Grass Valley Hard Rock Quarry

Water Management Assessment

Resource Group (WA)

16 December 2019

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20040029_R01v01 Grass Valley Quarry

16 December 2019

Greg Kennedy
Resource Group (WA)
Via email: greg.kennedy@westnet.com.au

Dear Greg,

Water Management Assessment

We are pleased to present our report enclosed of the water management assessment for the Grass Valley hard rock quarry proposal.

If you have any queries, please do not hesitate to contact me on (08) 6555 0105.

Yours sincerely,

Scott Wills
Principal Scientist | Regional Manager WA

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WATER TECHNOLOGY PTY LTD

EXECUTIVE SUMMARY

In June 2018, Resource Group (WA) Pty Ltd submitted to the Shire of Northam an application for Development Approval and an Extractive Industry Licence, for the proposed quarrying, crushing and screening of ~~150,000~~ tonnes per annum of hard rock at 792 Clydesdale Rd, Grass Valley.

The scope of this report is to provide guidance on the potential impact of the proposed hard rock quarry to the water values and water resources of the site. This report also considers the proposed development layout to identify preliminary locations for water control structures – such as bunding, culverts and sediment traps.

The Study Area is located in a rural setting and the neighbouring lots are zoned 'Rural' under the Shire's Local Planning Scheme. The surrounding land is utilised for cropping.

Topographically the area comprises a series of minor valleys, hills and ridge lines. The Study Area is located in a minor valley towards the top of a hill. The crest of the hill is immediately north of the development boundary and the hill ridge line runs north-west to south-east. Runoff is south and west within the narrow valleys.

A drilling program completed with the development area included over a dozen bores to a depth of 60 m. Groundwater was not encountered in any of these bores and the geological study concludes that the quarry pits in their ultimate design position will be above any water table that may be present.

Based on the drilling program there is no Surficial Aquifer and any groundwater that may occur is localised in rock fractures. Based on the available data, there is no evident connection between the surface water hydrology and any localised groundwater.

The proposed pits, stockpiles, plant and tracks are located in the valley, with the stockpile location and Pit 4 disturbing the two minor creeks. The flow past the stockpile is the most significant and will require the greatest level of surface water management.

Based on the assessment completed the following comments and associated surface water management recommendations are made:

- One diversion drain is required to divert the Catchment A creek around the stockpile and crushing facility. Water Technology recommends this drain is sized to the 1% AEP flood level (plus a 0.3 m freeboard) given its importance to the operation. Alignment and subsequent erosion protection requirements should be refined at detailed design phase.
- Two sediment control ponds are proposed. Water Technology's assessment of the Catchment 'Ä' sediment pond indicates an impractically large pond, and we recommend options are considered to manage sediment using a number of smaller ponds 'offline' from Catchment 'A' creek. The ponds have been sized to allow settlement of fines during the 10-Year 6-hour event only and have not been sized to store the annual sediment load. Greater detail on embankment conditions (e.g. slope, material) and sediment characteristics are required to refine the concept and Water Technology recommends this be completed at detailed design phase. All sediment ponds should be designed with an inlet and spillway to safely release a rainfall event >10% AEP.
- Culvert crossings are required in two locations where tracks cross Catchment 'Á' creek. Water Technology recommend the creek crossing for the main entrance road is serviceable up to the 5% AEP rainfall event. The internal track crossing can be designed to a lower level of serviceability.
- Modelling results also provide guidance on erosion control requirements across the site. Analysis shows that erosion protection is required in the majority of the proposed diversion channel due to velocities assessed to be >2m/s.

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1 INTRODUCTION

In June 2018, Resource Group (WA) Pty Ltd submitted to the Shire of Northam an application for Development Approval and an Extractive Industry Licence, for the proposed quarrying, crushing and screening of 150,000 tonnes per annum of hard rock at 792 Clydesdale Rd, Grass Valley.

The land is currently owned by Grant Collard Cooke and Angus John Cooke, and Resource Group (WA) has negotiated with the landowners to establish and operate the quarry.

The application is supported by a number of environmental and engineering investigations including acoustic, fire, landform, groundwater, flora and fauna, transport and engineering design of the pits and facilities.

1.1 Report Objectives

The scope of this report is to provide guidance on the potential impact of the proposed hard rock quarry to the water values and water resources of the site. Water Technology has completed a desktop assessment and broadly addressed the EPA Environmental Factor Guidelines; Inland Waters and Terrestrial Environmental Quality.

Water Technology has assessed the water values of the site by considering:

- the groundwater/surface water regimes,
- the frequency and duration of surface water flows based on the catchment extent and ground conditions, and
- consideration of the local and regional context for impacts on downstream waters.

This report also considers the proposed development layout to identify preliminary locations for water control structures – such as bunding, culverts and sediment traps, and based on the size and frequency of the expected flows, determine the appropriate specifications for the structures.

2 HYDROLOGICAL SETTING

2.1 Location and Land Use

Resource Group (WA) Pty Ltd (herein referred to as RG) is proposing a hard rock (granite) quarry at 792 Clydesdale Road, Grass Valley, in the Shire of Northam, as shown on Figure 2-1. The property is approximately 204.5 ha in total and is located approximately 7 km ENE of the locality of Grass Valley and 16 km east of the Northam township. The proposed quarry development is 15.2 ha.

The Study Area is located in a rural setting and the neighbouring lots are zoned 'Rural' under the Shire's Local Planning Scheme. The surrounding land is utilised for cropping.

