Eskom	Specification	Technology

Title	**Kriel Power Station: Raw Water Reservoir Assessment and Remediation of Liner**	Unique Identifier	**EAP0543**
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CONTENTS

Page

FIGURES

1. INTRODUCTION

Kriel Power Station is located approximately 16km south-west of the town Kriel in Mpumalanga. The circular raw water reservoir is positioned 350m north of the main power station building. Raw water is pumped from Jericho Dam and stored in the raw water reservoir for supply to the power station.

The scope of work is to clean, conduct detail assessments and execution of remedial works to bring Kriel Power Station Raw Water Dam compartments' (East & West) back to original design.

Figure 1 Raw Water Reservoir Location

For a category II dam in terms of sub-regulation 32 (1) (d) GNR 139 REGARDING THE SAFETY OF DAMS IN TERMS OF SECTION 123(1) OF THE NATIONAL WATER ACT of 1998, remedial works need to be approved and under supervision of an Approved Professional Person. The scope therefore includes the appointment of an Approved Professional Person to approve and supervise the design and execution of remediation works.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers the minimum technical requirements for the Civil engineering scope of the *works*. The scope of work includes the following:

- Investigation into the origin of continuous inflow of water into drainage collection sumps and ponding water.
- Emptying/Cleaning of the remaining sludge and water of the Dam,
- Conduct detailed assessment of condition of lining system of both compartments of the RWR and produce detailed assessment report of findings,

- Remedial actions to bring the RWR back to its original design under the supervision of an APP,
- Make recommendations of alternative remedial actions should it not be possible to reinstate the dam as per the original design,
- Ensure adequate engagement with the relevant authorities should the item above be required.

2.1.1 Purpose

The purpose of this document is to outline the minimum scope of work for the detailed assessment and remediation of the RWR at Kriel PS.

2.1.2 Applicability

This document applies to Kriel Power Station only.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ISO 9001 Quality Management Systems.

[2] National Environmental Management Act (NEMA) 107 of 1998

[3] Construction Regulations, 2014

[4] 32-727 - Eskom Safety, Health, Environment and Quality (SHEQ) Policy

[5] Occupational Health and Safety Act No. 85 of 1993

[6] 32-520 - Occupational Health and Safety Risk Assessment Procedure

[7] 32-95 - Environmental, Occupational Health and Safety Incident Management Procedure

[8] National Water Act GNR 139 REGARDING THE SAFETY OF DAMS IN TERMS OF SECTION 123(1) OF THE NATIONAL WATER ACT of 1998

[9] 0.45/7284 KEY PLAN, SETTING OUT, ACESS ROUTES, GENERAL

[10] 0.45/3795 RAW WATER RESERVOIR – GENERAL ARRANGEMENT & DETAIL

[11] 0.45/7290 RAW WATER RESERVOIR ANCILLIARY WORKS

[12] 0.45/7285 RAW WATER RESERVOIR – GENERAL ARRANGEMENT & DETAILS

[13] 0.45/11897 RAW WATER RESERVOIR – UNDERLINING DRAIN CONNECTION TO PUMP HOUSE 1

[14] 0.45/30839 RAW WATER RESERVOIR – LINING FIXING DETAIL

[15] 0.45/30840 REPAIR OF WESTERN HALF SUBSOIL DRAINAGE LAYOUT & DETAIL

[16] 0.45/7841 RAW WATER SUPPLY RESERVOIR & PUMPING PLANT SITE LAYOUT

[17] 0.45/7290 RAW WATER RESERVOIR ANCILLARY WORKS

[18] KRIEL POWER STATION, RAW WATER RESERVOIR, EAST COMPARTMENT – Aquatan

[19] KRIEL POWER STATION - ESKOM - REPAIR OF RAW WATER DAM LINER – EASTERN SECTION – Pascoe Waste and Environmental Consulting CC

[20] Dam safety inspection report of the raw water dams at kriel power station March 1991

[21] Aquatan – HI-DRAIN Rev4

[22] Aquatan – HI-DRILINE HDPE SMOOTH Rev2

[23] EAP0571 - Kriel Power Station - Raw Water Reservoir - Dam Safety Inspection Report - November 2019

