

Group procedure – D5 – Management of tailings and water storage facilities v1.2

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Direct linkages to other relevant policies, standards, procedures or guidance notes:

- Rio Tinto management system standard
- D5 Tailings and water storage facility management standard
- D3 Management of slope geotechnical hazards standard and group procedure
- E13 Chemically reactive mineral waste control standard
- E14 Land disturbance and rehabilitation control standard
- E11 Water quality protection and water management standard
- Closure standard
- RIS-B-01 Risk management standard
- D7 Functional safety standard
- Rio Tinto study definition guidance notes

Document purpose:

This Group procedure specifies the mandatory requirements for the management of tailings and water storage facilities including associated infrastructure.

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SECTION I - OVERVIEW

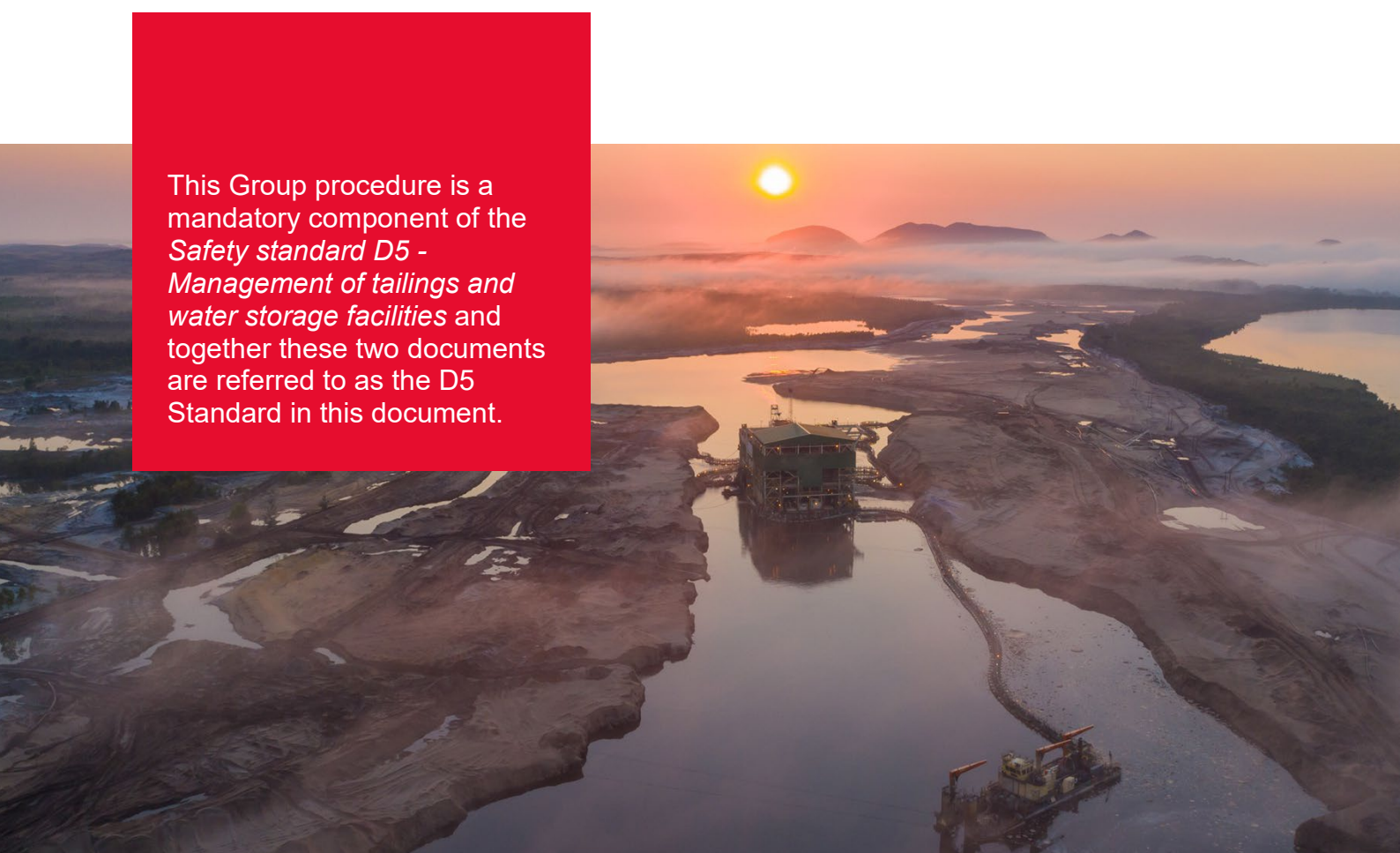
Introduction

This Group procedure is a mandatory component of the *Safety standard D5 - Management of tailings and water storage facilities* and together these two documents are referred to as the D5 Standard in this document. The D5 Standard describes the minimum Rio Tinto requirements for the management of hazards associated with tailings storage facilities (TSFs) and water storage facilities (WSFs). Waste/tailings piles with functionality, material behaviour and hazards similar to TSF are also covered by the D5 Standard.

The intent of the D5 Standard is to provide a framework for the identification, assessment and management of hazards and to minimise risks associated with tailings and water storage facilities in support of Group safety and business performance objectives.

For hazard assessment purposes, Consequence Category levels 1 through 8 for non-financial consequence descriptors presented in Rio Tinto *Risk management standard* for qualitative assessments, inserted as Appendix 1 with this document, are adopted. Consequence classification is undertaken using the Maximum Reasonable Consequence (MRC) approach. MRC is defined as the “largest realistic or credible consequence from an event, considering the credible failure of controls”.

The Health Safety and Environment assurance processes assess business unit conformance to the D5 Standard. Technical details and the adequacy of inputs into TSF and WSF management are not assessed by these processes. The technical details and adequacy are assured through the design peer review process and the independent review requirements set out in the D5 Standard.



This Group procedure is a mandatory component of the *Safety standard D5 - Management of tailings and water storage facilities* and together these two documents are referred to as the D5 Standard in this document.

Scope

The D5 Standard applies to all Rio Tinto projects, business units and managed operations, including new acquisitions, closed and legacy sites. It covers all development phases from planning, design through construction, operation, closure and, post-closure where applicable. Facilities inherited from mergers or acquisitions are required to comply with the D5 Standard within 12 months of acquisition.

TSF comprises:

- the entire impoundment structure including the embankments, internal dikes, surface water diversion dikes, spillways, storage basin, placed tailings (including dry stacks), foundations, drainage and liner systems, and access roads/ramps on the facility;
- the tailings delivery and distribution systems and return water piping and decant structures; and
- TSF monitoring equipment, seepage management system, and collection ponds.

The battery limits for a TSF are the inlet flange of the tailings delivery pumps or tank outlet flange, in the case of gravity discharge, at the process plant and the discharge point of the return water pipe at the process/raw water tanks or ponds or at the point of environmental release. The battery limit for filtered/dry stacked tailings is the filter discharge point. It is acknowledged that battery limits for certain facilities may need to be different to those stated above. In such cases, the operation needs to apply for a variance to the D5 Standard via the HSE variance process described below.

WSF comprises:

- the impoundment and its confining structures including the embankments, abutments, spillways, liner system, monitoring equipment; and
- diversion/drainage dikes, water retaining dikes/levees/land-bridges or coffer dams.

TSF and WSF Hazards

TSF and WSF hazards covered by this D5 Standard are grouped under three broad classes:

1. Uncontrolled release of water/tailings which may have impacts including loss of life, environmental damage, and contamination, caused by uncontrolled subsurface (foundation) seepage beyond design expectations, and/or leakage from a TSF/WSF, tailings or return water pipework, and uncontrolled surface releases either through emergency spillways or the result of facility overtopping. Design/regulated discharge through operational spillways or licenced discharge points is not considered to be an uncontrolled release in this D5 Standard.
2. Embankment failure which may have impacts including loss of life, environmental damage, and direct and indirect economic losses, caused by a TSF/WSF embankment (wall) failure and release of tailings and water.
3. Geotechnical safety hazards associated with construction and operations of TSF/WSF which may have impacts including loss of life or harm to an operator eg a dozer operator working on a dike raise, truck stability on a filtered stack, etc.

These hazards, along with their impact on Rio Tinto reputation and license to operate, must be considered in determining the hazard classification (MRC) for application of the D5 Standard.

