LAKE VERMONT RESOURCES ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 9 FLOODING AND REGULATED STRUCTURES

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9 Flooding and Regulated Structures

9.1 Environmental objectives and performance outcomes

This chapter has been prepared in order to assist the DES in carrying out their environmental objective assessment in respect of the following requirements stated in the Project ToR:

Flooding

> *The construction and operation of the proposed Project should aim to ensure that the risk and potential adverse impacts from flooding are avoided, minimised or mitigated to protect people, property and the environment.*

Regulated structures

> *The design of the facility permits the operation of the site, at which the activity is to be carried out, in accordance with best practice environmental management (the design objective).*
>
> *The potential consequences of the failure of a regulated structure on human life and the environment require that the highest standards are used for their design, construction, operation, modification and decommissioning. The industry, government and the Australian National Committee on Large Dams Inc. have published several guidelines, which should be used to further develop objectives and outcomes for individual projects and the regulated structures they involve.*

Flooding and regulated structures have been assessed for the Project by WRM Water and Environment Pty Ltd as a component of the Project Surface Water Assessment (Appendix F, Surface Water Assessment; Appendix W, Geomorphological Assessment Report; Appendix Y, Site Water Balance and Water Management; and Appendix Z, Flood Modelling Assessment Report). The flooding and regulated structures assessment has been prepared in consideration of the 'EIS Guideline–Water' (DES 2020d) and the 'EIS Guideline–Regulated Structures' (DES 2020e). Regulated structures have been assessed in accordance with the DES 'Manual for assessing consequence categories and hydraulic performance of structures' (DES 2016) and the DES Guideline 'Structures which are dams or levees constructed as part of environmentally relevant activities' (DES 2022b).

9.2 Description of existing values

The following sections identify the existing values relevant to flooding and regulated structures. Local and regional environmental values for water quality and water resources are described in Chapter 7, Groundwater and Chapter 8, Surface Water. The environmental values for aquatic ecosystems of the Project are described in Chapter 11, Aquatic Ecology.

9.2.1 Nearby water resources

The Project is within the Isaac Connors Sub-catchment of the greater Fitzroy Basin catchment and near to the main watercourse of the Isaac River (Figure 3.4). Ground elevations to the west of the Project are marginally higher in elevation (approximately 10 mAHD), with the Project generally draining west to east towards the Isaac River. The surface between Phillips Creek and Boomerang Creek is a broad, flat floodplain that slopes gently to the east from approximately 180 mAHD in the west to around 170 mAHD in the east (Figure 9.1).

The Project is on the floodplains of Phillips Creek, One Mile Creek, Boomerang Creek and Ripstone Creek, which are tributaries of the Isaac River. Phillips Creek traverses the proposed infrastructure corridor and meanders to the south of the Project's underground mining area and into the Isaac River. Ripstone Creek (north of the Project) flows eastward before flowing into Boomerang Creek (east of the Project area) and shortly after into the Isaac River (Figure 9.1).

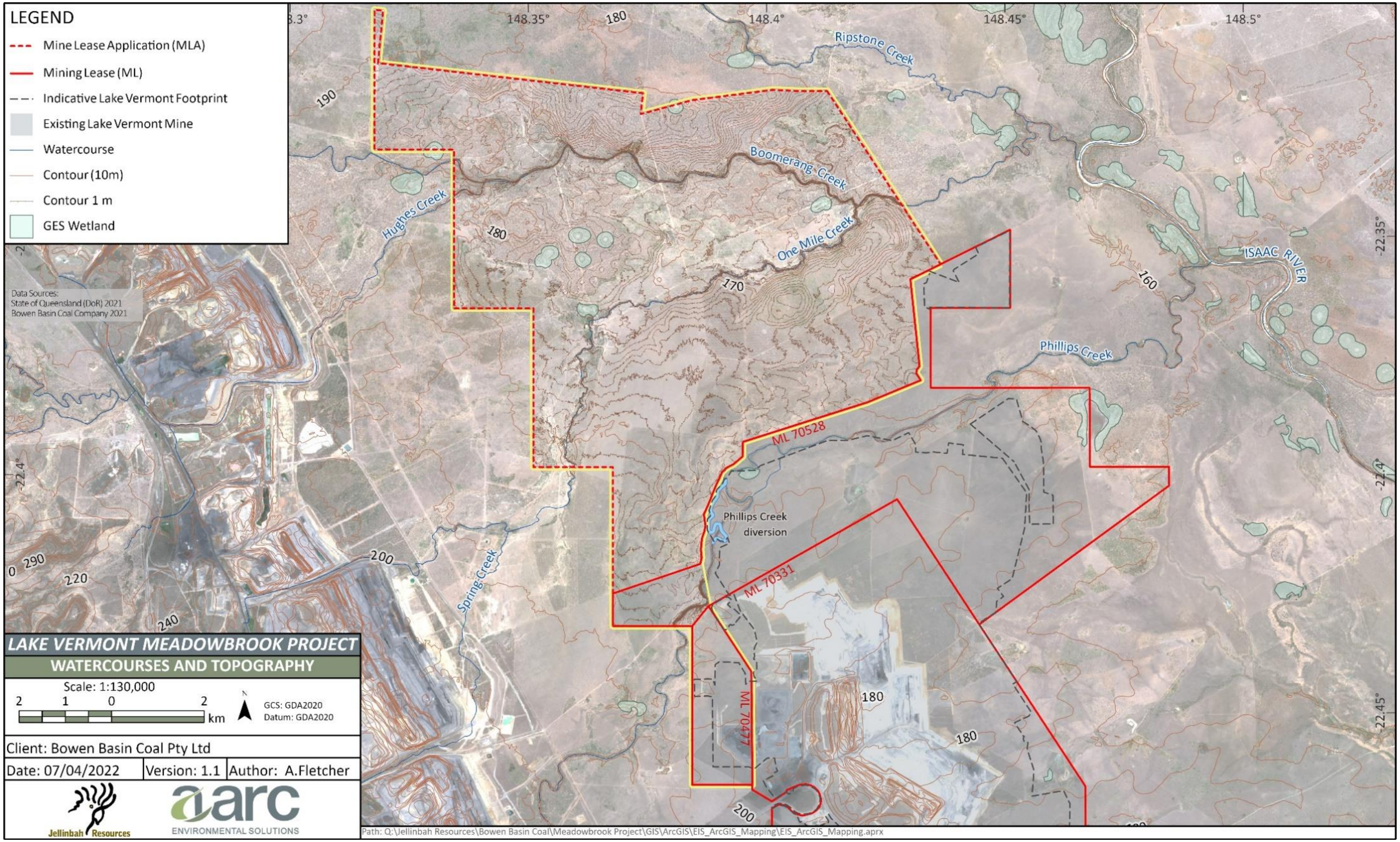

Figure 9.1: Project watercourses and topography

Hughes Creek traverses the MLA and converge with Boomerang Creek and One Mile Creek. The confluence of Hughes Creek and Boomerang Creek occur in the west of the Project, with One Mile Creek flowing into Boomerang Creek in the east of the Project area (Figure 9.1).

9.2.2 Land uses and regional context

The Project is on the floodplain of tributaries of the Isaac River, which is some of the land mapped as an ‘Important Agricultural Area’ by the ‘Queensland Agricultural Land Audit’ (Figure 3.7).

The Project contains a small area mapped as potential SCL under the RPI Act (referred to as the SCL trigger area on Figure 3.6, Chapter 3, Project Description). The land within the MLA is currently used for beef cattle grazing and resource exploration activities.

9.2.3 Proximity to infrastructure

The Project is located near existing and proposed coal mining operations of the Bowen Basin (Figure 3.1).

Golden Mile Road, which crosses the Isaac River on the south-east floodplain, runs between the Project site and Dysart.

9.2.4 Flood modelling

9.2.4.1 Regional hydrological model

An XP-RAFTS hydrological model of the Isaac River catchment has been developed to assess the current flood risk and the potential impacts of the Project on flooding. Details of the model are provided in Appendix Z, Flood Modelling (Section 1.2).

The Isaac River catchment regional model extends downstream to the confluence of Phillips Creek with the Isaac River and includes 248 sub catchments (Figure 9.2). Separate XP-RAFTS runoff-routing models of the Isaac River catchment have been used to estimate the 50%, 10%, 2%, 1% and 0.1% AEP peak design discharges and the Probable Maximum Flood (PMF) for a range of durations up to 48 hours. Rainfall data (rainfall depths, areal reduction factors and temporal patterns) have been applied in accordance with ensemble event procedures in ‘Australian Rainfall & Runoff’ (Ball et al. 2019). Design peak flows from the regional Isaac River model have been reconciled against the flood frequency analysis of the peak annual flow series at the Queensland Government Deverill gauge (130410A) (Appendix Z, Flood Modelling, Section 1.2.5).

A comparison of the Isaac River design rainfall intensities has been made at the southern, western, centroid, and eastern boundaries for the 1% AEP event across all durations. Due to small variations in design rainfall estimates over most of the catchment, a uniform spatial rainfall distribution has been adopted across the model (Appendix Z, Flood Modelling, Section 1.2.3).

9.2.4.2 Local hydrological model

An XP-RAFTS model of the local creek system has been developed as the basis of the present hydrological analysis for local flooding conditions. The local creek hydrological model (Figure 9.3) includes the catchments of Boomerang Creek, Ripstone Creek, One Mile Creek and Phillips Creek and extends to the confluence of Phillips Creek with the Isaac River (Appendix Z, Flood Modelling, Section 1.2).

The model of the local creek system has been calibrated to flows recorded at Lake Vermont Mine Phillips Creek streamflow gauge during the Cyclone Debbie flood event. Design peak flows in Phillips Creek have been reconciled against the flood frequency analysis of the peak annual flow series of historical flow data recorded at the Tayglen gauging station (130409A) (Figure 9.2 and Figure 9.3). The local model was used to determine creek inflows for the 50%, 10%, 2%, 1%, 0.1% AEP and PMF design events. Due to small variations in design rainfall estimates over most of the catchment, a uniform spatial rainfall distribution has been adopted across the model. Details of the model are provided in Appendix Z, Flood Modelling, Section 1.2 .

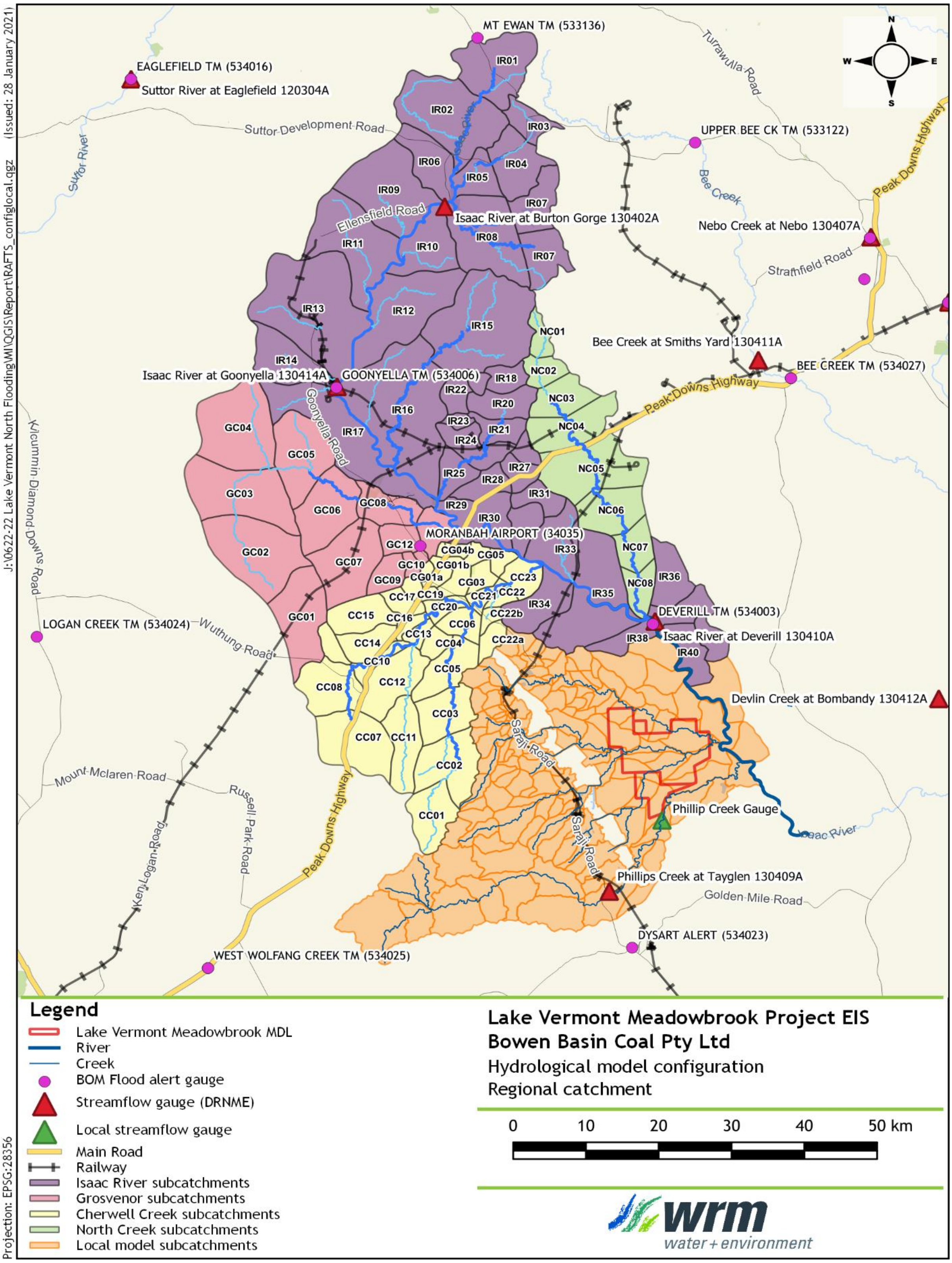

Figure 9.2: Isaac River catchment regional model (XP-RAFTS regional configuration)

