ERF 1486, VERMONT – STORMWATER MANAGEMENT PLAN

12 February 2026

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TABLE OF CONTENTS

ANNEXURES

1. INTRODUCTION

DECA Consulting Engineers were appointed by the developer to compile a Stormwater Management Report for the proposed development i.e.Erf 1486, Vermont. The site for development is situated adjacent to a wetland area and treatment of stormwater was therefore taken into consideration. It should be noted that the site for development is situated in a large catchment area, mainly consisting of the mountainous areas North of the site and the site therefore forms a small portion of the catchment area. The proposed development will; for the purpose of this report hereinafter be referred to as "the site".

2. AVAILABLE INFORMATION

The following information was made available to DECA:

a) Planet GIS cadastral and 5m contours of the study area

b) Existing applications for development in the study area

c) Existing cadastral information of the study area

d) Aerial photographs of the study area obtained from Surveys and Mapping

e) Cape Farm Mapper geotechnical information of the study area

f) Proposed rezoning and subdivision plan for Erf 1486, Vermont from Iner Active Town and Regional Planning

3. SITE DESCRIPTION

The site is situated in the Vermont Area, on the corner of the R43 and Lynx Avenue.

The site is very flat in gradient and drains into an easterly direction towards the Vermont Salt Pan (wetland area). The portion of the catchment area North of the development is very steep, since it forms part of the mountainous area.

Please find the locality plan of the site attached hereto as **Annexure A** and the proposed layout plan of the proposed development as **Annexure B.**

The proposed land use of the site is summarized hereunder:

	Description	Size (m²)	Current Zoning	Proposed Zoning
	Erf 1486, Vermont	15 069	Agricultural	Town Housing

Table 1 – Proposed Land Usage

4. GEOTECHNICAL INFORMATION

No Geotechnical investigation was carried out for the site, but the geology of the site and catchment area can be described as follows:

4.1 The Site for Development – South of R43 – CA2

Geology
Lithostratigraphic group of Nardouw Supergroup. Lithology of white coarse-grained to fine-grained, thick-bedded pebbly quartz arenite, thin bedded feldspathic and ferruginous sandstone, very subordinate shale and siltstone.

Broad Soil Classification
Grey regic sands and other soils with geology of recent coastal sand and dunes with slight occurrence along the coast of shale of the Bokkeveld Group and sandstone of the Peninsula Formation, Table Mountain Group.

Soil Type
Soils with limited pedological development – Greyish, sandy excessively drained soils. Clay content of less than 15% with depth in excess of 750mm. Soil Classification – ED

Soil Description (Green Ampt)	:	Sand
Soil Type (SCS)	:	A
Conductivity (Green Ampt)	:	120.396
Suction Head (Green Ampt)	:	49.022

4.2 Mountainous area of Catchment Area – North of R43 – CA1

Geology
Lithostratigraphic group of Nardouw Supergroup. Lithology of white coarse-grained to fine-grained, thick-bedded pebbly quartz arenite, thin bedded feldspathic and ferruginous sandstone, very subordinate shale and siltstone.

Broad Soil Classification
Miscellaneous land classes, rocky areas with miscellaneous soils with geology of quartzitic sandstone of the Skurweberg Formation, Table Mountain Group, on the northern upper midslopes and of the Rietvlei Formation, Table Mountain Group on the lower midslopes. Mainly quartzitic sandstones of the Penintula Formation, Table Mountain Group.

Soil Type
Rocky areas with rock and limited soils.
Classification - GA

Soil Description (Green Ampt)	:	Sand
Soil Type (SCS)	:	D
Conductivity (Green Ampt)	:	120.396
Suction Head (Green Ampt)	:	49.022

5. STORMWATER

5.1 Calculations

Hydrological calculations are executed according to various approved methods (Rational, SCS and Time Area Methods), with each based on its own set of data. The results of each method can only be assumed as an approximation of actual events and a relatively large variation between these methods could occur.

The **applicable catchment area** (proposed development area) is small (<8Km²), therefore the Alternative Rational Method (Storm Intensity with Op-Ten-Noordt, TR102 and Hershfield) was used to calculate the peak flow runoff and the difference between the pre- and post development runoff. The extent of the attenuation and treatment facility required was determined with the aid of PCSWMM with a 24-hour SA Type 1 SCS storm.

5.2 Risks cost estimate and design flood frequencies

Although run-off calculations are performed with great care, it is still possible that the capacity of a system could be exceeded because of non-hydrological reasons. There has to be a limit to the elimination of probabilities as costs could become unrealistically high in comparison with the benefit of lower risks.

Although the relationship between function, risk, original cost and maintenance cost plays a major role in determining the design flood frequency, it is assumed in general that the flood frequencies as discussed in Table 4 below should be provided for under normal circumstances.

The applicable analysis: assessment and design standard will be those given in table 6.1 and 6.2 of the "Red Book" and are as follows:

Land Use	Design Storm Return Period (Major storm events)
Residential	50 years
Institutional (e.g.) schools	50 years
General Commercial and Industrial	50 years
High Value Central Business Districts	50 - 100 years
Land Use	**Design Storm Return Period (Minor storm events)**
Residential	1 - 5 years
Institutional (e.g.) schools	2 - 5 years
General Commercial and Industrial	5 years
High Value Central Business Districts	5 - 10 years

Table 2 – Typical Stormwater analysis requirements based on land-uses

In the light of the general application and support of the above-mentioned guidelines, it is accepted as minimum acceptable standards for stormwater drainage. Any deviation from these standards should be justified on the basis of economic and risk analysis.