Examples of application of this Standard include, but are not limited to:

- planning and design of a TSF/WSF at the project development (PFS or higher) stage;
- construction of a new TSF/WSF;
- operation of an existing TSF/WSF including active and inactive facilities;
- construction and/or operation of internal/separation dikes/buttresses;
- construction and/or operation of water retaining dikes;
- expansion or raising of an existing TSF/WSF;
- an existing TSF/WSF where design is changed for any reason such as modification of storage capacity, realignment of embankment, addition of a stability buttress etc;
- curtailed or partially curtailed facilities;
- closed, under rehabilitation, and facilities in post closure status (including legacy facilities);
- filtered tailings stacks and waste piles with soil-like material behaviour;
- hydropower facilities/dams; and
- closure designs for TSFs and WSFs.

Status of D5 facilities

Status of D5 facilities, for the purpose of D5 Standard, is presented in Table 1.

Table 1: D5 facility status definitions

D5 Status	Definition
Study	Facility in design stage at the level of prefeasibility or higher stage
New Construction	Facility in detailed design stage and/or under construction for initial start-up or re-start-up
Active	Facility being used for deposition/placement of tailings and/or water
Inactive ¹	Facility Active in past but currently not Active with a plan to be Active in future
Closed ^{1,2}	Facility currently not Active with no plans to be Active in future; rehabilitation not commenced
Closed Active ²	Facility is Closed with rehabilitation work underway
Closed Passive ^{1,2}	Facility is Closed with rehabilitation work completed

1 Could be under care and maintenance.

2 May include legacy sites; sites operated and closed by others and acquired by Rio Tinto with legal obligations.

Applicable clauses of the standard

The criteria and application to the D5 standard is presented in Table 2.

Table 2 - Criteria and application to the D5 Standard

Criteria	Application
Studies/projects in prefeasibility or higher stage; including those in construction	Must comply with all applicable clauses of the D5 Standard.
All Active and Inactive TSFs	Must comply with all clauses of the D5 Standard
TSFs of status Closed, Closed Active and Closed Passive with an MRC of level 5 or greater	Must comply with all clauses of the D5 Standard
TSFs of status Closed, Closed Active and Closed Passive with an MRC of level 3 or 4	Must comply at least with clauses 1.1, 1.3, 1.4, 1.5, 1.9, 2.8, 2.9 and 3.3.
WSFs with an MRC of level 5 or greater	Must comply with all but clause 1.4 of the D5 Standard.
WSFs with an MRC of level 3 or 4	Must comply at least with the clauses 1.1, 1.2, 1.8 ¹ , 1.9, 1.14 ^{1,2,3} , 2.7 ² , 2.9, 3.3 ⁴
TSFs of status Closed Passive with an MRC of level 1 or 2 and WSFs with an MRC of level 1 or 2	Not mandatory to comply with the D5 Standard, however, must complete a Risk Assessment to verify MRC at least every two years

1 Could be one report for multiple dams.

2 Rigour depends on complexity of structure and consequences of dam failure.

3 Generic Operations, Maintenance and Surveillance (OMS) manual covering multiple WSFs is acceptable.

4 Site inspection and fit for purpose assessment required.

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Additional considerations

The following must be taken into consideration in the application of the D5 Standard.

1. Where there is a risk of interaction between a TSF/WSF and surface or underground mining (pit excavation, blasting, underground shaft construction etc) this D5 Standard will apply in managing the TSF/WSF risks. The mining risks will be managed by the application of the D1 and D3 safety standards.
2. Closure planning for TSF & WSF's. Closure must be planned and implemented in accordance with the *Rio Tinto Closure standard*. The Design Engineer for TSFs/WSFs must ensure closure is considered in the design of the facility and be documented in the design report. Any modifications to the facility for the purpose of rehabilitation and closure must be endorsed by the Design Engineer.
3. Environmental risks associated with chemical/ geochemical nature of the tailings must be managed by controls in the Environment performance standards, in particular, the *E13 standard – Chemically reactive mineral waste control* and the *E11 standard – Water quality protection and water management*. When chemical/geochemical risks arise due to TSF operational issues, the D5, E11 and E13 standards will apply.
4. Co-disposal in waste dumps and in-pit disposal facilities. These facilities must consider the safety aspects of the *D3 standard – Management of slope geotechnical hazards*.
5. Hydropower and water dams under direct control of an operation are WSFs.

It is acknowledged that due to some special/unique conditions it may not be feasible for a certain operation to comply with a particular clause of this D5 Standard. In such cases, the operation could apply for a variance to particular clauses of the standard via the HSE variance process. The application for the variance must be supported by a justification, risk assessment and a review of alternative options. Guidance on obtaining variance to a standard clause is presented in *Rio Tinto Management System standard*, clause 0.3 – Non-Implementation and Variance.

Additional and potentially more stringent requirements than the D5 Standard must be considered and applied, if required by the location of the facility and the prevailing laws in the area of operation. Technical and operational guidelines are available from relevant NGOs and government agencies and Rio Tinto Legal should be consulted for any advice necessary on local legislative requirements.

Independent review requirements

Three types of independent reviews are required in D5 Standard:

- Independent Design Reviews required by clauses 1.12 and 2.4;
- Independent Technical Review Board (ITRB) required by clause 2.1 (only for applicable facilities); and
- Independent Operational Reviews required by clause 3.3.

An individual retained for one type of review can also be engaged in the other type of reviews ie separate individuals are not required for the three type of reviews. It is preferred that an ITRB member is also engaged in either the detailed design review(s) or the operational review. Such a dual engagement would enhance the effectiveness and efficiency of ITRB.

It is acknowledged that different operations may employ different models for the three types of independent reviews. For example, an operation may organise its ITRB in such a manner that the board, in addition to the ITRB requirements, also fulfils the independent design review requirements. All such models are acceptable as long as the requirements for the three types of independent reviews, as stated in this D5 Standard, are satisfied.

The term “Independent” means not reviewing their own work. The independent reviewer must be an external subject matter specialist who has not been involved in carrying out or directing the work being reviewed. The reviewer must have the required qualifications, training and experience to provide the expertise necessary to carry out the review. Reviewers must be chosen such that their area of expertise is commensurate with the areas of significant risks being reviewed.

The reviewer could be engaged by Rio Tinto on other projects and could be the same person for repeated reviews. Government or regulatory inspectors do not qualify as independent reviewers.

Terms

The definitions for all technical terms within this document are located in the HSE definitions database. The HSE definitions database is found on the Rio Tinto HSE intranet portal page.

SECTION II- PROCESS STEPS

1. Planning

1.1 Appoint accountable D5 Nominated Manager

The general manager responsible for the facility (GM Responsible) must appoint a D5 Nominated Manager to be accountable for the facilities' compliance with the D5 Standard. The D5 Nominated Manager is a site-based role and must have a good understanding of:

- the TSF/WSF including its expected performance, long-term vision and budgetary needs; and
- operational limitations of the design, and be able to recognise when performance limitations unduly impact the safety of the TSF/WSF.

D5 Nominated Manager appointee must formally acknowledge the appointment and ensuing accountabilities and responsibilities of the role by way of a signed acknowledgment letter.

Multiple D5 Nominated Managers may be appointed in large operations with multiple facilities and one D5 Nominated Manager may be assigned to two or more facilities. It is important to ensure that each facility has only one D5 Nominated Manager.

The responsibilities and accountabilities of the D5 Nominated Manager are presented in Appendix 2.

1.2 Qualified Site Representative

The D5 Nominated Manager must assign a Qualified Site Representative (QSR) for managing day-to-day operations of the TSF/WSF. The QSR is a site based role and must be:

- familiar with the requirements of the Operations, Maintenance and Surveillance (OMS), Emergency Risk Plan (ERP), and the site risk register; and
- suitably trained and deemed competent to recognise and identify potential risks associated with the facility such that they can be addressed and corrected in a timely manner.

The responsibilities and accountabilities of QSR are presented in Appendix 2.

1.3 Responsible Dam Engineer

The GM Responsible for the facility or PG-SME¹ is responsible for appointing a Responsible Dam Engineer (RDE) for providing technical support to the D5 Nominated Manager to manage TSF/WSF risks. The RDE must be a civil/geotechnical engineer with demonstrated experience in dam safety and tailings management consistent with hazard classification and complexity of the facility. Facilities with MRC of level 5 or higher must be assigned an RDE. One RDE could be assigned to multiple facilities. The RDE is the champion for implementing the technical requirements of the D5 Standard on site.

The responsibilities and accountabilities of the RDE are presented in Appendix 2.