[24] EAP0564 - Kriel Power Station - Factual Geotechnical Investigation Report - October 2019

2.2.2 Informative

[25] EAP0064 - Maintenance Execution Strategy for Civil & Structures

[26] 240-144332407 Standard for Eskom Power Stations Concrete Remedial Work

[27] Reduced 01 MYD-GPS KHH2283 Kriel Power Station Dam Safety - Rev0

[28] Reduced 02 MYD-GPS KHH2283 Kriel Power Station Dam Safety - Rev0

2.3 DEFINITIONS

2.3.1 Disclosure Classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
APP	Approved Professional Person
CBR	California Bearing Ratio
CoE	Centre of Excellence
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
DSO	Dam Safety Office
HDPE	High Density Poly Ethylene
QA	Quality Assurance
OHS	Occupational Health and Safety
PS	Power Station
QC	Quality Control
QCP	Quality Control Plan
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System

Abbreviation	Description
SANS	South African National Standards

2.5 ROLES AND RESPONSIBILITIES

Roles and responsibilities are as follows. The Contractor ensures:

- All relevant Eskom design standards, procedures and guidelines have been adhered to;
- All relevant norms, guidelines and governing national and international standards are adhered to;
- Review all relevant existing site information inclusive of existing geological and geotechnical data;
- The Works are performed as described in this document;
- A detailed method statement is compiled for the execution the works is compiled for the Employers Engineer's approval;
- Submission of a detailed programme of the works for the Employer to accept.
- Submission of a detailed QCP for the Employers Engineer to accept. The Contractor is to notify the Employer about any upcoming intervention points at least 48 hours in advance. It is up to the Employer to make a representative available for these intervention points.
- All products proposed by the Contractor are submitted to the Employers Engineer for acceptance.
- All site instructions are recorded in a site instruction book and signed off by the Employers Project Coordinator after each instruction.
- Record of all works is kept in a daily diary which is signed off by the Project Coordinator on the weekly basis. If there is a need, the duration of sign off intervals may be reduced.
- All construction works are performed in accordance to SANS 1200. It is on the onus of the Contractor to perform any testing that is required in accordance to SANS 1200. All test results must be submitted to the Employers Engineer for acceptance. It is the responsibility of the contractor to ensure that the constructed works meet the technical requirements.

2.6 PROCESS FOR MONITORING

An accepted detailed programme of the works, to allow for monitoring of tasks and to align the completion of activities.

An accepted detailed QCP will be used to monitor the quality of the works in accordance to the interventions on the document.

2.7 RELATED/SUPPORTING DOCUMENTS

N/A

3. SCOPE OF WORKS

The scope of work includes cleaning, assessment, and remedial actions to the raw water reservoir's liner, subsoil drainage system, founding and embankment layers. The remedial actions will either reinstate the original design or provide alternate remediation's should

reinstatement of the original design not be possible. Should “new designs” be implemented then necessary engagement with authorities will be needed (i.e. DEA/DWS/DSO).

Due to the need for raw water for operations at Kriel P/S, assessment and remedial works can only occur on one compartment at a time. The compartment will need to be fully reinstated and operable before works can commence on the next compartment.

3.1 BACKGROUND

The raw water reservoir is circular in shape and consists of two compartments (east and west) of total storage capacity of 680Ml (figure 1). The circular raw water reservoir is position 350 m north of the main power station building. Raw water is pumped from the Jericho Dam and stored in the raw water reservoir for supply to the power station. The floor of the dam basin is located 5 m below the natural ground level. The dam was designed to have water depth full supply level of 14 m and a maximum wall height of 9 m. The east compartment is lined with 2.0 mm HDPE geo-membrane. The western compartment is lined with 1.5 mm thick polyethylene membrane as referenced in Dam safety inspection report of the raw water dams at kriel power station March 1991 (section 2.2.1 item [20]).

During routine monitoring around the raw water reservoirs, it was noted that there are recent instances wherein the raw water reservoirs seepage sump has been overflowing into the adjacent storm water channel. The water overflowing from the sump is clean as it is raw water, it therefore does not pollute or cause harm to any receiving environment. It is suggested that the Raw Water Reservoir lining is leaking referenced in section 2.2.1 items [27] and [28].

