JAN BRINK
CONSULTING ENGINEERING

PO Box 10865, George, 6530
Email: jan@janbrink.co.za
Our reference: JB2049-01
Your reference: Bosse Dam
2019-12-12

Langkloof Plase (Pty) Ltd
PO Box 689
Oudtshoorn, 6620
Att: Mr H Jonker (hein.jonker@opsa.co.za)

Sir,

**ASSESSMENT OF BOSSE DAM, SCHOONBERG FARM**

## INTRODUCTION

The undersigned was appointed to provide an assessment on the design and condition of Bosse Dam on the farm Lower Schoonberg 108.

The purpose of the assesment and this report is to provide information requested in a notice to issue a directive in terms of unlawful water use to the owner by the Breede-Gouritz Catchment Management Agency (BGCMA) ref. 4/9/2/J34E/Schoonberg 109&108 on 2019-08-21. The notice references the Dam Safety Regulations (Government Notice R. 139 of 24 February 2012) and specifically instructs the owner to provide the following:

- Location map
- Capacity curve
- A hydrological study
- Current water storage on the farm
- Spillway capacity calculations
- As-built drawings and/or design drawings of future work

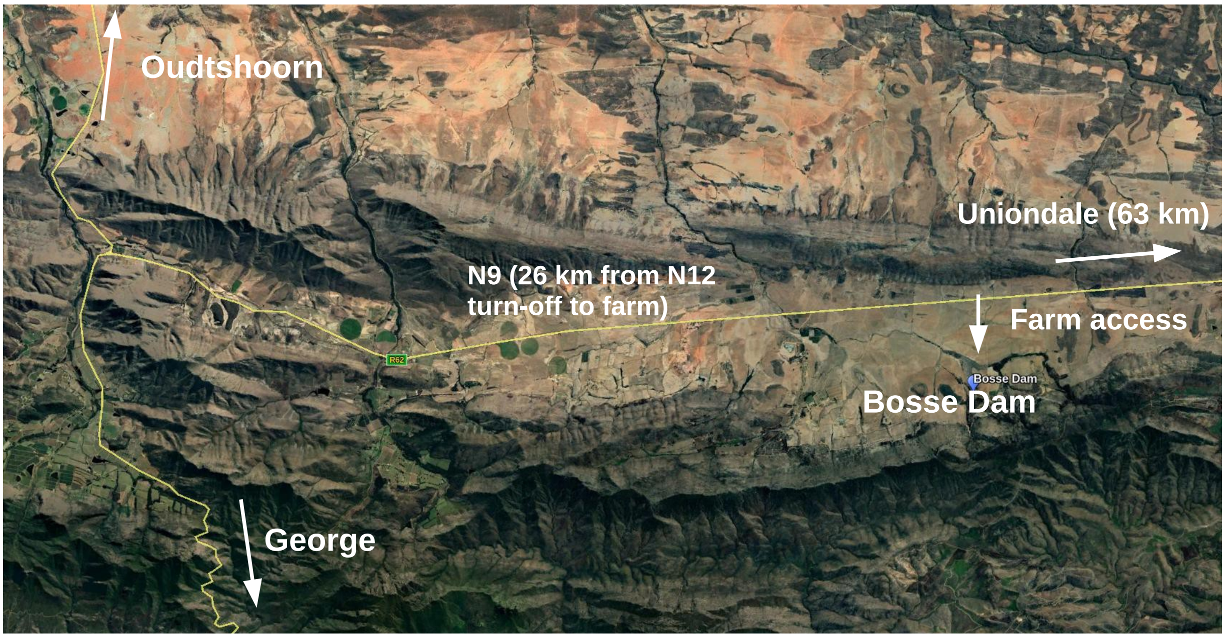
This report therefore provides the above information in the form of a professional review of the condition of the dam. The assessment is not a statutory Dam Safety Evaluation. Based on the recommendations of this report the Dam Safety Office (DSO) of the Department of Water and Sanitation will instruct whether further evaluations are required.

