AMC Consultants Pty Ltd
ABN 58 008 129 164

Level 1, 1100 Hay Street
WEST PERTH WA 6005
AUSTRALIA

T+61 8 6330 1100
F+61 8 6330 1199
Eperth@amcconsultants.com
W amcconsultants.com

Report

Nolans Scoping Study – Site Layout Planning Update
Arafura Resources Limited

AMC Project 217047
19 September 2017

Quality control

The signing of this statement confirms this report has been prepared and checked in accordance with the AMC Peer Review Process.

Author	***Signature Removed***	19 September 2017
	Jonathan Dray	**Date**
Peer Reviewer	***Signature Removed***	19 September 2017
	Koray Gundem	**Date**

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1 e-copy to Mr Richard Brescianini, Arafura Resources Limited
1 e-copy to AMC Perth office

1 Introduction

Arafura Resources Limited (Arafura) commissioned AMC Consultants Pty Ltd (AMC) to update conceptual mine planning (the Study) in relation to site layout and waste dump design for the Nolans Rare Earths Project (the Project). The outputs will be used by Arafura to update an environmental impact statement (EIS) and will also allow the basis of the design to be confirmed for the upcoming feasibility study (FS) for the Project. The Study is an update to the Nolans site layout planning completed in April 2017[1] (the Previous Study), necessitated by revised mine planning inputs that resulted in revised mine waste volumes, as summarized in the September 2017 Nolans Mining Scoping Study Update (Scoping Study Update)[2].

Two scenarios are presented in the Study:

- Measured and Indicated (M&I). The pit limits and associated ore and waste volumes are based on Measured and Indicated Mineral Resources.
- Life-of-mine (LOM). The pit limits and associated ore and waste volumes are based on Measured, Indicated and Inferred Mineral Resources.

[1] AMC Consultants Pty Ltd report, Nolans Scoping Study – Site Layout Planning, dated 6 April 2017 (AMC report AMC216025C)

[2] Report not completed at time of writing

2 Design

2.1 Design criteria

The following mine design criteria were provided by Arafura and applied by AMC in the Study:

- Pit limits for the M&I and LOM scenarios as defined in the Scoping Study Update, prepared by AMC. (AMC reference: Pit optimization runs nl66 and nl68 for the M&I and LOM scenarios respectively).
- Waste rock dumps and stockpiles:
  - Simple landforms without allowance for access ramps (future detailed designs will incorporate ramps).
  - Maximum height limit of approximately 50 m.
  - Lift height of 10 m.
  - Berm width of 5 m every 10 m vertically.
  - Overall slope angle of approximately 15°.
  - Swell factor of 30%.
  - Stand-off distance from the LOM final pit edge of 50 m (LOM pit limit was used for both the M&I and LOM scenarios to avoid potential sterilization of ore in the M&I scenario).
- Mine waste classification criteria as summarized in Table 2.1.
- Mine waste destination and management criteria as summarized in Table 2.2.
- Waste and other material (for example, material types M3AO and NP2O) quantities as defined in the LOM and M&I strategic schedules produced in the Scoping Study Update and summarised in Table 2.3.
- Material types M3AO and NP2O are to be stored for possible future processing. These two material types have been defined in part by a cut-off grade of 1% total rare earth oxide (TREO). Storage of M3AO and NP2O material is to be as close as possible to the run-of-mine (ROM) pad but to be contained within a dedicated waste dump and completely covered by approximately 2 m of benign waste rock, comprising gneiss and schist. AMC has assumed they can be stored adjacent to one another in the same internal stockpile.

Other design criteria applied by AMC in the Study included:

- Waste dump batter angle 16.7° to achieve the target overall slope angle for the specified lift height and berm width.
- Minimum stand-off distance of 50 m from the mineral lease boundary (ML 26659).
- Nolans Creek treated as an exclusion zone.
- The northern area within ML 26659 is the preferred waste dump location, as advised by Arafura. The objective is to leave as much area as possible available in the south of ML 26659 to locate the plants, and tailings and residue storage facilities for the various processing cases.

