REPORT ON

SURFACE WATER MANAGEMENT

WONARAH PHOSPHATE PROJECT

Prepared for

Minemakers Limited

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Report Distribution

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EXECUTIVE SUMMARY

Minemakers Australia Pty Ltd (MML) have undertaken a Bankable Feasibility Study (BFS) for their Wonarah Project in the Barkly Tablelands region of Northern Territory. MML has commissioned Groundwater Resource Management Pty Ltd (GRM) to complete the hydrological and surface water management component of the BFS.

GRM recently completed a Stage 1 - Baseline Hydrological Assessment for the project which presented the findings from a desktop study of regional hydro-meteorological data. It found that runoff will on occasion report to on-site watercourses and drainages and appropriate surface water management measures will be required to minimise operational interruptions and asset damage or loss.

This report presents the Stage 2 – Surface Water Management Study and builds on the hydro-meteorological, topographic and current mine planning data to provide feasibility engineering level designs of the works required to protect the proposed project facilities.

The following key findings were noted:

- Although there are no discernible river or creek channels within the project limits, there are several watercourses or drainages which may be inferred from inspection of the site topography and surface vegetation. These watercourses are ephemeral with flows occurring periodically during the summer months from January to March, when the potential exposure to high intensity rainfall is greatest. Consequently runoff will report to the watercourses in the vicinity of the Wonarah Project site and, on occasion, flows may be high and may cause flooding if appropriate measures are not in place.

- Based on a desktop review of the available data, it is assessed that the greatest flooding risk to the proposed project facilities relates to the approximately 868 km^2 catchment area upstream and to the southeast of the proposed Arruwurra Zone pits. Given its relatively large upstream catchment area, poorly defined alignment and indiscernible channel geometry it is possible that floodwater from this watercourse could report to the proposed Arruwurra pits or could cause flooding over much of the proposed Arruwurra mining area. The severity of the potential flooding at the Arruwurra site is exacerbated due to its relatively flat, low-lying topography, typically 30 m lower than ground level over the Main Zone mining area.

- Base Case flood protection measures will be required along the 2,900 m south-eastern perimeter of the proposed Arruwurra Year 1 and Year 2/3 pits. These measures may include dedicated flood berms, or strategically placed waste rock dumps, stockpiles and above-grade haul roads. Given the potential consequences of floodwaters reporting to the pits, it is recommended that these flood protection measures be designed for the 100 year average recurrence interval event.

- The preliminary alignment of the Arruwurra flood protection measures is presented in this report in addition to that for the upstream catchment diversion and arterial drainage ditches. Opportunities exist to reduce the required extent of these flood protection measures at the detailed design stage of the project through the judicious placement of waste rock dump/stockpile material and construction of haul roads.

The deliverables from the preliminary design of the Base Case flood protection and surface water management measures (calculations, description of proposed works, quantity estimate and feasibility level design drawings) are presented in this report. At this stage the design of the measures is at a feasibility level in order to develop construction quantities for MML's cost estimation purposes.

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1.0 INTRODUCTION

1.1 General

Groundwater Resource Management (GRM) has been assisting Minemakers Australia Pty Ltd (MML) with their permitting and feasibility studies for the Wonarah Phosphate Project, located about 240 km east of Tennant Creek in the Northern Territory. In addition to ongoing groundwater supply investigations, GRM recently completed a Stage 1 - Baseline Hydrological Assessment[1] for the project.

That report presented the findings from a desktop study of regional hydro-meteorological data for use in the analyses and design of the proposed water management measures at the Wonarah Project. In particular it found that although the project is situated in a semi-arid region with average annual rainfalls of between 300 and 400 mm, significant short duration rainfall events can and do occur, with daily rainfalls in excess of half the annual average having been recorded locally. Therefore runoff will on occasion report to on-site creeks and drainages and appropriate surface water management measures will be required to minimise operational interruptions and asset damage or loss.

This report presents surface water investigations completed as part of the Stage 2 – Surface Water Management Study required for the Environmental Impact Assessment and Bankable Feasibility Study currently being prepared by others. It builds on the hydro-meteorological, topographic and current mine planning data to provide feasibility engineering level designs of the works required to protect the proposed mine and associated facilities.

The Stage 2 scope of work comprised the following surface water analysis and design tasks:

- Floodwater management - hydrologic and hydraulic analyses;
- Surface water and sediment management - philosophy and design criteria;
- Feasibility level design of water management measures - described in the report and presented on preliminary plan/profile and sectional drawings; and,
- Risk assessment - completed in accordance with AMC methodology (July 2009).

It should be noted that the catchment delineation presented in this report has been developed using GIS spatial analysis tools based on the April 2009 Lidar[2] topographic data set. It was not possible to field verify the accuracy of either this data set or the catchment boundaries developed using the GIS tools. Detailed ground based survey data should be collected prior to completing the detailed design of all water management measures.

Further, the feasibility level design of the floodwater and drainage measures presented in this report relate solely to those required for start-up of mining operations and for the first two to three years thereafter and are considered to form the Base Case. It is currently not possible to prepare water management plans beyond this Base Case given the likelihood of changes to the mine plan.

The hydrologic and hydraulic calculations required as part of this study have been presented in the Appendices. The accompanying drawings have been completed to a level

[1] *Stage 1 - Baseline Hydrological Assessment*, GRM, July 2009
[2] Light Detection and Ranging - a technology that employs an airborne scanning laser rangefinder to produce topographic surveys.

suitable for inclusion in the project feasibility study and to form part of the future detailed civil engineering design of the project.

1.2 Surface Water Management Objectives

The following three goals define the objectives for surface water management for the Wonarah Project:

Goal No 1 - Reduce the Potential Risk of Loss of Life, Health Hazards and Property Damage:

- Provide protection for life, livelihood, and property;
- Control the incidence of nuisance or damage related to flooding, poor drainage and sedimentation to an acceptable level; and,
- Protect project infrastructure.

Goal No 2 - Preserve the Environment

- Minimise the potential project impacts such as changes in the streamflow regime, alteration of habitat, pollution or increased erosion and sedimentation;
- Where feasible, maintain the shape and composition (geomorphology) of the natural watercourse geometry, natural biological indicator conditions and flow conditions;
- Employ protection measures, to prevent adverse hydrological and water quality impacts, for all recognised watercourses within the site limits;
- Promote sound development that respects the natural environment; and,
- Rehabilitate any watercourses that are impacted as soon as practicable.

Goal No 3 - Conserve Social and Financial Resources

- Treat water as a resource, ensuring that water management facilities are functional and integrate multi-use objectives where possible;
- Provide a system of infrastructure that enhances site personnel convenience and safety, and allows development to proceed according to the mine plan;
- Sustain future mine development, support orderly and managed development of resources and integration of land uses within the site limits;
- Use best management water and sediment practices where feasible; and,
- Encourage economic design of drainage systems.

These objectives are intended to ensure a consistent approach to:

- Planning and analyses required for surface water management;
- Constructing new operational phase surface water management works; and,
- Installing future closure phase surface water management works.

The design philosophy for floodwater management is presented in Section 3.0 of this report, while that for surface water and sediment management is presented in Section 4.0.

2.0 FLOODWATER MANAGEMENT

2.1 Flood Protection Design Philosophy

The Stage 1 - Baseline Hydrological Assessment found that the Wonarah Project site sits within a region that is internally draining and which comprises gently undulating sand ridges and semi-desert of low relief. All watercourses and drainages in the vicinity of the site are ephemeral and tend to flow only for short periods following heavy rainfall. No discernible creeks or drainage channels have been found within the site limits and the only notable surface water feature is the presence of seasonally flooded swamps in the southwest of the project site, around Arruwurra.

However, rainfall runoff may report to the surface drainages and watercourses in the vicinity of the project periodically during the months of January to March, when the potential exposure to high intensity rainfall is greatest. Occasionally such flows may be high and may cause flooding if appropriate measures are not in place.

The findings from a site visit and inspection of the topographical maps and aerial photography for the project site indicate that there are a number of local watercourses that could adversely impact the proposed project facilities if not managed properly. They are shown on Figure 1 and include the following (note the following nomenclature has been developed for use in this report only):

- *Arruwurra Zone Watercourse* – draining an area of some 868 km^2 from the south-eastern limit of Barkly Surface Water Management Area (SWMA) in a generally northwesterly direction towards the Arruwurra mining area.

- *Main Zone Watercourse 1* – draining an approximately 6.6 km^2 area at the southwestern corner of the Main Zone mining area, in the vicinity of Pit C.

- *Main Zone Watercourse 2* – draining an approximately 15.7 km^2 area in the northwest of the Main Zone mining area, in the vicinity of Pit A.

- *Main Zone Watercourse 3* – draining an approximately 16.3 km^2 area in the northeast of the Main Zone mining area, in the vicinity of Pits A and B.

While all of the above watercourses will require some degree of management, it is assessed that the greatest flooding risk to the proposed project facilities relates to the Arruwurra Zone Watercourse (refer to Section 5.0 - Risk Assessment). Given its large upstream catchment area, poorly defined alignment and indiscernible channel geometry it is possible that floodwater from this watercourse could report to some of the proposed Arruwurra pits or could cause flooding over much of the proposed Arruwurra mining area. The severity of the potential flooding at the Arruwurra site is exacerbated due to its relatively flat, low-lying topography, typically 30 m lower than ground level over the Main Zone mining area.

Consequently the proposed Arruwurra mine facilities will require flood protection which may take the form of constructed berms and diversion ditching or strategically placed waste rock dumps, stockpiles and above-grade haul roads (as described later). Given the potential consequences of floodwaters reporting to the pit or the mine facilities, it is recommended that these flood protection measures be designed for the 100 year average recurrence interval (ARI) runoff event. The probability of occurrence for this event during the envisaged 10 year Stage 1 operational life of the project is approximately 10%.

A more likely, but perhaps with lower consequence, scenario requiring water management is the temporary collection of runoff in localised low lying areas close to the proposed mining areas and its infiltration into the open pits. Such areas occur naturally over the whole site but particularly around Arruwurra, where localised areas have storage capacities of up to approximately 2 GL. Runoff will collect seasonally in such areas following significant rainfall and the portion that infiltrates into the proposed pits will require in-pit sump pumping. Possible infiltration rates and the requirements of such pumping systems is presented in GRM's Groundwater Studies report.

2.2 Hydrologic and Hydraulic Analysis

Feasibility study level hydrologic analysis (100 year ARI peak flow estimation) and hydraulic analysis (preliminary flow depth estimation) are presented in the following sections, along with the methods and assumptions used.

2.2.1 Arruwurra Zone Watercourse Peak Discharge Estimation

Generally flow statistics at any location of interest can be generated using three different approaches (in order of preference):

- Site Measured Streamflow Analysis - From long-term streamflow records collected at the location of interest;
- Regional Hydrological Analysis - From streamflow records collected at the nearby watersheds with similar hydrological characteristics (e.g., similar drainage area, soils, vegetation, and slopes); and,
- Hydrological calculation/modeling.

Given the non-availability of site streamflow data and the paucity of regional streamflow data (refer to Stage 1 – Baseline Hydrological Assessment), it was decided to use the hydrologic calculation methods presented in ARR97[3] to estimate peak flows in the Arruwurra Zone Watercourse under 100 year ARI conditions. The parameters adopted are presented in the following sections.

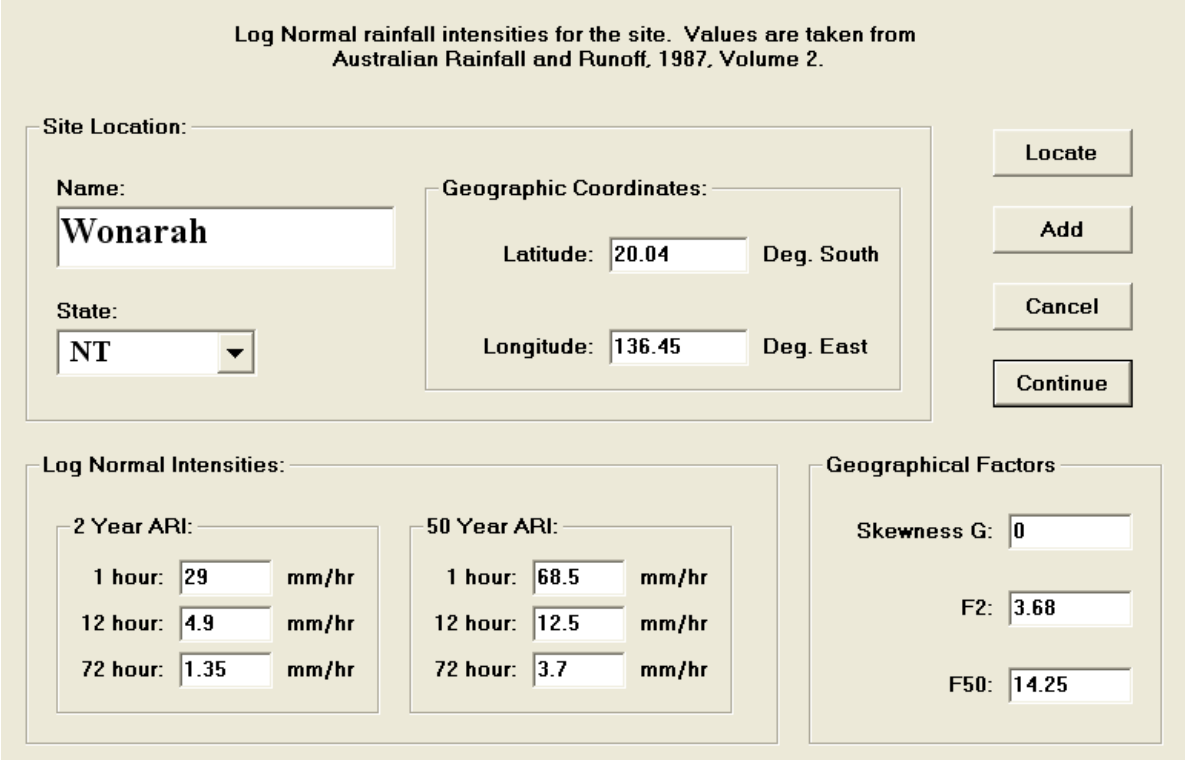
Intensity-Frequency-Duration Relationship

Intensity-Frequency-Duration (IFD) data were developed for Wonarah in accordance with Chapter 2 of ARR97 using the AUS-IFD computer software. The input parameters shown below were selected using Volume 2 of ARR97.

