Appendix 5

Surface Water Pollution Reduction Program Report

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Perilya Broken Hill Limited

EPL 2683 Pollution Reduction Program 100-year ARI Assessment

North Mine (Broken Hill)

REPORT

June 2014

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1.0 Introduction

Perilya's North Mine is located on the north-eastern edge of Broken Hill, far-western NSW. The site is shown as the highlighted area in **Figure 1**.

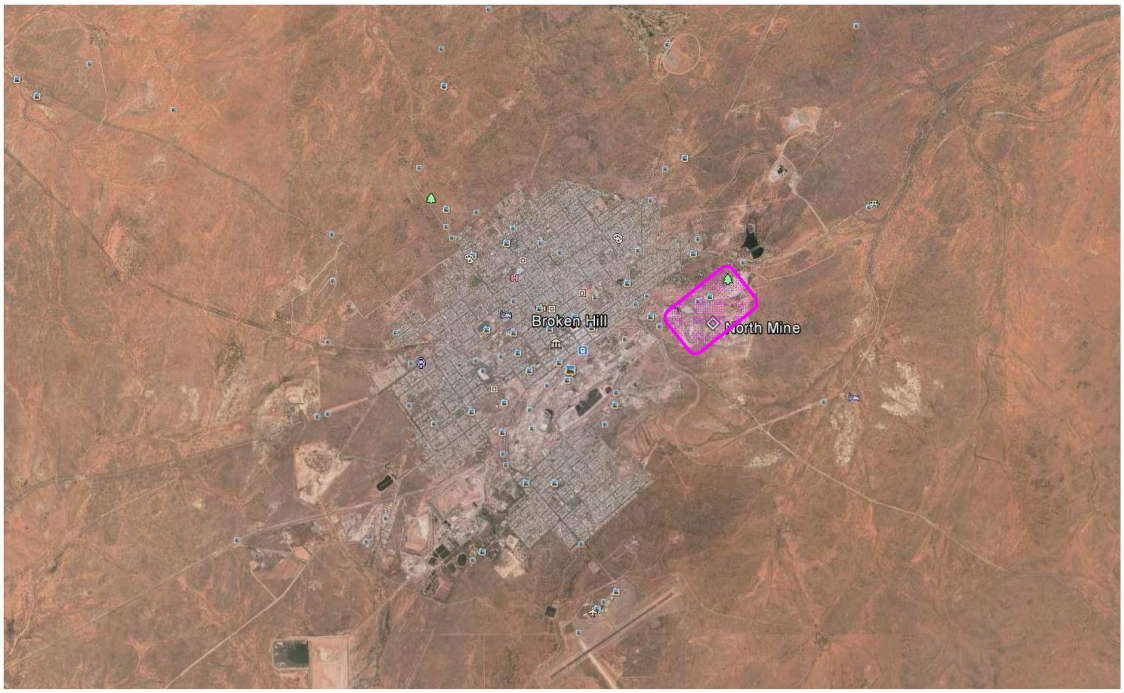

Figure 1. Location of North Mine in relation to Broken Hill – width of the view in this figure is 20 kilometres. (map source: Google)

2.0 Site overview

North Mine is located in the upper catchment of one of the smaller tributaries of Stephen's Creek which feeds one of the storages managed by Essential Water for the supply of water to urban areas and industry of the region. Whilst the mine is located approximately 11.5 creek kilometres off the southern tip of Stephen's Creek Reservoir, the broader catchment for this reservoir extends away from Broken Hill in a north-westerly direction into the nearby Barrier Range. Extent of this reach is approximately 28 creek kilometres giving rise to a catchment area in the order of 46,300 hectares.

At a more local scale, **Figure 2** shows North Mine in context with its immediate surrounds and the predominant surface drainage pathways of the area. This figure shows two main drainage pathways that traverse the mine:

- McCulloch drainage line which starts approximately 2.4 kilometres west of the mine in the broader area of the Broken Hill CBD and reports to an upstream point on the north-western edge of the North Mine boundary near the Chettle Street/McCulloch Street intersection; and
- A lesser disturbed and smaller drainage line which starts on the eastern edge of South Broken Hill near Mawson's Quarry and the southern boundary of CBH Resource's Rasp Mine and reports to an upstream point on the south-western corner of the North Mine boundary adjacent to Menindee Road.

The McCulloch drain is the larger of the two drainage lines and passes through the North Mine site via a number of purposed built conveyance structures to discharge at a point on the eastern boundary of the mine near the Barrier Highway. From this point, waters follow a natural gully line to join a larger drainage line downstream of Imperial Lake which is another storage managed by Essential Water. From this point these waters join the larger Willa Willyong Creek and ultimately the wider Stephen's Creek system which flows into Stephen's Creek Reservoir.

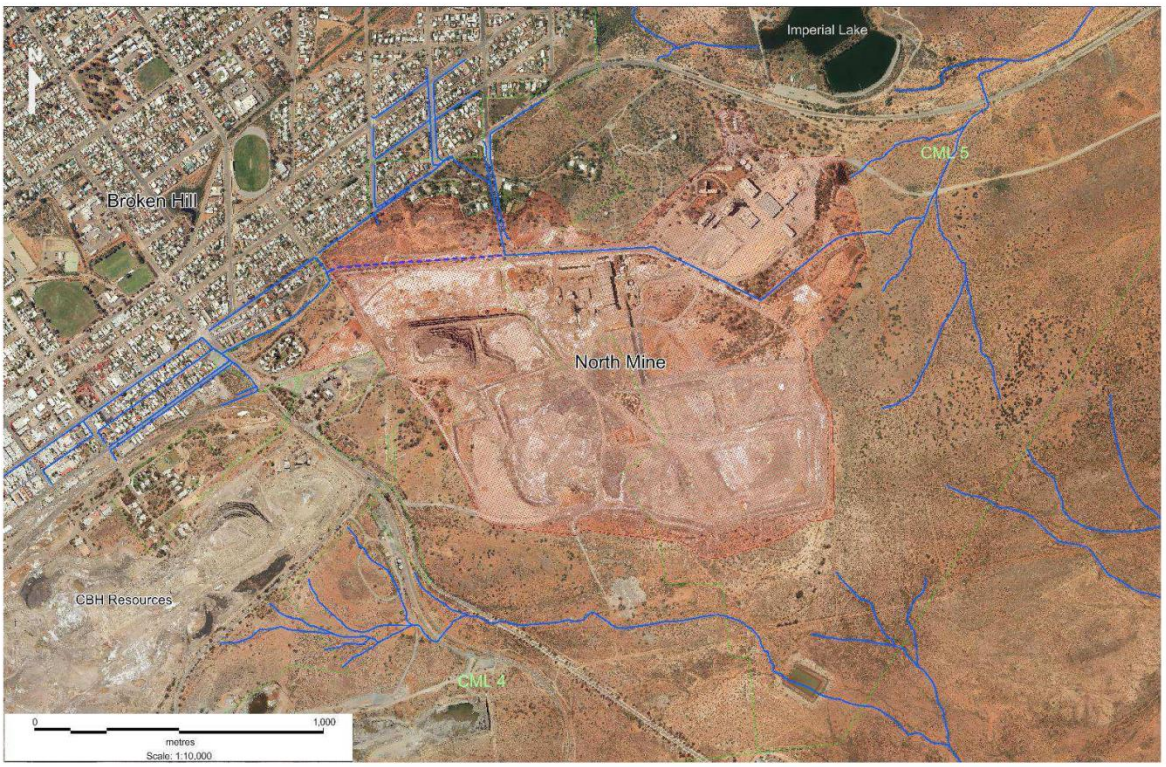

Figure 2. General view of North Mine showing broader surface drainage patterns of the site. In this figure the following information refers – drainage lines (solid blue line); North Mine disturbed area (red stipple hachure); CML boundaries (light green line).

