BATHURST
RESOURCES LIMITED

Water Infrastructure Design Plan

April 2026

BPCP-ENV-PLN-012 v2

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Glossary of Terms and Abbreviations

Term	Definition
ARI	Average Recurrence Interval
AEMR	Annual Environmental Monitoring Report
AMD	Acid and Metalliferous Drainage
AWP	Annual Work Plan
Bathurst	Bathurst Resources Limited, including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd
BPCP	Buller Plateau Continuation Project
ESE	Escarpment Extended
FTAA	Fast Track Approvals Act 2024
HDPE	High density polyethylene
km	kilometre
m^2	metres squared
m^3/s	cubic metres per second
m	metres
m/m	metre by metre
m/s	metres per second
MFS	Mt Frederick South
mm/h	millimetres per hour
min	minute
NPSH	Net Positive Suction Head
RCP	Representative Concentration Pathway
RPM	Revolutions Per Minute
SDR	Standard Dimension Ratio
SMT	Senior Management Team
SSE	Senior Site Executive
The Project	The Buller Plateau Continuation Project
Water Infrastructure	Water management structures e.g. sumps, pumps, drains, dams, ponds, pipelines and monitoring equipment.
WID	Water Infrastructure Design

1.0 Introduction

1.1 Purpose and Scope

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, Buller Coal Ltd, and joint venture BT Mining Ltd) (Bathurst) are seeking approvals through the Fast-track Approvals Act 2024 (FTAA) for the Buller Plateaux Continuation Project (BPCP, or the "Project").

This Water Infrastructure Design Plan (also referred to as the "Plan",) is developed as part of the BPCP and sets out the methodology for designing water infrastructure within the BPCP. Its purpose is to ensure environmental effects are avoided or minimised.

This Plan is targeted towards infrastructure that is within the operational mining areas where water does not report directly to the natural catchment. It recognises industry best practice with application to site specific aspects.

The design of water infrastructure referred to in this Plan uses a risk rating and structure permanence to define ARI design criteria, and then focuses on:

- Design flows
    - Rainfall Annual Recurrence Interval (ARI)
    - Time of Concentration
    - Climate Change
    - Catchment
    - Peak Flows
- Culverts
- Channels
- Sumps
- Pipelines
- Pumps
- Dams

The Plan is a technical design supplement to the Stockton Environmental Water Management Sub Plan (STO-ENV-PLN 013), Acid and Metalliferous Drainage (AMD) Water Management Plan (relating to MFS and ESE) (BPCP-ENV-PLN-010), and Millerton Block Water and AMD Management Plan (STO-ENV-PLN-027).

The above-mentioned Plans outline how water is managed at each respective site across development, construction, operation, decommissioning and closure of the BPCP project including:

- Description and characterisation of the environmental setting associated with the geology and catchment(s) of the respective site, including climate, geology, geochemistry, and topography to support the identification and management of potential environmental risks.

- Identification and assessment of the key environmental effects on water that may occur during the construction, operational and closure phases of the BPCP.
- Definition of the management practices and infrastructure to be employed during the construction, operational and closure phases to manage the water-related environmental risks.

The water infrastructure design methodology, herein this Plan, supports the management and minimisation of adverse effects on the receiving environment to the greatest extent practicable and consistent with the requirements of associated water and AMD management plans.

All BPCP water infrastructure designs are to be undertaken by a suitably qualified professional in accordance with this Plan.

Supporting spreadsheets for design of the infrastructure described in this Plan have been developed to standardise designs to meet BPCP requirements.

The design spreadsheets are as follows: (WID is an acronym for Water Infrastructure Design)

- WID01 – Design flows
- WID02 – Culvert design
- WID03 – Channel design
- WID04 – Sump design
- WID05 – Pipeline design
- WID06 – Pump selection
- WID07 – Dam design

It is expected that all personnel using or directed to use aspects of this Plan and supporting design spreadsheets will have adequate knowledge and experience to apply the design principles correctly.

Where the design spreadsheets are not applicable to infrastructure requiring design, then these must be designed by a suitably qualified professional.

The Plan (and supporting spreadsheets) is intended to be a practical operational document for internal use. Water infrastructure design will be noted in the Annual Work Plan (AWP) lodged with regulators as required, but each individual design does not require external approval.

In addition, Annual Environmental Monitoring Reporting (AEMR) may mention water infrastructure used or designed to avoid, mitigate or remedy non-compliant environmental effects.

1.2 Objectives

The objectives of this Plan are to:

- Provide design guidance for water infrastructure to improve discharge water quality and management efficiency across the BPCP.
- Ensure that as an operational plan for internal use, water infrastructure is suitably designed to avoid environmental effects and subsequent resource consent compliance issues.
- Provide consistent design guidelines across the BPCP that achieve operational and safety requirements.
- Simplify the design process for water infrastructure.

2.0 Adaptive Management

The process of adaptive management seeks to enable an environmental management approach that can evolve and adapt in response to measured data or changes in best management practices.

Adaptive management requires a ‘plan-do-check-act’ approach to be undertaken whereby the ongoing monitoring and reporting that is proposed creates a continuous feedback loop.