¹ subject matter experts in dam safety and tailings management based centrally in the product group

1.4 No reliance on TSFs for excess water storage

TSFs must not be used to store or hold excess water during operations or closure. This clause does not preclude the development of supernatant ponds with clarification as the core function. Similarly, ponds for the recycle of process water are allowed, provided they are within the limits defined in the site water balance and the OMS manual.

Where TSFs have a volume of water stored outside the limits defined in the site water balance or OMS (such as due to storm surges and/or upset conditions), a risk assessment must be completed with participation from the Design Engineer to identify the additional risks resulting from excess water storage. In such cases, actions would need to be taken immediately to remove the excess water as soon as practicable. A review of possible alternative water storage options must be included.

In some cases additional water storage may be required to limit sulphide oxidation. In such cases, attempts must be made to limit the volume of stored water and the facility must be designed to safely accommodate the additional water. Where storage of excess water is necessary in above ground TSF due to process commissioning, topography, hydrological and/or geochemical issues, an application via the HSE variance process supported by a justification, risk assessment and a study of alternative options, is required. Variance is required even if the TSF is designed to store excess water, especially under post closure conditions.

1.5 Tailings Management Plan / Water Storage Plan

A Tailings Management Plan (TMP) must be developed and implemented for any project that includes a TSF and any site with operating tailings facility(s). A TMP is not required for a Closed Passive site. The TMP is a site specific plan for all existing and future facilities at the site.

The Water Storage Plan (WSP) must be developed and implemented for operations requiring multiple water storage facilities developed over the life of the operation. The WSP is a site specific plan (each WSF is not required to have a separate WSP) for all existing and future facilities at the site. A site with a single WSF with an MRC of consequence category level 5 or higher is required to have a WSP.

TMP/WSP must be developed in tandem with the Life of Mine plan using production rates and the mining schedule presented therein and must include:

- name, title, and contact information for the D5 roles;
- battery limits with approved variances, if applicable;
- consequence classification for all facilities both with and without business impacts
- list of site processes employed for the management of each facility (reference/list of safe working procedures, Management of Change (MoC), maintenance orders, action management etc);
- comprehensive document map to each facility;
- training requirements;
- planning, resources and capital forecasts for the management of tailings/water in the short term (1 to 2 years), medium term (5 years) and Life of Mine (LoM);
- arrangements/concepts and analyses of viable storage options and high level capital and operating cost estimates;
- lead times and schedules for design, approvals, and construction of new storages (including expansion of existing storages) relative to the estimated time of filling of existing storages;
- range of tailings production data from the mine/ concentration process. This must include the expected ranges of the slurry solids content, tailings yield, particle size distribution and mineralogy. This data forms a fundamental part of the TSF design criteria and the impact of any changes of the data on the design or operation of the TSF must be fully evaluated before implementation;
- key technical risks including risks to achieving the storage schedule to highlight what needs to be tracked and measured;
- closure options, design modifications for closure and identification of closure risks and cost estimates consistent with the relevant estimating guidance for each PG and Group *Closure standard*;
- document control requirements for the TMP; and
- summary of performance against plan over the past year.

The plan must be agreed and signed off by the GM Responsible. WSP is not applicable for hydropower dams.

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1.6 Annual review and update of TMP/WSP

Actual TSF/WSF performance must be compared with the TMP/WSP on an annual basis and the plan(s) must be kept updated. The TMP must be revised when changes to the mine plan indicate a material change in the requirements for TSF storage capacity. Similarly, the WSP must be revised with anticipated changes to mine water storage requirements. Change in key management elements, such as change in D5 nominated personnel, must also trigger an update to the plans.

Changes to the plan must be agreed and signed off by the GM Responsible and the D5 Nominated Manager.

1.7 Site and technology selection

The earlier that tailings hazards and associated uncertainties are identified and reduced, the greater the potential for meeting long-term tailings management objectives. Options evaluations for selecting site and/or technology for deposition/placement of tailings must include multiple account analysis (MAA), which is a structured decision making process that describes how corporate, project, technical, safety, environmental, and socio-economic factors are considered in the assessment process. An assessment of all uncertainties in models (geological, hydrogeological, geochemical, and geomechanical models) must be conducted for all options under consideration.

The risk management process needs to start at the project planning stage, with risk treatment options being considered in attempting to eliminate or reduce the quantity and improve the stability of the waste. The first risk analysis for the viable options should be in the form of potential problem analysis (PPA), which is a systematic method for determining what could go wrong in a plan under development. The PPA is to focus on major hazards and consequences. Controls and mitigation measures are dealt at a higher level in PPA.

Risk assessments to include risk identification, risk analysis, and risk evaluation. Formal risk assessments must consider the availability of sufficient technical data regarding foundation characterisation, hydrology, groundwater, tailings characterisation, climatic conditions including water balance forecasts, embankment construction, results from the slope stability analyses, and other operational constraints. This is needed to clearly understand the risks involved in construction, operation, closure and post-closure phases of the facility. Identification of all credible failure modes is needed to effectively assess dam safety risks.

The multi-disciplinary risk assessment team must include individuals with appropriate technical skills and knowledge of the design and operational limitations of the facility. The risk assessment must take into account the requirements of site closure, rehabilitation and post-closure monitoring that will evolve over the life of the facility.

A dam break study provides the inundation map(s) which is required to determine the potential impact zone(s). This information must be considered in the risk assessment. Consideration must be given when siting a TSF/WSF to ensuring that the potential impacts to any existing or proposed mining operations, communities or the environment are minimised.

Input from independent review also needs to be sought in the options evaluations, MAA and risk assessments.

1.8 Design prepared by suitable qualified and experienced Design Engineer(s)

A Design Engineer must be appointed to develop the TSF and/or WSF designs and must have the following minimum levels of education and experience:

- 15 years direct and continuous experience in the design of TSFs/WSFs and similar level of experience in engagements with construction and operation of TSFs/WSFs;
- post graduate university degree in civil/ geotechnical engineering; and
- registration(s)/ membership of professional associations in their country/state base of operation.

A Design Engineer could be an individual or a company. If a company, the company must nominate a senior engineer to represent the company as the Design Engineer. The nominated individual must satisfy the requirements for Design Engineer listed above and the company should confirm that in writing. A Design Engineer must be selected based on qualifications, capability and relevant experience. Cost should be a secondary criterion. Key responsibilities of Design Engineer are presented in Appendix 2.

The Design Engineer is responsible for coordination of all input into the design of the facilities. The design must be based on data collected to accepted industry standards. The design must be undertaken with due consideration for the closure strategy and post-closure land-use of the facility. The level of site information and data collected must reflect the complexity of the regional geology and the size and level of risk of the proposed facility. Expert studies from the following must be considered:

- process/thickener engineers;
- mechanical pump and pipeline designers;
- geologists;
- geotechnical engineers;
- seismologists;
- hydrogeologists;
- hydrologists/hydraulic engineers;
- environmental and geochemical scientists; and
- dam designers and filtered tailings stack designers, if applicable.

Design Engineer must verify that the facility is designed, constructed and performing in accordance with the design intent, performance indicators, applicable guidelines, standards and legal requirements. Design Engineer must be empowered by the GM Responsible to provide technical direction and must have the authority to escalate major issues to the GM Responsible and where appropriate to the PG and/or Group level. In some jurisdictions the Design Engineer role also serves as the Engineer of Record (EoR) role as defined by the jurisdiction.

For facilities where multiple Design Engineers are involved, the D5 Nominated Manager must designate one Design Engineer as the nominated D5 Design Engineer for the facility. The scope of work for the nominated D5 Design Engineer must include reviewing works completed by others in order to verify that all works completed for the facility are in conformance with the facility's design intent.

1.8.1 Dam break study

A dam break study (DBS) is required for assessing the hazard/consequence class of a facility; identifying the design criteria; and for developing the ERP. DBS needs to estimate the extent and nature of release of tailings and/or water from a "hypothetical" breach of the facility. The failure modes and scenarios considered in DBS need to be "credible" (physically possible) with a sound technical basis. Population at risk (PAR) and potential loss of life (PLL) numbers need to be estimated from the DBS results, where applicable. DBSs undertaken for developing consequence classification and design criteria must be completed for the ultimate/final design height of the facility. DBSs undertaken for ERP need to be completed for the near-term relevant height of the facility.

