MULTI-USE DEVELOPMENT OF ERF RE1627 SEDGEFIELD

FLOOD MANAGEMENT STUDY

30 March 2022
Rev. 0

Prepared for: **Developers of erf RE1627**
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Report AF1101-1-r0

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Abbreviations:

CCT	City of Cape Town
FGL	Finished Ground Level
m amsl	metres above mean sea level
NGL	Natural Ground Level
RI	Recurrence Interval

1. Introduction

We refer to the proposed land use changes of erf RE1627 Sedgefield. The property is situated within the area known as The Island (Sedgefield Extension 1) and located between Montage Village to the East, Scarab Village to the West, Island Village to the South, and the N2 National Road to the North, as shown by Figure AF1101-1.

A prominent feature is the Perdespruit River which passes through the property.

Fraser Engineers were asked to provide information on flood risks. The Author's credentials are presented as Appendix A.

2. The Topography and Site Sensitivity

The erf RE1627 is 26.6 ha in extent.

The site is in the low lying areas of Sedgefield and falls below the 5m contour. The topography is described by Drawing AF1101-02.

According to Dabrowski (2021), 11.4 ha of the 26.6 ha property lies between the 2.5m and the 3m amsl contours, while 3.7 ha is above the 3m amsl contour. This represents 43% and 14 % of the property, totaling 57 % above the 2.5m amsl contour.

The remaining 43% is mainly around the Perdespruit, with a small section towards the Scarab Market.

It is also evident from Drawing AF1101-02 that the erf is significantly higher on the western side of the Perdespruit, as opposed to the eastern or Montage Village side.

Dabrowski (2021) describes the site's environmental sensitivity to development in an easterly to westerly direction. In the East the site is wetland and sensitive to development, whilst the site becomes progressively less sensitive to the West where the site is modified grassland.

3. Catchment Characteristics.

Fraser (2009) states that there has been extensive research on the Swartvlei catchment. Extracts of the Fraser (2009) literature research are presented as Appendix B.

Sedgefield is situated at the base of the Swartvlei catchment area which consists of four major sub-catchments as shown in Figure 1 of Appendix B. The total catchment area is approximately 370km^2. Sedgefield erf RE1627 is situated towards the mouth of the Swartvlei system. The Swartvlei system is fed by the Wolwe River system (125km^2), the Hoogekraal River system (109km^2) and the Karatara River system (106km^2), totaling 340km^2. There is a further 30km^2 (approx.) catchment area for the Swartvlei basin.

Key catchment data is presented as Table 1 below.

Table 1. Key Catchment Data

Parameter	Description
Quaternary Catchments	K40A, K40B, K40C & K40D
Catchment Area	370 km^2
Time of Concentration	25 hours
Mean Annual Runoff	64.7 x 10^6 m^3/year
Surface area of Swartvlei and the Estuary	10.8 km^2
Surface area of the Floodplain	14.2 km^2

Fijen (1995) presented estimates of flood flow information, as shown in Table 2 below.

Table 2. Flood Flow Information (from Fijen (1995), pg 15)

Unitgraph	**Recurrence Interval (RI) – years**			
	10	20	50	100
Peak Flow (m^3/s)	527	747	1153	1412
Duration (h) (in the order of)	45	45	45	45
Volume (million m^3)	17.8	25.5	39.2	48.1

4. Historical Rainfalls

Our information of Sedgefield flooding dates to December 1980 and there were no destructive floods until 1996. However more recently Sedgefield has experienced flooding in November 1996, March 2003, August 2006 and November 2007.

The raingauges within the catchment are:

- gauge 29294 Bergplaats
- gauge 29624 Karatara
- gauge 29684 Farleigh

The gauge 29805 Goudveld is near the catchment.

The most significant flood events of the Swartvlei system have, in chronological order, been:

- November 1996
- March 2003
- August 2006 (refer Photographs Appendix C)
- November 2007(refer Photographs Appendix C).

The rainfall recorded during these events at the Karatara, Farleigh and Goudveld gauges are shown in Table 3.

Table 3. Storm Rainfall Information (Source of Information: SANRAL (2009); SAWS (2010)).