For the purpose of this report these guidelines will thus apply throughout as reference and any deviation from that will be motivated.

5.3 Hydrology

5.3.1 Climate

The study area is situated in the winter rainfall region of the Western Cape. No extreme rainfall intensities occur. A representative mean annual rainfall (MAP) of **591mm for the site** has been obtained from the Design Rainfall and Flood Estimation in South Africa (JC Smithers and RE Schiltze) report.

5.3.2 Storm Rainfall

A summary of the rainfall station search and related storm rainfall data is given in the table below:

	Station Name	Fish'ns Haven	Hermanus	Accepted
	SAWS Station No.	0006232_W	0006415_W	
Location	Latitude	34˚22'	34˚25'	
	Longitude	19˚08'	19˚14'	
	Mean annual Precipitation (mm)	556	626	591
	Altitude	18	24	
	Distance from Catchment Centroid (km)	4.0	9.2	
	Length of Record (years)	27	64	
	Return Period	One Day Rainfall Depth (mm)		
Rainfall Depth	1 in 2 year	50.1	48.2	49.2
	1 in 5 year	70.6	67.8	69.2
	1 in 10 year	86.4	83.0	84.7
	1 in 20 year	103.4	99.3	101.4
	1 in 50 year	128.6	123.6	126.1
	1 in 100 year	150.1	144.3	147.2

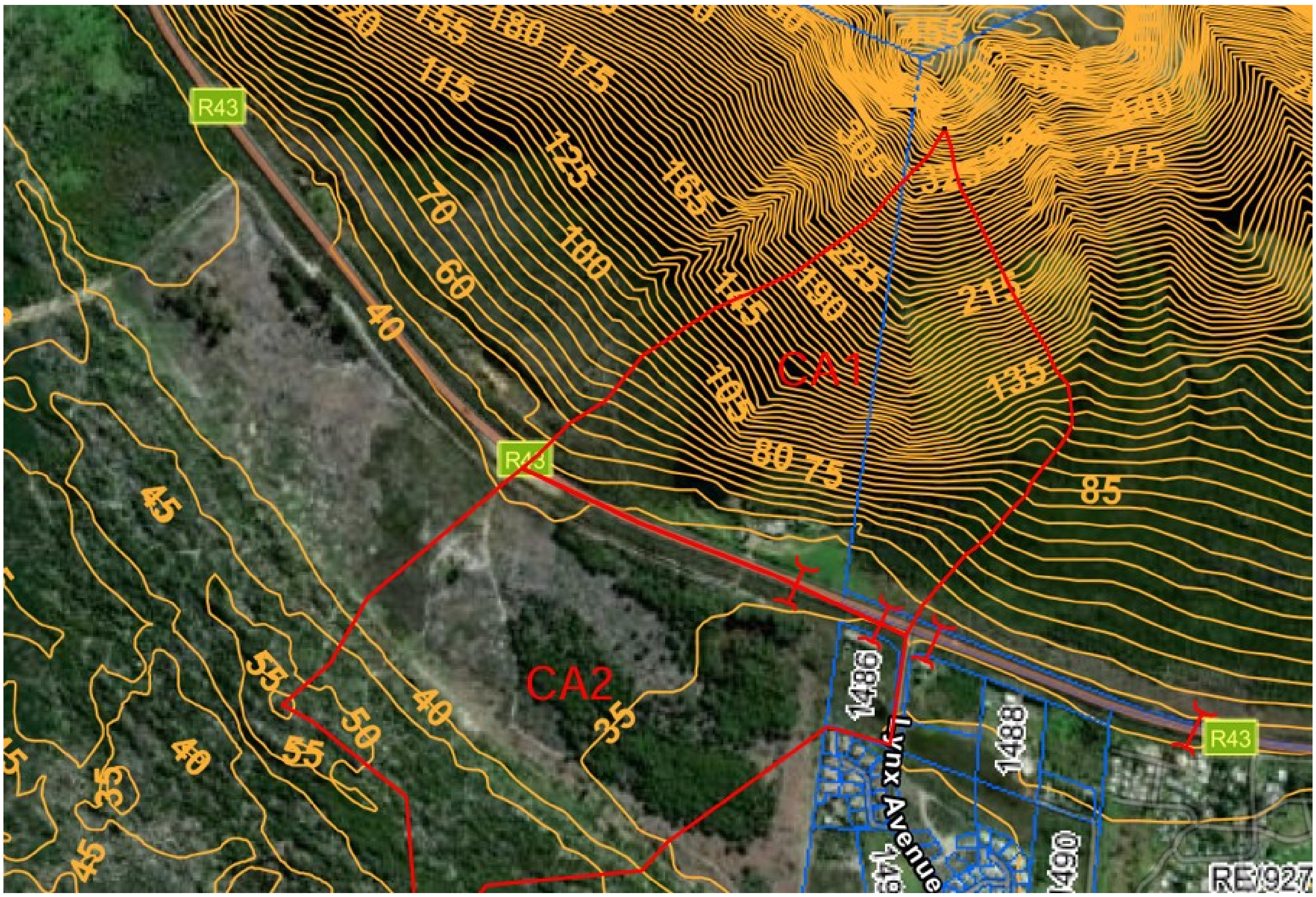
Table 3 – Rainfall records

5.4 Pre- and Post-Development Peak Flow Runoff

The catchment area was sub-divided into two sub-catchment areas, which is as follows:

Catchment area 1 (CA1) – North of the R43
Catchment area 2 (CA2) – South of the R43

The catchment areas are indicated in the following aerial photo:



Drawing 1 – Catchment area of Site for Development

The peak flow runoff for the various recurrence interval storm events are as follows:

Catchment Area 1 (CA1)

Return Period	Pre-development (m^3/s)	Post-development (m^3/s)
Q2	1.72	1.72
Q5	2.55	2.55
Q10	3.19	3.19
Q20	3.89	3.89
Q50	4.93	4.93
Q100	5.82	5.82

Table 4 – Pre- and Post development Runoff -CA1

Catchment Area 2 (CA2)

Return Period	Pre-development (m³/s)	Post-development (m³/s)
Q2	0.29	0.29
Q5	0.41	0.41
Q10	0.51	0.50
Q20	0.61	0.60
Q50	0.76	0.75
Q100	0.89	0.88

Table 5 – Pre- and Post development Runoff – CA2

The catchment area North of the R43 (CA1) discharge through the R43 via various culverts along the road, which discharge to the catchment area South of the R43 (CA2). Both catchment areas discharge into a natural attenuation facility, which forms part of the wetland area. It was accepted that the attenuation area provides approximately 10 000m² in area. Should this natural attenuation area be takin into consideration, the peak flow runoff for the various recurrence interval storm events that discharge through the existing 2 x 750mm x 0.5mm box culvert in Lynx Avenue are as follows:

Return Period	Pre-development (m³/s)	Post-development (m³/s)
Q2	0.669	0.727
Q5	1.071	1.106
Q10	1.420	1.467
Q20	1.831	1.892
Q50	2.491	2.575
Q100	3.107	3.211

Table 6 – Pre- and Post development Runoff – Culvert at Lynx Avenue

The maximum depth that the water rises in the wetland area during the various recurrence interval storm events are as follows:

Return Period	Pre-development (m)	Post-development (m)
Q2	0.29	0.29
Q5	0.38	0.38
Q10	0.44	0.45
Q20	0.51	0.52
Q50	0.60	0.61
Q100	0.67	0.69

Table 7 – Pre- and Post development water level in attenuation area

The location of the various culverts that discharge through the R43 towards Catchment Area 2 and the 2 x 750mm x 500mm culvert that discharge through Lynx Avenue are as follows:

Drawing 2 – Culverts along R43 and discharge through Linx Avenue

5.5 City of Cape Town – Management of Urban Stormwater Impacts Policy

According to the City of Cape Town – Management of Urban Stormwater Impacts Policy (May 2009), the following shall apply to the proposed development:

SUDS OBJECTIVES	Brownfields and Existing Development Sites 4 000m² - 50 000m² And Total impervious area (exist & new) > 5% of site
Control Quantity and Rate of Runoff	Combination of on-site and regional off-site measured to achieve requirements as for development sites > 50 000m², i.e. 50-year RI peak flow reduced to existing
Improve Quality of Runoff	Combination of on-site and regional off-site measures to achieve target reductions: SS – 80% reduction TP – 45% reduction

