Appendix N

Final landform design

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EMM Consulting Pty Ltd.

Hunter Valley Operations Continuation Project

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Hunter Valley Operations Continuation Project

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WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Executive summary

Hunter Valley Operations (HVO) is a multi-pit open cut mining complex approximately 24 kilometres (km) north-west of Singleton in the Hunter Valley of New South Wales (NSW). HVO comprises two mine sites separated by the Hunter River, HVO North and HVO South. While the two mine sites are approved under separate development consents, they are operated as one complex with fully integrated environmental management systems. HVO is owned by subsidiary companies of Yancoal and Glencore, as participants in the unincorporated HVO Joint Venture (JV).

The HVO Continuation Project (the Project) broadly comprises the continuation of the life of HVO North and HVO South, from the current approved mining completion dates of 2026 and 2030 respectively, to the end of 2045 at HVO North and the end of 2042 at HVO South. The continuation of mining across the HVO Complex will increase resource recovery from the existing operation, predominantly by mining through previously mined areas and to the extent of existing mining tenements and extracting coal from deeper seams at HVO North.

An Environmental Impact Statement (EIS) (EMM 2022) for the Project was submitted to the (then) NSW Department of Planning and Environment (DPE) and subsequently placed on public exhibition from Monday 30 January 2023 through to Monday 27 February 2023. To respond to matters raised in submissions on the Project during the public exhibition period, a Submissions Report (EMM 2023a) and Amendment Report (EMM 2023b) was prepared.

During the subsequent assessment of the Project by the NSW Department of Planning, Housing and Infrastructure (DPHI), a number of requests for information (RFI) were issued to HVO, who provided responses as required. In response to an RFI received 5 July 2024, HVO completed a detailed review of the Project and is subsequently seeking to amend the SSD applications in the following ways:

- Reduce the project mine plan to avoid coal extraction within gas Domain 1 at HVO North and reduce the total ROM coal To be extracted by the amended Project by approximately 220 Mt.
- Maintain the current approved maximum annual ROM coal production from HVO North of 22 Mtpa but reduce the proposed maximum annual production limit at HVO South from 18 Mtpa to 13 Mtpa.
- Propose a maximum annual production limit for the HVO Complex of 26 Mtpa ROM, compared to the current approved maximum annual production of 42 Mtpa.
- Reduce the proposed life of mining operations at HVO North by five years, from the end of 2050 to the end of 2045.
- Reduce the proposed life of mining operations at HVO South by three years from the end of 2045 to the end of 2042.
- Expand the HVO North ROM coal stockpile to improve coal management.
- Remove approval for the construction and operation of the Lemington Coal Preparation Plant (LCPP) and associated rail facilities, which is currently approved, but not constructed, under the HVO South Project Approval.
- Temporary transport of product coal by truck from the Howick Coal Preparation Plant (CPP) to the Liddell stockpile for transport to market via the Liddell coal handling and train loading facilities during upgrades of the Newdell Load Point (LP).
- Establishment of a levee (Mitchell East Levee) to provide flood protection for the final void in Mitchell Pit.
- Minor alterations to disturbance boundaries to accommodate construction activities such as Lemington Road and electricity transmission lines.

This report presents the conceptual final landform design for the amended Project, incorporating a geomorphic approach that mimics stable alluvial natural landforms as far as is practical. These landforms tend to have average slopes of around 5 or 6 per cent, which is applicable to a large proportion of the revised HVO South landform which has gently undulating slopes. For steeper slopes, a similar approach is utilised incorporating dendritic drainage networks, convex ridgelines, and gradual slope transitions, but with the addition of an erosion risk assessment used to identify where rock armouring may be required. Typically, this is applied only in the drainage lines, and on slopes averaging around 10 per cent or steeper. This applies to the majority of HVO North where there is limited flat gradient, and then the portions of HVO South in the east and around the final void.

To accommodate the final land use of agriculture on the flatter areas and woodlands on the steeper slopes, the target maximum slope is 14 degrees (1V:4H). This has been largely achieved except for on the low walls, which are expected to be woodland areas. The average slopes on HVO North average 6.7 degrees, and in the south 6.4 degrees, excluding highwall areas.

The general drainage for each of the sites is largely perpendicular to the direction of mining, in order to facilitate shedding water back to the natural ground level. The split of catchments has been assessed as part of the Surface Water study by Engeny.

Surface water modelling using Lisflood under high rainfall scenarios informed the placement of sediment ponds, attenuation features and rock scour protection to manage runoff and reduce erosion. Preliminary estimates suggest most drainage lines will require D_{50} rock sizes between 200–300 mm, with refinement to occur during the detailed design. Importantly, the design approach favours wider drainage with shallow flows, which facilitates sediment accumulation within the voids of the placed rock, and revegetation of the drains. This approach allows the drains to eventually accommodate flood events significantly greater than the design flood event, which is the 1 per cent Annual Exceedance Probability (AEP) event.

To ensure the landform is erosionally stable, work was undertaken by Landloch to determine the allowable limits for catchment area and slopes for the particular material to be used in the rehabilitation. Previous work using SIBERIA undertaken by Landloch on a previous design indicated that the target erosion risk limit (referred to as the Topographic Factor (TF)) of 50 would be appropriately precautionary to allow site to establish vegetation without a risk of significant erosion when combined with deep ripping. More importantly, once revegetated, the average erosion rates are expected to appropriate for stable final landforms. For internally draining areas (primarily the final voids) a TF of 80 has been targeted due to the reduced impact associated with sediment movement off the surface.

Rock armouring is proposed where these erosion risk thresholds are exceeded.

The revised final landform design meets the Project's existing rehabilitation objectives and regulatory requirements, while supporting HVO's commitment to responsible mine closure and sustainable rehabilitation. Further refinement of the conceptual final landform design will occur during detailed design and construction phases.

1 Introduction

Hunter Valley Operations (HVO) is a well-established multi-pit open cut coal mining complex, comprising two mine sites separated by the Hunter River, HVO North and HVO South. HVO is approximately 24 kilometres (km) north-west of Singleton in the Hunter Valley of New South Wales (NSW). While the two mine sites are approved under separate development consents issued under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act), they operate as one complex with fully integrated environmental management systems.

HVO North operates under Development Consent DA 450-10-2003 issued by the then NSW Minister for Infrastructure and Planning in 2004, which allows extraction of up to 22 million tonnes per annum (Mtpa) of run of-mine (ROM) coal until 31 December 2026. HVO North comprises the approved mining areas of West Pit, Mitchell Pit, Carrington Pit and North Pit, as well as the Hunter Valley (HV) and Howick Coal Preparation Plants (CPP) and the Howick and HVO North mine infrastructure areas(MIA). The Newdell Load Point (LP) and Hunter Valley (HVLP) train loading facilities are also at HVO North.

HVO South operates under Project Approval (PA) 06_0261 issued by the then NSW Minister for Planning in 2009 and comprises the approved mining areas of Riverview Pit, Cheshunt Pit, Riverview South East Extension and South Lemington Pits 1 and 2, as well as the MIA, and the Lemington CPP (LCPP) and rail loop (approved but not constructed). PA 06_0261 allows extraction of up to 20 Mtpa of ROM coal until 24 March 2030.

Significant coal resources remain across the HVO Complex beyond what is currently approved for extraction under the existing development consents. HVO is therefore seeking approval for the HVO Continuation Project (the Project) from the NSW Minister for Planning and Public Spaces, or delegate, under the provisions of Part 4 of EP&A Act. The Project broadly comprises the continuation of mining at HVO North and HVO South, beyond the current approved mining completion dates of 2026 and 2030 respectively. The Project will seek to maintain separate development consents for HVO North and South, as is currently the case.

Given that the two mine sites operate as one complex, one environmental impact statement (EIS, EMM 2022) was prepared to support the two State Significant Development (SSD) applications for the Project, being:

— SSD-11826681 – HVO North Open Cut Coal Continuation Project

— SSD-11826621 – HVO South Open Cut Coal Continuation Project.

The EIS was subsequently placed on public exhibition from Monday 30 January 2023 through to Monday 27 February 2023. During the public exhibition of the EIS, a total of 1,060 submissions were received by the NSW Department of Planning, Housing and Infrastructure (DPHI) from individuals, organisations, public authorities, councils, and government agencies for the two development applications.

To respond to matters raised in submissions on the Project during the public exhibition period, a Submissions Report (EMM 2023a) was prepared, along with an Amendment Report (EMM 2023b) outlining proposed amendments to the HVO North Project.

During the subsequent assessment of the Project by the NSW Department of Planning, Housing and Infrastructure (DPHI), a number of requests for information (RFI) were issued to HVO, who provided responses as required. In response to an RFI received 5 July 2024, HVO completed a detailed review of the Project and is subsequently seeking to amend the SSD applications in the following ways:

— Reduce the project mine plan to avoid coal extraction within gas Domain 1 at HVO North and reduce the total ROM coal to be extracted by the amended Project by approximately 220 Mt.

— Maintain the current approved maximum annual ROM coal production from HVO North of 22 Mtpa but reduce the proposed maximum annual production limit at HVO South from 18 Mtpa to 13 Mtpa.

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- Establishment of a levee (Mitchell East Levee) to provide flood protection for the final void in Mitchell Pit.
- Minor alterations to disturbance boundaries to accommodate construction activities such as Lemington Road and electricity transmission lines.

WSP Australia Pty Ltd (WSP) was previously engaged to develop a final landform design for the original Project. Following the amendments to the Project, EMM Consulting Pty Ltd (EMM) subsequently engaged WSP to update the final landform design in accordance with the amended mine plan.

The battery limits for the redesign are as follows:

- HVO North includes the West Pit (comprised of Mitchell Pit and Wilton Pit), North Pit Tailings Storage Facility (TSF), Dam 6W TSF, and Carrington Pit.
- HVO South includes Cheshunt Pit, and Riverview Pit.

This report captures the design assumptions, intent, outcomes of the revised landform design, and the results of our in-house static erosion risk assessments. It should be noted that the long-term predicted erosion risk performance of the original landform was assessed in a separate study undertaken by Landloch using the SIBERIA Landscape Evolution Model (LEM).

2 Landform design approach

The landform design for the Hunter Valley Operations (HVO) Continuation Project adopts a geomorphic approach, in contrast to traditional methods based on linear slopes that rely on engineered contour banks and drop structures. This approach is grounded in the principles of geomorphology, the study of natural landform evolution through erosion and deposition processes and aims to replicate the stability and functionality of appropriate natural analogue landforms under local climatic conditions.

2.1 Design philosophy

The geomorphic method begins by identifying appropriate stable natural analogues in the Hunter Valley region. These analogues inform the design of engineered geomorphic landforms by mimicking the characteristics that contribute to long-term stability.

