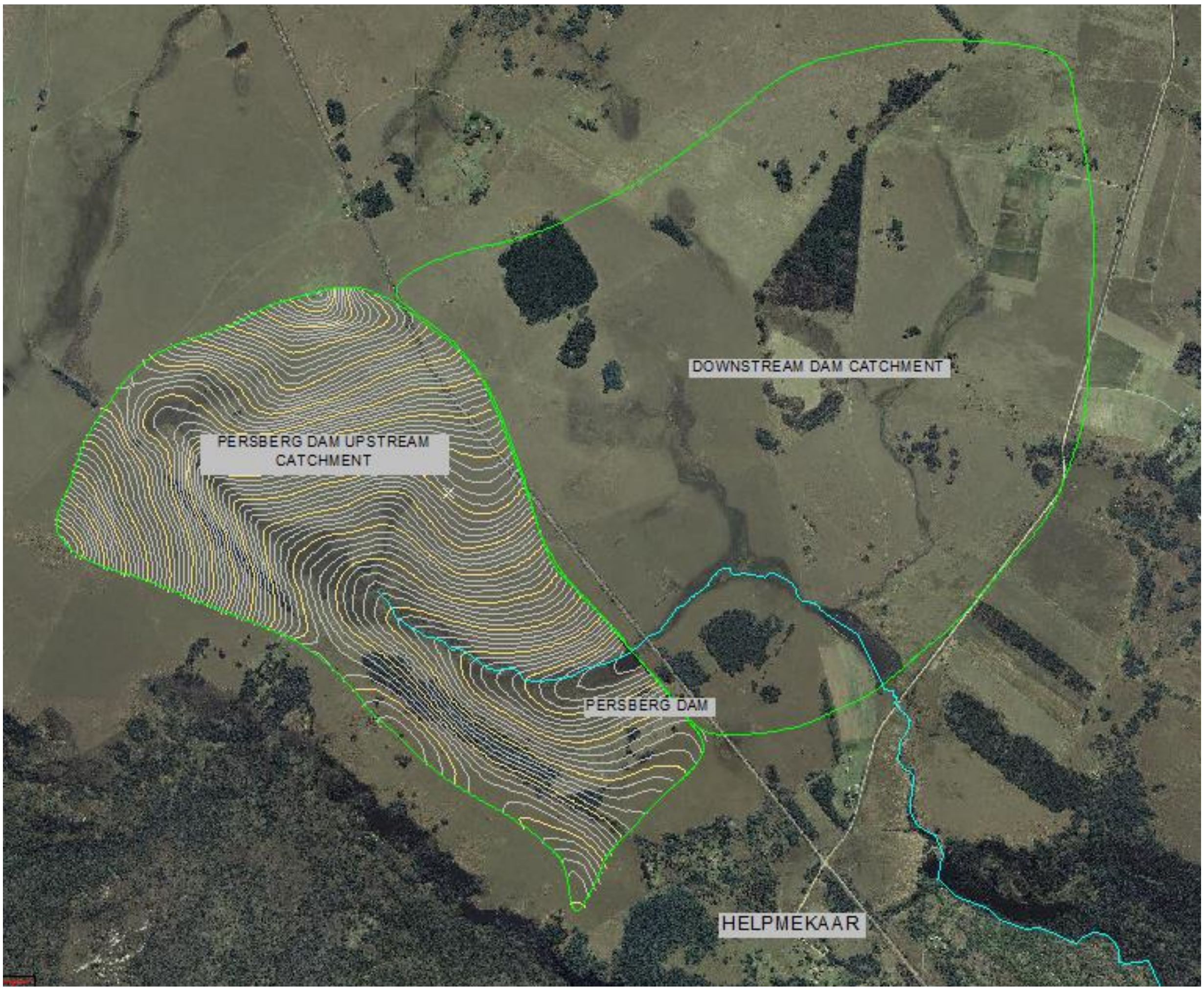
PERSBERG FARM DAM

HYDROLOGY AND DAM SAFETY REPORT

19 JANUARY 2016



EMPLOYER:	ENGINEER:
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PERSBERG FARM DAM

HYDROLOGY REPORT

19 JANUARY 2016

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PERSBERG FARM DAM

HYDROLOGY REPORT

19 JANUARY 2016

1. QUALITY MANAGEMENT AND APPROVALS

STATUS OF REPORT: DRAFT

Approved by GFK Consulting Engineers cc

………………………. ………………….

F.Krugel Date

Accepted and Approved by the Employer

……………………………………………….. ………………..

Employer Date

………………………………………………..…...(Print name)

PERSBERG FARM DAM

HYDROLOGY REPORT

19 JANUARY 2016

EXECUTIVE SUMMARY

The analysis indicates that the dam yield at the current volume with the proposed 90ha maize and 40ha oats will not nearly be sufficient to meet the full irrigation demand. It is proposed to plant a smaller area of both maize and oats to reduce the risk of the dam running empty. In our opinion planting 30ha maize and 10 ha oats will result in an acceptable risk of the dam running empty.

The present spillway capacity is inadequate. The eventual size will depend on the final selected full supply level and the safety categorization. As an interim measure we propose that the spillways be cut level as per attached drawing, each one at least 14m wide, minimum 1.2m deep. Tyres are used as the current rip rap. It is suggested to extend the tyres to the crest of the dam wall to accommodate wave action. The tyres would need to be anchored properly to avoid lifting up and moving.

A dam with a capacity of just under 50 000m^3 would still yield water at an acceptable risk with 30 ha maize and 10 ha oats, although the risk will be slightly higher of running empty. Obviously the owner can evaluate the feasibility of planting oats after the rainy season by evaluating the dam levels prior to planting each year. Should the volume be lower than 50 000 m^3 the dam would not need to registered but a licence to store and use water will still be required.

It was found that the increased capacity of the upstream Persberg Farm Dam will not negatively impact on the downstream dam, as the lower dam has its own significantly larger catchment and there is no water demand from the dam at present.

Soil compaction tests indicate that the compaction on top is less than what is generally prescribed for earth dams. However, DCP tests indicate an increase of compaction with depth and it is estimated that the general required compaction has been achieved from approximately 2 m deep from the crest and deeper, where it is the most important.

A slope stability analysis indicates that both the upstream and downstream slopes are safe, as the safety factors are above the required minimum.

Due to the fairly high permeability of the embankment material and the absence of any vertical cut-off drains, there may be some seepage on the downstream slope. It is recommended that a sand cut-off filter/drain be cut into the downstream toe and a 110mm drainage pipe be placed at the bottom of the filter. This would allow seepage water to be collected safely in the filter and drained downstream of the dam.

A dam break analysis indicates that in the event of a "Sunny day" dam break, with a full breach developing in 12 minutes, that the resulting flood water will overtop the road by approximately 100mm. In the event that the breach develops over 18 minutes the resulting flood water will safely pass under the road through the culvert. In accordance to statistics there is a slight possibility that such a breach can develop in 12 minutes. It is debatable whether a flood over a very short time of 100mm deep over the road will impose a serious enough risk to classify the dam as a Category II dam.

Our recommendation would be to immediately make the recommended changes to the spillways etc. but that the Dam Safety Office of Department of Water Affairs is requested to categorize the dam at its present full supply level or recommend at what volume the dam would be acceptable from a safety risk perspective. Should the full supply level be dropped (without lowering the wall) to just less than 50 000m^3 a "sunny day" dam break will pass safely under the road through the culvert.

2. INTRODUCTION

GFK Consulting Engineers were appointed by Mr. Erich Müller to undertake a Hydrology Assessment and a Safety Analysis of the dam on the farm Persberg, for development appraisal and dam/water use licencing purposes.

3. GENERAL CLIMATOLOGICAL DATA.

The site lies within quaternary catchment number V33B.

Quaternary catchment details extracted from WR 2012 are as follows:

Table 1: Quaternary Catchment Details

Quaternary Catchment	Catchment Area		Forestry	Alien Vegetation	Irrigation	Rainfall		S Pan	MAR
	Gross (km²)	Net (km²)	Area (km²)	Area (km²)	Area (km²)	Zone	MAP (mm)	(mm)	Net (mcm)
V33B	407	407	0	1	0.09	V3D	736	1500	24.61

Climatological data from rainfall station 335746W was used to determine the mean annual precipitation used for the analysis of 736mm. This station lies approximately 3 km south of the site. The monthly Symons Pan evaporation was obtained from station W2E004 and adjusted using the MAE of the quaternary catchment as published by the Water Research Commission (WRC). Station W2E004 is situated at Klipfontein dam just south of Vryheid. The A-Pan evaporation was determined from the SA Atlas isohyets at the site of the dam.

The evaporation and rainfall indicated in Table 2.3 and 4 are as follows:

Table 2: Evaporation

Evaporation (mm)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Symons Pan	141	149	158	153	131	127	104	95	83	94	123	142	1500
A-Pan	164	166	194	187	157	146	125	108	94	104	140	159	1744

Table 3: Monthly evaporation station for W2E004 adjusted for local Mean Annual Evaporation.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1985	169	158	139	130	93	93	97	142	139	151	182	149	1641
1986	153	48	149	104	101	95	104	140	155	155	152	177	1533
1987	184	162	141	114	129	91	113	122	104	129	127	170	1585
1988	167	156	140	123	101	90	100	126	126	140	153	147	1569
1989	155	102	141	106	92	78	102	144	170	166	138	169	1563
1990	167	146	134	110	92	94	95	119	140	143	193	163	1595
1991	151	131	113	137	106	78	102	142	143	151	170	173	1597
1992	169	174	150	135	134	113	107	141	161	198	185	192	1858
1993	189	118	129	119	110	89	105	124	150	131	152	165	1581
1994	154	139	138	101	94	107	106	120	158	156	168	188	1629
1995	194	173	138	113	89	84	112	144	168	152	152	160	1679
1996	147	126	126	103	68	95	82	119	201	165	171	194	1596
1997	169	155	106	116	90	104	87	135	129	129	152	146	1519
1998	154	144	142	105	119	102	96	126	150	140	147	162	1585
1999	176	147	152	126	102	94	101	127	130	127	147	123	1552
2000	110	94	106	79	70	59	88	108	140	110	117	140	1223
2001	152	111	126	82	80	70	73	110	129	118	118	140	1308
2002	159	111	129	102	94	69	89	82	116	140	145	136	1371
2003	153	132	148	103	86	54	82	128	114	164	134	174	1471
2004	130	107	84	87	80	68	69	101	111	153	162	153	1306
2005	138	122	118	85	93	84	87	113	146	136	155	156	1433
2006	124	112	97	85	89	64	93	105	118	132	132	179	1331
2007	168	164	137	97	107	75	108	125	149	109	135	147	1521
2008	128	145	122	85	71	57	96	123	144	145	142	161	1418
2009	137	110	112	94	81	70	76	105	118	112	114	153	1282
2010	125	130	128	84	100	70	75	116	167	139	137	158	1429
2011	153	131	127	105	95	78	94	123	142	141	149	158	1496
2012	153	131	127	104	95	87	94	123	142	141	149	139	1485
2013	128	119	102	102	102	97	83	139	148	138	163	115	1435
2014	147	135	110	92	92	98	95	118	173	125	126	145	1457
2015	148	129	120	99	98	82	89	122	120	141	149	158	1455
Average	153	131	127	104	95	83	94	123	142	141	149	158	1500

Patched data

Table 4: Monthly rainfall data for rainfall station 335746

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1920	101	142	165	89	173	79	11	14	0	0	0	67	841
1921	55	71	247	159	118	62	4	41	45	9	82	32	926
1922	126	167	136	91	97	13	5	0	11	9	12	0	666
1923	45	104	94	174	160	87	36	21	0	0	16	46	782
1924	70	129	137	159	141	80	53	6	1	9	0	65	850
1925	92	75	123	126	50	59	19	25	55	0	0	75	698
1926	137	150	128	97	181	86	2	0	0	18	20	22	839
1927	99	78	167	183	65	70	11	27	0	0	13	64	776
1928	72	26	58	60	66	163	21	4	37	28	15	102	651
1929	21	139	98	97	58	79	60	0	0	5	12	28	597
1930	40	22	193	119	59	37	8	0	0	7	0	0	485
1931	90	42	30	70	284	112	0	46	11	5	0	17	706
1932	14	99	140	78	108	55	24	0	0	32	0	2	552
1933	45	186	169	260	139	69	12	47	0	52	50	0	1029
1934	59	153	182	93	82	66	89	11	9	0	1	22	766
1935	18	52	155	143	150	121	5	112	3	1	0	27	785
1936	78	248	64	210	137	124	11	0	7	0	0	26	905
1937	27	35	288	128	124	22	7	0	74	67	8	24	804
1938	113	41	173	78	148	55	0	44	0	40	6	59	755
1939	37	207	239	102	66	73	0	15	64	0	0	79	882
1940	25	86	298	164	133	27	128	0	0	6	0	21	888
1941	17	62	98	205	137	81	20	21	19	0	27	57	745
1942	69	146	159	158	77	94	128	69	7	85	128	10	1131
1943	194	126	143	152	144	53	0	3	61	0	0	116	993
1944	78	48	96	107	61	185	11	15	0	0	0	6	606
1945	11	35	8	106	22	49	0	0	0	1	0	3	234
1946	130	129	40	36	85	70	28	0	42	0	4	33	597
1947	62	192	134	143	124	101	64	0	0	0	0	34	853
1948	122	156	147	188	198	116	96	1	9	4	0	41	1077
1949	82	135	148	72	36	95	43	29	0	0	21	9	670
1950	79	150	114	61	69	181	33	18	9	0	110	42	866
1951	76	6	151	218	40	55	41	11	4	46	6	3	656
1952	58	124	153	158	256	64	51	0	6	0	61	30	958
1953	24	123	55	73	148	138	27	61	14	2	0	54	720
1954	162	203	126	252	162	74	30	4	0	0	0	5	1016
1955	71	103	68	29	180	120	0	41	0	0	3	35	650
1956	45	209	272	127	56	41	87	0	12	77	38	158	1122
1957	114	54	31	114	52	44	126	0	0	0	0	20	555
1958	85	114	89	67	136	26	25	40	0	28	9	23	643
1967	68	139	172	119	31	91	12	14	0	0	50	18	711
1968	29	76	143	101	125	239	70	27	8	25	0	14	854
1969	123	30	152	141	144	49	19	0	4	14	121	82	878
1970	85	67	58	117	59	71	46	112	0	25	54	14	707
1971	157	101	172	167	113	107	20	53	12	10	17	3	929
1972	94	112	89	97	210	40	83	7	0	0	53	60	843
1973	9	122	30	191	17	53	55	6	24	0	21	5	532
1974	20	121	59	88	104	12	66	0	0	0	8	84	559
1975	14	80	110	105	116	88	14	48	0	1	0	18	593
1976	108	31	55	182	51	107	11	0	0	0	9	92	644
1977	99	50	118	332	84	65	0	0	0	0	0	64	813
Average	73	106	129	132	111	81	34	20	11	12	19	38	767

4. YIELD ANALYSIS

4.1. IRRIGATION REQUIREMENTS

The total monthly and annual irrigation requirement was calculated using SAPWAT software. The initial proposal by the client was to plant 90 ha maize in October and 40 ha oats in April.

The irrigation requirement where the monthly rainfall is included was done with SAPWAT. An analysis was also run assuming the worst case with no rain, for academic purposes. The results including rain is further used in the analysis. The results can also be found in the annexure.

Crop	No rain analysis	Including rain analysis
Maize (90ha)	596 700 m³/a	171 900 m³/a
Oats (40ha)	181 600 m³/a	111 600 m³/a
Total	778 300 m³/a	283 500 m³/a

The crop factors and monthly evapotranspiration per crop type were also determined by SAPWAT and are indicated below in Table 3 and Table 4 respectively.

Table 3: Crop Factors

Crop factors	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maize	0.1	0.6	1.1	1.1	1.1	0	0	0	0	0	0	0
Oats	0	0	0	0	0	0	0.1	0.2	0.5	0.75	1	1.1

Table 4: Evapotranspiration

Evapotranspiration (mm)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Maize	74.4	115	147.2	129	110.7	85.2	0	0	0	0	0	0	663
Oats	33.6	0	0	0	0	0	43.8	73.6	59.3	64.1	81.8	98.8	454

The monthly irrigation requirements are indicated in the table below.

Table 6: Monthly gross irrigation requirements including rain (SAPWAT)

Including Rainfall (mm)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Maize	14	17	57	48	32	23	0	0	0	0	0	0	191
Oats	0	0	0	0	0	0	35	35	17	39	82	71	279

The average irrigation requirements using simple formula results in irrigation requirements of approximately 15% more than indicated above. The SAPWAT software uses a daily water balance procedure and would therefore be much more accurate. The WRSM software uses the same crop factors with monthly rainfall figures over 84 years, but with average evaporation and average rainfall effectivity figures. The crop demands would thus be more in the WRSM analysis, but the actual amount supplied correlates well with SAPWAT figures for a fair reliability of supply. For a high reliability of supply the WRSM analysis supply more irrigation water than indicated by SAPWAT and less for a low reliability of supply.

4.2. DAM YIELD ANALYSIS AND IRRIGATION AREA OPTIMIZATION

The yield analysis of the dam was calculated using the WRSM 2000 model. The catchment of the upstream dam on the Persberg Farm as well as that of the downstream dam on the neighbouring dam was analysed. This is done to determine whether the dam would be able to meet the required irrigation demands. Further the effect of the newly constructed upstream dam on the downstream neighbouring farm dam was also analysed. The following parameters were used for the analysis:

Table 5: Catchment characteristics

Catchment	Catchment Area		Forestry	Alien Vegetation	Irrigation	Farm Dams		Rainfall	
	Gross (km²)	Net (km²)	Area (km²)	Area (km²)	Area (km²)	Area (km²)	Volume (m³)	Station	MAP (mm)
Persberg Dam Catchment	3.5	3.5	0.27	0	0.9	0.062	85000	335746	733
Downstream Dam Catchment	6.3	6.3	0.5	0	0	0.047	40000	335746	733

Table 6: Dam volume calculation at current FSL

AREA AT	FSL mMSL	AREA (m²)	VOLUME (m³)	VOLUME (Mm³)	FSL DEPTH (m)
LOWEST CONTOUR	1511	8551	8701	0	2
CONTOUR ABOVE	1512	32078	32765	0	3
CONTOUR ABOVE	1513	61531	85777	0	4

The volume of the dam was calculated using data from arIal surveyed points on a 30 x 30 m grid. To determine the total volume, excavated material used for the dam, estimated at 15000m³ is included in the estimated volume of 85 777 m³.

There is no irrigation demand from the smaller downstream dam and the catchment directly contributing to flow to the smaller downstream dam is significantly larger than for the upper dam under investigation. The runoff of this catchment would be more than adequate to provide the downstream dam with sufficient water to be always full, given the fact that there is no irrigation from the lower dam. In the event that irrigation will be done from this lower dam in future, the size will be the restricting factor, not the fact that some of the runoff from the two catchments combined will be held back in the upper dam.

Table 10 indicates the probability of the dam running empty with various crop models. This is based on crop factors as determined by SAPWAT.

Table 7: Probability of dam running empty at current volume

Crops (ha)	Probability of dam running empty (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Maize - 40 Oats	41	44	68	64	59	0	0	8	25	47	73	95
40 Maize - 20 Oats	24	24	54	48	39	0	0	0	9	24	33	51
30 Maize - 10 Oats	7	7	20	22	20	0	0	0	5	6	8	14
20 Maize - 20 Oats	15	11	15	16	14	0	0	0	5	11	18	28
20 Maize - 10 Oats	2	2	4	6	4	0	0	0	1	1	2	5

From the results above, it is suggested that planting 30 ha maize and 10 ha oats is an acceptable risk at the current volume of the dam or 20 ha maize and 20 ha oats.

The dam full supply level could be lowered to a level of approximately 1512.3 m in order to reduce the volume to approximately 50 000 m³. The dam will then fall outside the requirement for categorization but a licence to use and store water will still be required.

Table 8: Dam volume calculation at a reduced FSL

AREA AT	FSL mMSL	AREA (m²)	VOLUME (m³)	FSL DEPTH (m)
LOWEST CONTOUR	1511.0	8551	8701	2
CONTOUR ABOVE	1512.0	32078	31765	3
CONTOUR ABOVE	1512.4	43000	49727	3

Should the dam be reduced to a volume of just less than 50 000 m³ the optimum area to be irrigated would still be in the order of 30 ha maize and 10 ha oats but with a slightly higher probability of running dry.

Table 9: Probability of dam running empty at a reduced dam volume (49 900m³)

Crops (ha)	Probability of dam running empty (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
40 Maize - 20 Oats	39	27	52	46	35	0	0	1	8	21	45	84
30 Maize - 10 Oats	11	12	28	29	24	0	0	0	2	7	11	18
20 Maize - 10 Oats	8	5	9	12	11	0	0	0	2	4	5	12

5. FLOOD DETERMINATION

The Persberg Dam catchment covers a total area of 3.5 km². The catchment area and slopes were determined using Civil Designer. Majority of the catchment is covered in grasslands. The proposed land to be cultivated as well as the light bush in the area was taken into account for the flood analysis.

Flood magnitudes were calculated using 5 methods, namely the Rational, Alternative Rational, Unit Hydrograph, Standard Design Flood (SDF) and Empirical method. The Alternative Rational method should be the most accurate since it uses the most site specific values whereas the SDF, Unit Hydrograph and Empirical methods use regional input values. The latter three methods are used as a check for the Rational and Alternative Rational methods. The values for the Alternative Rational method are indicated in the table below. Refer to the annexures for more details.

Main catchment characteristics are as indicated below in Table 10 (See other detail on calculation sheets).

Table 10: Catchment Characteristics & Alternative Rational Floods

Catchment Area (km²)	3.5
Longest water course (km)	2.34
Height difference 10-85% slope (m)	39.1
Percentage rural (%)	100
Percentage urban/industrial (%)	0
1:5 Year flood (m³/s)	22.38
1:10 Year flood (m³/s)	31.11
1:20 Year flood (m³/s)	40.64
1:50 Year flood (m³/s)	53.70
1:100 Year flood (m³/s)	65.23
1:200 Year flood (m³/s)	73.85

6. MAXIMUM CAPACITY AND DESIGN FLOODS

The maximum discharge was calculated using the current triangular spillway shape with the total freeboard available being 1.2 m above FSL at the wing wall sides. Both the left and right wings were analysed as the slope differs on either side. The maximum capacities of the present spillways are as follows:

Q (right) = 25.08 m^3/s

Q (left) = 23.20 m^3/s

Total = 48.28 m^3/s

The present spillways will not be able to even accommodate the 1:50 year flood (See table below)

The Recommended Design Flood (RDF) and the Safety Evaluation Flood (SEF) were also determined. The dam may be regarded as a small Category I dam (5m to 12m high). However due to the downstream road it may have a significant hazard rating, hence the Category II floods were also determined. According to DWA, the Category I dam RDF should be the 1:20 or 1:50 year flood and the SEF the 1:100 year flood. The Category II dam RDF should be the 1:100 year flood and the SEF the 1:200 year flood.

The calculations on the maximum discharge and the design floods can be found in the annexure with results indicated in the table below.

Table 11: Design floods

	Category I		**Category II**	
RDF	1:50	53.75 m^3/s	1:100	65.23 m^3/s
SEF	1:100	65.23 m^3/s	1:200	73.85 m^3/s

7. SPILLWAY

Spillway design for the RDF should further allow for a dry freeboard over and above the flood height through the spillway. The calculation of the dry freeboard is shown in the table below. A total dry freeboard of 0.51 m is required to accommodate wave action. Tyres are used as the current riprap on the dam wall and the run-up factor was determined taking this into consideration. The tyres should be placed to the crest of the wall to accommodate wave action.

Table 12: Dry freeboard calculation

FETCH	396.03	m
WIND SPEED OVER LAND	28	m/s
WIND SPEED RATIO	1.07	
WIND SPEED OVER WATER	29.96	
Cd	0.002149	
X	2014	Dimensionless
Ux	1.39	Dimensionless
H	1.85	Dimensionless
Hs	0.36	Wave height (m)
SLOPE 1: (3)	2.2	
W50	6	kg
D50	0.14	m
THICKESS RIPRAP REQUIRED	0.28	m
RUNUP FACTOR	1.4	
RUNUP =DRY FREEBOARD	0.51	m Vertical

The spillway is sized according to the RDF and SEF for both a Category I and Category II dam. The following spillway lengths were calculated considering wave action during a flood:

Table 13: Spillway lengths required for the spillways cut level

	Category I			**Category II**		
	Flood	**Length (m)**		**Flood**	**Length (m)**	
		Left Wing	**Right Wing**		**Left Wing**	**Right Wing**
RDF	1:50	25	25	1:100	31	30
SEF	1:100	6	6	1:200	8	8

The spillway widths indicated above assumes the full supply level will remain as is, with only the existing spillways cut level into the side slope with lengths as indicated. If the FSL is dropped to reduce the size of the dam to less than 50 000m³, the required spillway length will reduce significantly.

8. DAM BUILDING MATERIAL TEST RESULTS

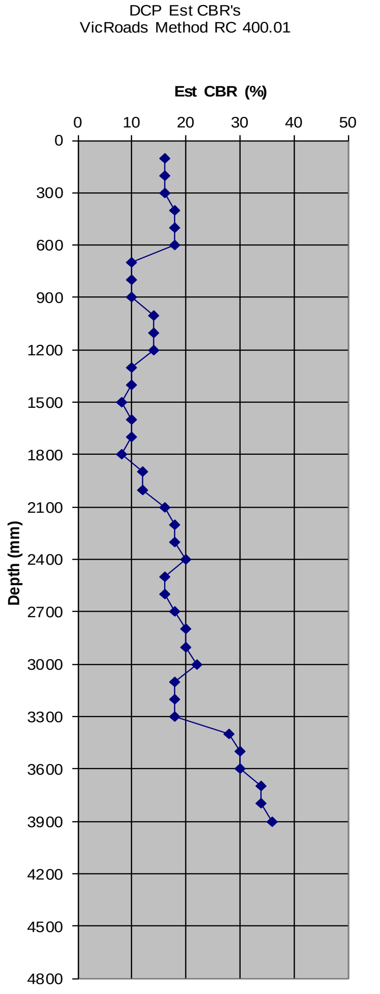
Troxler (nuclear density instrument) and DCP (Dynamic Cone Penetrometer) compaction tests were conducted at five locations across the dam wall. From the results obtained it can be concluded that the compaction over the first meter does not meet the general required compaction of 95% of Maximum Proctor density. An average compaction of 86% is achieved, with only one location exceeding the requirement at 98.3%. However, the compaction increases with an increase in depth of the dam wall and is higher at the bottom. By extrapolating the DCP results with increased depths to the compaction achieved at the top, it can be estimated that the required compaction is met at approximately 2m from the dam crest and exceeded towards the bottom where it counts most. The DCP results are indicated below.