During the preliminary investigations referenced in section 2.2.1 items [27] and [28], it was found that there is certain amount of water which has been seeping beneath the dams and then gets contained into the seepage sumps as per design; it was also found that the recoverypumps at the seepage sumps have also been running constantly. Further investigation to understand the root cause of the problem was initiated. Further investigations were done by the Approved Professional Person (APP) during the statutory Dam Safety Evaluation and the following was recommended by the APP.

“The flow rates of the leak in the two sumps must be determined and if the flow rate is > 10litre/s the source of the seepage must be determined by isotope testing of water samples from both compartments, both sumps and the pond water northeast of the dam. If is confirmedthat the leakage is from the reservoir, the reservoir must be emptied, the damage to the liner determined and repaired.” See report Reduced 01 MYD-GPS KHH2283 Kriel Power Station Dam Safety [27] and Reduced 02 MYD-GPS KHH2283 Kriel Power Station Dam Safety -Rev0 [28]

It was taken up by Eskom, to clean, inspect and repair both compartments (East and West), instead of monitoring to see which compartment was leaking. Unfortunately due to unforeseen circumstances, only the Eastern Compartment was assessed during execution stages referenced in section 2.2.1 items [18] and [19].

The raw water reservoir eastern compartment was recently emptied and cleaned to inspect and repair any suspected damages to the HDPE liner.

Upon inspection, the dam showed the existing HDPE or geomembrane liner had been extensively damaged during the desludging process conducted by the contractor. Due to

damages caused by the Employer, it was uncertain which damage was long standing and which was newly created. Apart from tears, cuts, scratches, forced down folds (creases) and punctures; large portions of the dam floor was found to be extensively undulated as a result of rutting of the soil layer beneath the HDPE liner. The subsoil or foundation material was also found to be fully saturated with extreme undulations, most likely in the order of 150mm deep. The very saturated and soft but stabilised base allowed ruts to form which is an indication of how wet the subsoil layer is.

In November 2019, a dam safety investigation was undertaken by a different APP, with reference to reports [23] and [24]. Trial pits were dug to investigate if the source of water ponding to the north of the reservoirs and continuous water inflow into the drainage sumpswas infact from a leaking liner or if there was a perched water table. The trial pits were unable to conclude.

3.2 ORIGIN OF PONDING AND DRAINAGE WATER

An investigation must be undertaken in order to find the origin of the continuous leakage/decanting from the drainage sumps to be investigated.

3.3 CLEANING OF DAMS

One dam compartment shall be emptied at a time. The dam takes 14 days to be emptied. The Employer shall be responsible for draining of the dam compartments to a level of 10%. The contractor shall be responsible for the draining of the remaining water and removal of mud/sludge. Sludge can be disposed of at the Ash Dam Complex as indicated below, located approximately 4000 m away.

Figure 2 Route from Raw Water Reservoir to Ash Dam Disposal Site

Sludge removal must be done without damaging the geo-membrane. Where there is a mechanical plant or personnel working in the lined area, or in the vicinity of the geo-

membrane, the contractor shall put in place necessary measures to protect the geo- membrane as well as the underlying foundations and drains against mechanical damages.

3.4 DAM AND LINER ASSESSMENT

The contractor shall conduct a detail walk-through of the lined area and visual check all seams and non-seamed areas of the geo-membrane for defects, holes, or signs of damage.

The contractor shall carry out all necessary tests on seams in accordance with SANS 10409:2005 to determine the integrity of the seams. The eastern compartment lining was replaced twelve years ago (mid 2007) with a liner system specified in figure 4 below referencing section 2.2.1 items [21] and [22]. It is therefore assumed that air pressure testing will be possible on the eastern compartment due to the presence of a double wedge seams.

The contractor required to develop as-built drawing of the field panel layout as per Figure C.1 of SANS 10409:2005 Annexure C, as can also be seen in figure 3-2. Due to unavailability of construction information, the contractor shall develop a seam & panel numbering system which shall be used for reporting purposes. On a separate field panel layout drawing, the contractor shall record location and reference photos of all the identified defects.