It is generally accepted that alluvial landforms, formed from weathered materials deposited by river systems, are appropriate analogues for mined overburden, for although the mined overburden is largely blasted rock, the intent is to ensure that the vegetated soil placed on the overburden is erosionally stable. Landforms that are located further upstream than the alluvial analogues tend to be shaped by mountain denudation and have bedrock present, which prevents the surfaces from being eroded to flatter profiles. Around the Singleton area, alluvial analogues tend to have average slopes around 4 or 5 per cent, although they do contain localised hills and valleys that are steeper.

Key features of geomorphic landforms include:

- Dendritic drainage patterns with appropriate drainage density (or number of drains per unit area). This relationship limits the length of the overland flows (non-concentrated flows) and the associated erosion risk.
- Drainage lines are typically concave and flatten with increasing catchment area.
- Non-linear topography, with convex ridges shedding to the concave drainage lines
- Gradual slope transitions, avoiding abrupt changes (both steepening or flattening) that can lead to erosion or sediment deposition.

The geomorphic design approach is particularly suited to post-mining landscapes that must remain stable for centuries, offering several advantages:

- Reduced reliance on engineered drainage structures such as contour banks and drop structures, and associated maintenance
- Improved integration with surrounding hydrology and natural landforms
- Enhanced potential for ecological diversity and habitat restoration.

2.2 Methodology

Geomorphic landform design is still considered a relatively novel design technique in mine rehabilitation, although the approach has been used internationally since the early 2000s and on a large scale in Australia since 2012. Therefore, it is by no means new or untested.

As indicated previously, the underlying philosophy is to understand what makes natural landforms stable over the long term and then apply similar characteristics to engineered landforms. However, there are several issues that make the process of applying an analogue a bit challenging. Firstly, the soils being used may vary from those of the natural analogue, and soils disturbed through mining may take several decades to reach the maturity and erosional stability of natural soils. In addition, the revegetation of the landforms will take several years, and initially is comprised of bare exposed soils that often erode prior to revegetation.

Proponents designing these landforms tend to use one of two methods, namely:

- Analogue-based methods (e.g., Geofluv™), which focus on replicating the hydrological characteristics of natural landforms. This method makes no adjustment for differences in soils or the lack of vegetation in the early stages.
- Erosion modelling methods, which assess soil erodibility using tools such as the Water Erosion Prediction Project (WEPP) and 3D Landscape Evolution Models (LEMs) like SIBERIA and CAESAR-Lisflood. These tend to focus exclusively on soils and slopes, initially in 2D and then progressing to 3D via the LEM modelling.

The landform design used by WSP for this Project uses a combination of these methods as follows:

- Catchments that have gradients similar to natural alluvial analogues, that is, around 4 or 5 per cent, were designed using alluvial analogue characteristics. Typically, these will be the larger flat catchments, such as the top surfaces of some of the larger dumps.
- Areas that are steeper than alluvial analogues were designed using similar drainage densities and geomorphic characteristics, but then assessed to determine where surface armouring may be required. This method uses a static erosion risk assessment method that is also used in the SIBERIA LEM and has been shown to reliably indicate erosional risk, provided this is then linked to soil erodibility assessments. All the side slopes tend to be designed using this approach.
- Soils erodibility data was compiled by Landloch (2022) and used as input to the static erosion risk assessments.

The work by Landloch (2022) for HVO included flume testing of soils, WEPP analysis of the erodibility of the soils, and the use of SIBERIA LEM to assess an alternative landform. While the landform has since been changed, the LEM outputs indicated a strong correlation with the static erosion risk assessment used by WSP, referred to as the Topography Factor (TF). The target TF discussed in this report for the final surface has used the same target value shown by the Landloch work to result in an erosionally stable final landform.

3 Landform design

The revised landform design for the Hunter Valley Operations (HVO) Continuation Project has been developed to meet the following key objectives set out in current approvals, including:

— Ensure long-term safety and erosional stability

— Support sustainable water management

— Align with the nominated post-mining land use as shown in Figure 3.1

— Integrate visually and hydrologically with the surrounding landscape.

The design incorporates a geomorphic approach, which aims to replicate the form and function of natural landforms. The design also incorporates specific considerations for Tailings Storage Facility (TSF) capping and elevation constraints such as for HVO South near sensitive receptors (e.g. Glider Club).

Note that detailed engineering and geotechnical stability analyses are not included in this scope of work and therefore have not been discussed.

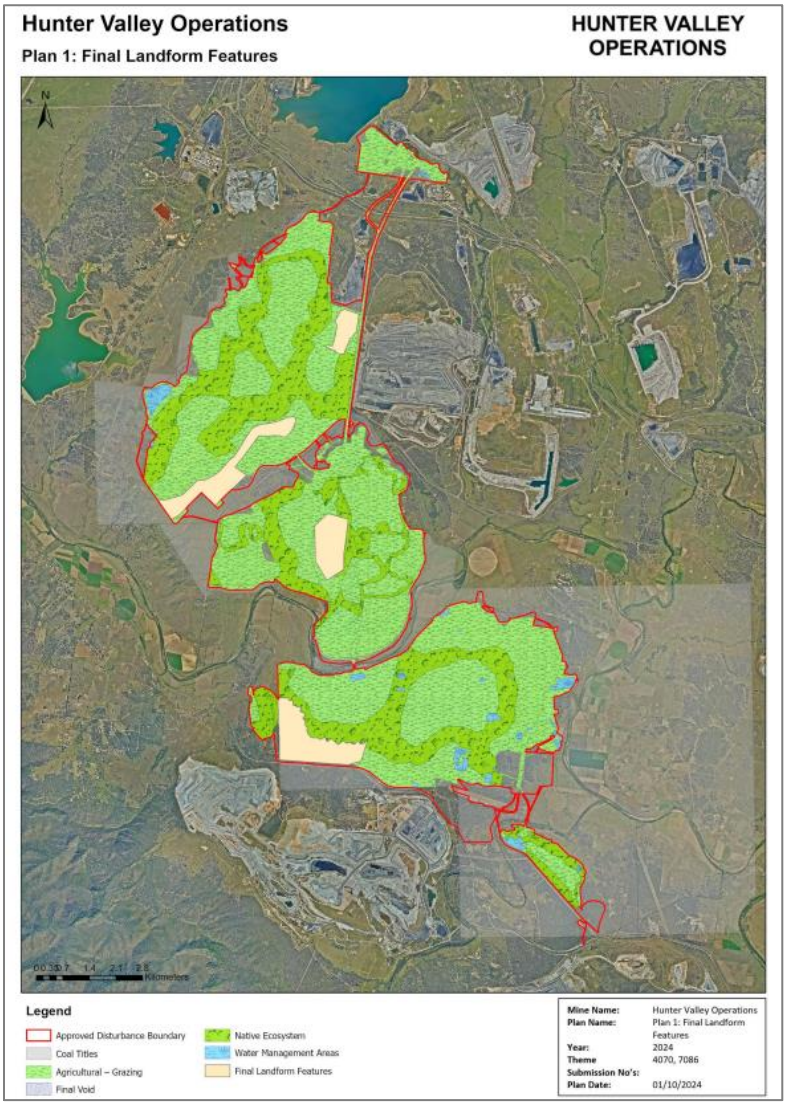

Figure 3.1 Current approved final landform (HVO Rehabilitation Management Plan, 2024)

3.1 Design process

The revised mine plan necessitated a redesign of the mine landforms, involving significant changes to the previous Mine Plan. The updated Mine Plan then serves as the basis for the new design in terms of the volume of overburden and overall spoil heights, as this landform has been optimised to limit haul distances, allow for progressive mining and rehabilitation, and ensure sufficient capacity within the available overburden emplacement.

Hydrological integration was a key consideration in the design process, as the elevation and fall required to shed water off-site, together with the sequence of mining, largely determines the drainage direction that allows water to be returned to natural systems as quickly and easily as possible. Where feasible, drainage was oriented perpendicular to the direction of mining to facilitate early tie-in of rehabilitated areas and minimise inflows to active open cut pits. The surface water team (Engeny) then reviewed the proposed post-mining catchment boundaries to ensure that any impacts on the natural catchments can be managed.

The drainage system was designed with a target drainage density of approximately 60 metres per hectare, based on field measurements taken from natural analogues in the Hunter Valley, combined with WSP's experience in the performance of landforms at other mine sites in the region. This density typically results in a spacing of around 200 metres between primary drainage lines, which is a practical spacing for operations such as deep ripping and topsoiling/revegetation. However, the drainage density was adjusted locally to account for variations in slope, erosion risk, and landform geometry. Steeper areas required tighter spacing to manage concentrated flows, while areas with flatter gradients allowed for wider spacing.

The preferred catchment delineations, location of likely sediment controls and future haul roads that need to be accommodated are then considered. The designs are then progressed through a series of iterations, forming drainage lines and ridges and shaping the landform to ensure it is stable.

Slope and erosion management are other important aspects of the design. Preferred slopes were set at or below 25 per cent (14 degrees), which is considered suitable for agricultural equipment and long-term stability, aligning with the post-mining land use on much of the site. The maximum slope is 33 per cent (18.3 degrees), which enables safe cross-ripping during rehabilitation. Slopes exceeding this threshold were avoided wherever practical, except in constrained areas such as final void highwalls and some low wall areas, where the native ecosystem is typically the proposed final land use. A static erosion risk assessment was then undertaken to evaluate the likely long-term erosional stability of the surface.

The landform geometry was then refined through multiple design iterations to balance slope stability, erosion risk, and material volume requirements. The mine planning team was included in the review process.

Erosion and sediment control measures were then integrated into the landform design to allow for the settling of sediment and prevent sedimentation in natural creeks downstream. As far as is practical, sediment basins were strategically located at the toe of the landform or close to the lower end of the landform, to minimise the need to construct off-landform dams during rehabilitation establishment. Drainage lines were flattened at the toe to reduce flow velocity and facilitate sediment capture. Space was allocated for shallow sediment dams, typically less than five metres in depth and set well back from any steep edges to limit the risk of piping failure, with detailed design to be completed during the engineering phase.

During mining, these sediment dams are pumped empty between rainfall events and will also spill in line with the design approach of the Landcom publication "Managing Urban Stormwater: Soils and Construction Volume 2E – Mines and Construction, (Table 6.1)" (Blue Book). After mining, the dams are likely to be removed or filled in, unless they are part of the agreed-upon post-mining land use.

Finally, the design was reviewed to ensure efficient construction, including practical considerations such as equipment access, safety, and the availability of suitable materials for shaping and rock armouring. The landform design has been developed to a conceptual level of detail and further refinements will be undertaken as part of the detailed design for construction.

3.2 HVO North

The proposed extension of the HVO North mining area from 2026 to 2045 will result in several key modifications to the final landform design. These changes include the extension of the pit and final void to the south-east, adjustments to the final void catchment area, and the application of a geomorphic landform design approach to some areas previously shaped using linear slopes. There are some existing, well-established rehabilitated areas that will remain in the final landform. This transition will increase topographic variation and integration with natural landforms, improve drainage resilience to differential settlement, and reduce long-term maintenance requirements for engineered drainage structures.

