Oparure Quarry South-Western Pit: Erosion and Sediment Control Toolkit

Prepared for

Graymont (NZ) Limited

13 July 2026

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Quality Control Sheet

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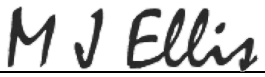
SIGNATURE  

Mark Ellis Blair Thornburrow

Limitations:

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1.0 Introduction

Graymont (NZ) Limited (Graymont) is developing the Oparure Quarry South-Western Pit (SW Pit) on Oparure Road, Te Kuiti. This document outlines the process to design the erosion and sediment control infrastructure to manage erosion and stormwater laden sediment, associated with the construction and operation of the SW Pit and new haul road.

The SW Pit may open potentially 59.6 hectares (ha) by 2053, although by 2053 some the 37.7 ha of the 59.6 ha is anticipated to have been backfilled with rehabilitated overburden. The SW Pit and associated mining infrastructure include the construction of the following:

- Haul road (1,300 m or 3.0 ha)
- New pit (SW Pit)
- Engineered Landform in the new pit (SW Pit)

Note – the placement of overburden in the Engineered Landform in the Oparure Quarry is covered in detail in the Oparure Erosion and Sediment Control Plan.

Erosion and sediment control (ESC) facilities are required around and within these elements to mitigate the potential adverse effects that sediment entrained in the stormwater runoff may have on the environment. The development of the Erosion and Sediment Control Plan (ESCP) and this toolkit reflect the requirements set out in the conditions of consent.

2.0 Purpose

As outlined in Figure 1, Graymont has established structured framework to manage the sediment and site stormwater associated with the SW Pit. Whilst the ESCP and associated ESC Stage Plans specifically document how the sediment and stormwater is managed, they draw upon the designs listed in the Oparure Quarry South-Western Pit Erosion and Sediment Control Toolkit ('Toolkit', being this document). The Toolkit has been developed to provide a suite of methods, assumptions, and details of how the erosion control devices are designed, typical layout and construction details.

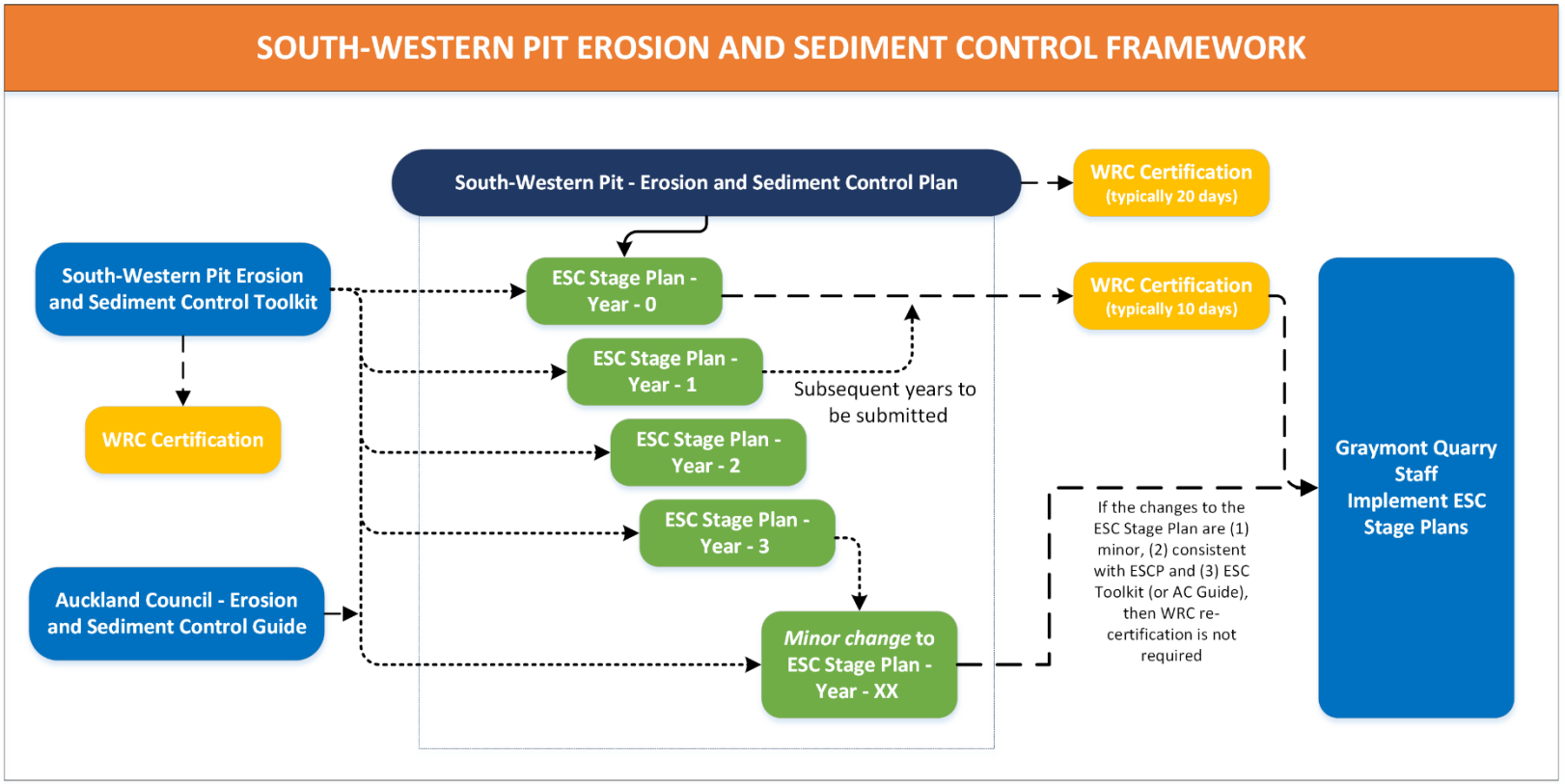


Figure 1: South-Western Pit Erosion and Sediment Control Framework

2.1 Roles and Responsibilities

This Toolkit has been developed for the use of the **Quarry Engineer**, specifically to aid the development of ESC Stage Plans, which are intended to be periodically updated as the quarry expands and evolves, and in response to any specific erosion and sediment control matters.

As outlined in the ESCP the roles of monitoring the implementation of the ESCP, water quality sampling, inspection of the performance of the ESC measures have been allocated to the **Environmental Advisor** and **Oparure Superintendent**; refer to the ESCP for specific roles and responsibilities.

3.0 Design Basis

3.1 Reference Documents

The following documents have been used in preparation of this Toolkit:

1. Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region (Auckland Council GD2016/005).
2. Hydraulic Design of Highway Culverts. Third Edition. U.S. Department of Transportation Federal Highway Administration. April 2012
3. HY-8 Culvert Hydraulic Analysis Program. U.S. Department of Transportation Federal Highway Administration.
4. Theory and Practice of Water and Wastewater Treatment. Ronald L Droste. 1997

3.2 Rainfall Intensity

The erosion and sediment control infrastructure shall be designed in accordance with the high intensity rainfall table presented in Appendix A. The rainfall depths are site-specific for the Oparure Quarry and have been extracted from the High Intensity Rainfall Design System (HIRDS, V4) https://hirds.niwa.co.nz/.

The rainfall depths, presented in Appendix A, have accounted for changes in rainfall intensity associated with climate change impacts, specifically they have considered a RCP4.5 climate change scenario for the period between 2031-2050.

3.3 Level of Service

The erosion and sediment control measures in this toolkit have been designed for the levels of service Table 1, accordance with the ESCP.

Table 1: Level of Service	
Control Measure	**Level of Service**
Clean Water Diversions	2% AEP
Short-Medium Term Dirty Water Diversions (< 5 years)	5% AEP
Long Term Dirty Water Diversions (>5 years)	2% AEP
Water Table Drains (alongside Haul Roads)	2% AEP
Culverts under Haul Roads	2% AEP
Sediment Retention Pond for Cropping Fields or Topsoil Stockpile	5% AEP
Emergency Spillway of Sediment Retention Pond	1% AEP
In-Pit Sediment Retention	5 % AEP, max. of 2 days storage
In-Pit Sediment Infiltration Pond	50% AEP

Quarry impacted stormwater will be passed through several erosion and sediment controls before being ultimately directed to the quarry pit. The quarry-impacted stormwater will be directed to one or more low points in the pit (sumps), where the stormwater will be retained within the pit sump; within these low points the 'In-pit Sediment Infiltration Pond' (refer Section 4.6) will be excavated/engineered to filter out the majority of the residual sediment in the stormwater prior to infiltration into the Karst System.

4.0 Toolkit

The toolkit includes the following components:

- Toolkit A: Design Flow Estimation
- Toolkit B: Channel Design
- Toolkit C: Culvert and Pipe Drop Structure Design
- Toolkit D: Sediment Retention Pond Design (for Cropping Fields and Topsoil Stockpile Areas)
- Toolkit E: In-pit Sediment Infiltration Pond Design

For ESC measures not specifically addressed in the above toolkits, then either (1) seek specialist advice from a suitably qualified and experienced Stormwater Engineer or (2) follow the guidance in the Auckland Council Erosion and Sediment Control Guide of Land Disturbing Activities in the Auckland Regional (correct for site specific rainfall intensities as shown in Appendix A).

4.1 Catchment Delineation

Delineating a stormwater catchment, also known as a watershed or drainage area, is the process of defining the boundary within which all stormwater runoff flows to a single, common outlet point (e.g. a specific ESC structure). This in turn will be used to predict the stormwater volume and/or peak discharge the ESC structure must manage.

Delineation can often be undertaken automatically in GIS (or topographical survey software) or determined manually (described below). Manual delineation is based on the principle that water flows downhill, perpendicular to the contour lines, to the lowest point, as the following method outlines:

1. *Identify the Outlet Point*: Locate the specific point on the map where you want to determine the contributing area. This might be an ESC measure, channel, culvert, or ultimately the In-pit Sediment Retention Pond.
2. *Locate Uphill Streams and Channels*: Trace the water bodies and channels that flow into the outlet point. Look for V-shaped contour lines that point toward the higher elevation, as this indicates a valley or drainage path.
3. *Find the Ridgeline/Divide:* Start at the outlet point and begin drawing the boundary line. This line, called the drainage divide or ridgeline, should always intersect the highest elevation points between the drainage area you're defining and the adjacent drainage areas.
4. *Cross Contour Lines Perpendicularly:* As you draw the boundary, ensure the line is always perpendicular (at a 90-degree angle) to the contour lines. This is the path water won't follow, as it marks the boundary where a drop of rain would flow to one watershed if it fell on one side, and to the adjacent watershed if it fell on the other.

   Hint: When contour lines "point" uphill (a V-shape opening downhill), it's a valley; the divide will cross near the point of the V. When they "point" downhill (a V-shape opening uphill), it's a ridge; the divide will follow the spine of the ridge.
5. *Connect High Points:* Connect all the marked high points and perpendicular-crossing points until the boundary line closes back to the original outlet point.

6. Verify the Catchment: As a check, imagine a drop of water falling at various points along your delineated boundary. It should always flow outside the area on one side and inside the area toward the outlet on the other.

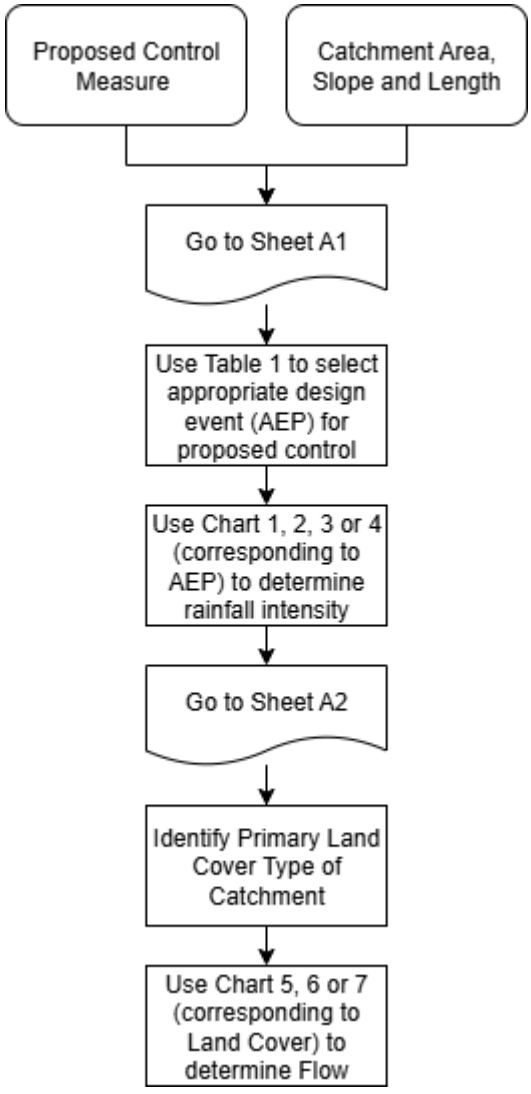
4.2 Toolkit A: Design Flow Estimation

4.2.1 Purpose

Toolkit A is used as the preliminary step to determine the expected flow from the catchment of interest, which is necessary for sizing the erosion and sediment controls covered in Toolkits B-E. Toolkit A can be used to calculate the design flow for any of the levels of service discussed in Section 3.3.

4.2.2 Design Method

Use Toolkit A (Sheet A1-A2) to determine the flow that must be managed from the catchment of interest. The method is shown in Flowchart 1.



Flowchart 1: Design Flow Estimation

4.3 Toolkit B: Channels

4.3.1 Purpose

The channel design in this toolkit can be used for clean water diversion channels, dirty water diversion channels and water table drains, up to 1 metre in depth (including 300 mm of freeboard).

If the channel is complex and/or needs to be greater than 1 metre in depth, then Graymont shall seek advice of a specialist Stormwater Engineer to develop a custom design solution.

4.3.2 Description

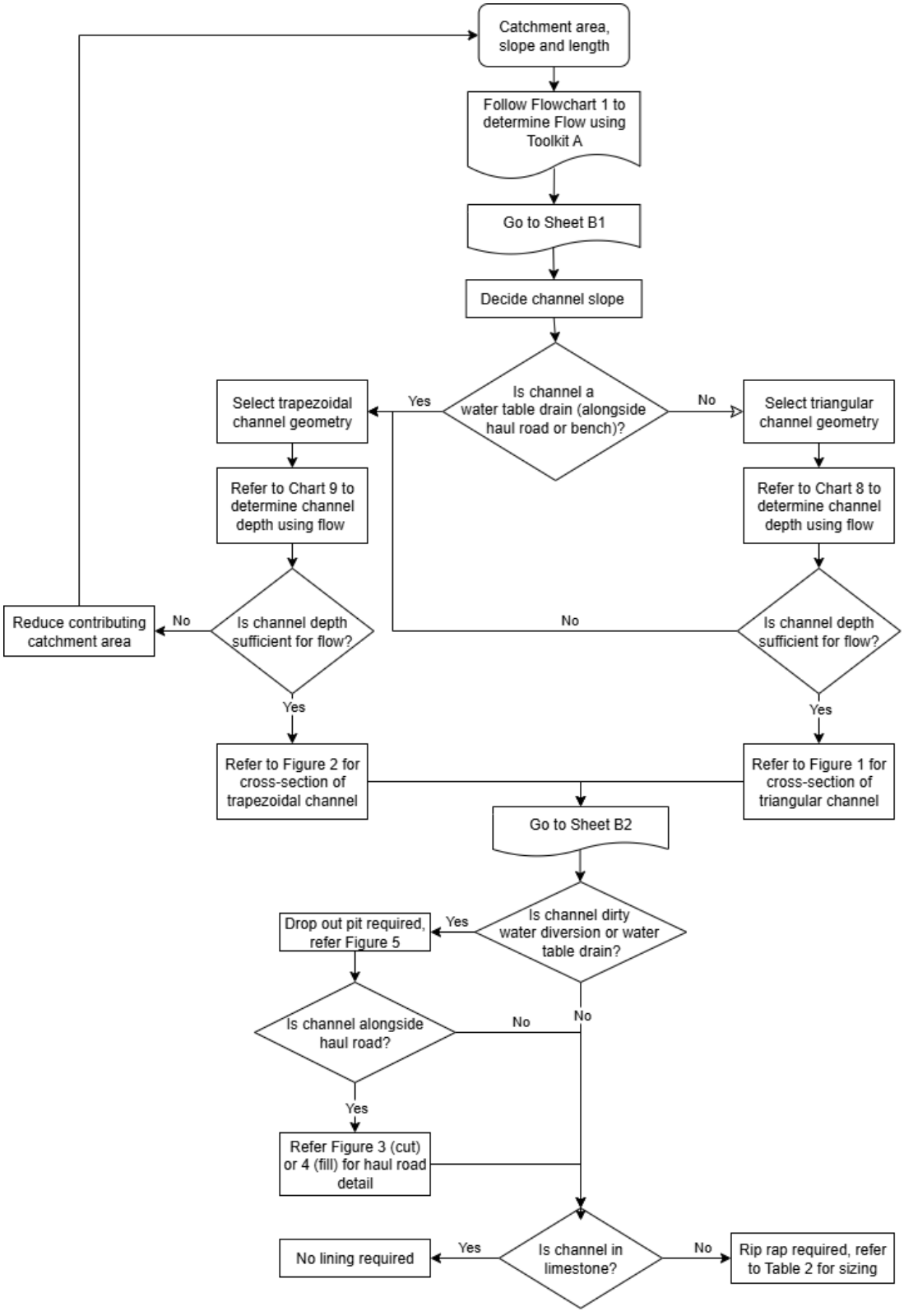
- Clean water diversion channels will capture clean water on the up-gradient side of the site to prevent it from flowing through the site and picking up sediment. Clean water diversion channels can be either triangular or trapezoidal (selection will depend on flow) and will have bunds on the down-gradient side.
- Dirty water diversion channels will capture dirty (i.e. sediment-laden) water from the site and direct it into sediment ponds (refer Section 4.5 or 4.6). Dirty water diversion channels can be either triangular or trapezoidal (selection will depend on flow) and will normally have bunds on the down-gradient side.
- Water table drains will be located alongside the haul roads to convey sediment-laden runoff around the carriageway to improve the road stability. They will also be located along the benches, adjacent to the high-wall, to convey sediment-laden runoff along the benches to a drop structure. The water table drains will discharge into sediment ponds (refer Section 4.5 or 4.6) via culverts (Section 4.4). Water table drains will be trapezoidal and will not have a bund, as they will be cut into the existing slope.