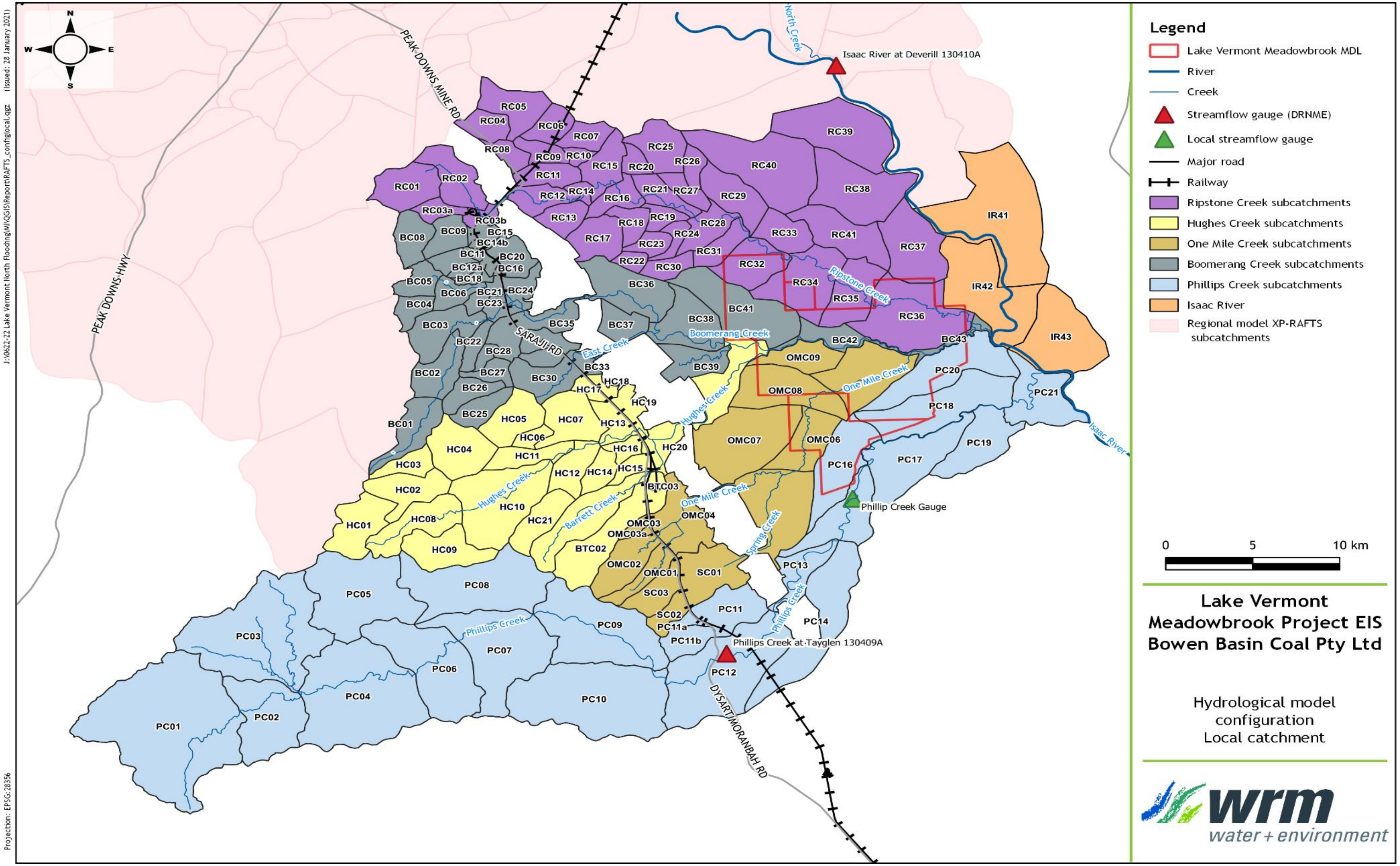

Figure 9.3: Local creeks catchment model (XP-RAFTS local configuration)

9.2.4.3 Hydraulic model

A hydrodynamic model has been developed by WRM (Appendix Z, Flood Modelling, Section 2) using TUFLOW software to assess the flow behaviour of the Isaac River, Ripstone Creek, Boomerang Creek, Hughes Creek, One Mile Creek and Phillips Creek in the vicinity of the Project, including flood extents, depths and velocities. The flood model also forms the basis of a more localised assessment of the impact of the Project on flow conditions in the mine lease area, which is detailed in the geomorphological assessment (Appendix W, Geomorphological Assessment Report, Section 4.5).

The hydraulic model has been used to simulate flood conditions under:

- approved site conditions (base case);
- operational conditions (with full longwall mining subsidence)
- post-closure conditions; and
- cumulative impact scenarios.

The scenario and event combinations for the hydraulic models are further described as follows:

- Pre-mining approved conditions, which assume the already approved Lake Vermont Mine pits and final landform and the already approved Phillips Creek diversion, are in place for:
    - local flooding: 50%, 10%, 2%, 1%, 0.1% AEP and PMF; and
    - regional flooding: 1%, 0.1% AEP and PMF.
- Developed conditions (Project Year 2051), (indicating mine site conditions) for local and regional flooding (approved condition flood AEP and PMF events) represent the greatest amount of disturbance to the floodplain with:
    - mine subsidence at its full extent;
    - earthworks and cross-drainage for the haul road;
    - levees around the MIA;
    - levees around the full extent of the open-cut operation; and
    - the implementation of channels and bunds to mitigate the extent of subsidence-induced ponding.
- Post-closure scenarios for local flooding (1%, 0.1%, and PMF) includes:
    - removal of all operational site activities (with the exception of the haul road which will remain post-closure);
    - presence of a rehabilitated pit landform with constructed elevation designed to prevent ‘extreme flood’ inflows into the rehabilitated pit landform (depression), and a rehabilitated waste rock emplacement; and
    - residual mine subsidence areas with bunds and drainage across subsided panels to mitigate subsidence-induced ponding.
- Cumulative impact scenarios, with all levees in place associated with the proposed Olive Downs Project, have been run for both Project Year 26 mine site conditions (indicatively 2051) and post-closure conditions.

Further details of the model are provided in Appendix Z, Flood Modelling (Section 2).

9.2.5 History of flooding

WRM (2019) has conducted a pre-mining flood study for the Project to provide initial planning advice on existing flood conditions of watercourses crossing the proposed mining area. The hydrological and hydraulic model for this study was developed using XP-RAFTS software.

The methodology for the hydrological model of the Isaac River, Boomerang Creek and Phillips Creek catchments involved calibration with the discharge hydrographs recorded at three recent historical flood events at the Deverill and Goonyella (GS130414A) gauging stations (Figure 9.2). The three historical flood events were in February 2008, December 2010 and March 2017, and have been calibrated against available sub-daily rainfall and stream flow data from the nearest rainfall stations:

- Isaac River at Deverill (130410A);
- Isaac River at Goonyella (130414A);
- Isaac River Bridge (534026);
- Moranbah WTP (34038); and
- Moranbah Airport (34035) (Figure 9.2).

Details of the historical flood events in the Isaac River catchment, including event duration and recorded peak discharge (m^3/s), are provided in Table 9.1 (WRM 2019).

WRM (2019) also recorded observations for modelling at three storage dams during the 2017 event. They included Burton Gorge Dam, Teviot Dam and Lake Elphinstone. Burton Gorge Dam had a spill event with a recorded peak discharge of about 235 m^3/s at the Burton Gorge Dam gauging station compared to a peak discharge of 215 m^3/s in the XP-RAFTS model. Lake Elphinstone and Teviot Dam were not observed to spill during the event or in the XP-RAFTS model.

Table 9.1: Historical (calibration) flood events, Isaac River catchment

Historical flood event	**Start date**	**Event duration (days)**	**Recorded peak discharge (m^3/s) - Goonyella**	**Recorded peak discharge (m^3/s) - Deverill**
February 2008	09/02/2008	9	1,070	2,142
December 2010	18/01/2010	15	91	1,827
March 2017	27/03/2017	7	199	1,614

As discussed in section 9.2.4.2, Local hydrological model, the Lake Vermont Mine Phillips Creek streamflow gauge recorded flows from the Cyclone Debbie flood event in March 2017. Local sub-daily rainfall data was also recorded on-site and provided by Lake Vermont Mine. The rainfall event began at midnight on 28 March 2017 and continued for approximately two days, with a total cumulative rainfall of 169 mm. The peak recorded discharge volume was 428 m^3/s (Appendix Z, Flood Modelling, Section 1.3.4).

9.2.6 Current flood risk

The flood modelling assessment contained in Appendix Z, Flood Modelling (Section 3.2), outlines the current local flood risk for 50%, 10%, 2%, 1%, 0.1% AEP and PMF flood events and regional flood risks of the Isaac River for 1%, 0.1% AEP and PMF events.

The depth of the Isaac River floodplain flow is significantly greater than for local creek flooding; however, this does not significantly impact flood levels in the Project area. As provided by WRM (Appendix Z, Flood Modelling):

> *[In] the absence of large local creek flows, breakouts flowing overland from the Phillips Creek northern floodplain to One Mile and Boomerang Creeks are not evident in flows less than the 0.1% AEP.*

The baseline flood mapping (approved conditions) for flood depths, heights and velocity for 0.1% and 1% AEP is provided in Appendix Z, Flood Modelling (Section 3.2). The 0.1% AEP modelled flood heights have been used as the basis for designing protection works around the surface operations at the MIA and open-cut pit. The 0.1% AEP mapping shows the extent of flooding, for which the flood protection levee is required to be designed in accordance with DES (2016) to ensure flood events do not interact with mining operations.

The baseline flood mapping for flood depths, heights, velocities for 50%, 10%, 2% AEP and PMF flood events are provided in Appendix Z, Flood Modelling (Section 3.2). In summary:

- Phillips Creek has a much greater channel capacity than the northern streams (Ripstone Creek, One Mile Creek and Boomerang Creek) and is confined within-bank during the 50% AEP flood event. However, during the 10% AEP event, minor out-of-bank water flows from the channel upstream of the Project area connect to a drainage line further downstream on the northern Phillips Creek floodplain. This breakout in the 2% AEP event becomes fully developed and forms a continuous flow path parallel to Phillips Creek before it re-joins the main channel upstream of its confluence with the Isaac River.
- The catchment boundary of One Mile Creek extends to a natural levee along the southern bank of Boomerang Creek. In the 50% AEP flood, two breakouts direct Boomerang Creek flow into the local drainage system, where it flows overland and joins One Mile Creek further downstream. In the 2% AEP event, the One Mile Creek floodplain joins Boomerang Creek due to these breakouts becoming more significant flow paths.
- Further upstream of Phillips Creek, in large flows approaching the 1% AEP, floodwater begins to overflow from the Phillips Creek floodplain through the proposed underground mining area towards One Mile Creek. These flow paths become fully engaged in the 0.1% AEP event.
- Point channel velocities in the 50% AEP event range between 1.3 and 1.8 m/s. One Mile Creek flow velocities are lower than other streams at typically less than 0.5 m/s.
- The 1% AEP event flow velocities in Phillips Creek are up to 2.5 m/s but below 1 m/s along One Mile Creek. Flow breaking out over the Phillips Creek northern floodplain are at velocities up to 1.2 m/s. Boomerang Creek velocities range between 1.3 to 1.5 m/s, and at one of the breakouts flowing across to One Mile Creek, velocities are up to 1.5 m/s.

9.2.7 Geomorphology

A geomorphology assessment has been undertaken by WRM (as a component of the Project Surface Water Assessment) to assess the potential impacts of the Project on the geomorphology of streams crossing the Project area. The geomorphology assessment is based on the results of the detailed hydraulic modelling undertaken by WRM and is provided in Appendix W, Geomorphological Assessment Report. A summary of the drainage characteristics of the Isaac River floodplain is provided in section 9.2.7.1, and a summary of the existing flooding characteristics is provided in section 9.2.7.2.

9.2.7.1 Drainage characteristics

The most significant watercourse in proximity to the Project is the Isaac River to the east of the Project, which flows in a south-easterly direction. The Isaac River is a seasonally flowing watercourse, typically with surface flows in the wetter months from November to April, reducing in the drier months from May to October. All waterways in the vicinity of the Project are ephemeral and experience flow only after sustained or intense rainfall within the catchment (Appendix W, Geomorphological Assessment Report, Section 2.2).

Waterways passing through the Project area drain into the Isaac River *via* tributaries of Phillips Creek (to the south) and Boomerang Creek (to the north) (Figure 9.1). The waterways originate in the Harrow Range, where they are confined within narrow valleys by hillslopes and bedrock (Appendix F, Surface Water Assessment, Section 4.3). Local hydrology is described in section 9.2 and in Chapter 8, Surface Water.

Long-term deposition of sediment over the Boomerang Creek channel banks during flooding has resulted in the formation of natural levees along the southern bank of Boomerang Creek, such that it is perched above the adjacent floodplain. As a result, runoff from out-of-bank areas immediately to the south of the channel drain independently of the Boomerang Creek channel to One Mile Creek. One Mile Creek is a tributary of Boomerang

Creek, and they share the same floodplain. The floodplain across the Project area is elevated (with several gilgai features) between the Boomerang and One Mile Creek channels. Floodwater frequently ponds in existing gilgai, meander cutoffs and remnant channels in the very flat floodplain between the two waterways (Appendix F, Surface Water Assessment, Section 4.8).

The Boomerang Creek channel has a breadth of 30 m and is typically 1.5 m to 2.5 m deep, with a sandy bed. Its capacity is relatively low, with floodwater flowing over the southern bank at several locations after a 50% AEP flood *via* two shallow south-easterly flow paths to One Mile Creek. One Mile Creek has a much smaller catchment than Boomerang Creek, and the channel is shallower (typically 0.75 m to 1.5 m deep) and narrower (around 15 m wide) (Appendix F, Surface Water Assessment, Section 4.8).

9.2.7.2 Existing flooding characteristics

Flood modelling for the Project has focused on storm event durations causing the largest flood peaks in the waterways crossing the Project area (Appendix F, Surface Water Assessment, Section 4.7.2).

Local catchment flooding has been considered more important when assessing the geomorphic response of waterways in the Project area compared to the Isaac River, which has a minor impact on flood levels in the eastern part of the Project area only (Appendix F, Surface Water Assessment, Section 4.7.2).

The ‘existing conditions’ modelling assumes that the Phillips Creek diversion has been constructed in accordance with the approved functional design, and there is no infrastructure across Boomerang Creek or One Mile Creek catchments (Appendix F, Surface Water Assessment, Section 4.7.2). The results of flood modelling for the ‘existing conditions’ scenario have been used in the geomorphology assessment to characterise hydraulic conditions of relevance to the floodplain geomorphology, including velocity, bed shear stress and stream power (Appendix F, Surface Water Assessment, Section 4.8). The assessment included the following scenarios:

- A 50% AEP flood event represented the behaviour of the creek channels at bank full flow conditions:
  - Bank full flow is the maximum flow that the channel can carry before it overflows onto the adjacent floodplain.
  - Bank full flow is often considered to be the stream forming flow, as it often exerts the greatest influence on channel geometry (Appendix F, Surface Water Assessment, Section 4.8).
- A 2% AEP flood event represented behaviour of the creeks and associated floodplains during large floods (Appendix F, Surface Water Assessment, Section 4.8).

