Appendix 7

Tailings Storage Facility Final Design Update

(Total No. of pages including blank pages = 164)

(Note: A colour version of this Appendix is available on the Project CD)

This page has intentionally been left blank

UNITY MINING LIMITED
DARGUES GOLD PROJECT



TAILINGS STORAGE FACILITY FINAL DESIGN UPDATE

PREPARED FOR:

Unity Mining Limited
Level 10, 350 Collins Street
Melbourne, Victoria
AUSTRALIA

PREPARED BY:

Knight Piésold Pty Limited
Level 1, 184 Adelaide Terrace
East Perth, WA 6004, AUSTRALIA
p. +61 9223 6300 • f. +61 9223 6399

Knight Piésold CONSULTING
www.knightpiesold.com

PE801-00139/10
Rev 0
July, 2015

DOCUMENT CONTROL PAGE

UNITY MINING LIMITED

DARGUES GOLD PROJECT

TAILINGS STORAGE FACILITY FINAL DESIGN UPDATE

KP Job No. PE801-00139/11

KP Report No. PE801-00139/10

CONTRACT
PROJECT CONTRACT #

DOCUMENT INFORMATION

REV	DESCRIPTION	PREPARED	REVIEW	KNIGHT PIESOLD APPROVAL	DATE
A	Issued as Draft	SJS	SJS	DJTM	03/06/15
0	Issued as Final	SJS	SJS	DJTM	01/07/15

DOCUMENT DISTRIBUTION

REV	DESTINATION	HARD COPY	ELECTRONIC COPY
A	UNITY MINING LIMITED, LEVEL 10, 350 COLLINS STREET, MELBOURNE	-	1
0	UNITY MINING LIMITED, LEVEL 10, 350 COLLINS STREET, MELBOURNE	-	1

Knight Piésold CONSULTING

CONTENTS **PAGE**

CONTENTS **PAGE**

CONTENTS PAGE

1. INTRODUCTION

1.1 GENERAL

Knight Piésold is an international firm of consulting engineers with Australian managed offices in Perth, Brisbane, Sydney, Singapore and Vietnam, which provide specialised services to the mining industry in the fields of environmental, geotechnical, geological, hydrogeological, waste management, and water resources engineering. The Knight Piésold Group is an international organisation with over 90 years of experience in the fields of mining, power, water, transport and environmental engineering. In addition to the Australian offices, the Knight Piésold Group has offices in the USA, Canada, Africa, South America and the UK.

Knight Piésold has been involved in the design of tailings management facilities for many hundreds of mining projects throughout the world. The Company has extensive experience with all types of tailings management systems, and has pioneered the development of alternative tailings management technologies such as drained sub-aerial systems, thickened/ultra-thickened/paste tailings disposal, and dewatered 'dry stack' tailings systems. Knight Piésold has also been responsible for the development of innovative concepts in the field of mine waste management and environmental protection, specifically with respect to geotechnical engineering, tailings disposal systems and heap leach facilities, construction, and in situ testing of soil and synthetic liners, hydrogeological and site water management systems, storage of acid-generating materials and environmental protection.

Knight Piésold has extensive recent and current experience conducting site investigations, tailings management and heap leach projects in Australia, including the following projects:

- Northparkes, NSW (Rio Tinto) - Feasibility design, detailed design, construction supervision and auditing for all three tailings storage facilities at the project comprising two conventional paddock facilities and an integrated pit backfill / above ground storage facility. Knight Piésold's involvement with the project extends over a period of 25 years.
- Cadia Project, NSW (Newcrest Mining) - Design and construction supervision of the main tailings facility to store 17 Mtpa of copper tailings, including tailings testing, basin preparation and embankment designs.
- Hillgrove Gold / Antinomy Project, NSW (Hillgrove Mines) - Feasibility study, final design, construction supervision and dam safety inspections for two tailings storage facilities at the site. Recent work includes detailed design and

construction of a Stage 2 raise for TSF2 and conceptual designs for a third tailings storage facility.

- Ulan Coal Project (Ulan Coal), NSW - Knight Piésold was commissioned to design a 450 ML storage facility for saline water resulting from underground dewatering at this project. The shallow surface aquifers at the water storage site were of high value and were an emotive issue for the local community. Knight Piésold therefore adopted Nevada State standards which require the facility to be designed to achieve nominal zero discharge, whereby no undesirable constituents are detected above background levels.
- Kempfield Silver Project, NSW (Argent Minerals) - Bankable feasibility study for tailings and waste rock management, surface water management and sediment control.
- Rocklands Copper Project, QLD (Cudeco). Completed in mid-2011 with mining lease granted in late 2011, Knight Piésold was involved in the design and environmental impact assessment for the Rocklands Copper Project. Knight Piésold conducted the feasibility and detailed design of the tailings storage facility, waste rock dumps (including detailed geochemical characterisation and PAF waste management), plant site geotechnics, surface water management (including creek diversion) and access and haul roads.
- Tropicana Gold Project, WA (Anglogold Ashanti / Independence Gold) - Feasibility study, final design and construction supervision for tailings storage (integrated waste landform), access road, airstrip and plant site investigation.
- Boddington Gold Mine, WA (Newmont Mining) - Feasibility study, final design and construction supervision for residue disposal area. On-going technical support, Stage 8 construction in progress.
- Granny Smith Gold Mine, WA (Barrick Mining) - Feasibility study for Cell 3. On-going technical support to the operation over the past twelve years.

Knight Piésold carried out the final design of the flotation tailings storage facility (TSF) for the Dargues Gold Project in 2011. This is presented in KP report PE801-00139/5 (Ref. 1). Subsequently, Unity Mining Limited (Unity) has taken ownership of the project and the project design criteria have been amended. This report presents a Final Design Update reflecting the change in design criteria.

1.2 PROJECT DESCRIPTION AND LOCATION

The Dargues Gold Project is a gold prospect located in New South Wales approximately 12 km south-south-west of the town of Braidwood and approximately

60 km east-south-east of Canberra, as shown on Drg. No. 801-139-A201-002. The operation has approval to mine up to 355,000 tonnes per annum using underground open stope mining methods via a decline. A paste fill process will be used in the stoped out areas and waste rock will also be used as stope backfill allowing maximum orebody extraction and limiting haulage of waste to surface.

The processing plant will utilise a gravity circuit to extract coarse gold, a flotation circuit to produce a gold concentrate and a conventional carbon-in-leach process to produce gold doré.

The proposed infrastructure for the mine comprises the following:

- A plant site located approximately 500 m to the west-north-west of the TSF and orientated north-south.
- The mine entrance portal will be situated approximately 400 m to the west-south-west of the TSF and will be orientated south to north. The portal is located at approximately 20 m below surrounding ground level.
- A decline falls in an east-west direction at a gradient of 1 in 7 from the portal to the orebody. The mine workings extend in a near vertical direction from between approximately 70 m below ground surface at the highest point to 500 m below ground surface at the lowest point.
- The tailings storage facility (TSF) will be located relative to the plant site and boxcut and is situated on an unnamed ephemeral creek and surrounding agricultural land.
- A paste hole, vent riser and escapeway are located approximately 150 m, 200 m and 200 m respectively south of the TSF embankment. The highest point of the underground mine workings are offset both horizontally and vertically approximately 200 m to the south of the downstream toe of the TSF.

1.3 LOCAL GEOLOGY

The Dargues mine occurs in the western part of a large granitic pluton, the Braidwood Granodiorite, that trends approximately north-south and extends from north of Braidwood to well south of Majors Creek. Major mineralisation occurs on the northern side of a diorite dyke which crops out in Spring Creek a short way downstream of the confluence of the unnamed creek beneath the TSF footprint with Spring Creek. It is possible that the dyke and the mine workings will intercept any seepage that originates from the TSF. However, a review of the available structural geology by Unity indicates that there is limited potential for a direct structural connection between the TSF and the underground workings.

The proposed TSF site is typically underlain by residual soils derived from weathering of the underlying granite to a depth of 2 m to 3 m. The residual soils are clayey in the upper metre, but are essentially non-plastic below this layer.

1.4 DESIGN PARAMETERS

The process design parameters provided by Unity for design of the TSF are summarised in Table 1.1, and are discussed in detail in Section 2.

Table 1.1: Design parameters

Design tonnage[1]	1.22 Mt
Life of mine[1]	65 months
Tailings throughput[1]	145,000 to 324,000 tonnes per annum
Tailings beach slope	1V:80H
Average concentrate tailings ratio[1]	10%
Tailings % solids[1]	64%

[1] provided by Unity

1.5 SITE SELECTION AND CONSTRAINTS

Site selection for the TSF was carried out prior to the bankable feasibility study, taking account of land ownership, the proximity of borrow for construction materials and the exploration potential within the existing leases. Options on land not owned by Unity's predecessor, Cortona Resources, were not assessed because the land was not available for sale or use by the Company. Two potential TSF sites were assessed:

- Option 1 – Nominal square / rectangular paddock facility to the south of the plant area.
- Option 2 – Valley storage to the east of the plant site.

Both of the options selected were considered to be viable tailings storage areas. Option 2 was considered to be a more efficient facility in terms of embankment fill per unit of storage capacity and was selected as the preferred location for the tailings storage facility. The final design and final design update were carried out on the Option 2 location as the preferred location of the tailings storage facility.

2. DESIGN CRITERIA

2.1 HAZARD RATING

2.1.1 General

The consequence assessment and consequence category for the Dargues Gold Project tailings storage facility (TSF) have been assessed in accordance with the following guidelines:

- Dams Safety Committee of New South Wales "DSC3A – Consequence Categories for Dams" (Ref. 2)
- Dams Safety Committee of New South Wales "DSC3F – Tailings Dams" (DSC3F) (Ref. 3)
- ANCOLD "Guidelines on the Consequence Categories for Dams (Ref. 4).

The guideline DSC3A notes that the DSC has adopted the ANCOLD guidelines, with qualifications noted in DSC3A, to assist dam owners in providing information for the DSC to make an initial determination on the consequence category for a dam.

The consequence category of the flotation TSF was previously prescribed by the DSC as "significant". The following sections provide details of the re-assessment of the consequence category to take account of the amended design parameters.

2.1.2 Dam Break Assessment

A comprehensive dam breach assessment was performed as part of the flotation TSF final design in order to assess the effects of a dam failure downstream of the facility. The assessment is detailed in KP report "*Dargues Reef Gold Project, Tailings Storage Facility, Dam Breach Assessment*", PE801-000139/8 (Ref. 5) and is summarised herein.

There are two types of consequence categories, which indicate the conditions that exist in the vicinity of the facility immediately prior to onset of a dam breach:

- Sunny Day Consequence Category (SDCC), which refers to failures that occur without any attendant natural flooding;
- Flood Consequence Category (FCC), which refers to failures that occur in association with a natural flood.

Three major failure scenarios were assessed through the implementation of dam breach modelling:

- An overtopping water breach occurring during a sunny day (i.e. without coincident precipitation) - the initial decant pond level for this scenario corresponds with the invert elevation of the main spillway, which defines the SDCC;

- An overtopping water breach initiated by a Probable Maximum Precipitation Design Flood (PMPDF) - the initial decant pond level for this scenario corresponds with average conditions during the last month of planned operations, which defines the FCC;
- An embankment failure which precipitates a tailings run-out, which is expected to occur *in addition to* either of the other two major failure scenarios.

Analysis of breach formation parameters led to the selection of the overtopping breach mechanism over the piping breach mechanism because it resulted in more extensive breach outflows.

Water inundation maps were prepared as a result of the first two major failure scenarios and a tailings run-out map was prepared for the third failure scenario. These maps were inspected and compared to determine the incremental consequences associated with each failure scenario. The results of this assessment indicate that any decant release and potential tailings run-out following a dam breach would not be expected to impact the downstream mine infrastructure (box cut entrance to underground workings, process plant site, offices, labs, workshops, paste hole, vent riser and escape way). Additionally, the town of Majors Creek is not expected to be impacted by a breach of the TSF.

The consequence assessment and TSF hazard rating are discussed in the following sections.

2.1.3 Population at Risk (PAR) Assessment

An assessment of the Population at Risk (PAR) and Potential Loss of Life (PLL) was undertaken as part of the calculation of the consequence category. The Total PAR is defined as the PAR within the total flood inundation zone. The total flood inundation zone includes that area affected by a natural flood event and any additional area flooded as a consequence of a dam break event. The adopted PAR range is then used in combination with the severity assessment to determine a consequence category. The incremental PLL is considered to measure “PLL with dam failure” minus the “PLL without dam failure” and can be influenced by factors including:

- Warning time for people exposed to life threatening flood waters;
- Severity of the flood event and types of failure scenarios used in the evaluation;
- Time of failure, including day, night, season;
- Inability to precisely determine the fatality rate.

The TSF is designed as a cross-valley storage facility which will be constructed as a downstream embankment at each stage using mine waste and local borrow. Whilst a dam breach could theoretically occur at any location around the facility perimeter, failure against natural ground due to surface run-off erosion is unlikely and has been eliminated in this assessment. The primary impact would arise if a breach occurred along the main embankment.

The dam breach assessment indicated that none of the infrastructure downstream of the embankment (box cut entrance to underground workings, process plant site, offices, labs, workshops, paste hole, vent riser and escape way) are likely to be inundated in an unlikely event of embankment failure. On this basis, the population at risk (PAR) category is defined as ≥1 to <10.

The PLL without dam failure is considered to be 0. During operations there will be regular routine inspections of the TSF by operating personnel, mine staff will be trained to recognise signs of potential failure mechanisms, and monitoring systems will be in place to provide early warning mechanisms. It is unlikely therefore that a dam failure could occur without any warning. The PLL with dam failure is assessed to be <1. Therefore the incremental PLL is <1.

2.1.4 Selection of Severity of Damage and Loss

A risk assessment was conducted to determine the severity level of damage and losses resulting from a large scale failure of the facility, in accordance with the classifications of severity of damage and loss provided in Appendix B of the ANCOLD guideline (Ref. 4) and the DSC additions to the ANCOLD guideline provided in Appendix A of DSC3A. The findings of this assessment are summarised in Table 2.1. A copy of Appendix B of the ANCOLD "Guidelines on the Consequence Categories for Dams" is presented in Appendix A.

Table 2.1: Selection of severity of damage and loss (ANCOLD 2012)

DAMAGE TYPE	SEVERITY
Total Infrastructure Costs Damage to the TSF itself would be expected to be repairable and at an earthworks cost of less than $5M. However, in addition to this there could be damage to the project infrastructure and clean-up costs associated with the dam break, as well as the opportunity cost of a temporary shutdown of the process plant. On this basis the overall costs would be expected to be in excess of $10M but less than $100M.	Medium

Table 2.1 (cont'd): Selection of severity of damage and loss (ANCOLD 2012)

Impact on Business A failure of the TSF would cause a major impact on the business as it is an essential part of the minerals processing infrastructure and directly impacts on the ability of the process plant to operate. There would likely be some to severe reaction from the regulatory authorities and local community with significant loss of business credibility. The financial implications would be significant. On this basis the impact on the owner's business is considered to be major.	Major
Health and Social Impacts In terms of human health and loss of services to the community, it is possible that 100 to 1000 people may potentially be affected as a result of an uncontrolled release of tailings. There could be some contamination of habitable areas and groundwater could be impacted. However, impacts associated with emergency management, dislocation of people and business, employment affected, loss of cultural heritage and loss of recreational facility are considered to be minor. On this basis the health and social impact of a dam break would be expected to be Medium. In recognition of community concerns a classification of Major has been adopted.	Major
Environmental Impact The area of impact would be contained within the creek lines downstream in a relatively narrow contained flow path. An impacted area less than 5 km^2 is expected. As the composite tailings solids are classified as "Potentially Acid Forming", it is possible that it would require between 5 years and 20 years for the environment to return to original conditions after initial clean up. Discharge from a dam break could contaminate water supplies used by stock and fauna, and may have significant impact on ecosystems, albeit that remediation should allow for natural recovery over several wet seasons. There is potential for localised impacts in river connectivity. On this basis the environmental impact of a dam break would be expected to be Major.	Major

In accordance with the ANCOLD and DSC guidelines, the worst case severity level of damage and loss should be used to select a consequence category. Due to the potential impacts on the business, community, and the environment the severity level is assessed to be Major.

2.1.5 Consequence Category

The severity of damage and loss resulting from the dam failure together with the assessed population at risk and probable loss of life are used to determine the consequence category. Based on a severity level of Major (Table 2.1) and a PLL of <1 the resulting consequence category would be "High C" for the design of the TSF, in accordance with the recommendations of Table 1 (DSC3A) and Table 4 (ANCOLD). For a PAR of ≥1 to <10 the resulting consequence category would be "High C" also, in accordance with the recommendations of Table 2 (DSC3A) and Table 3 (ANCOLD).

2.1.6 Design Category and Design Criteria

On the basis of the assessment provided in the sections above, the composite TSF is rated as a 'HIGH C' consequence category facility. The design criteria applicable to this category are drawn from the ANCOLD "Guidelines on Tailings Dams" (Ref. 6) and the DSC guideline "DSC3F - Tailings Dams" (Ref. 3). The design criteria are summarised in tables 2.2 and 2.3.

Table 2.2: ANCOLD design criteria summary

Guideline Requirement	Description of requirements	Guideline Reference
Extreme storm storage	1 in 100 year AEP 72 hour duration storm with no release, evaporation or decant*	ANCOLD 2012 Table 4
Contingency freeboard	Wave run-up associated with a 1:10 AEP wind velocity and an additional freeboard of 0.5 m	ANCOLD 2012 Table 5
Spillway capacity	1 in 100,000 year Annual Exceedance Probability (AEP) design flood with freeboard allowance to suit wave run-up for 1:10 AEP wind velocity	ANCOLD 2012 Table 6
Design earthquake loading	OBE 1 in 1,000 year MDE 1 in 10,000 year Post Closure MCE	ANCOLD 2012 Table 7
Stability minimum factor of safety	Long term drained 1.5 Short term undrained • Potential loss of containment 1.5 • No potential loss of containment 1.3 • Post seismic 1.0 – 1.2	ANCOLD 2012 Table 8
Dam safety/ inspection frequency	Inspection by Dam Designer or equivalent qualified Engineer - Annual inspections. Routine inspections – daily to 3 times per week	ANCOLD 2012 Tables 9 and 10

* in light of community concern the Proponent has elected to increase the facility storm capacity by one order of magnitude to 1 in 1000 year AEP 72 hour duration

Table 2.3: DSC flood design criteria summary

Guideline	Design requirement
Beach Freeboard (AEP 72 hr storm) - min	1 in 100
Pond Recovery Time (days) – max	7
Operational Freeboard (mm) – min	500
Environmental Freeboard (AEP 72 hr storm) - indicative	1 in 100*
Total freeboard (AEP critical duration) - min	1 in 10,000

* in light of community concern the Proponent has elected to increase the facility storm capacity by one order of magnitude to 1 in 1000 year AEP 72 hour duration

The definitions of the flood design criteria specified in Table 2.3 are as follows:

- Beach freeboard – the vertical distance between the top of the tailings abutting the upstream face of the dam, and the tailings pond level which will contain the rainfall volume of a 72-hour storm (AEP as defined in Table 2.3) after inflow of a 1 in 100 AEP, 72-hour rainfall event on top of normal operating pond level.
- Pond recovery time – facilities should be available that will allow recovery of the pond level formed by inflow of a 1 in 100 AEP, 72-hour rainfall event, back to the Operational Pond Limit (maximum extent of the pond under normal operating conditions) within a specified period.
- Operational Freeboard – the vertical distance between the top of the tailings and the adjacent embankment crest.
- Environmental Containment Freeboard – this is the vertical distance between the Operational Pond Limit and the spillway crest level.
- Total Freeboard – this is the vertical distance between the Operational Pond Limit and the crest of the dam, and represents the capacity of the dam to pass an extreme storm by combination of storage and spillway discharge, and prevent overtopping of the dam.

2.2 SEISMIC DESIGN PARAMETERS

An assessment of the seismicity of south-eastern Australia has been carried out and probabilistic seismic hazard analyses have been completed for the Dargues Gold Project site. Existing information and historical data, including earthquake catalogues and technical publications on the tectonics and seismicity of the region have been reviewed. The most prominent seismic source in the region that defines the seismic hazard for the project is the Lachlan Fold Belt, an areal source zone thought to be capable of causing earthquakes up to Magnitude 6.1. The Dalton-Gunning zone, located approximately 30 km to the north of the site, is another areal source zone that contributes significantly to the seismic hazard at the Dargues site. This seismic source zone is also thought to be capable of causing earthquakes of up to M6.1.

The computer program EZ-FRISK was used to develop a seismic hazard model for the Dargues project site. Seismic sources defined in the hazard model include shallow crustal earthquake sources such as the Lachlan Fold Belt and Dalton-Gunning zone, but also those located within the wider Sydney Basin area and Tasman Sea Margin. Appropriate attenuation models defining the relationship between earthquake magnitude, source to site distance and peak ground acceleration have been used in the probabilistic analysis.

Seismic design parameters have been determined for use in the design of the TSF. Seismic ground motion parameters (including peak ground acceleration, earthquake magnitude and response spectra) have been determined using the results of the probabilistic seismic hazard analysis.

Based on the assessed consequence category it is recommended that the 1 in 1,000 year earthquake equivalent peak ground acceleration of 0.11 g is adopted as the Operating Basis Earthquake (OBE) for the TSF. For a design operating life of 65 months the probability of exceedance for the OBE event is 0.5%. The TSF and appurtenances are expected to remain functional and any damage from the occurrence of earthquake shaking not exceeding the OBE would be readily repairable.

The recommended Maximum Design Earthquake (MDE) for the TSF is 0.34g, which is equivalent to an annual exceedance probability (AEP) of 1 in 10,000. Considerable damage to the tailings dam is acceptable under seismic loading from the MDE, provided that there is no uncontrolled loss of storage due to partial or complete failure of the dam.