Description	**Raingauges**			
	Karatara	**Farleigh**	**Goudveld**	**Average**
Gauge reference	29624	29684	029805	
Altitude (amsl)	225m	511m	262m	
MAP (mm/year)	762mm	1092mm	830mm	
Peak one day theoretical rainfalls (mm/day):				
20 Year RI	143mm	150mm	142mm	145mm
50 year RI	193mm	192mm	181mm	187mm
100 year RI	217mm	228mm	216mm	220mm
200 year RI	256mm	270mm	255mm	260mm
Peak two day theoretical rainfalls (mm/2 days):				
20 year RI	177mm	193mm	184mm	185mm
50 year RI	222mm	242mm	231mm	232mm
100 year RI	261mm	284mm	270mm	272mm
200 year RI	303mm	331mm	315mm	316mm
Recorded Rainfalls for Recent Rainstorms:				
1996 November:				
1-19 Nov	124mm	No data	109mm	117mm
20 Nov.	34mm	No data	29mm	32mm
21 Nov.	99mm	No data	99mm	99mm
2003 March:				
1-22 March	77mm	99.4mm	79mm	85mm
23 Mar	48mm	86.5mm	24mm	53mm
24 Mar	188mm	100mm	141mm	143mm
25 Mar	25mm	100mm	20mm	48mm
26 Mar				
2006 August:				
1 Aug	111mm	100mm	129mm	113mm
2 Aug	133mm	172mm	144mm	150mm
2007 November:				
1-20 Nov	27mm	32mm	40mm	33mm
21 Nov	135mm	188mm	201mm	175mm
22 Nov	162mm	214mm	202mm	193mm
23 Nov	45mm	59mm		

The Time of concentration of the catchment is in the order of 25 hours, which is an indication that the catchment responds with the highest flow rates to storms whose duration is in the same order of magnitude, 24 hours. That is unless a longer duration storm results in very high antecedent moisture conditions (very saturated catchment), and the resultant peak runoff from a two day storm can be higher than two separate one day storms. Furthermore, rainfall data is measured once daily at 08h00, though an extremely intense 24 hour storm can straddle the daily reading times of 08h00.

The March 2003, August 2006 and November 2007 had significantly high two day rainfalls, and we compare these two day rainfalls with the theoretical two day rainfalls for various Return Intervals (RI's). Table 4 below uses the average values for the rainfalls as derived from Table 2.

Table 4. Comparison of theoretical two day rainfalls with recorded two day rainfalls

Description	Two day rainfalls for average of Karatara, Farleigh and Goudveld raingauges mm/(2 day)
Theoretical 2 day rainfalls:	
20 year RI	185mm
50 year RI	232mm
100 year RI	272mm
200 year RI	316mm
Recorded rainfalls over 2 consecutive days	
24 – 25 March 2003	191mm
1 -2 August 2006	263mm
21 - 22 November 2007	368mm

From the above it is evident that the recorded two day rainfalls of 1 - 2 August 2006, 263mm, were of the order of a 100 year RI theoretical rainfall two day event which is 272mm/(2 days); the recorded two day rainfalls of 21 – 22 November 2007 (368mm/(2 days) were in excess of the theoretical statistical 200 year RI two day event (316mm/(2 days).

Furthermore, if hourly rainfall data were available, it may be apparent that during the two days, a particular 24 hour period may have particularly intense rainfall that makes it equivalent of at least a 100 year RI 24 hour event.

5. Catchment Response to Peak Rainfalls

The peak rainfalls caused flooding, with Appendix C showing key Photographs.

Following the severe rainfalls, peak flow rates and excessive flooding of November 2007, Fraser Engineers cc surveyed the levels reached by flood debris. These are presented in Drawing AF1101-03. Table 5 gives the levels recorded in the vicinity of erf RE1627.

Table 5. Flood levels Recorded in Vicinity of erf RE1627

Ref	Description	Flood level
1	Chimney	2.901m m amsl
2	Old Paper Factory	3.106m amsl
3	(Island Village Main Gate)	(3.715m amsl)
4	Wally vd Walt Street	3.692m amsl
5	Moodie Street	2.950m amsl
6	Dr Malan Street	2.950m amsl
	Average (1,2,4,5,6)	3.12m amsl

The Island Village Main gate level of 3.715m amsl appears an outlier. The average of the other 5 readings is 3.12m amsl. The above leads us to conclude that a flood, probably in excess of the 100 year RI flood, will cause water levels in the order of 3.1m amsl at erf RE1627.