The second and smaller drainage line that arises in the eastern edge of South Broken Hill traverses the lower, south-western corner of the mine to enter a constructed storage on an adjacent grazing property to the south of the mine. From this point, these waters ultimately join Willa Willyong Creek.

Apart from localised drainage works associated with the National Railway Line, the Menindee road and a creek diversion on North Mine, this drainage line is comprised largely of natural channel. In terms of contact with the mine, traverse length of the second and smaller drainage line within the mine boundary is 0.93 kilometres compared to 1.96 kilometres of the McCulloch Street drain.

All drainage lines described above are strongly ephemeral and only flow for short durations following receipt of significant rainfall in their catchments. In their undisturbed form, these gullies and creeks are typically wide and flat-bottomed in profile and carry heavy bed loads of coarse sandy to gravelly sediments.

3.0 Pollution Reduction Program

Associated with the Perilya's North Mine is Environmental Protection Licence No 2683 (EPL2683) administered by NSW Environmental Protection Agency. Included in this licence are two conditions relating to a Pollution Reduction Program (PRP) that focuses on Perilya's North Mine site. These two conditions are shown in **Table 1**.

Table 1. Excerpt from EPL2683 showing Conditions U1, U2 relating to the PRP applicable to the North Mine site.

8 Pollution Studies and Reduction Programs

U1 Water management structure works

U1.1 The licensee must undertake the following staged works.

Stage	Works Required	Completion Date
1	The licensee must prepare a report that nominates works that will be undertaken on the floor and walls of water storage 57A designed to prevent leaks and seepage of water. This report must be submitted to the Head, Griffith Unit for approval by the specified completion date.	31 October 2012
2	Undertake and complete the works identified in Stage 1 as approved by the EPA.	6 months after written approval of Stage 1 from the EPA.

U2 ARI modelling

U2.1 The licensee must undertake an assessment that determines the capability of each water storage on the premise to capture and retain rainfall runoff based on a 24 hour rainfall event that is Broken Hill's 100 year Average Recurrence Interval.

The completed assessment results must be provided to the Head, Griffith Unit by 30 June 2013.

In terms of Condition U1 of the PRP, focus of this part is understood to be management of pollution potentially moving out from the mine site into the surrounding environment via surface water pathways. Specifically, Condition U1.1 addresses works to be undertaken on water storage 57A Dam to prevent leaks and seepage of water.

Prior to the PRP, 57A Dam was the final downstream structure constructed to intercept runoff arising from the wider extent of ground located upstream between McCulloch Drain and the North Mine TSF/WRE. Included in this area is the North Mine No2 Shaft complex of remnant structures. Works to address Condition U1.1 are detailed in the following section, **4.0 Works implemented to meet PRP (U1)**, of this report.

Condition U2 of the PRP seeks a quantification of runoff expected to occur from the North Mine site as a result of the 24-hour, rainfall event that is Broken Hill's 100-year Average Recurrence Interval (ARI). As a point of note, this assessment was undertaken after many of the works supporting Condition U1 had already been completed.

Detail of the 24-hour 100-year ARI (100'ARI) assessment is contained in **7.0 Assessment undertaken to meet PRP (U2)**.

4.0 Works implemented to meet PRP (U1)

Condition U1.1 of the EPL'2683 PRP calls for action on the floor and walls of 57A Dam to address leaks and seepage of water observed to be occurring on this dam. Location of this dam is shown in **Figure 3** along with location and names of other storages of the North Mine surface water management infrastructure.

It is recognised that 57A Dam is a site water dam and leakage from this storage represents movement of site water from the mine site's surface water management circuit across to the 'clean side' of the wider environment.

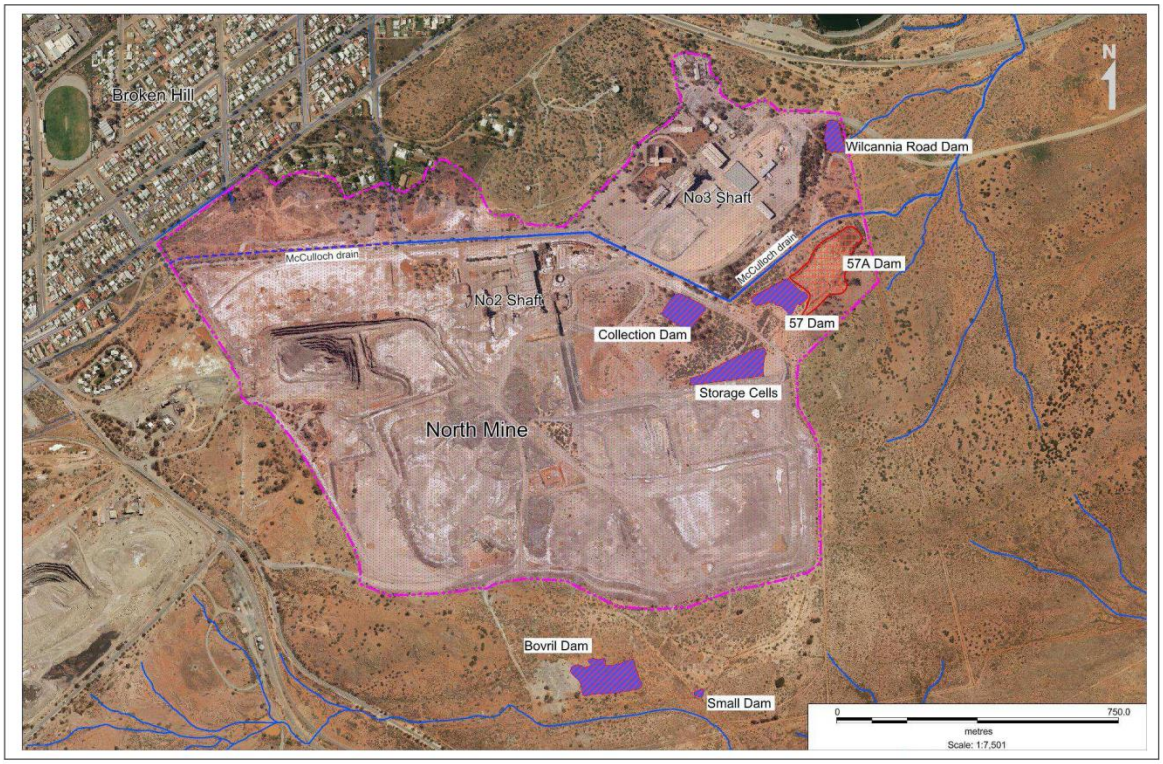

Figure 3. General view of North Mine showing storages underpinning the surface water management infrastructure of the site.