2.3 DESIGN STANDARDS

The design criteria and standards presented in Table 2.4 have been adopted for design of the TSF.

Table 2.4: Design criteria

HYDRAULIC DESIGN	
Diversion channel capacity	• Stage 1 - 1:10 AEP. Final – 1 in 100 AEP
TSF storm storage capacity	The more onerous of the following scenarios apply: • 1:100 AEP, 72 hour storm event in addition to the maximum pond operating volume for average climatic conditions without the pond abutting the embankment wall. • 1:1000 AEP, 72 hour storm event in addition to the maximum pond operating volume for average climatic conditions without the emergency spillway operating. • 1:10,000 AEP, critical duration storm event in addition to the maximum pond operating volume for average climatic conditions without exceeding the capacity of the emergency spillway.
TSF spillway	• Operation – 1:100,000 AEP • Closure - TSF basin will be graded to be free-draining and the emergency spillway will be designed for a PMF storm event.

Table 2.4 (cont'd): Design criteria

EMBANKMENT STABILITY/EARTHQUAKE CRITERIA	
Earthquake Loading - Operating Basis Earthquake (OBE) - Maximum Design Earthquake (MDE)	• 0.11g (1000 yr event) • Maximum Credible Earthquake (MCE) – 0.34 g
Stability Factors of Safety - Static - Seismic (OBE) - Seismic (MDE)	• 1.5 (minimum) (ANCOLD Guidelines (2012)) • 1.1 (minimum) (ANCOLD Guidelines (2012)) • Damage and deformation allowed (<freeboard allowance) No release of tailings or water
OPERATIONS	
Capacity - Final - Starter	• 1.22 Mt of dry tails over 65 months. • 234,000 t of dry tails – 1 year initial capacity.
Design factor for pipes and pumps	• 20%
Slurry Characteristics	• 64% solids by weight. • Slurry settled density = 1.35 to 1.50 t/m^3. • Supernatant release – 17% of water in slurry. • Underdrainage release – 5 to 10% of water in slurry. • Potentially Acid Forming.
Fluid Management	• Partial basin drainage system which gravity drains to a sump and is then pumped back to the supernatant pond. • Decant tower removal of supernatant solution via a pumping system and pressure pipeline back to the plant.
PRIMARY EMBANKMENT	
General	• Deposition from main embankment crest. • Minimum tailings freeboard of 0.5 m. • The supernatant pond will form at the head of the valley. Decant structures will be constructed at Stage 1 and final stage to permit removal of water from the pond.
Construction	• Upstream toe cut-off key trench and drain. • Zoned starter embankment constructed from mine waste and local borrow, comprising an upstream low permeability zone (with HDPE lining on the upstream face) and downstream structural zone. • 6 m crest width.
Materials	• Remove unsuitable foundation soils from embankment footprint. Structural fill won from mine waste and local borrow. • Low permeability material won from selected local borrow areas within and near to the basin.
TAILINGS BASIN	
Basin Lining	• In situ soils, scarified, moisture conditioned and compacted to form a soil liner. • Composite liner (compacted in situ soil plus 1.5 mm smooth HDPE liner).
Basin Underdrainage	• Partial basin underdrainage system comprising main collector drains along the basin spine and branch/finger drains across the basin area.

3. TAILINGS CHARACTERISTICS

Physical and geochemical testing of the flotation tailings was carried out as part of the original final design. The findings of this testing are presented in Section 4 of the final design report, reference PE801-00139/5 Rev. 0 (Ref. 1). Subsequently, physical and geochemical testing of a sample of the concentrate tailings was carried out and reported under separate technical memoranda, reference PE801-139-EMEM-KP005 and PE14-00923. Copies of these memoranda are presented as Appendices B and C.

A composite tailings sample was not available for physical and geochemical testing at the time of the final design update. Tailings characteristics for the composite tailings were therefore generated based on the findings of the previous testing programmes for the flotation and concentrate tailings, as follows:

- Water (supernatant) release will be in the order of 17% of the water in slurry, not accounting for rainfall and evaporation.
- Underdrainage release should typically average around 5 to 10% depending on the arrangement of underdrainage collection and basin treatment.
- Assuming that the TSF is operated efficiently, a settled density of between 1.35 t/m^3 and 1.50 t/m^3 is expected.
- The composite tailings solids are assumed to be "Potentially Acid Forming" based on the concentrate tailings geochemical characteristics (Potentially Acid Forming High Capacity). It should be noted that the flotation tailings were classified as "Non Acid Forming".

It is considered that the TSF will require a composite basin liner and drainage system due to the acid generating potential of the tailings and the potentially low pH of the supernatant.

4. WATER MANAGEMENT

4.1 GENERAL

Management of water for the project site is critical in terms of the TSF design and decant return water pumping requirements. A site water management model was developed in order to understand and control the flow of water around the site and to determine design embankment crest levels to cater for extreme storm events.

Water management of the TSF consists of three major components:

- Tailings storage facility.
- External stormwater run-off.
- Plant site.

The model uses the design tailings throughput together with estimated settled tailings densities to determine the tailings level at various stages in the facility life. The model then examines a range of extreme rainfall events to determine supernatant pond volumes and the required embankment stage crest levels. A range of extreme dry rainfall events was also analysed to determine the water shortfall that could potentially occur.

The model was run on a monthly time-step for the duration of the operating life. Modelled flows do not represent the design duties for pumps and pipelines or peak flows for rainfall as they are averaged over the month and do not take into account efficiency and availability of the infrastructure.

4.2 WATER BALANCE MODELLING PARAMETERS

4.2.1 General

The water management model requires a number of input parameters. The following sub-sections outline the selection of parameters used for the water management modelling.

4.2.2 Climatic Conditions

Climatic data for the site were obtained from the Australian Bureau of Meteorology (BOM) *"Climatic Atlas of Australia"* (Ref. 7). The rainfall data used are from the Braidwood weather station (Wallace Street – 069010) which is located approximately 12 km north-north-east of the site. Climate data are available from 1920 to 2009 with some minor gaps. The data were analysed and design monthly rainfall parameters were generated as summarised in Table 4.1.

Table 4.1: Summary of rainfall data

Month	Average Rainfall (mm)	1 in 100 AEP\1 Wet Year (mm)	1 in 100 AEP Dry Year (mm)
January	65	91	9
February	43	69	78
March	64	261	69
April	38	300	23
May	48	164	17
June	52	42	14
July	63	104	6
August	80	49	19
September	54	71	24
October	70	19	8
November	74	260	10
December	73	140	48
Total	724	1570	326

\1 AEP = Annual Exceedance Probability

The evaporation data utilised are presented in Table 4.2.

Table 4.2: Evaporation data

Month	Average Evaporation (mm)
January	230
February	180
March	150
April	100
May	80
June	65
July	80
August	90
September	110
October	130
November	165
December	235
Total	1615

Precipitation intensity-duration-frequency (IDF) data were derived for the Dargues Reef site using procedures given in *"Australian Rainfall and Runoff, Volume 1 – A Guide to Flood Estimation"* (ARR) (Ref. 8) for Frequent to Large storms. IDF data for Rare to Extreme storms were derived using storm interpolation procedures given in ARR between the 1:100 AEP storm and the Probable Maximum Precipitation (PMP) storm event. PMP was estimated using procedures given in *"The Estimation of Probable Maximum Precipitation in Australia; Generalised Short-Duration Method (GSDM)"* (Ref. 9) and *"Generalised Southeast Australia Method (GSAM) for Estimating Probable Maximum Precipitation"* (Ref. 10). A summary of resulting IDF data is presented in Table 4.3, and IDF curves are shown in figures 4.1 and 4.2.

Table 4.3: Storm intensity-duration-frequency data

Storm Category	Storm Frequency		Point Rainfall Intensity (mm/h) for given Storm Duration				
	Return Period (yrs)	AEP %	6 min	1 h	12 h	24 h	72 h
Frequent	5	20	116	38	9.3	6.1	3.0
	10	10	133	43	11	7.1	3.5
	20	5	155	51	13	8.4	4.2
Large	50	2	185	60	15	10	5.2
	100	1	209	68	17	12	6.1
Rare	200	0.5		78	20	14	7.0
	500	0.2		94	24	16	8.6
	1,000	0.1		107	28	19	10
	2,000	0.05		121	31	21	11
Extreme	10,000	0.01		156	41	27	13
	50,000	2E-03		199	52	34	16
	200,000	5E-04		241	64	40	18
PMP	10,000,000	1E-05		360	96	58	24

4.2.3 Run-off Coefficients

The area around the facility is cleared ground currently used for agricultural purposes. The adopted run-off coefficients used in the modelling for various ground surface conditions were calculated using the rational method in accordance with the guidelines given in ARR. The run-off coefficients used for water balance modelling are presented in Table 4.4.

Table 4.4: Adopted run-off coefficients

Condition	Run-off Coefficient
Undisturbed Bush	0.09
Cleared Agricultural Land	0.2
Topsoil Stripped Areas within Basin	0.5
Drying Tailings Beach	0.8
Active Tailings Beach (Supernatant Producing Areas)	1.0
Ponds	1.0

4.2.4 Tailings Beach Slope

The viscous nature of the tailings and high slurry density means that the tailings flow will generally be laminar with minimal segregation of material. The adopted beach slope used for design is 1.25% ±0.4%, based on observed tailings beach slopes at other sites and calculations from the viscosity data.

4.2.5 Additional Modelling Parameters

The tailings slurry design parameters are provided in Section 1.3. The modelling parameters such as tailings properties and facility design characteristics are discussed elsewhere.

4.3 TSF WATER BALANCE

4.3.1 Model

The TSF water balance has been modelled using specially developed computer software. The program is a computer model written in Visual Basic/Excel specifically for tailings storage facilities and incorporates a database of information derived from both laboratory and field data accumulated over the past 20 years by KP Australia. The program calculates tailings densities achieved in the storage, and determines the volume of water available for return to the process plant taking into account rainfall, evaporation, and supernatant and underdrainage release from the tailings due to consolidation.

4.3.2 Modelling Runs

The model was run under average climatic conditions. In addition, the effects of 1 in 100 Annual Exceedance Probability (AEP) wet and dry years were assessed. The effects of storm events on the facility were also examined.

4.3.3 Results of Modelling Runs

Four different conditions were modelled as follows:

4.3.3.1 Average Climatic Conditions

The model was run with a repeating sequence of average conditions. The estimated water balance for average conditions is summarised on a monthly basis in Table 4.5. The plots of tailings density and rate of rise are presented in Figure 4.3. Pond volume and percent recycle are plotted on Figure 4.4.

Based on the modelling the following conclusions can be made:

- The tailings storage facility operates with a water deficit under average conditions. The pond remains at or close to minimum pond size (specified in the modelling as 5,000 m^3), except in Year 6 of operation, when the pond increases to a maximum of 14,800 m^3. The average make-up water required in Year 1 is

76% of the initial water in the slurry, and ranges from 2,800 m^3 to 14,300 m^3 per month.

- The recycle from the TSF back to the Process Plant in Year 1 varies from 0% to 48% of water in slurry and from 15% to 85% in Year 2. The average recycle volume over the life of the facility is 41% of the water in slurry. The supernatant contributes approximately 14% of this volume with rainfall providing the remaining 86%. The low rate of recycle is due to the low supernatant release as a result of the high percent solids of the tailings and the high evaporation losses relative to rainfall.
- The initial tailings dry density is approximately 1.22 t/m^3. The average settled dry density gradually increases as a result of consolidation of the underlying tailings, achieving a final average density of approximately 1.45 t/m^3.

Table 4.5: Water balance – Average conditions

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density Layers	Tailings density Mass	Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
		mm	mm	t	RL m	t/m^3	t/m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	%	m^3	m^3
1	Jan-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Feb-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Mar-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Apr-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	May-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Jun-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Jul-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Aug-16	80	90	4,975	689.5	1.22	1.22	2,796	498	2,332	136	5,150	-	-	-		2,796
	Sep-16	54	110	15,671	692.4	1.37	1.32	6,010	1,071	1,708	418	5,139	-	2,373	39		3,637
	Oct-16	70	130	25,044	693.6	1.37	1.34	5,267	939	2,333	669	5,211	-	2,531	48		2,736
	Nov-16	74	165	45,724	695.3	1.37	1.35	11,621	2,071	2,624	1,182	5,413	-	3,311	28		8,309
	Dec-16	73	235	62,635	696.5	1.37	1.36	9,503	1,694	2,814	2,299	5,477	-	2,145	23		7,358
2	Jan-17	65	230	92,466	698.1	1.37	1.36	16,763	2,988	2,640	2,875	5,295	-	2,945	18		13,818
	Feb-17	43	180	98,373	698.3	1.37	1.36	3,319	592	1,745	2,394	5,000	-	253	8		3,066
	Mar-17	64	150	124,713	699.2	1.37	1.37	14,802	2,638	2,607	1,966	5,139	-	3,174	21		11,628
	Apr-17	38	100	143,864	699.9	1.37	1.37	10,762	1,903	1,588	1,268	5,077	-	2,297	21		8,465
	May-17	48	80	171,388	700.6	1.36	1.37	15,467	2,709	2,058	998	5,121	-	3,890	25		11,577
	Jun-17	52	65	198,030	701.3	1.35	1.37	14,971	2,608	2,314	803	5,115	-	4,200	28		10,772
	Jul-17	63	80	233,106	702.3	1.34	1.37	19,710	3,389	2,920	1,001	5,141	-	5,364	27		14,346
	Aug-17	80	90	263,934	703.0	1.35	1.37	17,323	2,949	3,791	1,137	5,142	-	5,714	33		11,609
	Sep-17	54	110	277,486	703.3	1.39	1.38	7,615	1,277	2,556	1,402	5,028	-	2,704	36		4,912
	Oct-17	70	130	304,046	704.0	1.37	1.38	14,925	2,474	3,362	1,674	5,071	-	4,278	29		10,647
	Nov-17	74	165	328,849	704.4	1.38	1.38	13,938	2,242	3,582	2,180	5,004	-	3,821	27		10,117
	Dec-17	73	235	355,301	704.8	1.40	1.39	14,864	2,263	3,626	3,229	5,000	-	2,912	20		11,953
3	Jan-18	65	230	377,857	705.2	1.41	1.39	12,675	1,916	3,311	3,142	5,000	-	2,260	18		10,415
	Feb-18	43	180	405,196	705.6	1.39	1.39	15,363	2,358	2,222	2,385	5,000	-	2,335	15		13,027
	Mar-18	64	150	431,115	706.0	1.39	1.40	14,565	2,311	3,404	1,949	5,000	-	3,901	27		10,664
	Apr-18	38	100	460,250	706.4	1.38	1.40	16,372	2,689	2,089	1,254	5,046	-	3,612	22		12,760
	May-18	48	80	479,242	706.7	1.38	1.40	10,672	1,783	2,660	991	5,053	-	3,560	33		7,112
	Jun-18	52	65	483,504	706.7	1.45	1.40	2,395	405	2,900	823	5,596	-	2,036	85		359
	Jul-18	63	80	504,348	707.0	1.38	1.40	11,713	1,957	3,575	1,028	5,076	-	5,098	44		6,616
	Aug-18	80	90	551,533	707.6	1.35	1.40	26,515	4,372	4,692	1,132	5,135	-	7,913	30		18,601
	Sep-18	54	110	577,989	708.0	1.39	1.40	14,867	2,391	3,225	1,402	5,035	-	4,369	29		10,497
	Oct-18	70	130	592,764	708.2	1.44	1.41	8,303	1,311	4,240	1,667	5,000	-	4,129	50		4,174
	Nov-18	74	165	608,010	708.3	1.46	1.41	8,567	1,297	4,483	2,160	5,000	-	3,731	44		4,837
	Dec-18	73	235	638,875	708.7	1.43	1.41	17,344	2,443	4,497	3,219	5,000	-	3,861	22		13,483
4	Jan-19	65	230	668,682	709.1	1.44	1.42	16,750	2,365	4,066	3,139	5,000	-	3,416	20		13,334
	Feb-19	43	180	704,927	709.6	1.41	1.42	20,367	2,969	2,705	2,382	5,000	-	3,437	17		16,930
	Mar-19	64	150	739,526	710.0	1.40	1.42	19,442	2,985	4,104	1,948	5,000	-	5,265	27		14,177
	Apr-19	38	100	768,694	710.3	1.39	1.42	16,391	2,640	2,484	1,252	5,023	-	3,965	24		12,426
	May-19	48	80	786,952	710.5	1.41	1.42	10,260	1,691	3,132	989	5,043	-	3,917	38		6,343
	Jun-19	52	65	805,305	710.7	1.40	1.42	10,313	1,722	3,419	797	5,064	-	4,406	43		5,907
	Jul-19	63	80	827,805	711.0	1.40	1.42	12,644	2,082	4,190	994	5,070	-	5,334	42		7,310
	Aug-19	80	90	850,305	711.2	1.40	1.42	12,644	2,060	5,365	1,128	5,083	-	6,334	50		6,310
	Sep-19	54	110	869,403	711.4	1.43	1.42	10,732	1,704	3,634	1,395	5,010	-	4,062	38		6,670
	Oct-19	70	130	886,871	711.6	1.46	1.43	9,816	1,529	4,763	1,664	5,000	-	4,682	48		5,134
	Nov-19	74	165	907,526	711.8	1.47	1.43	11,607	1,725	5,042	2,160	5,000	-	4,646	40		6,961
	Dec-19	73	235	916,920	711.9	1.47	1.43	5,279	725	4,996	3,232	5,000	-	2,522	48		2,757
5	Jan-20	65	230	933,660	712.1	1.47	1.43	9,407	1,299	4,498	3,127	5,000	-	2,701	29		6,705
	Feb-20	43	180	942,306	712.1	1.47	1.43	4,859	696	2,953	2,368	5,000	-	1,305	27		3,554
	Mar-20	64	150	959,007	712.3	1.48	1.43	9,385	1,425	4,461	1,943	5,000	-	3,967	42		5,418
	Apr-20	38	100	979,783	712.5	1.42	1.43	11,675	1,868	2,698	1,251	5,003	-	3,329	29		8,345
	May-20	48	80	992,631	712.6	1.45	1.44	7,220	1,184	3,398	987	5,033	-	3,584	50		3,636
	Jun-20	52	65	1,005,283	712.7	1.43	1.44	7,110	1,182	3,704	796	5,057	-	4,088	57		3,022
	Jul-20	63	80	1,016,057	712.8	1.47	1.44	6,054	993	4,519	993	5,073	-	4,520	75		1,534
	Aug-20	80	90	1,019,508	712.8	1.48	1.44	1,939	316	5,790	1,328	8,220	-	1,649	85		291
	Sep-20	54	110	1,030,268	712.9	1.46	1.44	6,047	965	3,928	1,757	6,231	-	5,140	85		907
	Oct-20	70	130	1,064,159	713.3	1.41	1.44	19,044	2,959	5,162	1,795	5,006	-	7,555	40		11,489
	Nov-20	74	165	1,079,908	713.4	1.48	1.44	8,850	1,304	5,432	2,159	5,000	-	4,592	52		4,258
	Dec-20	73	235	1,079,909	713.4	1.48	1.44	-	0	5,393	3,579	6,835	-	0			-
6	Jan-21	65	230	1,096,557	713.5	1.47	1.44	9,355	1,289	4,862	3,481	5,000	-	4,524	48		4,831
	Feb-21	43	180	1,119,888	713.7	1.48	1.44	13,111	1,859	3,202	2,373	5,000	-	2,696	21		10,415
	Mar-21	64	150	1,131,006	713.8	1.48	1.44	6,247	942	4,812	1,945	5,000	-	3,824	61		2,423
	Apr-21	38	100	1,157,304	714.1	1.42	1.44	14,778	2,353	2,918	1,251	5,007	-	4,030	27		10,748
	May-21	48	80	1,160,051	714.1	1.48	1.44	1,544	253	3,667	1,077	6,552	-	1,312	85		232
	Jun-21	52	65	1,164,911	714.1	1.47	1.44	2,731	455	4,009	995	7,717	-	2,321	85		410
	Jul-21	63	80	1,166,907	714.1	1.47	1.44	1,122	186	4,914	1,443	10,429	-	954	85		168
	Aug-21	80	90	1,177,193	714.2	1.46	1.45	5,780	952	6,308	1,824	10,957	-	4,913	85		867
	Sep-21	54	110	1,178,628	714.2	1.46	1.45	806	130	4,258	2,379	12,283	-	685	85		121
	Oct-21	70	130	1,178,629	714.2	1.45	1.45	-	0	5,592	3,130	14,747	-	0			-
	Nov-21	74	165	1,199,924	714.4	1.45	1.45	11,966	1,831	5,875	3,703	8,580	-	10,171	85		1,795
	Dec-21	73	235	1,213,601	714.5	1.47	1.45	7,686	1,054	5,711	3,974	5,101	-	6,271	82		1,415

4.3.3.2 1 in 100 AEP Wet Sequence

The effects of a 1 in 100 AEP Wet year were analysed by inserting a wet year independently into each year of the model. As the pond level can return to a minimum each year, the water balance impact is independent of the previous year's rainfall.

The maximum pond volume of 44,200 m^3 was generated by inserting a 1 in 100 AEP Wet year towards the end of the operation as shown in Table 4.6. The storage volume available on the tailings without encroaching on the embankment at that time is 66,000 m^3 and the maximum pond level for the 1 in 100 AEP Wet year precipitation is only 40% of the capacity available on the tailings. The maximum recycle rate of 85% of water in slurry occurs in 38 of the 65 modelled months. No spillway flows are expected under these conditions. The size of the pond and the effect on the recycle rate are shown in Figure 4.5.

