SINSKE CONSULT

FLOOD STUDY
ERF 8378 (VLAKKELAND), PAARL
MBEKWENI, KLEINBOSCH and DAL RIVERS

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CONTENTS

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1 INTRODUCTION

1.1 Terms of reference

It was requested by by Jubelie Projects, Plattekloof, on behalf of the Provincial Government of the Western Cape, Departments, that a flood study for Erf No. 557 and Erf No. 8378 (Vlakkeland), Paarl, be conducted and reported on.

The purpose of the study is the determination of the 5-, 50- and 100-year flood peaks at certain points in the Mbekweni, Kleinbosch and Dal Rivers and the investigation of the possibility to divert certain river courses in order to accommodate the proposed development.

1.2 Study Area

Erf 557 (ca. 5,8 ha) is situated in the corner west of Jan van Riebeeck Drive and south of Wamkelekile Street. As there is not a river in the vicinity of erf 557, the flood study therefore only refers to the Vlakkeland development (erf 8378).

The proposed Vlakkeland development (ca. 100 ha) consists of a smaller area between Jan van Riebeeck Drive (R303) and Beets Street. The major part, however, is situated east of Beets Street: The northern boundary is the residential area Newton with the two undeveloped erven 2569 and 361. The eastern boundary is Bo Dal Street; the southern boundary is formed by erf 8398 and a large undeveloped area (erf 1341).

Relevant maps: 1:10 000 Orthophoto maps 3318 DB 20 and 3319 CA 16

The study area is shown on an aerial photograph,   Figure 1, APPENDIX
(Scale 1: 20 000)
The proposed development is shown on a cadastral plan,   Figure 2, APPENDIX

1.3 Related Studies

In August 2010, a team of specialists under the leadership of Nortje & de Villiers Consulting Engineers, Paarl, submitted a feasibility report "Low Cost, Emergency and GAP Housing on the Vlakkeland Site" to the Drakenstein Municipality. Sinske Consult was then a member of the team, appointed to do the floodline study.
Our report: "Floodline Investigation, Mbekwi and Kleinbosch Rivers, Erf 8378, Paarl, July 2010" has been handed over to the Drakenstein Municipality and should be available for interested parties. In the report the water courses of the Mbekweni and Kleinbosch Rivers through the undeveloped Vlakkeland area have been identified and a preliminary floodline has been established.

The flood determination of the Mbekweni River in the July 2010 report was based one earlier flood studies done for Messrs Nortjé & De Villiers, viz:
    Erf 2568: October 2007
    Erven 1254 and 361: June 2008 and July 2009
    Erf 2569: November 2009 and January 2010

2 CATCHMENT

The proposed Vlakkeland development is affected by four rivers. They are from north to south: Mbekweni River, Seven Springs, Kleinbosch River and Dal River.
Note: Seven Springs and Kleinbosch are no official names. The names have been chosen for the purpose of the study, according to prominent places in their catchments.

All four catchments are situated in Drainage Region G10 and cover in total 4% of sub-region G10 D (WRC, 1994).
Total catchment of the four rivers, upstream of Beets Street: $A = 25,15$ km^2

The four catchments are shown (scale 1: 30 000)   Figure 3 APPENDIX
Relevant maps: 1:50 000 Topo Sheets 3318 DB and 3319 CA

2.1   Mbekweni River

The Mbekweni River is originating on the lower western flank of the Hawekwa Mountains (highest point 466 m) and is flowing in westerly direction towards the Bo Dal Road.
After crossing Bo Dal Road, the river is diverted around the residential area of Newton by a system of canals and pipe conduits. Downstream of Rand Street the river is restored in its natural channel and continues its flow towards Beets Street. .

Catchment are, upstream of Bo Loop Road: 3,45 km^2
upstream of Beets Street: 3,85 km^2

2.2   Seven Springs

The catchment of the seven Springs River is a small catchment, wedged between the Mbekweni and the Kleinbosch River catchments. The highest point in the catchment is 430 m. The river flows in westerly direction towards Bo Dal Street. Part of the flow is entering the proposed Vlakkeland development on the eastern boundary, whilst another part flows through a marshy (vlei) and enters the proposed development on the southern boundary. Through a network of channels, situated within the area of the proposed development, the flow is directed towards Beets Street.

