water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

PROPOSED REHABILITATION WORKS OF CASTEEL DAM
ADDENDUM TO DESIGN REPORT NO. 12/2/X302-26/D/1/30

July 2014

NWRI BRANCH	*Department of Water and Sanitation*
STRATEGIC ASSET MANAGEMENT	*Private Bag X313 PRETORIA 0001 South Africa*

TITLE : **PROPOSED REHABILITATION WORKS OF CASTEEL DAM ADDENDUM TO DESIGN REPORT NO. 12/2/X302-26/D/1/30**

Author: **M. Mosome**

Status of Report: **Final**

DWA Report No:

DWA Locality No: **12/2/X302/26**

Date of this Issue:

Compiled by: M. Mosome
PR. Eng Technician

Signature

20/7/2015
Date

Reviewed by: H. Durieux
Approved
Professional Person
PR. Eng

Signature

20/8/2015
Date

Approval by: W. Ramokopa
Director: Strategic
Asset Management
(Acting)

Signature

26/08/2015
Date

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Background

This report is the addendum to the design report that was submitted to Dam Safety Office for issuing of license to construct. The proposed draft report was evaluated according to the dam safety regulations with the following comments to be considered:

- The maximum spillway discharge capacity (with zero freeboard) is given as 172 m^3/s (in section 4.3, page 2)
- The spillway type is mentioned as Broad crested weir (other report clarified as sharp crested weir).
- Coefficient of discharge is taken as 1.93, the value is over estimated.
- Height of the weir is only 1m and during the SEF, the weir will be totally submerged. The weir will not be control point. The spillway channel geometry will be control and for the discharge calculation according to the formulae for by-wash spillway ($Q = 1.705kBH^{1.5}$ for a rectangular shaped concrete structure with square corners k = 0.82).
- For this weir the discharge coefficient is about 1.4 which will give maximum discharge capacity of 125 m^3/s. If the SEF flood has to pass the spillway, the minimum required freeboard is 4.26 m and embankment has to be raised by 2.4 m at RL 606.4 m and not 605.5 m (section 7.1.2, page 13).
- According to the SANCOLD guideline, the SED use the peak value of RMF without routing. For a more accurate calculation for the spillway, a Hec-Ras analysis is required to perform and determine the spillway discharge capacity, then determine the required increase level for the embankment.
- For the siphon design, the calculation you made according to the WRC report, the dam has to supply the shortfall for the irrigation with 30 % Non -availability of the time to be equivalent to 0.24 m^3/s, the siphon capacity was determined as 0.102 m^3/s, is this sufficient?
- Also the siphon design only address to the irrigation water supply, how to address the drawdown reservoir for the safety issues?

  Trash screen design type in your drawing is not easy to clean and it is recommended a box cage type for diver safety consideration, also the siphon pipe material and size is required. Careful selection for operating (clean blockage) and priming consideration.

- Chimney and blanket drain layer design 300 mm seem too slim. According to FEMA , filters for embankment dams design criteria that the minimum practical thickness of a drainage blanket is 460 mm suggest to increase to 500 mm for blanket drainage and on the inclined slope filter thickness should be around 1 m.

- Coarse filter does not comply with piping criterion $D_{15}/D_{85} > 5$

The clarification of the above comments have been considered on this report.

Spillway Capacity

In accordance with the SANCOLD guidelines, the non-risk requirement for a category II dam, the rehabilitated spillway must be designed for 1:100 year flood and must be able to discharge the maximum capacity equivalent to RMF/SEF without causing failure to the embankment. The dam should not fail during the occurence of the SEF and no overtopping is allowed during this event.

To address the comment from Dam safety office:

Spillway is a sharp crested weir according to First Dam Safety Inspection report (2001)

$Q = C_dLH^{1.5}$

H=1.87 m

L=35 m

C_d = varies between 1.30 and 1.4 (**Appendix A** model study report of Casteel dam)

Therefore maximum capacity the spillway can handle is 125 m^3/s

Using the determined C_d from the model study, the routed RMF overtopped the non overspill crest by 1.94 m. **Figure 1.1** shows flood routing of Casteel Dam. From the model study it was observed that the weir is the control point.