4.3.3.3 Storm Events

The design elevation of the TSF embankment is a function of the required storm capacity of the facility in excess of the tailings beach level. DSC guideline DSC3F was noted as defining various freeboard requirements related to the flood handling capacity of the facility. A rainfall-run-off model was employed to model various storm scenarios for the purpose of verifying that the proposed design meets DSC3F freeboard criteria. These are discussed below:

- Beach Freeboard – beach freeboard was not considered as the facility will be constructed fully downstream, i.e. it will not have any upstream or modified centreline lifts.
- Pond Recovery Time – the decant pumping system should be designed such that the 1:100 AEP, 72 hour storm event can be removed within 7 days. The 1:100 AEP, 72 hour storm run-off added to the maximum pond operating volume under average climatic conditions gives a resulting total decant pond volume of 70,232 m^3, which corresponds to a pond level of RL714.2 m.
- Operational Freeboard – this is the vertical distance between the top of the tailings (RL714.6 m) and the adjacent embankment crest (RL716.0 m). The minimum recommended value suggested by DSC3F is 500 mm. The TSF design provides 1,400 mm of Operational Freeboard, far exceeding the specified minimum value.
- Environmental Containment Freeboard – this is the vertical distance between the Operational Pond Limit (RL712.9 m) and the spillway crest (RL715.1 m). This is normally set to contain the rainfall run-off volume produced by a 72-hour

storm of a certain AEP without discharging from the facility. For a High C category dam the design storm is a 1:100 AEP, 72 hour storm. For a High B category dam the design storm is a 1:1000 AEP, 72 hour storm. The modelling shows that for a 1:100 AEP 72 hour storm the resulting pond level is RL714.2 m, and for a 1:1000 AEP 72 hour storm the resulting pond level is RL714.9 m, both of which lie *below* the proposed final stage spillway level (RL715.1 m). Consequently, Environmental Containment Freeboard is satisfied for both High C and High B category dams and the facility should not discharge under storm events up to and including a 1 in 1000 AEP 72-hour magnitude event.

- Total Freeboard – this is the vertical distance between the Operational Pond Limit (RL712.9 m) and the crest of the embankment (RL716.0 m). The design storm event for a *High C* consequence category is the 1:100,000 AEP, critical duration storm. Starting with a pond level of RL714.8 m (that is 0.6 m above the pond level resulting from a 1:100 AEP 72 hour storm event), the peak decant pond level during passage of a 1:100,000 AEP, 72 hour storm is RL715.6 m, that is 0.5 m below the final crest level. Accordingly, Total Freeboard is satisfied.

4.3.3.4 1 in 100 AEP Dry Sequence

The results for the 1 in 100 AEP Dry year simulations are summarised in Table 4.7. The table summarises the results of multiple individual modelling runs for a single 1 in 100 AEP Dry event. Each year is independent, as the pond level reverts to its minimum volume each year, allowing multiple individual modelling runs for the Dry event to be carried out without impacting on one another. The 1 in 100 AEP Dry year precipitation is 326 mm. The average recycle volume under 1 in 100 AEP Dry year conditions is 19% of the water in slurry, which yields 570,000 m^3 shortfall in total, ranging between 220 m^3 and 22,200 m^3 per month during the operation.

There may be periods of several months when no water return should be expected from the TSF and during which time all process water will have to be supplied from alternative sources.

Table 4.6: Water balance – 1 in 100 AEP Wet conditions

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m³	t/m³	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Jan-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Feb-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Mar-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Apr-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	May-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
1	Jun-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Jul-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Aug-16	49	90	4,975	689.5	1.22	1.22	2,796	498	1,428	136	5,114	-	-	-		2,796
	Sep-16	71	110	15,671	692.4	1.37	1.32	6,010	1,071	2,256	418	5,182	-	2,842	47		3,169
	Oct-16	19	130	25,044	693.6	1.37	1.34	5,267	939	631	668	5,083	-	1,001	19		4,266
	Nov-16	260	165	45,724	695.3	1.37	1.35	11,621	2,071	9,258	1,182	5,952	-	9,278	80		2,343
	Dec-16	140	235	62,635	696.5	1.37	1.36	9,503	1,694	5,407	2,299	5,739	-	5,017	53		4,487
	Jan-17	91	230	92,466	698.1	1.37	1.36	16,763	2,988	3,688	2,875	5,398	9	4,150	25		12,612
	Feb-17	69	180	98,373	698.3	1.37	1.36	3,319	592	2,824	2,408	5,114	15	1,308	39		2,012
	Mar-17	261	150	124,713	699.2	1.37	1.37	14,802	2,638	10,766	2,031	5,582	34	10,940	74		3,862
	Apr-17	300	100	143,864	699.9	1.37	1.37	10,762	1,918	13,456	1,530	10,291	12	9,148	85		1,614
	May-17	164	80	171,388	700.6	1.37	1.37	15,467	2,757	7,452	1,333	6,183	163	13,147	85		2,320
2	Jun-17	42	65	198,030	701.3	1.36	1.37	14,971	2,620	1,890	856	5,100	76	4,813	32		10,159
	Jul-17	104	80	233,106	702.3	1.34	1.37	19,710	3,390	4,791	1,004	5,194	77	7,161	36		12,549
	Aug-17	49	90	263,934	703.0	1.35	1.37	17,323	2,949	2,321	1,138	5,100	117	4,343	25		12,981
	Sep-17	71	110	277,486	703.3	1.39	1.38	7,615	1,277	3,375	1,400	5,053	154	3,453	45		4,162
	Oct-17	19	130	304,046	704.0	1.37	1.38	14,925	2,473	909	1,670	5,003	156	1,919	13		13,006
	Nov-17	260	165	328,849	704.4	1.38	1.38	13,938	2,259	12,674	2,283	5,911	105	11,847	85		2,091
	Dec-17	140	235	355,301	704.8	1.39	1.39	14,864	2,289	6,990	3,429	5,000	248	7,009	47		7,855
	Jan-18	91	230	377,857	705.2	1.41	1.39	12,675	1,916	4,614	3,148	5,000	135	3,517	28		9,158
	Feb-18	69	180	405,196	705.6	1.39	1.39	15,363	2,359	3,578	2,390	5,000	156	3,703	24		11,659
	Mar-18	261	150	431,115	706.0	1.39	1.40	14,565	2,340	13,984	2,161	6,921	138	12,380	85		2,185
	Apr-18	300	100	460,250	706.4	1.37	1.40	16,372	2,767	16,755	1,794	10,868	136	13,916	85		2,456
	May-18	164	80	479,242	706.7	1.38	1.40	10,672	1,841	9,465	1,660	11,510	69	9,071	85		1,601
3	Jun-18	42	65	483,504	706.7	1.41	1.40	2,395	415	2,456	1,344	11,018	16	2,036	85		359
	Jul-18	104	80	504,348	707.0	1.38	1.40	11,713	1,996	6,023	1,474	7,619	12	9,956	85		1,757
	Aug-18	49	90	551,533	707.7	1.35	1.40	26,515	4,404	2,896	1,303	5,082	8	8,542	32		17,973
	Sep-18	71	110	577,989	708.0	1.39	1.40	14,867	2,390	4,260	1,399	5,060	121	5,395	36		9,472
	Oct-18	19	130	592,764	708.2	1.44	1.40	8,303	1,311	1,147	1,663	5,000	298	1,154	14		7,149
	Nov-18	260	165	608,010	708.3	1.46	1.41	8,567	1,344	16,157	2,975	12,397	152	7,282	85		1,285
	Dec-18	140	235	638,875	708.7	1.41	1.41	17,344	2,578	8,826	4,631	5,231	171	14,110	81		3,234
	Jan-19	91	230	668,682	709.1	1.44	1.41	16,750	2,369	5,673	3,191	5,000	48	5,130	31		11,620
	Feb-19	69	180	704,927	709.6	1.41	1.42	20,367	2,969	4,359	2,387	5,000	205	5,146	25		15,221
	Mar-19	261	150	739,526	710.0	1.40	1.42	19,442	3,003	16,822	2,102	6,367	170	16,526	85		2,916
	Apr-19	300	100	768,694	710.3	1.39	1.42	16,391	2,704	19,957	1,897	13,346	147	13,932	85		2,459
	May-19	164	80	786,952	710.5	1.39	1.42	10,260	1,749	11,256	1,968	15,761	98	8,721	85		1,539
4	Jun-19	42	65	805,305	710.8	1.38	1.42	10,313	1,763	2,901	1,472	10,217	30	8,766	85		1,547
	Jul-19	104	80	827,805	711.0	1.39	1.42	12,644	2,112	7,024	1,412	7,214	21	10,747	85		1,897
	Aug-19	49	90	850,305	711.2	1.40	1.42	12,644	2,070	3,307	1,273	5,028	41	6,331	50		6,313
	Sep-19	71	110	869,403	711.4	1.43	1.42	10,732	1,703	4,801	1,392	5,036	64	5,168	48		5,564
	Oct-19	19	130	886,871	711.6	1.46	1.42	9,816	1,529	1,289	1,660	5,000	81	1,276	13		8,540
	Nov-19	260	165	907,526	711.8	1.47	1.43	11,607	1,776	18,125	2,950	12,147	62	9,866	85		1,741
	Dec-19	140	235	916,920	711.9	1.44	1.43	5,279	790	9,985	5,711	12,773	50	4,487	85		792
	Jan-20	91	230	933,660	712.1	1.44	1.43	9,407	1,379	6,447	4,955	7,658	10	7,996	85		1,411
	Feb-20	69	180	942,306	712.2	1.46	1.43	4,859	710	4,813	2,933	6,127	8	4,130	85		729
	Mar-20	261	150	959,007	712.3	1.47	1.43	9,385	1,479	18,744	3,064	15,333	24	7,977	85		1,408
	Apr-20	300	100	979,783	712.5	1.40	1.43	11,675	1,982	22,643	3,136	26,928	29	9,923	85		1,751
	May-20	164	80	992,631	712.6	1.39	1.43	7,220	1,261	12,830	3,114	31,773	4	6,137	85		1,083
5	Jun-20	42	65	1,005,283	712.8	1.38	1.43	7,110	1,246	3,329	2,542	27,765	2	6,043	85		1,066
	Jul-20	104	80	1,016,057	712.9	1.40	1.43	6,054	1,053	8,156	3,043	28,787	1	5,146	85		908
	Aug-20	49	90	1,019,508	712.9	1.40	1.43	1,939	336	3,871	3,445	27,903	3	1,649	85		291
	Sep-20	71	110	1,030,268	713.0	1.40	1.43	6,047	1,034	5,607	4,078	25,329	2	5,140	85		907
	Oct-20	19	130	1,064,159	713.3	1.39	1.43	19,044	3,123	1,469	3,696	10,041	2	16,187	85		2,857
	Nov-20	260	165	1,079,908	713.4	1.46	1.43	8,850	1,390	20,078	4,237	19,752	4	7,523	85		1,328
	Dec-20	140	235	1,079,909	713.4	1.43	1.43	-	0	11,088	7,978	22,900	39	0			-
	Jan-21	91	230	1,096,557	713.6	1.42	1.43	9,355	1,447	7,187	7,417	16,173	8	7,952	85		1,403
	Feb-21	69	180	1,119,888	713.8	1.44	1.44	13,111	1,968	5,341	4,182	8,161	5	11,144	85		1,967
	Mar-21	261	150	1,131,006	713.9	1.47	1.44	6,247	990	20,516	3,700	20,676	19	5,310	85		937
	Apr-21	300	100	1,157,304	714.1	1.40	1.44	14,778	2,512	24,778	3,628	31,828	51	12,561	85		2,217
	May-21	164	80	1,160,051	714.1	1.40	1.44	1,544	270	14,011	3,588	41,216	7	1,312	85		232
6	Jun-21	42	65	1,164,911	714.2	1.38	1.44	2,731	482	3,654	3,116	39,918	4	2,321	85		410
	Jul-21	104	80	1,166,907	714.2	1.39	1.44	1,122	198	8,990	3,946	44,208	1	954	85		168
	Aug-21	49	90	1,177,193	714.3	1.38	1.44	5,780	1,018	4,266	4,468	40,112	1	4,913	85		867
	Sep-21	71	110	1,178,628	714.3	1.39	1.44	806	141	6,169	5,337	40,400	1	685	85		121
	Oct-21	19	130	1,178,629	714.3	1.39	1.44	-	0	1,638	6,142	35,897	1	0			-
	Nov-21	260	165	1,199,924	714.4	1.40	1.44	11,966	2,058	22,589	8,010	42,363	1	10,171	85		1,795
	Dec-21	140	235	1,213,601	714.6	1.38	1.44	7,686	1,305	12,255	11,916	37,475	1	6,533	85		1,153

Table 4.7: Water balance – 1 in 100 AEP Dry conditions

Year	Month	Rainfall mm	Evaporation mm	Cumulative Tonnage t	Tailings Level RL m	Tailings density Layers t/m³	Tailings density Mass t/m³	Water in Slurry m³	Supernatant Runoff m³	Rainfall Runoff m³	Evaporation Losses m³	Pond Volume m³	Consolidation Volume m³	Available TSF Recycle m³	Available TSF Recycle %	Discharge m³	Make Up Requirement m³
	Jan-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Feb-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Mar-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Apr-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	May-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
1	Jun-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Jul-16	-	-	-	-	-	-	-	-	-	-	-	-	-			-
	Aug-16	19	90	4,975	689.5	1.22	1.22	2,796	498	555	135	5,079	-	-	-		2,796
	Sep-16	24	110	15,671	692.4	1.37	1.32	6,010	1,071	775	416	5,067	-	1,443	24		4,568
	Oct-16	8	130	25,044	693.6	1.37	1.34	5,267	939	263	666	5,056	-	546	10		4,721
	Nov-16	10	165	45,724	695.3	1.37	1.35	11,621	2,071	346	1,182	5,228	-	1,063	9		10,558
	Dec-16	48	235	62,635	696.5	1.37	1.36	9,503	1,694	1,853	2,299	5,380	-	1,096	12		8,408
	Jan-17	9	230	92,466	698.1	1.37	1.36	16,763	2,988	355	2,875	5,083	9	775	5		15,988
	Feb-17	78	180	98,373	698.3	1.37	1.36	3,319	592	3,202	2,365	5,140	15	1,387	42		1,932
	Mar-17	69	150	124,713	699.2	1.37	1.37	14,802	2,638	2,809	1,985	5,147	34	3,489	24		11,312
	Apr-17	23	100	143,864	699.9	1.37	1.37	10,762	1,903	970	1,267	5,057	12	1,707	16		9,055
	May-17	17	80	171,388	700.6	1.36	1.37	15,467	2,709	748	994	5,081	163	2,602	17		12,864
2	Jun-17	14	65	198,030	701.3	1.35	1.37	14,971	2,607	604	799	5,064	76	2,505	17		12,466
	Jul-17	6	80	233,106	702.3	1.34	1.37	19,710	3,387	283	994	5,068	83	2,755	14		16,955
	Aug-17	19	90	263,934	703.0	1.35	1.37	17,323	2,947	902	1,126	5,061	112	2,842	16		14,482
	Sep-17	24	110	277,486	703.3	1.39	1.37	7,615	1,276	1,160	1,391	5,000	160	1,266	17		6,349
	Oct-17	8	130	304,046	704.0	1.37	1.38	14,925	2,472	379	1,663	5,000	160	1,348	9		13,577
	Nov-17	10	165	328,849	704.4	1.38	1.38	13,938	2,240	472	2,160	5,000	110	662	5		13,276
	Dec-17	48	235	355,301	704.8	1.40	1.39	14,864	2,263	2,387	3,223	5,000	250	1,678	11		13,186
	Jan-18	9	230	377,857	705.2	1.41	1.39	12,675	1,916	448	3,130	5,000	174	-	-		12,675
	Feb-18	78	180	405,196	705.6	1.39	1.39	15,363	2,358	4,082	2,391	5,000	140	4,189	27		11,174
	Mar-18	69	150	431,115	706.0	1.39	1.40	14,565	2,311	3,657	1,950	5,004	135	4,148	28		10,417
	Apr-18	23	100	460,250	706.4	1.38	1.40	16,372	2,689	1,276	1,253	5,025	135	2,825	17		13,547
	May-18	17	80	479,242	706.7	1.38	1.40	10,672	1,783	967	987	5,008	115	1,894	18		8,778
3	Jun-18	14	65	483,504	706.7	1.45	1.40	2,395	404	756	791	5,000	97	474	20		1,921
	Jul-18	6	80	504,348	707.0	1.38	1.40	11,713	1,953	346	985	5,000	75	1,389	12		10,325
	Aug-18	19	90	551,533	707.6	1.35	1.40	26,515	4,370	1,116	1,121	5,053	50	4,363	16		22,152
	Sep-18	24	110	577,989	708.0	1.39	1.40	14,867	2,389	1,463	1,391	5,000	54	2,569	17		12,298
	Oct-18	8	130	592,764	708.2	1.44	1.41	8,303	1,311	478	1,654	5,000	207	341	4		7,962
	Nov-18	10	165	608,010	708.3	1.46	1.41	8,567	1,297	591	2,148	5,000	109	-	-		8,567
	Dec-18	48	235	638,875	708.7	1.43	1.41	17,344	2,443	2,961	3,214	5,000	140	2,330	13		15,014
	Jan-19	9	230	668,682	709.1	1.44	1.42	16,750	2,365	550	3,126	5,000	122	-	-		16,750
	Feb-19	78	180	704,927	709.6	1.41	1.42	20,367	2,969	4,971	2,389	5,000	145	5,696	28		14,671
	Mar-19	69	150	739,526	710.0	1.40	1.42	19,442	2,985	4,409	1,949	5,000	124	5,568	29		13,874
	Apr-19	23	100	768,694	710.3	1.39	1.42	16,391	2,639	1,517	1,251	5,002	116	3,020	18		13,370
	May-19	17	80	786,952	710.5	1.41	1.42	10,260	1,691	1,139	985	5,000	100	1,946	19		8,313
4	Jun-19	14	65	805,305	710.7	1.40	1.42	10,313	1,721	893	792	5,006	80	1,897	18		8,417
	Jul-19	6	80	827,805	711.0	1.40	1.42	12,644	2,082	406	985	5,000	60	1,569	12		11,075
	Aug-19	19	90	850,305	711.2	1.40	1.42	12,644	2,059	1,276	1,116	5,000	49	2,268	18		10,376
	Sep-19	24	110	869,403	711.4	1.43	1.42	10,732	1,703	1,649	1,384	5,000	47	2,016	19		8,716
	Oct-19	8	130	886,871	711.6	1.46	1.43	9,816	1,529	537	1,654	5,000	44	456	5		9,360
	Nov-19	10	165	907,526	711.8	1.47	1.43	11,607	1,725	664	2,149	5,000	38	279	2		11,328
	Dec-19	48	235	916,920	711.9	1.47	1.43	5,279	725	3,290	3,196	5,000	33	852	16		4,427
	Jan-20	9	230	933,660	712.1	1.47	1.43	9,407	1,299	608	3,114	5,000	32	-	-		9,407
	Feb-20	78	180	942,306	712.1	1.47	1.43	4,859	697	5,427	2,406	5,081	24	3,661	75		1,197
	Mar-20	69	150	959,007	712.3	1.47	1.43	9,385	1,426	4,793	1,954	5,000	23	4,369	47		5,016
	Apr-20	23	100	979,783	712.5	1.42	1.43	11,675	1,868	1,648	1,249	5,000	18	2,284	20		9,391
	May-20	17	80	992,631	712.6	1.45	1.44	7,220	1,184	1,236	984	5,000	19	1,454	20		5,765
5	Jun-20	14	65	1,005,283	712.7	1.43	1.44	7,110	1,182	967	791	5,000	21	1,379	19		5,730
	Jul-20	6	80	1,016,057	712.8	1.47	1.44	6,054	993	438	983	5,000	18	465	8		5,589
	Aug-20	19	90	1,019,508	712.8	1.48	1.44	1,939	314	1,365	1,114	5,000	17	582	30		1,357
	Sep-20	24	110	1,030,268	712.9	1.48	1.44	6,047	954	1,762	1,382	5,000	15	1,349	22		4,698
	Oct-20	8	130	1,064,159	713.3	1.41	1.44	19,044	2,948	580	1,657	5,000	11	1,882	10		17,162
	Nov-20	10	165	1,079,908	713.4	1.48	1.44	8,850	1,304	716	2,147	5,000	12	-	-		8,850
	Dec-20	48	235	1,079,909	713.4	1.48	1.44	-	0	3,535	3,306	5,248	20	0			-
	Jan-21	9	230	1,096,557	713.5	1.48	1.44	9,355	1,277	654	3,163	5,000	17	-	-		9,355
	Feb-21	78	180	1,119,888	713.7	1.48	1.44	13,111	1,859	5,884	2,380	5,000	11	5,373	41		7,738
	Mar-21	69	150	1,131,006	713.8	1.48	1.44	6,247	942	5,169	1,950	5,000	14	4,175	67		2,073
	Apr-21	23	100	1,157,304	714.1	1.42	1.44	14,778	2,353	1,782	1,249	5,000	16	2,901	20		11,877
	May-21	17	80	1,160,051	714.1	1.48	1.44	1,544	252	1,328	984	5,000	14	609	39		934
6	Jun-21	14	65	1,164,911	714.1	1.48	1.44	2,731	453	1,035	791	5,000	17	715	26		2,016
	Jul-21	6	80	1,166,907	714.1	1.48	1.45	1,122	183	466	982	5,000	12	-	-		1,122
	Aug-21	19	90	1,177,193	714.2	1.48	1.45	5,780	934	1,460	1,115	5,000	10	1,289	22		4,491
	Sep-21	24	110	1,178,628	714.2	1.48	1.45	806	127	1,872	1,389	5,032	8	586	73		220
	Oct-21	8	130	1,178,629	714.2	1.48	1.45	-	0	606	1,660	5,000	8	-			-
	Nov-21	10	165	1,199,924	714.4	1.48	1.45	11,966	1,754	751	2,148	5,000	6	363	3		11,603
	Dec-21	48	235	1,213,601	714.5	1.48	1.45	7,686	1,034	3,725	3,197	5,000	5	1,566	20		6,120

KP_svr\...\PE801-139_10 Dargues Gold Project TSF Final Design Update Rev 0.docx

4.4 DILUTION MODELLING

KP undertook an assessment of the anticipated stormwater volumes that would enter the facility under the following extreme rainfall events. The rainfall depth associated with each event is presented in parenthesis.

