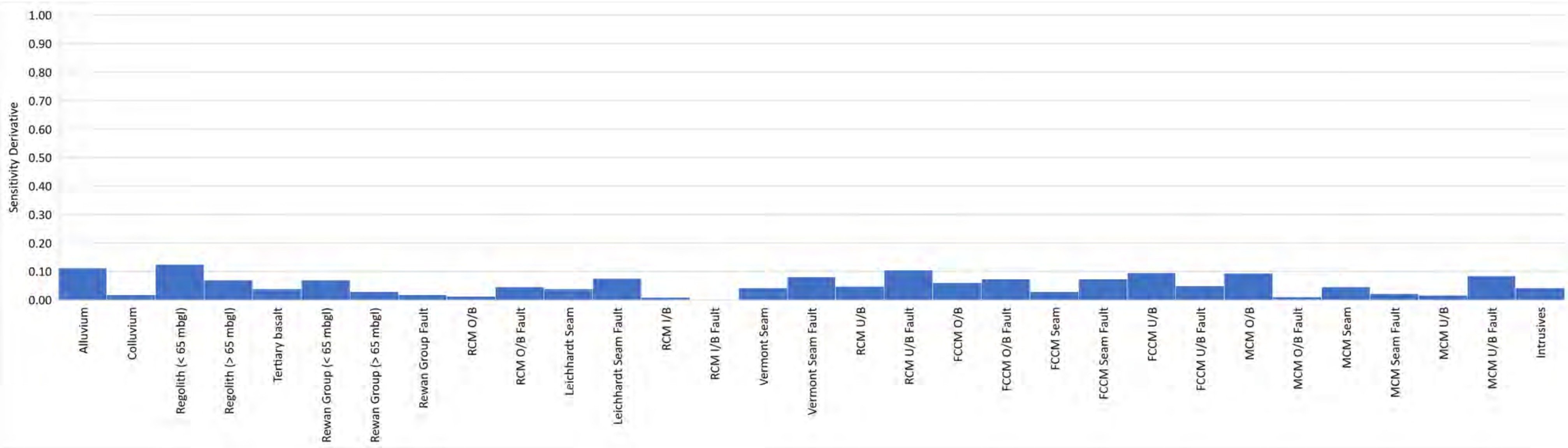


Figure F-9 Impacted Alluvium / Colluvium Drawdown Area (Layer 1) Sensitivity Derivatives – Specific Yield