In this figure, the following information refers – surface water storages (dark blue, diagonal hachure); 57A Dam (red cross hachure, red outline); mine affected area (pink dot hachure, pink dashed outline); major drainage lines (blue line).

Early review of the works required to repair 57A Dam indicated an elevated cost profile beyond that which was initially practicable to achieve a solution in comparison to construction of a new storage. Early work undertaken to meet the requirements of Condition U1.1 of the PRP sought to bypass 57A Dam and leave 57 Dam as the final downstream structure for this particular sub-catchment.

Summary of measures implemented in order to achieve solution to leakage occurring on 57A Dam:

1. Removing 57A Dam from the North Mine surface water management circuit;
2. Reinstate the original 57 Dam as the final downstream receiving structure for the sub catchment;
3. Close the 57 Dam water flow aperture that discharges to the adjacent and downstream 57A Dam;
4. Construct a new storage structure (Collection Dam) upstream of 57 Dam so as to increase storage capacity of the system as well as provide increased buffering against higher-order storm events;
5. Implement an active pump-out facility in 57 Dam to ensure NIL-release is maintained with this structure;
6. Provide on-site receiving capacity for any pumped-out waters from 57 Dam through use of a series of storage cells ('Storage Cells') constructed on the north-eastern side of the North Mine WRE/TSF; and

7. Provide pump-out facility at the Storage Cells to draw-down excess water that may occur in this storage system should full capacity ever occur.

Further to the above works, Perilya implemented additional works across the wider North Mine in order to deliver better security in the management of pollutants expected to occur on the site. These works are detailed in the next section.

5.0 Implementation of further works under PRP (U1)

A key principle underlying the PRP is understood to be potential for movement of surface or near-surface pollutants through action of surface drainage waters.

Solutions to prevent or control this movement would seek measures/strategies that either interrupt or intercept this process with outcome of the retention of pollutants on the mine site. Onsite retention prevents movement across boundaries to the wider environment, thereby simplifying the task of later programs that would be assigned to manage these materials.

Whilst achieving the immediate goal of addressing leaks in 57A Dam, additional works across the wider North Mine site implemented are shown in **Figure 4**. Based on two key strategies of (1) retention of pollutants within designated areas and (2) separation of non-site waters from site waters, these works include:

- Conversion of the open earth channel section of the McCulloch drain to a sealed and covered conduit;
- Construction of overland flow barriers and channels to intercept and direct surface drainage flows; and
- Construction of storage capacity for intercepted site waters.

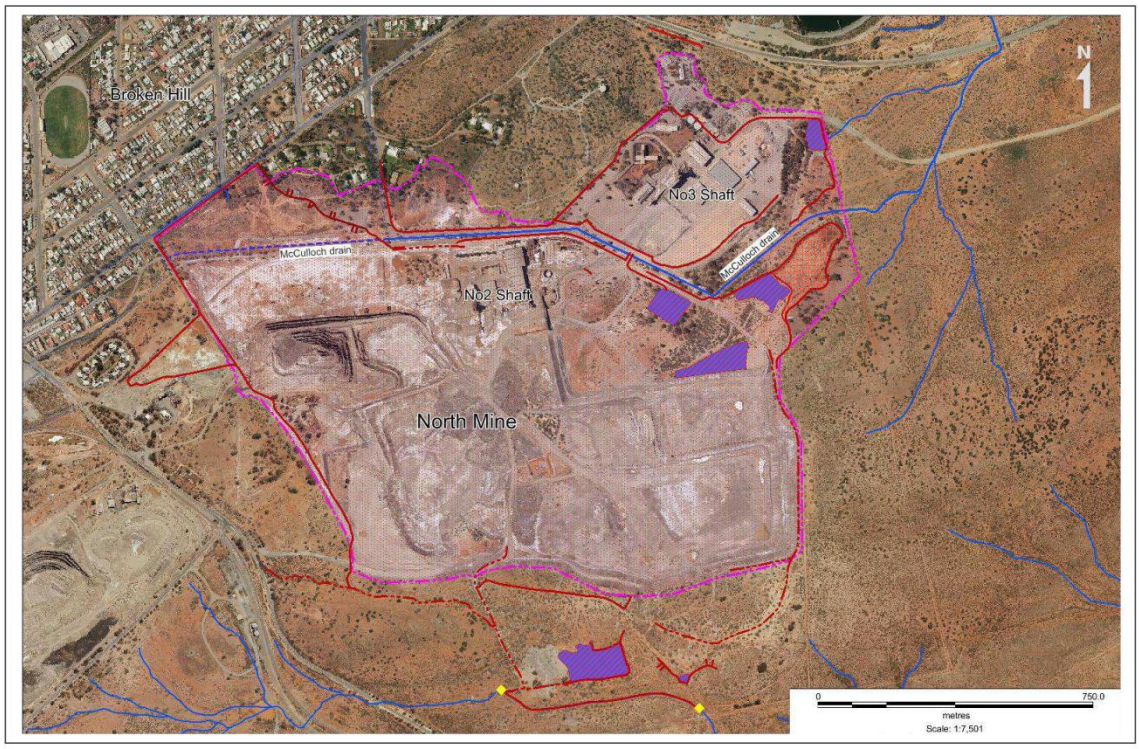

Figure 3. General view of North Mine showing additional works established to manage potential pollution on site.

In this figure the following information refers – overland flow barriers (red solid line); channels, drains or inverts (dashed red line); topographical divide (red barbed line); drainage lines (solid blue line) and North Mine disturbed area (stipple hachure with double-dashed outline). Constructed storages are shown in pink highlight with their name.

The southern stream diversion is shown as the length between yellow diamonds marked on the face of the image.

Detail relating to the additional works undertaken on the North Mine site is included in the following sections.

5.1 Conversion of the open earth channel section of the McCulloch Street drain

Prior to this conversion, non-site waters entering North Mine via the Sturt Street drain flowed along 600 metres of open earth channel of the McCulloch Street drain. Due to the open nature of this part of the conduit, there was little provision to prevent intermingling of site water with non-site waters in the drain.

Location of the McCulloch Street conversion is shown in **Figure 4**.

Completed in the early part of 2013, the conversion consisted of:

- 600 metres of large-diameter storm pipe connecting point of entry to existing lined channel section;
- Inlet secured with security/trash screen (**Figure 5**);
- Enclosed receiving area with wing walls, apron, security screen plus perimeter fencing (**Figure 6**);
- Constructed discharge end tail wall with security barrier (**Figure 7**); and
- Buried pipeline with raised and profiled backfill (**Figure 8**).

Figure 4. View of the NW corner of North Mine showing location of the buried section of the McCulloch Street drain conversion – red stipple hachure denotes disturbed areas of the North Mine.