DYNAMIC CONE PENETROMETER - RESULT SHEET

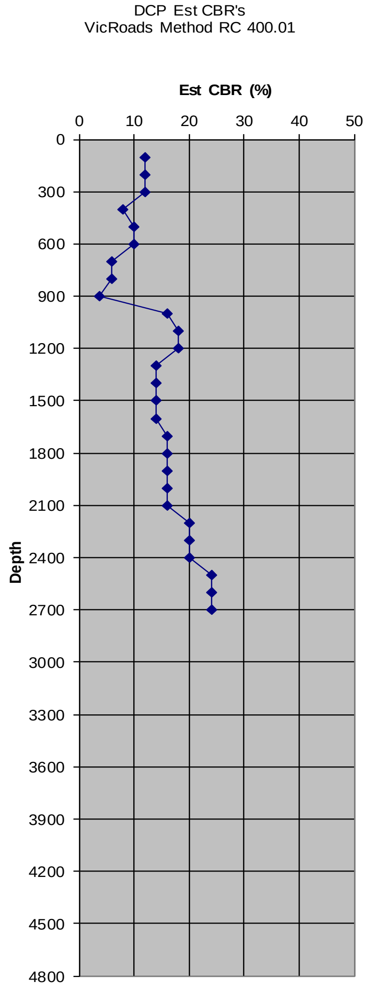
Client	Erich Muller
Project	Persberg dam
Location	Helpmekaar
Operator	Soilco
Date	27/11/2015
Job #	2015/11/01
Lab #	PONGOLA

GFK
Consulting Engineers and Project Managers
119 Deputasie Street
VRYHEID
3100
Tel: 034 982 3425
Fax: 034 982 3425
fkrugel@raws.co.za

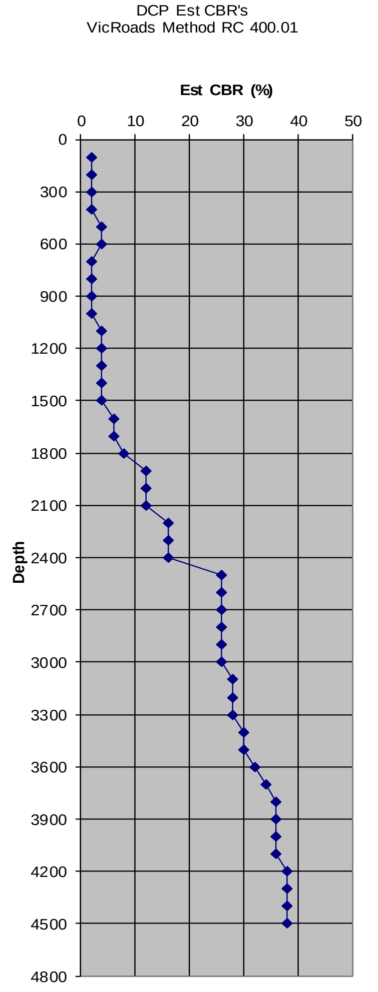
Site # Helpmekaar
Location DCP1



Site # Helpmekaar
Location DCP2



Site # Helpmekaar
Location DCP3



VicRoads Test Method 402.01 - Estimated California Bearing Ratio Using Dynamic Cone Penetrometer Tests

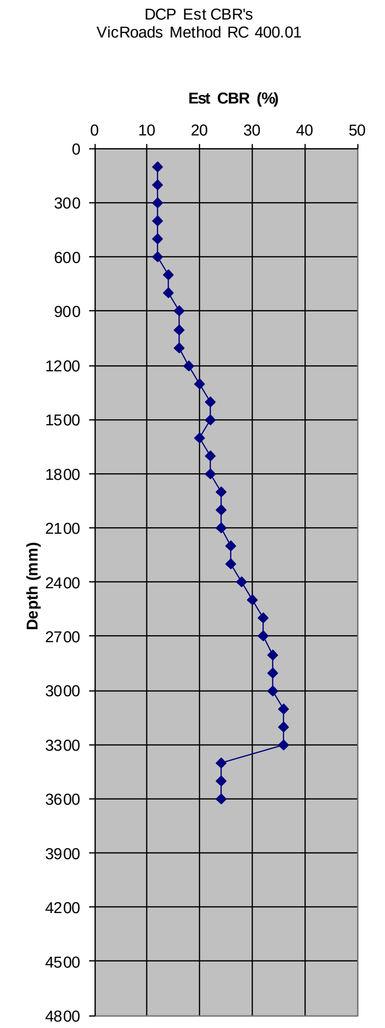
This method covers the calculation of the estimated California Bearing Ratio (CBR) of cohesive soils from the penetration results obtained using the dynamic cone penetrometer described in AS 1289.6.3.2

DYNAMIC CONE PENETROMETER - RESULT SHEET

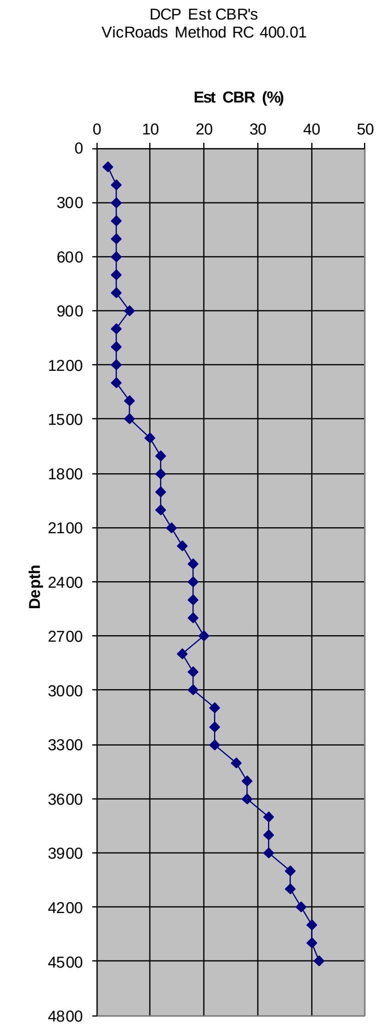
Consulting Engineers and Project Managers
119 Deputasie Street
VRYHEID
3100
Tel: 034 982 3425
Fax: 034 982 3425
fkrugel@raws.co.za

Client	Erich Muller
Project	Persberg dam
Location	Helpmekaar
Operator	Soilco
Date	27/11/2015
Job #	2015/11/01
Lab #	VRYHEID

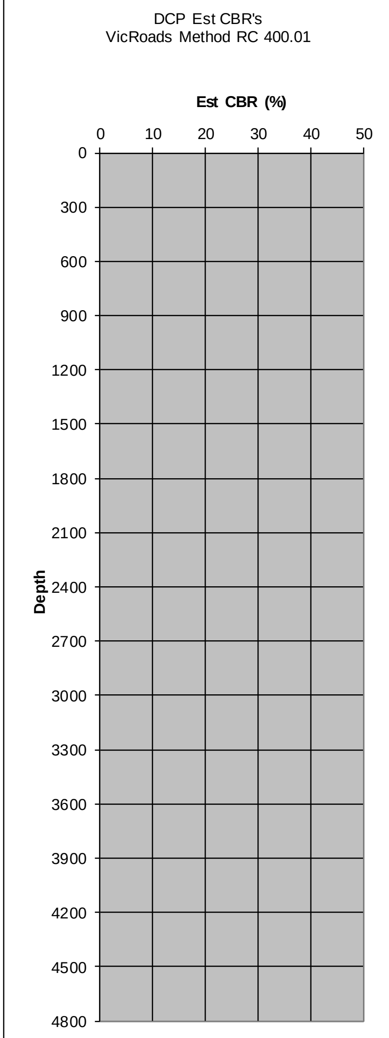
Site #	Helpmekaar
Location	DCP4



Site #	Helpmekaar
Location	DCP5



Site #	NA
Location	NA



VicRoads Test Method 402.01 - Estimated California Bearing Ratio Using Dynamic Cone Penetrometer Tests

This method covers the calculation of the estimated California Bearing Ratio (CBR) of cohesive soils from the penetration results obtained using the dynamic cone penetrometer described in AS 1289.6.3.2

Pit 1 and Pit 2 (as indicated in the annexure) indicate the results for the natural foundation and embankment respectively. The following results were obtained:

Table 14: Soil Parameters

	Natural Ground (foundation) (Pit 1)	**Embankment (Pit 2)**
Permeability (cm/sec)	9.306×10^{-8}	1.083×10^{-5}
Unified Soil Classification	CL	OH or MH
Cohesion (kPa)	27	21
Friction angle (°)	22	27

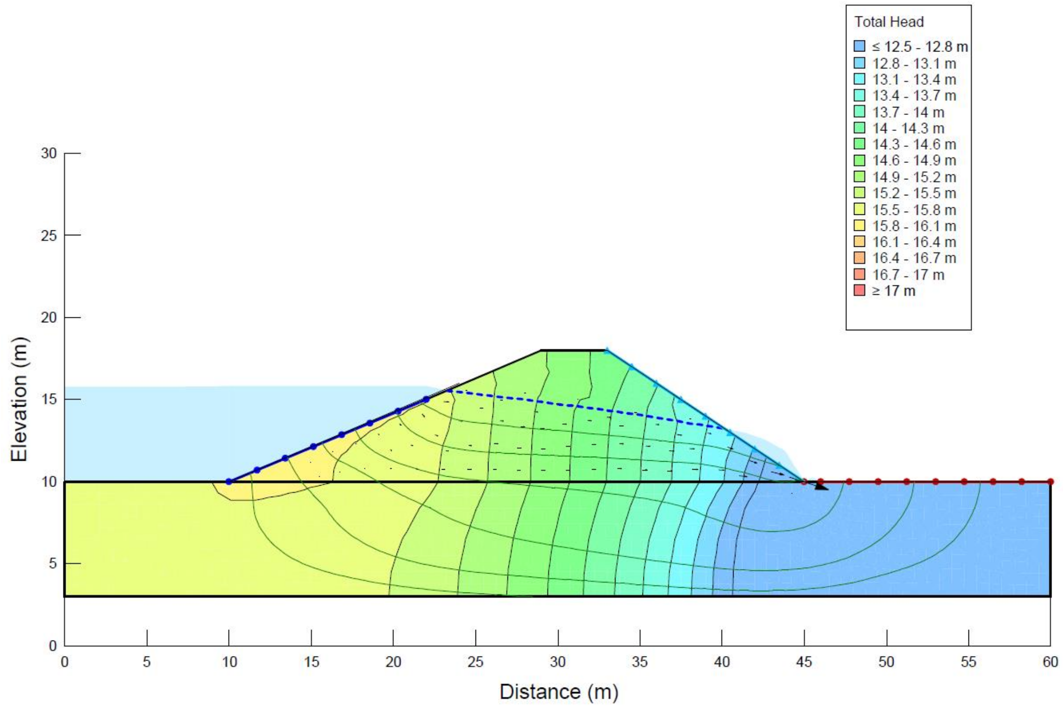
The permeability was tested at a compacted density of 95% of Maximum Proctor density. The results as indicated above may not be a true reflection as the actual in-situ compaction measured is lower than 95% at the top of the dam wall but most likely higher at the bottom where it counts most. Higher compacted materials may have a lower permeability due to excess voids removed. The permeability of the embankment may be higher at the top due to insufficient compaction. The foundation permeability is lower than that of the embankment making the embankment material suitable for construction.

Cohesion and friction were obtained from consolidated drained shear box tests. The laboratory results can be found in the annexure.

9. SEEPAGE LINE AND SLOPE STABLILTY

The phreatic surface as shown in Figure 1 below was determined using a permeability of 9.306 x 10-8 cm/sec for the natural ground and 1.083 x 10-5 cm/sec for the embankment. Due to the fairly high permeability of the homogeneous embankment there may be some seepage on the downstream toe. A sand filter could be cut into the toe where the seepage water is expected to exit the embankment. A 110 mm drainage pipe can be placed at the bottom of the filter to allow the water to drain. See attached drawings for details.

Figure 1: Phreatic surface and seepage through dam wall



Using the above phreatic surface the slope stability of the dam was analysed to determine if it would be stable during operation. The soil unit weight and saturated unit weights as indicated in Table 15 were obtained from the soil parameters of the two test pits.

Table 15: Unit weights of soil used for slope analysis

	Natural Ground	**Embankment**
Bulk unit weight	17.4	16.3
Saturated unit weight	17.8	21.7

The slope stability was analysed at full supply level and the minimum factors of safety (FOS) were determined using the Slope Stability software. Provision was made to accommodate seismic action at 0.1g. The critical section of the dam wall was analysed where the following slopes were measured:

- Upstream slope: 1:2.48
- Downstream slope: 1:1.66

The following minimum Factors Of Safety (FOS) were obtained:

- Upstream slope FOS: 1.92
- Downstream slope FOS: 1.63

According to The U.S. Army Corps of Engineers (2003), the long term downstream factor of safety should not be lower than 1.5. The FOS as calculated in the analysis is 1.63 which is sufficient and should not pose any significant problems. Similarly the minimum upstream slope safety factor is 1.5 The upstream calculated FOS is 1.92 which is significant larger than the required minimum of 1.5. Both FOS are above 1.3 which is the minimum after construction.

Relatively high safety factors are observed for the steep slopes. This may be due to the high friction angles in the embankment as well as the foundation material. The upstream slope FOS is higher than the downstream slope FOS due to the steep downstream slope of 1:1.66.

The list of calculated factors of safety as well as the graphical representation of the slip circles can be found in the annexure.

10. DAM BREAK ANALYSIS

A dam break analysis was simulated on HEC-RAS to determine the effect a possible dam break would have on the downstream road. The dam break was analysed with an estimated final bottom width of 3 m and side slopes of 1:0.7 on either side over a development time period of 1 hour.

Table 16: Dam Break Results Summary

Event	**Flood**	**Effect on downstream road**
Dam break at Present FSL	Without flood (Sunny day dam break)	Flood water will flood the road by approximately 100mm deep.
Dam break at FSL for 49 900m³ dam	Without flood (Sunny day dam break)	Flood water will pass safely under the road through the culvert.
Flood without dam break	1:20	Insignificant. The culvert size is sufficient to accommodate a 1:20 flood.
Flood without dam break	1:50	Significant. Flood causes water to flow over the road with a depth of approximately 0.5m.

The risk of a potential dam break in conjunction with the 1:20 or 1:50 year flood is deemed negligible as the probability of the two events happening simultaneously is nearly impossible as the wall is likely to only break when overtopped during floods. Due to the spillways being sized according to the design floods the dam should be able to accommodate a 1:50 year flood, hence the probability of the dam overtopping is low. In the nearly impossible event of a dam break during a 1:20 or 1:50 year flood, the water would flow over the road at a depth of approximately 0.6 and 0.9m respectively. It can thus be argued that a dam break will increase the risk of flooding the road in the event it occurs during a 1:20 year flood, but the probability is so low that it can be ignored. In the event of a 1:50 year flood the road will be overtopped anyway and will pose a serious risk. With a simultaneous dam break, the risk will not necessarily be significantly more. It can also be argued that in the event that the water level in the dam is low, that it will attenuate a 1:50 year flood which will make the risk of flood water overtopping the road less.

Figure 2 below indicates the maximum rise in water level in the culvert due the dam break without a flood for a dam with FSL for a 49 900m³dam. There is sufficient space between the maximum water level and the top of the culvert hence the road should not sustain any damage. The results regarding the floods can be seen in the annexure.

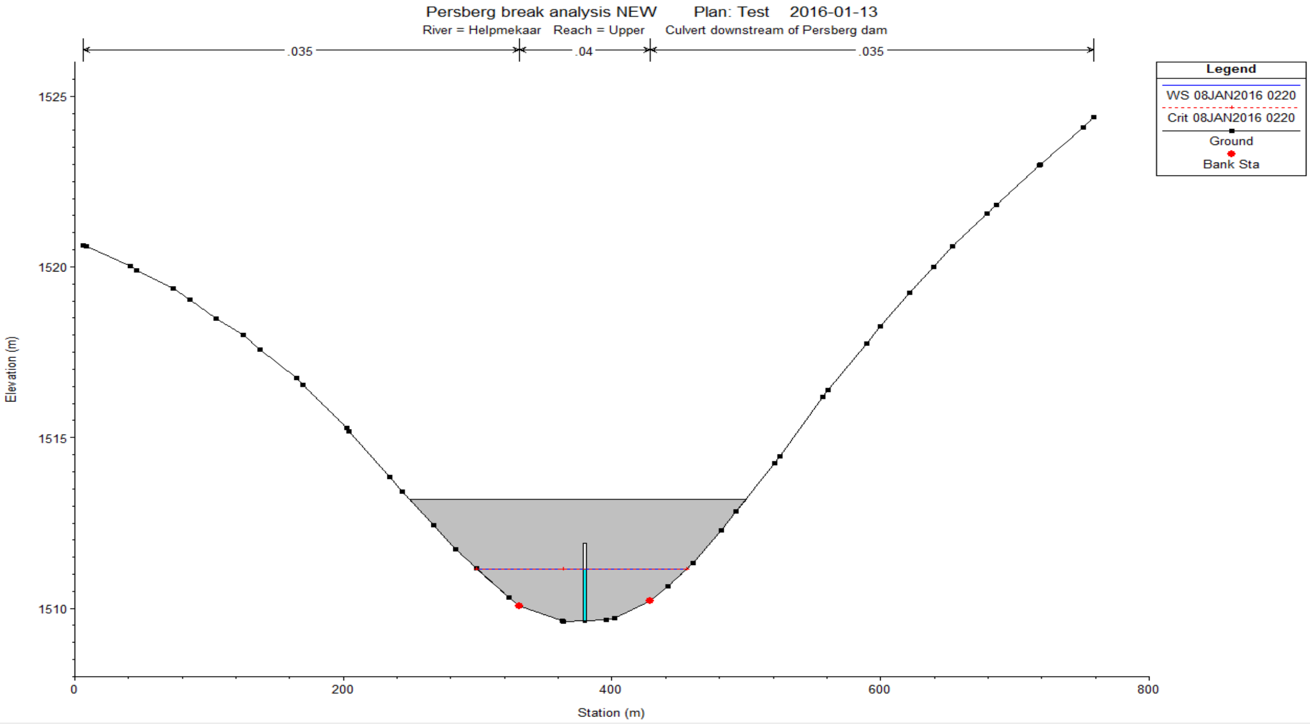


Figure 2: Effect of dam break without a flood on downstream culvert

The effect of the dam break as far as 7.8 km downstream was analysed. A large cliff is found approximately 6 km downstream of the dam. The flow conditions downstream of this cliff were analysed separately as there are no obstructions. A flow rate was determined from HEC-RAS just upstream of the cliff which was then used to calculate the flow depth of the water in the river channel. A normal flow depth of 0.6 m was calculated indicating the water would flow in the river channel and not cause any significant damage should the Persberg Farm Dam break. Figure 3 below indicates the critical flow depth as well as the normal flow depth.

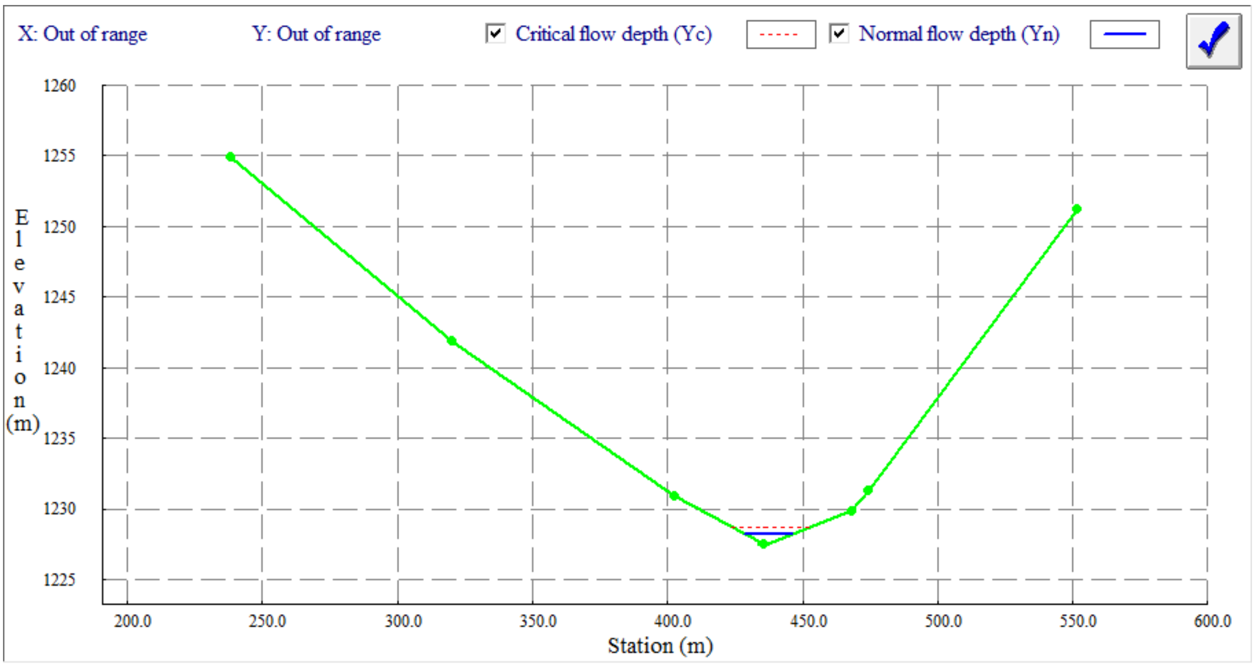


Figure 3: Flow depth in river downstream of cliff

11. REFERENCES

Kriel JP, 1963, *Recent investigations on the Evaporation from large water surfaces and evaporation tanks in South Africa*, International Association of Scientific Hydrology. Bulletin, 8:4, 10-18

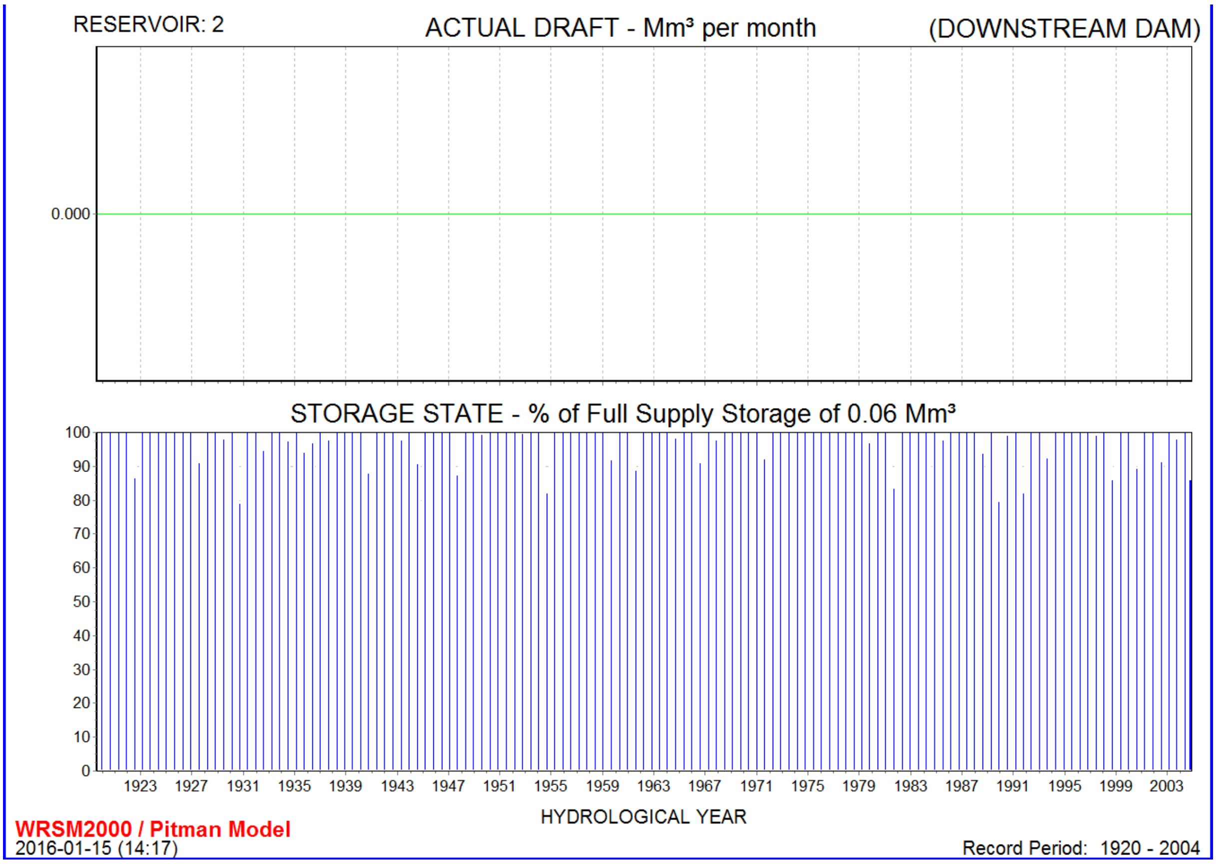
Rust E, Design of Small Dams

2003, DEPARTMENT OF THE ARMY U.S. Army Corps of Engineers Washington, Engineering and Design SLOPE STABILITY