Results	
Max inlow(m^3/s)	430
Max outflow (m^3/s)	364
Max stage (m)	3.81
Depth of overtopping (m)	1.94
duration of overtopping(h)	3.00
Attenuation factor	-15%
Water level (m)	605.94

Table 1: Routing RMF at Casteel Dam

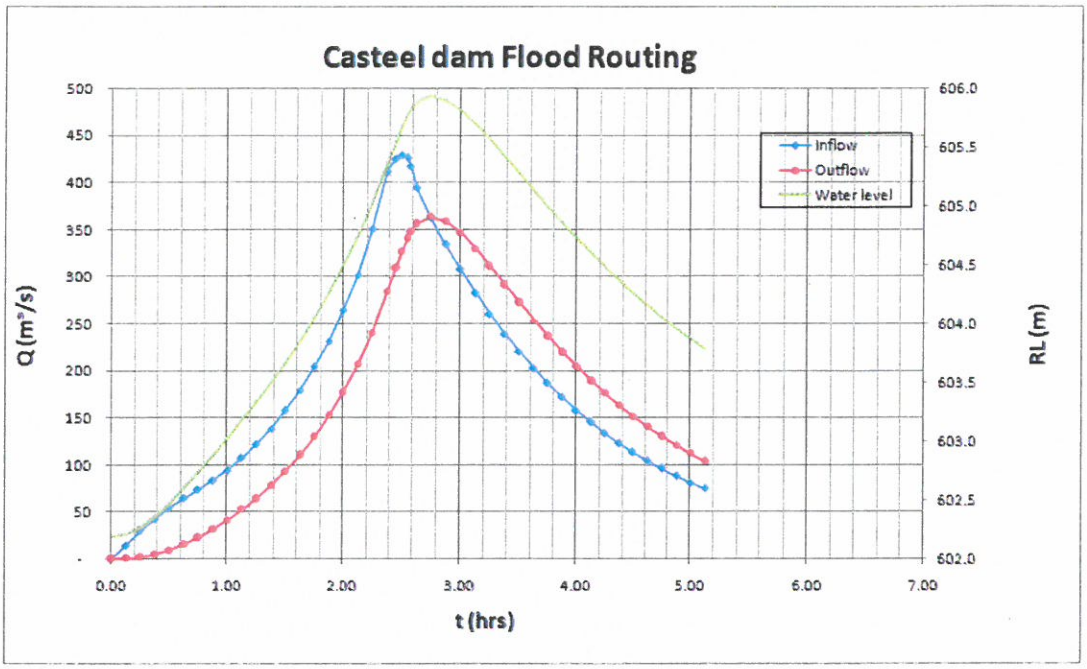

Figure 1.1 : Casteel dam flood routing

To accommodate the Regional Maximum flood of 430 m^3/s, with the current spillway the dam embankment Noc will have be raised with 2 m .

Siphon Design

The priority is to repair the existing outlet works. A detailed inspection on the outlet works can only be done during construction. A separate report will be compiled on repairing the outletworks. A drawdown of the reservoir safety requirements will be issued once enough information is collected. Reason for this is that, swamp-like conditions on the downstream make the outlet works inaccessible.

It has to be emphasised that the use of a siphon is the last resort for this project.

Slope Protection

The slope of Casteel Dam is designed for two layers, the inner layer is of coarse sand and the outer is of gravel. The relation between the grading of two adjacent layers must comply to the filter rules in order to prevent the piping of material from the underlying inner layer through the pores of the outer material. If these rules are not regarded, the surface runoff

can erode the under layer, undermine the rockfill layer, damage all the surface protection and form gullies in the protected embankment (ICOLD,2011).

To address the comments from Dam safety office:

An inclined chimney drain of 1m thickness is too much, in practise a 500 mm inclined chimney drain and blanket drain will be sufficient. Both the chimney drain and blanket was revised to thickness of 500mm. To support this decision, most recent rehabilitation project like Mokotswane dam used inclined chimney drain of 400mm. The cost of filter sand will also be a factor. Drawing in **Appendix B** shows the revised chimney drain and blanket drain.

The Gravel band for slope protection was revised as shown in the attached filter gradation on **Appendix C**. Based on the new gradation the following results were achieved:

- Slope protection gravel band

Piping Criterion: : $Df_{15}/Ds_{85} \leq 5$

Df_{15}/Ds_{85} =18.5/4 =4.6 <5 therefore ok

From DSO comments this criterion did not comply because the gravel band D_{15} was checked against base material D_{85}. This gravel band is underlain by sand filter as shown in Drawing in **Appendix B ,** therefore D_{85} is of sand filter.