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1.9 Industry standard design criteria and design bases studies

The design criteria are explicit goals and/or defined targets that the design has to meet/achieve throughout its lifecycle, including closure and post-closure phases. They must be developed in accordance with the mine plan, process flow sheet, license conditions, and other operational requirements. The design criteria must meet all applicable regulatory and permitting obligations and leading practice principles. The design bases lists the key characteristics and parameters that are adopted in the design to achieve the requirements listed in the design criteria. Design considerations, which include items such as scheduling, interaction with other structures, constraints or limitations, borrow sources, etc are also listed with the design basis.

Results from DBS and consequence classification assessment must be used in developing the design criteria – more stringent design criteria for high consequence facilities. The design criteria and design bases must be accepted by the D5 Nominated Manager, PG-SME¹ and independent reviewer(s) prior to commencement of the design. Any changes in the design bases must be subject to a MoC process.

The scope and rigour of geotechnical investigations including field and laboratory testing must be commensurate with the consequence class and complexity of the facility.

Seepage analyses must be completed to support the phreatic surface and pore pressure conditions adopted within the stability analyses. Steady state conditions and where applicable transient conditions should be assessed. Permeability and anisotropy of materials should be selected to reflect in-situ conditions and uncertainty in material properties must be addressed.

For filtered stacks, target moisture contents for safe transport and geotechnical stability must be evaluated. Potential for stack saturation, swell potential, and compaction requirements in the field to ensure material maintains dilative behaviour under full stack height must be considered.

1.9.1 Hydrologic and earthquake design criteria

Hydrological investigations and modelling must consider the risk to the facility of extreme precipitation and/or drought events. A seismic hazard study is required to determine the magnitude and return periods of earthquakes that must be considered in design. The seismic hazard study must consider both probabilistic and deterministic approaches where applicable and select the design criteria that meets jurisdictional requirements and reduces operational and closure risk.

The minimum dam safety design criteria for flood and seismic design for TSFs must not be less than that provided in Table 3. These criteria are intended to prevent failure of the facility resulting in release of the stored contents.

Operational criteria should be adopted for serviceability requirements on the basis of risk assessment. Operational criteria are intended to limit damage so that operations could continue after repairs to the facility. Operating basis earthquake (OBE) is an example of operational criteria. Operational criteria must be set in consultation with the D5 Nominated Manager.

All operating and new TSFs must have the ability to either safely store or release at least a 1:5,000 AEP 72 hr flood through an emergency spillway to protect the dam. The emergency spillway must be designed for a 1:5,000 AEP peak flow developed from critical storm derivation. Operational spillways (different than emergency spillways) must be designed as per the applicable regulatory requirements.

Table 3: Minimum hydrologic and earthquake design criteria for TSFs

Max. Reasonable Consequence (MRC) ¹	Min Annual Exceedance Probability for IDF	Min. Design Basis Earthquake (DBE) Return Period	Min. Design Earthquake / IDF Return Period Post Closure
Consequence category level 7 or 8	1/10,000	10,000 year or MCE	MCE/ PMF
Consequence category level 5 or 6	1/5,000	5,000 year or MCE	MCE / PMF
Consequence category level 3 or 4	1/2,500	2,500 year or MCE	MCE / PMF

Terms:

IDF – inflow design flood for freeboard/emergency spillway design

MCE – maximum credible earthquake

PMF – probable maximum flood

Notes:

1. As per the risk evaluation scheme presented in Appendix 1 for non-financial consequence categories 1 through 8.
2. The annual exceedance probability for floods refers to individual storm events. The requirement for return periods for precipitation over long periods, for example tropical wet seasons, spring thaw/freshets are lower and are usually set by regional regulation.
3. Where the extent of active faults can lead to assessment of a realistic MCE, this value can be used as an upper limit for the DBE.
4. The selection of the probabilistic or deterministic design earthquake must consider the seismic setting and the reliability and applicability of each method.
5. Hydropower facilities in Canada to comply as a minimum with applicable provincial and federal regulations.

The earthquake design criteria provided in Table 3 is for the maximum design earthquake (MDE) or design basis earthquake (DBE) and not for the OBE. OBE is generally expected to cause limited damage/deformations that could be repaired without significantly disrupting operations. OBE must not be less than a 1:250 year event. The hydrologic and earthquake criteria presented in Table 3 is not intended to be applied retroactively. However, risk assessment needs to be completed to verify that the risk with staying with a lower criteria is tolerable.

The minimum dam safety design criteria for WSFs must be determined on the basis of risk. The assessment must include the size of the facility and the incremental consequence of failure. For WSF the IDF must not be less than 1/100 year and the return period for the MDE not less than 1:475 year.

1.9.2 Water balance

A water balance must be developed and maintained for all TSFs and input directly to the site-wide water balance. The TSF water balance must be reconciled against measured performance on a quarterly basis and forecast pond volumes for at least two years and preferably for as long as allowed by the current level of detail in the facility design. Forecasts must be linked with the deposition plan for the facility. At a minimum, the water balance must incorporate the expected and worst case estimates of the following:

- slurry moisture content;
- tailings production;
- long-term average decant pumping capacity;
- statistical data on rainfall and evaporation;
- entrained water; and
- seepage.

Forecasts for rainfall and evaporation for input to the TSF water balance must test a credible range of inputs with variable annual probability of exceedance. The design criteria for the decant facility must be developed to achieve the design TSF water balance.

1.9.3 Stability analyses

Stability analyses must account for undrained behaviour of materials that are contractive and could generate excess pore pressures on shearing. In addition to Effective Stress Analysis (ESA), these materials must always be modelled with the Undrained Strength Analysis (USA) approach (Ladd, 1991)², known as the S_u/p' approach, or equivalent. An accurate estimate of in-situ effective stresses must be made in the application of the US approach to assess the p' term. This includes accurate estimate of pore pressure distribution in the tailings stack especially for underdrain conditions and for under-consolidated tailings.

For construction loading case, pre-construction shear strengths must be used for materials expected to demonstrate undrained behaviour (unconsolidated-undrained loading). Staged construction approach (Ladd, 1991) should be used for staged impoundment/embankment raises.

For rapid unloading case (including rapid removal of water), potential for liquefaction or strength loss in the underlying materials (due to reduction in effective stress) must be considered.

Pseudo-static stability analyses are not appropriate for the determination of seismic stability and shall only be used to estimate the yield coefficient for potential sliding mass displacement calculations such as Bray, 2007³ or Jibson (USGS)⁴. The post seismic stability must be assessed using post seismic strengths, where appropriate.

Shear strength estimates used in the design analyses must be based on site specific field and/or laboratory measurements.

The minimum recommended targets for the factors of safety against instability of TSFs/WSFs are provided in Table 4.

Table 4: Target factors of safety for embankment stability

Loading Condition	Minimum Factor of Safety ¹
Static drained and/or undrained with potential loss of containment	1.5
Static drained and/or undrained with no potential loss of containment. Also during construction of dam raises with no potential for uncontrolled release.	1.3
Rapid drawdown ²	1.2
Post seismic ³ . Also for post-peak ⁴ condition ⁵ .	1.0 - 1.1 ⁶

1 Considering typical standard of care for dam engineering.

2 Water dams and for some TSFs with ponds which could experience rapid drawdown due to high rate decant systems.

3 For design basis earthquake (DBE) and not for operating basis earthquake (OBE). For OBE, higher minimum Factor of Safety (FS) may be needed to limit the damage and keep the facility in serviceable state.

4 Post-peak strength is not necessarily residual strength. Judgement has to be based on realistic expectation of shear strains.

5 This criteria must be treated as a safety net after demonstrating minimum FS of 1.5 with peak undrained strengths.

6 To be related to the confidence in selection of shear strength. 1.0 may be adequate for use with well-considered lower bound results. If the Post seismic FS < 1.1, deformation analysis is required to validate the design.

² Ladd, C.C., "Stability Evaluation during Staged Construction" ASCE Journal of Geotechnical Engineering, Vol. 117, No4, April 1991.

³ Bray, JD 2007, 'Simplified Seismic Slope Displacement Procedures', in 4th International Conference on Earthquake Geotechnical Engineering.

⁴ Randall W. Jibson and Matthew W. Jibson, Slope Performance During an Earthquake, USGS Open-File Report 03-005.

The factor of safety is a means of managing risk due to uncertainty in material behaviour and loading conditions and reflects the consequences of failure. The target factors of safety, if met, are viewed as acceptable practice. Where these targets are not met the operation could apply for a variance via the HSE variance process. Furthermore, where these targets are not met the risk exposure must be managed through further investigations and analyses, supplemented by comprehensive use of the observational method to reduce uncertainty. Justification for the use of lower targets accepted by the D5 Nominated Manager must be clearly stated in the design report. Similarly, difficult ground conditions and high potential consequences of a failure may warrant higher target factors of safety.