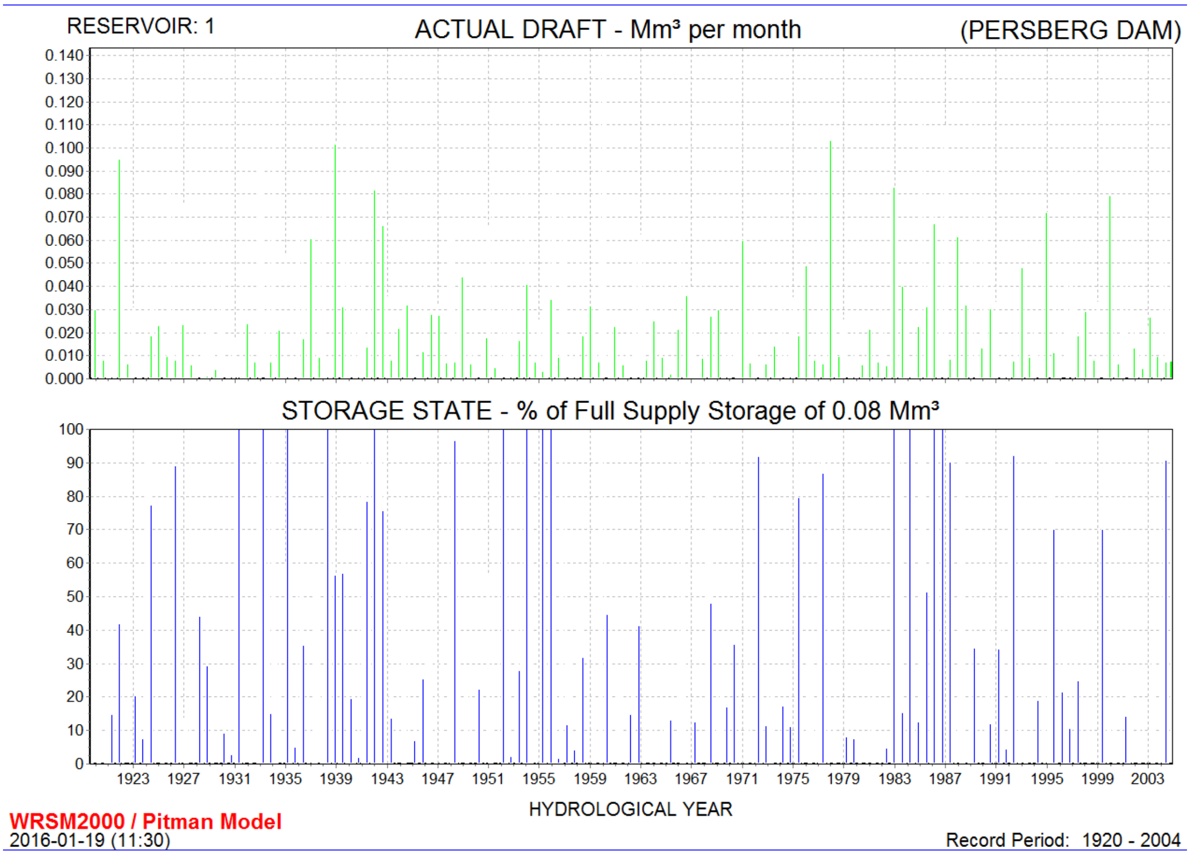
12. ANNEXURES

12.1. YIELD ANALYSIS

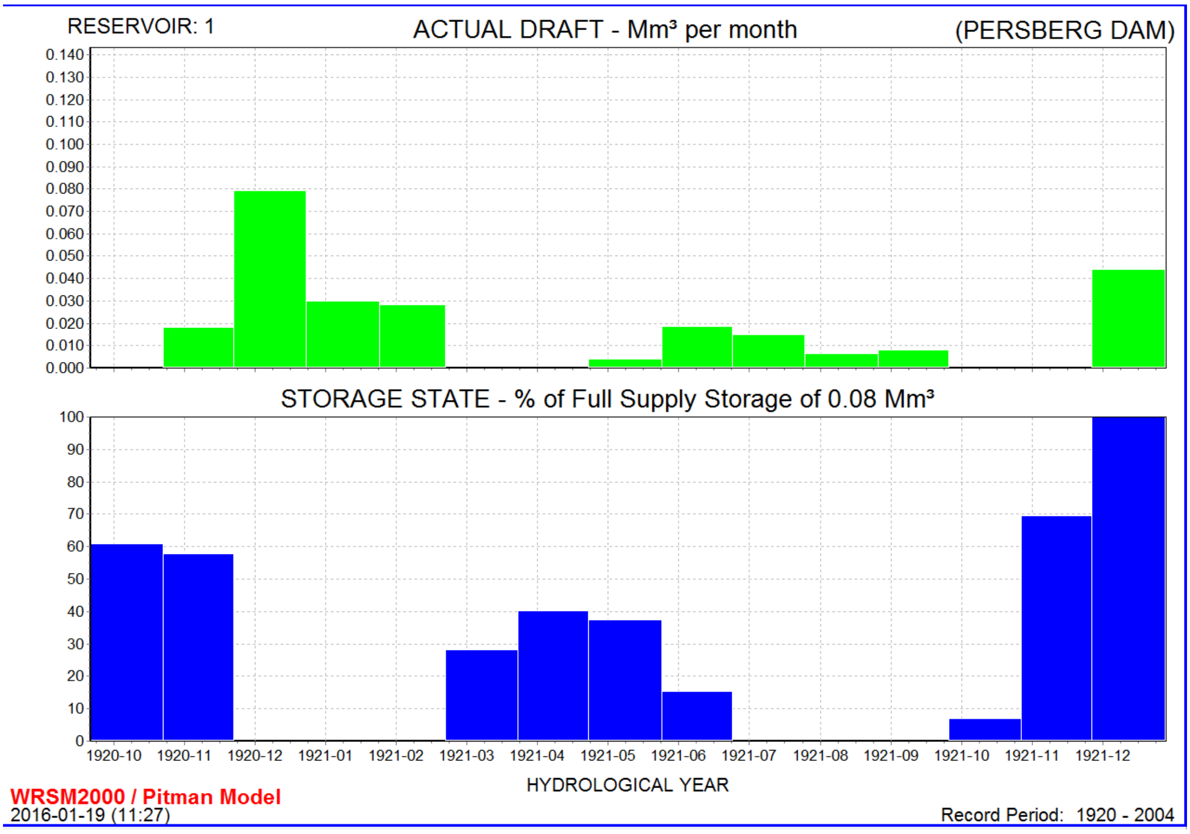
DOWNSTREAM DAM STORAGE



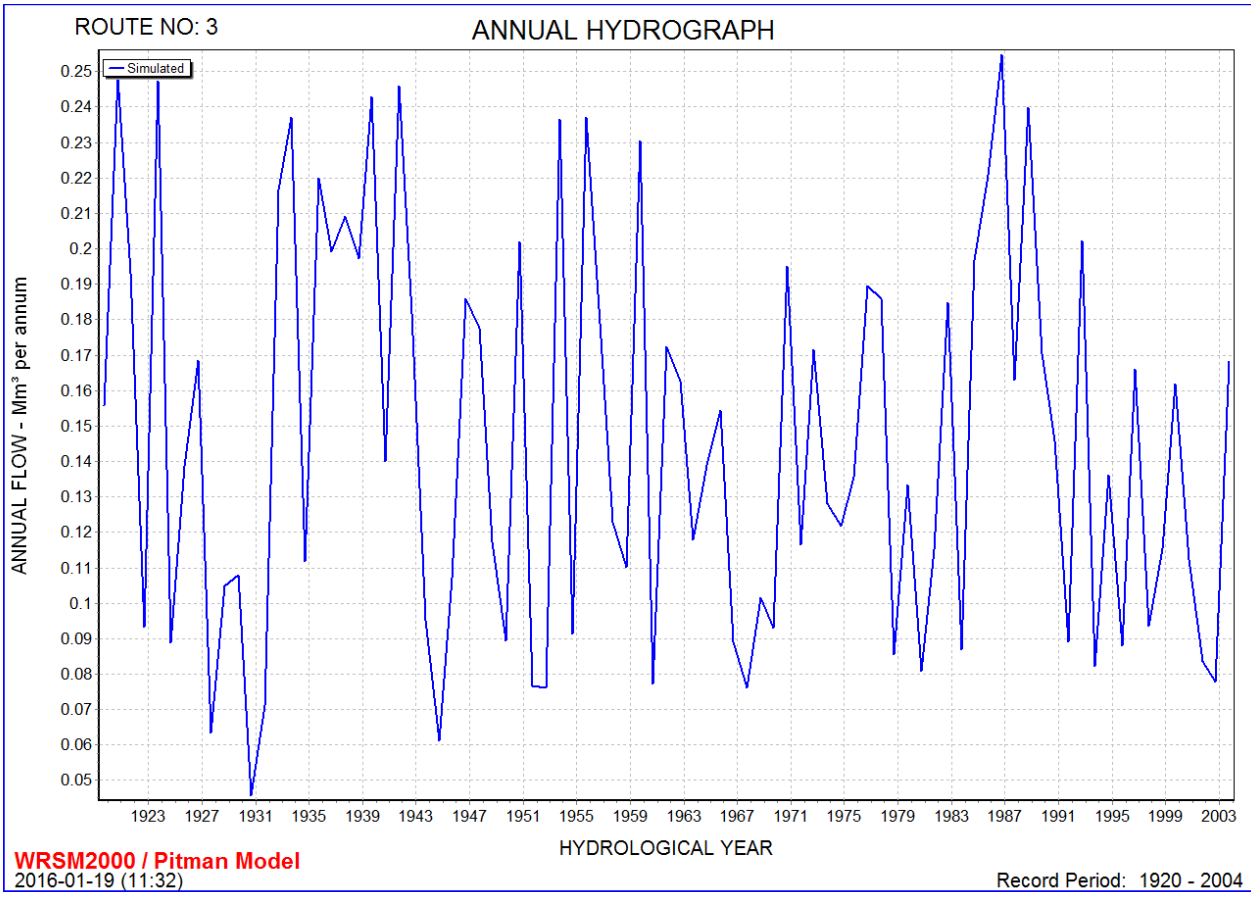
PERSBERG DAM STORAGE OVER THE FULL RECORD PERIOD – 90 HA MAIZE AND 40 HA OATS



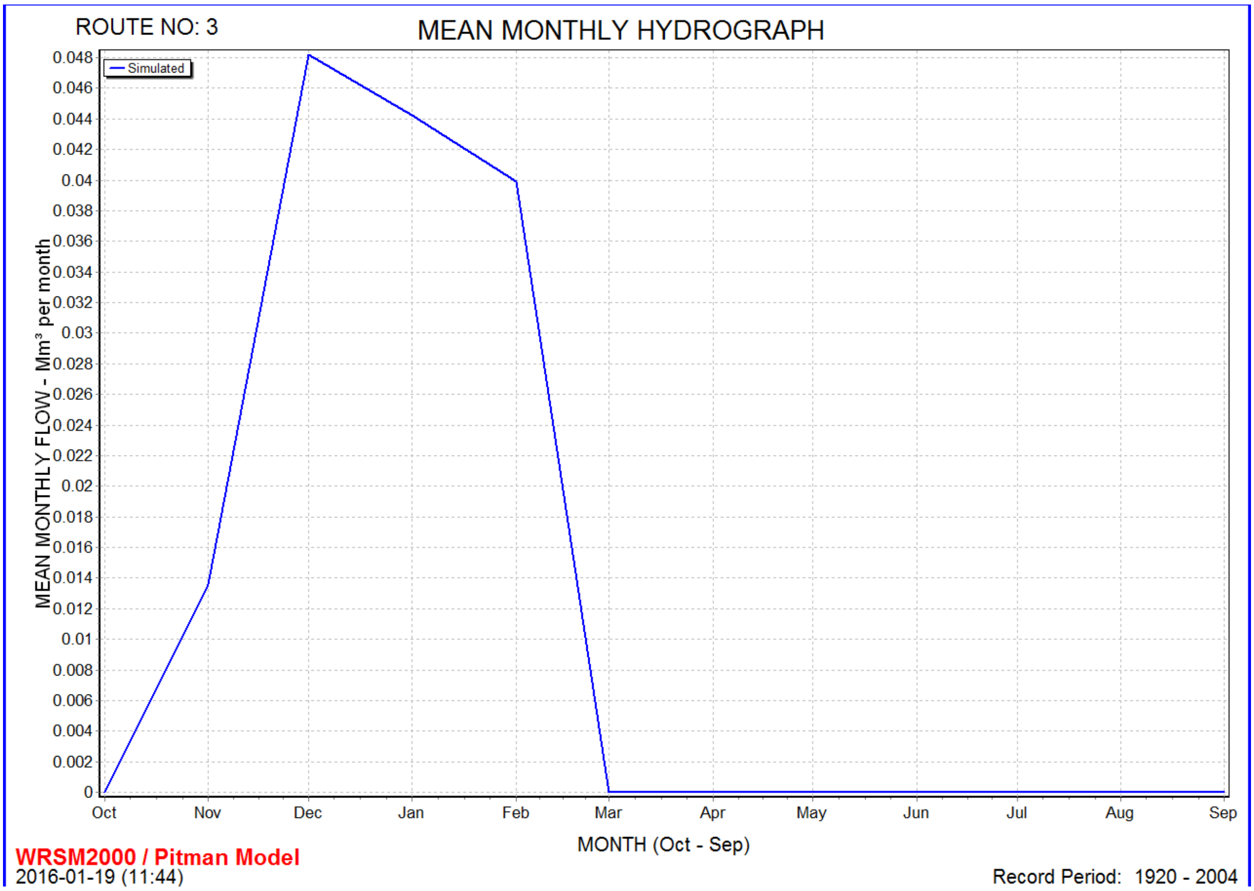
PERSBERG DAM STORAGE OVER 1 YEAR – 90 HA MAIZE AND 40 HA OATS



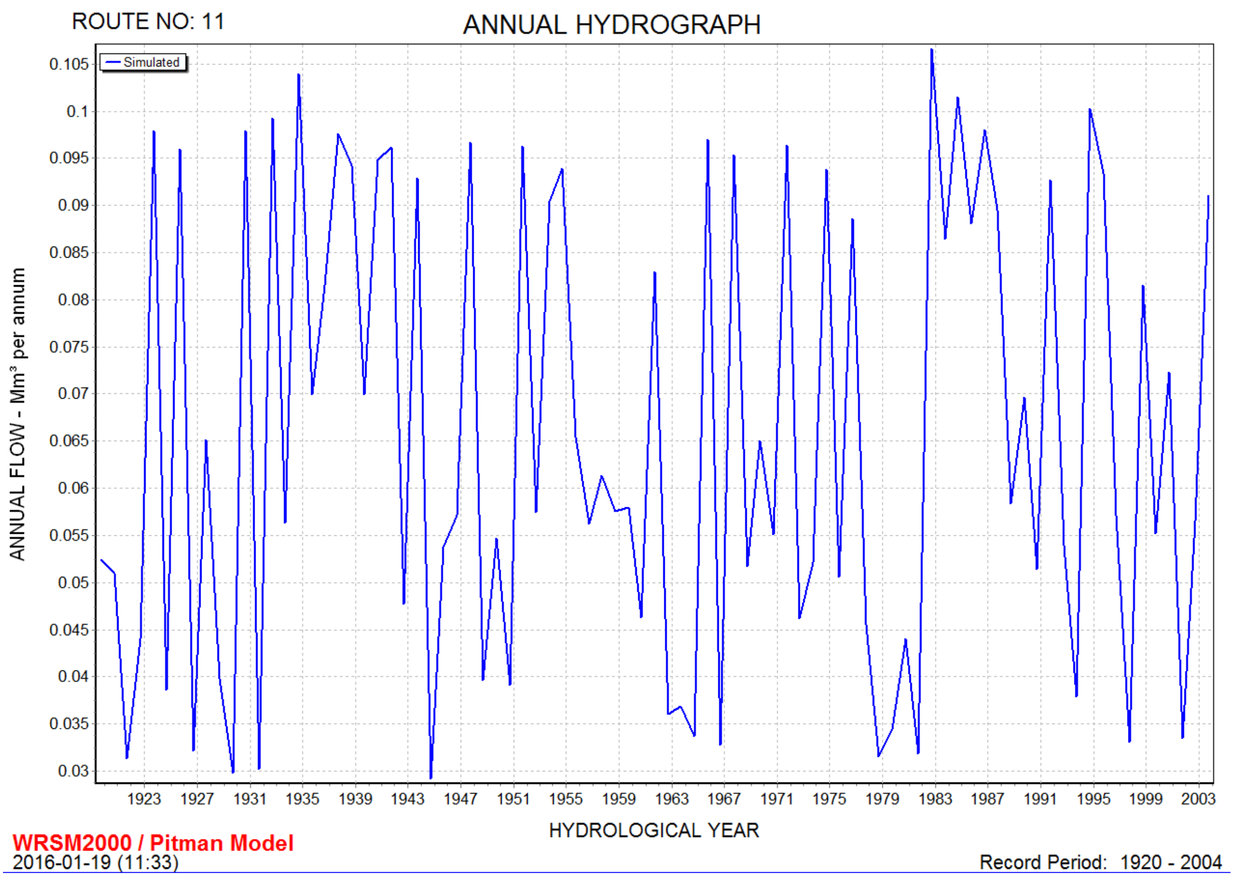
ANNUAL HYDROGRAPH OF RESERVOIR TO MAIZE IRRIGATION (90 HA)



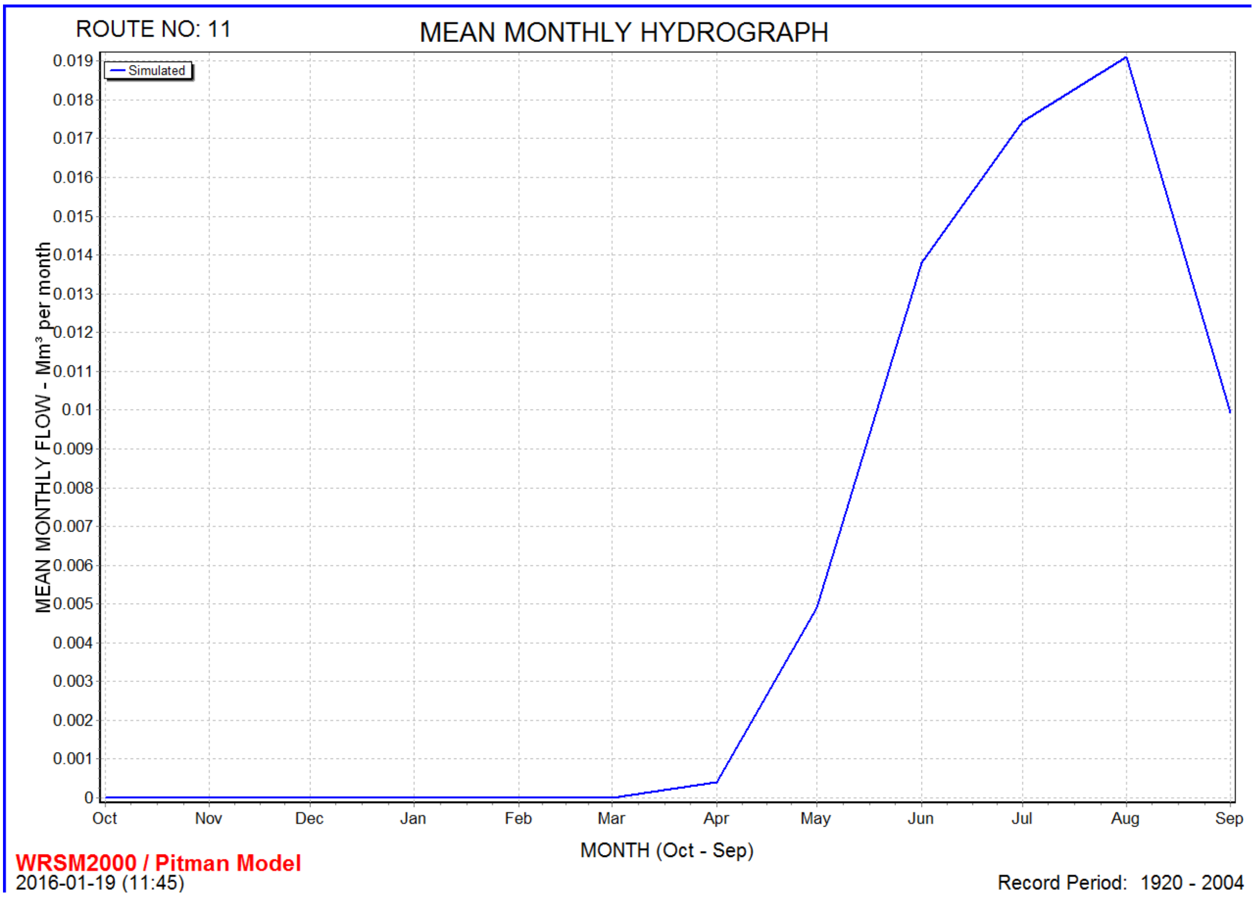
MONTHLY HYDROGRAPH OF RESERVOIR TO MAIZE IRRIGATION (90 HA)



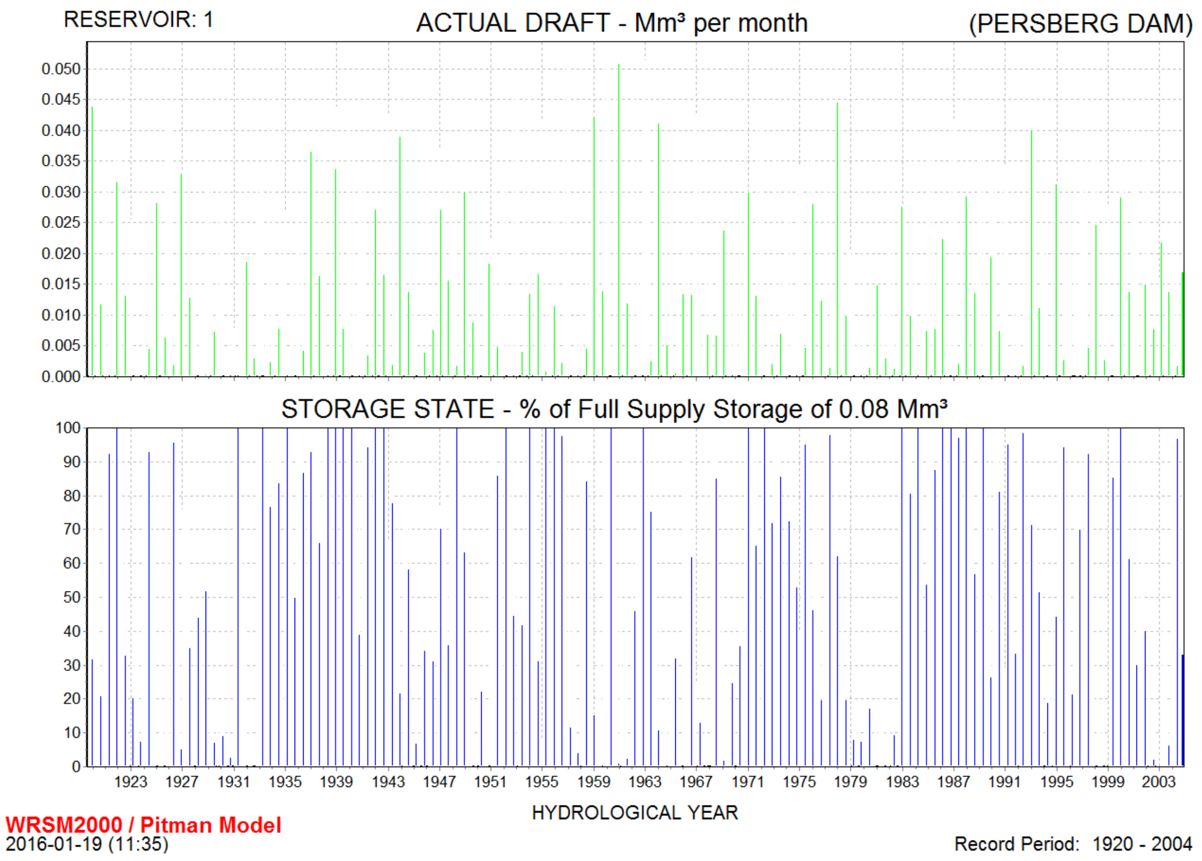
ANNUAL HYDROGRAPH OF RESERVOIR TO OATS IRRIGATION (40 HA)



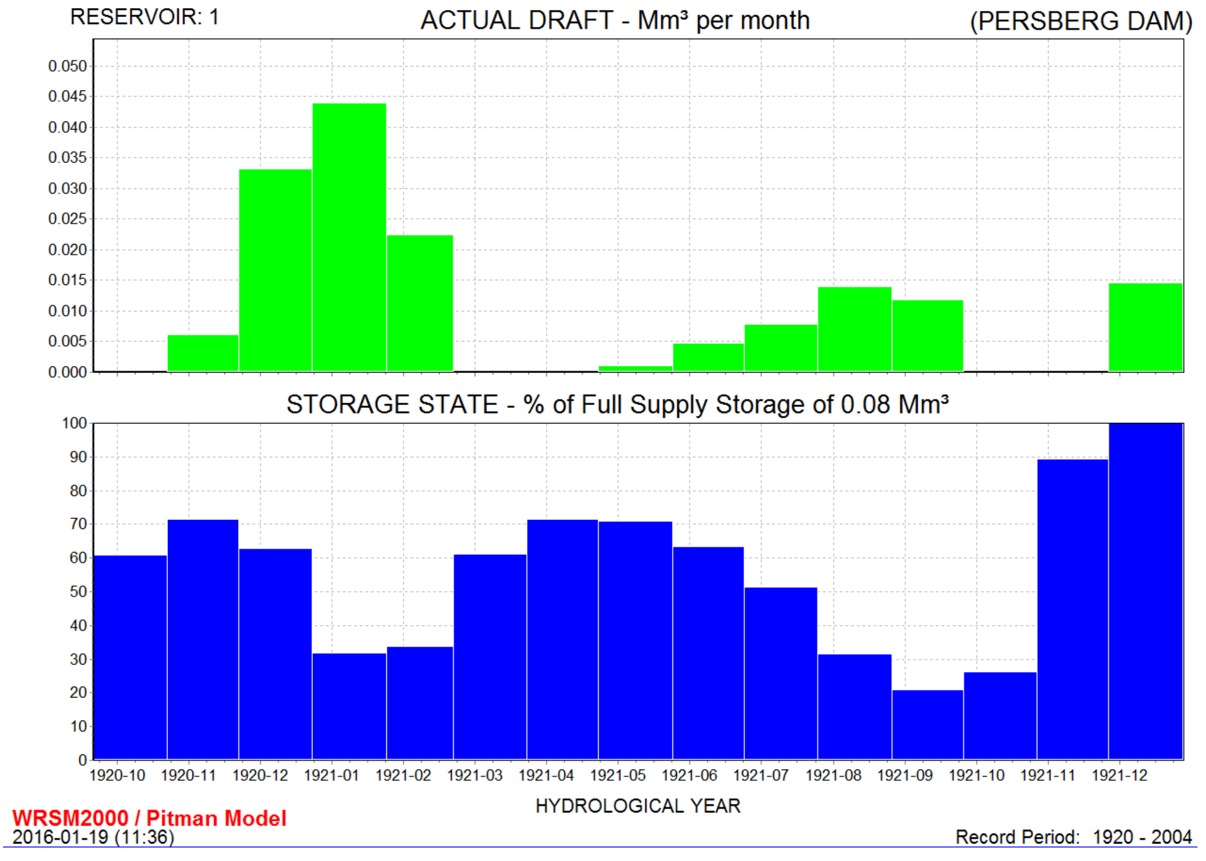
MONTHLY HYDROGRAPH OF RESERVOIR TO OATS IRRIGATION (40 HA)