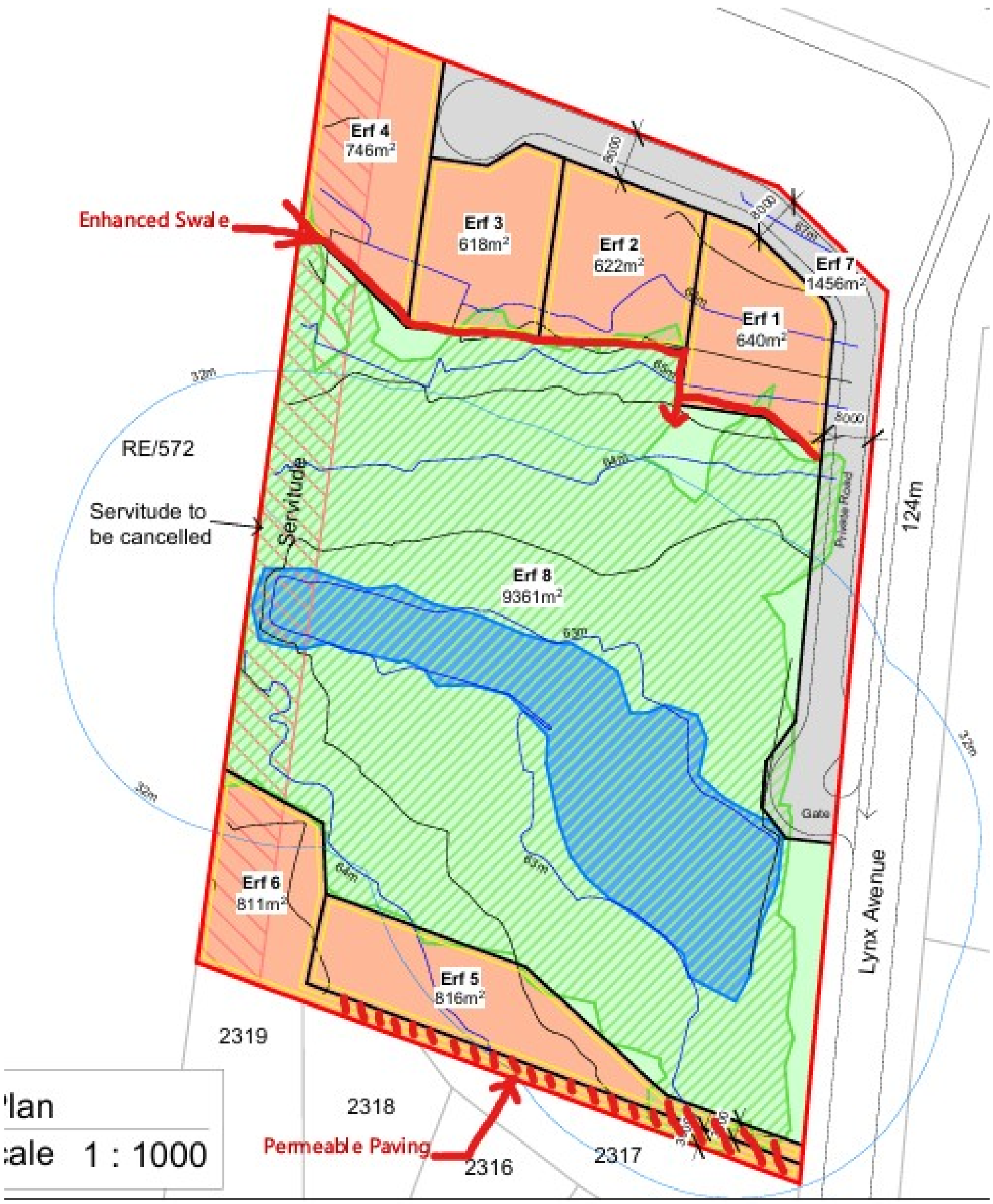
Table 8 – Criteria for achieving sustainable Drainage Objectives

5.6 Control Quantity and Rate of Runoff

To achieve the above (**Table 8**) objectives, stormwater quantity and rate of runoff, the following Low Impact Development (LID) is proposed:

- Permeable Paving for a section of the road for the section south of the wetland.
- Enhanced swale for the section North of the wetland area.

The location of the proposed permeable paving and enhanced swale is as follows:



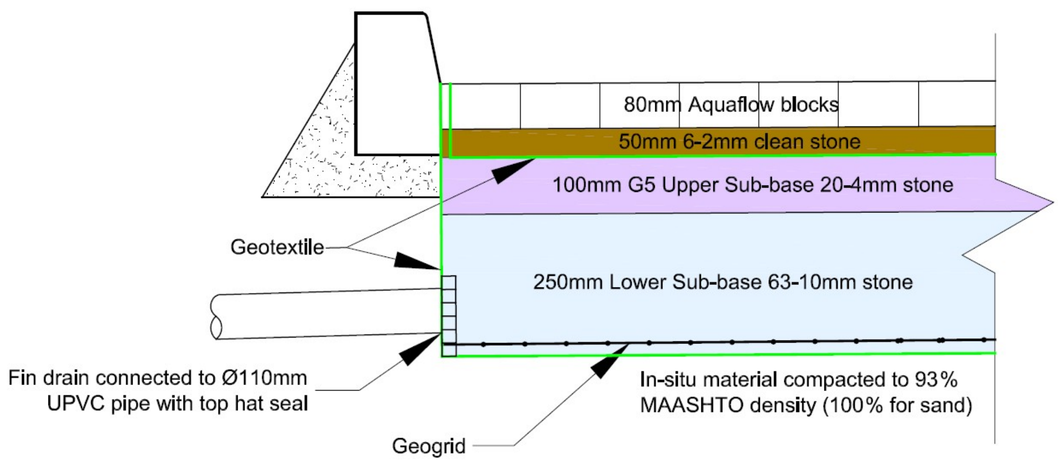
Drawing 4 -Proposed location of Permeable Paving and Enhanced Swale

5.6.1 Permeable Paving for section south of wetland

ITEM	VALUE	COMMENT
SURFACE		
Storage Depth	50mm	Kerb height
Vegetation Fraction	0	No Vegetation growth
Manning n	0.03	
Surface Slope	0.5%	
PAVEMENT		
Thickness	80mm	
Void Ratio	0.12	10% voids in paving
Impervious Surface	0	Total surface as permeable paving
Permeability	360mm/hour	For clogged paving system
Clogging Factor	0	Taken into consideration above
STORAGE		
Height	400mm	Base course depth
Void Ratio	0.43	30% voids in base course
Conductivity	120mm/h	Conductivity of in-situ material
Clogging Factor	0	Taken into consideration above
UNDERDRAIN		
Drain Coefficient	1.667mm/hour	
Drain Exponent	0.5	Conduit
Drain Offset	0	Invert of Base course