The resulting IFD relationship is presented in Appendix A of this report. In summary, the 100 year ARI intensities for 1, 3, 12, 24 and 72 hr duration events are 78.0, 37.2, 14.4, 9.3 and 7.3 mm/hr respectively i.e. giving equivalent storm depths of 78, 112, 173, 223[4] and 526 mm.

[3] *Australian Rainfall and Runoff*, *Volume One, Book Four, Estimation of Design Peak Discharges*, Institution of Engineers of Australia, 1997.

[4] The IFD value of 223 mm in 24 hours for the 100 year ARI event agrees well with the maximum recorded regional daily rainfall depth of 215 mm at Annitowa on 29 February 2000 during TC Steve (refer to Table 8 in Stage 1 – Baseline Hydrological Assessment report).



Catchment Characteristics

The combined Arruwurra Zone Watercourse catchment upstream of the Arruwurra mining area was found to have the following characteristics based on inspection of the topographical mapping and other data available for the region:

- Catchment Area, A = 867.72 km^2 comprising the following sub-catchments (refer to Figure 2):
  - Area 1 = 78.63 km^2
  - Area 2 = 49.45 km^2
  - Area 3 = 116.46 km^2
  - Area 4 = 46.96 km^2
  - Area 5 = 317.19 km^2
  - Area 6 = 82.47 km^2
  - Area 7 = 176.56 km^2
- Mainstream Length, L = 45.66 km;
- Equal Area Stream Slope, Se = 1.1 m/km; and,
- Average Annual Rainfall, P = 326 mm (median Ranken River value used).

ARR97 Estimation of 100 Year ARI Peak Discharge

The Arruwurra Zone Watercourse catchment characteristics fall within the relatively limited range of "South Australia Northern and Western Region" and "Western Australia Wheatbelt Loamy and Lateritic Catchments" identified in ARR97 for application of the Rational Method for peak discharge estimation.

Application of both versions of the Rational Method give 100 year ARI flood peaks in the Arruwurra Zone Watercourse in the vicinity of the of the proposed mining area in the order of 480 m^3/sec (see Appendix B for calculation). Assuming a simple triangular hydrograph with a total duration of 24 hours such an event could give rise to a total floodwater volume in excess of 20 GL.

Despite criticism of the Rational Method for its simplicity and tendency to overestimate peak flows, especially on larger, well vegetated catchments, its use was considered appropriate in this instance. The development of a detailed hydrological catchment model was not warranted at this stage, especially given the fact that there is no site data to calibrate such a model. The peak discharge rate and flood volume estimated above were therefore considered to represent upper bound values, but suitable for feasibility level design purposes.

2.2.2 Benchmarking with Gauged Stations

Given the synthetic nature of the two ARR97 Rational methods it was decided to compare the results with peak flows at the two closest comparable gauged catchments (Ranken River and Georgina River, presented previously in the Stage 1 – Baseline Hydrological Assessment[5]). This is a common hydrological method used in areas of sparse data and is typically carried out using a non-linear relationship of the following form:

$$Flow_{site} = Flow_{station} \times (Area_{site}/Area_{station})^{0.7}$$

For the purposes of this study it was assumed that the maximum flows recorded at the two gauged stations were, at least, indicative of significant rainfall/runoff events in the region and are suitable for benchmarking the 100 Year ARI flood peaks estimated using the ARR97 formulae.

Application of the non-linear relationship stated above gives flows at the Arruwurra Zone watercourse as follows:

$Flow_{site} = 2{,}000 \times (867.72 / 4{,}360)^{0.7} = 646$ m^3/sec (using Ranken River station[6])

$Flow_{site} = 3{,}832.8 \times (867.72 / 118{,}398)^{0.7} = 123$ m^3/sec (using Georgina River station)

These flows indicate that the average 100 year ARI estimate of 480 m^3/sec obtained from the ARR97 methods is of the correct magnitude. This estimated flow was therefore adopted for the feasibility level design.

[5] The record lengths at Ranken River and Georgina River are approximately 42 and 21 years respectively. There are three other regional flow monitoring stations on the Playford River, James River and Shakespeare Creek. However, rating curves have not been developed for these stations and only stage data are available.

[6] Estimate only as flow on 4 January 2009 exceeded the rating curve for the station.

2.2.3 Hydraulic Analysis (Preliminary Flow Depth Estimate)

Given the available topographic data it was not possible, nor appropriate, to carry out detailed hydraulic analysis for this feasibility level study, including peak floodwater elevation or backwater analyses. However, a preliminary assessment of the flow depth that might occur along Arruwurra Zone Watercourse under 100 year ARI flood conditions was made using Manning's Equation as follows:

$Q = (A\ R^{2/3}\ S^{1/2})/n$

where:

- Q = flow rate = 480 m^3/sec;
- A = cross-sectional area of hypothetical channel (m^2), assumed to be a trapezoidal cross-section with 0.5:1 (H:V) side slopes;
- R = hydraulic radius = cross-sectional area, A, divided by wetted perimeter, P (m);
- n = roughness coefficient, assumed to be 0.040 for a natural channel; and,
- S = river channel slope = 0.001 m/m as per watercourse existing slope.

By rearranging Manning's Equation, it was possible to obtain an estimate of the depth of flow required to pass the 100 year ARI flow for a range of hypothetical channel widths. The results of this analysis are shown in Table 1.

Table 1: Depths of Flow Required to Pass 100 Year ARI Peak Flow for Hypothetical Channel Widths

Hypothetical Channel Width (m)	Assumed Channel Roughness 'n'	Channel Slope (m/m)	100 Year ARI Peak flow (m^3/s)	Required Depth (m)	Calculated Flow Velocity (m/s)
100	0.040	0.001	480	2.98	1.59
200	0.040	0.001	480	1.95	1.22
300	0.040	0.001	480	1.53	1.04
400	0.040	0.001	480	1.29	0.93
500	0.040	0.001	480	1.12	0.85
600	0.040	0.001	480	1.01	0.79
700	0.040	0.001	480	0.92	0.75
800	0.040	0.001	480	0.85	0.71
900	0.040	0.001	480	0.79	0.68
1000	0.040	0.001	480	0.74	0.65

Note: All above results assume a hypothetical trapezoidal channel cross-section with 0.5:1 (H:V) side slopes

Despite the simplicity of this analysis it can be seen that significant flow depths, up to approximately 3 m for a hypothetical channel width of 100 m or almost 0.75 m for a channel width of 1 km are required to pass the 100 year ARI peak flow. Given that the Arruwurra Watercourse has no discernible channel it is possible that under such flood conditions the area affected could be well in excess of 1 km wide.

In the light of the above preliminary analysis it is recommended that the minimum height of all pit flood protection berms should be set at 2 m above existing ground level[7]. This should also be the minimum height of waste rock or stockpile material or haul road height where they are used in lieu of a flood berm. The proposed Arruwurra mine facilities area, including workshops, fuel storage and truck parking, should be situated at least 2 m above the watercourse average elevation of 255 mRL.

The feasibility level design of the flood protection measures are presented in Section 4.0.

As mentioned earlier, the possible infiltration rates from runoff stored in localised low-lying areas adjacent to open pits and the required pumping rates are presented in GRM's Groundwater Studies report.

[7] A 2 m minimum berm height is required if flood protection berms are to be used also for closure berms according to "*Safety Bund Walls Around Abandoned open Pit Mines – Guideline*", DoIR Western Australia, December 1997.

3.0 SURFACE WATER AND SEDIMENT MANAGEMENT

In addition to protecting the proposed project facilities against flooding from low frequency flood events such as the 100 year ARI event discussed above, it will also be necessary to manage runoff from more common tropical depression related rainfall events that occur typically between January and March. Although such events give rise to much lower runoff rates and volumes they will still need to be managed appropriately in order to protect project infrastructure, minimise erosion and reduce the potential loss of sediment laden or other contaminated runoff from the project site.

The drainage philosophy for the various project facilities are outlined in the following sections, while the feasibility level design of protection measures for the process plant site are presented in Section 4.0.

3.1 Drainage and Sediment Management Philosophy

The various project facilities should be segregated as follows for the management of stormwater:

- Processing facilities;
- Non processing facilities;
- Hazardous material storage areas;
- Disturbed areas; and,
- Undisturbed areas.

3.1.1 Processing Facilities

Rain falling within processing areas, e.g. screening and crushing areas, should be collected within bunded areas and returned to the process. Provision should be made for the return of such flows to the process by means of drains, launders, sumps, pumps etc.

3.1.2 Non Processing Facilities

Runoff from non process areas within the process plant area e.g. roads, roofs, yards, ROM area etc, should be captured in open drains. The drains should report to a sedimentation pond, before either being reused or, if suitable, released off-site.

To aid water quality management runoff from areas likely to be impacted by hydrocarbons, e.g. fuel storage and dispensing areas, truck wash and workshops, should also be captured in open drains that report to an oily water separator (OWS) provided upstream of the sedimentation pond.

Non process area drains reporting to a sedimentation pond should be sized for the peak of the 10 year ARI event as a minimum. Open drains should have a minimum freeboard of 500 mm and flow velocities along such drains should be limited to minimise erosion and the generation of sediment (refer to design criteria in Section 3.2).

3.1.3 Hazardous Materials Storage Areas

All chemical, oil and other hazardous material storage areas should be bunded in accordance with the relevant codes and standards. Water collected within the bunds should be assessed prior to release. If no leaks or spills are evident and the quality of the collected water is suitable, then the area can be drained to the closest non-process drain that reports to a sedimentation pond.

Water collected within the bunds that is assessed and is found to be impacted should either be returned to the process or disposed of appropriately.

3.1.4 Disturbed Areas

Outside the processing facilities the majority of project facilities will comprise pits, various topsoil stockpiles and waste rock dumps. Source controls and sedimentation ponds should be used to improve the quality of runoff from these areas prior to reuse or discharge off-site.

For runoff within the proposed pits source controls should comprise practices such as mining from upper levels or processing stockpiled material following significant rainfall events. In-pit staged sumps should be used to settle out sediment from collected runoff prior to pumping to surface for re-use or discharge off-site.

Source controls for dumps include minimising bench widths and inter-bench heights to limit sediment generation, back-grading benches to minimise potential overtopping and gully formation on slopes and longitudinal bench grading to engineered rock-lined chutes. These engineering design measures should be combined with Best Management Practices such as progressive rehabilitation and revegetation, placing brush barriers at dump toes, constructing check dams to minimise runoff flow velocity etc.

3.1.5 Undisturbed Areas

Run-off from undisturbed areas within the project boundaries should be diverted around proposed project facilities into existing natural watercourses or drainage lines by providing diversion drains typically sized for the 10 year ARI event with a minimum 500 mm freeboard. Flow velocities along all diversion drains should be limited to minimise erosion and the generation of sediment.

Where active mining areas or other sensitive facilities require protection from runoff from undisturbed areas the 100 year ARI event should typically be used for the design of flood protection berms.

3.2 Drainage and Sediment Management Design Criteria

As a minimum the following design criteria should be applied to drainage measures for the proposed project facilities:

3.2.1 Peak Flow Estimation

Peak discharges from catchment areas of less than 10 hectares should be estimated using the Rational Method (i.e. Q = CIA). The average run-off coefficient (C) should be based on the values presented in Table 2 below.

Table 2: Run-off Coefficients

Catchment Type	Run-off Coefficient
Undisturbed areas	0.20
Gravel roads and yard areas	0.50
Asphalt, concrete and roof areas	0.90

Rainfall intensity (I) for the critical event duration should be interpolated from the rainfall Intensity Duration Frequency (IDF) relationship developed for the Wonarah site provided in Appendix A. The time of concentration of each catchment area should be determined in accordance with the Kirpich Equation as follows:

$T_c = 0.00032 \times L^{0.77} \div S^{0.385}$

Where:

T_c = Time of concentration (hours).

L = Maximum length of water travel (m).

S = Average Slope (m/m).

The minimum time of concentration to be used for design purposes should be 5 minutes.

Catchment areas (A) should either be measured directly in the field or calculated using CAD tools and the latest field survey data.

Peak discharge estimates from areas larger than 10 hectares should be obtained by using hydrologic modelling methods such as those presented in Books 4 and 5 of ARR97.

3.2.2 Channel Design

Channel design parameters should be determined using Manning's Equation as follows:

$Q = (A\ R^{2/3}\ S^{1/2})/n$

where:

- Q = flow rate (m^3/sec).
- A = cross-sectional area of channel (m^2).
- n = roughness coefficient, as per values presented below (dimensionless).
- R = hydraulic radius = cross-sectional area, A, divided by wetted perimeter, P (m)
- S = channel slope (m/m).

Roughness coefficients should be based on the values presented in Table 3 below:

Table 3: Roughness Coefficients

Channel Type	Roughness Coefficient
Unlined Earth, Clean, recently completed	0.016-0.018
Unlined Earth, With short grass, few weeds	0.022-0.027
Unlined Rock, Smooth and uniform	0.035-0.040
Unlined Rock, Jagged and irregular	0.040-0.045
Lined, Formed concrete	0.017-0.020
Lined, Random stone mortar	0.020-0.023
Lined, Dry rubble (rip-rap)	0.023-0.033

3.2.3 Drainage Design

Open Drain Construction

Open drain construction should maintain:

- Minimum self cleansing velocity of 0.7 m/sec for 2 year ARI event;
- Maximum velocity of 1.0 m/sec for 10 year ARI event for unlined earth channels with no specific erosion protection;
- Maximum velocity of 1.5 m/sec for 10 year ARI for grassed channels with no specific erosion protection;
- Minimum 500 mm freeboard on open drains; and,
- Channel erosion control protection in the form of appropriate drop structures, rock check dams, rock-lined channels or concrete lined channels.

