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DAM ENGINEERING SPECIALISTS

PASSION | EXCELLENCE | INNOVATION

Reference No: DJH097.2-R02

28 July 2021

BASS DIII BERRIES (PTY) LTD

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ENLARGEMENT OF BASS DIII DAM, WORCESTER: STORMWATER MANAGEMENT PLAN

Dear

Messrs Balie Swart and Stephan Badenhorst

1 Introduction

During the online site inspection meeting regarding the WULA (Ref No WU19718) for the construction of Bass Diii Dam held on 12 July 2021, the completion of a stormwater management plan, including the spillway design was requested by Breede Gouritz Catchment Management Agency (BGCMA).

This stormwater management plan is proposed to sufficiently address this request.

The proposed Bass Diii Dam site is located 22 km south east of Worcester in the Western Cape. Refer to the locality map below.

In general, the farm area is flat with no significant catchments. Due to this and the existing cut-off canal major stormwater drainage problems are therefore not experienced.

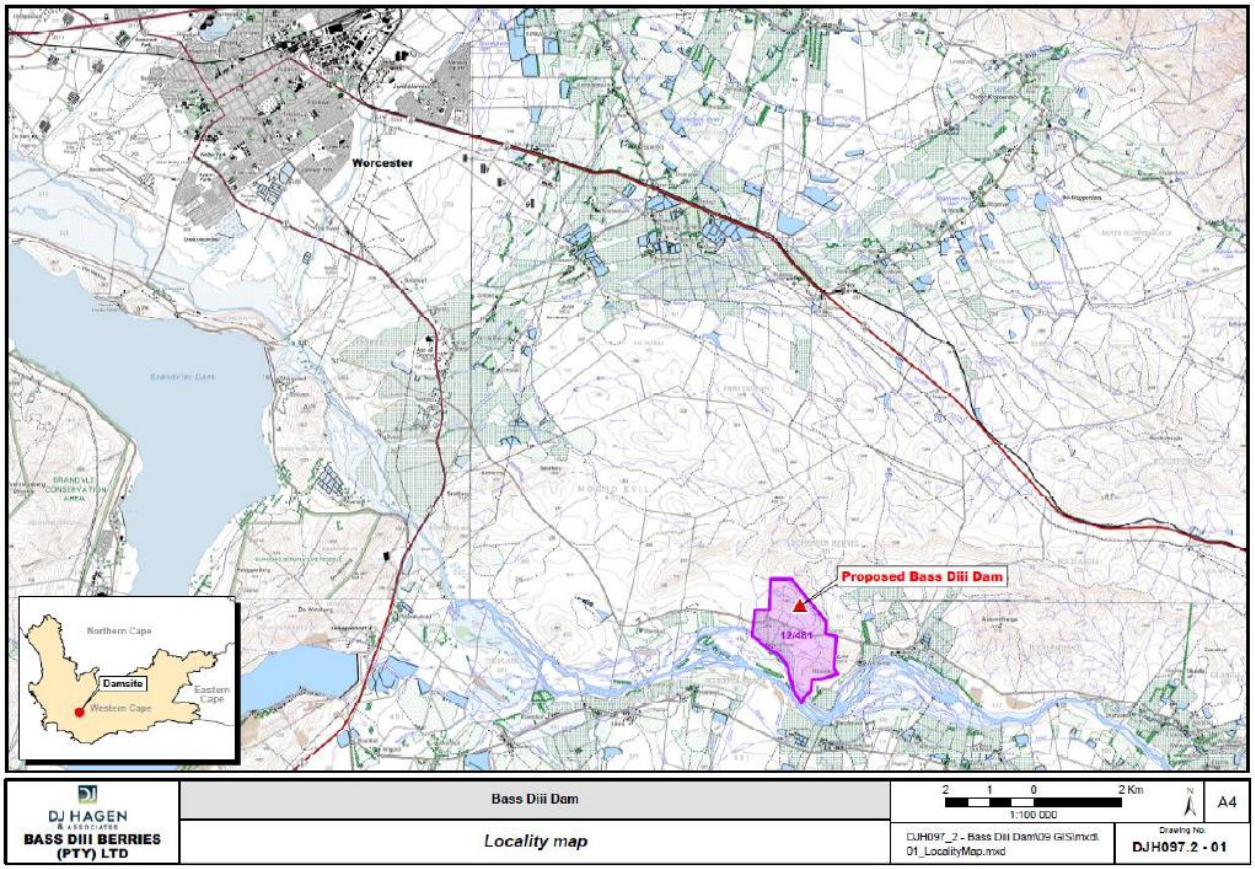


Figure 1: Locality map, showing the affected property boundary

2 Stormwater management

The project includes the following developments:

- Enlargement of a small existing dam
- Borrowing from a windblown sand borrow area
- Construction of a new pipelines and pumpstations
- Clearing of new cultivation areas

These planned developments are shown in **Figure 2** below.