- 1 in 200 year, 72-hour event magnitude (507mm).
- 1 in 500 year, 72-hour event magnitude (616mm).
- 1 in 1,000 year, 72-hour event magnitude (705mm).
- 1 in 2,000 year, 72-hour event magnitude (789mm).
- 1 in 5,000 year, 72-hour event magnitude (890mm)
- 1 in 10,000 year, 72-hour event magnitude (936mm)
- 1 in 50,000 year, 72-hour event magnitude (1 152mm).
- 1 in 200,000 year, 72-hour event magnitude (1 296mm).
- 1 in 10 million year, 72-hour event magnitude (1 728mm).

In estimating the stormwater volumes that would enter the facility, Knight Piésold conservatively assumed that the clean water diversion around the facility may fail and stormwater run-off from upslope of the facility would not be diverted around the facility. As a result, the assumed volume of stormwater is likely to be a conservative overestimate.

Based on the above, Knight Piésold determined, on a month-by-month basis for each of the above rainfall scenarios:

- whether the facility had sufficient capacity to store the anticipated stormwater; and, if not;
- the volume of water that would be expected to discharge from the facility and the anticipated dilution factor.

Table 4.8 presents the results of the TSF stormwater event and dilution assessment, which may be summarised as follows.

- The minimum stormwater storage capacity, and thus the period of greatest risk of overtopping in the event of an extreme rainfall event, occurs in month 41, immediately prior to the construction of Lift 4 when approximately 137,396 m^3 of stormwater storage capacity would be available.
- Of the rainfall events considered, the event that would result in the lowest dilution and thus the highest concentration of cyanide being discharged via the emergency spillway would be a 1 in 10,000 year-72 hour event. This event

would result in approximately 186,000 m^3 of water being deposited within the facility. Based on an operating supernatant pond volume of approximately 14,800 m^3, this would result in a dilution rate of approximately 13 times. Other rainfall depth events would result in greater dilution as a result of the higher volume of water that would be deposited within the facility relative to pond volume at the time of the event. For example, a 1 in 10 million year or Maximum Probable Precipitation rainfall event would result in a dilution rate of approximately 22 times.

- A 1 in 2,000 year rainfall event would result in overtopping of the tailings storage facility during 4 months of the modelled 65 month life of the facility. The probability of overtopping the facility once during the 65 month life under a 1 in 2,000 rainfall event is 0.05%.
- A 1 in 10 million year or Maximum Probable Precipitation rainfall event would result in discharge from the facility in 59 of the modelled 65 month life of the facility. The probability of discharge from the facility once during the 65 month life under a 1 in 10,000,000 rainfall event is 0.00005%.
- As a result, the scenario with the greatest risk of occurring (0.05%) would be a 1 in 2,000 year rainfall event. The minimum dilution under this scenario would be approximately 28 times.

Table 4.8: Summary of TSF stormwater run-off and dilution assessment

		1 in 10 year, 72 hr						1 in 100 year, 72 hr					1 in 200 year, 72 hr			
Year	Month	Runoff Volume (m^3)	Pond Volume (m^3)	Pond Elevation (m)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Pond Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution
1	Jan-16															
	Feb-16															
	Mar-16															
	Apr-16															
	May-16															
	Jun-16															
	Jul-16															
	Aug-16	20,836	25,986		189,499	No	N/A	32,120	37,270	178,215	No	N/A	97,931	112,404	No	N/A
	Sep-16	20,825	25,964		181,707	No	N/A	32,109	37,248	170,423	No	N/A	97,920	104,612	No	N/A
	Oct-16	20,897	26,108		174,715	No	N/A	32,181	37,392	163,431	No	N/A	97,992	97,620	No	N/A
	Nov-16	21,099	26,512		159,203	No	N/A	32,383	37,796	147,919	No	N/A	98,194	82,108	No	N/A
	Dec-16	21,163	26,641		146,744	No	N/A	32,447	37,925	135,460	No	N/A	98,258	69,649	No	N/A
2	Jan-17	20,981	26,275		125,374	No	N/A	32,265	37,559	114,090	No	N/A	98,076	48,279	No	N/A
	Feb-17	20,686	25,686		121,775	No	N/A	31,970	36,970	110,491	No	N/A	97,781	44,680	No	N/A
	Mar-17	20,825	25,964		333,237	No	N/A	32,109	37,248	321,953	No	N/A	97,920	256,142	No	N/A
	Apr-17	20,763	25,840		319,837	No	N/A	32,047	37,124	308,553	No	N/A	97,858	242,742	No	N/A
	May-17	20,807	25,927		299,688	No	N/A	32,091	37,211	288,404	No	N/A	97,902	222,593	No	N/A
	Jun-17	20,801	25,917		280,195	No	N/A	32,085	37,201	268,911	No	N/A	97,896	203,100	No	N/A
	Jul-17	20,827	25,968		254,372	No	N/A	32,111	37,252	243,088	No	N/A	97,922	177,277	No	N/A
	Aug-17	40,056	45,198		218,528	No	N/A	65,172	70,314	193,412	No	N/A	97,923	160,661	No	N/A
	Sep-17	39,942	44,970		209,445	No	N/A	65,058	70,086	184,329	No	N/A	97,809	151,578	No	N/A
	Oct-17	39,985	45,056		190,360	No	N/A	65,101	70,172	165,244	No	N/A	97,852	132,493	No	N/A
	Nov-17	39,918	44,922		173,280	No	N/A	65,034	70,038	148,164	No	N/A	97,785	115,413	No	N/A
	Dec-17	39,914	44,914		154,895	No	N/A	65,030	70,030	129,779	No	N/A	97,781	97,028	No	N/A
3	Jan-18	39,914	44,914		139,429	No	N/A	65,030	70,030	114,313	No	N/A	97,781	81,562	No	N/A
	Feb-18	39,914	44,914		120,349	No	N/A	65,030	70,030	95,233	No	N/A	97,781	62,482	No	N/A
	Mar-18	39,914	44,914		102,364	No	N/A	65,030	70,030	77,248	No	N/A	97,781	44,497	No	N/A
	Apr-18	39,960	45,005		314,327	No	N/A	65,076	70,121	289,211	No	N/A	97,827	256,460	No	N/A
	May-18	39,967	45,021		301,205	No	N/A	65,083	70,137	276,089	No	N/A	97,834	243,338	No	N/A
	Jun-18	40,510	46,105		297,729	No	N/A	65,626	71,221	272,613	No	N/A	98,377	239,862	No	N/A
	Jul-18	39,990	45,065		284,004	No	N/A	65,106	70,181	258,888	No	N/A	97,857	226,137	No	N/A
	Aug-18	40,049	45,184		257,354	No	N/A	65,165	70,300	232,238	No	N/A	97,916	199,487	No	N/A
	Sep-18	39,949	44,984		239,439	No	N/A	65,065	70,100	214,323	No	N/A	97,816	181,572	No	N/A
	Oct-18	39,914	44,914		229,854	No	N/A	65,030	70,030	204,738	No	N/A	97,781	171,987	No	N/A
	Nov-18	39,914	44,914		220,017	No	N/A	65,030	70,030	194,901	No	N/A	97,781	162,150	No	N/A
	Dec-18	39,914	44,914		199,105	No	N/A	65,030	70,030	173,989	No	N/A	97,781	141,238	No	N/A
4	Jan-19	39,914	44,914		179,207	No	N/A	65,030	70,030	154,091	No	N/A	97,781	121,340	No	N/A
	Feb-19	39,914	44,914		154,116	No	N/A	65,030	70,030	129,000	No	N/A	97,781	96,249	No	N/A
	Mar-19	39,914	44,914		130,170	No	N/A	65,030	70,030	105,054	No	N/A	97,781	72,303	No	N/A
	Apr-19	39,937	44,961		109,845	No	N/A	65,053	70,077	84,729	No	N/A	97,804	51,978	No	N/A
	May-19	39,957	44,999		97,439	No	N/A	65,073	70,115	72,323	No	N/A	97,824	39,572	No	N/A
	Jun-19	39,978	45,042		250,216	No	N/A	65,094	70,158	225,100	No	N/A	97,845	192,349	No	N/A
	Jul-19	39,984	45,054		234,665	No	N/A	65,100	70,170	209,549	No	N/A	97,851	176,798	No	N/A
	Aug-19	39,997	45,080		228,251	No	N/A	65,113	70,196	203,135	No	N/A	97,864	170,384	No	N/A
	Sep-19	39,924	44,934		215,640	No	N/A	65,040	70,050	190,524	No	N/A	97,791	157,773	No	N/A
	Oct-19	39,914	44,914		204,212	No	N/A	65,030	70,030	179,096	No	N/A	97,781	146,345	No	N/A
	Nov-19	39,914	44,914		190,640	No	N/A	65,030	70,030	165,524	No	N/A	97,781	132,773	No	N/A
	Dec-19	39,914	44,914		184,801	No	N/A	65,030	70,030	159,685	No	N/A	97,781	126,934	No	N/A
5	Jan-20	39,914	44,914		173,764	No	N/A	65,030	70,030	148,648	No	N/A	97,781	115,897	No	N/A
	Feb-20	39,914	44,914		168,292	No	N/A	65,030	70,030	143,176	No	N/A	97,781	110,425	No	N/A
	Mar-20	39,914	44,914		157,199	No	N/A	65,030	70,030	132,083	No	N/A	97,781	99,332	No	N/A
	Apr-20	39,917	44,920		142,918	No	N/A	65,033	70,036	117,802	No	N/A	97,784	85,051	No	N/A
	May-20	39,947	44,981		134,333	No	N/A	65,063	70,097	109,217	No	N/A	97,814	76,466	No	N/A
	Jun-20	39,971	45,027		125,702	No	N/A	65,087	70,143	100,586	No	N/A	97,838	67,835	No	N/A
	Jul-20	39,987	45,060		118,643	No	N/A	65,103	70,176	93,527	No	N/A	97,854	60,776	No	N/A
	Aug-20	43,134	51,353		254,652	No	N/A	68,250	76,469	229,536	No	N/A	101,001	196,785	No	N/A
	Sep-20	41,146	47,376		251,384	No	N/A	66,261	72,492	226,268	No	N/A	99,012	193,517	No	N/A
	Oct-20	39,920	44,926		230,063	No	N/A	65,036	70,042	204,947	No	N/A	97,787	172,196	No	N/A
	Nov-20	39,914	44,914		219,942	No	N/A	65,030	70,030	194,826	No	N/A	97,781	162,075	No	N/A
	Dec-20	41,749	48,584		216,551	No	N/A	66,865	73,700	191,435	No	N/A	99,616	158,684	No	N/A
6	Jan-21	39,914	44,914		208,986	No	N/A	65,030	70,030	183,870	No	N/A	97,781	151,119	No	N/A
	Feb-21	39,914	44,914		193,995	No	N/A	65,030	70,030	168,879	No	N/A	97,781	136,128	No	N/A
	Mar-21	39,914	44,914		186,859	No	N/A	65,030	70,030	161,743	No	N/A	97,781	128,992	No	N/A
	Apr-21	39,921	44,927		168,534	No	N/A	65,037	70,043	143,418	No	N/A	97,788	110,667	No	N/A
	May-21	41,466	48,018		163,990	No	N/A	66,582	73,134	138,874	No	N/A	99,333	106,123	No	N/A
	Jun-21	42,631	50,349		158,481	No	N/A	67,747	75,465	133,365	No	N/A	100,498	100,614	No	N/A
	Jul-21	45,343	55,772		151,958	No	N/A	70,459	80,888	126,842	No	N/A	103,210	94,091	No	N/A
	Aug-21	45,871	56,827		143,942	No	N/A	70,987	81,943	118,826	No	N/A	103,738	86,075	No	N/A
	Sep-21	47,197	59,480		140,522	No	N/A	72,313	84,596	115,406	No	N/A	105,064	82,655	No	N/A
	Oct-21	49,661	64,409		135,658	No	N/A	74,777	89,525	110,542	No	N/A	107,528	77,791	No	N/A
	Nov-21	43,494	52,075		133,303	No	N/A	68,610	77,191	108,187	No	N/A	101,361	75,436	No	N/A
	Dec-21	40,015	45,116		131,357	No	N/A	65,131	70,232	106,241	No	N/A	97,882	73,490	No	N/A

		1 in 500 year, 72 hr				1 in 1,000 year, 72 hr				1 in 2,000 year, 72 hr				1 in 5,000 year, 72 hr			
Year	Month	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution
1	Jan-16																
	Feb-16																
	Mar-16																
	Apr-16																
	May-16																
	Jun-16																
	Jul-16																
	Aug-16	117,878	92,457	No	N/A	134,165	76,170	No	N/A	149,537	60,798	No	N/A	168,020	42,315	No	N/A
	Sep-16	117,867	84,665	No	N/A	134,154	68,378	No	N/A	149,526	53,006	No	N/A	168,009	34,523	No	N/A
	Oct-16	117,939	77,673	No	N/A	134,226	61,386	No	N/A	149,598	46,014	No	N/A	168,081	27,531	No	N/A
	Nov-16	118,141	62,161	No	N/A	134,428	45,874	No	N/A	149,800	30,502	No	N/A	168,283	12,019	No	N/A
	Dec-16	118,205	49,702	No	N/A	134,492	33,415	No	N/A	149,864	18,043	No	N/A	168,347	None	440	31
2	Jan-17	118,023	28,332	No	N/A	134,310	12,045	No	N/A	149,682	None	3,327	28	168,165	None	21,810	32
	Feb-17	117,728	24,733	No	N/A	134,015	8,446	No	N/A	149,387	None	6,926	30	167,870	None	25,409	34
	Mar-17	117,867	236,195	No	N/A	134,154	219,908	No	N/A	149,526	204,536	No	N/A	168,009	186,053	No	N/A
	Apr-17	117,805	222,795	No	N/A	134,092	206,508	No	N/A	149,464	191,136	No	N/A	167,947	172,653	No	N/A
	May-17	117,849	202,646	No	N/A	134,136	186,359	No	N/A	149,508	170,987	No	N/A	167,991	152,504	No	N/A
	Jun-17	117,843	183,153	No	N/A	134,130	166,866	No	N/A	149,502	151,494	No	N/A	167,985	133,011	No	N/A
	Jul-17	117,869	157,330	No	N/A	134,156	141,043	No	N/A	149,528	125,671	No	N/A	168,011	107,188	No	N/A
	Aug-17	117,870	140,714	No	N/A	134,157	124,427	No	N/A	149,529	109,055	No	N/A	168,012	90,572	No	N/A
	Sep-17	117,756	131,631	No	N/A	134,043	115,344	No	N/A	149,415	99,972	No	N/A	167,898	81,489	No	N/A
	Oct-17	117,799	112,546	No	N/A	134,086	96,259	No	N/A	149,458	80,887	No	N/A	167,941	62,404	No	N/A
	Nov-17	117,732	95,466	No	N/A	134,019	79,179	No	N/A	149,391	63,807	No	N/A	167,874	45,324	No	N/A
	Dec-17	117,728	77,081	No	N/A	134,015	60,794	No	N/A	149,387	45,422	No	N/A	167,870	26,939	No	N/A
3	Jan-18	117,728	61,615	No	N/A	134,015	45,328	No	N/A	149,387	29,956	No	N/A	167,870	11,473	No	N/A
	Feb-18	117,728	42,535	No	N/A	134,015	26,248	No	N/A	149,387	10,876	No	N/A	167,870	None	7,607	34
	Mar-18	117,728	24,550	No	N/A	134,015	8,263	No	N/A	149,387	None	7,109	30	167,870	None	25,592	34
	Apr-18	117,774	236,513	No	N/A	134,061	220,226	No	N/A	149,433	204,854	No	N/A	167,916	186,371	No	N/A
	May-18	117,781	223,391	No	N/A	134,068	207,104	No	N/A	149,440	191,732	No	N/A	167,923	173,249	No	N/A
	Jun-18	118,324	219,915	No	N/A	134,611	203,628	No	N/A	149,983	188,256	No	N/A	168,466	169,773	No	N/A
	Jul-18	117,804	206,190	No	N/A	134,091	189,903	No	N/A	149,463	174,531	No	N/A	167,946	156,048	No	N/A
	Aug-18	117,863	179,540	No	N/A	134,150	163,253	No	N/A	149,522	147,881	No	N/A	168,005	129,398	No	N/A
	Sep-18	117,763	161,625	No	N/A	134,050	145,338	No	N/A	149,422	129,966	No	N/A	167,905	111,483	No	N/A
	Oct-18	117,728	152,040	No	N/A	134,015	135,753	No	N/A	149,387	120,381	No	N/A	167,870	101,898	No	N/A
	Nov-18	117,728	142,203	No	N/A	134,015	125,916	No	N/A	149,387	110,544	No	N/A	167,870	92,061	No	N/A
	Dec-18	117,728	121,291	No	N/A	134,015	105,004	No	N/A	149,387	89,632	No	N/A	167,870	71,149	No	N/A
4	Jan-19	117,728	101,393	No	N/A	134,015	85,106	No	N/A	149,387	69,734	No	N/A	167,870	51,251	No	N/A
	Feb-19	117,728	76,302	No	N/A	134,015	60,015	No	N/A	149,387	44,643	No	N/A	167,870	26,160	No	N/A
	Mar-19	117,728	52,356	No	N/A	134,015	36,069	No	N/A	149,387	20,697	No	N/A	167,870	2,214	No	N/A
	Apr-19	117,751	32,031	No	N/A	134,038	15,744	No	N/A	149,410	372	No	N/A	167,893	None	18,111	33
	May-19	117,771	19,625	No	N/A	134,058	3,338	No	N/A	149,430	None	12,034	30	167,913	None	30,517	33
	Jun-19	117,792	172,402	No	N/A	134,079	156,115	No	N/A	149,451	140,743	No	N/A	167,934	122,260	No	N/A
	Jul-19	117,798	156,851	No	N/A	134,085	140,564	No	N/A	149,457	125,192	No	N/A	167,940	106,709	No	N/A
	Aug-19	117,811	150,437	No	N/A	134,098	134,150	No	N/A	149,470	118,778	No	N/A	167,953	100,295	No	N/A
	Sep-19	117,738	137,826	No	N/A	134,025	121,539	No	N/A	149,397	106,167	No	N/A	167,880	87,684	No	N/A
	Oct-19	117,728	126,398	No	N/A	134,015	110,111	No	N/A	149,387	94,739	No	N/A	167,870	76,256	No	N/A
	Nov-19	117,728	112,826	No	N/A	134,015	96,539	No	N/A	149,387	81,167	No	N/A	167,870	62,684	No	N/A
	Dec-19	117,728	106,987	No	N/A	134,015	90,700	No	N/A	149,387	75,328	No	N/A	167,870	56,845	No	N/A
5	Jan-20	117,728	95,950	No	N/A	134,015	79,663	No	N/A	149,387	64,291	No	N/A	167,870	45,808	No	N/A
	Feb-20	117,728	90,478	No	N/A	134,015	74,191	No	N/A	149,387	58,819	No	N/A	167,870	40,336	No	N/A
	Mar-20	117,728	79,385	No	N/A	134,015	63,098	No	N/A	149,387	47,726	No	N/A	167,870	29,243	No	N/A
	Apr-20	117,731	65,104	No	N/A	134,018	48,817	No	N/A	149,390	33,445	No	N/A	167,873	14,962	No	N/A
	May-20	117,761	56,519	No	N/A	134,048	40,232	No	N/A	149,420	24,860	No	N/A	167,903	6,377	No	N/A
	Jun-20	117,785	47,888	No	N/A	134,072	31,601	No	N/A	149,444	16,229	No	N/A	167,927	None	2,254	33
	Jul-20	117,801	40,829	No	N/A	134,088	24,542	No	N/A	149,460	9,170	No	N/A	167,943	None	9,313	33
	Aug-20	120,948	176,838	No	N/A	137,235	160,551	No	N/A	152,607	145,179	No	N/A	171,090	126,696	No	N/A
	Sep-20	118,959	173,570	No	N/A	135,246	157,283	No	N/A	150,618	141,911	No	N/A	169,101	123,428	No	N/A
	Oct-20	117,734	152,249	No	N/A	134,021	135,962	No	N/A	149,393	120,590	No	N/A	167,876	102,107	No	N/A
	Nov-20	117,728	142,128	No	N/A	134,015	125,841	No	N/A	149,387	110,469	No	N/A	167,870	91,986	No	N/A
	Dec-20	119,563	138,737	No	N/A	135,850	122,450	No	N/A	151,222	107,078	No	N/A	169,705	88,595	No	N/A
6	Jan-21	117,728	131,172	No	N/A	134,015	114,885	No	N/A	149,387	99,513	No	N/A	167,870	81,030	No	N/A
	Feb-21	117,728	116,181	No	N/A	134,015	99,894	No	N/A	149,387	84,522	No	N/A	167,870	66,039	No	N/A
	Mar-21	117,728	109,045	No	N/A	134,015	92,758	No	N/A	149,387	77,386	No	N/A	167,870	58,903	No	N/A
	Apr-21	117,735	90,720	No	N/A	134,022	74,433	No	N/A	149,394	59,061	No	N/A	167,877	40,578	No	N/A
	May-21	119,280	86,176	No	N/A	135,567	69,889	No	N/A	150,939	54,517	No	N/A	169,422	36,034	No	N/A
	Jun-21	120,446	80,667	No	N/A	136,732	64,380	No	N/A	152,104	49,008	No	N/A	170,587	30,525	No	N/A
	Jul-21	123,157	74,144	No	N/A	139,444	57,857	No	N/A	154,816	42,485	No	N/A	173,299	24,002	No	N/A
	Aug-21	123,685	66,128	No	N/A	139,972	49,841	No	N/A	155,344	34,469	No	N/A	173,827	15,986	No	N/A
	Sep-21	125,011	62,708	No	N/A	141,298	46,421	No	N/A	156,670	31,049	No	N/A	175,153	12,566	No	N/A
	Oct-21	127,475	57,844	No	N/A	143,762	41,557	No	N/A	159,134	26,185	No	N/A	177,617	7,702	No	N/A
	Nov-21	121,308	55,489	No	N/A	137,595	39,202	No	N/A	152,967	23,830	No	N/A	171,450	5,347	No	N/A
	Dec-21	117,829	53,543	No	N/A	134,116	37,256	No	N/A	149,488	21,884	No	N/A	167,971	3,401	No	N/A