An adaptive management approach for effective water infrastructure design will be employed to reflect new information and changes in best practice as it becomes available over the life of the BPCP. This will inform ongoing effectiveness, mitigation of environmental effects, and adjustments to monitoring, reporting and management measures. Part of the adaptive management may involve reassessing design methodology.

Information from monitoring, routine inspections, and incident responses will be reviewed to identify opportunities for improvement. Where necessary, the design methodology may be refined or adjusted in response to the following (but not limited to):

- Observed trends and incremental changes in the state of waterway quality and aquatic ecosystems over time.
- Performance assessments of the installed infrastructure.
- Updates in industry best practise recommendations.
- Further understanding of the BPCP environment and idiosyncrasies which affect water behaviours.
- Changes in climate conditions that affect the nature of rainfall.
- Changes in downstream conditions that require more stringent water control.

Spreadsheets described in this Plan are considered live documents and can be updated to improve the design process or methodology as required. Any changes must be authorised by the documents owner and peer reviewed by a suitably qualified professional where appropriate.

Changes to internal water infrastructure design may also be triggered as part of the five yearly water quality and ecology review process, described in InStream (2026).

3.0 Water Infrastructure Design

The following outlines the design methodology to be implemented during design of water infrastructure and references applicable spreadsheets that standardise designs to meet BPCP requirements, ensuring environmental effects are managed over the duration of the BPCP.

When determining the most appropriate design method to select for each aspect, industry best practise, existing technical reports, site specific knowledge and historic experience of existing water infrastructure performance were considered.

The BPCP environment is unique with high rainfall, varying topography and in many cases sparse vegetation cover. The following methodologies for each infrastructure design were determined as the best fit to the environment and targeted objectives.

Historically for some of the Project areas, specific design requirements have been in place regardless of where and for how long the infrastructure was to be used. This often resulted in over design of some structures. This Plan uses a risk assessment basis for determining suitable ARI's, which is in line with what is typically done elsewhere in New Zealand, the intention of which is to design water infrastructure to be fit for purpose, engineered to match its life expectancy and purpose.

3.1 Design Flows

Design flows are the peak flow rates to be used to determine the sizing of the water infrastructure outlined in this Plan. Flows determined are required for design of all water infrastructure.

The design flows take into account catchment sizes, expected infiltration characteristics, topography, rainfall intensities, climate change, and peak flows. Correct assessment of the design flows ensures the subsequent water infrastructure is designed fit for purpose with required safety, reliability and cost-effectiveness aspects to be achieved.

Design flows are calculated as per the following data and process.

3.1.1 Rainfall ARI

Determining the correct Average Recurrence Interval (ARI) is fundamental to design adequacy as this indicates how often a rainfall intensity of a given magnitude is expected to occur on average.

The selected rainfall ARI shall be based on the lifespan of the structure to be designed and the risk of failure based on the current BRL risk matrix[1].

Tables 1 and 2 below set out the minimum design ARI for temporary and permanent water infrastructure respectively depending upon the risk rating as obtained by the BRL risk matrix. These ARI's related to risk are typical to what is used within New Zealand.

Table 1: Design rainfall ARI based on assessed risk rating for temporary structures

Temporary Structures	
Risk Rating	**Minimum Design ARI**
Low	1 in 2.33 year
Medium	1 in 5 year
High	1 in 10 year

Source: Internal design assessment

Table 2: Design rainfall ARI based on assessed risk rating for permanent structures

Permanent Structures	
Risk Rating	**Minimum Design ARI**
Low	1 in 20 year
Medium	1 in 50 year
High	1 in 100 year

Source: Internal design assessment

For the purposes of this Plan, permanent refers to structures that will remain in place at time of mine closure. Temporary structures are ones that will have been removed at time of mine closure.

Exceedance of the design ARI does not necessarily mean the infrastructure or the surrounding area will be damaged.

All structures regardless of ARI must be checked for the failure flow paths and resulting outcome if the structure is overwhelmed as part of the design process.

Meteorological stations (Met Sites) record various weather parameters including rainfall (amongst others). Consequently, extensive rainfall data is available for all BPCP sub-areas and the selected Met Site to be used at each area is based on reduced level above mean sea level.

[1] BRL risk matrix: A matrix where the risk rating is determined through the expected consequence and likelihood of that occurring.

The Met Site to be used for design of water infrastructure is selected based on which Met site has a similar RL to where the water infrastructure is to be located as per Table 3 below.

Table 3: Appropriate meteorological site to use at each BPCP region

Site/Area	Met Site	Met Site RL
Stockton - Mt Fred; No 2 South	Mt Fred	1056
Stockton – A Drive; Webb; Mangatini	Stockton	795
Stockton -Millerton; Hope Lyons; Rockies	Millerton	569
Mt Frederick South	Mt Fred	1056
Escarpment Extended	Lake Brazil	639

Source: Internal design assessment

3.1.2 Time of Concentration

The time of concentration is used to determine the rainfall duration that is likely to have the most effect on the water infrastructure.

Due to the varied topography and infrastructure that may already be in place upstream of the water infrastructure to be designed, the velocity method is the preferred option for determining the time of concentration (Refer Figure 1).

Figure 1: Time of Concentration – Velocity Method

$$T_t = \frac{L}{60V}$$

Where,

Tt = travel time, min

L = flow length, m

V = flow velocity, m/s

Source: Highway hydrology equation (3.4)

Flow paths are separated into:

- Sheet flow.
- Shallow concentrated flow.
- Culvert and channel flow.