Brittle behaviour with sharp and large drop in strength, characteristic of materials susceptible to static liquefaction, must be investigated irrespective of trigger mechanisms. In this exercise, it must be noted that not all contractive materials are susceptible to static liquefaction. Many loose tailings may show contractive undrained behaviour, however, if the behaviour is not brittle accompanied with sharp and large drop in strength, such materials should not be characterised as susceptible to static liquefaction. Where avoidance of materials susceptible to static liquefaction is not viable, stability of the facility must be checked using dual criteria: first with minimum FS of 1.5 using peak undrained strengths and second with minimum FS of 1.1 using post-peak (generally not residual) strengths. Magnitude of shear strains expected within the materials must be considered in estimating the post-peak strengths. Arbitrarily assigning residual shear strengths to all contractive materials is not realistic and should be avoided. Residual shear strengths, by definition, develop after material undergoes very large strains typically following failure.

Results from conventional Factor of Safety (deterministic) approach must be presented and considered for all design cases in the decision-making process. For facilities with MRC of consequence category level 5 or higher (as per the risk evaluation scheme in Appendix 1), deterministic and probabilistic analyses must be completed. Probabilistic analyses shall be completed to add insight into the deterministic analyses, help reduce uncertainty, and assist in selecting effective measures to reduce risk. Probabilistic approaches alone must not be used as stability criteria. For probabilistic analyses, it must be noted that the calculated probability of failure is not equal to the likelihood of failure, which requires other inputs such as likelihood of conditions modelled in the stability analyses. For deterministic approach, sensitivity analyses must be completed especially for high consequence and/or complex ground conditions.

Strain incompatibility issues in limit equilibrium type analyses must be recognised and addressed. Circular and non-circular shear surfaces that could cause significant damage must be investigated – reporting of results from shallow failure surfaces, not expected to cause significant damage, should be avoided.

Care must be taken with over-consolidated soils that become normally consolidated when loaded beyond the pre-consolidation pressures.

Where warranted, more sophisticated Finite Element or Finite Difference methods such as FLAC⁵ should be used with appropriate and well documented input parameters. Such analyses, could be required for:

- investigating potential for static liquefaction by evaluating magnitude of shear strains;
- overcoming strain incompatibility issues in limit equilibrium analyses; and
- estimating post-seismic deformations for Design Basis Earthquake (DBE) and/or Operating Basis Earthquake (OBE) conditions.

⁵ FLAC, Computer program for advance geotechnical analysis of soil and rock. Itasca Consulting Group, Minneapolis, Minnesota.

1.10 Risk identified and addressed in design

The design of facilities must address the risks associated with construction, operation and closure and post-closure. Controls, engineering and operational, required to mitigate the risks must be identified. A constructability assessment and a construction safety review of the design must be completed. The design must consider operator safety, seasonal and extreme weather, the effect of process upsets, seepage, etc. The design must also consider long term ground water impacts and controls.

To identify dam safety risks and associated controls, all credible failure modes need to be considered in accordance with the Failure Modes and Effects Analysis (FMEA) or similar methodology. Rigour needed depends upon complexity of structure and consequences of dam failure.

A performance-based approach includes setting performance objectives, operating in accordance with those objectives, and assessing whether objectives are being met. This approach also provides a basis to predict future performance and make necessary adjustments to improve future performance. Performance objectives need to be developed for the life cycle of the tailings facility and address:

- protection of employees and public health and safety;
- design objectives and criteria;
- mitigation of environmental impacts; and
- closure objectives and post-closure use

A risk-informed approach includes assessing risks (considering both consequences and likelihood of dam failures), and evaluating if the risks are tolerable and managed to an ALARP (as low as reasonably practicable) level, and current risk controls/measures are adequate, and if not, whether alternative risk reduction measures are justified. It provides a means to compare the relative contribution of different failure modes to the dam safety risk of a dam.

Incorporation of higher risk design elements into a TSF/WSF, including perforation of embankments by pipelines, use of geotextiles for critical applications, decant towers etc must include special risk reviews by the Design Engineer to evaluate the safety and cost/benefit of applications over the long term.

Where possible, observational method must be adopted in the geotechnical design. During design of TSFs, geotechnical predictions (deposit densities, beach slopes, etc) are often based on limited knowledge. The observational method is a process of verifying design assumptions and using additional data, knowledge, and lessons learnt to revise, improve and optimise the design. It requires prior identification of practical mitigation measures in the event that observations reveal that they are prudent or necessary. If observed behaviour is better than what was adopted in design, opportunities need to be identified for design optimisation purposes.

The design must consider the operational practices and construction effort that will achieve the final closure landform.

1.11 Life-of-facility design must be documented in a design report

A life-of-facility design, encompassing closure and post-closure phases, for each TSF/WSF is required that sets out the final ultimate design for the facility. For facilities built in stages the life-of-facility design must include the anticipated stages of construction and must be to a level of detail that establishes the technical feasibility, stability and operational requirements for the facility. The TSF life-of-facility designs must be implemented by detailed stage designs. Life-of-facility design and detailed stage designs could be presented in the same or separate reports. WSFs are generally not constructed in stages and hence the life-of-facility design of WSF includes the detailed design.

The design bases including key assumptions and design criteria, including closure aspects, must be clearly set out upfront in the design report. Results from all design basis studies, including field and laboratory investigations, design criteria, risk evaluations etc, must be summarised in the design report.

The design report must include the operational requirements to meet the intent of the design with quantifiable and measurable performance objectives. The design must be based on realistic assumptions as to how the facility will be operated and how the design assumptions would be verified during operations. Facility design must consider closure aspects such as closure strategy, post-closure land use and construction effort required to meet closure requirements. All assumptions, quantifiable performance objectives and requirements for the operation, monitoring and maintenance of the facility must be clearly stated in the design report.

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The design reports must, at least, include the following elements:

- performance-Based, Risk Informed Approach including FMEA or similar;
- geological mapping of footprint;
- field investigations including material strength characterisations;
- all aspects of clause 1.9;
- deposition plan and water management;
- an assessment of seepage and seepage management measures;
- an assessment of tailings consolidation and safe rate of rise;
- detailed stability assessment of all stages of development and closure;
- water balance and pumping requirements for delivery decant pumping;
- operational requirements with quantifiable and measurable performance objectives;
- engineering and/or operational controls required to manage risks;
- design drawings;
- geotechnical and operational monitoring program specifying instruments with threshold values to be included in construction and operations monitoring programs;
- identification of viable borrow sources;
- supporting appendices of foundation investigations, laboratory testing, stability analysis and other evaluations completed;
- closure aspects such as closure strategy, post-closure land use and construction effort required to meet closure requirements along with a discussion of closure considerations included as part of the design process; and
- a summary of assumptions regarding the operating criteria (tailings yields, deposition solids content, tailings grind) and factors that may change during the life of the facility.

1.12 Independent design review of life-of-facility design

The life-of-facility design must be reviewed by independent tailings/dam specialist(s) prior to the implementation of the design. Design reviews must be carried out at different stages of the design process. Last minute reviews must be avoided – deficiencies requiring re-work are hard to fix and can affect schedule and budget. Scope of work for independent design review must include detailed technical review of all aspects of design with special emphasis on design basis analyses including site and material characterisations, water balance, and stability analyses.

Any changes in design and/or rework including those required to support closure activities and final landform design must also be subject to independent design review.

The findings of the review must be addressed and closed and changes made, including those during construction, must be referred back to the reviewer(s) for verification prior to implementation. The reviewer(s) must be recognised in the industry as having the knowledge and experience to carry out the detailed design reviews.

1.13 Application of the Environment (E11, E13, and E14), Functional safety (D7), and Closure standards

E11 – Water quality protection and water management standard: Governs the management of water abstraction, discharge and use to limit the impacts and risks to surrounding water resources, ecosystems and communities. Water management infrastructure is required to safely manage the predicted variability in flows and volumes, and to control the risk of catastrophic failure or release of contaminated water.

E13 – Chemically reactive mineral waste control standard: Governs the management of mineral wastes including tailings which are chemically reactive due to issues such as acid rock drainage, contained salinity or radioactivity. The standard seeks to control geochemical risks through characterization, prediction, design and monitoring. If significant geochemical hazards exist, a four-yearly external review of the mineral waste management program is required.