The proposed mine excavated volumes requiring storage are expressed in millions of loose cubic metres (Mlcm) and are inclusive of the 30% swell factor allowance, whilst the waste dump and stockpile capacities referred to later in this report are shown in millions of cubic metres (Mm^3).

Table 2.1 Non-ore material classification (Arafura)

Material Type	Model Code	REO Cut-Off	Classification	
			<1 Bq/g	>1 Bq/g
Waste	f_WASTE	–	BENWST	NORM
Low Grade Ore	f_PAPLP	<COG Note 1	Note 2	LGO
Ore Loss	f_PAPLP	–	Note 2	NORM
NP1	f_NP1	>1% REO	Note 2	M3A
NP2	f_NP2	>1% REO	Note 2	NP2
Low Grade NP1, NP2	f_NP1, F_NP2	<1% REO	Note 2	NORM

Source: Arafura
Note:
[1] Cut-off grade to be determined during mine planning and pit optimization
[2] Assumed to be all >1 Bq/g

Table 2.2 Destination and management of various materials (Arafura)

Classification	Comments
BENWST	Waste dump. Requires management to ensure placement on dump perimeter embankments. If excessive quantities, will require suitable placement for possible later reclamation for TSF, RSF rehabilitation etc.
NORM	Corresponding to "WASTE" material type in Table 2.1. Deposited undifferentiated within waste dumps inside perimeter embankments of BENWST.
LGO	Stockpiled separately in locations suitable for easy reclamation at end of life. May be further classified by grade bins.
NORM	Corresponding to "ORE LOSS" material type in Table 2.1. Ore lost to waste during mining. Deposited undifferentiated within waste dumps inside perimeter embankments of BENWST.
M3A	Material type 3A, >1% REO cut-off. Stockpiled separately within a waste dump near ROM – may be able to be reclaimed and blended during mining. (Not considered at Scoping Study).
NP2	Stockpiled and encapsulated in a dedicated location within a waste dump near the ROM. (Possibly future plant feed, Post PAPL).
NORM	Corresponding to "LOW GRADE NP1, NP2" material type in Table 2.1. Deposited undifferentiated within waste dumps inside perimeter embankments of BENWST.

Source: Arafura

Table 2.3 Mine waste quantities requiring storage

Item	Unit	M&I	LOM
Internal stockpiles:			
M3AO	Mt	0.2	0.2
NP2O	Mt	8.8	15.7
Waste dumps:			
BENWST	Mt	46.2	128.7
NORM	Mt	75.6	173.5
Total mine waste material	**Mt**	**130.9**	**318.1**
Internal stockpiles:			
M3AO	Mbcm	0.1	0.1
NP2O	Mbcm	3.2	5.6
Waste dumps:			
BENWST	Mbcm	18.4	50.5
NORM	Mbcm	29.6	66.7
Total mine waste material	**Mbcm**	**51.3**	**123.0**
Internal stockpiles:			
M3AO	Mlcm	0.1	0.1
NP2O	Mlcm	4.2	7.3
Waste dumps:			
BENWST	Mlcm	23.9	65.7
NORM	Mlcm	38.4	86.8
Total mine waste material	**Mlcm**	**66.7**	**159.9**

2.2 Design logic and approach

AMC was guided by the mine layout from the Previous Study. The Study waste dump and stockpiles were designed iteratively until designs with sufficient capacity were achieved to contain the required volumes (refer Table 2.3), and that met the required design criteria summarized in Section 2.1.

The combined M3AO and NP2O stockpiles are contained wholly within waste dumps and allow for approximately 2 m capping on the exterior surfaces using benign waste from the overlying waste dump.

2.3 Site layouts

The site layouts showing the waste dumps (WD1, WD2, WD3, WD4, WD5), internal stockpiles (combined storage for M3AO and NP2O) and potential topsoil storage areas (TS_MI, TS1, TS2, TS3, TS4, TS5, TS6) designed as part of the Study are shown in Figure 2.1 and Figure 2.2, for the M&I and LOM scenarios respectively.

The pit limits for the M&I and LOM were generated as part of the Scoping Study Update. The long term ore stockpile has been increased in area, but not height, to provide an indicative area required for the larger stockpiles from the Scoping Study Update.