## INSPECTION

The dam was visited on 21 August 2019 for a site inspection in the company of the farm manager, Mr Uys Tomlinson, and Ms Louise-Mari van Zyl of Cape EAPrac. The inspection consisted of a visual observation of the dam wall and discussions with Mr Tomlinson. At the same time a basic topographic survey of the dam was conducted by Mr Pieter du Plessis of Greenworld Irrigation.

Subsequent to the inspection, further information was provided by Mr Tomlinson and the contractor for the upgrade works, Mr Thys Swart of Buffelskloof Grondverskuiwing.

The location of the dam is shown on the map below.




Bosse Dam location

## Description and condition

### General

Bosse Dam is an earthfill embankment dam with an unlined bywash spillway on the left flank. It has a single bottom outlet at the highest section of the dam. The attached drawing JB2049-01 shows the layout and a typical section through the dam. The main dimensions and pertinent figures are tabulated below.

**Table 1: Summary of dam dimensions**

| | | | |
|---|---|---|---|
| **Location** | 33°49'06" S | 22°37'40" E | |
| **Wall type** | Earthfill | **Wall height** | 11 m |
| **Storage capacity** | 164 000 m³ | **Spillway type** | Bywash |
| **Crest length** | 273 m | **Crest width** | 8 m |

### Embankment

The original embankment appears to have been constructed from random fill material scraped/excavated from the basin and loosely compacted. Very little foundation preparation was done and no cut-off was constructed. This left a semi-porous layer of alluvial material under the embankment. This likely lead to the reported continuous leakage that compelled the owner to upgrade the dam. Seepage through an embankment continuously washes fine material from the fill structure. This eventually leads to internal erosion, causing piping failure and sudden collapse of the dam. The dam therefore had to be sealed to prevent failure.

The upgrades chosen by the owner consisted of the excavation of a cut-off trench downstream of the existing embankment and the construction of a water tight zone up to the non-overspill crest (NOC). The cut-off and water tight zone were constructed with dense clay excavated from the dam basin. The upgraded embankment can therefore be described as a zoned embankment with an upstream zone of random fill and a water tight downstream zone.

The embankment slopes are 1:2 (horizontal:vertical) upstream and 1:1,5 downstream. This is relatively steep for clayey material and may be susceptible to surface instability and erosion. The 8 m wide crest is generous and contributes to overall stability.

Burnt-out tree stumps were placed against a section of the downstream slope, supposedly to prevent erosion (see Figure 3). Large voids remain below and between the stumps and will hide erosion rather than prevent it. The owner was advised to not proceed with this. It is recommended that the stumps be removed and that other means of erosion protection be employed. The most effective protection of dam embankment slopes is good grass coverage. Grass grow low enough to keep the slope visible for monitoring, but matted root systems provide good erosion resistance.

The upstream slope also requires some form of wave erosion protection. Dumped rock riprap provides the best protection, but this is an expensive solution for a relatively small dam. The owner may consider a combination of gravel and/or vegetation and regular maintenance.

**Spillway**

The dam's original spillway was located on the right flank, but the owner elected to move it to the left. A deep erosion gulley developed on the downstream right flank and was presumably the motivation for the relocation. The new spillway is an uncontrolled bywash channel that was excavated into reasonably competent material. No formal return channel was constructed to guide water back to the downstream flow channel. Storm water flowing through the spillway may cause erosion along the downstream left flank. The owner may choose to repair any erosion that may occur after each spilling, rather than constructing a formal return channel, as long as no flow along the embankment toe is allowed.

**Outlet**

The new outlet pipe is a ⌀ 250 mm Class 9 PVC pipe. The new pipe was placed in a trench through the old embankment that was excavated into reasonably competent material. Three 1,2 m x 2,5 m concrete collars were placed around the pipe in the new water tight zone. A T-piece of perforated similar PVC pipe is used as an intake strainer. It stands approximately 1 m higher than the pipe invert, effectively creating the lowest draw-down level for the dam at 598 m.a.s.l. See Figure 2. Flow control is by means of a gate valve on the downstream end of the pipe.