In this figure, the conversion section of the McCulloch Street drain is shown as dashed blue line with start and end points denoted by light blue triangle symbols.

Location of the conversion drain's upstream head works, trash screen and security enclosure is shown as the pink circle located near the intersection of Chettle Street with McCulloch Street.

Figure 5. Upstream headwall and trash screen of drain.

Figure 6. Drain safety screen within its security enclosure.

Figure 7. Tail headwall and security screen.

Figure 8. Alignment of the McCulloch drain conversion.

5.2 Overland flow barriers and channels to intercept/direct surface drainage flows

Key to separation of site water from non-site waters is provision of barriers to both intercept and direct surface water flows occurring on site and which may have access to non-site waters. Augmenting the function of the flow barriers are channels, drains and inverts which provide greater diversity of application when addressing the range of situations faced on a mine site.

Location of flow barriers and channels deployed at North Mine is shown previously in Figure 3.

Summary of the main applications where the barrier/channel measures were used includes:

- Diversion bank to close the low-end of the McCulloch Street drain conversion – discharges across the railway line to the No2 Shaft area (**Figure 9**);
- Diversion banks and inverts constructed below the No2 Shaft to prevent ingress into the adjacent, open but lined channel of the McCulloch Street drain – contains runoff from No2 Shaft area plus input waters from McCulloch Street drain conversion (**Figure 10**);
- Diversion banks to convey accumulated waters from the No2 Shaft area to the Collection Dam (**Figure 11**);
- Existing high ground plus constructed side drains of the North Mine main access road embankment – intercepts and detains runoff waters from hills across the north side of the mine (**Figure 12**);
- Existing high ground of the No3 Shaft access road – prevents waters from No3 Shaft area entering the main channel of the lower end of the McCulloch Street drain.(**Figure 13**);
- Excavated channel around eastern side plus half of the southern side of the North Mine WRE/TSF – intercepts runoff from this structure and directs any waters to 57 Dam (**Figure 14**);

- Constructed bank across natural gully line of creek cutting across south-western corner of the mine site – redirects non-site waters in creek line into constructed creek diversion – prevents non-site water entering site and compromising capacity of Bovril Dam (**Figure 15**);
- Excavated channel as creek diversion in order to convey non-site waters across the lower corner of the mine site – reconnects with natural drainage line at mine site boundary (**Figure 16**).

Location of these images is shown on a map of the site in Figure 15. Numbers in square brackets in figure captions relate to number given on face of Figure 17.

Figure 9. Diversion bank at McCulloch Street drain diversion.

Figure 10. Diversion bank and invert below No2 Shaft.

Figure 11. Diversion bank feeding Collection Dam.

Figure 12. Mine access road embankment .

Figure 13. Embankment at No3 Shaft perimeter road.

Figure 14. Perimeter toe drain around WRE/TSF.

Figure 15. Diversion bank in creek merging to channel.

Figure 16. Constructed creek diversion channel.

5.3 Provision of storage capacity for intercepted site waters

Whist both overland flow barriers and channels are effective tools in the management of surface water flows, they are not complete without some form of capacity to hold and manage intercepted waters. This part looks at storages implemented in the management of North Mine surface waters.

Determined largely by site topography, storage capacity underpinning North Mine surface water management falls into a number of distinct sub-catchments (**Figure 17**).

These sub-catchments with their corresponding surface storages are:

1. Central zone which includes the No2 Shaft area – consists of a strip of ground bounded by the McCulloch drain to the north and the North Mine TSF/WRE to the south and occupies the full east-west width of the mine site;
    - Collection Dam (**Figure 18**)
    - 57 Dam (**Figure 19**)
    - Storage Cells (**Figure 20**)
2. No3 Shaft area plus the North Mine Core Yard (Northern Zone) – located in north-east corner of the site;
    - Wilcannia Road Dam (**Figure 21**)
3. McCulloch-Argent corner and Helicopter Pad sub-catchments (Northern Zone) and located in the north-western corner of the mine site, north of McCulloch drain;
    - Internally drained sub-catchments with no formal surface storage except a number of large-scale ponding elements.
4. Outfall areas on the western, southern and eastern sides of the North Mine WRE/TSF; and
    - Bovril Dam (**Figure 22**)
    - Small Dam (**Figure 23**)
5. Localised, small-scale ponding elements interspaced throughout the mine which are regulated more by local terrain than any broader drainage pattern. These informal storages are discussed in more detail in **Section 5.4**.

The North Mine WRE/TSF complex is a dominant landscape feature that spans almost the full east-west width of the mine site. Including the No1 mine void, this is an internally draining structure with its own storage capacity.

The two non-site water, through-flow systems of McCulloch drain and south-west drainage line are conveyance structures and not surface water storages and, therefore, are not included at this part.