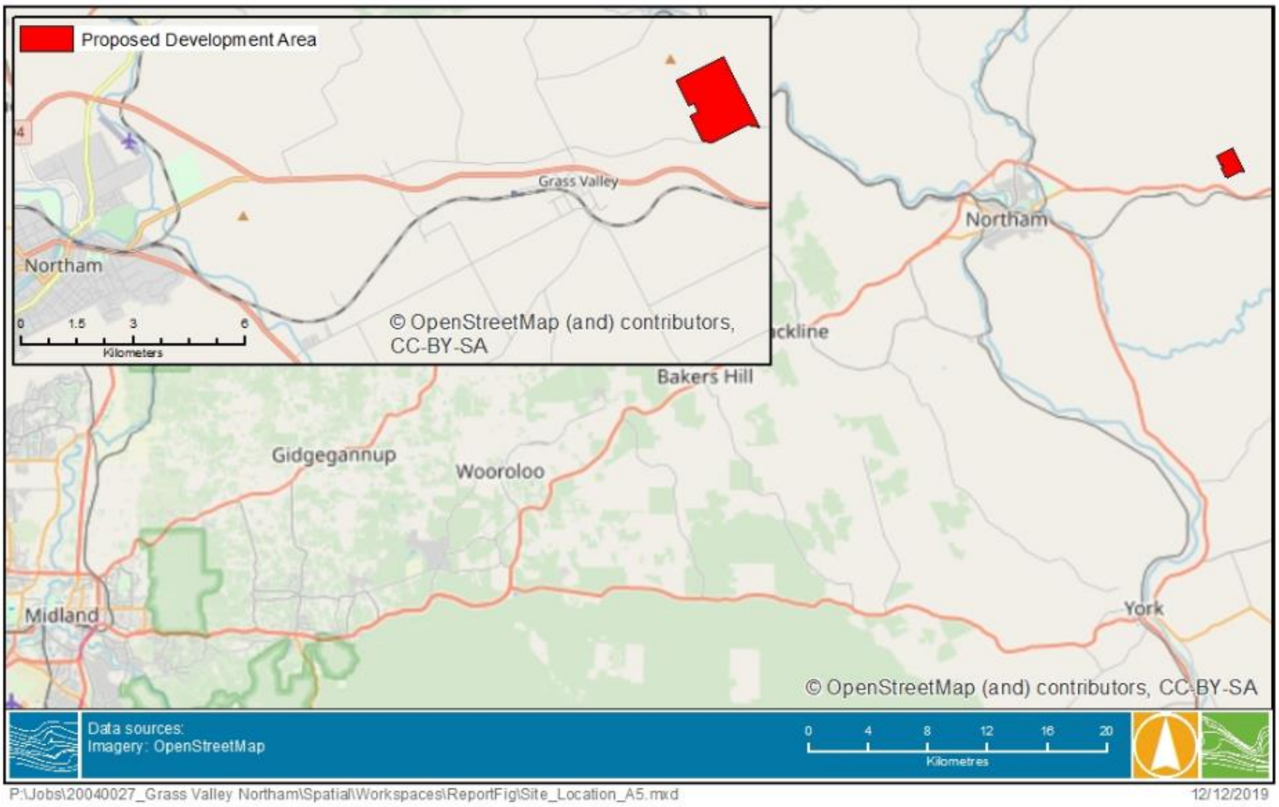

FIGURE 2-1 SITE LOCATION PLAN

2.2 Climate

The Study Area is located within the western Avon Basin region of WA, a region that experiences a temperate climate with cool wet winters and warm dry summers.

Most of the winter rainfall is delivered by frontal systems originating in the south-west, with the majority of annual rainfall occurring in the winter months from June to August. Rainfall data from the nearest long-term (since 1887) Bureau of Meteorology (BoM) weather station were obtained from Grass Valley (Station No. 010150) which is located approximately 3.6 km west of the Study Area. The average annual rainfall for the station is approximately 400 mm/yr and Figure 2-2 shows the rainfall recorded in 2019 to date. It should be noted that BoM quality checks have not yet been completed on the dataset.

Temperature data is available from Northam (Station No. 010111), which is located approximately 15 km west of the Study Area. The maximum daytime temperature regularly exceeds 35 °C during the summer months and minimum temperatures will occasionally drop to zero degrees in winter.

Average annual pan evaporation is approximately 2000 mm per year.

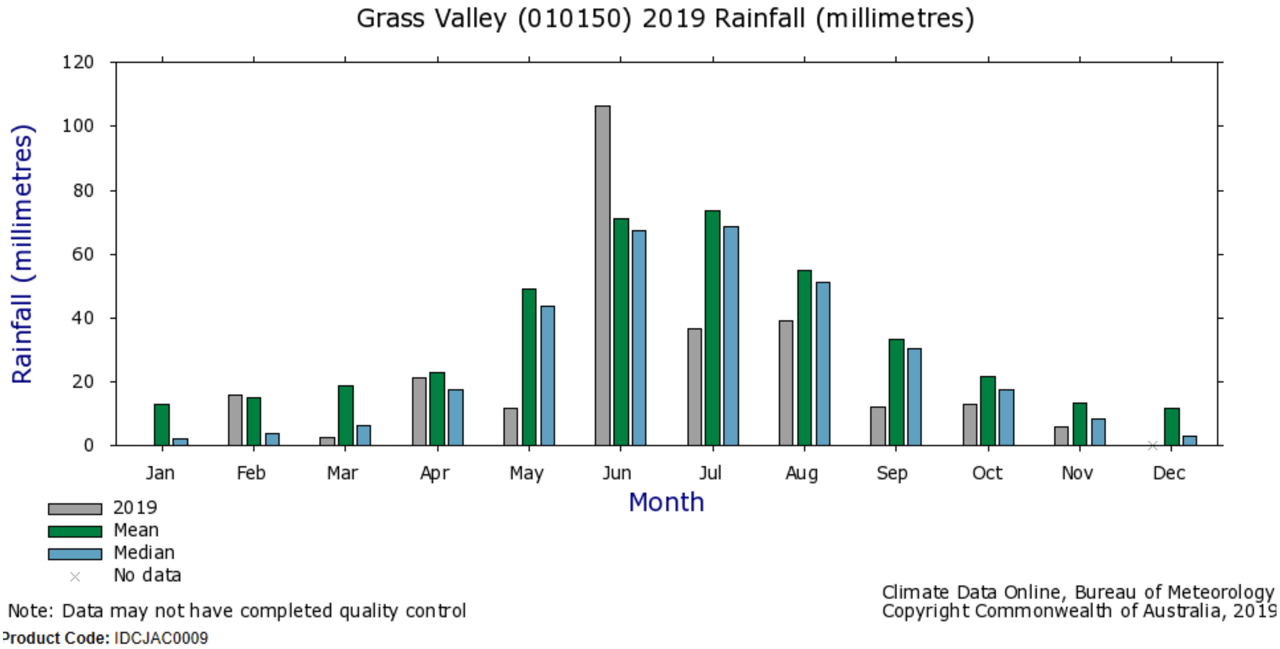

FIGURE 2-2 RAINFALL DATA FROM GRASS VALLEY BOM STATION (SOURCE: BOM, 2019)

2.3 Topographical Survey

Ground elevations for this Study Area have been taken from the 25 m grid SRTM dataset produced by Geoscience Australia. A topographical survey of approximately the development area was completed by Paul Kraft & Associates (2018) to provide finer resolution around key areas of the proposed development.

2.4 Site Geology & Soils

A geological study of the site has been undertaken by Graham Lee & Associates (2019). It notes that the site falls within the Avon sub-region on the Yilgarn Block. The site is located within the Zone of Rejuvenated Drainage and is characterised by narrower and steeper valleys leading to numerous localised watercourses. The region is underlain by granitic rocks together with gneiss and dolerite, which have been weathered to produce extensive areas of laterite, with lesser clay, sand and gravel.

Soil on the site is thin, skeletal, and sandy over much of the area, In the shallow valleys beside rock outcrop the soils thicken to sandy grey and pale brown coloured soil.