Catchment assessment is required to determine when sheet flow may turn into shallow concentrated flow. Topography will be the main control as to when the transition occurs. General recommendations are for sheet flow to be present for less than 90m flow length and less than 50mm flow depth.

3.1.2.1 Sheet Flow

Sheet flow is characterised by a very shallow, uniform layer of runoff that moves along a plane before gathering into rills with visible flow paths. Sheet flow is calculated as per Figure 2.

Figure 2: Sheet Flow Travel Time

$$tt = \frac{\alpha}{i^{0.4}}\left(\frac{nL}{\sqrt{S}}\right)^{0.6}$$

Where,

t_t = travel time, min

α = unit conversion constant equal to 6.9 in SI units (0.93 in CU units), dimensionless

i = rainfall intensity for a duration of tc, mm/h

n = roughness coefficient, dimensionless (McCuen, 1989)

L = flow length, m

S = slope of the surface, m/m

Source: Highway hydrology equation (3.6)

As the rainfall is required to initially calculate the time of concentration, an initial estimated intensity shall be selected by using the U.S. Soil Conservation (also known as the Kirpich) time of concentration formula. Refer Figure 3.

Figure 3: U.S. Soil Conservation Service Time of Concentration

$$Tc = \left(\frac{0.87L^3}{H}\right)^{0.385}$$

Where,

Tc = time of concentration, hours

L = maximum flow length, km

H = difference in elevation between the highest and lowest points, m

Source: TM61 A Method for Estimating Design Peak Discharge Appendix B Equation 3

3.1.2.2 Shallow concentrated flow

Sheet flow transitions into shallow concentrated flow when the flow depth is no longer uniform, rills or microchannels form, and flow accelerates. Factors that affect when this occurs are changes in topography, slope steepness and/or a reduction in surface roughness. Shallow concentrated flow is calculated as per Figure 4.

Figure 4: Shallow Concentrated Flow

$$v = \alpha k s^{0.5}$$

Where,

V = velocity, m/s

α = unit conversion constant equal to 10 in SI (33 in CU), dimensionless

k = function of land cover, dimensionless (McCuen, 1989)

s = slope, m/m

Source: Highway hydrology equation (3.8)

3.1.2.3 Culvert and Channel Flow

Where the shallow concentrated flow reports into formed channels or culverts, the velocity can be calculated with the Mannings equation as per Figure 5.

Figure 5: Mannings Equation

$$V = \frac{\alpha}{n} R^{2/3} S^{1/2}$$

Where,

V = velocity, m/s

α = unit conversion equal to 1.0 in SI units (1.49 in CU units), dimensionless

n = Manning's roughness coefficient, dimensionless

R = hydraulic radius, m

S = slope, m/m

Source: Highway hydrology equation (3.9)

Design flow spreadsheet WDI01 guides the time of concentration process.

3.1.3 Climate Change

The repercussions of climate change are becoming more apparent with changes in rainfall patterns and intensities. It is paramount to accommodate these changes where possible allowing for adaptive water infrastructure design.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change in 2014 used Representative Concentration Pathways (RCP's) to determine how the climate may change in the future, depending upon current and predicted behaviours.

Of the four RCP's, 2.6, 4.5, 6.0, 8.5, it was considered that RCP 6.0 was applicable for predicting rainfall intensities on the BPCP. This allowed for some improvement in emissions compared with the current predicted path and therefore not worst case but not overly optimistic either. Review of this Plan every 5 years will allow for adjustments of the RCP as necessary.

Following selection of the rainfall intensity, the rainfall is increased by the percentage as shown in Table 4 below. Calculations are based on the RCP 6.0 expected increases in temperature and subsequent increases in rainfall against the life span of the structure.

Climate change adaptation is included in design flows spreadsheet WID01.

Table 4: Increase in rainfall intensity based on design infrastructure lifespan

Life Span of Structure	Temperature Increase (Celsius)	Rainfall Intensity
0 to 2 years	0	As per ARI
2 to 5 years	0.2	Increase by 2.6%
5 to 20 years	0.7	Increase by 8.9 %
20 to 100 years	1.6	Increase by 21.4%
> than 100 years	2.3	Increase by 30.3%

Source: Climate Change Projections for New Zealand, 2018 Table 13 and Table 14

Met Site rainfall ARI's and climate change adaptation are reviewed 5 yearly to update the design inputs with current rainfall measurements and updated predicted rainfall intensity changes. This will allow adaptative changes to the design infrastructure to meet the predicted changing climate and/or assess the adequacy / risk of permanent structures already constructed.

3.1.4 Catchment

The catchment area is determined by topography and delineated by differing runoff surfaces.

Assessment must be given to planned changes of the catchment throughout the specific infrastructure's lifecycle to account for increases to the catchment size or changes in topography, including surface conditions that will affect the function of the designed infrastructure.

Other assumptions are made about the runoff coefficient, for example the surface not being saturated during the design rainfall event.

Often catchments are larger than the recommended 50 hectares for the Rational Method, and in these cases, design decisions must be made on the appropriateness of this method and if used, an explanation as to why it can be considered suitable.