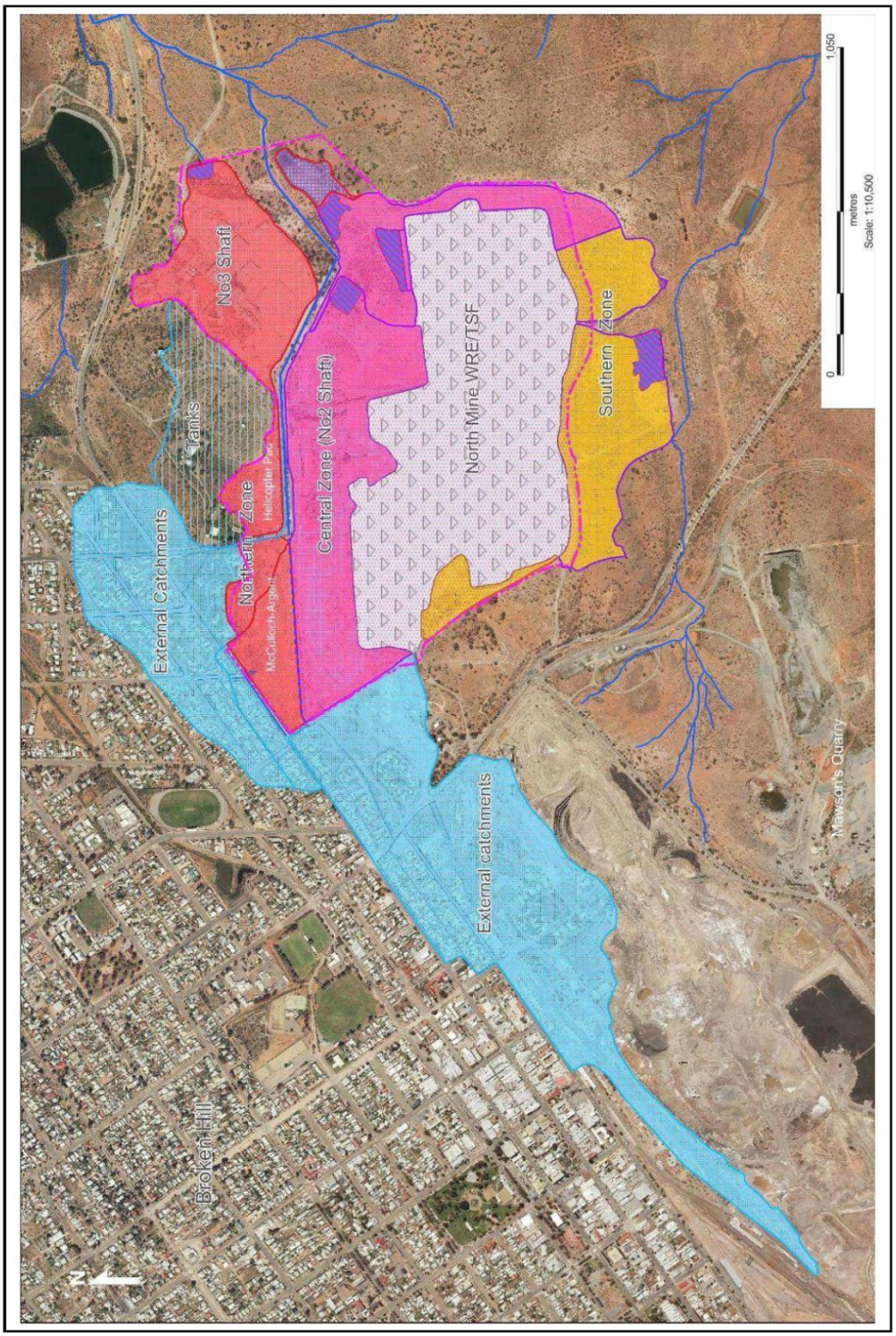

Figure 17. Surface water drainage sub-catchments associated with the North Mine.

In this figure, the following are shown: external catchments (blue), north zone of mine site (red), central zone (maroon), southern zone (yellow), mine WRE/TSF (diamond hachure), mine site boundary (red dashed line), storages (dark blue).

Figure 18. General view of the newly constructed Collection Dam.

Figure 19. General view of 57 Dam surface storage.

Figure 20. General view of the Storage Cells surface storage – looking in an easterly direction.

Figure 21. General view of Wilcannia Road Dam surface storage.

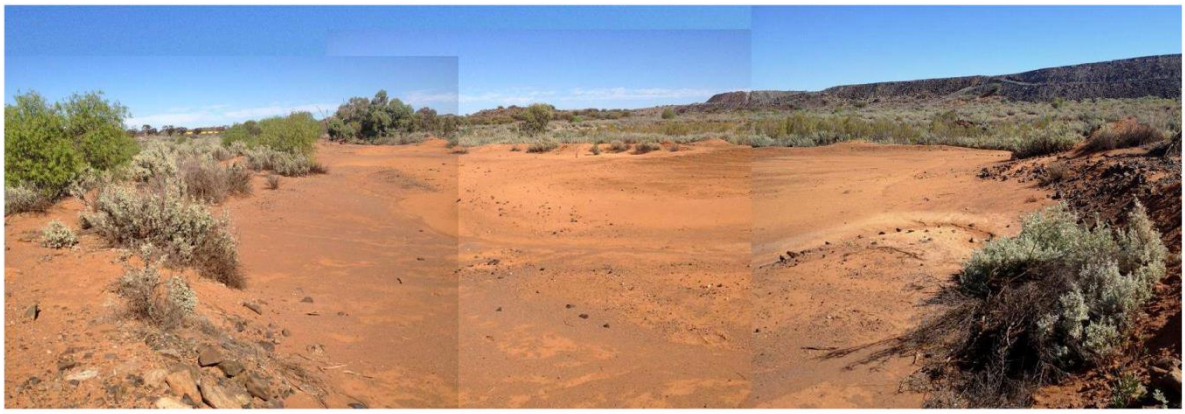

Figure 22. General view of Bovril Dam surface storage.

Figure 23. General view of Small Dam surface storage.

5.4 Localised ponding elements

In contrast to formally constructed storages such as dams, localised ponding elements consist largely of small-scale depressions and settlement areas built into the wider structure of the mine landscape. Whilst these informal structures do not have the size, scale and volume of their larger counterparts, they function in a similar manner.

Ponding elements intercept and detain overland flow site water, thereby preventing migration of this water into the more defined regions of a drainage system. Use of these structures becomes important in space constrained areas of the site where limited space does not permit construction of larger structures. The smaller size of ponding structures also enables them to be used in conjunction with other structures such as embankments, roads, fill zones or simple landscaping profiles.

Whilst many of these elements occur throughout the wider North Mine surface water management system, they are not all itemised in this report. Notwithstanding, a number are illustrated below to provide examples of their use across the site (**Figure 24**, **Figure 25**, **Figure 26**, **Figure 27**).

Figure 24. Ponding against mullock and in vegetation.

Figure 25. Ponding element between bank and track.

Figure 26. Ponding againt road embankment & in vegetation.

Figure 27. Ponding against a low windrow on WRE bench.

6.0 Volume of surface storage

Estimated volumes of the North Mine surface water storages are summarised in **Table 2**.

Table 2. Summary of North Mine surface water storages and storage volumes

Storage ID	Zone	Volume (m^3)	Volume (ML)	System TOTALS	
Wilcannia Road Dam	Northern Zone (No3 Shaft)	4,477	4.4	4.4	ML
Collection Dam	Central Zone (No2 Shaft)	8,845	8.8		
57 Dam	Central Zone (No2 Shaft)	6,500	6.5		
Storage Cells	Central Zone (No2 Shaft)	10,434	10.4	25.8	ML
Bovril Dam	Southern Zone	18,390	18.4		
Small Dam	Southern Zone	523	0.5	18.9	ML
	Site **TOTAL**	**49,169**	**49.0**		

Note: volumes are derived from calculations based on conservative field measurements rather than formal survey.

In this table, total volumes are provided for each of the zones that contain formally constructed storages:

- Northern Zone (No3 Shaft) – 4.4 ML
- Central Zone (No2 Shaft) – 25.8 ML
- Southern Zone – 18.9ML

At mine scale, these zones belong to separate sub-catchments and function independently to each other at this scale across the North Mine site.