In summary, the modelling results for the 50% AEP flood event indicate:

- Flows are confined within Ripstone Creek upstream of the Project, but then lose definition with a low carrying capacity downstream of the Project area.
- Flows would be contained in-bank in Phillips Creek, with local catchment runoff contributing all flow in its northern floodplain.
- Apart from some localised areas where overbank flows are concentrated, floodplain flow velocities are relatively low (less than 0.5 m/s).
- Boomerang Creek downstream of the overflow path to the One Mile Creek confluence drains independently of the floodplain flows, with the remaining 50% AEP flows contained in-bank.
- One Mile Creek has low channel capacity, with the 50% AEP flows draining along several channels and as shallow overbank flows.
- One Mile Creek receives Hughes Creek overflows, and then Boomerang Creek overflows to effectively become the primary flow path during flood flows (Appendix F, Surface Water Assessment, Section 4.7.3).

In summary, the modelling results for the 2% AEP flood event indicate:

- The south-east-flowing overflow paths from Boomerang Creek to One Mile Creek are significantly wider and deeper, but the perched Boomerang Creek channel downstream of the overflow paths continues to drain independently of the floodplain.
- Flooding along One Mile Creek becomes wider. Downstream of the flow path from Boomerang Creek, flow depths increase beyond 4 m but, with the exception of relatively short sections of the main channel, velocities are less than 1 m/s.
- Flows escape the channel of Phillips Creek just upstream of the Project area and run north along a drainage path within the western Phillips Creek floodplain before turning east. The Phillips Creek channel is perched with a wide levee of naturally deposited material separating the independently flowing channel from its floodplain.
- In their lower reaches, the Ripstone Creek, Boomerang Creek, One Mile Creek and Phillips Creek floodplains combine and merge with the Isaac River floodplain (Appendix F, Surface Water Assessment, Section 4.7.3).

9.3 Proposed infrastructure

Key water management infrastructure proposed to manage the Project flooding risk includes:

- flood protection levees;
- diversion drains;
- mine dewatering infrastructure; and
- sediment dams.

These infrastructure items are discussed in sections 9.3.1 to 9.3.4.

9.3.1 Flood protection levees

Two flood protection levees are proposed to be constructed with 0.1% AEP design event flood protection, to protect the MIA and open-cut area from potential inundation. The flood protection levee will be constructed around the MIA at the start of the Project to protect infrastructure (Figure 3.24). A second flood protection levee will be constructed around the open-cut mining area before commencing open-cut mining in Project Year 20 (Figure 3.2). Levees will be designed to withstand the predicted velocities during operations (Appendix Z, Flood Modelling, Section 3.3.3). A conceptual levee design is provided in (Figure 9.4).

Project levees are proposed to have a 5 m wide crest (sufficient for a light vehicle to traverse), with external batters constructed at a grade of 1 in 3 and internal batters constructed at a grade of 1 in 3.5. As the proposed levee structures are required to protect infrastructure from a 0.1% AEP flood event, they will be considered regulated structures (Appendix F, Surface Water Assessment, Section 7.3).

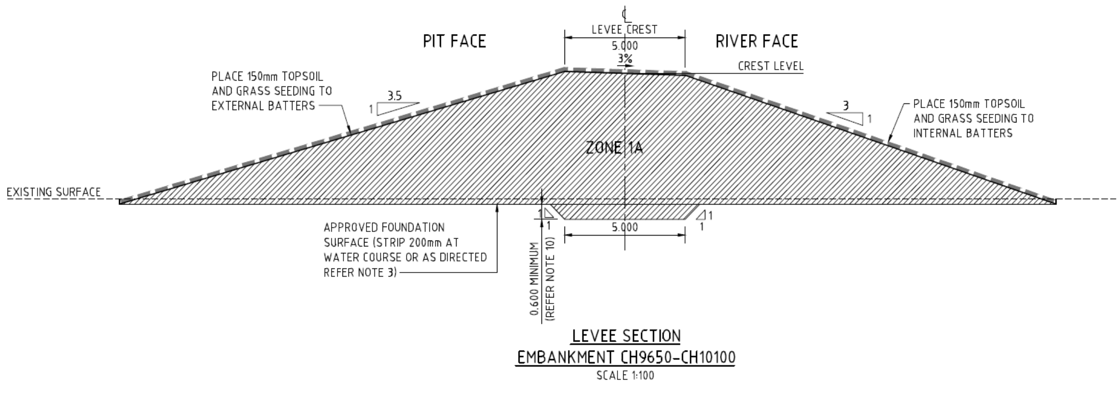

Figure 9.4: Conceptual levee cross-section

Project flood levees will be constructed using nondispersive, low permeability, engineered fill. The batters and surrounding disturbed areas will be revegetated with grasses to stabilise the levee structure and prevent sediment runoff. The flood levee crest level and design freeboard allowances will be reviewed and certified as part of the future detailed design for the proposed levee structure. Model EA conditions for regulated structures (i.e. levees) will also require the development of certified design drawings prior to the commencement of levee construction.

The proposed crest elevations for the levees will allow for a 0.50 m freeboard. The maximum crest of the proposed MIA levee is 3.11 m above ground level (178.9 mAHD) in the south-western corner of the MIA (Chainage 228) (Figure 9.5). The average height of the MIA levee will be 1.74 m (178.23 mAHD) with a minimum construction height of 0.64 m (Chainage 1,700) (Figure 9.5).

The maximum crest of the proposed open-cut mining area levee is 5.18 m above ground level (181.96 mAHD) in the south-eastern section adjacent to Phillips Creek (Chainage 1703) (Figure 9.6). The average height of the levee in this area will be approximately 2.35 m (179.64 mAHD). In the north-western area of the levee and adjacent to One Mile Creek, the maximum crest height will be 2.64 m (at Chainage 7183) (Figure 9.6). A minimum crest height of 0.50 m is assumed for areas of higher topography.

The 2051 developed conditions with mitigations scenario model (Appendix Z, Flood Modelling, Section 3.3) produced results indicating that the levees around the open-cut operation and MIA would locally reduce floodplain conveyance and storage. This would have the effect of locally increasing upstream flood levels and redistributing downstream flow to the opposite floodplains until the levees are decommissioned, and the floodplain landform is returned to pre-mining levels (Appendix Z, Flood Modelling, Section 3.3).

Detailed levee designs will incorporate appropriate erosion protection measures such as rock armouring where velocities are sufficient to erode the compacted earth embankment. Velocities adjacent to the MIA levee and northern open cut levee are predicted to be less than 1.5 m/s in the 1 in 1000 AEP flood, and erosion protection works are therefore unlikely to be required in these areas. The southern open cut levee would likely require erosion protection works near the southern and north-eastern corners. (Appendix Z, Flood Modelling, Section 3.3).

Modelled mapping of peak flood depth and extent for the developed conditions (2051 conditions with mitigation) for the 0.1% AEP and PMF flood events are shown in Appendix Z, Flood Modelling, Section 2.3. These modelling outputs demonstrate that the operational flood levees provide 0.1% AEP flood protection to mining infrastructure. Modelling also demonstrates that post-mining, the rehabilitated pit depression will be located outside areas affected by flood levels up to and including the PMF flood level. The final landform design includes elevation to ensure water ingress into the final rehabilitated pit area is prevented in the event of a 0.1% AEP flood event. Surface water interactions with the rehabilitated pit depression are discussed in Chapter 6, Rehabilitation and Chapter 8, Surface Water.

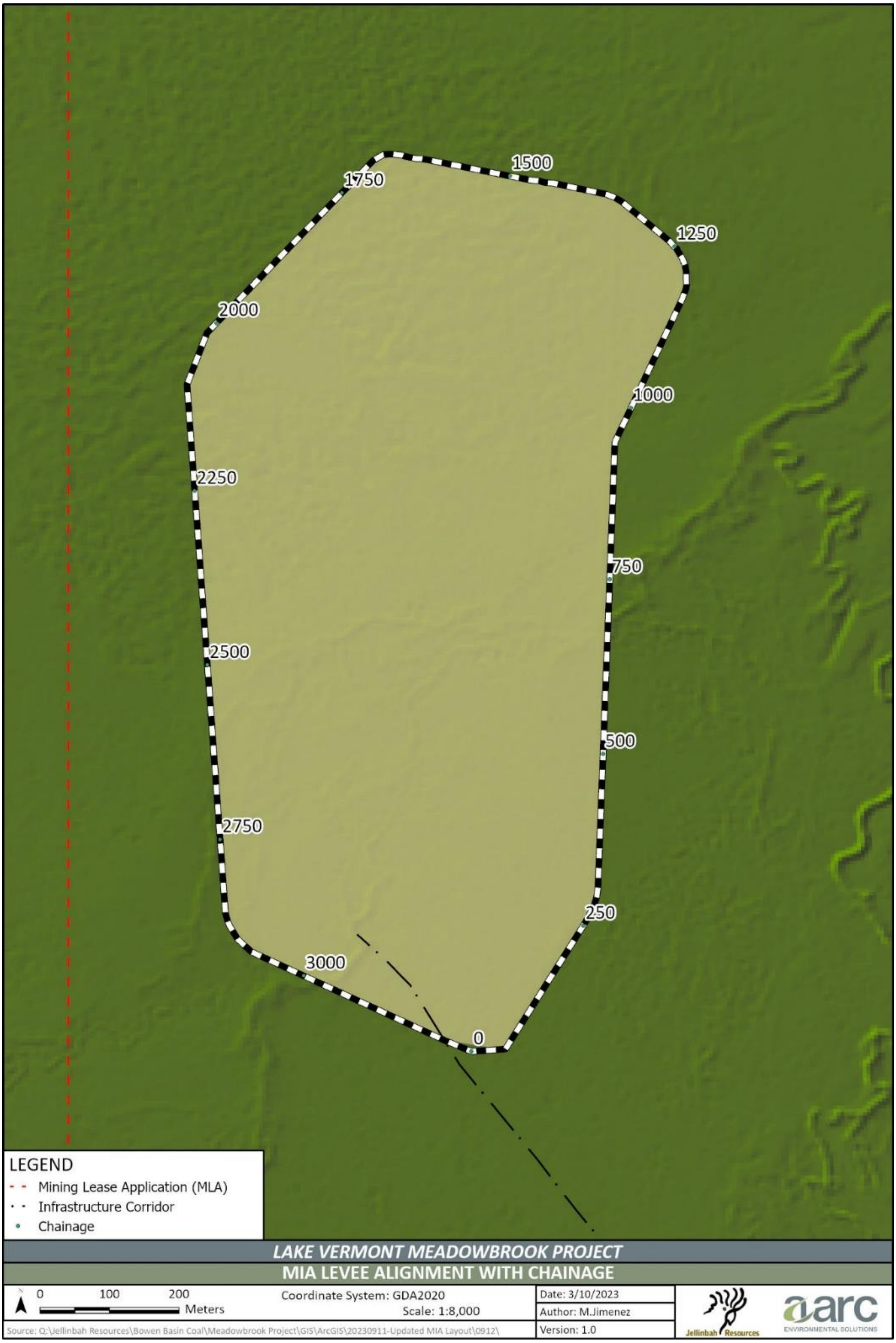

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Figure 9.5: *Proposed MIA levee alignment with chainage in metres*

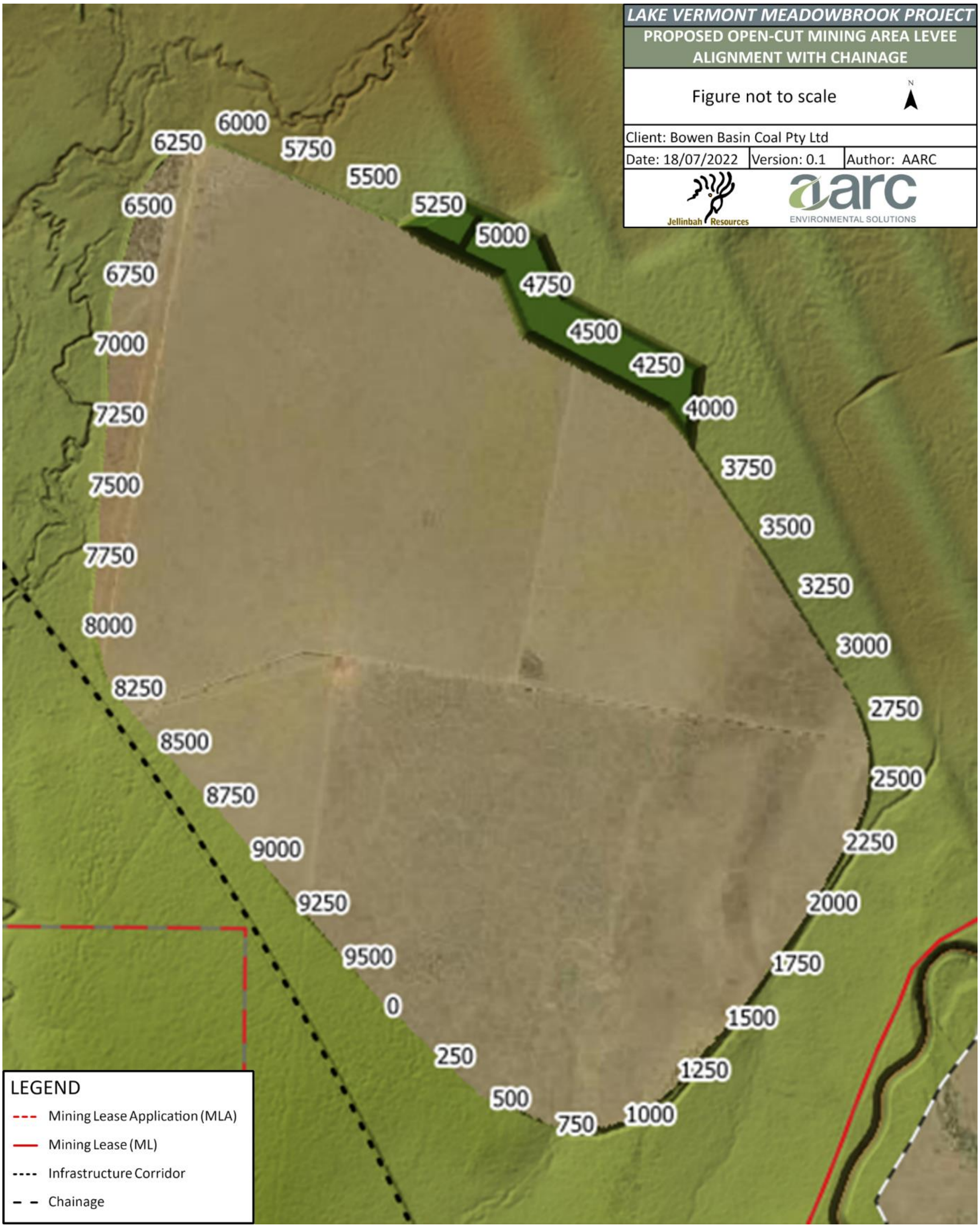

Figure 9.6: *Proposed open-cut mining area levee alignment with chainage in metres*

9.3.2 Diversion drains

A diversion drain is proposed to be developed during the construction phase to support the diversion of clean water around the southern extent of the MIA levee (refer to Figure 3.24, Chapter 3, Project Description). An additional diversion drain is proposed to be constructed during the Project operational phase (indicatively Project Year 20) to divert clean water around the southern extent of the open-cut pit levee (Figure 3.2).