2.5 Flora & Fauna

An ecological survey of the site has been undertaken by Ecologia Environment (2019). It found no evidence of EPBC Act listed or BC Act listed 'Threatened' flora species or DBCA listed 'Priority' flora species within the Study Area. It also found no evidence of EPBC Act listed 'Threatened fauna' taxa, BC Act listed 'Threatened fauna' taxa or DBCA classified 'Priority' fauna taxa recorded.

2.6 Conservation Areas and Wetlands

The Study Area is not located near any Ramsar wetlands or any other wetlands of conservation significance. There are two Nature Reserves within 10 km of the Study Area; the Meenaar Nature reserve (4.2 km to the east) and Throssell Nature Reserve (1.5 km to the east). The Study Area drains south and then west, so there is no hydrological interaction between the site and the nature reserves.

2.7 Groundwater

A drilling program completed with the development area included over a dozen bores to a depth of 60 m. Groundwater was not encountered in any of these bores and the geological study concludes that the quarry pits in their ultimate design position will be above any water table that may be present (*pers comm*. Greg Kennedy, 2019).

Based on the drilling results there is no Surficial Aquifer and any groundwater that may occur is localised in rock fractures. Based on the available data, there is no evident connection between the surface water hydrology and any localised groundwater.

If groundwater is encountered in future investigations, the recharge pathways for the groundwater source should be considered as part of the resource assessment.

3 HYDROLOGICAL CHARACTERISATION

3.1 Regional Hydrology

The Study Area is situated within the Mortlock River catchment, which merges into Avon river further downstream, as shown on Figure 3-1. The catchment area that covers the site has been estimated to be 2.1 km^2. Based on previous studies and areal imagery, the Study Area consists of mostly cleared rural land with low vegetation cover.

In general, the regional hydrology is characterised by:

- Seasonal, but sometimes intense, rainfall resulting in runoff events and ponding in local low points;
- Consistently high rates of evaporation resulting in extremely low soil moisture content and dry antecedent conditions for much of the year, which limits surface water responses to lower rainfall events; and
- Potentially low infiltration rates associated with variable soils, including clays and silts, a dissected laterite profile and underlying crystalline rock (Sawkins, D N, and Department of Agriculture and Food, 2010).

Hydrological responses and drainage morphology across the study region are characterised by ephemeral stream, creek and drainage networks, with surface runoff events occurring in responses to significant storm events or following frequent or prolonged periods of rainfall. Surface water runoff in the region is channelized within the upper reaches and lower reaches are flood plains.

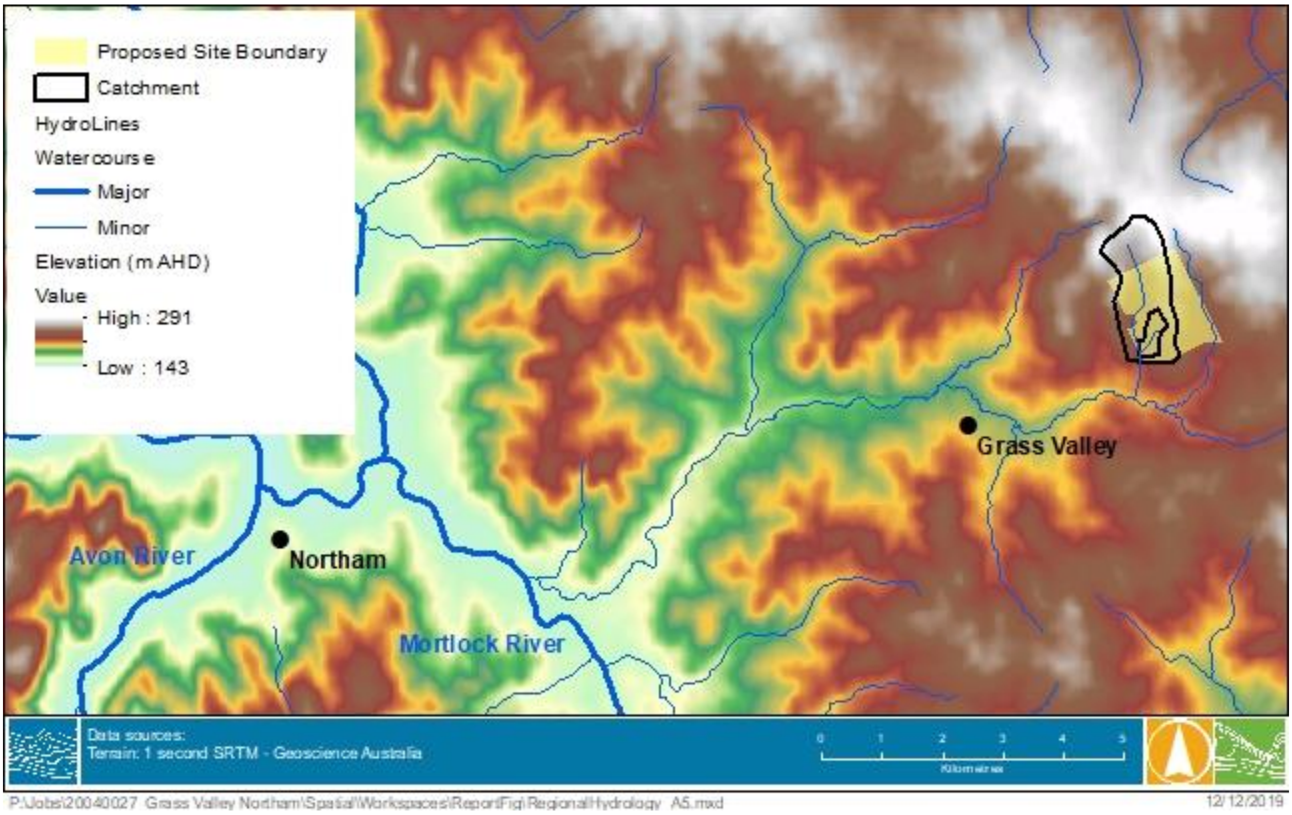

FIGURE 3-1 REGIONAL HYDROLOGY

3.2 Catchment Details

Surface water drainage systems and associated sub-catchments have been delineated from the available topographic data. The derived drainage paths have been validated against aerial photography, where possible, to ensure they closely match with visible drainage morphology.

Topographically the area comprises a series of minor valleys, hills and ridge lines. The Study Area is located in a minor valley towards the top of a hill. The crest of the hill is immediately north of the development boundary and the hill ridge line runs north-west to south-east. Runoff is south and west within the narrow valleys.

All drainage is by first order headwater ephemeral creeks. The majority of the surface water flows at the site are confined to shallow broadly defined ephemeral drainage systems off the hills in which the Project resides. An un-named creek extends from the north of the site and travels down to Clydesdale Rd passing through a culvert out into the adjacent paddock. This creek has been observed to be dry for most of the year, with ephemeral flows expected in response to rainfall events.