Both the dirty water diversion channels and water table drains require sediment drop out pits to be constructed into the channel at least every 40 metres, to allow sediment to drop out of the water in a confined location. An excavator can be used to empty these pits as required.

All channels (clean water, dirty water and water table) need to be lined with rip rap, unless they are being constructed in limestone (in which case no lining is required). For medium to long-term channels, with slopes greater than 4%, there is a risk the rip rap will be dislodged during a heavy rainfall event; high risk channels should be grouted in place with concrete.

4.3.3 Design Method

Use Toolkit B (Sheet B1-B2) to size and construct the channels. The method is shown in Flowchart 2.



Flowchart 2: Channel Design

4.3.4 Operation and Maintenance Requirements

As outlined in the ESCP Trigger Response Action Plan, the Haul Road water table drains shall be visually inspected following heavy rainfall and weekly.

4.4 Toolkit C: Culverts and Pipe Drop Structures

4.4.1 Purpose

The culverts and pipe drop structures in this toolkit can be used for conveying flow from water table drains under the haul road, and for conveying flow down over the benches into the quarry pit.

4.4.2 Description

To convey flow from a water table drain (refer Section 4.3.2) under the haul road, a culvert is required. The culvert can be reinforced concrete RRJ or PE material, and will be sized based on flow from the contributing catchment. As outlined in Table 3, in Sheet C1, culvert sizes between DN300 and DN450 have been specified and can convey up to 0.25 m^3/s of flow. If the required conveyance flow is greater than 0.25 m^3/s, then (1) the a number of culverts, of the same diameter, could in install in the crossing, or (2) additional channels could be installed to reduce the contributing catchment area.

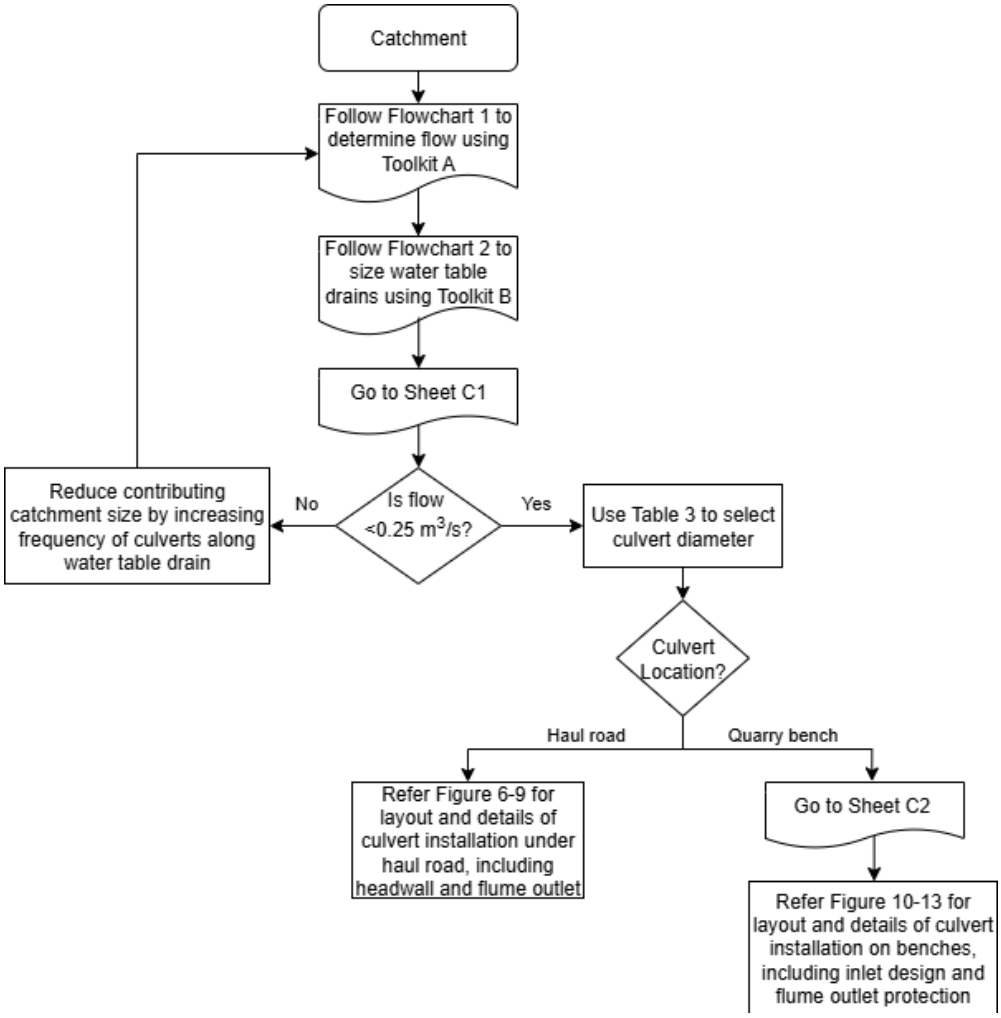
Culverts will have a headwall constructed of Dricon Culvert Bags (or similar approved) to provide stability and protect the haul road foundation. A safety barrier will be constructed on the crest of the haul road using boulders (or a limestone bund), to provide a minimum separation of 1.5 m between the culvert headwall and the traffic. The minimum cover required for the culvert is subject to traffic loading requirements and shall not be less than 500 mm.

A Cirtex Aquaduct Flume (or similar approved flexible flume) will be attached to culvert outlets. This flume will act as a pipe drop structure to convey water down benches. The flume should be the same diameter as the culvert it is connecting to. It is critical that the flume is properly secured at the culvert outlet and at the downstream end, and if practical the flume it should be pinned along the length (in accordance with the manufacturer's instructions).

As presented in Sheet C2, the outlet of the flexible flume shall discharge into a water table drain with a Gabion Dissipation Basket, to absorb the energy of the water as it falls down the bench. To direct the flow into a subsequent culvert and flexible flume, as Sheet C2 demonstrates, a bund will be constructed in the water table drain to direct the flow into the culvert. It should be noted that the contributing catchment and design flow in the water table drain, culvert and flexible flume progressively increases as the water steps down the highwall.

4.4.3 Design Method

Use Toolkit C (Sheet C1 to C2) for the culvert sizing and design details for haul roads and benching drop-structures. The method is shown in Flowchart 3.



Flowchart 3: Culvert Design

4.4.4 Operation and Maintenance Requirements

As outlined in the ESCP Trigger Response Action Plan, the culverts shall be visually inspected following heavy rainfall and weekly.

4.5 Toolkit D: Sediment Retention Ponds

4.5.1 Purpose

The sediment retention pond (SRP) design in Toolkit D should be used for two purposes:

- To manage sediment-laden runoff from cropping fields as part of the Cropping Field Management Plan; and
- To manage sediment-laden runoff from topsoil stockpile areas.

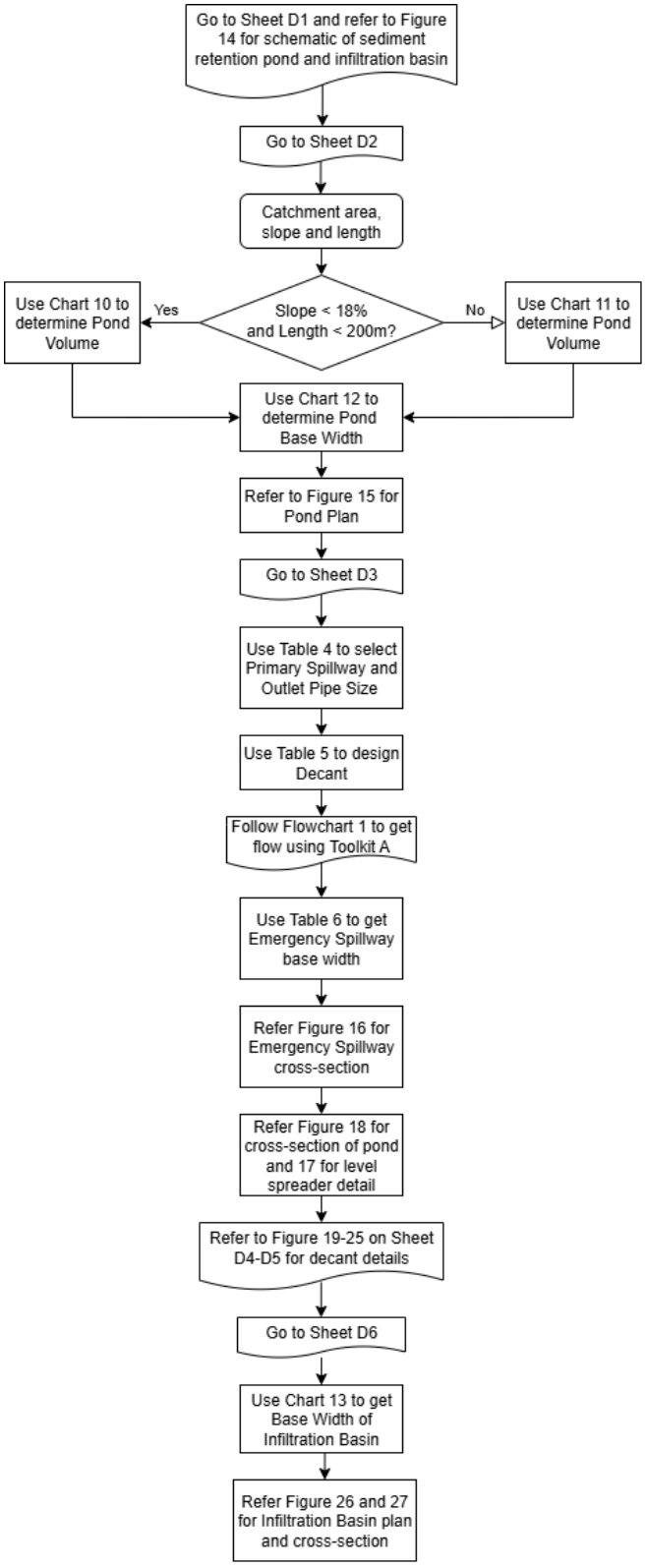
The SRP design should not be used within the quarry pit; a separate design for an In-Pit Sediment Retention Pond has been developed, refer to Section 4.6.

4.5.2 Description

The SRP will receive sediment-laden runoff via dirty water diversion channels (refer to Section 4.3). The runoff will enter the sediment forebay, then pass over the level spreader into the main pond. The flow will exit the pond via a decant system which connects to the outlet pipe. The outlet pipe will discharge into a grassed infiltration basin, where the flow will filter through the base of the pond into the soil column.

4.5.3 Design Method

Use Toolkit D (Sheet D1-D6) to size and construct the SRP and infiltration basin. The method is shown in Flowchart 4.



Flowchart 4: Sediment Retention Pond Design

4.5.4 Operation and Maintenance Requirements

Inspection Frequency:

- Fortnightly; and
- Before and after each heavy rainfall event.

Sediment Removal:

- Clean out main pond before the accumulated sediment volume reaches 20% of the total SRP volume. To assist with this, the 20% volume height should be marked on the decant riser during construction.
- Use excavators to remove sediment and load onto sealed tip trucks.
- Ensure excavator access to the forebay is maintained at all times.
- Remove sediment from the forebay after each rainfall event if there is any evidence of sediment deposition.

Repairs:

- Immediately repair any damage to SRP or forebay caused by erosion or construction equipment.

4.6 Toolkit E: In-Pit Sediment Infiltration Ponds

4.6.1 Purpose

Toolkit E provides the design for sediment infiltration ponds (SIPs) which are to be located in the quarry pit itself. The current design in Toolkit allows for a catchment of up to 5 ha being directed to a single in-pit SIPs. If the catchment directed to the quarry pit exceeds 5 ha, then the divide the catchment into sub-catchments not exceeding 5 ha and install multiple SIP; alternatively seek specialist input to the design of the SIP.

The SIPs have been designed as rapid sand filters, designed to reduce the sediment load passing through the quarry floor into the Karst system.

4.6.2 Description

In-pit SIPs are designed to capture stormwater in the base of the pit and provide infiltration of treated stormwater through quarry floor into the Karst system. Sediment-laden water will be conveyed to the in-pit SIP via dirty water diversion channels (see Section 4.3).

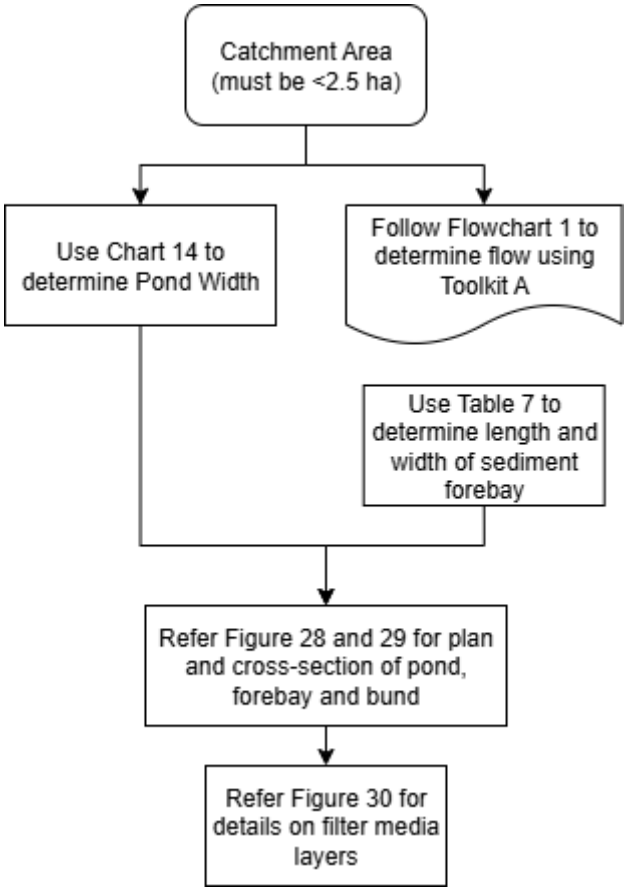
The in-pit SIP will be excavated into the limestone on the quarry floor. It will include a 1 metre deep sediment forebay, which will receive the flow from the dirty water diversion channels. The forebay is designed to allow sand size (and greater) sediment to drop out of the water and settle on the base. Water then flows over via a short channel to the SIP. The SIP will be 1.75 m deep, excavated into the limestone, with approximately vertical walls. The end nearest the forebay will have 0.5 m steps built in for safe exit. The main pond will have filter media installed underneath to allow infiltration, as illustrated in Sheet E1.

For safety, a 500 mm high compacted limestone bund shall be constructed around the SIP and forebay, with an opening for a front-end loader to reach the forebay and remove settled sediment.

It should be noted that during heavy rainfall events the SIP will be inundated, and stormwater will pond on the quarry floor. The size of the SIP has been minimised so as to maximise space for quarrying activities; as a consequence, it is anticipated that the quarry floor inundation may extend for up to two days during heavy or prolonged rainfall events.

4.6.3 Design Method

Use Toolkit E (Sheet E1) to size and construct the in-pit sediment infiltration pond. The method is shown in Flowchart 5.



Flowchart 5: In-pit Sediment Infiltration Pond Design

4.6.4 Operation and Maintenance Requirements

Inspection Frequency:

- Weekly; and
- Before and after each rainfall event.

