BEST PRACTICE GUIDELINES FOR WATER RESOURCE PROTECTION IN THE SOUTH AFRICAN MINING INDUSTRY
BPG A4: POLLUTION CONTROL DAMS (PCDs)
Structure of BPG A4

- Chapter 1 - Introduction to guideline
- Chapter 2, 3 - Principles, objectives and key considerations
- Chapter 4 - Philosophy of water management for PCDs
- Chapter 5 - Legal framework
- Chapter 6 - Design of PCDs
- Chapter 7 - Construction of PCDs
- Chapter 8 - Operation of PCDs
- Chapter 9 - Closure of PCDs
- Chapter 10 - Practical considerations
Introduction

Purpose of PCDs:
- Minimise the impact of polluted water on the water resource
- Minimise polluted area as far as possible, by separating clean and dirty catchments,
- Capture and retain the dirty water contribution to the PCDs that can not be discharged,
- Manage dirty water through recycling, reuse, evaporation and/or treatment and authorised discharge.
General Principles

- PCDs must comply with the legal and regulatory conditions in South Africa.
- Worst-case conservative assumptions must be made in instances where the quality of water to be contained within the PCD cannot be established with certainty.
- PCDs are to be sited, sized and operated to maximise the opportunities for water reuse and reclamation and to minimise the impacts on the water resource.
- Designs should adhere to the generally accepted principles of sustainable development and Best Practical Environmental Option (BPEO).
- Technical studies and design of PCDs should be undertaken by suitably qualified personnel.
- Designs should adopt a holistic approach, including sustainability, full life cycle of the PCD, water quantity and quality, and surface water and groundwater.
Objectives of BPG A4

- To provide guidance on water management best practice for PCDs
- To provide information on the procedures for the specification and design of PCDs
- To provide guidance on planning, operations and closure of PCDs and integration into the overall mine water management system
- To ensure that potential impacts on safety and the water resource are acceptable/managed over the life of the PCD, and
- To provide guidance on appropriate tools for the design and management of PCDs, to complement those that are covered in other BPGs.
Typical lined PCD
<table>
<thead>
<tr>
<th>Type</th>
<th>Primary function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process water/return water dam</td>
<td>Temporary storage of dirty water within the process water system</td>
<td>Operate at level to accommodate dirty water inflow; divert clean stormwater; return dirty water to process water system</td>
</tr>
<tr>
<td>Stormwater dams</td>
<td>Retention of dirty stormwater runoff</td>
<td>Operate empty or at level to accommodate stormwater inflow; dynamically manage water quality; return or discharge</td>
</tr>
<tr>
<td>Evaporation dams</td>
<td>Storage and evaporation of dirty water</td>
<td>Operate at level to accommodate dirty water inflow; water generally not reused</td>
</tr>
</tbody>
</table>

Generally not considered best practice to use natural storage areas as PCDs, unless this approach is justified through appropriate studies.
Legal framework (Appendix A)

National Water Act, 1998: Water use authorisation required,

GN 704: Regulations on use of water for mining and related activities, aimed at protection of the water resource,

Dam Safety Regulations: PCDs require a safety classification and “permit to construct”

NEMA, 1998: EIA for the construction of a PCD,

MPRDA, 2002: EIA and EMP (or amendment)
Design of PCDs

- Design is site-specific
- Design to address some or all of:
  - Geotechnical assessment and design (GD)
  - Hydrogeology (HG)
  - Dam water balance (WB)
  - Hydrology and stormwater (HS)
- Steps in design process:
  - Preliminary input
  - Conceptualisation and planning
  - On-site investigations
  - Design
Design: Preliminary input

- Legal compliance
- Data gathering and desk study (background information, reports, maps, etc.)
Design: Conceptualisation and planning

**Geotechnical and Design (GD)**
- GD1: Identify site options
- GD2: Prepare conceptual layouts
- GD3: Undertake trade-off study and site selection

**Hydrogeology (HG)**
- HG1: Undertake hydrocensus
- HG2: Identify groundwater impacts

**Water Balance (WB)**
- WB1: Prepare preliminary model
- WB2: Identify surface water impacts

**Hydrology and Stormwater (HS)**
- HS1: Delineate catchments
- HS2: Undertake hydrological calculations

Prepare Planning report
### Design: On-site investigations

<table>
<thead>
<tr>
<th>Geotechnical and Design (GD)</th>
<th>Hydrogeology (HG)</th>
<th>Water Balance (WB)</th>
<th>Hydrology and Stormwater (HS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD4: Geotechnical investigations</td>
<td>HG3: Borehole siting</td>
<td>HG4: Borehole drilling and testing</td>
<td></td>
</tr>
</tbody>
</table>

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**On-site investigations Section 6.3**
Design aspects

- Stability analysis
- Spillway design (ICOLD and SANCOLD)
  - Recommended design flood (RDF): Must be accommodated with required freeboard
  - Safety Evaluation flood (SEF): Must be accommodated without failure
### Design aspects

<table>
<thead>
<tr>
<th>Dam size</th>
<th>Hazard rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Small</td>
<td>RDF 20 to 50 year</td>
</tr>
<tr>
<td>(5 m to 12 m high)</td>
<td>SEF 100 year</td>
</tr>
<tr>
<td>Medium</td>
<td>RDF 100 year</td>
</tr>
<tr>
<td>(12 m to 30 m high)</td>
<td>SEF 200 year</td>
</tr>
<tr>
<td>Large</td>
<td>RDF 200 year</td>
</tr>
<tr>
<td>(&gt; 30 m)</td>
<td>SEF RMF</td>
</tr>
</tbody>
</table>