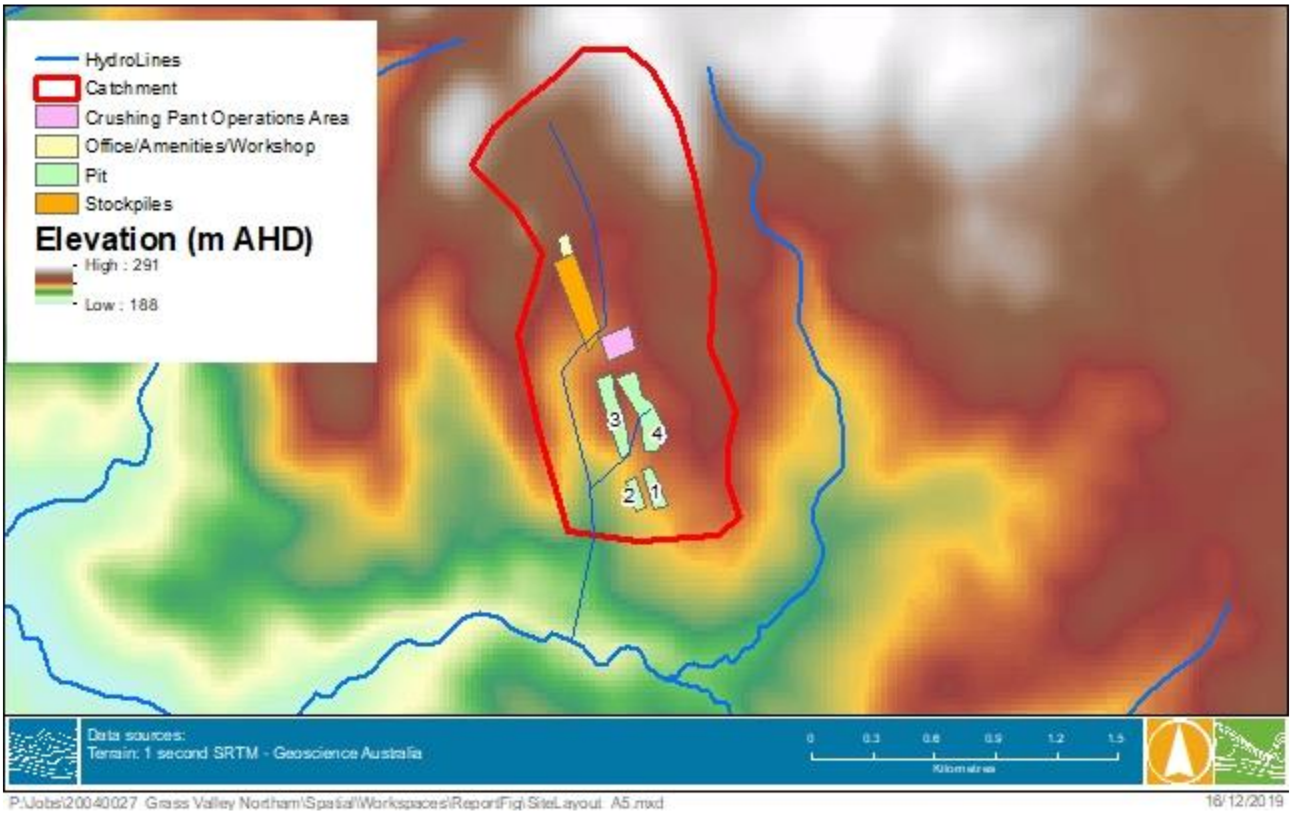

FIGURE 3-2 PROPOSED QUARRY DEVELOPMENT

A second short watercourse emanates from a small dry dam structure located near the centre of the proposed site, at the head of a gully that drains to the SW (the shorter watercourse depicted above). The dam wall has been built on the 230 m contour and is approximately 3 m high. This watercourse has also been observed as being dry for much of the year.

The local surface water paths and catchments are presented in Figure 3-2. Due to the complexity of the catchment arrangement these catchment areas are for reference only and are not to be used for planning purposes. More up-to-date aerial imagery and LIDAR is required to further refine the catchments. Generally, the catchment distribution highlights the complex nature of the topography and the small contributing catchments which are likely to generate only minor surface water flows.

The proposed pits, stockpiles, plant and tracks are located in the valley, with the Stockpile, Pit 3 and Pit 4 disturbing the two minor creeks. The flow under the track and past the stockpile is the most significant and will require the greatest level of surface water management; this is discussed below within sections 4 and 5 of this report.

Also, worth attention are the flows generated from the Stockpile, which may contribute impacted runoff into the crushing plant and will also require surface water management.

3.3 Peak Flow Estimates

For ungauged and undeveloped catchments, one of the methods recommended by ARR 2019 for peak flow estimation is using a Regional Flood Frequency Estimation (RFFE) approach. The RFFE transfers flood frequency characteristics from a group of gauged catchments to any catchment of interest. This ensures that the estimate produced is based on recorded data within the region.

In the absence of any streamflow or rainfall data (closest gauge to the study area is over 60 km away) within the Study Area's catchment, RFFE has been adopted to provide design peak flow estimates for this study. The design peak flows are tabulated in Table 3-1 and illustrated in Figure 3-3.

While this is the best estimate given the available data in the area, it is important to note that the variation on the estimate's confidence limits increase as the events becomes rarer, to approximately a factor of 4. The surface water management measures outlined in Section 5 are based on the design event flow, which has the potential to be underestimating the peak flow. In addition, all mitigation measures have been design based on the peak runoff at the outlet of the catchment even though they are situated at various locations within the catchment. This approach is considered more conservative as oppose to breaking down each structure's individual catchment area.

TABLE 3-1 RFFE DESIGN PEAK FLOW ESTIMATES AND CONFIDENCE LIMITS

AEP (1 in Y)	Flow (m^3/s)		
	Design	5% CL	95% CL
2	0.37	0.1	1.42
5	0.90	0.23	3.45
10	1.32	0.34	5.06
20	1.94	0.51	7.47
50	2.55	0.65	9.9
100	3.39	0.87	13.2