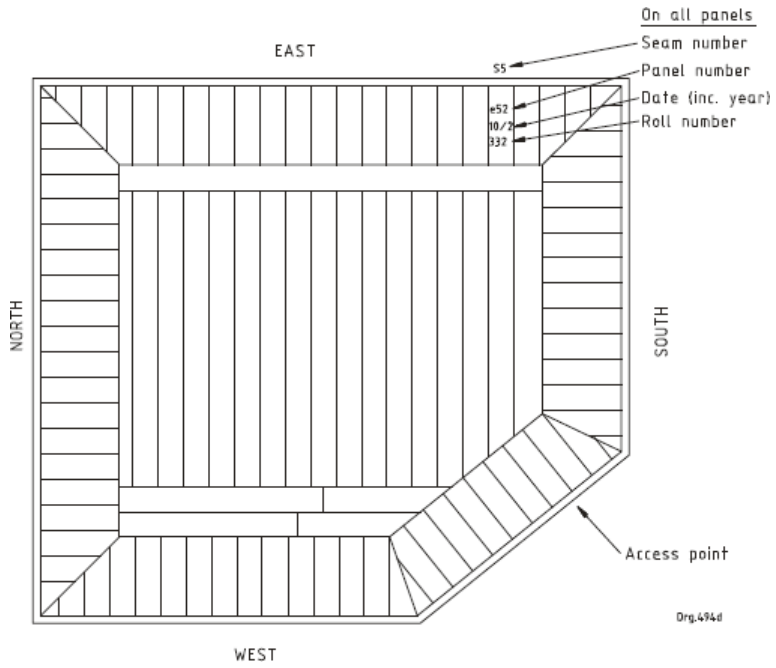

Figure 3 Typical field panel layout drawing

The contractor shall then prepare a detailed photographic assessment report with explanations with high focus on the following sections of the liner:

- Seams
- Anchorage Systems (Anchor trenches & Mechanical Anchoring)
- Structures which penetrate the lining systems (Outlet & Inlet structures, pipes, overflows)
- Areas with uneven surface of the underlying layer

On areas of defect, detail inspection must be conducted to assess the extent of damage (i.e. Erosion), including damage to the underlying layer.

An assessment of the interior of inlet and outlet pipes must be assessed by means of a camera inspection to highlight the condition. Remedial actions must be highlighted.

A detailed method statement must be included for the remedial actions of each highlighted defect.

3.5 GEOTECHNICAL WORK

The embankment material has to be exposed in predetermined areas (chosen by the APP) to sample material for moisture content and stability parameters obtained from vane shear test. Mini auger holes should also be drilled in the based to determine the level of the groundwater. The hand drilling should also be extended to the outside of the dam.

Once the geotechnical information (soil strengths and water depth/saturation levels) is known additional requirements may be identified).

The APP will recommend the amount of testing required on the soil. The amount of testing will be based on the detailed assessments made of the compartments. The Contractor must make provision for the following geotechnical tests to be conducted as a minimum:

- In-situ moisture contents
- Foundation Indicator: Sieve and Hydrometer Analysis plus Atterburg Limits
- Vane Shear tests (or equivalent assessment of the undrained shear strength of the in-situ soils)
- Seasonal and Permanent water table location
- California Bearing Ratio (CBR) test
    - Moisture/Density Relationship at Proctor Compaction Effort (as specified for remedial works)
- All samples are tested at a SANAS accredited laboratory

3.6 REMEDIAL ACTIONS

According to reports in section 2.2.1 [18] and [19], typical remedial measures are as follows.

Remove and replace the entire 2mm HDPE floor liner including the geotextile and cuspated drainage layer.

Once floor liner has been removed, founding layers must be allowed to dry to suitable moisture levels proposed by the APP.

Expose the subsoil drainage in predetermined areas (by the APP) to determine whether it functions properly and is void of sand or silt. NB. The original design drawing shows a low spot on the drainage system to the north while it should be higher than the other levels on the system and be draining southward, this may be a concerning item.