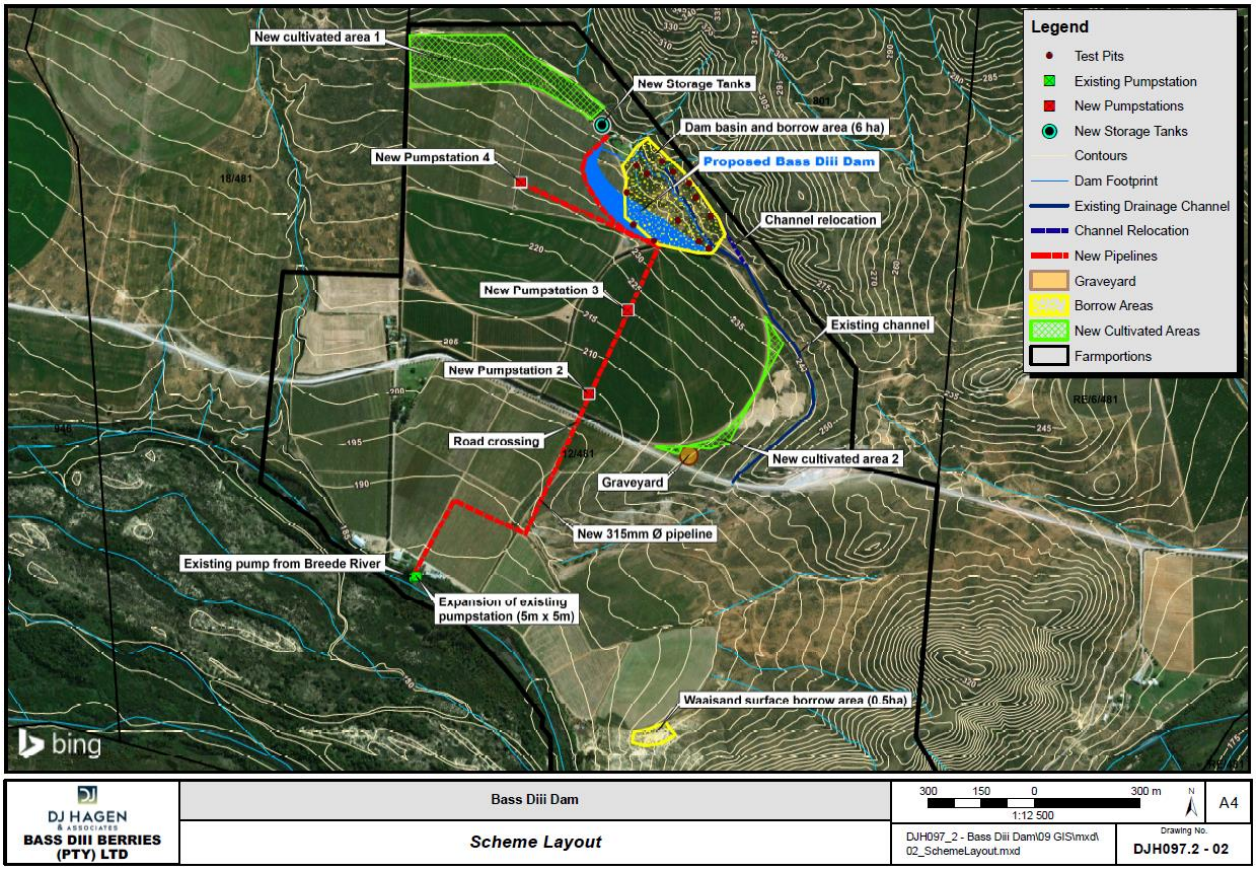


Figure 2: Bass DIII Berries planned developments

The proposed enlargement footprint is indicated in **Figure 3** (in green). The dam has not yet been classified, but it is expected that the dam will be classified as a Medium dam with a Significant hazard rating. It should be noted that the dam is deemed to be on-channel as it will be constructed in a stream, although practically 50% of the runoff is diverted around the dam basin by an existing diversion channel, which will be relocated to above the new dam basin. The diversion channel draining to the west seem to have a small capacity from the Kloof. In the event of an extreme flood, it is expected that both the diversion channels will overtop, and all water will flow into the dam basin, which should be accommodated by it's spillway. The proposed spillway will be located on the proposed dams left abutment and will drain into the drainage channel further downstream.

After the construction of the enlarged dam, the dam would provide significant flood attenuation that will reduce the impact of flow downstream of the dam. For the flood attenuation and spillway capacity refer to **Section 3 and 4**.

The dam embankment will be protected against surface erosion by placing topsoil and establishing vegetation on the downstream face, rip-rap rock protection on the upstream face and a gravel capping on the embankment crest with a crossfall of 2% to the upstream face. The spillway and its discharge channel will be excavated into erosion resistant rock with its side slopes (where in soil) topsoiled and vegetated.