Catchment area, upstream of Bo Loop Road   1,25 km^2
upstream of Beets Street: 2,00 km^2

2.3   Kleinbosch River

The Kleinbosch River is originating on the northern tip of the Klein-Drakenstein Mountain (highest point 1008 m). The river is flowing in westerly direction towards Dal Loop Road (continuation of Bo Dal Road). Downstream of the Dal Loop Road, the river flows into a marshy area (vlei), situated near the southern boundary of the proposed Vlakkeland development. From here the river flows through a network of channels in south-westerly direction towards Beets Street.

Catchment area, upstream of Dal Loop Road: 7,25 km^2
upstream of Beets Street: 8,50 km^2

2.4   Dal River

The catchment of the Dal River is situated south of the Kleinbosch River catchment. Originating on the Klein-Drakenstein Mountain (highest point 1092 m), the river flows in westerly direction and, after crossing Dal Loop Road, further in north-westerly direction towards Beets Street.

Catchment area, upstream of Dal Loop Road: 9,75 km^2
upstream of Beets Street: 10,80 km^2

3 CULVERTS

3.1 Position of Culverts

Joubert and Brink Surveys, Parow, provided a plan showing the position of the culverts, as well as the dimensions of the culverts,
The position of the culverts is shown,   Figure 4 APPENDIX
(Scale 1: 20 000)
Photographs of all culverts: Plates 1 to 13, APPENDIX

All flow entering the Vlakkeland study area is crossing Bo Dal Road and Dal Loop Road. These two roads have recently been tarred and partly re-aligned, with 20 new culverts in place. The culverts are labelled [4A] to [4T].
The dimensions of the Bo Dal/Dal Loop Road culverts are listed,   Table 1, APPENDIX

Culverts along the Mbekweni River between Bo Dal Road and Beets Street are labelled [5A] to [5H].
The dimensions of the Mbekweni River culverts are listed,   Tables 2 and 3, APPENDIX

All flow leaving the Vlakkeland study area is crossing Beets Street and ca.150 m further Jan van Riebeeck Drive.
Beets Street culverts are labelled [1A], [2A] [3A].
Jan van Riebeeck Drive culverts are labelled [1B], [2B] and [3B].

The dimensions of these culverts are listed,   Table 4, APPENDIX

3.2 Hydraulic Capacity of Culverts

The hydraulic capacity of the culverts has been determined for free surface flow and submerged flow and entered in Tables 1 to 4.
Free surface flow has been calculated according to (Chow, 1959, Franke, 1970/71; Hager & Wanoschek, 1986). Submerged flow (no road overflow) has been calculate according to DIN 19661-1 (1986) and GFG (2008). It has been assumed that the culverts are free of excessive sand and debris. A floor substratum of 10 to 30 cm, however, has been adopted.
Hydraulic capacity of the culverts: Tables 1 to 4 APPENDIX

4 PRESENT DRAINAGE CHANNELS

4.1 Contour Plan

Joubert and Brink Surveys, provided the contour plan of the site (contour interval 1,00 m) with an indication of the drainage channels. The plan has been put on a Google image.

Contour plan (Joubert and Brink Surveys)   Figure 5, APPENDIX
(Scale 1: 10 000)

In order to obtain the full picture of the drainage channels, the relevant information has been transferred to a larger contour plan (contour interval 1 m), derived from a DTM. This plan shows how the main drainage channels run from beyond Bo Dal/Dal Loop Road through the culverts towards Beets Street. The plan also shows the boundaries of the 4 catchments, as defined in § 2.