Table 9 – Criteria of Permeable Paving System

The road structure is proposed to be as follows:



Drawing 5 – Proposed Permeable Paving System

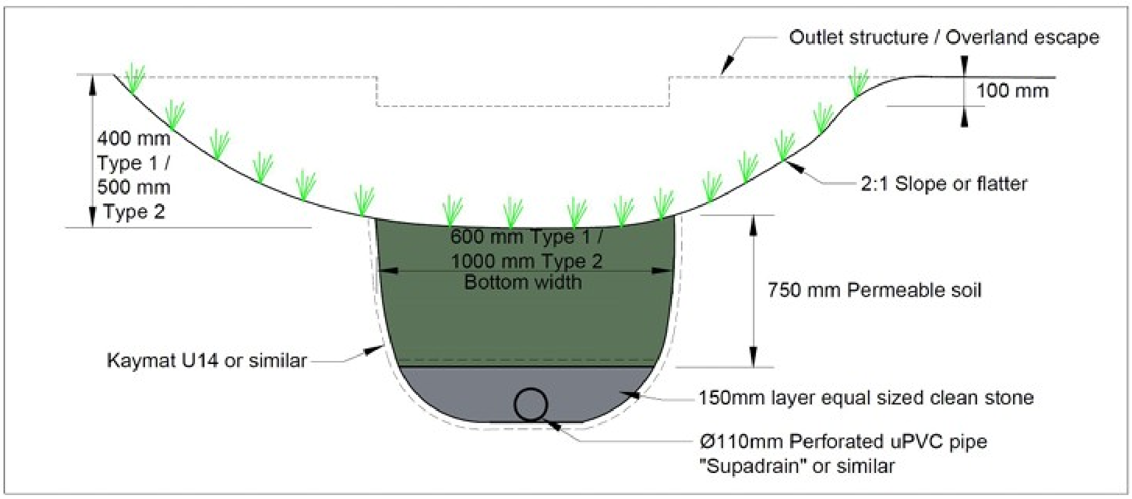
Note:
Outlet to be 160mm dia. uPVC pipe

5.6.2 Enhanced Swale for section North of wetland

ITEM	VALUE	COMMENT
SURFACE		
Storage Depth	400mm	
Vegetation Fraction	0.75	No Vegetation growth
Manning n	0.24	
Surface Slope	0.5%	
STORAGE		
Height	750mm	Base course depth
Void Ratio	0.43	30% voids in base course
Conductivity	120mm/h	Conductivity of in-situ material
Clogging Factor	0	Taken into consideration above
UNDERDRAIN		
Drain Coefficient	1.667mm/hour	
Drain Exponent	0.5	Conduit
Drain Offset	0	

Table 10 – Criteria of Enhanced Swale System

Typical section of the proposed enhanced swale is as follows:



Drawing 6 – Proposed Enhanced Swale System

The pre- and post-development stormwater runoff for the various recurrence interval storm events with the proposed permeable paving and enhanced swale are as follows:

Return Period	Pre-development (m^3/s)	Post-development (m^3/s)	Post-development with LID (m^3/s)
Q2	0.669	0.727	0.60
Q5	1.071	1.106	1.00
Q10	1.420	1.467	1.41
Q20	1.831	1.892	1.82
Q50	2.491	2.575	2.45
Q100	3.107	3.211	3.10

Table 11 – Pre- and Post Development Runoff with LID

The maximum depth that the water rises in the wetland area during the various recurrence interval storm events are as follows:

Return Period	Pre-development (m)	Post-development (m)	Post-development with LID (m^3/s)
Q2	0.29	0.29	0.29
Q5	0.38	0.38	0.38
Q10	0.44	0.45	0.44
Q20	0.51	0.52	0.51
Q50	0.60	0.61	0.60
Q100	0.67	0.69	0.67

Table 12 – Pre- and Post Development water level in attenuation area

5.7 Improve Quality of Runoff

According to the specifications of City of Cape Town, the SS should be reduced with 80% and TP should be reduced with 45% during the ½ year RI, 24-hour storm event. The above should be done in combination with on-site and off-site regional facilities.

It is proposed to meet the above requirements with the proposed permeable paving (Modular Porous Paver System) and Enhanced Swale as indicated above.