Culvert Installation

The minimum culvert diameter should be 450 mm. Culverts and underground stormwater pipes should be installed at slopes that should provide self-cleansing minimum velocities of 0.7 m/s for one-third depth of full-flow wherever possible.

Hardstand Area Drainage

Hardstand area drainage should be designed with a minimum surface grade of 0.5% in open yard areas and a minimum grade of 2% for a distance of 25 m away from structures.

3.2.4 Sedimentation Pond Design

For feasibility level design purposes sedimentation ponds should be designed to store runoff from the 10 year-24-hour rainfall event (i.e. 128 mm rainfall) without discharge. Sedimentation ponds should have a minimum live settling depth of 1 m and an aspect ratio (length:width) of not less than 3:1 and preferably 5:1. Sufficient provision for dead (sediment) storage and freeboard should also be made.

The future detailed design of sedimentation ponds should be based on removing the settleable fraction down to a selected minimum design particle size based on an analysis of the sediment particle size distribution reporting to the pond. The adopted design particle size should correspond to 25% of the sample passing by weight or an absolute minimum particle size of 20 micron (unless chemical coagulant dosing is used). The required pond surface area should be estimated using the peak inflow rate and design particle settling velocity according to Stokes Law and applying published sedimentation efficiency factors[8].

3.2.5 Oily Water Separator Design

Unless noted otherwise for specific facilities, all on-site OWS should be of the simple gravity type designed to remove free oil globules larger than 150 micron. The hydraulic design of all OWS should provide sufficient detention time for a maximum rise rate of 1×10^{-3} m/s, or an absolute minimum detention time of 45 minutes. Submerged inlet and outlet pipework should be used along with internal baffles to facilitate skimming. Provision should be made for removal of sludge that collects on the floor of the OWS.

[8] *The Constructed Wetlands Manual (Volumes 1 & 2)*, Department of Land and Water Conservation, New South Wales, 1998.

4.0 FEASIBILITY DESIGN OF MANAGEMENT MEASURES

The accompanying Figures 3 to 5 and Drawing Nos. J090004-D01 to -D04 show the preliminary layout of the proposed surface water facilities for the project site described in the following sections. This layout has been based on the aerial photography and Lidar topographical data set supplied by MML in April 2009 and the project infrastructure and pit crest plans supplied by GHD and AMC respectively in late July 2009.

The flood protection and drainage measures outlined in this report are considered to be appropriate for feasibility level planning of start-up to Year 2/3 mining operations in the Arruwurra Zone and Main Zone mining areas and, as such, form the Base Case for surface water management works. Additional flood protection and water management measures should be reviewed in advance of further project developments.

Further, it is understood that detailed mine planning and waste scheduling for the project is currently underway. The feasibility level design of the surface water management measures presented in this report should therefore be reviewed in the light of that work and modified as necessary. In particular the judicious placement of mine waste and construction of above-grade haul roads may allow the length of the flood protection berms to be reduced. The re-use of partially back-filled pit voids as water management ponds should also be considered where practical.

4.1 Flood Protection Berm

Given that flooding from the Arruwurra Zone Watercourse is possible under certain extreme conditions and is considered to pose the greatest flooding risk to the project, it is recommended that 100 year ARI flood protection be provided along the south eastern perimeter of the proposed Year 1 and Year 2/3 Arruwurra pits. This protection may take the form of a dedicated flood protection berm, strategically placed waste rock dump and stockpile materials, above-grade haul roads or a combination of these measures over a length of 2,900 m (refer to Dwg. No. J090004-D01).

The alignment of the flood protection berm has been set back a minimum of 150 m from the proposed pit crests if it is to also act as a pit closure berm. This setback is based on a 40 m maximum depth and a 25° design angle for weathered rock within the Arruwurra Zone pits. As discussed earlier, it is recommended that the minimum height of all such flood protection measures should be set at 2 m above existing ground level. The adequacy of these flood protection berms should be reviewed once the waste rock dump, stockpile and haul road design and construction schedule is completed.

The flood protection berm should not be constructed by end dumping of waste materials in piles, but instead the berm footprint should be cleared and it should be built from select waste material placed and compacted in controlled layers. The upstream (outside) face of the flood berm should be armoured with suitable graded waste rock or rip-rap.

The key specifications for the flood berms are as follows:

- Upstream maximum side slope = 2:1 (H:V);
- Downstream maximum side slope = 1.5:1 (H:V);
- Minimum height above existing ground = 2 m;

- Minimum base width = 10 m;
- Maximum compacted layer thickness = 300 mm;
- Minimum compaction standard = 95 % standard maximum dry density;
- Moisture conditioning = ± 2% optimum moisture content;
- Berm fill material to be select graded clayey gravel material from pit excavation with maximum particle size of 150 mm; and
- Riprap specification to be Dmax= 450 mm, D50= 300 mm and thickness = 700 mm.

A typical section through the Arruwurra flood protection berm is shown on Dwg. No. J090004–D04.

Dedicated flood protection berms are deemed unnecessary for the Main Zone Year 1 and Year 2/3 pits, provided that normal pit crest safety berms are provided. The initial Main Zone pits are located on a local high spot with minimal reporting upstream catchment area (refer to Dwg. Nos. J090004–D02 & D03). However if the mine plan changes the need for additional flood protection berms should be reviewed.

4.2 Diversion Ditches

In addition to the Arruwurra flood protection berm two upstream catchment diversion ditches will be required at the following locations (refer to Dwg. Nos. J060012-D01 to D03):

- Arruwurra Upstream Catchment Diversion Ditch – should be constructed immediately upstream of the proposed Arruwurra mine services area and non-DSO ore stockpile in order to divert runoff from a 3.94 km^2 undisturbed catchment. The diversion ditch will be some 3,420 m long and will collect runoff along its length, with a 10 year ARI peak flow at its outlet of approximately 10 m^3/s, which will be discharged to the north of the proposed flood protection berm alignment.
- Airstrip Upstream Catchment Diversion Ditch – two sections of diversion ditching should be constructed along the northeast side of the proposed airstrip facility to divert runoff from the a 3.33 km^2 undisturbed upstream catchment that may otherwise report to the runway. The high point of both drains should be on either side of the airstrip terminal facility. The northern drain will divert runoff over some 2,000 m towards the north-western corner of the airstrip, while the southern drain will extend some 1,000 m to the south-eastern corner of the airstrip. The 10 year ARI peak flows at the northern and southern outlets will be approximately 4.5 and 2.5 m^3/s respectively.

Table 4 summarises the preliminary design parameters for the diversion ditches discussed above.

Table 4: Diversion Ditch Preliminary Design Parameters for 10 Year ARI Event

Parameter	Unit	Arruwurra	Airstrip North	Airstrip South
Length	(m)	3,420	2,000	1,000
Side Slopes	(H:V)	2:1	2:1	2:1
Manning's Roughness	"n"	0.035	0.035	0.035
Flow Depth	(m)	1.4	0.9	0.7
Free-board	(m)	0.5	0.5	0.5
Total Ditch Depth	(m)	1.9	1.4	1.2
Average Channel Slope	(%)	0.25	0.25	0.20
10 Year ARI Peak Flow	(m^3/s)	10	4.5	2.5
Base Width	(m)	3.0	3.0	3.0
Maximum Earthworks Cut	(m^2/lin m)	12.40	7.95	6.00

A preliminary base width of 3 m was adopted for the design of the ditches given that the ditches will most likely be dozer cut. The minimum design flow depth required to safely pass the 10 year ARI peak flow was then determined before adding a freeboard allowance of 500 mm.

Where possible excavated spoil from construction of the diversion ditches should be placed opportunistically on the down-gradient, or facility site, side of the ditch to provide additional protection. The spoil should be setback approximately 3 to 5 m from the edge of the ditch to provide access for channel inspection and maintenance. The spoil should nominally be compacted with excavation equipment and re-vegetated to minimise erosion.

Minor natural channel realignment and riprap lined entrance treatments may be required where existing drainage lines join the diversion ditches. In addition, to reduce flow velocities and minimise erosion of the ditch sides and inverts, rock check dams should be installed along the steeper parts where the gradient exceeds 1%. Similarly, a stabilised basin with riprap lining should be provided at outfalls from the ditches. Typical details of the check dams and stabilised basins are shown on Drawing J090004–D04.

An approximately 1,200 m long section of diversion ditch may be required to divert runoff from the relatively limited catchment immediately to the south of the proposed Central mine services area. However, its preliminary design has not been included here given its minor nature and the possibility that this ditch may be incorporated into the roadside drainage channel of the proposed access road.

Upstream catchment diversion ditches are not required for the Year 1 and Year 2/3 Main Zone pits, again due to their relatively elevated location close to the catchment divide. However, if the mining plan should change this requirement should be reviewed.

4.3 Arterial Drainage Channels and Culverts

Arterial drainage channels will be required to collect runoff from the various mine facilities and convey it to sedimentation and, if suitable, off site. In addition culverts will also be used to safely convey the runoff below the Arruwurra and other site roads as required.

The detailed design of these drains and culverts is beyond the scope of the current study, but the following feasibility level design parameters are provided:

- The following drainage channels will be required at Arruwurra:
  - 1,000 m long channel to collect runoff from the mine services area and deliver it to and discharge it from the proposed Arruwurra Mine Services Area Sedimentation Pond;
  - 2,200 m long channel to collect runoff from the south-eastern side of the non-DSO stockpile and deliver it to the proposed Arruwurra Stockpile/Dump Sedimentation Pond;
  - 500 m long channel to collect runoff from the southern side of the waste rock dump and deliver it to the proposed Arruwurra Stockpile/Dump Sedimentation Pond; and,
  - 1,150 m long channel to discharge overflow from the proposed Arruwurra Stockpile/Dump Sedimentation Pond to the nearest drainage line to the east.
- The following drainage channels will be required at the Year 1 and Year 2/3 Main Zone pits:
  - 800 m long channel to collect runoff from the mine services area and deliver it to and discharge it from the proposed Central Mine Services Area Sedimentation Pond;
  - 780 m long channel to collect runoff from the northern side of the non-DSO stockpile and deliver it to the proposed Central Stockpile/Dump Sedimentation Pond; and,
  - 1,170 m long channel to collect runoff from the southern side of the waste rock dump and deliver it to the proposed Central Stockpile/Dump Sedimentation Pond.
- For all arterial drainage channels a minimum 10 Year ARI design flow and 0.5 m freeboard allowance should be used along with a Manning's roughness of 0.035, minimum base width of 1 m and side-slopes of 2H:1V.
- Approximately 12 to 15 culvert crossings will be required along the Arruwurra and other access roads. For feasibility level design purposes it may be assumed that each crossing will comprise two 600 mm diameter barrels, some 15 m long. All culverts should be helically wound, lock seamed, zinc galvanized, corrugated steel pipe with a minimum wall thickness of 1.6 mm.

4.4 Sedimentation Ponds

The use of two sedimentation ponds each at the Arruwurra and Central facilities i.e. four ponds in total, is recommended to allow separate treatment of potentially high suspended solids runoff from stockpile/waste rock dump areas and potential oily water from the mine services areas. The mine services area sedimentation ponds should have OWSs placed upstream of their inlets given that they will receive runoff from workshops, fuel storage and bowsers etc. All ponds should have emergency spillways/outlets in order to safely pass flow volumes greater than 10 year ARI magnitude around the ponds and off-site.

The detailed design of these ponds is beyond the scope of the current study but a feasibility level design has been carried out basing the pond volumes on storing runoff from the 10 year 24 hour rainfall event (i.e. 128 mm) from the catchment areas without discharge. The

resulting required pond capacities and preliminary design parameters are presented in Appendix B and summarised in Table 5.

Table 5: Sedimentation Pond Preliminary Design Parameters

Parameter	Mine Facilities Pond	Dump/Stockpile Pond
Live Storage Capacity (m^3)	7,680	10,240
Dead Storage Capacity (m^3)	720	870
Combined Storage Capacity (m^3)	8,400	11,110
Excavated Pond Volume (m^3)	15,690	20,440
Pond Top Length (m)	200	225
Pond Top Width (m)	40	45
Fluid Depth (m)	1.5	1.5
Freeboard (m)	1.0	1.0
Pond Total Depth (m)	2.5	2.5

Note: Assumes side-slopes at 3H:1V.

The four sedimentation ponds have been placed as shown on Dwg. Nos. J090004–D01 to D03. Their exact configuration and location, including opportunities to integrate pond sides into haul road embankments and divert parts of the catchment that will likely be undisturbed, should be revisited as part of the project detailed design.

4.5 Oily Water Separators

OWSs should be provided at the following four facilities as a minimum:

- Arruwurra Fuel Storage & Workshops;
- Central Fuel Storage & Workshops;
- Airstrip Fuel Storage; and,
- LV Washdown and HME Tyre Wash.

The design of these facilities is currently too preliminary to permit the dimensions of the require OWS to be accurately determined. However none of these OWS is likely to exceed a maximum capacity of 100 m^3. For feasibility level design purposes all of them can be assumed to be constructed as in-ground reinforced concrete sumps with internal baffle walls and submerged inlets and outlets.

4.6 Preliminary Facility Elevations

Inspection of the current layout plan, topographical data set and inferred drainage paths suggests that the finished ground surface elevations shown in Table 6 should be adopted for the feasibility level design of the various mine facilities.

Table 6: Suggested Finished Elevations for Preliminary Design of Mine Facilities

Proposed Facility	Suggested Finished Elevations (mAHD)
Site Access T-Junction	280.0
Gatehouse, Security and Weighbridge	299.5
Administration Offices	299.5
LV Washdown and HME Tyrewash	299.5
Power Station	291.5
Sewage Treatment Plant & Putrescent Dump	293.0
Accommodation Village	299.5
Airstrip Terminal Facility	293.0
Central Mine Facilities	295.0
Explosives Storage	293.5
Central Fuel Storage & HME/LV Workshop	295.5
Arruwurra Mine Services Area	265.5

All of the above elevations comprise a degree of protection against potential flood events. However the adequacy of these elevations should be revisited as part of the detailed design of the project facilities.