Contour plan with main drainage channels and catchment boundaries
(Scale 1: 15 000, image Google Earth),   Figure 6, APPENDIX

4.2 Description of Drainage Channels

4.2.1   Mbekweni River

Bo Dal Road has recently been tarred. The old Mbekweni River culvert has been replaced by a new culvert [4A] and adjacent culvert [4B]. (Photographs: Plate 1)

At Aurora Street the Mbekweni River flows into a pipe conduit (entrance [5A], exit [5B]). As the capacity of the conduit is too small, part of the flow continues in an open channel along Aurora Street to a second pipe conduit (entrance [5C]). From [5B] the river flows in an open channel to a third pipe conduit (entrance [5D]). (Photographs: Plate 2)

Pipe conduits 2 and 3 discharge into an outlet structure [5E] situated at Rand Street. Downstream of the Rand Street outlet the Mbwkweni River is restored in its natural channel and flows along the boundary between even 2568 and 2569. After crossing an access road (culvert [5F]) the river flows towards Beets Street. At Beets Street part of the flow continues straight on over the road (probably the old river course, as indicated on map 3318 DB), and part of the flow is directed towards erf 8378 into a channel that runs parallel to Beets Street on the eastern side of the road. (Photographs: Plate 3)

It is obvious that the dimensions of the channel along Beets Street are too small to convey the flow of the Mbekweni River. Even during smaller flood events the channel will flow over Beets Street into the area enclosed by Jan van Riebeeck Drive and Beets Street. Culvert [5G], situated on the channel at the boundary to erf 8378, is too small to convey the flow, just as culvert [5H], situated 250 m downstream. From culvert [5H] the Mbekweni River flows in a right turn towards culvert [1A] under Beets Street. Just in front of culvert [1A], it is joined by the Seven Springs River that drains the total area of the proposed Vlakkeland development. (Photographs: Plate 4)

The flow of the Mbekweni River in the channel east of Beets Street, together with the flow of the Seven Springs River, is conveyed through culvert [1A] under Beets Street. Finally, an outfall channel (length 125 m) transfers the flow from culvert [1A] to culvert [1B], situated under Jan van Riebeeck Drive. The channel also picks up the Mbekweni River flow collected west of Beets Street. (Photographs: Plate 5)

4.2.2   Seven Springs

Flow originating in the Seven Springs catchment crosses Bo Dal Road through five culverts, [4C] to [4G].

Flow through culverts [4C], [4D], [4E], [4F] and [4G] enters the proposed development on the eastern boundary. (Photographs: Plates 6 and 7)

Through a network of channels the total flow from Seven Springs is directed to culvert [1A] under Beets Street, and together with the Mbekweni River flow to culvert [1B] under Jan van Riebeeck Drive. (Photographs: Plate 5)

4.2.3 Kleinbosch River

The Kleinbosch River crosses Dal Loop Road through culvert [4L]. The river flow, together with tributary flow through culverts [4H], [4I], [4J] and [4K], is directed in westerly direction towards a marshy area (vlei). (Photographs: Plates 8 and 9)

Further tributaries of the Kleinbosch River cross Dal Loop Road through culverts [4M], [4N], [4O] and [4P]. (Photographs: Plates 9 and 10)

Through a network of channels, the total flow of the Kleinbosch River finally is directed to culvert [2A] under Beets Street, and further in an outfall channel (length 170 m) to culvert [2B] under Jan van Riebeeck Drive. (Photographs: Plate 11)

4.2.4   Dal River

The Dal River only affects the proposed development situated between Beets Street and Jan van Riebeeck Drive. The Dal River crosses Dal Loop Road through culvert [4T], with tributary flow through culverts [4Q], [4R] and [4S]. The river flows in westerly direction towards Beets Street. (Photographs: Plates 12 and 13)

The river crosses Beets Street through culvert [3A] and flows on in an outfall channel (length 120 m) to culvert [3B] under Jan van Riebeeck Drive. (Photographs: Plate13)

5   FLOOD DETERMINATION

Estimates for the 50- and 100-year flood peaks for the Mbekweni, Kleinbosch and Dal Rivers are given in the report: "Floodline Investigation, Mbekweni and Kleinbosch Rivers, Erf 8378, Paarl" of July 2010 (vide § 1.3).