7.0 Assessment undertaken to meet PRP (U2)

7.1 100'ARI assessment

Assessment of the 24-hour 100-year ARI (100'ARI) runoff followed the following broad procedure:

1. Delineate catchments external to the mine site which impact or deliver runoff waters to the site – these are shown in **Figure 28**;
2. Delineate sub-catchments within mine site plus their corresponding points to which they report (Figure 28);
3. Identify surface water control structures implemented across the mine site (Figure 3) and include these in delineation of site sub-catchments;
4. Assess sub-catchment characteristic in relation to potential pollution and likelihood for transfer of any pollutants to the wider environment via runoff waters (Figure 28);
5. Determine sub-catchment areas – both internal and external to the site;
6. Obtain the Rainfall Intensity-Frequency-Duration data for North Mine – sources are Australian Rainfall & Runoff (ARR) or Bureau of Meteorology (BoM) (**Table 3**);
7. Determine total rainfall runoff volume (*V*) expected from the design event – runoff formula (**Figure 29**) used similar to the Rational Formula through evaluation of:
    (i) Design rainfall Intensity (*i*)
    (ii) Sub-catchment Runoff Coefficient (*C*)
    (iii) Duration of design event (*d*) through evaluation of Time of Concentration (t_c)
8. Determine peak discharge (Q) using the Rational Formula (**Figure 30**) through evaluation of:
    (i) Sub-catchment Runoff Coefficient (*C*)
    (ii) Design rainfall Intensity (*i*)

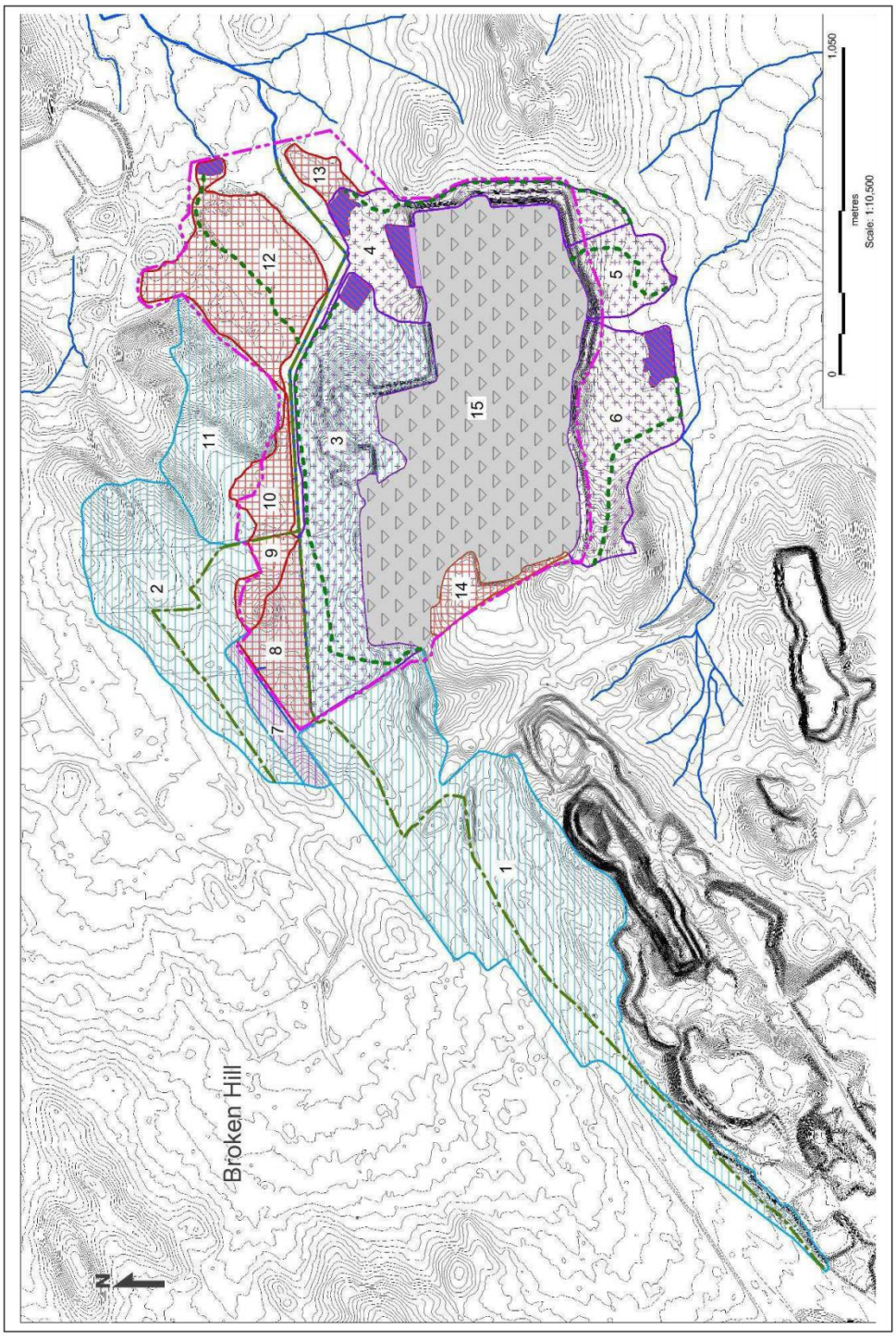

Figure 28. Rainfall runoff catchments relevant to Condition U2 of the EPL'2683 PRP and shown on a terrain map of the area.

In this figure, the following information refers: external catchments contributing runoff to the site (blue cross hatch); site sub-catchments terminating as ponded containment (red cross hatch); site sub-catchments reporting to dedicated storage (purple cross hachure); internally draining WRE/TSF (grey diamond hachure); dedicated storages (dark blue) and longest flow path for each sub-catchment (green dashed line).

Table 3. Copy of the IFD chart for North Mine, Broken Hill (source: BoM, issued 05-05-14).

Intensity-Frequency-Duration Table

Location: 31.950S 141.500E NEAR.. North Mine, Broken Hill NSW Issued: 5/5/2014

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

	Average Recurrence Interval						
Duration	**1 YEAR**	**2 YEARS**	**5 YEARS**	**10 YEARS**	**20 YEARS**	**50 YEARS**	**100 YEARS**
5Mins	49.9	66.2	92.7	109	131	159	182
6Mins	46.2	61.4	85.9	101	121	148	169
10Mins	37.4	49.7	69.5	82.0	97.9	119	136
20Mins	27.1	36.0	50.2	59.2	70.6	86.1	98.2
30Mins	21.8	28.9	40.3	47.5	56.6	69.0	78.7
1Hr	14.2	18.8	26.2	30.9	36.9	44.9	51.3
2Hrs	8.70	11.6	16.2	19.1	22.9	27.9	31.9
3Hrs	6.43	8.57	12.1	14.3	17.1	20.9	23.9
6Hrs	3.80	5.07	7.19	8.53	10.2	12.6	14.4
12Hrs	2.25	3.00	4.28	5.10	6.13	7.54	8.65
24Hrs	1.33	1.78	2.54	3.03	3.64	4.49	5.16
48Hrs	.763	1.02	1.46	1.74	2.09	2.58	2.97
72Hrs	.530	.710	1.02	1.21	1.46	1.80	2.07

(Raw data: 19.11, 3.02, 0.71, 45.54, 7.58, 1.8, skew=0.00, F2=4.34, F50=15.04)

$$V = i.d.C.A.10^{-3}$$

where:

- V = volume runoff produced from the design rainfall event (m^3)
- i = design rainfall intensity (mm/hr)
- d = duration of design rainfall event (hr)
- C = runoff coefficient
- A = catchment or drainage area (m^2)

Figure 29. Formula underlying the determination of the total runoff for the 24-hour 100'ARI design event.

$$Q = 0.0028\ C.i.A$$

where:

- Q = design or peak discharge runoff rate (m^3/s) produced as a result of a particular rainfall event
- C = runoff coefficient
- i = design rainfall intensity (mm/hr)
- A = catchment or drainage area (ha)

Figure 30. Formula underlying the determination of peak discharge for the 24-hour 100'ARI design event.