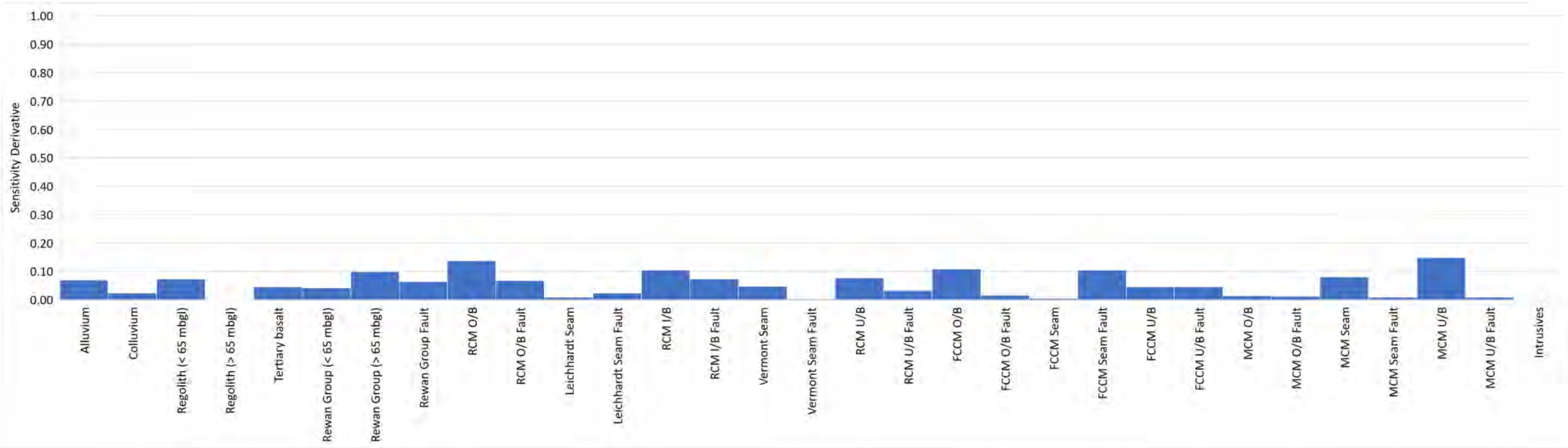


Figure F-10 Impacted Coal Seam Drawdown Area (Layer 7) Sensitivity Derivatives – Specific Yield

