BLACKWATER MINE PROGRESSIVE REHABILITATION AND CLOSURE PLAN

Voids in Floodplain Modelling

Whitehaven Coal Limited

28 May 2026

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DETAILS

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1 INTRODUCTION

1.1 OVERVIEW

Whitehaven, the owners of Blackwater Mine (BWM), has requested WRM Water & Environment Pty Ltd (WRM) to undertake hydrologic and hydraulic modelling to define the floodplain at BWM, to supplement the BWM Progressive Rehabilitation and Closure Plan (PRCP). BWM requires a PRCP to be completed in accordance with BWM's Environmental Authority (EA) (EPML00717813), and PRCP Guideline Requirements.

As part of the PRCP for BWM, it is proposed to incorporate 15 final voids as Non-use Management Areas (NUMAs). Figure 1.1 and Figure 1.2 show the pre-mining conditions drainage characteristics of the study area as well as the locations and extents of the proposed final voids at BWM.

This "Void in Floodplain Modelling" report was prepared to address the requirements in Section 3.4 – General rehabilitation practices (flooding) of the Department of Environment, Tourism, Science and Innovation (DETSI) (formally the Department of Environment, Science and Innovation) Progressive rehabilitation and closure plans (PRC plans) guideline (Version 3.01) (DETSI, 2024), as well as the Information Sheet - Void in flood plains.

This study was undertaken to identify if the proposed final voids in the BWM final landform would be situated wholly or partially in a "flood plain", defined in PRCP guideline (DETSI, 2024) as land that is the same height as, or lower than, the level modelled as the peak water level during a 0.1% (1 in 1,000) annual exceedance probability (AEP) flood event for a relevant watercourse.

1.2 METHOD OF ASSESSMENT

1.2.1 Relevant watercourses

DETSI (2024) require floodplain modelling to be undertaken only for a "relevant watercourse", which is defined as those watercourses that are classified as stream order 4 or higher under the Strahler stream order classification system. A review of the Strahler Stream Order classifications within the study area, under pre-mining conditions, indicate that the following watercourses are of Strahler stream order 4 or greater and are therefore considered as relevant watercourses for the purpose of this study (refer to Figure 1.1):

- Blackwater Creek;
- Two Mile Gully;
- Taurus Creek (downstream of the Emu Creek confluence); and
- Sirius Creek.

Therefore, hydrologic and hydraulic modelling was undertaken for the above relevant watercourses.

1.2.2 Artificial features

DETSI (2024) require floodplain modelling to be undertaken to represent the flood plain at the time that all temporary structures or features have been removed. Hence, floodplain hydraulic modelling was undertaken by excluding any levees, mining pits, overburden dumps, stream diversion channels as well as road, rail and cross drainage infrastructure within the BWM mine lease area.

1.2.3 Hydrologic and hydraulic modelling

SLR previously prepared the flood assessments for previous version of the BWM final landform (SLR, 2024a and 2024b). In the SLR (2024a and 2024b) studies, hydrologic modelling was undertaken using XP-RAFTS and hydraulic modelling was undertaken using TUFLOW. The SLR (2024a and 2024b) flood

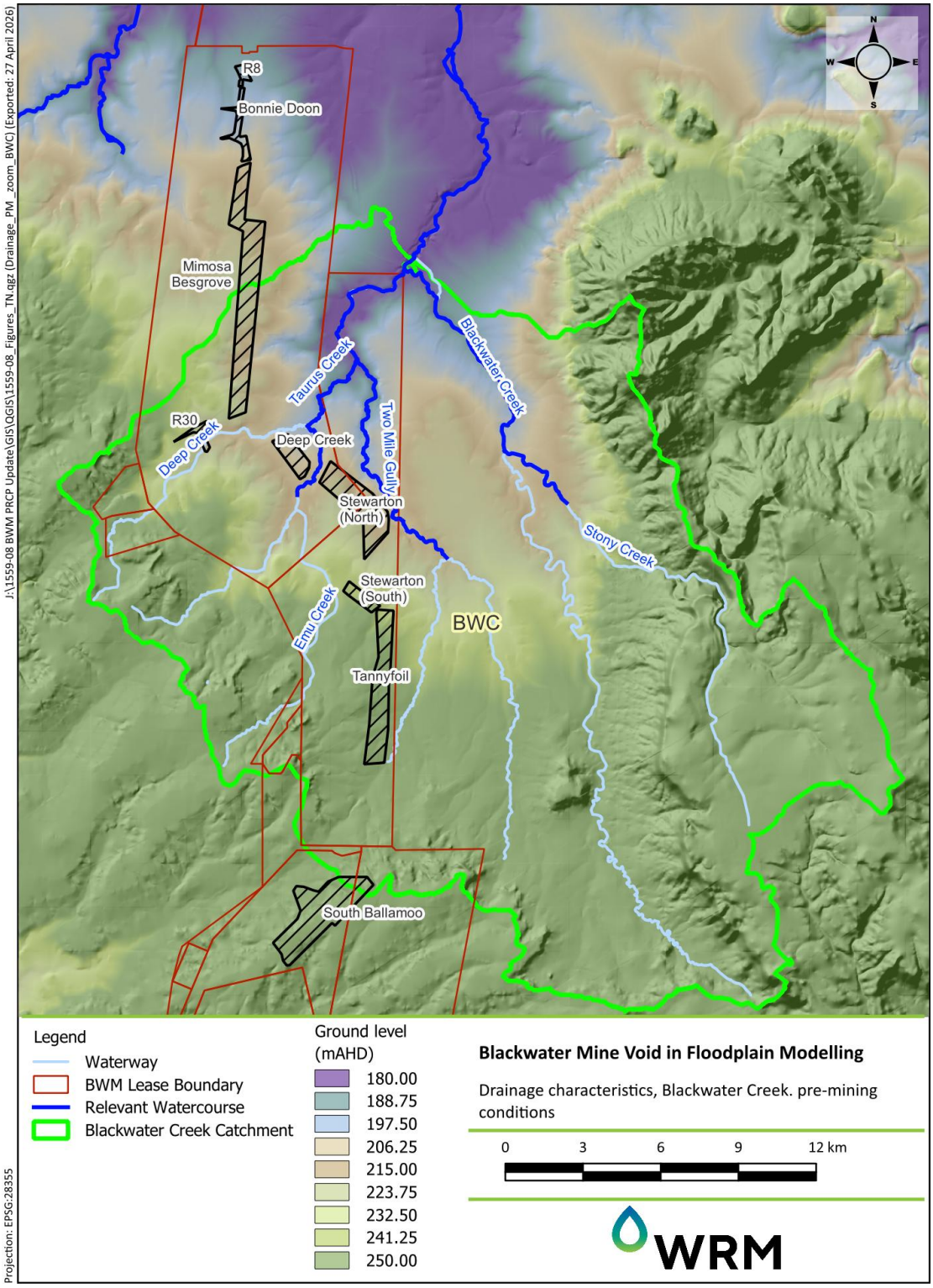


Figure 1.1 Drainage characteristics under pre-mining conditions, and the locations of the proposed final voids in the vicinity of Taurus Creek, Two Mile Gully and Blackwater Creek

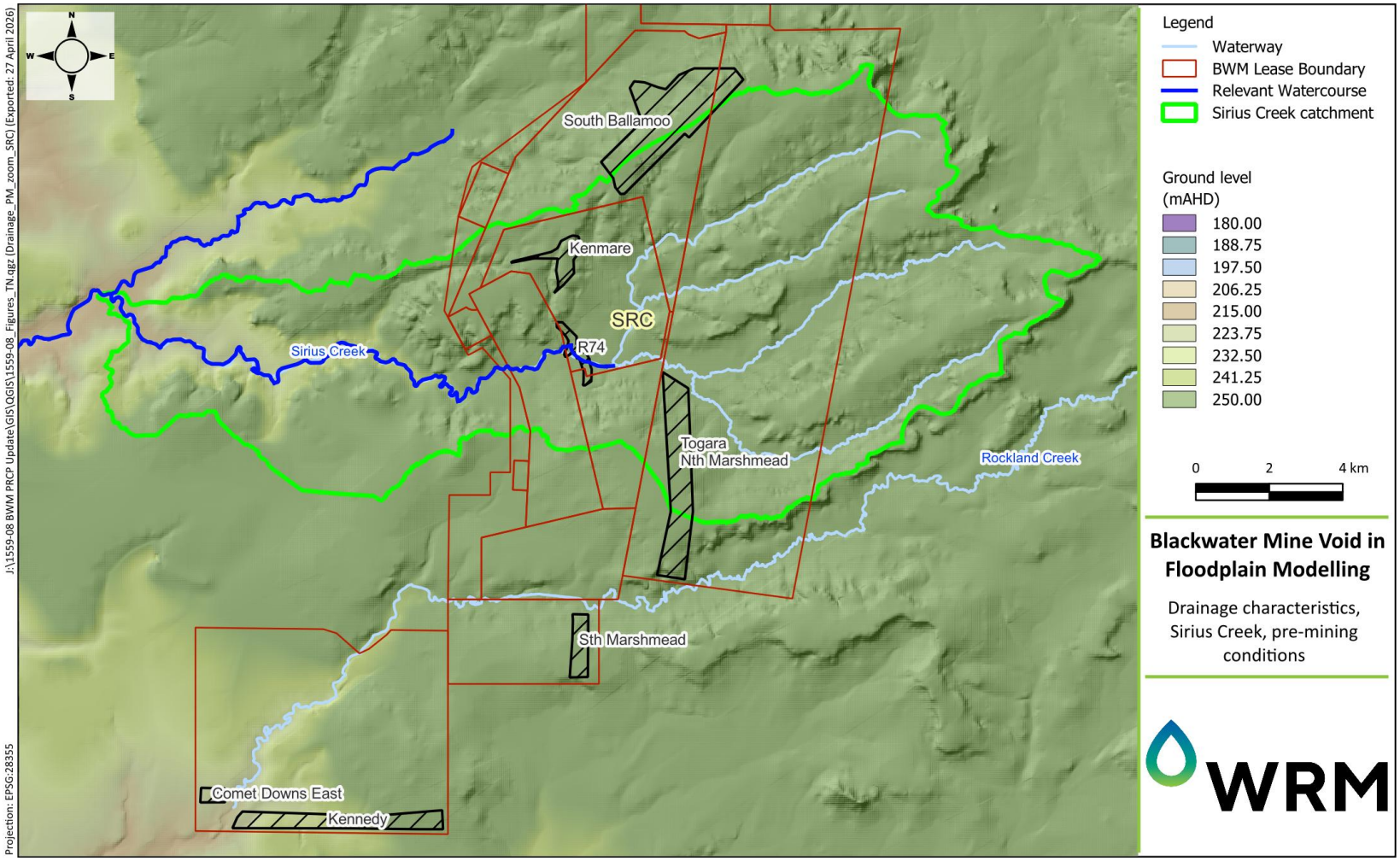


Figure 1.2 Drainage characteristics under pre-mining conditions, and the locations of the proposed final voids in the vicinity of Sirius Creek

models were developed based on the XP-RAFTS and TUFLOW models originally developed by GHD for the 2021 Blackwater Mine Flood Study (GHD, 2021).

For this study, new hydrologic models were developed using the URBS software package, which incorporates the latest climate change guidance from Australian Rainfall and Runoff 2019 Version 4.2 (ARR 2019 v4.2) (Ball et al, 2019). The URBS models were calibrated to recorded rainfall and water level data for the March 2017 and January 2020 events where suitable data is available. Details of the URBS model development and calibration are documented in the Hydrologic Model Development and Calibration Report provided in Appendix B.

The SLR (2024a and 2024b) TUFLOW hydraulic models were updated to incorporate the updated design discharges from the URBS hydrologic models. Hydrologic and hydraulic modelling were undertaken for the 0.1% AEP event.

1.3 REPORT STRUCTURE

The report is structured as follows:

- Section 2 is an overview of the data available for this study;
- Section 3 describes the estimation of design discharges;
- Section 4 describes the hydraulic model development;
- Section 5 presents the hydraulic modelling results;
- Section 6 presents a summary of the findings; and
- Section 7 is a list of references.

2 AVAILABLE DATA

2.1 OVERVIEW

Available data for this study was provided by Whitehaven and consisted of:

- Previous hydrologic and hydraulic studies;
- Recorded rainfall and water level data;
- LiDAR topographic data; and
- Proposed final landform surface.

2.1.1 Blackwater Mine Flood Study (2021)

The Blackwater Mine Flood Study undertaken by GHD (2021) assessed existing flood risks across BWM. XP-RAFTS hydrologic and TUFLOW hydraulic models were developed for this study. In this study, the hydrologic models for Burngrove Creek and Speculation Creek were calibrated to recorded water level data. The GHD (2021) study report was provided for this study, but the XP-RAFTS and TUFLOW models were not available.

2.1.2 Blackwater Mine Progressive Rehabilitation and Closure Plan (2024)

The XP-RAFTS hydrologic and TUFLOW hydraulic models used by SLR (2024a and 2024b) for the previous PRCP flood assessment were provided for this study. These models appear to have been developed based on the GHD (2021) hydrologic and hydraulic models. Separate models were provided for the Blackwater Creek and Sirius Creek catchments.

2.2 TOPOGRAPHIC DATA

The available topographic data used for this study is described as follows:

- A 1 m resolution LiDAR covering the BWM mine lease area captured in February 2024 (referred to as the 2024 LiDAR data);
- Topographic data embedded in the SLR (2024) TUFLOW hydraulic models;
- A 30 m resolution Copernicus Digital Surface Model (DSM) satellite ground level observation data obtained from the European Space Programme on 31 January 2025 (referred to as the Copernicus DSM data); and
- The Fitzroy River catchment 25 m resolution Digital Elevation Model (DEM) embedded in the SLR (2024a) hydraulic model supplied by Whitehaven.

Limited topographic data representing the pre-mining conditions within the BWM mine lease area was available for this study. The available 1 m LiDAR topographic data are generally representative of pre-mining topography outside of the BWM. Therefore, the available detailed LiDAR data was not used within the BWM mine lease area.

The Fitzroy River catchment 25 m resolution DEM provides the best representation of pre-mining topography within the BWM mine lease area and was therefore adopted in this study only for areas within BWM for the purpose of hydrologic and hydraulic modelling.

2.3 RAINFALL AND WATER LEVEL DATA

Whitehaven supplied recorded rainfall data from three subdaily rainfall (pluviograph) stations and recorded water level data for six stream gauging stations across BWM. Rating curves were also provided for the stream gauging stations. The data was used to calibrate the URBS hydrologic models.

Details of the station locations, the recorded data and the stream gauge rating curves are described in the Hydrologic Model Development Report in Appendix B.

3 ESTIMATION OF DESIGN DISCHARGES

3.1 OVERVIEW

3.1.1 Development and calibration of seven URBS hydrologic models

Two URBS models were developed for the Blackwater Creek (including Taurus Creek and Two Mile Gully) and Sirius Creek catchments. The Blackwater Creek (including Taurus Creek and Two Mile Gully) and Sirius Creek URBS models were calibrated to recorded data for the April 2017 and January 2020 flood events.

Design discharges for the 1% AEP event from the seven URBS models were validated against estimates derived using the Rational Method, the Quantile Regression Technique (QRT) and the Regional Flood Frequency Estimation (RFFE) method. The purpose of the model validation is to derive appropriate initial losses (ILs) and continuing losses (CLs) for the seven models.

The hydrologic model development, calibration and validation are described in detail in the "Hydrologic Model Development and Calibration Report" given in Appendix B. The estimation of validation of design discharges were undertaken based on current (year 2025) catchment and climate conditions.

3.1.2 Modification of URBS hydrologic models for final landform conditions

For the void in floodplain modelling assessment, the calibrated and validated URBS models were modified to reflect catchment conditions for pre-mining conditions. That is, the URBS model subcatchment boundaries were adjusted to reflect pre-mining conditions.

The modified hydrologic models were then used to derive design discharges for the 0.1% AEP flood event for pre-mining conditions. Details of hydrologic model development are provided below. Design discharges for pre-mining conditions were derived based on current (year 2025) climate conditions.

3.2 HYDROLOGIC MODEL CONFIGURATION

3.2.1 Subcatchment parameters

The boundaries of the URBS subcatchments were adjusted to represent the pre-mining conditions of the Blackwater Creek (BWC) and Sirius Creek (SRC) catchments (see Figure A.1 and Figure A.2 in Appendix A. The URBS model parameters were updated to reflect the changes in the catchment area, slope, imperviousness, and roughness values. The boundaries of the pre-mining conditions subcatchments were delineated based on the 25 m Fitzroy River catchment DEM provided by Whitehaven. A summary of model parameters is given in Table A.1 and Table A.2 in Appendix A.

3.2.2 Adopted global URBS model parameters

The global URBS model parameters, including channel lag parameter (alpha), catchment storage parameter (beta), catchment non-linearity (M) and channel routing exponent (N) for all seven hydrologic models are given below and were unchanged from the calibrated/validated hydrologic models.

- Channel routing "alpha" (α) = 0.1
- Catchment routing "beta" (β) = 1.0
- Catchment routing exponent (M) = 0.715
- Channel routing exponent (N) = 1.0

3.3 DESIGN RAINFALLS

3.3.1 Design rainfall depths

Design rainfall intensity-frequency-duration (IFDs) for the 0.1% AEP design event was obtained from the Bureau of Meteorology (BoM). Aerial Reduction Factors (ARFs) were applied to the design rainfalls for each model based on a focal point at the location of the proposed voids in each catchment.

3.3.2 Temporal patterns

The Jordan (2005) temporal patterns were adopted for durations up to 9 hours. The *Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Tropical Storm Method* (GTSMR) (BoM, 2005) temporal patters were adopted for durations longer than 9 hours.

3.3.3 Adjustment for climate change

Based on the latest guidance on climate change provided in ARR 2019 v4.2, global temperatures have already risen since the baseline historical rainfall data midpoint of 1961-1990. Therefore, to derive design rainfalls representative of current (year 2025) conditions, design rainfall estimates require factoring up to account for this temperature increase that has already occurred.

Design Intensity-Frequency-Duration (IFD) design rainfall intensities were scaled up using uplift factors obtained from ARR datahub[1], corresponding to the SSP5-8.5 (year 2030) climate scenario. The associated pre-burst rainfalls were also scaled up accordingly.

The SSP5-8.5 climate adjustments account for approximately 1.3°C of global warming up to 2025 since the historical baseline period of 1961-1990. Table 3.1 shows the corresponding 1% AEP design rainfall uplift factors for various storm durations (as percentage increases compared to the baseline).

Table 3.1 Adopted design rainfall uplift factors (SSP5-8.5 year 2030)

Storm duration	Rainfall uplift factor
<1 hour	20%
1.5 Hours	18%
2 Hours	17%
3 Hours	16%
4.5 Hours	14%
6 Hours	13%
9 Hours	13%
12 Hours	12%
18 Hours	11%
>24 Hours	11%

[1] https://data.arr-software.org/

3.3.4 Losses

For the 0.1% AEP event, a conservative approach was adopted by adopting an IL of 0 mm and CL of 1 mm/h. These are the losses recommended in ARR 2019 for the Probable Maximum Flood (PMF) design event.

3.4 HYDROLOGIC MODEL RESULTS

The URBS model predicted design peak discharges, critical storm durations and representative temporal patterns for the 0.1% AEP event for pre-mining conditions at key reporting locations are summarised in Table 3.2. The key reporting locations are shown in Figure 3.1.

Table 3.2 URBS output hydrographs, pre-mining conditions

Model	Location	0.1% AEP event		
		Critical duration (hours)	Peak discharge (m^3/s)	Representative temporal pattern
Blackwater Creek (BWC)	BWC_03	4.5h	1,062	4
	TRM2	6h	1,831	4
	BWC_706	9h	2,017	9
	BWC_Out	9h	3,180	4
Sirius Creek (SRC)	SRC_01	2h	1,740	4

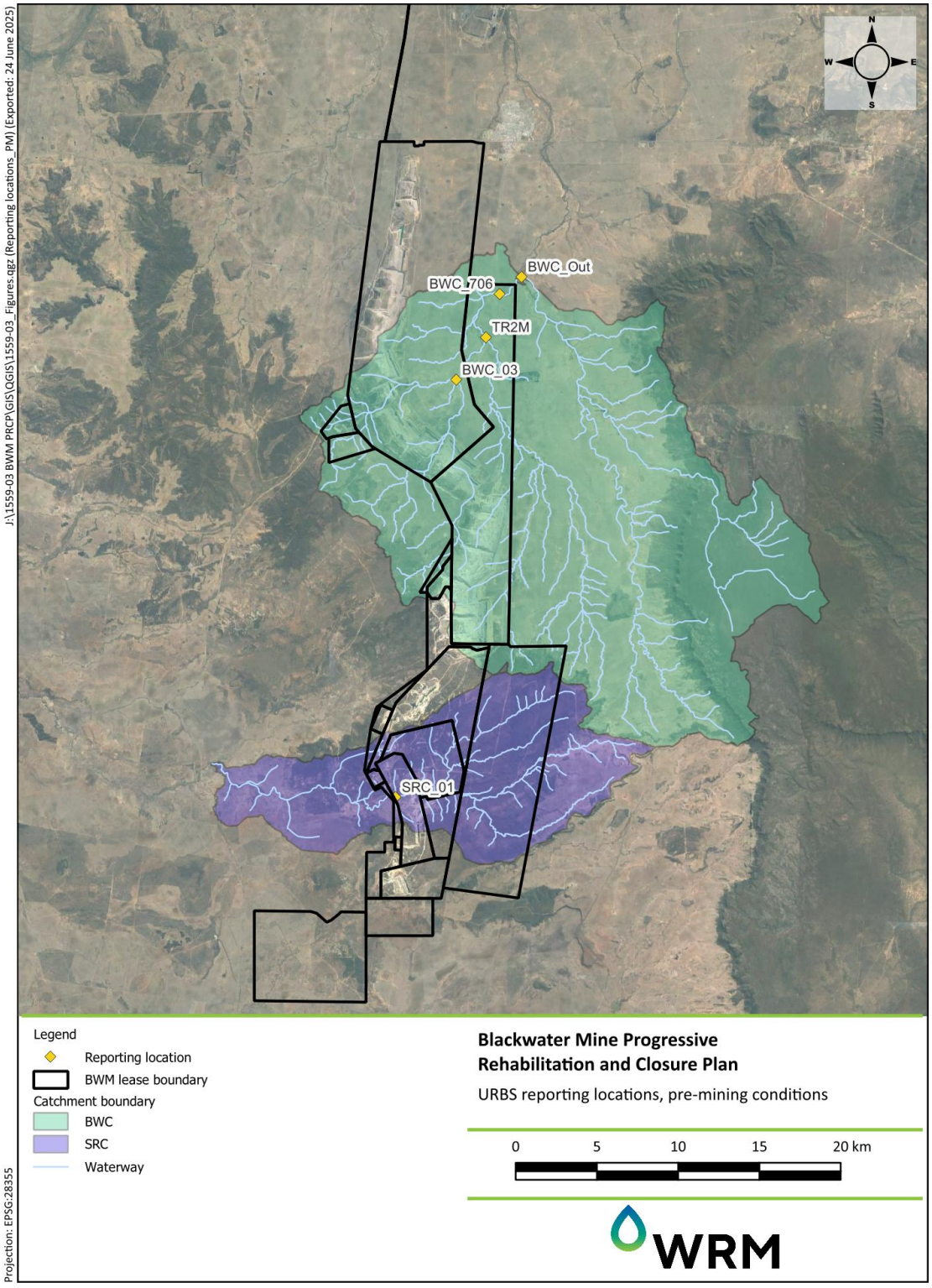


Figure 3.1 URBS design discharge reporting locations

4 HYDRAULIC MODELLING

4.1 OVERVIEW

The TUFLOW hydraulic models originally developed by SLR (2024b) were updated to represent the pre-mining conditions within the Blackwater Creek and Sirius Creek catchments. (Figure 4.1 and Figure 4.2).

Changes to the SLR (2024) model configuration are summarised as follows:

- Refinements of the model code boundary to reflect the modelled areas;
- Updates to the model inflow boundary conditions to reflect revised URBS hydrological model inputs; and
- Updates to the model topography using more detailed resolution data where available.

The TUFLOW hydraulic models were run for a series of key storm durations and temporal patterns selected based on the URBS hydrologic model results, as well as preliminary hydraulic modelling. The hydraulic model results were then used to characterise design flood depths, levels, extents and velocities for 0.1% AEP design event under pre-mining conditions.

4.2 MODEL CONFIGURATION

4.2.1 Model extent, resolution and topography

A 5 m grid cell TUFLOW model was developed for the Blackwater Creek (BWC) and Sirius Creek (SRC) catchments. Figure 4.1 and Figure 4.2 show the pre-mining conditions TUFLOW model configuration and extent for BWC and SRC, respectively. The models were configured with a grid cell size of 5 m. The models cover an area of 102 km^2 and 44 km^2 for BWC and SRC, respectively.

The pre-mining conditions model topography was configured using the following data:

- The 25 m Fitzroy River catchment DEM for areas within the BWM mine lease boundary;
- Detailed 1 m LiDAR topographic for areas outside of the BWM mine lease area where available; and
- The 30 m resolution Copernicus DEM for areas outside of the BWM mine lease area not covered by the 1 m LiDAR data.