With the design change for the waste dumps and long term ore stockpile, locations of potential topsoil storage were also altered. Other infrastructure is the same as that used previously in the 2015 site drainage and land tenure investigation[3] (Site Drainage Study) and the Previous Study.

Option D from the Site Drainage Study was selected by Arafura as the preferred diversion drain location to carry forward for future design work and site layouts, and accordingly is included in the Study site layouts.

[3] AMC Consultants Pty Ltd report, Nolans Feasibility Study – Preliminary Studies, Site Drainage and Land Tenure, dated 7 April 2015 (AMC report AMC215004B_2)

Figure 2.1 Site layout – M&I scenario

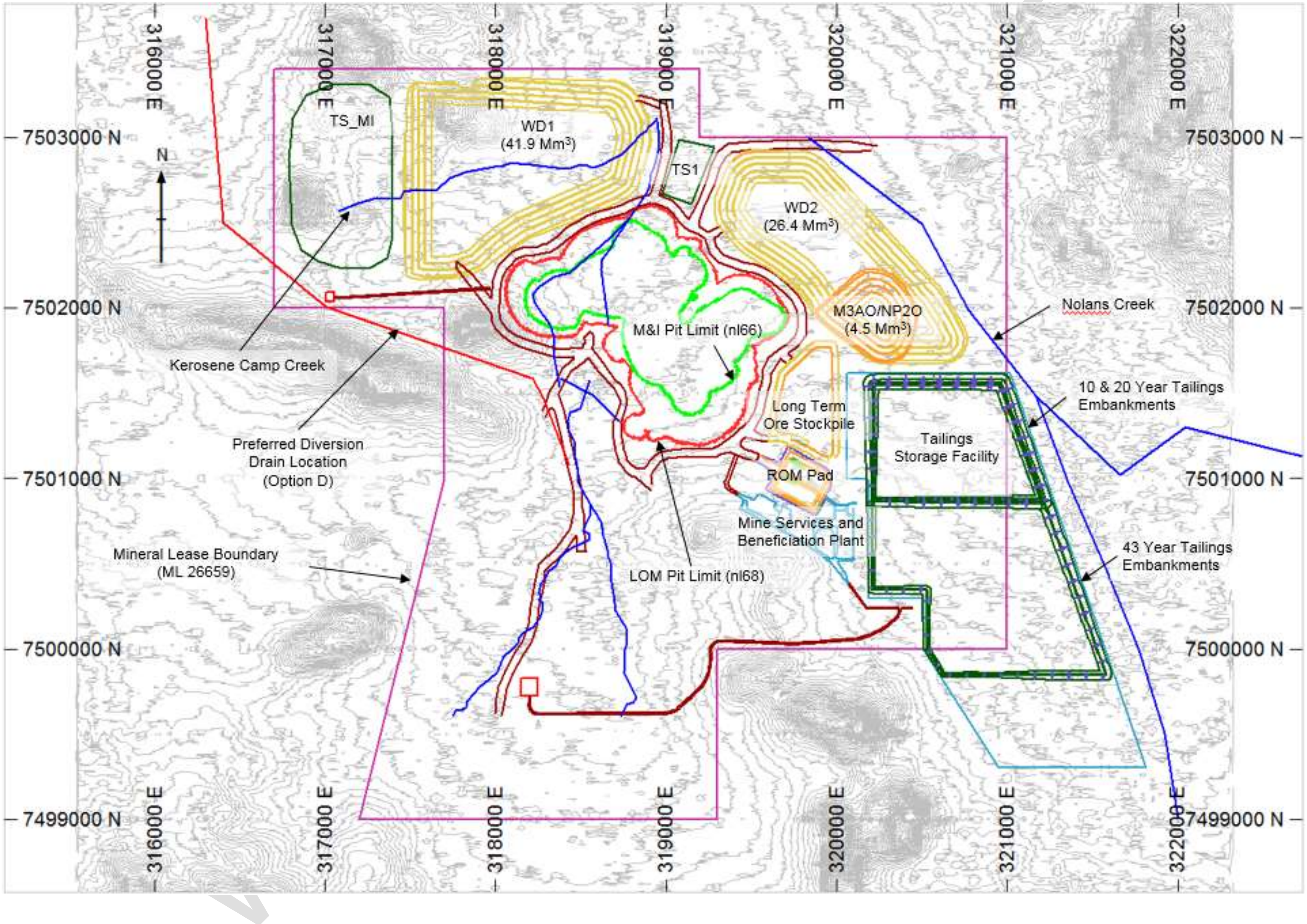
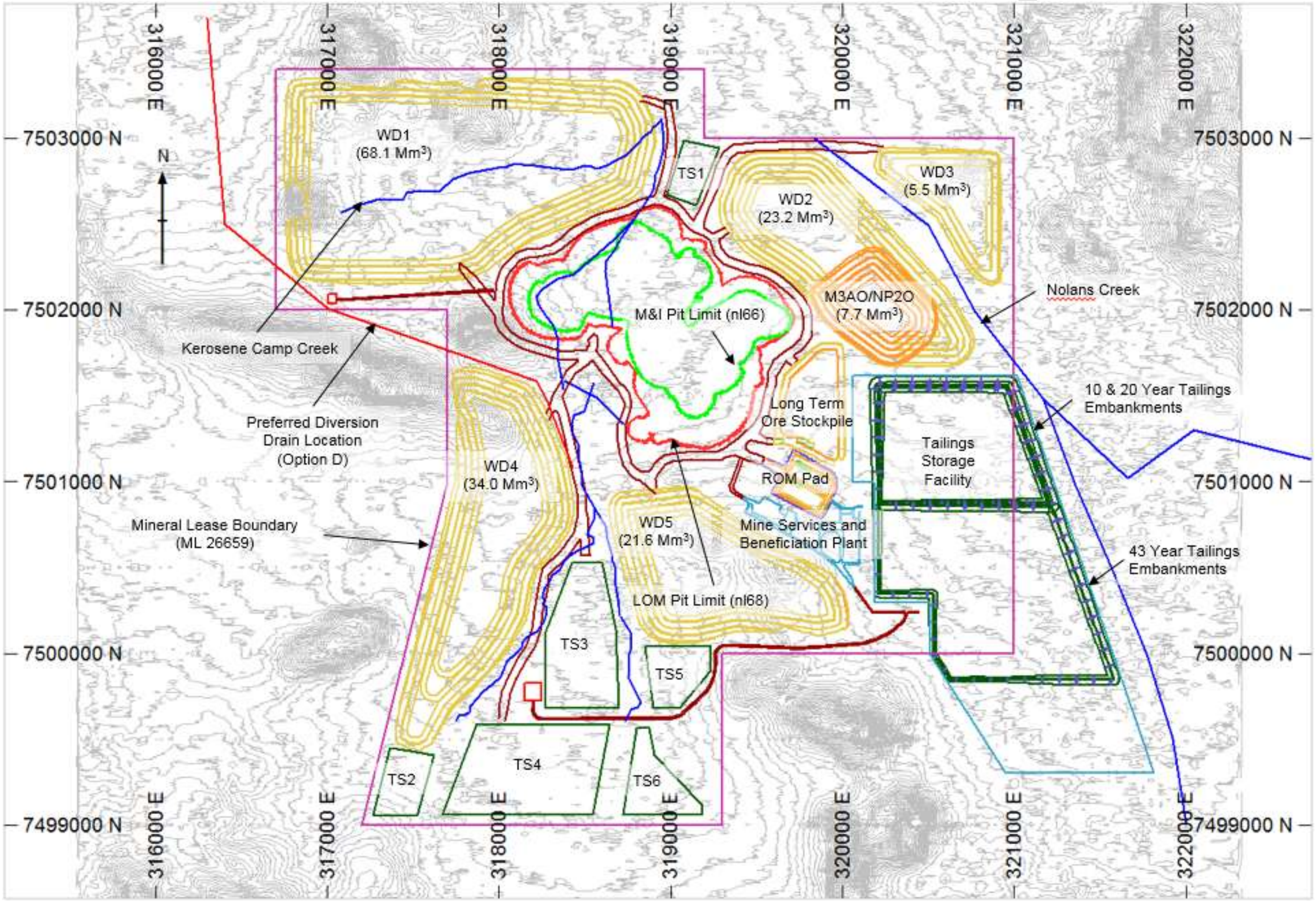


Figure 2.2 Site layout – LOM scenario



2.4 Landform capacities and footprint areas

The capacities and footprint areas of the Study landforms are shown in Table 2.4, Table 2.5 and Table 2.6. The designs have sufficient capacity to contain the waste generated from the Scoping Study Update pit optimization shells (runs nl66 and nl68).

