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Zemeljska dela - 7. del: Hidravlična namestitev mineralnih odpadkov

Earthworks - Part 7: Hydraulic placement of extractive waste

Erdarbeiten - Teil 7: Hydraulische Einbringung von mineralischen Abfällen

Terrassements - Partie 7 : Placement hydrauliques de déchets miniers

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Earthworks - Part 7: Hydraulic placement of extractive waste

Terrassements - Partie 7 : Placement hydrauliques de déchets miniers

Erdarbeiten - Teil 7: Hydraulische Einbringung von mineralischen Abfällen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 16907-7:2019) has been prepared by Technical Committee CEN/TC 396 “Earthworks”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document is one of the European Standards within the framework series of EN 16907 on *Earthworks.* The set of standards prepared by CEN/TC 396 is divided into several parts, which correspond to different steps of the planning, execution and control of earthworks and should be considered collectively as a group of standards for executing earthworks. The full set of Parts is as follows:

— EN 16907-1, Earthworks — Part 1: Principles and general rules (this document);

— EN 16907-2, Earthworks — Part 2: Classification of materials;

— EN 16907-3, Earthworks — Part 3: Construction procedures;

— EN 16907-4, Earthworks — Part 4: Soil treatment with lime and/or hydraulic binders;

— EN 16907-5, Earthworks — Part 5: Quality control;

— EN 16907-6, Earthworks — Part 6: Land reclamation earthworks using dredged hydraulic fill;

— EN 16907-7, Earthworks — Part 7: Hydraulic placement of waste.

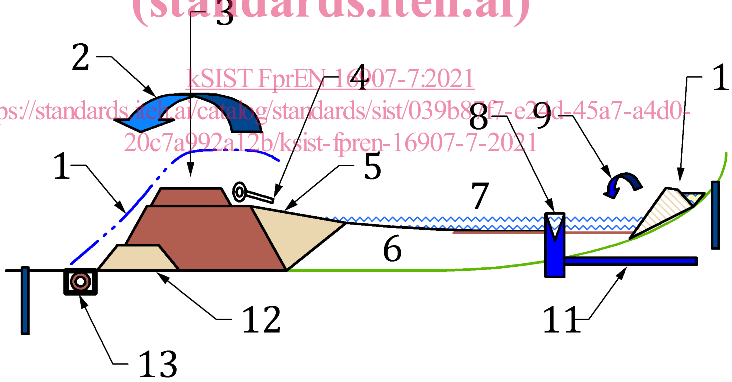
Within this standard references to specific parts of the standard are written by reference the full reference (e.g. “EN 16907-2”).

These “Earthworks standards” do not apply to the environmental planning and geotechnical design that determines the required form and properties of the earth-structure that is to be constructed. They apply to the design of the earthworks materials, execution, monitoring and checking of earthworks construction processes to ensure that the completed earth-structure satisfies the geotechnical design.

Introduction

European Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from the extractive industries states that that the preparation of a waste management plan is required for certain mine waste facilities (MWFs). One of the objectives of the waste management plan is to ensure both short- and long-term safe disposal of the extractive waste by choosing a design which achieves geotechnical and geochemical stability of any hydraulic fill placed above a pre-existing ground surface. By inference this requires that suitable features are incorporated into the design, construction, operation and maintenance, closure and after-closure of a MWF to prevent major accidents and to limit any adverse consequences for human health and/or the environment. This Standard addresses all technical stages of the development of a hydraulic fill project in the context of the Extractive Waste Directive (EWD), with an emphasis on waste and facility characterization and on earthworks procedures.