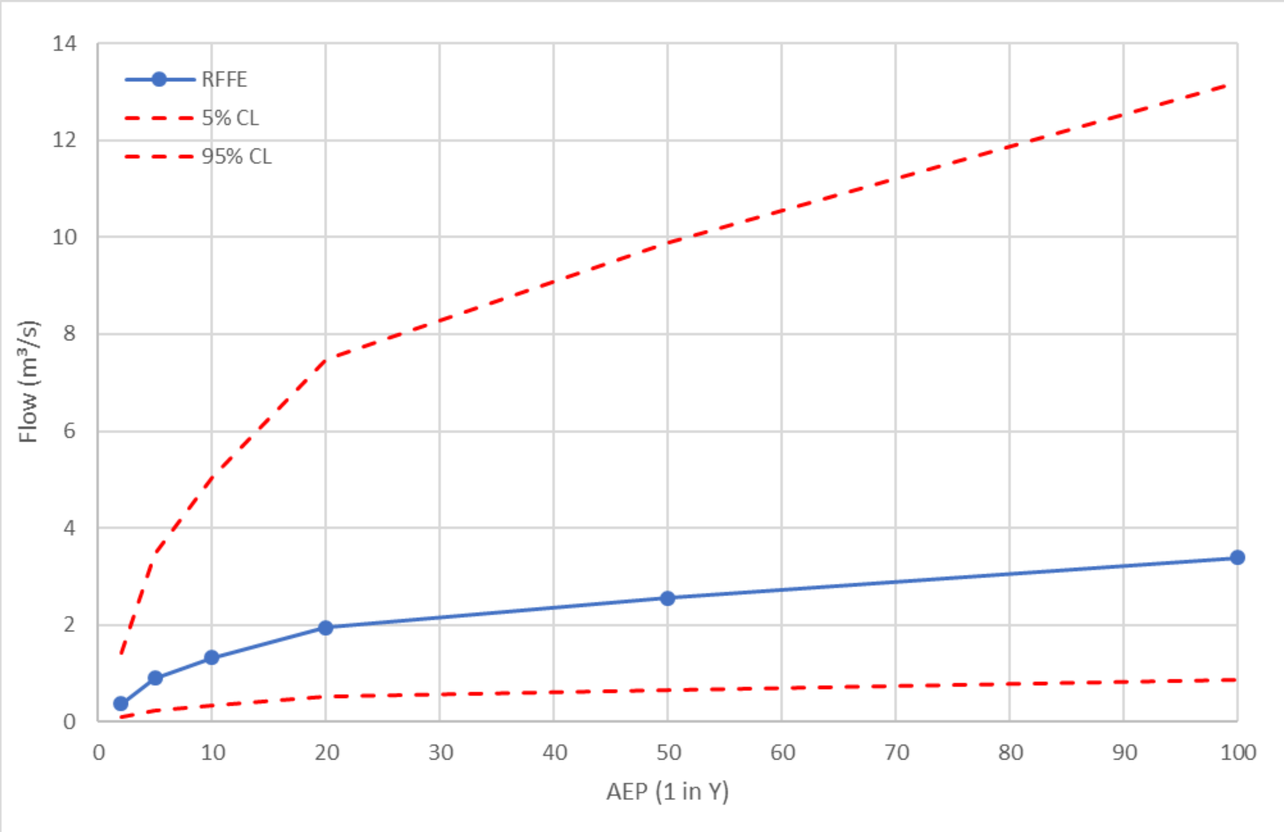

FIGURE 3-3 RFFE ESTIMATES AND CONFIDENCE LIMIT

4 CONCEPTUAL SURFACE WATER MANAGEMENT PLAN

4.1 Water Supply

Water Technology understands that the ultimate water supply for the quarry (e.g. for dust management and firefighting) is intended to be groundwater. Initially scheme water will be purchased and carted to site from a supply at the corner of Clydesdale and Jennapullin roads. Further investigations are required to try and locate a suitable groundwater supply. Water Technology recommends a groundwater pumping impact assessment is completed if a suitable groundwater supply is identified.

There is currently no proposal to capture or store surface water runoff for the quarry water supply.

4.2 Work Permits

The Study Area is located within the Avon River Catchment Area, which is a proclaimed surface water area. A review of the Department of Water and Environmental Regulation (DWER) guidance on permit requirements, indicates that a *Permit to Interfere with the Bed and Banks of a Watercourse* is likely to be required for the proposed development activity.

RG should contact DWER regarding the application prior to any ground disturbing activities to confirm the permit is required and make the application.

4.3 Potential Impacts

The proposed development area of 15.2 ha which includes 4 pits, a crushing facility, stockpiles, offices and vehicle tracks and is shown in Figure 3-2 above.

Vehicle access to the site will be via an existing farm access road adjoining Clydesdale Rd and this access will be widened and sealed. Two culverts are planned in the location of the creek crossings to allow vehicular access through the site in wetter winter months when the ground may become boggy. There are two sediment traps planned to capture the sediment mobilised and prevent it discharging from site. These will be designed in such a manner as to allow easy clean-out when required.

It is proposed that all refuelling of plant and equipment will occur on site. To enable this to occur a 25,000 litre self-bunded diesel fuel tank compliant with the WA Mines Act Regulations will be installed. Additionally, three 1,000 litre self-bunded engine oil storage tanks will also be installed. Waste oil will be taken from site by a licenced waste oil recycler.

As the life of the quarry will be around 30 years, we expect the final location and size of water control structures will be designed in detail prior to construction commencing.

On completion of mining operations and in line with DMIRS standards, the Mining Closure Plan stipulates that the landscape will be returned and blended in with the pre-extraction surface. Slopes will be stabilised and revegetated. At present no plan exists for the post development layout and therefore it is beyond the scope of this study.

4.4 Surface Water Runoff Definitions

Definitions of runoff sources for the site are outlined below:

- *Non-Impacted Runoff* - runoff generated from undisturbed areas, typical of baseline water quality.
- *Impacted Runoff* - runoff generated from disturbed areas, potentially contaminated and containing

sediment.

4.5 Management Strategies

The conceptual stormwater management strategies outlined below are designed to address the potential impacts described in Section 4.3. Figure 4-1 presents the conceptual level SWMP and a breakdown of each management use area.

Where practical, flow velocities within the diversion channels and flood protection bunds should be limited to minimise erosion and the generation of sediment.

4.5.1 Undisturbed Areas

The undisturbed areas include those catchments within the Site boundary, but outside of the development catchment, as depicted on Figure 3-1. All 'non-impacted runoff' from undisturbed catchments areas, will continue to flow unaffected by the proposed development.

4.5.2 Disturbed Areas

Stockpiles

Currently there is one stockpile proposed. Given the steepness of the batters and the likely erodibility and deposition of any fine material, sediment ponds are required at the locations depicted in Figure 4-1 to remove any sediment entrained in the runoff prior to its release downstream. A diversion drain positioned on the downstream side at the toe of the stockpile will convey any sediment laden runoff into the proposed sediment pond.

Open Pits

The four open pits are located along the head of the catchment ridge/hill. The majority of water reporting to the pit will be as a result of incident rainfall directly within the pit surface area. Water collected within pit areas from direct rainfall or minor inflows could be used within the mine for dust suppression and processing. The pit perimeter on the up-gradient side should be bunded to minimise runoff volumes reporting to the pit from any minor upslope areas. This would comprise construction of small bunds.

Tracks

The road/tracks will cross the Catchment A creek line in two locations. Even if the creek does not flow regularly, it is likely to be a boggy area over winter and culverts are proposed for the road/track to traverse these two locations, referred to as Culvert 01 and Culvert 02.