The floods of 1 – 2 August 2006 produced peak water levels at Montage Village, which is hydraulically parallel to erf RE1627, that did not reach their floor levels. Refer to Photograph C1. The floor levels of Montage Village are 3.0m amsl. By referring to the Photographs, the water levels reached are probably in the order of 2.85m amsl.

We therefore conclude that the 100 year RI Flood levels are in the order of 3.0m to 3.2m amsl. However we advise that no floors should be built below the 3.6m amsl level. The 3.6m amsl level allows for more severe events and provides greater surety, particularly with the possibilities of climate change.

The levels in the order of 3.0m amsl and 3.2m amsl correspond with the Photographs C2 and C3 which show significant unflooded areas between the western corner of Island Village and the northern sides of the bowling greens. This adds extra confidence to the analysis.

Using information from similar Estuaries, our Literature Research (Appendix B), and a knowledge of the Swartvlei Estuary, we recommend that the 2.8m amsl contour is used as the indicative 50 year RI flood level, and the 2.5m amsl contour as the 20 year RI flood level. In all instances, to allow tolerances, we

recommend that residential development Finished Floor Levels (FFL's) be at least 3.6m amsl. Table 6 below shows the recommended flood levels.

Table 6. Recommended Flood Levels

Description	Flood Level
20 year RI	2.5m amsl
50 year RI	2.8m amsl
100 year RI	3.1m amsl
Floor Levels	Minimum 3.6m amsl

Drawing AF1101-04 shows the erf RE1627 split into these areas.

6. Artificial Breaching of the Swartvlei River Mouth

Following the floods of 2007 SANParks commissioned an Environmental Basic Assessment Report titled "Artificial Breaching of the Touw and Swartvlei River Estuaries and Sediment Management within the Wilderness Lakes System"(Hilland(2009)). A primary objective was to alleviate the possibilities of flooding. A successful Record of Decision (ROD) was received on 17 February 2010 and this has significantly changed the flooding characteristics of the Swartvlei Estuary. Prior to this decision the mouth would only be breached when the incoming flood waters had caused the estuary to reach a fairly high water level. The positive ROD allows the water levels to be lowered before the flood waters arrive.

Historically, before SANParks took custodianship of the Estuary in circa year 2000, the Municipality with the help of the Community would open the River mouth.

The Hilland (2009) document presents a letter from the Sedgefield Ratepayers and Residents Associated (SRRA), dated 6 August 2009, in which they state: "The oral history of an area cannot be disregarded. Residents who have spent decades living in Sedgefield (in some cases more than 40 years), attest to that there was no history of severe flooding in earlier years, because in those times the Municipality kept the mouth open by regular breaching of the sand bar".

According to the SRRA (2009), the frequency of flooding increased after the year 2000, when SANParks instituted rigid water level criteria which were extremely difficult to apply, and were therefore not practical or successful in providing any form of control for the protection of the large areas of the village that were threatened by the predicted floods, and consequently suffered accordingly (SRRA, 2009).

Under the 2000 to 2010 system of control SANParks could only open the mouth in the case of an emergency, roughly defined as 'when damage is already occurring'. This explains the circumstances leading to the high flood water levels of 2003 and 2007.

Since 2010, SANParks can breach (open) the mouth in anticipation of flooding. With the advantages of highly accurate weather forecasting, a series of real-time gauges in the catchment area, and early preparation for breaching, SANParks have skillfully managed the Estuary mouth system.

Whereas before, such as in 2003, the mouth was opened when the Estuary reached flooding water levels, the mouth can now be opened earlier if there are forecasts of significant rainfall that may cause flooding.

The system involves preparing the mouth for opening on the basis of weather forecasts, and then opening the mouth at levels dependent on the depths of rainfall recorded in the autographic raingauges upstream in the catchment. The mouth is typically opened at 2.0m amsl if there is no threat of significant rainfalls, or at lower levels such as 1.8m or 1.6m amsl (or lower) depending on the amount of rainfall recorded. This allows the estuary levels to recede towards the average level when open of 0.7m amsl before the excess flows reach Sedgefield.

An additional reason behind breaching on or before 2m amsl is to protect the Karawater fresh water abstraction point. This abstraction point is the primary water supply to Sedgefield and is 10km upstream from erf RE1673, at Karawater, alongside the Karatara River. There is a weir built in 2012, with a weir height of 2.0m amsl, that keeps the downstream saline Swartvlei water away from the fresh water upstream of the weir. If Swartvlei water levels exceed 2.0m amsl, the upstream fresh water is contaminated and impacts upon the Sedgefield fresh water supply.