Both of these diversion drains have been designed to facilitate the passage of overland flow, which would otherwise be impeded by levee construction.

A conceptual cross-section of the proposed Project diversion drains is provided in Figure 9.7. Diversion drains will be unlined, will have an approximate 3 m channel base and channel walls constructed at a grade of 1:3. The MIA diversion drain will be constructed in parallel with the MIA levee construction, while the open-cut diversion drain will be constructed in parallel with the open-cut pit levee construction (circa Project Year 20).

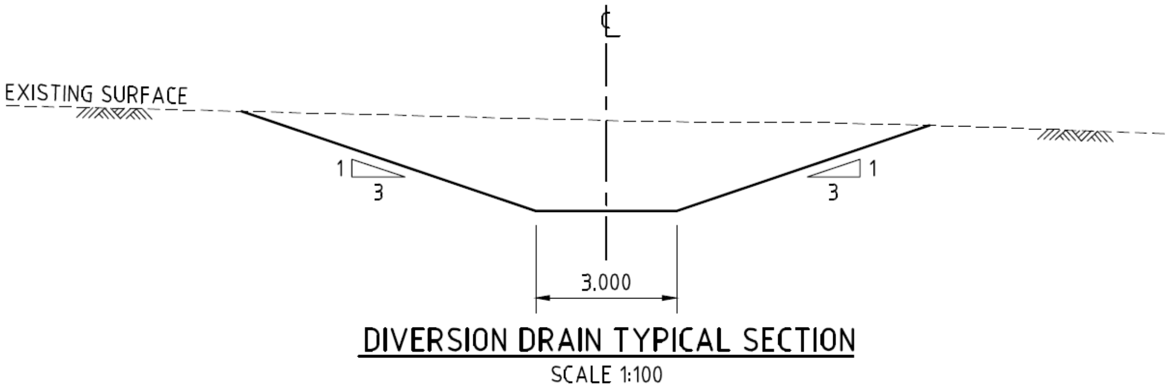

Figure 9.7: Conceptual diversion drain cross-section

9.3.3 Underground mine dewatering infrastructure

To manage groundwater ingress into the underground mine workings, mine dewatering will occur. Underground mine dewatering will involve pumping water from the underground workings to the surface infrastructure within the MIA.

Dewatering infrastructure proposed to be developed during Project construction includes the Dewatering Dam and the MIA Dam. A Raw Water Dam (for storage of clean, raw water) will be constructed within the MIA. These dams will be located as shown in Figure 3.24 of Chapter 3, Project Description. Further details of these proposed dams are provided in Table 9.2, with operation of these dams detailed in Chapter 8, Surface Water Assessment.

Table 9.2: MIA Dam sizing

Storage name	Storage type	Maximum catchment area (ha)	Storage capacity (ML)
Raw Water Dam	Raw water	0.4	20
Dewatering Dam	Mine-affected water	0.4	20
MIA Dam	Mine-affected water	73	440

Water pumped from the underground will initially be transferred to the Dewatering Dam (a Turkey's nest dam) within the MIA. From here, water may be pumped into the adjoining MIA Dam (for further dilution), utilised for dust suppression or pumped back to the Lake Vermont Mine to support processing requirements. While local groundwater resources are notably of poor quality (i.e. highly saline), water pumped to the surface from the underground will be significantly diluted by the volume of raw water sent underground for dust suppression (estimated to be a ratio of three parts pipeline water to one part groundwater).

A consequence assessment has been completed for the dams identified in Table 9.2 in accordance with the 'Manual for assessing consequence categories and hydraulic performance of structures' (DES 2016) and the 'Structures which are dams or levees constructed as part of environmentally relevant activities'(DES 2022b). Each dam is assigned a 'Consequence Category' of High, Significant or Low depending on its potential to cause harm (DES 2016). A structure categorised as a Significant or High consequence is referred to as a regulated structure. Such structures must comply with hydraulic performance objectives (DES 2016). A summary of the Consequence Category assessment of Project dams is provided in section 9.4.5.2.

9.3.4 Sediment dams

Sediment dams will be constructed within the proposed open-cut mining area to assist in managing rainfall and runoff. During open-cut mining operations, catchment runoff from overburden dumps will be captured in three sediment dams, namely; the:

1) Southern Sediment Dam;
2) Northern Sediment Dam 1; and
3) Northern Sediment Dam 2.

Locations of these sediment dams are provided in Figure 3.27, Chapter 3, Project Description. Sediment dams will be designed to contain a one in 10-year ARI 24-hour rainfall event and will be operated in accordance with the DES Guideline 'Stormwater and environmentally relevant activities' (DES 2021c). Sediment dam catchment areas and proposed storage capacities are provided in Table 9.3 (Appendix Y, Site Water Balance and Water Management System Report).

Table 9.3: Sediment dam sizing

Storage name	Storage type	Maximum catchment area (ha)	Storage capacity (ML)
Northern Sediment Dam 1	Sediment dam	327	240
Northern Sediment Dam 2	Sediment dam	223	155
Southern Sediment Dam	Sediment dam	256	180

During rainfall events exceeding dam design capacity, the Northern Sediment Dams would overtop to One Mile Creek, while the Southern Sediment Dam would overtop to Phillips Creek (*via* an existing drainage line). Environmental risks related to sediment dams are discussed in Chapter 8, Surface Water.

The Northern Sediment Dam 1 would be initially constructed by pre-excavating overburden material near the northern corner of the open-cut pit levee. Once the existing ground surface is mined out, sediment dams would be formed into localised depressions, both north and south of the open-cut pit (Site Water Balance and Water Management System Report, Section 2.2.11). Sediment dam locations are provided in Figure 3.27, Chapter 3, Project Description. All sediment dams will be removed and rehabilitated as part of mine closure.

9.3.5 Other infrastructure

Additional infrastructure that may have an impact on flood behaviour include:

- the haul road:
    - located within the infrastructure corridor;
    - connects the existing Lake Vermont Mine and the proposed MIA;
    - includes crossings at Phillips Creek, the Phillips Creek northern floodplain and One Mile Creek; and
    - requires several cross-drainage structures; and
- a rehabilitated waste rock emplacement area.

9.4 Potential impacts

9.4.1 Flood depth and afflux impacts

Flood depth and extent for all scenarios described in section 9.2.4.3 (i.e. each AEP flood event [50%, 10%, 2%, 1%, 0.1%] and the PMF flood events) is provided in Appendix Z, Flood Modelling Assessment Report (Section 3.2.2). Flood depth mapping shows the difference between the scenarios modelled for each flood event assessed. As an example, the modelled peak flood depths for the existing conditions and developed conditions for the 1% AEP flood event are shown in Figure 9.8 and Figure 9.9, respectively.

Flood afflux mapping for 2051 conditions minus approved conditions (local and regional) is provided in Appendix Z, Flood Modelling Assessment Report (Section 3.3) for each flood event assessed. Figure 9.9 shows the 1% AEP afflux local flooding.

The flood impact assessment for the modelled scenarios indicates:

- Underground mine subsidence would locally reduce flood levels but increase the depth and extent of flooding.
- Subsidence would increase floodplain storage, which would reduce downstream flood flows, levels and extents for 50% and 10% AEP flood events at Phillips Creek, One Mile Creek and Boomerang Creek by between 50 and 100 mm.
- For the 10% AEP event over the subsidence panels on the Phillips Creek floodplain downstream of the open-cut mine, reductions in flood levels are up to 2 metres in some areas. In larger events, reductions in level are smaller and within the range of 700 mm to 850 mm.
- For the subsidence areas on One Mile Creek, reductions in levels range from one metre to 700 mm.
- Along Boomerang Creek, some flood levels have reduced by as much as 3 metres in the 10% AEP event to 2.5 metres in the PMF in the most affected locations.
- Afflux downstream of the mine lease area is negative for all events, ranging from a 600 mm reduction at the Isaac River in the 50% AEP to 300 mm in the 10% AEP. Reductions in the floodplain of the Isaac River in the larger events from the 2% AEP to the PMF range from 60 mm to 100 mm.
- In the 0.1% AEP and PMF events, there is also some positive afflux in the vicinity of the confluence of the Boomerang and Isaac Rivers of approximately 30 mm to 50 mm.
- In the 1% AEP event for regional flooding conditions, off-lease impacts are limited to the Phillips Creek northern floodplain, with reductions of up to 100 mm just south of the open-cut pit and small increases of 30 mm on the western side of the open-cut pit.
- In the 0.1% AEP flood event, reductions downstream in the Phillips Creek northern tributary are approximately 150 mm.

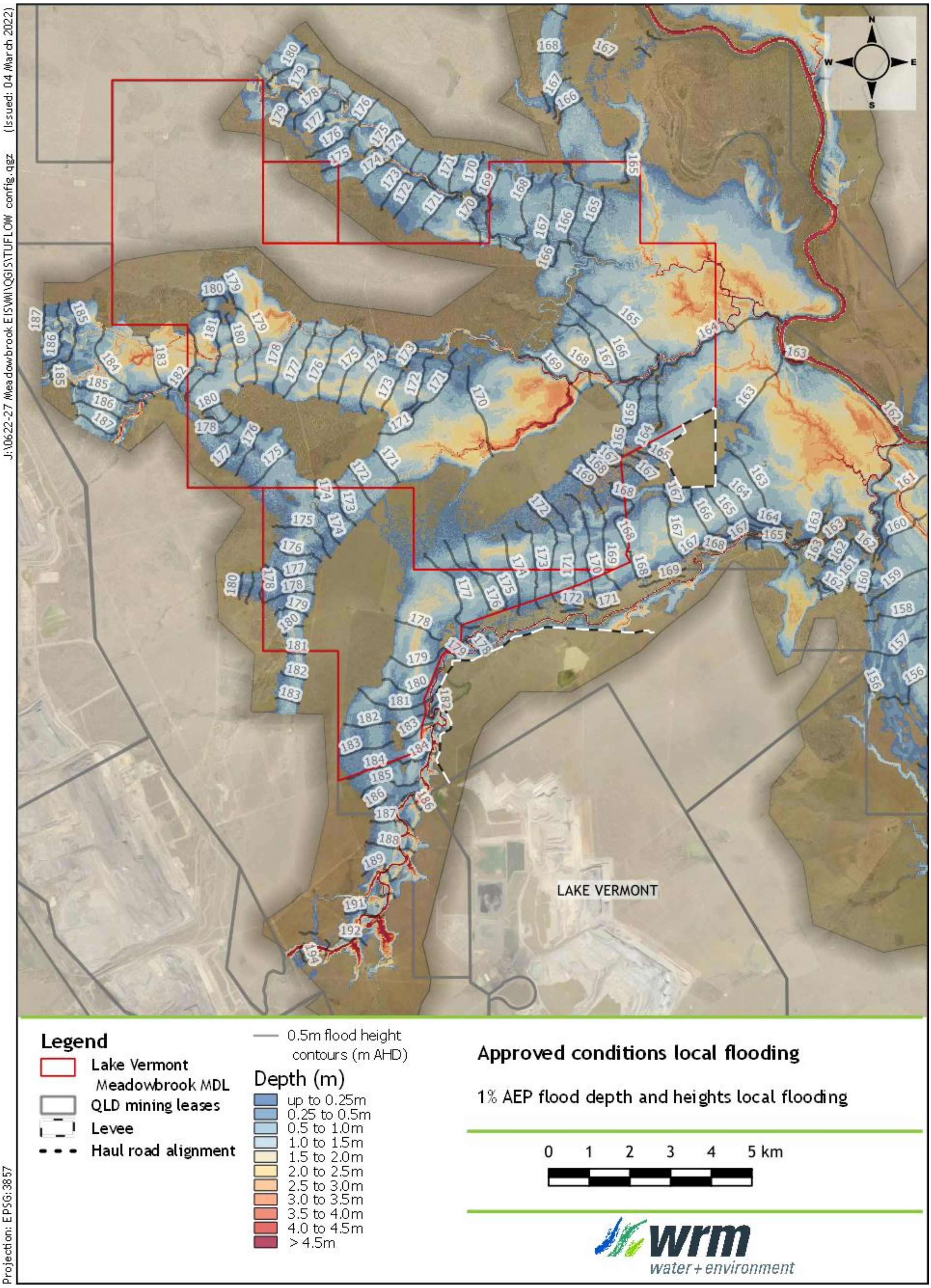

Figure 9.8: 1% AEP approved conditions local flood depths and heights

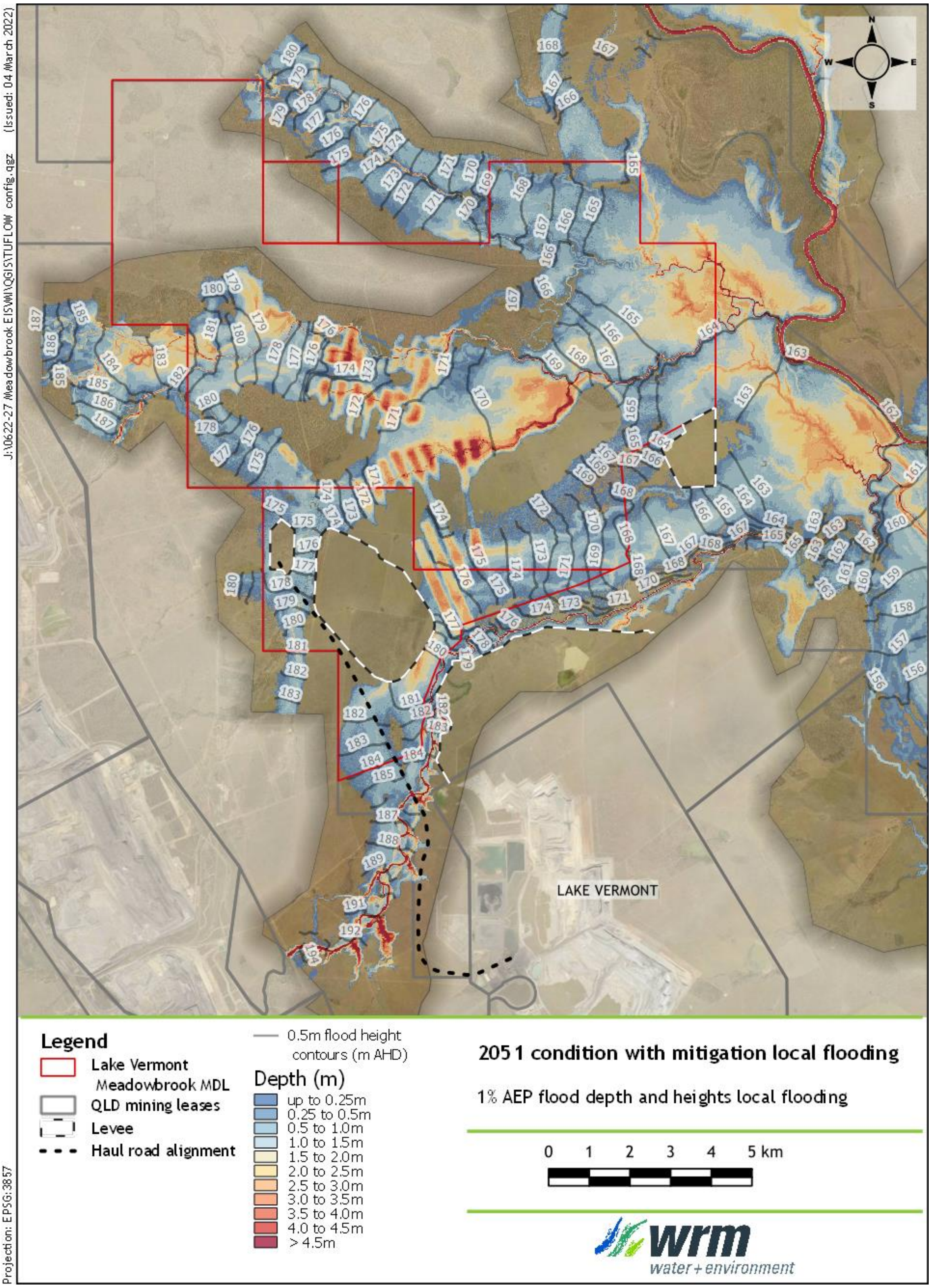

Figure 9.9: 1% AEP developed condition flood depth and heights local flooding

9.4.2 Flood velocity impacts

Flood velocity mapping for all scenarios described in section 9.2.4.3 is provided in Appendix Z, Flood Modelling Assessment Report (Section 3.3), for each flood event assessed. The modelled 1% AEP flood velocities for the 2051 operations scenarios are shown in Figure 9.10 and Figure 9.11. The modelled changes in velocity for the 2051 mine site conditions compared with approved conditions for the 1% AEP event are shown in Figure 9.12.