The bulk of the 100'ARI assessment work was conducted in a spreadsheet external to this report. Only a broad overview of the methodology and some of the underlying steps are presented as shown above.

7.2 Outcome of the 100'ARI assessment

Total runoff and peak discharge values estimated by the 100'ARI assessment for sub-catchments identified across the North Mine site are provided in **Appendix B**.

8.0 Outcome of assessment undertaken to meet PRP (U2)

8.1 Shortfall in North Mine 100'ARI runoff capacity

The 100'ARI assessment identified a number of shortfalls in the capacity of the North Mine surface drainage infrastructure to suitably manage runoff arising from the design storm. These are summarised in **Table C1**.

8.2 Works required to achieve capacity for the design storm event

Works proposed to bring North Mine surface water management infrastructure into capacity for the design event are summarised in Table C1.

9.0 Summary

9.1 PRP (U1)

Solution to the leaking 57A Dam was achieved initially through bypassing this structure and reassigning end-of-line status to 57 Dam which is located immediately upstream of the bypassed structure. Reduction in total storage volume to the system through loss of 57A Dam was initially considered to be compensated through construction of a new and less vulnerable upstream structure called Collection Dam.

9.2 PRP (U2)

Subsequent to initial works undertaken to address PRP Condition U1, the 100'ARI assessment undertaken in response to PRP Condition U2 revealed shortfall in the capacity of three (3) of the five (5) site water storages established earlier to contain mine site runoff.

Works to address these shortfalls are summarised in Table C1.

10.0 Closing request

Perilya requests that NSW EPA accept the above as sufficient to meet the requirements of EPL2683 PRP and, with this acceptance, remove the PRP from Environmental Protection Licence No 2683 upon completion of the proposed additional works.

Appendix A Location of where on the North Mine site certain photos in the text were taken.

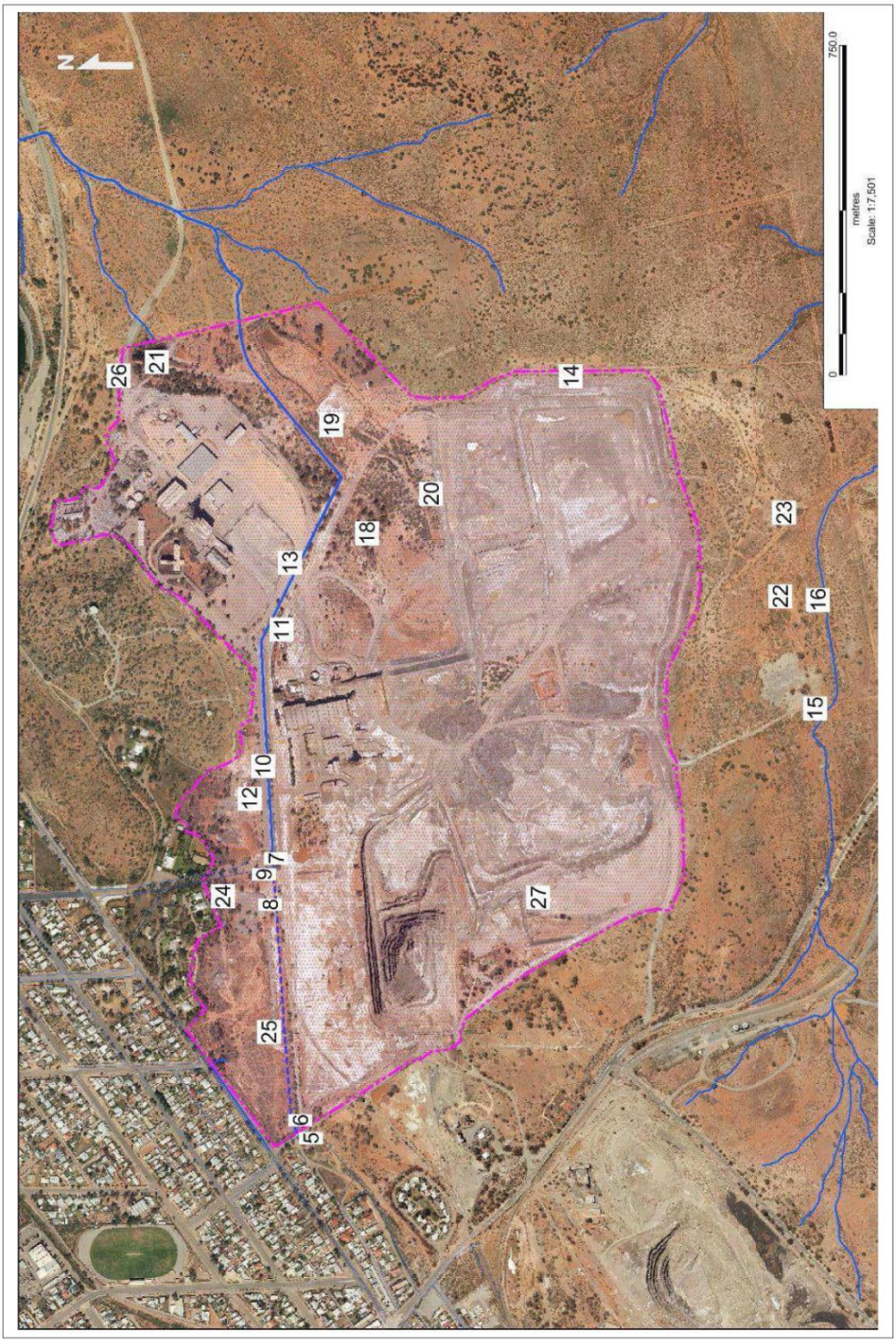

Figure A1. Key to locations where photos in this report were taken – numbers on the face of this figure relate to the figure number of the photo being referred to in the text.

Appendix B. Outcome of the 24-hour 100-year ARI rainfall event assessment

Table B1. Assessment of Storage capacity for the 100-year ARI design event ...