Sediment Removal:

- Clean out Infiltration Pond when the rate of infiltration is compromised. This will involve scraping out the top 100mm of the upper sand layer, and replacing with clean (or washed) No.1 Sand (either aggregate or limestone derived sand).
- Ensure excavator access to the forebay is maintained at all times.
- Remove sediment from the forebay after each rainfall event if there is any evidence of sediment deposition.
- Use excavators to remove sediment and load onto sealed tip trucks.

Repairs:

- Immediately repair any damage to SIP, forebay or bund caused by erosion or construction equipment.

5.0 Toolkit Register

Graymont shall keep a Register of all erosion and sediment control devices implemented on the Quarry, specifically all devices that have been designed in accordance with this Toolkit. The Register shall include date of design, construction, and reference the relevant Toolkit.

6.0 Toolkit Approval and Revision

This toolkit shall be reviewed, redrafted, and certified in accordance with the Resource Consent Conditions, and Graymont's management procedures.

Once certified, the Toolkit shall be reviewed at least every three years by Graymont and if material changes are made then the Toolkit shall be submitted to WRC for re-certification.

More frequent reviews may also occur due to any significant change in the operations of the SW Pit or findings from any incidents and community complaint investigations. Reasons for making changes to Toolkit shall be documented. A copy of the original Toolkit and subsequent versions will be kept and marked as obsolete. Each new/updated version will be issued with a version number and date to prevent obsolete documentation from being used.

Appendix A: Design High Intensity Rainfall Depths (HIRDS)

The HIRDS (Version 4) was assessed to predict the design high intensity rainfall depths for the proposed ESC structures (https://hirds.niwa.co.nz/). The table below represents the rainfall depth-duration-frequency (measured in mm) based the RCP4.5 (4.5 W m^{-2} representative concentration pathway) scenario for the period 2031-2050; as identified by the IPCC Fifth Assessment (IPCC, 2013).

Table A1: Erosion and Sediment Control – Design Rainfall Depth-Duration-Frequency Table

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	10.4	14.4	17.4	23.6	31.6	48.9	63.4	81.5	103	118	130	140
2	0.5	11.4	15.8	19	25.8	34.6	53.3	68.9	88.2	112	128	140	151
5	0.2	15	20.6	24.7	33.4	44.5	67.9	87.4	111	140	160	175	187
10	0.1	17.8	24.3	29.1	39.1	51.9	78.8	101	128	161	183	200	214
20	0.05	20.7	28.2	33.7	45.1	59.6	90.1	115	145	182	206	225	240
30	0.033	22.5	30.6	36.5	48.8	64.4	96.9	123	155	194	220	240	256
40	0.025	23.8	32.4	38.6	51.5	67.8	102	130	163	203	230	250	267
50	0.02	24.9	33.8	40.2	53.6	70.5	106	134	169	210	238	259	276
60	0.017	25.8	35	41.6	55.4	72.7	109	138	173	216	244	266	283
80	0.012	27.2	36.8	43.7	58.2	76.3	114	144	181	225	254	276	295
100	0.01	28.3	38.3	45.5	60.4	79.1	118	149	187	232	262	285	303
250	0.004	33.1	44.6	52.8	69.8	91	135	170	211	261	294	319	339

Appendix B: Toolkits

A1

INSTRUCTIONS

1. USE TABLE 1 TO SELECT DESIGN EVENT.
2. REFER TO CHART FOR CHOSEN DESIGN EVENT, AND USE CATCHMENT LENGTH AND SLOPE TO DETERMINE RAINFALL INTENSITY WHERE:
   - 2.1. LENGTH SHALL BE TAKEN AS THE DISTANCE FROM THE FURTHEST POINT IN THE CATCHMENT TO THE CONTROL MEASURE BEING DESIGNED; AND
   - 2.2. SLOPE SHALL BE TAKEN AS THE AVERAGE SLOPE ALONG THIS DISTANCE.
3. PROCEED TO SHEET A2 TO DETERMINE FLOWS.

TABLE 1: DESIGN EVENT SELECTION

CONTROL MEASURE	DESIGN EVENT
CLEAN WATER DIVERSION	2% AEP
HAUL ROAD WATER TABLES	2% AEP
HAUL ROAD CULVERTS	2% AEP
SHORT-MEDIUM TERM DIRTY WATER DIVERSIONS (<5 YEARS)	5% AEP
LONG TERM DIRTY WATER DIVERSIONS (>5 YEARS)	2% AEP
SEDIMENT RETENTION POND FOR CROPPING FIELDS OR TOPSOIL STOCKPILE	5% AEP
EMERGENCY SPILLWAY OF SEDIMENT RETENTION POND	1% AEP
IN-PIT SEDIMENT RETENTION	5% AEP, MAX OF 2 DAYS STORAGE
IN-PIT SEDIMENT INFILTRATION POND	50% AEP

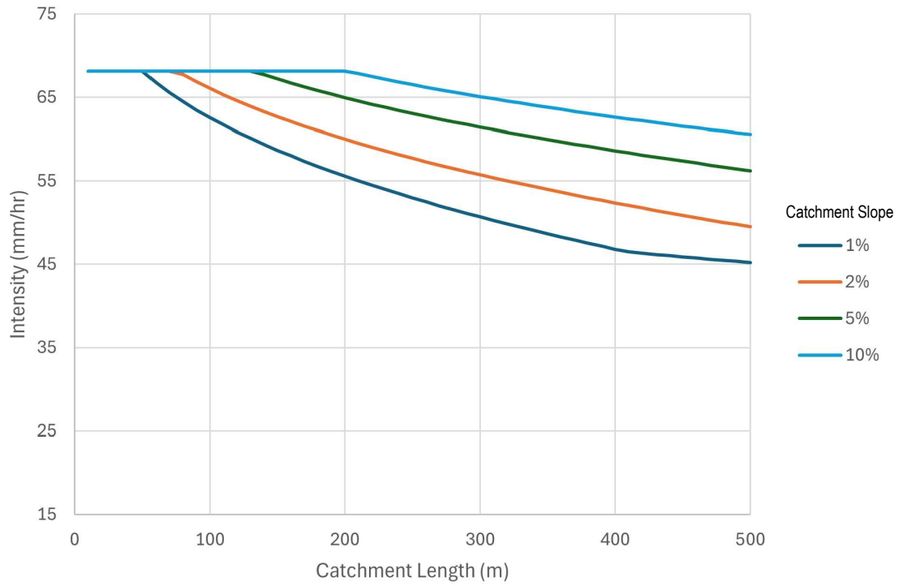


CHART 1: INTENSITIES FOR 50% AEP EVENT

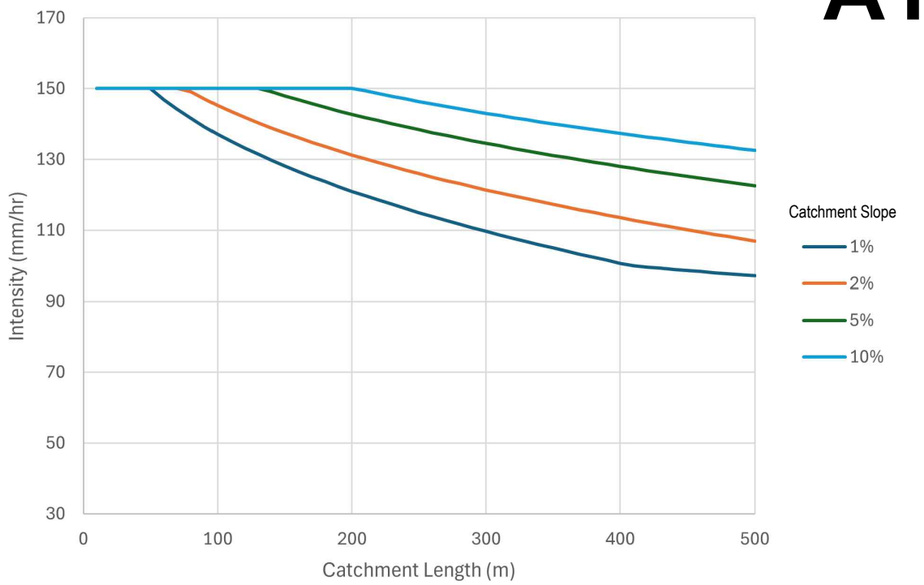


CHART 3: INTENSITIES FOR 2% AEP EVENT

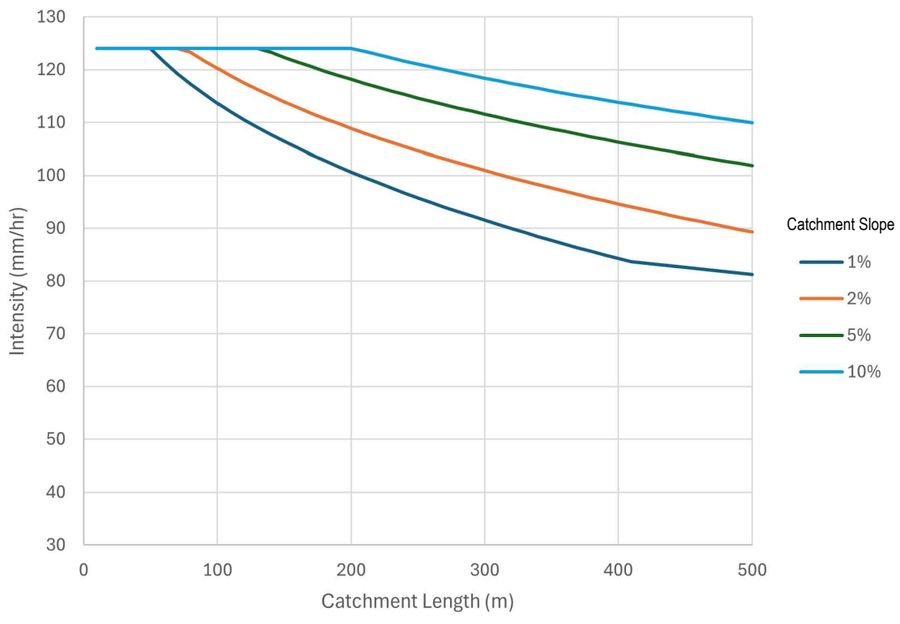


CHART 2: INTENSITIES FOR 5% AEP EVENT

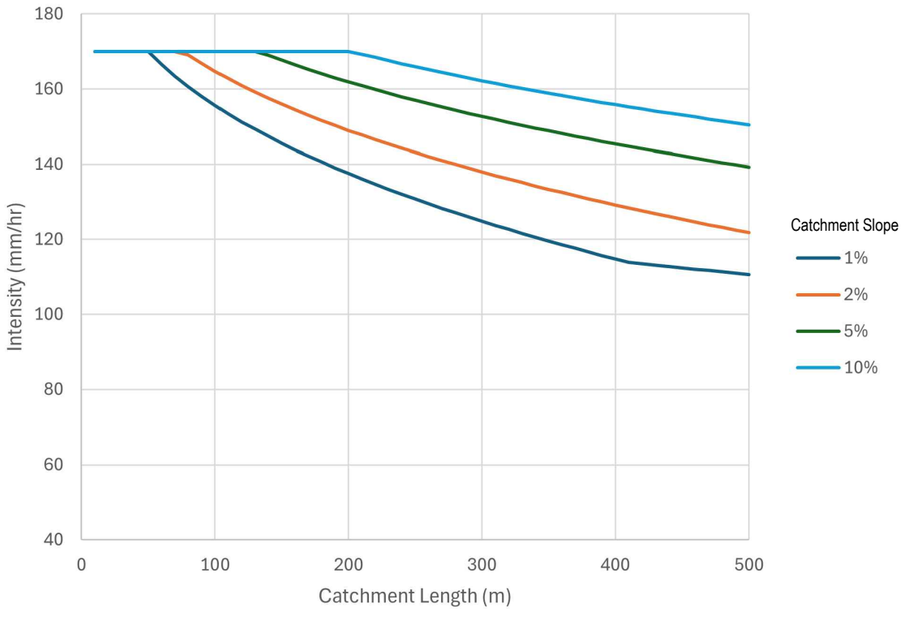


CHART 4: INTENSITIES FOR 1% AEP EVENT

FOR CONSENT

ORIGINAL DRAWING IN COLOUR

NO.	REVISION	DATE	APP.
C	FOR CONSENT	JUL 26	
B	DRAFT FOR CLIENT REVIEW	JUN 26	
A	DRAFT FOR CLIENT REVIEW	OCT 25	

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PROJECT: OPARURE QUARRY SOUTH-WESTERN PIT ESC TOOLKIT

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DRAWN	DRAWING CHECK	DATE	THIS DRAWING IS NOT FOR CONSTRUCTION UNLESS SIGNED AS APPROVED	
L.C		OCT 25		

TOOLKIT A: FLOWS
DESIGN EVENTS

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A2

INSTRUCTIONS

1. SELECT CHART WHICH CORRESPONDS TO PRIMARY COVER TYPE OF CATCHMENT (PASTURE/GRASS, EXPOSED SOIL OR EXPOSED LIMESTONE).
2. USING DESIGN RAINFALL INTENSITY FROM SHEET A1 AND CATCHMENT AREA, DETERMINE THE **DESIGN FLOW** FROM THE GRAPH.