In order to determine the capacity required for the permeable paving and Enhanced Swale, the method proposed in the Georgia Stormwater Management Manual, which is based on Darcy's Law was used:

WQv = RD x Rv x A

WQv = Water Quality Volume or total volume to be captured (m^3)
Rv = Runoff Factor
I = Percent Impervious Cover (%)
A = Site Area (m^2)
RD = Rainfall depth for ½-year RI (m)
Rv = 0.05 + (0.009 x I)

5.7.1 Treatment proposed by means of Modular Porous Pavement System:

A = 2 114m^2
RD = 0.0246m for ½-year RI
I = 70%
Rv = 0.05 + (0.009 x 70) = 0.680
WQv = 0.0246 x 0.680 x 2 114 = 35.363m^3 - Required

Volume Storage Available in Porous Paving System:

350m^3 x 0.4 = 140m^3 - Provided

Treatment of stormwater includes the following reduction:
Total Suspended Solids = N.A.
Total Phosphorous = 50%
Total Nitrogen = 65%
Fecal Colriform = N.A.
Heavy Metals = 60%

5.7.2 Treatment proposed by means of Enhanced Swale System:

A	=	5 283m²		
RD	=	0.0246m for ½-year RI		
I	=	65%		
Rv	=	0.05 + (0.009 x 65)	=	0.635
WQv	**=**	**0.0246 x 0.635 x 5 283**	**=**	**82.526m³ - Required**

Volume Storage Available in Enhanced Swale System:

90 x 1.0x 0.90 = 81.0m³ - Provided

Treatment of stormwater includes the following reduction:

Total Suspended Solids	=	N.A.
Total Phosphorous	=	50%
Total Nitrogen	=	65%
Fecal Colriform	=	N.A.
Heavy Metals	=	60%

5.8. Inspection and Maintenance

5.8.1 Permeable Paving System

Activity	Schedule
Ensure that the porous paver and outlet structures are free of sediment	Monthly
Check that the system dewaters between storms	Monthly
Ensure that contributing are and porous paver surface are clear of debris	As needed, based on inspection
Ensure that the contributing and adjacent area is stabilized and mowed with clippings removed	As needed, based on inspection
Vacuum sweep porous paver surface to keep free of sediment	Typically, three to four times a year
Inspect the surface for debris or spalling	Annually
Totally rehabilitate the porous paver system, including the top and base course as needed	Upon failure

Table 13 – Inspection and Maintenance for Permeable Paving System

5.8.2 Enhanced Swale System

Schedule	Components	Action
After Storms	Inflow points	Check for scouring channeling and erosion – Repair as necessary
	Side slopes	Check for scouring channeling and erosion – Repair by adding soil and replanting as necessary
	Channel base	Check for scouring channeling and erosion – Repair by adding soil and replanting as necessary
	Plants & soil	Check stormwater is filtering through soil following storm events – Remove weeds
Monthly	Outlet	Check outlet for scouring or erosion – Repair as necessary
	Inflow points	Remove rubble and debris
	Channel base	If grassed – mow channel to shorter than 150mm Use catcher and remove clippings Re-seed bare patches of grass and water in dry conditions If planted – check plants are healthy, and growth is dense Remove weeds Replant gaps and water new plants in dry conditions
	Plants and soil	Check plants are healthy, and growth is dense. Remove weeds Replant gaps and water new plants until established
Two Yearly	Outlet	Remove rubble and debris from outlet grate or catchpit
	Channel base	Check for boggy patches and ponding of water Check soil is not compacted and aerated surface or top up dips to repair
	Grass, plants and soil	Remove weeds, rubble and debris Replant gaps and re-seed bare patches and water if required to establish Aerate soil to prevent natural compaction, similar to coring sports field and bowling greens Check stormwater is filtering through soil by either monitoring after storm runoff or by running water across swale

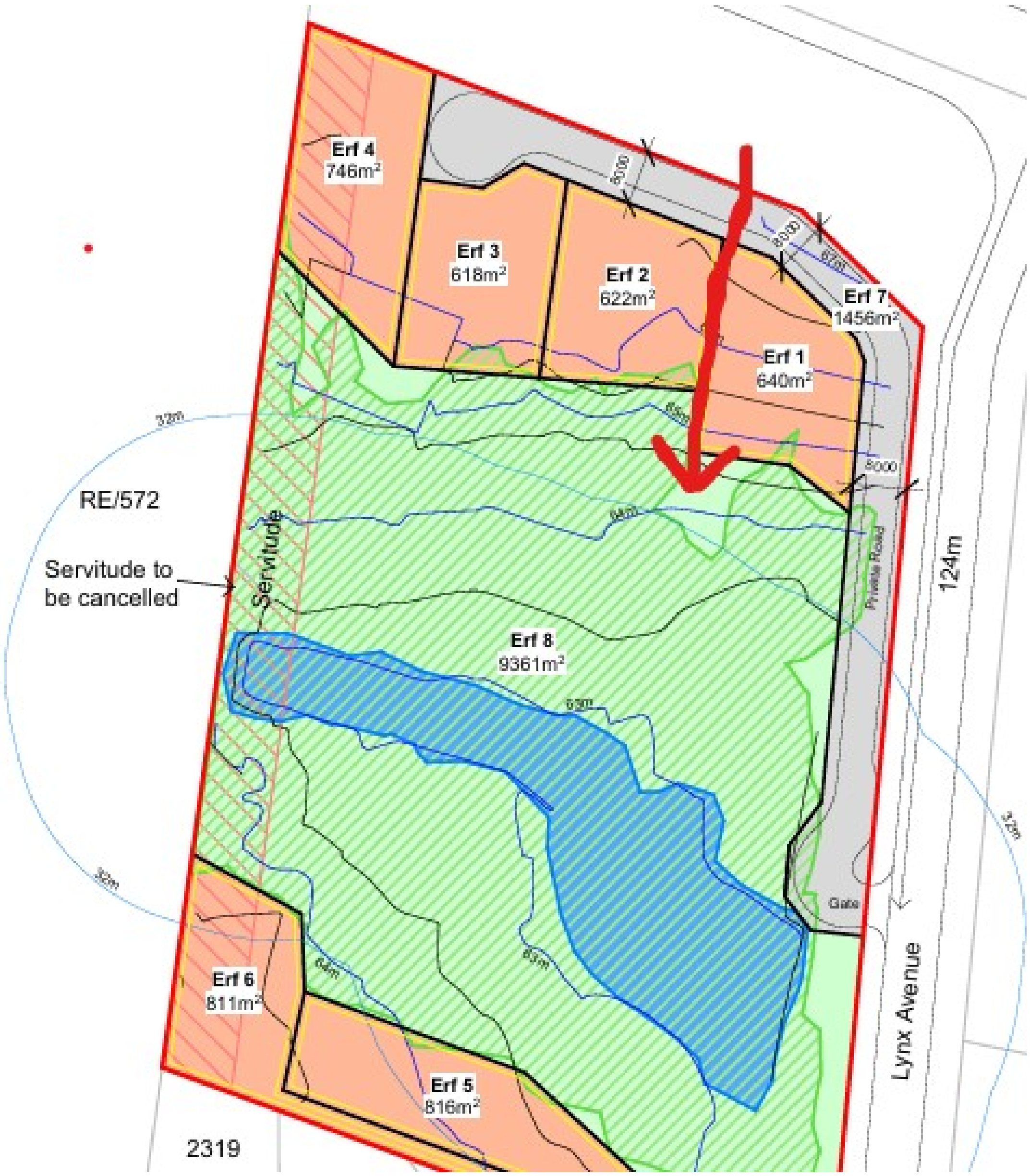
Table 14 – Inspection and Maintenance for Enhance Swale System