The final outputs of the HVO North landform surface using the geomorphic design approach are discussed in the following sections.

3.2.1 Overall volumes

The final mining surface for HVO North, developed by the HVO mine planning team, is shown in Figure 3.2. This figure includes both the proposed DA boundary and the primary landform design area reviewed by WSP. The primary landform design area does not include all areas considered in the proposed final landform such as areas of existing rehabilitation, emplacement areas designed to a predetermined surface (such as the Carrington West Wing area), or the rehabilitated ROM stockpile area.

This surface reflects the final pit and emplacements at the end of the planned LoM (2045) and forms the basis for the conceptual final landform design. Using this surface, WSP developed a revised landform using a geomorphic approach, as illustrated in Figure 3.3 to Figure 3.6. The designed surface has the same overall volumes as the LoM mine plan, with the volumes located largely in similar areas to the mine plan.

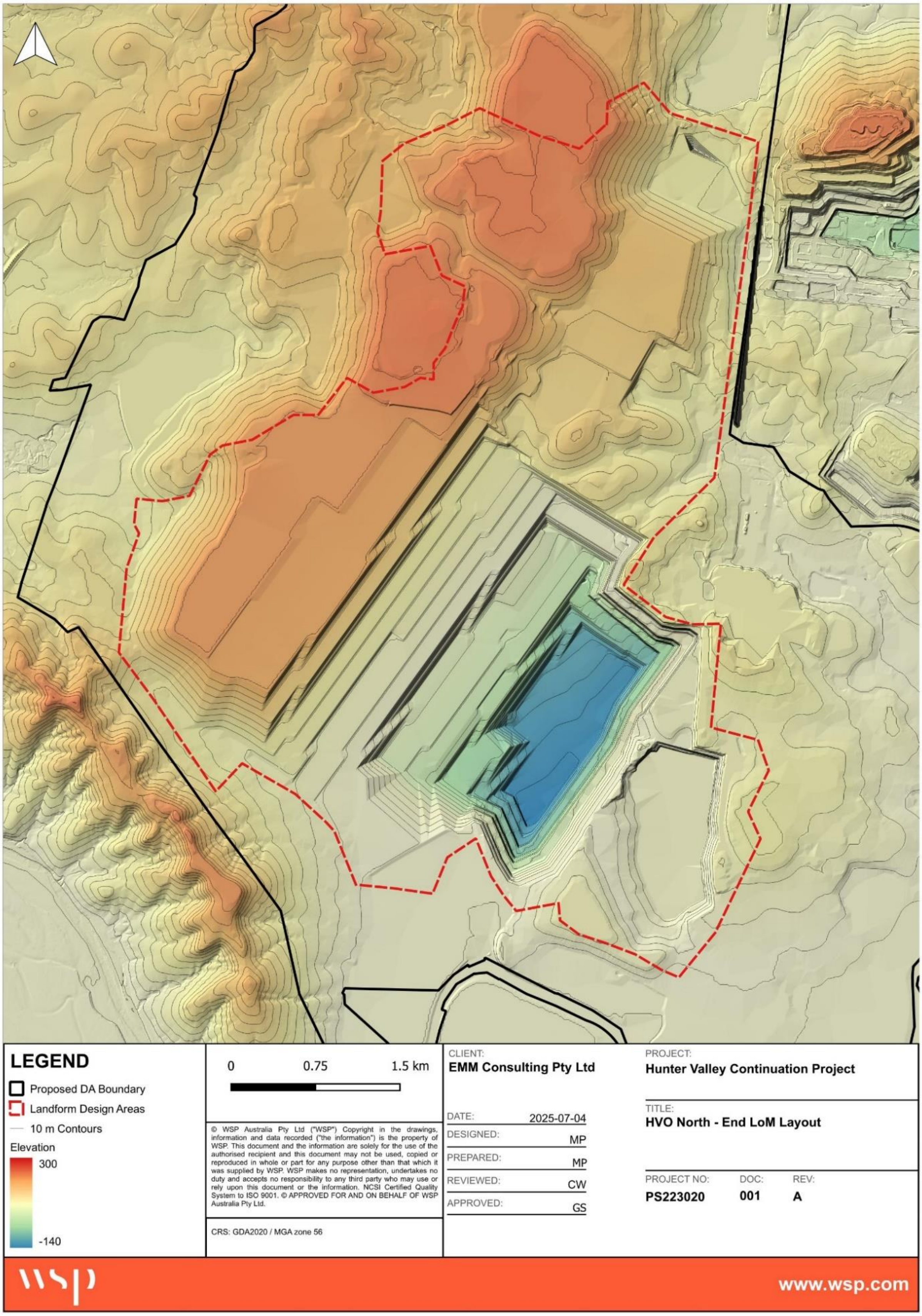

Figure 3.2 Final mining surface (2045) used to develop the proposed conceptual final landform; HVO North

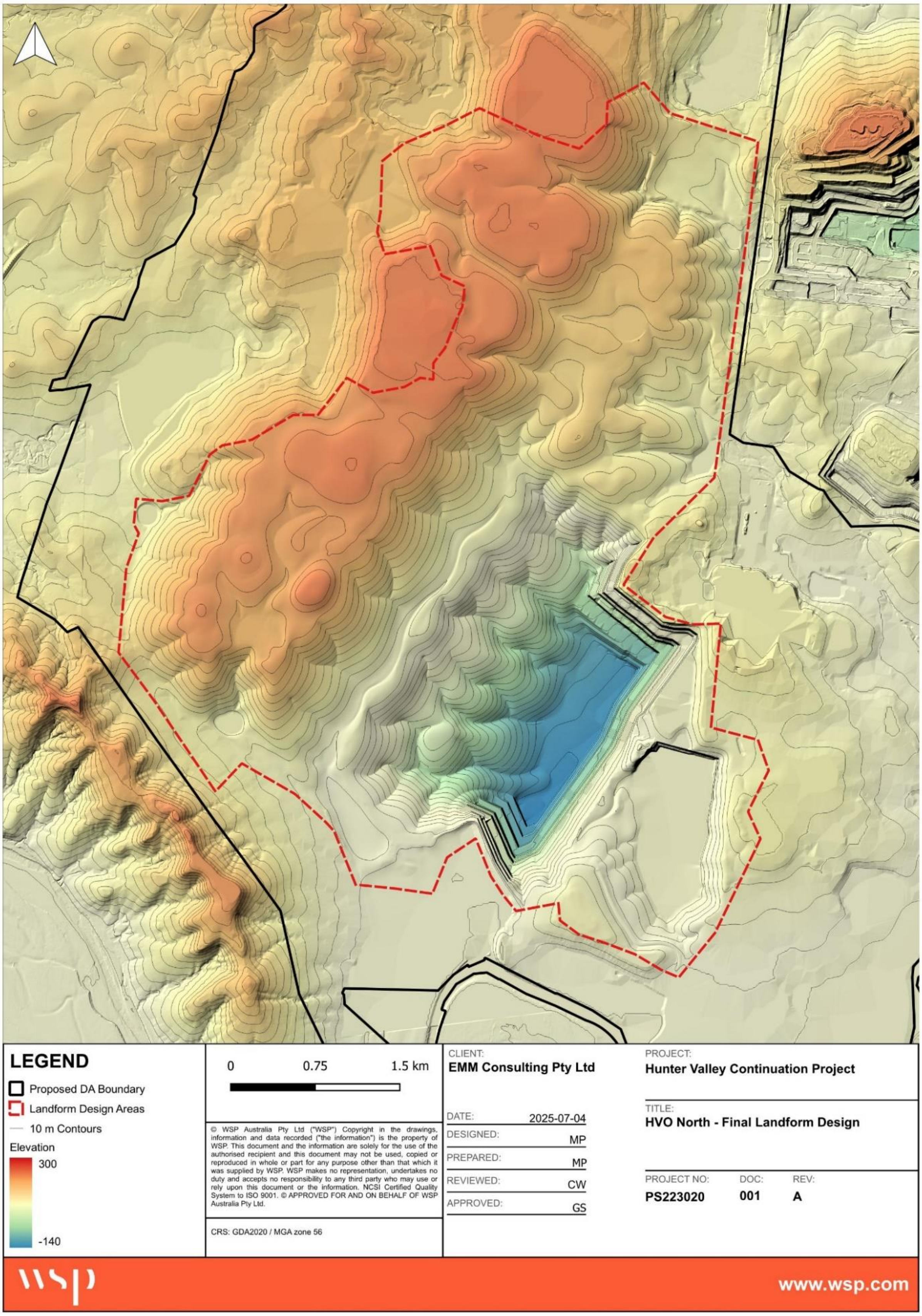

Figure 3.3 Proposed conceptual final landform design; HVO North

3.2.2 Visual outputs

The revised landform surfaces for HVO North are presented in Figure 3.4 and Figure 3.5, which include 3D isometric views from the south-west and south-east. These visualisations demonstrate the integration with the surrounding landscape and application of geomorphic principles, including non-linear ridgelines and dendritic drainage networks which integrate with surrounding natural drainage lines reporting to the Hunter River as can be seen in the foreground of Figure 3.5.

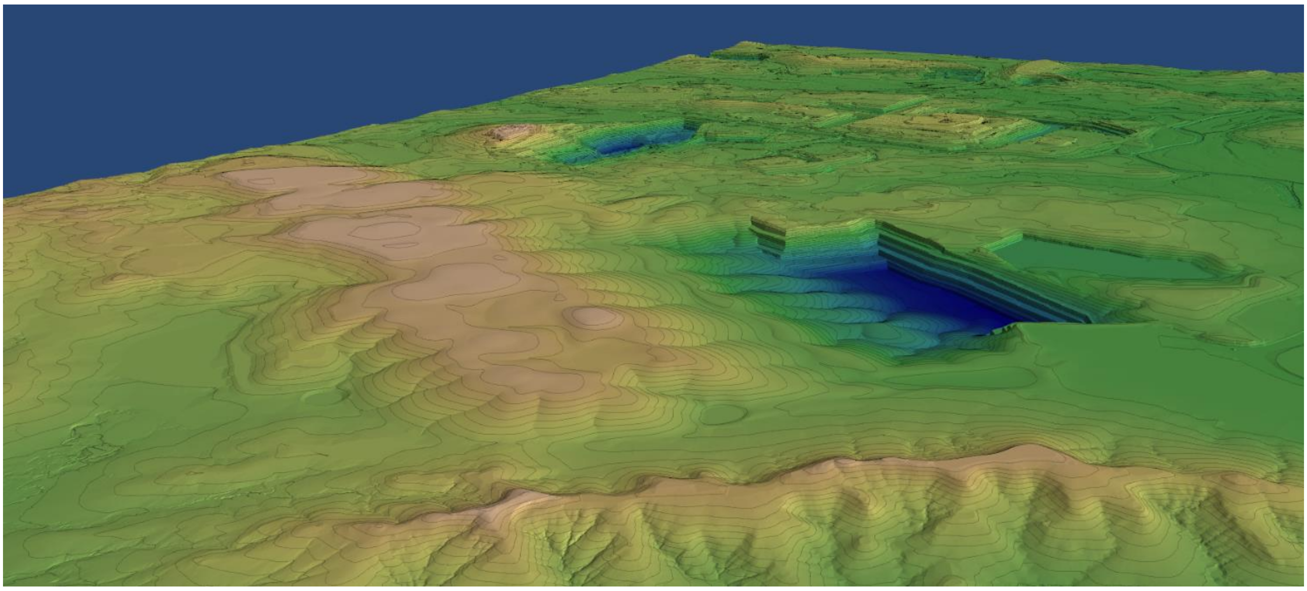

Figure 3.4 View of the revised HVO North conceptual landform; schematic from the south-west