		1 in 10,000 year, 72 hr				1 in 50,000 year, 72-hr				1 in 100,000 year, 72-hr				1 in 200,000 year, 72-hr				1 in 10 million year, 72-hr			
Year	Month	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution	Runoff Volume (m^3)	Available airspace at spillway invert (m^3)	Discharge (m^3)	Dilution
1	Jan-16																				
	Feb-16																				
	Mar-16																				
	Apr-16																				
	May-16																				
	Jun-16																				
	Jul-16																				
	Aug-16	176,438	33,897	No	N/A	215,966	None	5,631	42	227,741	None	17,406	44	242,318	None	31,983	47	321,374	None	111,039	62
	Sep-16	176,427	26,105	No	N/A	215,955	None	13,423	42	227,730	None	25,198	44	242,307	None	39,775	47	321,363	None	118,831	63
	Oct-16	176,499	19,113	No	N/A	216,027	None	20,415	41	227,802	None	32,190	44	242,379	None	46,767	47	321,435	None	125,823	62
	Nov-16	176,701	3,601	No	N/A	216,229	None	35,927	40	228,004	None	47,702	42	242,581	None	62,279	45	321,637	None	141,335	59
	Dec-16	176,765	None	8,858	32	216,293	None	48,386	39	228,068	None	60,161	42	242,645	None	74,738	44	321,701	None	153,794	59
2	Jan-17	176,583	None	30,228	33	216,111	None	69,756	41	227,886	None	81,531	43	242,463	None	96,108	46	321,519	None	175,164	61
	Feb-17	176,288	None	33,827	35	215,816	None	73,355	43	227,591	None	85,130	46	242,168	None	99,707	48	321,224	None	178,763	64
	Mar-17	176,427	177,635	No	N/A	215,955	138,107	No	N/A	227,730	126,332	No	N/A	242,307	111,755	No	N/A	321,363	32,699	No	N/A
	Apr-17	176,365	164,235	No	N/A	215,893	124,707	No	N/A	227,668	112,932	No	N/A	242,245	98,355	No	N/A	321,301	19,299	No	N/A
	May-17	176,409	144,086	No	N/A	215,937	104,558	No	N/A	227,712	92,783	No	N/A	242,289	78,206	No	N/A	321,345	None	850	63
	Jun-17	176,403	124,593	No	N/A	215,931	85,065	No	N/A	227,706	73,290	No	N/A	242,283	58,713	No	N/A	321,339	None	20,343	63
	Jul-17	176,429	98,770	No	N/A	215,957	59,242	No	N/A	227,732	47,467	No	N/A	242,309	32,890	No	N/A	321,365	None	46,166	63
	Aug-17	176,430	82,154	No	N/A	215,958	42,626	No	N/A	227,733	30,851	No	N/A	242,310	16,274	No	N/A	321,366	None	62,782	63
	Sep-17	176,316	73,071	No	N/A	215,844	33,543	No	N/A	227,619	21,768	No	N/A	242,196	7,191	No	N/A	321,252	None	71,865	64
	Oct-17	176,359	53,986	No	N/A	215,887	14,458	No	N/A	227,662	2,683	No	N/A	242,239	None	11,894	48	321,295	None	90,950	63
	Nov-17	176,292	36,906	No	N/A	215,820	None	2,622	43	227,595	None	14,397	45	242,172	None	28,974	48	321,228	None	108,030	64
	Dec-17	176,288	18,521	No	N/A	215,816	None	21,007	43	227,591	None	32,782	46	242,168	None	47,359	48	321,224	None	126,415	64
3	Jan-18	176,288	3,055	No	N/A	215,816	None	36,473	43	227,591	None	48,248	46	242,168	None	62,825	48	321,224	None	141,881	64
	Feb-18	176,288	None	16,025	35	215,816	None	55,553	43	227,591	None	67,328	46	242,168	None	81,905	48	321,224	None	160,961	64
	Mar-18	176,288	None	34,010	35	215,816	None	73,538	43	227,591	None	85,313	46	242,168	None	99,890	48	321,224	None	178,946	64
	Apr-18	176,334	177,953	No	N/A	215,862	138,425	No	N/A	227,637	126,650	No	N/A	242,214	112,073	No	N/A	321,270	33,017	No	N/A
	May-18	176,341	164,831	No	N/A	215,869	125,303	No	N/A	227,644	113,528	No	N/A	242,221	98,951	No	N/A	321,277	19,895	No	N/A
	Jun-18	176,884	161,355	No	N/A	216,412	121,827	No	N/A	228,187	110,052	No	N/A	242,764	95,475	No	N/A	321,820	16,419	No	N/A
	Jul-18	176,364	147,630	No	N/A	215,892	108,102	No	N/A	227,667	96,327	No	N/A	242,244	81,750	No	N/A	321,300	2,694	No	N/A
	Aug-18	176,423	120,980	No	N/A	215,951	81,452	No	N/A	227,726	69,677	No	N/A	242,303	55,100	No	N/A	321,359	None	23,956	63
	Sep-18	176,323	103,065	No	N/A	215,851	63,537	No	N/A	227,626	51,762	No	N/A	242,203	37,185	No	N/A	321,259	None	41,871	64
	Oct-18	176,288	93,480	No	N/A	215,816	53,952	No	N/A	227,591	42,177	No	N/A	242,168	27,600	No	N/A	321,224	None	51,456	64
	Nov-18	176,288	83,643	No	N/A	215,816	44,115	No	N/A	227,591	32,340	No	N/A	242,168	17,763	No	N/A	321,224	None	61,293	64
	Dec-18	176,288	62,731	No	N/A	215,816	23,203	No	N/A	227,591	11,428	No	N/A	242,168	None	3,149	48	321,224	None	82,205	64
4	Jan-19	176,288	42,833	No	N/A	215,816	3,305	No	N/A	227,591	None	8,470	46	242,168	None	23,047	48	321,224	None	102,103	64
	Feb-19	176,288	17,742	No	N/A	215,816	None	21,786	43	227,591	None	33,561	46	242,168	None	48,138	48	321,224	None	127,194	64
	Mar-19	176,288	None	6,204	35	215,816	None	45,732	43	227,591	None	57,507	46	242,168	None	72,084	48	321,224	None	151,140	64
	Apr-19	176,311	None	26,529	35	215,839	None	66,057	43	227,614	None	77,832	45	242,191	None	92,409	48	321,247	None	171,465	64
	May-19	176,331	None	38,935	35	215,859	None	78,463	43	227,634	None	90,238	45	242,211	None	104,815	48	321,267	None	183,871	64
	Jun-19	176,352	113,842	No	N/A	215,880	74,314	No	N/A	227,655	62,539	No	N/A	242,232	47,962	No	N/A	321,288	None	31,094	63
	Jul-19	176,358	98,291	No	N/A	215,886	58,763	No	N/A	227,661	46,988	No	N/A	242,238	32,411	No	N/A	321,294	None	46,645	63
	Aug-19	176,371	91,877	No	N/A	215,899	52,349	No	N/A	227,674	40,574	No	N/A	242,251	25,997	No	N/A	321,307	None	53,059	63
	Sep-19	176,298	79,266	No	N/A	215,826	39,738	No	N/A	227,601	27,963	No	N/A	242,178	13,386	No	N/A	321,234	None	65,670	64
	Oct-19	176,288	67,838	No	N/A	215,816	28,310	No	N/A	227,591	16,535	No	N/A	242,168	1,958	No	N/A	321,224	None	77,098	64
	Nov-19	176,288	54,266	No	N/A	215,816	14,738	No	N/A	227,591	2,963	No	N/A	242,168	None	11,614	48	321,224	None	90,670	64
	Dec-19	176,288	48,427	No	N/A	215,816	8,899	No	N/A	227,591	None	2,876	46	242,168	None	17,453	48	321,224	None	96,509	64
5	Jan-20	176,288	37,390	No	N/A	215,816	None	2,138	43	227,591	None	13,913	46	242,168	None	28,490	48	321,224	None	107,546	64
	Feb-20	176,288	31,918	No	N/A	215,816	None	7,610	43	227,591	None	19,385	46	242,168	None	33,962	48	321,224	None	113,018	64
	Mar-20	176,288	20,825	No	N/A	215,816	None	18,703	43	227,591	None	30,478	46	242,168	None	45,055	48	321,224	None	124,111	64
	Apr-20	176,291	6,544	No	N/A	215,819	None	32,984	43	227,594	None	44,759	45	242,171	None	59,336	48	321,227	None	138,392	64
	May-20	176,321	None	2,041	35	215,849	None	41,569	43	227,624	None	53,344	45	242,201	None	67,921	48	321,257	None	146,977	64
	Jun-20	176,345	None	10,672	35	215,873	None	50,200	43	227,648	None	61,975	45	242,225	None	76,552	48	321,281	None	155,608	64
	Jul-20	176,361	None	17,731	35	215,889	None	57,259	43	227,664	None	69,034	45	242,241	None	83,611	48	321,297	None	162,667	63
	Aug-20	179,508	118,278	No	N/A	219,036	78,750	No	N/A	230,811	66,975	No	N/A	245,388	52,398	No	N/A	324,444	None	26,658	39
	Sep-20	177,519	115,010	No	N/A	217,047	75,482	No	N/A	228,822	63,707	No	N/A	243,399	49,130	No	N/A	322,455	None	29,926	52
	Oct-20	176,294	93,689	No	N/A	215,822	54,161	No	N/A	227,597	42,386	No	N/A	242,174	27,809	No	N/A	321,230	None	51,247	64
	Nov-20	176,288	83,568	No	N/A	215,816	44,040	No	N/A	227,591	32,265	No	N/A	242,168	17,688	No	N/A	321,224	None	61,368	64
	Dec-20	178,123	80,177	No	N/A	217,651	40,649	No	N/A	229,426	28,874	No	N/A	244,003	14,297	No	N/A	323,059	None	64,759	47
6	Jan-21	176,288	72,612	No	N/A	215,816	33,084	No	N/A	227,591	21,309	No	N/A	242,168	6,732	No	N/A	321,224	None	72,324	64
	Feb-21	176,288	57,621	No	N/A	215,816	18,093	No	N/A	227,591	6,318	No	N/A	242,168	None	8,259	48	321,224	None	87,315	64
	Mar-21	176,288	50,485	No	N/A	215,816	10,957	No	N/A	227,591	None	818	46	242,168	None	15,395	48	321,224	None	94,451	64
	Apr-21	176,295	32,160	No	N/A	215,823	None	7,368	43	227,598	None	19,143	45	242,175	None	33,720	48	321,231	None	112,776	64
	May-21	177,840	27,616	No	N/A	217,368	None	11,912	33	229,143	None	23,687	35	243,720	None	38,264	37	322,776	None	117,320	49
	Jun-21	179,005	22,107	No	N/A	218,533	None	17,421	28	230,308	None	29,196	30	244,885	None	43,773	32	323,941	None	122,829	42
	Jul-21	181,717	15,584	No	N/A	221,245	None	23,944	21	233,020	None	35,719	22	247,597	None	50,296	24	326,653	None	129,352	31
	Aug-21	182,245	7,568	No	N/A	221,773	None	31,960	20	233,548	None	43,735	21	248,125	None	58,312	23	327,181	None	137,368	30
	Sep-21	183,571	4,148	No	N/A	223,099	None	35,380	18	234,874	None	47,155	19	249,451	None	61,732	20	328,507	None	140,788	27
	Oct-21	186,035	None	716	13	225,563	None	40,244	15	237,338	None	52,019	16	251,915	None	66,596	17	330,971	None	145,652	22
	Nov-21	179,868	None	3,071	21	219,396	None	42,599	26	231,171	None	54,374	27	245,748	None	68,951	29	324,804	None	148,007	38
	Dec-21	176,389	None	5,017	35	215,917	None	44,545	42	227,692	None	56,320	45	242,269	None	70,897	47	321,325	None	149,953	63

Table 4.9: Summary of calculated dilution factors downstream of TSF

Rainfall Event (ARI 72-hour)	Minimum dilution in TSF	Spillway Flow (m^3)	CP07		CP05		CP01	
			Flow (m^3)	Dilution Factor[1]	Flow (m^3)	Dilution Factor[1]	Flow (m^3)	Dilution Factor[1]
2,000	28	3,327	833,460	486	6,716,610	4,086	13,906,920	8,432
10,000	13	716	1,033,120	18,220	8,325,590	146,739	17,238,320	303,813
10 million	22	145,652	1,903,590	316	15,340,430	2,386	31,762,670	4,917

Note 1 - including dilution in TSF

KP_svr\...\PE801-139_10 Dargues Gold Project TSF Final Design Update Rev 0.docx

This page has intentionally been left blank

In addition, Knight Piésold also undertook an analysis of dilution of water discharged from the emergency spillway to Spring Creek and downstream. This assessment was undertaken using the stream flow model established by KP as part of the dam break assessment (Ref. 5). The model identifies 14 sub-catchments within and surrounding the Project Site (refer Figure 4.6), including:

- Spring Creek upstream of the Tailings Storage Facility emergency spillway (Catchments SC07 and SC08);
- Spring Creek downstream of the spillway and upstream of Major Creek (SC05 and SC06);
- Majors Creek upstream of Spring Creek (SC10 to SC14); and
- Majors Creek downstream of Spring Creek (SC01 to SC04).

Table 4.9 presents the modelled flows and resulting dilutions at the following key locations downstream of the TSF.

- CP07 - Confluence of the emergency spillway and Spring Creek.
- CP05 - Confluence of Spring and Majors Creeks.
- CP01 - downstream limit of the hydrological model, approximately 3.5km downstream of the Project Site boundary.

Knight Piésold notes the following points in relation to the modelling.

- The rainfall events assessed were 72-hour duration events at fixed annual recurrence intervals. These events may not be the critical duration or recurrence events, with events that just result in spillway flow potentially resulting in marginally less dilution. It is noted that the minimum dilution within the TSF that would coincide with a potential discharge via the emergency spillway would be approximately 13 times and would occur during month 70 of the facility operation when the volume of the supernatant pond would be approximately 14,800 m^3 and the available stormwater storage capacity would be approximately 185,320 m^3. For consistency with other hydrological modelling undertaken for the facility, the selected duration and annual recurrence intervals have been used.
- The *Hydrologic Modelling System HECHMS* Model was un-calibrated.
- Initial loss (0.1 mm) and constant loss (1 mm/hr) used for all model runs was that for a PMP or 1 in 10 million year event.
- Areal reduction and spatial patterning of the precipitation was not considered for any of the model runs. Point precipitation depth was assumed.

- The end result of the model is the comparison of the total run-off that passes a control point in the model and the total spillway flow. The calculation does not calculate instantaneous dilution, just the volume to volume dilution. The actual dilution factor is likely to vary during a storm event.

4.5 SURFACE WATER MANAGEMENT

Following discussions with the client it was agreed that the catchment area of the TSF would be kept as small as practicable and on this basis catchment diversion channels would be utilised. The total catchment area reporting to the facility is approximately 23 Ha, and of this total approximately 6.7 ha and 9.1 ha lie within the perimeters defined by the Stage 1 and final diversion channels respectively. From a design perspective, it was assumed that the run-off from the upstream catchment is diverted during the various water balance simulations. For the storm storage and freeboard calculations, i.e. for extreme flood events, it was conservatively assumed that the diversion channels were not operational.

Run-off is expected to sheet across the landscape rather than form discrete watercourses; hence the diversion channels have been designed to intercept surface run-off along their entire lengths. The diversion channels will be triangular in shape, a minimum of 1 m deep, with side slopes of 2:1 (H:V) and a channel gradient of 0.5%. The channels are sited to drain to existing natural drainage channels on either side of the TSF embankment abutments. The diversion channels are designed to have sufficient capacity to convey the peak run-off from 1:10 AEP (Stage 1 diversion) and 1:100 AEP (final diversion), critical duration (2 hours) storm event using the solution of Manning's equation for normal depth, with an additional freeboard allowance of 200 mm.

The hydraulic results (critical velocities) predicted during passage of the 1:100 AEP, 2 hour storm indicate that erosion protection is not required within the diversion channels except at the respective outfalls where rip-rap could be justified. However, no erosion protection is provided for, and it is assumed that any erosion will be repaired as necessary and that sediment run-off associated with these channels will be captured by facilities in place downstream of the TSF.

General arrangements of the proposed surface water management layout at Stage 1 and Stage 5 are shown in Drg. Nos. 801-139-A501-011 and 801-139-A501-015. Sections and details of the diversion channels are presented in Drg. No 801-139-A501-021.

5. TAILINGS FACILITY DESIGN

5.1 GENERAL DESCRIPTION

The facility will comprise a cross-valley storage with a zoned embankment. The design incorporates a basin underdrainage system to reduce seepage, and a toe drain located at the upstream toe to lower the phreatic surface adjacent to the embankment. The upstream toe drains and underdrainage system drain by gravity to a collection sump located at the upstream toe of the embankment. Supernatant water will be decanted from the facility via a decant tower located at the head of valley. Solution recovered from the underdrainage and decant systems will be pumped back to the plant for re-use in the process circuit. An emergency spillway will be constructed for each raise to control the discharge of any extreme storm events exceeding the design event.

Tailings will be discharged into the facility by sub-aerial deposition methods, via spigots spaced at regular intervals along the embankment crest, so as to maximise tailings density and evaporation of water. Deposition will occur mainly from the embankment towards the valley in order to form a supernatant pond towards the north-eastern perimeter.

The general layout and typical details of the TSF are shown on Drg. Nos. 801-139-A201-011 to 801-139-A201-091.

5.2 EMBANKMENT CONSTRUCTION

The TSF embankment will be constructed in five stages. Stage 1 will be constructed initially and will provide for the first 12 months of operation. All of the five stages will be constructed by downstream construction to achieve the final embankment height. The typical embankment cross-section is shown on Drg. No. 801-139-A201-022. A more detailed description of the embankment is outlined below.

Embankment construction will comprise a zoned embankment constructed of selected local borrow. The embankment consists of an upstream low permeability zone (Zone A) and a downstream structural zone (Zone C). Typical material specifications for the embankment are summarised below:

- Zone A material will be selected local borrow with an average hydraulic conductivity not greater than 3 x 10^{-8} m/s. Zone A material will comprise a combination of mine waste from the box cut and cut material from excavation of the diversion channels and re-shaping of the valley spine, and will comprise extremely weathered granite.
- Zone C material for Stage 1 construction will also comprise a combination of mine waste from the box cut and cut material from excavation of the diversion channels

and re-shaping of the valley spine, supplemented by local borrow, if required. Zone C material for subsequent stages will comprise mine waste, or material borrowed locally.

The initial embankment will have upstream and downstream slopes of 1V:3H with a crest width of 6 m. The same crest width will be adopted for subsequent stages. It is expected that the tailings will not be suitable as a construction material and the design is based on all lifts being constructed using mine waste and local borrow.

Construction of the stage raises will commence before the current stage is full so that there is adequate storage volume available throughout the life of mine and to minimise construction delays. A summary of the proposed embankment staging is provided in Table 5.1.

Table 5.1: Staged embankment construction

Stage	Duration (months)	Cumulative Tailings Production (t) [1]	Embankment Design Crest (m RL) [2]	Construction Schedule
1	12	233,106	704.0	February to June 2016
2	12	504,348	709.0	Dec 2016 to Feb 2017
3	12	827,805	712.5	Jan 2018 to Mar 2018
4	12	1,016,057	714.5	Mar 2019 to May 2019
Final	17	1,213,601	716.0	May 2020 to July 2020

Notes: 1. Production based on the Unity mining plan (May 2015).
2. Embankment crest levels based on tailings beach slope of 1 in 80.

5.3 SEEPAGE CONTROL

In order to mitigate seepage losses through the basin area and increase the settled density of the deposited tailings, a number of seepage control and underdrainage collection features have been integrated into the design. The seepage control and underdrainage collection systems will consist of the following components:

i. Cut-off trench.

ii. Low permeability soil liner.

iii. Geosynthetic liner.

iv. Basin underdrainage collection system.

v. Underdrainage collection sump.

vi. Leak collection system.

vii. Embankment upstream toe drain.

5.3.1 Cut-Off Trench

Primary seepage control from the tailings facility will comprise the construction of a cut-off trench excavated into the foundation soils and backfilled with low permeability fill to reduce seepage loss through the embankment foundation.

The cut-off trench will be located beneath the upstream toe of the embankment and will be cut to a depth of approximately 2 m to 3 m (depending on ground conditions). The cut-off trench will be constructed continuously along the upstream toe of the embankment to the full deposition elevation to limit potential seepage at any level. If the cut material is suitable as Zone A fill it may be replaced in the excavation in compacted layers; alternatively, suitable low permeability material will be won, conditioned, placed and compacted in the trench.