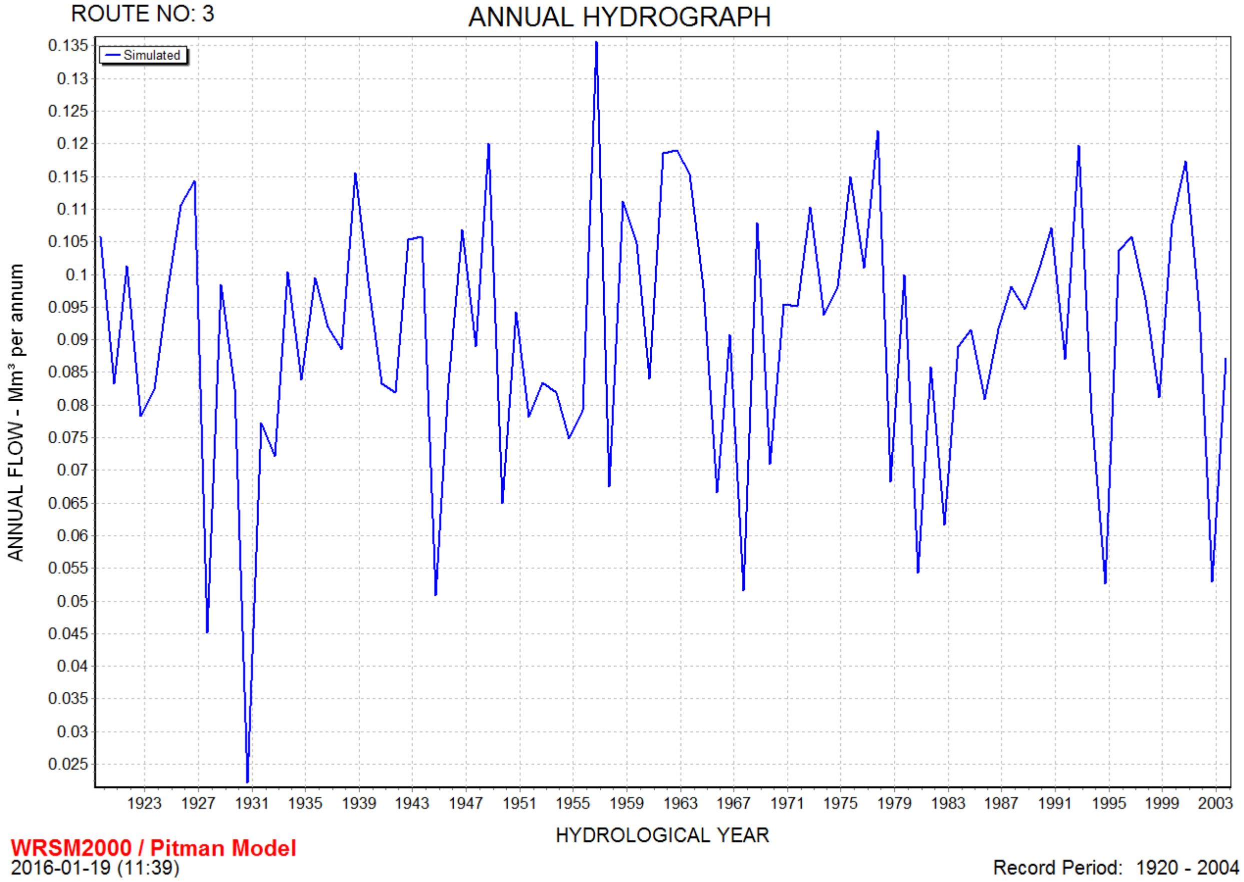
PERSBERG DAM STORAGE OVER THE FULL RECORD PERIOD - 30 HA MAIZE AND 10 HA OATS



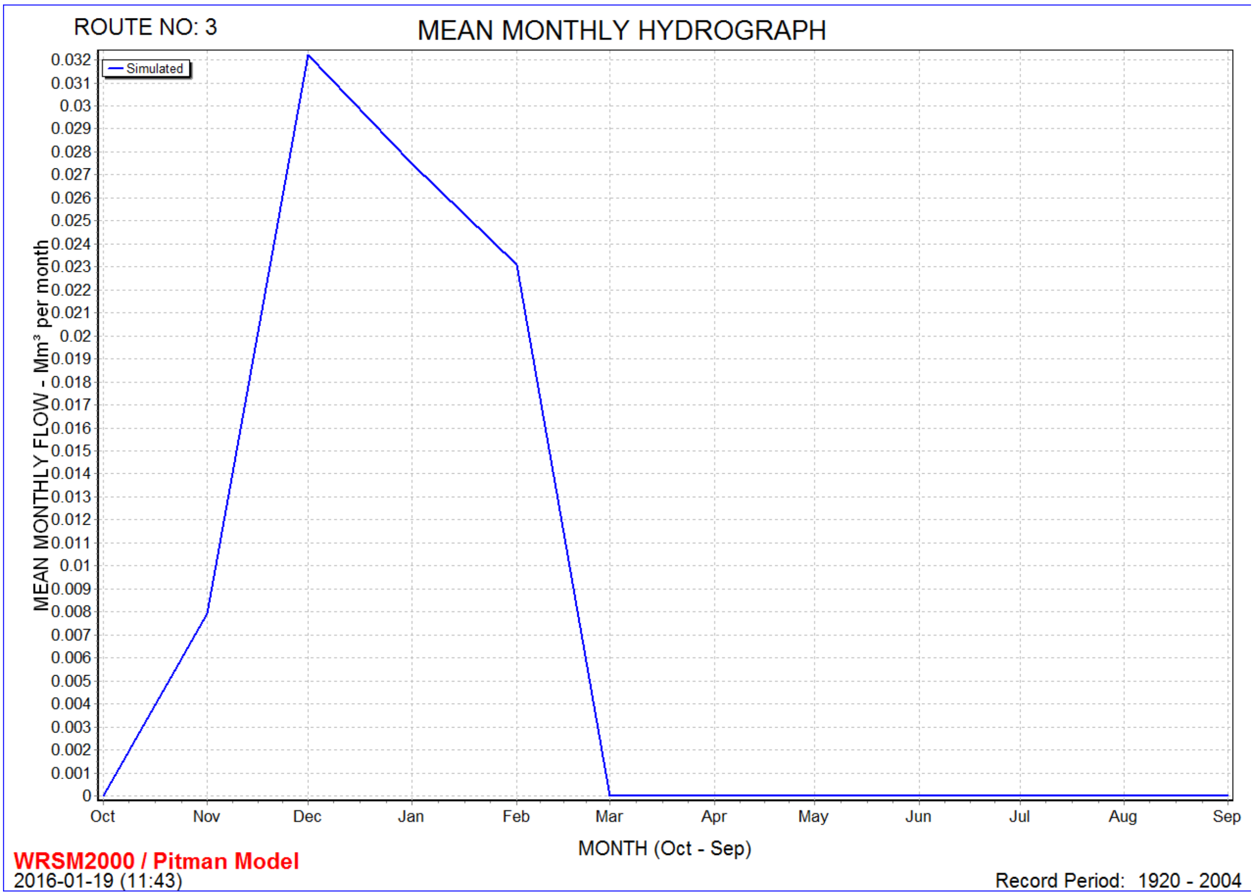
PERSBERGDAM STORAGE OVER 1 YEAR - 30 HA MAIZE AND 10 HA OATS



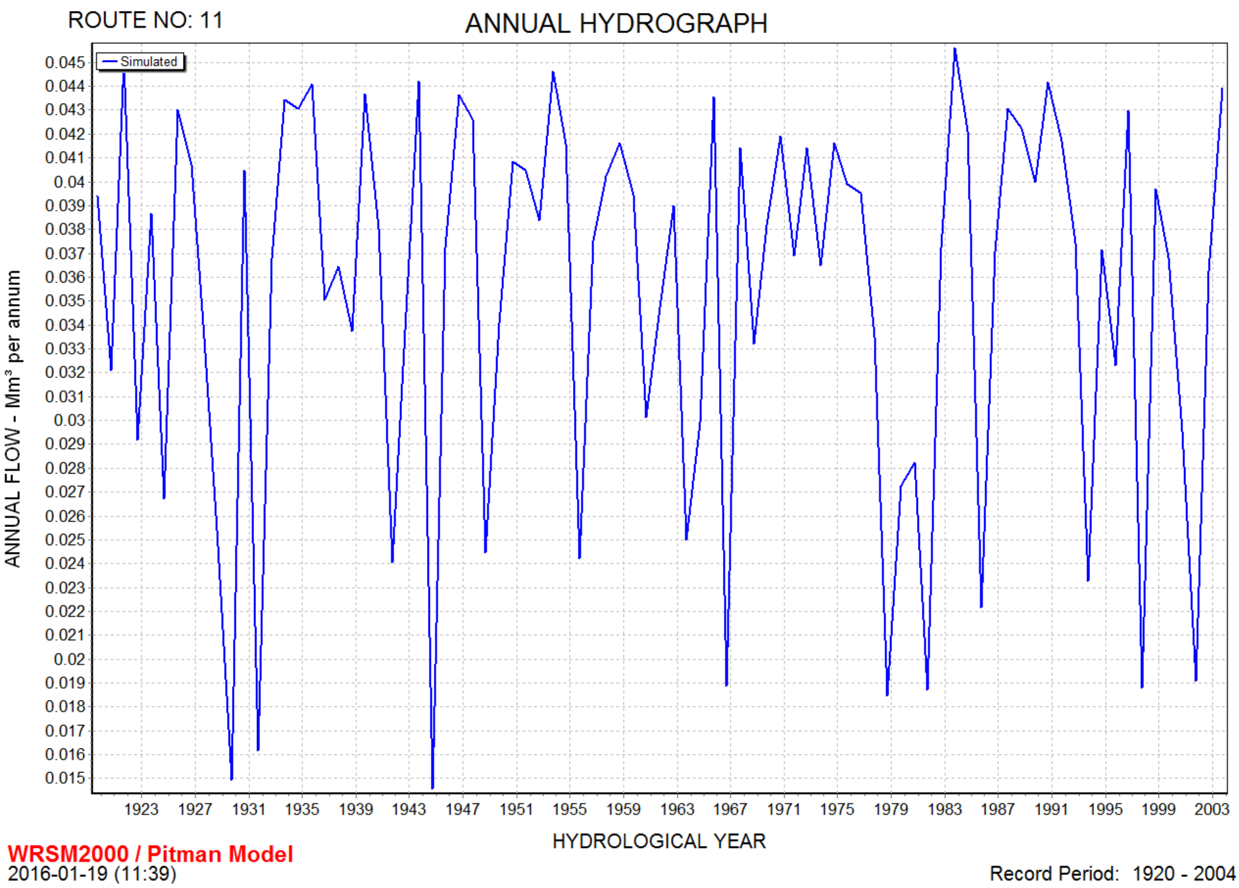
ANNUAL HYDROGRAPH OF RESERVOIR TO MAIZE IRRIGATION (30 HA)



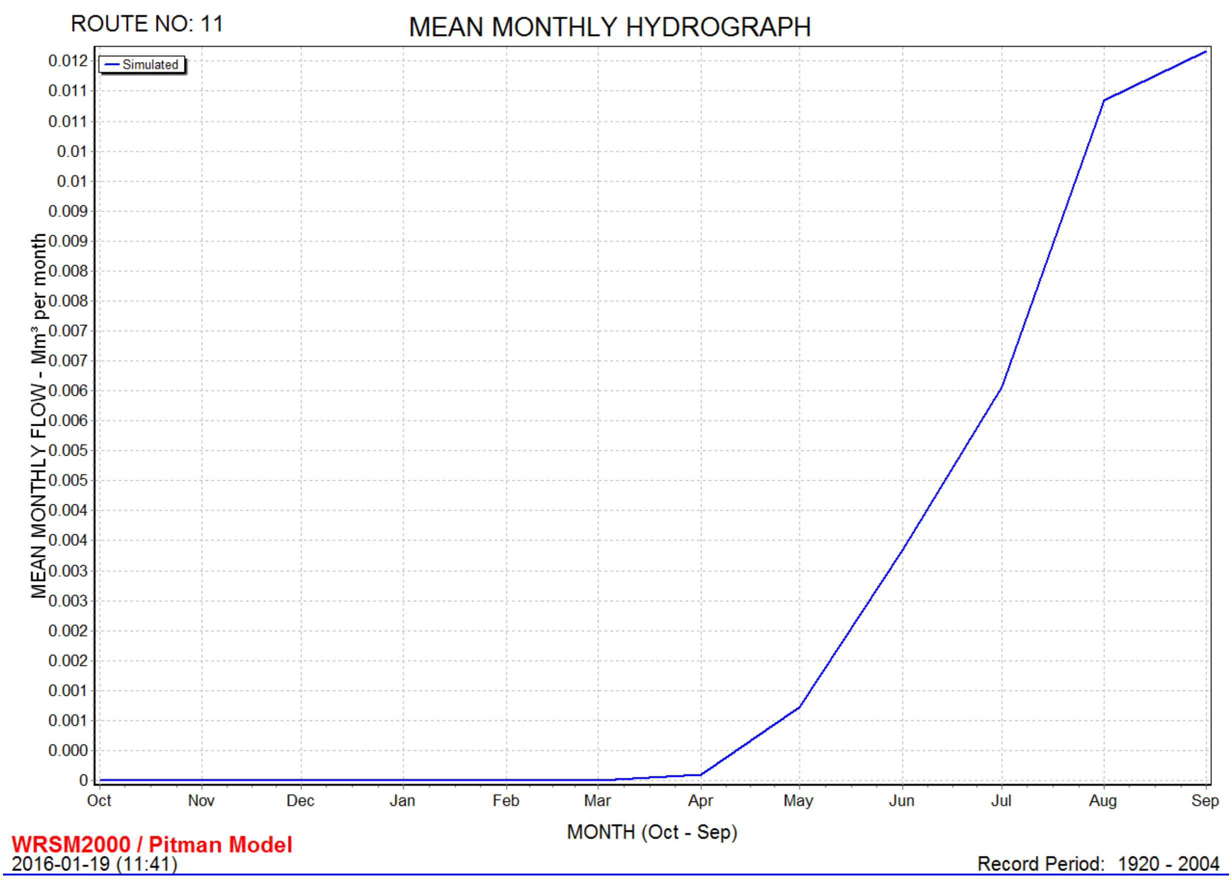
MONTHLY HYDROGRAPH OF RESERVOIR TO MAIZE IRRIGATION (30 HA)



ANNUAL HYDROGRAPH OF RESERVOIR TO OATS IRRIGATION (10 HA)



MONTHLY HYDROGRAPH OF RESERVOIR TO OATS IRRIGATION (10 HA)



12.2. FLOOD CALCULATIONS

Sinotech

Utility Programs for Drainage
Flood calculations

Project name:	**Persberg Dam**
Analysed by:	**B Muhl**
Name of river:	
Description of site:	**Persberg Dam Catchment**
Filename:	**\\FILESERVER\raws\GFK PROJECTS\DAM HELPMEKAAR\Flood Calculations.fld**
Date:	**11 December 2015**

Printed: 17 December 2015 **Page 2**

Flood Frequency Analysis: Alternative Rational Method

Project	= Persberg Dam
Analysed by	= B Muhl
Name of river	=
Description of site	= Persberg Dam Catchment
Date	= 2015-12-11
Area of catchment	= 3.5 km^2
Dolomitic area	= 0.0 %
Length of longest watercourse	= 2.34 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 39.1 m
Area distribution	= Rural: 100 %, Urban: 0 %, Lakes: 0 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	24	Very permeable	1	Thick bush & forests	2
Flat area	76	Permeable	25	Light bush & cultivated land	30
Hilly	0	Semi-permeable	70	Grasslands	66
Steep areas	0	Impermeable	4	Bare	2

Days on which thunder was heard	= 70 days/year
Weather Services station number	= 335746
Weather Services station location	= HELPMEKAAR (SAP)
Mean annual precipitation (MAP)	= 709 mm

Duration	2	5	10	20	50	100	200
1 day	57	75	88	103	123	140	158
2 days	70	93	111	129	155	176	199
3 days	82	112	135	159	194	223	255
7 days	105	143	170	199	240	273	309

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.02228 m/m
Time of concentration	= 33.1 min
Run-off factor	
Rural - C1	= 0.389
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.389

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m^3/s)
1:2	0.55	24.23	100.0	43.88	0.75	29.2	12.44
1:5	0.55	40.87	100.0	74.02	0.80	31.1	22.38
1:10	0.55	53.46	100.0	96.82	0.85	33.0	31.11
1:20	0.55	66.05	100.0	119.62	0.90	35.0	40.69
1:50	0.55	82.69	100.0	149.76	0.95	36.9	53.78
1:100	0.55	95.28	100.0	172.56	1.00	38.9	65.23
1:200	0.55	107.87	100.0	195.36	1.00	38.9	73.85

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name: Persberg Dam
Analysed by: B Muhl
Name of river:
Description of site: Persberg Dam Catchment
Filename: \\FILESERVER\raws\GFK PROJECTS\DAM HELPMEKAAR\Flood Calculations.fld
Date: 11 December 2015

Printed: 17 December 2015 **Page 1**

Flood Frequency Analysis: Rational Method

Project	= Persberg Dam
Analysed by	= B Muhl
Name of river	=
Description of site	= Persberg Dam Catchment
Date	= 2015-12-11
Area of catchment	= 3.5 km²
Dolomitic area	= 0.0 %
Mean annual rainfall (MAR)	= 733.00 mm
Length of longest watercourse	= 2.34 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 39.1 m
Rainfall region	= Inland
Area distribution	= Rural: 100 %, Urban: 0 %, Lakes: 0 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	24	Very permeable	1	Thick bush & forests	2
Flat area	76	Permeable	25	Light bush & cultivated land	30
Hilly	0	Semi-permeable	70	Grasslands	66
Steep areas	0	Impermeable	4	Bare	2

Average slope	= 0.02228 m/m
Time of concentration	= 33.1 min
Run-off factor	
Rural - C1	= 0.389
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.389

The HRU, Report 2/78, Depth-Duration-Frequency diagram was used to determine the point rainfall.

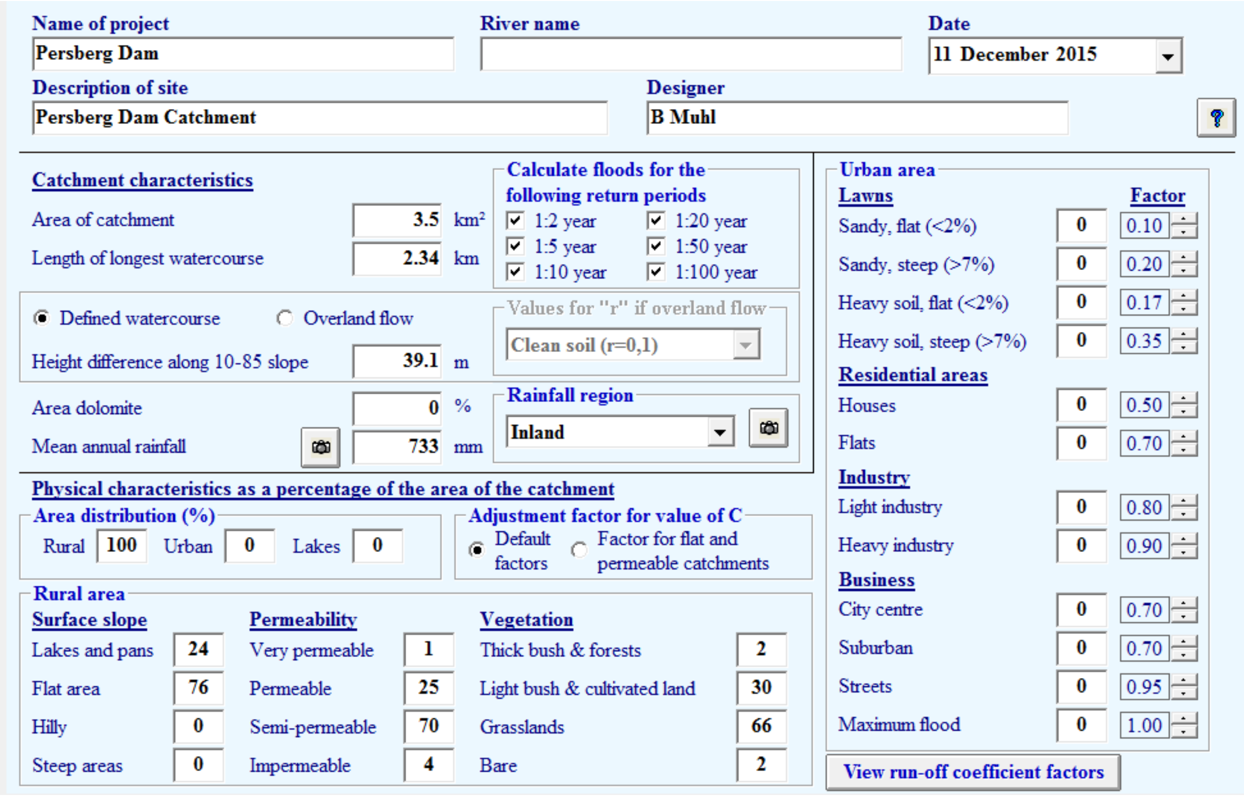
Return Period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	0.55	28.2	99.5	50.9	0.75	29.2	14.43
1:5	0.55	38.5	99.3	69.2	0.80	31.1	20.92
1:10	0.55	48.7	99.2	87.4	0.85	33.0	28.09
1:20	0.55	60.1	99.0	107.7	0.90	35.0	36.64
1:50	0.55	78.1	98.7	139.6	0.95	36.9	50.12
1:100	0.55	96.1	98.3	171.3	1.00	38.9	64.73

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Summary of peak floods for different return periods

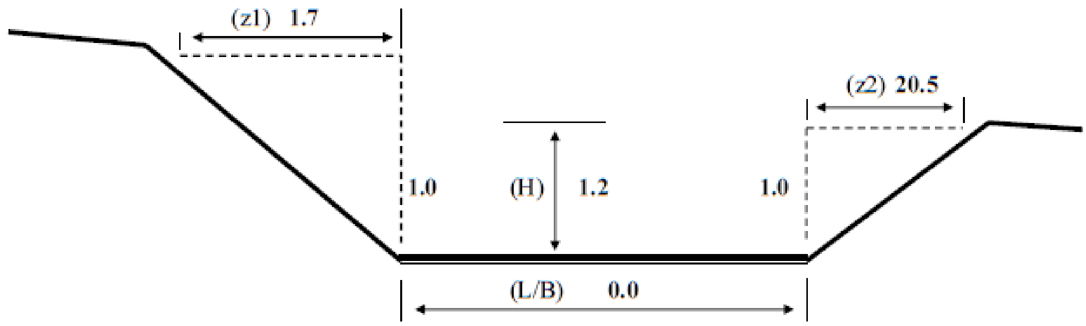
Method	1:2	1:5	1:10	1:20	1:50	1:100	1:200	Design year
Rational method	14.43	20.92	28.09	36.64	50.12	64.73		60
Alternative rational method	12.44	22.38	31.11	40.69	53.78	65.23	73.85	60
Unit hydrograph method	15.77	26.17	38.20	53.36	80.58	111.83		65
Standard design flood method	5.056	15.70	25.46	36.42	52.69	66.29	80.68	60
Empirical method			19.14	26.03	36.36	45.93		50



12.3. MAXIMUM DISCHARGE CALCULATIONS

LEFT WING

CALCULATION OF THE MAXIMUM DISCHARGE CAPACITY AT BY-WASH SPILLWAYS IN cub.m./sec. USING THREE (3) METHODS



MEASUREMENTS:

z1 - sideslope to 1	1.66
z2 - sideslope to 1	20.50
H - total freeboard available (m)	1.20
L/B - length of spillway (m)	0.0

Q - CALCULATIONS:

equation: Q1 = 4.43k (h^0.5) (H - h) ((B + z (H - h)) *where k = 0.9*

equation: h = (3 (2zH + B) - (16z^2.H^2 + 16zBH + 9B^2)^0.5) / 10z

with: h (in meter) = **0.24**

with: **Q1** (in kub.m./sek.) = **20.83**

equation: Q2 = a.L.H^1.5 + 1.35z.H^2.5 *where a = 1.5*

with: **Q2** (in kub.m./sek.) = **23.60**

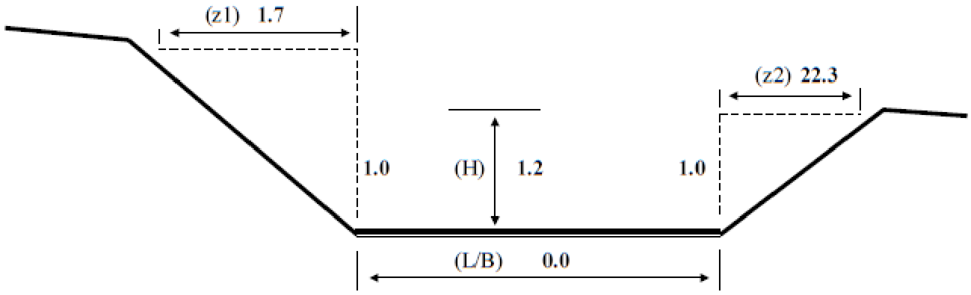
equation: Q3 = C.Le.H^1.5 *where Le = L + 0.9zH* *and C = 1.6*

with: **Q3** (in kub.m./sek.) = **25.17**

Average Q ((Q1+Q2+Q3)/3) in kub.m./sek. = **23.20**

RIGHT WING

CALCULATION OF THE MAXIMUM DISCHARGE CAPACITY AT BY-WASH SPILLWAYS IN cub.m./sec. USING THREE (3) METHODS



MEASUREMENTS:

z1 - sideslope to 1	1.66
z2 - sideslope to 1	22.30
H - total freeboard available (m)	1.20
L/B - length of spillway (m)	0.0