4.7 Quantity Estimation

The water management measure construction quantities are presented in Appendix C and are summarised in Table 7. These may be used for feasibility level cost estimating purposes by MML.

Table 7: Water Management Measure Construction Quantity Summary

Description	Quantity	Unit
Flood Protection Berm Clearing and Foundation Preparation	40,600	m^2
Flood Protection Berm Earthworks (fill)	43,500	m^3
Flood Berm Rip-rap, 700 mm thick (D50 = 300 mm)	10,440	m^2
Diversion Ditch Clearing	86,932	m^2
Diversion Ditch Earthworks (cut)	64,308	m^3
Arterial Drainage Ditch Clearing	98,800	m^2
Arterial Drainage Ditch Earthworks (cut)	68,400	m^3
Culverts (12 crossings with 2 x 600 mm dia. barrels x 15 m long each.)	360	L m
Sedimentation Pond Clearing	48,950	m^2
Sedimentation Pond Earthworks (cut)	72,260	m^3

Note: Material cut from ditch excavation may be suitable for re-use to construct flood berms, subject to approval.

5.0 RISK ASSESSMENT

A primary risk analysis workshop was carried out on 20th August 2009 and was facilitated by Mr Mark Chesher of AMC. The risk analysis methodology and the workshop findings are presented in Section 19 of the Wonarah Project Bankable Feasibility Study report.

The following sections outline those risks relating solely to surface water management. Risks associated with the proposed project groundwater supply are dealt with in GRM's Groundwater Studies report.

5.1 Surface Water Management Risks

Four surface water risks to the project have been assessed as follows[9], based upon a ranking matrix provided by AMC Consultants Pty Ltd[10]:

- *Flood risk to Arruwurra Pits* – as discussed earlier in this report a potential flood risk exists for the proposed Arruwurra open pits due to the adjacent watercourse which drains a relatively large upstream catchment area. The alignment and channel geometry of this watercourse is poorly defined and, following a significant rainfall-runoff event, it is possible that floodwater could report to some of the proposed Arruwurra pits or could cause flooding over the proposed Arruwurra mining area.

  However, although possible, it is unlikely that such flooding will occur during the envisaged 10 year Stage 1 operational life of the project and the likelihood has been assessed as a level 2. The consequences of such an event are rated as being moderate due to potential loss of revenue of between $10 and $100 million and has been given a level of 3. Combining the likelihood and consequence values gives a moderate risk rank requiring floodwater management measures to be implemented during operations. The feasibility level design of the Base Case flood protection measures are presented in this report.

- *Flood risk to site infrastructure/facilities* – similarly potential risks exist for flooding of surface infrastructure and mining facilities due to runoff from on-site catchment areas following significant rainfall events.

  Again, although possible, it is unlikely that such flooding will occur more frequently than say once in five years and the likelihood has been assessed as a level 2. The consequences of such an event are rated as being moderate due to potential loss of revenue of between $10 and $100 million and has been given a level of 3. The combined values give a moderate risk rank requiring appropriate drainage measures to be implemented during operations. The feasibility level design of the Base Case drainage measures are presented in this report.

- *In-pit water management (rainfall and surface water runoff)* – direct precipitation will fall within the proposed pit crests during the months of January to March, when the potential exposure to high intensity rainfall is greatest. As a result runoff from the walls and floor of the pits will collect at low spots and may affect day-today mining operations.

[9] Flood risks to offsite infrastructure such as Barkly Highway and tenant Creek to Darwin railway that could affect ore transportation have been dealt with by others.
[10] AMC, 2009. "Wonarah feasibility study Minemakers Australia Pty Ltd Section 19 risk assessment", draft report dated June 2009.

Give that such occurrence is highly likely it has been given a likelihood level of 4, however, the consequences of such events are regarded as being relatively insignificant and a level of 1 has been applied. These values result in a medium risk ranking and will require that in-pit water management measures are implemented during operations. Such measures are likely limited to pit floor sumps with pumping to sedimentation ponds on surface prior to re-use or occasional discharge, subject to suitability. In-pit sumps and pumps will be required in any event to remove groundwater that may report to the proposed pits (refer to GRM's Groundwater Studies report).

- *Unacceptable surface water quality discharge off-site (elevated TSS and hydrocarbons)* – following significant rainfall it is possible that surface water of unacceptable quality may be discharged off-site due to large scale earthmoving activities and the presence of mechanical equipment. Surface water quality impacts may be related to elevated Total Suspended Solids (TSS) and/or hydrocarbons, particularly free oil and grease.

  While such an event is possible, it is unlikely to occur more frequently than say once in five years and the likelihood has been assessed as a level 2. The consequences of such an event are rated as being moderate due to short term environmental impacts and has been given a level of 3. The combined values give a moderate risk rank requiring appropriate water management measures, including the use of sedimentation ponds and OWSs, to be implemented during operations. The feasibility level design of the Base Case drainage measures are presented in this report.

The above risks and their likelihood of occurrence, resulting consequence and risk raking are summarised in Table 8.

Table 8: Surface Water Management Risks

Primary Risk Description	Likelihood Level	Consequence Level	Risk Rank
Flood risk to Arruwurra Pits	2	3	M
In-pit water management (from rainfall and surface water runoff)	4	1	M
Flood risk to site infrastructure/facilities	2	3	M
Unacceptable surface water quality discharge off-site (elevated TSS and hydrocarbons)	2	3	M

Note: Refer to BFS Section 19 for risk assessment conventions relating to likelihood, consequence and ranking.

6.0 RECOMMENDATIONS

The recommended floodwater protection and drainage and sediment management philosophies are presented in Sections 2 and 3 of this report. The resulting recommended Base Case surface water management works are summarised in Table 9.

Table 9: Summary of Surface Water Management Recommendations

Recommendation	Report Section
Arruwurra Flood Protection Berm	4.1
Arruwurra Upstream Catchment Diversion Ditch	4.2
Airstrip Upstream Catchment Diversion Ditch (North)	4.2
Airstrip Upstream Catchment Diversion Ditch (South)	4.2
Arruwurra Drainage Mine Services Area to Sedimentation Pond	4.2
Arruwurra Drainage Non DSO stockpile to Sedimentation Pond	4.3
Arruwurra Drainage Waste Dump to Sedimentation Pond	4.3
Arruwurra Drainage Sed Pond Outlet Drain	4.3
Central Drainage Mine Services Area to Sedimentation Pond	4.3
Central Drainage Non DSO stockpile to Sedimentation Pond	4.3
Central Drainage Waste Dump to Sedimentation Pond	4.3
Culverts (allowance)	4.3
Arruwurra Mine Services Area Sedimentation Pond	4.4
Arruwurra Dump/Stockpile Sedimentation Pond	4.4
Central Mine Services Area Sedimentation Pond	4.4
Central Dump/Stockpile Sedimentation Pond	4.4
Oily Water Separators	4.4

7.0 CLOSING REMARKS

This report builds on the findings of a hydro-meteorological study completed earlier and presents the feasibility level design of the Base Case water management measures required for the proposed project and, in particular, for the initial development of the Arruwurra Zone. The preliminary alignment of the Arruwurra flood protection measures is presented in this report in addition to that for the upstream catchment diversion and arterial drainage ditches.

Opportunities exist to reduce the required extent of these flood protection measures at the detailed design stage of the project through the judicious placement of waste rock dump/stockpile material and construction of haul roads

We trust that this report satisfies Minemakers current requirements and we look forward to discussing the ongoing development of the project with you.

Groundwater Resource Management Pty Ltd

Alistair Lowry **Rob Garnham**

Senior Water Resources Engineer **Principal Hydrogeologist**

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ARRUWURRA FUEL STORAGE FACILITY

NON DSO ORE STOCKPILE

ARRUWURRA PITS

WASTE ROCK DUMP

ARRUWURRA PITS

ARRUWURRA PITS

WASTE ROCK DUMP

NON DSO ORE STOCKPILE

MAIN ZONE PITS

CENTRAL FUEL STORAGE

CENTRAL CRUSHER, ROM PAD & STOCKPILE

1 2 3 4 5 6 7

0 1,000 2,000 4,000 6,000 8,000 10,000

DATUM:GDA94, PROJECTION, MGA94, ZONE53S (Metres)

Legend

- PROJECT TENEMENTS
- APPROXIMATE FLOWPATH
- APPROXIMATE CATCHMENT
- 1 Main Zone Watercourse
- 1 Arruwurra Zone Watercourse

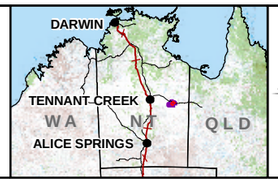
Elevation

- 300 - 305
- 295 - 300
- 290 - 295
- 285 - 290
- 280 - 285
- 275 - 280
- 270 - 275
- 265 - 270
- 260 - 265
- 255 - 260
- 250 - 255
- 248 - 250

MAIN ZONE WATERCOURSE	
ZONE ID	APPROX. DRAINING AREA
1	6.6 km2
2	15.7 km2
3	16.3 km2

NOTES:

1. ELEVATION TIN, FLOWPATHS AND CATCHMENT AREAS DEVELOPED USING GIS TOOLS TO BE CONFIRMED IN FIELD.
2. BARKLY SRTM DATA USED IN CATCHMENT DELINEATION.
3. ONLY PIT CRESTS FOR YEAR 1 AND YEAR 2/3 PITS SHOWN.
4. REFER TO FIGURE 2 FOR EXTENTS OF ARRUWURRA ZONE WATERCOURSE CATCHMENT AREA



GROUNDWATER RESOURCE MANAGEMENT

CLIENT	MINEMAKERS AUSTRALIA PTY LTD	PROJECT	WONARAH PROJECT
DRAWN	DFH	DATE	24.08.2009
CHECKED	ARL	DATE	24.08.2009
TITLE	LOCAL CATCHMENT DELINEATION PLAN		
SCALE	1:100,000 @ A3	PROJECT No	J090004
FIGURE No	1		

File Location : I:\CarrickConsulting\J090004_Wonarah_NT\03_ProjectData\01_Workspace

600000

Legend

PROJECT TENEMENTS

1 Main Zone Watercourse

1 Arruwurra Zone Watercourse

MAIN ZONE AREA

ARRUWURRA ZONE AREA

ARRUWURRA ZONE WATERCOURSE CATCHMENT AREA 867.7km2

N

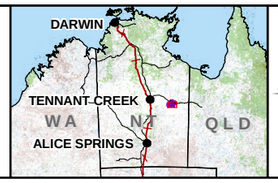
0 2,500 5,000 10,000 15,000 20,000 25,000

DATUM:GDA94, PROJECTION, MGA94, ZONE53S (Metres)

600000

NOTES:

1. ELEVATION TIN, FLOWPATHS AND CATCHMENT AREAS DEVELOPED USING GIS TOOLS TO BE CONFIRMED IN FIELD.
2. REFER TO REPORT FOR SUB-CATCHMENT AREAS



GROUNDWATER RESOURCE MANAGEMENT

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CHECKED	ARL	DATE	24.08.2009
TITLE	ARRUWURRA ZONE WATERCOURSE CATCHMENT DELINEATION		
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FIGURE No	2		