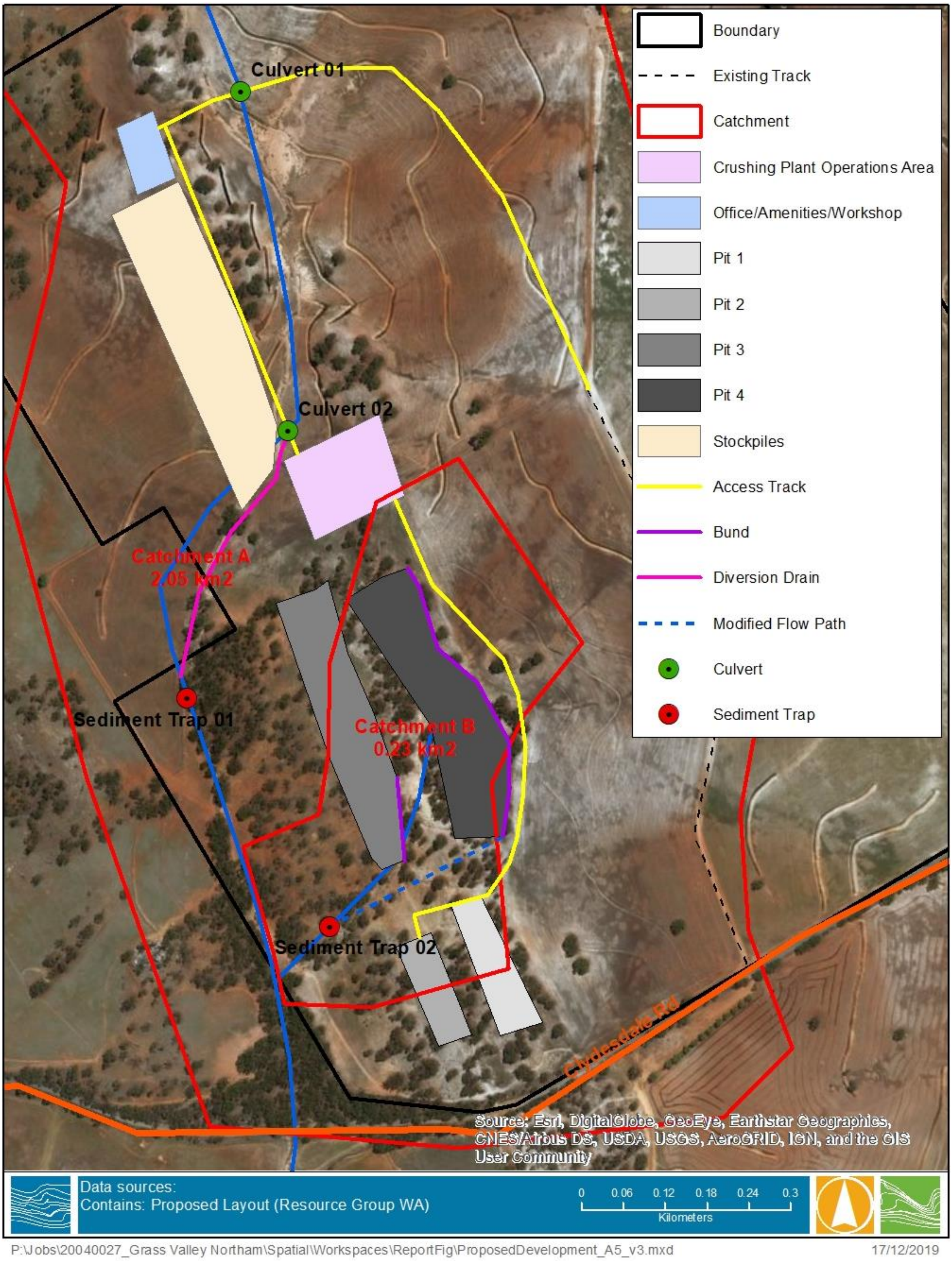

FIGURE 4-1 CONCEPTUAL SURFACE WATER MANAGEMENT PLAN

5 SURFACE WATER MANAGEMENT MEASURES

5.1 Diversion Channel

Due to the position of the stockpile, which overlays the creek alignment for a short section, the creek will need to be diverted in this location for the creek flow to be conveyed between the stockpiles and crushing facility. The diversion drain will also act as a cut-off drain by collecting any of the sediment laden water from the stockpile and prevent this runoff flooding the crushing facility. Any smaller diversion channels required for stormwater management of impacted runoff within the site were not sized as part of this study.

The diversion channel has been designed to convey impacted runoff towards the sediment pond before being released off site. Channel dimensions are presented in Table 5-1 and the conceptual alignment of the drain is indicated in Figure 4-1.

The channel was sized to accommodate the 1% AEP flood (plus a 0.3 m freeboard) according to Manning's equation as below:

$$Q = 1/n*A*R^{2/3} *S^{1/2}$$

where:

Q = flow rate (m^3/s)

A = cross-sectional area of channel (m^2)

n = roughness coefficient, assumed to be 0.05 for unlined channel

R = hydraulic radius (cross-sectional area, A, divided by wetted perimeter, P (m)), and

S = channel slope (m/m).

Trapezoidal drain profile was assumed and Manning's equation was solved for various channel dimensions using proprietary software.

As the catchment is relatively steep (approx. 10% longitudinal grade), to reduce the flow velocity in the drain a channel roughness coefficient of 0.06 has been assumed in the Manning's calculation. This is not a smooth channel and the channel roughness should be considered on detailed design of the drain, with consideration for rock lining of the channel, which is discussed further in Section 5.2.

Water Technology recommend a small bund/windrow be placed along the upgradient side of the diversion channel running adjacent the crushing facility.

The alignment and subsequent erosion protection requirements of the drain should be refined at detailed design phase.

TABLE 5-1 DIVERSION CHANNEL REQUIREMENTS

ID	Length (m)	Depth (m)	Channel Base Width (m)	Batter Slope (Vertical/Horizontal)	1% AEP Peak Flow (m^3/s)	10% AEP Peak Velocity (m/s)
1	390	1.2	2	1:3	3.4	2.5

5.2 Erosion Protection Measures

The results of the analysis indicate flow velocities within the proposed diversion channels are greater than >2 m/s (Table 5-1) which is likely to result in erosion at the outlet, subsequent sedimentation downstream and regular maintenance of the structures. Therefore, Water Technology recommends that rip-rap protection be provided along the base and batters slopes of the channel using facing or light class rock at a thickness of 0.5 to 0.75 m, as outlined in Table 5-2.