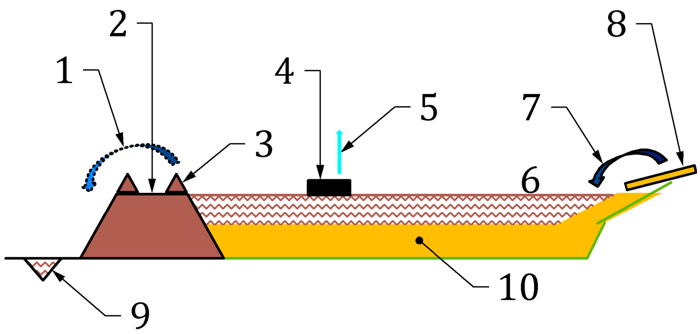
All sectors of the extractive industry are likely to produce a residue which, during mineral processing, will have been physically, and sometimes chemically, altered due to both the comminution and concentration processes employed. These residues (tailings) comprise fine particulate materials which are generally discharged from the process plant in slurry form as a hydraulic fill, noting that coarse particles are generally neither transported nor deposited by hydraulic means. Such extractive wastes, regardless of their consistency and general characteristics, need to be placed in a secure containment facility unless they are to be immediately recycled. The aggregates and industrial minerals sectors tend to refer to these facilities as “silt lagoons”, the energy sector as “ash lagoons” and the metal mining industry as “tailings management facilities”. Within this standard, all three are referred to as mine waste facilities (MWFs) Figure 1 and Figure 2.



Key

1	Seepage recycle	8	Process water / Excess runoff via decant
2	Emergency spillway	9	Plant site runoff
3	Confining embankment	10	Diversion system
4	Tailings discharge pipeline	11	Return pipeline to process plant
5	Tailings beach	12	Seepage control drain
6	Slimes	13	Seepage return pump
7	Reservoir		

Figure 1 — Typical section - tailings management facility



Key

1	Emergency overflow	6	Lagoon
2	Homogenous earthfill confining embankment	7	Site runoff
3	Edge protection	8	Silt discharge pipeline
4	Floating pump lagoon level control system	9	Drainage control channel
5	Return to clean water lagoon	10	Unconsolitaded silt deposit

Figure 2 — Typical section — silt lagoon

When deposited using hydraulic filling techniques, the MWF for such fine particulate wastes comprises an engineered facility impounding or containing both the extractive waste and a proportion of free water derived from processing operations, from other site waters and from rainfall. This process requires the design and construction of a dam, confining embankment or other structure serving to contain, retain, confine or otherwise support such wastes on surface in a terrestrial environment together with the appurtenant infrastructure.

Numerous techniques are available for the execution, operation and rehabilitation of a MWF, some of which are standardized and have a long history of application to the extractive industry. It is therefore recognized that no standard can prescribe or recommend specific engineering or environmental elements of the design of a complex hydraulic fill structure such as a MWF, which is site-specific and determined by the climate, geology, topography, hydrology, seismology and environmental setting. However, of importance is that hydraulic placement of extractive waste can only be managed properly if sufficient knowledge of its geochemical, physical and geotechnical properties and behaviour is available. Such knowledge may be obtained through detailed characterization of the waste and of the waste facility and its subsequent consequence classification. The different regional situations in geology and climate result in national differences in the earthwork procedures and therefore this standard identifies the principles and systems for the execution, operation and rehabilitation of a MWF as they relate to earthworks.

This document is part of a European Standard on Earthworks, it having been decided by CEN/TC 396 to establish a stand-alone document on the hydraulic placement of extractive wastes as it relates to earthworks. This document provides geotechnical and geochemical standards necessary to meet the requirements of Directive 2006/21/EC, presents a unified approach for all stakeholders involved in the development of hydraulic fill projects and a framework for project initiation and implementation.

This document is generic in content, and much of the text is synoptic as it is recognized that the range of extractive operations is broad and that the precise characteristics of each waste and its depositional properties will be dependent on the geology, the extraction and mineral processing techniques adopted, and on the type and location of the MWF. For more detail, reference is made to the *The hydraulic transport and storage of extractive waste, Guidelines to European Practice (Cambridge, 2018).*