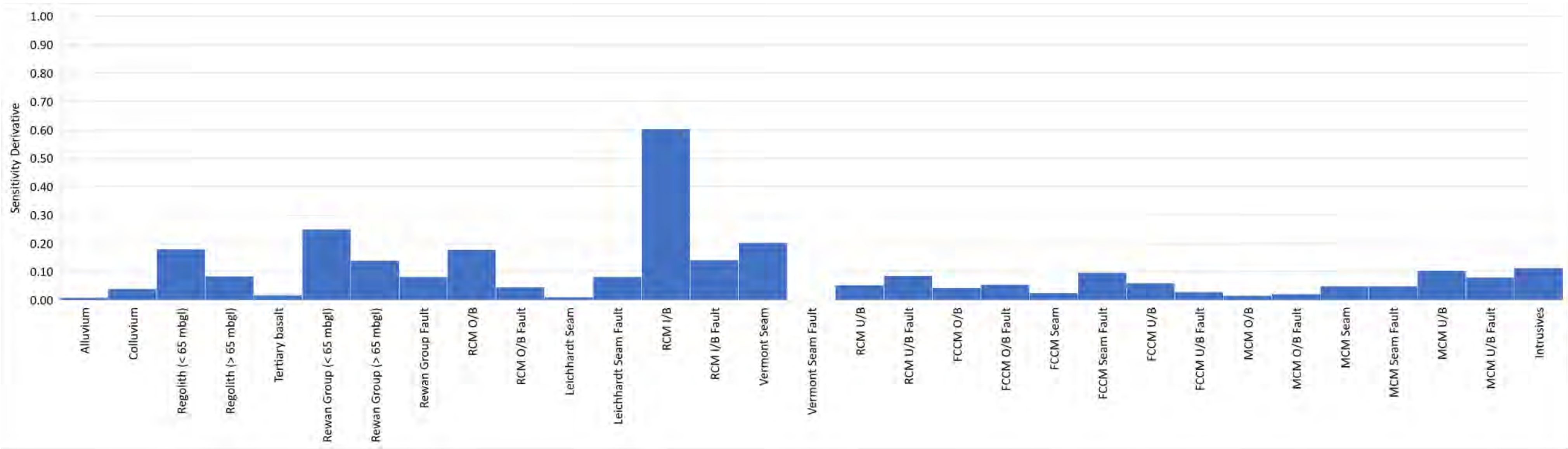


Figure F-11 Project Inflow Sensitivity Derivatives – Specific Yield

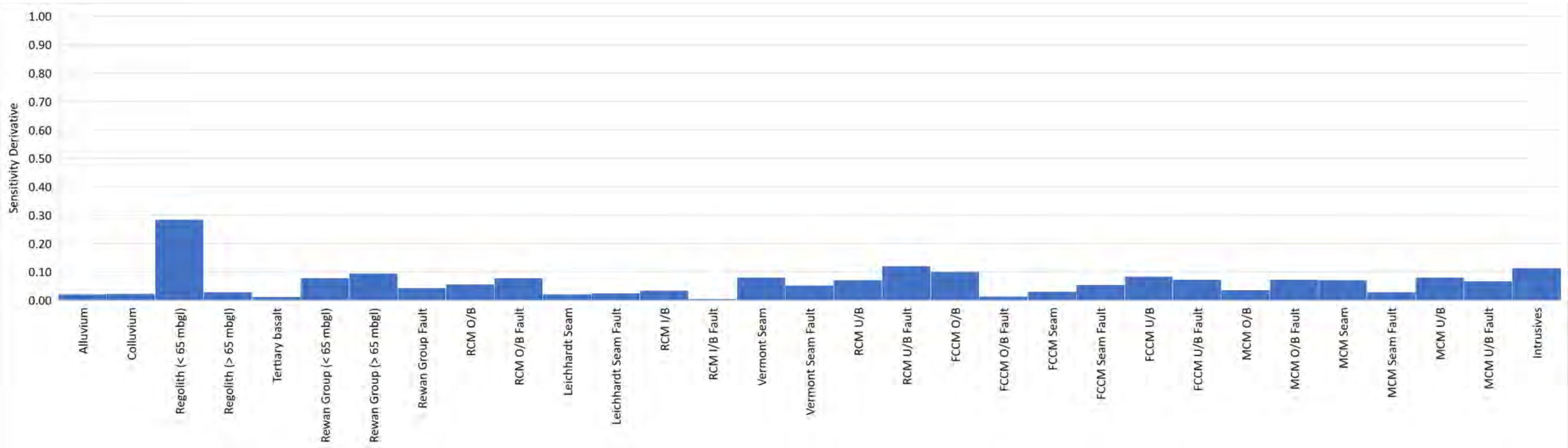


Figure F-12 Alluvial Drawdown Magnitude Sensitivity Derivatives – Specific Yield

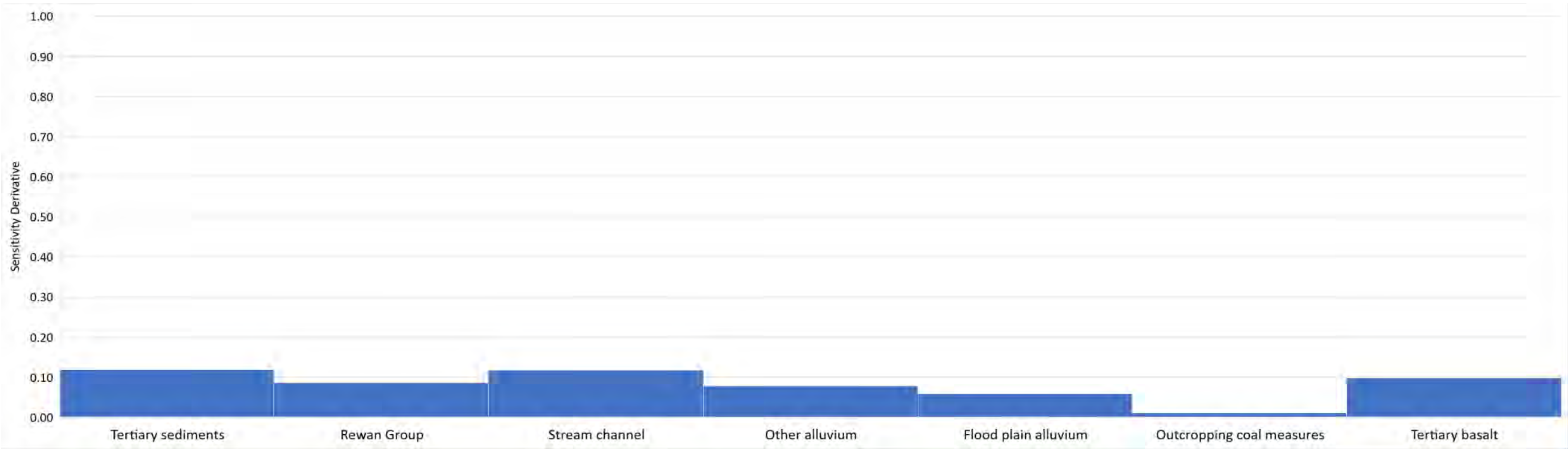


Figure F-13 Impacted Alluvium / Colluvium Drawdown Area (Layer 1) Sensitivity Derivatives – Recharge