4.2.2 Boundary conditions

Design discharge hydrographs estimated using the new URBS hydrologic models were applied at the inflow boundary locations for the range of design events. Figure 4.1 and Figure 4.2 show the location of inflow and outflow boundaries in the BWC and SRC TUFLOW models, respectively. The inflow boundaries included in the models are as follows:

- BWC:
  - Fourteen (14) total inflow boundaries representing the inflows from the URBS subcatchments outside the hydraulic model boundary;
  - Fifteen (15) local inflow boundaries representing inflows from the URBS subcatchments within the hydraulic model boundary;
  - one (1) ‘stage-discharge’ (HQ) type downstream outflow boundary, with a fixed downstream flood slope of 0.13%;

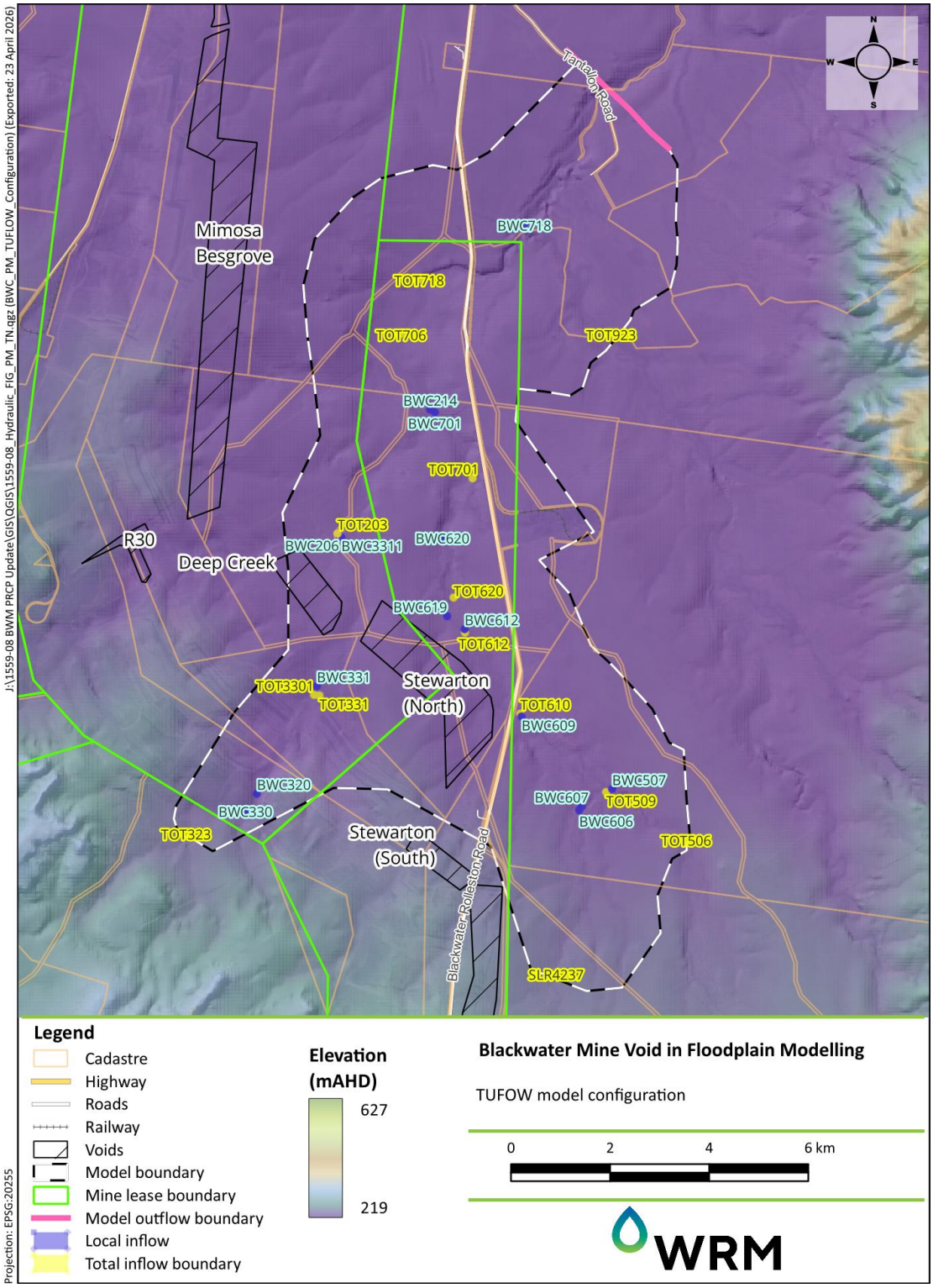


Figure 4.1 Blackwater Creek TUFLOW model configuration

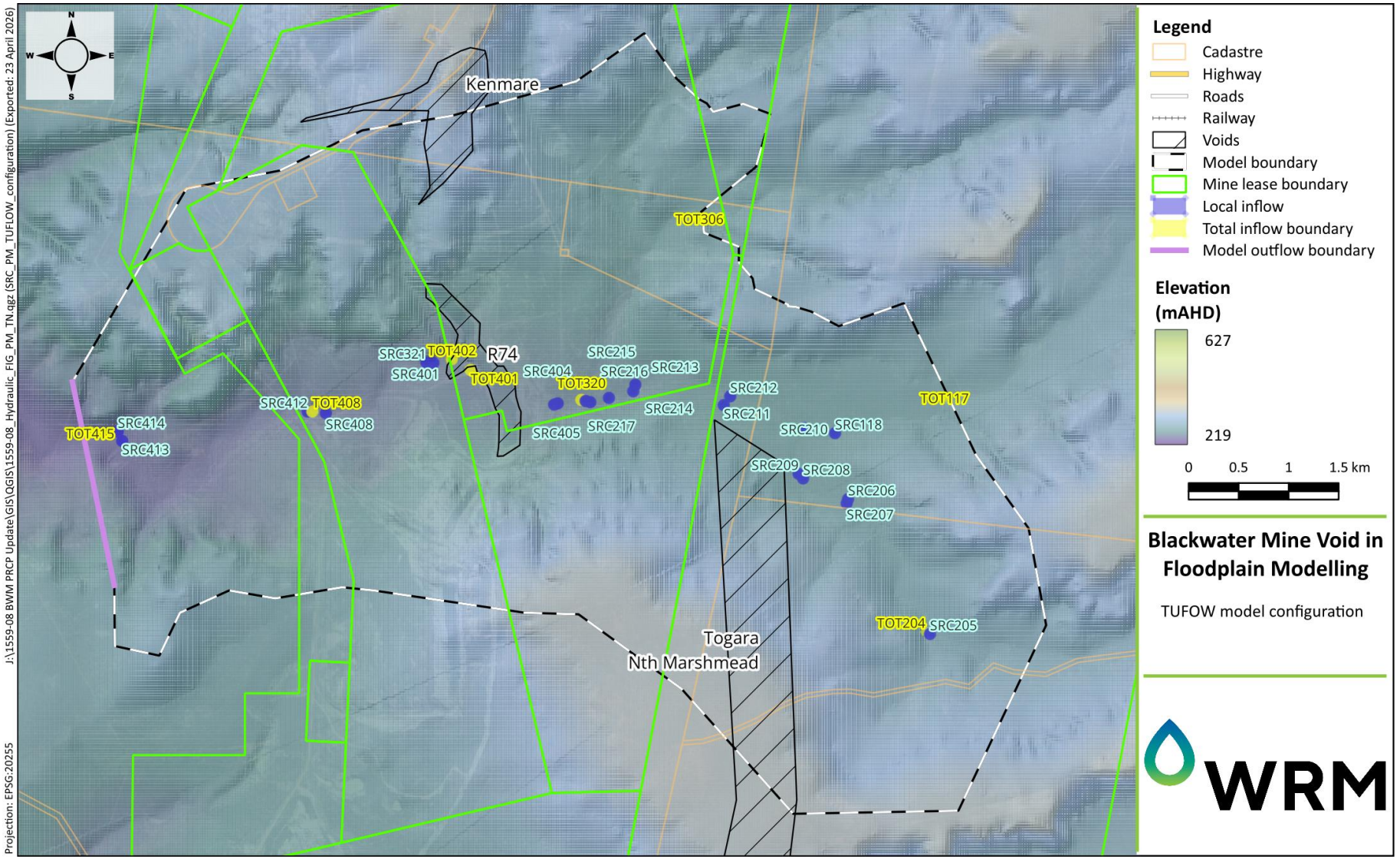


Figure 4.2 Sirius Creek model TUFLOW model configuration

- SRC:
  - Eight (8) total inflow boundaries representing the inflows from the URBS subcatchments outside the hydraulic model boundary;
  - Twenty-two (22) local inflow boundaries representing inflows from the URBS subcatchments within the hydraulic model boundary;
  - one (1) 'stage-discharge' (HQ) type downstream outflow boundary, with a fixed downstream flood slope of 0.53%.

4.2.3 Hydraulic resistance

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness. Discrete regions of continuous vegetation types and land uses were mapped, and appropriate roughness values assigned to each region. Vegetation and land use mapping was undertaken using an aerial photograph. Table 4.1 shows the adopted Manning's 'n' values adopted in the hydraulic model. The adopted Manning's n values for each land use type were unchanged from those adopted in the SLR (2024) studies.

Table 4.1 Adopted hydraulic roughness coefficients

Location	Adopted Manning's 'n'
Short grass	0.04
Sparse trees	0.06
Dense trees	0.08
Creeks	0.05
Water surface	0.02
Paved Roads	0.02

5 HYDRAULIC MODELLING RESULTS

5.1 BLACKWATER CREEK CATCHMENT

Figure 5.1 and Figure 5.2 show the predicted peak flood extents, levels, depths, and velocities along Taurus Creek, Two Mile Gully and Blackwater Creek. The model results are sumarised below.

The Deep Creek void is located partially within the Taurus Creek inundation extent for a 0.1% AEP flood event. Therefore, it is partially situated within a floodplain as defined by DETSI (2024). The final landform will be designed to prevent the ingress of floodwater into the Deep Creek void for all events up to and including a 0.1% AEP flood event at minimum.

The Stewarton North and Stewarton South voids are located outside of the Taurus Creek and Two Mile Gully inundation extents for a 0.1% AEP flood event. Therefore, these voids are not situated within a floodplain as defined by DETSI (2024).

5.2 SIRIUS CREEK CATCHMENT

Figure 5.3 and Figure 5.4 show the predicted peak flood extents, levels, depths, and velocities along Sirius Creek. The model results are sumarised below.

The Kenmare and Togara North Marshmead voids are located outside of the Sirius Creek inundation extent for a 0.1% AEP flood event. Therefore, these voids are not situated within a floodplain as defined by DETSI (2024).

The R74 void is situated across the Sirius Creek inundation extent for the 0.1% AEP flood event.

- Under current (operational) conditions, there is currently a licensed diversion for Sirius Creek (authorisation reference 52652F) that diverts Sirius Creek around the existing R74 open cut pit. The R74 pit is proposed to remain under post-mining conditions as the R74 void, as shown in Figure 5.3 and Figure 5.4.
- To maintain free drainage of the Sirius Creek catchment under post-mining conditions, a permanent diversion of Sirius Creek is required, to be developed in accordance with the watercourse diversion guideline (DNRME, 2019).

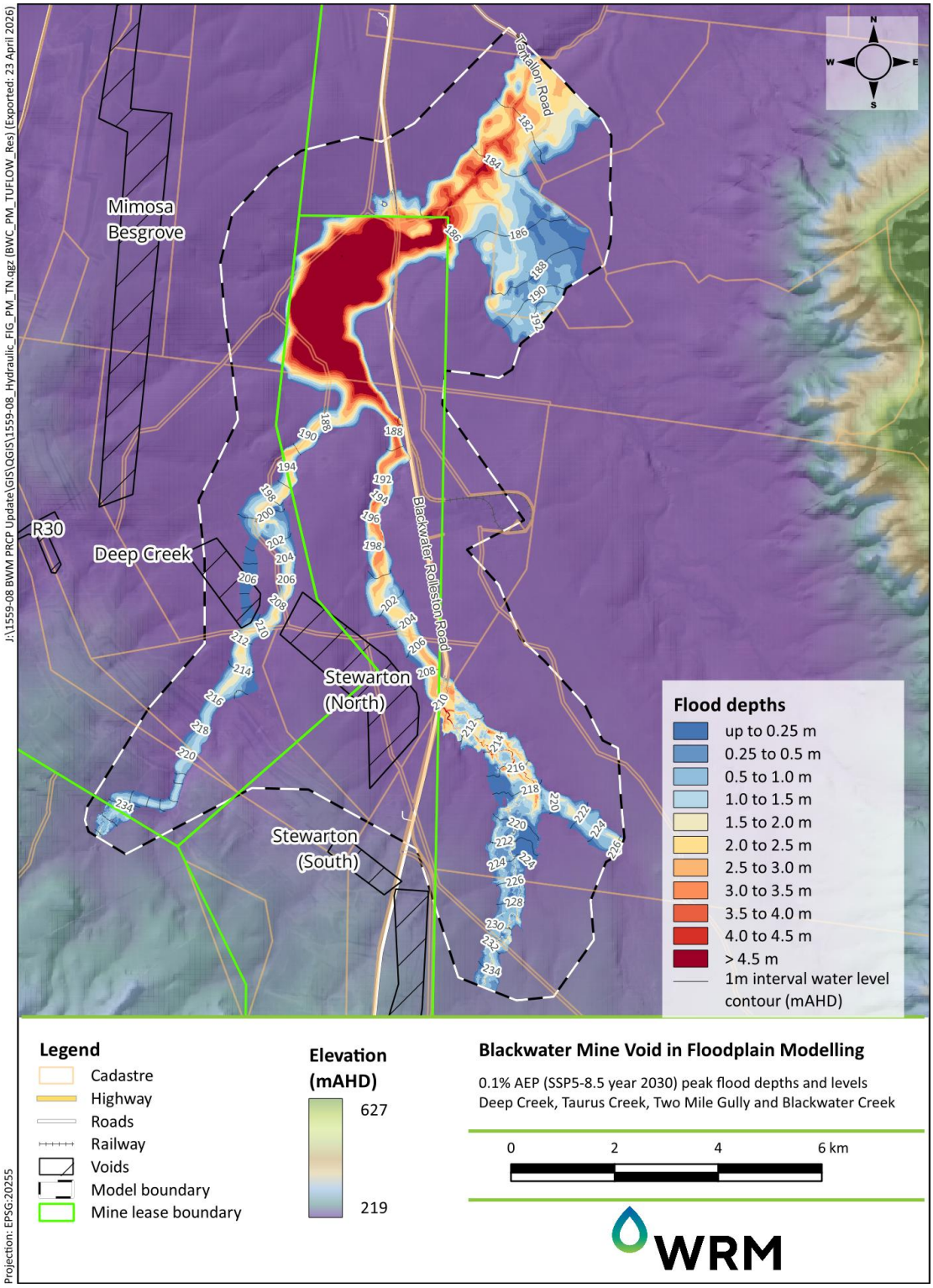


Figure 5.1 Peak flood depths and levels for 0.1% AEP event, Blackwater Creek

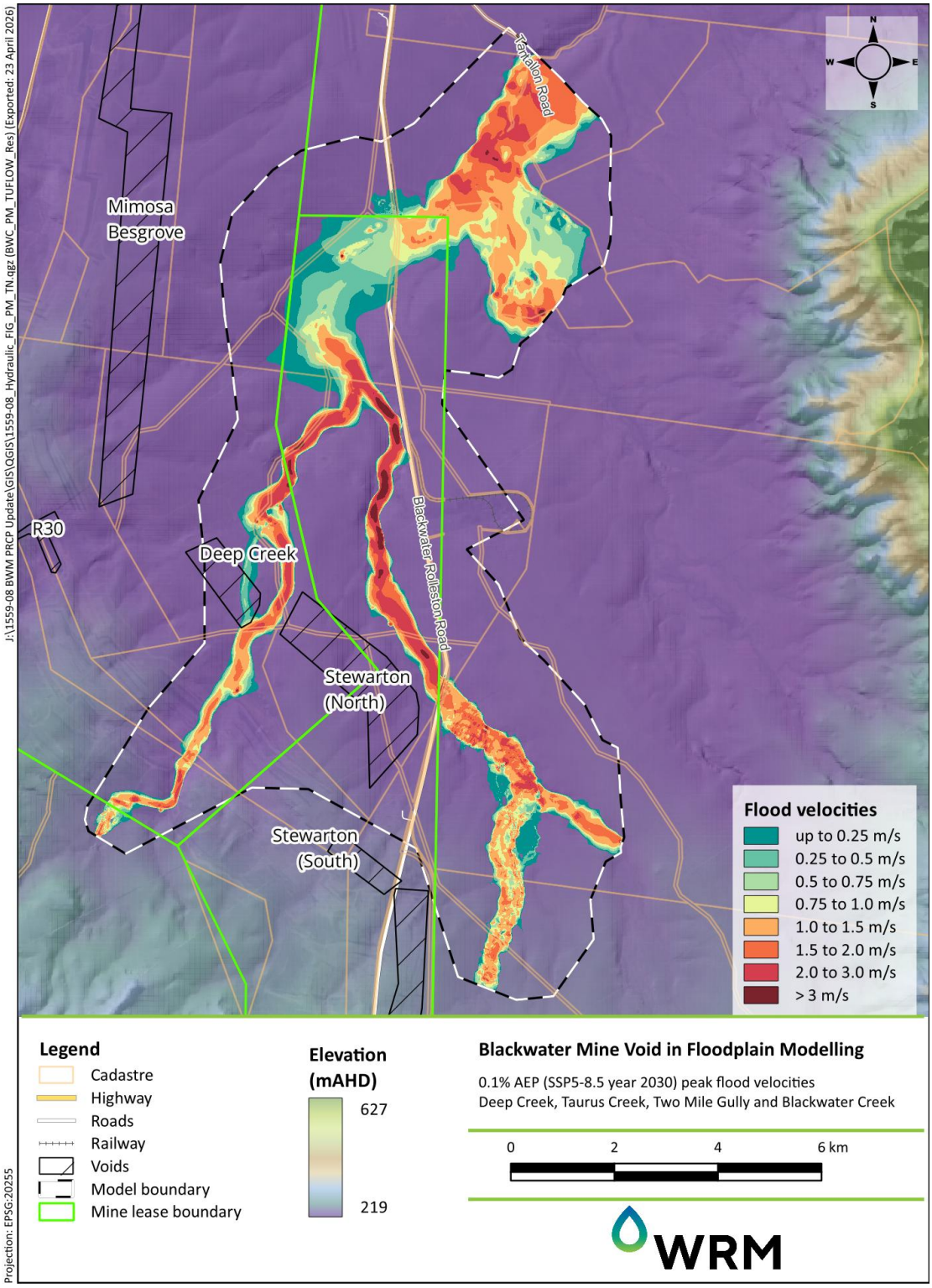


Figure 5.2 Peak flood velocities for 0.1 %AEP event, Blackwater Creek

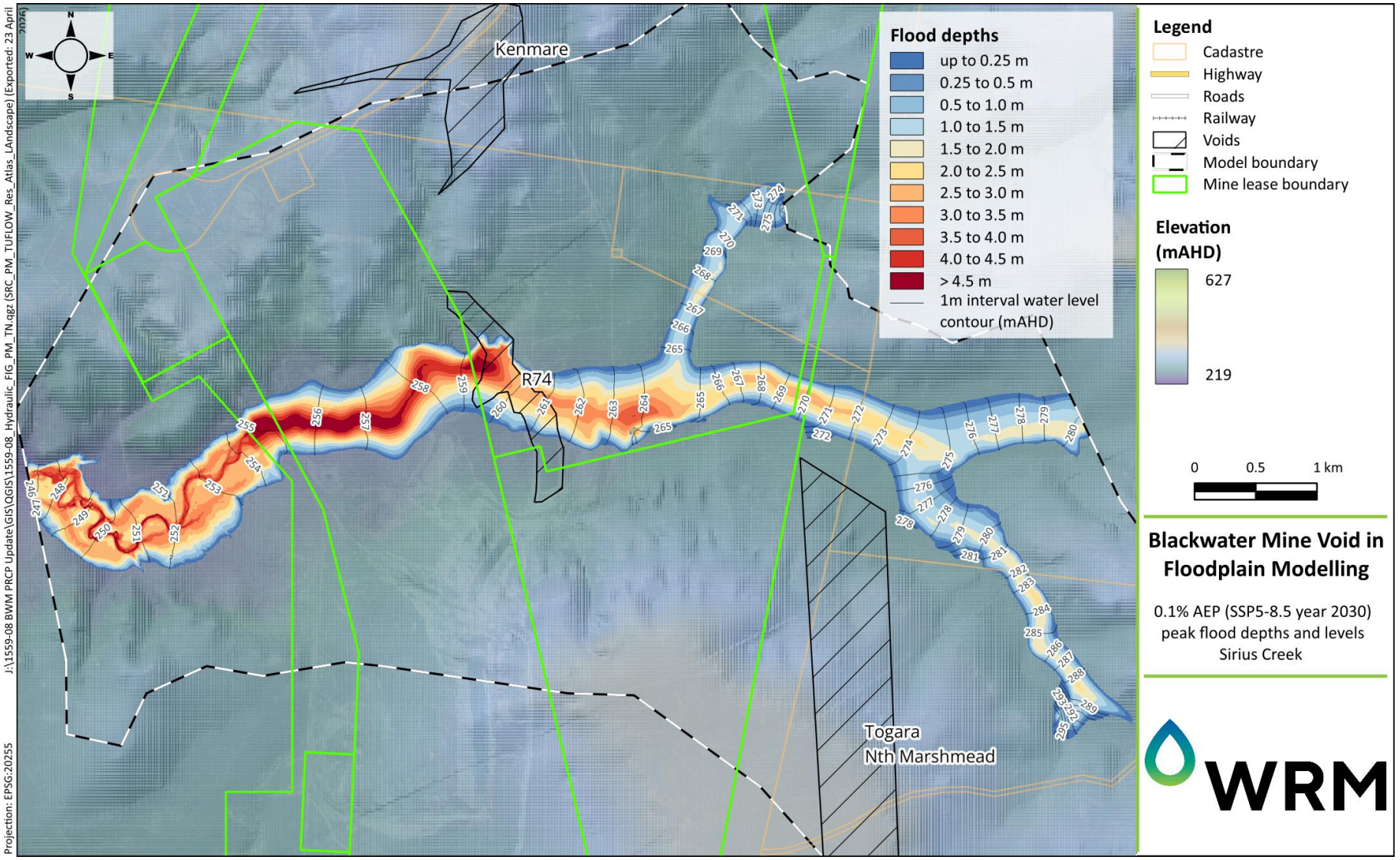


Figure 5.3 Peak flood depths and levels for 0.1 %AEP, Sirius Creek

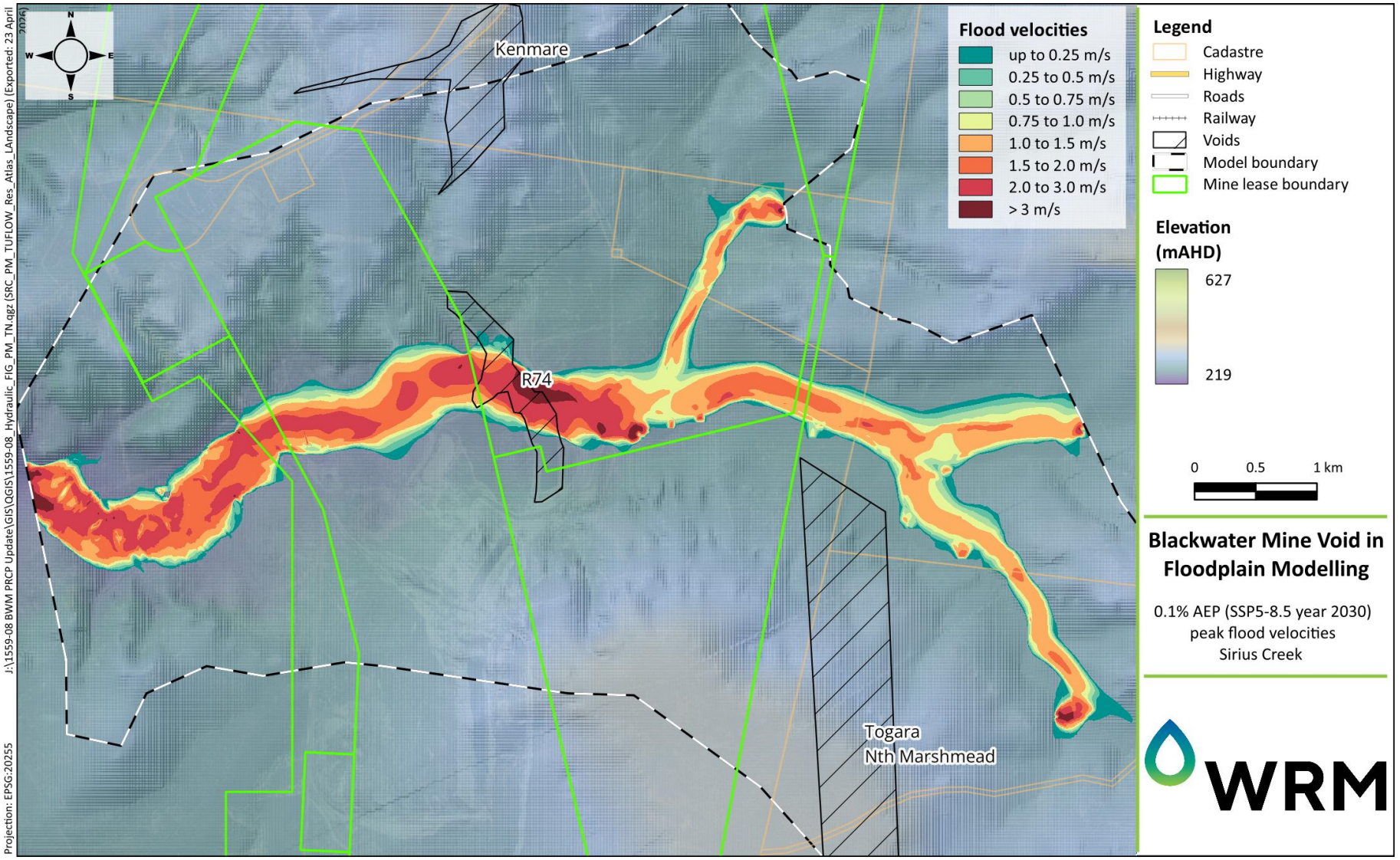


Figure 5.4 Peak flood velocities for 0.1 %AEP, Sirius Creek

6 SUMMARY OF FINDINGS

6.1 OVERVIEW

Hydrologic and hydraulic modelling of pre-mining conditions at BWM was undertaken to define the floodplain as defined in the PRCP guideline (DETSI, 2024), to supplement the BWM PRCP. As part of the PRCP for BWM, it is proposed to incorporate 15 final voids as Non-use Management Areas (NUMAs).

The following watercourses are of Strahler stream order 4 or greater and are therefore considered as relevant watercourses for the purpose of this study:

- Blackwater Creek;
- Two Mile Gully;
- Taurus Creek (downstream of the Emu Creek confluence); and
- Sirius Creek.

6.2 HYDROLOGIC AND HYDRAULIC MODEL DEVELOPMENT

Hydrologic and hydraulic modelling was undertaken to assess flood behaviour under pre-mining conditions along Taurus Creek, Two Mile Gully, Blackwater Creek and Sirius Creek.

New URBS hydrologic models were developed and calibrated to recorded data for the April 2017 and January 2020 flood events where data was available. Design event hydrologic modelling was undertaken in accordance with ARR 2019, for the 0.1% AEP design flood event. The new URBS models incorporate the latest climate change guidance from Australian Rainfall and Runoff 2019 Version 4.2 (ARR 2019 v4.2) (Ball et al, 2019). Design flood discharges were estimated based on the SSP5-8.5 (year 2030) climate scenario.

TUFLOW hydraulic models for the Blackwater Creek and Sirius Creek catchments previously developed by SLR (2024a and 2024b) were updated to incorporate new design discharge from the new URBS hydrologic models. The updated hydraulic models were used to estimate flood levels, depths, extents and velocities for 0.1% AEP design event.

6.3 VOIDS WITHIN THE FLOODPLAIN

The Deep Creek void is located partially within the Taurus Creek inundation extent for a 0.1% AEP flood event. Therefore, it is partially situated within a floodplain as defined by DETSI (2024). The final landform will be designed to prevent the ingress of floodwater into the Deep Creek void for all events up to and including a 0.1% AEP flood event at minimum.

The Stewarton North and Stewarton South voids are located outside of the Taurus Creek and Two Mile Gully inundation extents for a 0.1% AEP flood event. Therefore, these voids are not situated within a floodplain as defined by DETSI (2024).

The Kenmare and Togara North Marshmead voids are located outside of the Sirius Creek inundation extent for a 0.1% AEP flood event. Therefore, these voids are not situated within a floodplain as defined by DETSI (2024).

The R74 void is situated across the Sirius Creek inundation extent for the 0.1% AEP flood event.

- Under current (operational) conditions, there is currently a licensed diversion for Sirius Creek (authorisation reference 52652F) that diverts Sirius Creek around the existing R74 open cut pit. The R74 pit is proposed to remain under post-mining conditions as the R74 void, as shown in Figure 5.1 and Figure 5.2.

- To maintain free drainage of the Sirius Creek catchment under post-mining conditions, a permanent diversion of Sirius Creek is required, to be developed in accordance with the watercourse diversion guideline (DNRME, 2019).

7 REFERENCES

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Jordan, 2005	Phillip Jordan et al, 2005, *Growth curves and temporal patterns of short duration design storms for extreme events.*
SLR, 2024a	SLR Consulting Australia, October 2024, *Blackwater Mine – Progressive Rehabilitation and Closure Plan – Rehabilitation Flood Assessments*.
SLR, 2024b	SLR Consulting Australia, October 2024, *Blackwater Mine – Progressive Rehabilitation and Closure Plan – Voids in Floodplain Modelling*.