7. Effect on Peak Water Levels of Breaching Estuary Mouth

The estuary has lower water levels during times when the river mouth is open. If the estuary water levels are low at the time of extreme rainfalls and river flow rates, less of the floodplains should be

inundated. Therefore there is less chance of flooding if the estuary mouth is opened well in advance to allow water levels to drop before the arrival of the peak flood flow.

The current methods used by SANParks to control the mouth are, amongst other criteria, to reduce flooding. Allowing for the water to subside, the water levels can drop from about 1.8m amsl to 0.7m amsl. This allows an additional 1.1m of freeboard against flooding.

When the mouth is open there is less build-up of water above 1.8m amsl.

A further mitigating issue is that the causeway, downstream of RE1627 and Montage Village' was significantly upsized after the 2007 floods, from 4 x 450mm diameter pipes to the current which are 4 x 3m wide x 1.5m deep box culverts. This will further assist in lowering the upstream water levels. Photograph C2 shows the build-up of water at the causeway before the upsizing of the culverts.

Based upon the artificial breaching of the river mouth, and to a lesser extent, the upsized culverts, the flood levels of Table 4 are considered to be conservative.

8. CCT Floodplain and River Corridor Management Policy

Drawing AF1101-03 shows the extent of erf RE1627 to be flanked by residential erven to the south (The Island, Sedgefield) and to the East (Montage Village). The area is large and can be better utilized. To this end, in the absence of more local policies, we recommend that the well-established policies of the City of Cape Town (CCT(2009)) are used.

The CCT developed their Floodplain and River Corridor Policy in 2009 and it has become a 'blue print' for assessing developments such as erf RE1627 throughout the Western Cape and beyond.

The objectives of CCT (2009) include:

i. limit or reduce exposure to flood risk by avoiding hazardous, uneconomic or unwise use of floodplains, thereby protecting life, property and community infrastructure;
ii. protects the natural flood carrying capacity of watercourses and wetlands;
iii. protects and enhances the intrinsic value and environmental goods and services provided by watercourses, wetlands and associated riparian areas and floodplains;
iv. facilitates the beneficial integration of watercourses into the urban landscape by creating an aesthetically pleasing public resource which will ultimately allow for the social and economic upliftment of communities adjacent to watercourses and wetlands;
v. provides an effective decision making tool for officials, developers and consultants by introducing an element of predictability with regard to applications for development along watercourses/river corridors and adjacent to wetlands; and
vi. promotes sustainable development from engineering, environmental and socio-economic perspectives.

The CCT (2009) have a Framework for the Assessment of Development Proposals which have certain additional requirements to be applied in certain circumstances.

Additional requirement 'R1' is that a registered Engineering Professional must be engaged by the developer to satisfactorily demonstrate and certify that:

a. The activity/development will not materially increase flood hazards for other property owners or adversely affect flood behavior or the stability of channels; and
b. Any structure can withstand the forces and effects of flowing floodwaters, including scour of foundations, debris forces and buoyancy forces.

In more sensitive areas such as below the 20 year RI floodline, additional requirement 'R4' is that the CCT (2009) require that an Aquatic Ecologist must be engaged by the developer to determine the ecological buffer and to satisfactorily demonstrate and certify that:

a. the activity development will not negatively impact on the present condition of the watercourses or wetland; or
b. the activity or development will improve the condition of the watercourse or wetland from it's present state.

This requirement (R4) has already been undertaken successfully by Dabrowski (2021).

The CCT (2009) describe areas as high hazard zone or low hazard zone. The hazard zones are graphically illustrated in Figure AF1101-5. High hazard zones are where the depth or flow velocity restricts the ability to wade or gain vehicular access, or compromises the stability of structures such as dwellings or boundary walls. No development should be considered in a high hazard zone.

Outside of the Buffer zone around the Perdespruit, and to the west of the Perdespruit, the natural ground levels of erf RE1627 are above 2.4 m amsl. The flood levels are below 3.1 m amsl and therefore the water depths are less than 0.8m in depth. Furthermore the water velocities are slow as it is a backwater effect (refer Photographs C3, C4 and C5), and therefore the entire area outside of the Buffer zone and to the west is a low hazard zone.