Permeability Criterion: $Df_{15}/Ds_{15} \geq 5$

Df_{15}/Ds_{15} =18/0.25 =72 > 5 therefore ok

Segregation: $Df_{50}/Ds_{50} \leq 25$

Df_{50}/Ds_{50} = 35/1.5 = 23 < 25 therefore ok

- Sand filter Band

Piping Criterion: $Df_{15}/Ds_{85} \leq 5$

Df_{15}/Ds_{85} =0.7/1.7 =0.41 <5 therefore ok

Permeability Criterion: $Df_{15}/Ds_{15} \geq 5$

Df_{15}/Ds_{15} =0.7/0.04 = 17.5 > 5 therefore ok

Segragation Criterion: $Df_{50}/Ds_{50} \leq 25$

Df_{50}/Ds_{50} =4.7/0.48=9.8 < 25 therefore ok

Appendix A

Model study report

CASTEEL DAM: MODEL STUDY REPORT

June 2015

Department of Water and Sanitation

Private Bag X313

Pretoria

0001

CASTEEL DAM

DOCUMENT CONTROL SHEET

Report no:	20/2/X302-26/D/1/8
Title:	By-Wash model study
Sub Title:	

Originator		Reviewed by		Approved by	
Name	Signature	Name	Signature	Name	Signature
WP Mynhardt		CW Hattingh		NJ van Deventer	

APP Approved		Director: Civil Engineering	
Name	Signature	Name	Signature
JH Durieux	15/1/2015	NJ van Deventer	

BACKGROUND

Casteel Dam is in Mpumalanga Province approximately 16 km North of Bushbuckridge , latitude 31^0 01' 35" and longitude 24^0 41' 30".

The dam is a homogeneous earth embankment dam with a crest length of 220m., with an uncontrolled by-wash that has a concrete weir with an crest length of 35.5m.

The following information was obtained from drawing X302/26, not DWS registered:

- Non Overspill Crest Level is 604.00 masl (metre above sea level).
- Spillway Crest Level is 602.13 masl.
- Total Freeboard is 1.87 m.
- Height of the dam is approximately 14 m.
- Capacity of the dam is approximately 1.23 million m^3
- Surface area is approximately 23.85 ha at Full Supply Level

Regional Maximum Flood was calculated for 430 m^3/s and the model was designed and builds to accommodate this flood.

The contour survey of the spillway channel is shown in Figure 1.