The flood peaks have been updated, taking into account recent urbanisation and the re-definition of catchment areas (Seven Springs has been separated from the Kleinbosch River catchment). Estimated flood peaks (5, 50 and 100 year return period) have been determined at Bo Dal Road, respectively Dal Loop Road, and at Beets Street.

5.1   Mbekweni River

Design flood determination: Mbekweni River at Bo Dal Road is attached in a separate document:

Flood Study 1: Mbekweni River (Bo Dal Road), APPENDIX

Result:

Bo Dal Road culverts: $Q_5 = 3,0$ m^3/s $Q_{50} = 7,5$ m^3/s $Q_{100} = 10,5$ m^3/s

The capacity of the Bo Dal Road culverts is sufficient to pass the 50- and 100-year flood.

The Mbekweni River is diverted through and around Newton by pipe conduits and open channels towards Rand Street.

Rand Street outlet: $Q_5 = 3,0$ m^3/s $Q_{50} = 8.0$ m^3/s $Q_{100} = 8,5$ m^3/s

Rand Street overflow $Q_5 = 0,5$ m^3/s $Q_{50} = 1,5$ m^3/s $Q_{100} = 3,0$ m^3/s

Between Rand Street and Beets Street the Mbekweni River flows in its natural channel: the flood peaks are:

Downstream of Rand Street: $Q_5 = 3,5$ m^3/s $Q_{50} = 9,5$ m^3/s $Q_{100} = 11,5$ m^3/s

Beets Street (Vlakkeland border) $Q_5 = 4,0$ m^3/s $Q_{50} = 10,6$ m^3/s $Q_{100} = 13,0$ m^3/s

As the capacity of culverts [5F], [5G] and [5H] is not sufficient, the Mbekweni River now flows on both sides of Beets Street towards culvert [1A] (distribution possibly 50/50). Part of the Mbekweni River flow, together with flow from the Seven Springs catchment, is passing through culvert [1A], while the remainder of the Mbekweni River flow joins the flow downstream of culvert [1A] towards culvert [1B]. (Calculation vide § 5.2)

5.2 Seven Springs

Design flood determination: Seven Springs at Bo Dal Road is attached in a separate document:

Flood Study 2: Seven Springs (Bo Dal Road), APPENDIX

Result:
Bo Dal Road culverts: $\qquad Q_5 = 3,2$ m^3/s $\qquad Q_{50} = 7,2$ m^3/s $\qquad Q_{100} = 9,2$ m^3/s

The capacity of the Bo Dal Road culverts is sufficient to pass the 50-year flood. During a 100-year flood road overflow at places can be expected.

Presently flow from the Bo Dal Road culverts reaches Beets Street culvert [1A] through a network of open channels. Once Vlakkeland is developed, the flow from the Bo Dal Road culverts will be directed through a stormwater system to Beets Street culvert [1A].
Increase in flow due to the larger catchment area is for the most part compensated by the longer concentration time.
Compensation for change of land use (urbanization): $A_{developed} = 100$ ha $= 1,0$ km^2
With the relations $A_{developed}/A = 1,0/2,0 = 0,50$ and $C_{developed}/C = 2$ follows

$$Q_{adjusted} = Q \cdot (1 + 0,50) = 1,50 \, Q$$

Beets Street culvert [1A]:

Seven Springs	$Q_5 = 4,8$ m^3/s	$Q_{50} = 10,8$ m^3/s	$Q_{100} = 13,8$ m^3/s
Mbekweni (50% approx.)	$Q_5 = 2,0$ m^3/s	$Q_{50} = 5,3$ m^3/s	$Q_{100} = 6,5$ m^3/s
Total	$Q_5 = 6,8$ m^3/s	$Q_{50} = 16,1$ m^3/s	$Q_{100} = 20,3$ m^3/s

The capacity of culvert [1A] is not sufficient to pass the 50- and 100-year flood.