APPENDIX A URBS MODEL CONFIGURATION

A.1 BWC CATCHMENT

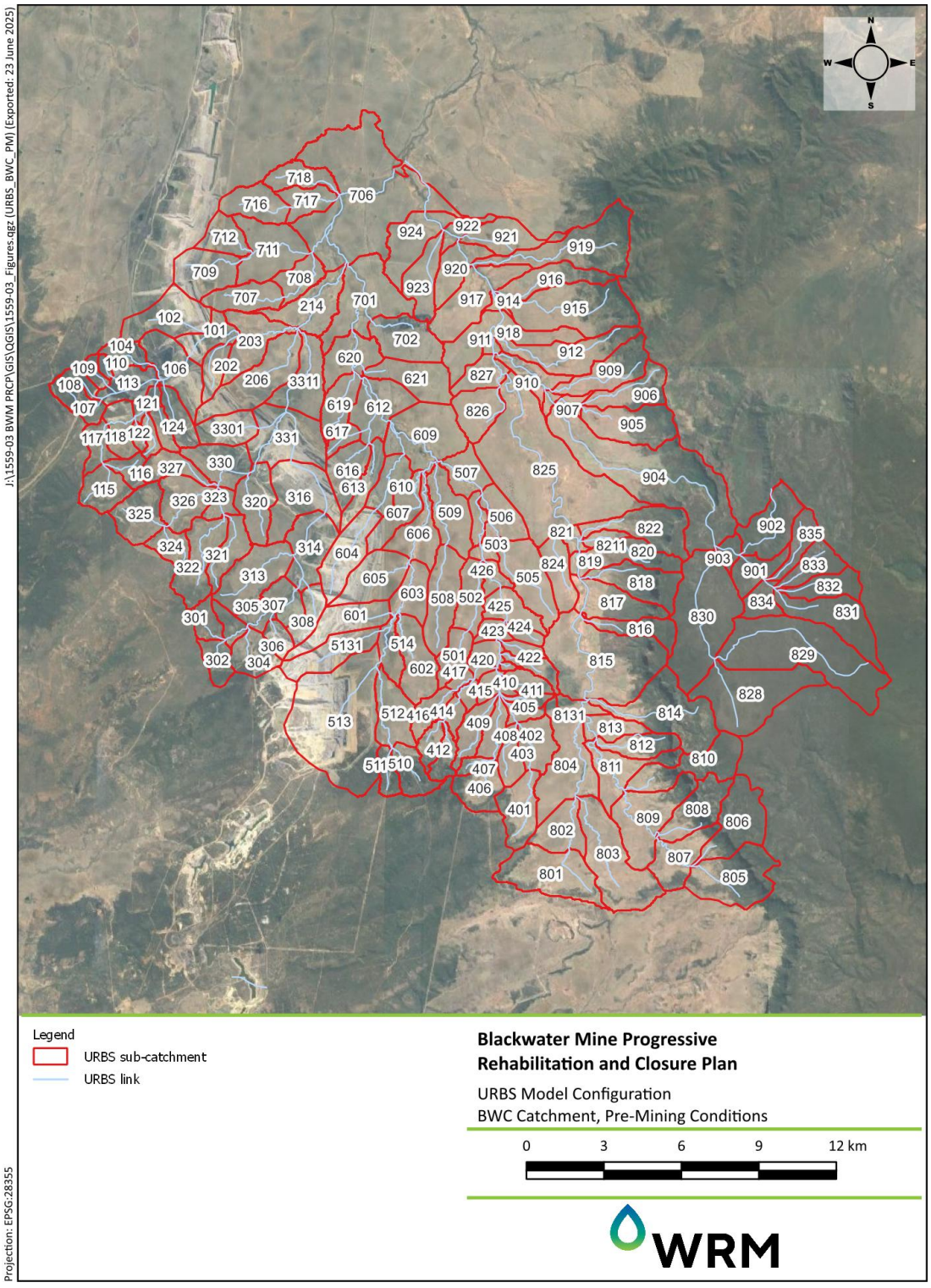


Figure A.1 URBS model configuration of the BWC catchment, pre-mining conditions

Table A.1 URBS subcatchment parameters, Blackwater Creek catchment, pre-minging conditions

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	2.24	0	0.07	0.007
102	4.38	0	0.07	0.016
104	1.37	0	0.07	0.031
106	4.24	0	0.07	0.014
107	2.03	0	0.07	0.031
108	0.80	0	0.07	0.053
109	0.73	0	0.07	0.045
110	0.36	0	0.07	0.050
113	2.61	0	0.07	0.010
115	2.55	0	0.07	0.017
116	1.21	0	0.07	0.007
117	1.58	0	0.07	0.014
118	2.19	0	0.07	0.021
120	0.49	0	0.07	0.042
121	0.88	0	0.07	0.007
122	0.79	0	0.07	0.029
123	1.05	0	0.07	0.023
124	1.96	0	0.07	0.014
202	1.61	0	0.07	0.012
203	3.80	0	0.07	0.008
206	5.86	0	0.07	0.010
214	4.02	0	0.07	0.006
301	1.38	0	0.07	0.027
302	1.68	0	0.07	0.020
303	1.14	0	0.07	0.024
304	2.49	0	0.07	0.028
305	1.24	0	0.07	0.010
306	1.16	0	0.07	0.022
307	1.90	0	0.07	0.028
308	1.83	0	0.07	0.019
313	4.87	0	0.07	0.017
314	4.14	0	0.07	0.006
316	5.68	0	0.07	0.012

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
320	3.47	0	0.07	0.017
321	2.47	0	0.07	0.020
322	4.10	0	0.07	0.017
323	1.07	0	0.07	0.019
324	1.70	0	0.07	0.025
325	3.44	0	0.07	0.023
326	3.48	0	0.07	0.017
327	2.11	0	0.07	0.017
330	3.25	0	0.07	0.010
3301	2.55	0	0.07	0.016
331	5.73	0	0.07	0.009
3311	3.96	0	0.07	0.006
401	3.40	0	0.07	0.015
402	2.59	0	0.07	0.012
403	1.73	0	0.07	0.014
404	0.92	0	0.07	0.011
405	0.74	0	0.07	0.027
406	2.67	0	0.07	0.025
407	0.62	0	0.07	0.043
408	1.72	0	0.07	0.014
409	2.13	0	0.07	0.019
410	1.21	0	0.07	0.003
411	1.35	0	0.07	0.030
412	1.33	0	0.07	0.028
413	1.28	0	0.07	0.030
414	0.97	0	0.07	0.015
415	0.66	0	0.07	0.017
416	1.65	0	0.07	0.014
417	0.55	0	0.07	0.009
418	0.57	0	0.07	0.009
419	0.21	0	0.07	0.011
420	1.00	0	0.07	0.009
421	1.25	0	0.07	0.030
422	0.87	0	0.07	0.014
423	1.00	0	0.07	0.009

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
424	0.79	0	0.07	0.014
425	2.31	0	0.07	0.008
426	1.00	0	0.07	0.004
501	2.03	0	0.07	0.011
502	2.62	0	0.07	0.007
503	0.64	0	0.07	0.002
504	1.03	0	0.07	0.006
505	4.68	0	0.07	0.007
506	2.69	0	0.07	0.005
507	2.41	0	0.07	0.006
508	4.43	0	0.07	0.005
509	3.89	0	0.07	0.006
510	2.33	0	0.07	0.031
511	1.25	0	0.07	0.035
512	3.45	0	0.07	0.016
513	14.59	0	0.07	0.013
5131	3.58	0	0.07	0.017
514	1.71	0	0.07	0.006
601	3.60	0	0.07	0.014
602	3.88	0	0.07	0.008
603	2.51	0	0.07	0.006
604	4.00	0	0.07	0.009
605	4.01	0	0.07	0.013
606	3.28	0	0.07	0.006
607	2.83	0	0.07	0.007
609	6.13	0	0.07	0.004
610	2.30	0	0.07	0.010
612	4.10	0	0.07	0.005
613	1.98	0	0.07	0.010
616	2.86	0	0.07	0.010
617	0.85	0	0.07	0.012
619	2.57	0	0.07	0.010
620	3.14	0	0.07	0.010
621	3.66	0	0.07	0.009
701	6.45	0	0.07	0.006

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
702	4.00	0	0.07	0.008
706	18.48	0	0.07	0.005
707	2.88	0	0.07	0.009
708	2.14	0	0.07	0.009
709	3.84	0	0.07	0.013
711	4.99	0	0.07	0.010
712	2.18	0	0.07	0.016
716	2.95	0	0.07	0.011
717	2.06	0	0.07	0.013
718	2.25	0	0.07	0.014
801	6.08	0	0.07	0.014
802	3.02	0	0.07	0.016
803	7.28	0	0.07	0.011
804	6.33	0	0.07	0.010
805	5.87	0	0.07	0.054
806	4.86	0	0.07	0.093
807	3.45	0	0.07	0.017
808	3.68	0	0.07	0.093
809	5.80	0	0.07	0.040
810	4.62	0	0.07	0.087
811	3.55	0	0.07	0.010
812	2.30	0	0.07	0.048
813	1.91	0	0.07	0.027
8131	1.06	0	0.07	0.020
814	7.10	0	0.07	0.079
815	11.57	0	0.07	0.037
816	2.31	0	0.07	0.102
817	3.79	0	0.07	0.067
818	3.83	0	0.07	0.066
819	0.56	0	0.07	0.013
820	3.15	0	0.07	0.056
821	0.75	0	0.07	0.000
8211	0.76	0	0.07	0.025
822	4.47	0	0.07	0.064
824	2.73	0	0.07	0.006

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
825	18.60	0	0.07	0.005
826	2.96	0	0.07	0.006
827	2.01	0	0.07	0.010
828	8.08	0	0.07	0.013
829	12.06	0	0.07	0.015
830	10.24	0	0.07	0.014
831	4.87	0	0.07	0.026
832	2.36	0	0.07	0.035
833	2.38	0	0.07	0.034
834	1.62	0	0.07	0.029
835	2.01	0	0.07	0.041
901	2.16	0	0.07	0.029
902	4.27	0	0.07	0.029
903	0.86	0	0.07	0.042
904	15.68	0	0.07	0.030
905	4.65	0	0.07	0.035
906	3.15	0	0.07	0.032
907	0.56	0	0.07	0.006
908	0.42	0	0.07	0.007
909	3.92	0	0.07	0.021
910	2.02	0	0.07	0.005
911	0.34	0	0.07	0.014
912	4.87	0	0.07	0.019
914	0.39	0	0.07	0.004
915	8.00	0	0.07	0.022
916	3.12	0	0.07	0.034
917	5.05	0	0.07	0.007
918	5.11	0	0.07	0.008
919	7.07	0	0.07	0.025
920	2.75	0	0.07	0.010
921	3.07	0	0.07	0.011
922	0.80	0	0.07	0.007
923	3.09	0	0.07	0.009
924	4.33	0	0.07	0.007

A.2 SRC CATCHMENT

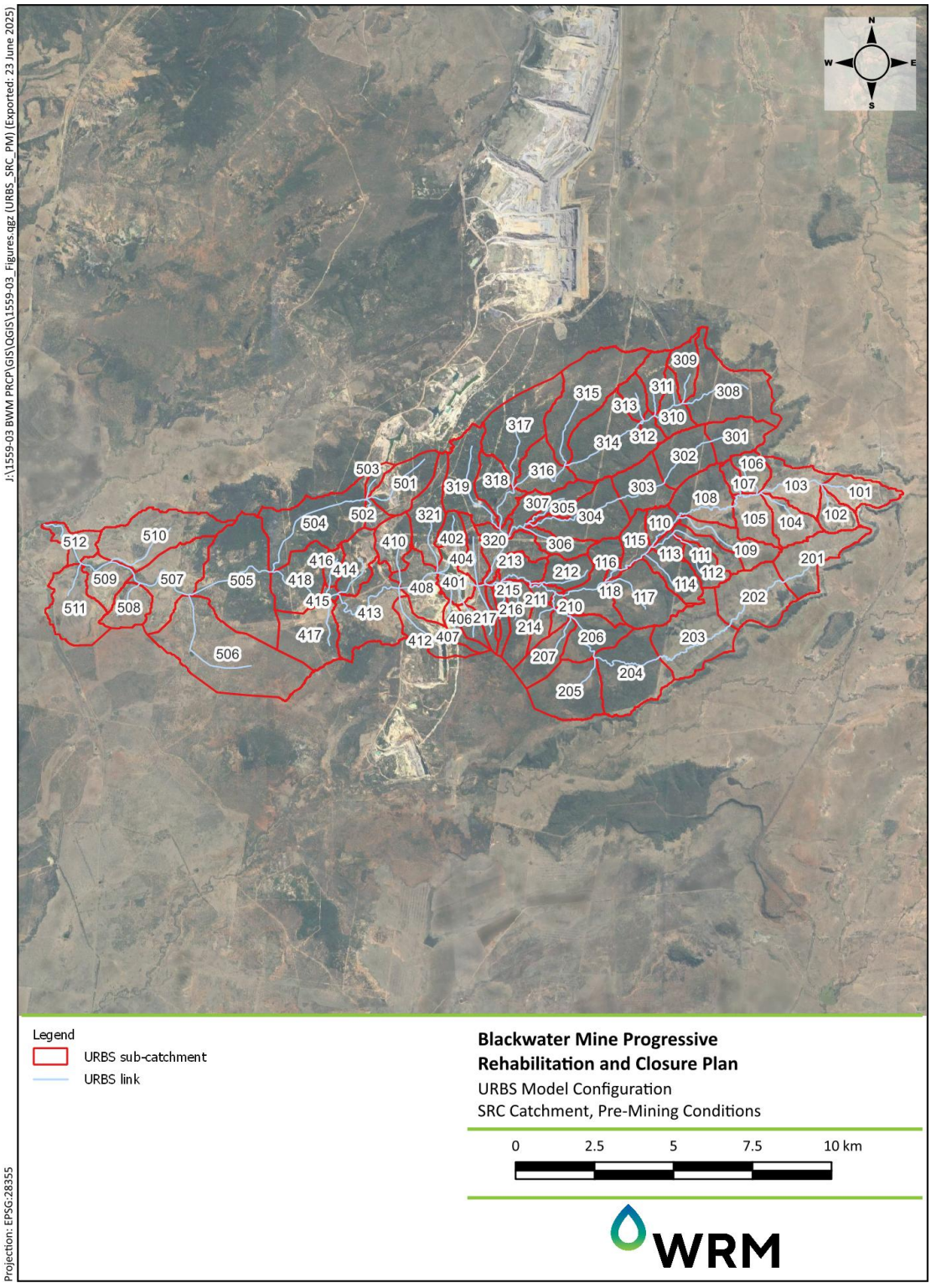


Figure A.2 URBS model configuration of the SRC catchment, pre-mining conditions

Table A.2 URBS subcatchment parameters, Sirius Creek catchment, pre-minging conditions

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	1.70	0	0.045	0.02
102	1.18	0	0.045	0.02
103	2.37	0	0.045	0.02
104	1.66	0	0.045	0.03
105	1.75	0	0.045	0.03
106	1.13	0	0.045	0.03
107	0.48	0	0.045	0.05
108	2.73	0	0.045	0.02
109	1.92	0	0.045	0.02
110	0.88	0	0.045	0.01
111	1.09	0	0.045	0.02
112	1.22	0	0.045	0.03
113	0.56	0	0.045	0.02
114	1.67	0	0.045	0.03
115	1.20	0	0.045	0.01
116	0.22	0	0.045	0.01
117	3.37	0	0.045	0.03
118	2.53	0	0.045	0.02
201	2.99	0	0.045	0.01
202	3.68	0	0.045	0.01
203	4.37	0	0.045	0.02
204	4.50	0	0.045	0.01
205	3.48	0	0.045	0.02
206	2.04	0	0.045	0.015
207	1.76	0	0.045	0.017
208	0.48	0	0.045	0.016
209	0.87	0	0.045	0.027
210	0.21	0	0.045	0.028
211	0.40	0	0.045	0.033
212	1.40	0	0.045	0.045
213	1.11	0	0.045	0.018
214	1.95	0	0.045	0.021
215	0.13	0	0.045	0.010
216	0.66	0	0.045	0.023

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
217	0.30	0	0.045	0.030
301	2.02	0	0.045	0.015
302	2.56	0	0.045	0.028
303	2.28	0	0.045	0.009
304	3.30	0	0.045	0.009
305	1.21	0	0.045	0.025
306	1.09	0	0.045	0.016
307	0.88	0	0.045	0.011
308	4.70	0	0.045	0.013
309	1.31	0	0.045	0.015
310	1.43	0	0.045	0.012
311	1.27	0	0.045	0.019
312	0.45	0	0.045	0.021
313	0.94	0	0.045	0.027
314	4.85	0	0.045	0.037
315	5.08	0	0.045	0.033
316	2.05	0	0.045	0.008
317	4.24	0	0.045	0.005
318	1.95	0	0.045	0.008
319	3.07	0	0.045	0.005
320	1.98	0	0.045	0.024
321	2.50	0	0.045	0.014
401	1.62	0	0.045	0.041
402	0.75	0	0.045	0.046
404	1.17	0	0.045	0.021
405	0.92	0	0.045	0.012
406	0.72	0	0.045	0.022
407	0.80	0	0.045	0.014
408	2.31	0	0.045	0.015
410	1.64	0	0.045	0.020
412	1.92	0	0.045	0.011
413	4.31	0	0.045	0.011
414	1.87	0	0.045	0.025
415	0.22	0	0.045	0.017
416	0.59	0	0.045	0.028

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
417	3.22	0	0.045	0.048
418	2.88	0	0.045	0.029
501	2.47	0	0.045	0.014
502	0.51	0	0.045	0.017
503	0.45	0	0.045	0.016
504	5.25	0	0.045	0.016
505	7.12	0	0.045	0.013
506	8.51	0	0.045	0.015
507	3.87	0	0.045	0.009
508	1.58	0	0.045	0.024
509	1.75	0	0.045	0.006
510	4.53	0	0.045	0.034
511	3.34	0	0.045	0.010
512	1.25	0	0.045	0.046

APPENDIX B HYDROLOGIC MODEL DEVELOPMENT, CALIBRATION AND VALIDATION REPORT

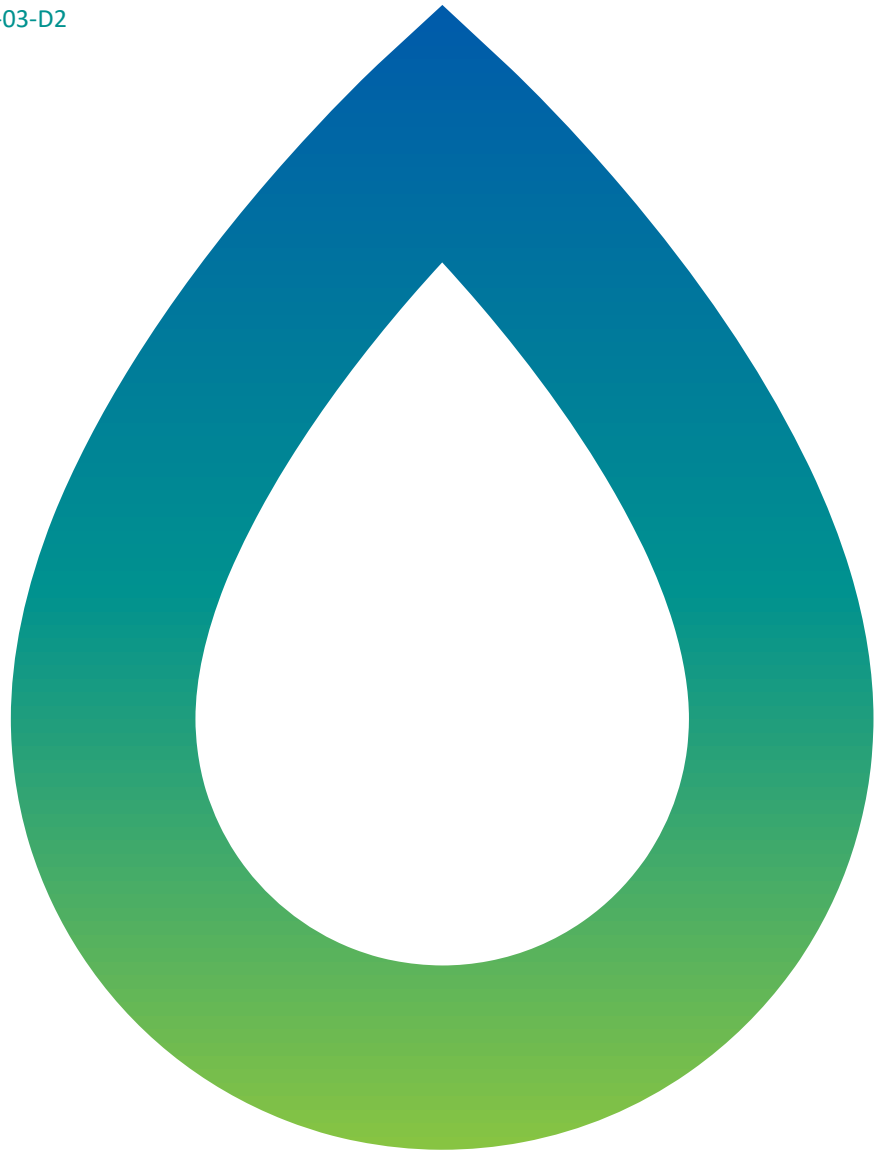
BLACKWATER MINE PROGRESSIVE REHABILITATION AND CLOSURE PLAN

Hydrologic Model Development, Calibration and Validation Report

Whitehaven Coal Limited

28 November 2025

1559-03-D2



DETAILS

Report Title	BLACKWATER MINE PROGRESSIVE REHABILITATION AND CLOSURE PLAN, Hydrologic Model Development, Calibration and Validation Report
Client	Whitehaven Coal Limited

THIS REVISION

Report Number	1559-03-D2
Date	28 November 2025
Author	Lorena Miranda
Reviewer	Ardianto Notodirdjo

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1 INTRODUCTION

1.1 OVERVIEW

Whitehaven, the owners of Blackwater Mine (BWM), has requested WRM Water & Environment Pty Ltd (WRM) to undertake hydrologic and hydraulic modelling for the BWM Progressive Rehabilitation and Closure Plan (PRCP) for Revision 2 (Rev 2) of the BWM final landform configuration.

New hydrologic models were developed using the URBS software package, which incorporates the latest climate change guidance from Australian Rainfall and Runoff 2019 Version 4.2 (ARR 2019 v4.2) (Ball et al, 2019). Additionally, URBS has increasingly become the industry standard (and preferred) software package for undertaking hydrologic modelling.

This "hydrologic model development report" presents the development, calibration and validation of seven (7) URBS hydrologic models for the catchments that drain across BWM. The modelled catchments are listed below and shown on Figure 1.1:

- Bonnie Doon Creek;
- Sagittarius Creek;
- Burngrove Creek;
- Blackwater Creek (including Deep Creek, Emu Creek, Taurus Creek and Two Mile Gully);
- Speculation Creek;
- Sirius Creek; and
- Rockland Creek.

This report provides the foundation for the following two flood assessments that inform the PRCP for Rev 2 of the BWM final landform:

- The Void in Floodplain Modelling assessment (WRM, 2025a); and
- The Final Landform Flood Modelling Assessment (WRM, 2025b).

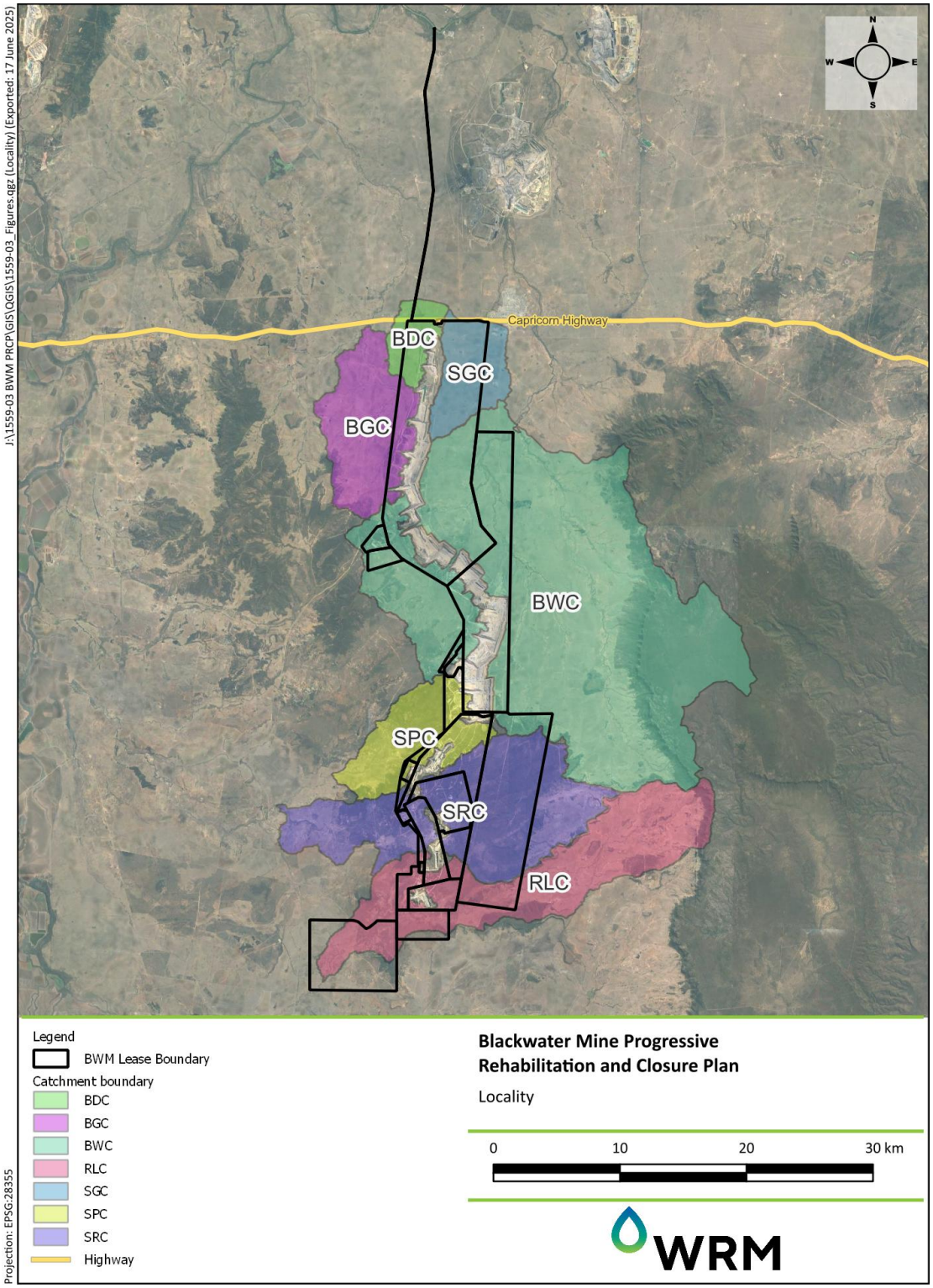


Figure 1.1 Study site locality

1.2 SCOPE OF STUDY

The proposed scope of works for this study included the following tasks:

- Development of a hydrologic model of the Burngrove Creek (BGC) catchment and calibration of the model using recorded water level data at the Burngrove Creek Upstream stream gauge (station 330127);
- Development of a hydrologic model of the Blackwater Creek (BWC) catchment and calibration of the model using recorded water level data at the Taurus Creek Downstream stream gauge (station 330101) and at the Two Mile Gully stream gauge (station 330124);
- Development of a hydrologic model of the Speculation Creek (SPC) catchment and calibration of the model using recorded water level data at the Speculation Creek stream gauge (station 330126);
- Development a hydrologic model of the Sirius Creek (SRC) catchment and calibration of the model using recorded water level data at the Sirius Creek Downstream stream gauge (station 330118), followed by validation of the model predicted 1% (1 in 100) annual exceedance probability (AEP) design discharges against discharge estimates from empirical methods.
- Development of hydrologic models of the Bonnie Doon Creek, Sagittarius Creek and Rockland Creek catchments and validation of the model predicted 1% AEP design discharges against discharge estimates from empirical methods.

1.3 REPORT STRUCTURE

The report is structured as follows:

- Section 2 is an overview of the data available for this study;
- Section 3 describes the development of the hydrologic model;
- Section 4 presents the hydrologic model calibration;
- Section 5 presents the hydrologic model validation;
- Section 6 is a list of references.