The sensitivity of waste dump capacities to increases in heights were assessed at the request of Arafura, using the LOM scenario as the basis. Increasing all five LOM waste dumps had the following affect:

- A height increase of 10 m increased the combined capacity by 14%, or 22.7 Mlcm.
- A height increase of 20 m increased combined capacity by 25%, or 39.8 Mlcm.

Table 2.4 Waste landform capacities – as designed (by volume)

Item	Elevation (at base case height) (mRL to topography)	Average Toe Elevation (mRL)	Unit	M&I	LOM	LOM Waste Dump Height Increased 10 m	LOM Waste Dump Height Increased 20 m
Stockpile:							
M3AO / NP2O combined	704	–	Mm^3	4.5	7.7	7.7 (not tested)	7.7 (not tested)
Waste dumps:							
WD1	705	665	Mm^3	41.9	68.1	80.5	91.1
WD2[1]	705	658	Mm^3	26.4	23.2	26.2	28.1
WD3	685	660	Mm^3	–	5.5	6.4	6.8
WD4	710	667	Mm^3	–	34.0	37.3	39.3
WD5	710	670	Mm^3	–	21.6	24.8	27.1
Subtotal waste dumps	–	–	Mm^3	68.3	152.5	175.5	192.6
Total			**Mm^3**	**72.8**	**160.2**	**182.9**	**200.1**
Surplus design capacity							
M3AO / NP2O stockpile	–	–	%	5	1	Not tested	Not tested
Waste dumps	–	–	%	10	0.2		
Total	–	–	**%**	**9**	**0.2**	**14**	**25**

[1] The volume shown for WD2 is exclusive of the volume shown for M3AO and NP2O. M3AO and NP2O are wholly contained within WD2

Table 2.5 Waste landform capacities – as designed (by tonnage)[1]

Item	Elevation (at base case height) (mRL to topography)	M&I		LOM	
		Average In Situ Density (t/m^3)	Tonnage (Mt)	Average In Situ Density (t/m^3)	Tonnage (Mt)
Stockpile:					
M3AO / NP2O combined	704	2.75	9.5	2.78	16.4
Waste dumps:					
WD1	705	2.54	81.9	2.58	135.2
WD2[1]	705	2.54	51.7	2.58	46.1
WD3	685	–	–	2.58	10.9
WD4	710	–	–	2.58	67.5
WD5	710	–	–	2.58	42.9
Subtotal waste dumps	–	–	133.6	–	302.7
Total	**–**	**–**	**143.0**	**–**	**319.2**

[1] The tonnages shown in Table 2.5 are based on a swell factor of 1.3 and the average in situ densities shown in Table 2.5

Table 2.6 Waste landform footprint areas and surface areas – as designed

Item	Footprint Area		Surface Area	
	M&I (ha[1])	LOM (ha)	M&I (ha)	LOM (ha)
Stockpile:				
M3AO / NP2O combined	21.9	32.6	Note 2	Note 2
Waste dumps:				
WD1	132.3	212.1	134.9	215.2
WD2	78.0[3]	67.3[3]	102.4	102.4
WD3	–	33.7	–	34.6
WD4	–	119.3	–	122.2
WD5	–	84.8	–	86.7
Subtotal waste dumps	210.3	517.3	237.2	561.0
Total	**232.2**	**549.9**	**237.2**	**561.0**

[1] ha= hectare (10,000 m^2)

[2] The surface areas for the combined M3AO/NP2O internal stockpiles are not shown because these are encapsulated by at least 2 m of waste from the WD2 designs

[3] The footprint areas shown for WD2 are exclusive of the footprint areas shown for the combined M3AO/NP2O internal stockpiles. The combined M3AO/NP2O internal stockpiles are wholly contained within the WD2 designs

2.5 LOM alternate design (Merging WD1 and WD2)

At the request of Arafura, AMC assessed an alternate design for the LOM waste dumps WD1 and WD2, in which they were merged into one, as shown by the red design strings in Figure 2.3. Merging these two waste dumps provides additional capacity of 8.7 Mm^3, as shown in Table 2.7.