Jan van Riebeeck culvert [1B]:

Seven Springs + Mbekweni	$Q_5 = 6,8$ m^3/s	$Q_{50} = 16,1$ m^3/s	$Q_{100} = 20,3$ m^3/s
Mbekweni (50% approx.)	$Q_5 = 2,0$ m^3/s	$Q_{50} = 5,3$ m^3/s	$Q_{100} = 6,5$ m^3/s
Total	$Q_5 = 8,8$ m^3/s	$Q_{50} = 21,4$ m^3/s	$Q_{100} = 26,6$ m^3/s

The capacity of culvert [1B] is sufficient to pass the 50-year and 100-year flood

5.3 Kleinbosch River

Design flood determination: Kleinbosch River at Bo Dal Road is attached in a separate document:

Flood Study 3: Kleinbosch River (Bo Dal Road), APPENDIX

Result:
Bo Dal Road culverts: $\qquad Q_5 = 13,9$ m^3/s $\qquad Q_{50} = 30,6$ m^3/s $\qquad Q_{100} = 38,3$ m^3/s

The capacity of the Bo Dal Road culverts is sufficient to pass the 50- year flood. During a 100-year flood road overflow at places can be expected.

Increase in flow due to the larger catchment area is for the most part compensated by the longer concentration time. The attenuating influence of the marshy area (vlei) has been estimated with $\alpha \approx 5\%$.

Beets Street culvert [2A]: $\qquad Q_5 = 13,2$ m^3/s $\qquad Q_{50} = 29,1$ m^3/s $\qquad Q_{100} = 36,4$ m^3/s

The capacity of culvert [2A] is not sufficient: Road overflow.

From culvert [2A] an outfall channel leads to culvert [2B] at Jan van Riebeeck Drive.

Jan van Riebeeck Drive [2B]: $\qquad Q_5 = 13,5$ m^3/s $\qquad Q_{50} = 29,3$ m^3/s $\qquad Q_{100} = 37,0$ m^3/s

The capacity of culvert [2B] is sufficient to pass the 50-year and 100-year flood

5.4 Dal River

Design flood determination: Dal River at Bo Dal Road is attached in a separate document:

Flood Study 4: Dal River (Bo Dal Road), APPENDIX

Result:

Bo Dal Road culverts: $Q_5 = 17,6 \text{ m}^3/\text{s}$ $Q_{50} = 38,2 \text{ m}^3/\text{s}$ $Q_{100} = 49,9 \text{ m}^3/\text{s}$

The capacity of the Bo Dal Road culverts is not sufficient. During a 50-year and 100-year flood road overflow at places can be expected.

Increase in flow due to the larger catchment area is for the most part compensated by the longer concentration time. A possible attenuating effect has been ignored..

Beets Street culvert [3A]: $Q_5 = 17,6 \text{ m}^3/\text{s}$ $Q_{50} = 38,2 \text{ m}^3/\text{s}$ $Q_{100} = 49,9 \text{ m}^3/\text{s}$

The capacity of culvert [3A] is not sufficient: Road overflow.

From culvert [3A] an outfall channel leads to culvert [3B] at Jan van Riebeeck Drive.

Jan van Riebeeck Drive [3B]: $Q_5 = 17,6 \text{ m}^3/\text{s}$ $Q_{50} = 38,2 \text{ m}^3/\text{s}$ $Q_{100} = 49,9 \text{ m}^3/\text{s}$

The capacity of culvert [3B] is sufficient to pass the 50- and 100-year flood, provided the middle and right barrels are cleared of earth deposits (vide photographs, Plate 13/5&6).

6 RECOMMENDATION

Several options are advanced for alterations/improvements of the proposed Vlakkeland development plan and discussed below.

For clarification an amended development plan is attached, Figure 7, APPENDIX

6.1 Mbekweni River

The three culverts under Beets Street are not sufficient and must be replaced with new culverts. In the case that Beets Street is upgraded or rebuilt, the following changes are recommended:

(1) The access road to erf 2569 (photograph, Plate 3/5) and culvert [5F] should be removed to restore unobstructed river flow towards Beets Street. Access to erf 2569 should be moved to Rand Street (Newton).