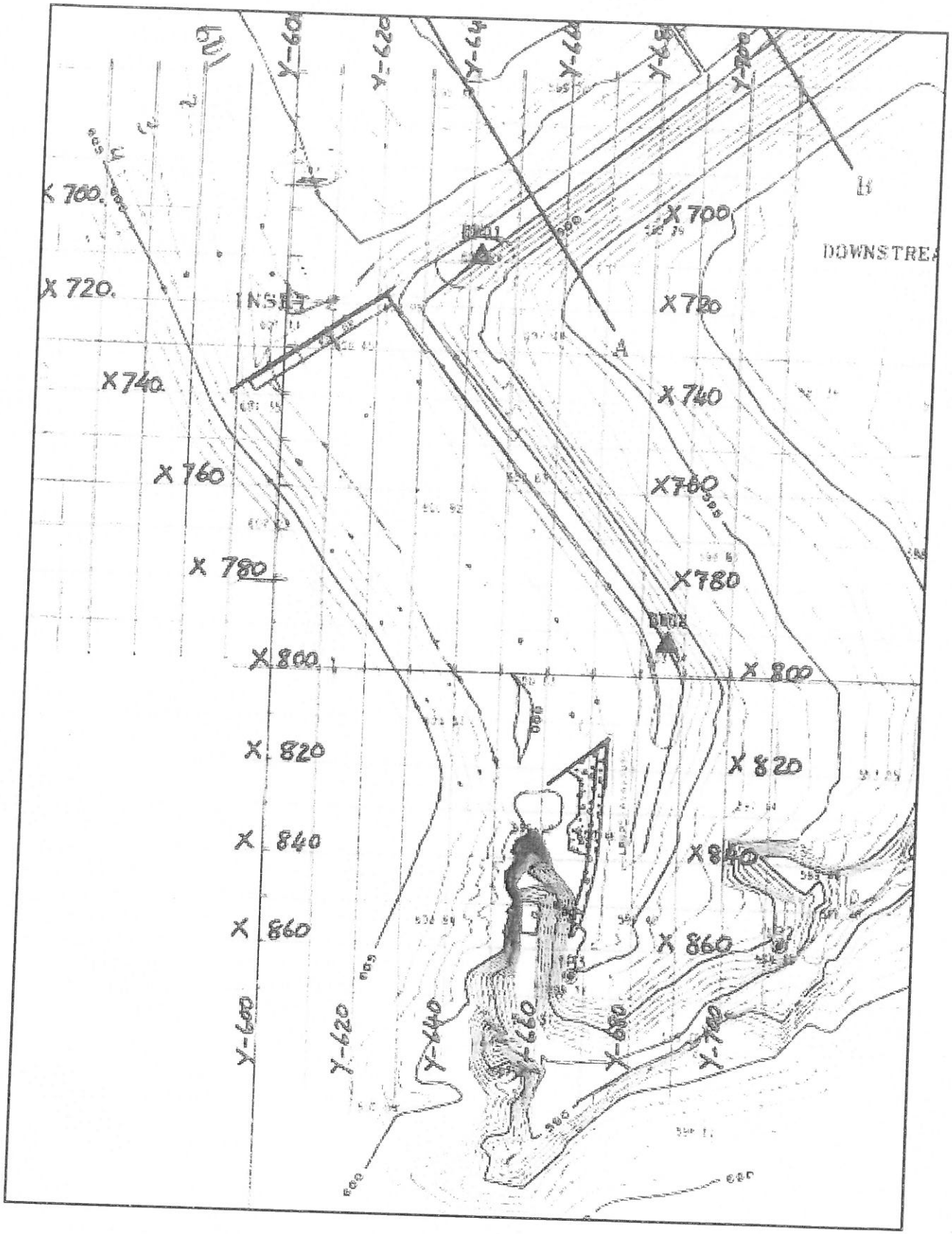

Figure 1: Drawing Number X302/26

OBJECTIVES OF STUDY

The objective of the model study was to determine the discharge rating curve of the by-wash spillway. In order to crosscheck on the validity of the outcome; the rating-curves for two discharge coefficients were also indicated.

METHOD

An undistorted scale of 1:20 was used to scale down the prototype. The roughness in the prototype is approximately 300mm. In the model the by-wash channel had a concrete lining with a roughness of approximately 10mm that represents only 200 mm in the prototype. This is regarded a non-substantial deviation.