5.9 Control of stormwater runoff through R43

As mentioned above, the stormwater runoff from CA1 discharge towards CA2 and the wetland area through various stormwater culverts under the R43. One of these culverts discharge towards Erf 1486, Vermont and should be controlled to protect the properties from flooding. The specific culvert is indicated as follows with a red circle:

Drawing 7 – Culvert Runoff to Erf 1486, Vermont

It is proposed that the stormwater runoff through the above 2 x 600mm dia. Pipe culvert be controlled by the provision of 2 x 900mm dia. Stormwater pipes though Erf 1486, Vermont at the following position (indicated with red arrow):



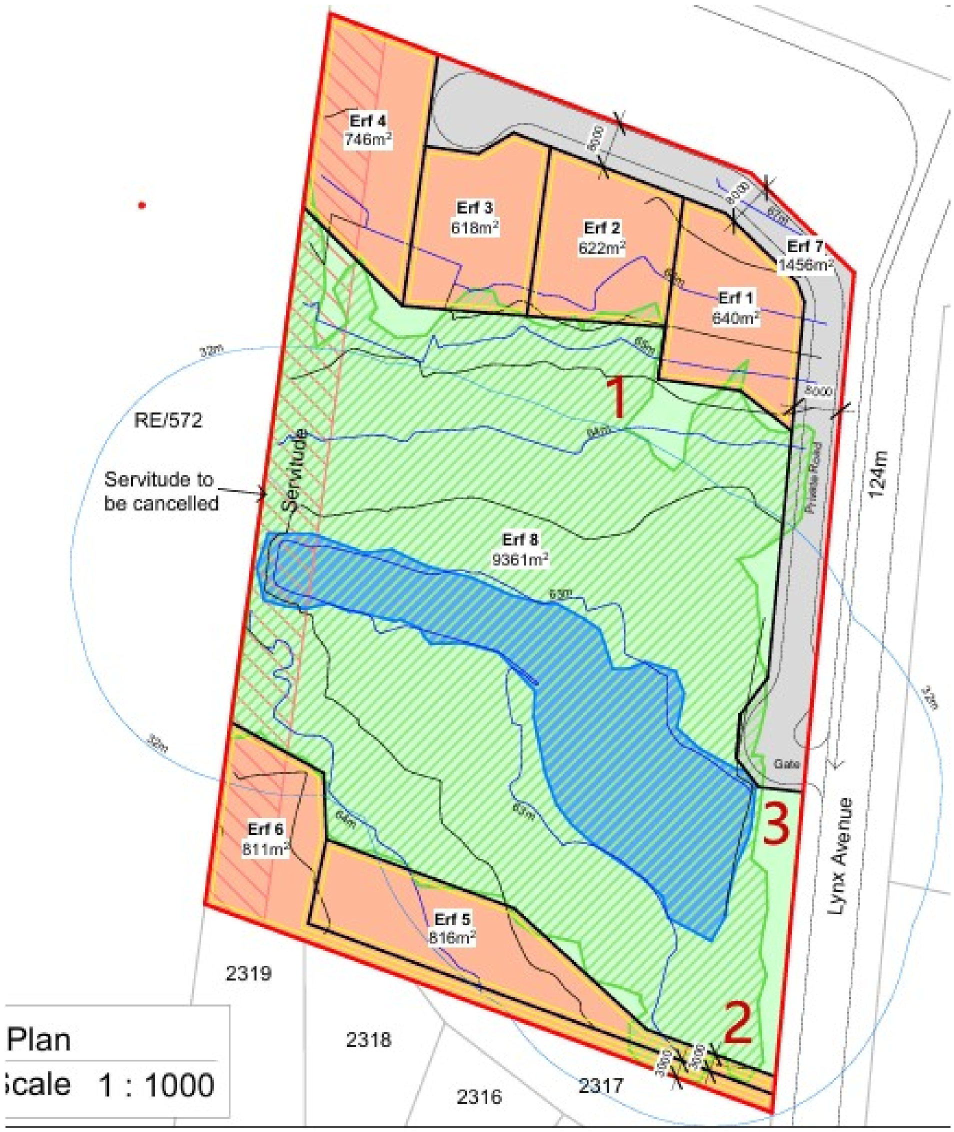
Drawing 8 – Position of proposed stormwater control through development