2 EXISTING DRAINAGE CHARACTERISTICS

Figure 2.1 shows the existing drainage characteristics in the vicinity of BWM, which are described as follows:

- Bonnie Doon Creek (BDC) drains in a northerly direction west of the BWM workings.
- Sagittarius Creek (SGC) drains in a northerly direction east of the BWM workings.
- The Burngrove Creek (BGC) catchment comprises the following three streams:
    - Burngrove Creek flows in a northeasterly direction west of the BWM workings. A 3 km section of the natural Burngrove Creek channel was removed by the BWM workings and replaced by a diversion channel that drains north between the railway and the BWM.
    - Cabbagetree Creek originates from the southwest of the catchment and drains in a northeasterly direction west of BWM before joining Burngrove Creek.
    - Tolmies Creek originates from the west of the catchment and drains in a northeasterly direction west of BWM before joining Burngrove Creek.
- The Blackwater Creek (BGC) catchment comprises the following five streams:
    - Blackwater Creek originates from the south of the catchment and flows in a northern direction. This creek does not interact with the BWM lease.
    - Taurus Creek, a major tributary of Blackwater Creek, originates from the east of BWM and drains in a northeasterly direction through BWM between the R38S and R42N open cut pits, eventually joining Blackwater Creek about 6 km east of BWM.
    - Deep Creek, a tributary of Taurus Creek, originates from the west of BWM and drains in a northeasterly direction through BWM via the temporary Deep Creek diversion between the R30S and R34S open cut pits, before joining Taurus Creek about 3 km east of BWM.
    - Two Mile Gully, a tributary of Taurus Creek, flows in a northerly direction east of BWM and joins Taurus Creek about 5 km east of BWM.
    - Emu Creek, a tributary of Taurus Creek, originates from the west (upstream) of BWM and flows in a northeasterly direction. It is then diverted in a northwesterly direction via the Emu Creek Diversion, which drains to Taurus Creek just upstream (west) of BWM.
- Speculation Creek (SPC) originates from the western extents of BWM and flows in a southwesterly direction away from BWM. The upper extents of the Speculation Creek catchment have been heavily disturbed by BWM mining operations.
- Sirius Creek originates from the east (upstream) of BWM. It flows in a westerly direction through BWM via the temporary Sirius Creek diversion between the R74 and R78N open cut pits. Downstream of the Sirius Creek Diversion, Sirius Creek continues to drain in a westerly direction away from BWM.
- Rockland Creek originates from the east (upstream) of the BWM. It flows in a westerly direction through BWM and south of the R82S open cut pit. Rockland Creek drains into Rockland Dam just upstream (east) of the mine.
    - Rockland Dam is formed by an earthen embankment across the Rockland Creek channel and floodplain. Rockland Dam is a free-draining structure, with a low-flow culvert outlet at the base of the dam and an overflow spillway weir and channel at the northern end of the dam.

- Table 2.1 shows the key characteristics of Rockland Dam obtained from the *Rockland Creek Diversion Construction Report* (PPK Consultants, 1994), the GHD (2021) report and the 2024 LiDAR data.

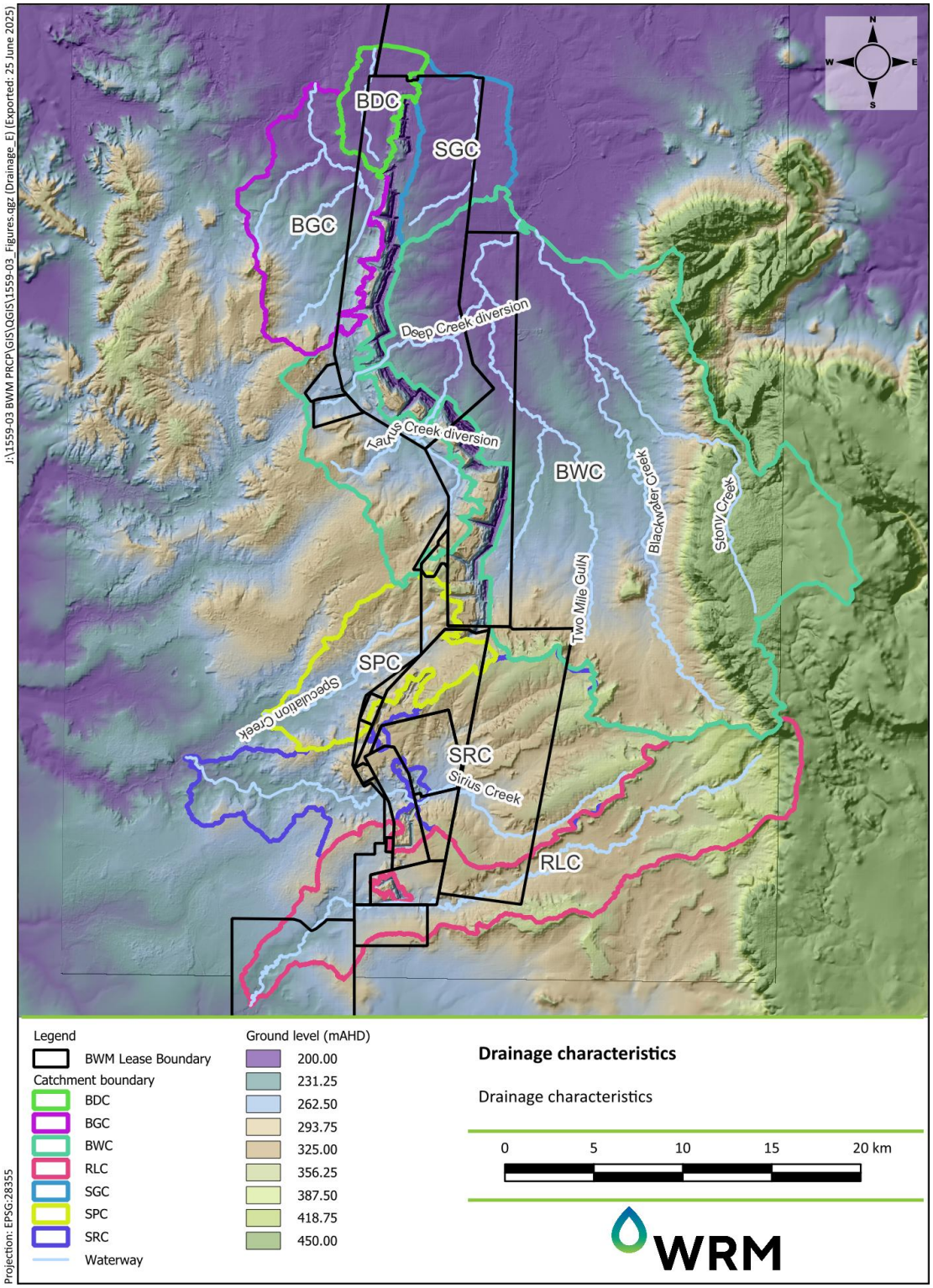


Figure 2.1 Study site drainage characteristics

- Figure 2.2 shows the stage-storage relationship for the dam derived from the LiDAR topographic data obtained in 2024. Figure 2.3 shows the stage-discharge relationship of the dam outlet derived from TUFLOW hydraulic model results.

Table 2.1 Rockland Dam key details

Dam feature	Value	Comment
Dam crest	281.2 mAHD	Based on 2024 LiDAR data
Dam crest width	8 m	Based on PPK (1994) construction report
Embankment height	16.1 m	Based on GHD (2021) report
Spillway invert	278.7 mAHD	Based on 2024 LiDAR data
Spillway width at crest	50 m	Based on GHD (2021) report
Outlet works	1.68 m wide and 1.95 m high box culverts Inlet invert = 263.4 mAHD Outlet invert = 262.8 mAHD	Based on GHD (2021) report
Storage volume at crest	20,310 ML	Based on PPK (1994) construction report

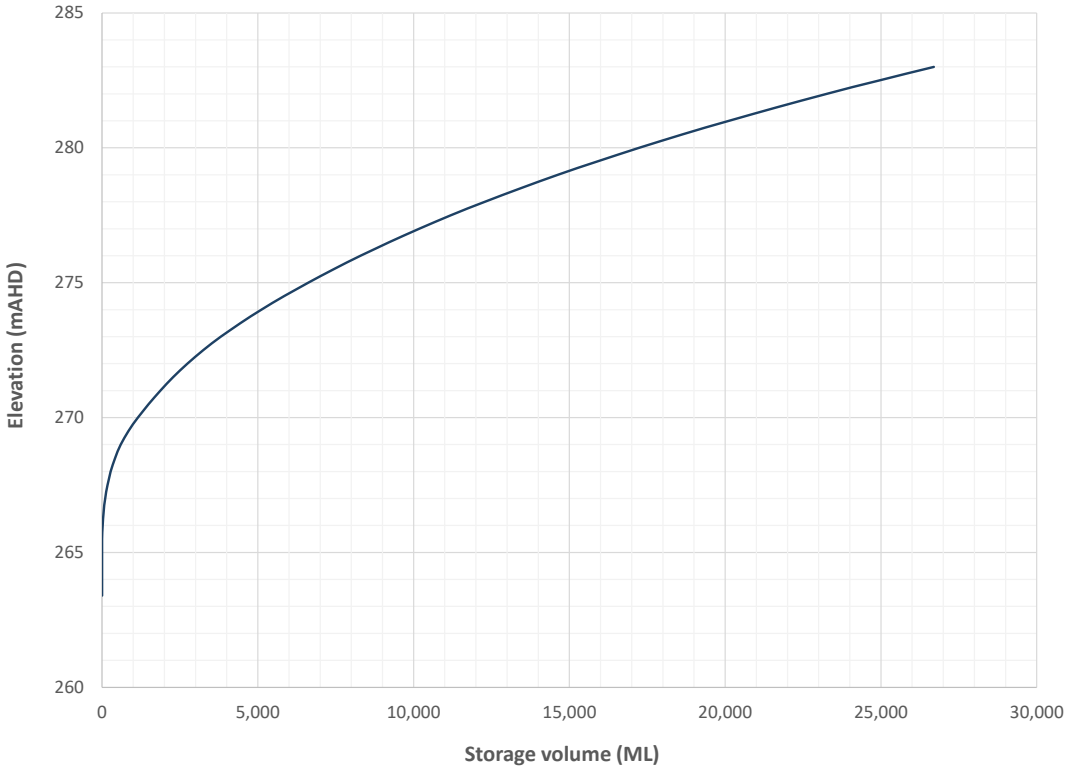


Figure 2.2 Stage-storage relationship for Rockland Dam

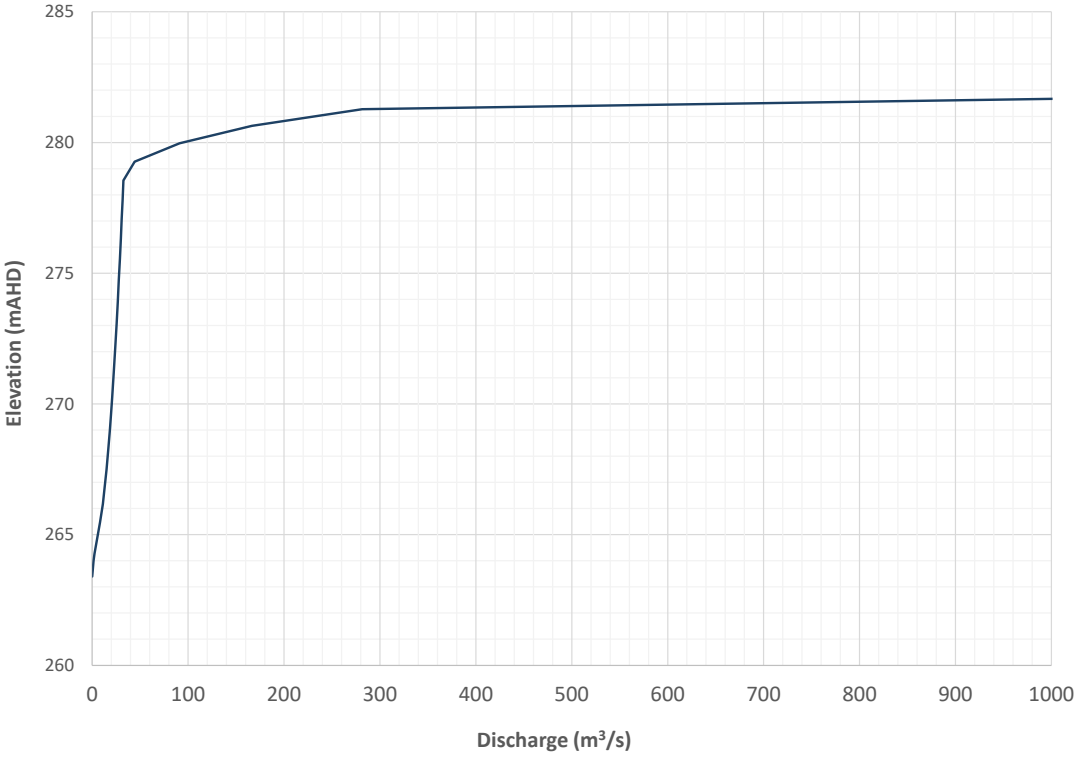


Figure 2.3 Stage-discharge relationship for the Rockland Dam outlet

3 AVAILABLE DATA

3.1 OVERVIEW

The following data was provided by Whitehaven for this study:

- Previous hydrologic and hydraulic studies;
- Recorded rainfall and water level data; and
- LiDAR topographic data.

3.2 PREVIOUS STUDIES

3.2.1 Blackwater Mine Flood Study (2021)

The Blackwater Mine Flood Study undertaken by GHD (2021) assessed existing flood risks across BWM. XP-RAFTS hydrologic and TUFLOW hydraulic models were developed for this study. In this study, the hydrologic models for Burngrove Creek and Speculation Creek were calibrated to recorded water level data. The GHD (2021) study report was provided for this study, but the XP-RAFTS and TUFLOW models were not available.

3.2.2 Blackwater Mine Progressive Rehabilitation and Closure Plan (2024)

The XP-RAFTS hydrologic and TUFLOW hydraulic models used by SLR (2024a and 2024b) for the Rev 1 PRCP flood assessment were provided for this study. These models appear to have been developed based on the GHD (2021) hydrologic and hydraulic models. Separate models were provided for the following catchments:

- Bonnie Doon Creek;
- Blackwater Creek;
- Burngrove Creek;
- Rockland Creek;
- Sagittarius Creek;
- Sirius Creek;
- Speculation Creek;
- Taurus Creek; and
- Two Mile Gully.

3.3 RAINFALL AND WATER LEVEL DATA

3.3.1 Rainfall and water level gauging stations

Figure 3.1 shows the location of three subdaily rainfall (pluviograph) stations and six stream gauging stations across BWM. Table 3.1 and Table 3.2 show details of these stations.

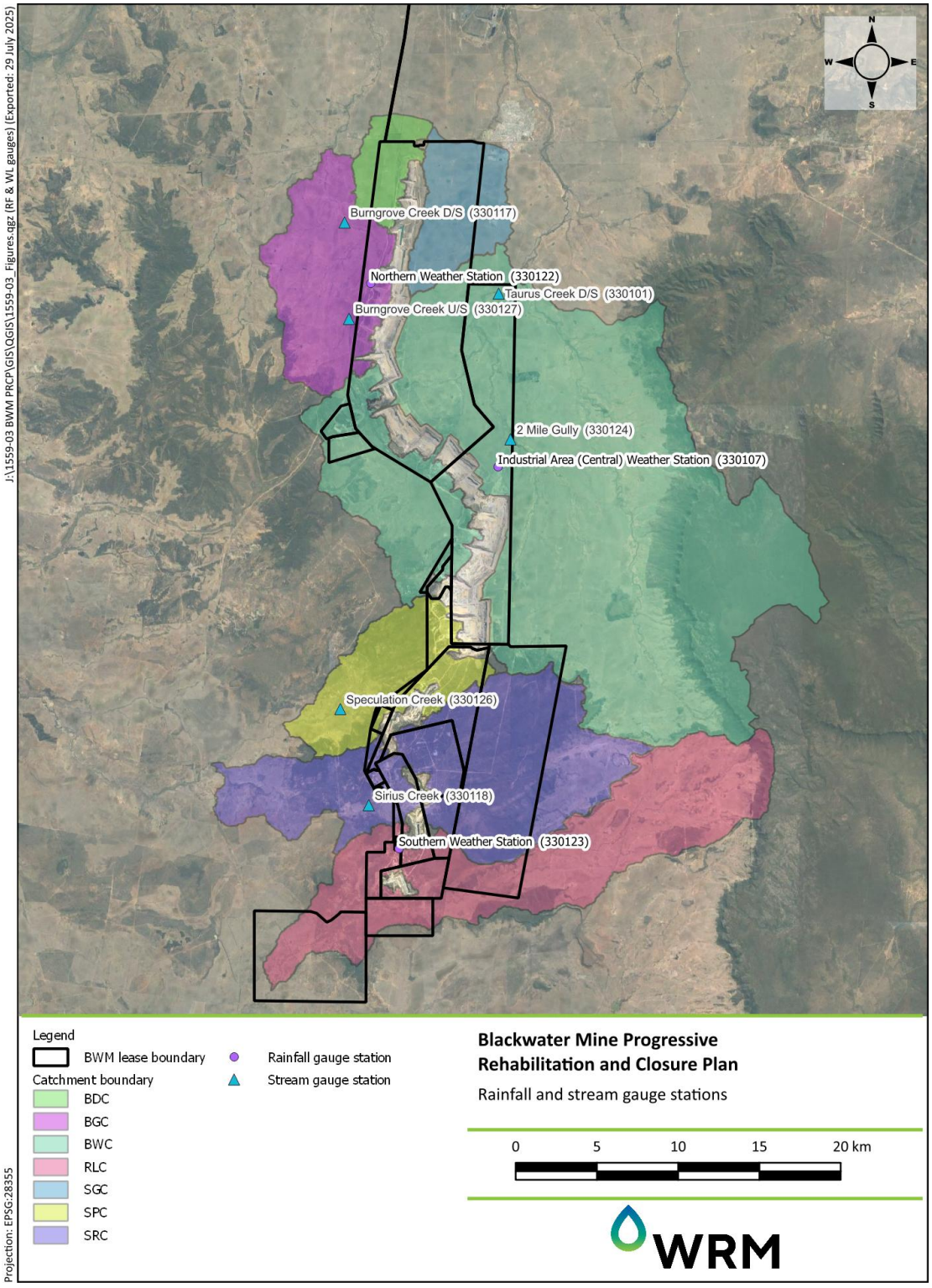


Figure 3.1 Location of rainfall and stream gauging stations

Table 3.1 Details of available subdaily rainfall (pluviograph) stations

Station Number	Station Name	Supplied data period
330122	Northern Weather Station	January 2016 – January 2025
330107	Industrial Areal (Central) Weather Station	January 2016 – January 2025
330123	Southern Weather Station	January 2016 – January 2025

Table 3.2 Details of available stream gauging stations

Station Number	Station Name	Supplied data period
330101	Taurus Creek D/S	January 2016 – January 2025
330118	Sirius Creek D/S	January 2016 – January 2025
330124	Two Mile Gully	January 2016 – January 2025
330126	Speculation Creek	January 2016 – January 2025
330127	Burngrove Creek U/S	January 2016 – January 2025
330117	Burngrove Creek D/S	January 2016 – January 2025

3.3.2 Rating curves

Whitehaven provided rating curves for the six gauges listed in Table 3.2 (referred to in this report as the Whitehaven rating curves). It was uncertain if the Whitehaven rating curves were derived from actual gaugings or from hydraulic modelling. For this study, the rating curves were verified and then modified and/or extended if necessary, using hydraulic modelling where detailed LiDAR data is available.

Figure 3.1 to Figure 3.4 compare the Whitehaven rating curves, the TUFLOW model generated rating curves and the final adopted rating curves for the Taurus Creek D/S, Two Mile Gully, Burngrove Creek U/S and Sirius Creek D/S gauges, respectively. For these four gauges, the “adopted” rating curves were used to convert recorded water levels into discharges for the hydrologic model calibration.

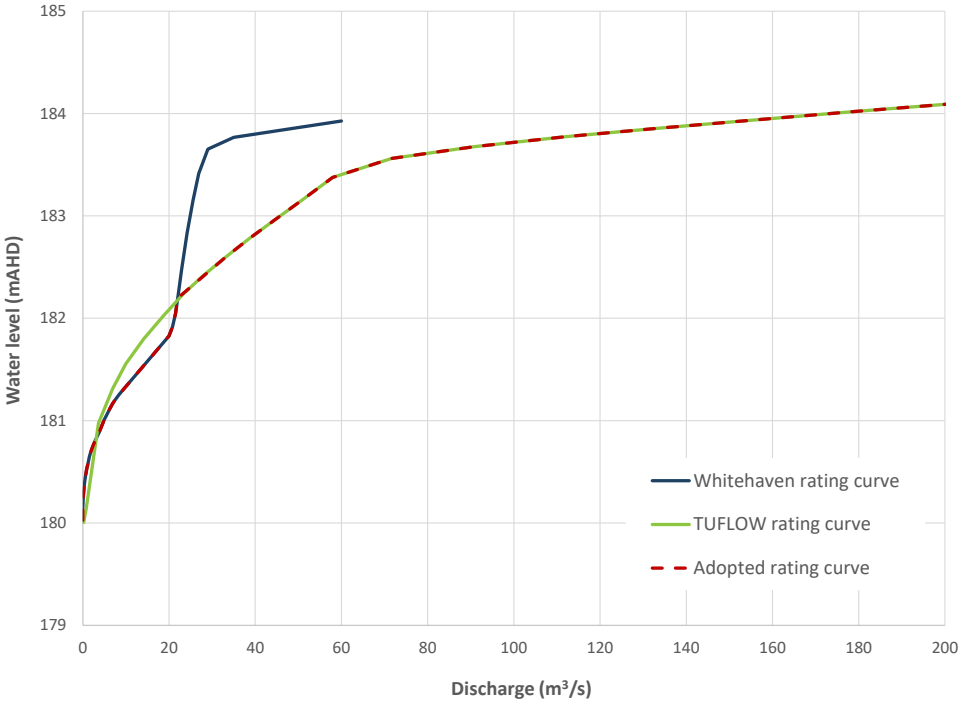


Figure 3.1 Comparison of Whitehaven-supplied, TUFLOW and adopted rating curves, Taurus Creek D/S gauging station

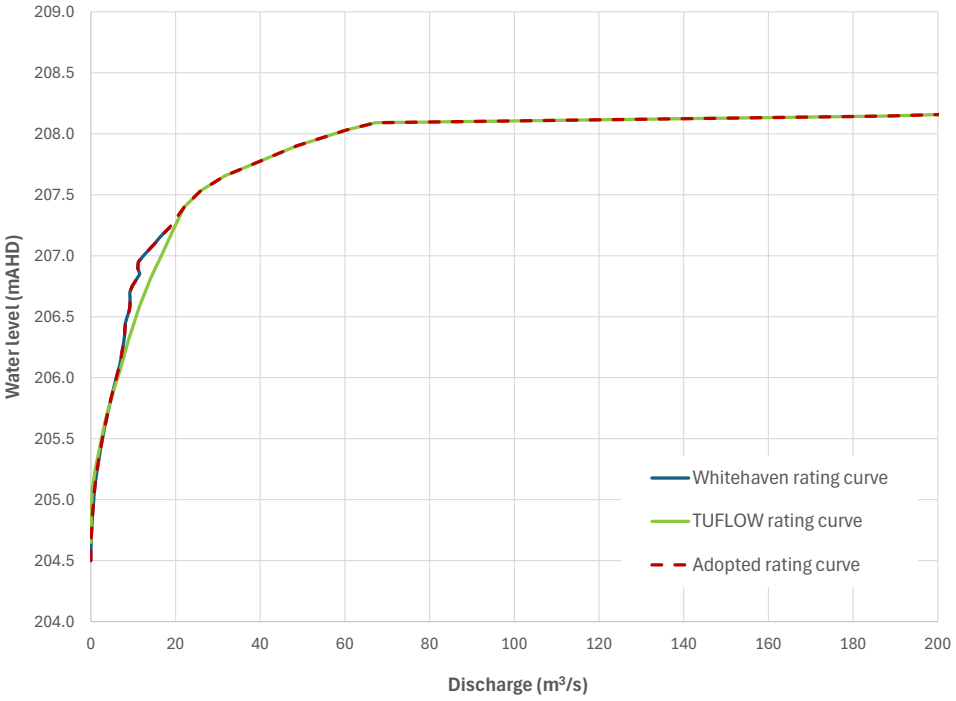


Figure 3.2 Comparison of Whitehaven-supplied, TUFLOW and adopted rating curves, Two Mile Gully gauging station

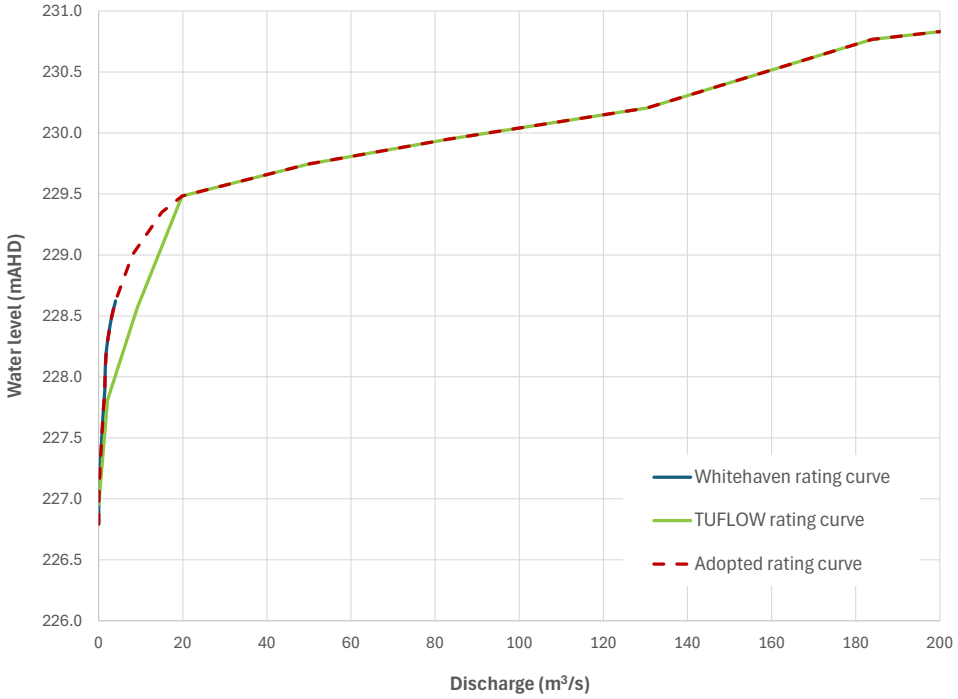


Figure 3.3 Comparison of Whitehaven-supplied, TUFLOW and adopted rating curves, Burngrove Creek U/S gauging station

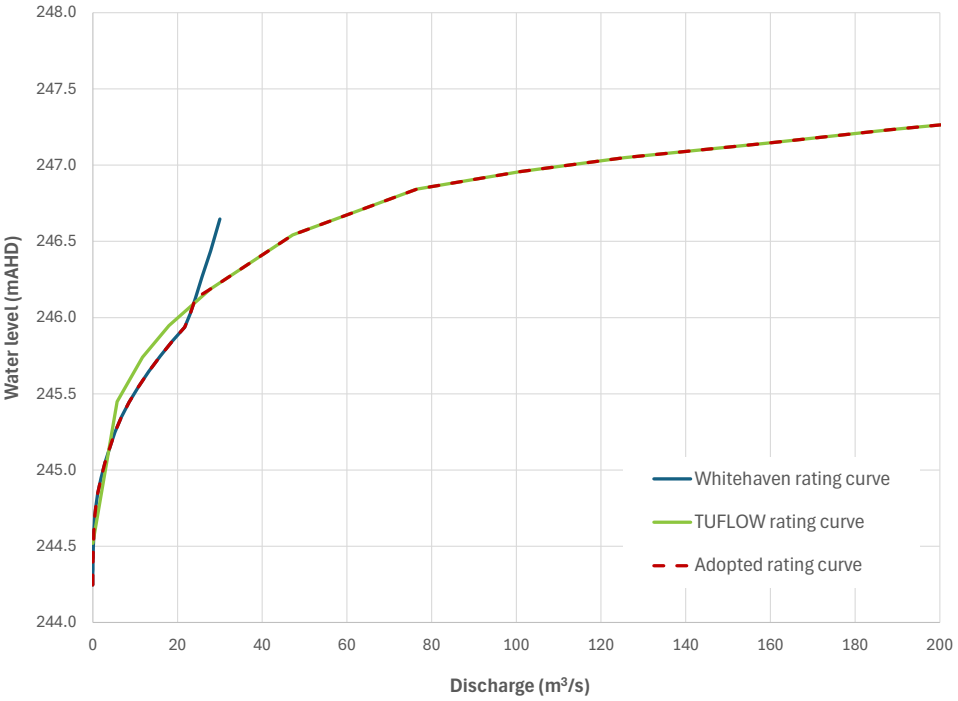


Figure 3.4 Comparison of Whitehaven-supplied, TUFLOW and adopted rating curves, Sirius Creek D/S gauging station

3.4 TOPOGRAPHIC DATA

The available topographic data used for this study is described as follows:

- A 1 m resolution LiDAR covering the BWM mine lease area captured in February 2024 (referred to as the 2024 LiDAR data);
- A 1 m resolution LiDAR covering the active mining pits of BWM captured in February 2025 (referred to as the 2025 LiDAR data); and
- A 30 m resolution Copernicus Digital Surface Model (DSM) satellite ground level observation data obtained from the European Space Programme on 31 January 2025 (referred to as the Copernicus DSM data).