E14 – Land disturbance control and rehabilitation standard: Governs the management of lands under our control and the rehabilitation of disturbed lands. Facilities should be located and designed to minimise new impacts. New and expanded mineral waste storage facilities (such as tailings impoundments) must also be constructed in a manner that facilitates successful rehabilitation.

D7 – Functional safety standard: All safety critical systems associated with the TSF/WSF must be in conformance with the intent of D7 standard.

Closure standard: Describes specific minimum requirements for closure and post-closure planning for all operations including TSFs and WSFs. The D5 Standard is not intended to modify or supersede the *Closure standard* requirements. Closure planning must be considered during all phases of the facility, with designs being refined throughout the project and operations lifecycle. Closure planning and cost must be included in assessments of tailings storage and/or management options.

1.14 The Operations, Maintenance and Surveillance manual

The Operations, Maintenance and Surveillance (OMS) manual is a live document that describes the means and methods of operating and maintaining the facility. The OMS manual must contain procedures that evaluate the conformance of the facility to the design and the design intent. Requirements for monitoring, inspection and observations must include measurable success criteria. The OMS manual must be reviewed and delivered to the operating team prior to deposition commencing. The OMS manual must at least include:

- deposition plan including water and seepage management principles;
- key requirements from water balance study/plan with associated actions to mitigate where performance deviates from that predicted;
- drawings to show locations of all monitoring instruments, in plan(s) and in sections;
- operational requirements to meet the design intent including frequency and responsibility for inspecting, monitoring, evaluating and reporting TSF/WSF performance;
- monitoring and associated conformance criteria (plan and schedule) for specific quantitative performance objectives (rate of rise, deposition cycles, reclaim pond management, flow meters for seepage collection), especially pore pressure performance;
- trigger Action Response Plan (TARP) including threshold values for all geotechnical monitoring instruments. For piezometers, need two sets of threshold values - Caution and Alert levels. TARP to also include criteria for triggering ERP;
- requirement to survey slopes and footprints to ensure conformance to design and periodic reconnaissance of vicinity area to ensure adequate buffer zones are maintained for public safety, social or environmental reasons;
- timing, scope, and procedure for design verification testing;
- maintenance requirements for civil and mechanical elements of the facility; and
- reference to incident management procedures.

Towards the end of the life of the facility, the OMS manual is to include closure and post-closure monitoring programs.

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A deposition plan must be developed and maintained for all TSFs. The TSF deposition plan must be reconciled against measured performance on a quarterly basis and forecast for at least two years and preferably for as long as allowed by the current level of detail in the facility design.

Changes or operational improvements must be reflected in annual updates or revisions to the OMS manual and the OMS manual must be kept updated with the current design requirements and operational practices.

1.15 Emergency Response Plan (ERP)

The specific section in the site ERP must include the following for TSF/WSF:

- Response plans to triggers identified in the OMS manual related to uncontrolled release of tailings and/or water based on site observations (excessive seepage, cracking, settlement, loss of free board etc) or an extreme event (large rainfall/flood event, large earthquake event etc.).
- Additional operational controls required for recovery period following an extreme event (equipment, pumps, repair material moved to concerned location etc).
- Inundation map that identifies people, property, infrastructure and environment values at risk from a failure of the facility. The inundation map must be determined by a DBS carried out by the Design Engineer. For ERP purposes, the DBS must be completed for the relevant height of the facility.
- Sequence of response, notifications, role specifications and responsibilities of responders, internal and external.
- Details of the escalation of response to site Business Resilience Team (BRT), product group BRT and Corporate BRT. This includes clearly defined roles/responsibilities based on requirements outlined in Element 12 of the Rio Tinto Management System and the *Business Resilience and Recovery Group procedure*.
- A schedule of resources, mobile equipment, stockpiled materials, contact information for local contractors, additional power sources and alternative communication plans to respond to an emergency.
- A community and government notification process with contact information. These must include local residents in the inundation area, police and emergency services, government agencies and departments with control over mining, environment and emergency services.

This information must be updated annually or when triggered by information change. ERP information must be reviewed by all key stakeholders, internal and external.

2. Implementation and operation

2.1 Independent Technical Review Board (ITRB)

Facilities with MRC of consequence category level 6 or higher (as per the risk evaluation scheme in Appendix 1) or those with PLL greater than one must have an Independent Technical Review Board (ITRB) appointed by the GM Responsible. The main purpose of ITRB is to provide senior management with independent, objective, expert commentary, advice; and assistance in identifying, understanding, and managing risks and opportunities associated with tailings facilities. ITRB should meet at regular designated intervals throughout the life cycle of the facility.

Its scope should be high level and broad to cover all aspects of tailings design, management and governance. ITRB should not be engaged to provide normal consulting or design services nor are they expected to undertake formal detailed review of the documents. ITRB must utilise “out of the box” thinking and provide commentary on applicability of leading industry practices and identify key risks and opportunities. Their comments should be in the form of advice and suggestions for senior management to help them make more informed decisions regarding safe management of tailings. ITRB should also advise the site on effectiveness and adequacy of critical control measures.

A minimum of three board members is required to constitute an ITRB; additional members should be included based upon the risk and complexity of the project. The ITRB should comprise a minimum of two internationally recognised independent (external) experts. One Rio Tinto tailings/water dam specialist must be included in the board or be closely associated with the board and must attend all board meetings. To be independent, the Rio Tinto specialist should be engaged from a product group other than the product group of the facility being reviewed. In cases where a Rio Tinto specialist is not included in the board, the ITRB must still be comprised of at least three board members.

The ITRB members must be selected in consultation with the SME in dam safety and tailings management based in product group central or at Group level. One ITRB may cover multiple facilities and individual members from one ITRB may be appointed on boards for other facilities.

ITRB is not mandatory for:

- Closed facilities with no ongoing construction and/or design modifications;
- Closed Passive facilities; or
- Hydropower facilities in Canada that are regulated by the provincial dam safety authorities.

2.2 Detailed design, construction drawings and technical specifications for each stage

Detailed designs must be prepared by the Design Engineer and documented in a design report prior to start of construction. Detailed design must align with the life-of-facility design or formal MoC needs to be carried out to modify the facility design. For TSFs built in stages, each stage (embankment raise) must have a detailed design. Multiple detailed stage/raise designs could be presented in a single design report.

Design of each new stage/raise must be developed or updated based on experience from construction and operation of the previous stage. Detailed stage design must provide the technical basis for the design, technical specifications, including QA/QC requirements, and drawings suitable for construction of the stage/annual raise. Any impact on the current geometry and future height of the facility must be addressed in the detailed stage design.

Detailed design must be based on comprehensive geotechnical investigations including field and laboratory testings. The scope and rigour of geotechnical investigations must be commensurate with the consequence class and complexity of the facility. Detailed design report must include construction requirements including identification and investigation of viable borrow areas and testing and haulage of borrow materials.

Where a TSF is being constructed continuously (ie construction using hydro-cyclones), the detailed design is included in the life-of-facility design report. Hence, separate detailed designs for ongoing stages are not required. In this case the life-of-facility design must meet all of the requirements for detailed design.

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2.3 Meeting design objectives during construction

The Design Engineer must develop technical specifications that outline construction performance acceptance criteria including material selection and construction requirements. Technical specifications must be comprehensive enough to ensure that construction of the facilities comply with the design and design intent.

The technical specifications must include a QA/QC program that clearly sets out the types and frequency of field and laboratory testing. The program must include a clear reporting and response procedure for nonconforming test results including the requirements for retesting, and reworking.

QA/QC and technical specifications must be made available by the Design Engineer before start of construction.

Identification of viable borrow areas, including testing, conditioning and haulage of borrow materials, must be included, where needed, in the construction requirements.

2.4 Independent design review of detailed stage designs

Each detailed stage design, including final closure design, must be reviewed by an independent tailings specialist prior to start of construction. A technical review panel must be engaged if warranted by the level of risk and/or complexity of the facility. All requirements stated under clause 1.12 must also be met for review of detailed stage design. The independent reviewer(s) must evaluate the technical aspects of the design including construction drawings and technical specifications and ensure that the stage designs align with the life-of-facility design.

In some jurisdictions the detailed design report may need to be submitted to regulators for approval, which must be considered within the project schedule.

2.5 Construction conforming to the intent of the approved design

Construction of the facilities must comply with the design and design intent. Significant changes to the scope or deviations of construction from the design must be approved by the Design Engineer and subject to a formal MoC process. A risk assessment must be carried out to determine the impact of the changes, including assessment of the impact of the change on the TMP, facility design, OMS manual and operational strategy. The Design Engineer/EoR must inspect construction periodically and review documentation in order to verify that construction conforms to the intent of the design.