9. Development Possibilities

Our development proposals are made with reference to CCT (2009) Table 1. This Table 1, titled "Framework for the Assessment of Development Proposals", is reproduced in Appendix D. Table 7 below lists a selection of the possible land uses. Please note the conditions R1, R2 and R3, and cross-reference with the Table 1 of Appendix D.

Table 7. Selection of Development Possibilities

Location	Type of Land-use	Remarks/conditions 1	Remarks/conditions 2
Below 20 year floodline	Nature reserve, conservancies		
	Private/public open space		
	Sports fields, picnic areas	R1	
	Stormwater facilities	R1	Possibly excavate ponds to raise ground levels elsewhere
	Urban agriculture	R1	
	Caravan and Camping Sites	R1	R3 (floors above 50 year flood levels)
Above 20 year floodline:			
	Sports fields, picnic areas	R3 (floors above 50 year flood levels)	
	Stormwater facilities	R1	Possibly excavate ponds to raise ground levels elsewhere
	Urban Agriculture	R1	
	Caravan and camping sites	R3 (floors above 50 year flood levels)	
	Parking Areas	R1	
Above 50 year floodline	Formal Residential	R2. Floors above 100 year flood levels	Recommend Floor Levels above 3.6m amsl
	Holiday resorts and bungalows	R1	R2. Recommend floor levels 3.6m amsl
	Earthwork Filling (raising ground levels)	R1	Must not negatively affect other properties
Above 100 year floodline	Formal Residential	Recommend Floor Levels above 3.6m amsl	
Additional Requirements/Conditions			
Key	Additional Condition		
R1	A registered Engineering Professional must be engaged by the developer to satisfactorily demonstrate and certify that: • The activity/development will not materially increase flood hazards for other property owners or adversely affect flood behavior or the stability of channels; and • Any structure can withstand the forces and effects of flowing floodwaters, including scour of foundations, debris forces and buoyancy forces.		
R2	Floors above 100 year RI flood level.		
R3	Floors above 50 year RI flood level.		

The CCT (2009) guidelines allow, in exceptional circumstances, minor "smoothing" of the 50/100 year floodlines, provided that equivalent compensatory stage storage volume is provided elsewhere within the

development precinct. We believe the circumstances of RE1627 are exceptional as it is prime land within the urban edge which could otherwise revert to wasteland.

We recommend that earthfill is cut to create Stormwater detention ponds and water features, and placed between the 3.0m and 3.1m amsl contours, raising ground levels to 3.1/3.2m amsl, to create a safer precinct for a residential development. Figure AF1101-6 then shows the area of FGL's above the 100 year RI floodlevels.

Areas still available for residential development in Sedgefield are very limited. Even though erf RE1627 has areas that were previously flooded, we consider that it's topography, as described in this report, make it suitable for limited residential development, subject to adequate building requirements to be applied, i.e.:

i. all floor areas of residential units to be raised to 3.6m amsl;
ii. all power distribution structures to be installed above 3.6m amsl;
iii. all manhole covers to underground services other than Stormwater run-off, to be raised to 3.1m amsl; and
iv. excavation of a number of Stormwater detention ponds in open areas. The excavated material to be used as infill to localized low areas within the erf to raise ground levels to approximately 3.1m to 3.2m amsl.

10. Summary

Sedgefield erf RE1627 is situated between the N2 National Road and two residential estates, Island Village and Montage Village. Erf RE1627 has developmental potential, though is low lying, and like the neighbouring Estates, parts of the property has been subject to historical flooding, particularly in November 2007.

The catchment area is 370km^2 and the Time of Concentration is 25 hours. The flood levels of the August 2006 floods were photographically recorded at the neighbouring estate, Montage Village, whilst the November 2007 flood levels were surveyed.

Referring to statistical rainfall data, neither the 2006 nor 2007 individual one day rainfalls exceeded the 100 year RI one day rainfalls. However, again looking at statistical rainfall data, the two day rainfalls of August 2006 were of the order of the 100 year RI two day rainfalls, and the November 2007 rainfalls well exceeded the 200 year RI two day rainfalls. Indications are that the flood flows of the 2007 rainfalls were well in excess of the 100 year RI flood flows.

From the historical rainfall data and the surveyed flood levels, the 50 year RI flood levels were estimated as 2.8m amsl and the 100 year RI flood levels were estimated as 3.1m amsl.