4 HYDROLOGIC MODEL DEVELOPMENT

4.1 OVERVIEW

A total of seven URBS hydrologic models were developed for the following catchments:

- Bonnie Doon Creek;
- Blackwater Creek (including Taurus Creek and Two Mile Gully);
- Burngrove Creek;
- Rockland Creek;
- Sagittarius Creek;
- Sirius Creek;
- Speculation Creek.

URBS is a runoff-routing computer model that uses a network of conceptual storages to represent the routing of rainfall excess through a catchment. The URBS model was used in the "split mode" which enables the separate simulation of catchment and channel routing.

The initial and continuing loss method was adopted for this study. This model assumes that there is an initial loss (IL) in mm before any rainfall becomes runoff. After this, a continuing loss (CL) rate in mm per hour is applied to the rainfall.

Full details of the URBS model and its features are given in the URBS User Manual (Carroll, 2021).

The following three models were calibrated to recorded data for the March 2017 and January 2020 flood events:

- Burnrgrove Creek;
- Blackwater Creek (including Taurus Creek and Two Mile Gully);
- Sirius Creek.

The above three models were selected for calibration due to due to having stream gauging stations located in areas where detailed LiDAR data is available. This allowed for the rating curves to be verified using hydraulic model results.

The following is of note with regard to the remaining four models:

- Bonnie Doon Creek, Sagittarius Creek and Rockland Creek – There are no stream gauging stations within this catchment and hence, a model calibration cannot be undertaken for this catchment.
- Speculation Creek – The supplied rating curve for the Speculation Creek D/S gauge does not capture the peak flows that occurred in the March 2017 and January 2020 events. In addition, the Speculation Creek D/S gauging station is located outside of the detailed 2024 LiDAR data extent and as such, the supplied rating curve cannot be verified using hydraulic modelling.

The URBS models were then used to estimate design discharges for the 1% AEP event. The 1% AEP design discharge estimates were validated against estimates derived using the Rational Method, the Quantile Regression Technique (QRT) and the Regional Flood Frequency Estimation (RFFE) method.

4.2 MODEL CONFIGURATION

4.2.1 Subcatchment parameters

The URBS model subcatchments were assigned with area, slope, imperviousness, and PERN parameters. Subcatchment slopes were calculated using based on the available topographic data. The spatial configuration of the seven URBS models are summarised below.

4.2.1.1 Bonnie Doon Creek (BDC)

Figure A.1 in Appendix A shows the URBS model subcatchments adopted for the BDC model. The model covers an area of 21.6 km^2 and consists of 18 subcatchments, ranging in size from 0.17 km^2 to 2.46 km^2. Table A.1 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.1.2 Sagittarius Creek (SGC)

Figure A.2 in Appendix A shows the URBS model subcatchments adopted for the SGC model. The model covers a catchment area of 42.7 km^2 and consists of 28 subcatchments, ranging in size from 0.02 km^2 to 3.34 km^2. Table A.2 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.1.3 Burngrove Creek (BGC)

Figure A.3 in Appendix A shows the URBS model subcatchments adopted for the BGC model. The model covers an area of 79.2 km^2 and consists of 54 subcatchments, ranging in size from 0.06 km^2 to 5.72 km^2. Table A.3 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.1.4 Blackwater Creek (BWC)

Figure A.4 in Appendix A shows the URBS model subcatchments adopted for the BWC model. The model covers an area of 509.8 km^2 and consists of 226 subcatchments, ranging in size from 0.02 km^2 to 17.8 km^2. Table A.4 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.1.5 Speculation Creek (SPC)

Figure A.5 in Appendix A shows the URBS model subcatchments adopted for the SPC model. The model covers an area of 60.31 km^2 and consists of 39 subcatchments, ranging in size from 0.07 km^2 to 4 km^2. Table A.5 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.1.6 Sirius Creek (SRC)

Figure A.6 in Appendix A shows the URBS model subcatchments adopted for the SRC model. The model covers an area of 162 km^2 and consists of 85 subcatchments, ranging in size from 0.13 km^2 to 6.15 km^2. Table A.6 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.1.7 Rockland Creek (RLC)

Figure A.7 in Appendix A shows the URBS model subcatchments adopted for the SRC model. The model covers ant area of 158.6 km^2 and consists of 62 subcatchments, ranging in size from 0.14 km^2 to 8.5 km^2. Table A.7 in Appendix A shows the subcatchment parameters adopted in the model under existing land use conditions.

4.2.2 Adopted global URBS model parameters

The global URBS model parameters included channel lag parameter (alpha), catchment storage parameter (beta), catchment non-linearity (M) and channel routing exponent (N). The following global URBS parameters were adopted for all seven models:

- Channel routing “alpha” (α) = 0.1
- Catchment routing “beta” (β) = 1.0
- Catchment routing exponent (M) = 0.715
- Channel routing exponent (N) = 1.0

4.3 INITIAL AND CONTINUING LOSSES

The initial loss (IL) and continuing loss (CL) method of accounting for rainfall losses was adopted for this study. For the calibration events, different initial and continuing losses were derived for each calibration event to reflect different antecedent catchment conditions (refer to Section 5.3). Design event ILs and CLs were derived during the model validation process (refer to Section 6.2.2).

5 HYDROLOGIC MODEL CALIBRATION

5.1 METHODOLOGY

The URBS models for the Burngrove Creek, Blackwater Creek and Sirius Creek were calibrated for the March 2017 and January 2020 flood events. The purpose of the model calibration was to achieve the best possible match between URBS-modelled discharge hydrographs against the recorded discharge hydrographs, using a common set of model parameters between flood events.

5.2 SELECTION OF CALIBRATION EVENTS

5.2.1 Overview

The March 2017 and January 2020 flood events were selected for calibration due to the availability of data and because the rainfalls during these events triggered similar responses at all catchments for which data is available. The March 2017 and January 2020 events were also the selected calibration events in the GHD (2021) study.

Table 5.1 shows the adopted historical event simulation periods for the calibration events in the URBS model. Table 5.2 shows the recorded rainfall depths at each station for the calibration events. Table 5.3 shows the recorded peak discharges at each gauging station for the calibration events.

Table 5.1 Calibration event simulation periods

Calibration Event	Simulation period
March 2017	28 March (0000 hours) – 1 April (0000 hours) - 4 days
January 2020	24 January (0000 hours) – 27 January (0000 hours) - 3 days

Table 5.2 Total rainfall depths recorded during the 2017 and 2020 events

Station Number	Station Name	Rainfall depth (mm)	
		March 2017	January 2020
330107	Central WS	119.0	148.0
330122	Northern WS	139.5	78.5
330123	Southern WS	142.5	49.5

Table 5.3 Peak discharges recorded during calibration events

Station Number	Station Name	Peak discharge (m^3/s)	
		March 2017	January 2020
330127	Burngrove Creek U/S	78.5	22.2
330101	Taurus Creek D/S	117	156.8
330124	Two Mile Gully	16.2	50.4
330118	Sirius Creek D/S	15.9	8.6

5.2.2 March 2017 event

Figure B.1 to Figure B.3 (Appendix B) show the rainfall intensity recorded at each available rainfall station listed in Table 5.2 over the period 0000 hours on 28 March 2017 to 0000 hours on 1 April 2017 within and near the catchments of interest. The highest rainfall intensity of 29 mm/h was recorded in the at the Southern WS Station (330123).

Figure B.4 to Figure B.8 (Appendix B) shows the recorded water levels at the stations listed in Table 5.3 over the same period.

5.2.3 January 2020 event

Figure B.9 to Figure B.11 (Appendix B) show the rainfall intensity recorded at each available rainfall station listed in Table 5.2 over the period 0000 hours on 24 January 2020 to 0000 hours on 27 January 2020 within and near the catchments of interest. The highest rainfall intensity of 46 mm/h was recorded at the Central WS Station (330107).

Figure B.12 to Figure B.16 (Appendix B) shows the recorded water levels at the stations listed in Table 5.3 over the same period.

5.2.4 Assignment of subcatchment rainfalls

Each URBS subcatchment was assigned a rainfall hyetograph based on the three nearest pluviograph stations, using the URBS SUBRAIN utility. The SUBRAIN utility calculates the weighted average rainfall depth for each subcatchment using an inverse distance squared method based on the relative distance between the rainfall station location and the subcatchment centroid.

5.3 INITIAL AND CONTINUING LOSSES

Table 5.4 shows the IL and CL adopted for the Blackwater Creek, Burngrove Creek and Sirius Creek catchments for the two calibration events. A CL of 3.5 mm/h was adopted for all three models and for all events. Different ILs were adopted for each model and for each event which reflect the different antecedent conditions prior to each event.

Table 5.4 Adopted initial and continuing losses

Model	March 2017		January 2020	
	IL (mm)	CL (mm/h)	IL (mm)	CL (mm/h)
BGC	52	3.5	53	3.5
BWC	82	3.5	75	3.5
SRC	125	3.5	73	3.5

5.4 MODEL CALIBRATION RESULTS

5.4.1 Overview

Table 5.5 shows the comparison of the calculated and recorded peak discharges at the four gauging stations for the 2017 and 2020 events.

Table 5.5 Summary of calibration results

Station Number	Station Name	Peak discharge (m^3/s)					
		March 2017			January 2020		
		Calculated	Recorded	Difference (%)	Calculated	Recorded	Difference (%)
330127	Burngrove Creek U/S	57.4	56.5	1.5%	22.5	22.2	1%
330101	Taurus Creek D/S	116.6	117.0	-0.3%	155.6	156.8	-1%
330124	Two Mile Gully	46.9	16.2	189.4%	79.1	50.4	57%
330118	Sirius Creek D/S	12.2	11.9	2.3%	9.0	8.6	4%

5.4.2 March 2017 event calibration results

Figure 5.1 to Figure 5.4 compare the modelled / calculated (C) and recorded (R) discharge hydrographs for the March 2017. The calibration results for the March 2017 event are summarised below.

- In Burngrove Creek, the calibration is considered good, with the modelled (calculated) hydrograph matching well with the recorded hydrograph peak, shape and timing at the Burngrove Creek U/S gauge.
- In Taurus Creek and Two Mile Gully:
  - The modelled (calculated) hydrograph matches well with the recorded hydrograph peak and shape at the Taurus Creek D/S gauge. However, the URBS model could not reproduce the recorded hydrograph shape, peak or timing further upstream at the Two Mile Gully gauge.
  - The recorded data suggests that the Two Mile Gully gauge appears to have malfunctioned during the event, as indicated by the following:

- The recorded water level hydrograph shape at the Two Mile Gully gauge is inconsistent with the recorded water levels at the Taurus Creek gauge (refer to Figure B.5 and B.6 in Appendix B).
- The catchment area to Two Mile Gully is around 27% of the catchment area to the Taurus Creek D/S gauge. Despite this, the recorded peak discharge at Two Mile Gully D/S is only 14% of the recorded peak discharge at Taurus Creek D/S. This indicates that the Two Mile Gully gauge likely did not capture the peak water level (and hence the peak discharge) during this event.
- In consideration of the above, the calibration in Two Mile Gully and Taurus Creek is considered acceptable.

- In Sirius Creek:
  - The modelled (calculated) hydrograph generally matches the recorded hydrograph shape and peak, but the timing of the modelled flood peak is significantly delayed compared to the recorded peak.
  - The reason for the discrepancy in timing between the modelled and recorded flood peak is uncertain. The catchment area to the Sirius Creek gauge is around 120 km^2 and on this basis, the flood peak is expected to occur much later than what the data is suggesting, similar to observations at the Taurus Creek and Two Mile Gully gauges for this event. This suggests that there could be an issue with the timing of the recorded water levels at the Sirius Creek gauge, but further investigation is required to confirm this.
  - In consideration of the above, the calibration in Sirius Creek is considered acceptable.

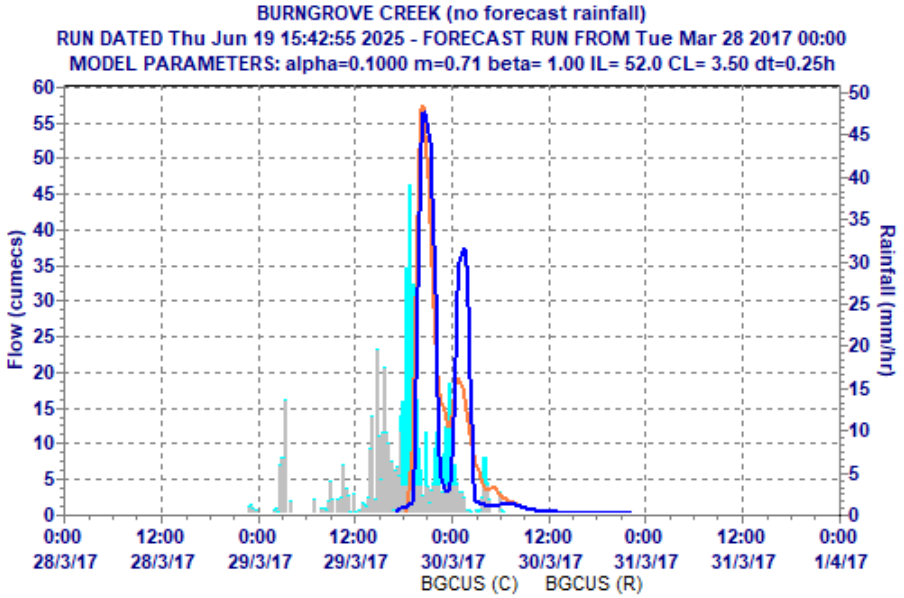


Figure 5.1 Calculated (C) and recorded (R) discharge hydrographs for March 2017 event at Burngrove Creek

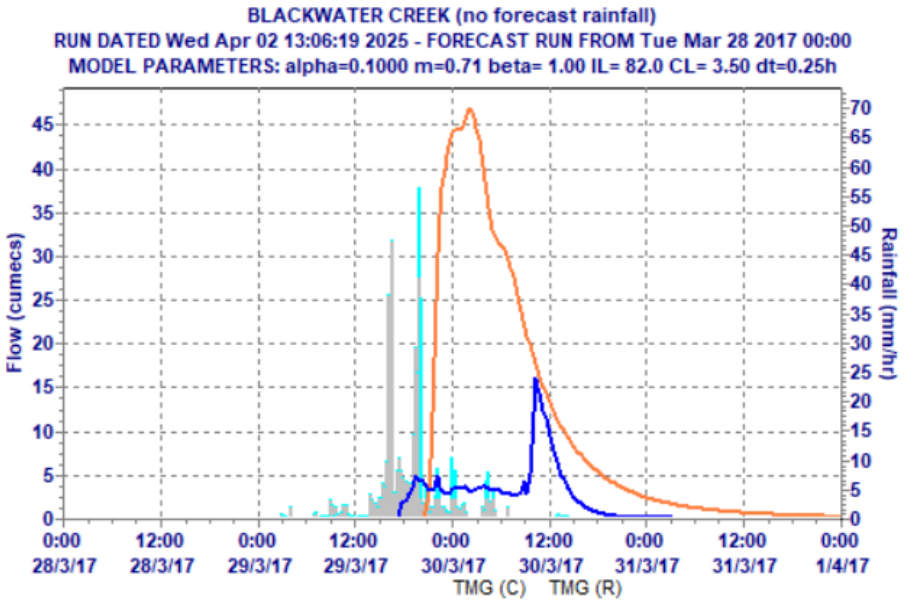


Figure 5.2 Calculated (C) and recorded (R) discharge hydrographs for March 2017 event at Two Mile Gully

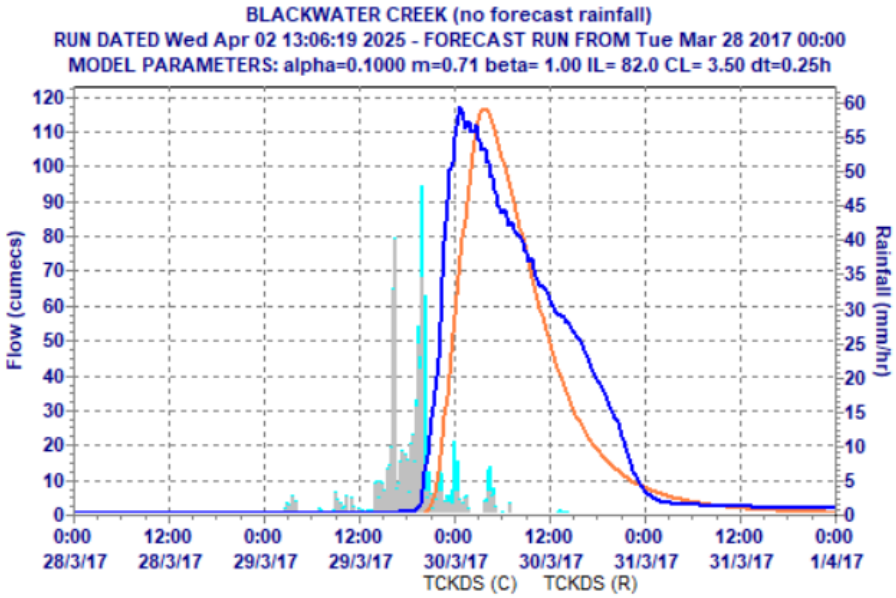


Figure 5.3 Calculated (C) and recorded (R) discharge hydrographs for March 2017 event at Taurus Creek

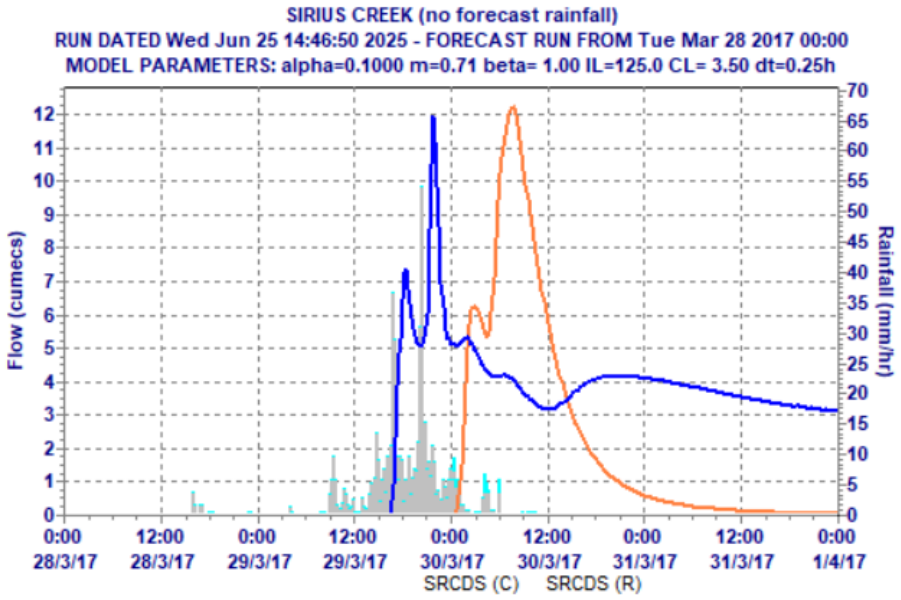


Figure 5.4 Calculated (C) and recorded (R) discharge hydrographs for March 2017 event at Sirius Creek

5.4.3 January 2020 event calibration results

Figure 5.5 to Figure 5.4 compare the modelled / calculated (C) and recorded (R) discharge hydrographs for the March 2017. The calibration results for the March 2017 event are summarised below

- In Burngrove Creek, the calibration is considered good, with the modelled (calculated) hydrograph matching well with the recorded hydrograph peak, shape and timing at the Burngrove Creek U/S gauge.
- In Taurus Creek and Two Mile Gully:
  - The modelled (calculated) hydrograph matches well with the recorded hydrograph peak and shape at the Taurus Creek D/S gauge. However, the URBS model could not reproduce the recorded hydrograph shape, peak or timing further upstream at the Two Mile Gully gauge.
  - Compared to the March 2017 event, there are similar discrepancies observed between the recorded water level hydrographs at Two Mile Gully and Taurus Creek D/S for the January 2020 event. This suggests that the Two Mile Gully gauge may not have accurately captured the peak flood level (and hence the peak discharge) during the January 2020 event, due to similar reasons described in Section 5.4.2 for the March 2017 event.
  - In consideration of the above, the calibration in Two Mile Gully and Taurus Creek is considered acceptable.
- In Sirius Creek:
  - The modelled (calculated) hydrograph generally matches the recorded hydrograph shape and peak, but the timing of the modelled flood peak is significantly delayed compared to the recorded peak.
  - The reason for the discrepancy in timing between the modelled and recorded flood peak is uncertain, but it is similar to the calibration results for the March 2017 event at this gauge

(refer to Section 5.4.2). This further suggests that there could be an issue with the timing of the recorded water levels at the Sirius Creek gauge, but further investigation is required to confirm this.

- In consideration of the above, the calibration in Sirius Creek is considered acceptable.

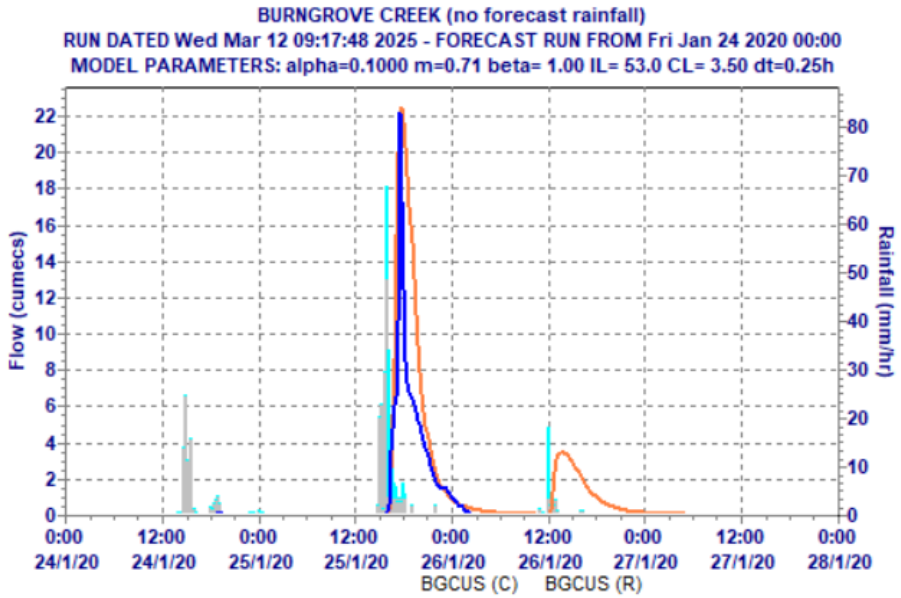


Figure 5.5 Calculated (C) and recorded (R) discharge hydrographs for January 2020 event at Burngrove Creek

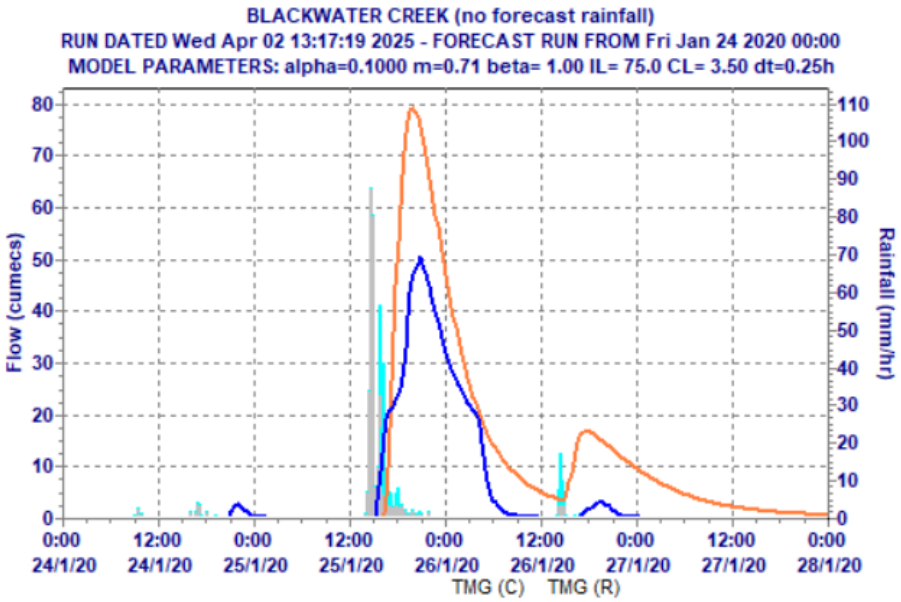


Figure 5.6 Calculated (C) and recorded (R) discharge hydrographs for January 2020 event at Two Mile Gully

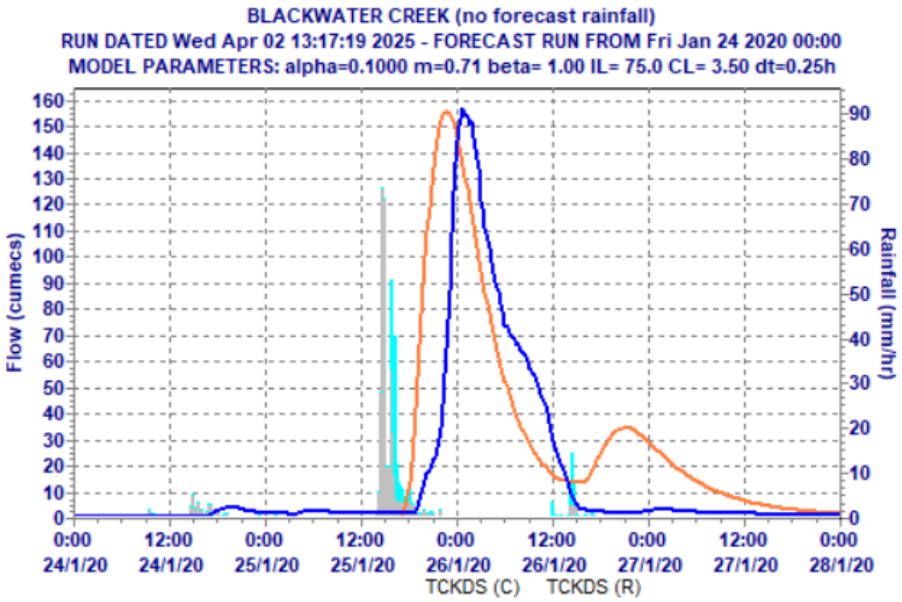


Figure 5.7 Calculated (C) and recorded (R) discharge hydrographs for January 2020 event at Taurus Creek

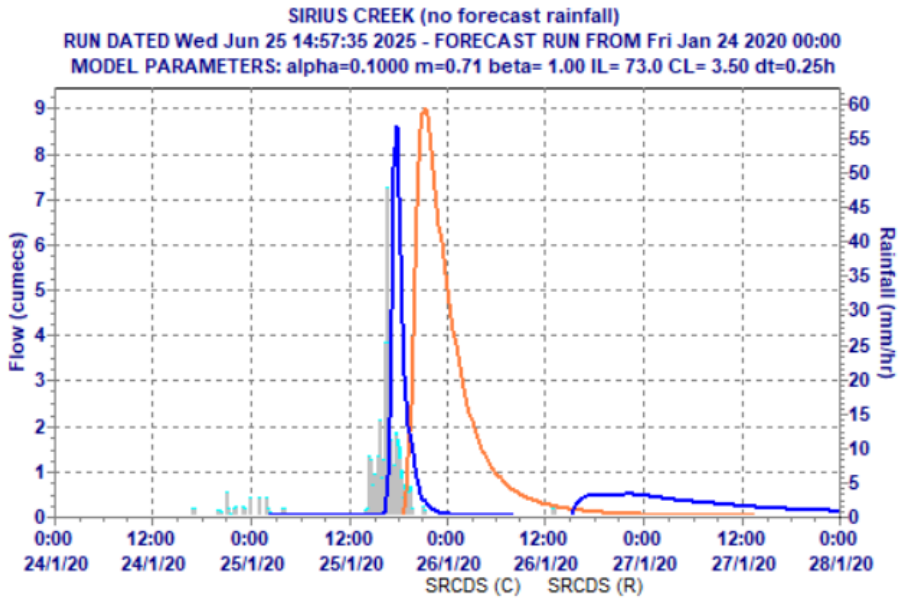


Figure 5.8 Calculated (C) and recorded (R) discharge hydrographs for January 2020 event at Sirius Creek

6 DESIGN DISCHARGE ESTIMATION AND VALIDATION

6.1 METHODOLOGY

URBS model design discharge estimates for all seven models were validated against discharge estimates derived using the Rational Method (RM), the Quantile Regression Technique (QRT) (Palmen and Weeks, 2015) and the Regional Flood Frequency Analysis (RFFE) method. Design peak discharges were validated for the 1% AEP event only, at key validation locations shown in Figure 6.1, which were selected to allow comparison of design discharges from all of the above-mentioned methods at the same location.