In other cases, with catchments greater than 50 hectares, the Modified Rational Method is used. This is whereby the critical duration is selected by calculating a series of peak runoff flows for each duration allowing volume and hydrograph shape to be determined. The Modified Rational Method is included within design flow spreadsheet WID01.

3.1.5 Peak Flows

The Rational Method is to be used for calculation of peak flows.

The Rational Method is used when the critical rainfall duration is considered to be equal to the time of concentration as per Figure 6.

It is intended that water infrastructure designed using this method does not have residual base flow that affects the capacity at the assessed flow.

In cases where the base flow is significant, these must be specifically designed by a suitably qualified professional.

Figure 6: Rational Method Equation

$$Q = CIA$$

Where,

Q = peak flow, m^3/s
C = runoff coefficient, dimensionless
I = rainfall intensity, m/s
A = catchment area, m^2

Source: MBIE E1 Surface Water Section 2.0.1

3.1.5.1 Runoff coefficients

Runoff coefficients represent the percentage of rainfall that transitions to runoff and contributes to the flow from the catchment. Runoff coefficients vary based on the ground surface type and slope.

Runoff coefficients outlined in Table 5 have been based on recommended values from varying land surface types and slopes then applied using experienced site judgement.

Table 5: Recommended runoff coefficients

Catchments/Ground surface type	Runoff Coefficients
Roads, paved areas	0.9
In-situ sandstone, coal floor	0.8
Active overburden dumps	0.6
Rehab	0.5
Undisturbed vegetated	0.5

Source: https://civilweb-spreadsheets.com/drainage-design-spreadsheets/runoff-and-rainfall-intensity-calculator-spreadsheet/rational-method-runoff-coefficient/

3.2 Culverts

Culverts are required to convey water typically from one channel to another underneath a roadway, embankment or through an area where a channel is not suitable.

Culverts are to be designed using the Mannings Formula followed by inlet or outlet control refinement as required by the specific installation conditions for each culvert. This will dictate the governing factor for design, such as grade and outlet channel geometry.

This design standard covers circular culverts only, box culverts will require specific design by a suitably qualified professional as it outside the scope of this Plan and supporting spreadsheets.

Note that it is not intended for culverts designed under this Plan to remain permanently at closure.

The Mannings equation (refer Figure 5) is based on the formula for full pipe flow conditions.

Inlet Control:

Culverts typically operate under inlet control where the inlet is submerged.

The culvert flow is restricted to the discharge which can pass the inlet with a given inlet shape and headwater level.

Outlet Control:

The culvert flow is restricted to the downstream conditions such as tailwater depth, culvert geometry and barrel friction that govern how much flow the culvert can pass.

Typically, culverts are under inlet control but must be assessed for both inlet and outlet conditions to determine which is the influential aspect.

3.2.1 Culvert Loading Capacity

Concrete culverts require specification of the correct class to ensure sufficient strength is available for the loading conditions which are typically but not limited to ground and traffic pressures. The software program 'PipeClass'' produced by the Concrete Pipe Association of Australasia (https://cpaa.asn.au/design-software-pipeclass/) provides the recommended class based on installation methodology and design loads. Concrete culverts are spun rubber ring jointed, although the rubber rings are not installed for gravity flow conditions.

High density polyethylene (HDPE) pipes are to be checked for the required standard dimension ratio (SDR) under the design loads using AS/NZS 2566.1:1998 Buried Flexible Pipelines.

Typical concrete culvert classes and HDPE SDRs for standard installations are provided within culvert design spreadsheet WID02. Conditions outside of those included in WID02 must be checked by specific design by a suitably qualified professional.

Preference is to use Class 4 concrete culverts and SDR17 HDPE culverts to maintain consistency over the sites. As culverts are often reused, this prevents inadvertently using an incorrect class of culvert.

3.2.2 Other Culvert Design Aspects

The design of the installation trench, which accommodates the culvert infrastructure, is to be supplied to the planning engineer showing dimensions and material specifications.

Following installation, culverts are to be surveyed with inlet and outlet inverts to be recorded with x, y and z coordinates and entered into the culvert register (refer Section 4.3.1).

Minimum grade of the culvert shall be 1 in 75. The maximum grade of the culvert is controlled by velocity which must be under 8 m/s for concrete culverts.

There are no culvert requirements for fish passage within the operational areas.

3.3 Channels

Channels are required to create a stable and efficient pathway to convey stormwater runoff collected within a catchment area to a downstream point without causing erosion or flooding in undesired areas. Channels keep water flow paths away from work areas and roads where the water would otherwise create hazardous situations. By minimising erosion along water conveyance points, the downstream sediment control sumps are not overwhelmed by sediment and costs for remedial clean-up work are reduced.

Channels are to be designed using Mannings formula (Refer Figure 6).

The minimum grade shall be 1 in 75 without specific design.

Allowable freeboard shall be based on the design flow depth and risk rating. For low to medium risk channels, the freeboard depth will be equal to the flow depth up to a maximum of 400 mm. For high risk channels, the freeboard shall be a minimum of 300 mm for flow depths of 100 to 300 mm and 500 mm for all other flow depths.

Riprap shall be sized according to the velocity conditions in the channel, refer to channel design spreadsheet WID03.