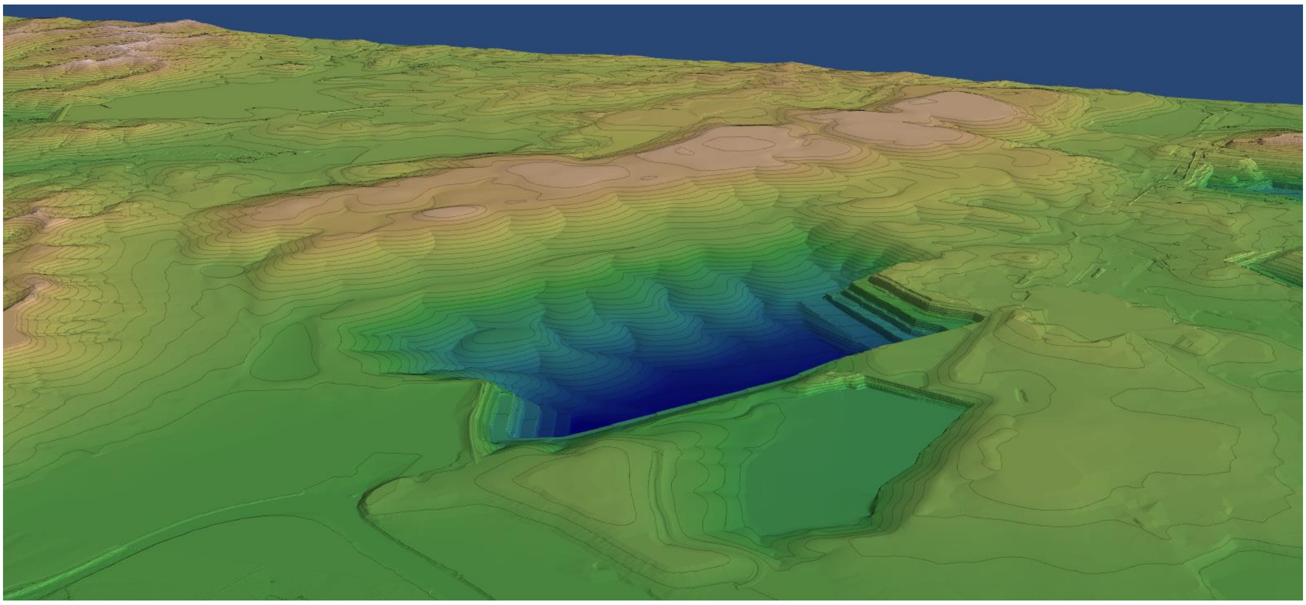

Figure 3.5 View of the revised HVO North conceptual landform; schematic from the south-east

3.2.3 Slopes

Slope gradients across the revised HVO North landform are shown in Figure 3.6. Most of the landform features slopes flatter than 25 per cent (14°), with steeper gradients confined to the low-wall and high-wall areas adjacent to the final void. These areas are internally draining and present spatial constraints that limit further flattening. While the low-wall can potentially be flattened to reduce the slopes further if needed, this option may be re-assessed closer to the end of mining. For now, it is considered that the areas can be made safe and stable, incorporating rock armouring as and where required.

Table 3.1 quantifies the distribution of slope ranges across the landform, excluding highwalls. While slopes up to 33 per cent (18°) are permitted, the design prioritises slopes of 25 per cent (14°) or less to support future agricultural use and minimise erosion risk. The average slope, excluding highwall areas, is 6.7 degrees.

Table 3.1 Overall slopes of the Geomorphic landform design (HVO North)

Slope Range (% and º)	Area Measured on Slope (ha)	Area (%)	Cumulative Area (%)	Comments
< 20 (11.3°)	2206.7	84.3	84.3	
20 (11.3°) to 25 (14°)	236.8	9.1	93.4	Slopes targeted as the preferred limit for HVO
25 (14°) to 28.5 (16°)	87.6	3.3	96.7	
28.5 (16°) to 33 (18°)	50.6	1.9	98.7	Target maximum slope (for cross ripping with a dozer). Challenging for agricultural implements.
> 33 (18°)	35.0	1.3	100.0	
Total	**2616.8**	**100.0**		

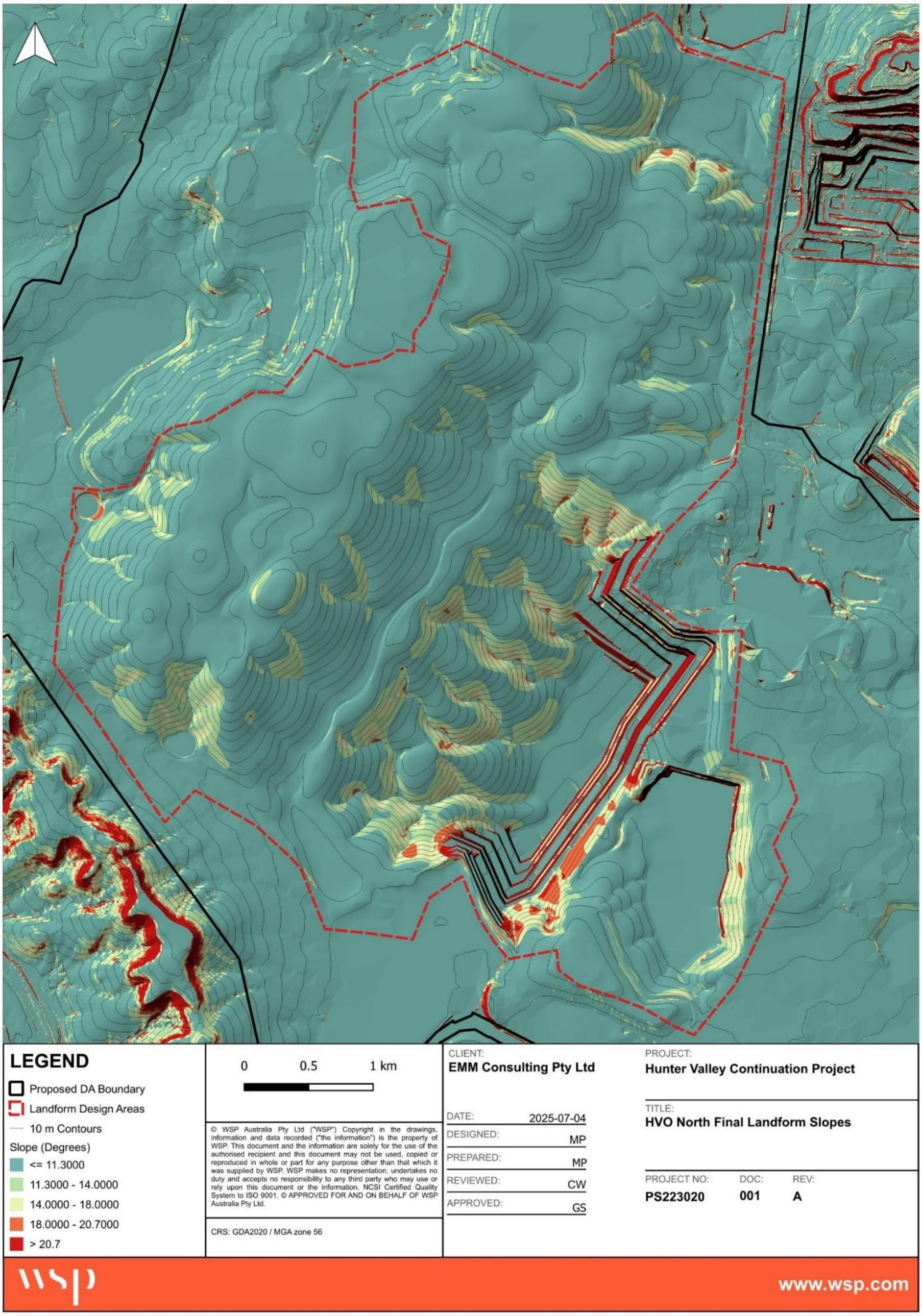

Figure 3.6 Slopes gradients of the revised HVO North conceptual final landform (degrees)

3.2.4 Water management

Surface water flow across the landform was modelled under a high rainfall scenario simulated using peak flows with the rain on grid Lisflood hydraulic model. The model outputs are shown in Figure 3.7, with the intent to show how water will flow and pond across the landform during a large storm. Although the rainfall used is close to a 1 per cent Annual Exceedance Probability (AEP) for some of the catchments, the output should not be considered as anything other than a general indication of flows. It should also be noted that much of the ponding indicated as occurring on the landform is temporary, being either dryland attenuation areas that only hold water during a significant flood event, or sediment ponds that are to be kept empty between storm events.

The figure shows that flows will tend to be in a north-east/south-west direction so as to be largely perpendicular to the direction of mining. This will allow rehabilitated areas to be drained back to the natural catchment and away from active mining during the operational phase.

Water will leave the site in almost every direction, with provision for sediment control ponds located upstream of the discharge points. These will both contain sediment, and in some cases, reduce the peak flows leaving the site.

Where possible, all sediment dams have been provided close to ground level to reduce the risk of piping. There are also several dryland attenuation features where drains transition to steeper gradients, which will remain dry most of the time with only temporary ponding between rainfall events.