6.2 URBS MODEL PARAMETERS

6.2.1 Global model parameters

The global URBS model parameters (alpha, beta, M and N) given in Section 4.2.2 were adopted for design event modelling for all models.

6.2.2 Initial and continuing losses

Table 6.1 shows the ILs and CLs adopted for 1% AEP design event in each model.

The design event ILs are generally lower than those adopted for the calibration events (refer to Section 5.3). This reflects the high degree of catchment saturation that is expected prior to the main rainfall burst during rare events such as the 1% AEP. In comparison, the March 2017 and January 2020 calibration events were much smaller and more frequent events than a 1% AEP design event.

The adopted CLs for the seven models are generally consistent with the calibration event CLs (3.5 mm/h) except for the Rockland Creek and Sagittarius Creek models. Lower CLs were adopted for these models to achieve a better match between URBS model peak discharges and those derived from empirical methods.

Table 6.1 Adopted design event initial and continuing losses for the 1% AEP event

URBS Model	1% AEP losses	
	IL (mm)	CL (mm/h)
Bonnie Doon Creek (BDC)	5	3.5
Burngrove Creek (BGC)	35	3.5
Sagittarius Creek (SGC)	0	2
Blackwater Creek (BWC)	0	3.5
Speculation Creek (SPC)	0	3.5
Sirius Creek (SRC)	50	3.5
Rockland Creek (RLC)	0	2

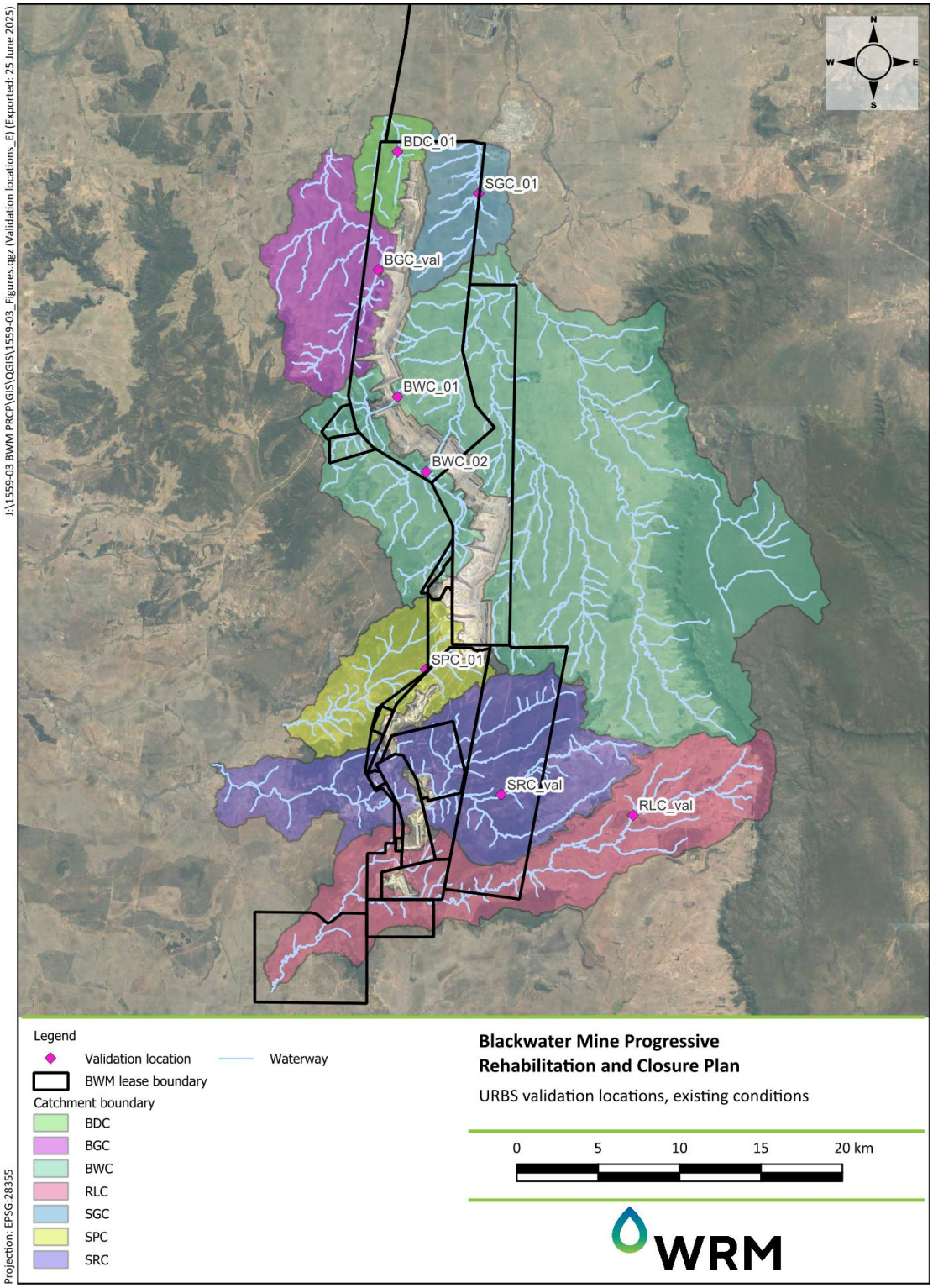


Figure 6.1 URBS validation locations

6.3 ADJUSTMENT FOR CLIMATE CHANGE

Based on the latest guidance on climate change provided in ARR 2019 v4.2, global temperatures have already risen since the baseline historical rainfall data midpoint of 1961-1990. Therefore, to assess current (2025) flood risks, design rainfall estimates require factoring up to account for this temperature increase that has already occurred.

Design Intensity-Frequency-Duration (IFD) design rainfall intensities were scaled up using uplift factors obtained from ARR datahub[1], corresponding to the SSP5-8.5 (year 2030) climate scenario. The associated pre-burst rainfalls were also scaled up accordingly.

The SSP5-8.5 climate adjustments account for approximately 1.3°C of global warming up to 2025 since the historical baseline period of 1961-1990. Table 6.2 shows the corresponding 1% AEP design rainfall uplift factors for various storm durations (as percentage increases compared to the baseline).

Table 6.2 Adopted design rainfall uplift factors (SSP5-8.5 year 2030)

Storm duration	Rainfall uplift factor
<1 hour	20%
1.5 Hours	18%
2 Hours	17%
3 Hours	16%
4.5 Hours	14%
6 Hours	13%
9 Hours	13%
12 Hours	12%
18 Hours	11%
>24 Hours	11%

6.4 MODEL VALIDATION RESULTS

Table 6.3 compares the URBS peak discharges for the 1% AEP design events against discharges estimated using the Rational Method, QRT and RFFE methods. For the RFFE, design peak discharges were estimated using both the 2016 and 2021 versions of the RFFE.

The validation results show that the URBS model predicted design peak discharges generally correspond well (within 20%) to the Rational Method and QRT design peak discharge estimates. However, the differences between URBS and RFFE peak discharges are greater.

There is considerable uncertainty in the RFFE design peak discharges, which are reliant upon the accuracy of Flood Frequency Analysis results from nearby gauged catchments. However, the URBS model predicted design peak discharges are generally within the range of uncertainty (i.e. 5th to 95th percentile) of the RFFE peak discharge estimates.

[1] https://data.arr-software.org/

Table 6.3 Model validation results for the 1% AEP event

Location (Figure 6.1)	1% AEP design peak discharge (m^3/s)					
	URBS	QRT	Rational Method	RFFE		
				Flow	5%ile	95%ile
BDC	78	77	73	316	83	1,102
BGC	259	203	222	493	144	1,550
BWC_L1	172	174	191	520	140	1,796
BWC_L2	190	189	176	471	130	1,596
RLC	110	176	119	785	212	2,758
SGC	147	182	170	535	141	1,868
SPC	117	116	133	583	155	2,049
SRC	203	190	168	1,084	304	3,672

7 REFERENCES

Ball et al, 2019	Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I (Editors), 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia.
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PPK, 1994	PPK Consultants Pty Ltd, March 1994, *Rockland Creek Diversion Construction Report*
SLR, 2024a	SLR Consulting Australia Pty Ltd, 10 October 2024, *Blackwater Mine Progressive Rehabilitation and Closure Plan – Voids in Floodplain Modelling*
SLR, 2024b	SLR Consulting Australia Pty Ltd, 10 October 2024, *Blackwater Mine Progressive Rehabilitation and Closure Plan – Rehabilitation Flood Assessments*
WRM, 2025a	WRM Water & Environment Pty Ltd, November 2025, *Blackwater Mine Progressive Rehabilitation and Closure Plan – Void in Floodplain Modelling*
WRM, 2025b	WRM Water & Environment Pty Ltd, November 2025, *Blackwater Mine Progressive Rehabilitation and Closure Plan – Final Landform Flood Modelling*

APPENDIX A URBS MODEL CONFIGURATION

A.1 BDC CATCHMENT

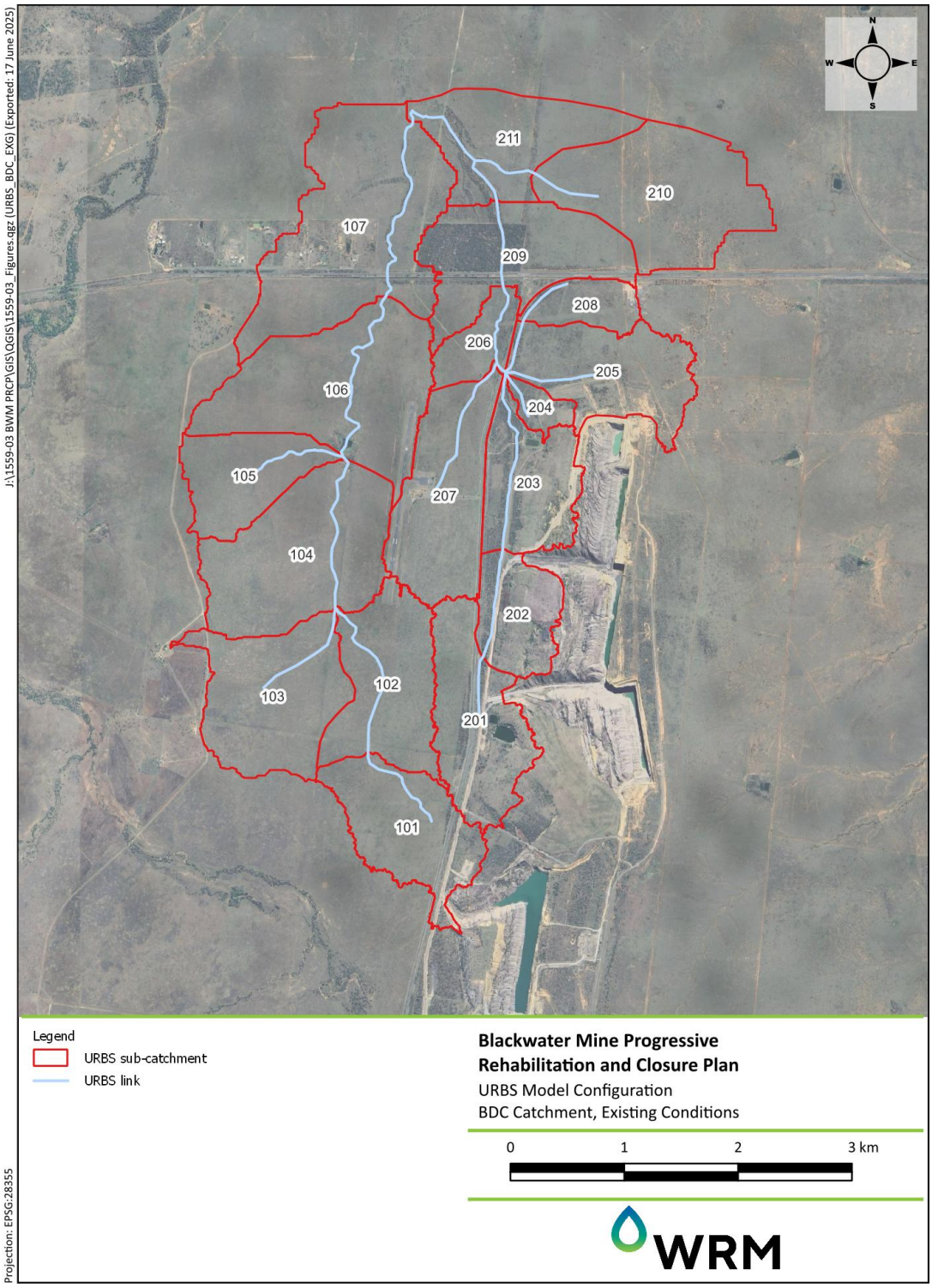


Figure A.1 URBS model configuration of the BDC catchment

Table A.1 URBS catchment parameters of the BDC catchment model

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	1.15	0	0.07	0.007
102	1.26	0	0.07	0.006
103	1.46	0	0.07	0.010
104	1.83	0	0.07	0.007
105	0.83	0	0.07	0.011
106	2.02	0	0.07	0.005
107	2.46	0	0.07	0.007
201	1.20	0	0.07	0.009
202	0.68	0	0.07	0.015
203	0.95	0	0.07	0.009
204	0.17	0	0.07	0.012
205	1.16	0	0.07	0.006
206	0.39	0	0.07	0.005
207	1.36	0	0.07	0.007
208	0.38	0	0.07	0.006
209	1.39	0	0.07	0.007
210	1.72	0	0.07	0.006
211	1.19	0	0.07	0.005

A.2 SGC CATCHMENT

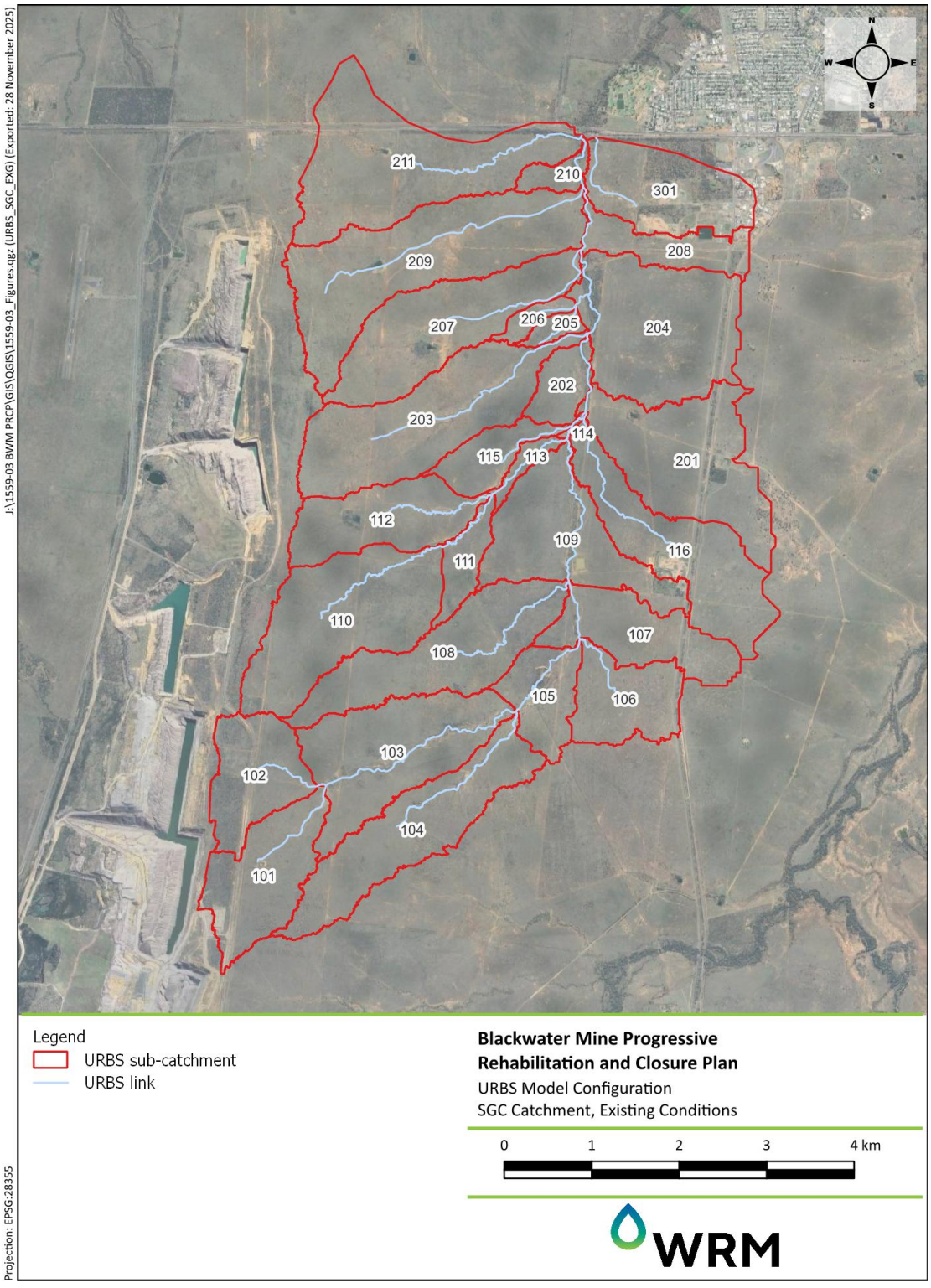


Figure A.2 URBS model configuration of the SGC catchment

Table A.2 URBS catchment parameters of the SGC catchment model

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	1.58	0	0.07	0.009
102	1.29	0	0.07	0.008
103	2.37	0	0.07	0.007
104	2.19	0	0.07	0.007
105	0.87	0	0.07	0.007
106	1.14	0	0.07	0.008
107	1.37	0	0.07	0.009
108	2.2	0	0.07	0.008
109	2.02	0	0.07	0.007
110	2.69	0	0.07	0.008
111	0.46	0	0.07	0.009
112	1.46	0	0.07	0.009
113	0.19	0	0.07	0.007
114	0.02	0	0.07	0.005
115	0.63	0	0.07	0.007
116	2.12	0	0.07	0.007
201	2.44	0	0.07	0.01
202	0.51	0	0.07	0.004
203	2.72	0	0.07	0.007
204	2.69	0	0.07	0.01
205	0.17	0	0.07	0.007
206	0.2	0	0.07	0.007
207	2.22	0	0.07	0.008
208	0.81	0	0.07	0.008
209	3.34	0	0.07	0.007

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
210	0.27	0	0.07	0.003
211	3.14	0	0.07	0.005
301	1.58	0	0.07	0.008

A.3 BGC CATCHMENT

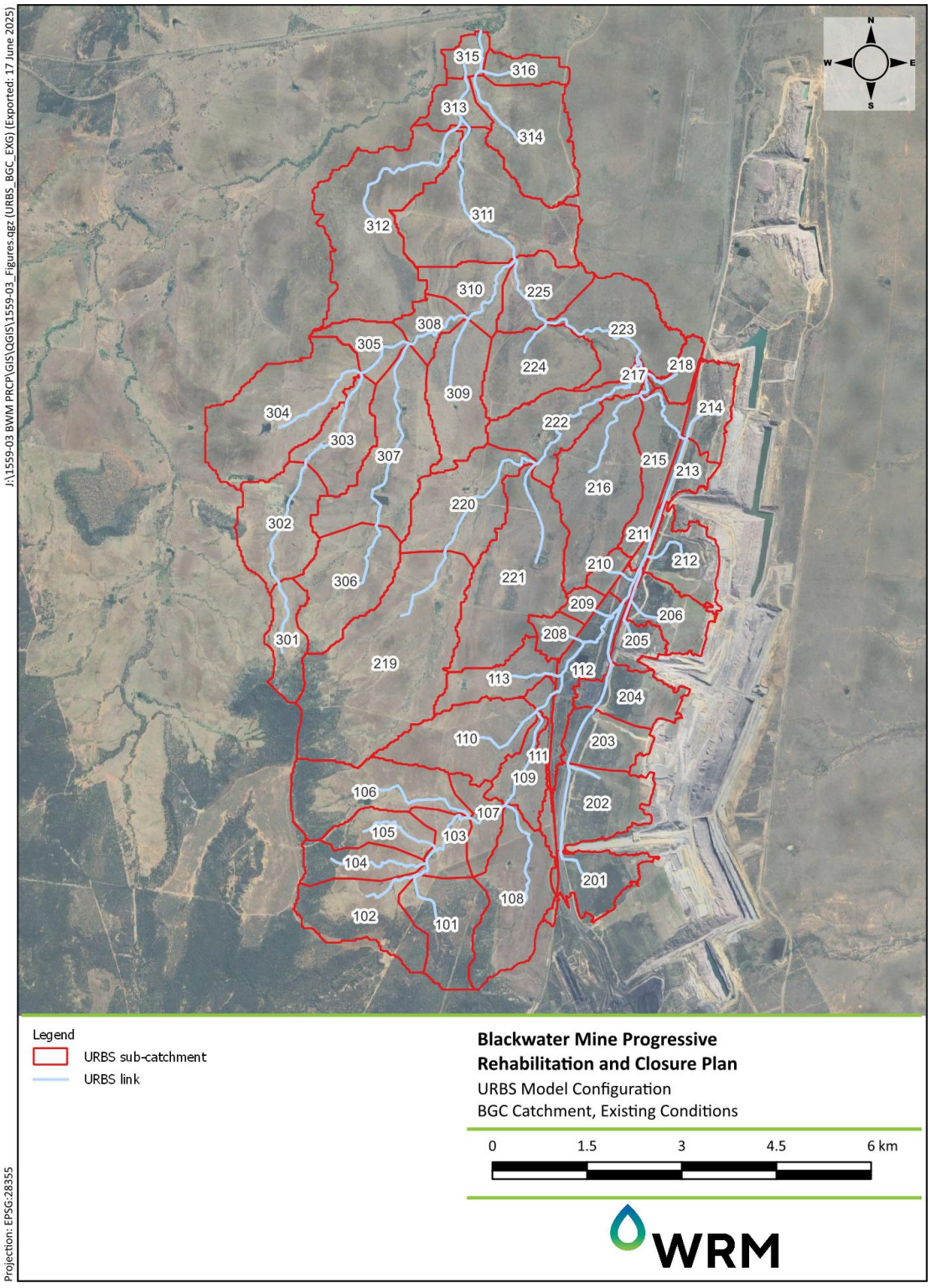


Figure A.3 URBS model configuration of the BGC catchment

Table A.3 URBS catchment parameters of the BGC catchment model

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	1.66	0	0.035	0.017
102	1.90	0	0.035	0.019
103	0.72	0	0.035	0.007
104	0.96	0	0.035	0.010
105	0.89	0	0.035	0.009
106	2.25	0	0.035	0.023
107	0.72	0	0.035	0.007
108	2.37	0	0.035	0.024
109	0.87	0	0.035	0.009
110	2.07	0	0.035	0.021
111	0.54	0	0.035	0.005
112	1.22	0	0.035	0.012
113	1.04	0	0.035	0.010
201	1.10	0	0.035	0.011
202	1.63	0	0.035	0.016
203	1.06	0	0.035	0.011
204	1.14	0	0.035	0.011
205	0.55	0	0.035	0.006
206	1.03	0	0.035	0.010
207	0.15	0	0.035	0.002
208	0.41	0	0.035	0.004
209	0.25	0	0.035	0.003
210	0.27	0	0.035	0.003
211	0.17	0	0.035	0.002
212	1.16	0	0.035	0.012

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
213	0.50	0	0.035	0.005
214	0.93	0	0.035	0.009
215	1.26	0	0.035	0.013
216	2.89	0	0.035	0.029
217	0.06	0	0.035	0.001
218	0.42	0	0.035	0.004
219	5.72	0	0.035	0.057
220	2.24	0	0.035	0.022
221	3.52	0	0.035	0.035
222	1.69	0	0.035	0.017
223	2.17	0	0.035	0.022
224	1.87	0	0.035	0.019
225	1.26	0	0.035	0.013
301	0.93	0	0.035	0.009
302	2.00	0	0.035	0.020
303	1.33	0	0.035	0.013
304	3.27	0	0.035	0.033
305	0.76	0	0.035	0.008
306	2.17	0	0.035	0.022
307	2.89	0	0.035	0.029
308	0.63	0	0.035	0.006
309	1.81	0	0.035	0.018
310	1.00	0	0.035	0.010
311	3.79	0	0.035	0.038
312	4.12	0	0.035	0.041

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
313	0.61	0	0.035	0.006
314	2.26	0	0.035	0.023
315	0.40	0	0.035	0.010
316	0.58	0	0.035	0.010