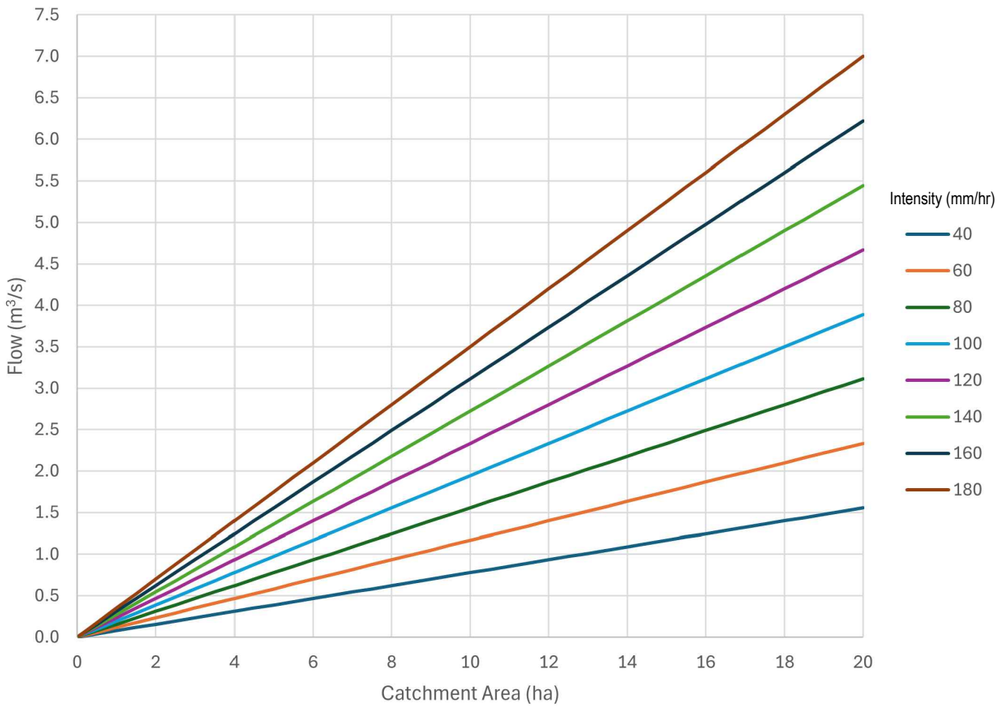

CHART 5: FLOWS - LIMESTONE CATCHMENT

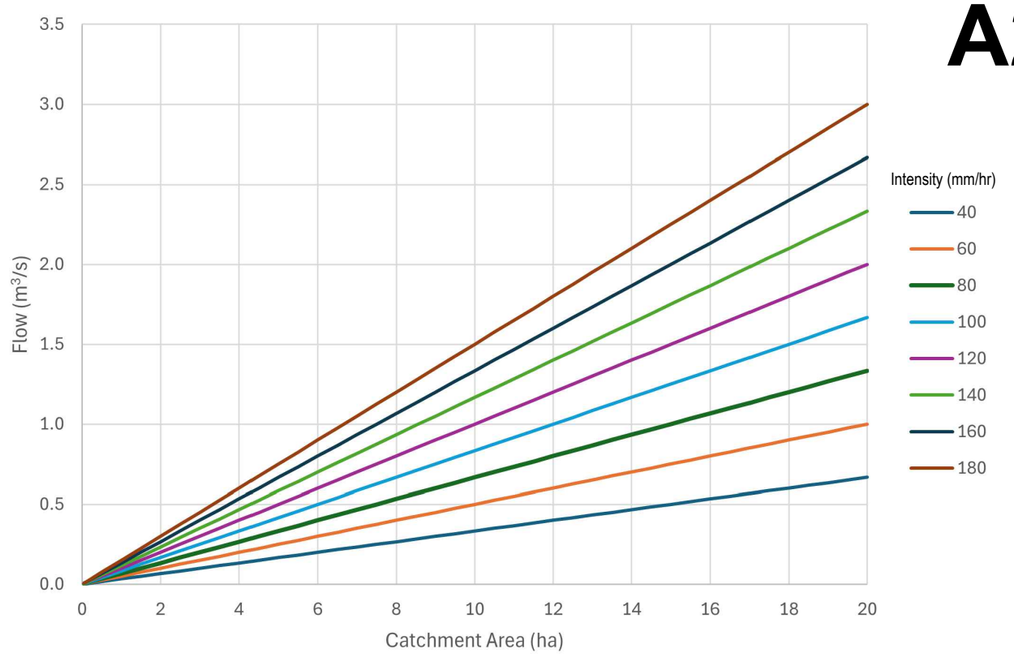

CHART 6: FLOWS - PASTURE/GRASS CATCHMENT

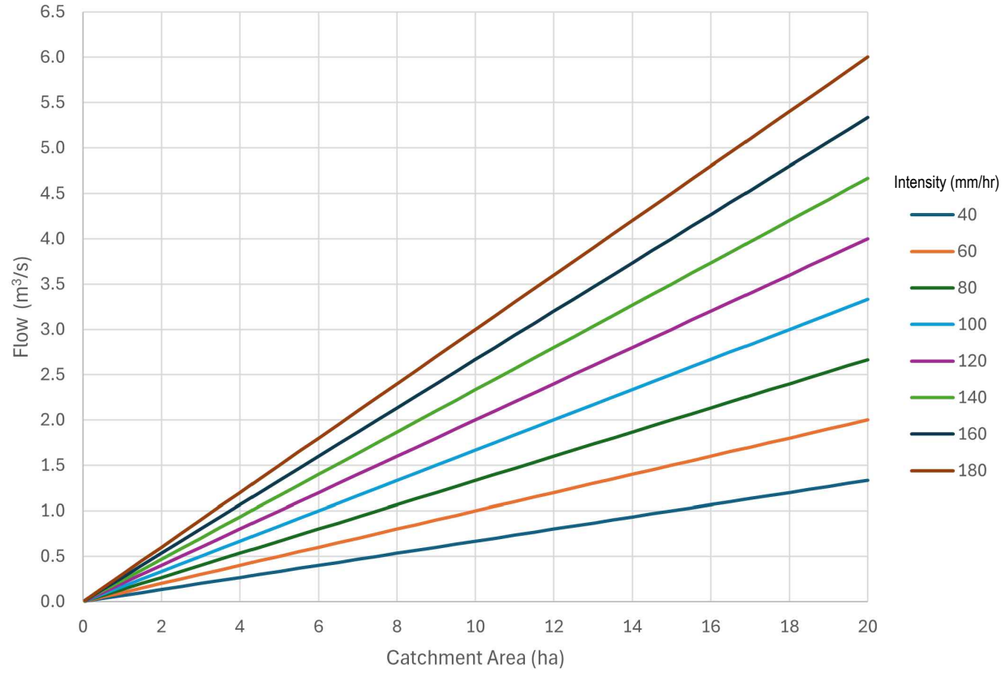

CHART 7: FLOWS - EXPOSED SOIL CATCHMENT

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TOOLKIT A: FLOWS
DESIGN FLOWS

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B1

INSTRUCTIONS

NOTE: THE CHARTS AND FIGURES ON THIS SHEET CAN BE USED TO SIZE CLEAN WATER DIVERSION CHANNELS/BUNDS, DIRTY WATER DIVERSION CHANNELS/BUNDS AND WATER TABLE DRAINS.

1. DECIDE A SLOPE FOR PROPOSED CHANNEL. THIS WILL LIKELY MATCH THE APPROXIMATE GROUND SLOPE WHERE CHANNEL IS TO BE CONSTRUCTED.
2. USE TOOLKIT A (SHEET A1 AND A2) TO DETERMINE THE DESIGN FLOW.
3. SELECT CHANNEL GEOMETRY. WATER TABLE DRAINS ARE NORMALLY TRAPEZOIDAL. ALL OTHER CHANNELS SHALL BEGIN WITH A TRIANGULAR CHANNEL IN THE FIRST INSTANCE. REFER TO CHART 8 FOR TRIANGULAR AND CHART 9 FOR TRAPEZOIDAL TO DETERMINE THE **DEPTH** BASED ON THE FLOW AND SLOPE. THE MAXIMUM DEPTH OF FLOW IS LIMITED TO 0.7 m . IF A TRIANGULAR CHANNEL WITH DEPTH OF UP TO 0.7 m DOES NOT PROVIDE SUFFICIENT CAPACITY FOR THE DESIGN FLOW, THEN CHANGE TO A TRAPEZOIDAL CHANNEL. NOTE THAT THE DEPTH IS FLOW DEPTH ONLY; AN ADDITIONAL 300 mm FREEBOARD MUST BE PROVIDED.
4. IF TRAPEZOIDAL CHANNEL WITH 0.7 m DEPTH DOES NOT PROVIDE SUFFICIENT FLOW, REDUCE THE CATCHMENT AREA BY REDIRECTING SOME FLOW TO A DIFFERENT LOCATION, OR SEEK SPECIALIST ADVICE.
5. REFER TO FIGURE 1 (TRIANGULAR) OR 2 (TRAPEZOIDAL) FOR THE CHANNEL DESIGN.

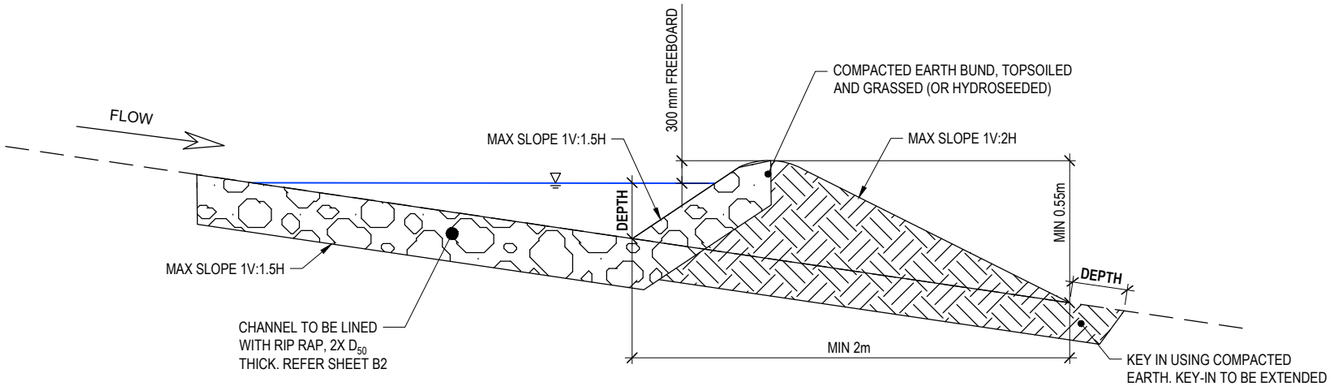

FIGURE 1: TRIANGULAR CHANNEL CROSS-SECTION

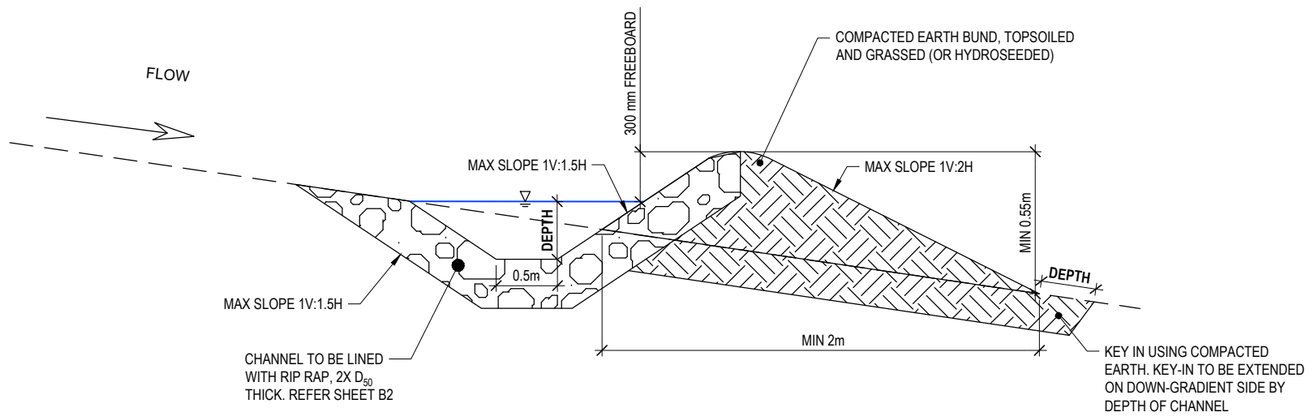

FIGURE 2: TRAPEZOIDAL CHANNEL CROSS-SECTION WITH BASE WIDTH = 0.5 m

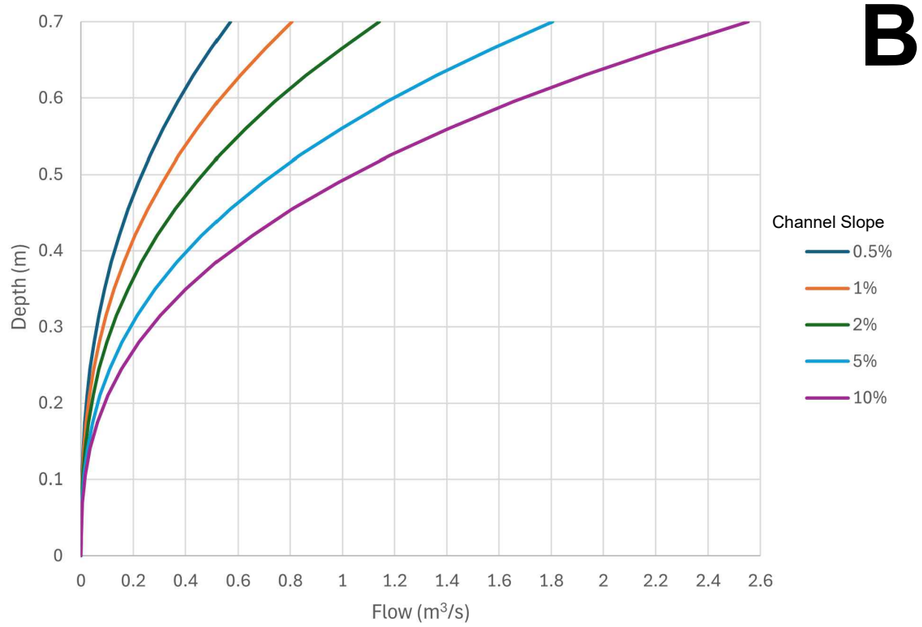

CHART 8: TRIANGULAR CHANNEL

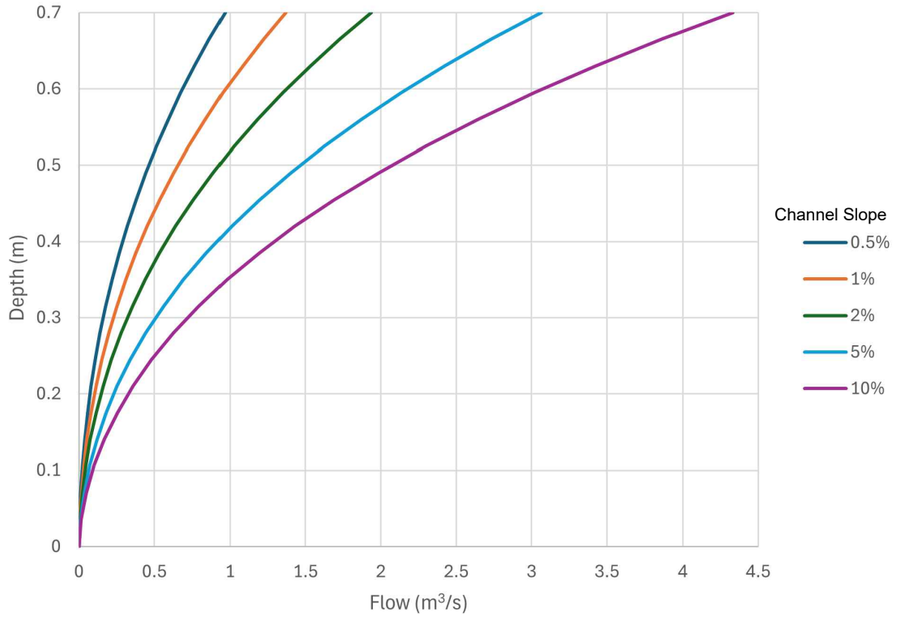

CHART 9: TRAPEZOIDAL CHANNEL WITH BASE WIDTH = 0.5 m

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TOOLKIT B: CHANNELS DIMENSIONS

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B2

INSTRUCTIONS

THIS SHEET PROVIDES DETAILS FOR THE HAUL ROADS, DROP OUT PITS AND CHANNEL LINING.

1. HAUL ROADS

1.1. REFER TO THE DESIGN IN FIGURE 3 FOR HAUL ROADS WHICH WILL BE CUT INTO THE SLOPE, AND FIGURE 4 FOR HAUL ROADS WHICH WILL BE FILLED.

1.2. USE THE METHOD ON SHEET B1 TO SIZE THE WATER TABLE DRAINS THAT ARE SHOWN IN FIGURE 3 AND 4.

1.3. FOR THE DESIGN OF CULVERTS THAT WILL CONVEY FLOW FROM THE WATER TABLE DRAINS UNDER THE HAUL ROAD, PROCEED TO SHEET C1.

2. DROP OUT PITS

2.1. REFER TO FIGURE 5 FOR A DETAIL OF THE DROP OUT PITS, WHICH SHALL BE INSTALLED IN ALL DIRTY WATER CHANNELS AND WATER TABLE DRAINS, AT A MAXIMUM SPACING OF 40m BETWEEN PITS.

3. CHANNEL LINING

3.1. ALL CHANNELS (CLEAN WATER, DIRTY WATER AND WATER TABLE DRAINS) SHALL BE LINED WITH RIP RAP UNLESS THEY ARE BEING CONSTRUCTED IN LIMESTONE.

3.2. USE THE CHANNEL SLOPE TO DETERMINE THE RIP RAP SIZING USING TABLE 2.

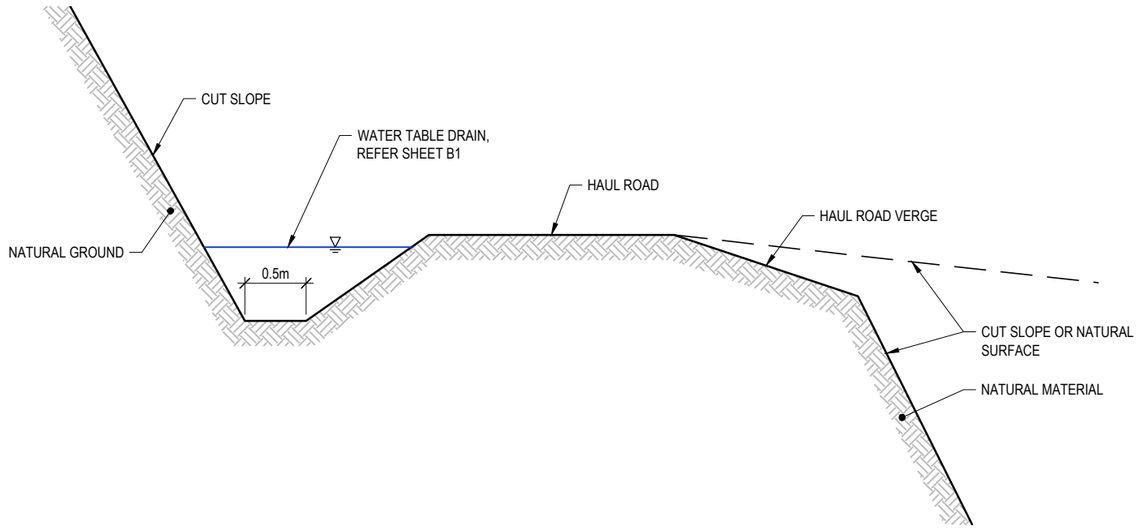

FIGURE 3: HAUL ROAD CUT AND CHANNEL DETAIL

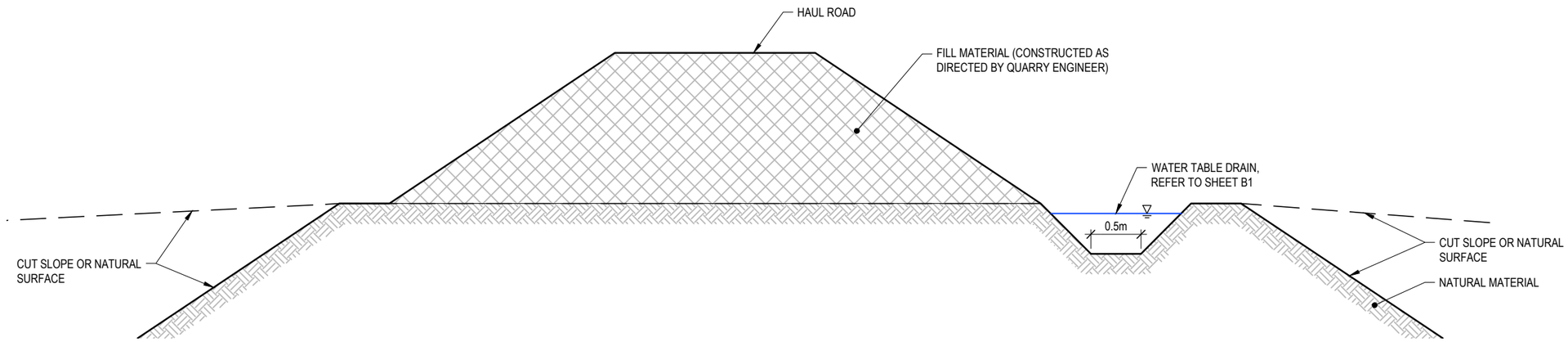

FIGURE 4: HAUL ROAD FILL AND CHANNEL DETAIL

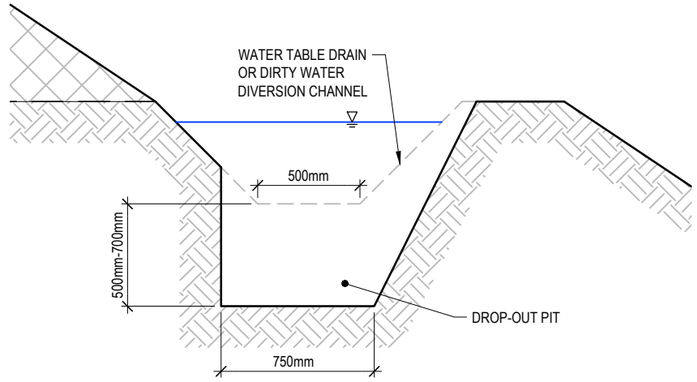

FIGURE 5: DROP OUT PIT DETAIL

TABLE 2: RIP RAP FOR CHANNEL LININGS	
CHANNEL SLOPE	RIP RAP D_{50} (mm)
<1%	200
<2%	250
<3%	280
<4%	300
>4%	SHORT TERM CHANNELS: 300 (WITH INCREASED MAINTENANCE). MEDIUM-LONG TERM CHANNELS: 300, GROUTED IN PLACE WITH 20 MPa BATCHED CONCRETE