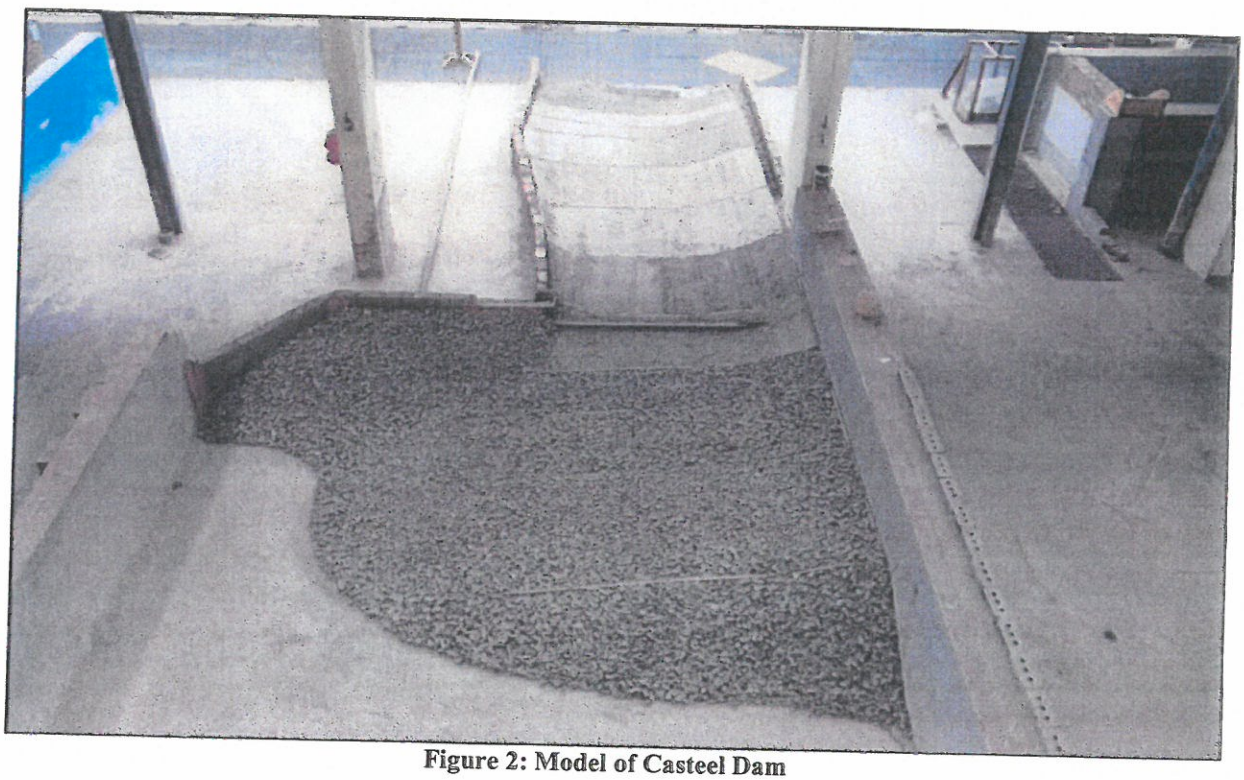

Figure 2: Model of Casteel Dam

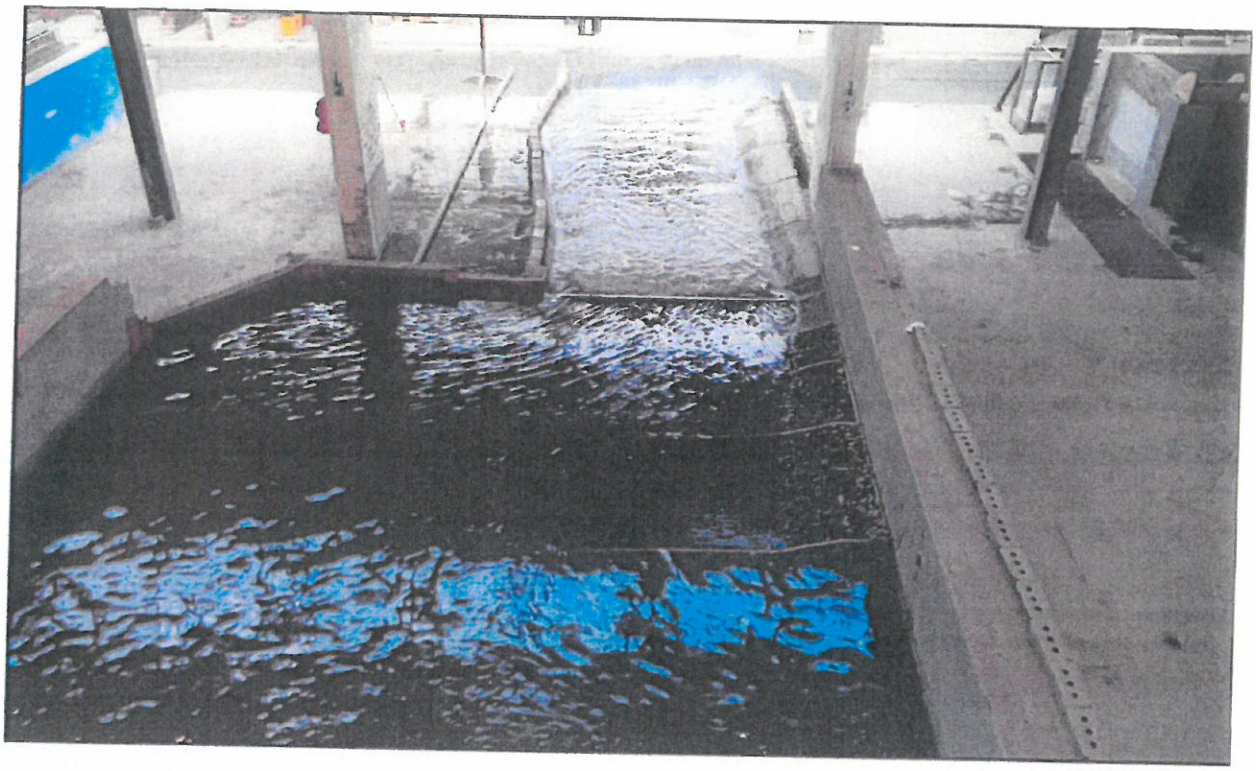

Figure 3: Model of Casteel Dam

The main materials used for the construction of the model were:

- Bricks for the outer shape
- Gravel to fill the cross-sections and approach
- Concrete topping just before the weir, and of the rest of channel.
- 18 mm Shutter ply wood for the cross-sections

In order to determine the discharge coefficient, flows between 90m³/s and 417m³/s were simulated in the model. The corresponding water levels were measured with a point gauge in a well on the side of the model.

RESULTS

The water level was measured with a point gauge in well connected to a relatively stagnant area. The discharge curve was determined from the different water levels and the corresponding flow rates. The discharge coefficient varies very little between 1.30 and 1.45

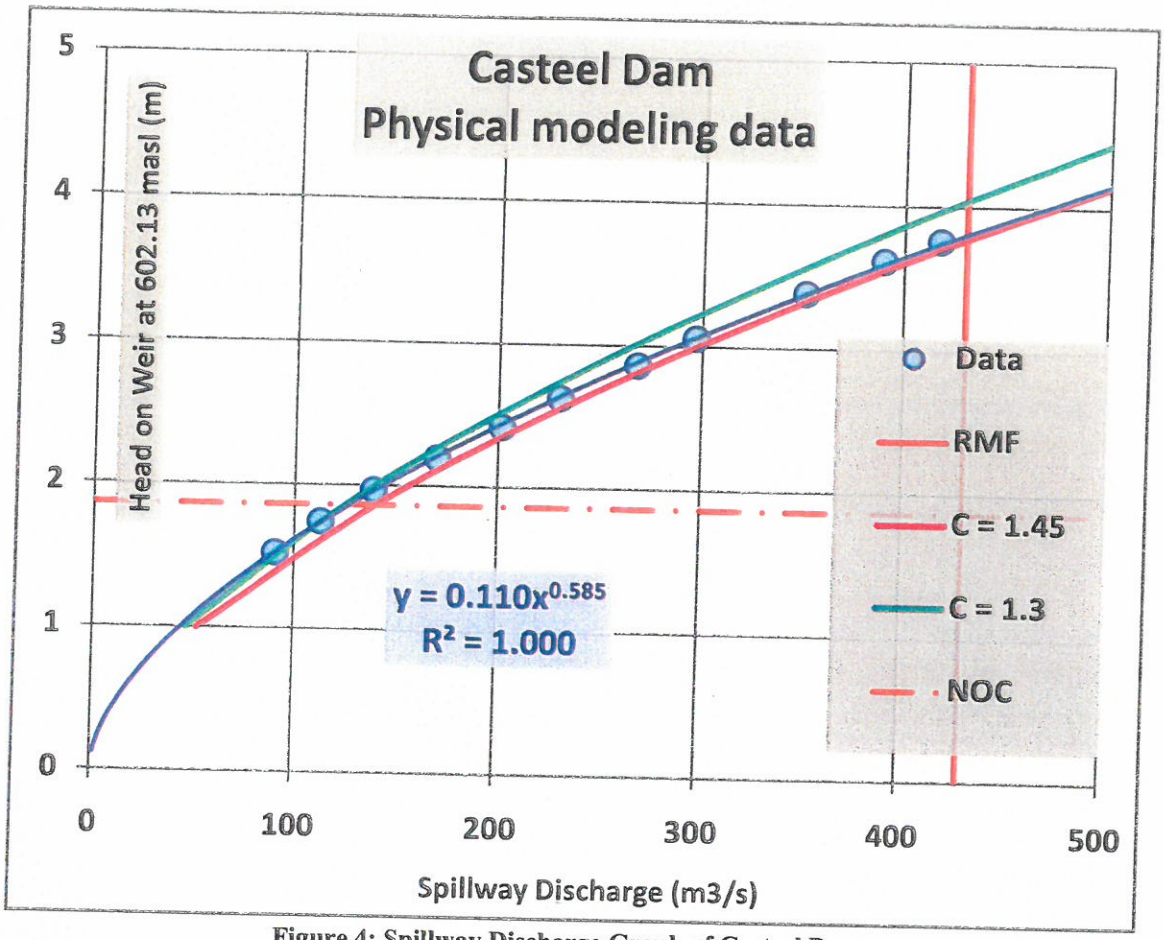

Figure 4: Spillway Discharge Graph of Casteel Dam

Conclusion

The current spillway capacity is about 125 m³/s with a discharge coefficient (C_D) that varies between 1.30 and 1.45.