The location and details of the embankment cut-off trench are shown on Drg. No. 801-139-A201-021.

5.3.2 Low Permeability Liner

The deeply incised creek will be widened to approximately 5 m width and the creek banks cut back to a slope of 1V:3H. The surplus material will be used for embankment construction. The basin will be compacted to form a low permeability soil liner to tie into the low permeability zone of the embankment. The liner will be constructed by scarifying the surface soils, moisture conditioning, and re-compacting to a target permeability of 3×10^{-8} m/s. Some cross movement of material may be required for areas with insufficient fines in the subgrade.

5.3.3 Geosynthetic Liner

The complete basin area and embankment upstream face will be lined with a 1.5 mm HDPE geomembrane liner in order to reduce any seepage from the tailings and the supernatant pond. The HDPE liner will be placed on top of the compacted soil liner forming a composite liner system. Smooth geomembrane will be utilised except at the location of the decant towers, where a textured geomembrane will be placed to provide additional stability to the causeway and decant towers.

Drg. No. 801-139-A201-015 shows the proposed extent of the HDPE geomembrane.

5.3.4 Basin Underdrainage Collection System

The underdrainage collection system is designed to reduce the phreatic surface on the tailings basin area under the decant pond and immediately upstream of the embankment. The underdrainage has several benefits as follows:

- Reduces seepage through the basin and under/through the embankment;
- Drains the tailings mass, thus increasing the density of the tailings and providing a more efficient facility in terms of storage;
- Increases the strength of the tailings mass immediately adjacent to the embankment.

The design of the underdrainage system takes advantage of the natural fall of the ground to reduce re-shaping of the basin. The underdrainage system will consist of three drainage networks, namely the main collector drains, branch drains and finger drains.

The collector drain will be constructed along the main drainage line. The drain will consist of a 7 m wide sand layer (Zone F) with a nominal thickness of 300 mm, with 4 no. 160 mm draincoil pipes running for the entire underdrainage length. The sand will be covered by an erosion protection layer (Zone E) of 150 mm thickness in order to reduce erosion losses and damage to the drains. The collector drain pipes will feed directly into the underdrainage collection sump located at the upstream toe of the embankment.

The branch drains will be constructed across the basin along the minor drainage lines and finger drains will be constructed across the HDPE lined area at approximately 25 metre spacings. Both branch and finger drains will be of triangular profile, with a 100 mm draincoil pipe along the centreline and a sand layer (Zone F) wrapped by geotextile, and will be held in place by welding HDPE straps to the geomembrane liner. The branch drains will feed directly to the collector drains and the finger drains will connect into the branch and collector drains.

The layout of the facility underdrainage system is shown on Drg. No. 801-139-A201-050 and relevant sections and details are shown on Drg. Nos. 801-139-A201-051 and 801-139-A201-052.

5.3.5 Underdrainage Collection Sump

An underdrainage collection sump will be constructed against the upstream toe of the TSF embankment. This sump will collect solution from the toe drains and underdrainage system and consists of the following components:

- An excavated sump, filled with clean gravel wrapped in geotextile. The sump will be located on top of the geomembrane liner.
- A 630 mm diameter HDPE (SDR26) solid riser pipe, slotted only at the base. The pipe is located on top of the geomembrane liner (protected with a wearsheet) and runs up the upstream embankment face.
- A submersible pump.
- A hoist and pulley to raise and lower the pump.

The underdrainage system details are shown on Drg. Nos. 801-139-A201-053 and 801-139-A201-054.

5.3.6 Leak Collection System

A leak collection drain will be constructed at the base of the valley within the TSF basin area to intercept seepage through the basin liner during operation. The drain will comprise a 50 mm diameter draincoil pipe situated at the base of a 1 m deep trench, backfilled with clean sand/gravel (Zone F) to 700 mm depth, wrapped with geotextile, overlain by a 300 mm thick low permeability material cap. The leak collection drain will feed directly into the leak collection sump which will incorporate the following components:

- An excavated sump, filled with clean gravel wrapped in geotextile. The sump will be located below the underdrainage sump and below the geomembrane liner.
- A 630 mm diameter HDPE (SDR26) solid riser pipe, slotted only at the base. The pipe is located below the geomembrane liner in a trench that runs up the upstream embankment face.
- A submersible pump.
- A hoist and pulley to raise and lower the pump.

Collected solution will be pumped back onto the tailings beach, with flows reporting to the supernatant pond for recycling back to the process plant. The leak collection system details are shown on Drg. Nos. 801-139-A201-053 and 801-139-A201-054.

5.3.7 Embankment Upstream Toe Drain

In addition to the basin drainage system, a toe drain will be constructed along the upstream toe of the embankment. The toe drain has two purposes. The main purpose is to increase the stability of the embankment by providing drainage of the tailings and hence lowering the phreatic surface adjacent to the embankment. The second purpose of the toe drain is to act as an underdrainage collection pipe.

The toe drain will be similar in design to the collector drains and will comprise a 160 mm draincoil pipe laid at the base of the drain within 300 mm of drainage material (Zone F) wrapped by geotextile. The toe drain will drain into the underdrainage collection sump for recycling back into the facility.

Details of the embankment toe drain are shown in Drg. No. 801-139-A201-021 and 801-139-A201-050.

5.4 ADDITIONAL SEEPAGE CONTROL MEASURES

The facility is designed with a number of seepage control measures. If the designed seepage control measures do not provide sufficient seepage control, there are a number of additional seepage control measures which can be incorporated into the facility at a later stage. The two main additional seepage control measures are:

- Downstream seepage interception trench (0 - 5 m zone). The trenches can be either open or closed (i.e. backfilled with drainage material) with sumps to collect the seepage and return it into the facility.
- Water recovery bores – these are used to intercept seepage flows at depths greater than 5 m.

5.5 DECANT AND RETURN WATER SYSTEM

The TSF will operate with two decant towers, both located towards the top of the valley. An initial decant tower will be constructed for Stage 1. It is expected that it will take approximately 3 to 6 months for the tailings beach to develop sufficiently for the pond to come into contact with the Stage 1 decant tower, at which stage it can become operational and water can be returned to the plant. The Stage 1 decant tower will become redundant later in the life of the TSF as the pond level rises and migrates further up the valley. The base of the second decant tower will be constructed as part of Stage 1 construction but the tower will be commissioned only once the Stage 1 decant becomes redundant. The second decant will operate for the remainder of the life of the facility. The decant towers will be raised as required with each embankment lift and will consist of the following components:

- An access causeway constructed of Zone C material;
- A slotted concrete decant tower consisting of a 1.8 m diameter slotted concrete pipe surrounded by clean waste rock (Zone G) with a minimum size of 100 mm;
- A submersible pump with float control switches mounted on a lifting hoist.

The decant pump will be raised on a regular basis to ensure that no tailings enters the pump intake.

The location of the decant towers are shown on Drg. Nos. 801-139-A201-011 and 801-139-A201-015; sections and details are shown on Drg. No. 801-139-A201-031.

5.6 EMERGENCY SPILLWAY

The tailings storage facility has been designed to completely contain storm events during operation up to and including an annual exceedance probability (AEP) of 1:1000 on top of the predicted maximum pond level under average climatic conditions, without the emergency spillway operating. Consequently, exceeding the storm storage capacity of the facility at any stage of operation is unlikely. Regardless, in the event that the storage capacity of the facility is exceeded, water which cannot be stored within the facility will discharge via an engineered spillway. The emergency spillway during operation is designed to convey run-off from a 1:100,000 AEP critical duration storm, assuming that the decant pond level is at the spillway invert level at commencement of the storm event.

A new spillway will be constructed at each stage of construction and will be excavated adjacent to the southern TSF embankment. The general layout and channel dimensions are shown in Drg. Nos. 801-139-A201-060 and 801-139-A201-061. Channel revetment will be placed in the excavated channel where the spillway crosses the embankment crest, and will be omitted downstream of the embankment where the spillway traverses natural ground (due to the transient nature of the spillway). At closure, the spillway will be deepened, widened and extended into the facility, and channel revetment will be placed as shown. Under closure conditions the emergency spillway has sufficient capacity to control the discharge from a PMPDF (or DCF) without overtopping the TSF embankment.

5.7 TAILINGS AND DECANT RETURN TRENCH

The tailings delivery and decant return pipelines will be located within a bunded corridor between the process plant and the TSF in order to contain spillage of tailings or decant water. The paste delivery pipeline will also be contained within the same trench between the process plant and the paste fill holes. Typical sections and details are shown in Drg. No. 801-139-A201-071.

5.8 SEEPAGE ASSESSMENT

5.8.1 General

Seepage analyses were undertaken on the TSF to assess the following aspects of the design:

- Estimate the position of the phreatic surface within the embankment. This indicates how much of the embankment material could be saturated and is therefore a consideration for slope stability. A high phreatic surface (and consequent high pore water pressures) is a key consideration in the assessment of embankment stability.
- Estimate the total seepage losses from the TSF. It is common to estimate the maximum possible seepage loss by making conservative assumptions. This result has implications for the potential environmental impact of the TSF.
- Estimate the influence of the basin underdrainage system on the phreatic surface within the TSF. This modelling indicates how critical the underdrainage system is to the performance of the TSF and what the consequences would be if the underdrainage system were to fail.

5.8.2 Geometry

The seepage model used for this analysis was based on a south-west to north-east aligned long section through the TSF. The section was aligned with the main creek along the valley floor. The sub-surface conditions beneath the facility are based on the geotechnical information derived from the site investigations. Beneath the spine of the valley the layer of alluvial sand at the surface has some impact on the seepage flows. The depth of this alluvial layer varies along the creek, as does the underlying soil profile. Embankment zoning is based on the design geometry shown in Drg. No. 801-139-A201-022.

In the TSF basin there are two separate underdrainage systems. The basin underdrainage system is above the geosynthetic liner and reports to the underdrainage sump. This system extends along the creek to the sump located at the toe of the TSF embankment. The seepage collection system is located at the upstream toe of the TSF embankment. The full length of the upstream toe drain reports to the underdrainage sump.

The seepage analysis program Seep/W was used to evaluate seepage losses for the TSF.

5.8.3 Material Types and Properties

The assumed cross-section through the facility is illustrated in Figure 5.1 and the adopted material properties of the facility are summarised in Table 5.2.

Table 5.2: Adopted material types and properties used in seepage model

Material Type	Permeability, k (m/s)	Source
Zone C – Structural Fill	1.0×10^{-7}	Assumed
Zone A – Low Permeability	3.0×10^{-8}	Assumed
Alluvial/Colluvium	5.0×10^{-5}	In Situ Field Data
HDPE Geomembrane*	1.0×10^{-11}	Specification
Compacted Soil Liner	3.0×10^{-8}	Assumed
Weathered Rock	8.0×10^{-7}	In Situ Field Data
Granite	1.0×10^{-9}	Assumed
Tailings	5.0×10^{-7}	Laboratory Data

* HDPE geomembrane is used in combination with a compacted soil liner.

The water table was based on observations made during the site investigation and was modelled at 2.0 to 2.5 m below natural ground level at the base of the valley.

5.8.4 Scenarios Modelled

Seepage from the facility at the end of the operation was modelled as the critical scenario. This model was used to determine seepage levels and pressures at the maximum tailings and pond levels. The scenario was broken down into two cases as follows:

- Case 1 – Expected Operational Conditions

  This model assumes an operational basin underdrainage system and HDPE liner. The decant pond is assumed to be that arising from average rainfall conditions. The results of this case are shown in Figure 5.2.

- Case 2 – Underdrainage System Not Operational

  The purpose of this model was to examine the effect of the underdrainage system on the performance of the TSF. The model is identical to Case 1 but with no underdrainage system. The results of this case are shown in Figure 5.3.

5.8.5 Boundary Conditions

The following boundary conditions were assumed in the analysis:

- The supernatant pond is represented by a constant head boundary condition, where the head is equal to the elevation of the pond surface.

- At the left edge of the model (i.e. at the embankment) the water level was set at 2.5 m below ground level.
- At the right side of the model the water level was set at 2 m below ground level.
- Drainage systems were modelled as a series of free draining points (or zero pressure nodes). These nodes were placed at the design underdrainage spacing to account for the infiltration rate.
- The downstream toe was modelled using flux (Q) review nodes, by maximum pressure (seepage may pass through the downstream toe).

5.8.6 Results of Seepage Assessment

The seepage modelling results are summarised in Table 5.3. The seepage rates tabled do not include discharge from the drainage systems (i.e. the rates listed are actual seepage losses from the TSF rather than water circulated through the tailings mass). The seepage through the basin is pro-rated by the ratio of the basin area to the length of the model.

Table 5.3: Results of seepage modelling for final stage

Case	Water flow through basin (L/s/m)	Water flow through basin (L/s)	No. of Times Case 1	Equivalent permeability (m/s)	Figure No.
Underdrainage Functioning Partially Saturated Tailings	1.53×10^{-4}	0.031	-	3.2×10^{-10}	5.2
Underdrainage Not Functioning Partially Saturated Tailings	9.25×10^{-4}	0.187	6	2.0×10^{-9}	5.3

The results of the two cases are discussed below:

- Case 1 – Expected Operational Conditions

  Case 1 was modelled with the basin underdrainage system operational. At the left side of the model (i.e. at the main embankment) the phreatic surface is at the level of the underdrainage system, and thus the tailings in this area are unsaturated. In the area beneath the decant pond the tailings are saturated. However, the underdrains reduce the pressure at the HDPE liner, indicating that the drainage is effective in lowering the pressure on the liner and reducing the seepage loss.

  The seepage collection system at the TSF embankment upstream toe acts to capture seepage and mitigates seepage into the downstream environment. The seepage rate of 0.031 L/s is equivalent to a basin permeability of 3.2×10^{-10} m/s.

- Case 2 – Underdrainage System Not Operational
  The impact of having the underdrainage non-operational is that the phreatic surface extends to the upstream toe of the embankment. Over the liner itself the pressure head is equal to the height of the pond. The increase in pressure results in an increase in seepage rate to 0.187 L/s, which is equivalent to a basin permeability of 2.0 x 10^{-9} m/s.

As shown in Table 5.3 the seepage rate increases by 6 times when the basin underdrainage system is non-operational. This indicates that water previously collected by the underdrainage now seeps through to the TSF embankment. At the embankment, the basin liner and seepage collection system largely intercept this seepage and the increased flow rate is within the capacity of the seepage collection system.

5.8.7 Conclusions

The results of the seepage modelling provide the following conclusions:

- The phreatic surface will remain well away from the TSF embankment under expected operational conditions.
- The proposed arrangement of the basin HDPE geomembrane liner with underdrainage system will result in significantly reduced seepage from the facility, by about 80% compared to the case where the underdrainage system is not operational.
- Inevitably some seepage will occur through the TSF basin. However, the seepage rates are equivalent to an overall basin permeability of between 2.0 x 10^{-9} m/s and 3.2 x 10^{-10} m/s.

5.9 STABILITY ASSESSMENT

5.9.1 Embankment Stability

The stability of the tailings storage facility embankment was assessed in order to confirm the factors of safety against shear failure under the range of possible operating conditions. In accordance with Australian National Committee on Large Dams (ANCOLD) guidelines on tailings dams (Ref. 6), the assessment covered the following steps:

- Analysis under static (drained and undrained) conditions.
- Analysis under post seismic conditions.
- Deformation analysis under earthquake loading (Swaisgood method and Pells and Fell method).
- Liquefaction potential assessment.

The computer program, SLOPE/W, was used for the analyses which were carried out using the modified Morgenstern-Price method. SLOPE/W calculates the magnitude of the de-stabilising forces in the embankment slope and compares this to the total strength of the soil structure. The calculated ratio of these two parameters is the factor of safety against slope failure. When the de-stabilising forces are equal to the strength of the structure, this ratio (the factor of safety) is equal to one and the embankment is said to be "just stable". As the factor of safety increases, the probability of an embankment failure is reduced.

Pseudo-static analysis is no longer recommended by the ANCOLD *"Guidelines for Design of Dams for Earthquake"* (Ref. 11) for assessment of embankment performance under seismic loading. The stability of the embankments under earthquake loading conditions was assessed using post-seismic stability analysis and empirical seismic deformation analysis. A horizontal ground acceleration of 0.11g was adopted as the operating basis design acceleration (OBE) based on the seismicity assessment for the site area. An event of this magnitude is calculated to have a return period of 1 in 1000 years or, in effect, a 5% probability of occurring in 50 years.

In addition to the above the stability of the facility was examined by applying a 1 in 10,000 year return period maximum design earthquake (MDE) acceleration of 0.34g in the analysis.

The stability of the embankments was measured under each load case against the minimum recommended factors of safety against failure, as provided in the ANCOLD guideline (Ref. 11). These factors are summarised in Table 5.4.

Table 5.4: Minimum factors of safety for design

Case being Analysed	Minimum FOS
Long-term drained stability	1.5
Short-term undrained stability (no potential loss of containment	1.3
Post seismic stability	1.0-1.2

5.9.2 Material Properties

The properties of the materials to be used for embankment construction are based on the results of the site investigation and laboratory testing of typical samples. The strength properties selected are considered to be representative of the various types of materials identified during the site geotechnical investigation and proposed to be used in the embankment, and are based on laboratory test data where this is available. Soft/loose alluvial clay/sand was observed within the creek during the site investigation programme. Undrained shear strength parameters were adopted to check the short term undrained stability of the TSF embankment. The adopted shear strength parameters for the various material horizons are defined in Table 5.5. The embankment material and soil are considered to be non-liquefiable. However, certain materials may be subject to strength loss and strain softening after an earthquake event. The post seismic residual strength is adopted as 80% of the static shear strength. The tailings are considered potentially liquefiable and the post-seismic shear strength is assumed to be 5°.

Table 5.5: Shear strength parameters

Material	γ_{moist} (kN/m^3)	γ_{sat} (kN/m^3)	c' (kPa)	Ø' (°)	Undrained
Zone A low permeability fill	18	19	5	28	s_u=0.3σ'$_v$, min =50kPa
Zone C structural fill	18	18	0	30	-
Tailings	14	16	0	20	-
Alluvium/ Colluvium	18	20	0	30	s_u=0.3σ'$_v$, min =30kPa
Weathered rock	21	22	0	33	-
Granite	23	24	0	40	-

5.9.3 Embankment Stability

The stability of the TSF embankment was assessed under drained, undrained and post seismic conditions, at both Stage 1 and final height. The models were analysed using conservative assumptions regarding the level of the tailings and the phreatic surface. For example, when downstream stability was being considered, the model assumed that the TSF was at full capacity. In addition, the effect of the pore water pressures on embankment stability was also modelled very conservatively by incorporating high phreatic surfaces in order to analyse the worst case scenario. In practice, it is expected that the decant pond will be located well away from the TSF embankment and that, even in the event of a storm event, the rise in pond level will be temporary only and should not cause a permanent rise in the phreatic surface. On this basis the analysed phreatic surfaces are considered to be higher than would be experienced in practice. Obviously, this will be monitored and the stability of the embankments will be reviewed regularly as part of ongoing monitoring of the facility.

The analysed sections were derived from Drg. Nos. 801-139-A201-021 and 801-139-A201-022 and represent the critical sections where the embankment height is greatest. The results of the stability analyses are presented in Table 5.6. The modes of failure and the geometry of the analysed sections are shown on figures 5.4 through 5.11.

Table 5.6: Summary of TSF embankment stability results

Case	Description	Drained Factor of Safety	Undrained Factor of Safety	Post Seismic Factor of Safety	Figure
1	Starter, High Pond	1.72	1.3	1.05	5.6, 5.7, 5.8
2	Final, High Pond	1.85	1.4	1.12	5.9, 5.10, 5.11

Comparison of the results with the ANCOLD minimum factors of safety indicates that the embankment sections are stable under both static and post seismic loadings.

5.9.4 Deformation Analysis

The empirical Swaisgood (1998) (Ref. 12) and Pells and Fell (2003) (Ref. 13) methods recommended in the ANCOLD guidelines were used to estimate the crest deformation under the OBE and MDE design earthquake scenarios.

The relative crest settlement approximation by Swaisgood is based on the embankment height, embankment type, depth of alluvium in the foundation, earthquake magnitude, peak ground acceleration, and focal distance of the embankment to the earthquake.

The vertical crest settlement (as a percentage) can be approximated by:

$$CS = SEF * RF$$

Where:

CS = vertical crest settlement considering embankment height and alluvium/colluvium thickness

SEF = seismic energy factor

RF = resonance factor

RF is calculated based on the dam type as follows:

$RF = 2.0\ D^{-0.35}$ (for earthfill dams)

$RF = 8.0\ D^{-0.35}$ (for hydraulic fill dams)

$RF = 0.12\ D^{0.61}$ (for rockfill embankments)

Where:

D = distance between seismic energy source and embankment (km)

SEF is calculated based on the earthquake parameters as follows:

$$SEF = e^{(0.72\,M + 6.28\,PGA - 9.1)}$$

Where:

M = earthquake magnitude

PGA = peak horizontal ground acceleration as a fraction of gravity

The Damage Classification System was developed by Pells and Fell. Data from 305 dams, 95 of which reported cracking, were gathered and classified for damage according to the system shown in the Table 5.7.

Table 5.7: Damage Classification System (Pells and Fell, 2003)

Damage Class		Maximum Longitudinal Crack Width (mm)	Maximum Relative Crest Settlement (%)
Number	Description		
0	No or Slight	< 10	< 0.03
1	Minor	10 – 30	0.03 – 0.2
2	Moderate	30 – 80	0.2 – 0.5
3	Major	80 – 150	0.5 – 1.5
4	Severe	150 – 500	1.5 – 5
5	Collapse	> 500	> 5

The crest settlement after the OBE and MDE events according to the above empirical methods are summarised in Table 5.8.