Figure 2.3 Alternate LOM waste dump design – WD1 and WD2

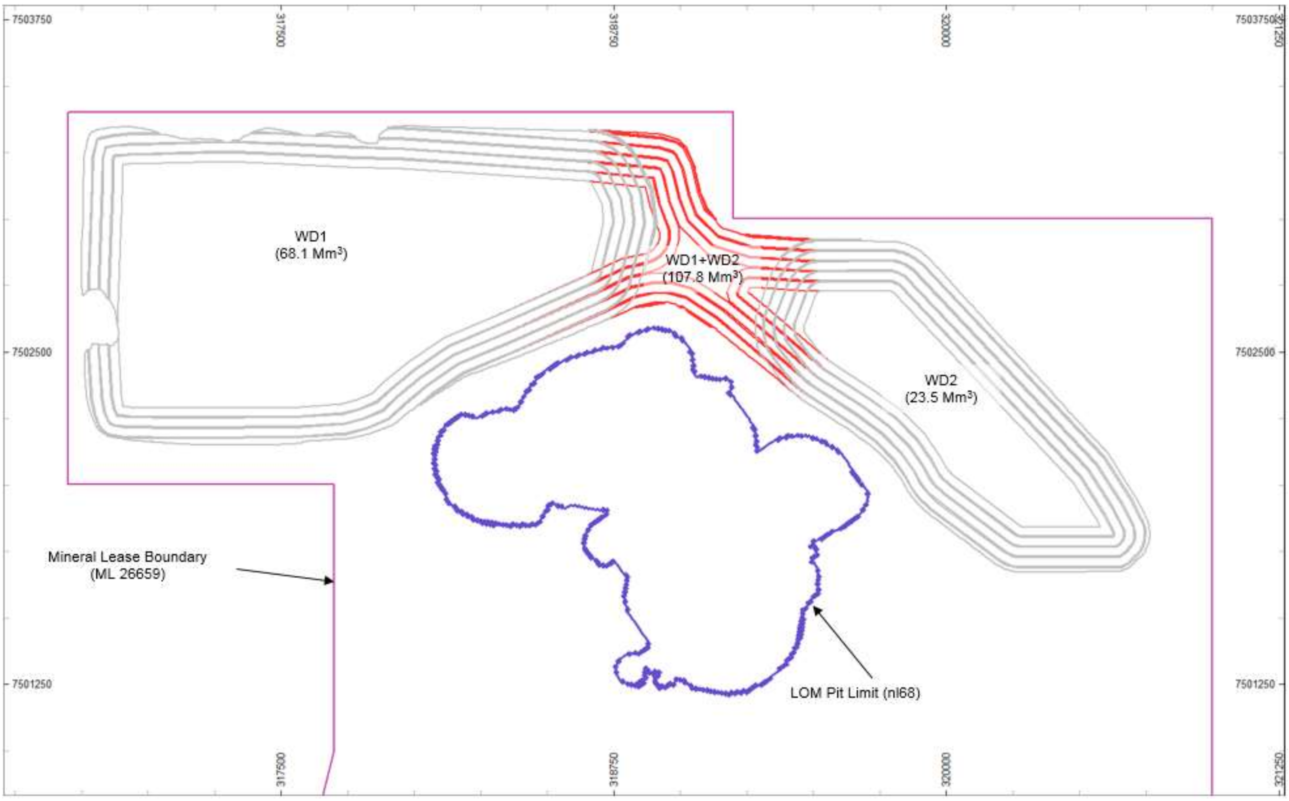


Table 2.7 Alternate LOM waste dump design – WD1 and WD2 capacity

Base Case Combined Capacity (Mm^3)	Merged Capacity (Mm^3)	Difference (Mm^3)	Difference (%)
99.1	107.8	8.7	8.8

2.6 Ore stockpile design

The LOM scenario showed a peak combined long term ore stockpile size of 5.5 Mt, larger than the combined 4 Mt size limit in the Previous Study. AMC increased the area of the long term ore stockpile into an area previously identified as a potential topsoil storage area. The resultant capacity is now sufficient to contain up to 6.6 Mt of ore, for one large stockpile, which would reduce if a number of small stockpiles were established. This should be explored further as part of the FS.