**Storage Capacity**

The dam's capacity was calculated by measuring the areas of the contours generated from the survey. This was then used to compile the capacity curve attached to the end of this report. The dam's capacity at full supply level (FSL), i.e. just before water starts flowing over the spillway, is approximately 130 000 $m^3$.

No information on the capacity before the upgrades were implemented could be located. The Contractor estimated that they removed approximately 30 000 $m^3$ of fill material from the basin to be used for the embankment. The bulk of this was, however, excavated above the full supply level and does not contribute to additional storage capacity. It is assumed that only 10% of the material was excavated below the FSL. This relates to 3 000 $m^3$ additional storage, which is both negligible in terms of the capacity of the dam and within the margin of error of the volume calculations.

The additional volume created between the FSL and the embankment crest (i.e. the freeboard of the dam) serves only as temporary storage. It increases flood retention time and reduces flood peaks downstream. It is not usable storage and does not contibute to the dam's capacity.

### Hydrology and spillway capacity

A flood hydrology calculation was done to check the spillway capacity. The catchment area of 3 km² is too small to utilise the Regional Maximum Flood-method recommended in by the SA National Committee on Large Dams (Safety in Relation to Floods, 1991) and a basic Rational Method was employed. A map of the catchment showing the area and water course lengths, as well as the flood calculations are attached.

The Guidelines recommend two flood sizes to be calculated for a dam. During the Recommended Design Flood (RDF) the spillway must discharge the full outflow from the dam, with no damage to the dam itself. During the Safety Evaluation Flood (SEF) the dam may sustain some damage, but the structure must not collapse and cause a larger downstream flood. For a dam of this size, a RDF equal to the 50-year flood and a SEF equal to the RMF are recommended. The calculations showed a 50-year flood of 32 m³/s. In place of the RMF a probable maximum flood (PMF) of 297 m³/s was calculated.

The spillway was assumed to function as a broad-crested weir. The maximum capacity calculated as 45 m³/s. This is more than the calculated 100-year flood, although less than the PMF. The SEF is therefore likely to overtop the NOC and cause significant damage to the dam. This may lead to rapid erosion and failure of the dam. Generally this is not acceptable, especially for a dam embankment with a steep and exposed downstream slope. It is recommended that the extreme floods and spillway capacity be evaluated in more detail.

### Dam Safety Legislation and risk

The National Water Act, Act 36 of 1998, classifies any dam with storage capacity more than 50 000 m³ and height more than five metre as a dam with a safety risk. Based on Bosse Dam's 11 m height and 164 000 m³ storage it will be classified as such. The Dam Safety Regulations (Government Notice R. 139 of February 2012) published in terms of the Act further categorises dams based on their hazard potential. There are no indications that failure of the dam will threaten human life, or have any significant impact on resource quality or economic loss. It will therefore likely be a Category 1 dam.

### Conclusion and Recommendations

The deficiencies in the original dam would eventually lead to failure of the dam and upgrades were vital. The upgrades appear to be largely successful. The following recommendations are made:

- The dam should be registered as a Category 1 dam with the Dam Safety Office.
- The extreme floods and spillway capacity should be re-evaluated in greater detail.
- The tree stumps must be removed from the downstream slope and more appropriate erosion protection implemented.
- During the first year the dam must be inspected for erosion damage after every rain storm.
- The spillway and downstream area must be inspected for erosion damage after every spill.