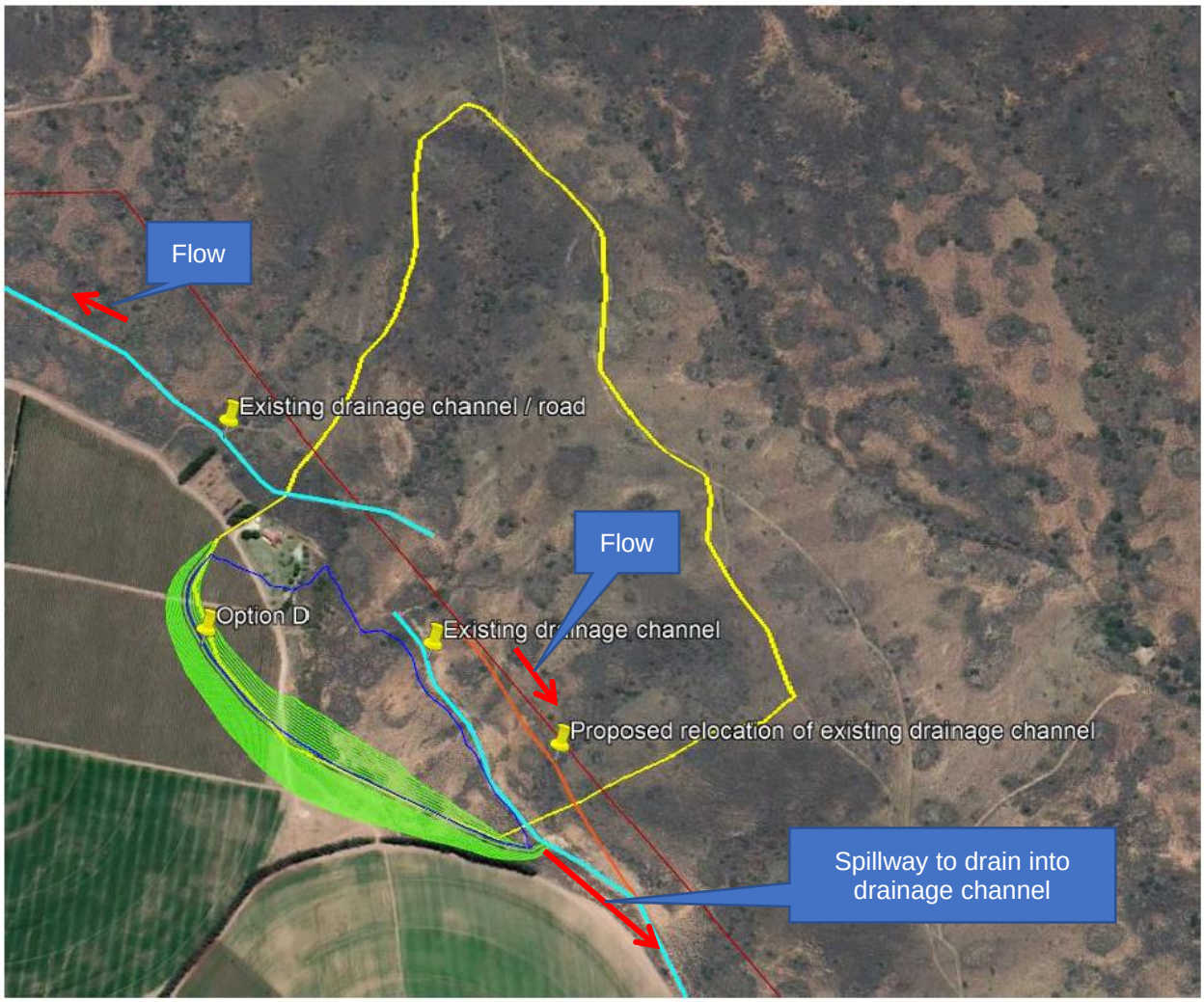


Figure 3: Proposed enlargement dam (green), catchment area (yellow), existing drainage channels (cyan), proposed relocation of existing drainage channel (orange) and property fence (red)

The proposed sand borrow area shown in **Figure 4**. This area is approx. 0.5 ha and will only be flattened, the borrow activity will not create a “hole” in the ground and the area will be left free draining after the borrowing exercise.

Figure 4: Proposed sand borrow area

All new clearing/planting areas as well as all general agricultural activities will include basic stormwater management agricultural practices such as ridging/contouring and open channels excavated into erosion resistant rock.

The impacts of the proposed development on the environment in the catchment area will be minimal since the proposed design and methods of implantation of the project will contribute to the mitigation of the naturally negative impacts of development.

3 Hydrology

3.1 Design flood guidelines

The guidelines used for the selection and determination of suitable design floods are described in the SANCOLD publication ''Guidelines on Safety in Relation to Floods'' (SANCOLD, 1991).

According to the guidelines, the design flood selection is dependent on the size of the dam as well as the hazard rating, as assigned by the Department of Water and Sanitation Dam Safety Office in terms of the regulations relating to the dam. The proposed Bass Diii Dam is expected to be classified as a Category II dam, Medium of size and with a Significant hazard potential rating. A two-assessment level approach should be followed.

The criteria for the first assessment level form a relatively coarse screen, through which many existing dams would pass, leaving only those caught on the screen to be given detailed scrutiny at the second assessment level. At the first assessment level, the recommended floods are based on the Regional Maximum Flood (RMF) and at the second assessment level the floods should be determined by using site-specific methods. As the concept of the RMF cannot be applied to the proposed Bass Diii Dam (small area 0.2 km^2 < 10 km^2), the second assessment level should be used for designing the spillway.

At the first level assessment, the Recommended Design Discharge (RDD) is 1:100-year flood and the Safety Evaluation Discharge (SED) is based on the Regional Maximum Flood (RMF) of a region numerically one step lower than that in which the catchment lies. At the second assessment

level, the Recommended Design Flood (RDF) should be the 1:100-year flood and the Safety Evaluation Flood (SEF) is equal to the Probable Maximum Flood (PMF) multiplied by a factor which is dependent on the RMF. Since the RMF concept is not considered applicable for Bass Diii Dam, it was decided to revert to the 1986 SANCOLD Guidelines to determine the SEF. The factor for a Medium dam with a Significant hazard rating according to the guidelines is 0.7.

3.2 Catchment characteristics

The dam's catchment area is shown in **Figure 3** and relevant parameters are provided in **Table 1**. Also, refer to **Appendix A**.

Table 1: Bass Diii Dam catchment characteristics

Characteristic	Value
Catchment area (km²)	0.2
Mean annual precipitation (MAP) (mm)	347
Length of longest water course (km)	0.5
Average river slope (m/m)	0.13
Time of concentration (hr)	0.25
Runoff coefficients for Rational Method: RDF PMF	 0.26 0.54
Point rainfall for t_c 1:100 year [1)] PMF[2)]	 17 mm 83 mm

1) RDF = 100D point rainfall of 66 mm for 1-day rainfall for Onderplaas Rainfall Station No 0023100_W (Smithers & Schulze, 2002)
2) PMF = 360 mm for 1-day extreme point rainfall zone 6 & 7 according to HRU1/72.

3.3 Flood peaks and design floods

The flood peaks calculated with the Rational Method on the abovementioned catchment characteristics are summarised below:

Table 2: Incoming flood peak magnitudes

Rational Method	Inflow
RDF (1:100 yr RI)	1 m^3/s
PMF (PMP = 360 mm 1-day)	10 m^3/s
SEF (0.5 x PMF)	5 m^3/s

The incoming flood peaks were routed through the enlarged dam basin and bywash spillway channel with a typical inflow hydrograph (rising limb 1 x Tc and 2 x Tc falling limb). The design flood peaks are summarised below.

Table 3: Design flood peaks routed magnitudes

Rational Method	Inflow	Outflow
RDF (1:100 yr RI)	1 m^3/s	0.03 m^3/s
SEF (0.5 x PMF)	5 m^3/s	0.3 m^3/s

The flood routing graphs is included in **Appendix A**. Refer to Section 4 for the flood levels discharged through the spillway. It should be noted that substantial routing will take place due to the small inflow volume vs the large basin storage capacity at the FSL.

4 Spillway and flood levels

4.1 Spillway type and stability

The spillway will consist of trapezoidal spillway channel excavated into harder/less weathered shale material on the left flank with a bottom width of 2 m across from the dam crest. Side slopes are 1V:2H on the left flank and 1V:2H on the right flank. The side slopes of the discharge channels will be top-soiled and grassed where it is in soil to limit erosion.

The water level control will consist of a reinforced concrete cut-off wall excavated into shale rock which will extend up to the NOC level of 62 masl. Spillway design and details drawings will be provided as part of the detail design.

4.2 Flood levels

The discharge capacity of the spillway is calculated by using an approximate equation based on the effective width (base width of 40% of the difference between the base width and the top width) of the trapezoidal channel (side slopes 1V:2H). A discharge coefficient of 1.45 (broad-crested weir) was calculated. The maximum spillway discharge capacity is calculated as 5.2 m^3/s, with the water level in the dam at NOC level of 62 masl. The flood levels for the design floods are summarised below:

Table 4: Flood peaks and water levels summary

Flood category	Flood peak inflow (m^3/s)	Flood peak outflow (m^3/s)	Max Water level (m)	Height above FSL RL 61 (m)	Height above NOC RL 62 (m)
RDF (1:100 yr)	1	0.03	61.04	0.03	-0.97
SEF (0.7xPMF)	7	0.5	61.27	0.27	-0.73

From **Table 4** above it is clear that the spillway and freeboard arrangements are sufficiently sized to safely discharge the routed flood magnitudes.