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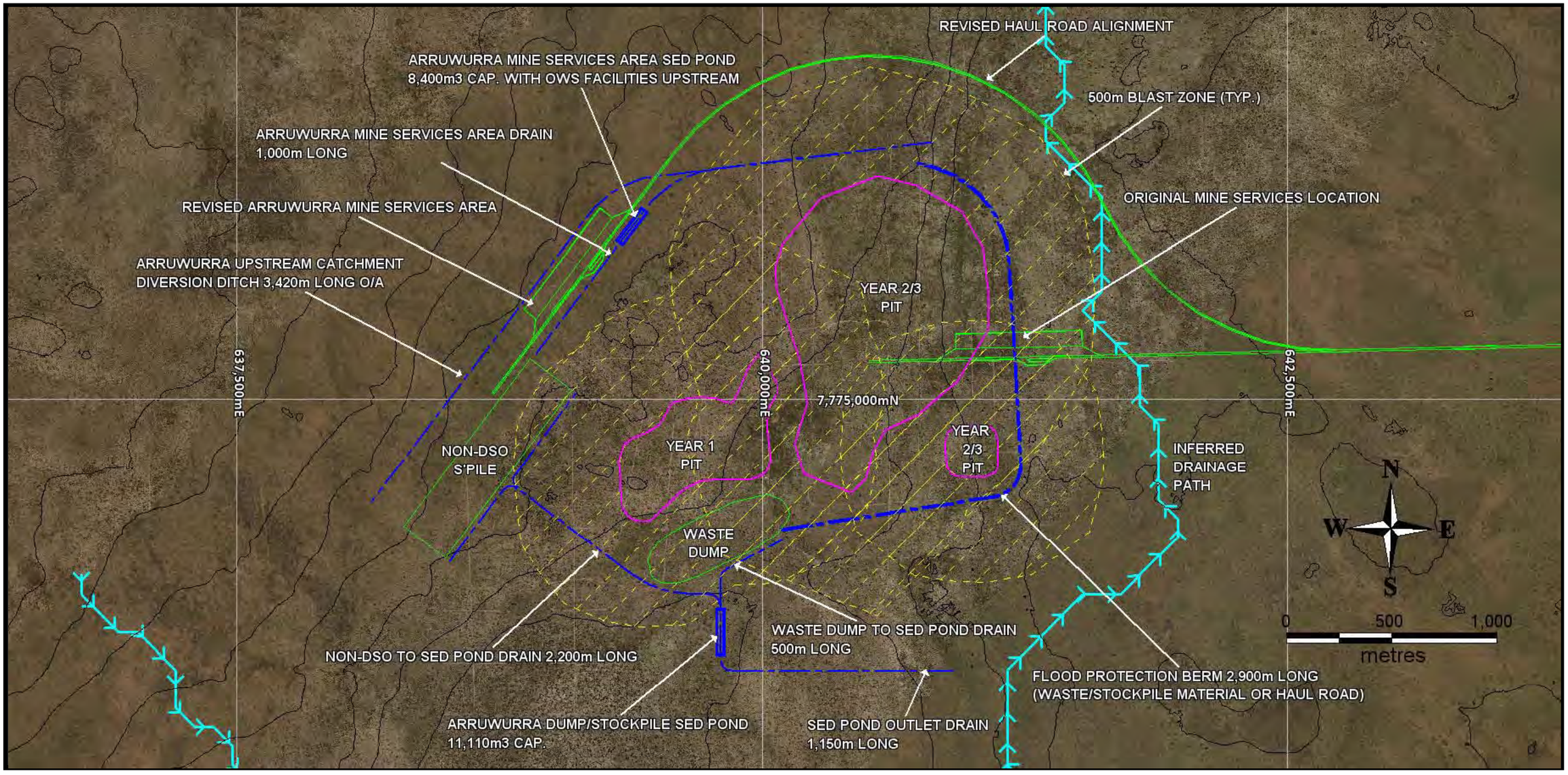
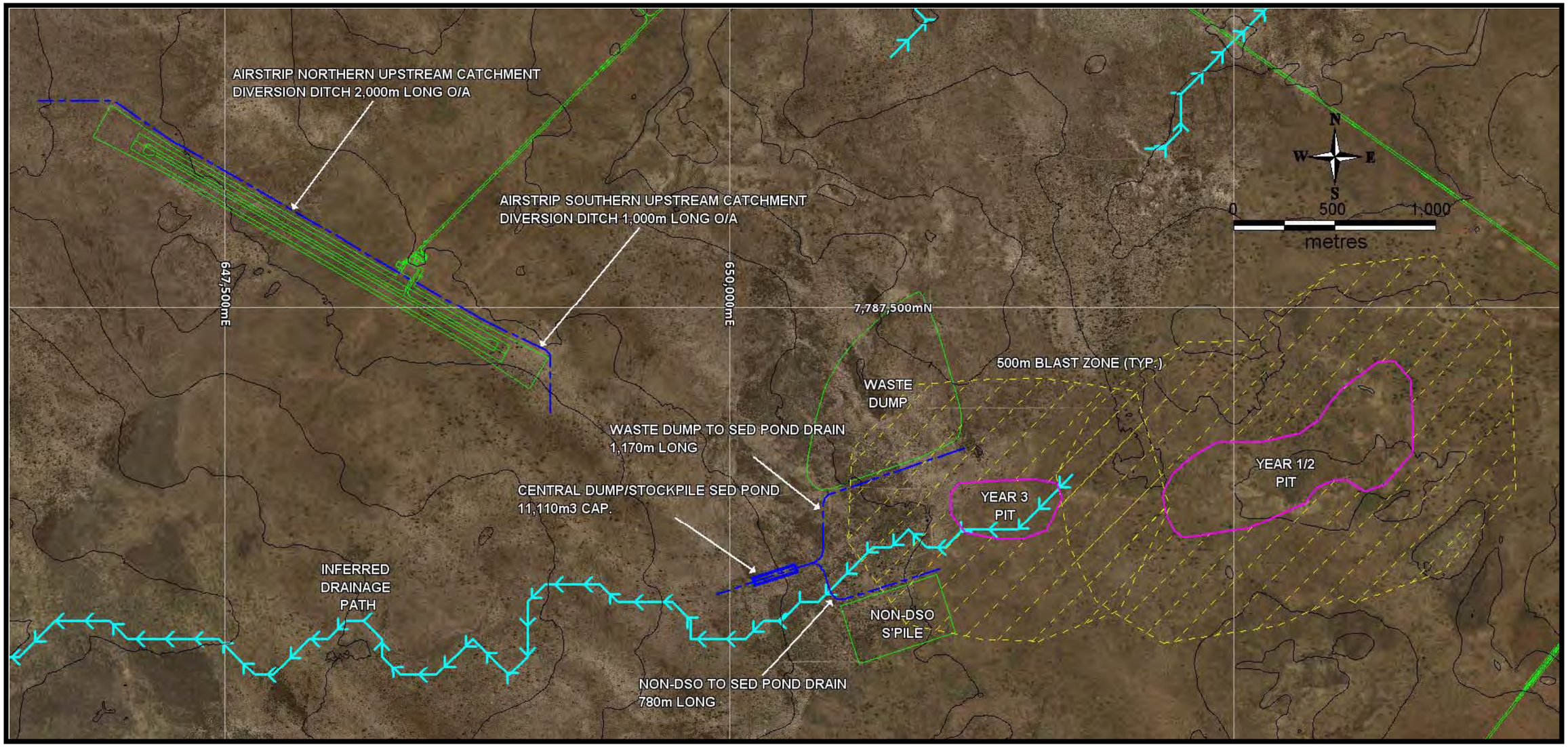


Notes:
1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

MINEMAKERS AUSTRALIA P/L			**PROPOSED SURFACE WATER MANAGEMENT MEASURES AT ARRUWURRA**
WONARAH PROJECT			
ARL	Aug09	**FIGURE 3**	

GROUNDWATER RESOURCE MANAGEMENT

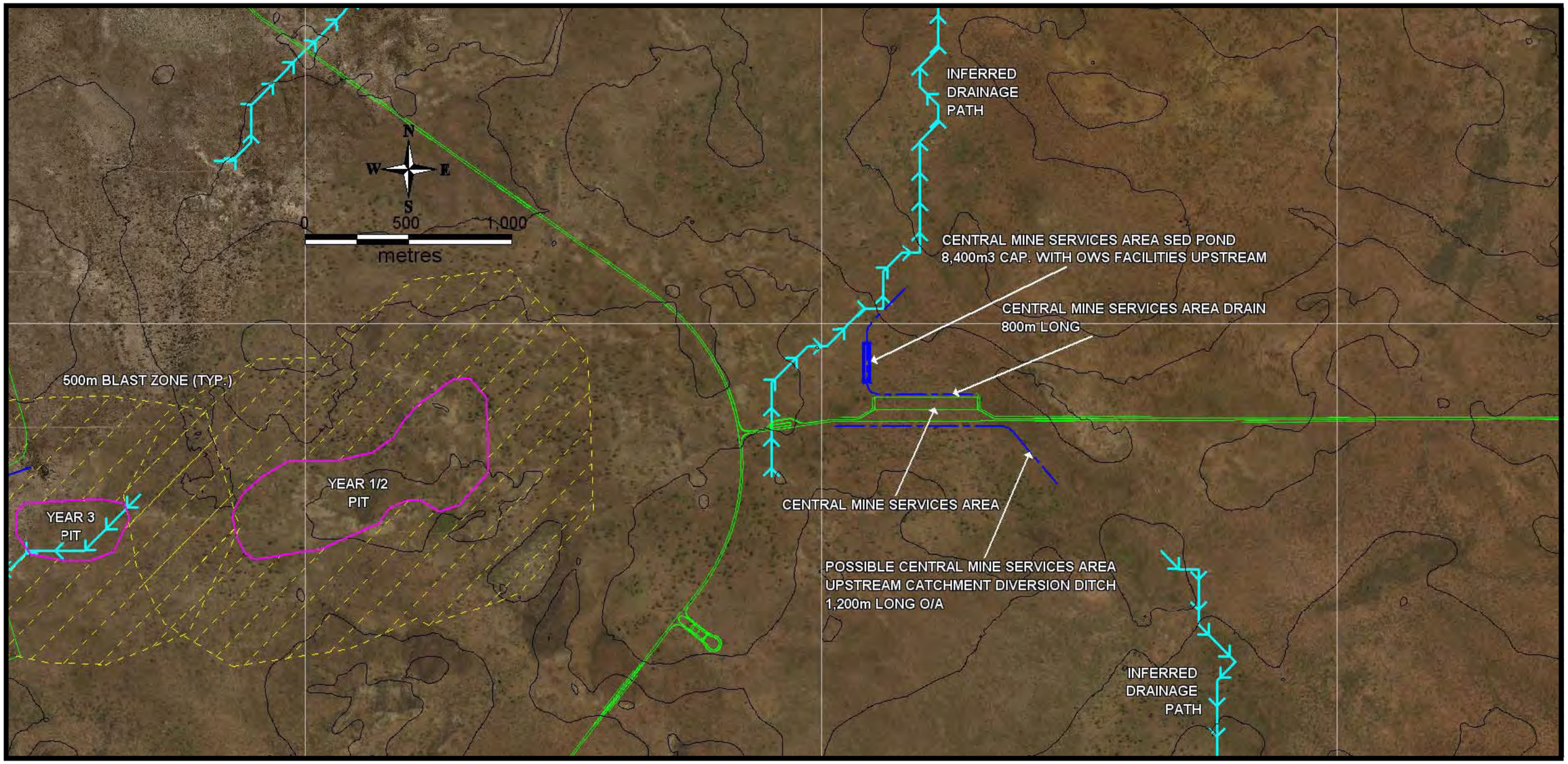


Notes:

1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

MINEMAKERS AUSTRALIA P/L			**PROPOSED SURFACE WATER MANAGEMENT MEASURES AT MAIN ZONE PITS & AIRFIELD**
WONARAH PROJECT			
ARL	Aug09	**FIGURE 4**	

GROUNDWATER RESOURCE MANAGEMENT



Notes:
1. Base Mapping provided by Minemakers Australia (GDA'94 Zone 53).
2. Drawing not to scale (2.5 km grid shown).
3. Contour interval is 2.5 m.

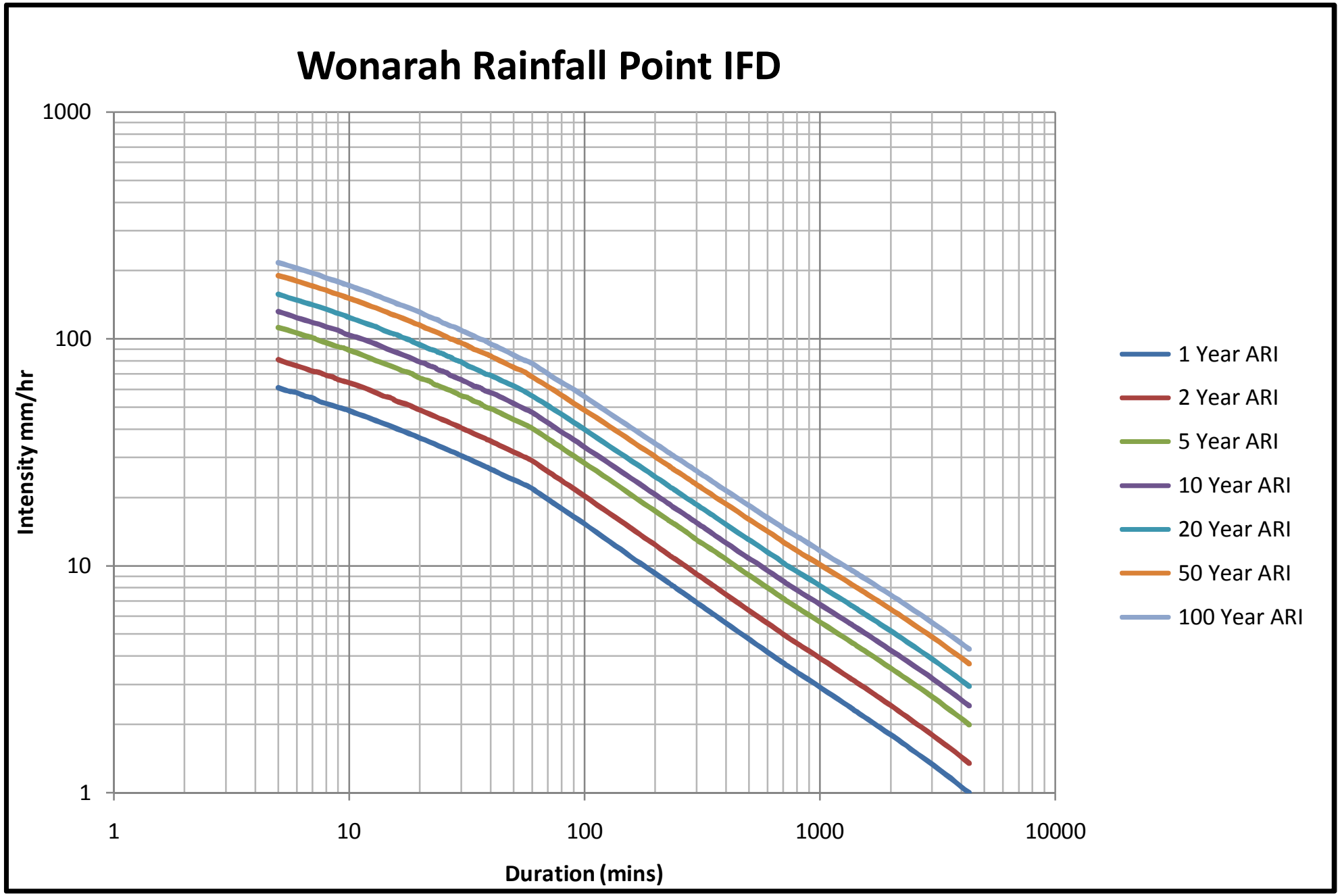
MINEMAKERS AUSTRALIA P/L			**PROPOSED SURFACE WATER MANAGEMENT MEASURES AT CENTRAL MINE SERVICES AREA**
WONARAH PROJECT			
ARL	Aug09	**FIGURE 5**	