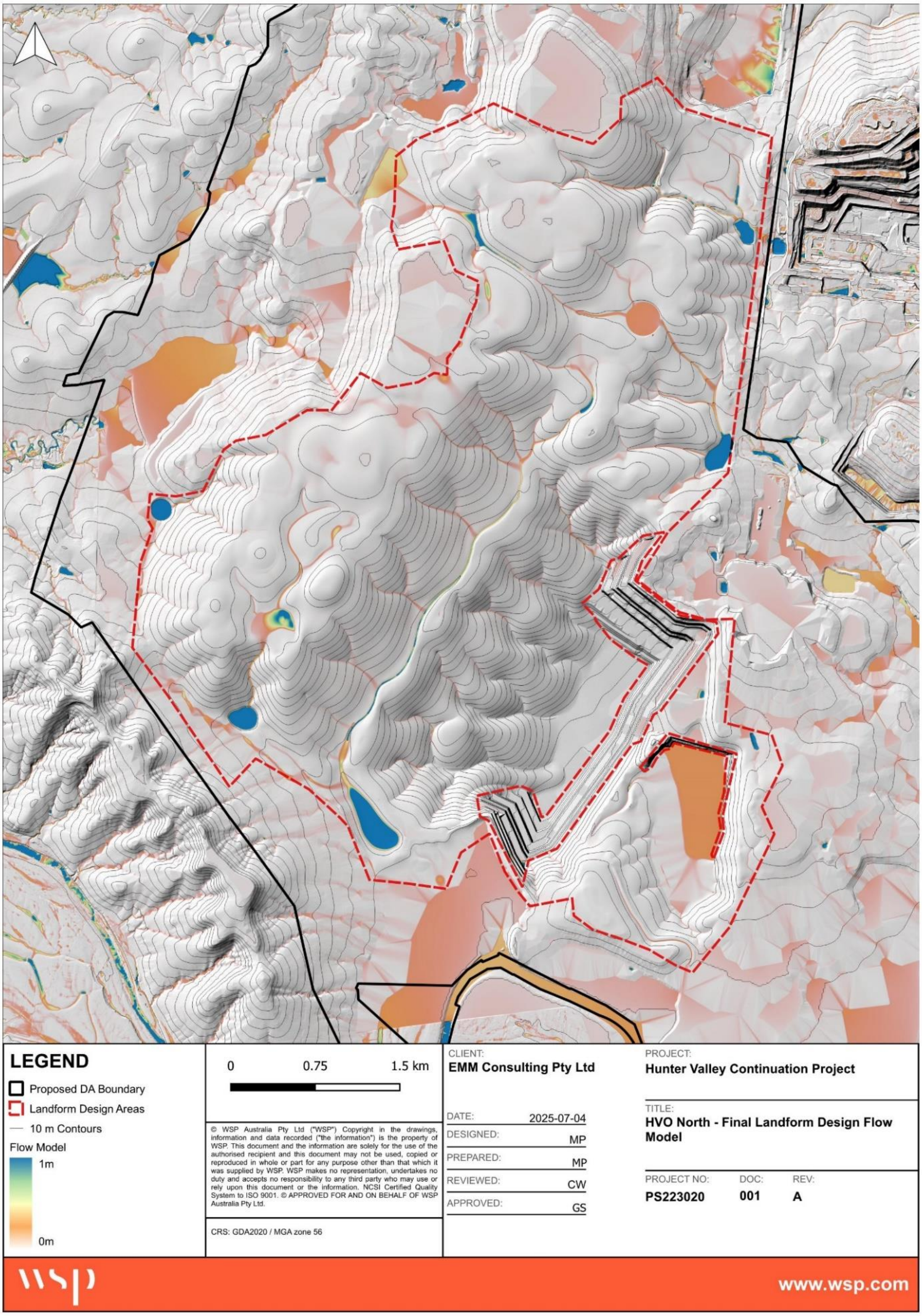

Figure 3.7 Water flow depth for typical high rainfall event

3.2.5 Preliminary rock sizing

The rock sizing for the revised HVO North landform will be undertaken during detailed design, using a combination of the peak flow assessments for each drainage line with the slope to compute the required size. The approach used by WSP favours the use of smaller rock with shallow flows on wider drainage lines with relatively low velocities. Drains are then designed for loose rock being able to withstand the 1 per cent AEP event, with the intent that, through the accumulation of sediment in the voids between the rocks and revegetation of the drains, the rock will become bedded in and able to withstand far more significant storm events.

An initial estimate of rock size using the Lisflood model has been calculated and indicates that most of the drains will utilise nominal rock typically a D_{50} of the order of 200 to 300 mm. This is expected be sufficient in most cases.

The rock volumes required are expected to be similar to that required for a traditional linear landform design.

The following key points should be considered:

- The rock sizing results are indicative only and subject to refinement during detailed design.
- The sourcing of suitable rock is a critical consideration. The material must be durable, competent, and of sufficient density to resist hydraulic forces.
- The potential for tunnel and gully erosion beneath or adjacent to concentrated flow paths presents a stability risk, particularly during the vegetation establishment phase. This risk will be addressed through appropriate design measures, including rock armouring, flow dispersion, and surface treatments.

3.3 HVO South

The proposed extension of the HVO South mining area from 2030 to 2042 will result in several key modifications to the final landform design similar to that proposed for HVO North. These changes include final void to the south-west, adjustments to the final void catchment area, and the use of geomorphic landform design approach for all of the areas that will be disturbed. The geomorphic approach will result in a final landform that is integrated visually and hydraulically with the surrounding natural landforms.

The final outputs of the HVO South landform surface using the geomorphic design approach are discussed in the following sections.

3.3.1 Overall volumes

The final mining surface for HVO South, developed by the HVO mine planning team, is shown in Figure 3.8. The figure includes both the proposed DA boundary and the primary landform design area reviewed by WSP. Noting the primary landform design area does not include all areas considered in the proposed final landform such as areas of existing rehabilitation or South Lemington Pit 1 rehabilitation. This surface reflects the final pit and emplacements at the end of the planned LoM (2042) and forms the basis for the conceptual final landform design. Using this surface, WSP developed a revised landform using a geomorphic approach, as illustrated in Figure 3.9 to Figure 3.11, with overall volumes largely aligning with the requirements and location of the material in the mine plan.

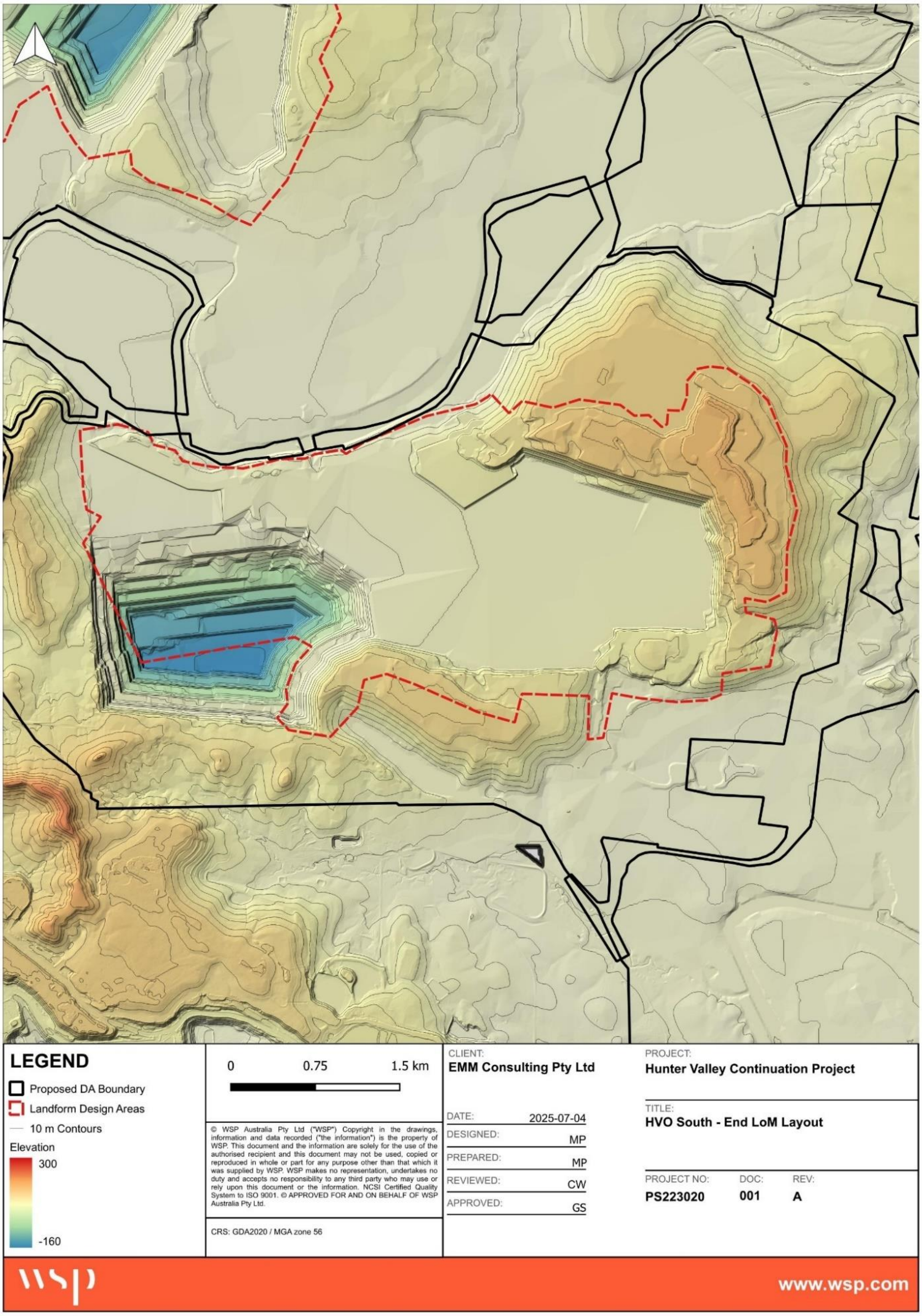

Figure 3.8 Final mining surface (2042) used to develop the proposed conceptual final landform; HVO South