Channel velocity that does not meet the typical conditions as included in channel design spreadsheet WID03 shall have riprap specified using the HEC-15 Design of Roadside Channels with Flexible Linings method (Hydraulic Design Manual, New Zealand Edition December 1997).

3.4 Sumps

Sumps are typically designed for 2 purposes, either capture and settling of sediment (see Section 3.4.1) or retention (see Section 3.4.2). These design procedures are included in sump design spreadsheet WID04.

3.4.1 Capture and settling of sediment

The capture and settling of sediment requires a sump to be sized and shaped to promote rapid dropping out of the sediment from the inflow.

The Modified Fair and Geyer (1954) is the method to be used (refer Figure 7). This method is adjustable for varying efficiencies of sump shapes and applies a particle settling velocity to allow for sump sizes to be adjusted for inflow material.

Figure 7: Modified Fair and Geyer Equation

$$R = 1 - \left[1 + \frac{1}{n}\frac{v_s}{Q\ /\ A}\frac{(de + d_P)}{(de + d^*)}\right]^{-n}$$

Where,

R = fraction of sediment removed, dimensionless
n = turbulence or short-circuiting parameter, dimensionless
Vs = settling velocity of target grain size, m/s
Q = design flow rate, m^3/s
A = pond surface area, m^2
de = extended detention depth above permanent pool level, m
dp = depth of permanent pool, m
d* = depth below the permanent pool to retain sediment, m

$$n = 1\ /\ (1 - \lambda)$$

Where,

ƛ is the hydraulic efficiency as determined by the sump configuration.

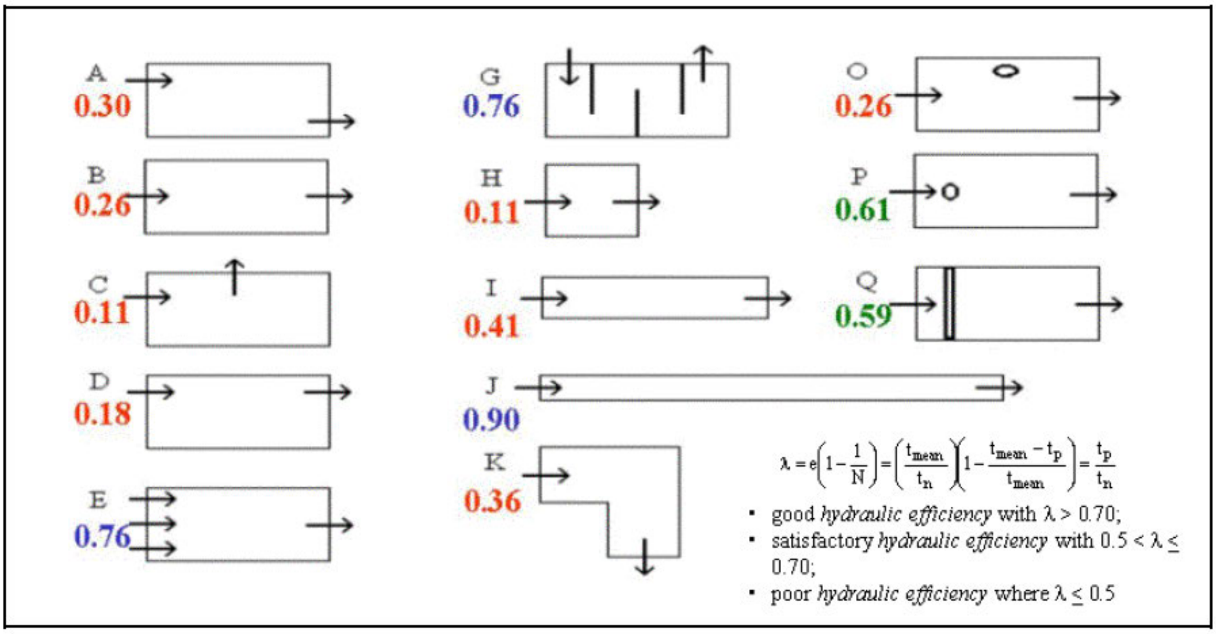
Source: WSUD Engineering Procedures for Stormwater Management in Tasmania 2012 Chapter 3 Sediment Basins

The hydraulic efficiency takes into account the sump configuration which can affect settling rates through short-circuiting, dead zones and high velocities etc.

Figure 8 shows some typical sump configurations and flow paths with the respective lambda (ƛ) value.

Good hydraulic efficiency will likely require use of flow spreaders, and configuration of outlet positioned to maximise travel distance and a length to width ratio of 3:1 or greater.

Figure 8: Sump Hydraulic Efficiency



Source: WSUD Engineering Procedures for Stormwater Management in Tasmania 2012 Chapter 3 Sediment Basins

Settling velocities are to be used for the target sediment particle size fraction to be removed and shall be determined by settling velocity tests if available, otherwise by Stokes Law as per Figure 9 below.