GROUNDWATER RESOURCE MANAGEMENT

APPENDIX A

Point Intensity Frequency Duration Relationship for Wonarah

Rainfall Intensity Frequency Duration data for; Wonarah NT							
Geographic Location: , 20.04 , Deg. South, 136.45 , Deg. East							
AUSIFD, Version 2.0, 19 February,2009							
Duration	**1 Year ARI**	**2 Year ARI**	**5 Year ARI**	**10 Year ARI**	**20 Year ARI**	**50 Year ARI**	**100 Year ARI**
(mins)	**(mm/hour)**	**(mm/hour)**	**(mm/hour)**	**(mm/hour)**	**(mm/hour)**	**(mm/hour)**	**(mm/hour)**
5	61	81	112	132	157	190	217
5.5	59	78	109	128	152	185	211
6	58	76	106	124	148	180	205
6.5	56	74	103	121	144	175	200
7	55	72	101	118	141	171	195
7.5	53	71	98	116	138	167	191
8	52	69	96	113	135	164	186
8.5	51	68	94	111	132	160	182
9	50	66	92	109	129	157	179
9.5	49.2	65	91	106	127	154	175
10	48.3	64	89	104	124	151	172
11	46.6	62	86	101	120	146	166
12	45.1	60	83	98	116	141	161
13	43.7	58	80	95	113	137	156
14	42.5	56	78	92	109	133	151
15	41.3	55	76	89	106	129	147
16	40.2	53	74	87	104	126	143
17	39.2	52	72	85	101	123	140
18	38.3	51	71	83	99	120	137
19	37.5	49.6	69	81	96	117	134
20	36.6	48.5	67	79	94	115	131
21	35.9	47.5	66	78	92	112	128
22	35.2	46.6	65	76	90	110	125
23	34.5	45.7	63	75	89	108	123
24	33.8	44.8	62	73	87	106	121
25	33.2	44	61	72	86	104	118
26	32.6	43.3	60	71	84	102	116
27	32.1	42.5	59	69	83	100	114
28	31.6	41.8	58	68	81	99	113
29	31.1	41.2	57	67	80	97	111
30	30.6	40.5	56	66	79	96	109
32	29.7	39.3	55	64	76	93	106
34	28.9	38.2	53	62	74	90	103
36	28.1	37.2	52	61	72	88	100
38	27.4	36.3	50	59	70	86	98
40	26.7	35.4	49.2	58	69	84	95
45	25.2	33.4	46.5	55	65	79	90
50	24	31.8	44.1	52	62	75	85
55	22.9	30.3	42.1	49.5	59	72	81
60	21.9	29	40.3	47.4	56	68	78
75	18.7	24.8	34.6	40.7	48.5	59	67
90	16.5	21.9	30.5	36	42.9	52	60
105	14.8	19.6	27.4	32.3	38.6	47.1	54
120	13.4	17.8	25	29.5	35.2	43	49.1
135	12.3	16.4	23	27.2	32.4	39.6	45.3
150	11.4	15.2	21.3	25.2	30.2	36.9	42.2
165	10.6	14.2	19.9	23.6	28.2	34.5	39.5
180	9.99	13.3	18.7	22.2	26.6	32.5	37.2
195	9.43	12.6	17.7	21	25.1	30.8	35.2
210	8.94	11.9	16.8	19.9	23.9	29.2	33.5
225	8.5	11.3	16	19	22.7	27.9	31.9
240	8.11	10.8	15.3	18.1	21.7	26.6	30.5
270	7.44	9.93	14.1	16.7	20	24.6	28.2
300	6.89	9.2	13	15.5	18.6	22.8	26.2
360	6.04	8.07	11.5	13.6	16.4	20.1	23.1
420	5.4	7.22	10.3	12.2	14.7	18.1	20.8
480	4.9	6.56	9.35	11.1	13.4	16.5	19
540	4.5	6.02	8.61	10.3	12.4	15.2	17.5
600	4.17	5.59	7.99	9.54	11.5	14.2	16.3
660	3.89	5.22	7.47	8.92	10.8	13.3	15.3
720	3.66	4.9	7.03	8.4	10.1	12.5	14.4
840	3.29	4.42	6.35	7.59	9.17	11.3	13.1
960	3.01	4.04	5.81	6.96	8.41	10.4	12
1080	2.77	3.73	5.38	6.44	7.79	9.65	11.1
1200	2.58	3.47	5.01	6.01	7.28	9.02	10.4
1320	2.42	3.25	4.7	5.65	6.84	8.48	9.79
1440	2.27	3.06	4.43	5.33	6.46	8.01	9.25
1800	1.94	2.62	3.81	4.58	5.56	6.92	8
2160	1.71	2.3	3.35	4.04	4.91	6.12	7.08
2520	1.52	2.05	3.01	3.63	4.41	5.5	6.37
2880	1.38	1.86	2.73	3.3	4.01	5.01	5.8
3240	1.26	1.7	2.5	3.02	3.68	4.6	5.33
3600	1.16	1.57	2.3	2.79	3.4	4.25	4.94
3960	1.07	1.45	2.14	2.59	3.16	3.96	4.6
4320	1	1.35	1.99	2.42	2.95	3.7	4.3


Wonarah Rainfall Point IFD
1000
100
10
1
Intensity mm/hr
1
10
100
1000
10000
Duration (mins)
1 Year ARI
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI

APPENDIX B

Hydrologic & Hydraulic Calculations

Minemakers Ltd. Wonarah Project

Calculation of Peak Flow Estimate for Arruwurra Zone Watercourse

Job No.: 090004		Sheet No.	of
Calc. By: Alistair Lowry		Chk'd By:	
Calc Date: 4Aug09		Chk'd Date:	

Catchment Characteristics:

Catchment Area , A =	867.72	km2
Mainstream Length, L =	45.66	km
Equal Area Stream Slope, Se =	1.1	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	326	mm

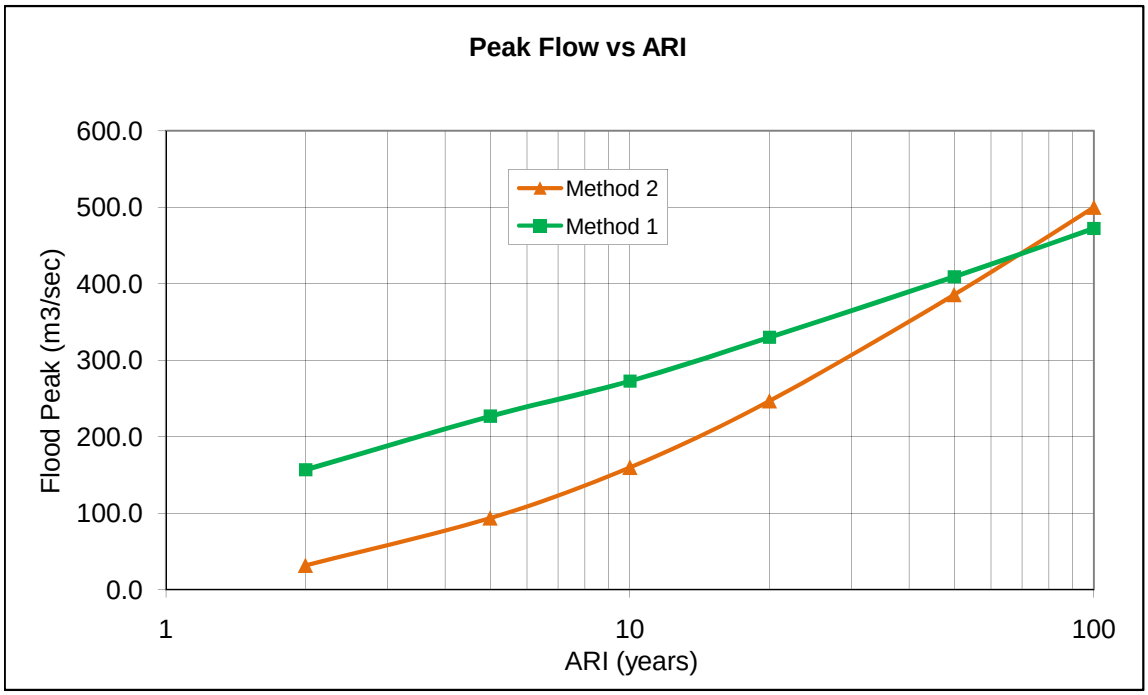
Method 1 - South Australia - Northern & Western Region Rational Method:

	2	5	10	20	50	100
Runoff Coefficient C for "very flat streams <0.2%"=	0.2					
Using Bransby-Williams Eqn for Time of Concentration, tc (mins) = 58L/(A^0.1)*(Se^0.2)						
tc =	1321 mins					
tc =	22 hours					
Use 22 hours for Time of Concentration => I_{tc} (mm/hr) =	3.25	4.7	5.65	6.84	8.48	9.79
Flood Peak Qy=0.278CIA (m3/sec) =	***157***	***227***	***273***	***330***	***409***	***472***

Method 2 - Western Australia - Wheatbelt Loamy Soil Catchment with Arid Interior Frequency Factors

Rational Method:	2	5	10	20	50	
tc=0.76A^0.38=	9.9 hours					
Use 10 hours for Time of Concentration => $I_{tc,Y}$ (mm/hr)=	5.59	7.99	9.54	11.5	14.2	N/A
C10=3.46*10^-1L^-0.42=	0.070	-				

	2	5	10	20	50	100
Frequency Factor (C_Y/C_{10}) =	0.34	0.7	1	1.28	1.62	N/A
Flood Peak Qy=0.278C$_{10}$(Cy/C10)IA (m3/sec) =	***31.9***	***93.8***	***160.0***	***246.8***	***385.7***	***500***



Pond Sizing Spreadsheet

MINEMAKERS LTD - Mine Facilities Sedimentation Pond

Calc. By:	A.Lowry	Sheet No.
Date:	11-Aug-09	Chk'd By:

Design based on 12ha disturbed area x C=0.5 x 128 mm = 7,680 m3 live cap.

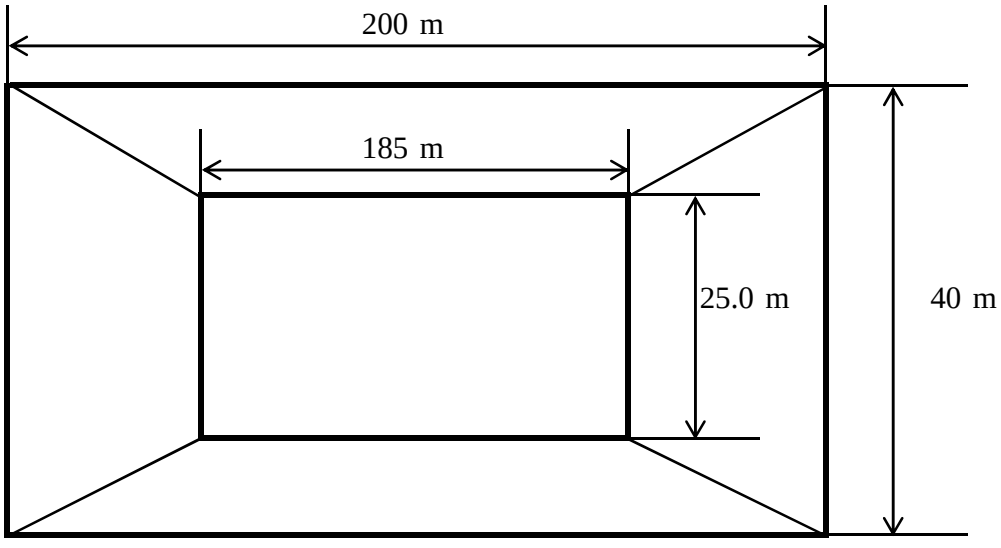
INPUT:

Top Length (m)	200.00
Top Width (m)	40.00
Side Slope (H: 1V)	3
Depth of Fluid (m)	1.50
Depth of Freeboard (m)	1.00
Total Pond Const. Depth (m)	2.50

OUTPUT:

Bottom Length (m)	185.00
Bottom Width (m)	25.00
Bottom Area (m2)	4,625
Fluid Length (m)	194.00
Fluid Width (m)	34.00
Fluid Area (m2)	6,596
Lined Surface Area (m2)	8,183
Volume of Fluid Stored (m3)	8,396
Volume of Excavation (m3)	15,688

SCHEMATIC:



Sideslopes 3 H: 1 V

Pond Sizing Spreadsheet

MINEMAKERS LTD - Waste Dump & Stockpile Sedimentation Pond

Calc. By:	A.Lowry	Sheet No.
Date:	11-Aug-09	Chk'd By:

Design based on 40ha disturbed area x C=0.2 x 128 mm = 10,240 m3 live cap.