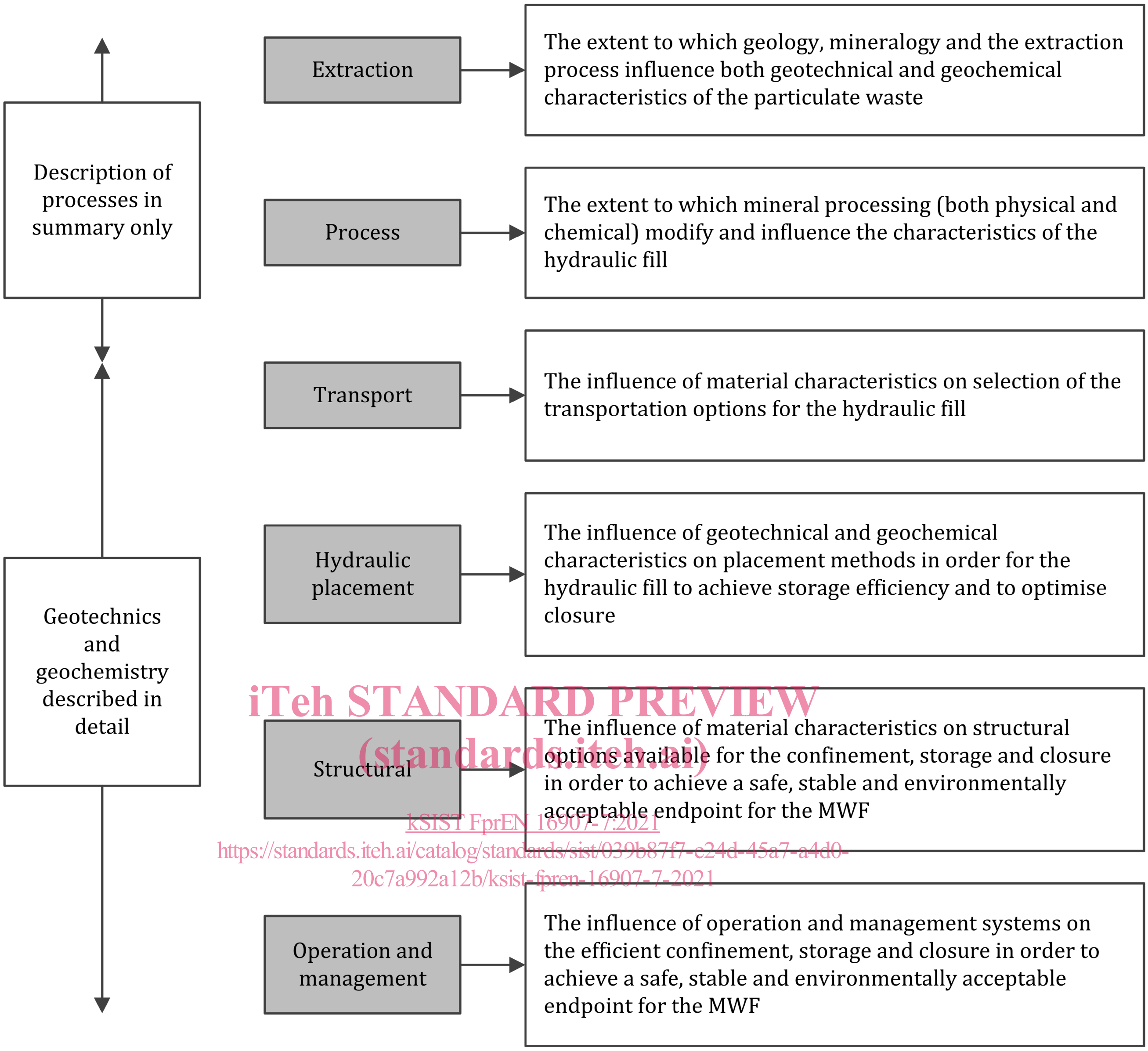


Figure 3 — Stages of hydraulic placement covered by this document

1 Scope

This document gives recommendations for the hydraulic placement of extractive wastes and may be applicable to the following:

— all stakeholders engaged in the deposition of mineral wastes using hydraulic placement techniques with respect to geotechnical and geochemical aspects of the investigation, engineering design, construction and operation of a mine waste facility and all subsequent monitoring activities;

— those extractive industries involving the production of fine particulate wastes which, in the course of industrial processing, require to be stored in a safe, stable and environmentally acceptable location;

— practitioners in non-extractive industries in fields where similar techniques may be applicable and for which no other European guidance exists.