Following the 2007 floods, an Environmental Basic Assessment Report (Hilland, 2009) reached a Record of Decision that allows the early breaching of the Estuary mouth in anticipation of peak estuary flood flow rates. This provides a safeguard against similar extreme rainfalls causing similarly high flood levels.

The CCT (2009) Floodplain and River Corridor Management Policy was referenced and a range of development land uses are proposed. These include:

- Residential developments above the 50 year flood levels with floor levels above the 100 year RI flood levels;
- Holiday resorts above the 50 year RI flood levels with floor levels above the 100 year RI flood levels.

For the case of the residential developments, we advocate floor levels to be above the 3.6m amsl elevation to allow for a greater safety margin for factors including the possibilities of climate change.

The CCT (2009) document allows, in exceptional circumstances, minor smoothing of the 50 and 100 year RI floodlines, provided that equivalent compensatory stage storage volume is provided within the development precinct. This allows for modifications of the floodlines. To this end we recommend earthworks to raise areas above the 3.0m amsl contour to above the 3.1m amsl contour, and to develop residential houses with floor levels above the 3.6m amsl elevation.

Further information is available within the document and Appendix D.

11. Conclusion

This report is based on a range of historical flood data, as detailed.

The alternative to using historical data would involve complex hydrological modelling, bathymetric surveys, bridge surveys, siltation modelling and other time consuming and expensive techniques. Such a study is typically done by Regional Authorities and not private Developers. We are of the opinion that such modelling would not significantly affect the conclusions reached as there is substantive historical data available.

The flood risks have been significantly reduced by the early mouth breaching policy. However the floodlines are conservative and do not take this into account. Furthermore the floor levels are recommended to be 3.6m amsl which is higher than the estimated 100 year RI floodlines. This allows a tolerance and for the possibilities of global warming.

We therefore recommend that, subject to the restrictions outlined in Section 9, Development Possibilities, erf RE1627 is suitable for limited development.

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Appendix A. Authors Credentials and Declaration of Independence.

The author of this report, Alastair Fraser of Fraser Engineers cc, is a registered Professional Engineer with the Engineering Council of South Africa (ECSA registration no. 940107). Mr Alastair Fraser is a Master of Science in Engineering graduate of the School of Bioresources and Hydrology of the University of Natal.

Continuing Professional Development Courses include:

- Development of Coastal Setback Lines
- Basic Coastal and Harbour Engineering
- Flood Hydrology
- 3 day workshop on SWMM and PCSWMM
- The Reduction and Removal of Urban Litter from Stormwater Systems
- River Hydraulics, Stormwater and Flood Management
- Pipeline Course
- Geometric Design of Urban and Rural Roads
- Sustainable Urban Drainage Systems.

Mr Alastair Fraser has 30 years of hydrology experience both in South Africa and the United Kingdom and flood management studies include:
Kuilsrivier (Cape Town). Eerste Rivier (Cape Town), Chatty River (Port Elizabeth), Cintsa River (East London), Knysna River (Knysna), Swartvlei System (Sedgefield), Klein Brak River (Mossel Bay), Breede River (4 Locations, Bonnievale to the mouth), Duiwenshoks River (Heidelberg and Vermaaklikheid), Vet River (Riversdale), Wolwe Rivier (Mossel Bay), Gouritz River (mouth), Grobbellaar's Rivier (Oudtshoorn), Moordkuils Rivier (Mossel Bay), Kat Rivier (George), Gouko Rivier (Riversdal), Rooi Rivier (George),Proposed Beaufort West Wind Farm, ABSA Devco Knysna Affordable Housing, etc.

Mr Alastair Fraser is a past-Chairman of the Southern Cape branch of the SA Institute of Civil Engineers.

Mr Alastair Fraser declares that he does not have any financial interest in the undertaking of the activity, other than remuneration of the work performed in the compilation this report.

Appendix B. Literature Research

This Appendix presents background information on the Swartvlei System In extracts of information from the Fraser (2009) Report titled “Sedgefield Flood Remedial Projects”.

Figure 1 of this Appendix B shows the catchment layout. It shows the minor catchment of Montage village, and erf RE1627 is immediately to the east of Montage Village.