**Diagram:**
- Spillway level
- Flood buffer zone
- Normal operating zone
- Free board
Design aspects

PCD liner system:
- Natural geological liner
- Engineered liner:
  - Clay liner,
  - Geosynthetic clay liner (GCL)
  - Geomembrane liner
  - Combination

Under-drainage and seepage control

Pumps and pipework

Sediment management
Liner for hazardous waste lagoon

- 2mm GEOMEMBRANE
- 600mm COMPACTED CLAY LINER (IN 4X150mm LAYERS)
- GEOTEXTILE
- 150mm LEAKAGE DETECTION AND COLLECTION LAYER
- 100mm PROTECTIVE SOIL LAYER
- 1mm GEOMEMBRANE
- 300mm COMPACTED CLAY LINER (IN 2X150mm LAYERS)
- 150mm BASE PREPARATION LAYER
- IN SITU SOIL
Double module silt trap

DOUBLE MODULE SILT TRAPS

INLET CHANNEL

OVERFLOW

DOUBLE MODULE LINED RETURN WATER DAM
Construction of PCDs

Contractual aspects:
- Owner-designed and built
- Owner-contractor
- Owner/consultant/contractor
- Turnkey

Specifications:
- SABS 1200 AD: General (small dams) (1986)
- SABS 1200 GA: Concrete (small works) 1982)
- SABS 1200 HA: Structural Steelwork (sundry items) (1990)
- SABS 1200 L: Medium-pressure Pipelines (1983)
Construction of PCDs

- Planning and programming of the works
- Quality assurance and quality control
- Role of Approved Professional Person (APP):
  - Category I dam: Not required
  - Category II and III dams: Sign-off on construction quality
Construction of PCDs

Role of professional engineer:

- Assist the owner in the selection of a contractor (if required)
- Assist in drafting an agreement with appropriate conditions of contract
- Explain and clarify the responsibilities of each of the parties involved
- Instruct the parties on key technical issues in the construction of small earthfill dams
- Quality control and quality assurance during construction
- Preparation and submittal of the “As-built” drawings, as part of the authorisation process
Operation of PCDs

Routine inspections (Appendix B):
- The full length of the wall crest and toe
- Observation of upstream and downstream slopes
- Spillway crest and downstream spillway channel
- Pumps stations and pipelines
- Control and instrumentation,
- Outlet works,
- Functioning of the liner system and sediment control systems, and
- The area downstream of the dam wall

More frequent inspections at first filling of dam and when dam spills strongly
Operation of PCDs

& Operations Manual (Appendix B):
– Background details of the dam
– Applicable design and water balance details
– Operating rules for the PCD:
  • Required minimum dam storage level
  • Pumping rates for the withdrawal of water
  • Maximum allowable inflows (evaporation dams)
– Details of the monitoring undertaken to ensure that the operating rules for the PCDs are met
– Emergency procedures for upset conditions (Appendix C).
Operation of PCDs

- Update Operations Manual on regular basis

- Update prompts:
  - Changes in the PCD water balance and/or the overall mine water balance
  - Sedimentation within the PCD and loss in dam capacity
  - A significant change in the mining infrastructure, e.g. greater areas are paved
  - A change in the water quality reporting to the PCD
  - Changes in the water use authorisation conditions
Closure of PCDs

Final land use and role of PCD: 3 options:

– Demolish the PCD wall and return the area back to free-draining
– Keep the PCD for beneficial long-term use such as:
  • A farm dam or water supply dam for the local communities, or
  • Use of the PCD for pollution control measures
– Provide an in-situ cap for the PCD
Closure of PCDs

PCD closure objectives:

– Based on post-closure role

– Should address:

  • Land use/land capability requirements for the area
  • Final shaping and surface drainage of the PCD area
  • Soil clean-up and safe disposal
  • Likely long-term water quality impacts and objectives
  • Re-vegetation and the sustaining of this
  • Long-term dam safety and stability (should the PCD have a beneficial post-closure use)
Closure of PCDs: Design considerations

Demolish PCD:

- Safe disposal of impounded contaminated water
- Decontamination of embankment material (including rip-rap and spillway material)
- Removal and safe disposal of liner material
- Assessment and possible soil clean-up underneath the liner system
- Reinstatement of drainage patterns, including the breaching and shaping of embankments, silt/sediment traps and routing channels
- Disposal of demolition waste and salvage of equipment (pumps, pipelines, etc.).
Closure of PCDs: Design considerations

Long-term beneficial use:

– Residual contamination:
  • Liner system
  • Rip rap
  • Soils below the liner system
– Long-term stability of dam embankments,
– Spillways checks
– Attention to aspects that could pose a safety risk:
  • Upslope silt traps,
  • Gangways to outlet control structures
  • Disused pipework and associated structures, etc
Closure of PCDs: Design considerations

In-situ cap:

- See BPG A2: Mine residue deposits
Closure of PCDs

- Closure risk assessment
- Rehabilitation and closure plan
- Financial provisions for closure
- Post-closure phase:
  - After-care and maintenance
  - Long-term monitoring plan
  - Financial arrangements and contractual agreements
Practical considerations

Appendix D:
- Dam failure issues
- Observations from good and poor planning,
- Examples of dam failures

Case study