Q - CALCULATIONS:

equation: Q1 = 4.43k (h^0.5) (H - h) ((B + z (H - h)) *where k = 0.9*

equation: h = (3 (2zH + B) - (16z^2.H^2 + 16zBH + 9B^2)^0.5) / 10z

with: h (in meter) = 0.24

with: **Q1** (in kub.m./sek.) = **22.52**

equation: Q2 = a.L.H^1.5 + 1.35z.H^2.5 *where a = 1.5*

with: **Q2** (in kub.m./sek.) = **25.51**

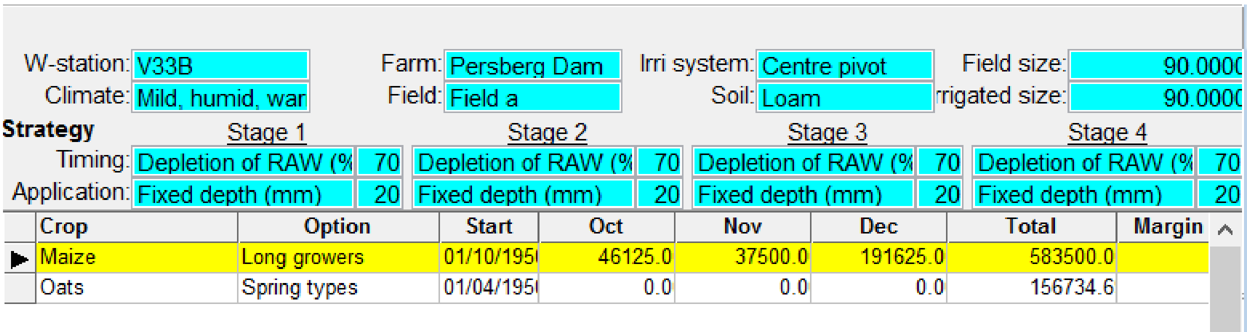
equation: Q3 = C.Le.H^1.5 *where Le = L + 0.9zH* *and C = 1.6*

with: **Q3** (in kub.m./sek.) = **27.21**

Average Q ((Q1+Q2+Q3)/3) in kub.m./sek. = **25.08**

12.4. IRRIGATION REQUIREMENTS

NO RAINFALL



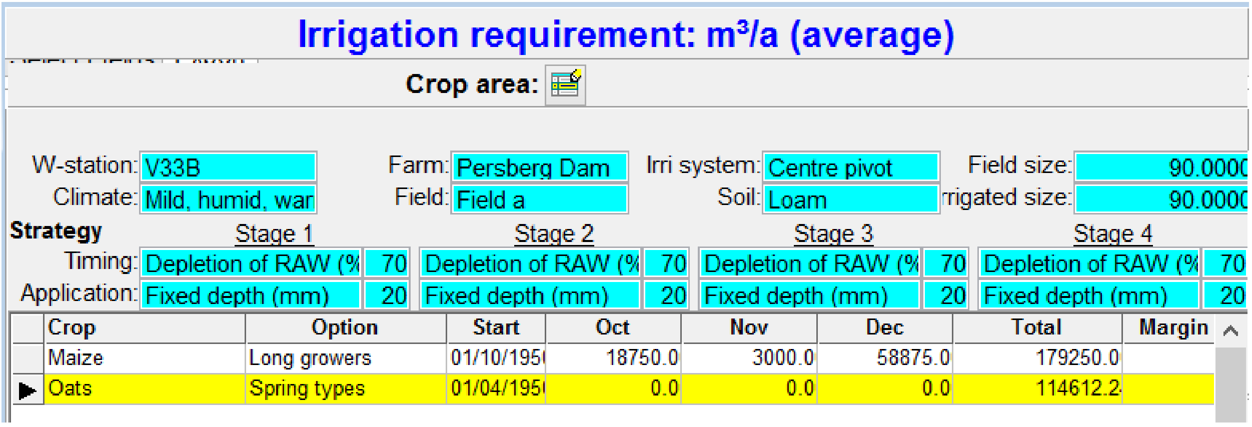
W-station: V33B | Farm: Persberg Dam | Irri system: Centre pivot | Field size: 90.000(

Climate: Mild, humid, war | Field: Field a | Soil: Loam | rrigated size: 90.000(

Strategy	Stage 1		Stage 2		Stage 3		Stage 4	
Timing:	Depletion of RAW (%	70	Depletion of RAW (%	70	Depletion of RAW (%	70	Depletion of RAW (%	70
Application:	Fixed depth (mm)	20	Fixed depth (mm)	20	Fixed depth (mm)	20	Fixed depth (mm)	20

Crop	Option	Start	Oct	Nov	Dec	Total	Margin
Maize	Long growers	01/10/195	46125.0	37500.0	191625.0	583500.0	
Oats	Spring types	01/04/195	0.0	0.0	0.0	156734.6	

INCLUDING RAINFALL



Irrigation requirement: m³/a (average)

Crop area:

W-station: V33B | Farm: Persberg Dam | Irri system: Centre pivot | Field size: 90.000(

Climate: Mild, humid, war | Field: Field a | Soil: Loam | rrigated size: 90.000(

Strategy	Stage 1		Stage 2		Stage 3		Stage 4	
Timing:	Depletion of RAW (%	70	Depletion of RAW (%	70	Depletion of RAW (%	70	Depletion of RAW (%	70
Application:	Fixed depth (mm)	20	Fixed depth (mm)	20	Fixed depth (mm)	20	Fixed depth (mm)	20

Crop	Option	Start	Oct	Nov	Dec	Total	Margin
Maize	Long growers	01/10/195	18750.0	3000.0	58875.0	179250.0	
Oats	Spring types	01/04/195	0.0	0.0	0.0	114612.2	

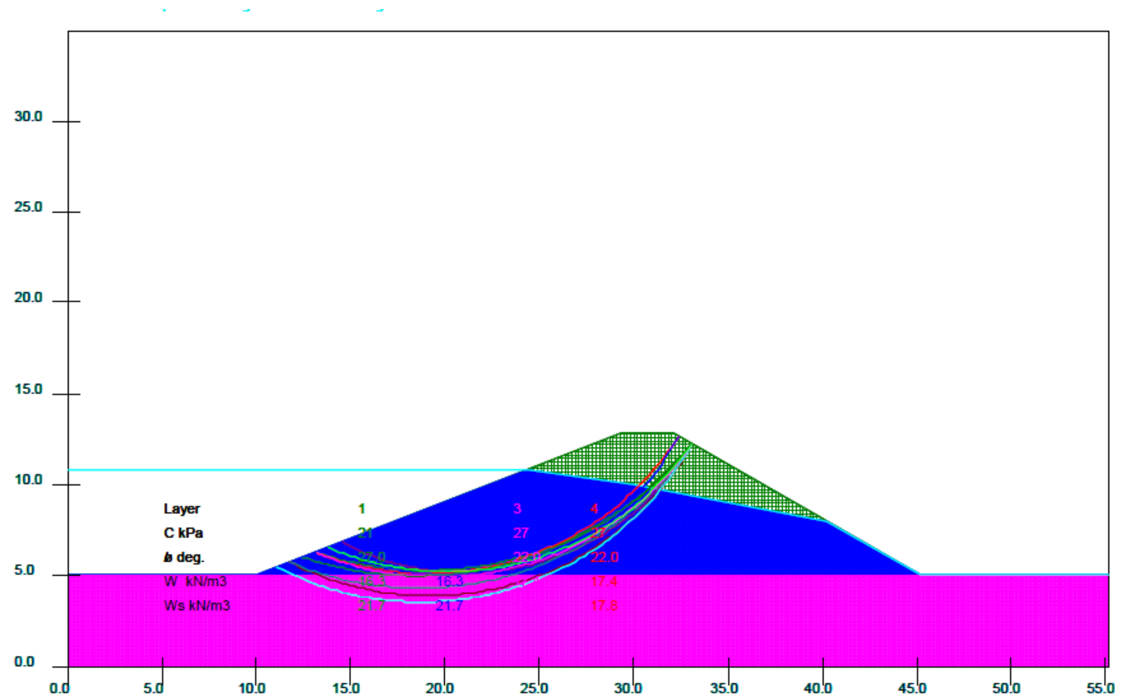
12.5. SLOPE STABILITY

UPSTREAM

The 10 Lowest Factors of Safety are:

Circle Centre		Radius	Surface Intercepts				Factors of Safety
X-Coord	Y-Coord		Higher		Lower		
17.8	17.7	16.3	33.1	12.3	7.6	5	1.92
18.1	17.7	16	33.1	12.3	8.3	5	1.92
17.9	18.3	16.4	33.1	12.3	8.3	5	1.92
17.6	18.3	16.7	33.1	12.3	7.6	5	1.92
17.8	18.6	16.6	33.1	12.3	8.3	5	1.92
17.3	18.4	16.9	33.1	12.3	6.9	5	1.92
18.3	17.6	15.7	33.1	12.3	9	5	1.92
18.1	18.3	16.1	33.1	12.3	9	5	1.92
17.4	19	17.1	33.1	12.3	7.6	5	1.92
18.2	17.2	15.7	33.1	12.3	8.3	5	1.92

Deep seated search of 'Very Fine' fineness

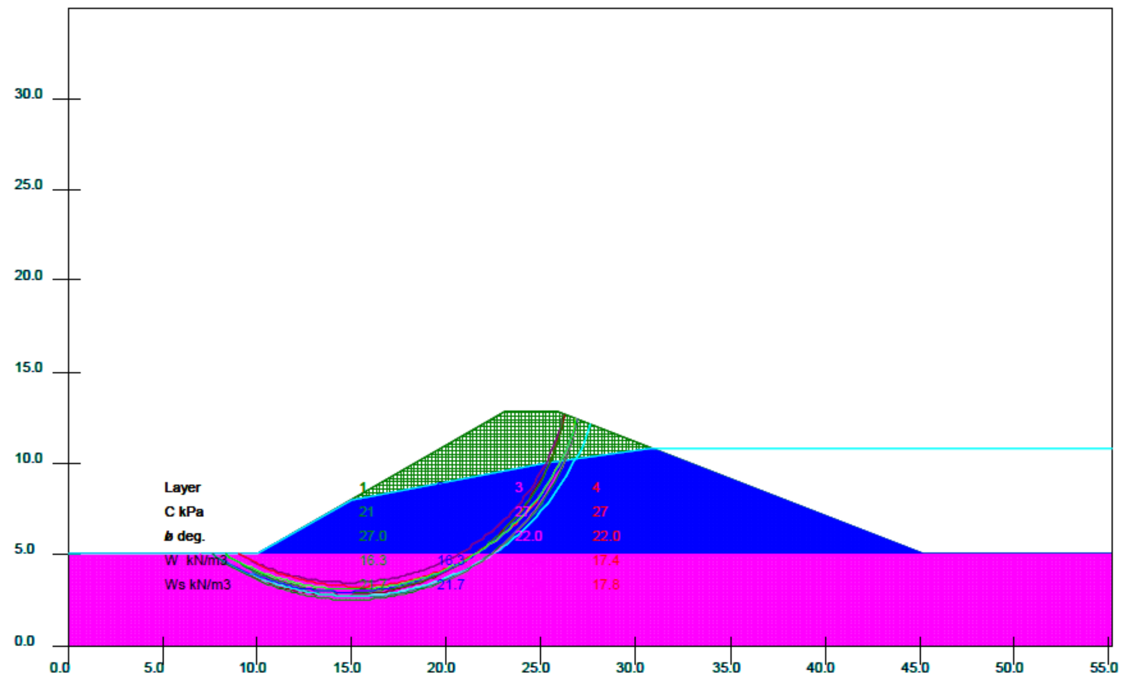


DOWNSTREAM

The 10 Lowest Factors of Safety are:

Circle Centre X-Coord	Circle Centre Y-Coord	Radius	Surface Intercepts Higher	Surface Intercepts Lower	Factors of Safety		
14.6	15.9	12	26.2	12.7	9.7	5	1.62
15.1	14.8	11.2	26.2	12.7	9.7	5	1.63
15.6	16.2	12.6	27.6	12.1	9.7	5	1.63
15.1	17.5	13.6	27.6	12.1	9.7	5	1.64
14.5	15.3	12	26.2	12.7	8.3	5	1.64
14.1	17.1	12.9	26.2	12.7	9.7	5	1.64
14.9	16.8	13.5	27.6	12.1	8.3	5	1.64
15.3	15.6	12.7	27.6	12.1	8.3	5	1.64
15.6	13.9	10.7	26.2	12.7	9.7	5	1.65
14.9	14.3	11.4	26.2	12.7	8.3	5	1.65

General search throughout slope of 'Fine' fineness



12.6. SOIL TEST RESULTS

SOILCO MATERIALS INVESTIGATIONS (PTY) LT

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg. No. : 1965/09585/07

NOOIGEDACHT FARM - LOUWSBURG ROAD P.O. BOX 872 VRYHEID 3100, KWAZULU - NATAL

TEL : 034 982 6012 FAX : 034 982 6013 e-mail : soilco@vhd.dorea.co.za

Date : 02 December 2015

For the attention of : Mr Muller

Selwyn Muller / Eric Muller
P O Box 478
Dundee
3000

Project Details : Persberg Helpmekaar Farm Dam
Job Card Number : 199520
Sample Number / s : V2518 - V2521

Dear Sir,

Herewith, please find the original report / s, pertaining to the above-mentioned project. All tests conducted are in accordance with prescribed test method. Information herein consists of the following :-

Materials Report and Reference No.	Test Conducted	Prescribed Method	No. of Pages
In-Place Density Report (Soilco SF 48)	Troxler Method	TMH 1 A10 (b)	1
Dynamic Cone Penetrometer - Plots	DCP Survey	DCP Survey	1
Moisture / Density Relationship (Soilco SF 38)	Modified AASHTO	TMH 1 A7	3
Unified Soil Clasification	External Labrotory	External Labrotory	3
Consolidated Drained Shearbox	External Labrotory	External Labrotory	4
Falling Head Permeability	External Labrotory	External Labrotory	1

We thank you for your valued support and look forward to assisting you in the near future.

Yours faithfully,

For Soilco

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg. No. : 1965/09585/07

NOOITGEDAGHT FARM - LOUWSBURG ROAD P.O.BOX 761 VRYHEID 3100 KWAZULU - NATAL

TELEPHONE : + 27 (0) 34 9826012 TELEFAX : + 27 (0) 34 9826013 email : soilco@vhd.dorea.co.za

IN SITU DENSITY REPORT

Client : Mr Selwyn Muller / Eric Muller

Project : Persberg Helpmekaar Farm Dam

Job Card No. : 199520

Date Received : 30/10/2015

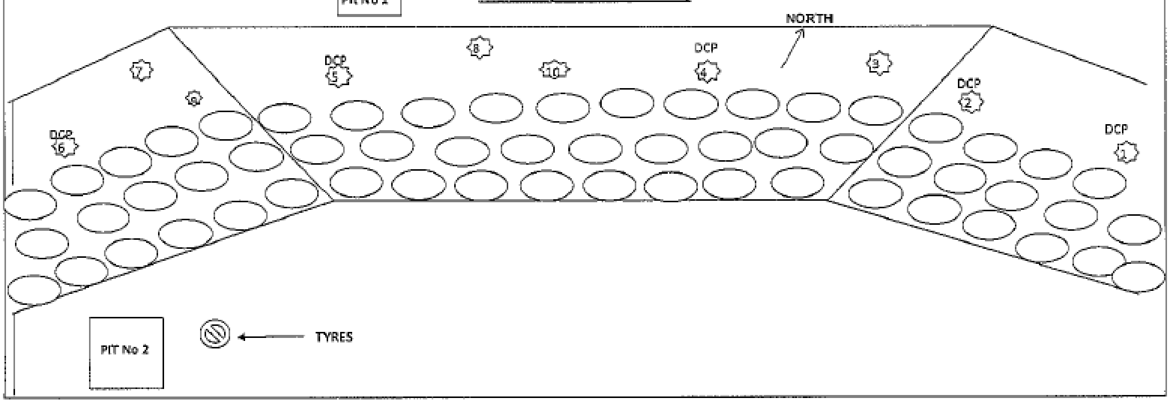
Date Tested : 30/10/2015

Date Reported : 17/11/2015

Tested By :	Jacob / Phumlani	**Test Method**		TMH 1 Method A 10 (b) **Nuclear Density Method**

Laboratory No.	Kilometer and Position	Description	Layer Tested	Depth (mm)	M.D.D. (kg/m³)	O.M.C (%)	Field Density (kg / m³) Wet	Field Density (kg / m³) Dry	Field M.C. (%)	Compaction (%)
1	3m DCP from Top of Dam	Reddish Brown Silty Clay	Fill	300	1727	14.9	1744	1577	10.6	91.3
2	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1865	1698	9.8	98.3
3	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1710	1503	13.8	87.0
4	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1703	1510	12.3	87.4
5	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1485	1331	11.6	77.1
6	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1528	1415	8.0	81.9
7	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1583	1468	7.8	85.0
8	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1686	1558	8.2	90.2
9	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1651	1498	10.2	86.7
10	"	Reddish Brown Silty Clay	Fill	300	1727	14.9	1744	1568	11.2	90.8

Sketch (Not to Scale)



Remarks : 3m DCP from top of Dam = :NB * Numbers are Densities

For Soilco :

Page 1 of 1

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg. No. : 1965/09585/07

NOOITGEDAGHT FARM - LOUWSBURG ROAD P.O.BOX 761 VRYHEID 3100 KWAZULU - NATAL

TELEPHONE : 034 982 6012 TELEFAX : 034 982 6013 email : soilco@vhd.dorea.co.za

Client : Mr Selwyn Muller / Eric Muller

Project : Persberg Helpmekaar Farm Dam

Job Card No: 199520

Date Tested 30-10-2015

Report Date : 27-11-2015

DYNAMIC CONE PENETROMETER (10 kg DPL)

DPL No. & Position	1 Dam wall - DCP 1	2 Dam wall - DCP 2	3 Dam wall - DCP 3	4 Dam wall - DCP 4	5 Dam wall - DCP 5
Depth (mm)	No. of Blows	No. of Blows	No. of Blows	No. of Blows	No. of Blows
300	24	18	3	18	5
600	27	14	5	18	6
900	15	8	3	22	7
1200	21	26	5	25	6
1500	15	21	6	32	8
1800	13	23	10	32	17
2100	20	24	18	36	19
2400	28	30	24	40	26
2700	25	36	39	47	28
3000	31	Refusal	39	51	26
3300	27		42	54	33
3600	44		46	36	41
3900	52		53	Refusal	48
4200	Refusal		55		55
4500			57		61
4800			Refusal		Refusal
5100					
5400					
5700					
6000					
Remarks					

This report is pertinent only to the area tested.

For Soilco: [signature]

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg. No. : 1965/09585/07

NOOIGEDACHT FARM - LOUWSBERG ROAD P.O. BOX 761 VRYHEID 3100

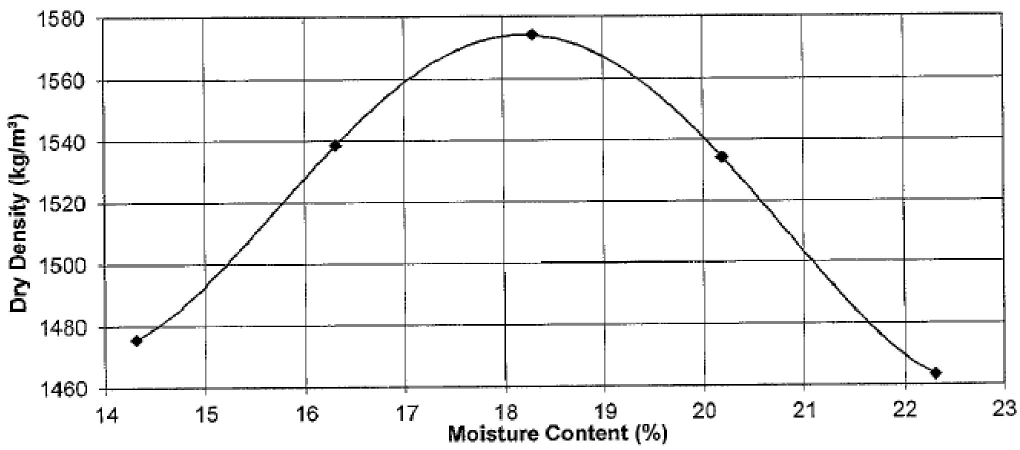
TEL : 034 9821909 FAX 034 9809235 e-mail : soilco@vhd.dorea.co.za

Client : Mr Selwyn Muller / Eric Muller		Job Card No.	199520
Project : Persberg Helpmekaar Farm Dam		Date Received	30/10/2015
Sampled by Jacob		Date Tested	16/11/2015
		Date Reported	17/11/2015

Laboratory Number	V2518
Field Reference No.	
Position in field	Pit 1
Depth (mm)	900 - 3000
Material Description	Yell.Brown Stained Lt Grey Sty Clay with Ferr.Nodules

MOISTURE / DENSITY RELATIONSHIP - PROCTOR EFFORT TMH1-METHOD (A7)

Moisture Content; (%)	14.3	16.3	18.3	20.2	22.3				
Dry Density ; (kg/m^3)	1476	1539	1574	1534	1463				



Maximum Dry Density	1574 kg/m^3
Optimum Moisture Content	18.3 %

For Soilco : ____________

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg. No. : 1965/09585/07

NOOIGEDACHT FARM - LOUWSBERG ROAD P.O. BOX 761 VRYHEID 3100

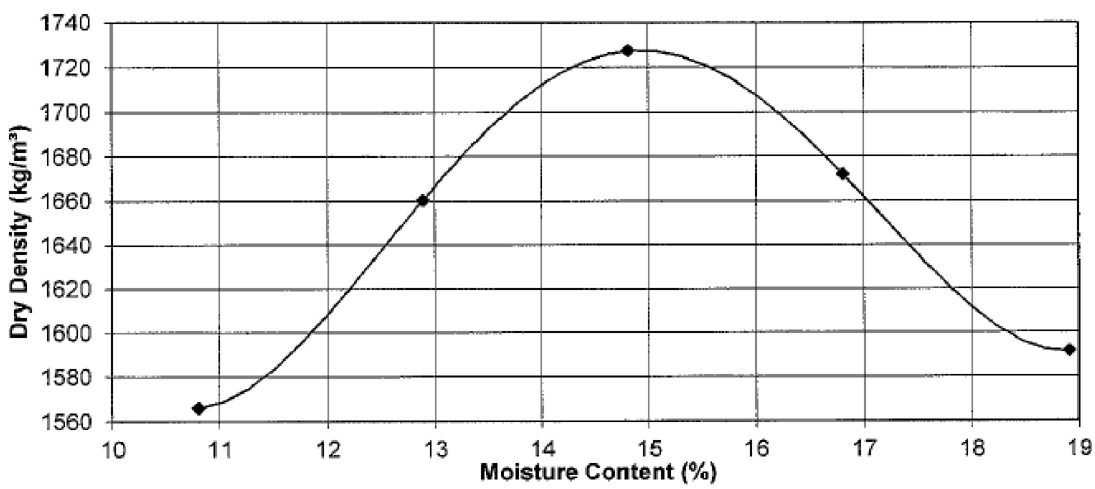
TEL : 034 9821909 FAX 034 9809235 e-mail : soilco@vhd.dorea.co.za

Client : Mr Selwyn Muller / Eric Muller		Job Card No.	199520
Project : Persberg Helpmekaar Farm Dam		Date Received	30/10/2015
Sampled by Jacob		Date Tested	16/11/2015
		Date Reported	17/11/2015

Laboratory Number	V2519
Field Reference No.	
Position in field	Pit 2
Depth (mm)	0 -600
Material Description	Reddish Brown Silty Clay

MOISTURE / DENSITY RELATIONSHIP - PROCTOR EFFORT TMH1-METHOD (A7)

Moisture Content; (%)	10.8	12.9	14.8	16.8	18.9				
Dry Density ; (kg/m^3)	1566	1660	1727	1672	1591				



Maximum Dry Density	1727 kg/m^3
Optimum Moisture Content	14.9 %

For Soilco : ____________________

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg. No. : 1965/09585/07

NOOIGEDACHT FARM - LOUWSBERG ROAD P.O. BOX 761 VRYHEID 3100

TEL : 034 9821909 FAX 034 9809235 e-mail : soilco@vhd.dorea.co.za

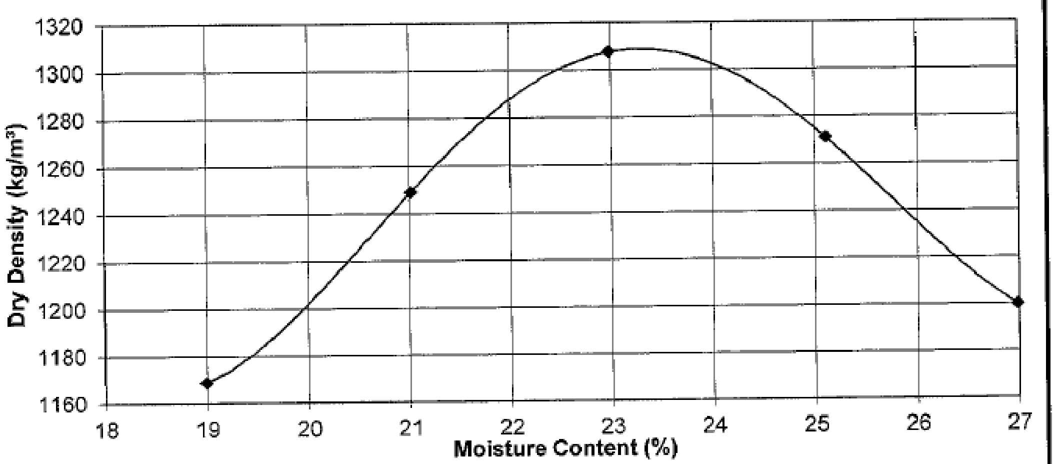
Client : Mr Selwyn Muller / Eric Muller
Project : Persberg Helpmekaar Farm Dam
Sampled by Jacob

Job Card No. 199520
Date Received 30/10/2015
Date Tested 16/11/2015
Date Reported 17/11/2015

Laboratory Number V2520
Field Reference No.
Position in field Fill
Depth (mm) 300
Material Description Reddish Brown Silty Clay

MOISTURE / DENSITY RELATIONSHIP - PROCTOR EFFORT TMH1-METHOD (A7)

Moisture Content; (%)	19.0	21.0	23.0	25.1	27.0				
Dry Density ; (kg/m^3)	1169	1249	1308	1271	1200				



Maximum Dry Density	1309 kg/m^3
Optimum Moisture Content	23.2 %

For Soilco : ____________

2003-02-24 Revision 2 Soilco SF 38

Laboratory Test Summary

THEKWINI SOILS LAB. CC

Job Description: Persberg Helpmekaar Dam - Ref. V4109
Job no.: 7940
Date: 01-12-2015

Lab no.			11059	11060								
Location			Pit 1	Pit 2								
Depth			0.90 - 3.00	0.0 - 0.60								
Description			-	-								
			-	-								
Binder Material			-	-								
Particle Size (mm)	75	Cumulative % Passing										
	53											
	37.5											
	26.5											
	19											
	13.2											
	9.5		100									
	4.75		97	100								
	2		91	100								
	0.425		81	99								
	0.25		77	98								
	0.15		72	96								
	0.075		67	92								
Hydrometer	0.05	% Passing	63	90								
	0.02		52	75								
	0.005		46	57								
	0.002		40	42								
Soil Mortar	Coarse Sand <2.0 >0.425mm	% Passing	10.2	0.6								
	Fine Sand <0.425>0.05mm		33.4	10.3								
	Silt <0.05 >0.005		15.0	32.8								
	Clay <0.005		41.4	56.3								
Atterberg Limits	Liquid Limit % (m/m)		47.9	67								
	Plasticity Index		24.7	27.6								
	Linear Shrinkage %		10.7	16.7								
	Natural MC %		-	-								
Mod AASHTO Density	Dry Density kg/m^3											
	OMC %											
CBR	100% MDD											
	98%											
	95%											
	93% (Inferred) *											
	90%											
	CBR Swell (%)											
AASHTO Soil Classification *			A - 7 - 6 (15)	A - 7 - 5 (33)								
Grading Modulus			0.61	0.09								
TRH 14 (1985) *												

Signature: ....
Title: ....