Catchment No	Catchment description	Area (ha)	Volume Runoff (m^3)	Reports to ...	Storage Volume (m^3)	Storage Surplus (m^3)	Storage Deficit (m^3)	Capacity FoS	
1	Upper Broken Hill urban catchment - McCulloch drain	65.28	32337	McCulloch Drain	-				Non-site water bypass (McCulloch drain)
2	NE BH (Warren) urban catchment - McCulloch drain	29.99	16713	McCulloch Drain	-				**49.0** ML
3	Onsite drainage reporting to Collection Dam	34.23	20771	Collection Dam	8845	-- deficit --	**11926**	-- FAILURE --	
4	Onsite drainage reporting to 57 Dam	13.28	5921	57 Dam	6500	579		0.09	
5	Onsite drainage reporting to Small Dam	7.032	3483	Small Dam	523	-- deficit --	**2960**	-- FAILURE --	
6	Onsite drainage reporting to Bovril Dam	19.07	9447	Bovril Dam	18390	8943		0.49	
7	NE BH (Jabez) urban catchment - terminates on site	3.96	2207	Contained onsite	-				Volume runoff McCulloch-Argent corner
8	McCulloch-Argent corner (A) - onsite containment	6.93	3175	Contained onsite	-				**7.0** ML
9	McCulloch-Argent corner (B) - onsite containment	3.069	1634	Contained onsite	-				
10	Helicopter Pad - onsite containment	4.51	2346	Contained onsite	-				Volume runoff – Helicopter pad
11	Tanks natural area - onsite containment	17.89	11964	Contained onsite	-				**14.3** ML
12	Shaft No3 area - onsite containment	20.15	13725	Wilcannia Rd Dam	4477	-- deficit --	**9248**	-- FAILURE --	
13	Decommissioned 57A Dam - onsite containment	2.066	921	Contained onsite	-				Conversions:
14	Western pocket - onsite containment	3.469	2277	Contained onsite	-				m^3 = 1000 litres
15	North Mine WRE top surface - onsite containment	69.9	39820	Contained onsite	-				m^3 = 0.001 ML
			53346 m^3		38735 m^3			0.09	lowest FoS (excepting failure)
	TOTAL ...		53.3 ML	TOTAL ...	38.7 ML			0.49	largest FoS(excepting failure)
	(onsite runoff directed to storages)			(storage volumes)				**3**	= number of storage failures

Appendix C. Summary of key shortfalls in North Mine surface water management infrastructure plus proposed works for their rectification

Table C1. Summary of shortfalls in the North Mine surface drainage infrastructure.

Catchment No	Shortfall	Location	Works
1	NIL SHORTFALL		NO WORKS REQUIRED – this is a 'feeder' catchment upstream of the North Mine site and under the jurisdiction of BHCC.
2	NIL SHORTFALL		NO WORKS REQUIRED – this is a 'feeder' catchment upstream of the North Mine site and under the jurisdiction of BHCC.
3	Capacity of Collection Dam insufficient to contain the expected 100'ARI runoff of 20,771m^3.	On low-lying ground next to McCulloch drain and immediately upstream of the No2 Shaft complex, positioned to intercept runoff from the upper catchment of Collection Dam	3(i) Construct earth storage from suitable material with capacity to manage stormwater runoff of 10,000m^3. Ensure this bank competently joins surrounding high ground; is provided with a bywash of suitable capacity and protection from erosion. Ensure both storage and its bywash connect adequately with existing surface water diversion structures.
4	Capacity of Collection Dam at capacity (FoS 0.09) for its immediate catchment.	57A Dam	REFER TO WORKS UNDER ITEM 13(i)
5	Capacity of Small Dam insufficient to contain the 100'ARI runoff of 3483 m^3.	Surcharge of Small Dam is expected on western side into adjacent gully	5(i) Construct an earth (clay) bank of sufficient capacity to cover the low ground on the western side of the dam. Existing capacity of Small Dam is 523m^3 which needs to be increased to 3,000m^3 to comply with the 100'ARI Licence requirement. Works to include clean out contaminated and salt affected bottom sediments from area upon which repairs are to be conducted along the inside face of the existing dam wall – ensure good key is established to ground. Construct a new clay wall lining to dam wall, ensuring suitable material of adequate thickness, compaction and height for the work.
6	NIL SHORTFALL		NO WORKS REQURED – assessment indicates the 13.4ML capacity of Bovril Dam is sufficient to contain 1.5 times the expected 100'ARI runoff of 9,947m^3.

Catchment No	Shortfall	Location	Works
7	NIL SHORTFALL		NO WORKS REQUIRED – this is a 'feeder' catchment upstream of the North Mine site and under the jurisdiction of BHCC.
8	NIL SHORTFALL		NO WORKS REQUIRED – this is an onsite containment area: containment is provided through the earth mound constructed above the buried section of the McCulloch drain and a diversion bank constructed at the lower end of the sub-catchment. This area receives runoff waters from the Jabez Street sub-catchment.
9	Inability to contain runoff from the 100'ARI design event and prevent movement of these waters into adjacent non-site water drain.	Southern end of the sub-catchment in the vicinity of the junction between the Warren/Argent Street service channel and the McCulloch drain.	9(i) Construct a sediment/detention basin at the lower end of this sub-catchment with capacity to contain 1.5 times the 100'ARI runoff of 1634m^3.
10	NIL SHORTFALL	--	NO WORKS REQURED – it is expected the hollow created by the road embankment of the main access road provides sufficient volume to contain 1.5 times the 100'ARI runoff of 11,964m^3.
11	NIL SHORTFALL	--	NO WORKS REQUIRED – watershed sub-catchment No 11 delivers runoff waters to sub-catchment No 10.
12	Inability to contain runoff from the 100'ARI design event and prevent movement of these waters offsite.	NE end of No3 Shaft to Wilcannia Road Dam	12(i) Construct runoff diversion bank &/or channel system to intercept runoff generated from the broader area of sub-catchment No12 and direct these waters to the dam.
12		No3 Shaft site with focus on southern-eastern-north eastern perimeter bunding	12(ii) Ensure perimeter bund around No3 Shaft site is continuous and of sufficient capacity and integrity to contain the 100'ARI runoff.
12		North Mine Core Yard (East)	12(iii) Construct intercept bank and pond along the mine boundary to intercept and contain runoff waters arising from the off-slope areas in the vicinity of the back gate access road which are not serviced by other drainage management structures.
12		North Mine Core Yard (West)	12(iv) Construct drainage interception and containment for runoff waters generated on the North Mine Core Yard (West) area.

Catchment No	Shortfall	Location	Works
13	Inability for structure to contain and hold waters	57A Dam	13(i) Reinstate the decommissioned 57A Dam with works necessary to fix leaking wall. Works to include clean out contaminated and salt affected bottom sediments from area upon which repairs are to be conducted along the inside face of the existing dam wall – ensure good key is established to ground. Construct a new clay wall lining to dam wall, ensuring suitable material of adequate thickness, compaction and height for the work. Incorporate the existing 57 Dam into the new structure which will then be called New 57 Dam. Additional volume capacity to result in an increase of at least 3,500m^3 on and above the existing 6,500m^3 of 57 Dam
14	NIL SHORTFALL	--	NO WORKS REQUIRED – storage capacity of existing road embankment is expected to contain the 2277m^3 runoff generated by this sub-catchment in the design event.
15	Partial loss of containment	Top surface of the North Mine TSF/WRE is constructed with a perimeter bund and acts as an internally draining and ponding structure. Compromise of this capacity occurs at vehicle access points where continuity of the permitter bunding has not been maintained.	15(i) Construct broad-based banks of at least 0.5m height and suitable material (unsorted mullock: fines + coarse) at the top of each access track to the top of the TSF/WRE structure. Perimeter bank prevents drainage waters generated on the top of the structure to runoff this surface, except where access tracks break continuity of the perimeter. In order to reduce incidence of runoff waters collecting along the main access track system on top of the structure, it is suggested that bank(s) be constructed to separate the wider area of the TSF/WRE top from this track. It is recognised that the track to the North Mine magazine is a strategic access way and needs to be maintained free of impediment.