TABLE 5-2 EROSION PROTECTION SPECIFICATIONS

Velocity (m/s)	Class of Protection	Section of Thickness (m)
<2	None	-
2 – 2.6	Facing	0.5
2.6 – 2.9	Light	0.75
2.9 – 3.9	¼	1.0
3.9 – 4.5	½	1.25
4.5 – 5.1	1.0	1.6

The rip-rap specifications should be confirmed by a geotechnical engineer and the detailed design of the diversion drain should ensure the cross sectional area of flow is achieved as per Table 5-1, in addition to the erosion protection section of thickness.

5.3 Sediment Control Ponds

RG has been advised by Northam Shire to implement a plan to control fines from discharging downstream.

The management strategy adopted assumes all flow through disturbed areas is routed through a sediment control pond before final release into the drainage network. A number of sediment control ponds are proposed within the disturbed project area (see Figure 4-1). The sediment pond locations have been provided to Water Technology as part of the proposed site layout.

Two sediment control ponds are proposed, however, this may if the site layout is modified. For feasibility level design purposes sediment control ponds are recommended to be able to store runoff from the 10% AEP 6-hour rainfall event without any discharge. All ponds should have an emergency spillway in order to safely pass flow volumes greater than 10% AEP magnitude around the pond and off-site. Sediment control ponds should also have an aspect ratio (length:width) of not less than 3:1. Sufficient provision for dead (sediment) storage and freeboard should also be made.

Sediment control ponds should be routinely inspected and cleaned out to maintain design storage capacity and routinely monitored to ensure effectiveness and modified, if required, during routine inspection and clean out. The ponds should be designed to allow access for a bobcat to clean out the sediment. The ponds are sized to contain the 10% AEP 6-hour rainfall event and not the annual sediment load.

The regular inspections should ensure:

- There are no low points in retention structures that could overtop in a large storm event.
- Design capacity and minimum freeboard levels are maintained.
- Outlets are clear and operating as intended.

To estimate the minimum area required for trapping sediment during the 10-Year:6 hour ARI storm event the method below was used:

$$A = 1.2*Q/Vs$$

where:

A = minimum surface area for trapping soil particles (m^2)

Vs = Settling velocity of the design particles size chosen (5µm)

Q = Peak basin flow rate (m^3/s)

1.2 = factor of safety

$$Q = C*I*A$$

where:

Q = Peak basin flow rate (m^3/s)

C = Runoff coefficient (unitless)

I = rainfall intensity for the 10-Year: 6 hour ARI event (mm/hr)

A = catchment area (m^2)

Table 5-3 presents preliminary sediment pond sizing for the 10% AEP 6-hour AEP. Sediment pond sizes could be reduced significantly if soils are predominantly sand. This design is based on a finer sediment (0.005 mm) similar to that of a silty clay. More detailed sediment tests (i.e. sieve analysis) to classify soil characteristics would be required to more accurately quantify soil classification.

TABLE 5-3 SEDIMENT POND REQUIREMENTS

Pond ID	Catchment Area (km^2)	Required Basin Area (m^2)	Length (m)	Width (m)	Depth (m)
1	2.05	58,100	415	140	1.0
2	0.23	6,550	145	45	1.0

The results show that sediment pond 1, located 'online' to the Catchment 'A' creek, is potentially very large. While there is sufficient space in the proposed location to construct a basin of this size, for a number of reasons, constructing a basin of this size is not practical. Options to shift the sediment pond 'offline' from the creek should be considered. If located 'offline' the sediment pond can be sized based on the contributing area within the quarry development, rather than including the additional upstream 'clean' catchment. While a number of sediment ponds would be required for this approach, the size of each pond would be significantly smaller than is shown in Table 5-3 for sediment pond 1.

An indicative concept for the smaller ponds is shown on Figure 5-1 below, with pond sizes provided in Table 5-4.

TABLE 5-4 'OFFLINE' SEDIMENT POND REQUIREMENTS

Pond ID	Catchment Area (km^2)	Required Basin Area (m^2)	Length (m)	Width (m)	Depth (m)
1	0.045	1,260	63	20	1.0
2	0.23	6,550	145	45	1.0
3	0.018	500	39	13	1.0