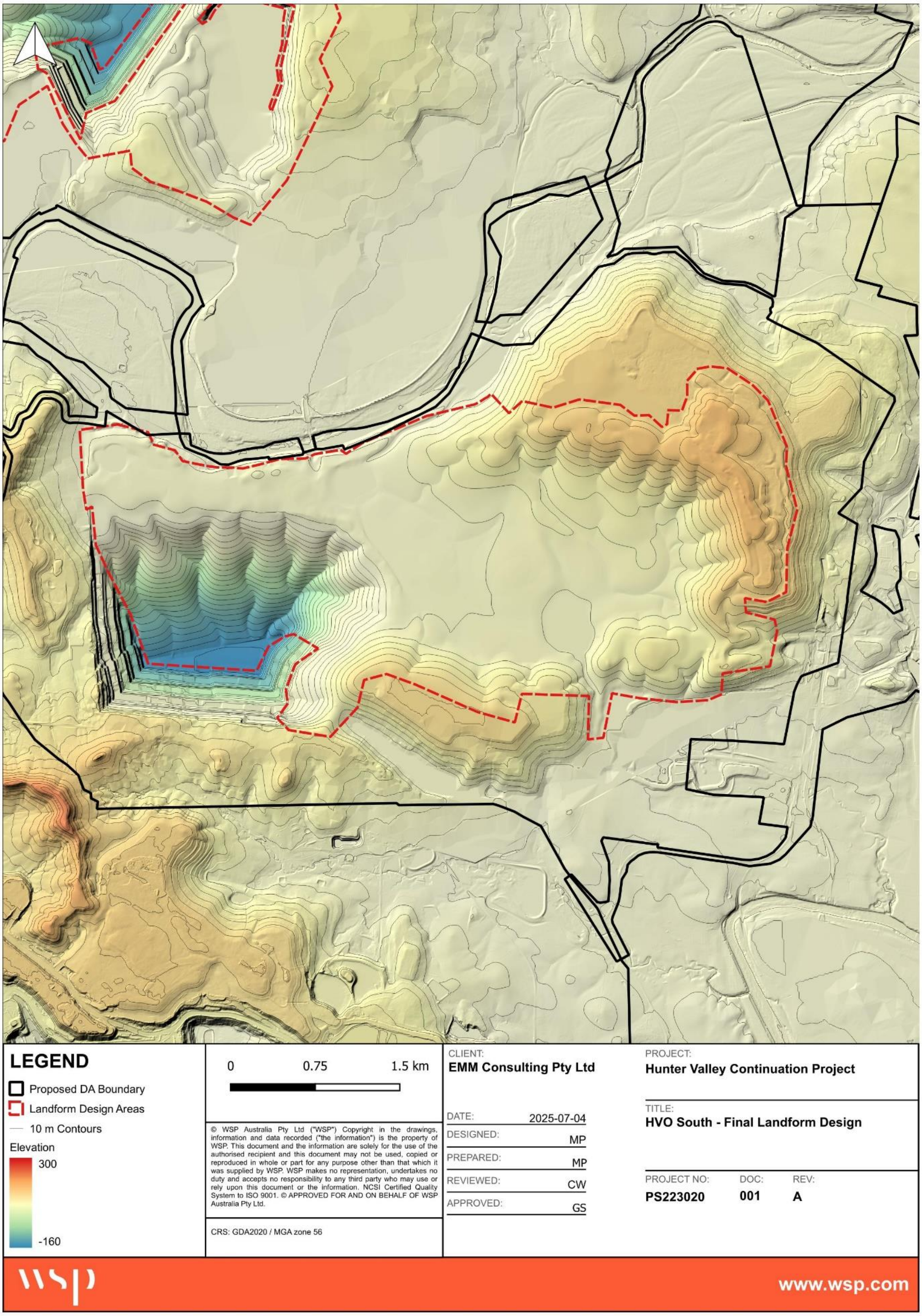

Figure 3.9 Proposed conceptual final landform design; HVO South

The final outputs of the landform surface using the geomorphic design approach are discussed in the following sections.

3.3.2 Visual outputs

The revised landform surfaces for HVO South are presented in Figure 3.10 and Figure 3.11, which include 3D isometric views from the south-west and south-east. These visualisations demonstrate the integration with the surrounding landscape and application of geomorphic principles, including non-linear ridgelines and dendritic drainage networks.

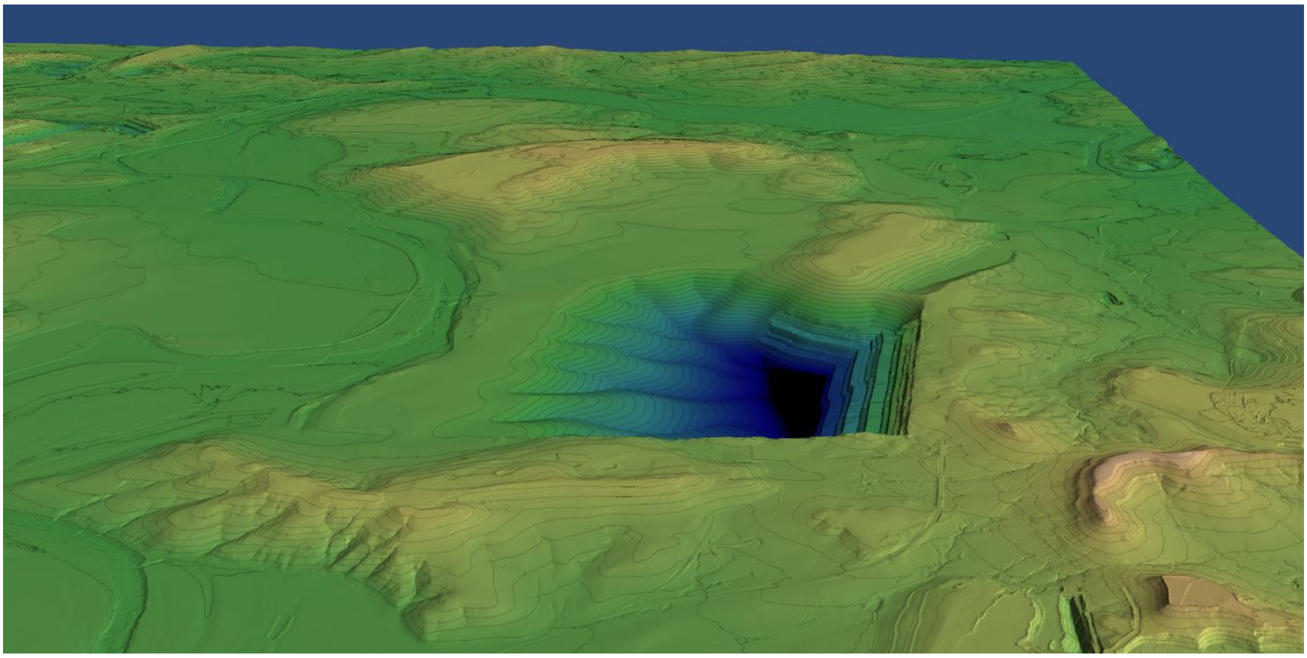

Figure 3.10 View of the revised HVO South conceptual landform; schematic from the south-west

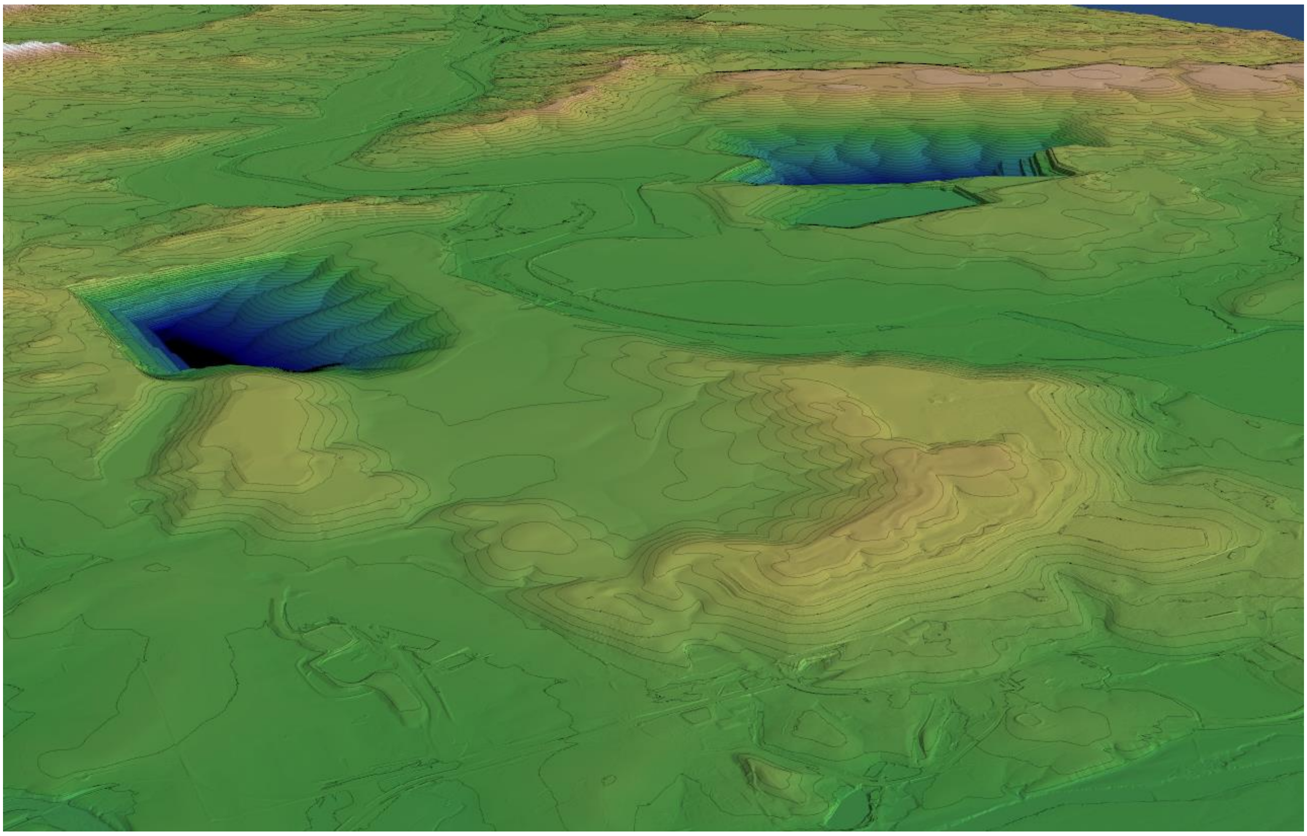

Figure 3.11 View of the revised HVO South conceptual landform; schematic from the south-east

3.3.3 Slopes

Slope gradients across the revised HVO South conceptual final landform are shown in Figure 3.12. Most of the landform features slopes flatter than 25 per cent (14°), with steeper gradients confined to the low-wall and high-wall areas adjacent to the final void. These areas are internally draining and present spatial constraints that limit further flattening. While the low-wall can potentially be flattened to reduce the slopes further, it may be re-assessed closer to the end of mining. For now, it is considered that the areas can be made safe and stable, incorporating rock armouring as and where required.

Table 3.2 quantifies the distribution of slope ranges across the landform, excluding highwalls. While slopes up to 33 per cent (18°) are permitted, the design prioritises slopes of 25 per cent (14°) or less to support future agricultural use and minimise erosion risk. The average slope, excluding highwall areas, is 6.4 degrees.