**Compiled by:** JA Brink Pr Eng

**Date:** 2019-12-12

**Signed:**

**Attached:**

1. Photographs
2. Capacity curve
3. Flood calculations
4. Spillway calculations
5. Catchment map
6. Drawing JB2049-01

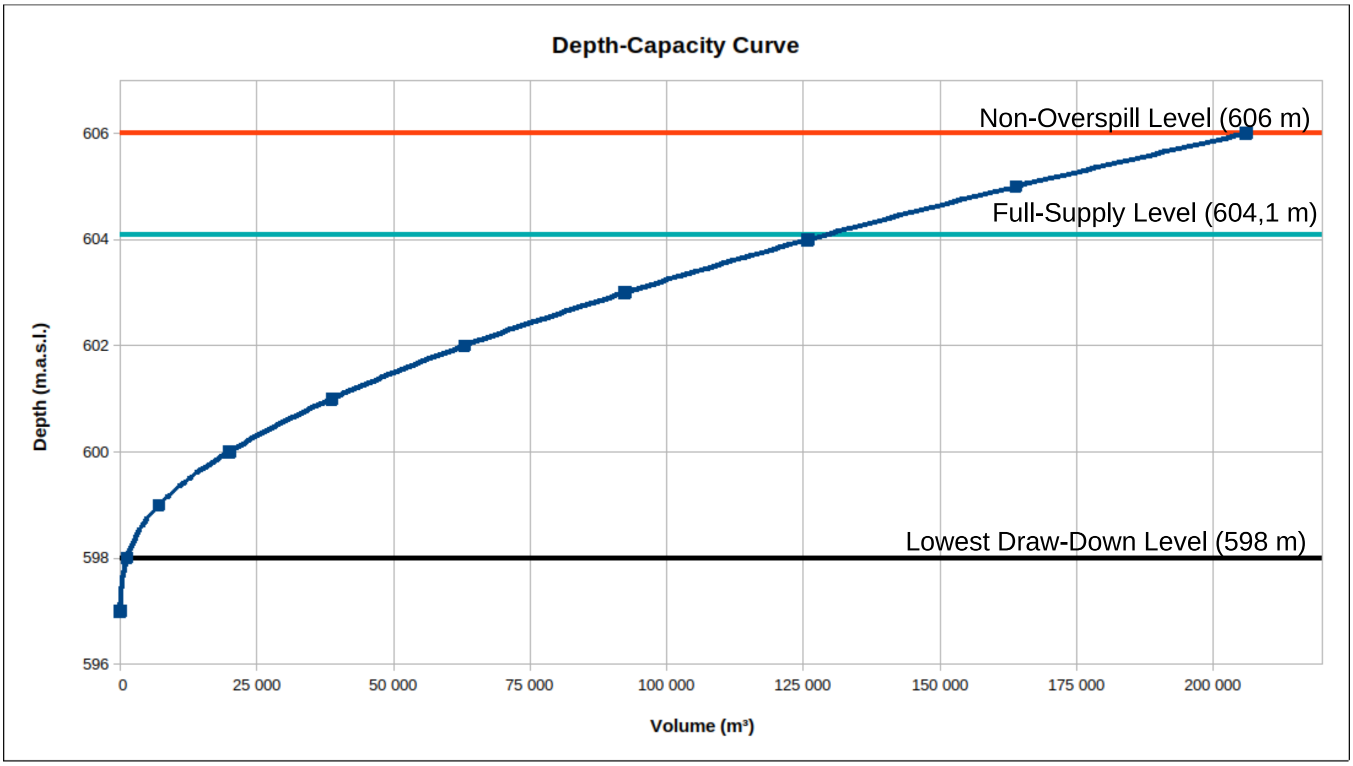
## PHOTOGRAPHS

**Figure 1: Crest and upstream slope**

**Figure 2: T-piece intake strainer**

**Figure 3: Downstream slope with tree stumps**

## Capacity Curve



# FLOOD FREQUENCY ANALYSIS
## RATIONAL METHOD
## (CALCULATION SHEET)

| GENERAL DATA | | TOPOGRAPHY AND GEOLOGY | |
|---|---|---|---|
| PROJECT NO. | JB2049 | CATCHMENT AREA (km²) | 3 |
| RIVER / AREA No. | Bossedam | LONGEST WATER COURSE (km) | 3.4 # |
| ANALYSIS BY | JB | HEIGHT DIFFERENCE (m) | 518 # |
| DATE | 2019-11-14 | DOLOMITIC AREA (%) | 0 |