2.7 Topsoil storage

The areas for potential topsoil storage are shown in Table 2.8 and Table 2.9 for the M&I and LOM scenarios respectively. These areas are also shown graphically in Figure 2.1 and Figure 2.2.

Table 2.8 M&I topsoil footprint area

Topsoil	Area (ha)
TS_MI	59.1
TS1	6.6
Total	65.7

Table 2.9 LOM topsoil footprint area

Topsoil	Area (ha)
TS1	6.6
TS2	9.8
TS3	30.3
TS4	43.4
TS5	10.9
TS6	12.8
Total	113.8

3 Summary

The primary objective of the Study was to design waste dumps and stockpiles of sufficient capacities to accommodate the mine waste generated from the M&I and LOM scenarios, and to locate these landforms to the north of ML 26659 as much as was practical, and in doing so, to identify areas that would remain available for Arafura to locate plants, and tailings and residue storage facilities to allow subsequent options and cost analyses, to confirm the FS basis of design.

In summary:

- Sufficient area exists within ML 26659 to accommodate the waste dumps and stockpiles for both the M&I and LOM scenarios for the applied design criteria (refer Section 2.1).
- AMC cannot comment whether the remaining area is sufficient for the required plants, and tailings and residue storage facilities. This will be subsequently determined by Arafura.
- For the M&I scenario, WD1 is reduced in size compared to the LOM WD1 design. When locating the M&I WD1, AMC positioned it close to the pit limit to reduce mine truck haulage distances. AMC notes that this positioning would require the Kerosene Camp Creek to be diverted around WD1 and that this would need to be considered in future mine planning.

AMC recommends:

- Redesign of the waste dumps, stockpiles, and overall site layout in general in greater detail in future work, including internal waste dump design to adequately demonstrate the placement of the various waste types. The Study designs are conceptual and adequate for Arafura's current intended purpose. AMC understands the proposed FS scope of work allows for such detailed design.
- Quantifying potential topsoil volumes from site clearing and making adequate storage allowances for these volumes. This would also be completed in the FS. For the Study, AMC kept the total potential topsoil area similar in size to that of the Previous Study.

Our offices

Australia

Adelaide

Level 1, 4 Greenhill Road
Wayville SA 5034 Australia
T +61 8 8201 1800
E adelaide@amcconsultants.com

Brisbane

Level 21, 179 Turbot Street
Brisbane Qld 4000 Australia
T +61 7 3230 9000
E brisbane@amcconsultants.com

Melbourne

Level 19, 114 William Street
Melbourne Vic 3000 Australia
T +61 3 8601 3300
E melbourne@amcconsultants.com

Perth

Level 1, 1100 Hay Street
West Perth WA 6005 Australia
T +61 8 6330 1100
E perth@amcconsultants.com

Canada

Toronto

Suite 300, 90 Adelaide Street West
Toronto, Ontario M5H 3V9 Canada
T +1 416 640 1212
E toronto@amcconsultants.com

Vancouver

Suite 202, 200 Granville Street
Vancouver BC V6C 1S4 Canada
T +1 604 669 0044
E vancouver@amcconsultants.com

Singapore

Singapore

Registered Office
16 Raffles Quay, #33-03 Hong Leong Building
Singapore 048581
T +65 8620 9268
E singapore@amcconsultants.com

United Kingdom

Maidenhead

Registered in England and Wales
Company No. 3688365

Level 7, Nicholsons House
Nicholsons Walk, Maidenhead
Berkshire SL6 1LD United Kingdom
T +44 1628 778 256
E maidenhead@amcconsultants.com

Registered Office: Monument House,
1st Floor, 215 Marsh Road, Pinner,
Greater London, HA5 5NE, United Kingdom