Material changes to the design must be presented for comments to the reviewer for who undertook the independent review of the original design.

2.6 Quality control and quality assurance

Quality control (QC) must involve the actual testing of materials to confirm the facility is constructed in accordance with the technical specifications provided by the Design Engineer.

Quality assurance (QA) must involve a review of the QC data to ensure testing is representative of the earthwork completed and that the design objectives are met. QA must be managed independently of QC and must involve additional testing to verify certain QC results. QA/QC results need to include statistical analysis of the data, log of non-conformances, and any deviations from the approved design.

2.7 Construction supervised by a Construction Supervisor

All stages of TSF construction, including closure modifications, must be supervised by a Construction Supervisor, selected in consultation with the Design Engineer/EoR. The Construction Supervisor must have direct experience in construction supervision and a good understanding of the intent and details of the design to ensure construction is in compliance with the approved design. The Construction Supervisor is responsible for the interpretation and implementation of the technical specifications and must be able to assess site conditions and determine if they are consistent with the design. The responsibilities and accountabilities of Construction Supervisor are presented in Appendix 2.

Where site conditions during construction vary from those identified during site investigations, the Construction Supervisor must consult with the Design Engineer and RDE to identify design modifications, if needed, to meet actual site and material conditions. Procedures must be in place to document new information as it becomes available and as construction progresses (ie from field observations, survey and measurement of performance).

Where a TSF is being constructed continuously using hydro-cyclones, the Construction Supervisor is not required to be continuously present on site. In such cases, quality of construction must be maintained using the QA/QC programs.

A detailed construction report must be prepared for each stage/annual raise of construction of a TSF/WSF by the Construction Supervisor. The construction report must provide all details of the construction including results (with a summary) from the QA/QC program, a pictorial record, records of any changes to the design and associated MoC records and as-built drawings.

The construction report needs to provide input into the design and construction of subsequent stages.

2.8 Updating of OMS manual

The OMS manual must be kept updated during operations. Changes in design, design objectives or operational practices must be reflected promptly in periodic updates or revisions to the OMS manual. TARPs and piezometer threshold values that are implemented in the field must always conform to the design that is currently being implemented.

Drawings, plans and sections, showing locations of all geotechnical instruments must also be kept updated. Updates must include, identification of non-working or unreliable instruments, replacement plan and plan for new/additional instruments.

The OMS must be updated near end of facility operations to include OMS requirements for the closure and post-closure phases.

Use of an outdated OMS manual with outdated TARPs and piezometer threshold values is considered a major non-conformance to the D5 Standard.

2.9 Risk assessment during operations

Formal risk assessments must consider all technical data from the current design and construction of the facility and operational constraints to clearly understand the risks involved in operation of the facility throughout its life cycle, including closure and post-closure phases. The risk assessment team must include individuals with appropriate technical skills and knowledge of the design, construction and operational limitations of the facility. The Design Engineer/EoR must participate in risk assessments. The risk assessment must take into account the requirements of site closure, rehabilitation and post closure monitoring that will evolve over the life of the facility.

Identification of all credible failure modes is needed in accordance with the FMEA or similar methodology to effectively assess dam safety risks. Results from dam break study, including inundation map(s), are required to determine the people at risk and the potential impacts on communities, the environment and infrastructure in the event of a potential failure, for consideration in the risk assessment. FMEA must be reviewed and updated annually.

Risks and controls identified during the site and technology selection and design phase must be considered in the risk assessments conducted during operations and closure. The risk register must include both threats and opportunities and must be reviewed by the independent reviewer during the independent operational reviews.

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2.10 Management of Change (MoC)

A formal MoC process must be carried out where material changes are proposed to the design, construction or operation of the facility including change of consultant. The process must consider potential change in risk due to increased likelihood of impacts on production, long term costs, safety, and/or regulatory non-compliance. Changes accepted must be incorporated in the TMP and other relevant documents such as OMS manual, TARPs, ERP etc. The Nominated Manager is accountable for implementing MoC.

Material changes must be reviewed by the Design Engineer/EoR and RDE. Significant changes include, but are not limited to:

- change in Nominated Manager;
- change in Design Engineer;
- change in the designed geometry of the facility, including during closure and post-closure phases;
- change in the construction / embankment raising methodology;
- change in the designed tailings depositional strategy including during start-up phase;
- change in operational practices including those that can impact size and location of the pond;
- change in monitoring scope and/or practices;
- change in closure design and post-closure land-use; or
- other changes that have a material impact on the performance of the facility.

Change in Design Engineer must incorporate handover of information and due diligence review by the new Design Engineer.

2.11 Trained and competent personnel

Personnel who carry out day-to-day operations of the facilities must be familiar with the OMS manual, ERP, the quantitative performance objectives and the site risk register, with specific focus on the requirements for water management, freeboard and free water pond control and intent of the operational methodology.

The personnel must be trained in the TSF/WSF operating requirements and obtain a level of competency that enables the identification of potential risks associated with the facility. These risks include signs of embankment instability such as slumping, bulging of the embankment toe, piping or internal erosion, seepage, uncontrolled releases, abnormal monitoring results and other issues outside the operating parameters of the facility. D5 Nominated Managers and QSRs must complete D5 training modules 1 and 2 on an annual basis. Trainings must be formally documented and kept up to date.

3. Monitoring

3.1 Monitoring and design verification

Personnel that carry out monitoring, survey and other design verification must be trained and familiar with the quantitative performance objectives contained within the design report and OMS, the interpretation of monitoring data in regards to stability, seepage and TSF/WSF performance. The RDE with support from the QSR must prepare reports of embankment performance at the frequency specified in the OMS, but not longer than annually.

The Design Engineer must inspect operations at least annually and review operational documentation in order to provide written confirmation that operation conforms to the intent of the design. The monitoring reports must be reviewed by the Design Engineer and the Design Engineer must provide written confirmation that the facility is operating within the design constraints. Unusual or unexpected monitoring data must be immediately shared with the Design Engineer and appropriate actions implemented by the D5 Nominated Manager.

For TSFs of Closed, Closed Active and Closed Passive status, a qualified external specialist may be used in lieu of the Design Engineer (where Design Engineer is no longer available) to review monitoring reports and provide written confirmation at least annually that the facility is performing within the design constraints – a site visit may or may not be required. The qualified specialist must have the minimum levels of engineering education and experience required for Design Engineer as listed under clause 1.8.

3.2 All significant incidents and non-conformances investigated, addressed and recorded

All significant incidents must be recorded along with actions assigned to the incident, accountabilities and schedule for mitigation. A significant incident or non-conformance is one that has a material impact or if left untreated would have a material impact on the operation, cost or risk level of the facility.

Significant incidents and non-conformances identified in the monitoring, observations or reviews of the TSF/WSF must be reported to the Design Engineer and RDE for review, investigation and action. The D5 Nominated Manager and the GM Responsible must be immediately informed of each significant incident/non-conformance.

Examples of significant incidents include, but are not limited to:

- appearance of cracks, subsidence, wet spots, surface seepage, bulging, movement, sinkholes, etc;
- damage to monitoring instruments;
- unusual or unexpected monitoring results including reading that have exceeded or are likely to exceed design threshold values;
- loss of beach ie water encroaching towards the embankment;
- significant increases in the size of the decant pond;
- damage to return water system including breakdown of decant pumps; and
- unauthorised construction on or in the vicinity of the TSF/WSF.

3.3 Independent operational reviews

Independent operational reviews must be completed through the facility life cycle, including closure and post-closure phases, to identify physical hazards (as opposed to chemical/geochemical hazards) associated with geotechnical, hydrological, hydrogeological and operational performance of the facility. This requirement is separate to the ITRB requirement outlined under clause 2.1.

The independent reviewer must be an external subject matter specialist in the main area of tailings / water facility risk being reviewed. Facilities with MRC of consequence category level 4 or lower may use a local/regionally recognised specialist while facilities with MRC of consequence category level 5 or higher must use nationally or internationally recognised experts. The reviewer could be engaged by Rio Tinto on other projects and could be the same person for repeated reviews. The independent reviewer(s) must:

- Be able to see “the forest as well as the trees” and pose challenging questions.
- Carry out a detailed review of facilities that, for historical reasons do not have the documentation for their design and construction. The detailed review is only required once for the current state of the facility.
- Provide advice and guidance on technical issues associated with the design, construction, operation and closure of the TSF/WSF.
- Provide independent advice to the business unit and its owners in relation to the current and proposed TSF/WSF and their ability to meet accepted design criteria and operational requirements.
- Complete and sign the Record of Inspection. A pro forma copy of the Record of Inspection is presented in Appendix 3.