To accommodate the Regional Maximum Flood, of 430 m³/s, with the current spillway, the dam embankment will need to be raised by approximately two metre.

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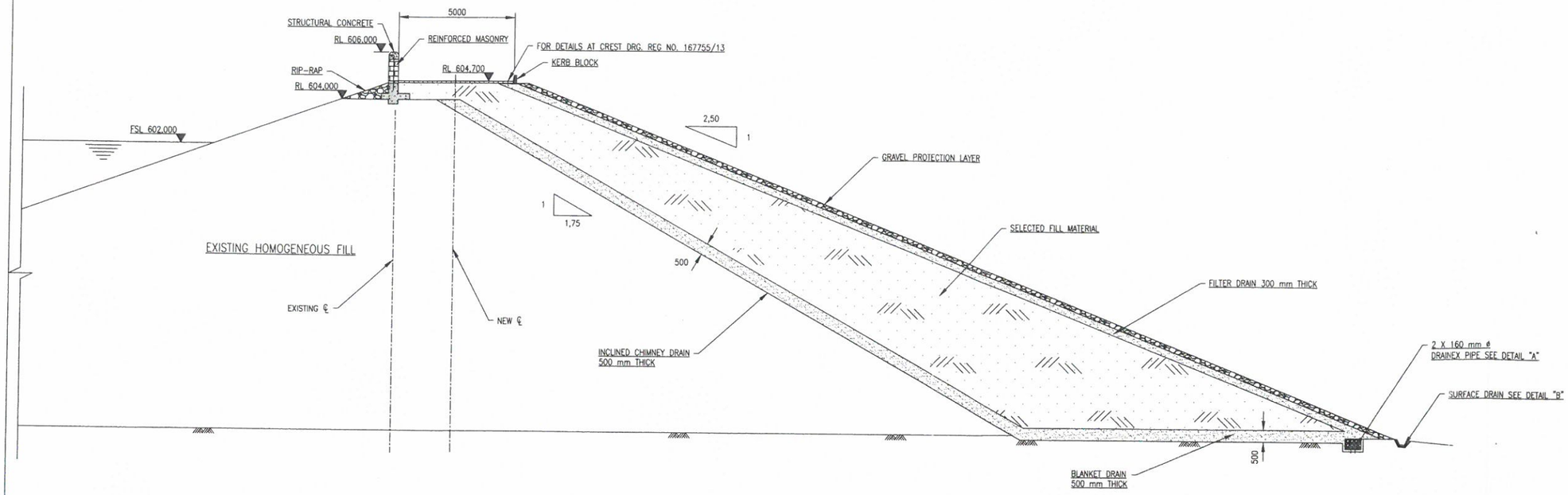
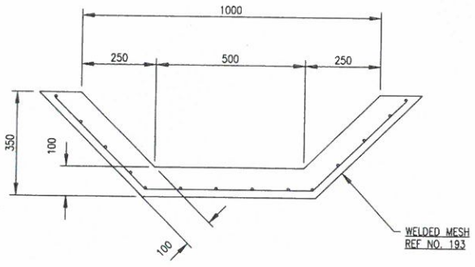
Appendix B