A detailed assessment of velocity impacts is provided in Appendix Z, Flood Modelling Assessment Report (Section 3.3). An overview of the Flood Impact Assessment for flood velocity indicates:

- There are no significant changes in velocity downstream of the mine lease area in design flood events.
- Across the range of events, the subsidence panels would typically experience velocity reductions up to 0.5 m/s and velocity increases between the panels up to 0.7 m/s (with some areas experiencing increases up to 1.2 m/s).
- The Phillips Creek floodplain near the south-eastern corner of the open-cut mine is predicted to experience the greatest velocity increases. Modelled point velocity increases the range from 0.8 m/s in the 10% AEP event to approximately 1.3 m/s in the 2% and 1% AEP events and up to 1.5 m/s in the 0.1% AEP event. These velocity increases would be temporary until the operational pit protection levee was decommissioned.
- In the 2% and 1% AEP events, increases of 0.2 m/s would occur upstream of the haul road in the channel of Phillips Creek, and increases of 0.1 to 0.2 m/s would occur along the haul road on the Phillips Creek northern floodplain.
- Minimal upstream velocity impacts are predicted for the 50% and 10% AEP floods. Minimal increases in velocity are predicted in the 0.1% AEP event.

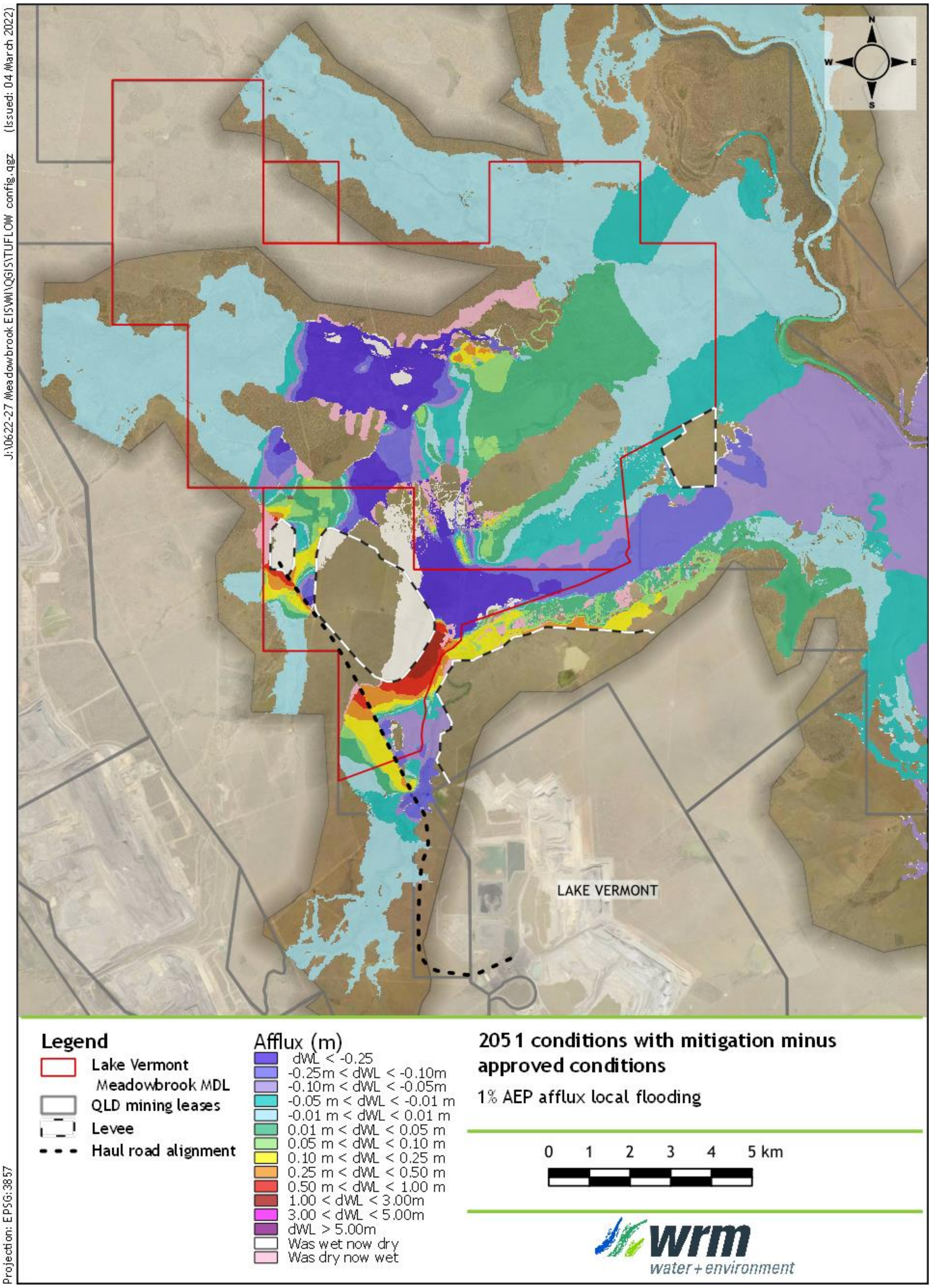

Figure 9.10: 1% AEP afflux (2051 conditions minus approved conditions)

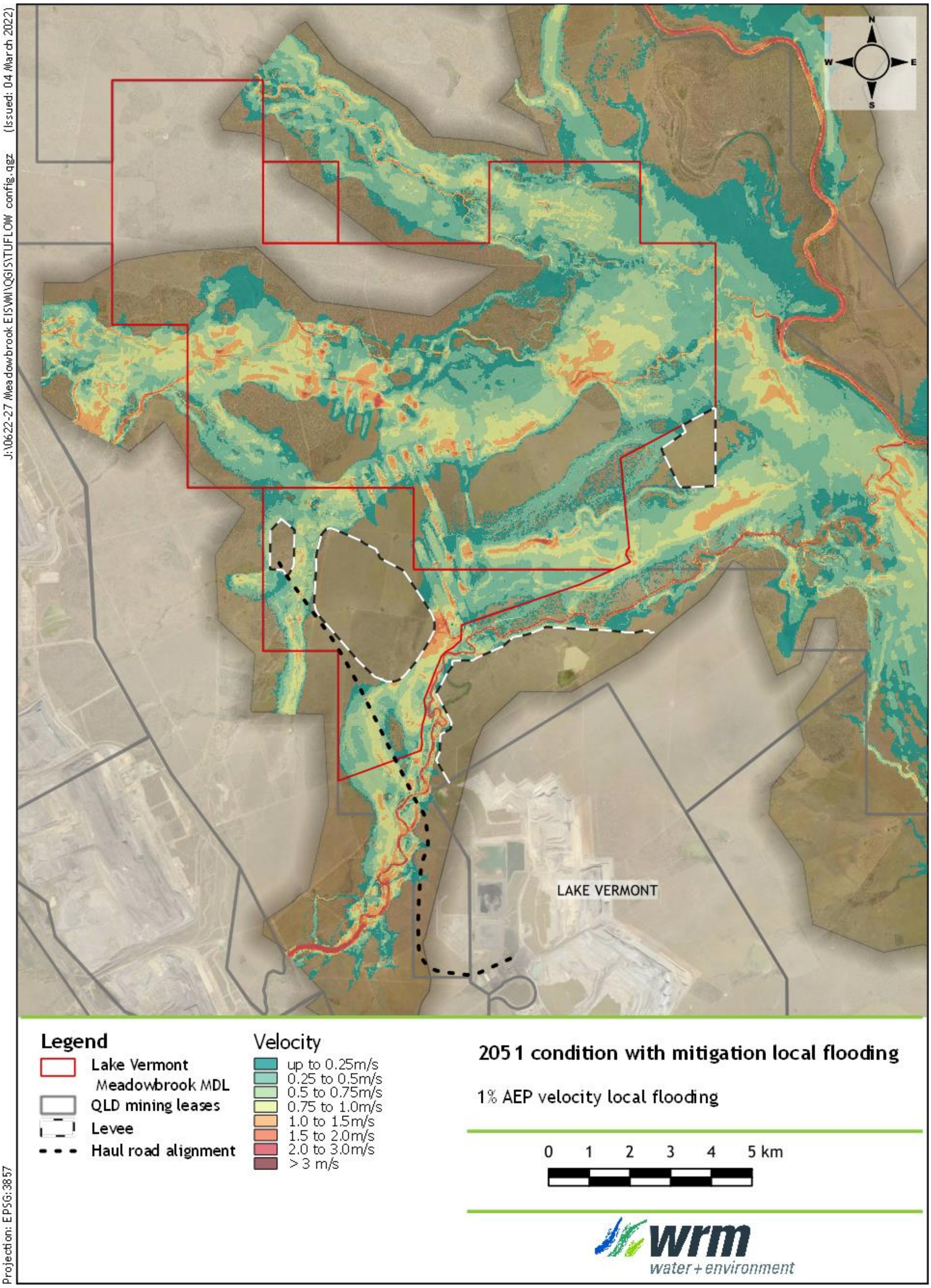

Figure 9.11: 1% AEP 2051 conditions local flood velocity

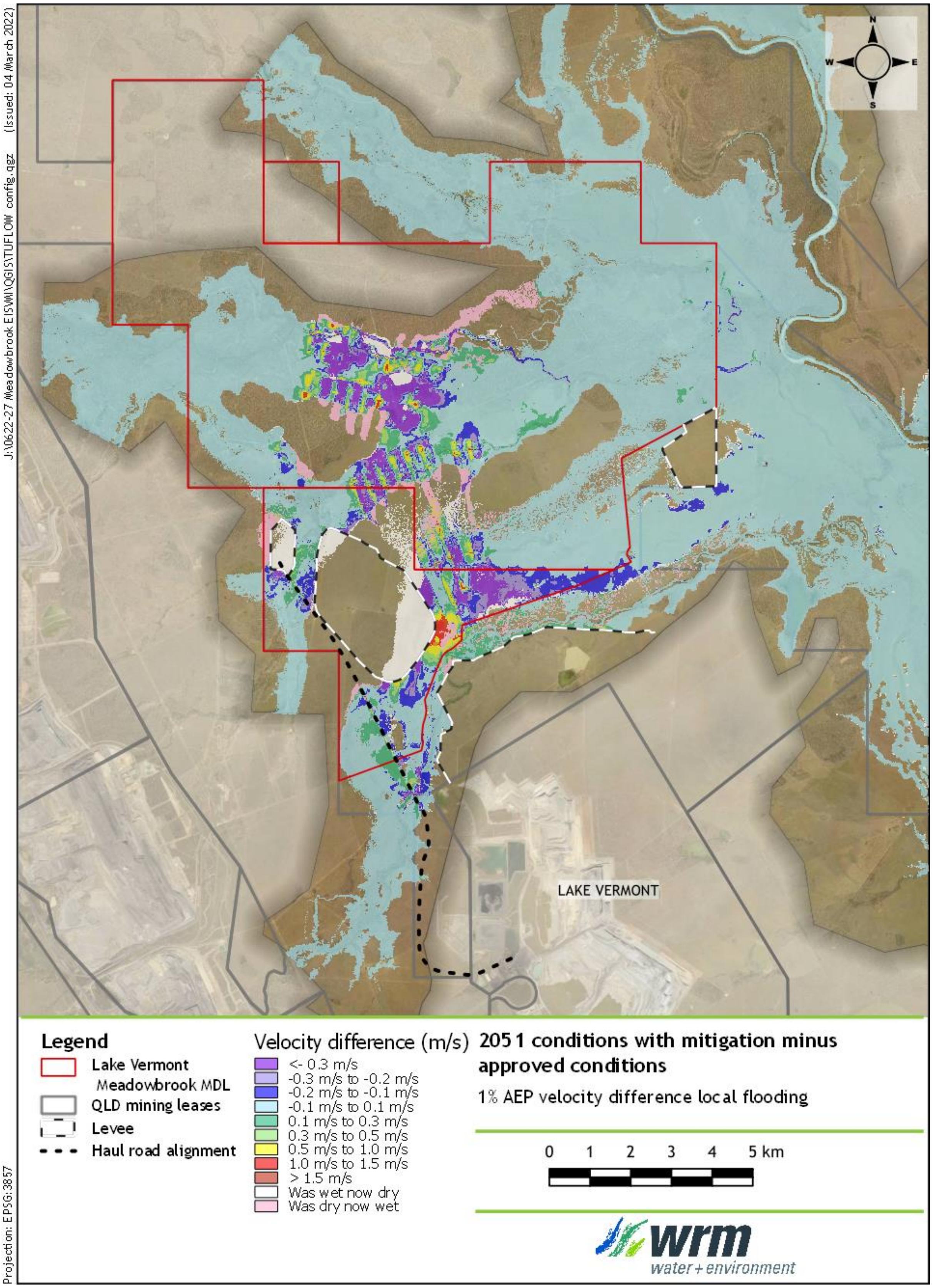

Figure 9.12: 1% AEP 2051 velocity difference (2051 conditions minus approved conditions)

9.4.3 Geomorphology impacts

An assessment of the 2051 development conditions of the Project has been undertaken to model potential effects on the geomorphological behaviour of the channels and floodplains of Boomerang Creek and One Mile Creek for the 50% and 2% AEP events (Appendix W, Geomorphological Assessment Report, Section 4). The results are outlined as follows for floodplain morphology and channel morphology.