An important component of independent operational review is evaluation of effectiveness, which includes an assessment of whether tailings management is achieving the intended results. It considers both the extent to which planned activities have been realised, and the extent to which performance objectives have been achieved.

Independent operational review must be able to ensure that the GM Responsible and D5 Nominated manager have an independent opinion regarding:

- risks and how risks are being managed;
- the performance of the tailings facility; and
- implementation of the tailings management system and OMS activities.

Government or regulatory inspectors do not qualify as independent reviewers. Independent operational reviews must be carried out at a frequency of not less than once every two years and more frequently for high consequence facilities. All material findings of the review must be reported along with action plans and schedules for implementation. The review report must be provided to the GM Responsible for the facility with significant findings communicated to the business unit managing director.

For TSFs of Closed, Closed Active and Closed Passive status, the reviewer may be the qualified specialist responsible for the monitoring and design verification reviews required under clause 3.1. The frequency of these reviews should be risk based with a minimum frequency of once every three years.

For WSFs with MRC of consequence category level 3 or lower, the review must comprise a site inspection and a fit for purpose assessment.

The TMP/WSP and FMEA updates must be reviewed as part of the independent operational reviews. The review report must be made available for review by the Group level tailings team.

For hydropower facilities in Canada, independent operational reviews must be carried out at a frequency of not more than once every five years, unless findings from the last independent review or 2nd line assurance activity indicate that they should be undertaken more frequently.

Title	Date released	Authorised by	Page
Group procedure – D5 – Management of tailings and water storage facilities v1.2		Stephen McIntosh	Page 26 of 32

Revision history

Version No.	Effective Date	Prepared by	Reviewed by	Authorised by	Comments
1.0	July 2015	Bruce Brown	BU & T&I geotechnical practitioners	Kevin McLeish	Initial release
1.0	August 2015	Bruce Brown	BU & T&I geotechnical practitioners	Kevin McLeish	Review requirements for historic sites. Design criteria for WSF
1.0	December, 2015	Bruce Brown	Final review for release	Joanne Farrell	Minor changes and format editing
1.1	April, 2017	Bruce Brown, Imran Gillani	Tailings Committee	Stephen McIntosh	Significant changes to the requirements for Class II WSFs
1.2	1 January, 2021	Imran Gillani and Tailings Working Group (TWG)	Marnie Pascoe	Stephen McIntosh	Adopted Consequence Category levels 1 through 8 from Rio Tinto <i>Risk management standard</i> ; added requirement for ITRB

Appendix 1 – Consequence Category levels 1 through 8 for non-financial consequence descriptors (hyperlink to Rio Tinto risk management scheme)

[RIS-B-001 Risk Management Standard, Appendix 1: Rio Tinto Risk Evaluation Scheme- Table 2: Qualitative consequences – Core](#)

Appendix 2 – D5 Nominated Roles, accountabilities and responsibilities

GM Responsible – The general manager responsible for the facility. Must have adequate understanding of the complexity and hazard classification of the facility.

Responsible for:

- Appointing D5 Nominated Manager who is accountable for implementation of the D5 Standard.
- Allocating sufficient time and resources for the D5 Nominated Manager to comply with his/her responsibilities/ accountabilities listed in the D5 Standard.
- Assigning authority to the Responsible Dam Engineer to conduct his/her function on site.

Accountable for:

- Owning risks associated with the TSF/WSF.
- Ensuring site has access to SME² support.
- Allocating technical and financial resources for management of the TSF/WSF according to the D5 Standard.
- Appointing Design Engineer/EoR, independent reviewers and review board members in collaboration with SME².
- Appointing or assigning a Responsible Dam Engineer in consultation with SME² and D5 Nominated Manager.
- Development of Tailings Management Plan (TMP) and/or Water Storage Plan (WSP).

D5 Nominated Manager ¹

Responsible for:

- Appointing Qualified Site Representative.
- Selecting Design Engineer/EoR and developing design criteria in collaboration with SME².
- Arranging development and up-keeping of all documents required by the D5 Standard.
- Actively managing all TSF/WSF risks.
- Reporting on the health of the TSFs/WSFs by responding to the D5 quarterly questionnaire.

Accountable for:

- Conformance to the D5 Standard.
- Completion of risk assessments.
- Implementing construction activities.
- Implementing Management of Change.
- Training and maintaining competencies of operating and maintaining staff.
- Arranging independent operational reviews.
- Reporting and adequately closing all D5 related incidents.

Qualified Site Representative (QSR) ¹

Responsible for:

- Managing day-to-day operations of the TSF/WSF.
- Operating/managing the facility in accordance with the design intent.
- Keeping D5 Nominated Manager informed of the performance of the TSF/WSF.
- Reporting on all D5 related incidents.

Accountable for:

- Arranging collection, evaluation and reporting of monitoring data as per the OMS² manual.

Responsible Dam Engineer (RDE) ³

Responsible for:

- Providing technical support to the D5 Nominated Manager to manage TSF/WSF risks.
- Assist D5 Nominated Manager with conformance to the D5 Standard.
- Facilitating/leading design activities such as planning, options evaluations, design criteria, risk assessments and hazard classification.
- Technical evaluation of D5 incidents, including action plan and incident classification.

Accountable for:

- Technical management of independent reviews.
- Deliver technical capacity on site for effective implementation of D5 Standard.

Design Engineer (DE)

Responsible for:

- Prepared design and its impact on the overall facility design.
- Design of the facility for start-up, operations, closure and post-closure.
- Providing design services for the facility including design report, construction drawings and technical specification(s).
- Participating in risk assessments.
- Responding to independent design reviews and significant incident reports.
- Certifying compliance of construction with design intent.
- Reviewing facility monitoring data, responding to abnormal issues and providing written confirmation that the facility is being operated in accordance with the design intent.
- Reviewing and endorsement of any facility modifications in support of rehabilitation and closure.

Construction Supervisor ⁴

Responsible for:

- Ensuring that the construction of the facility meets the full intent of the design.
- Interpretation and implementation of technical specifications.
- Referring changes in site conditions to the Design Engineer.
- Preparing construction report including QA/QC results.

Accountable for:

- Implementing quality assurance and quality control procedures.

Independent reviewer(s)⁵ – Independent specialist who has specific industry recognised expertise relevant to the significant risks being reviewed.

Responsible for:

- Reviewing design/construction reports.
 - Carry out independent operational reviews.
 - Reviewing risk assessments.
 - Signing Record of Inspection.
 - Verifying that detailed staged design(s) are aligned with the life-of-facility design.
 - Escalating major issues to GM Responsible if his/her concerns are not addressed in a timely manner.
-

Notes:

1 The D5 Nominated Manager and the QSR can be the same person.

2 SME – Subject matter experts in dam safety and tailings management based in product group central or at Group level.

3 RDE, D5 Nominated Manager, and/or QSR could be the same person. One RDE could service multiple sites/facilities

4 In staged/incremental construction/raising of TSFs, QSR could take on the role of Construction Supervisor.

5 Could be the same person for repeated reviews.

Appendix 3 – Record of inspection

Review and sign-off on tailings and water storage facilities

Record of inspection

At the request of Rio Tinto site XX I/we(insert name, occupation and organisation of the assessment team) carried out independent review of tailings and water storage facilities at Site XX on(insert date). The facilities inspected are as follows:

Number	Facility name	Description of facility

The scope of the inspection covered a review of design, construction, operational, management and monitoring issues (including compliance with local regulatory requirements and currently accepted engineering and environmental practices).

Except as noted below there were no issues identified as a Class III or IV risk that could:

- affect the integrity of the facility;
- impact upon human health and safety or the surrounding environment;
- affect the continued operation of the facility;
- be in non-compliance with local and national regulations; or
- be outside evolving relevant industry accepted practices.

Class IV Risks ¹

Number	Facility name	Description of facility

Class III Risks ¹

Number	Facility name	Description of facility

A number of Class II and Class I risks were also identified. These are described in the associated report titled(insert report title).

In view of the nature of the hazards and risks, it is recommended that the next inspection of the facilities be held in months time²

Signed:

Date:

¹ It is a Rio Tinto requirement that these issues be reported in the biannual HSEC reporting process.

² Time not to exceed 24 months from the date of the current inspection.