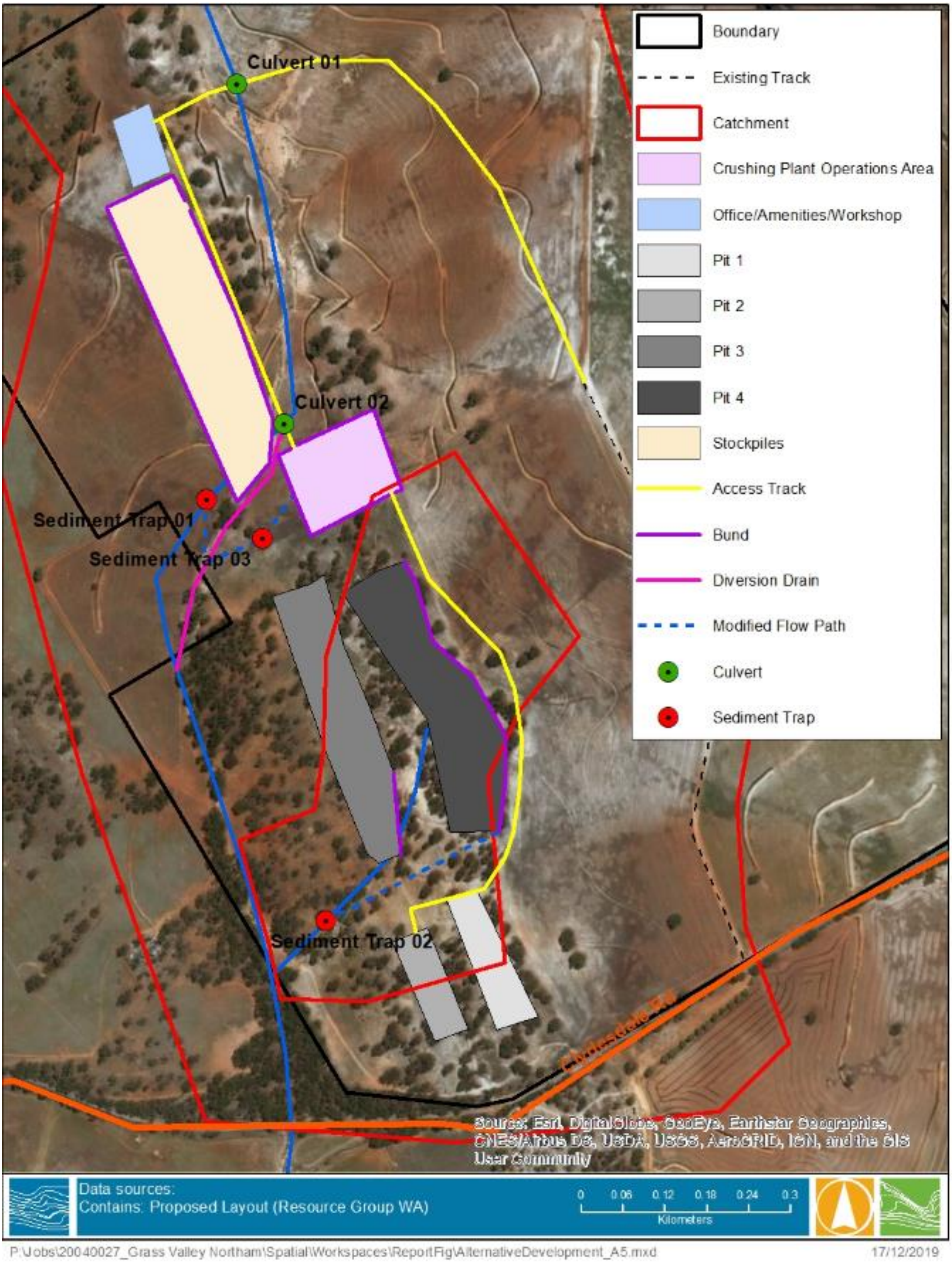

FIGURE 5-1 ALTERNATIVE SURFACE WATER MANAGEMENT PLAN

5.4 Road Crossings

Based the proposed track layout Water Technology has identified two locations where the roads cross the creek within Catchment A. The appropriate level of serviceability for these crossings depends on the importance of access to and from the site during a major storm event, but the additional maintenance works required if the culvert overtops (i.e. scour) should also be considered.

Generally, road crossings will meet at least a 20% AEP level of service, but for significant roads a 5% or 1% AEP may be more appropriate.

TABLE 5-5 CATCHMENT 'A' ROAD CROSSING CULVERT SIZES FOR VARIOUS AEP'S

ID	20% AEP	5%AEP	1%AEP
Peak Flow Estimate	0.90	1.94	3.39
Culvert 01	2 x Φ 450 mm	2 x [450x 600 mm] box	3 x [600x 600 mm] box
Culvert 02	2 x Φ 450 mm	2 x [450x 600 mm] box	3 x [600x 600 mm] box

Water Technology recommend adopting the 5% AEP flow for Culvert 01, servicing the main entrance road. The other internal tracks can adopt a lower service level.

If the final alignment of the track from the office to the crushing facility crosses over the diversion drain, it should be noted that the diversion drain profile will need to flare out in the location of the track crossing to at least the width of the culverts installed.

5.5 Flood Protection Bunds

5.5.1 Current Proposal

With implementation of the diversion drain around the stockpile, only minor bunding is required around the site as shown in Figure 4-1.

During pit development, the pit perimeter on the up-gradient side could be bunded to minimise runoff volumes reporting to the pit from any minor upslope areas. This would comprise construction of small bunds with a height of 1m, with the toe of the bund graded longitudinally to direct water around the pit and back to the natural gully.

5.5.2 Alternative Sediment Pond Design

More bunding will be required if the alternative management plan is adopted to allow construction of smaller sedimentation ponds. Bunding will be required around the stockpile and crushing facility as shown in Figure 5-1, with the Stockpile bund the most significant. The bunding will be required to store the 1% AEP outside of the creek, with a decant flow to the sediment pond via a pipe outlet.

5.6 Spill Mitigation Measures

To prevent surface runoff contamination, any fuel, oil and chemical storage areas, and wash-down facilities should be contained by adequate bunding in accordance with the appropriate regulations.

This report assumes these measures will be in place and the concept design of these structures is outside the scope of this report.

6 CONCLUSIONS AND RECOMMENDATIONS

In summary, Water Technology conducted a flood modelling assessment to derive surface water protection measures the Grass Valley site to primarily limit sediment movement and prevent inundation of active quarry areas. Given the position of the quarry near the top of the catchment, runoff within the development area is relatively insignificant and only minimal surface water management is required to control overland flows. As such only minor diversion channels and bunding are recommended to mitigate flooding and prevent downstream impacts.

Site investigations to date have not encountered groundwater and no groundwater management measures are proposed in this report. Further investigations are proposed to try and locate a suitable groundwater supply for the quarry operations. Water technology recommend a groundwater impact assessment is completed if a groundwater source is located.

To prevent surface runoff contamination from any fuel, oil or chemical storage areas, and wash-down facilities should be contained by adequate bunding in accordance with the appropriate regulations. This report assumes these measures will be in place and the concept design of these structures is outside the scope of this report.

In the absence of any streamflow or rainfall data (closest gauge to the study area is over 60 km away) within the Study Area's catchment, RFFE has been adopted to provide design peak flow estimates for this study. The design peak flows are tabulated in Table 3-1 and illustrated in Figure 3-3. While this is the best estimate given the available data in the area, it is important to note that the variation on the estimate's confidence limits increase as the events becomes rarer, to approximately a factor of 4. The surface water management measures outlined in Section 5 are based on the design event flow, which has the potential to be underestimating the peak flow.

Based on the assessment detailed above the following comments and associated surface water management recommendations are made:

- One diversion drain is required to divert the Catchment A creek around the stockpile and crushing facility. Water Technology recommends this drain is sized to the 1% AEP flood level (plus a 0.3 m freeboard) given its importance to the operation. Alignment and subsequent erosion protection requirements should be refined at detailed design phase.
- Two sediment control ponds are proposed. Water Technology's assessment of the Catchment 'A' sediment pond indicates an impractically large pond, and we recommend options are considered to manage sediment using a number of smaller ponds 'offline' from Catchment 'A' creek. The ponds have been sized to allow settlement of fines during the 10-Year 6-hour event only and have not been sized to contain the annual load. Greater detail on embankment conditions (e.g. slope, material) and sediment characteristics are required to refine the concept and Water Technology recommends this be completed at detailed design phase. All sediment ponds should be designed with an inlet and spillway to safely release a rainfall event >10% AEP.
- Culvert crossings are required in two locations where tracks cross Catchment 'Á' creek. Water Technology recommend the creek crossing for the main entrance road is serviceable up to the 5% AEP rainfall event. The internal track crossing can be designed to a lower level of serviceability.
- Modelling results also provided guidance on erosion control requirements across the site. Analysis shows that erosion protection is required in the majority of the proposed diversion channel due to velocities assessed to be >2m/s.

Once additional information is available, Water Technology recommend detailed design of the aforementioned surface water structures in and around the development area to prevent 'sediment laden/contaminated' runoff being transported off-site into the downstream environments.

Recommended work and data required to further refine the surface water management onsite include:

- Assessment of soil samples to refine sediment pond sizing;
- High resolution LIDAR of the entire site to allow catchment areas to be refined and to avoid 'banding' and 'blocky' levels in detailed flood mapping; and
- Any available data and information from existing geotechnical investigations carried out on site (from test pits) to support design studies and construction specifications for surface water management infrastructure.

7 REFERENCES

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