The geomorphology assessment undertaken by WRM (Appendix W, Geomorphological Assessment Report, Section 4) also considers predicted direct subsidence impacts on floodplain drainage. Flood level impacts from subsidence are provided in Appendix F, Surface Water Assessment.

9.4.3.1 Floodplain morphology

Impacts on floodplain morphology for the proposed 2051 development conditions are described in detail in Appendix W, Geomorphological Assessment Report (Section 4.2). In summary, the Project has the potential to have the following affects on flow velocities:

- Reduced flow velocities across much of the floodplain will occur as water is stored in the subsided areas. This will promote the deposition of sediment in these areas and the surrounding floodplain. Long-term impacts will result in the gradual accretion of floodplain depressions.
- Increased velocities in areas where overbank floodwater drains into subsidence troughs are predicted to occur (Figure 4.7 and 4.8 of Appendix W, Geomorphological Assessment Report, Section 4.4), including:
  - a 50% AEP event that will initiate:
    - increases of more than 0.5 m/s in small areas of the floodplain, with the potential to cause localised erosion initially; and
    - increases of 0.25 m/s to 0.5 m/s where the additional floodplain water from Boomerang Creek drains into One Mile Creek.
  - A 2% AEP event that will allow:
    - velocities to remain mostly below 1 m/s, with significant alterations to floodplain morphology considered unlikely.

9.4.3.2 Channel morphology

The results of flood modelling of the Boomerang Creek and One Mile Creek floodplains for the 2051 development conditions have been used to assess impacts on channel morphology, including changes to flood velocities, bed shear and stream power. The results have been modelled from 50% and 2% AEP events (Appendix W, Geomorphological Assessment Report, Section 4.5). The key findings of the assessment are detailed below. Appendix W, Geomorphological Assessment Report (Section 4.5) should be referred to for the locations of drainage references shown in the sections below.

Boomerang Creek

- Subsidence results indicate a series of six main troughs in the bed due to the interaction of the differential settlement across the longwall panels and the intervening unmined pillars in the two overlying coal seams. The subsidence troughs above each longwall panel cause decreases in channel velocity, bed shear and stream power, as the channel drains out of each subsidence trough and traverses the adjoining chain pillar.
- Increase in channel velocity, bed shear and stream power will occur as the channel drains into the mine subsidence zone at Ch 9,250. The deep bed sediments in these reaches are expected to erode relatively quickly as the channel morphology changes to reflect the higher bed grade. Potentially, this will lead to an increase in bank erosion as the channel capacity increases.
- Increase in channel velocity, bed shear and stream power will occur as flow enters the second and fourth subsidence troughs (Ch 10,200, and Ch 11,700 to Ch 12,000). The observed volumes of sediment in the

overall system are significant enough to indicate expected aggradation of the bed, resulting in the post-subsidence channel velocity, bed shear and stream power reverting towards pre-mining conditions.

One Mile Creek

- The predicted subsidence troughs (eight main troughs in the bed) above each longwall panel significantly decrease channel velocity, bed shear and stream power as the channel drains out of each subsidence trough and traverses the adjoining chain pillar. This will cause a major reduction in sediment transport capacity in each trough and promote aggradation of the bed in these areas.
- Increase in channel velocity, bed shear and stream power will occur as the channel drains into the mine subsidence zone at Ch 9,750. Velocities in this area would remain less than guideline values but, given the relatively fine sediment in this area and the apparent limitation in sediment supply, these reaches are expected to erode as the channel morphology changes to reflect the higher bed grade. This may also lead to increases in bank erosion as the channel capacity increases.
- Increase in channel velocity, bed shear and stream power will occur as flow enters the second to fifth subsidence troughs (working west to east). The bed sediments on the downstream side of these localised elevated sections of the stream bed are expected to scour, and headward erosion would occur through this elevated section of stream bed.

As part of mitigation and monitoring measures outlined in section 9.5, a subsidence monitoring program will be implemented to assess the extent of the channel changes, including changes in bed levels and the impact of increased localised sedimentation. Bank protection measures will be considered if monitoring indicates that the increase in erosion is having a demonstratable impact on the channel form.

9.4.4 Subsidence impacts

Flood level impacts near the subsidence zone and the predicted direct subsidence impacts were modelled by WRM and are provided in Appendix W, Geomorphological Assessment Report (Section 3). The predicted direct impact results consider the depth and extent of subsidence and the impacts of subsidence on floodplain drainage, as discussed in sections 9.4.4.1 to 9.4.4.3.

9.4.4.1 Flood level impacts

The most significant reductions in flood levels tend to be localised around the subsidence areas and are of a similar magnitude to the predicted subsidence depths (Appendix Z, Flood Modelling Assessment Report, Section 3.3.1). The WRM assessment made the following conclusions:

- Over the subsidence panels on the Phillips Creek floodplain downstream of the open-cut mine, reductions in flood levels are up to 2 m in some areas in the 10% AEP event.
- In the 50% and 10% AEP events, there is a reduction in the wetting of the floodplain downstream of the subsidence.
- For the subsidence areas on One Mile Creek, reductions in levels range from 1 m to 700 mm. Along Boomerang Creek, some flood levels have reduced by as much as 3 m in the 10% AEP event and 2.5 m in the PMF in the most affected locations.
- The increase in flood storage in subsided areas results in a reduction of 50% and 10% AEP flood levels further downstream at Phillips Creek, One Mile Creek and Boomerang Creek of between 50 mm and 100 mm.
- For the 2% AEP and larger flow events, reductions in flow along the tributary of Phillips Creek that lies on the subsided floodplain become more significant (i.e. between 100 mm and 250 mm) as flow is diverted along the subsidence panels and joins One Mile Creek. This effect would be mitigated by the construction of bunds across the subsidence panels, thereby limiting afflux in the One Mile Creek and Boomerang Creek floodplains to 50 mm to 100 mm. The subsidence would result in a small reduction in flood levels downstream of the subsidence zone.

- Afflux downstream of the mine lease area is negative for all events and ranges from a 600 mm reduction at the Isaac River in the 50% AEP to 300 mm in the 10% AEP. Reductions in the floodplain of the Isaac River in the larger events from the 2% AEP to the PMF range from 60 mm to 100 mm.
- In the 0.1% AEP and PMF events, there is some positive afflux in the vicinity of the confluence of the Boomerang and Isaac Rivers of approximately 30 mm to 50 mm.
- Within the subsidence zone of Boomerang Creek, peak flood levels would be reduced by up to approximately 3.5 m in the 50% AEP and approximately 3.0 m in the 2% AEP flood. The extent of inundation would be increased slightly by backwater flowing up the subsidence troughs. During small flood events, additional flood storage would significantly reduce the peak flow rate and peak flood levels in downstream reaches of Boomerang Creek by as much as 0.3 m to 0.5 m (Geomorphological Assessment Report, Section 5.2).
- Within the subsidence zone of One Mile Creek, peak flood levels would be reduced by up to approximately 1.3 m in the 50% AEP flood and approximately 1.5 m in the 2% AEP flood (Appendix W, Geomorphological Assessment Report, Section 5.3).

9.4.4.2 Depth and extent of subsidence

The maximum depth of predicted subsidence varies with location around the proposed operation, with impacts greater where two seams are mined (Appendix W, Geomorphological Assessment Report, Section 3.2). Subsidence depths relevant to flooding impacts are considered as follows:

- The channel of Phillips Creek would not be directly affected by subsidence. Maximum subsidence depths on the Phillips Creek northern floodplain would be up to between 2.5 m and 3.0 m.
- Maximum subsidence depths on the One Mile Creek channel and southern floodplain would be up to between 2.5 m and 3.0 m.
- Maximum subsidence depths in the floodplain between One Mile Creek and Boomerang Creek would be over 4.5 m in localised areas.
- The channel and floodplain of Boomerang Creek would see maximum subsidence depths of up to 4.0 m (Appendix W, Geomorphological Assessment Report, Section 3.2).

9.4.4.3 Impacts of subsidence on floodplain drainage

Changes to local topography resulting from predicted subsidence would increase the number and extent of areas not free draining (i.e. residual ponding areas). Residual ponding areas are primarily located directly above longwall panels, with the surface area of the panel subsiding as the underlying coal strata is removed.

Bowen Basin Coal has undertaken work to identify and mitigate the extent of residual ponding areas. This can be achieved in some areas by:

- constructing bunds to prevent surface water ingress into subsided areas; or
- constructing drains to facilitate water egress from subsided areas.

This work has resulted in the development of proposed ‘mitigation bunds’ and proposed ‘mitigation drains’. The drains achieve the reduction of residual ponding areas from 370 ha to 213 ha. Figure 9.13 shows both the pre-mitigation and post-mitigation ponding footprints in conjunction with the proposed locations of mitigation bunds and mitigation drains.

On the northern Phillips Creek floodplain, a mitigation drain is proposed to drain the four subsided panels downstream *via* an existing drainage line (Figure 9.13). The proposed earthworks would extend for approximately 2.5 km from the deepest point of the westernmost panel. The channel would be up to 2.8 m deep at the peak of each pillar and would have a base width of approximately 5 m, consistent with the existing floodplain channel in the area (Appendix W, Geomorphological Assessment Report, Section 3.3.2).

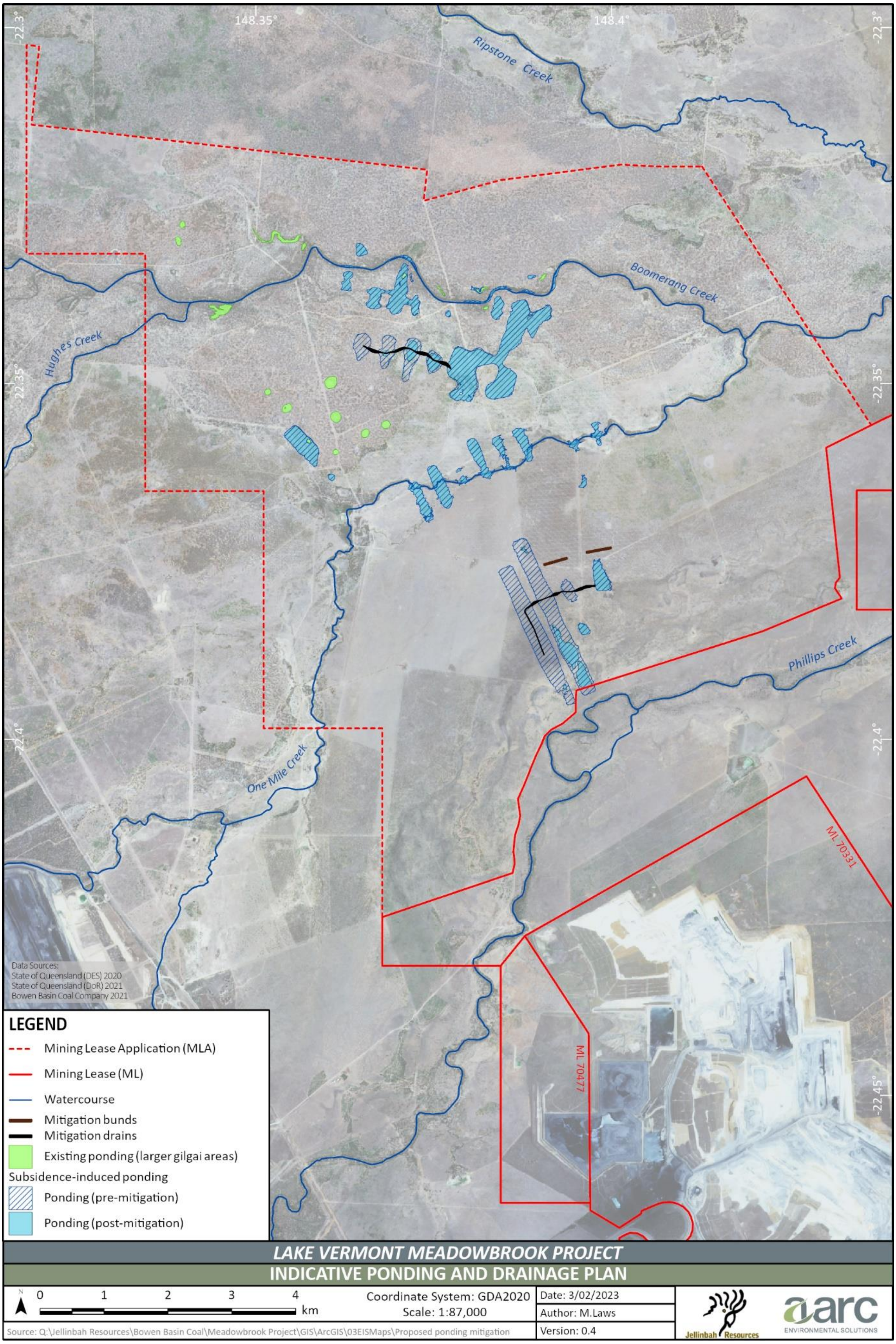

Figure 9.13: Residual ponding areas and proposed mitigations

On the floodplain between One Mile Creek and Boomerang Creek, a mitigation drain is proposed to drain four subsided panels (Figure 9.13). The proposed earthworks would extend for approximately 1.4 km from the deepest point of the westernmost panel. The channel would be up to 3 m deep at the peak of each pillar and would have a base width of approximately 5 m (Appendix W, Geomorphological Assessment Report , Section 3.3.2).

Two mitigation bunds are also proposed to be constructed across the panels in the Phillips Creek floodplain (Figure 9.13). These mitigation bunds are designed to maintain flows in the minor drainage paths during flood conditions and reduce the potential for Phillips Creek floodwater to be diverted to One Mile Creek in minor floods. Mitigation bunds will be constructed to a maximum height of approximately 2.7 m (at the deepest point of the subsided ponds) and a maximum width up to approximately 27 m (based on a 1:5 slope at the maximum height). The length of each mitigation bund is up to a maximum of approximately 350 m.

With proposed ponding mitigation works, it is noted that it has not been possible to drain the residual ponding areas in the north-eastern part of the One Mile Creek and Boomerang Creek floodplains, due to relative elevations (Appendix W, Geomorphological Assessment Report, Section 3.3.3). Nonetheless, significant reductions in ponding areas would be achieved through the proposed mitigation bunds and mitigation drains. This works to significantly reduce the impact to ecological values. Ecological impacts from residual ponding are discussed in Chapter 10, Terrestrial Ecology, and Chapter 11, Aquatic Ecology.