Figure 9: Stoke Law Equation

$$V_s = \frac{2}{9}\frac{p_\rho - p_f}{\mu} gR^2$$

Where,

Vs = settling velocity, m/s

p_p = density of the particle, kg/m^3

p_f = density of the fluid, kg/m^3

µ = dynamic viscosity, kg/m.s

g = gravitational acceleration, m/s^2

R = radius of the particle, m

Source: https://stormwaterbook.safl.umn.edu/sedimentation-practices

3.4.2 Retention

Where sumps are used for retention, (e.g. an inpit pump sump), the required volume shall be calculated based on the frequency of time the sump can be overtopped. This can be assessed using the rational formula (refer Figure 5) for runoff and site specific rainfall data to ensure typical rainfall patterns are accounted for.

The available drawdown either by a decant system or by pumping is taken into account by calculating the removal capacity of the pump and decant.

Sumps required for water storage are also assessed using the same procedure but with the focus on capacity storage and how much water is required to be available for use. Water removal either though pumping or usage shall be taken into account.

Spillways from sumps will be designed using the channel design spreadsheet WID03.

3.5 Pipelines

Pipelines are required for transfer of water typically from pumps to the outflow point. These are flexible HDPE pipelines connected by butt welding, electrofusion welding or stub flanges with backing rings.

Temporary connections, when the preceding options are not possible due to site conditions, can be Victaulic couplers.

Flexible hoses used for discharge pipes are to have beaded ends to prevent failure of a hose tail connection when under pressure.

Pipelines, connections, and fittings must be correctly rated for the maximum pressure rating.

Air valves are required to release trapped air in the pipeline. These are to be fitted as per design recommendations in pipeline design spreadsheet WID05.

As part of the analysis the hydraulic grade line and total energy lines are calculated to identify any areas of negative pressures and assist with pipe pressure selection. This is included in pipeline design spreadsheet WID05.

Head loss throughout the pipe is characterised by ht = hf + hl

Friction head is calculated using the Darcy-Weisbach formula as per Figure 10.

Figure 10: Darcy-Weisbach Formula

$$h_f = f \frac{L}{D} \frac{v^2}{2g}$$

Where,

hf = head loss due to friction, m
f = friction factor, dimensionless
L = length of pipeline, m
D = inner diameter of pipeline, m
v = velocity of fluid, m/s
g = gravitational acceleration, m/s^2

Source: https://www.pipeflow.co.uk/public/articles/Darcy_Weisbach_Formula.pdf

As the flow is typically turbulent, the friction factor is determined by the Swamee-Jain equation as per Figure 11.

Figure 11: Swamee-Jain Friction Factor Equation

$$f = \frac{0.25}{\left[\log_{10}\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re\,0.9}\right)\right]^2}$$

Where,

f = friction factor, dimensionless
ε = absolute pipe roughness, mm
D = inner diameter of pipeline, m
Re = Reynolds number, dimensionless

Source: https://www.engineersedge.com/calculators/swameejain_friction_factor_15811.htm

The Reynolds number (Figure 12) is a ratio that compares inertial forces to the viscous forces and gives indication as to the flow regime as being either laminar flow (Re < 2000), transitional flow (Re 2000 – 4000) or turbulent flow (Re > 4000). For pumped pipeline flow, we are typically dealing with turbulent flow.

For the Swamee-Jain friction factor in Figure 11, the range of Re is valid for $5000 < Re < 10^8$.

Design for values of Re outside of the range must be undertaken by specific design.

Figure 12: Reynolds Number

$$Re = \frac{VD}{\nu}$$

Where,

Re = Reynolds number, dimensionless
V = velocity, m/s
D = inner diameter of pipeline, m
ν = kinematic viscosity, m^2/s

Source: White, Frank M. 2011. Fluid Mechanics Seventh Edition. McGraw Hill.

Local losses due to fittings occur due to interferences in the flow regime caused by valves, tees, flow meters etc. Figure 13 outlines the calculation used. A list of local loss coefficients for common fittings are included in pipeline design spreadsheet WID05.

Figure 13: Local losses in a pipeline

$$h_L = K\frac{V^2}{2g}$$

Where,

h_L = local losses due to fittings, m
K = local loss coefficient, dimensionless
V = velocity of fluid, m/s
g = gravitational acceleration, m/s^2

Source: Crane Co. (2018). Flow of Fluids Through Valves, Fittings, and Pipe (Technical Paper No. 410).

3.6 Pumps and Pontoons

The typical pumps to be used are centrifugal diesel and electric pumps for the majority of dewatering purposes. Electric submersible pumps are used for smaller in-pit sumps where space or access is limited.

All centrifugal pump wet ends are to be stainless steel, either 316 or 304. Submersibles used in water with pH water greater than 5 can be mild steel, due to the lower corrosion risk. Belzona coating of mild steel for use in low pH water / AMD can be suitable for short time frames in low sediment laden water where sediment erosion of the coating will not occur.

Pumps are selected based on the design flow and head demand as calculated by the pipeline design spreadsheet WID05. The design flow point shall be as close to the best efficiency line for the pump as possible as shown on the pump curve. Typical pump RPM (revolutions per minute) is 1800.

The net positive suction head (NPSH) available is calculated and compared to the pumps required NPSH for each pump set up. This is related to each pump included in pipeline design spreadsheet WID05.

Where possible, pumps are set up to operate automatically with control by a float switch or level sensor between the desired start and stop water levels.

Pumps must be installed on pontoons where they are at risk of flooding. Pontoons are to be stainless steel where used in AMD affected water and of a barge style unless otherwise assessed as appropriate. Pontoons must be assessed for buoyancy and stability for the pump to be used and for required personnel access.