The scope of this document includes all aspects of a dam, confining embankment or other structure serving to contain, retain, confine or otherwise support such wastes on surface in a terrestrial environment. The overall framework for the standard and for each stage of a hydraulic fill project is shown in Figure 3. This standard therefore addresses the characterization of the extractive waste for the purposes of hydraulic placement in the MWF both as part of the confining embankment and for safe storage and, in addition:

— specifies minimum requirements for the data to be acquired before the design and execution stage of a hydraulic fill project;

— provides guidelines for the selection of the type of confining embankment appropriate for the selected site;

— provides guidelines for the selection and characterization of the construction materials;

— establishes general principles on how to design and execute the hydraulic fill project from pre-deposition through operation to closure and rehabilitation;

— provides guidelines for monitoring and quality control of all stages of the hydraulic fill project to ensure long-term safety and stability.

This document considers how to store safely a given material resulting from a preceding process. It does not define, establish or specify detailed elements of the design of a hydraulic fill project but provides overall guidelines in order to comply with good regulatory and engineering practice. he document recognizes that similar techniques may be applicable to the hydraulic placement of materials in the non-extractive industries where no other European guidance exists, but notes that it is not applicable to landfill, dredging or the hydraulic filling aspects related to grouting.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 17892 (series), *Geotechnical investigation and testing — Laboratory testing of soil*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE For further information, see Directive 2006/21/EC.

3.1
confining embankment
engineered dam constructed from both natural and processed geotechnical materials to retain in safety the fine-grained materials (tailings) derived from a mineral-processing plant, together with excess process water and natural runoff

3.2
decant
engineered structure designed to facilitate recycling of process water and, as appropriate, to discharge natural runoff

Note 1 to entry: This structure may comprise a tower, a floating/static pump or gravity overflow system

3.3
emergency spillway

engineered structure designed to pass in safety an extreme flood event without endangering the stability of the confining embankment

3.4
hydraulic fill
particulate solids, for example tailings, which are transported and placed via suspension in a fluid matrix

3.5
hydraulic fill system
reticulation and deposition pipework and infrastructure necessary to transport and to deposit the hydraulic fill as part of the mine waste facility

3.6
independent
free from any personal interest in the planning, design and operation of the mine waste facility and, in particular, from family and financial interests in the outcome of a related inspection

Note 1 to entry: Payment for inspection services is not to be considered as an impairment to independence

3.7
inspection
activity which entails checking and monitoring of an MWF and its compliance with design and performance criteria in order to confirm that identified objectives have been met

3.8
regulatory inspection
activity which entails checking and confirming compliance with relevant legislation (e.g. local, national or international regulations or permit conditions) and/or monitoring impacts to determine whether further action is required in order to secure such compliance (e.g. with safety, stability or environmental provisions)

Note 1 to entry: Regulatory inspections may be carried out by any designated responsible public authority or may be delegated, under its supervision, to independent experts acting on its behalf

3.9
technical inspection
activity which entails checking and confirming compliance with design criteria (e.g. geotechnical, corporate, managerial, safety, or environmental) and/or monitoring performance to determine whether further action is required to secure such compliance

Note 1 to entry: Technical inspections may be carried out by any suitably qualified "competent expert" who is designated responsible by a public authority or by the owner/operator of a facility

3.10
mine waste facility
engineered structure which, together with all necessary appurtenant works, is designed to retain or confine in safety the extractive waste resulting from industrial processing of naturally-occurring soil, ore or rock and to store and recycle, where appropriate, process and flood waters

Note 1 to entry: These facilities are known by the quarries/industrial minerals sector as "silt lagoons", by the energy sector as "ash lagoons" and by the metal mining industry as "tailings management facilities"

3.11
mineral Processing
mechanical, physical, biological, thermal or chemical process or combination of processes carried out on a mineral resource with the purpose of extracting the economic mineral

Note 1 to entry: This may involve size change, classification, separation and leaching, and the re-processing of previously discarded waste, but excluding smelting, thermal manufacturing processes (other than the burning of limestone) and metallurgical processes

3.12
monitoring
systematic surveillance of the mine waste facility including all associated operations such as geochemical and geotechnical characterisation, physical measurements, instrumentation readings, together with their processing, analysis and interpretation