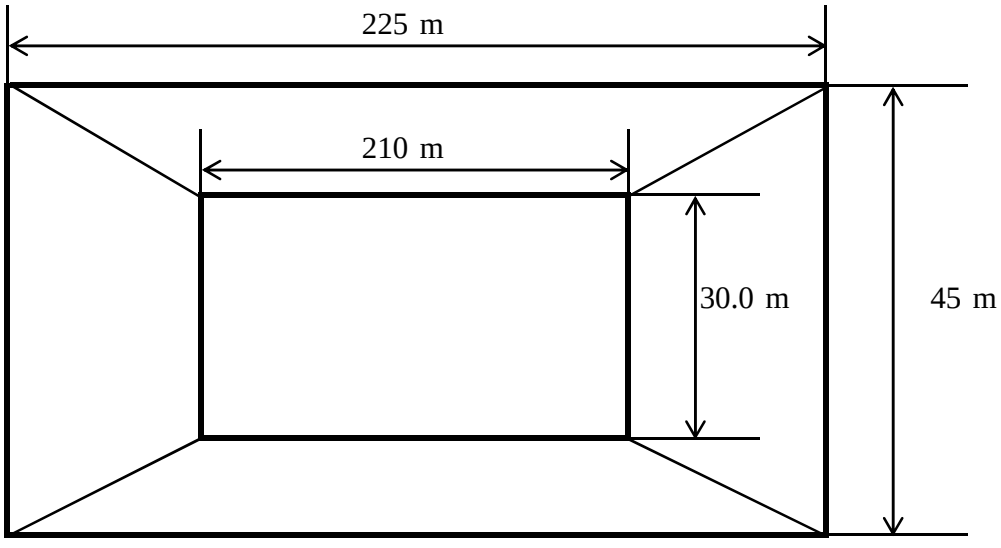
INPUT:

Top Length (m)	225.00
Top Width (m)	45.00
Side Slope (H: 1V)	3
Depth of Fluid (m)	1.50
Depth of Freeboard (m)	1.00
Total Pond Const. Depth (m)	2.50

OUTPUT:

Bottom Length (m)	210.00
Bottom Width (m)	30.00
Bottom Area (m2)	6,300
Fluid Length (m)	219.00
Fluid Width (m)	39.00
Fluid Area (m2)	8,541
Lined Surface Area (m2)	10,332
Volume of Fluid Stored (m3)	11,111
Volume of Excavation (m3)	20,438

SCHEMATIC:



Sideslopes 3 H: 1 V

APPENDIX C

Water Management Measure
Construction Quantity Estimate

Wonarah Project Prelim Surface Water Measures - Quantities

A. Lowry

20-Aug-09

Description	Unit	Arruwurra Flood Protection Berm	Arruwurra UCD	Airstrip UCD (North)	Airstrip UCD (South)	Arruwurra Drainage Mine Services Area to Sed Pond	Arruwurra Drainage Non DSO stockpile to Sed Pond	Arruwurra Drainage Waste Dump to Sed Pond	Arruwurra Drainage Sed Pond Outlet Drain	Central Drainage Mine Services Area to Sed Pond	Central Drainage Non DSO stockpile to Sed Pond	Central Drainage Waste Dump to Sed Pond	Culverts (allowance)	Arruwurra Mine Services Area Sed Pond	Arruwurra Dump/S'pile Sed Pond	Central Mine Services Area Sed Pond	Central Dump/S'pile Sed Pond	TOTAL
Flood Protection Berm Clearing and Foundation Prep.	m^2	40,600																***40,600***
Flood Protection Berm Earthworks (fill)	m^3	43,500																***43,500***
Flood Berm Rip-rap, 700 mm thick (D_{50} = 300 mm)	m^2	10,440																***10,440***
UCD Diversion Ditch Clearing	m^2		49,932	25,200	11,800													***86,932***
UCD Diversion Ditch Earthworks (cut)	m^3		42,408	15,900	6,000													***64,308***
Arterial Drainage Ditch Clearing	m^2					13,000	28,600	6,500	14,950	10,400	10,140	15,210						***98,800***
Arterial Drainage Ditch Earthworks (cut)	m^3					9,000	19,800	4,500	10,350	7,200	7,020	10,530						***68,400***
Culverts (12 crossings with 2 x 600 mm dia. barrels x 15 m long each.)	lm												360					***360***
Sedimentation Pond Clearing	m^2													11,000	13,475	11,000	13,475	***48,950***
Sedimentation Pond Earthworks (cut)	m^3													15,690	20,440	15,690	20,440	***72,260***
Notes:																		
1. Cut & Fill quantities based on lengths and cut/fill allowances shown below:																		
Approx. Length	m	2,900	3,420	2,000	1,000	1,000	2,200	500	1,150	800	780	1170	N/A	N/A	N/A	N/A	N/A	
Cut/Fill allowance per lineal m.	m2/m	15	12.4	7.95	6	9	9	9	9	9	9	9	N/A	N/A	N/A	N/A	N/A	
2. Berm and ditch clearing areas include 2m additional width along both sides.																		
3. Pond clearing areas include 10m additional length at both ends and 5 m additional width along both sides																		

7,777,000mN
7,776,000mN
7,775,000mN
7,774,000mN
638,000mE
639,000mE
640,000mE
641,000mE
642,000mE
643,000mE
N
STABILISED OUTLET (TYP.) SEE DETAIL 3 D04
ROCK CHECK DAMS (TYP.) SEE DETAIL 4 D04
ARRUWURRA MINE SERVICES SED. POND (8,400m3 CAP.)
ARRUWURRA MINE SERVICES AREA
ARRUWURRA MINE SERVICES AREA DRAIN (1,000m LONG)
ARRUWURRA UPSTREAM CATCHMENT DIVERSION DRAIN (3,420m LONG O/A)
NON-DSO STOCKPILE
STOCKPILE TO SED. POND DRAIN (2,200m LONG)
ARRUWURRA DUMP/STOCKPILE SED. POND (11,110m3 CAP.)
SED. POND OUTLET DRAIN
DUMP TO SED. POND DRAIN (500m LONG)
YEAR 2/3 PIT
YEAR 1 PIT
YEAR 2/3 PIT
WASTE ROCK DUMP
MINE SERVICES AREA ACCESS/HAUL ROAD ALIGNMENT
500m BLAST ZONE (TYP.)
PROPOSED FLOOD PROTECTION BERM SEE DETAIL 1 D04
INFERRED DRAINAGE PATH (TYP.)
FLOW
FLOW
FLOW
FLOW
Ch 0m
Ch 250m
Ch 500m
Ch 750m
Ch 1000m
Ch 1250m
Ch 1500m
Ch 1750m
Ch 2000m
Ch 2250m
Ch 2500m
Ch 2750m
Ch 2900m
272.5
270.0
267.5
265.0
262.5
260.0
257.5
255.0

REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–
		CHECKED		APPROVED	

NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT	MINEMAKERS AUSTRALIA PTY LTD		
DRAWN ARL	DATE 18-08-2009	DRAWING CHECK	DATE
DESIGNED ARL	DATE 18-08-2009	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE 1:7500 @A1	

PROJECT: WONARAH PROJECT

DRAWING TITLE: PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES ARRUWURRA ZONE PLAN

PROJECT No J090004 | DWG No D01 | A

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PLOTSCALE

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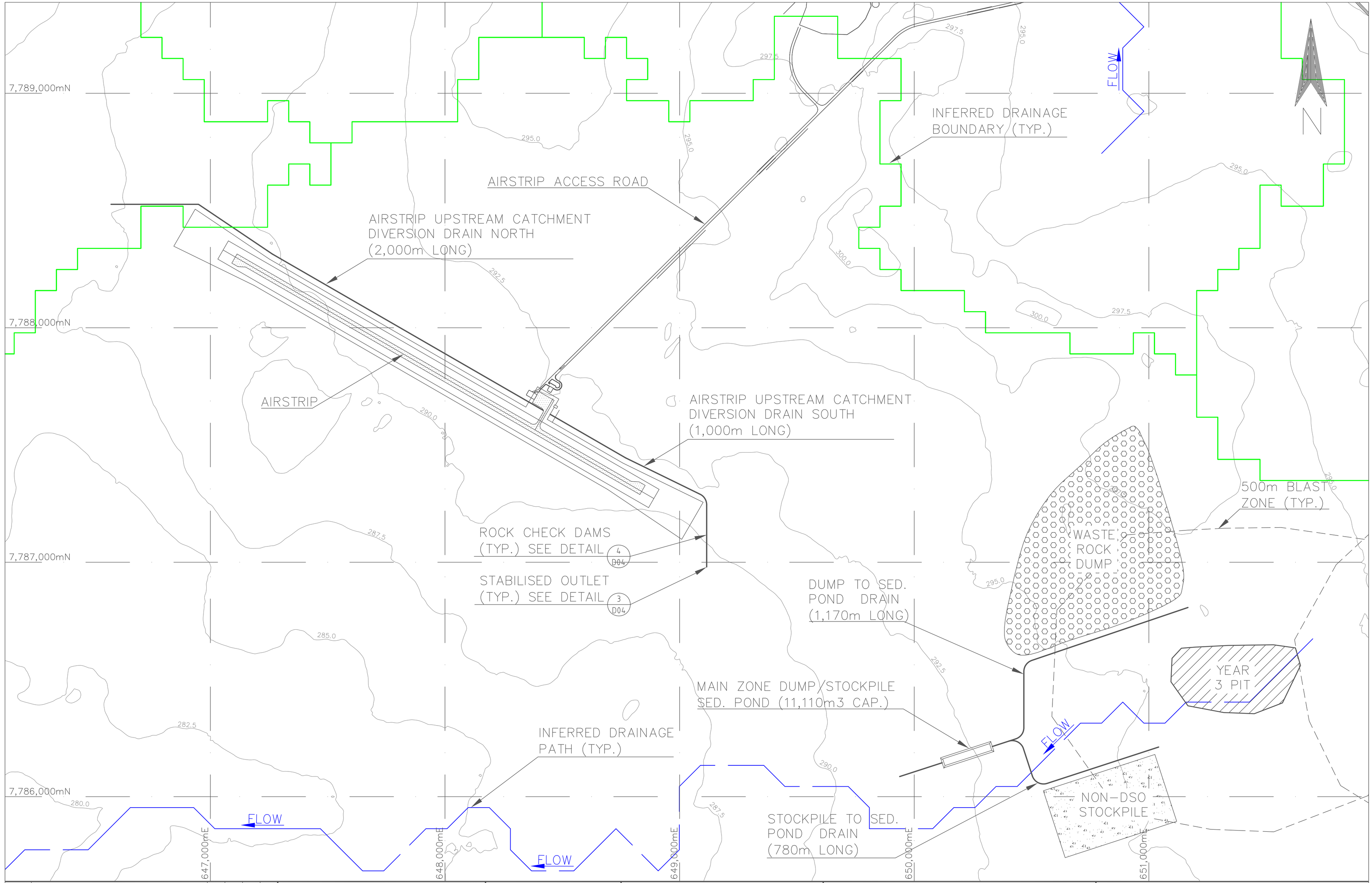

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A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–
		CHECKED		APPROVED	

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GROUNDWATER RESOURCE MANAGEMENT

CLIENT	MINEMAKERS AUSTRALIA PTY LTD
DRAWN	ARL — DATE 18-08-2009 — DRAWING CHECK — DATE
DESIGNED	ARL — DATE 18-08-2009 — DESIGN CHECK — DATE
AUTHORISED	DATE — SCALE 1:7500 @A1
PROJECT	WONARAH PROJECT
DRAWING TITLE	PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES MAIN ZONE & AIRSTRIP PLAN
PROJECT No	J090004 — DWG No D02 — A

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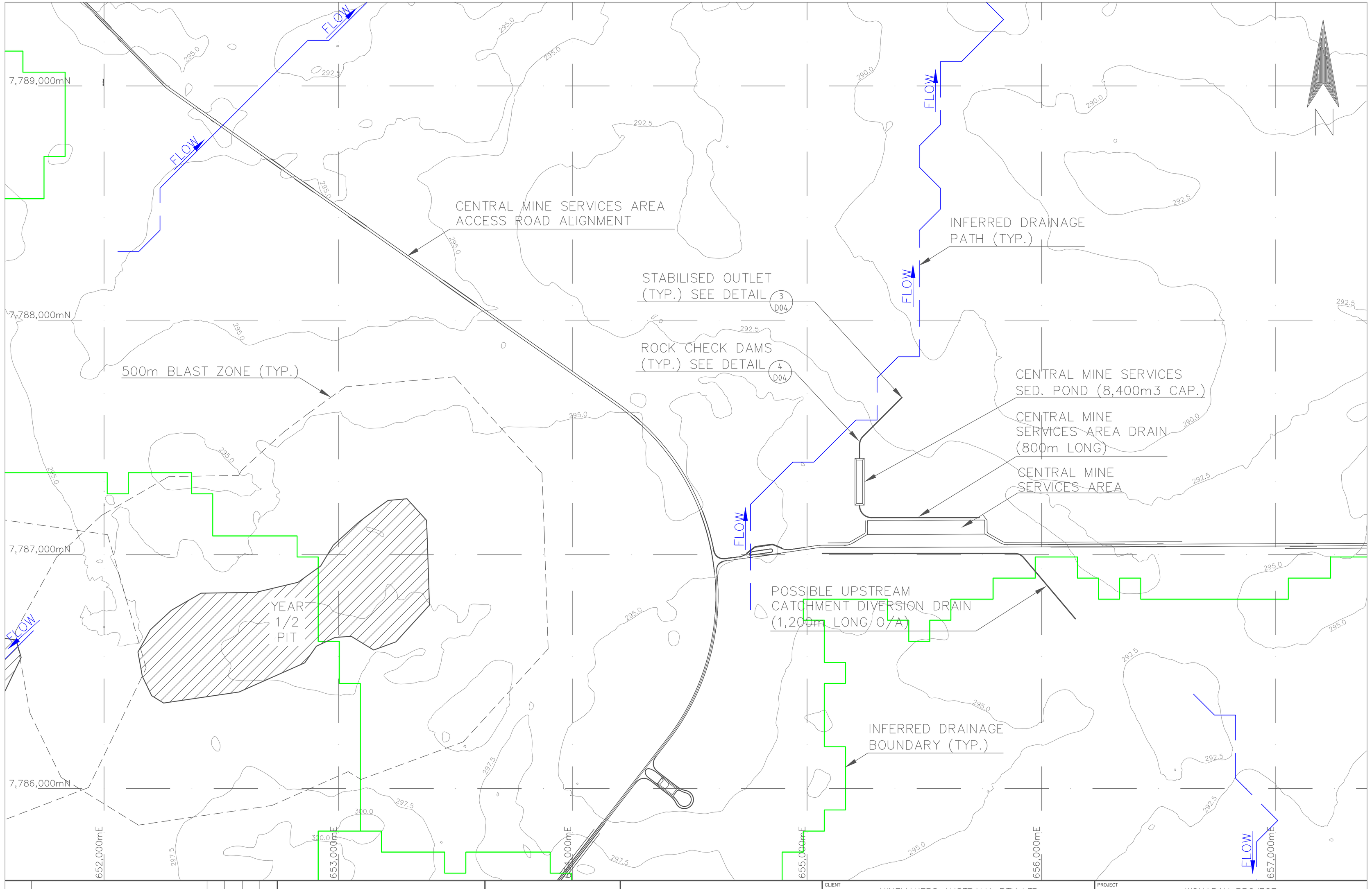

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A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–
		CHECKED		APPROVED	

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GROUNDWATER RESOURCE MANAGEMENT

CLIENT	MINEMAKERS AUSTRALIA PTY LTD		
DRAWN ARL	DATE 18–08–2009	DRAWING CHECK	DATE
DESIGNED ARL	DATE 18–08–2009	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE 1:7500 @A1	