Table 5.8: Maximum Crest Settlement using empirical methods

Method	Settlement Stage 1 (mm)		Settlement Final (mm)	
	OBE	MDE	OBE	MDE
Swaisgood 1998	5	20	5	30
Pells and Fell 2003	10	10-50	10	10-75

The estimated deformation is less than 0.1 m, well below the embankment freeboard, and therefore the potential for uncontrolled loss of storage is insignificant.

Relating satisfactory dam performance to earthquake induced deformation can be very subjective, and generally depends on dam specific criteria about the allowable loss of freeboard, or the tolerable extent of horizontal displacements. Whilst the calculated magnitude of displacements is fairly insignificant, there are a number of additional reasons why the stability of the embankment under earthquake loading conditions is considered to be acceptable:

- Historically, even at short distances from an earthquake epicentre, there have been no complete failures of embankments built of clay soils, but several dams have come close to failure.
- Dams which have suffered complete failure as a result of earthquake shaking have been constructed primarily with saturated sandy materials or on saturated sand foundations. Liquefaction was a major contributing factor in these failures.
- Well-constructed dams of clay soils on clay or rock foundations not susceptible to strain weakening can withstand extremely strong shaking resulting from earthquakes of up to magnitude 8.25 with peak ground acceleration ranging from 0.35g to 0.8g.
- The foundation soils and proposed embankment construction materials are not subject to strain softening, and are not liquefiable. The static factor of safety of the critical failure surfaces involving loss of crest elevation are greater than 1.5 under working conditions expected prior to an earthquake.
- The minimum horizontal thickness of the constructed embankment will be 6 m, which is relatively thick in relation to potential movements of the embankment.
- There are no outlet works or low strength seams passing through the embankment or foundation which could produce leakage or potential piping erosion in the embankment.

In addition, it should be noted that under most conditions there will only be a limited amount of water in the facility.

5.9.5 Liquefaction Assessment

The embankment foundation comprises weathered rock and the embankment construction materials comprise clay and rock materials, and therefore neither are considered to be liquefiable.

The liquefaction potential of the tailings may be classified according to its particle size distribution. In general terms, saturated sands, silty sands, silts and gravelly sands are most susceptible to liquefaction, whilst finer grained soils are usually less susceptible. However, experience has shown that even soils with small amounts of clay may liquefy. In addition, mine tailings are more susceptible to liquefaction than natural soils, possibly reflecting their uniform size and recent deposition. There is some evidence that tailings will “age” and develop greater resistance to liquefaction with time.

Figure 5.12 shows the particle size distributions of the flotation and concentrate tailings samples in comparison to the particle size envelopes for slimes with low resistance to liquefaction and potentially liquefiable soils. This shows that the particle size distribution of both tailings samples lie predominantly within the boundaries of either potentially or most liquefiable soils.

Following the guidance provided in *"Ground Motions and Soil Liquefaction During Earthquakes"* (Ref. 14), liquefaction can only occur if all three of the following conditions are met:

- The clay content (particles less than 5 microns) is less than 15% by weight.
- The liquid limit is less than 35%.
- The moisture content is no less than 0.9 times the liquid limit.

Based on Atterberg Limit tests, the liquid limits of the flotation and concentrate tailings are 27% and 25% respectively. According to the particle size distribution tests, the clay-sized particle fraction of both tailings types is approximately 7% by weight. In addition, it is estimated that the moisture content of the tailings will generally remain above the liquid limit. Thus, the tailings properties for both types of tailings fulfil all three criteria for liquefaction potential. This analysis together with the tailings particle size distributions, suggests that liquefaction of the combined tailings is a possibility.

Regardless of the liquefaction potential of the combined tailings, each raise of the TSF will be constructed downstream and therefore the potential impact of tailings liquefaction is inconsequential.

5.10 TAILINGS STORAGE FACILITY MANAGEMENT

5.10.1 Tailings Deposition System

The deposition of tailings into the storage facility will be primarily from the TSF embankment. The tailings delivery pipeline will be routed from the process plant up to the crest of the TSF embankment. The tailings distribution pipeline will be located on the embankment crest and will be raised with each stage.

Deposition will occur from single offtakes inserted along the tailings distribution pipeline. The deposition location will be moved on a daily basis to one of the deposition points, or as required to control the location of the supernatant pond. All of the valves in the deposition system will be provided with pneumatic actuators for ease of operation.

5.10.2 Deposition Technique

Tailings deposition will be carried out using the sub-aerial technique in order to promote the maximum amount of water removal from the facility by the formation of a large beach for drying and draining. Together with keeping the pond size to a minimum, sub-aerial deposition will increase the settled density of the tailings and hence maximise the storage potential and efficiency of the facility.

The tailings will be deposited into the facility from the embankment in such a way as to encourage the formation of beaches over which the slurry will flow along the spine of the basin in a laminar non-turbulent manner. Limited settlement and water release will occur. The released water will form a thin film on the surface of the tailings. This water will flow to the supernatant pond from where it will be removed from the storage area via a decant tower. The Stage 1 decant tower is located such that it will first receive water approximately 3 to 6 months after commissioning the facility.

Deposition of the tailings will be carried out on a cyclic basis with the tailings being deposited over one area of the storage until the required layer thickness has been built up. Deposition will then be moved to an adjacent part of the storage to allow the deposition layer to dry and consolidate. This will facilitate maximum storage to be achieved across the whole valley.

After deposition on a particular area of beach ceases and settling of the tailings has been completed, further de-watering will take place due partly to drainage into the underdrainage system, but mainly due to evaporation. As water evaporates and the moisture content drops, the volume of tailings will reduce to maintain a condition of full saturation within the tailings. This process will continue until interaction between the tailings particles negates volume reduction.

6. CONSTRUCTION QUANTITIES

On the basis of the design presented, operating parameters supplied and/or assumed, construction quantities for the life of the facility have been determined. The quantities given are deemed accurate enough for an overall accuracy of ±10% - 15%.

Life of operation quantities for construction of the tailings storage facility are presented in Table 6.1. The following assumptions were made:

- Zone A will be obtained from mine waste (box cut) and construction earthworks for Stage 1, and from mine waste or local borrow for subsequent construction stages.
- Zone C will be obtained from mine waste (box cut) and construction earthworks for Stage 1, and from mine waste or local borrow for subsequent construction stages.
- Zone D will be obtained from mine waste (box cut).
- Zone E will be selected material from mine waste (box cut).
- Zone F will be imported from a local borrow source.
- Zone G will be selected material from mine waste (box cut).

Table 6.1: Tailings Storage Facility, Bill of Quantities – Final Design Update

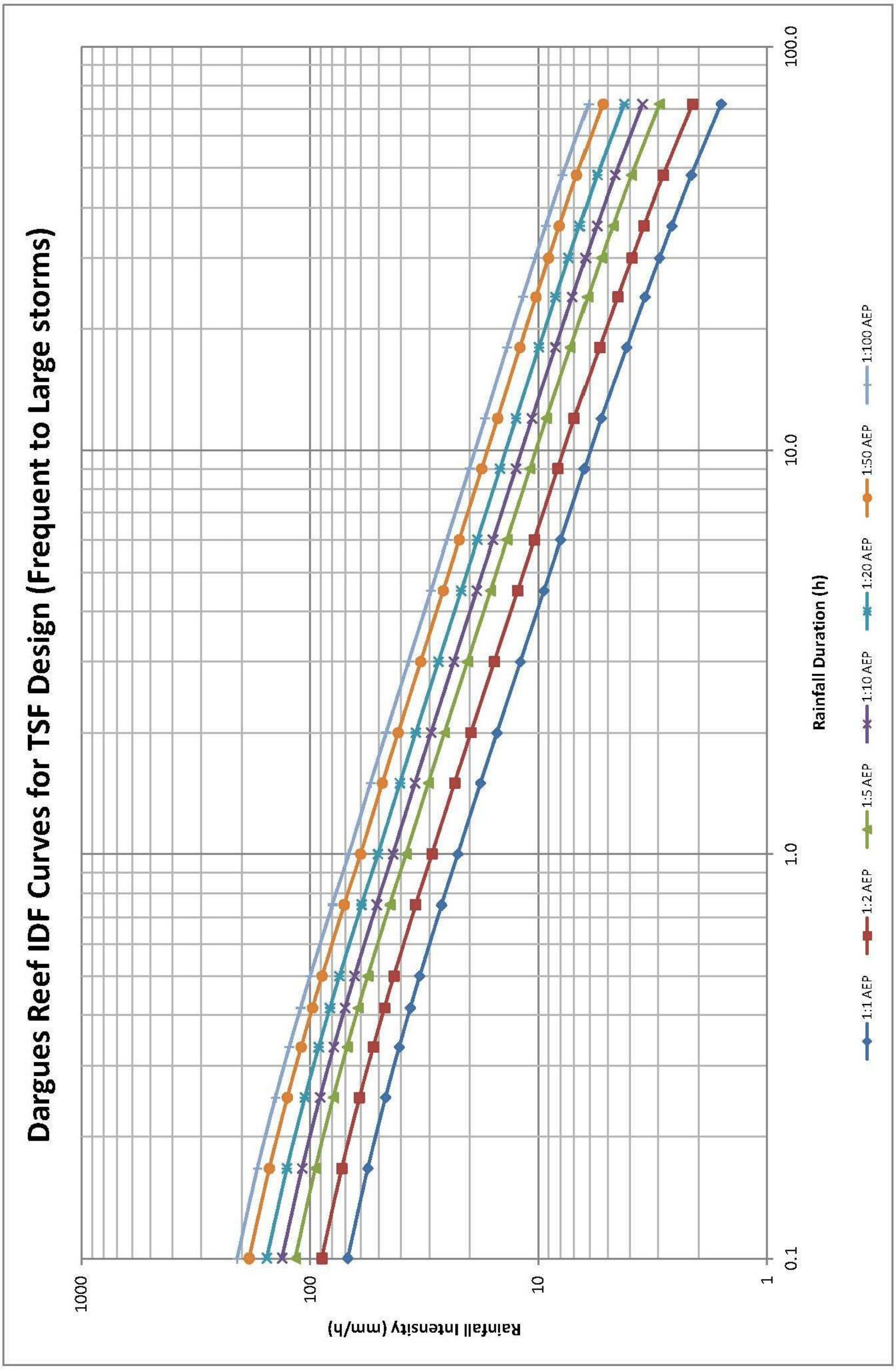
			Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
ITEM	**Description**	**Unit**	**Qty**	**Qty**			**Qty**	**Qty**
1	**Preliminary and General**							
1.1	Mobilise to site	item	1	1	1	1	1	5
1.2	De-mobilise from site	item	1	1	1	1	1	5
1.3	Fixed costs while established on site	weeks	20	12	12	12	12	68
1	**TOTAL FOR PRELIMINARY AND GENERAL (nominal 15%)**							
2	***Foundation Preparation***							
2.1	Clear and grub embankment footprint	sq m	17,064	15,506	16,534	11,921	10,194	71,220
2.2	Strip topsoil (300 mm nominal) from embankment foundation and stockpile	sq m	17,064	15,506	16,534	11,921	10,194	71,220
2.3	Excavate embankment cut-off trench, haul, place and spread excavated material in Zone C	cu m	6,700	2,300	2,200	1,500	700	13,400
2.4	Scarify, moisture condition and compact embankment foundation (includes cut-off trench plus 5 m)	sq m	17,064	15,506	16,534	11,921	10,194	71,220
2.5	Win from borrow area, spread, moisture condition and compact Zone A material in cut-off trench	cu m	6,700	2,300	2,200	1,500	700	13,400
2	**TOTAL FOR FOUNDATION PREPARATION**							
3	***General Embankment Earthworks***							
3.1	Win from borrow, load, haul, spread, moisture condition and compact Zone A material in embankment zones	cu m	8,470	8,170	7,598	5,204	4,257	33,699
3.2	Win from mine waste, load, haul, spread, moisture condition and compact Zone C material in embankment	cu m	102,571	127,728	159,922	127,201	118,128	635,550
3.3	Supply and install 160 mm dia class 400 slotted CPT draincoil, with tees, bends and joints inclusive for toe	m	319	108	102	68	31	627
3.4	Win from local borrow, haul and place Zone F sand material to upstream toe drain	cu m	220	80	70	50	30	450
3.5	Supply and install geotextile to upstream toe drain	sq m	1,230	420	400	270	120	2,440
3.6	Supply and install 1.5 mm (60 mil) smooth HDPE geomembrane to embankment upstream face	sq m	6,805	6,309	5,857	4,092	3,309	26,372
3.7	Win from local borrow, load, haul, place and compact wearing course onto embankment crest (150mm thick)	cu m	300	500	600	700	700	2,800
3.8	Win from local borrow, load, haul, and place Zone D fill as crest safety berm	cu m	200	300	300	400	400	1,600
3	**TOTAL FOR GENERAL EMBANKMENT EARTHWORKS**							
4	***Spillway***							
4.1	Clear vegetation from spillway area	Ha	0.20	0.23	0.26	0.29	0.33	1.31
4.2	Grub spillway area	Ha	0.20	0.23	0.26	0.29	0.33	1.31
4.3	Strip topsoil (300 mm) from spillway foundation, load and haul to stockpile	cu m	300.0	400	400	500	500	2100
4.4	Excavate emergency spillway, load, haul and place excavated material to embankment Zone C	cu m	3,717	4,001	4,285	4,569	4,853	21,425
4.5	Win from local borrow and place Zone E rip rap to spillway channel	cu m	991	1,150	1,310	1,469	1,628	6,548
4	**TOTAL FOR SPILLWAY**							
	Basin Construction							
5.1	Clear and grub basin area	sq m	40,081	19,847	17,351	11,579	11,709	100,566
5.2	Re-shape basin area along valley spine (nominal allowance)	cu m	150	-	-	-	-	150
5.3	Strip topsoil (300 mm nominal) and stockpile	sq m	40,081	19,847	17,351	11,579	11,709	100,566
5.5	Scarify, moisture condition and compact basin in situ materials to form basin liner	sq m	40,081	19,847	17,351	11,579	11,709	100,566
5.6	Prepare basin subgrade for HDPE lined area	sq m	40,081	19,847	17,351	11,579	11,709	100,566
5.7	Supply and install 1.5 mm HDPE liner to basin underdrainage area	sq m	40,081	19,847	17,351	11,579	11,709	100,566
5	**TOTAL FOR BASIN CONSTRUCTION**							
6	***Underdrainage System***							
6.1	Proof roll basin area	Ha	4.0	2.0	1.7	1.2	1.2	10.1
6.2	Excavate Main Collector drain and LCRS drain to Zone C or designated local stockpile	cu m	330	-	-	-	-	330
6.3	Win from local borrow, load, haul, place and spread Zone F drainage sand for main collector drains	cu m	160	-	-	-	-	160
6.4	Win from local borrow, load, haul, place and spread Zone F drainage sand for branch drains	cu m	90	-	-	-	-	90
6.5	Win from local borrow, load, haul, place and spread Zone F drainage sand for finger drains	cu m	80	-	-	-	-	80
6.6	Win from local borrow, haul and place Zone E erosion protection layer (150 mm thick) to main collector drains and tailings flow channel	cu m	130	-	-	-	-	130
6.7	Win from local borrow, load, haul, place and spread Zone A protection layer to decant tower	sq m	3,280	-	-	-	-	3,280
6.8	Supply and Install Geotextile (Bidim A14 or equivalent) to main collector drains	sq m	6,600	-	-	-	-	6,600
6.9	Supply and Install Geotextile (Bidim A14 or equivalent) to branch drains	sq m	1,200	-	-	-	-	1,200
6.10	Supply and Install Geotextile (Bidim A14 or equivalent) to finger drains	sq m	1,200	-	-	-	-	1,200
6.11	Supply and Install Geotextile (Bidim A14 or equivalent) to LCRS drains	sq m	400	-	-	-	-	400
6.12	Supply and install 160 mm class 400 CPT draincoil to main collector drain, with filter sock, tees, bends and joints (includes connector pipes)	m	470	-	-	-	-	470
6.13	Supply and install 100 mm class 400 CPT draincoil to branch drain, with tees, bends and joints	m	470	-	-	-	-	470
6.14	Supply and install 100 mm class 400 CPT draincoil to finger drain, with tees, bends and joints	m	820	-	-	-	-	820
6.15	Supply and install 50 mm class 400 CPT draincoil to LCRS drain, with tees, bends and joints	m	120	-	-	-	-	120
6	**TOTAL FOR UNDERDRAINAGE SYSTEM**							
7	***Underdrainage Collection Sump***							
7.1	Excavate underdrainage collection sump to Zone C or designated spoil stockpile	cu m	245	-	-	-	-	245
7.2	Win from local borrow, load, haul, place and compact Zone A soil liner for underdrainage sump	cu m	60	-	-	-	-	60
7.3	Win from local borrow, load, haul and place clean gravel backfill to underdrainage sump	cu m	409	-	-	-	-	409
7.4	Win from local borrow, load, haul and place clean gravel backfill to LCRS sump	cu m	40					
7.5	Supply and install geotextile (Bidim A24 or equivalent) to underdrainage sump and LCRS sump	sq m	420	-	-	-	-	420
7.6	Supply and install 1.5 mm HDPE liner to underdrainage sump and LCRS sump	sq m	310					
7.7	Supply and install 630 mm dia HDPE (SDR 11) riser pipe (slotted) including all fittings	m	5.0	-	-	-	-	5
7.8	Supply and install 630 mm dia HDPE (SDR 11) riser pipe (un-slotted) including all fittings	m	129.8	31.6	22.1	12.6	9.5	206
7.9	Supply and install solid end cap to riser pipe	No	2.0	-	-	-	-	2
7.10	Excavate riser pipe channel for LCRS sump	cu m	130	30	20	10	10	200
7.11	Supply, place and compact Cement Stabilised Sand to riser pipes.	cu m	220	50	40	20	20	
7.12	Supply and install 1.5 mm (60 mil) textured HDPE lower wear-sheet for underdrainage sump and riser pipe	sq m	300	70	50	30	20	470
7.13	Supply and install 1.5 mm (60 mil) textured HDPE upper wear-sheet for underdrainage sump and riser pipe	sq m	210	50	40	20	20	340
7.14	Install HDPE pipe boot (includes two steel band clamps)	No	1.0	-	-	-	-	1
7	**TOTAL FOR UNDERDRAINAGE COLLECTION SUMP**							
8	***Decant System***							
8.1	Spread, moisture condition and compact Zone A protective layer as base of decant causeway	cu m	984	-	-	-	-	984
8.2	Spread, moisture condition and compact Zone C decant access causeway fill	cu m	1,333	-	450	345	1,211	3,339
8.3	Win from adjacent stockpile, load, haul and place Zone G selected clean rockfill decant surround	cu m	6,201	-	2,457	1,886	513	11,057
8.4	Supply and install 25 MPa concrete base including formwork and reinforcement	cu m	12.0	-	-	-	-	12
8.5	Supply and install 2600 mm square slotted reinforced concrete decant tower	m	10.0	10	13.5	15.5	17.0	66
8.6	Supply and Install Geotextile (Bidim A24 or equivalent) to decant access causeway Zone D / rockfill transition	sq m	285	-	121	90	77	573
8.7	Win from local stockpile, load, haul, place and compact wearing course to decant access causeway (150 mm thick)	cu m	60	-	50	63	75	247
8.8	Win from local borrow, load, haul and place Zone D material as safety berm on decant access causeway	cu m	24	-	19	23	27	92
8	**TOTAL FOR DECANT SYSTEM**							
9	**Diversion Channels**							
9.1	Excavate diversion channels, haul and place to embankment Zone C	cu m	3,400	2,500	-	-	-	5,900
9	**TOTAL FOR DIVERSION CHANNELS**							
10	**Miscellaneous**							
10.1	Install and survey settlement pins	No.	10	10	10	10	10	50
10.2	Install piezometers	No.	4	4	4	4	4	20
10.3	Construct complete downstream monitoring bore stations	No.	5	0	0	0	0	-
10	**TOTAL FOR MISCELLANEOUS**							

7. REFERENCES

1. Knight Piésold Pty Ltd (October 2010) "*Dargues Reef Gold Project, Tailings Storage Facility, Final Design*", Ref. PE801-000139/5 Rev. 0, December 2011.
2. New South Wales Dams Safety Committee (DSC). *"DSC3A – Consequence Categories for Dams"*, June 2010 (updated May 2014).
3. New South Wales Dam Safety Committee (DSC). "*DSC3F – Tailings Dams*", June 2012.
4. Australian National Committee on Large Dams Inc. (ANCOLD). "Guidelines on the Consequence Categories for Dams". October 2012.
5. Knight Piésold Pty Ltd (November 2011) "*Dargues Reef Gold Project, Tailings Storage Facility, Dam Breach Assessment*", Ref. PE801-000139/8.
6. Australian National Committee on Large Dams Inc. (ANCOLD). "Guidelines on Tailings Dams". May 2012.
7. Australian Bureau of Meteorology (BOM). *"Climatic Atlas of Australia"*, 1988.
8. Institute of Engineers Australia (IEAUST). *"Australian Rainfall and Runoff, Volume 1 – A Guide to Flood Estimation"*, May 2003.
9. Australian Bureau of Meteorology (BOM). *"The Estimation of Probable Maximum Precipitation in Australia; Generalised Short-Duration Method (GSDM)"*, June 1993.
10. Australian Bureau of Meteorology (BOM). *"Generalised Southeast Australia Method (GSAM) for Estimating Probable Maximum Precipitation"*, HRD Report No. 4, August 1996.
11. Australian National Committee on Large Dams Inc. (ANCOLD). "Guidelines on Design of Dams for Earthquake". 1998.
12. Swaisgood, J.R. (1998). Seismically-induced deformation of embankment dams. 6th US National Conference on Earthquake Engineering, Seattle, Washington.
13. Pells, S. and Fell, R. (2003). Damage and cracking of embankment dams by earthquake and the implications for internal erosion and piping. Proceedings 21st International Congress on Large Dams, Montreal. ICOLD, Paris Q83–R17, International Commission on Large Dams, Paris.