3.13
risk assessment
overall process of risk identification, risk analysis and risk evaluation, including the identification of all potential hazards and the risk of occurrence

3.14
risk management
engineering design, operation and closure to achieve the agreed level of risk mitigation

3.15
risk mitigation
process of reducing risk and consequence through risk management procedures in order to reduce the probability and/or negative consequences of occurrence to the highest acceptable rate of death, injury or damage

3.16
tailings
extractive waste that remains after mineral processing by separation processes (e.g. crushing, grinding, size-sorting, flotation and other physico-chemical techniques) to remove the economic minerals from the less valuable rock

3.17
tailings dam
see 3.10

3.18
Tailings Management Facility
TMF
see 3.10

4 Abbreviations

ABA	Acid Base Accounting
ARD	Acid Rock Drainage
BFS	Bankable Feasibility Study
BAT	Best Available Techniques
CQA	Construction Quality Assurance
EWD	Extractive Waste Directive (see also MWD)
ICOLD	International Commission On Large Dams
IIE	Independent Inspecting Engineer
MWF	Mine Waste Facility (see also TMF)
MWP	Mine Waste Plan
MOD	Metres above Ordance (National) Datum
O&M	Operation and Maintenance (see also OMS)
OMS	Operation, Maintenance and Surveillance
PMF	Probable Maximum Flood
TMF	Tailings Management Facility (see also MWF)

5 Development of hydraulic placement projects

This section describes the derivation and sources of the hydraulic fill and the subsequent placement of such extractive wastes in surface MWFs as exemplified in the flow sheet Figure 4.