Extracts of Report:

There has been extensive research on the Swartvlei catchment. The research documents from Whitfield (1983) and Fijen (1995) provide us with the most research information for the project. Table B4 presents general information whilst Table B5 presents flood flow information.

Table B4. Literature Search

Characteristic	Data	Reference
Catchment Areas:		
Wolwe Rivier System	125 km^2	Whitfield (1983) pg 4
Hoëkraal (Hoogekraal) System	109 km^2	Whitfield (1983) pg 4
Karatara System	106 km^2	Whitfield (1983) pg 4
Mean Annual Runoffs:		Whitfield (1983) pg 4
Wolwe Rivier System	19.8 $m^3 \times 10^6$	Whitfield (1983) pg 4
Hoëkraal (Hoogekraal) System	24.8 $m^3 \times 10^6$	Whitfield (1983) pg 4
Karatara System	20.1 $m^3 \times 10^6$	Whitfield (1983) pg 4
Surface Areas:		
Swartvlei Lake	8.8 km^2	Whitfield (1983) pg 10
Surface area Estuary (downstream rail bridge)	2 km^2	Liptrot (1978) cited by Whitfield (1983) pg 10
Surface area of flood plain	14.2 km^2	Fijen (1995) pg1
Tidal ranges:		
Extreme at mouth	1.98m	Whitfield (1983) pg 12
0.5km upstream from mouth	Reduced by one third	Whitfield (1983) pg 12
At rail bridge	Reduced by 90%	Whitfield (1983) pg 12
Tidal lag (outgoing tide)	2 hours	Whitfield (1983) pg 12
General:		
High flow resistance at:	Railway bridge	Whitfield (1983) pg 12
	River mouth	Whitfield (1983) pg 12
Swartvlei Flood Flow Regime	Floods flow over the lake surface in layers of 0.2 m to 0.5 m thick	Whitfield (1983) pg 13

Historic Sea Levels:		
14 000 years ago	100 m below present level	Various cited by Whitfield (1983) pg 14
6000 years ago	2.5m above present level	Various cited by Whitfield (1983) pg 14
4000 years ago	Similar to current	Various cited by Whitfield (1983) pg 14
Location of river mouth	Migrated from Swartvlei Beach and stopped from migrating further by rocks on eastern side of current mouth	Whitfield (1983) pg 15
Elevations for Development	As the Swartvlei lake levels reach +2m amsl before opening of the Estuary, development of property below 3m amsl should not be allowed under any circumstances. The +5m contour is recommended for future development.	Whitfield (1983) pg 39
	If development is allowed under the 5m contour then public pressure to open the mouth early will increase.	Whitfield (1983) pg 40
Guidelines for the future special development of the Swartvlei area	Island Village was zoned as Agriculture/Forestry. Montage Village was zoned as recreational.	Department Constitutional Development and Planning (1983), cited by Whitfield (1983) pg 37
Opening of the River Mouth		
Percentage open	The mouth is generally open 55% of the time	Fijen (1995) pg 30
	The mouth should be opened when the Estuary reaches a level of 2m amsl. Under high risk conditions (at high lake levels and heavy rains) consideration can be given to opening before level 2m amsl is reached.	Department of Planning(1970), Knysna-Wilderness-Plettenberg Bay Guide Plan (1983), all cited by Whitfield (1983) pg 36-38
	Artificial opening of the mouth has become an essential requirement for maintaining the Estuary in its present condition	Howard Williams and Allanson (1979), cited by Fijen (1995) pg 19
	An opening of the river mouth can be regarded as successful if it lowers estuary water levels to alleviate flooding	Fijen (1995) pg 21
	Opening of the river mouth during winter should not be attempted unless it is imperative as it is not conducive to fish recruitment	Kok and Whitfield (1986), cited by Fijen (1995) pg 21

Swartvlei Lake flood levels for different mouth opening levels	For a ten year RI flood of 474 m^3/s, if the mouth is opened at 1.20 m amsl instead of 1.50 m amsl, the peak flood water level in Swartvlei lake drops from 2.48 m amsl to 2.28 m amsl.	Fijen (1995) pg 35-36
Mouth flow rates for different opening levels	10 year flood only: Mouth opened at 1.80m amsl: flow rate = 110 m^3/s. Mouth opened at 2.07m amsl: flow rate = 138 m^3/s.	Fijen (1995) pg 35 36