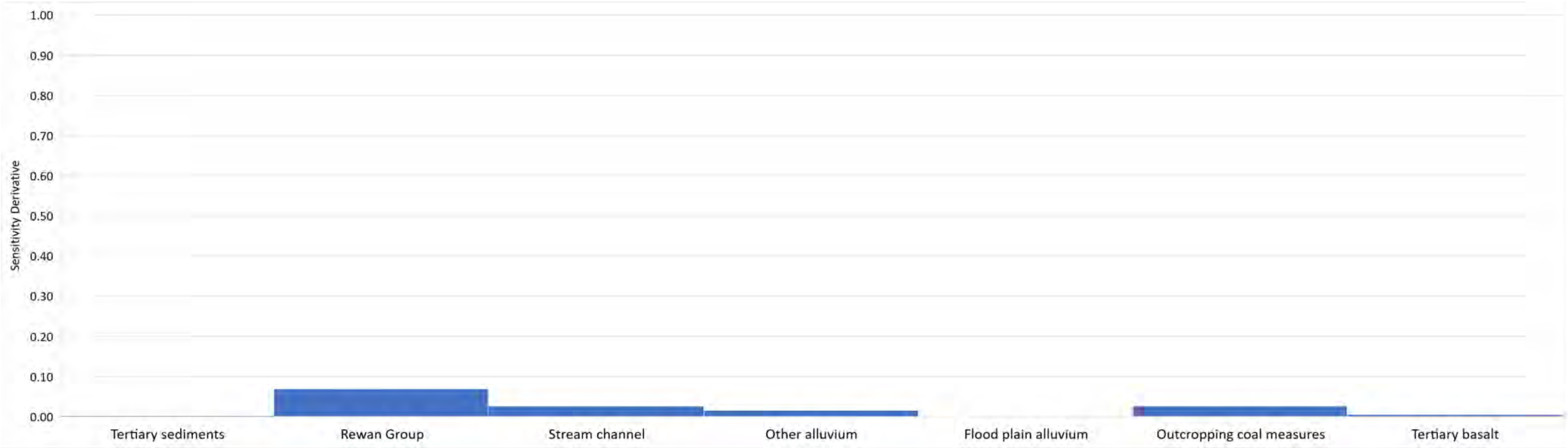


Figure F-14 Impacted Coal Seam Drawdown Area (Layer 7) Sensitivity Derivatives – Recharge