4.3 Freeboard

Various combinations of conditions are recommended in the SANCOLD Guidelines (SANCOLD, 2011) for determining the minimum recommended freeboard allowance. The results of calculations for the combinations that usually lead to the highest freeboard requirement based on the dam's classification, is summarised below:

Table 5: Freeboard calculations

Aspect	Values
Full Supply Level (masl)	61.0
Non-Overspill Crest level (masl)	62.0
Maximum outflow head (RDF) above FSL (m)	0.04
Maximum outflow head (SEF) above FSL (m)	0.27
Wave water level (1:100 yr RI):	
Wave height, $H_{2\%}$ (m)	0.86
Wave run-up (m)	0.77
Minimum calculated freeboard required (RDF + wave run-up)	0.81
Minimum calculated freeboard required {SEF} {alternative case}	0.27
Provided freeboard (m)	1.0

From **Table 5** above, it is clear that the 1.0 m design freeboard is sufficient for both required cases (RDF + wave run-up and SEF). The guidelines recommend a minimum freeboard of 1.54 m which is based on the minimum difference in level between still-water RDF surcharge level and non-overspill crest (m) + 1.5 m additional freeboard (dependant on the classification of the dam (Cat II or III). This is however considered to be too conservative for Bass Diii Dam and the site-specific parameters and the design freeboard of 1.0 m is deemed acceptable. Refer to **Figure 5** below for the measurement of the fetch length which influences wave run-up.

Figure 5: Fetch measured length

5 Conclusions and recommendations

Good stormwater management practices are currently being followed on the Bass DIII Berries farm. Stormwater erosion will not be an issue once the enlarged dam and developments are completed in accordance with the designs.

The dam's detail design includes a spillway, designed to reduce the peak outflows. All new clearing/planting areas as well as all general agricultural activities will include basic stormwater management agricultural practices such as ridging/contouring and open channels excavated into erosion resistant rock.

Yours faithfully

DJ Hagen & Associates

DJ Hagen
Pr Eng

C Starke
Engineer

Appendix A: Hydrology, flood routing and storage capacity table

RATIONAL METHOD

CATCHMENT DESCRIPTION	**Bass Diii Dam**	**CALC BY:**	**C Starke**
LOCATION:	**Worcester**	**DATE:**	**2021-07-28**

PHYSICAL CHARACTERISTICS

			AREA DISTRIBUTION FACTORS α+β+Ϋ=1		
			RURAL α	URBAN β	LAKES Ϋ
Size (A)	0.2	km^2			
Longest collector (Lc)	0.5	km			
Average slope	0.13	m/m			
Dolomitic	0	%	1.00	0.00	0.00

Input
Calculated

RURAL						URBAN	
SURFACE SLOPE	**%**	**PERMEABILITY**	**%**	**VEGETATION**	**%**	**USE**	**%**
Vleis & pans	0%	Very permeable	0%	Thick bush & plantation	100%	Lawns & parks	0%
Flat	80%	Permeable	20%	Light bush & farmlands	0%	Residential	0%
Hilly	20%	Semi permeable	20%	Grasslands	0%	Industrial	0%
Steep	0%	Impermeable	60%	No vegetation	0%	Commercial	0%
TOTAL	100%		100%		100%		0%

RAINFALL

Mean annual rainfall (mm)	347
Storm duration (h)	**0.25**

NOTE: 1). Storm duration (h) = Tc (h)
2). Mean annual rainfall (mm) = MAP (mm)

RETURN PERIOD (YRS)	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**PMF**
Point rainfall (mm)	32.00	42.00	48.00	53.00	61.00	66.00	72.00	360.00
Point intensity (mm/h)	29.44	38.64	44.16	48.76	56.12	67.40	73.53	331.20
Area reduction factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average intensity (i) (mm/h)	29.44	38.64	44.16	48.76	56.12	67.40	73.53	331.20

RUNOFF FACTOR

RETURN PERIOD (YRS)	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**PMF**
Rural (C1)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.54
Urban (C2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lakes (C3)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Combined (C=αC1+βC2+ϒC3)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.54

PEAK FLOW Qp

RETURN PERIOD (YRS)	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**PMF**
Qp (CiA/3.6) (m3/s)	0.43	0.57	0.65	0.72	0.82	0.99	1.08	9.97
Adjustment factor (Ft)	0.75	0.80	0.85	0.90	0.95	1.00	1.00	1.00
Adj peak (QpxFt) (m3/s)	**0.3**	**0.5**	**0.6**	**0.6**	**0.8**	**1.0**	**1.1**	**10.0**

NOTE:

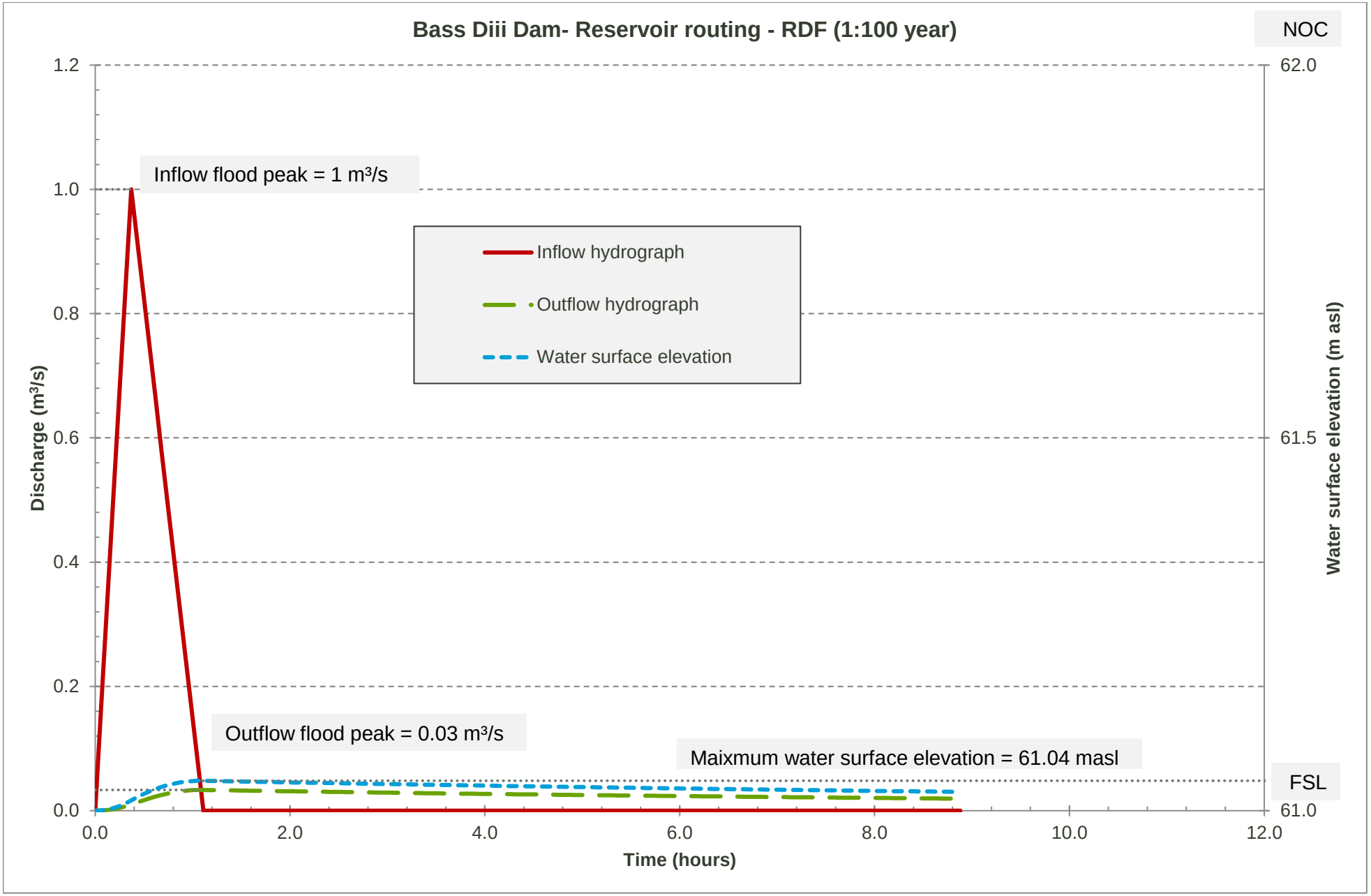
1). Point rainfall (mm) can be obtained from SAWB - Design rainfall depths at selected stations in South Africa or using design rainfall estimation software.

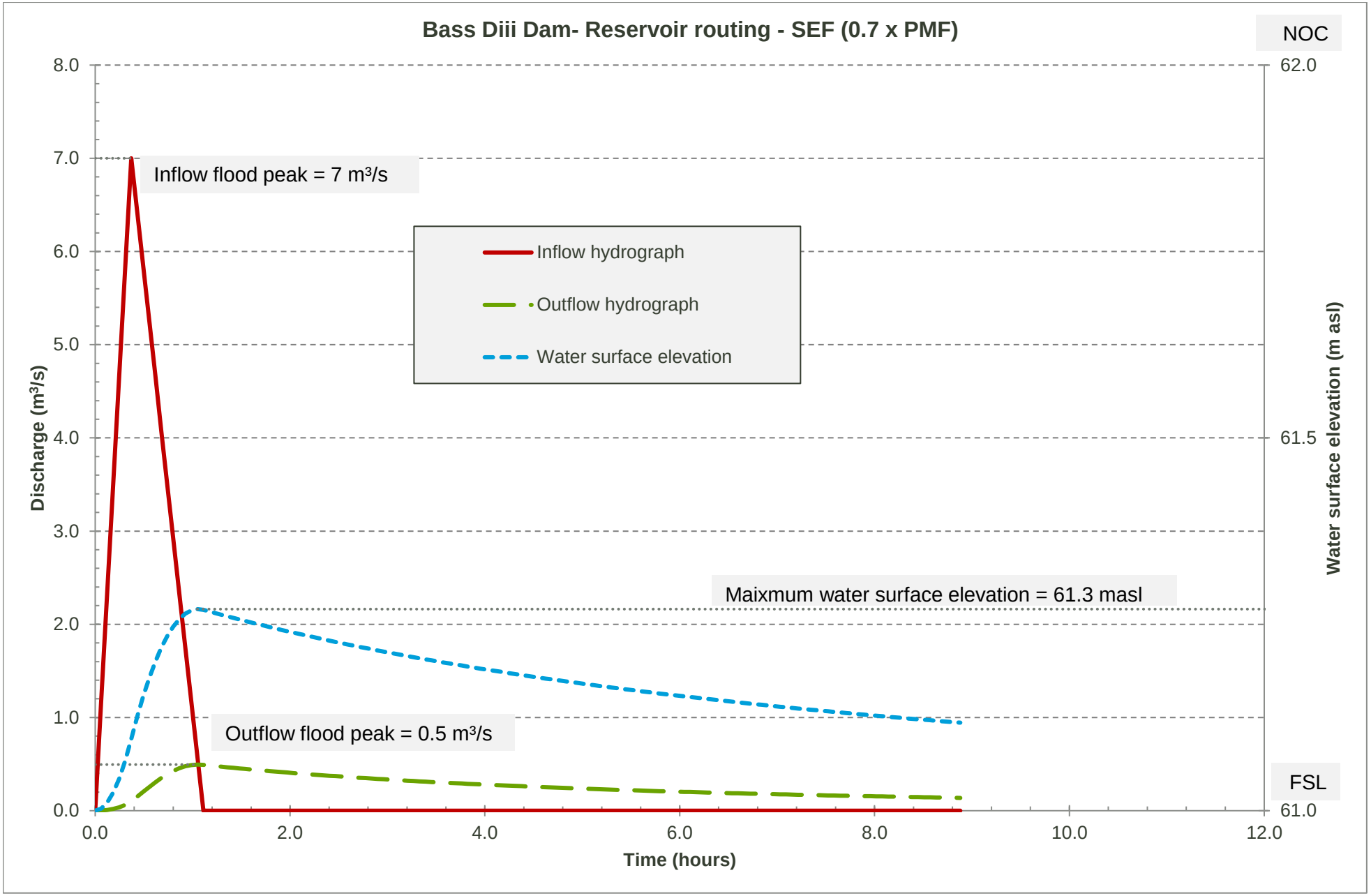
2). Point rainfall (mm), the probable maximum precipitation (PMP) can be obtained from Figure 3.22 (Maximum observed point rainfall in South Africa) for estimation of the Probable Maximum Flood (PMF).