(2) Beets Street should be closed at the boundary to erf 2569 to allow unobstructed river flow towards Jan van Riebeeck Drive, and along Jan van Riebeeck Drive in a newly-built channel in southerly direction.

(3) The new channel must cross the access road to Vlakkeland. A culvert, labelled [5I] will be necessary here.

The culvert must be designed for $Q_5 = 4,0 \text{ m}^3/\text{s}$ $Q_{50} = 10,6 \text{ m}^3/\text{s}$ $Q_{100} = 13,0 \text{ m}^3/\text{s}$

(4) The existing channel east of Beet Street with the insufficient culverts [5G] and 5[H] is now unnecessary and can be removed.

(5) In case Beets Street must be maintained and cannot be closed, an additional culvert will be necessary to convey the Mbeweni River under Beets Street.

The culvert must be designed for $Q_5 = 4,0 \text{ m}^3/\text{s}$ $Q_{50} = 10,6 \text{ m}^3/\text{s}$ $Q_{100} = 13,0 \text{ m}^3/\text{s}$

6.2 Seven Springs

Flow through the Bo Dal Road culverts and stormwater runoff from the Vlakkeland development is collected in a channel. The collector starts at point "C" and first runs along the southern boundary of the development, and then changes direction towards a new culvert [1A] under Beets Street.

An alternative would be to split the Vlakkeland stormwater system: Only the southern portion of the stormwater system is collected in the channel, while the northern portion is collected along the west - east main road, and is fed into the channel at point "E".

Culvert [1A] must be designed for $Q_5 = 4,8$ m^3/s $Q_{50} = 10,8$ m^3/s $Q_{100} = 13,8$ m^3/s

From culvert [1A] an outfall channel leads towards Jan van Riebeeck Drive. In front of culvert [1B] is the confluence with the Mbekweni River.
Total flow through culvert [1B]: $Q_5 = 8,6$ m^3/s $Q_{50} = 21,4$ m^3/s $Q_{100} = 26,8$ m^3/s

Culvert [1B] can pass Q_{100} with free surface flow.

6.3 Kleinbosch River

The new Beets Street culvert [2A] must be designed for
$$Q_5 = 13,2 \text{ m}^3/\text{s} \quad Q_{50} = 29,1 \text{ m}^3/\text{s} \quad Q_{100} = 36,4 \text{ m}^3/\text{s}$$

The same flood peaks are applicable for Jan van Riebeeck Drive culvert [2B].
The culvert is sufficient; Q_{50} and Q_{100} with free surface flow.

6.4 Dal River

The new Beets Street culvert [3A] must be designed for
$$Q_5 = 17,6 \text{ m}^3/\text{s} \quad Q_{50} = 38,2 \text{ m}^3/\text{s} \quad Q_{100} = 49,9 \text{ m}^3/\text{s}$$

The same flood peaks are applicable for Jan van Riebeeck Drive culvert [3B].
The culvert is sufficient; Q_{50} can be passed with free surface flow, Q_{100} with submerged flow, provided the middle and right barrels are cleared of earth deposits.

6.5 Alternative

An alternative has been investigated to re-route the Seven Springs collector channel at point "D" in westerly direction along the boundary towards Beets Street, and then into the Kleinbosch River in front of culvert [2A]. The advantage would be culvert [1A] would no more be required. Culvert [2A] must now be designed for
$$Q_5 = 18,0 \text{ m}^3/\text{s} \quad Q_{50} = 39,9 \text{ m}^3/\text{s} \quad Q_{100} = 50,2 \text{ m}^3/\text{s}$$

The same flood peaks are applicable for Jan van Riebeeck Drive culvert [2B].
The capacity of the culvert (49,4 m3/s submerged flow) would then be exhausted and road overflow could be expected.
This alternative is shown, Figure 8, APPENDIX

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APPENDIX

Figures

Photographs

Tables

Flood Studies