14. Seed and Idriss. "*Ground Motions and Soil Liquefaction During Earthquakes*", Earthquake Engineering Research Institute, 1982.

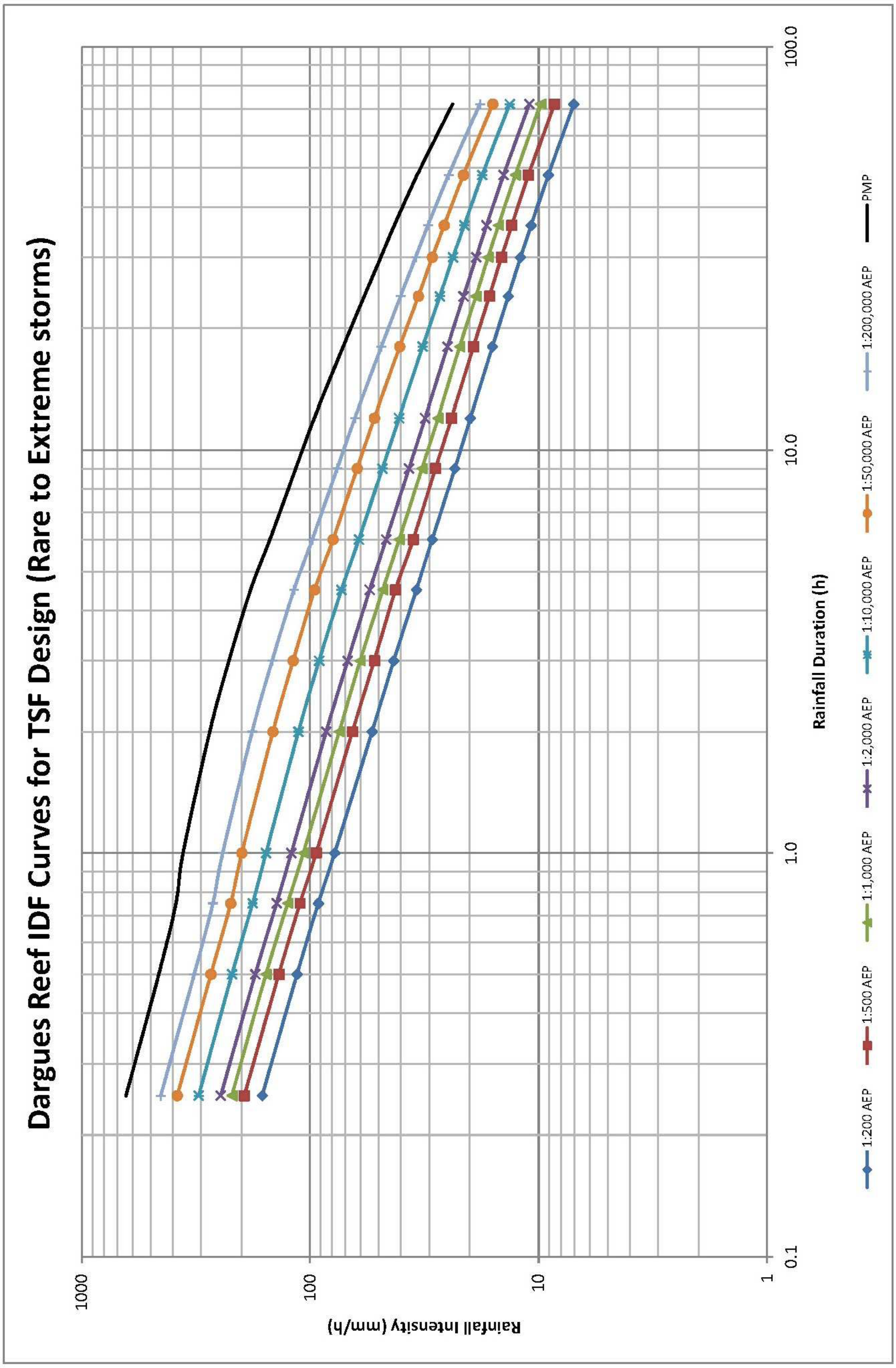
FIGURES



Knight Piésold CONSULTING

DARGUES GOLD PROJECT
RAINFALL INTENSITY DURATION FREQUENCY DATA
FREQUENT TO LARGE STORMS

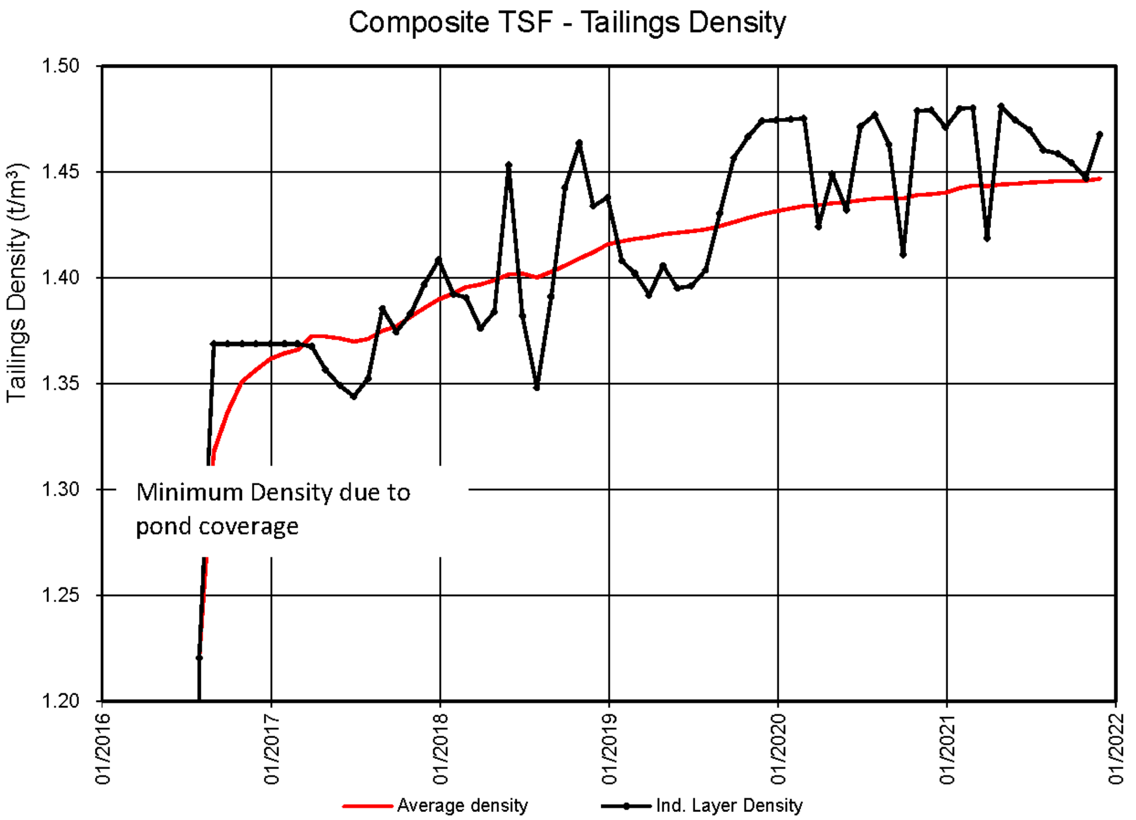
Ref: PE801-00139/10
Figure 4.1

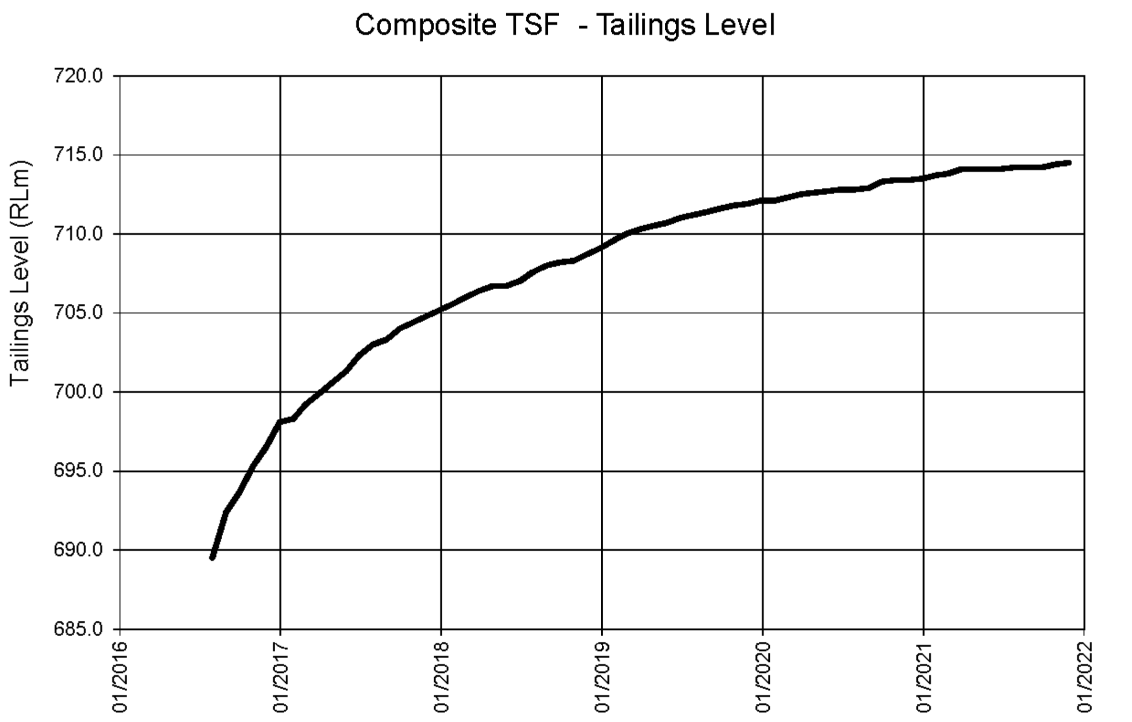


Knight Piésold CONSULTING

DARGUES GOLD PROJECT
RAINFALL INTENSITY DURATION FREQUENCY DATA
RARE TO EXTREME STORMS

Ref: PE801-00139/10
Figure 4.2

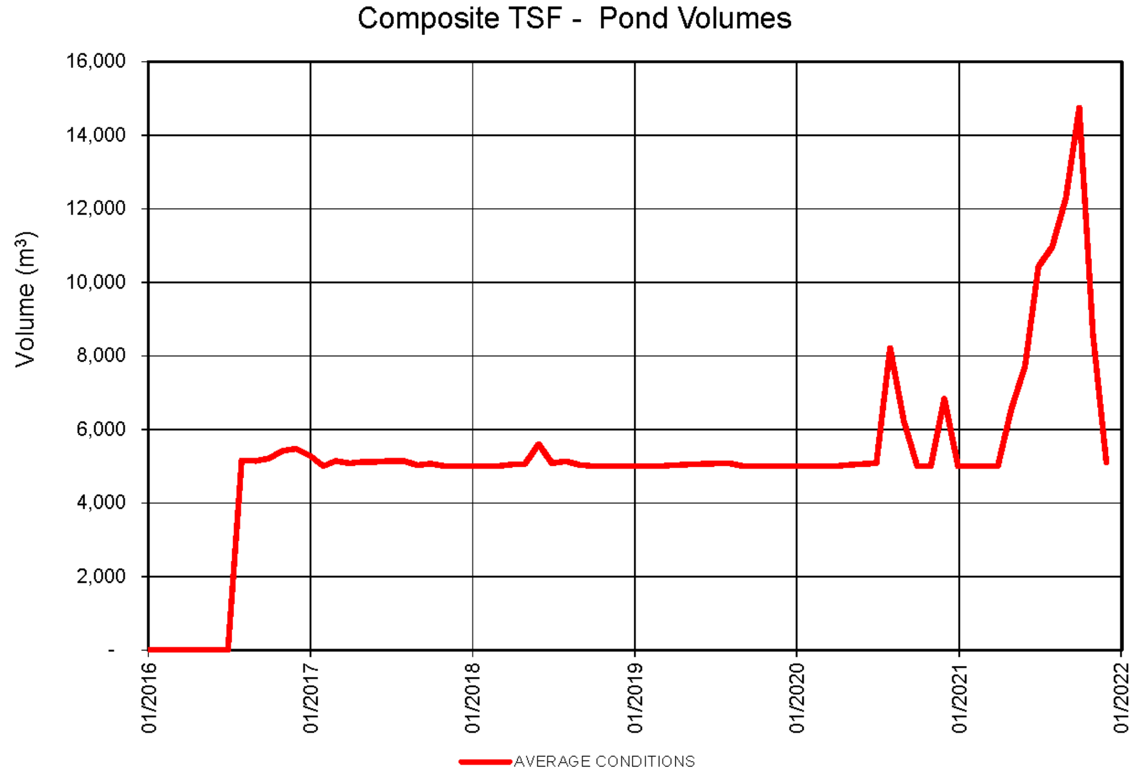


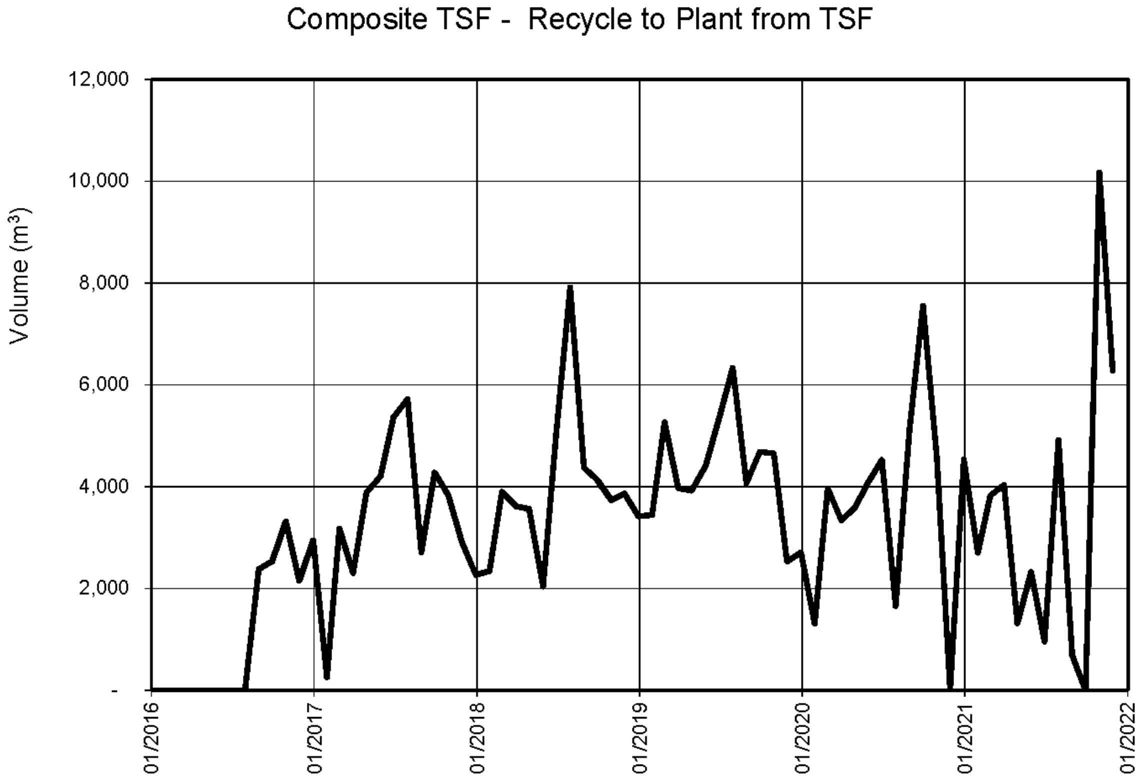


Knight Piésold CONSULTING

DARGUES GOLD PROJECT
COMPOSITE TSF WATER BALANCE
TAILINGS DENSITY AND RATE OF RISE - AVERAGE CONDITIONS

Ref: PE801-139/10
Figure 4.3



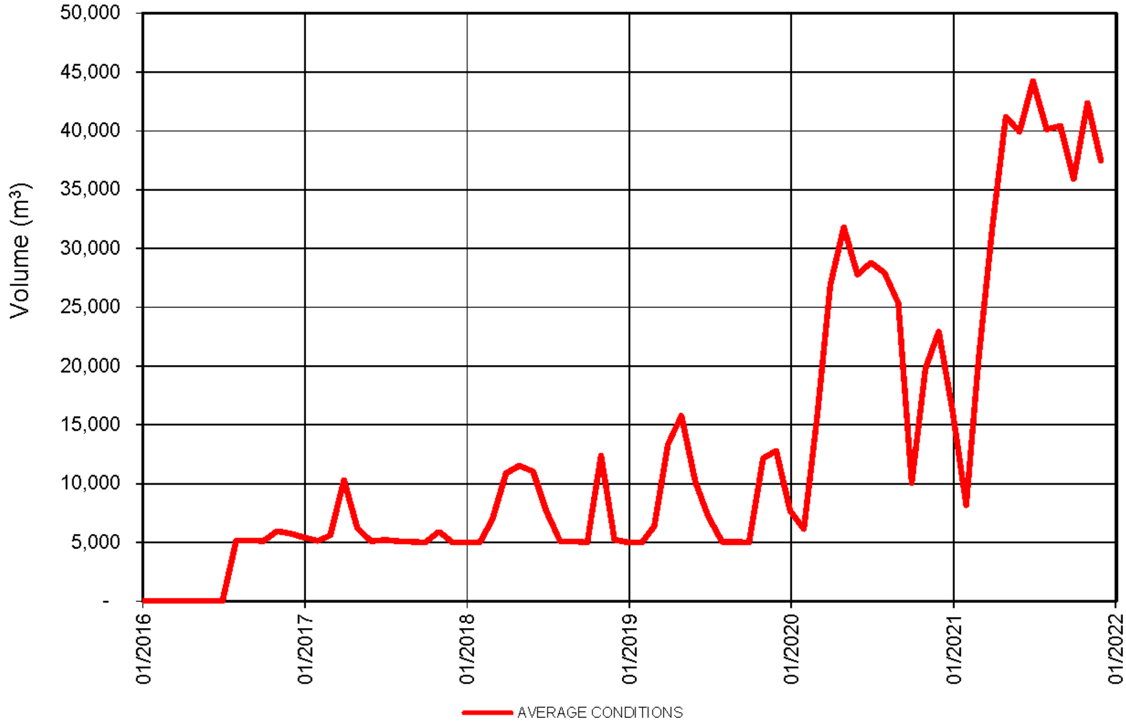


Knight Piésold CONSULTING

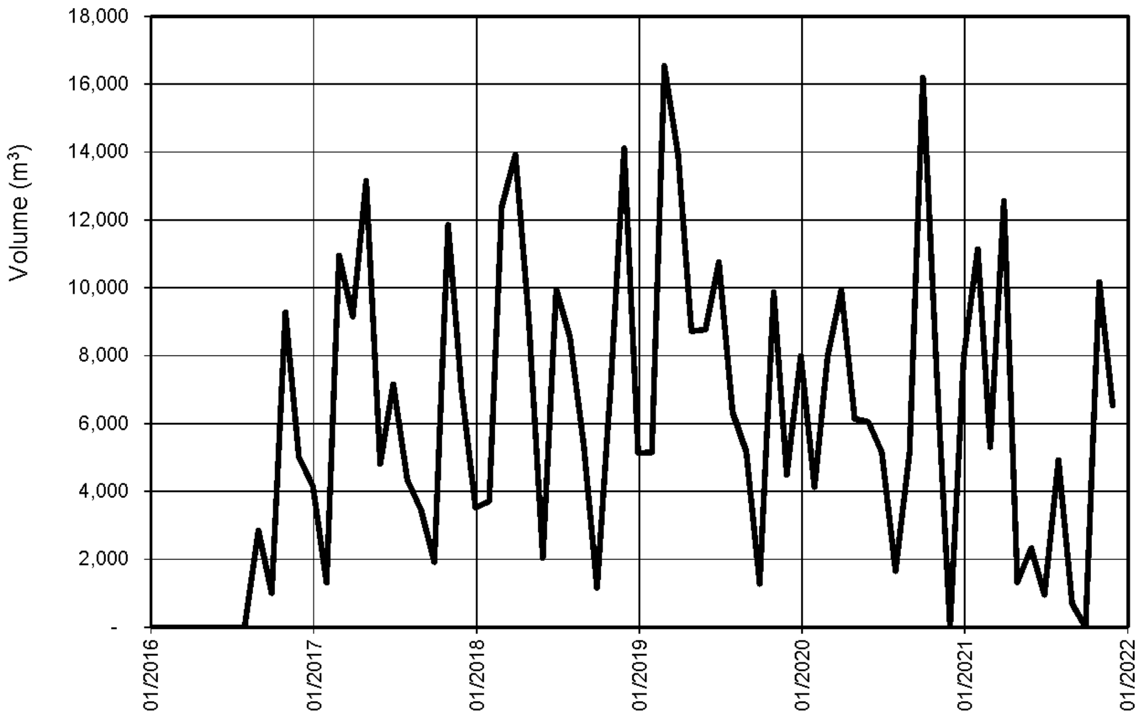
DARGUES GOLD PROJECT
COMPOSITE TSF WATER BALANCE
POND VOLUME AND PLANT RECYCLE - AVERAGE CONDITIONS

Ref: PE801-139/10
Figure 4.4

Composite TSF - Pond Volumes



Composite TSF - Recycle to Plant from TSF



Knight Piésold CONSULTING

DARGUES GOLD PROJECT
COMPOSITE TSF WATER BALANCE
POND VOLUME AND PLANT RECYCLE - 1 IN 100 YEAR (AEP) WET SEQUENCE

Ref: PE801-139/10
Figure 4.5