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TOOLKIT B: CHANNELS DETAILS

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INSTRUCTIONS

1. USE TOOLKIT A (SHEET A1 AND A2) TO DETERMINE THE DESIGN FLOW FOR THE CATCHMENT.
2. USE TABLE 3 TO DETERMINE THE REQUIRED CULVERT DIAMETER FOR THE DESIGN FLOW.
   2.1. IF THE FLOW IS GREATER THAN 0.25 m^3/s, THE CATCHMENT SIZE SHOULD BE REDUCED (BY INCREASING THE FREQUENCY OF CULVERTS).
3. REFER TO FIGURE 6, 8 AND 9 FOR THE LAYOUT AND SECTIONS FOR CULVERT CONSTRUCTION UNDER THE HAUL ROADS.

FIGURE 7: TYPICAL CULVERT / FLUME CONNECTION DETAIL

TABLE 3: CULVERT SELECTION	
MAX FLOW (m^3/s)	CULVERT DIAMETER (mm)
0.10	300
0.15	375
0.25	450

NOTES

1. DRICON CULVERT BAGS (OR SIMILAR) TO BE INSTALLED AS PER THE MANUFACTURER'S INSTRUCTIONS.
2. PLACE THE FIRST TIER OF BAGS END-TO-END. STACK THE FOLLOWING TIERS LIKE BRICKS IN AN INTERLOCKING FASHION. BATTER BAGS BACK APPROXIMATELY 10mm TO LOCK BAGS INTO PLACE.
3. SECURE BAGS IN PLACE WITH WARRTAHS (Y POSTS), BASALT OR STEEL REBAR. PLACE THE STAKES EVERY SECOND BAG AND START AT THE THIRD LEVEL.
4. WATER THE BAGS DOWN AFTER PLACEMENT.

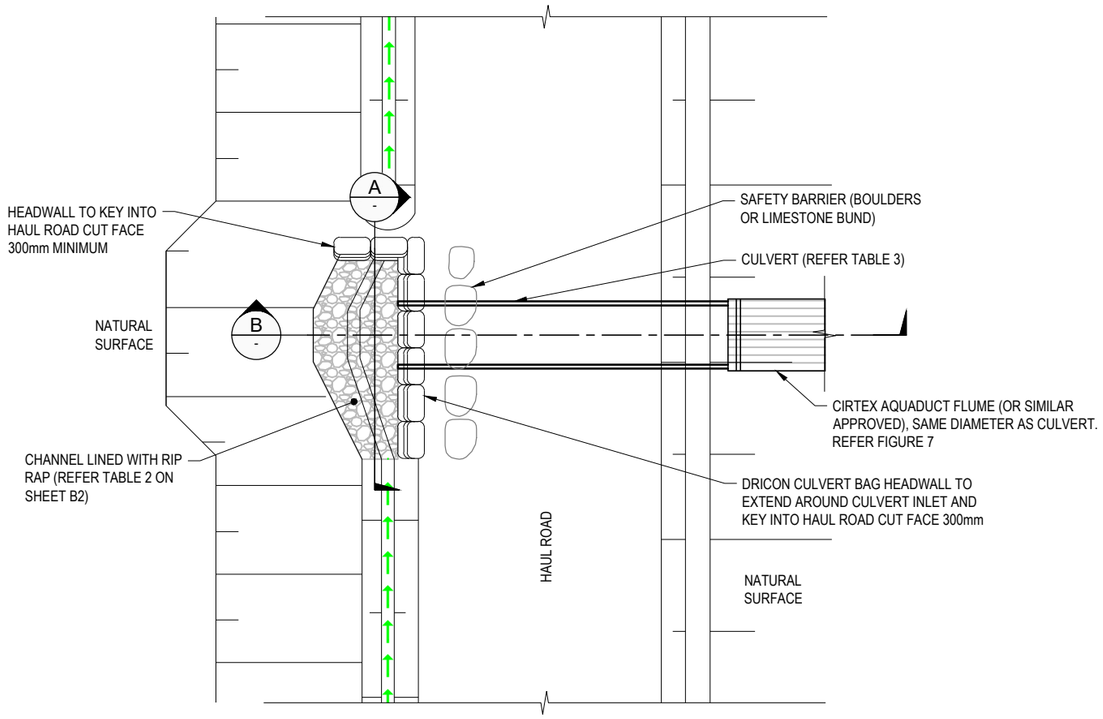

FIGURE 6: HAUL ROAD CULVERT LAYOUT

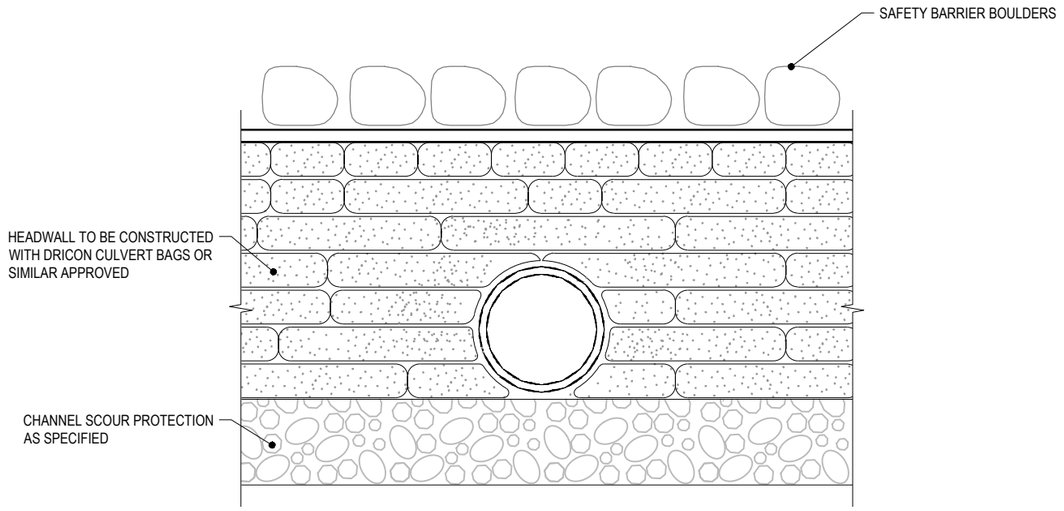

FIGURE 8: CULVERT HEADWALL SECTION (A / -)

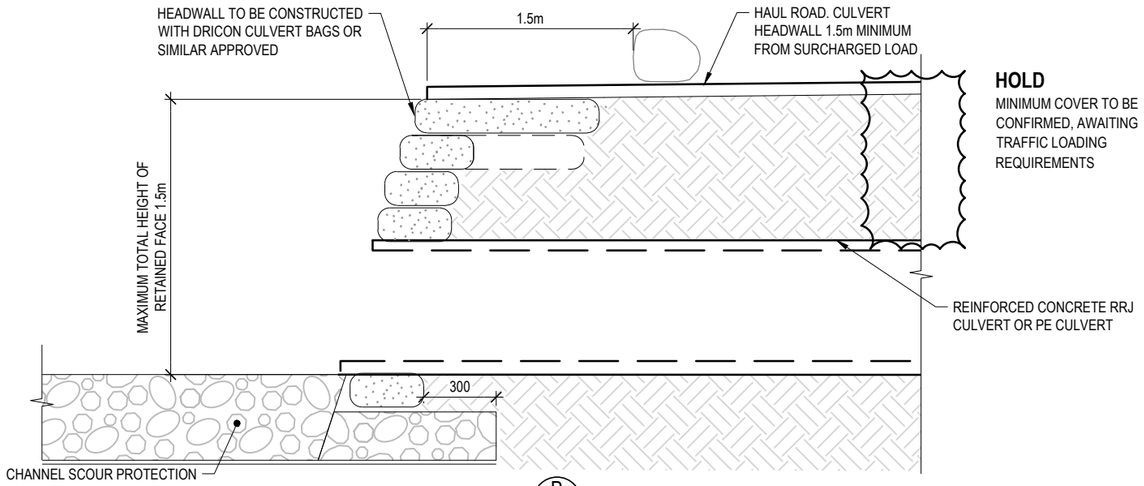

FIGURE 9: CULVERT SECTION (B / -)

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TOOLKIT C: CULVERTS AND DROP STRUCTURES

CULVERT DETAILS

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INSTRUCTIONS

THIS SHEET SHOWS HOW THE PIPE DROP STRUCTURES AND WATER TABLE DRAINS WILL CONVEY FLOW FROM THE CULVERTS AT THE TOP OF THE PIT, DOWN THE BENCHES TO THE BASE OF THE PIT.

1. DETERMINE THE DIMENSIONS FOR THE WATER TABLE DRAINS ALONG THE BENCHES USING THE METHOD ON SHEET B1.
2. DETERMINE THE CULVERT SIZES USING TABLE 3 ON SHEET C1.
   - 2.1. NOTE THAT THE CONTRIBUTING CATCHMENT AREA WILL INCREASE DOWN THE BENCHES, AS EACH NEW CULVERT WILL NEED TO RECEIVE THE FLOW FROM THE CULVERT ABOVE PLUS ADDITIONAL FLOW FROM THE BENCH AREA CONTRIBUTING TO THE WATER TABLE DRAIN ALONG THE BENCH.
3. REFER TO FIGURE 10, 11, 12 AND 13 FOR THE ARRANGEMENT AND DETAILS OF THE CULVERTS AND THE DROP STRUCTURES BETWEEN BENCHES.

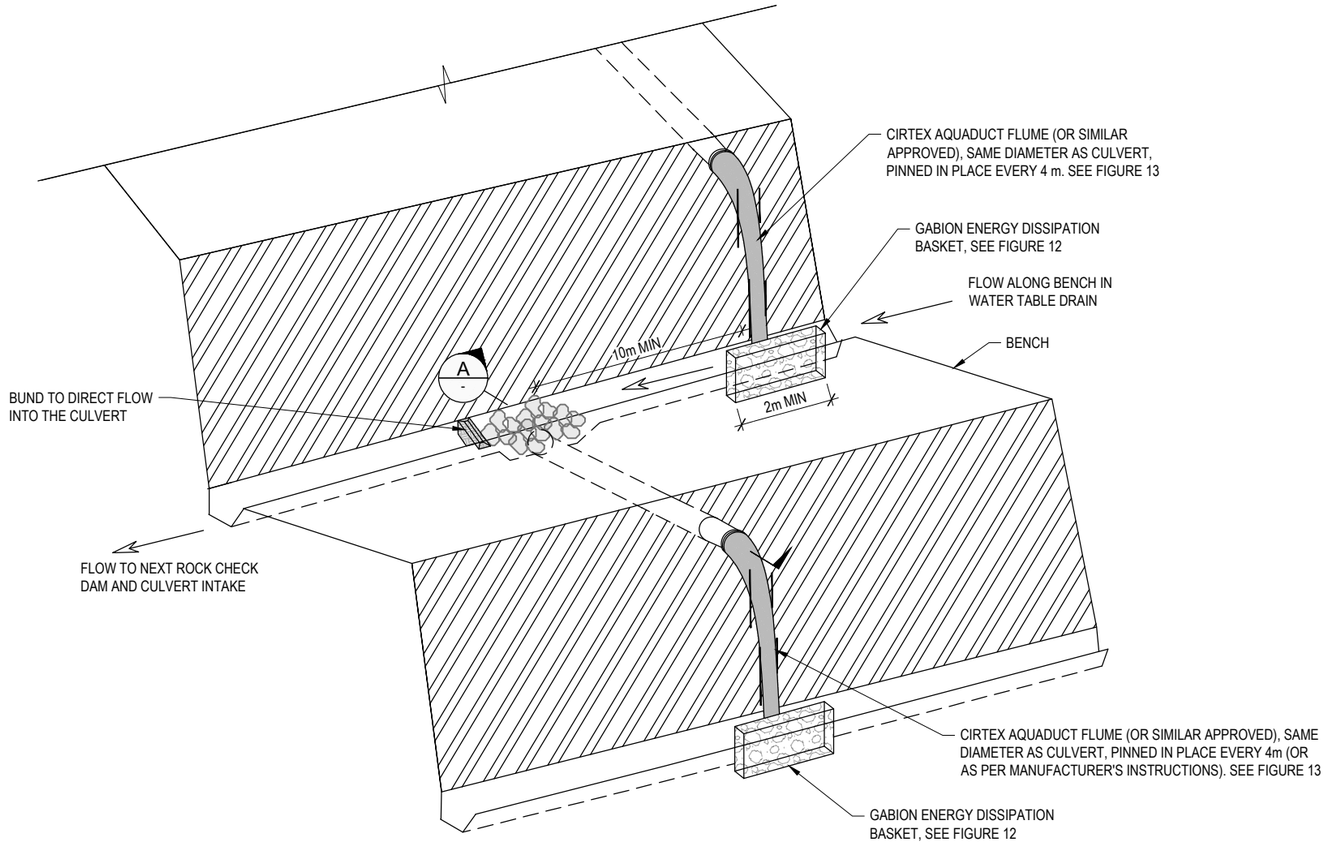

FIGURE 10: TYPICAL FLUME INSTALLATION

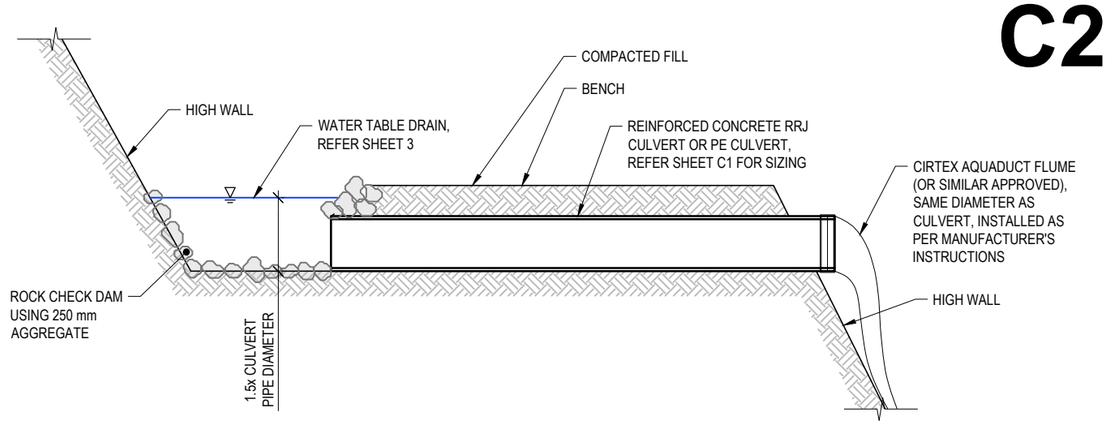

FIGURE 11: CROSS-SECTION OF ROCK CHECK DAM AND FLUME INTAKE (A)

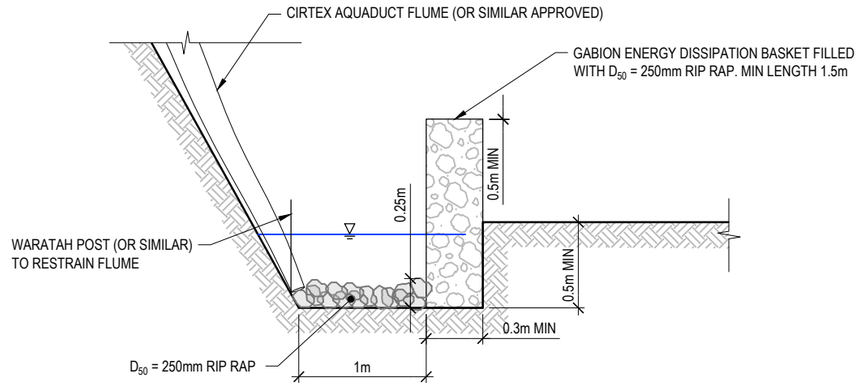

FIGURE 12: CROSS-SECTION OF WATER TABLE DRAIN WITH GABION ENERGY DISSIPATION BASKET

FIGURE 13: TYPICAL FLUME INSTALLATION

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TOOLKIT C: CULVERTS AND DROP STRUCTURES

DROP STRUCTURES FOR BENCHES

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INSTRUCTIONS

TOOLKIT D PROVIDES THE DESIGN OF A SEDIMENT RETENTION POND WHICH DISCHARGES INTO AN INFILTRATION BASIN, AS SHOWN ON FIGURE 14. THIS DESIGN IS ONLY APPLICABLE TO SEDIMENT RETENTION PONDS CONSTRUCTED FOR THE CROPPING FIELDS OR TOPSOIL STOCKPILE.