Page 2 of ...

TEST REPORT

MATERIALS ANALYSIS

THEKWINI SOILS LAB. CC

Project: Persberg Helpmekaar Dam - Ref. V4109

Ref no.: 7940 **Lab no.:** 11059 **Borehole/Pit no.:** Pit 1 **Fig no.:** -

Description: -

Depth: 0.90 - 3.00 -

Test Methods: TMH1 METHOD A1(a), A2, A3 & A4, ASTMD422

Grading Analysis

Grain Size (mm)	%Passing
75	100.0
53	100.0
37.5	100.0
26.5	100.0
19	100.0
13.2	100.0
9.5	100.0
4.75	97.4
2	90.6
0.425	81.4
0.25	76.5
0.15	72.3
0.075	67.0
0.05	62.8
0.02	52.4
0.005	46.1
0.002	39.8

M.I.T SIZE CLASSIFICATION *

Cobble%		0.0
Gravel%	9.4	
Coarse		0.0
Medium		1.9
Fine		7.5
Sand%	26.1	
Coarse		8.2
Medium		8.0
Fine		9.9
Silt%	24.7	
Coarse		12.1
Medium		5.9
Fine		6.7
Clay%	39.8	

PLASTICITY

Liquid Limit, %	47.9
Plasticity Index	24.7
Linear Shrinkage, % (L/L)	10.7

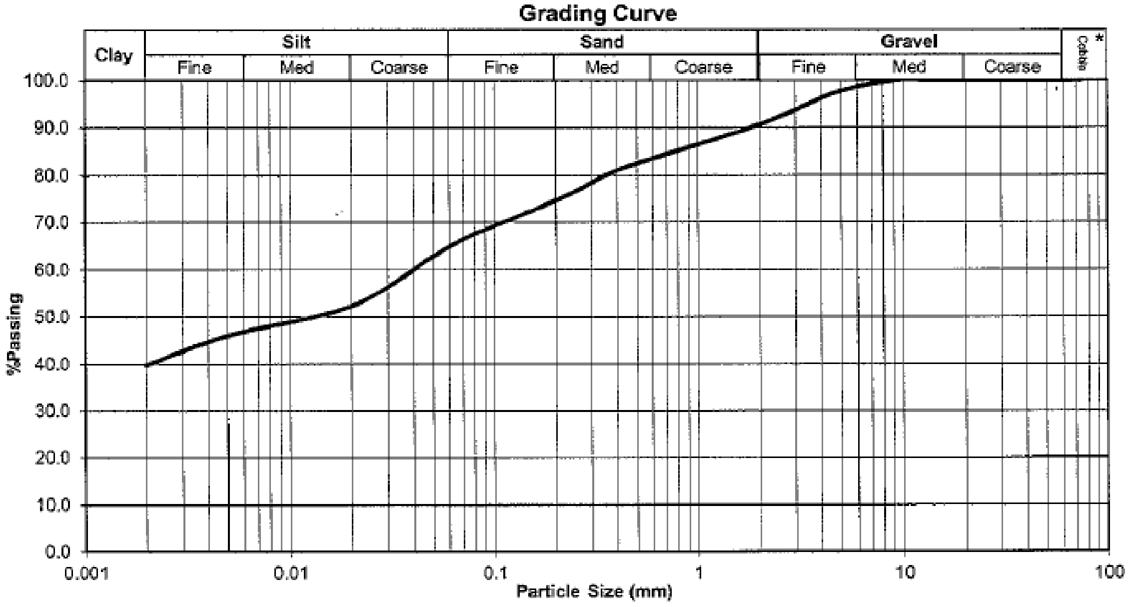
GRADING

D10 Size (mm)	<0.002
Uniformity Coefficient	*
Grading Modulus	0.61

CLASSIFICATION *

Potential Expansiveness	Medium
Group Index	15
AASHTO Soil Classification	A - 7 - 6
Unified Classification	CL or OL

Grading Curve



Ref no.: 7940 Fig no.: -

* Information marked with an asterisk is outside the scope of Accreditation.
The results only relate to the samples tested.
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Page 3 of ...

TEST REPORT

MATERIALS ANALYSIS

THEKWINI SOILS LAB. CC

Project: Persberg Helpmekaar Dam - Ref. V4109

Ref no.: 7940 **Lab no.:** 11060 **Borehole/Pit no.:** Pit 2 **Fig no.:** -
Description: -

Depth: 0.0 - 0.60 -

Test Methods: TMH1 METHOD A1(a), A2, A3 & A4, ASTMD422

Grading Analysis

Grain Size (mm)	%Passing
75	100.0
53	100.0
37.5	100.0
26.5	100.0
19	100.0
13.2	100.0
9.5	100.0
4.75	100.0
2	99.9
0.425	99.3
0.25	98.2
0.15	96.1
0.075	92.0
0.05	89.6
0.02	75.5
0.005	56.6
0.002	42.5

M.I.T SIZE CLASSIFICATION *

Cobble%		0.0
Gravel%	0.1	
Coarse		0.0
Medium		0.0
Fine		0.1
Sand%	9.3	
Coarse		0.5
Medium		2.2
Fine		6.6
Silt%	48.1	
Coarse		15.1
Medium		17.6
Fine		15.4
Clay%	42.5	

PLASTICITY

Liquid Limit	67
Plasticity Index	27.6
Linear Shrinkage	16.7

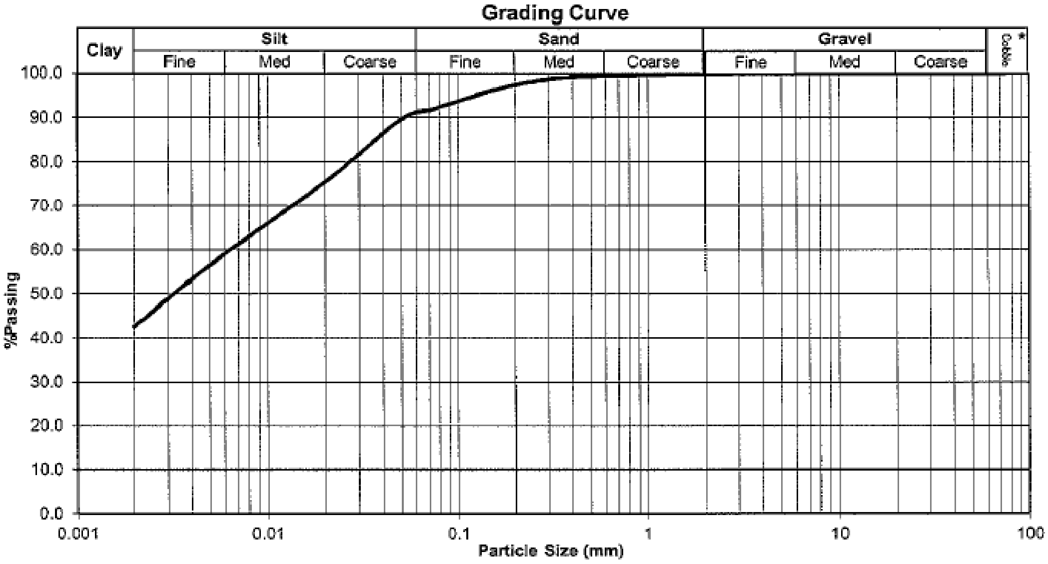
GRADING

D10 Size (mm)	<0.002
Uniformity Coefficient	NA
Grading Modulus	0.09

CLASSIFICATION *

Potential Expansiveness	High
Group Index	33
AASHTO Soil Classification	A - 7 - 5
Unified Classification	MH or OH

Grading Curve



Ref no.: 7940 Fig no.: -

* Information marked with an asterisk is outside the scope of Accreditation.
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CONSOLIDATED DRAINED SHEAR BOX TEST
TEST RESULTS

THEKWINI SOILS LAB. CC

V.A.T. REGISTRATION NO. 4590210081.

68 Ridge Road, Tollgate, DURBAN Tel : (031) 201-8992

P.O. Box 30464, MAYVILLE, 4058 Fax : (031) 201-7920

a SANAS Accredited Testing Laboratory - Facility No. T0640

Project Persberg Helpmekaar Dam
Ref no. 7940
Lab no. 11059
Depth (m): 0.90 - 3.0
Position: Pit 1

Description:
-

Sample Type:
Recompacted to 95% of MOD.

Test 1

Inputs
Normal Stress (kPa) 100 | MC at Test (%) 18.3
Prooving Ring Factor 69.83 | Dry Density (kg/m^3) 1495.3
Area (cm^2) 36 | Volume at Test (cm^3) 71.892
Volume (cm^3) 79.2

Strain Guage	Prooving Ring	Vertical Gauge	Total Strain (mm)	Total Strain %	Δ V/Vo	Shear Stress kN/m^2
0	0	1250				
0.2	0.115	1247	0.3	0.33	-0.02	22.3
0.43	0.164	1244	0.6	0.72	-0.03	32.0
0.74	0.192	1234	1.6	1.23	-0.08	37.6
0.98	0.212	1220	3.0	1.63	-0.15	41.7
1.21	0.233	1216	3.4	2.02	-0.17	45.9
1.45	0.25	1210	4.0	2.42	-0.20	49.5
1.87	0.267	1204	4.6	3.12	-0.23	53.2
2.09	0.277	1201	4.9	3.48	-0.25	55.4
2.37	0.279	1197	5.3	3.95	-0.27	56.1
2.68	0.287	1195	5.5	4.47	-0.28	58.0
2.91	0.289	1193	5.7	4.85	-0.29	58.6
3.3	0.296	1191	5.9	5.50	-0.30	60.4
3.96	0.298	1188	6.2	6.60	-0.31	61.6
4.31	0.295	1187	6.3	7.18	-0.32	61.3
4.79	0.297	1186	6.4	7.98	-0.32	62.3
5.36	0.294	1185	6.5	8.93	-0.33	62.3
5.8	0.292	1185	6.5	9.67	-0.33	62.4
6.12	0.291	1185	6.5	10.20	-0.33	62.5
6.56	0.3	1184	6.6	10.93	-0.33	65.0
7.25	0.283	1184	6.6	12.08	-0.33	64.3
8.16	0.297	1183	6.7	13.60	-0.34	66.3
9.02	0.29	1183	6.7	15.03	-0.34	65.8
10.03	0.287	1182	6.8	16.72	-0.34	66.5
11.03	0.283	1182	6.8	18.38	-0.34	66.9

Test 2

Inputs
Normal Stress (kPa) 200 | MC at Test (%) 18.3
Prooving Ring Factor 81.35 | Dry Density (kg/m^3) 1495.3
Area (cm^2) 36 | Volume at Test (cm^3) 66.924
Volume (cm^3) 79.2

Strain Guage	Prooving Ring	Vertical Gauge	Total Strain (mm)	Total Strain %	Δ V/Vo	Shear Stress kN/m^2
0	0	1097				
0.2	0.119	1096	0.1	0.33	-0.01	26.9
0.43	0.181	1087	1.0	0.72	-0.05	41.1
0.74	0.234	1078	1.9	1.23	-0.10	53.3
0.98	0.27	1071	2.6	1.63	-0.13	61.7
1.2	0.298	1066	3.1	2.00	-0.16	68.4
1.44	0.32	1061	3.6	2.40	-0.18	73.7
1.85	0.351	1052	4.5	3.08	-0.23	81.3
2.07	0.368	1049	4.8	3.45	-0.24	85.6
2.34	0.386	1045	5.2	3.90	-0.26	90.2
2.67	0.4	1043	5.4	4.45	-0.27	93.9
2.89	0.409	1040	5.7	4.82	-0.29	96.4
3.28	0.42	1036	6.1	5.47	-0.31	99.7
3.95	0.437	1033	6.4	6.58	-0.32	104.9
4.3	0.44	1032	6.5	7.17	-0.33	106.3
4.78	0.44	1031	6.6	7.97	-0.33	107.2
5.35	0.435	1029	6.8	8.92	-0.34	107.1
5.79	0.43	1029	6.8	9.65	-0.34	106.7
6.11	0.434	1029	6.8	10.18	-0.34	108.3
6.56	0.432	1028	6.9	10.93	-0.35	108.7
7.23	0.428	1028	6.9	12.05	-0.35	109.1
8.14	0.42	1027	7.0	13.57	-0.35	108.9
9.01	0.411	1026	7.1	15.02	-0.36	108.4
10.03	0.41	1026	7.1	16.72	-0.36	110.3
11.03	0.408	1026	7.1	18.38	-0.36	112.0

Test 3

Inputs
Normal Stress (kPa) 300 | MC at Test (%) 18.3
Prooving Ring Factor 82.3 | Dry Density (kg/m^3) 1495.3
Area (cm^2) 36 | Volume at Test (cm^3) 64.872
Volume (cm^3) 79.2

Strain Guage	Prooving Ring	Vertical Gauge	Total Strain (mm)	Total Strain %	Δ V/Vo	Shear Stress kN/m^2
0	0	1012				
0.19	0.107	1012	0.0	0.32	0.00	24.5
0.41	0.21	1011	0.1	0.68	-0.01	48.2
0.71	0.297	1005	0.7	1.18	-0.04	68.4
0.96	0.36	100	91.2	1.60	-4.57	83.1
1.17	0.401	995	1.7	1.95	-0.09	92.9
1.4	0.431	989	2.3	2.33	-0.12	100.1
1.82	0.472	982	3.0	3.03	-0.15	110.4
2.03	0.494	978	3.4	3.38	-0.17	115.9
2.31	0.519	974	3.8	3.85	-0.19	122.3
2.62	0.541	970	4.2	4.37	-0.21	128.1
2.85	0.554	966	4.6	4.75	-0.23	131.7
3.22	0.568	962	5.0	5.37	-0.25	135.9
3.89	0.58	957	5.5	6.48	-0.28	140.3
4.24	0.583	955	5.7	7.07	-0.29	141.9
4.72	0.584	954	5.8	7.87	-0.29	143.4
5.29	0.59	952	6.0	8.82	-0.30	146.3
5.74	0.58	951	6.1	9.57	-0.31	145.1
6.06	0.57	951	6.1	10.10	-0.31	143.4
6.5	0.58	950	6.2	10.83	-0.31	147.1
7.18	0.573	950	6.2	11.97	-0.31	147.2
8.06	0.569	949	6.3	13.43	-0.32	148.6
9.11	0.55	948	6.4	15.18	-0.32	146.7
10	0.539	947	6.5	16.67	-0.33	146.3
11	0.534	947	6.5	18.33	-0.33	147.9

CONSOLIDATED DRAINED SHEAR BOX TEST

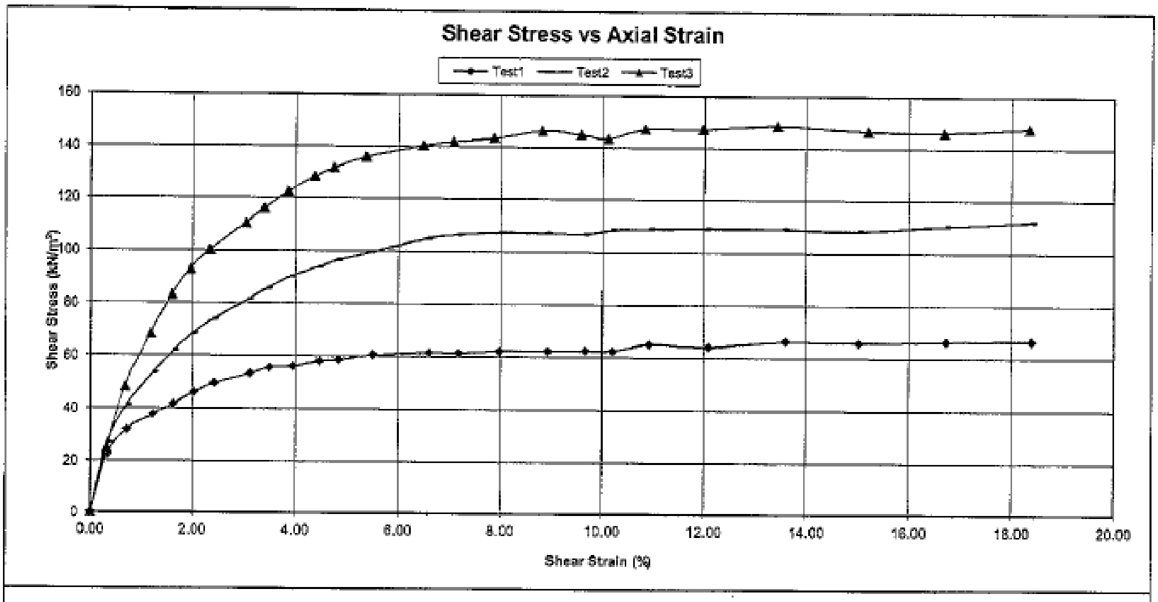
THEKWINI SOILS LAB. CC
V.A.T. REGISTRATION NO. 4590210661.
68 Ridge Road, Tollgate, DURBAN
Tel : (031) 201-8992
P.O. Box 30464, MAYVILLE, 4058
Fax : (031) 201-7920
a SANAS Accredited Testing Laboratory - Facility No. T0640

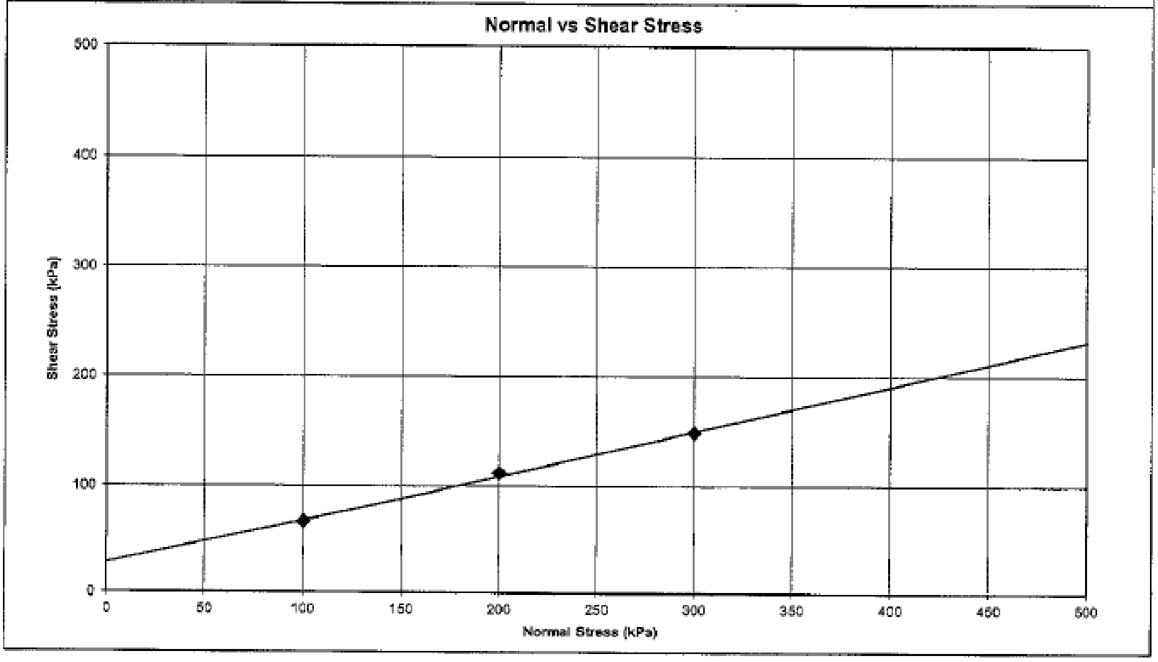
Project Persberg Helpmekaar Dam
Ref no. 7940
Lab no. 11059 **Sample Type**
Depth (m): 0.90 - 3.0 Recompacted to 95% of MOD.
Position: Pit 1 **Description:**

	Test 1	Test 2	Test 3
Normal Stress (kN/m^2)	100	200	300
Dry Density (kg/m^3)	1495	1495	1495
Moisture Content (%)	18.3	18.3	18.3
Shear Strain (%)	18.4	18.4	13.4
Shear Stress (kN/m^2)	66.9	112.0	146.6

Shear Strength Perameters

Angle of Internal Friction (O°)	22
Cohesion (kPa)	27





CONSOLIDATED DRAINED SHEAR BOX TEST
TEST RESULTS

THEKWINI SOILS LAB. CC
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Fax : (031) 201-7920
a SANAS Accredited Testing Laboratory - Facility No. T0640

Project Persberg Helpmekaar
Ref no. 7940
Lab no. 11060
Depth (m): 0.0 - 0.60
Position: Pit 1

Description:
-
Sample Type:
Recompacted to 95% of MOD.