| AREA WEIGHTING FACTORS % | | | | | |
|---|---|---|---|---|---|
| URBAN | 0 | RURAL | 100 | LAKES | 0 |

| MAP (mm) |
|---|
| 480 |

| RETURN PERIOD ADJUSTMENT FACTOR | | |
|---|---|---|
| RETURN PERIOD | RURAL | URBAN |
| T (years) | $f_T$ | |
| 2 | 0.32 | For return periods equal or greater than 50 years $C_T$ = 1.00 |
| 5 | 0.50 | |
| 10 | 0.61 | |
| 20 | 0.71 | |
| 50 | 0.83 | |
| 100 | 0.92 | |
| 200 | 1.00 | |
| $C_T = f_T( C_Y + C_P + C_V)$ | | |

| TIME OF CON. Tc (hr) | |
|---|---|
| [ 0.87*L^3/H]]^0.385 | |
| 0.31 | |

| LIGHTNING DENSITY | |
|---|---|
| 4 | |

| FRANCOU - RODIER REGIONAL COEFF. | |
|---|---|
| 5 | |

## PHYSICAL CHARACTERISTICS AND RECOMMENDED VALUES OF RUNOFF COEFFECIENTS (RURAL)

| PHYSICAL CHARACTERISTICS | | RECOMM. RUNOFF COEFF. C | | | | |
|---|---|---|---|---|---|---|
| STEEPNESS | % OF AREA | MAP | | | 'C' | $C_Y$ |
| | | < 600 | 600-900 | >900 | | |
| < 3 % | 0 | 0.01 | 0.03 | 0.05 | 0.01 | 0.000 |
| 3 to 10% | 0 | 0.06 | 0.08 | 0.11 | 0.06 | 0.000 |
| 10 to 30% | 10 | 0.12 | 0.16 | 0.20 | 0.12 | 0.012 |
| 30 to 50% | 40 | 0.22 | 0.26 | 0.30 | 0.22 | 0.088 |
| > 50% | 50 | 0.26 | 0.30 | 0.34 | 0.26 | 0.130 |
| | | | | | $C_S$ = | 0.230 |

| PHYSICAL CHARACTERISTICS | | RECOMM. RUNOFF COEFF. C | | | | |
|---|---|---|---|---|---|---|
| PERMEABILITY | % OF AREA | MAP | | | 'C' | $C_P$ |
| | | < 600 | 600-900 | >900 | | |
| VERY PERMEABLE | 0 | 0.03 | 0.04 | 0.05 | 0.03 | 0.000 |
| PERMEABLE | 35 | 0.06 | 0.08 | 0.10 | 0.06 | 0.021 |
| SEMI-PERMEABLE | 60 | 0.12 | 0.15 | 0.20 | 0.12 | 0.072 |
| IMPERMEABLE | 5 | 0.21 | 0.26 | 0.30 | 0.21 | 0.011 |
| | | | | | $C_P$ = | 0.104 |

| PHYSICAL CHARACTERISTICS | | RECOMM. RUNOFF COEFF. C | | | | |
|---|---|---|---|---|---|---|
| VEGETATION | % OF AREA | MAP | | | 'C' | $C_V$ |
| | | < 600 | 600-900 | >900 | | |
| DENSE BUSH, FOREST | 60.00 | 0.03 | 0.04 | 0.05 | 0.03 | 0.018 |
| CULTIVATED LAND | 30.00 | 0.07 | 0.11 | 0.15 | 0.07 | 0.021 |
| GRASS LAND | 10.00 | 0.17 | 0.21 | 0.25 | 0.17 | 0.017 |
| BARE SURFACE | 0.00 | 0.26 | 0.28 | 0.30 | 0.26 | 0.000 |
| | | | | | $C_V$ = | 0.056 |