A.4 BWC CATCHMENT

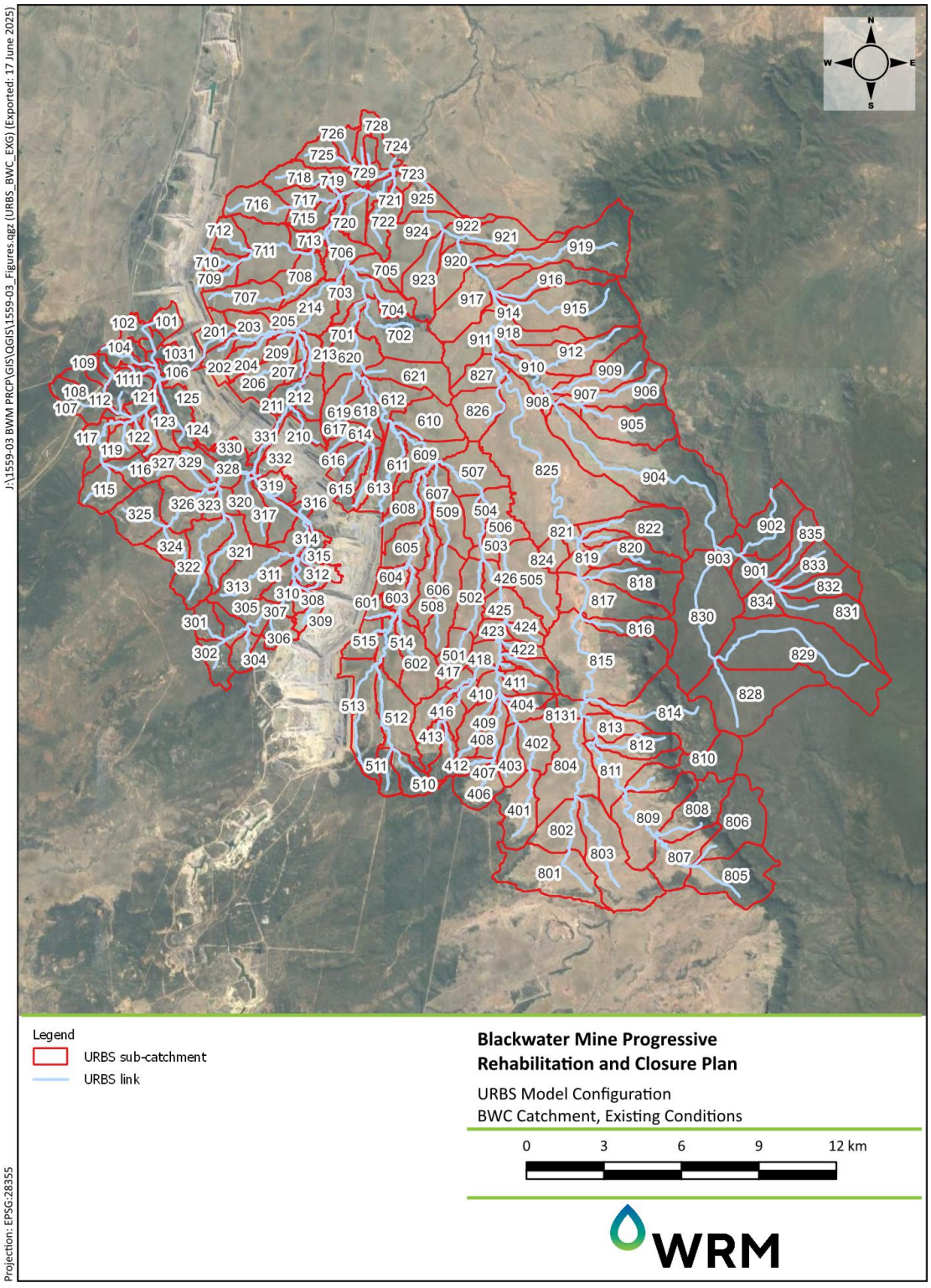


Figure A.4 URBS model configuration of the BWC catchment

Table A.4 URBS catchment parameters of the BWC catchment model

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	1.11	0	0.07	0.019
102	0.88	0	0.07	0.009
103	0.47	0	0.07	0.022
104	0.97	0	0.07	0.028
105	0.51	0	0.07	0.021
106	0.37	0	0.07	0.004
107	2.02	0	0.07	0.030
108	1.10	0	0.04	0.070
109	0.65	0	0.07	0.028
110	0.42	0	0.07	0.044
111	0.02	0	0.07	0.006
112	0.10	0	0.07	0.009
113	1.94	0	0.07	0.005
114	0.33	0	0.07	0.020
115	2.55	0	0.07	0.017
116	1.21	0	0.07	0.015
117	1.61	0	0.07	0.012
118	0.28	0	0.07	0.010
119	1.14	0	0.07	0.036
120	0.50	0	0.07	0.029
121	0.95	0	0.07	0.009
122	0.79	0	0.07	0.023
123	1.05	0	0.07	0.018
124	0.60	0	0.07	0.027
125	1.72	0	0.07	0.013

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
201	1.45	0	0.07	0.006
202	1.26	0	0.07	0.012
203	1.77	0	0.07	0.007
204	1.65	0	0.07	0.008
205	0.32	0	0.07	0.002
206	2.94	0	0.07	0.008
207	0.46	0	0.07	0.007
208	0.39	0	0.07	0.003
209	0.67	0	0.07	0.008
210	0.83	0	0.07	0.010
211	1.36	0	0.07	0.006
212	1.54	0	0.07	0.011
213	1.04	0	0.07	0.004
214	3.78	0	0.07	0.004
301	1.34	0	0.07	0.033
302	1.71	0	0.07	0.018
303	1.05	0	0.07	0.026
304	1.20	0	0.07	0.026
305	1.23	0	0.07	0.009
306	1.29	0	0.07	0.019
307	0.62	0	0.07	0.019
308	0.56	0	0.07	0.037
309	0.83	0	0.07	0.044
310	0.10	0	0.07	0.016
311	1.08	0	0.07	0.015

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
312	0.69	0	0.07	0.030
313	4.53	0	0.07	0.017
314	1.21	0	0.07	0.004
315	1.44	0	0.07	0.007
316	0.39	0	0.07	0.074
317	1.80	0	0.07	0.009
318	0.78	0	0.07	0.053
319	0.35	0	0.07	0.085
320	2.47	0	0.07	0.013
321	2.35	0	0.07	0.017
322	4.18	0	0.07	0.016
323	1.05	0	0.07	0.013
324	1.70	0	0.07	0.019
325	3.44	0	0.07	0.023
326	3.05	0	0.07	0.013
327	2.58	0	0.07	0.013
328	0.66	0	0.07	0.004
329	1.04	0	0.07	0.015
330	1.44	0	0.07	0.018
331	0.80	0	0.07	0.006
332	0.57	0	0.07	0.029
401	3.50	0	0.07	0.015
402	2.59	0	0.07	0.011
403	1.73	0	0.07	0.012
404	0.92	0	0.07	0.017

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
405	0.74	0	0.07	0.032
406	2.38	0	0.07	0.018
407	0.62	0	0.07	0.027
408	1.72	0	0.07	0.012
409	2.13	0	0.07	0.015
410	1.21	0	0.07	0.007
411	1.35	0	0.07	0.030
412	1.33	0	0.07	0.022
413	1.28	0	0.07	0.024
414	0.97	0	0.07	0.016
415	0.66	0	0.07	0.015
416	1.65	0	0.07	0.013
417	0.55	0	0.07	0.011
418	0.57	0	0.07	0.011
419	0.21	0	0.07	0.018
420	1.00	0	0.07	0.015
421	1.25	0	0.07	0.026
422	0.87	0	0.07	0.015
423	1.00	0	0.07	0.008
424	0.79	0	0.07	0.016
425	2.31	0	0.07	0.009
426	1.00	0	0.07	0.005
501	2.03	0	0.07	0.010
502	2.62	0	0.07	0.006
503	0.56	0	0.07	0.005

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
504	1.46	0	0.07	0.005
505	4.78	0	0.07	0.007
506	2.93	0	0.07	0.006
507	3.35	0	0.07	0.004
508	3.88	0	0.07	0.006
509	3.46	0	0.07	0.006
510	1.80	0	0.07	0.032
511	1.23	0	0.07	0.031
512	3.76	0	0.07	0.015
513	4.77	0	0.07	0.013
514	1.85	0	0.07	0.007
515	1.57	0	0.07	0.012
601	0.63	0	0.07	0.012
602	3.63	0	0.07	0.008
603	1.13	0	0.07	0.005
604	1.69	0	0.07	0.011
605	2.43	0	0.07	0.006
606	2.29	0	0.07	0.007
607	0.69	0	0.07	0.004
608	2.44	0	0.07	0.005
609	2.66	0	0.07	0.006
610	3.38	0	0.07	0.006
611	2.97	0	0.07	0.007
612	2.44	0	0.07	0.006
613	1.09	0	0.07	0.009

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
614	0.38	0	0.07	0.006
615	1.36	0	0.07	0.007
616	1.19	0	0.07	0.010
617	1.02	0	0.07	0.013
618	1.58	0	0.07	0.003
619	2.57	0	0.07	0.009
620	3.14	0	0.07	0.008
621	3.18	0	0.07	0.009
701	1.23	0	0.07	0.005
702	4.86	0	0.07	0.007
703	1.79	0	0.07	0.005
704	1.35	0	0.07	0.006
705	1.22	0	0.07	0.012
706	2.13	0	0.07	0.005
707	2.90	0	0.07	0.008
708	2.27	0	0.07	0.007
709	0.93	0	0.07	0.010
710	0.89	0	0.07	0.012
711	4.49	0	0.07	0.008
712	1.47	0	0.07	0.012
713	1.27	0	0.07	0.004
714	0.55	0	0.07	0.002
715	1.15	0	0.07	0.006
716	2.84	0	0.07	0.011
717	1.89	0	0.07	0.009

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
718	2.25	0	0.07	0.008
719	0.73	0	0.07	0.007
720	1.69	0	0.07	0.005
721	0.77	0	0.07	0.004
722	2.29	0	0.07	0.009
723	0.36	0	0.07	0.002
724	0.88	0	0.07	0.008
725	1.67	0	0.07	0.007
726	1.07	0	0.07	0.007
727	0.61	0	0.07	0.008
728	0.92	0	0.07	0.012
729	0.52	0	0.07	0.004
730	0.46	0	0.07	0.012
801	6.29	0	0.07	0.011
802	3.02	0	0.07	0.013
803	7.28	0	0.07	0.009
804	6.31	0	0.07	0.009
805	5.39	0	0.07	0.075
806	4.86	0	0.07	0.108
807	3.45	0	0.07	0.040
808	3.68	0	0.07	0.107
809	5.80	0	0.07	0.044
810	4.62	0	0.07	0.106
811	3.55	0	0.07	0.008
812	2.30	0	0.07	0.059

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
813	1.92	0	0.07	0.021
814	7.10	0	0.07	0.074
815	11.57	0	0.07	0.015
816	2.31	0	0.07	0.104
817	4.75	0	0.07	0.072
818	3.83	0	0.07	0.076
819	0.74	0	0.07	0.010
820	3.15	0	0.07	0.039
821	0.75	0	0.07	0.005
822	4.47	0	0.07	0.062
824	1.24	0	0.07	0.010
825	17.80	0	0.07	0.004
826	2.94	0	0.07	0.014
827	2.01	0	0.07	0.008
828	8.08	0	0.07	0.019
829	12.06	0	0.07	0.015
830	10.24	0	0.07	0.009
831	4.87	0	0.07	0.030
832	2.36	0	0.07	0.039
833	2.38	0	0.07	0.070
834	1.62	0	0.07	0.034
835	2.01	0	0.07	0.045
901	2.16	0	0.07	0.037
902	4.27	0	0.07	0.034
903	0.86	0	0.07	0.031

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
904	15.68	0	0.07	0.028
905	4.65	0	0.07	0.041
906	3.15	0	0.07	0.034
907	0.56	0	0.07	0.006
908	0.42	0	0.07	0.010
909	3.92	0	0.07	0.027
910	2.02	0	0.07	0.005
911	0.34	0	0.07	0.005
912	4.87	0	0.07	0.022
914	0.39	0	0.07	0.004
915	8.00	0	0.07	0.022
916	3.12	0	0.07	0.022
917	5.05	0	0.07	0.006
918	5.11	0	0.07	0.005
919	7.07	0	0.07	0.030
920	2.75	0	0.07	0.007
921	3.07	0	0.07	0.011
922	0.80	0	0.07	0.002
923	3.09	0	0.07	0.007
924	4.33	0	0.07	0.005
925	2.19	0	0.07	0.002
1031	0.72	0	0.07	0.012
1111	0.44	0	0.07	0.021
3091	0.20	0	0.07	0.036
8131	1.06	0	0.07	0.021

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
8211	0.76	0	0.07	0.026

A.5 SPC CATCHMENT

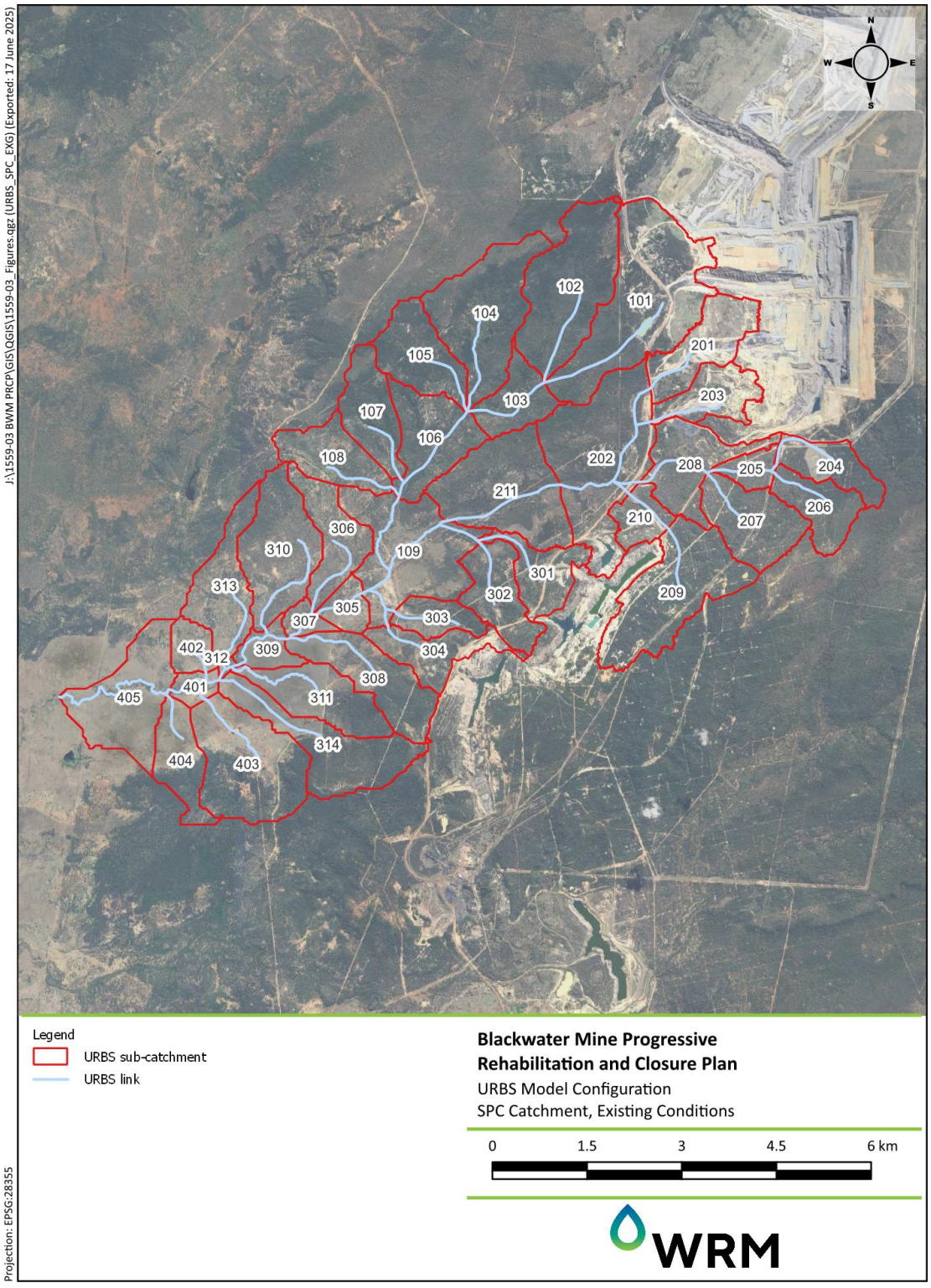


Figure A.5 URBS model configuration of the SPC catchment

Table A.5 URBS catchment parameters of the SPC catchment model

ID	Total Area (km2)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	4.00	0	0.07	0.012
102	2.89	0	0.07	0.018
103	1.00	0	0.07	0.016
104	2.70	0	0.07	0.016
105	1.47	0	0.07	0.028
106	1.69	0	0.07	0.017
107	1.31	0	0.07	0.027
108	1.27	0	0.07	0.027
109	2.90	0	0.07	0.009
201	1.45	0	0.07	0.019
202	3.63	0	0.07	0.007
203	1.05	0	0.07	0.025
204	0.98	0	0.07	0.032
205	0.45	0	0.07	0.029
206	1.07	0	0.07	0.032
207	1.60	0	0.07	0.029
208	1.55	0	0.07	0.011
209	2.80	0	0.07	0.038
210	0.66	0	0.07	0.027
211	2.77	0	0.07	0.011
301	1.06	0	0.07	0.017
302	1.30	0	0.07	0.022
303	0.69	0	0.07	0.024
304	1.12	0	0.07	0.022
305	0.49	0	0.07	0.009

ID	Total Area (km2)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
306	1.32	0	0.07	0.010
307	0.31	0	0.07	0.009
308	1.77	0	0.07	0.019
309	0.53	0	0.07	0.005
310	2.18	0	0.07	0.017
311	1.56	0	0.07	0.015
312	0.07	0	0.07	0.006
313	1.57	0	0.07	0.013
314	2.15	0	0.07	0.012
401	0.33	0	0.07	0.014
402	0.52	0	0.07	0.024
403	2.73	0	0.07	0.019
404	1.13	0	0.07	0.025
405	2.24	0	0.07	0.007

A.6 SRC CATCHMENT

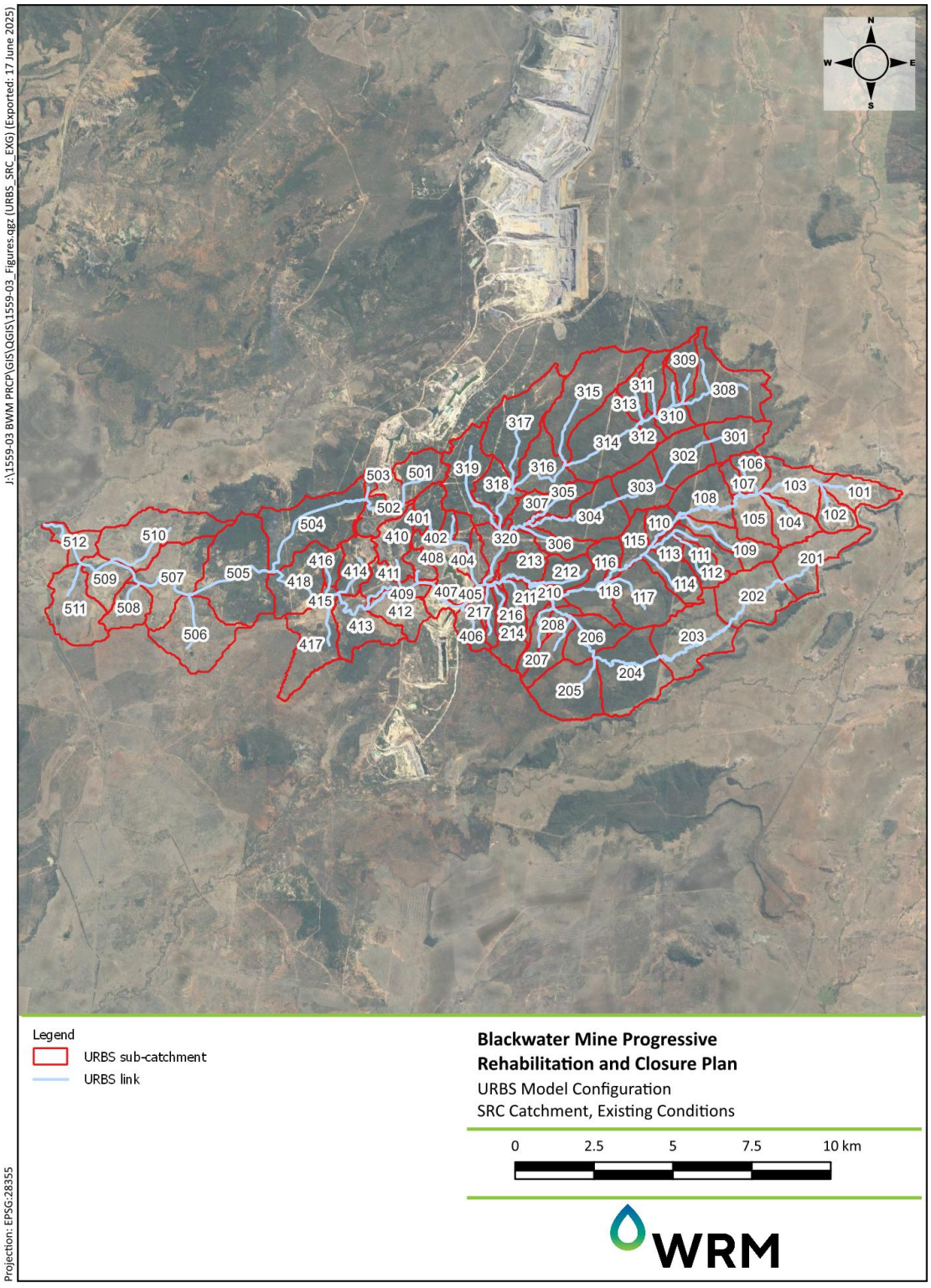


Figure A.6 URBS model configuration of the SRC catchment

Table A.6 URBS catchment parameters of the SRC catchment model

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	1.70	0	0.045	0.016
102	1.18	0	0.045	0.016
103	2.37	0	0.045	0.016
104	1.66	0	0.045	0.024
105	1.75	0	0.045	0.027
106	1.13	0	0.045	0.039
107	0.48	0	0.045	0.048
108	2.73	0	0.045	0.019
109	1.92	0	0.045	0.017
110	0.88	0	0.045	0.010
111	1.09	0	0.045	0.022
112	1.22	0	0.045	0.030
113	0.56	0	0.045	0.013
114	1.67	0	0.045	0.025
115	1.17	0	0.045	0.009
116	0.22	0	0.045	0.015
117	3.37	0	0.045	0.025
118	2.75	0	0.045	0.013
201	2.99	0	0.045	0.015
202	3.56	0	0.045	0.010
203	4.26	0	0.045	0.016
204	4.50	0	0.045	0.017
205	3.45	0	0.045	0.022
206	2.04	0	0.045	0.017
207	1.33	0	0.045	0.028

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
208	0.50	0	0.045	0.028
209	0.97	0	0.045	0.031
210	0.21	0	0.045	0.014
211	0.93	0	0.045	0.016
212	1.40	0	0.045	0.020
213	1.11	0	0.045	0.016
214	2.08	0	0.045	0.026
215	0.13	0	0.045	0.005
216	0.40	0	0.045	0.042
217	0.58	0	0.045	0.044
301	2.00	0	0.045	0.015
302	2.56	0	0.045	0.014
303	2.28	0	0.045	0.031
304	3.32	0	0.045	0.011
305	1.21	0	0.045	0.013
306	1.09	0	0.045	0.022
307	0.88	0	0.045	0.015
308	4.36	0	0.045	0.012
309	1.31	0	0.045	0.028
310	1.47	0	0.045	0.024
311	1.18	0	0.045	0.032
312	0.45	0	0.045	0.053
313	0.99	0	0.045	0.033
314	4.85	0	0.045	0.014
315	4.84	0	0.045	0.019

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
316	2.33	0	0.045	0.021
317	4.29	0	0.045	0.018
318	1.76	0	0.045	0.012
319	3.29	0	0.045	0.016
320	1.98	0	0.045	0.008
401	1.30	0	0.045	0.039
402	0.52	0	0.045	0.022
403	0.50	0	0.045	0.023
404	0.91	0	0.045	0.004
405	0.46	0	0.045	0.015
406	1.07	0	0.045	0.044
407	0.73	0	0.045	0.010
408	0.63	0	0.045	0.007
409	0.43	0	0.045	0.017
410	1.99	0	0.045	0.018
411	0.90	0	0.045	0.011
412	1.82	0	0.045	0.010
413	2.61	0	0.045	0.005
414	1.77	0	0.045	0.016
415	0.22	0	0.045	0.032
416	0.59	0	0.045	0.037
417	3.27	0	0.045	0.020
418	2.92	0	0.045	0.021
501	1.80	0	0.045	0.015
502	1.17	0	0.045	0.019

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
503	0.23	0	0.045	0.032
504	5.17	0	0.045	0.012
505	6.15	0	0.045	0.006
506	4.05	0	0.045	0.017
507	3.90	0	0.045	0.007
508	1.60	0	0.045	0.034
509	1.75	0	0.045	0.019
510	4.43	0	0.045	0.008
511	3.38	0	0.045	0.015
512	1.25	0	0.045	0.003

A.7 RLC CATCHMENT

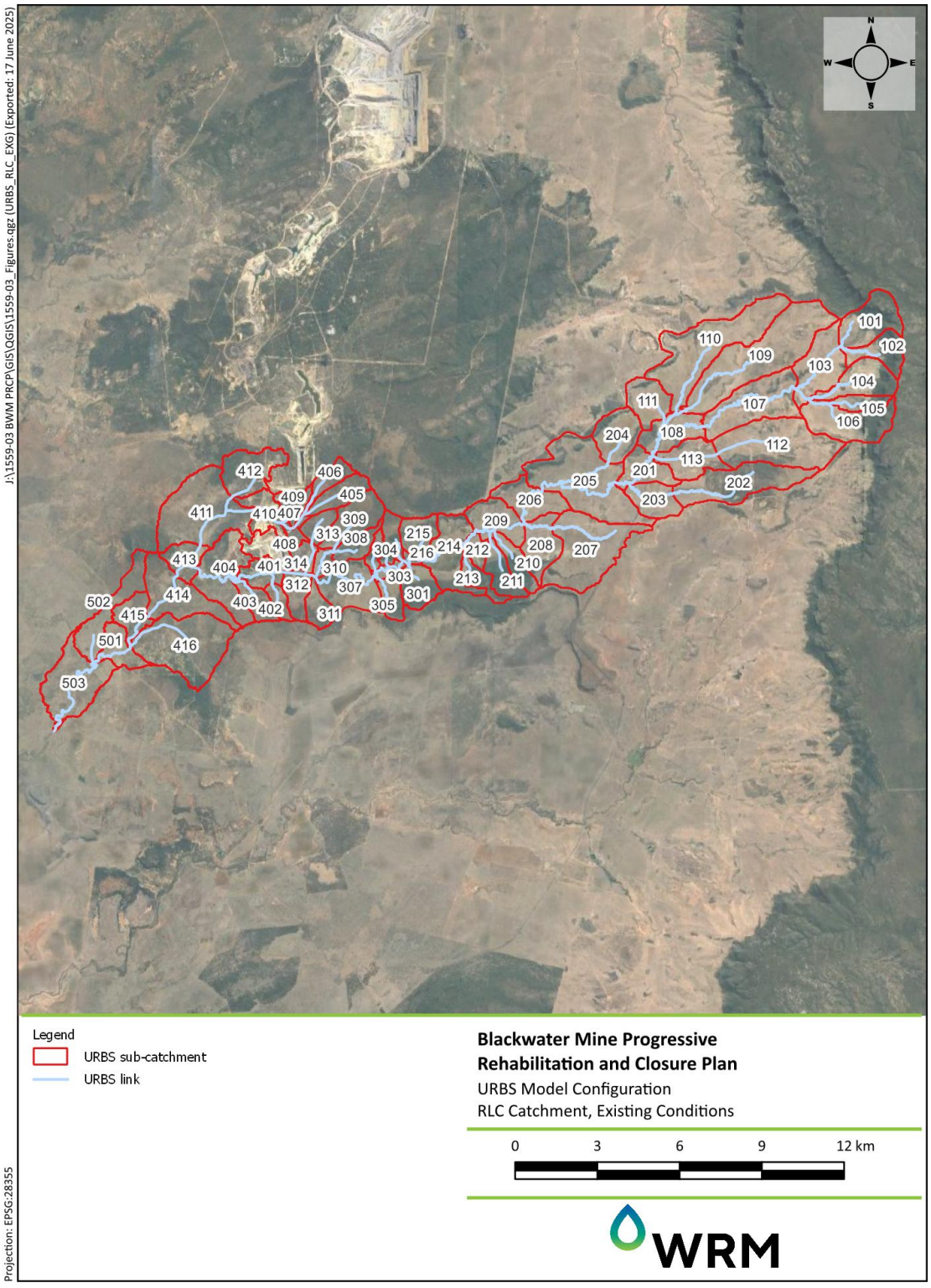


Figure A.7 URBS model configuration of the RLC catchment

Table A.7 URBS catchment parameters of the RLC catchment model

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
101	8.50	0	0.07	0.085
102	7.98	0	0.07	0.080
103	7.54	0	0.07	0.075
104	6.86	0	0.07	0.069
105	6.46	0	0.07	0.065
106	6.42	0	0.07	0.064
107	6.24	0	0.07	0.062
108	4.87	0	0.07	0.049
109	4.84	0	0.07	0.048
110	4.63	0	0.07	0.046
111	4.16	0	0.07	0.042
112	4.10	0	0.07	0.041
113	3.77	0	0.07	0.038
201	3.65	0	0.07	0.037
202	3.55	0	0.07	0.036
203	3.29	0	0.07	0.033
204	3.11	0	0.07	0.031
205	2.99	0	0.07	0.030
206	2.96	0	0.07	0.030
207	2.73	0	0.07	0.027
208	2.60	0	0.07	0.026
209	2.57	0	0.07	0.026
210	2.55	0	0.07	0.026
211	2.49	0	0.07	0.025
212	2.48	0	0.07	0.025