Test 1

Inputs
Normal Stress (kPa) 100
Prooving Ring Factor 80.73
Area (cm^2) 36
Volume (cm^3) 79.2
MC at Test (%) 23.2
Dry Density (kg/m^3) 1243.55
Volume at Test (cm^3) 72.144

Strain Guage	Prooving Ring	Vertical Gauge	Total Strain (mm)	Total Strain %	Δ V/Vo	Shear Stress kN/m^2
0	0	1208				
0.26	0.092	1206	0.2	0.43	-0.01	20.7
0.55	0.14	1196	1.2	0.92	-0.06	31.6
0.76	0.155	1191	1.7	1.27	-0.08	35.1
1.11	0.182	1183	2.5	1.85	-0.12	41.5
1.4	0.198	1178	3.0	2.33	-0.15	45.3
1.98	0.223	1170	3.8	3.30	-0.19	51.5
2.3	0.233	1164	4.4	3.83	-0.22	54.1
2.92	0.25	1159	4.9	4.87	-0.24	58.7
3.33	0.257	1155	5.3	5.55	-0.26	60.7
3.8	0.262	1152	5.6	6.33	-0.28	62.4
4.34	0.269	1149	5.9	7.23	-0.29	64.7
4.86	0.271	1147	6.1	8.10	-0.30	65.8
5.37	0.273	1145	6.3	8.95	-0.31	66.9
5.79	0.28	1143	6.5	9.65	-0.32	69.1
6.34	0.277	1141	6.7	10.57	-0.33	69.1
6.84	0.274	1138	7.0	11.40	-0.35	69.0
7.26	0.271	1137	7.1	12.10	-0.35	68.8
7.66	0.27	1134	7.4	12.77	-0.37	69.1
8.48	0.263	1130	7.8	14.13	-0.39	68.3
9.17	0.254	1125	8.3	15.28	-0.41	66.9
9.62	0.25	1123	8.5	16.03	-0.42	66.4
10.36	0.24	1118	9.0	17.27	-0.45	64.7
11.07	0.229	1113	9.5	18.45	-0.47	62.7

Test 2

Inputs
Normal Stress (kPa) 200
Prooving Ring Factor 79.5
Area (cm^2) 36
Volume (cm^3) 79.2
MC at Test (%) 23.2
Dry Density (kg/m^3) 1243.55
Volume at Test (cm^3) 69.12

Strain Guage	Prooving Ring	Vertical Gauge	Total Strain (mm)	Total Strain %	Δ V/Vo	Shear Stress kN/m^2
0	0	1165				
0.23	0.111	1164	0.1	0.38	0.00	24.6
0.51	0.186	1161	0.4	0.85	-0.02	41.3
0.71	0.214	1157	0.8	1.18	-0.04	47.7
1.17	0.259	1150	1.5	1.95	-0.07	58.1
1.35	0.287	1144	2.1	2.25	-0.10	64.5
1.94	0.348	1136	2.9	3.23	-0.14	78.9
2.26	0.371	1126	3.9	3.77	-0.19	84.6
2.9	0.41	1125	4.0	4.83	-0.20	94.5
3.76	0.441	1105	6.0	6.27	-0.30	103.1
4.31	0.46	1099	6.6	7.18	-0.33	108.5
4.82	0.474	1096	6.9	8.03	-0.34	112.8
5.32	0.486	1089	7.6	8.87	-0.38	116.7
5.73	0.507	1086	7.9	9.55	-0.39	122.6
6.28	0.507	1082	8.3	10.47	-0.41	123.9
6.77	0.509	1078	8.7	11.28	-0.43	125.5
8.6	0.511	1070	9.5	14.33	-0.47	130.4
9.43	0.503	1063	10.2	15.72	-0.51	130.5
10.12	0.487	1058	10.7	16.87	-0.53	128.1
10.55	0.472	1055	11.0	17.58	-0.55	125.3
11.29	0.443	1048	11.7	18.82	-0.58	119.4
12.02	0.413	1042	12.3	20.03	-0.61	113.1

Test 3

Inputs
Normal Stress (kPa) 300
Prooving Ring Factor 79.94
Area (cm^2) 36
Volume (cm^3) 79.2
MC at Test (%) 23.2
Dry Density (kg/m^3) 1243.55
Volume at Test (cm^3) 67.284

Strain Guage	Prooving Ring	Vertical Gauge	Total Strain (mm)	Total Strain %	Δ V/Vo	Shear Stress kN/m^2
0	0	1215				
0.2	0.1	1214	0.1	0.33	0.00	22.2
0.48	0.21	1212	0.3	0.80	-0.01	46.8
0.69	0.262	1211	0.4	1.15	-0.02	58.6
1.03	0.331	1202	1.3	1.72	-0.06	74.4
1.31	0.378	1197	1.8	2.18	-0.09	85.3
1.89	0.453	1187	2.8	3.15	-0.14	103.1
2.21	0.488	1181	3.4	3.68	-0.17	111.6
2.86	0.535	1172	4.3	4.77	-0.21	123.6
3.73	0.6	1159	5.6	6.22	-0.28	140.6
4.26	0.632	1152	6.3	7.10	-0.31	149.4
4.78	0.655	1146	6.9	7.97	-0.34	156.2
5.28	0.672	1141	7.4	8.80	-0.37	161.6
5.69	0.702	1138	7.7	9.48	-0.38	170.0
6.22	0.7	1133	8.2	10.37	-0.41	171.2
6.71	0.699	1129	8.6	11.18	-0.43	172.5
7.55	0.672	1122	9.3	12.58	-0.46	168.5
8.39	0.62	1116	9.9	13.98	-0.49	158.2
9.54	0.59	1109	10.6	15.90	-0.53	154.0
10.26	0.56	1105	11.0	17.10	-0.55	148.3
11.02	0.531	1102	11.3	18.37	-0.56	142.9

CONSOLIDATED DRAINED SHEAR BOX TEST

THEKWINI SOILS LAB. CC
V.A.T. REGISTRATION NO. 4590210091
68 Ridge Road, Tollgate, DURBAN
Tel : (031) 201-8992
P.O. Box 30464, MAYVILLE, 4058
Fax : (031) 201-7920
a SANAS Accredited Testing Laboratory - Facility No. T0640

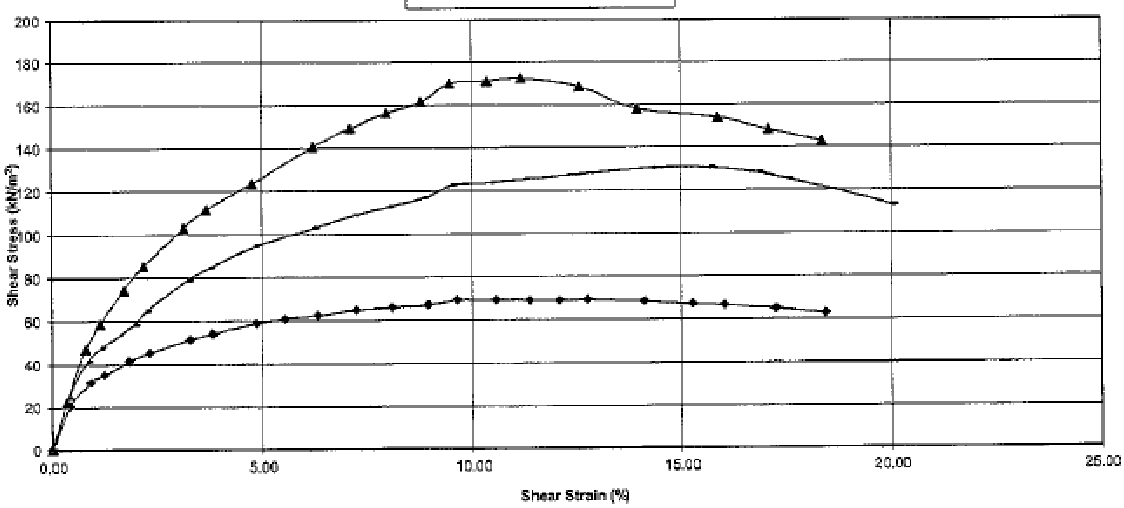
Project Persberg Helpmekaar
Ref no. 7940
Lab no. 11060 **Sample Type**
Depth (m): 0.0 - 0.60 Recompacted to 95% of MOD.
Position: Pit 1 **Description:**
-

	Test 1	Test 2	Test 3
Normal Stress (kN/m^2)	100	200	300
Dry Density (kg/m^3)	1244	1244	1244
Moisture Content (%)	23.2	23.2	23.2
Shear Strain (%)	9.7	15.7	11.2
Shear Stress (kN/m^2)	69.1	130.5	172.5

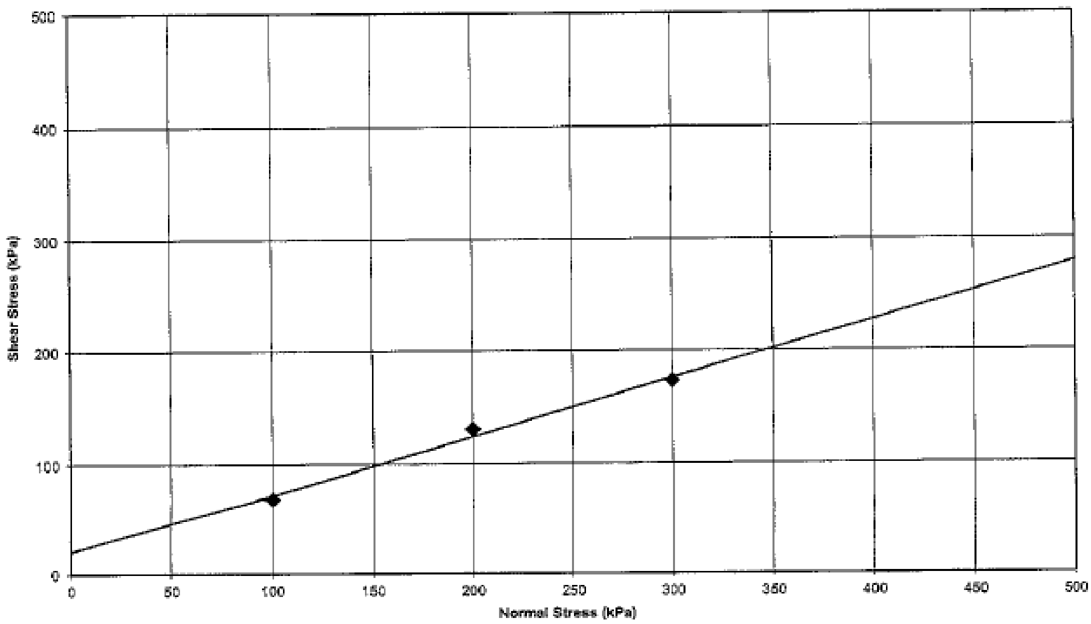
Shear Strength Perameters

Angle of Internal Friction (O°)	27
Cohesion (kPa)	21

Shear Stress vs Axial Strain



Normal vs Shear Stress



Falling Head Permeability

THEKWINI SOILS LAB. CC

Date : 01-12-2015

Ref : 7940

Client : Soilco Materials Investigation

Project : Persberg Helpmekaar Dam

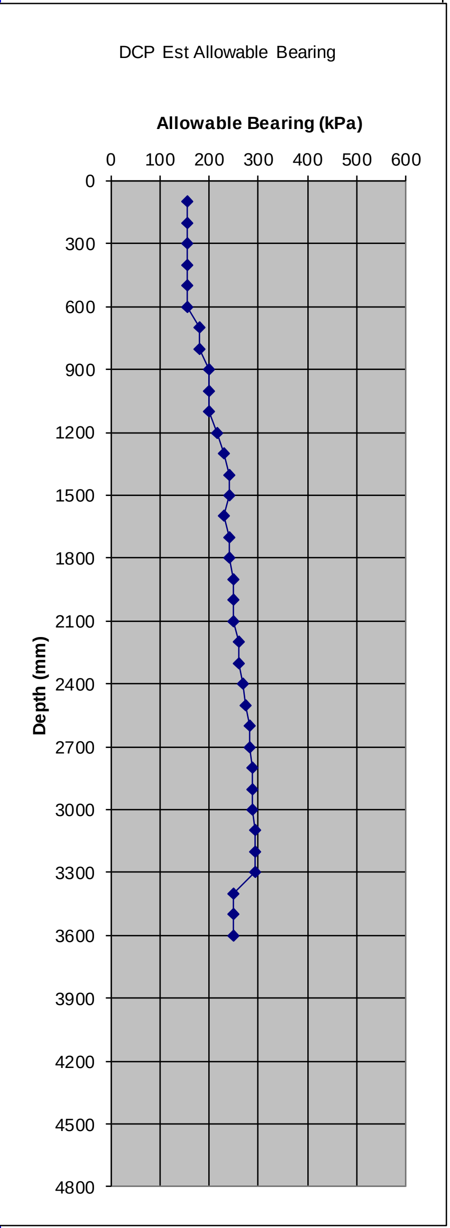
Laboratory Number	Sample Number	Proctor MOD kg/m^3	OMC %	Recompacted Dry Density Kg/m^3	Permeability k = cm/sec
5 meter head height					
11059	-	1574	18.3	1495	9.306×10^{-8}
11060	-	1629	17.0	1596	1.083×10^{-5}

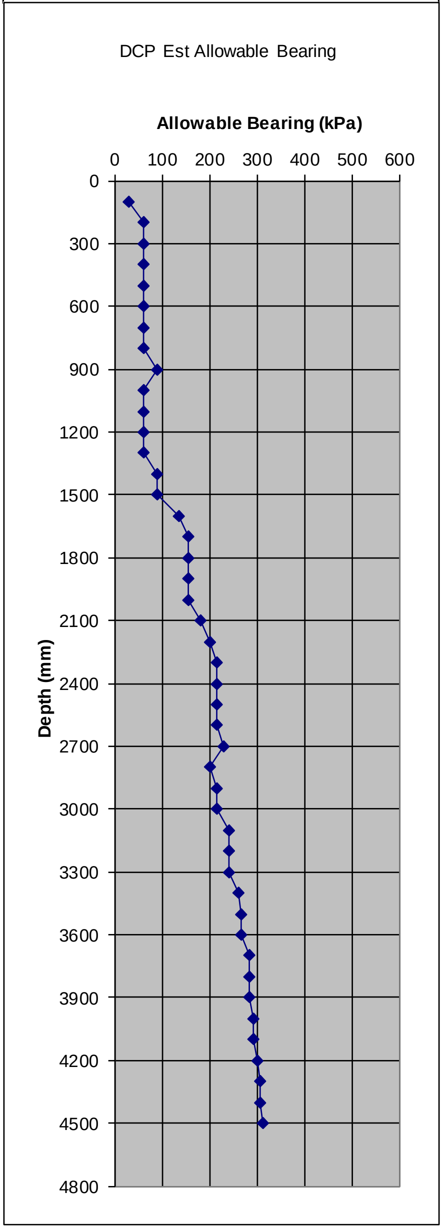
DYNAMIC CONE PENETROMETER - RESULT SHEET

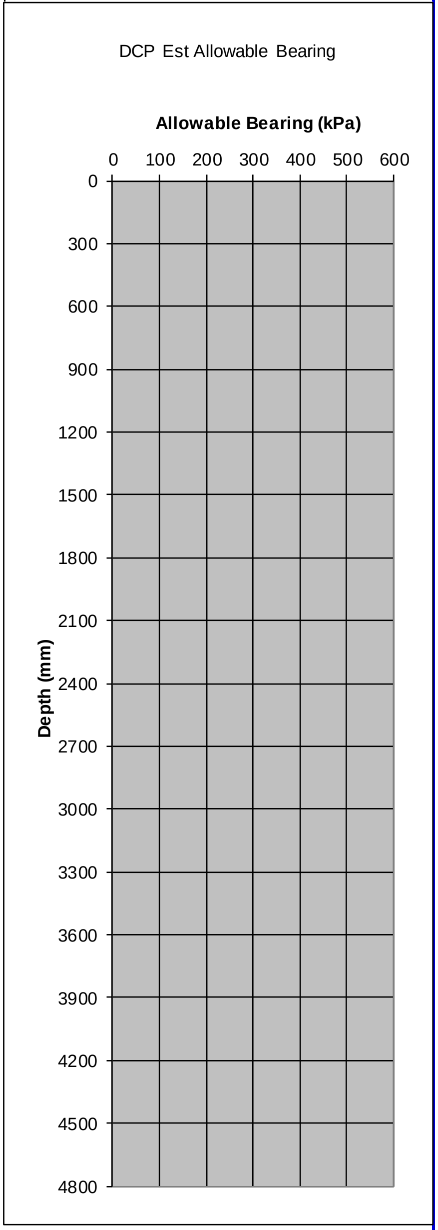
GFK
Consulting Engineers and Project Managers
119 Deputasie Street
VRYHEID
3100
Tel: 034 982 3425
Fax: 034 982 3425
fkrugel@raws.co.za

Client	Erich Muller
Project	Persberg dam
Location	Helpmekaar
Operator	Soilco
Date	27/11/2015
Job #	2015/11/01
Lab #	VRYHEID

Site #	Helpmekaar	Site #	Helpmekaar	Site #	NA
Location	DCP4	Location	DCP5	Location	NA







Note: The Allowable Bearing Capacity data applies to cohesive soils only and is based on bearing capacity factor Nc = 5 and FOS = 5 Approximate Cu = 0.8 x allowable bearing capacity.

DYNAMIC CONE PENETROMETER - RESULT SHEET

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Consulting Engineers and Project Managers
119 Deputasie Street
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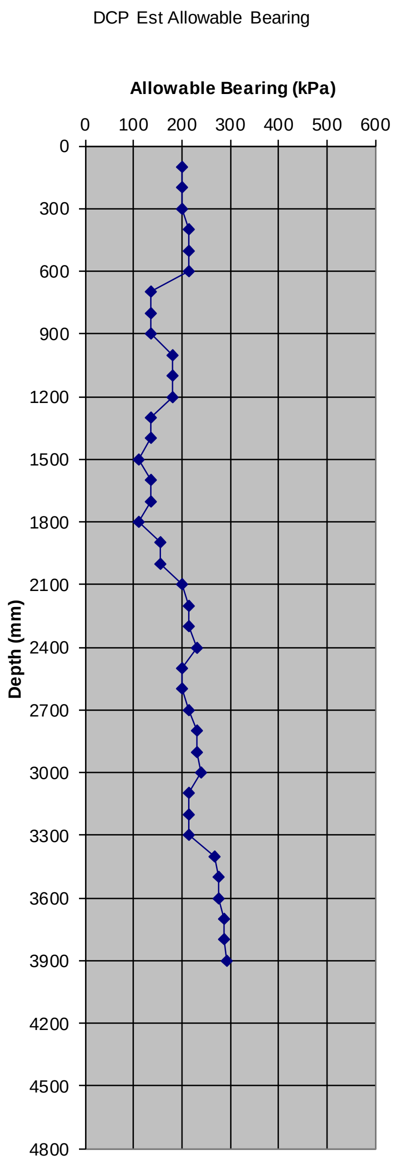
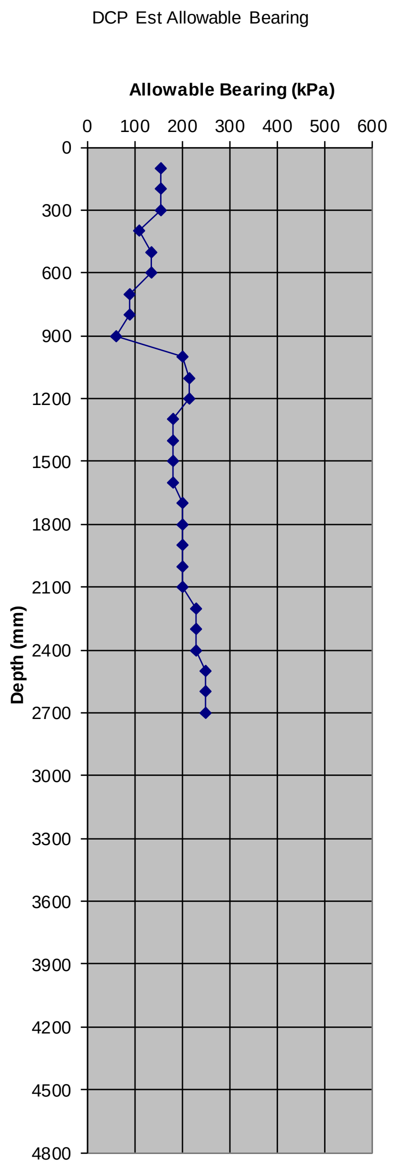
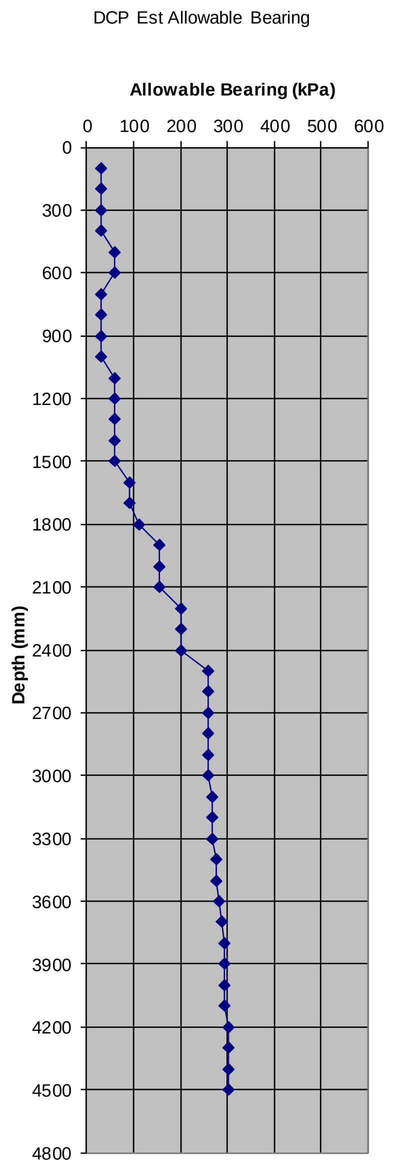
3100
Tel: 034 982 3425
Fax: 034 982 3425
fkrugel@raws.co.za

Client	Erich Muller
Project	Persberg dam
Location	Helpmekaar
Operator	Soilco
Date	27/11/2015
Job #	2015/11/01
Lab #	VRYHEID

Site #	Helpmekaar	Site #	Helpmekaar	Site #	Helpmekaar
Location	DCP1	Location	DCP2	Location	DCP3



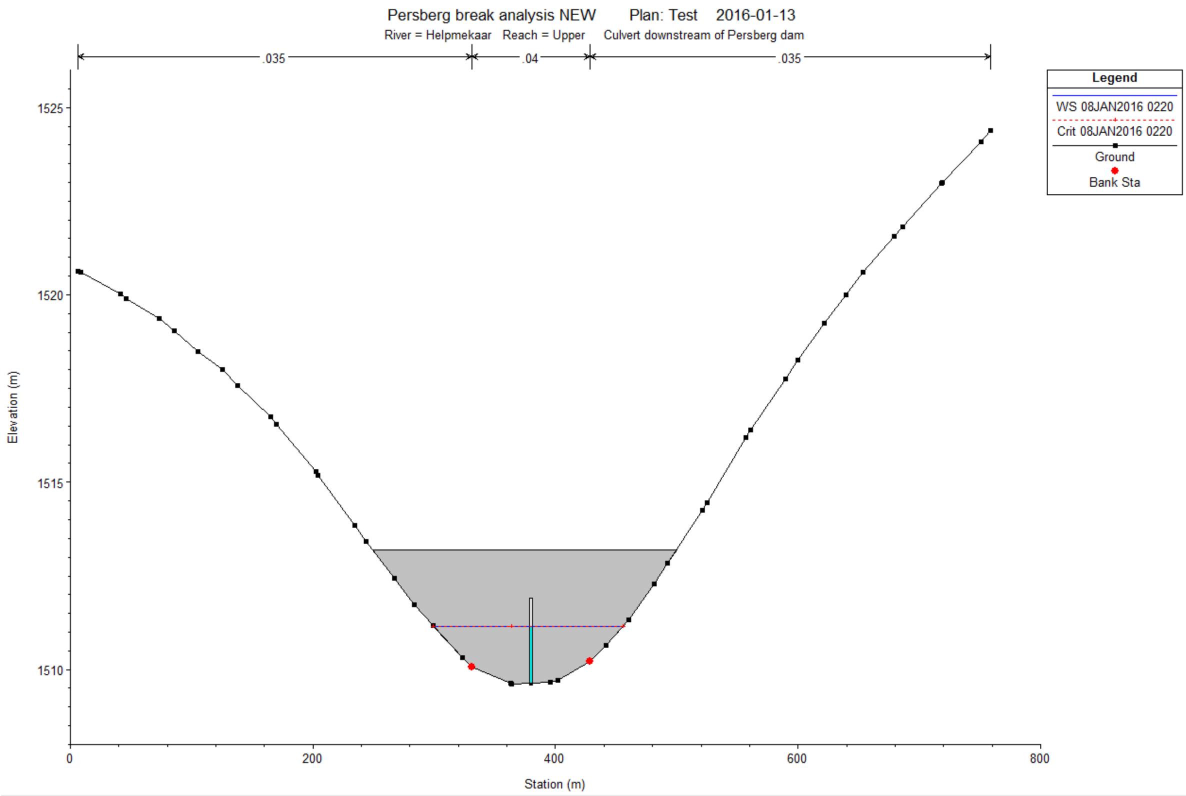




Note: The Allowable Bearing Capacity data applies to cohesive soils only and is based on bearing capacity factor Nc = 5 and FOS = 5 Approximate Cu = 0.8 x allowable bearing capacity.

12.7. DAM BREAK ANALYSIS

DAM BREACH for dam under 50 000m³



River:	Helpmekaar	Profile:	08JAN2016 0220	Culv Group: Culvert #1	
Reach	Upper	RS:	17.1	Plan:	Sunny Day

Plan: Sunny Day Helpmekaar Upper RS: 17.1 Culv Group: Culvert #1 Profile: 08JAN2016 0220

Q Culv Group (m3/s)	12.73	Culv Full Len (m)	
# Barrels	1	Culv Vel US (m/s)	3.90
Q Barrel (m3/s)	12.73	Culv Vel DS (m/s)	5.43
E.G. US. (m)	1512.25	Culv Inv El Up (m)	1509.60
W.S. US. (m)	1512.62	Culv Inv El Dn (m)	1509.20
E.G. DS (m)	1509.80	Culv Frctn Ls (m)	0.11
W.S. DS (m)	1509.79	Culv Exit Loss (m)	2.03
Delta EG (m)	2.45	Culv Entr Loss (m)	0.31
Delta WS (m)	2.83	Q Weir (m3/s)	
E.G. IC (m)	1512.10	Weir Sta Lft (m)	
E.G. OC (m)	1512.25	Weir Sta Rgt (m)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (m)	1511.16	Weir Max Depth (m)	
Culv WS Outlet (m)	1510.33	Weir Avg Depth (m)	
Culv Nml Depth (m)	0.78	Weir Flow Area (m2)	
Culv Crt Depth (m)	1.56	Min El Weir Flow (m)	1513.20

Errors, Warnings and Notes

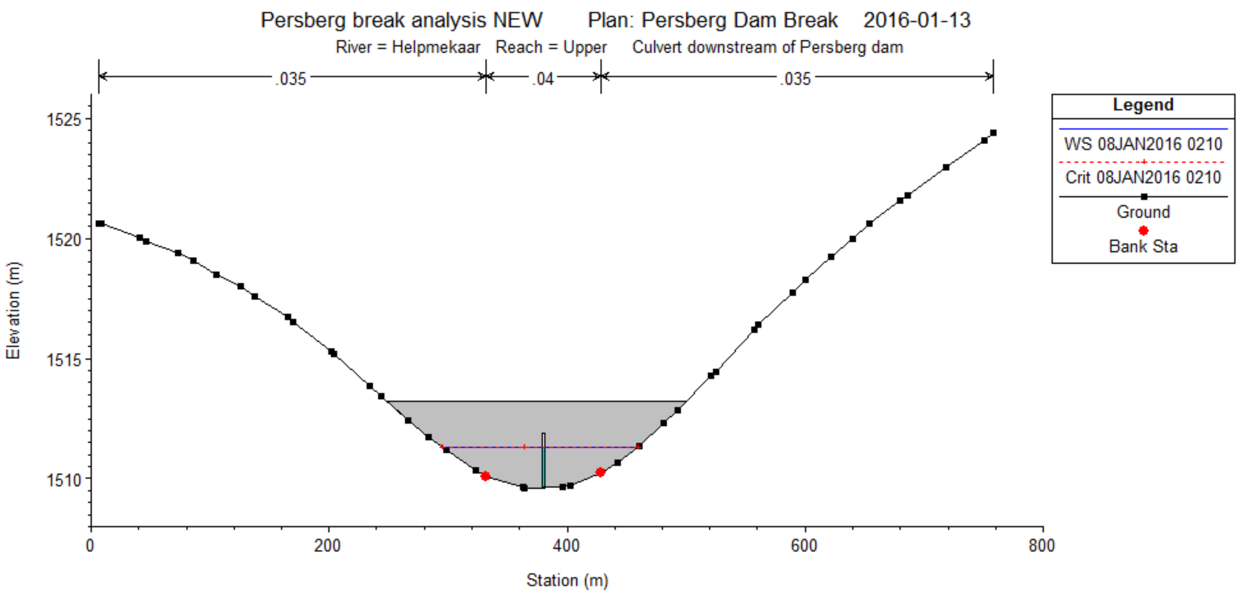
Note:	The flow in the culvert is entirely supercritical.