## PHYSICAL CHARACTERISTICS AND RECOMMENDED VALUES OF RUNOFF COEFFECIENTS (URBAN)

| PHYSICAL CHARACTERISTICS | | RECOMM. RUNOFF COEFF. C | | | | |
|---|---|---|---|---|---|---|
| OCCUPATION | % OF AREA | | | | 'C' | CV |
| **LAWNS, PARKS** | | | | | | |
| SANDY, FLAT < 2 % | 0.00 | 0.05 | to | 0.10 | 0.08 | 0.00 |
| SANDY, STEEP > 7 % | 0.00 | 0.15 | to | 0.20 | 0.18 | 0.00 |
| HEAVY SOIL, FLAT < 2 % | 0.00 | 0.13 | to | 0.17 | 0.15 | 0.00 |
| HEAVY SOIL, STEEP < 7 % | 0.00 | 0.25 | to | 0.35 | 0.30 | 0.00 |
| **RESIDENTIAL** | | | | | | |
| SINGLE DWELLING AREA | 0.00 | 0.30 | to | 0.50 | 0.40 | 0.00 |
| FLATS | 0.00 | 0.50 | to | 0.70 | 0.60 | 0.00 |
| **INDUSTRIAL** | | | | | | |
| LIGHT INDUSTRIES | 0.00 | 0.50 | to | 0.80 | 0.65 | 0.00 |
| | | | | | | |
| HEAVY INDUSTRIES | 0.00 | 0.50 | to | 0.90 | 0.70 | 0.00 |
| **BUSINESS** | | | | | | |
| DOWNTOWN | 0.00 | 0.70 | to | 0.95 | 0.83 | 0.00 |
| NEIGHBOURHOOD | 0.00 | 0.50 | to | 0.70 | 0.60 | 0.00 |
| **NEIGHBOURHOOD** | | | | | | |
| STREETS | 0.00 | 0.70 | to | 0.95 | 0.83 | 0.00 |
| | | | | | $C_U$ = | 0.00 |

## RAINFALL

| POINT RAINFALL FOR TIME OF CONCENTRATION $t_c$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| RETURN PERIOD (years) | 5 | 10 | 20 | 50 | 100 | 200 | PMF |
| POINT RAINFALL DEPTH (mm) | 21 | 27 | 33 | 43 | 53 | 66 | 150 |
| POINT INTENSITY (mm/h) | 67 | 85 | 104 | 136 | 167 | 209 | 477 |
| AREA REDUCTION FACTOR % | 87 | 87 | 87 | 87 | 87 | 87 | 90 |
| AVERAGE INTENSITY (mm/h) $I_T$ | 58 | 74 | 91 | 118 | 145 | 182 | 429 |

## AREA WEIGHTED RUNOFF COEFFICIENT

| RETURN PERIOD (years) | 5 | 10 | 20 | 50 | 100 | 200 | |
|---|---|---|---|---|---|---|---|
| RURAL | 0.19 | 0.24 | 0.28 | 0.32 | 0.36 | 0.39 | 0.83 |
| URBAN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| LAKES | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AREA WEIGHTED AVERAGE $C_T$ | 0.19 | 0.24 | 0.28 | 0.32 | 0.36 | 0.39 | 0.83 |

## PEAK DISCHARGE
## (m³/ s)

| RETURN PERIOD (years) | 5 | 10 | 20 | 50 | 100 | 200 | PMF |
|---|---|---|---|---|---|---|---|
| $Q_T = 0.278\ C_T I_T A$ | 9 | 15 | 21 | 32 | 43 | 59 | 297 |

RECOMMENDED PROCEDURE

1. Locate the site on 1:50 000 or 1:250 000 topographical maps.
2. Determine the following catchment characteristics for the site:
   a) Demarcate the catchment boundary on the 1:50 000 topographical maps, or 1:250000 maps if the catchment covers more than four 1:50 000 sheets.
   b) Measure the area of the catchment. Subtract areas of significant internal drainage (eg large pans) if any. Use transparent graph paper with 2mm quares. One hundred squares have an equivalent area of one square kilometer on a 1:50 000 scale map. Count the number of squares to determine the area.
   c) Produce a longitudinal profile along the longest tributary from the site to the watershed. Use dividers for measuring the main stream length. These should be set at 0.2 km for 1:50000 maps and 1.0 km for 1:250000 maps. When the latter maps are used the length should be multiplied by a factor 1.2 to correct for a loss of resolution.