Table 3.2 Overall slopes of the Geomorphic landform design (HVO South)

Slope Range (% and º)	Area Measured on Slope (ha)	Area (%)	Cumulative Area (%)	Comments
< 20 (11.3°)	1136.8	79.3	79.3	
20 (11.3°) to 25 (14°)	163.6	11.4	90.7	Slopes targeted as the preferred limit for HVO
25 (14°) to 28.5 (16°)	60.6	4.2	94.9	
28.5 (16°) to 33 (18°)	44.6	3.1	98.0	Target maximum slope (for cross ripping with a dozer). Challenging for agricultural implements.
> 33 (18°)	28.6	2.0	100.0	
Total	**1434.2**	**100.0**		

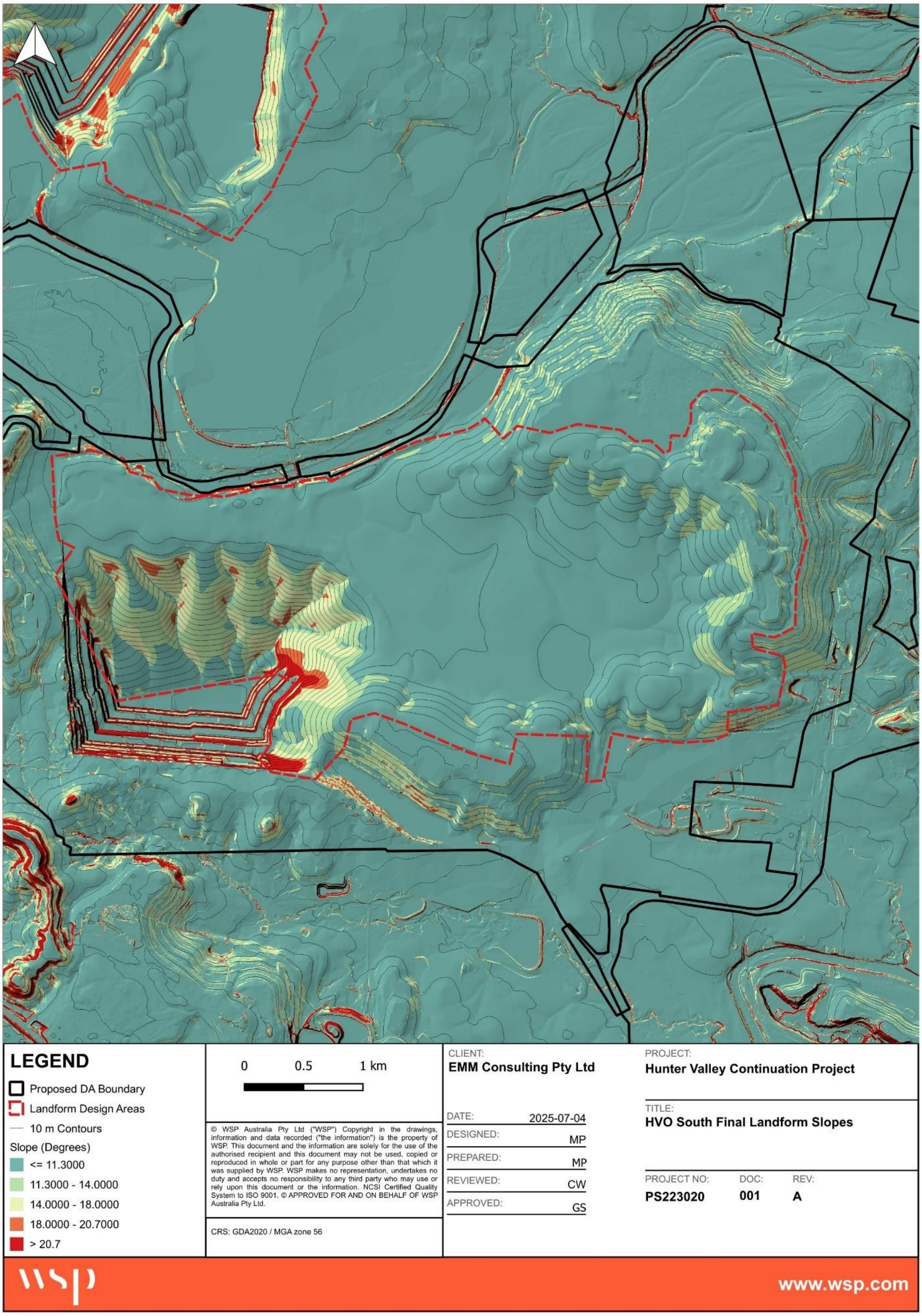

Figure 3.12 Slopes gradients of the revised HVO South conceptual final landform (degrees)

3.3.4 Water management

Surface water flow across the landform was modelled under a high rainfall scenario using the rain on grid Lisflood hydraulic model to simulate peak flows and flow depths. The model outputs are shown in Figure 3.13, and the location of drainage lines and areas of ponding water during an extreme event can be seen. As for the modelling for HVO North, although the rainfall used is close to a 1 per cent AEP event, the outputs are only indicative of flow. Again, much of the ponding is temporary, being either dryland attenuation areas that only hold water during a large flood event, or sediment ponds that are to be kept empty between storm events.

The figure shows that the drainage will initially be to the south for the eastern portions of the rehabilitation, transitioning to draining to the north towards the end of mining for the western portions.

The prominent areas of ponding upstream of discharge off-site are intended to be used as shallow sediment ponds, in addition to providing flow attenuation to minimise the peak flows that discharge to the steeper drains that direct flows back to the natural catchments.

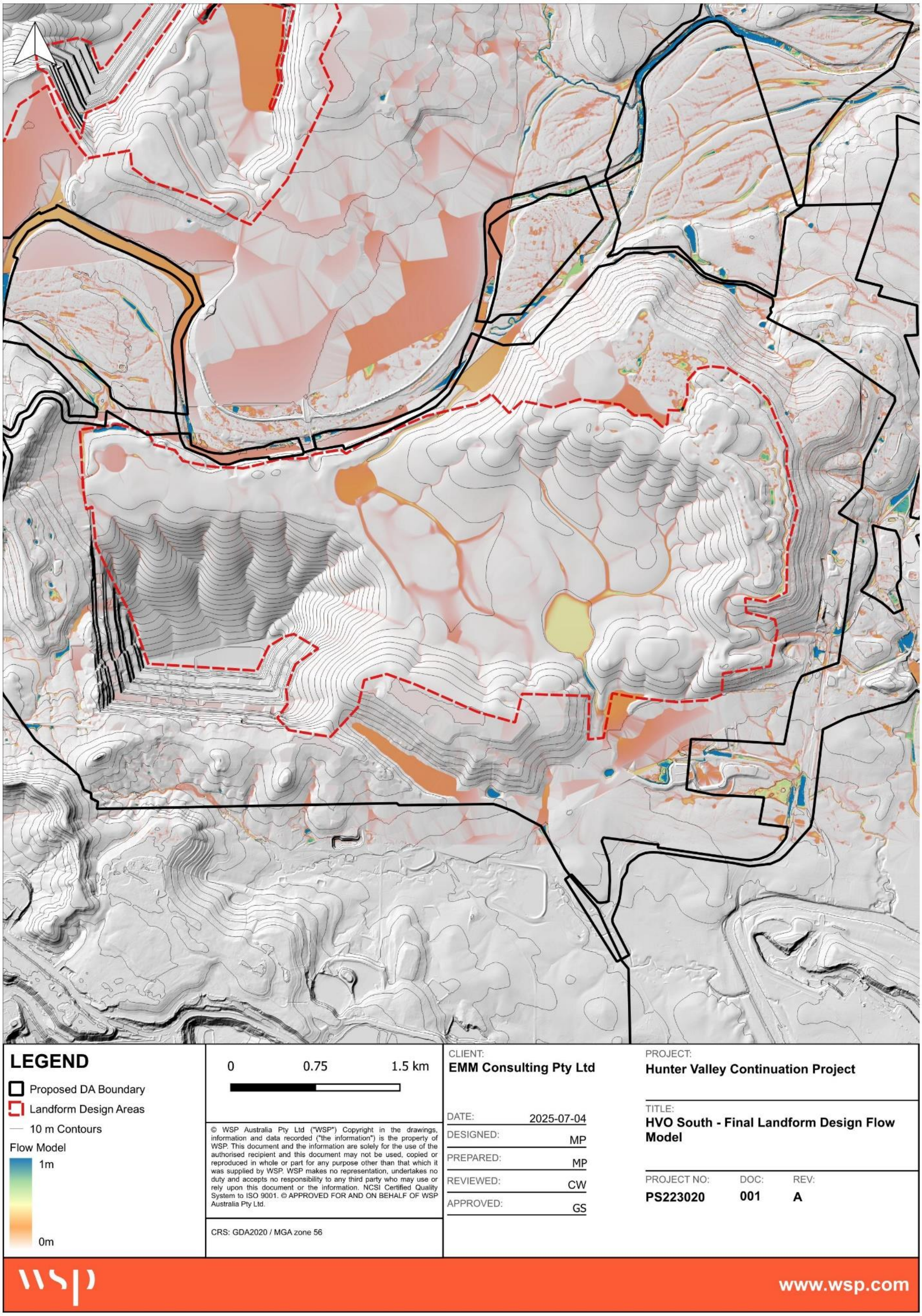

Figure 3.13 Water flow depth for a typical high rainfall event

3.3.5 Preliminary rock sizing

The rock sizing approach set out for HVO South is the same as that applied to HVO North. The outputs provided are again indicative only, with the rock sizing likely to be similar to that indicated for HVO North. Apart from the main drainage in the north and the south-east, the rock required is typically around a D_{50} of 200mm. The maximum required size is expected to be 300mm (D_{50}).

The concept is again that the rock as placed during construction will be able to withstand the 1 per cent AEP event, and the process of sediment accumulation and revegetation in the drains will bed the rock in so that, with time, the rock will be able to withstand far more significant storm events than the 1 per cent AEP event.

The rock volumes required are expected to be similar to those required for a traditional linear landform design, and the rock will need to be durable, competent and of an appropriate density. The drains will be refined during detailed design.

3.4 Erosional stability (HVO North and HVO South)

3.4.1 Static erosion risk assessment

The static erosion risk assessment for the proposed final landform at HVO North and South is illustrated in Figure 3.14 and Figure 3.15, using a metric referred to as the Topography Factor (TF). This factor, derived from the Einstein-Brown equation within the SIBERIA Landform Evolution Model (LEM), which estimates fluvial sediment transport capacity and is particularly relevant in areas where flow concentration leads to incision. The TF relates catchment area and slope at each grid point to assess erosion risk.

This assessment provides a first-order estimate and should be interpreted alongside knowledge of soil erodibility—both bare and vegetated. Soil erodibility values were informed by Landloch modelling, incorporating data from the Water Erosion Prediction Project (WEPP) model, soils flume testing and experience at HVO and on adjacent sites. Based on this, target TF values were established:

- Bare soil: TF between 14–28, assuming limiting horizontal lengths of 20–40 m and 5 m rill spacing.
- Vegetated surfaces:
  - 70% represents good pasture vegetative cover
  - 50% represents good woodland vegetative cover

At 50% vegetative cover, most soils (excluding subsoil) show erosion rates of <5 t/ha/yr. This was found to equate to a TF of 54.

While the above seems to indicate a limiting TF of 54 should be considered, much of the data is asymptotic indicating potentially far higher values could be stable. Considering the topsoil, TF values of around 80 will limit erosion rates to 5 t/ha/yr once vegetated, while TF values up to 120 will result in erosion rates of 10 t/ha/yr. Since the TF is used as peak limits only rather than average values across the site, targeting a TF of 120 may still result in acceptable average erosion rates.