1. REFER TO SHEET D2 TO SIZE THE MAIN POND.
2. REFER TO SHEET D3-D5 TO SIZE THE SPILLWAY AND DETERMINE THE OUTLET STRUCTURE/DECANT ARRANGEMENT FOR THE MAIN POND.
3. REFER TO SHEET D6 TO SIZE THE INFILTRATION BASIN.

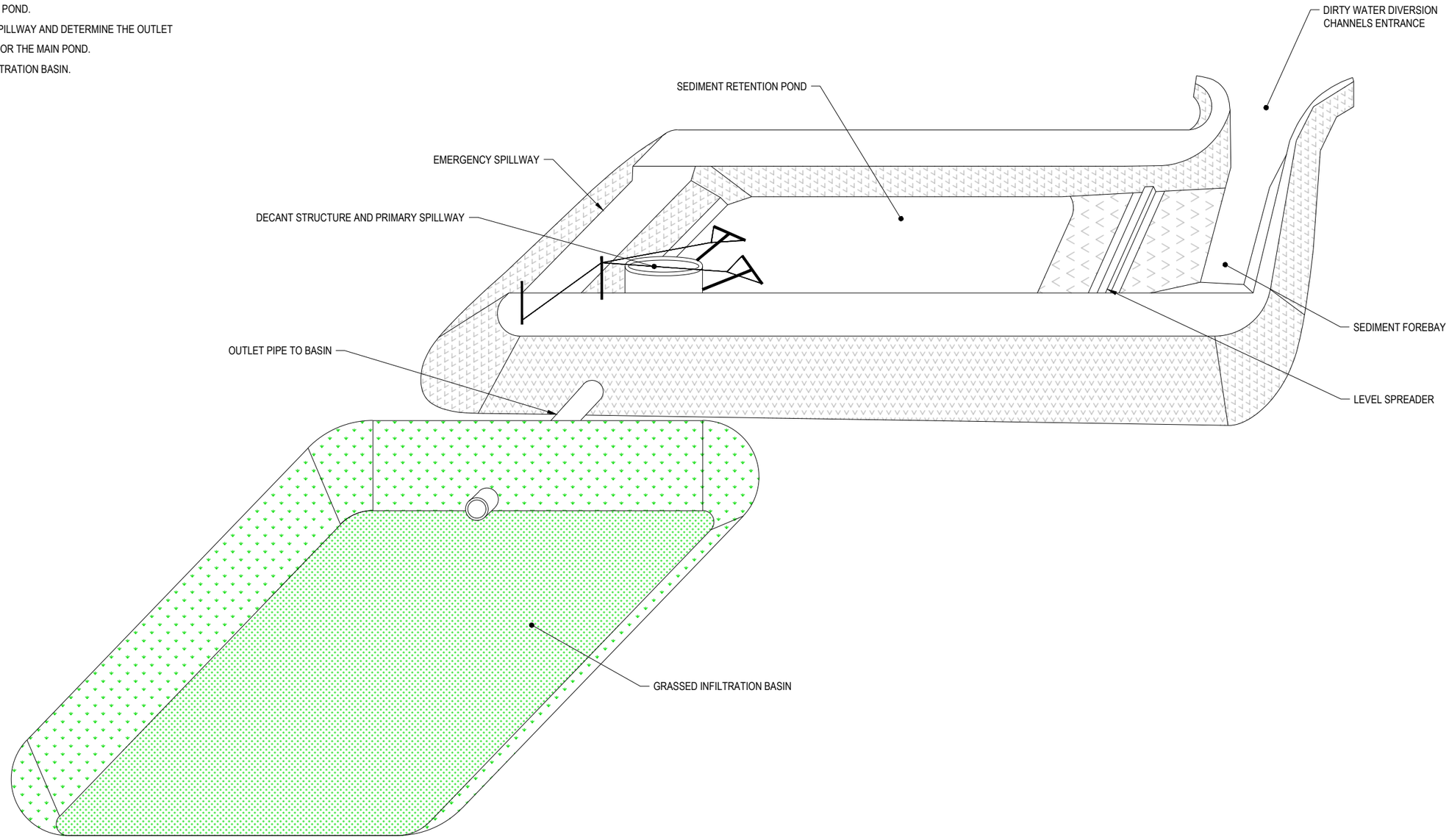

FIGURE 14: SCHEMATIC OF TYPICAL SEDIMENT RETENTION POND AND INFILTRATION BASIN

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TOOLKIT D: SEDIMENT RETENTION PONDS SCHEMATIC

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INSTRUCTIONS

1. DETERMINE THE CATCHMENT AREA THAT WILL CONTRIBUTE TO THE POND. THE POND SHOULD ONLY BE USED FOR CATCHMENTS UP TO 5ha. IF THE CATCHMENT EXCEEDS 5ha, DIVERT SOME OF THE AREA TO A DIFFERENT POND.
2. SELECT CHART 10 OR 11 BASED ON THE CATCHMENT SLOPE AND CATCHMENT LENGTH, WHERE:
   - 2.1. LENGTH SHALL BE TAKEN AS THE DISTANCE FROM THE FURTHEST POINT IN THE CATCHMENT TO THE CONTROL MEASURE BEING DESIGNED; AND
   - 2.2. CATCHMENT SLOPE SHALL BE TAKEN AS THE AVERAGE SLOPE ALONG THIS DISTANCE.
3. USING THE RELEVANT CHART, DETERMINE THE REQUIRED POND VOLUME.
4. USE CHART 12 TO DETERMINE THE **BASE WIDTH** OF THE POND FOR THE VOLUME.
5. REFER TO FIGURE 15 FOR THE CONFIGURATION OF THE POND.
6. PROCEED TO SHEET D3 FOR THE DECANT STRUCTURE, PRIMARY OUTLET AND EMERGENCY SPILLWAY SIZING.

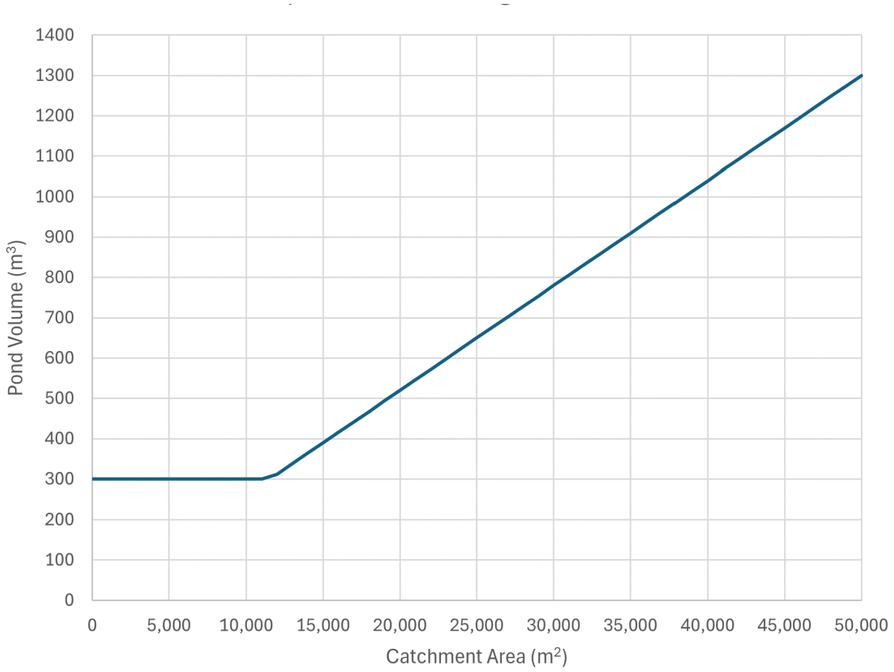

CHART 10: POND VOLUME - CATCHMENT SLOPE < 18% AND < 200 m LONG

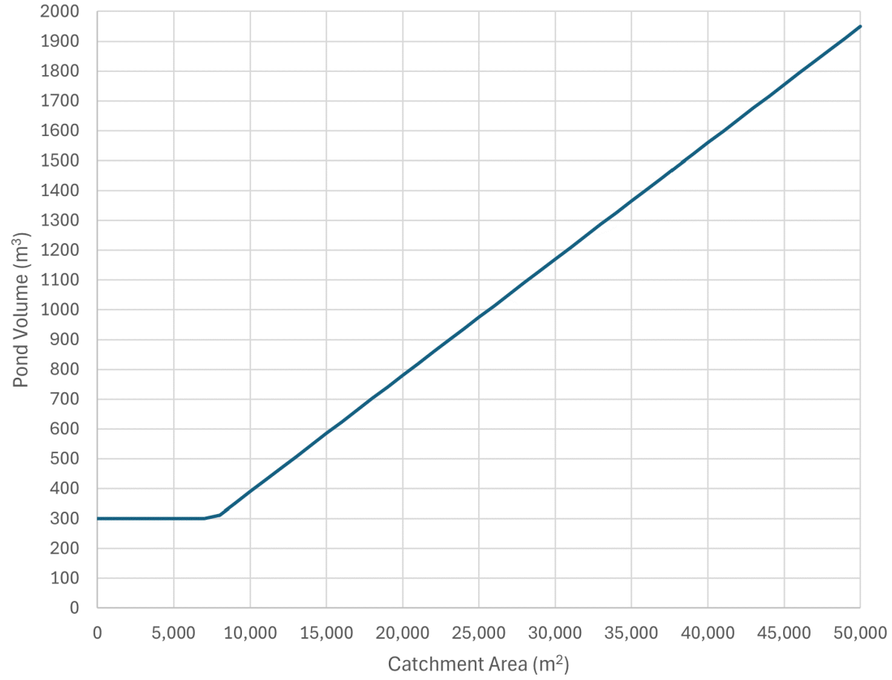

CHART 11: POND VOLUME - CATCHMENT SLOPE > 18% OR > 200 m LONG

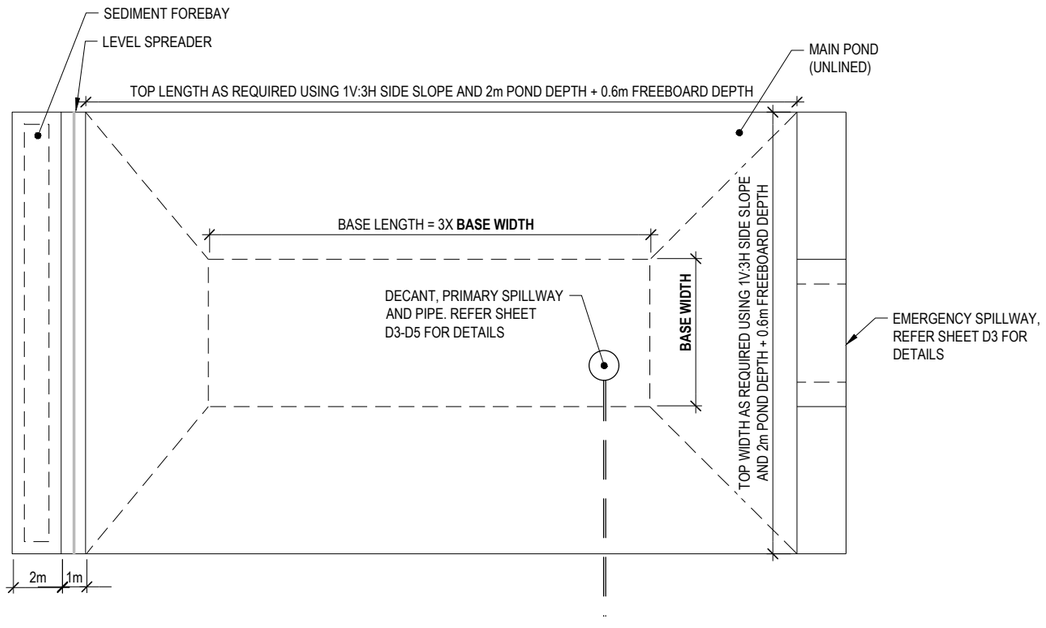

FIGURE 15: PLAN VIEW OF SEDIMENT RETENTION POND

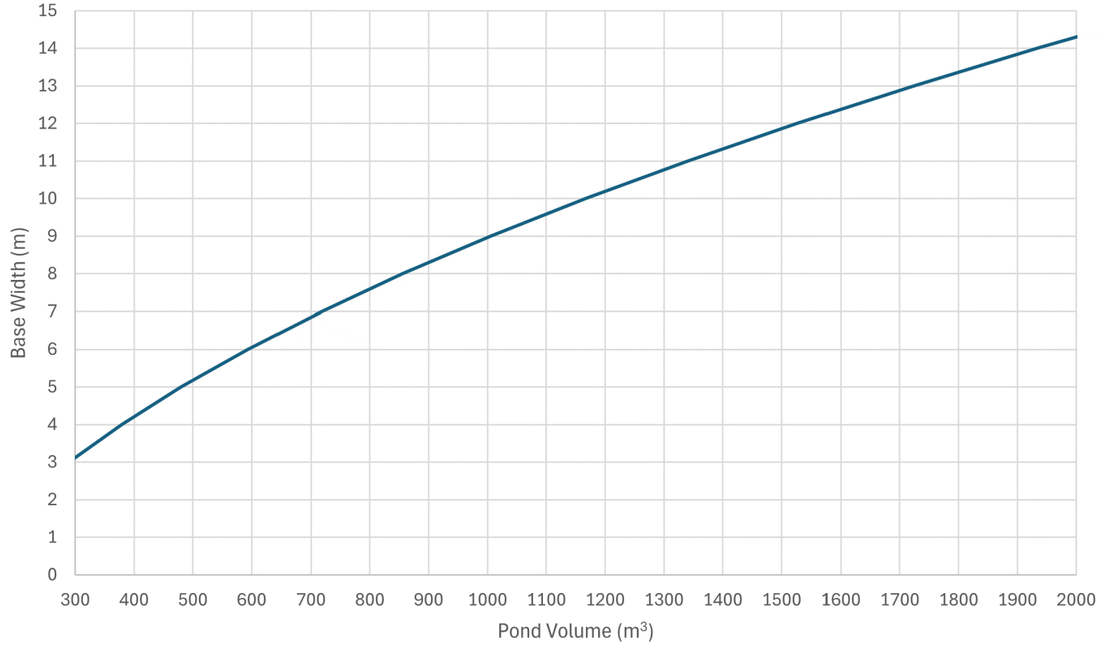

CHART 12: POND BASE WIDTH

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TOOLKIT D: SEDIMENT RETENTION PONDS
POND DIMENSIONS

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INSTRUCTIONS

1. USE TABLE 4 TO SELECT THE **PRIMARY SPILLWAY TYPE** AND THE **OUTLET PIPE** SIZE BASED ON THE CATCHMENT AREA THAT IS CONTRIBUTING TO THE SEDIMENT RETENTION POND.
2. USE TABLE 5 TO DETERMINE THE **NUMBER OF DECANTS** REQUIRED FOR THE CATCHMENT AREA, AS WELL AS THE **HEIGHT** OF EACH DECANT, AND THE **NUMBER OF HOLES PER DECANT.**
3. REFER TO THE FIGURES ON SHEET D4 AND D5 FOR THE DECANT STRUCTURE ARRANGEMENT.
4. USE TOOLKIT A (SHEET A1 AND A2) TO DETERMINE THE FLOW FROM THE CATCHMENT CONTRIBUTING TO THE SEDIMENT RETENTION POND.
5. USE TABLE 6 TO IDENTIFY THE **BASE WIDTH** OF THE POND EMERGENCY SPILLWAY.
6. REFER TO FIGURE 16 FOR CROSS-SECTION OF THE EMERGENCY SPILLWAY.
7. REFER TO FIGURE 17 FOR LEVEL SPREADER DETAIL.
8. REFER TO FIGURE 18 FOR THE CROSS-SECTION OF THE WHOLE SEDIMENT RETENTION POND, INCLUDING THE OUTLET STRUCTURE, FOREBAY AND EMERGENCY SPILLWAY.