      The distances along the length of stream where the contour lines are crossed should be used to plot the profile. Where waterfalls and rapids are clearly evident as discontinuities in the profile, the profile should be adjusted downwards to eliminate them.
   d) Determine the height difference along the equal area and 1085 slopes.
   e) Locate the centroid of the catchment site by eye and measure the distance along the main channel length from the site point to a point opposite the centroid.
3. Determine the MAP over the catchment. The catchment MAP is the average of the quartenary catchments within which the catchment of interest is located as shown in the HRU series of publications.
4. Determine whether the catchment is located in the coastal or inland region.
5. Note the presence of any dams upstream of the site.
6. Identify the RMF region in which the site is located and determine the value of the RMF k-factor.
7. Determine the catchment characteristics required for the rational method as listed on this sheet.
8. Add any other comments relevant.

COMMENTS

| | |
|---|---|
| **PROJECT:** | **Bossedam** |
| **PROJECT NUMBER:** | **JB2049** |
| **DATE:** | **2019-11-13** |
| **DESIGN:** | **JAB** |

## BROAD-CRESTED WEIR

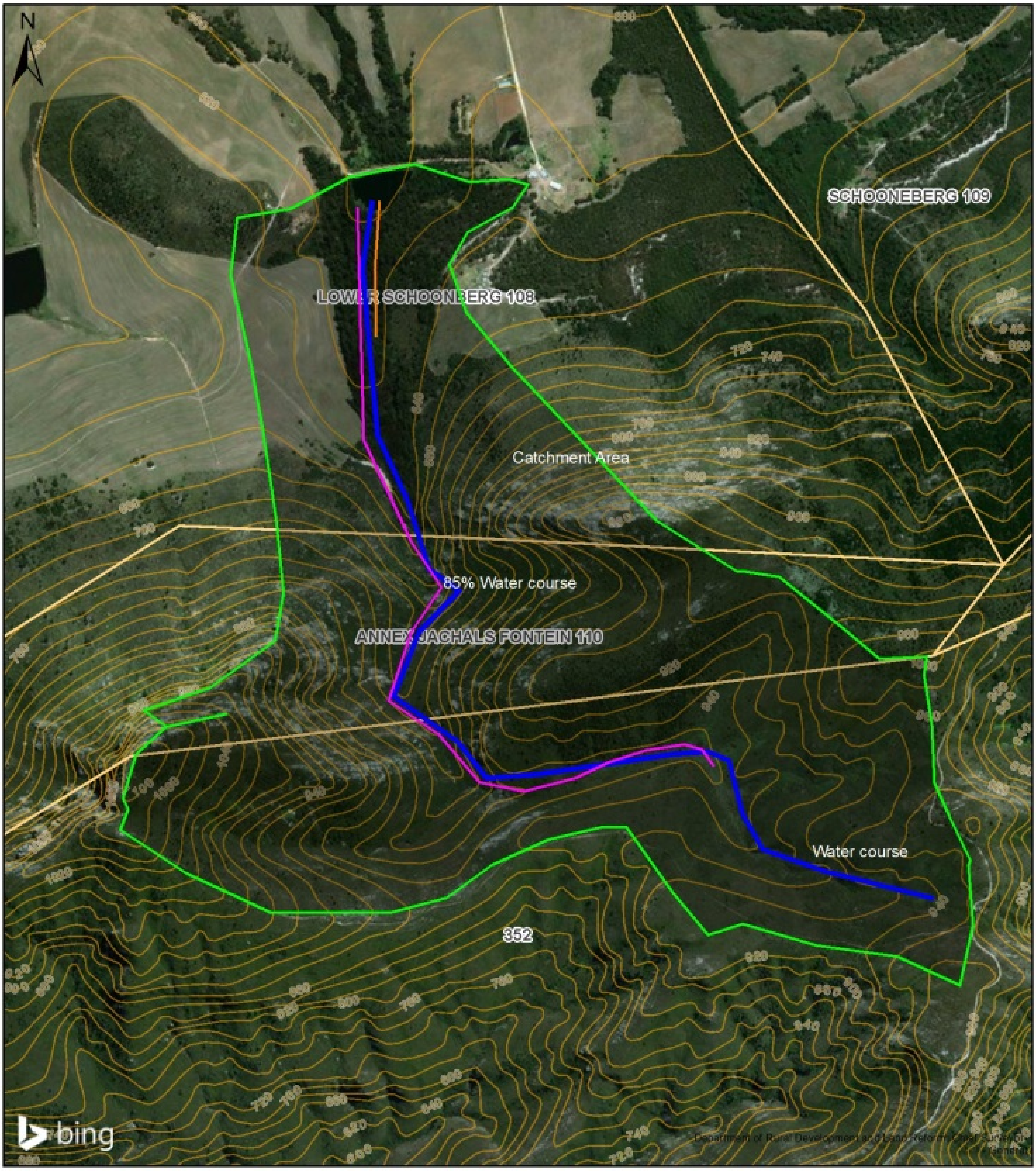
$$Q = 0.327 * b * \sqrt{2 * g} * H^{3/2}$$