PROJECT	WONARAH PROJECT		
DRAWING TITLE	PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES CENTRAL MINE FACILITIES PLAN		
PROJECT No J090004	DWG No D03	A	

1 2 3 4 5 6 7 8 9 10 11 12

PLTDATE

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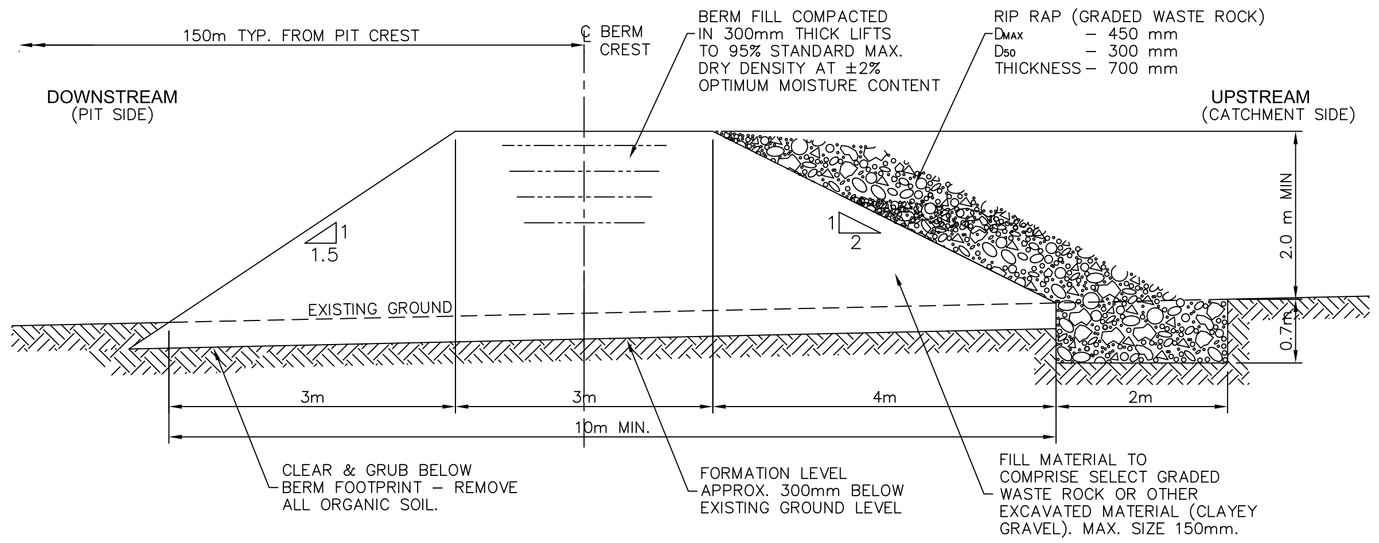

FLOOD PROTECTION BERM DETAIL (1 / –)
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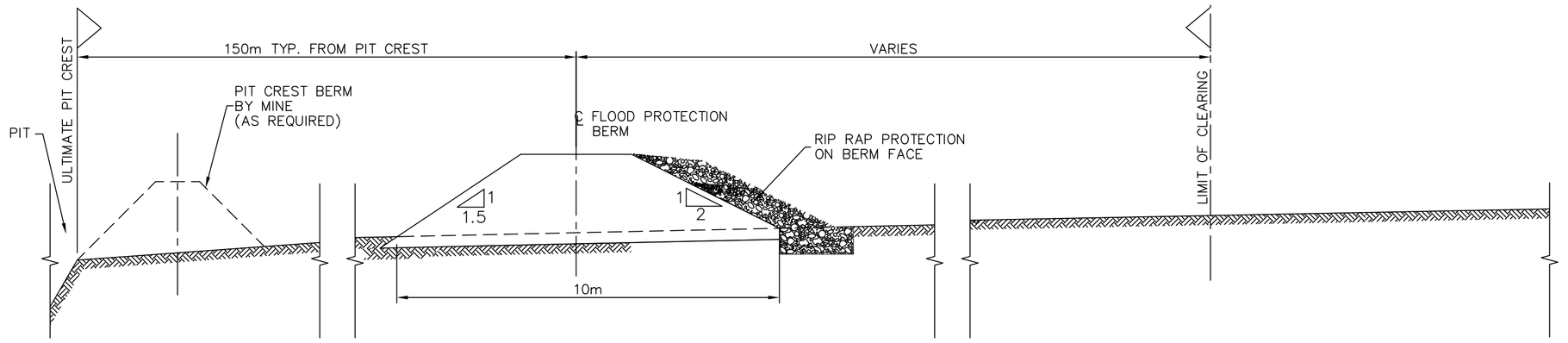
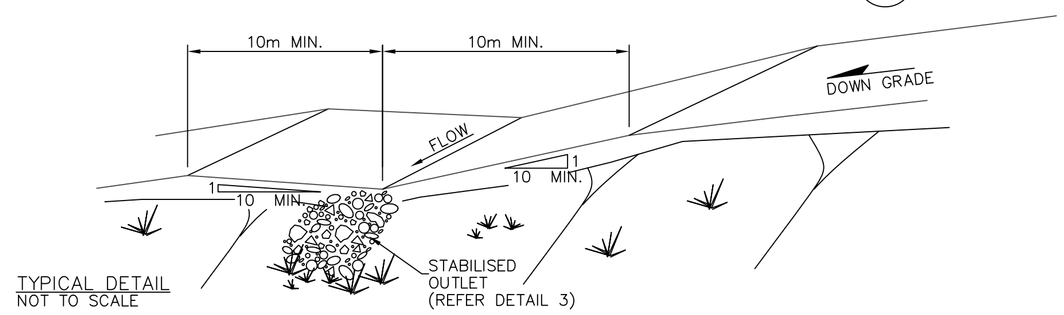


TYPICAL SECTION (A / D01)
SCALE - 1 : 100 @A1

DRIVE–THROUGH DETAIL (2 / –)

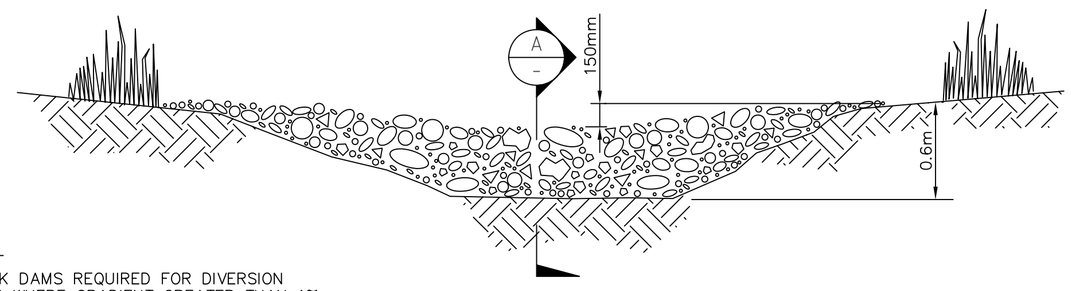


TYPICAL DETAIL
NOT TO SCALE

NOTES:

1. ENTRANCE & EXIT GRADE ON DRIVETHROUGH TO BE NO STEEPER THAN 10%.
2. HAUL ROAD PAVEMENT & SHEETING DETAILS AS PER MINEMAKERS INSTRUCTIONS.

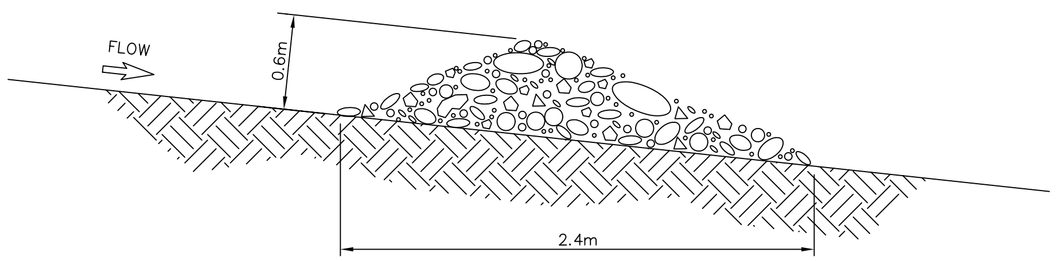
ROCK CHECK DAM DETAILS (4 / –)



NOTES:

1. CHECK DAMS REQUIRED FOR DIVERSION DITCH WHERE GRADIENT GREATER THAN 1%.
2. KEY STONE INTO CHANNEL BANKS AND EXTEND IT BEYOND THE ABUTMENTS A MINIMUM OF 0.5m TO PREVENT FLOW AROUND DAM.

VIEW LOOKING UPSTREAM
NOT TO SCALE



SECTION (A / –)
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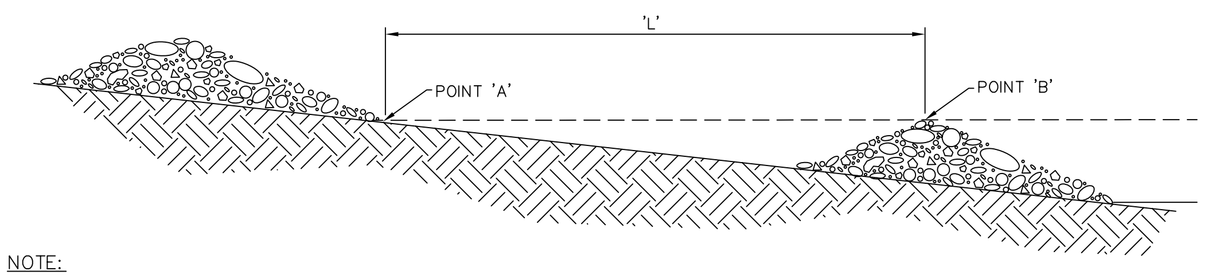
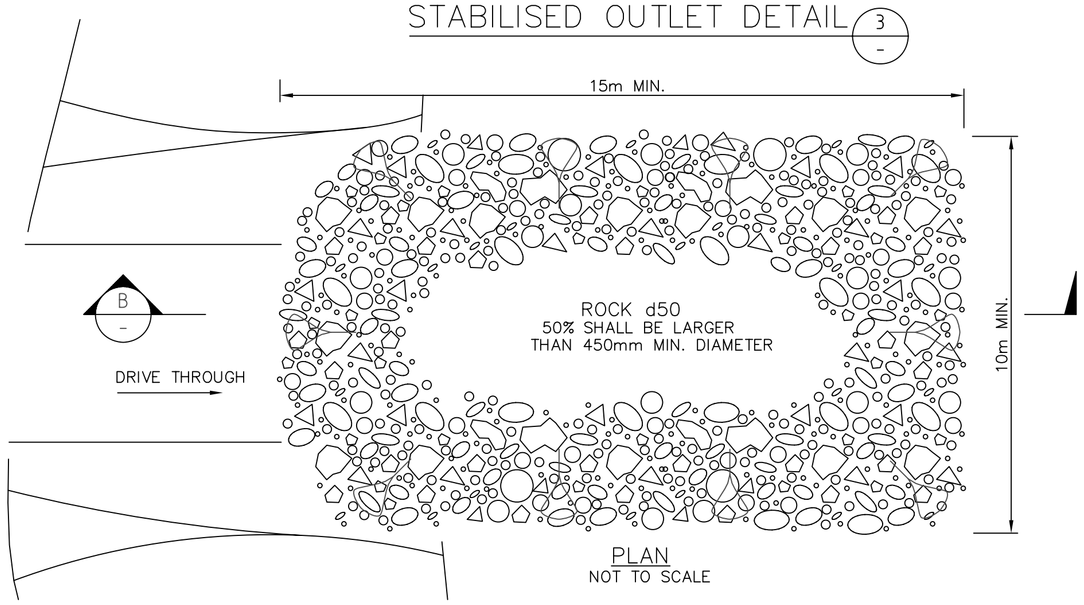


NOTE:

'L' = THE DISTANCE SUCH THAT POINT 'A' AND 'B' ARE OF EQUAL ELEVATION

SPACING BETWEEN CHECK DAMS
NOT TO SCALE

STABILISED OUTLET DETAIL (3 / –)



PLAN
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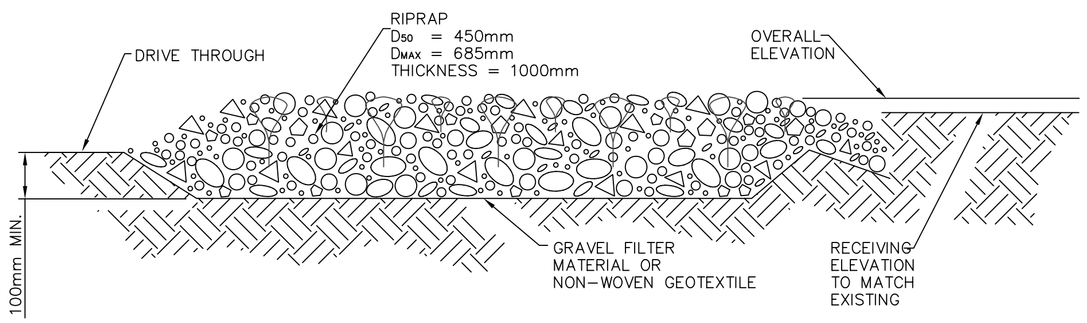

SECTION (B / –)
NOT TO SCALE

REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
A	ISSUED WITH DRAFT REPORT	AL	28/08/09	–	–

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GROUNDWATER RESOURCE MANAGEMENT

CLIENT	MINEMAKERS AUSTRALIA PTY LTD
DRAWN	ARL — DATE 18–08–2009 — DRAWING CHECK — DATE
DESIGNED	ARL — DATE 18–08–2009 — DESIGN CHECK — DATE
AUTHORISED	DATE — SCALE AS SHOWN
PROJECT	WONARAH PROJECT
DRAWING TITLE	PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES TYPICAL SECTIONS & DETAILS
PROJECT No	J090004 — DWG No D04 — A

PLTDATE
CADFILE
PLOTSCALE

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