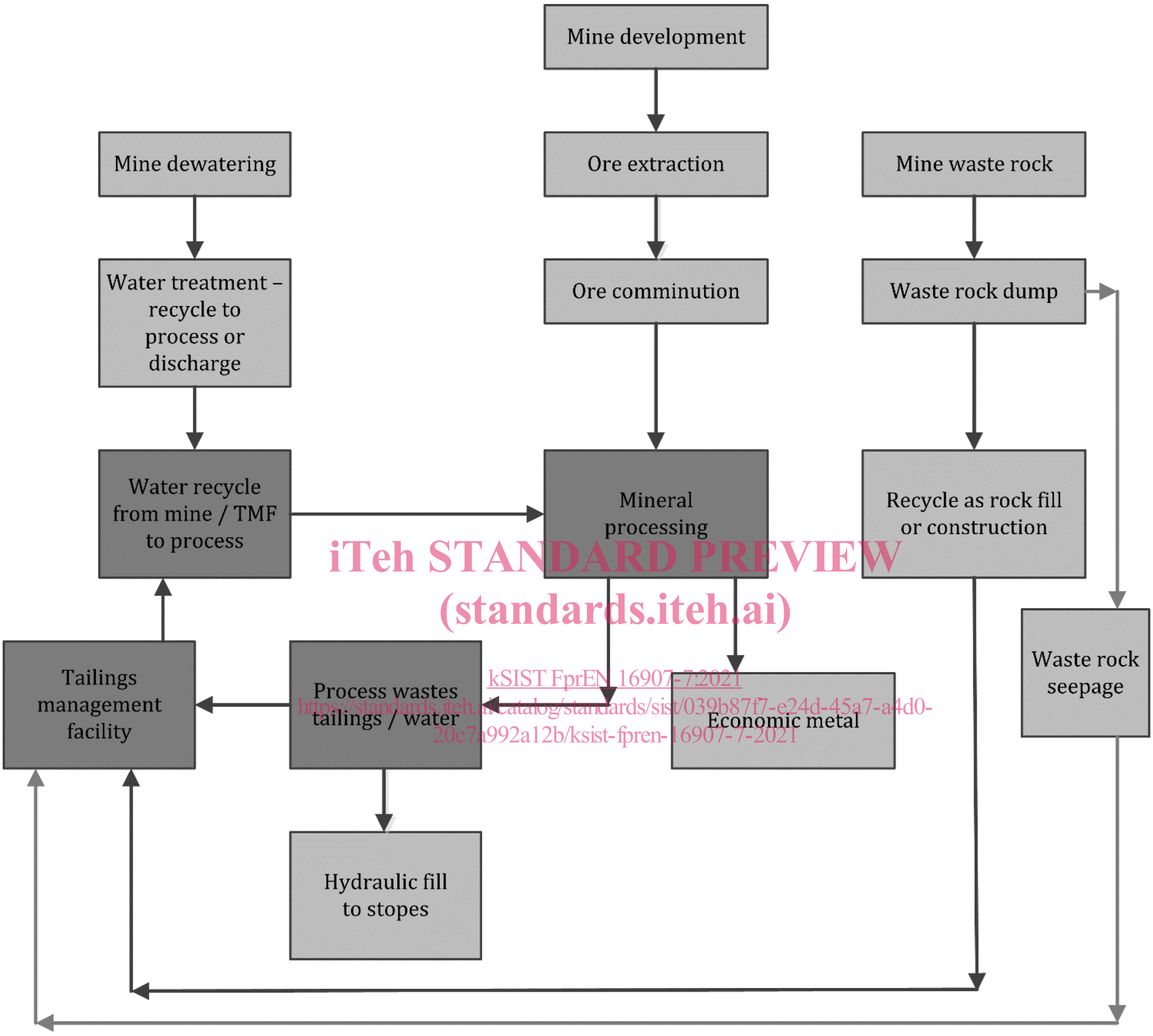


Figure 4 — Typical hydraulic fill flow sheet for a mining project

All sectors of the extractive industry are likely to produce a residue which, during mineral processing, will have been physically, and sometimes chemically, altered due to both the comminution and concentration processes employed. These residues (tailings) comprise fine particulate materials which are generally discharged from the process plant in slurry form as a hydraulic fill. Such extractive wastes, regardless of their consistency and general characteristics, need to be placed in a secure containment facility unless they are to be immediately recycled. In most cases the resulting waste product would not be stable unless confined within an engineered impoundment area, i.e. a reservoir or lagoon developed behind a confining embankment. As the terminology implies, the industrial processes, both mineral processing and placement, generally involve significant volumes of water as a transportation medium. This water, by virtue of its contact with the waste, constitutes an integral part of the hydraulic filling process. The efficiency and economics of the industrial process, environmental requirements and the site water balance will normally require that water used to transport the solid fraction be recycled and reused in subsequent mineral processing. As a result the MWF normally includes provision not only for containment of the hydraulically transported fill but also for the effective sedimentation of the particulate waste and the decanting and return of the excess water to the mineral processing plant for reuse.

The effective storage of the hydraulic fill and the efficient recycling of the resulting water requires the appropriate design, operation and management of the mineral processing and residue storage system to achieve long-term safe, stable and sustainable storage in a MWF. The options for transport from the mineral processing plant and for placement and deposition in a stable MWF are numerous, but the principal drivers are the long-term goal of safe, stable and efficient storage to an agreed sustainable end point and are common to all such projects where good practice is applied.

The principal objective is to deposit the extractive wastes by hydraulic placement in a custom-built MWF. The MWF may vary in area from less than 10,000m² to several square kilometres and in height from a few metres for an aggregate silt lagoon to over 100m for a tailings management facility for a large and complex polymetallic mining operation. Typical sections through a tailings management facility and a silt lagoon are shown in Figures 1 and 2 and provide an indication of the key features of such MWFs. It is noted that, depending on the setting, not all of the features shown may be required.

The particulate residue resulting from mineral processing is usually pumped or fed under gravity in slurry form from the mineral processing plant to the MWF. The consistency of the slurry will vary from project to project dependent on the geological origin of the ore, its geotechnical characteristics, the industrial processing, the configuration of the storage basin and the geographical setting. The slurry may take the form of a thin pulp with solids concentrations as low as 5 %, as for many silt lagoons, or be thickened to 70 % or 80 % solids and be deposited as a “paste-type” hydraulic fill. The purpose of the MWF is thus twofold:

— to provide a cost-effective and environmentally appropriate means of storing the waste and of recycling the process water;

— to provide safe storage of the waste such that at closure the MWF will remain geotechnically and geochemically stable, effectively in perpetuity.