**Measurements from survey supplied**

| | | |
|---|---|---|
| NOC | 606.000 | m |
| SW invert | 604.100 | m |
| SW width | 12.000 | |

| | | | |
|---|---|---|---|
| **Main SW** | H = | 1.900 | m |
| | b = | 12.000 | m |
| | g = | 9.810 | |
| | μ = | 0.327 | |
| | Q = | 45.521 | m³/s |

# Bossedam Hydrology




**Legend**

- Parent Farms
- Contours 20m

0 0.225 0.45 0.9 km

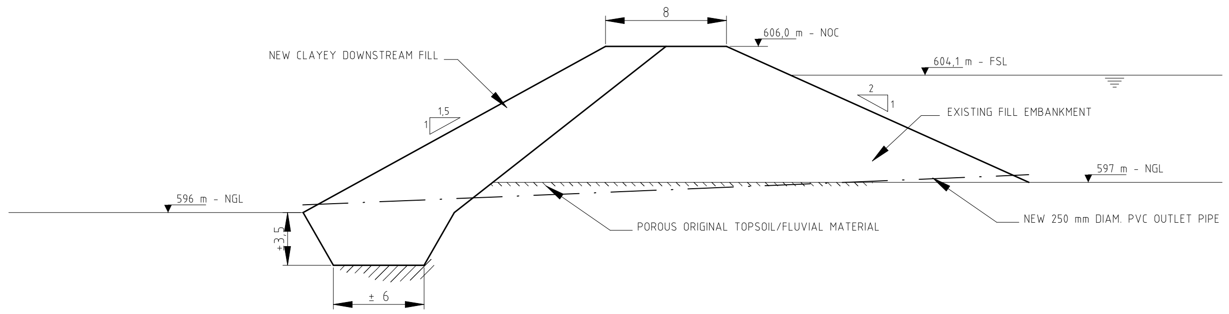
**Scale:** 1:18 056

**Date created:** November 15, 2019

Western Cape Government
Agriculture


DAM LAYOUT

N.T.S.




TYPICAL SECTION THROUGH EMBANKMENT

N.T.S.

**General Notes**

1.Drawing based on survey and information supplied by owner

| ABBREVIATIONS | |
|---|---|
| FSL | Full Supply Level |
| NGL | Natural Ground Level |
| NOC | Non-Overspill Crest |
| RC | Reinforced Concrete |

| No | Revision/Issue | Date |
|---|---|---|
| 00 | Draft | 20/11/19 |

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Project Name and Address

**Bosse Dam**
**Langkloof Plase (Pty) Ltd**
**Posbus 689**
**Oudtshoorn, 6620**

Bosse Dam As-Built

| Drw Number | Revision |
|---|---|
| JB2049-01 | 00 |
| Date: 2019-11-14 | Drafted: JAB |
| Scale: n.t.s. | |