Repair the base of the dam by ripping and re-compacting the base layer (Ideally a 150 mm thick compacted clay layer to a required density and moisture content, typically a minimum density of 95% Standard Proctor maximum dry density at a water content of Proctor optimum to optimum +2%).

The liner must be reinstated to the original design of a geotextile layer and a cuspated layer beneath the HDPE liner the client may want to retain the original design especially as the embankment drainage will need to drain down towards to the base into the subsoil drainage system.

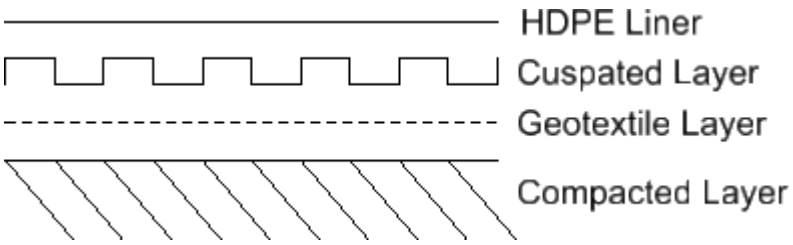

Figure 4 Original Design Details of Eastern Compartment

All highlighted defects in the assessment report must be repaired in accordance to theaccepted method statement.

Once exposed (drained and desilted) the main pipe inlet and outlet structures will need to be assessed to determine whether special design details are required to accommodate the turbulence and suction forces when water is pumped into the dam or extracted from the dam (possible cause to earlier reported liner damage).

Once the geotechnical information (soil strengths and water depth/saturation levels) is known additional requirements may be identified.

All vehicle ruts and undulations on the crest must be backfilled and compacted to 95% Mod. AASHTO

Erosion on the vertical road cutting through the outer slope must be rehabilitated and slope stability must be implemented to prevent further erosion and slippage.

All vegetation growth on the crest at interfacing parts of the liner anchorage system must be permanently removed.

All trees on or near the dam embankments must be permanently removed. Careful consideration is taken to prevent damage during vegetation removal. Reinstate grass vegetation is areas where larger vegetation has been removed.

For larger roots, compaction is required post vegetation removal.

The Operations and maintenance manual and Emergency Preparedness Programme (EPP) must be reviewed by the APP and must include all necessary means to service the dam especially on the subsoil drainage/leakage detection system as well as liner protection on the embankment (subsidence, unwanted vegetation, erosion and minor damage repairs).

Post assessment, should it not be achievable to reinstate the original design; the contractor must make recommendations on remedial measures to be taken. The newly recommended remedial measures will required the necessary approval by relevant authorities.

3.7 EMPLOYER'S REQUIREMENTS

All repairs are required to be in accordance with the following *Employer's* Design Standards:

- 240-144332407 - Standard for Eskom Power Stations Concrete Remedial Work
- All repairs shall conform to SANS 10409 and the geo-membrane to be used for patching must comply with SANS 1526.
- All repairs must be done with the approval from an APP appointed by the contractor
- For a category II dam in terms of sub-regulation 32 (1) (d) GNR 139 REGARDING THE SAFETY OF DAMS IN TERMS OF SECTION 123(1) OF THE NATIONAL WATER ACT of 1998, remedial works need to be approved and under supervision of an Approved Professional Person. The APP is to laisse with the DSO of all work that is to be executed on the raw water reservoir.
- Original Design, 0.45/7285 RAW WATER RESERVOIR – GENERAL ARRANGEMENT & DETAILS
- Original Design, 0.45/30839 RAW WATER RESERVOIR – LINING FIXING DETAIL
- Original Design, 0.45/30840 REPAIR OF WESTERN HALF SUBSOIL DRAINAGE LAYOUT & DETAIL
- Western Compartment Design, Dam safety inspection report of the raw water dams at kriel power station March 1991
- Eastern Compartment Design, KRIEL POWER STATION - ESKOM - REPAIR OF RAW WATER DAM LINER – EASTERN SECTION – Pascoe Waste and Environmental Consulting CC
- KRIEL POWER STATION, RAW WATER RESERVOIR, EAST COMPARTMENT - Aquatan

3.8 SITE SERVICES AND FACILITIES

3.8.1 Electrical Supply

1. The *Employer* makes available to the *Contractor* temporary electrical supplies free of charge from the closest existing point of supply.
2. The *Contractor* makes provisions for the necessary extensions and plug points. Any changes made to existing supplies will be on the *Contractor's* account.