It should also be noted that the residual ponding areas shown in Figure 9.13 provide the ‘worst-case’ scenario, as this representation assumes subsided areas are full of water, which will rarely be the case (Appendix W, Geomorphological Assessment Report, Section 3.3.1). Residual ponding areas would nonetheless form after rainfall and flood events. Under the 50% AEP flood event, residual ponds created by subsidence are predicted to be inundated by flooding at least every few years on average (Appendix W, Geomorphological Assessment Report, Section 3.3.3).

Further, the proponent proposes to use pumping equipment to reduce the total volume of overland flow captured, by pumping water out of subsided depressions into downstream flow paths, when accumulated volumes become significant.

Pumps will be located at the deepest sections of each subsidence depression and deliver water to the pre-mining overland flow path. The effectiveness of pumping out each of the depressions at a nominal rate of 50 L/s (4.3 ML/d) when water depth exceeds 0.5 m above the lowest point, was tested using the water balance model. The results show that pumping reduces the volume captured in the depressions to 11% of the total runoff draining to the depressions (Appendix W, Geomorphological Assessment Report, Section 3.3.4.1).

It is noted that no works are proposed by the Project, for the purposes of capturing overland flow. Indeed, proposed works are only designed to limit the accumulation of overland flow. As such, a licencing requirement under the Fitzroy Water Plan is not considered to arise for the Project.

Post mining, it is expected that subsidence depressions will naturally refill with sediment. Based on estimated average sediment supply rates to the catchment, in the absence of significant depletion of sediment in the reach of Boomerang Creek between the two projects, it is expected to take 15 to 45 years for the Meadowbrook subsidence depressions to refill with sediment (post-mining). Complete replenishment of residual sediment loss attributable to the Saraji East project could take a similar time, however large floods occurring after the completion of mining could significantly reduce these timeframes. (Appendix W, Geomorphological Assessment Report, Section 3.3.4.1).

Mitigations such as the backfilling of subsidence depressions was considered as part of Project studies, however this option was discounted as a result of the more significant impact it presents to environmental values in these areas. Indeed, it is preferable to maintain ecosystem function within subsided areas, as opposed to presenting a greater impact within these footprints (resultant of building a new overlying landform). Further, there is also some argument that ponded areas arising as a result of subsidence will support increased habitat availability for some locally present threatened species (eg ornamental snake, squatter pigeon and greater glider).

With catchment losses downstream of the Once Mile Creek and Boomerang Creek confluence representing just 1.8% of the 489 km^2 total catchment, impacts to floodplain drainage are therefore expected to be minimal.

9.4.5 Water management infrastructure risk

As described in section 9.3.1, temporary flood protection levees with 0.1% AEP design event flood protection will be constructed around the MIA and open-cut pit prior to operations.

The MIA levee is predicted to cause some minor additional off-lease inundation to depths of up to 150 mm adjacent to One Mile Creek. This is expected to increase to 200 mm in a (0.1%) AEP event (Appendix Z, Flood Modelling Assessment Report, Section 3.3.2). These depth increases would be temporary until the open-cut mining area levee is decommissioned (Appendix Z, Flood Modelling Assessment Report, Section 3.3).

The open-cut mining area levee is predicted to induce floodplain flow velocity increases. Under the developed conditions (2051 scenario), the Phillips Creek floodplain near the south-eastern corner of the open-cut mining area is predicted to experience the greatest velocity increase. Modelled point velocity has increased the range from 0.8 m/s in the 10% AEP event to approximately 1.3 m/s in the 2% and 1% AEP events and up to 1.5 m/s in the 0.1% AEP event. These velocity increases would be temporary until the open-cut mining area levee is decommissioned (Appendix Z, Flood Modelling Assessment Report, Section 3.3.3).

9.4.5.1 Post-closure conditions

Post-closure conditions for local creek flooding have been modelled for a 0.1% AEP and PMF flood event. However, the proposed rehabilitated pit is outside the 0.1% AEP (approved conditions) flood extent, and the surrounding land would be shaped to mitigate the risk of inundation of the rehabilitated pit from floods not exceeding the 0.1% AEP flood event (Appendix Z, Flood Modelling Assessment Report, Section 3).

The depth and velocity results for the 0.1% AEP flood event are shown in Figure 9.14 and Figure 9.15. The results of the analysis of the PMF under post-closure conditions is provided in Appendix Z, Flood Modelling Assessment Report, Section 3.4.

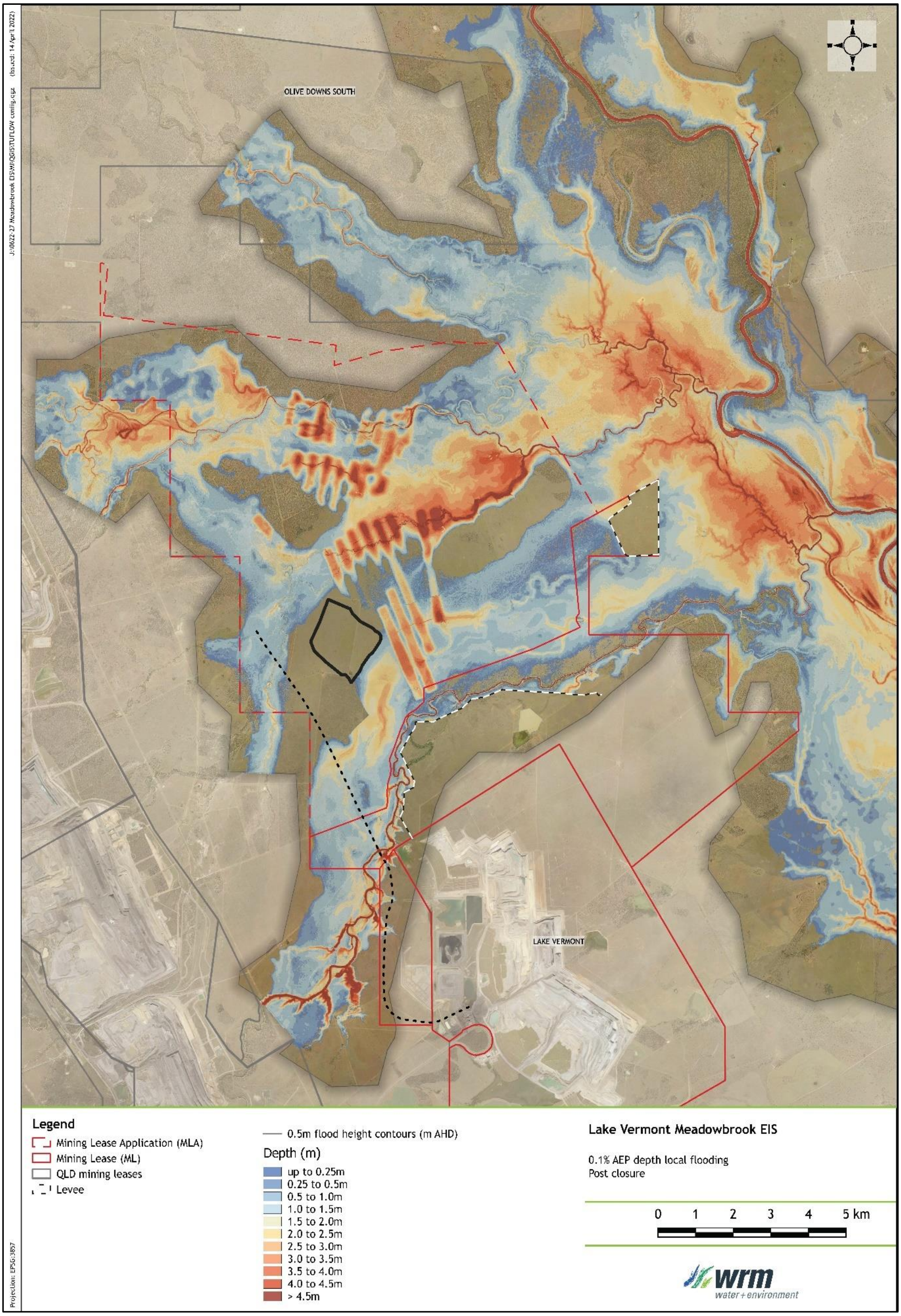

Figure 9.14: Post-closure conditions 0.1% AEP depth

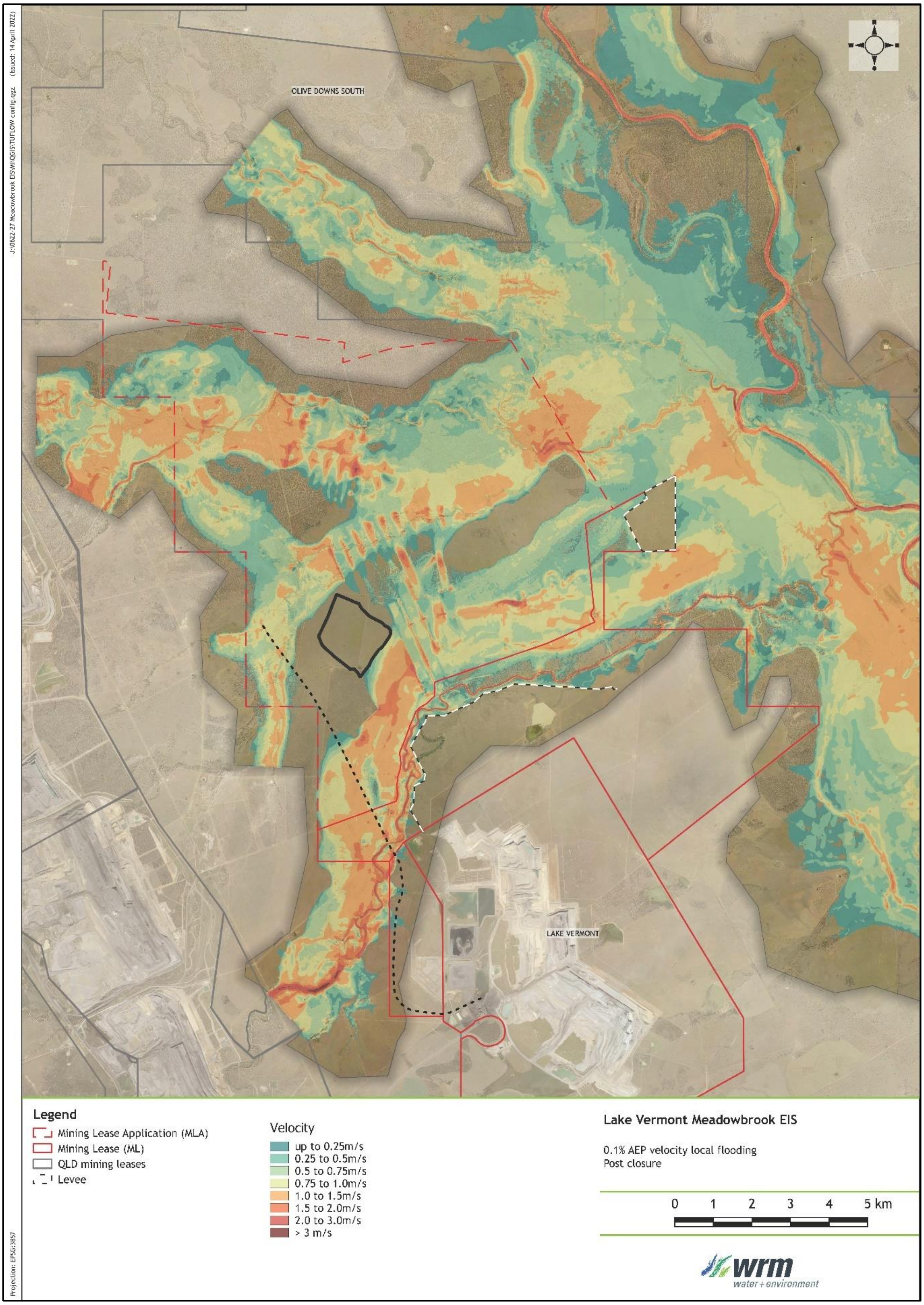

Figure 9.15: Post-closure conditions 0.1% AEP velocity

9.4.5.2 Consequence Category assessments

Proposed Project levees (MIA levee and open-cut mining area levee) are designed to protect infrastructure from a 0.1% AEP flood event. As such, these levees will be considered 'regulated structures' (Appendix F, Surface Water Assessment, Section 5.3.1). Project levees have been conceptually designed in accordance with the 'Manual for assessing consequence categories and hydraulic performance of structures' (DES 2016) and the 'Structures which are dams or levees constructed as part of environmentally relevant activities' (DES 2022b). Model EA conditions for regulated structures will require the development of certified design drawings prior to the commencement of levee construction.

A consequence category assessment has also been completed for all dams proposed for the Project in accordance with the 'Manual for assessing consequence categories and hydraulic performance of structures' (DES 2016), which sets out the requirements of the administering authority for consequence category assessment and certification of the design of regulated structures.

Each dam is assigned a Consequence Category of High, Significant or Low depending on its potential to cause harm. A structure categorised as a Significant or High consequence is referred to as a regulated structure. Such structures must comply with hydraulic performance objectives (DES 2016).

DES (2016) requires an assessment of the potential for harm under the following failure event scenarios:

- **Failure to contain – seepage**—spills or releases to ground and/or groundwater *via* seepage from the floor and/or sides of the structure;
- **Failure to contain – overtopping**—spills or releases from the structure that result from a loss of containment due to overtopping of the structure; and
- **Dam break** — collapse of the structure due to any possible cause.

For each failure event scenario, a consequence category is assigned depending on the potential to cause harm to humans and/or wildlife or general economic loss or general environmental harm. Assessment of the consequence category of Project dams is discussed as follows.

Failure to contain – seepage

Seepage risks from Project dams are considered to be low. While seepage from the Dewatering Dam and MIA Dam may have the potential to impact ecological values of One Mile Creek and its tributaries, any such impact would be limited in extent (Appendix Y, Site Water Balance and Water Management, Section 6.1.3).

The expected water quality of excess water pumped from the underground operation is considered to present a low risk of seepage impact, effectively being diluted by a ratio of three parts raw water to one part groundwater prior to dewatering. The Dewatering Dam and MIA Dam have, therefore, been assigned to the Low Consequence Category. However, it is recommended that this is reviewed once the detailed engineering and design of Project water storage infrastructure is finalised.