NOTES

1. SPILLWAY TO BE LINED WITH TWO LAYERS OF GEOTEXTILE. THE LOWER LAYER SHALL BE UV STABILISED NON-WOVEN GEOTEXTILE SUCH AS CIRTEX ENVIROFORCE OR SIMILAR APPROVED. THE UPPER LAYER SHALL BE UV STABILISED HIGH-STRENGTH WOVEN GEOTEXTILE SUCH AS CIRTEX DURAFORCE WG21 OR SIMILAR APPROVED. GEOTEXTILES SHALL BE SECURED WITH GROUND STAPLES AT 0.5 m CENTRES WITH MIN 0.1m OVERLAP.

TABLE 4: OUTLET DESIGN

CATCHMENT AREA (ha)	PRIMARY SPILLWAY	OUTLET PIPE SIZE (mm)
<1.5	150mm UPSTAND	150
1.5-3	150mm UPSTAND	150
3-5	1050mm CONCRETE MANHOLE RISER	300

TABLE 5: DECANT DESIGN

CATCHMENT AREA (ha)	NUMBER OF DECANTS	DECANT HEIGHTS ABOVE INVERT (m)	NUMBER OF HOLES PER DECANT
0.1	1	0.8	13
0.5			67
1			133
1.5			200
2	2	0.8 and 1.4	133
2.5			167
3			200
3.5	3	0.8, 1.2, 1.6	156
4			178
4.5			200
5			222

TABLE 6: EMERGENCY SPILLWAY DESIGN

BASE WIDTH (m)	MAX CAPACITY (m^3/s)
2	0.5
4	0.9
6	1.3
8	1.7

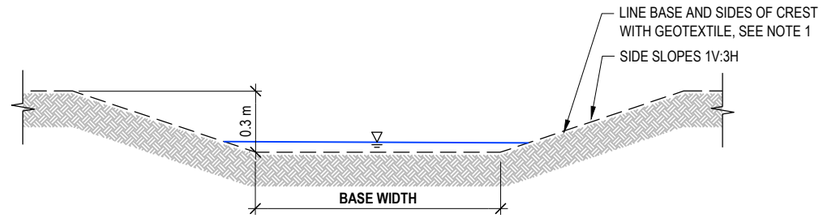

FIGURE 16: CROSS-SECTION OF EMERGENCY SPILLWAY

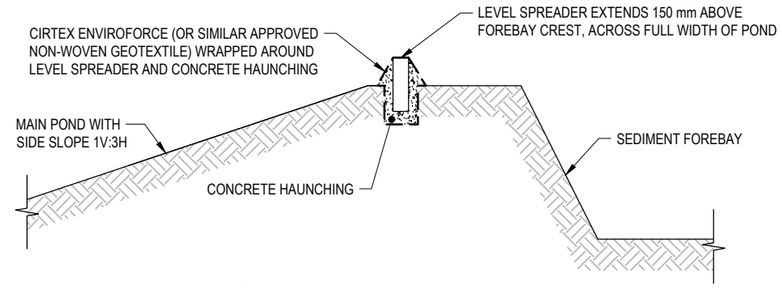

FIGURE 17: LEVEL SPREADER DETAIL

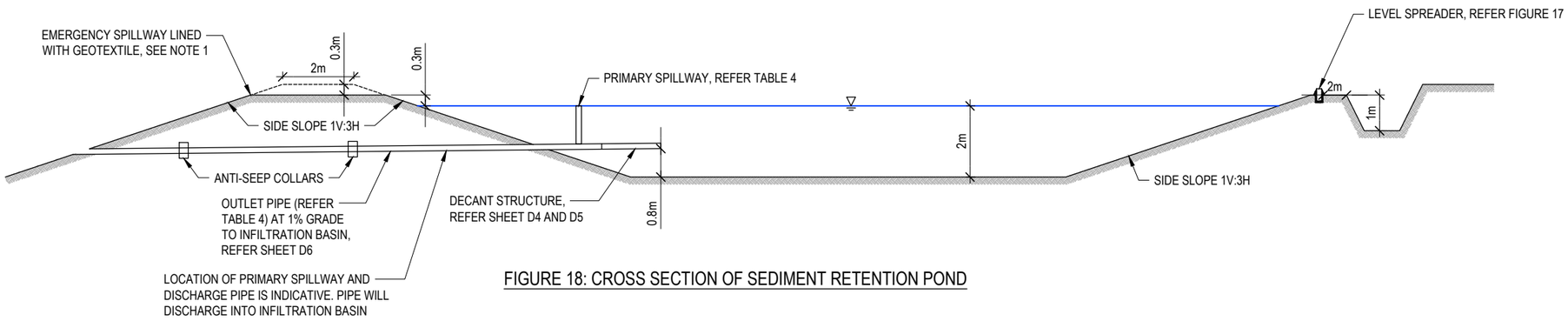

FIGURE 18: CROSS SECTION OF SEDIMENT RETENTION POND

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TOOLKIT D: SEDIMENT RETENTION PONDS
OUTLET, EMERGENCY SPILLWAY, AND DECANTS

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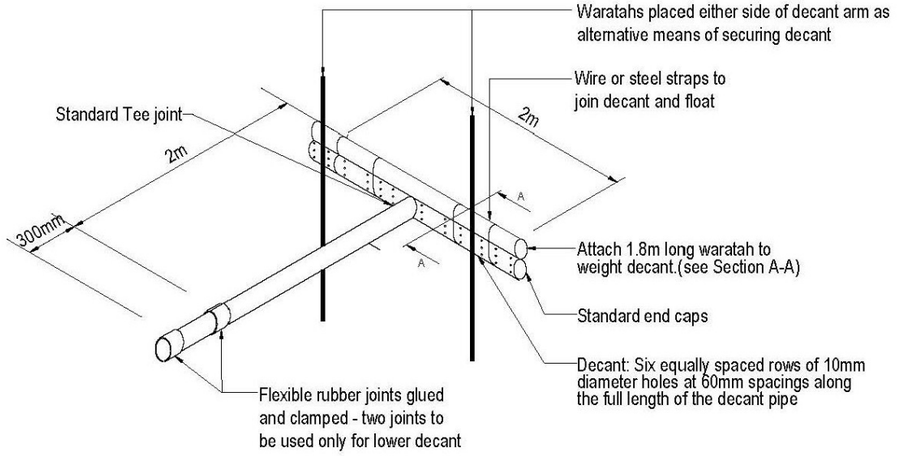

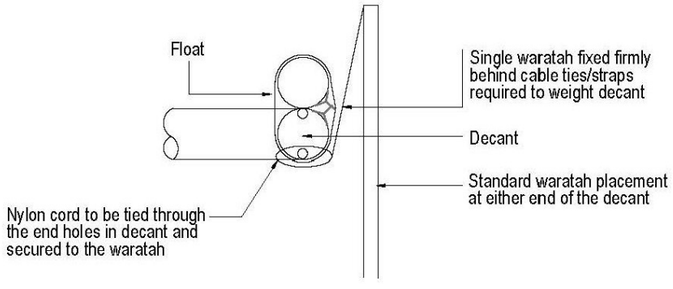

FIGURE 19: SCHEMATIC OF STANDARD DECANT T-BAR DESIGN

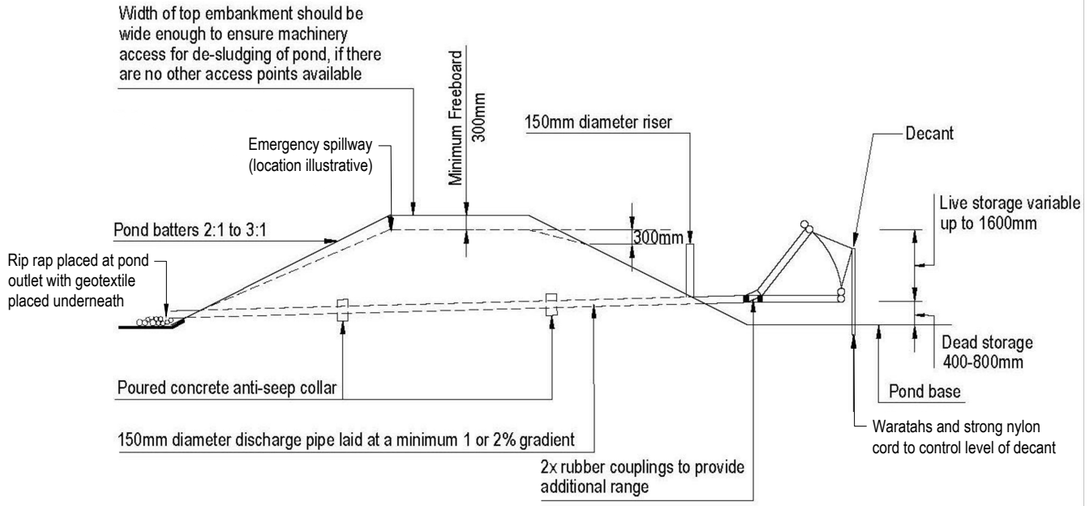

FIGURE 20: CROSS-SECTION OF OUTLET FOR <1.5ha CATCHMENT

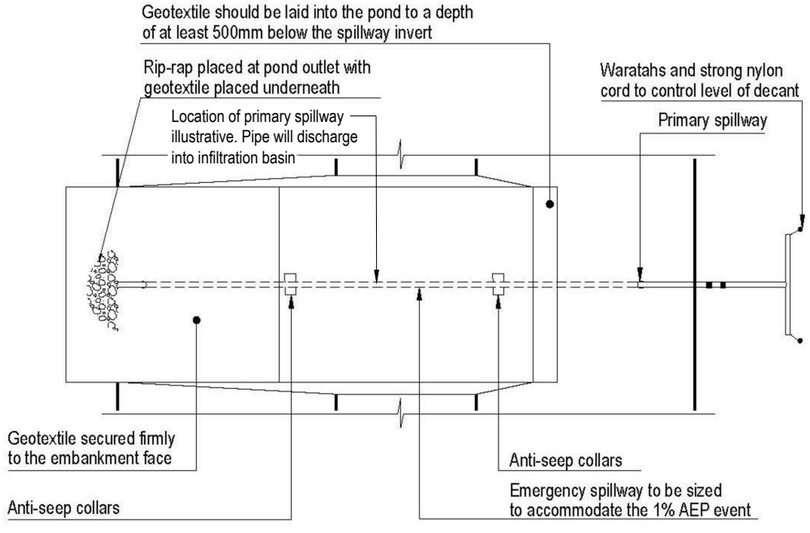

FIGURE 21: PLAN OF OUTLET FOR <1.5ha CATCHMENT

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TOOLKIT D: SEDIMENT RETENTION PONDS
DECANT DETAILS
SHEET 1 OF 2

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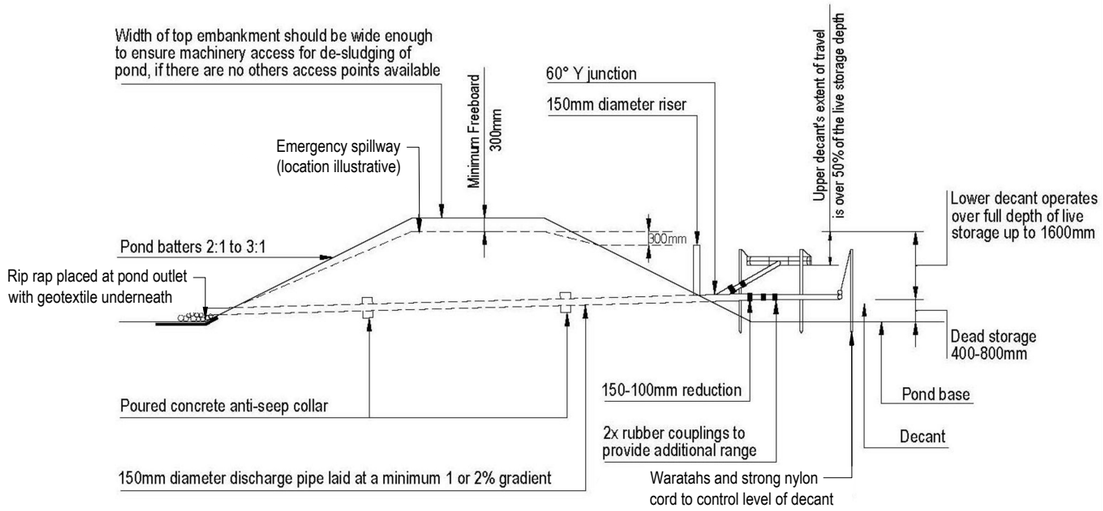