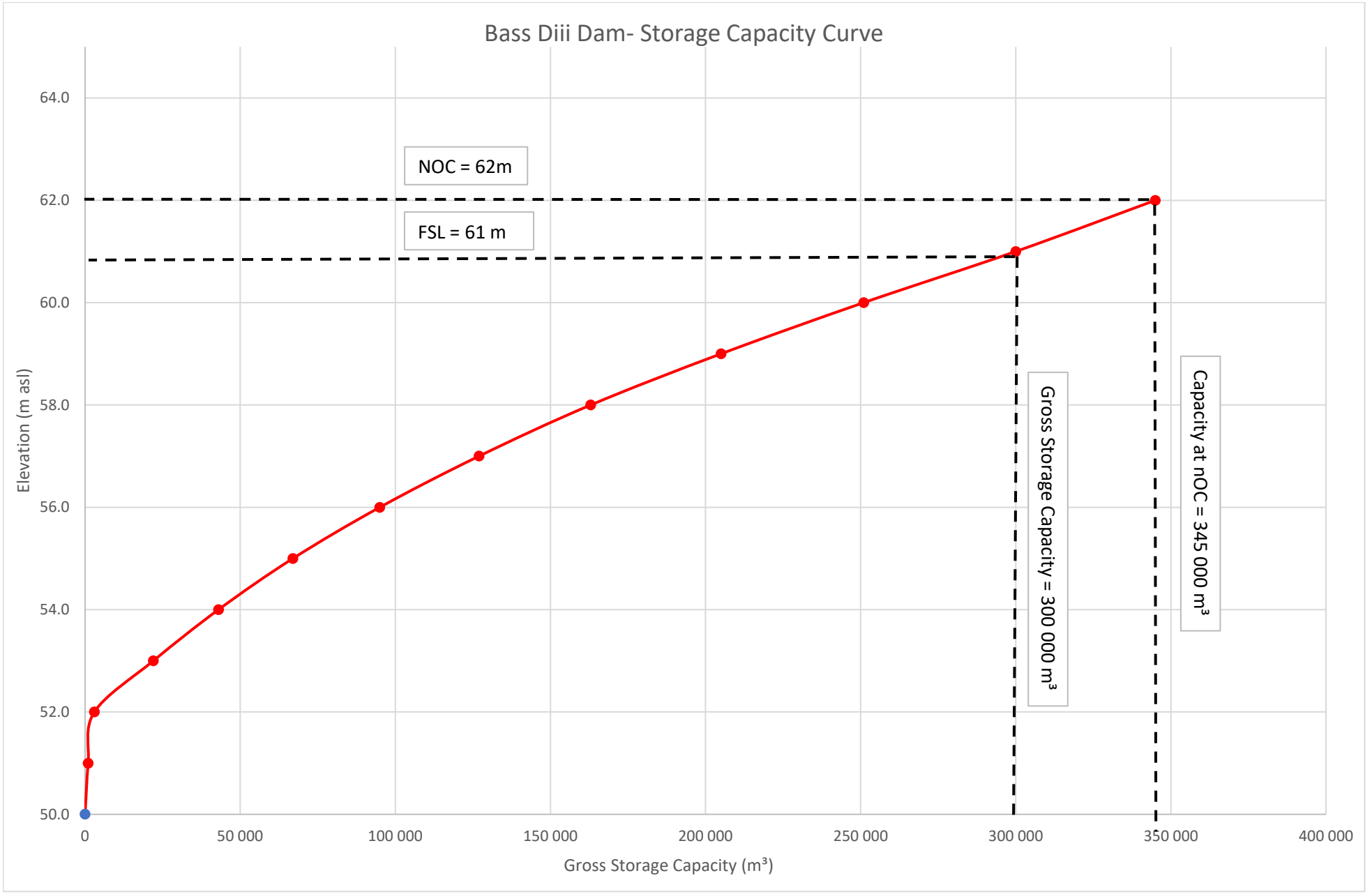
	SEF
	SEF = PMF x Factor
Factor	0.7
Q (m^3/s)	**7.0**

RECOMMENDED VALUES OF RUNOFF FACTOR C

	RURAL (C1)				**URBAN (C2)**		
COMPONENT	CLASSIFICATION	MEAN AVERAGE RAINFALL (mm) <600	600-900	>900	USE	CLASSIFICATION	FACTOR
SURFACE SLOPE Ch	Vlei's & pans (<3%)	0.01	0.03	0.05	LAWNS & PARKS	Sandy, flat (<2%)	0.05-0.10
	Flat (3-10%)	0.06	0.08	0.11		Sandy, steep (>7%)	0.15-0.20
	Hill (10-30%)	0.12	0.16	0.20		Heavy soil, flat (<2%)	0.13-0.17
	Steep (>30%)	0.22	0.26	0.30		Heavy soil, steep (>7%)	0.25-0.35
Selected values		**0.07**	**0.10**	**0.30**			0.00
PERMEABILITY Cd	Very permeable	0.03	0.04	0.05	RESIDENTIAL	Houses	0.30-0.50
	Permeable	0.06	0.08	0.10		Group housing	0.50-0.70
	Semi permeable	0.12	0.16	0.20		Flats	0.60-0.80
	Impermeable	0.21	0.26	0.30			
Selected values		**0.16**	**0.20**	**0.24**			0.04
VEGETATION Cp	Thick bush & plantation	0.03	0.04	0.05	INDUSTRIAL	Light industry	0,50-0,80
	Light bush & farmlands	0.07	0.11	0.15		Heavy industry	0,60-0,90
	Grasslands	0.17	0.21	0.25			
	No vegetation	0.26	0.28	0.30			
Selected values		**0.03**	**0.04**	**0.05**			0.00
Rural factor		1.00	0.00	0.00	COMMERCIAL	City centre	0.70-0.90
						Suburban	0.50-0.70
						Streets	0.70-0.95
Selected values							0.06
Total		**0.26**	**0.00**	**0.00**			**0.00**
Cmax		0.54	0.64	0.90			
Rural factor		1.00	0.00	0.00			
Cmax		**0.54**	**0.00**	**0.00**			