3.7 Dams

Dams can be required to lift a low area within a sump extent, increase sump retention capacity, or in low flow channels to slow the flow velocity thus minimising erosion and facilitating sediment precipitation.

Design specifications for small dams are shown in dam design spreadsheet WID07. These are for dams that do not meet the specification of a classifiable dam as outlined below. Dams covered under this Plan are small earth bund types. Other materials used to construct dams such as concrete must be undertaken as a specific design by a suitably qualified professional.

Dams that meet the classifiable dam specification (i.e., have a height of 4 or more metres and store 20,000 or more cubic metres of water or other fluid) are outside the scope of this Plan. These dams shall be specifically designed following the New Zealand Society on Large Dams Dam Safety Guidelines 2024 for design, construction and management. Classifiable dam design typically requires assistance from external consultants.

Spillways for dams will be designed using the channel design spreadsheet WID03.

4.0 Monitoring and Maintenance

4.1 Monitoring and maintenance measures

An as-built will be undertaken following construction to ensure the installation is to design and provides a basis for future comparisons. If it is identified that the as-built does not meet the design criteria, assessment shall be made as to whether the variance is acceptable or rework is required.

All infrastructure shall be entered into a monitoring checklist with inspections undertaken following an exceedance in each structures design ARI and as per Table 6.

Table 6: Monitoring Inspection Frequency

Monitoring Inspection Frequency						
Water Infrastructure Type						
Risk Level	**Culverts**	**Channels**	**Sumps**	**Pipelines**	**Pumps and Pontoons**	**Dams**
Low	Quarterly	Yearly	Yearly	Quarterly	Yearly	Yearly
Medium	Monthly	Quarterly	Quarterly	Monthly	Quarterly	Quarterly
High	Fortnightly	Monthly	Monthly	Fortnightly	Monthly	Monthly

Monitoring of infrastructure will assess performance to design and any damage sustained.

Maintenance required shall be carried out as soon as possible unless urgent, in which case it shall be completed within 8 hours of notification.

5.0 Data Management

Data management systems are important to retain information related to each water infrastructure design. This will allow reviews when required and understanding of what infrastructure is located where and what the original purpose of that infrastructure was.

5.1 GIS

Water infrastructure information will be managed in Vulcan by the Survey Team and in GIS by the Environmental Team. The Vulcan data is related to location in the x,y and Z planes, while the GIS data also has detailed information to do with the specific infrastructure design and purpose, including dates of construction. Water infrastructure shall be surveyed and added to the mining software program, Vulcan within 7 days of installation and updated monthly in ArcGIS.

5.2 Design Spreadsheets

All design spreadsheets shall be saved in the relevant folders to do with the infrastructure and location. The GIS information can include a link to these design spreadsheets by selecting the desired infrastructure.

Design spreadsheets will be version controlled. New/updated versions of design spreadsheets will be issued with a version number and date to eliminate obsolete design spreadsheets being used. A copy of the original design spreadsheet and subsequent versions will be kept for records and marked as obsolete.

A record of each piece of infrastructure designed will be kept. The information will include the version of the design spreadsheet the infrastructure was designed to, and the date of design.

5.3 Naming Conventions

Where names of the infrastructure are required, the infrastructure name shall start with the catchment it is in, then follow sequential numbering. If the infrastructure covers more than one catchment, it shall be the catchment the water flow starts in that is the chosen name.

6.0 Management Responses

6.1 Incident Responses

Incident response shall follow the BRL Incident Reporting and Notification Standard – BRL-HST-STD-002.

6.2 Adaptative Management and Design Review

Based on the outcomes of the monitoring, designs may need to be adapted if the water infrastructure is not performing as expected.

This will likely be an alteration to the selected ARI if it is shown the design plan is resulting in over or under design of structures that are subsequently not cost effective or repeatedly not meeting the design objectives. Other changes may be required due to industry updates on best practises for these specific design criteria.

In addition, Met Site rainfall ARI’s and climate change adaptation will be reviewed 5 yearly to update the design inputs with current rainfall measurements and updated predicted rainfall intensity changes. This will allow adaptative changes to the design infrastructure to meet the predicted changing climate.

7.0 Reporting

Reporting is undertaken to document monitoring outcomes and effectiveness of water infrastructure design, management measures and resourcing.

Information from water infrastructure effectiveness monitoring, routine inspections, and incident responses will be reviewed to identify opportunities for improvement and will be reported as required or as necessary.

Reporting in accordance with this Plan is proportionate to the scale and nature of monitoring undertaken.

7.1 Internal Reporting

Internal reporting will consist of:

- Daily feedback on pump performance and water issues to the Daily Production Meeting.
- Weekly Mining Pit Review with Operations Teams.
- Weekly updates on water management aspects to the Senior Management Team (SMT) Meetings.
- Bi-monthly water management meetings with Technical, Pump Crew and Operations Teams.
- Monthly BT Mining Management Reports.
- Monthly Pump Meetings with Pump Crew, Fixed Plant and Mobile Plant Teams.
- Preparation of memoranda describing the results of targeted performance monitoring/milestones.