FIGURE 22: CROSS-SECTION OF OUTLET FOR 1.5-3ha CATCHMENT

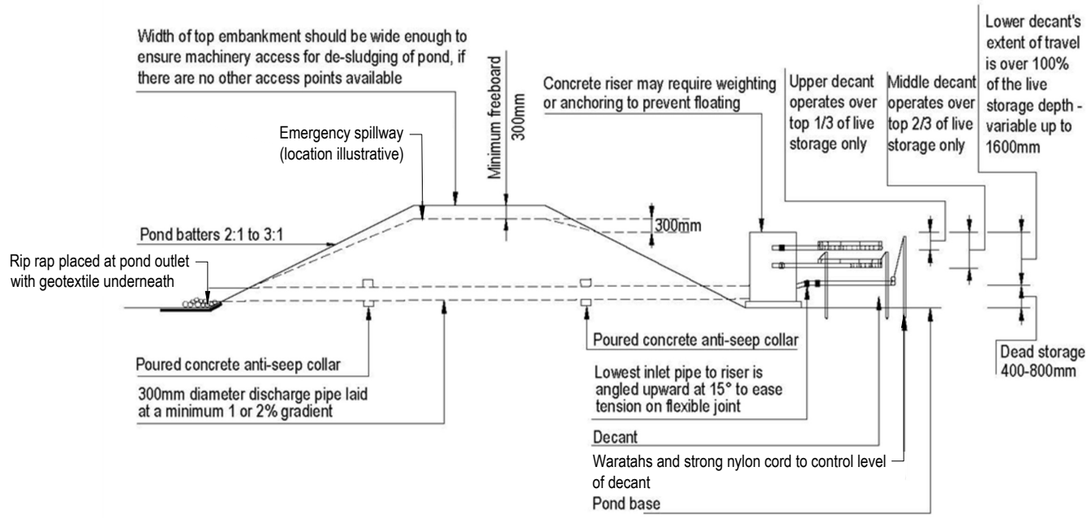

FIGURE 24: CROSS-SECTION OF OUTLET FOR 3-5ha CATCHMENT

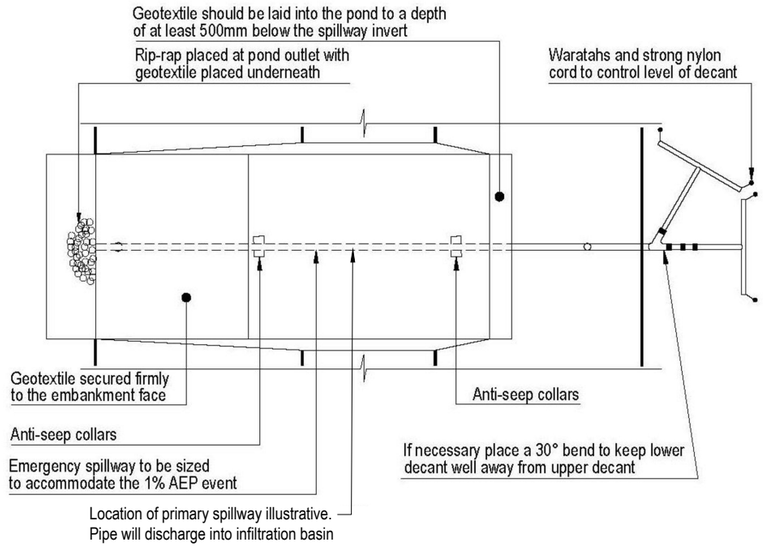

FIGURE 23: PLAN OF OUTLET FOR 1.5-3ha CATCHMENT

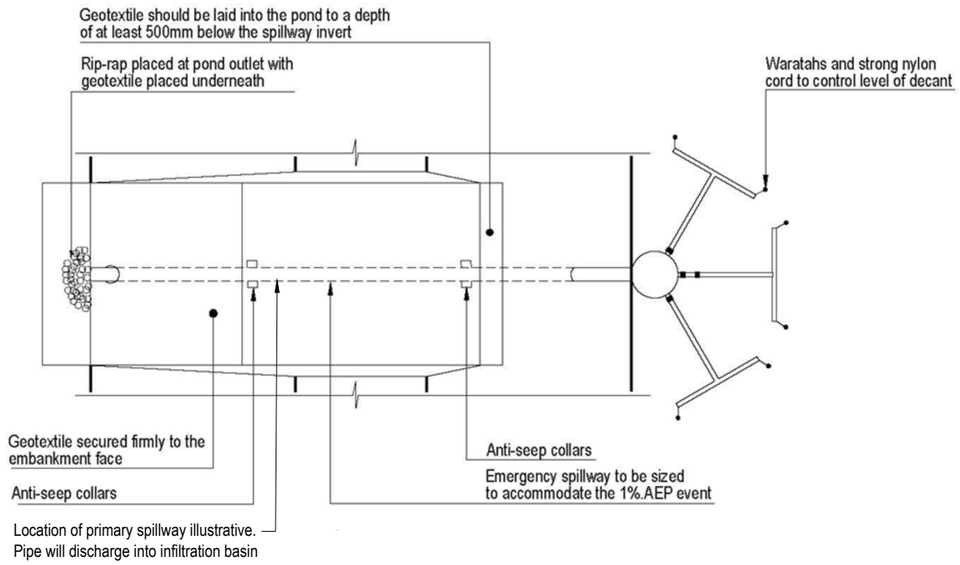

FIGURE 25: PLAN OF OUTLET FOR 3-5ha CATCHMENT

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TOOLKIT D: SEDIMENT RETENTION PONDS
DECANT DETAILS
SHEET 2 OF 2

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INSTRUCTIONS

1. USE CHART 13 TO DETERMINE INFILTRATION BASIN **BASE WIDTH** USING CATCHMENT AREA (SAME CATCHMENT AREA AS FOR SEDIMENT RETENTION POND).
2. REFER TO FIGURE 26 AND 27 FOR THE INFILTRATION BASIN DESIGN. THE ELEVATION OF THE BASIN RELATIVE TO THE SEDIMENT RETENTION POND AND THE CONNECTING PIPE LENGTH WILL NEED TO BE SET SUCH THAT THE PIPE FALLS AT A 1% GRADE FROM THE POND TO THE BASIN.

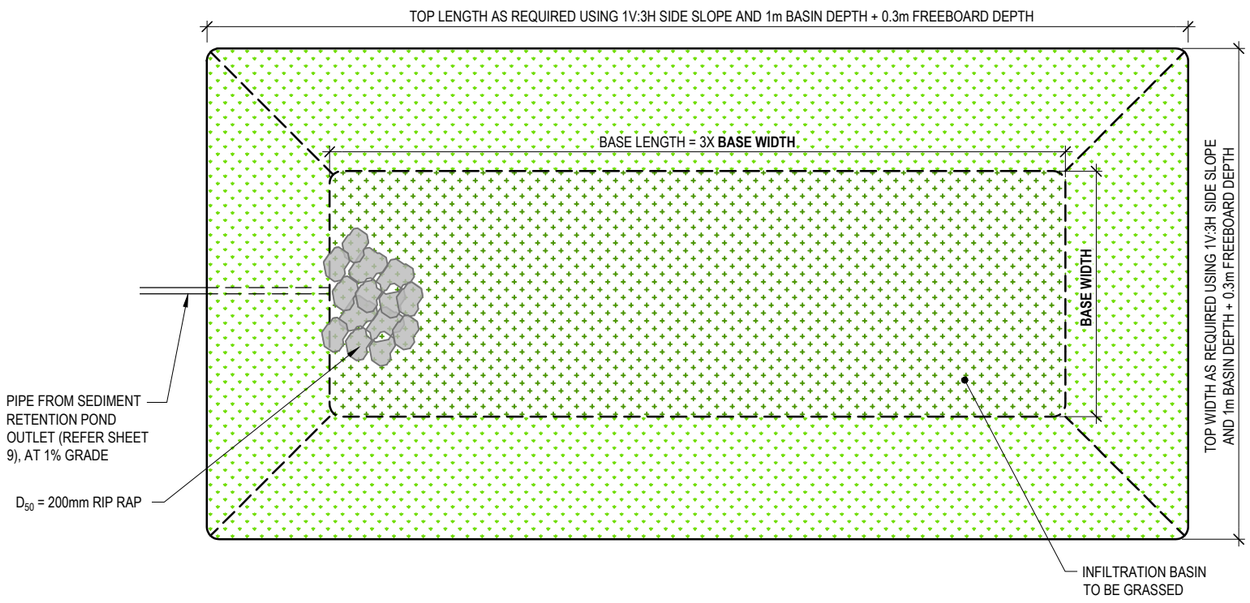

FIGURE 26: INFILTRATION BASIN PLAN VIEW

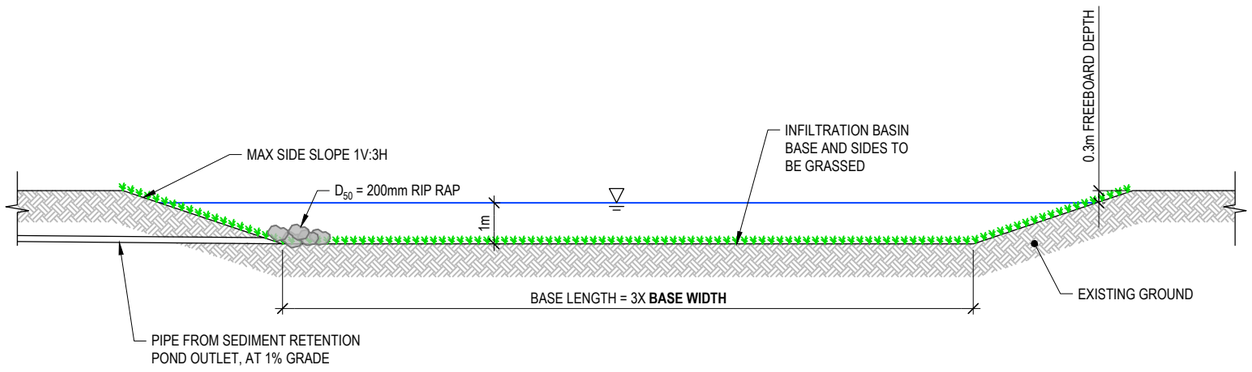

FIGURE 27: INFILTRATION BASIN CROSS-SECTION

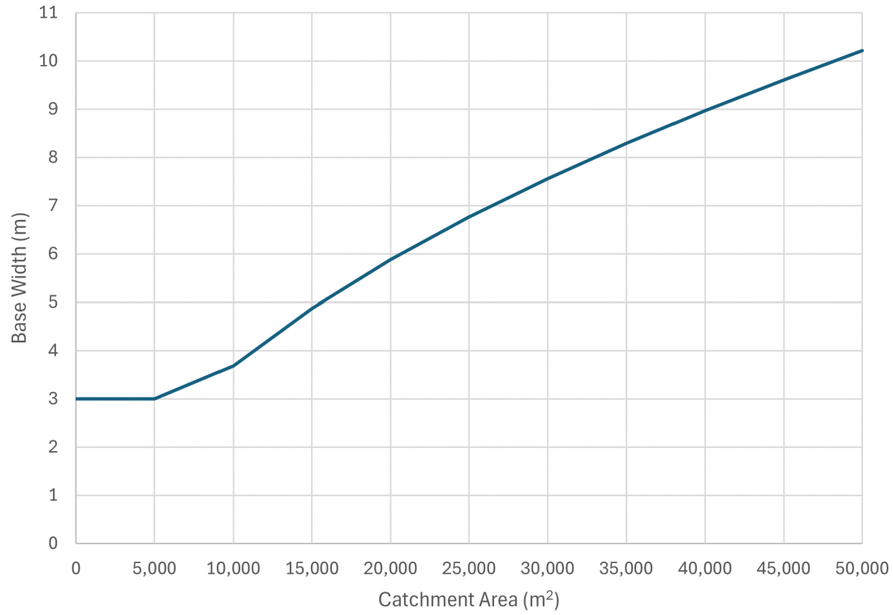

CHART 13: INFILTRATION BASIN BASE WIDTH

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TOOLKIT D: SEDIMENT RETENTION PONDS
INFILTRATION BASIN

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INSTRUCTIONS

1. DETERMINE THE CATCHMENT AREA THAT WILL CONTRIBUTE TO THE IN-PIT SEDIMENT INFILTRATION POND.
   - 1.1. THE POND SHOULD ONLY BE USED FOR CATCHMENTS UP TO 5ha. IF THE CATCHMENT EXCEEDS 5ha, DIVERT SOME OF THE AREA TO A DIFFERENT POND.
2. USING CHART 14, DETERMINE THE POND **WIDTH** BASED ON THE CATCHMENT AREA.
3. USE TOOLKIT A TO DETERMINE THE FLOW FROM THE CONTRIBUTING CATCHMENT.
4. USING TABLE 7, DETERMINE THE SEDIMENT FOREBAY **WIDTH** AND **LENGTH.** MULTIPLE FOREBAYS COULD BE PROVIDED.
5. REFER TO FIGURE 28 AND 29 FOR THE DESIGN CONFIGURATION.
6. REFER TO FIGURE 30 FOR THE FILTER MEDIA SIZING AND LAYER THICKNESS.

TABLE 7: SEDIMENT FOREBAY DIMENSIONS

FLOW (m^3/s)	FOREBAY LENGTH (m)	FOREBAY WIDTH (m)
<0.1	3	1
0.1-0.2	3	1.5
0.2-0.3	3	2.5
0.3-0.5	4	2.5
0.5-0.8	4	3
0.8-1.3	6	5
1.3-1.8	7	6

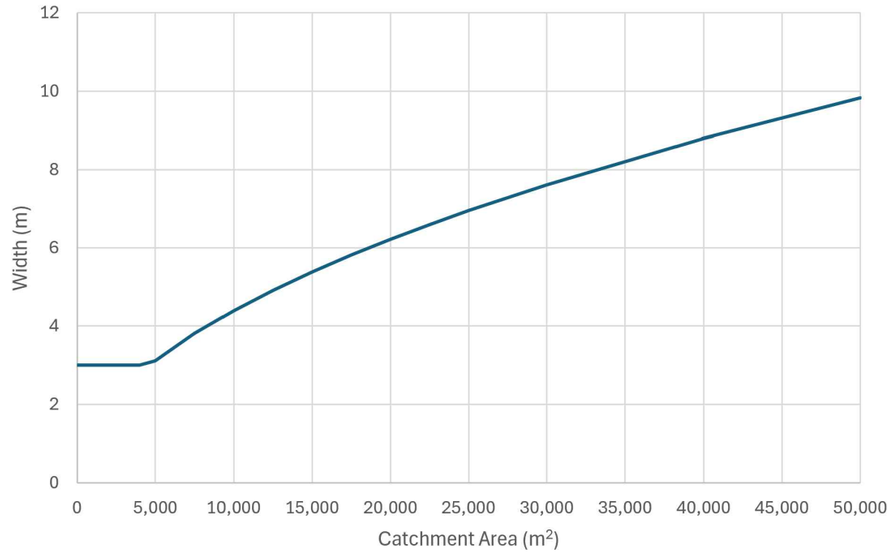

CHART 14: POND WIDTH

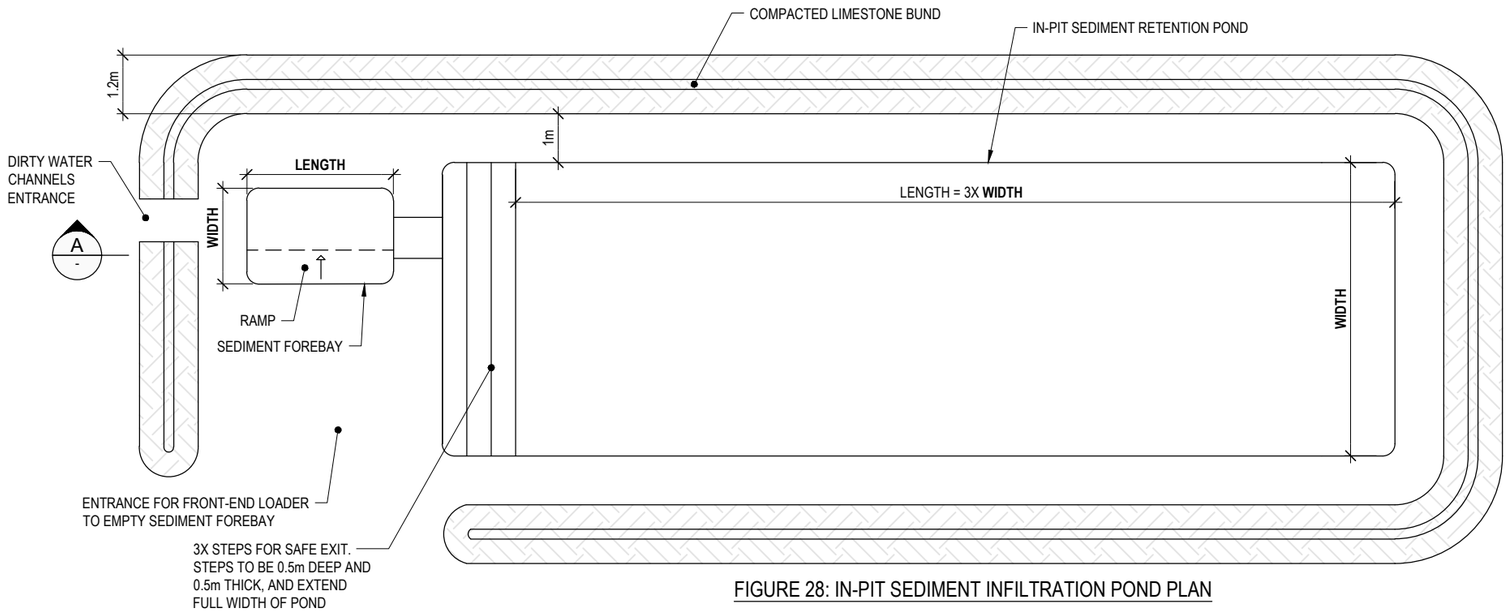

FIGURE 28: IN-PIT SEDIMENT INFILTRATION POND PLAN

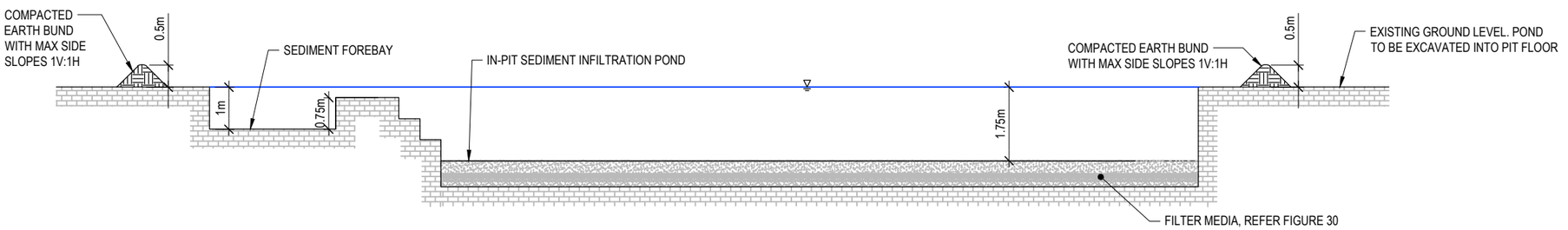

FIGURE 29: IN-PIT SEDIMENT INFILTRATION POND CROSS-SECTION

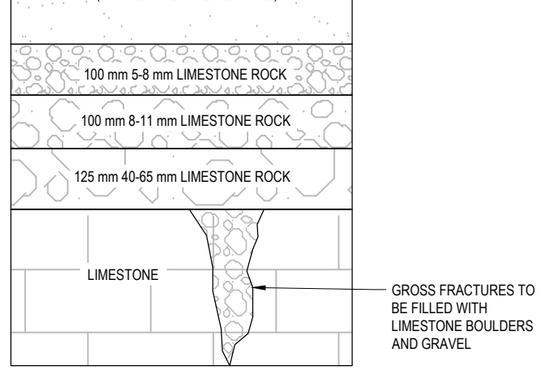

FIGURE 30: FILTER MEDIA

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TOOLKIT E: IN-PIT SEDIMENT INFILTRATION PONDS

POND, FOREBAY, AND BUND

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