Drawing



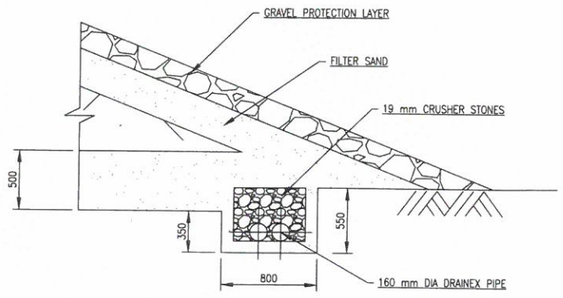
SECTION 01-01

SCALE 1:100



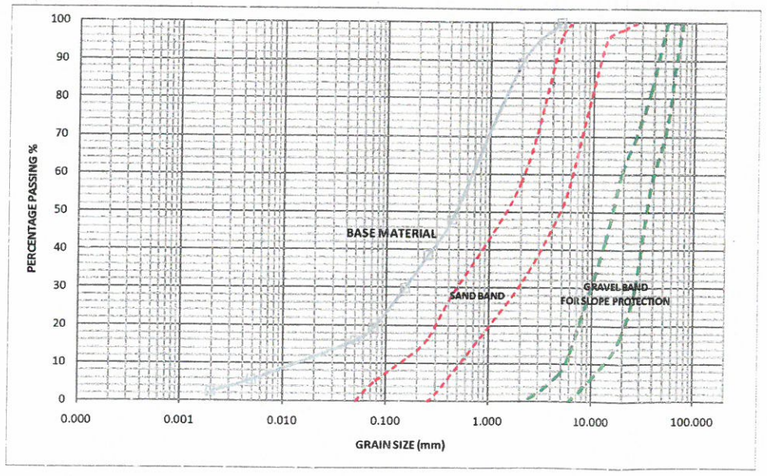
SURFACE DRAIN – DETAIL "B"

SCALE 1:10



TOE DRAIL – DETAIL "A"

SCALE 1:25



FILTER GRADATION

NTC

SECTION
07 / 3 — SECTION NUMBER / SHEET NUMBER

NOTES:

1. GRADING OF THE FILTER MUST BE APPROVED BY APP.
2. FILTER SAND MUST NOT BE COMPACTED BUT PLACED.
3. MINIMUM COMPACTION EFFORT OF THE HOMOGENEOUS FILL MUST BE USED TO OBTAIN A STANDARD PROCTOR DENSITY OF BETWEEN 95% AND 97% AT ± 1% OF OMC. Maximum dry density at optimum water content must be not less than 1750 kg/m³ and not more than 2100 kg/m³.
4. FILTER MATERIAL SHALL COMPLY WITH PRESCRIBED FILTER GRADING WITHOUT DEVIATION, FILTER MUST BE PLACED IN LIFTS NOT EXCEEDING 1.5 m.

SPECIFICATION:

GRADING REQUIREMENT FOR SAND FILTER	
SIZE RANGE (mm)	% PASSING
13.2	100
9.5	100–78
4.75	88–48
2.36	60–35
1.18	46–20
0.30	20'–2
0.15	0

GRADING REQUIREMENT FOR GRAVEL PROTECTION LAYER	
SIZE RANGE (mm)	% PASSING
75	100
53	95–68
37.5	78–50
19	62–15
13.2	42–8
9.50	28'–5
4.75	6'–0
2.36	0

SCALE 1:10 — 0 0,1 0,2 0,3 0,4 0,5 1 2 m

SCALE 1:25 — 0 0,5 1 1,5 2 2,5 5 m

SCALE 1:100 — 0 1 2 3 4 5 10 20 m

REVISION				
MOD No.	DATE	DESCRIPTION	FDR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
DAM SAFETY
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 SCHOEMAN STREET
PRETORIA
(012) 336-7500

Ms. M.A Diedricks
DIRECTOR GENERAL

DESIGN: M. MOSOME
CHECKED: DATE: DRAWN: M. MOSOME
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

	STATUS: CONSTRUCTION	
2/1	NEW LAYOUT PLAN	167751/13
2/2	LONGITUDINAL PROPOSED REHABILITATION WORKS	167752/13
2/3	MAIN EMBANKMENT: CROSS SECTION	167753/13
2/4	MAIN EMBANKMENT: SECTION THROUGH SPILLWAY	167754/13
2/5	MAIN EMBANKMENT: CREST DETAILS	167755/13
SHEET	DESCRIPTION OTHER No.	REG. No.

LIST OF DRAWINGS

DAM SAFETY REHABILITATION PROJECT

CASTEEL DAM

CROSS SECTION THROUGH PROPOSED EMBANKMENT

PROVINCE: MPUMALANGA | DISTRICT: EHLANZENI | KEYCODES: X X X – – | OTHER NUMBER X
LOCALITY No.: X | TENDER/ CONTRACT No. – | CALCULATION FILE: X
SHEET 4 of 15 | REG. No. 167753/13 | REV. 00

Appendix C

Filter gradation