Failure to contain – overtopping

DES (2016) states that a dam is to have a Significant Consequence Category if it meets the following criteria:

- *Location such that contaminants may be released so that adverse effects…would be likely to be caused to Significant Values—and at least one of the following:*
  - *i) loss or damage or remedial costs greater than $10,000,000 but less than $50,000,000; or*
  - *ii) remediation of damage is likely to take more than 6 months but less than 3 years; or*
  - *iii) significant alteration to existing ecosystems; or*

iv) *the area of damage (including downstream effects) is likely to be at least 1 km^2 but less than 5 km^2 (DES, 2016).*

Given the relatively small volume and concentrations of contaminants within Project dams, it is unlikely that remedial measures would meet these criteria (Appendix Y, Site Water Balance and Water Management, Section 6.1.3).

The Dewatering Dam and MIA Dam are located within an area surrounded by a levee structure (the MIA levee) further preventing the passage of overtopping water to the receiving environment. Project sediment dams are designed to overtop and function effectively as sediment dams. Overtopping risks from Project dams are, therefore, considered to be in the Low Consequence Category.

The nearest known town water supply systems are on the Fitzroy River, and they would not be materially affected by discharge from any of the dams at the Project due to the total stored volume being less than 500 ML and the very large dilution potential during wet season flows (Appendix Y, Site Water Balance and Water Management, Section 6.1.2.1).

Dam break

Due to the sparse population in the region, there are no workplaces or dwellings in the potential failure impact zone of the site water dams. In accordance with 'Manual for assessing consequence categories and hydraulic performance of structures' (DES 2016), site personnel are not considered in the dam break assessment. All dams are located such that people are not routinely present in the potential failure path if an embankment were to fail (Appendix Y, Site Water Balance and Water Management, Section 6.1.2.1).

In respect of general economic loss, it is noted that there are no significant commercial operations in the immediate downstream reaches of the Isaac River or its tributaries likely to be affected by contamination under any of the potential failure impact scenarios (Appendix Y, Site Water Balance and Water Management, Section 6.1.2.2).

Similarly, the potential damage caused by a dam break of the MIA Dam embankment is likely to be limited due to its limited height (planned to be less than 5 m) and storage capacity (Appendix Y, Site Water Balance and Water Management, Section 6.1.2.2). The proposed MIA levee will also work to mitigate a dam break scenario at the Dewatering Dam and the MIA Dam.

With respect to the potential for environmental harm resultant from a dam break, it is noted that stored water quality in the Dewatering Dam and the MIA Dam are likely to be similar to mine water dams at other Central Queensland mine sites (e.g. elevated salinity and pH and some dissolved metals). As there are no High Environmental Value (HEV) zones identified in the downstream receiving environment, there is limited potential to cause harm to Significant Environmental Values (Appendix Y, Site Water Balance and Water Management, Section 6.1.2.3). As such, Project dams are assessed as being in the Low Consequence Category for dam break.

The assessment outcomes (consequence categories) for proposed Project dams are provided in Table 9.4.

Consequence category assessments will require review and revision once the detailed engineering and design of the water infrastructure is finalised (Appendix Y, Site Water Balance and Water Management, Section 6). Once this occurs, certifications for any regulated structures will be provided.

Table 9.4: Summary of consequence category assessment (dams)

Consequence scenario	Dewatering Dam	MIA Dam	Raw Water Dam	Sediment Dams
Failure to contain–seepage				
Harm to humans	L^	L	L	L
General environmental harm	L	L	L	L
General economic loss/damage	L	L	L	L
Failure to contain–overtopping				
Harm to humans	L	L	L	L
General environmental harm	L	L	L	L
General economic loss/damage	L	L	L	L
Dam break				
Harm to humans	L	L	L	L
General environmental harm	L	L	L	L
General economic loss/damage	L	L	L	L
Overall Consequence Category assessment rating				
Requires DSA/MRL*	N	N	N	N
Requires engineered spillway	Y	Y	Y	Y
Requires clay lining (unless detailed groundwater investigation indicates risks are low)	Y	Y	N	N

^ L=Low consequence; S=Significant consequence. *DSA=Design Storage Allowance; MRL=Mandatory Reporting Level.

9.4.6 Haul road and watercourse crossings

The proposed haul road construction will obstruct floodplain and channel flow, locally increasing upstream flood levels (Appendix Z, Flood Modelling Assessment Report, Section 3.3). However, vertical alignment and cross-drainage structures have been designed to mitigate upstream impacts and preserve downstream flow distribution. In events greater than 50% AEP, the proposed haul road would increase upstream, off-lease flood levels within the channel of Phillips Creek by less than 60 mm (Appendix Z, Flood Modelling Assessment Report, Section 3.3.2).

Immediately upstream of the haul road crossing at One Mile Creek, the haul road causes a local afflux of approximately 400 mm in the 1% AEP flood. However, the afflux does not extend significantly off-lease. In the 10%, 2% and 1% AEP events, the low-level crossing at Phillips Creek becomes drowned out, and the afflux is reduced so that off-lease flood levels upstream of the haul road are not increased by the Project. The 0.1% AEP and PMF flood events show no afflux in Phillips Creek upstream of the haul road crossing (Appendix Z, Flood Modelling Assessment Report, Section 3.3.2).

9.4.7 Waste rock emplacements

The rehabilitated waste rock emplacement area (that will remain post-mine closure) is outside the defined 0.1% AEP flood area and will not impact flooding profiles or be impacted by flooding.

Coal reject management procedures utilised at the existing Lake Vermont Mine will also be adopted for the Project. Specifically, the existing coal-disposal facilities will be used to manage Project coal reject. These facilities are regulated structures that have been designed and certified by a Registered Professional Engineer of Queensland in accordance with government regulations. Rehabilitation of the co-disposal facilities is described in Chapter 6, Rehabilitation.

9.4.8 Cumulative impacts

The Flood Impact Assessment has considered existing structures and nearby projects that may affect flood behaviour. Cumulative impact conditions include all levees associated with the proposed Olive Downs Project. Flood impacts of the Project and proposed Olive Downs Project would potentially interact due to the Willunga and Olive Downs South domains of the Olive Downs Project that extend onto the Isaac River floodplain downstream and upstream of the Lake Vermont Meadowbrook Project.

Cumulative impact modelling has included two scenarios representing combined impact by the Project. The two scenarios are:

1) 2051 mine site conditions with mitigation measures (plus other projects); and

2) post-closure conditions of the Project (plus other projects).

A cumulative impact assessment has been undertaken for a 0.1% AEP regional flood event (Appendix Z, Flood Modelling Assessment Report, Section 4).

The results indicate that cumulative flooding outside the Project area is caused by relatively large impacts on Isaac River floodplains by other approved projects.

The impacts of the Lake Vermont Meadowbrook Project are relatively minor, with little cumulative interaction between the Project and the impacts of other proximate projects.

The cumulative impact scenario of all known proposed floodplain developments near the Isaac River floodplain is increased water levels within the Project area by 60 mm post-closure (Appendix Z, Flood Modelling Assessment Report, section 5).

9.4.9 Sensitivity assessments

An assessment of the Project’s vulnerability to climate change has been undertaken in Chapter 4, Climate. This assessment has been conducted according to projections generated by the ‘Coupled Model Intercomparison Project Phase 5’ and information contained in the ‘Queensland Future Climate Dashboard, Qld 2021’.

In summary:

- The average annual rainfall is projected to decrease slightly by 2050, continuing to decrease until 2070.
- Seasonal rainfall projections indicate that spring rainfall will decrease slightly by 2050, continuing to decrease until 2070, while summer rainfall will increase by 2070.
- The intensity of extreme rainfall events is expected to decrease between 2050 and 2070.
- Average and maximum daily temperatures are considered likely to increase over the life of the mine due to climate change.
- Evaporation is expected to increase with the projected increased temperatures.

An impact assessment for climate change on peak flows for the 50%, 10%, 2% and 1% AEP flooding events was also undertaken. This assessment was based on the Representative Concentration Pathway (RCP) 8.5 scenario for 2060 (Appendix Z, Flood Modelling Assessment Report, Section 1.3.12). RCP8.5 corresponds to a worst-case scenario. The ARR datahub provides a Climate Change Factor (CCF) for each RCP for each decade from 2030 up to 2090. As the Project finishes sometimes between 2050 and 2060, the year 2060 was selected for this assessment. According to the ARR Datahub the increase in rainfall intensity for RCP8.5 at the location of the Project for 2060 is 11.5%. The rainfall intensity for the selected flood events was therefore factored up by 1.115 and new discharges derived at the key locations (Appendix Z, Flood Modelling Assessment Report, Section 1.3.12).

Based on this, under modelled climate change conditions in the vicinity of the project disturbance, flood maps would be representative of flow conditions in more frequent events, as described below:

- the 50% AEP map would have an AEP of about 56%;
- the 10% AEP map would have an AEP of about 17%;
- the 2% AEP map would have an AEP of about 3.8%;
- the 1% AEP map would have an AEP of about 1.8%; and
- the 0.1% AEP map would have an AEP of about 0.3%.

Overall therefore, modelled climate changes are not anticipated to increase the risk of harm to environmental values, resultant of the Project.

9.5 Mitigation and management measures

The mitigation, management and monitoring measures outlined below are proposed to avoid, minimise and/or mitigate the Project's impacts on flooding with respect to the safety of people, wildlife, property and the environment.

9.5.1 Flood protection levees

While conceptual flood levee designs have been developed for this EIS (per section 9.3.1), detailed levee designs will be developed prior to construction in accordance with 'Manual for assessing consequence categories and hydraulic performance of structures' (DES 2016) and the 'Guideline, Structures which are dams or levees constructed as part of environmentally relevant activities' (DES 2022b).

To best manage risks associated with levee construction, Bowen Basin Coal is committed to:

- review flood levee crest levels and the design freeboard as part of detailed design works;
- develop and submit certified design drawings (and supporting documentation) prior to the commencement of levee construction in accordance with the requirements prescribed by DES (2016);
- use only non-dispersive, low permeable, engineered fill for levee construction;
- revegetate batters and surrounding areas with grasses to stabilise the structure and prevent sediment runoff; and
- decommission and rehabilitate levees in accordance with the Project PRCP (Appendix B, Progressive Rehabilitation and Closure Plan, Section 3.5.5.2).

With flood protection levees proposed to be regulated structures, they will be inspected by a suitably qualified and experienced person in advance of the wet season each year. In addition, following major flood events, a visual inspection of levees will be conducted by site personnel to identify any potential issues with erosion, settlement or slumping.

Two diversion drains will be constructed to support the management of surface water drainage around the proposed levee structures. These drains will be at the southern extent of the MIA levee and the southern extent of the open-cut mining area levee (Appendix Z, Flood Modelling Assessment Report, Section 2.3). Conceptual design details for these diversion drains are provided in section 9.3.2.

9.5.2 Ponding mitigation drains and bunds

Mitigation measures to limit the extent of residual ponding due to subsidence will include:

- construction of a 2.5 km long mitigation drain (with a 5 m channel base) to alleviate the extent of ponding within the subsidence panels immediately to the north of Phillips Creek (refer Figure 9.13);
- construction of a 1.4 km long mitigation drain (with a 5 m channel base) to alleviate the extent of ponding in the subsidence panels to the south of Boomerang Creek (refer Figure 9.13); and
- construction of two earthen mitigation bunds across these subsidence panels to prevent floodwater flowing north and into One Mile Creek (Appendix Z, Flood Modelling Assessment Report, Section 2.3).

Detailed design drawings will be prepared for this infrastructure, to support construction. The proposed disturbance from this infrastructure has also been considered within the Project assessment of impacts (refer to Chapter 10, Terrestrial Ecology and Chapter 11, Aquatic Ecology).

A further flood bund is proposed as part of the final landform for the Project to prevent water ingress into the final rehabilitated pit in a major flood event. A post-closure flood model showing a 0.1% AEP flood depth is provided in Figure 9.14. Construction of the proposed final rehabilitated pit landform will be located within the disturbance footprint of the open-cut mining area as part of the final earthworks. The landform will be designed to prevent water ingress into the rehabilitated pit during major flood events, supporting a post-mining land use for grazing. Post-mining land uses are detailed in Chapter 6, Rehabilitation.

9.5.3 Sediment dams

Sediment dams will be constructed within the proposed open-cut mining area to assist in managing rainfall and runoff. During open-cut mining operations, catchment runoff from overburden dumps will be captured in three sediment dams (referred to as the Southern Sediment Dam, the Northern Sediment Dam 1 and the Northern Sediment Dam 2).

To mitigate risk, sediment dams will be designed to contain a 1 in 10 year ARI 24 hour rainfall event and will be operated in accordance with the ‘DES Guideline: Stormwater and environmentally relevant activities’ (DES 2021c). Sediment dam catchment areas and proposed storage capacities are provided in Table 9.3.

The existing ‘Sediment and Erosion Control Plan’ for the Lake Vermont Mine will be updated to detail the management of proposed sediment dams prior to their construction and operation.

9.5.4 Haul road drainage

The proposed haul road construction is anticipated to obstruct floodplain and channel flows, locally increasing upstream flood levels (Appendix Z, Flood Modelling Assessment Report, Section 5).

These risks are proposed to be mitigated through the design of road embankment and associated cross-drainage structures. It is noted that prior to construction, the haul road design will be refined, with the vertical profile and cross-drainage structure details chosen to ensure impacts do not exceed those in the preliminary design. For the purposes of this study, the preliminary design and the indicative number and sizing of cross-drainage structures along the haul road have been adopted (Appendix Z, Flood Modelling Assessment Report, Section 2.3).

9.5.5 Receiving environment monitoring

Boomerang Creek is anticipated to experience increases in channel velocity, bed shear and stream power as the channel drains into mine subsidence zones (Appendix F, Surface Water Assessment, Section 7.4.1). The deep bed sediments in these reaches are expected to erode relatively quickly as the channel morphology changes to reflect the higher bed grade. This may also lead to an increase in bank erosion as the channel capacity increases.

The existing 'Receiving Environment Monitoring Plan' will, therefore, be updated prior to the commencement of underground mining to include additional sites to enable monitoring of potential impacts as a result of the proposed Project. Incidental management measures may also be implemented if monitoring indicates that an increase in erosion is having a demonstrable impact on the Boomerang Creek channel (Appendix F, Surface Water Assessment, Section 7.4.4).

9.5.6 Subsidence monitoring

As per the findings in the geomorphology assessment, the Project will implement a subsidence monitoring plan as part of ongoing monitoring and mitigation measures (Appendix F, Surface Water Assessment, Section 7.4.4).

The subsidence monitoring plan will facilitate monitoring to assess the extent of channel changes, including changes in bed levels and the impact of increased localised sedimentation. Incidental management measures, including bank protection, will also be considered if monitoring indicates that an increase in erosion is having a demonstrable impact on the Boomerang Creek channel.

9.5.7 Adaptation strategies

The risk to the Project posed by climate change has been assessed as low, with adaptation strategies proposed to include:

- development of infrastructure designed to meet local cyclone protection standards;
- construction of levies to protect key infrastructure areas from flooding and extreme rainfall events; and
- development of a PRC Plan (that considers climate hazards and climate change risks within rehabilitation strategies).