DAM BREACH CROSS SECTION DATA AT MAXIMUM WATER SURFACE ELEVATION

HEC-RAS Plan: Persberg River: Helpmekaar Reach: Upper Profile: 08JAN2016 0340 | Reload Data

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude #
Upper	22	08JAN2016 0340	0.10	1510.25	1512.72		1512.72	0.000000	0.00	336.80	202.39	
Upper	21	08JAN2016 0340	9.86	1510.25	1512.72		1512.72	0.000001	0.03	336.80	202.39	
Upper	20.1		Lat Struct									
Upper	20	08JAN2016 0340	12.77	1510.25	1512.72	1510.48	1512.72	0.000001	0.04	336.71	202.37	
Upper	19.1		Inl Struct									
Upper	19	08JAN2016 0340	12.77	1509.95	1512.71		1512.71	0.000001	0.03	388.37	212.94	
Upper	18	08JAN2016 0340	13.13	1509.62	1512.71		1512.71	0.000000	0.03	462.58	229.58	
Upper	17.1		Culvert									
Upper	17	08JAN2016 0340	13.13	1509.24	1509.79		1509.80	0.000751	0.36	36.43	95.46	
Upper	16	08JAN2016 0340	26.98	1506.90	1507.45		1507.49	0.004588	0.85	31.80	89.66	
Upper	15	08JAN2016 0340	39.60	1501.75	1502.44		1502.55	0.012255	1.49	26.63	67.58	
Upper	14	08JAN2016 0340	39.61	1498.49	1499.39		1499.41	0.001534	0.72	55.53	94.02	
Upper	13	08JAN2016 0340	39.65	1496.36	1498.99	1496.84	1498.99	0.000008	0.13	345.54	204.08	
Upper	12.1		Inl Struct									
Upper	12	08JAN2016 0340	39.65	1496.04	1496.61		1496.69	0.008730	1.24	32.01	85.57	
Upper	11	08JAN2016 0340	39.88	1495.71	1496.26		1496.34	0.009961	1.27	31.51	87.21	
Upper	10	08JAN2016 0340	40.76	1494.89	1495.44		1495.54	0.014048	1.43	28.44	84.51	
Upper	9	08JAN2016 0340	43.61	1493.94	1494.49		1494.55	0.006978	1.12	38.82	98.34	
Upper	8	08JAN2016 0340	45.31	1492.03	1493.74	1492.54	1493.74	0.000102	0.33	145.42	122.68	

1:20 YEAR FLOOD



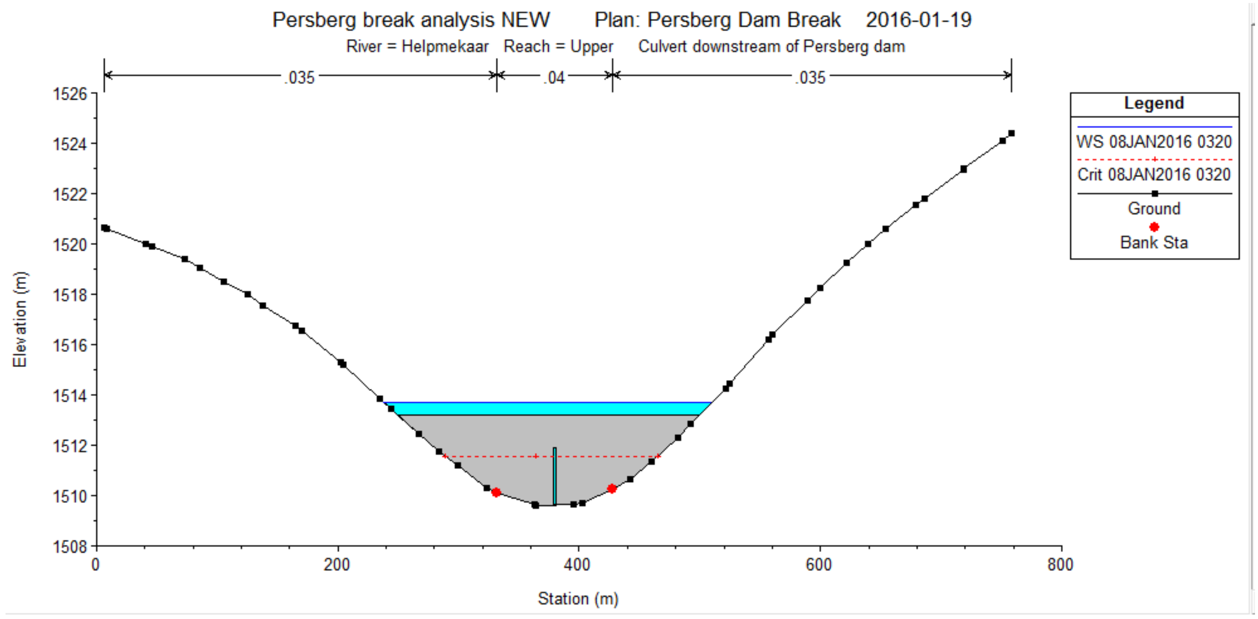
River: Helpmekaar | Profile: 08JAN2016 0210 | Culv Group: Culvert #1

Reach: Upper | RS: 17.1 | Plan: Persberg

Plan: Persberg Helpmekaar Upper RS: 17.1 Culv Group: Culvert #1 Profile: 08JAN2016 0210

Q Culv Group (m3/s)	14.53	Culv Full Len (m)	
# Barrels	1	Culv Vel US (m/s)	4.08
Q Barrel (m3/s)	14.53	Culv Vel DS (m/s)	5.59
E.G. US. (m)	1512.49	Culv Inv El Up (m)	1509.60
W.S. US. (m)	1513.00	Culv Inv El Dn (m)	1509.20
E.G. DS (m)	1509.80	Culv Frctn Ls (m)	0.11
W.S. DS (m)	1509.79	Culv Exit Loss (m)	2.24
Delta EG (m)	2.69	Culv Entr Loss (m)	0.34
Delta WS (m)	3.21	Q Weir (m3/s)	
E.G. IC (m)	1512.40	Weir Sta Lft (m)	
E.G. OC (m)	1512.49	Weir Sta Rgt (m)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (m)	1511.31	Weir Max Depth (m)	
Culv WS Outlet (m)	1510.45	Weir Avg Depth (m)	
Culv Nml Depth (m)	0.85	Weir Flow Area (m2)	
Culv Crt Depth (m)	1.71	Min El Weir Flow (m)	1513.20

1:50 YEAR FLOOD



File Type Options Help

River: Helpmekaar Profile: 08JAN2016 0320 Culv Group: Culvert #1

Reach Upper RS: 17.1 Plan: Persberg

Plan: Persberg Helpmekaar Upper RS: 17.1 Culv Group: Culvert #1 Profile: 08JAN2016 0320

Q Culv Group (m3/s)	17.82	Culv Full Len (m)	
# Barrels	1	Culv Vel US (m/s)	4.37
Q Barrel (m3/s)	17.82	Culv Vel DS (m/s)	5.86
E.G. US. (m)	1512.91	Culv Inv El Up (m)	1509.60
W.S. US. (m)	1513.69	Culv Inv El Dn (m)	1509.20
E.G. DS (m)	1509.84	Culv Frctn Ls (m)	0.12
W.S. DS (m)	1509.83	Culv Exit Loss (m)	2.56
Delta EG (m)	3.07	Culv Entr Loss (m)	0.39
Delta WS (m)	3.86	Q Weir (m3/s)	
E.G. IC (m)	1513.11	Weir Sta Lft (m)	
E.G. OC (m)	1512.91	Weir Sta Rgt (m)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (m)	1511.55	Weir Max Depth (m)	
Culv WS Outlet (m)	1510.66	Weir Avg Depth (m)	
Culv Nml Depth (m)	0.99	Weir Flow Area (m2)	
Culv Crt Depth (m)	1.95	Min El Weir Flow (m)	1513.20

RIVER CHANNEL DOWNSTREAM OF CLIFF

Channel shape

Irregular section (river)

Friction calculation method

Manning formula

Solve for

Normal depth (Yn) | Solve

Irregular section (river channel)

Cross section X-Y coordinates (Station-Elevation)

Station (m)	Elevation (m)	n (s/m^1/3)
238.48	1254.83	0.019
320.24	1241.82	0.019
402.62	1230.89	0.019
435.45	1227.51	0.024
435.96	1227.48	0.024
468.28	1229.83	0.024
474.53	1231.29	0.019
551.68	1251.18	0.019

Flow rate (Q) 45.31 m^3/s

Channel slope (S) 0.08 m/m

Normal depth (Yn) 0.745 m

Results

Flow area (A)	6.667	m^2
Wetted perimeter (P)	17.760	m
Hydraulic radius (R)	0.375	m
Top width (B)	17.695	m
Critical depth (Yc)	1.240	m
Critical slope (Sc)	0.00559	m/m
Velocity (V)	6.796	m/s
Velocity head (Hv)	2.354	m
Specific energy (Es)	3.099	m
Froude number (Fr)	3.5349	
Flow type	Supercritical	

Sinotech

Utility Programs for Drainage
Basic hydraulic calculations

Project: Persberg Dam
River: Helpmekaar
Designer: B Muhl
Date: 13 January 2016
Description: Downstream of cliff
Filename: \\FILESERVER\raws\GFK PROJECTS\DAM HELPMEKAAR\Downstream cliff 2.bhp

BASIC HYDRAULIC CALCULATIONS

INPUT DATA

Channel shape selected:	Irregular section (river channel)
Friction calculation method:	Manning formula
Flow rate (Q):	45.31 m^3/s
Channel slope (S):	0.08 m/m
Normal depth (Yn):	0.745 m (Solved)

Station(m)	Elevation(m)	Roughness value (s/m^1/3)
238.48	1254.83	0.019
320.24	1241.82	0.019
402.62	1230.89	0.019
435.45	1227.51	0.024
435.96	1227.48	0.024
468.28	1229.83	0.024
474.53	1231.29	0.019
551.68	1251.18	0.019

RESULTS

Flow area (A):	6.667 m^2
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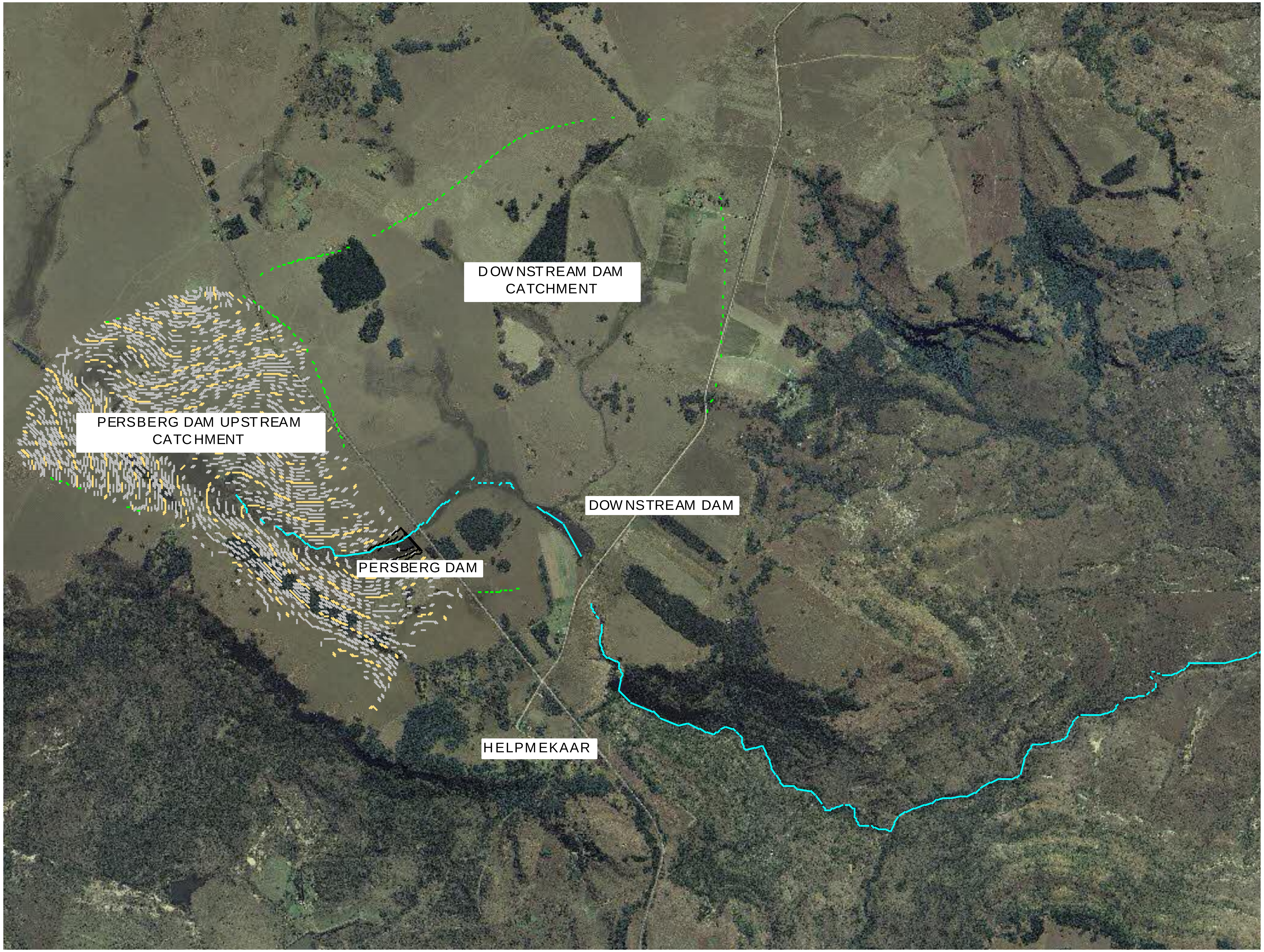
Critical slope (Sc):	0.00559 m/m
Velocity (V):	6.796 m/s
Velocity head (Hv):	2.354 m
Specific energy (Es):	3.099 m
Froude number (Fr):	3.5349
Flow type:	Supercritical

Calculated using Utility Programs for Drainage 1.1.0



Notes

Reference drawings

No.	Description
2012/05/01/01	LAYOUT PLAN

Amendment

No.	Date	By	Description

GFK CONSULTING ENGINEERS
Consulting Civil and Project Managers
119 Deputasie street
P.O.Box 2266 Vryheid
Tel & Fax: 034 982 3425

Designed	Drawn	Checked
F KRUGEL	B MUHL	F KRUGEL

Client

ERICH MULLER

Project

PERSBERG FARM DAM

Drawing description

CATCHMENT LAYOUT PLAN

Scale	Date
NTS	13/01/2016

Drawing number
2015/01/01/01

d

CONSTRUCTION NOTES :

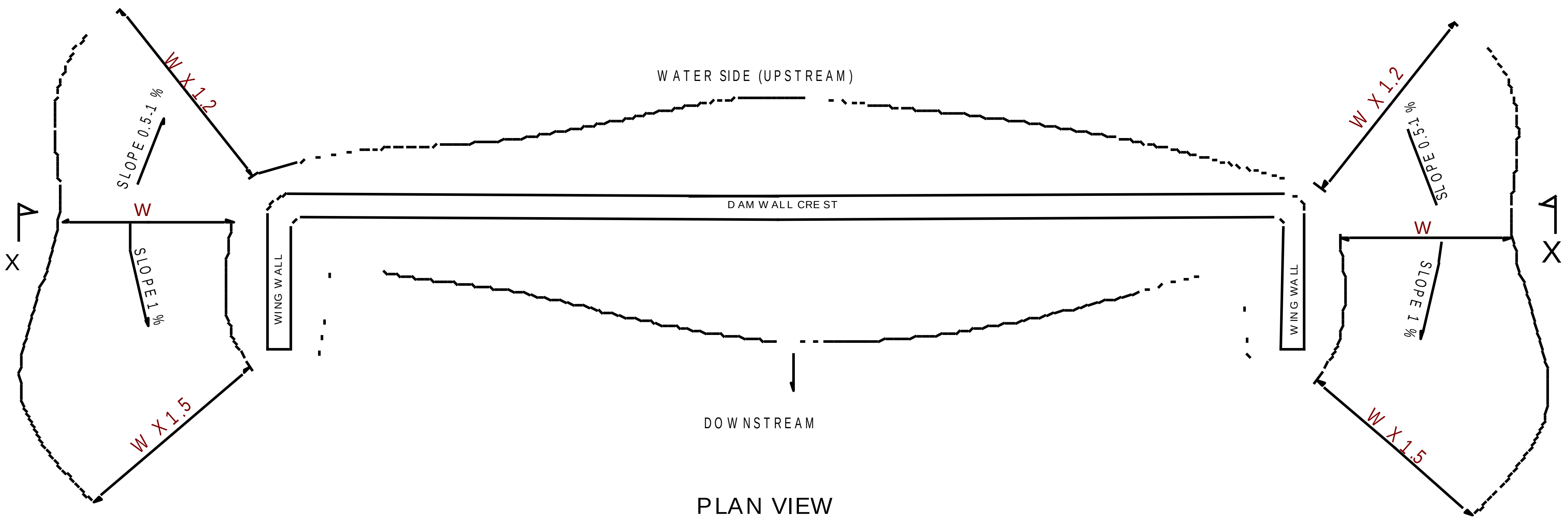
Construction shall be in accordance with SABS 1200 DE

SPILLWAY :

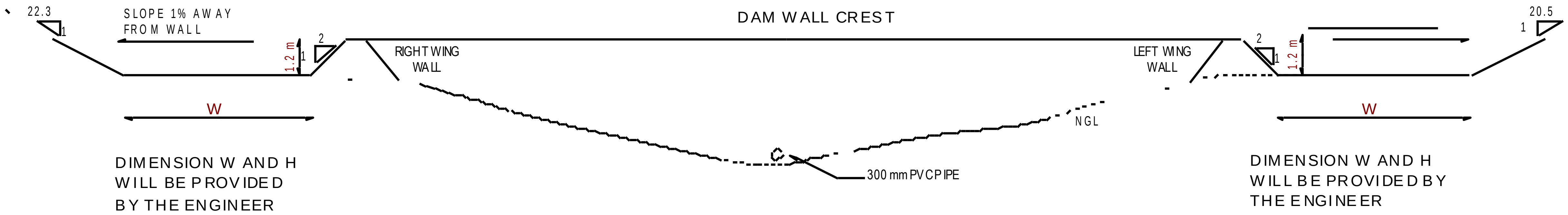
The spillway is to be excavated to the recommended minimum width. The total freeboard of the embankment is to be no less than the minimum recommended height above the spillway level. The spillway and the slope downstream of the spillway shall be cleared of obstructions such as trees, boulders, etc., and all depressions filled in an approved manner. The slope of the open cut flanking the spillway shall be sloped to a minimum slope of 1:2 or flatter. The face of the training wall must be carefully lined with stone to a depth of 250 mm. The entire spillway and the slope downstream of the spillway shall be topsoiled and grassed. The topsoil shall be lightly compacted by wheeled vehicles or by tamping. The final thickness of topsoil after compaction shall be at least 75 mm.

GRASSING AND FINISHING :

The entire exposed embankment surfaces shall be topsoiled and planted with an approved grass to be well fertilized until growth is firmly established. The embankment crest shall be sloped slightly backwards towards the dam basin to aid with the drainage of rain water from the crest.



PLAN VIEW



SECTION X - X

Notes

Reference drawings

No.	Description

Amendment

No.	Date	By	Description

GFK

GFK CONSULTING ENGINEERS
Consulting Civil
and Project Managers

119 Deputasie street
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Designed	Drawn	Checked
F KRUGEL	B MUHL	F KRUGEL

Consulting Engineer — Date

Client — Date

Client

ERICH MULLER

Project

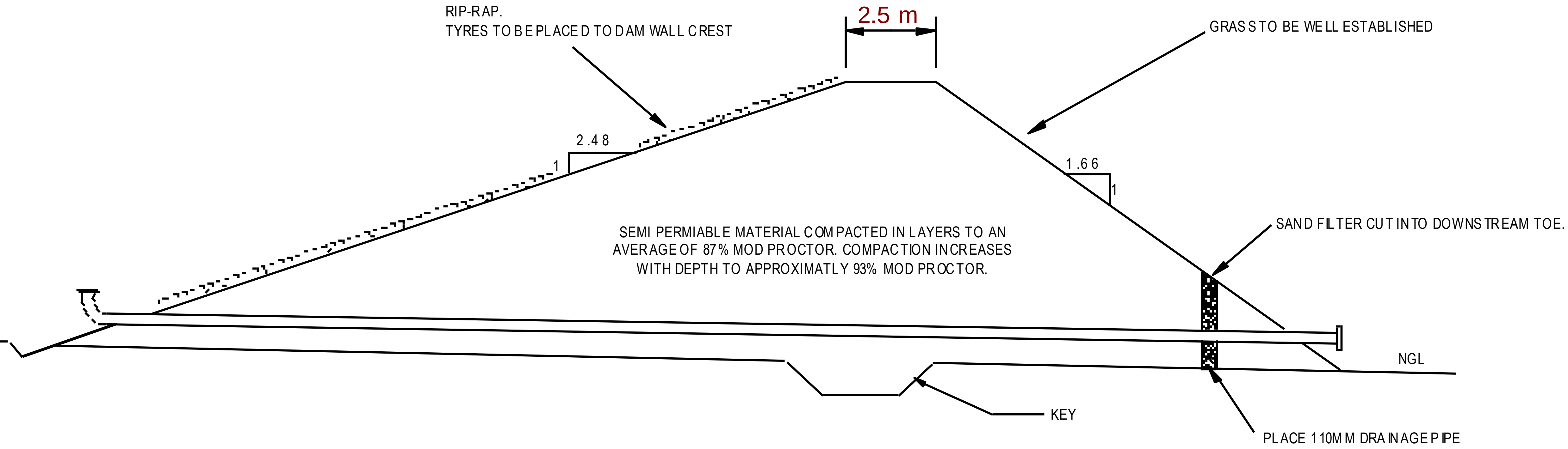
PERSBERG FARM DAM

Drawing description

DAM WALL DETAIL

Scale	Date
NTS	13/01/2016

Drawing number
2015/01/01/02



SECTION OF DAM WALL

Notes

Reference drawings	
No.	Description

Amendment			
No.	Date	By	Description

GFK CONSULTING ENGINEERS
Consulting Civil
and Project Managers

119 Deputasie street
P.O.Box 2266 Vryheid
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Designed	Drawn	Checked
F KRUGEL	B MUHL	F KRUGEL

Consulting Engineer — Date

Client — Date

Client

ERICH MULLER

Project

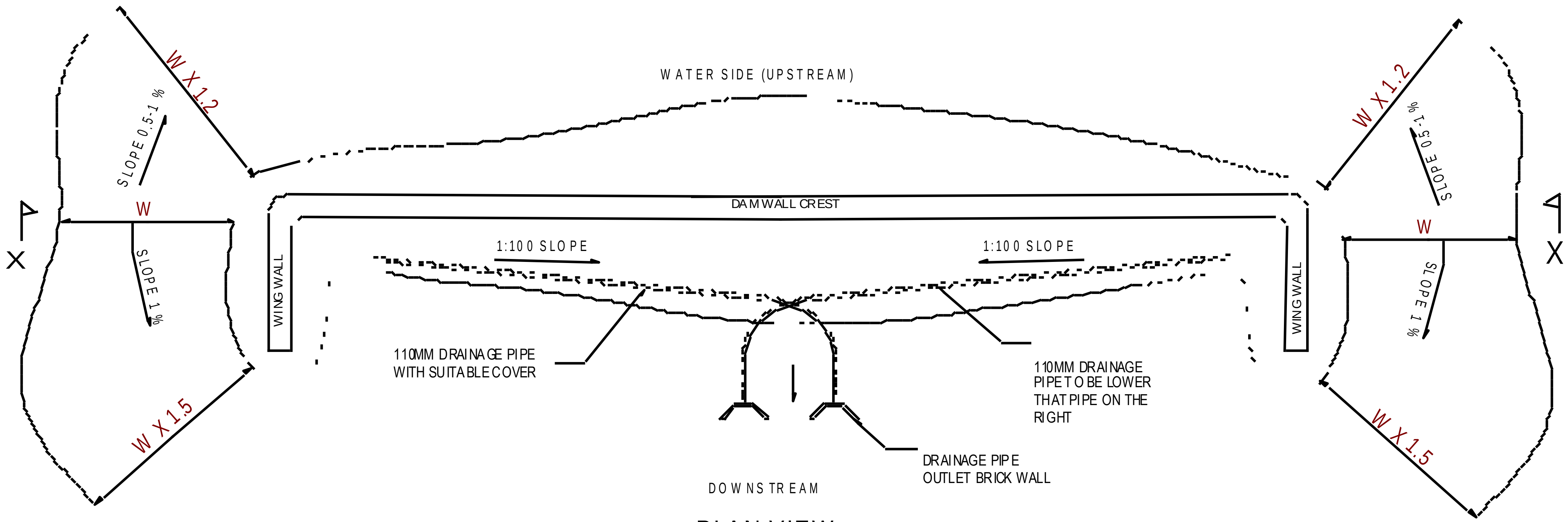
PERSBERG FARM DAM

Drawing description

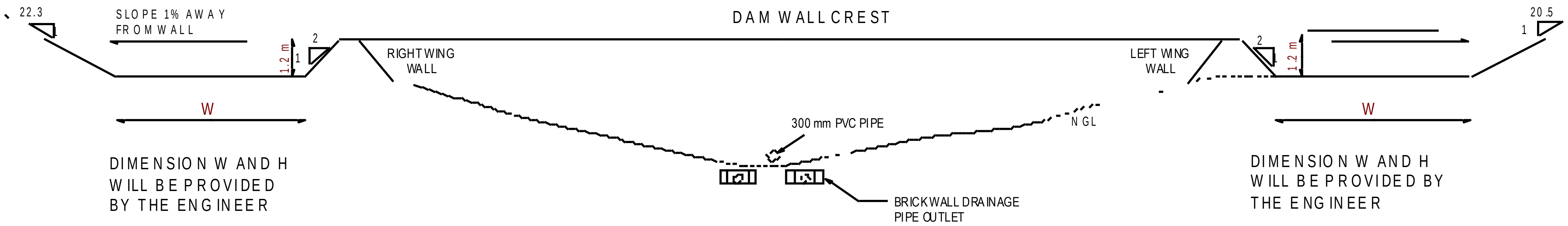
DAM WALL DETAIL

Scale	Date
NTS	13/01/2016

Drawing number
2015/01/01/02



PLAN VIEW



FRONT ELEVATION

Notes

Reference drawings

No.	Description

Amendment

No.	Date	By	Description

GFK CONSULTING ENGINEERS
Consulting Civil and Project Managers
119 Deputasie street
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Tel & Fax: 034 982 3425

Designed	Drawn	Checked
F KRUGEL	B MUHL	F KRUGEL

Consulting Engineer ____ Date

Client ____ Date

Client

ERICH MULLER

Project

PERSBERG FARM DAM

Drawing description

DAM WALL DETAIL

Scale: NTS
Date: 13/01/2016

Drawing number
2015/01/01/04