Feedback from scheduled inspections and monitoring outcomes will be communicated to site personnel through toolbox talks or other appropriate forums as required to reinforce good practice and inform staff behaviour. Where required, additional inspections will be undertaken to verify the effectiveness of revised controls.

7.2 External Reporting

This Plan (and supporting spreadsheets) is intended to be a practical operational document for internal use.

Water infrastructure design will be noted in the AWP lodged with regulators as required, but each individual design does not require external approval or reporting.

In addition, the AEMR may mention water infrastructure used or designed to avoid, mitigate remedy or mitigate non-compliant environmental effects. Updates of the water management plans and design guidelines will be provided to specific project Peer Review Panels where required.

8.0 Roles, Responsibilities, and Training

Effective implementation of this Plan relies on clearly defined roles, responsibilities, and appropriate training for all personnel involved in implementation of this Plan.

Responsibilities under this Plan support the management pathway whereby monitoring and observations identify potential issues and trigger appropriate responses.

8.1 Roles and Responsibilities

Key roles and responsibilities associated with this Plan are outlined in Table 7.

Table 7: Responsible Personnel and Tasks

Position	Accountable Task
Senior Site Executive (SSE)	• Ensuring that Water Infrastructure Design initiatives are recognised as a core business imperative. • Managing risk when site standards cannot be met due to operational or topographical constraints.
Environment and Community Manager	• Ensuring that the objectives of this Plan are incorporated into mine plans and the planning process at all levels. • Ensure adequate resources are sought and provided by the business to achieve the objectives of this Plan. • Support the communication and implementation of the requirements of this Plan and associated procedures. • Investigate any incidents or non-conformances. • Actively promote reporting of potential situations. • Facilitate Broad Brush Risk Assessments covering critical water management and infrastructure design aspects for the business.
Environment and Community Superintendent	• Development and maintenance of this Plan and supporting documentation. • Apply and enforce the requirements of this Plan. • Investigate any incidents or non-conformances. • Responsible for ensuring the instruction of workers (alongside Water Engineer), implementation and overseeing of the requirements of this Plan, including monitoring the effectiveness. • Maintain a documented record of any audits or inspections completed.
Water Engineer	• Ensuring that water infrastructure designs adhere to this Plan and incorporate the relevant site strategies and standards.

	• Ensuring the instruction of workers (alongside Environment and Community Superintendent), implementation and overseeing of the requirements of this Plan, including monitoring and review of the effectiveness. • Ensuring that the inspection, management of data, and development of work schedules for maintaining water infrastructure is undertaken. • Providing site representation and input in relation to mine projects. • Ensuring that monitoring and reporting obligations are fulfilled. • Maintain the database of water infrastructure with locations and design information.
Senior Environmental Planner	• Ensuring that water infrastructure designs adhere to this Plan and incorporate the relevant site strategies and standards. • Ensuring the instruction of workers (alongside Environment and Community Superintendent), implementation and overseeing of the requirements of this Plan. • Providing site representation and input in relation to mine projects including new disturbance. • Supporting the Environmental Manager and/or Environment and Community Superintendent, Water Engineer and AMD Scientist with water monitoring and investigations and reporting.
Environmental Monitoring Officer	• Supporting the Environmental Manager and/or Environment and Community Superintendent, Water Engineer and AMD Scientist with water monitoring, investigation and reporting.
Contractors	• Contributing to achievement of the objectives of this Plan. • Ensure all their employees are fully trained and aware of relevant requirements of this Plan and associated procedures. • Reporting any water infrastructure related issue that they perceive presents a risk to site performance and/or reputation. • Ensure compliance with all site regulations and engage in safe work practices.
All Personnel	• Contributing to achievement of the objectives of the Plan wherever this relates to their role. • Reporting any water infrastructure related issue that they perceive presents a risk to site performance and/or reputation.

	• Ensure compliance with all site regulations and engage in safe work practices.

9.0 Training and Inductions

Relevant personnel implementing this Plan will be adequately trained and inducted as required.

This training reinforces the link between monitoring outcomes, trigger identification, and appropriate operational responses.

10.0 Document Management

This Plan forms part of the SEMP and will be managed in accordance with *BRL-HST-STD-003 Document Control Standard*. This Plan will be reviewed five (5) yearly or:

- Following any notable updates to the referenced standards or formulas and equations used;
- Following significant incidents;
- Plan review;
- If monitoring shows inadequate performance due to design;
- At the request of management.

10.1 Change Register

This Plan is issued, revised, and amended under the authorisation of the Site Senior Executive (SSE). Controlled electronic copies will be available to all workers, and a signed hard copy will be maintained in the Westport document library.

Reasons for changes will be documented in the document management table (refer Table 8). Superseded versions will be retained for record purposes and marked as obsolete. Each revised version will be issued with a unique version number and date to prevent the use of outdated documents.

Table 8: Document Management

Document Management:			
Regulatory Approvals Authorities:			
Document Owner:			
Document Owner Name:			
GM HSEC Approval Signature:			
Date:			
Document Approver:			
SSE/GM Name:			
SSE/GM Signature:			
Date Approved:			
Revision History:			
Date	**Version No.**	**Lead Author**	**Contributing Authors**
April 2026		[redacted]	
Version No.:	**Detail / Changes:**		
Next Planned Review:			

11.0 References

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