Bass Diii Dam- Reservoir routing - RDF (1:100 year)
NOC
FSL
Inflow flood peak = 1 m³/s
Outflow flood peak = 0.03 m³/s
Maixmum water surface elevation = 61.04 masl
Inflow hydrograph
Outflow hydrograph
Water surface elevation
Discharge (m³/s)
Water surface elevation (m asl)
Time (hours)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
62.0
61.5
61.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0


Bass Diii Dam- Reservoir routing - SEF (0.7 x PMF)
NOC
FSL
Inflow flood peak = 7 m³/s
Outflow flood peak = 0.5 m³/s
Maixmum water surface elevation = 61.3 masl
Inflow hydrograph
Outflow hydrograph
Water surface elevation
Discharge (m³/s)
Water surface elevation (m asl)
Time (hours)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
62.0
61.5
61.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0


Bass Diii Dam- Storage Capacity Curve
64.0
62.0
60.0
58.0
56.0
54.0
52.0
50.0
Elevation (m asl)
NOC = 62m
FSL = 61 m
Gross Storage Capacity = 300 000 m³
Capacity at nOC = 345 000 m³
0
50 000
100 000
150 000
200 000
250 000
300 000
350 000
400 000
Gross Storage Capacity (m³)

Appendix B: Spillway capacity and freeboard

Spillway capacity

Project No DJH097.2
Project name Bass Diii Dam
Area Worcester
Overflow depth to low concrete gravity structure

Date 2021/07/28
Cherie Starke

Parameter	Value	
	Spillway	Embankment crest
Crest length, L (m)	2.00	530.00
Crest Level (m)	61.00	62.00
Crest width, l (m)	5.00	4.00
Non-overspill crest level (m)		
Side slope (1V : H) RIGHT	2.00	
Side slope (1V : H) LEFT	2.00	
Freeboard	1.00	0.00

Discharge

$$Q = CL_eH^{1.5}$$

Discharge coefficient

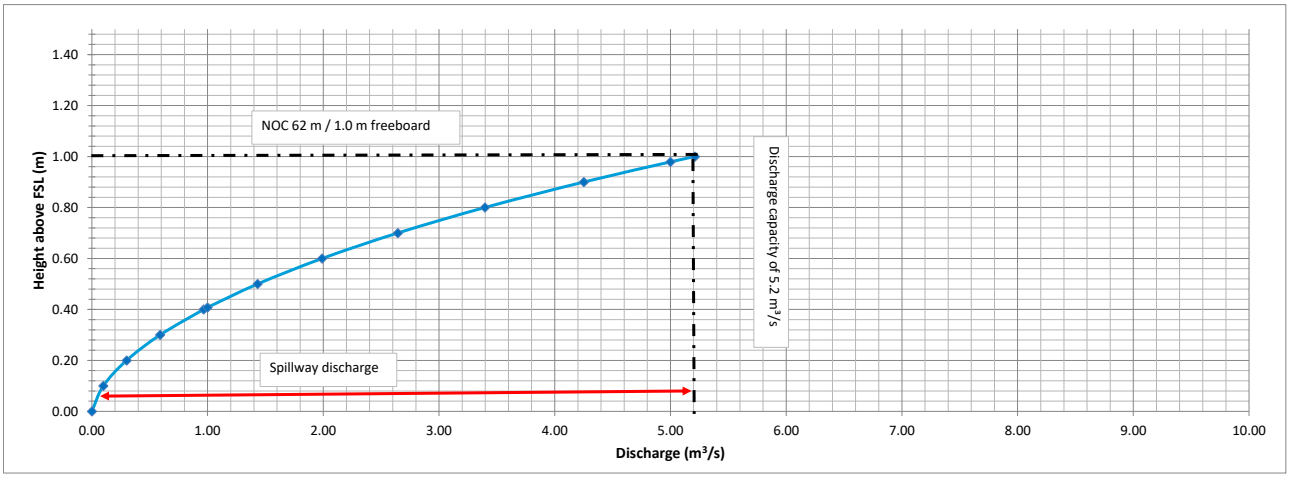
$$C_d = \sqrt{2g} \times 0.42\left[1 - \frac{2}{9(1+(\frac{H}{w})^4}\right]$$ ....(eq. Rao & Muralidhar)

Input

Flood Magnitudes

RDF	1.0	0.03
SEF	7.0	0.5

Water level (m)	Head above FSL (m)		Discharge coefficient, C		Discharge (m3/s)			
	Spillway	Embankment crest	Spillway	Embankment crest	Spillway	Embankment crest	TOTAL	
61.00	0.00	0.00	1.45	1.45	0.00	0.00	0.00	**FSL**
61.10	0.10	0.00	1.45	1.45	0.10	0.00	0.10	
61.20	0.20	0.00	1.45	1.45	0.30	0.00	0.30	
61.30	0.30	0.00	1.45	1.45	0.59	0.00	0.59	
61.40	0.40	0.00	1.45	1.45	0.97	0.00	0.97	
61.41	0.41	0.00	1.45	1.45	1.00	0.00	1.00	RDF (Inflow)
61.50	0.50	0.00	1.45	1.45	1.43	0.00	1.43	
61.60	0.60	0.00	1.45	1.45	1.99	0.00	1.99	
61.70	0.70	0.00	1.45	1.45	2.64	0.00	2.64	
61.80	0.80	0.00	1.45	1.45	3.40	0.00	3.40	
61.90	0.90	0.00	1.45	1.45	4.25	0.00	4.25	
61.98	0.98	0.00	1.45	1.45	5.00	0.00	5.00	SEF (inflow)
62.00	1.00	0.00	1.45	1.45	5.21	0.00	5.21	NOC



Freeboard Calculations for Bass Diii Dam

Project Number:	DJH097.2	**Date:**	2021/07/28
Title:	Bass Diii Dam	**Calculated by:**	C Starke
River:	Tributary of Bree River		Input
Location:	Worcester		Calculated

1. DAM DETAILS

Dam name	Bass Diii Dam		Full Supply Level	61.00	masl
Full Supply Volume	0.30	Mm^3	Non Overspill Crest	62.00	masl
Full Supply Area	4.00	ha	Bed level	50.00	masl
Depth at wall	11.0	m	Available freeboard	1.00	m
Wall height (as per regulations)	18.3	m			
Average depth	15.0	m	Spillway Type	By-wash channel	
			Spillway base width	2.00	m
Dam Size	Medium		NOC Length	530.00	m
Hazard Rating	Low				
Dam Category	II		Upstream slope	3.00	H:1V
Dam Type	Earthfill dam		Upstream slope protectio	Rough - Rip-rap (double layer)	

2. FLOOD SURCHARGE

Flood level at the dam wall after taking attenuation into account (either via level pool flood routing or hydrodynamic modelling).