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
213	2.46	0	0.07	0.025
214	2.46	0	0.07	0.025
215	2.19	0	0.07	0.022
216	2.00	0	0.07	0.020
301	1.99	0	0.07	0.020
302	1.89	0	0.07	0.019
303	1.82	0	0.07	0.018
304	1.79	0	0.07	0.018
305	1.69	0	0.07	0.017
306	1.67	0	0.07	0.017
307	1.66	0	0.07	0.017
308	1.61	0	0.07	0.016
309	1.56	0	0.07	0.016
310	1.56	0	0.07	0.016
311	1.46	0	0.07	0.015
312	1.37	0	0.07	0.014
313	1.31	0	0.07	0.013
314	1.29	0	0.07	0.013
401	1.29	0	0.07	0.013
402	1.24	0	0.07	0.012
403	1.23	0	0.07	0.012
404	1.16	0	0.07	0.012
405	1.16	0	0.07	0.012
406	1.12	0	0.07	0.011
407	1.07	0	0.07	0.011

ID	Total Area (km²)	Percentage Impervious (%)	PERN 'n'	Catchment Slope (m/m)
408	1.05	0	0.07	0.011
409	1.00	0	0.07	0.010
410	0.76	0	0.07	0.008
411	0.75	0	0.07	0.008
412	0.75	0	0.07	0.008
413	0.66	0	0.07	0.007
414	0.60	0	0.07	0.006
415	0.51	0	0.07	0.005
416	0.49	0	0.07	0.005
501	0.29	0	0.07	0.003
502	0.23	0	0.07	0.002
503	0.14	0	0.07	0.001

APPENDIX B CALIBRATION EVENTS

B.1 2017 EVENT

B.1.1 Recorded rainfall

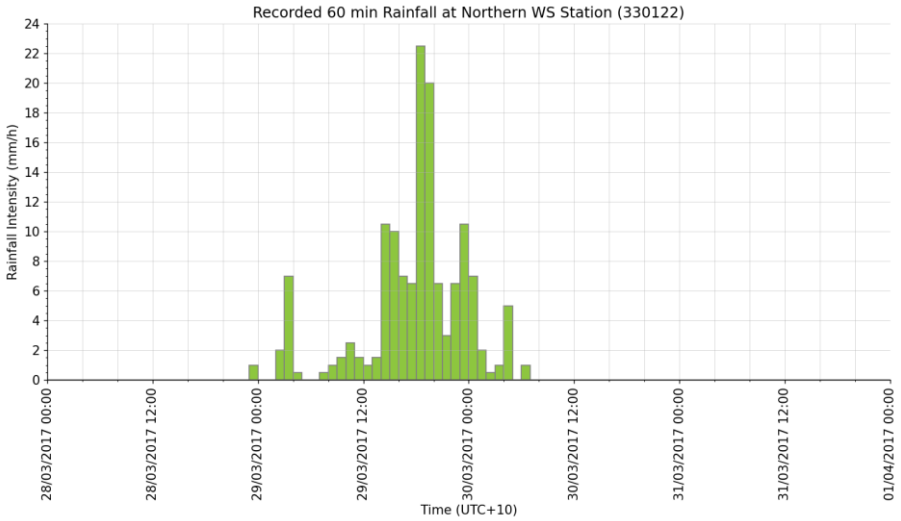


Figure B.1 Recorded rainfall at Northern WS Station (330122), 2017 event

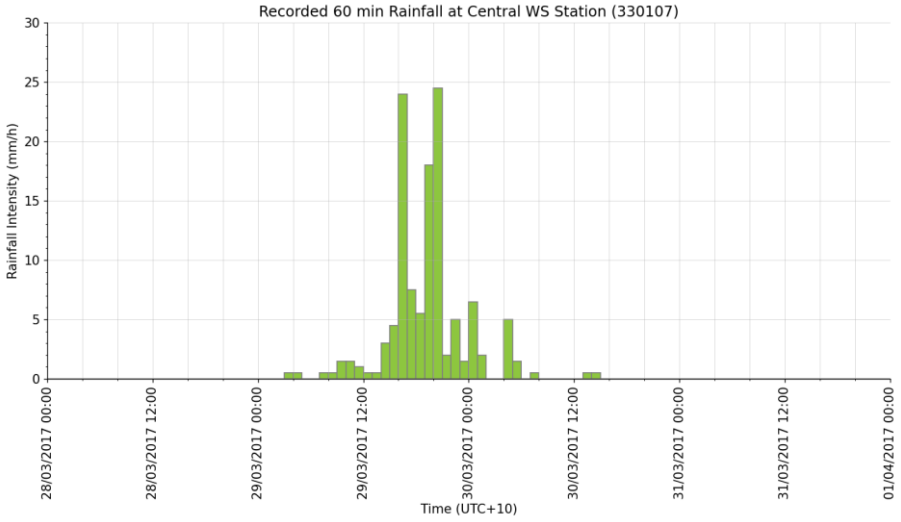


Figure B.2 Recorded rainfall at Central WS Station (330107), 2017 event

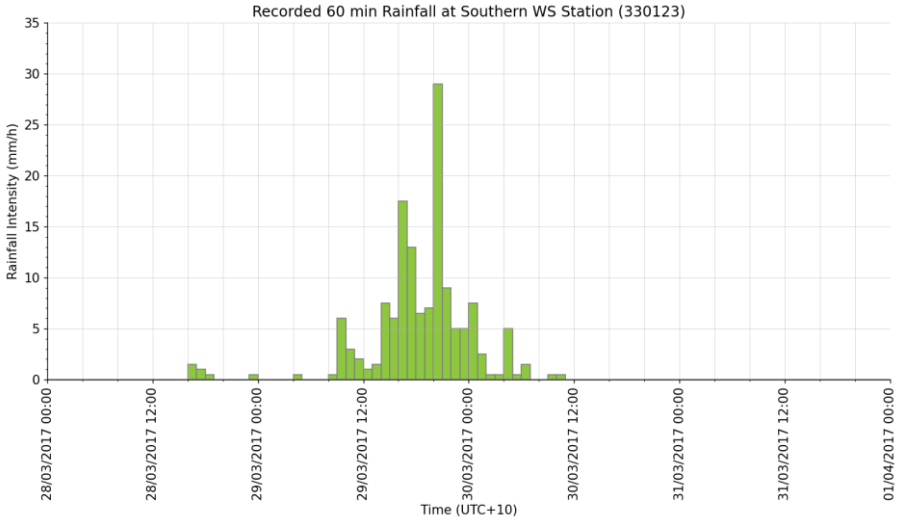


Figure B.3 Recorded rainfall at Southern WS Station (330123), 2017 event

B.1.2 Recorded water levels

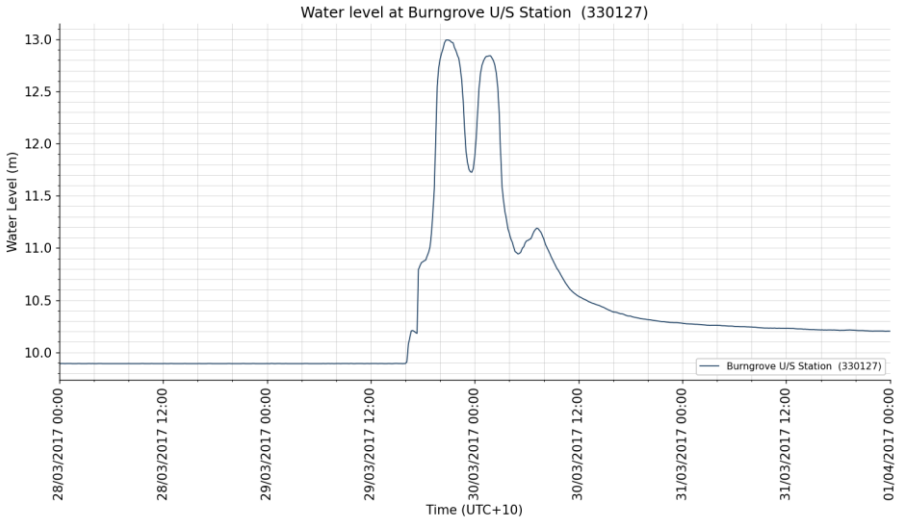


Figure B.4 Recorded water level at Burngrove D/S Station (330117), 2017 event

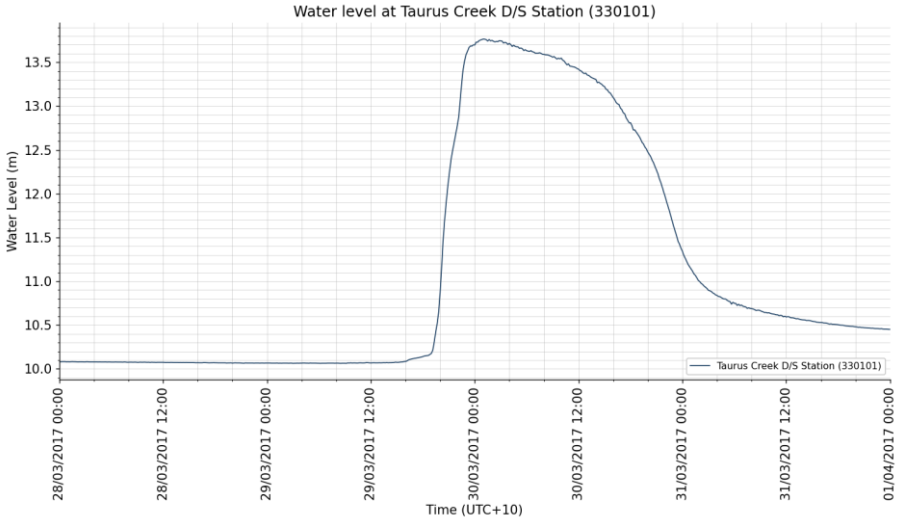


Figure B.5 Recorded water level at Taurus Creek D/S Station (330101), 2017 event

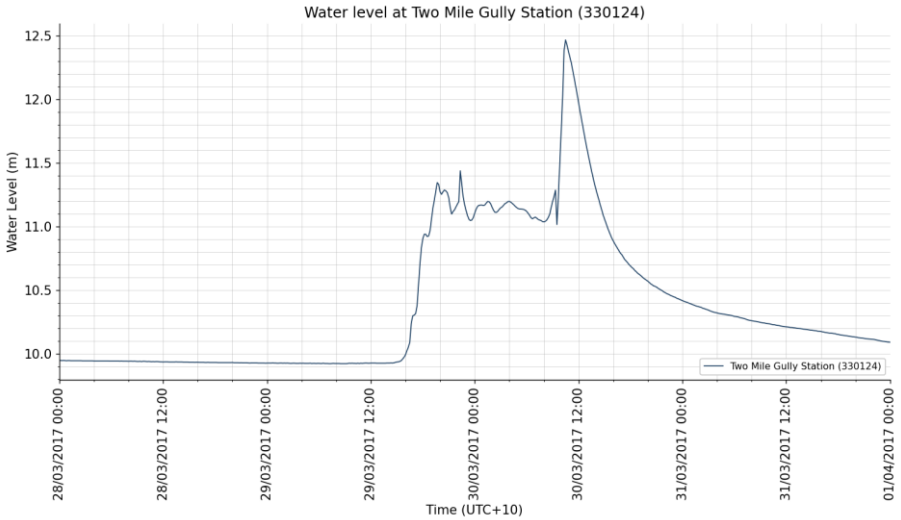


Figure B.6 Recorded water level at Two Mile Gully Station (330124), 2017 event

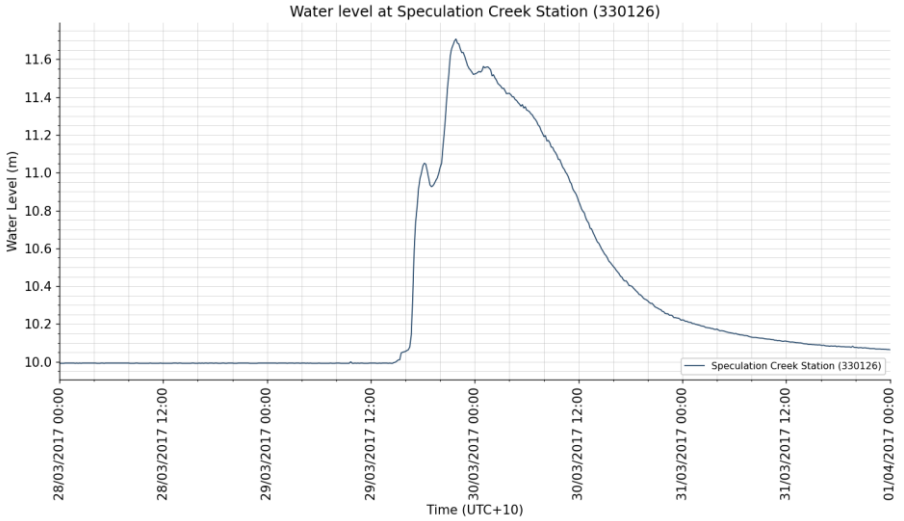


Figure B.7 Recorded water level at Speculation Creek Station (330126), 2017 event

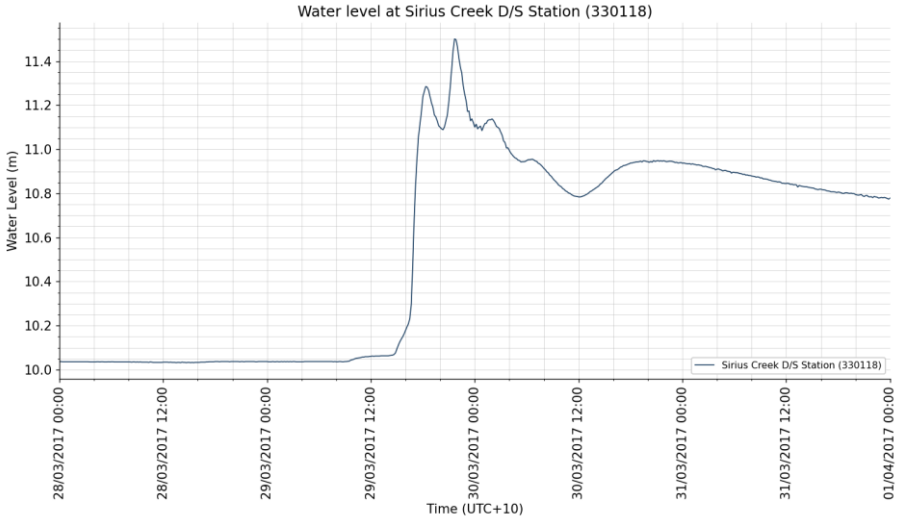


Figure B.8 Recorded water level at Sirius Creek Station (330118), 2017 event

B.2 2020 EVENT

B.2.1 Recorded rainfall

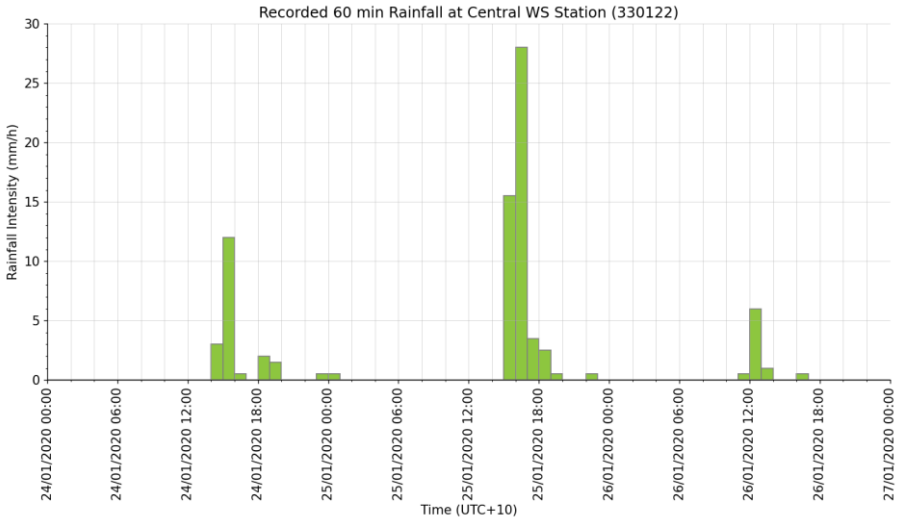


Figure B.9 Recorded rainfall at Northern WS Station (330122), 2020 event

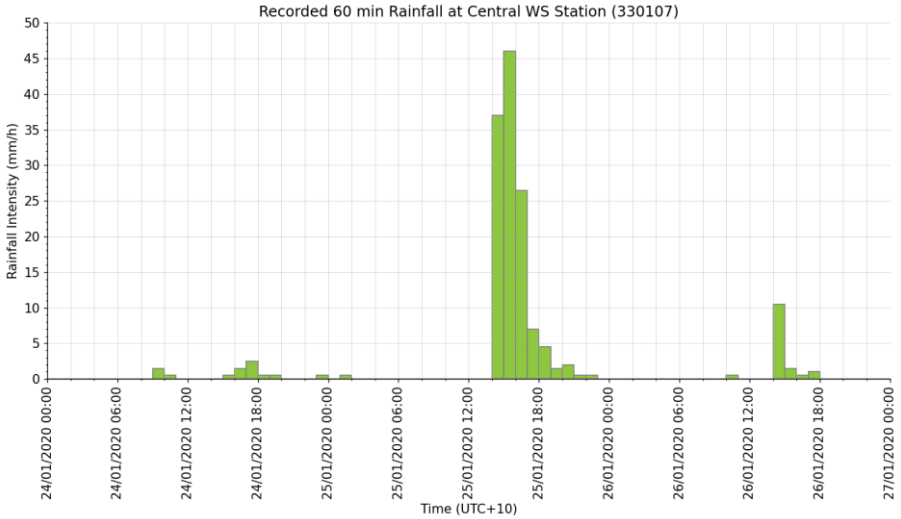


Figure B.10 Recorded rainfall at Central WS Station (330107), 2020 event

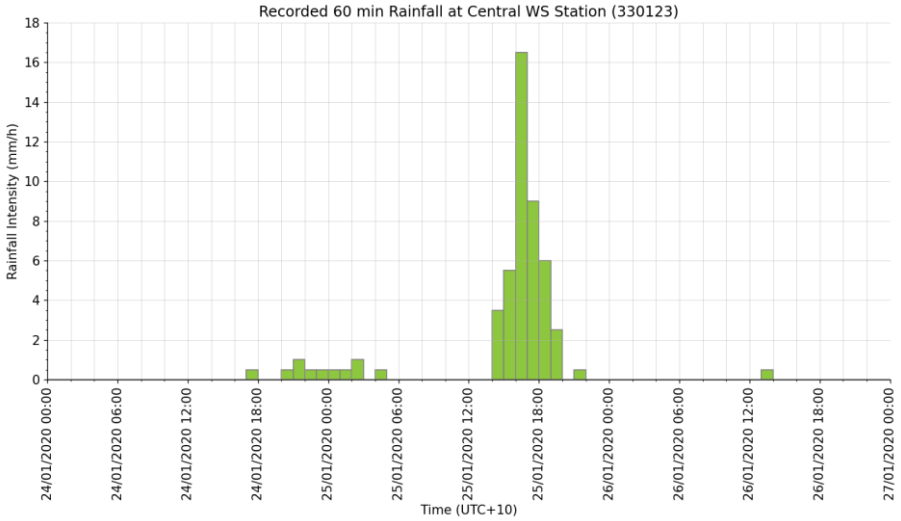


Figure B.11 **Recorded rainfall at Southern WS Station (330123), 2020 event**

B.2.2 Recorded water level

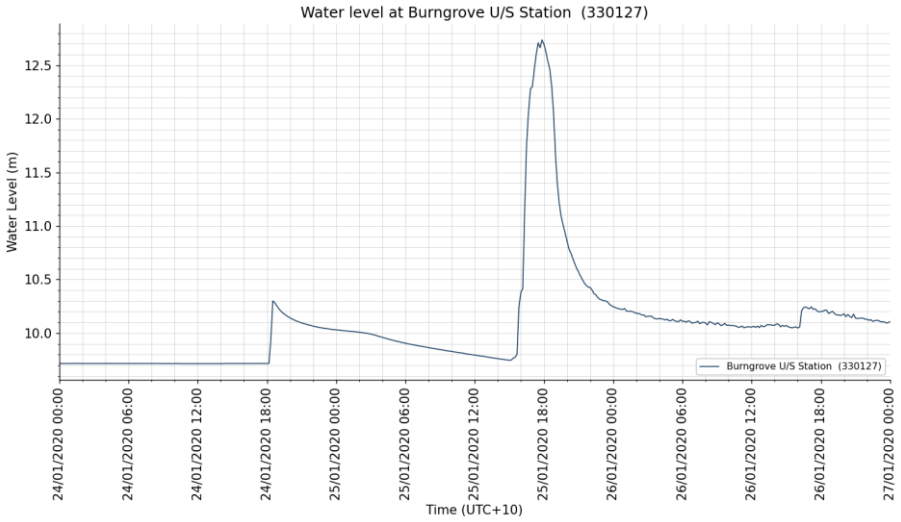


Figure B.12 **Recorded water level at Burngrove U/S Station (330127), 2020 event**

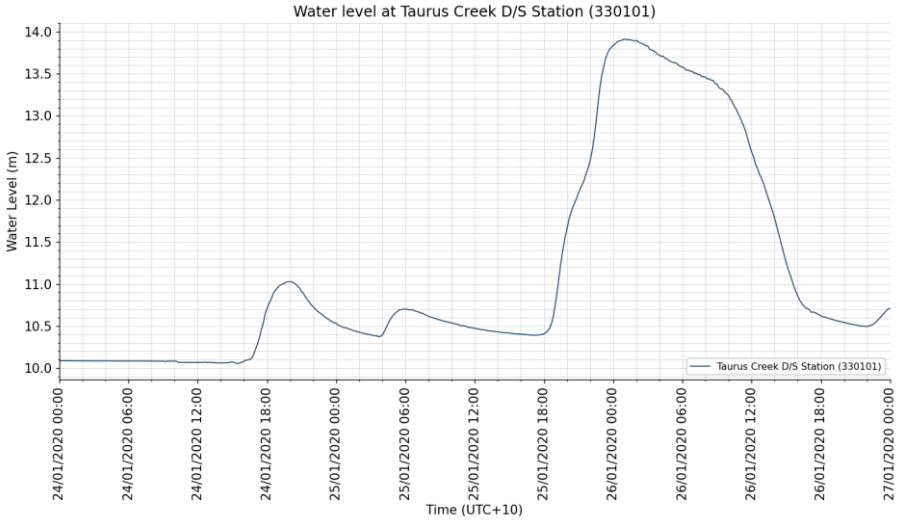


Figure B.13 **Recorded water level at Taurus Creek D/S Station (330101), 2020 event**

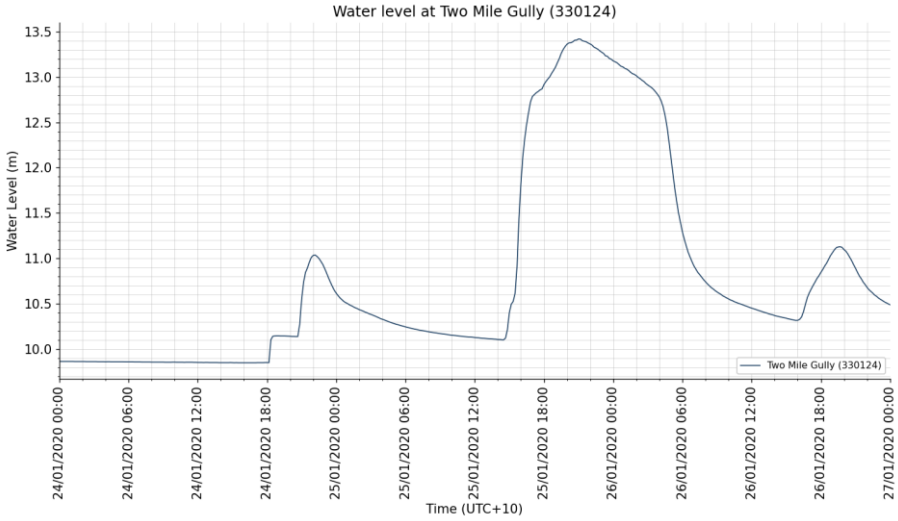


Figure B.14 **Recorded water level at Two Mile Gully Station (330124), 2020 event**

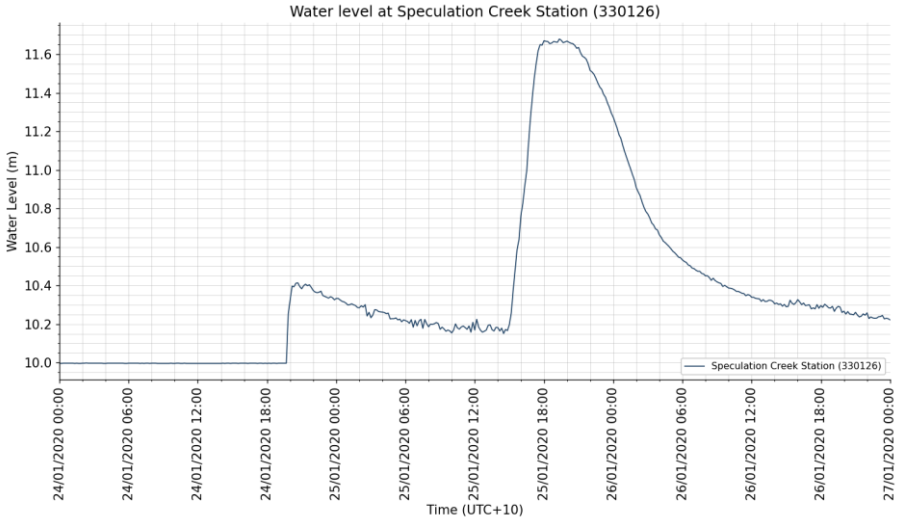


Figure B.15 **Recorded water level at Speculation Creek Station (330126), 2020 event**

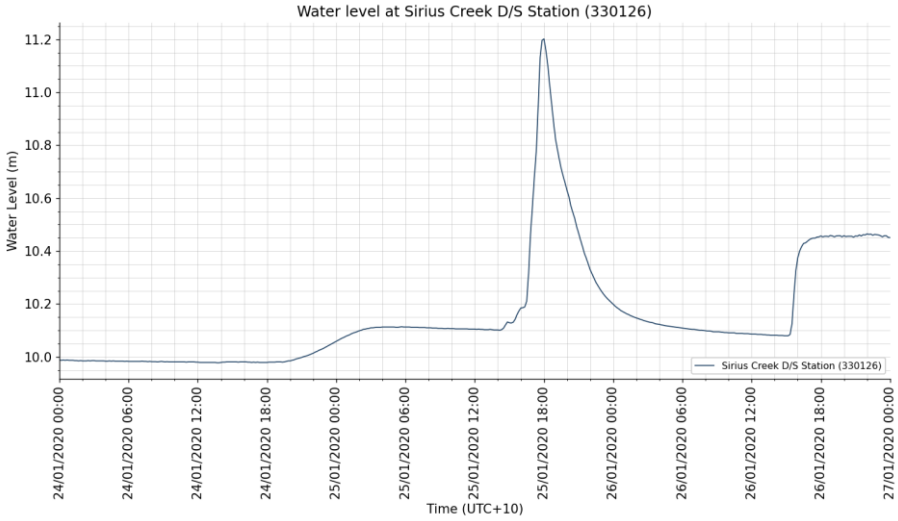


Figure B.16 **Recorded water level at Sirius Creek Station (330118), 2020 event**



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