The approach WSP have developed from experience is to select a target erosion risk somewhere between that required for bare soil and that for the fully vegetated surface. This avoids the design being either overly conservative, or too optimistic, since for the period between seeding and vegetation establishing, deep ripping is used to increase infiltration and limit runoff. Revegetation can be significantly impacted by the range in weather conditions in the Hunter Valley, changing soil properties, and the time it takes to mitigate any dispersive soil behaviour.

The Project has adopted the following thresholds for erosion risk

- TF = 50 for externally draining areas without rock armouring.
- TF = 80 for internally draining areas (e.g. final void slopes, where a higher erosion risk is considered reasonable)

Areas exceeding these thresholds (shown in red in Figure 3.14 and Figure 3.15) are likely to require rock armouring, primarily in drainage lines where concentrated flow is observed, rather than overland flow areas.

The following should be noted:

- The intent to only require rock in the drainage lines has largely been achieved for the landform draining off-site. However, for the final void, some areas outside drainage lines may also require rock/soil matrix treatments or rock mulch, particularly where TF > 80.
- The surface is designed to be stable once vegetation is established based on typical soil parameters for the area. Interim erosion control measures may include:
  - Soil/gravel mixes with sufficient soil to ensure vegetation establishment and erosion resistance.
  - Rapid establishment of cover crops (preferably annuals) to provide protection until target vegetation is established.
  - Application of soil stabilising polymers or hydro-mulches.
  - Deep ripping or aeration to enhance water infiltration.

Further details of soil stabilisation techniques will be included in the Rehabilitation Management Plan.

- Rock lining is required in most of the drainage lines and will become a permanent feature of the landform.
- The erosion modelling uses a 2x2 m grid, which may not capture finer features such as contour banks. Erosion risks shown on linear surfaces will only materialise if these engineered features fail. This resolution limitation does not affect geomorphic surfaces, which are not as reliant on engineered structures.

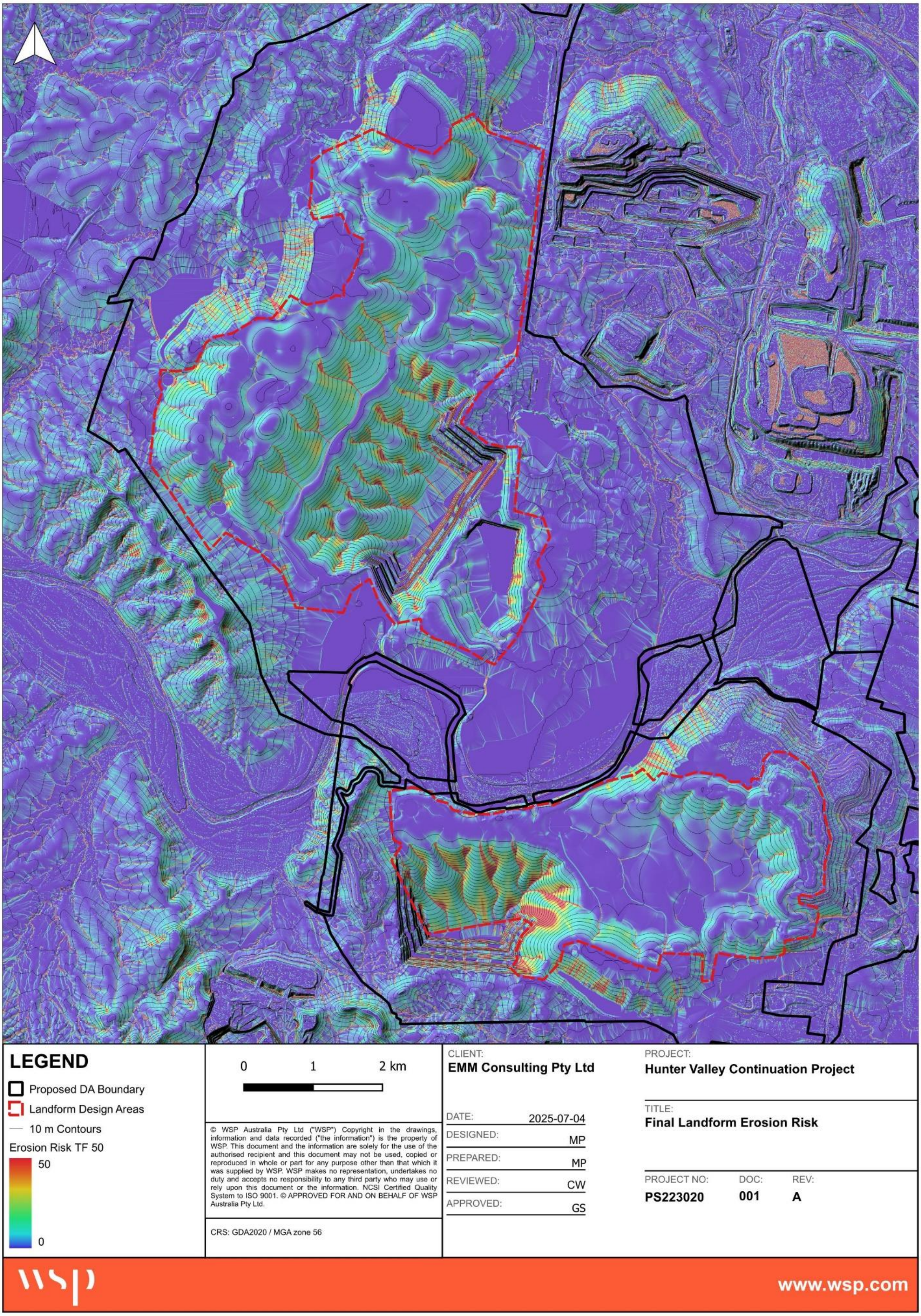

Figure 3.14 Static Erosion Risk Assessment TF 50

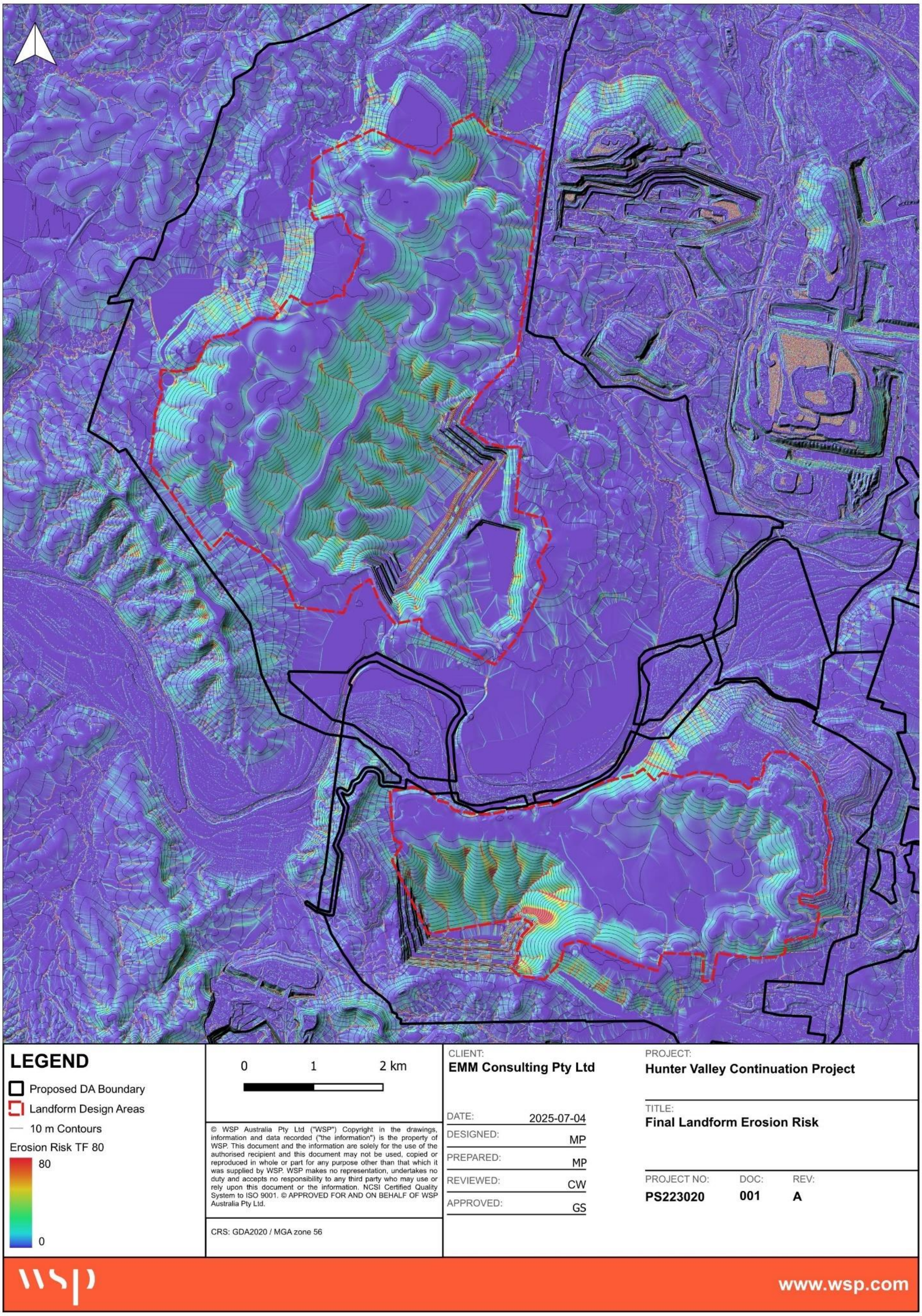

Figure 3.15 Static Erosion Risk Assessment TF 80

4 Conclusion

The revised landform design for the HVO Continuation Project aligns with the revised mine plan, updated regulatory expectations and best practices in geomorphic landform design. Developed through a collaborative process between HVO, WSP and EMM Consulting, the design integrates hydrological, geotechnical, and environmental considerations to deliver a landform that modelling indicates is likely to be safe, stable, and sustainable over the long term.

The adoption of a geomorphic design approach has enabled the creation of surfaces that are visually and functionally integrated with the surrounding landscape. This approach reduces reliance on engineered drainage structures, enhances erosion resistance, and supports ecological restoration. The use of erosion risk thresholds, informed by previous LEM modelling completed by Landloch (2022) and validated against local soil conditions, has provided a robust assessment for managing erosion risk associated with the final landform design.

The design process has been iterative incorporating hydrological modelling, slope analysis, and sediment control planning to ensure compliance with rehabilitation objectives. Key features such as dendritic drainage networks and designated sediment basin areas have been strategically incorporated to manage surface water and minimise sediment transport.

While the current design provides a conceptual level final landform, it is acknowledged that further refinement will be required during the detailed design and construction phases. This includes validation of slopes, rock sizing, and sediment control infrastructure, as well as the integration of site-specific revegetation strategies. The design will continue to evolve as additional data becomes available and as lessons are learned from ongoing geomorphic landform construction activities at HVO.

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