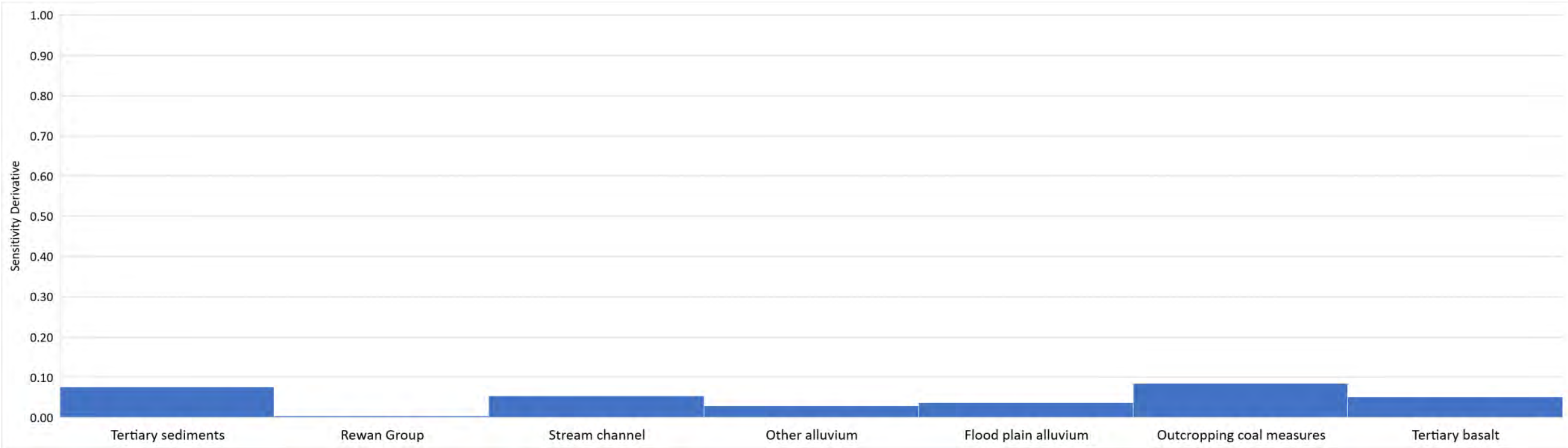


Figure F-15 Project Inflow Sensitivity Derivatives – Recharge

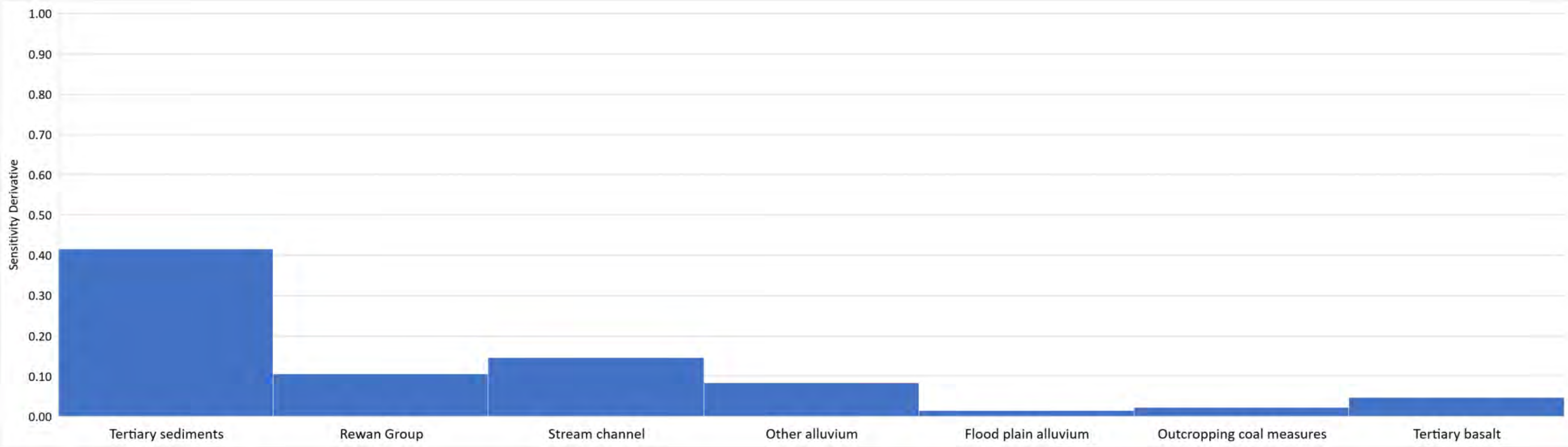


Figure F-16 Sensitivity Derivative – Recharge vs Alluvial Drawdown Magnitude

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

TOWNSVILLE SOUTH
12 Cannan Street
Townsville South QLD 4810
Australia
T: +61 7 4772 6500

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 404 939 922

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628