Recommended Design Flood (RDF)			Safety Evaluation Flood (SEF)		
Recurrence Interval	100	years	Recurrence Interval	0.7*PMF	
Inflow	1.00	m^3/s	Inflow	5.00	m^3/s
Outflow	0.03	m^3/s	Outflow	0.50	m^3/s
Maximum Water Elevation	61.04	masl	Maximum Water Elevatio	61.27	masl
Level above spillway	0.04	m	Level above spillway	0.27	m

3. DAM BREAK FLOOD SURCHARGE

Should an upstream dam fail, the additional volume of water which enters the dam should be accounted for in the flood routing.

Dam break flood surcharge (incremental above normal flood event)	0.0	m

4. GATE FAILURE SURCHARGE

Whenever there are controlled gates at a dam that are relied upon to release flood water, it must be assumed that 25% of these will not be operable (ie closed).

Gate failure surcharge (incremental above normal flood event) - 1 of 4 gates fails	0.00	m

5. WIND SPEED AND FETCH

The base wind speed can be determined either from available data, weather models or from the graphs presented in the SANCOLD freeboard guidelines, 2011 (See Figure A)

Fetch

Fetch length (longest straight line distance from the dam to the edge of the basin)	400	m

Note that, in certain conditions, wave effects can move around slight bends in the basin reservoir.

Wind speed

1:100yr Mean hourly wind speed (from Figure A) at 10 m elevation	22.0	m/s
Determine time required for wind to reach generation equilibrium (from Figure B)	0.12	hours
Adjustment factor to convert hourly wind speed to duration wind speed	1.07	-
Mean duration wind speed (1:100yrs)	23.52	m/s
Adjustment factor to convert overland wind speed to over water wind speed (from Figure C)	1.20	-
Over water wind speed	28.22	m/s

6. WIND SET-UP

Wind set-up is the result of surface water being driven in the downwind direction resulting in a build up of water against the dam wall.

Fetch multiple	1.0	

Note that, wind set-up effects can move around substantial bends in the basin reservoir (hence the fetch is often doubled).

Wind set-up	0.01	m

7. DESIGN WAVE HEIGHT

The calculations provided in the SANCOLD 2011 guidelines are provided in the "SANCOLD calcs" tab

Significant wave height (H_s)	0.56	m
Allowance for overtopping	1.10	

Use this factor with caution: It assumes that concrete dams can readily be overtopped whereas earthfill dams are vulnerable to downstream erosion. This may or may not be the case. Use cell U63 if needed.

Design wave height	0.62	m
2% Exceedence wave height ($H_{2\%}$)	0.86	m

8. WAVE RUN-UP

The calculations provided in the SANCOLD 2011 guidelines are provided in the "SANCOLD calcs" tab

Base Wave Run-up ($R_{2\%}$)	0.77	m
Wave angle to dam wall (0° is normal to the wall)	0	°
Adjustment for oblique wave front ()	1.00	
Foreshore slope (see figure alongside)	25	H:1V
Adjustment for shallow foreshore ()	1.00	
Additional adjustment factor (to account for berms, …)	1.00	
Recommended (Design) wave run-up	0.77	m

9. SEICHES AND SURGES

Surges refer to rises in the reservoir level induced by variations in atmospheric pressure. Only applicable to medium (0.5m for >10km2) or large reservoirs (1.0m for >100km2).

Atmospheric pressure variation surge allowance 0.00 m

Seiches refer to long-period oscillations that persist in a body of water due to resonance of its natural modes with an external wave (such as the closing of a gate, squalls, flash floods, ...) - from local data.

Oscillation / Seiche allowance 0.00 m

10. EARTHQUAKES

Refer to Figures D to determine waves caused by earthquakes. Usually only applicable to concrete dams.

Ground acceleration	0.16	g
Oscillation period	2.00	s
Amplitude of movement	0.16	m
Amplitude of wave	0.16	m

11. LAND SLIDES

Only applicable to reservoirs with steep and unstable slopes.

Water depth	15.00	m
Slide volume falling into the reservoir (ie volume of water displaced)	0	m^3
Slide width	20.0	m
Density ratio of slide material to water (ρ_s/ρ_w)	1.60	
Impact angle (α)	30.0	°
Radius from centre of slide impact	2 000	m
Propagation direction (γ) (see figure alongside)	90.00	°
Wave height	0.00	m
Wave amplitude	0.00	m

12. COMBINING FREEBOARD COMPONENTS

The above freeboard elements are to be combined using the following criteria

	RDF Water Level	SEF Water Level	Wave Run-up	Wind Set-up	Surges & Seiches	Earthquake	Landslide	Flood gates failure	
1	x		x						0.81 m
2	x		x	x	x				0.81 m
3						x			0.16 m
4	x						x		0.04 m
5	x		x	x	x			x	0.81 m
6		x							0.27 m

Dam Size	Medium	
Hazard Rating	Low	
Freeboard criteria	1;5;6	
Required freeboard	0.81	m

12.1 MINIMUM FREEBOARD REQUIREMENTS

Despite the above calculations there are certain minimum freeboard requirements that should be met.

Type of dam	Minimum total freeboard (m)	Minimum difference in level between stillwater RDF surcharge level and non-overspill crest (m)
Earthfill (Category I)	0.8	0.5
Earthfill (Categories II & III)	0.0	1.5
Rockfill (Categories II & III)	0.0	1.5
Concrete (Categories II & III)	1.5	1

Minimum freeboard for a Category II, Earthfill dam 1.54 m

13. FREEBOARD RESULTS

Required freeboard	1.54	m
Provided freeboard	1.00	m

INSUFFICIENT FREEBOARD

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