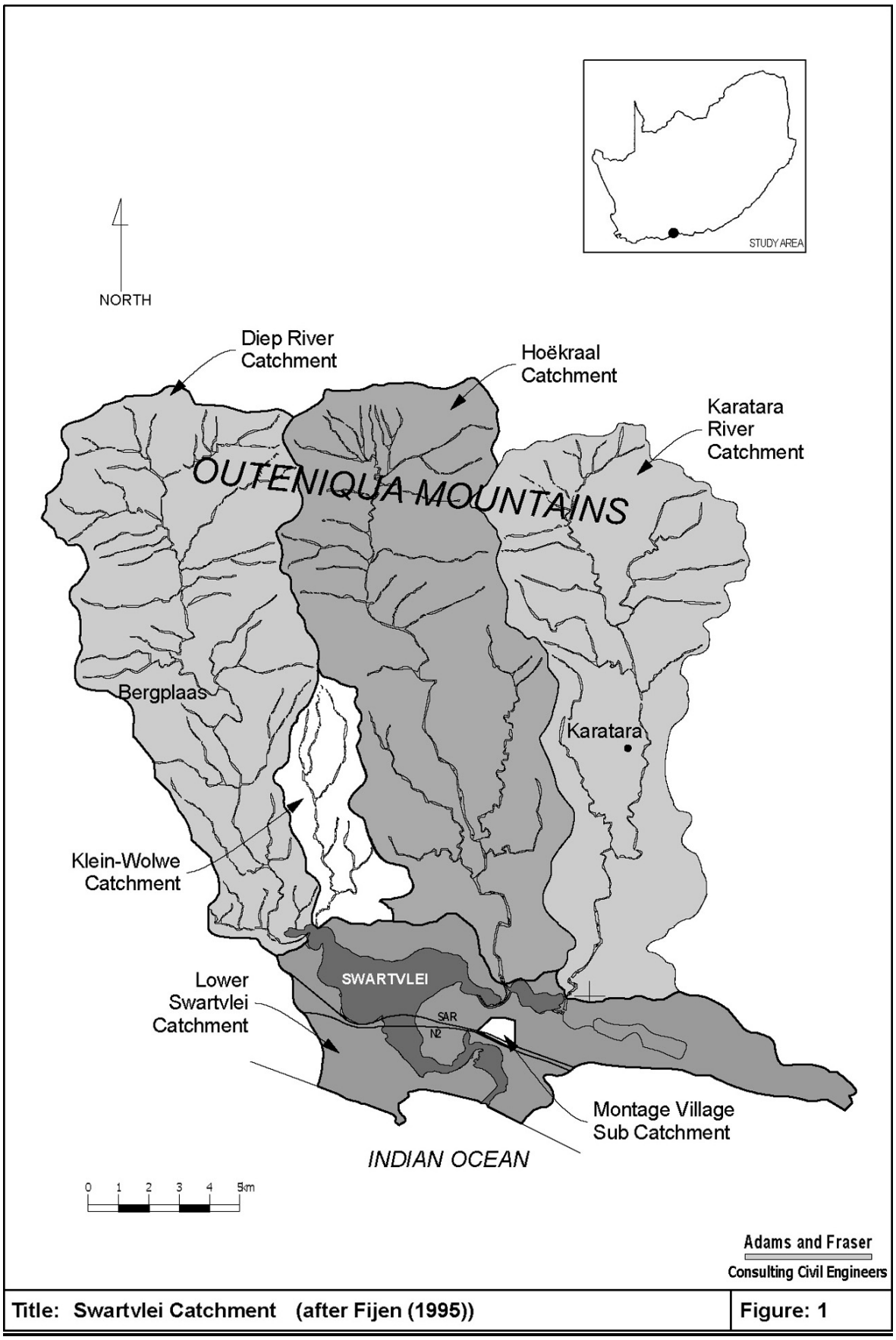

Figure 1 of Appendix B

Appendix C. Photographs

Photograph C1. August 2006: Montage Village flood levels below the 3.0m amsl floor levels.

Photograph C2. August 2006: the Perdespruit causeway backs up water upstream to Montage Village and erf RE1627

Photograph C3. November 2007: an area north-west of bowling club is not flooded.

Photograph C4. November 2007: Low lying areas flooded, high lying areas not flooded

Photograph C5. November 2007: Low lying areas flooded

Appendix D. Framework for the Assessment for Development Proposals