3.8.2 Water

1. The *Employer* makes available reasonable quantities of raw water and potable water required for the purposes of this Contract.
2. The *Contractor* provides at his own cost, all connection equipment necessary to lead water from the *Employer's* point of supply to where it is required. Such fittings are compatible with *Employer's* fittings to prevent galvanic corrosion.
3. The *Contractor* is responsible to maintain the equipment and remove it on completion.
4. The *Contractor* is responsible for ensuring that no unwanted sources of water pass into the project area so as to delay the project.

5. The *Contractor* is responsible for the drainage of any unwanted water that may cause delays to the works

3.9 QUALITY MANAGEMENT

1. The *Contractor* submits a fully detailed Quality Control Plan (QCP) for acceptance within four weeks of the Contract Date.
2. All relevant intervention points' at all key stages of the execution of the works are included in the QCP's. The *Employer* thereafter adds the necessary intervention points for each stage in the QCP and provides this to the *Contractor*.
3. The *Contractor* submits a schedule of unpriced orders to be placed and this is updated regularly.
4. The *Contractor* is responsible for defining the level of QA/QC (intervention Points) or inspection to be imposed on his *Subcontractors* and suppliers of material in the Quality Control Plans (QCPs). This level is based on the criticality of equipment and be submitted to the *Project Manager* for acceptance.
5. The *Contractor* submits on a monthly basis, the following QA returns:
    - A register of Defects with those older than 30 days being flagged and an explanation attached
    - Register of accepted Defects
    - A register of Non Conformance Report
    - Monthly Project Quality Report
    - Monthly updated Site and pre-site programmes
    - Inspection dates
    - Site Acceptance Tests
    - Inspections completed / outstanding

4. SPECIFICATIONS FOR THE *WORKS*

4.1 APPLICABLE NATIONAL STANDARDS

The *Contractor* is required to adhere to the latest editions of, and the normative references within, the following SANS standards, codes of practice, regulations & standards:

Number	Title
240-56364545	Structural Design and Engineering Standard
240-82332389	Civil Inspection Manual for Dams and Waterways (Including Dam Safety Inspection Procedure)
240-86973501	Engineering drawing Standard
240-107981296	Constructability Assessment Guideline
240-56364535	Architectural Design and Green Building Compliance Manual
240-66920003	Documentation Management Review and Handover Procedure for Gx Coal Projects
240-76992014	Project / Plant Specific Technical Documents and Records Management Work Instruction

Number	Title
SANS 10400	The Application of the National Building Regulations
SANS 10409	Design, selection and installation of geomembranes
SANS 1526	Thermoplastics sheeting for use as a geomembrane
SANS 10221	Testing of geotextiles

4.2 ADDITIONAL REQUIREMENTS AND PREREQUISITES

N/A

5. INFORMATION ISSUED BY THE *EMPLOYER*

The following document:

- EAP0064 - Maintenance Execution Strategy for Civil & Structures
- 240-144332407 Standard for Eskom Power Stations Concrete Remedial Work
- 0.45/7284 KEY PLAN, SETTING OUT, ACESS ROUTES, GENERAL
- 0.45/3795 RAW WATER RESERVOIR – GENERAL ARRANGEMENT & DETAIL
- 0.45/7290 RAW WATER RESERVOIR ANCILLIARY WORKS
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- 0.45/30839 RAW WATER RESERVOIR – LINING FIXING DETAIL
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- KRIEL POWER STATION, RAW WATER RESERVOIR, EAST COMPARTMENT - Aquatan

6. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

7. REVISIONS

Date	Rev.	Compiler	Remarks
September 2019	0.1	[redacted]	First Draft for Review
September 2019	1.0	[redacted]	Final Document for signature

APPENDIX A – DRAWINGS