The size of the pipe system is proposed to be as follows:

- 2 x 900mm dia. Pipes

5.10 Control of Erosion and Litter

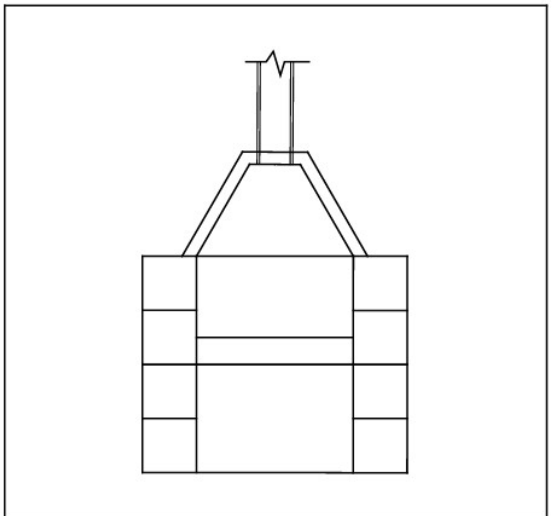
All the outlet structures into the wetland area should be provided with erosion and litter prevention measures. The position of possible outlet structures is as follows:



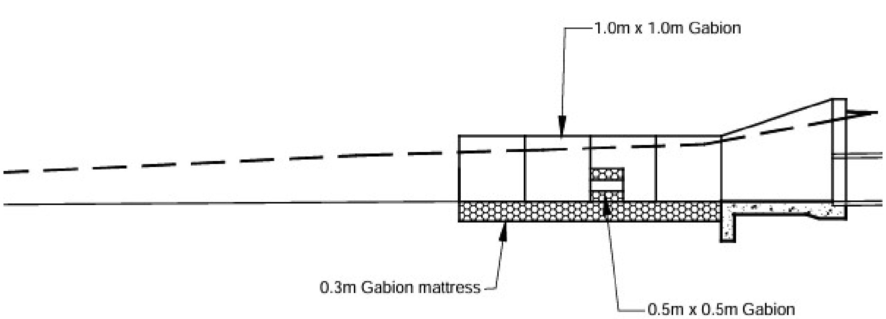
The above possible outlet structures can be described as follows:

1: Outlet for stormwater from the mountains above the R43 with swale outlet
2: Outlet for the permeable paving and stormwater in road
3: Outlet for stormwater along road

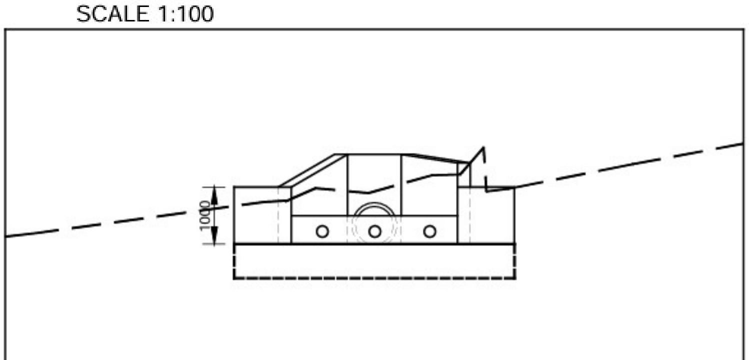
It is proposed that all outlet structures be provided with the following typical gabion control measure for litter and erosion control:



PLAN
SCALE 1:100



SECTION
SCALE 1:100



VIEW
SCALE 1:100

6. CONCLUSION/RECOMMENDATION

From the above, the following can be concluded:

6.1 That the proposed permeable paving and enhanced swale system system will reduce the post development runoff to equal or less than the pre-development recurrence interval storm.

6.2 That the proposed permeable paving and enhanced swale system will ensure that the water level in the attenuation area will remain to that of the pre-development level.

6.3 That the proposed permeable paving and enhanced swale system will treat the stormwater runoff quality to the requirements.

6.4 That the stormwater runoff from above the R43 be controlled to discharge through the site for development as proposed in Paragraph 5.9.

6.5 That the proposed development be protected from flooding by ensuring that the properties are above at least 1.0m from the wetland area.

6.6 That all outlet structures be provided with erosion and litter control structures.

COMPILED BY:

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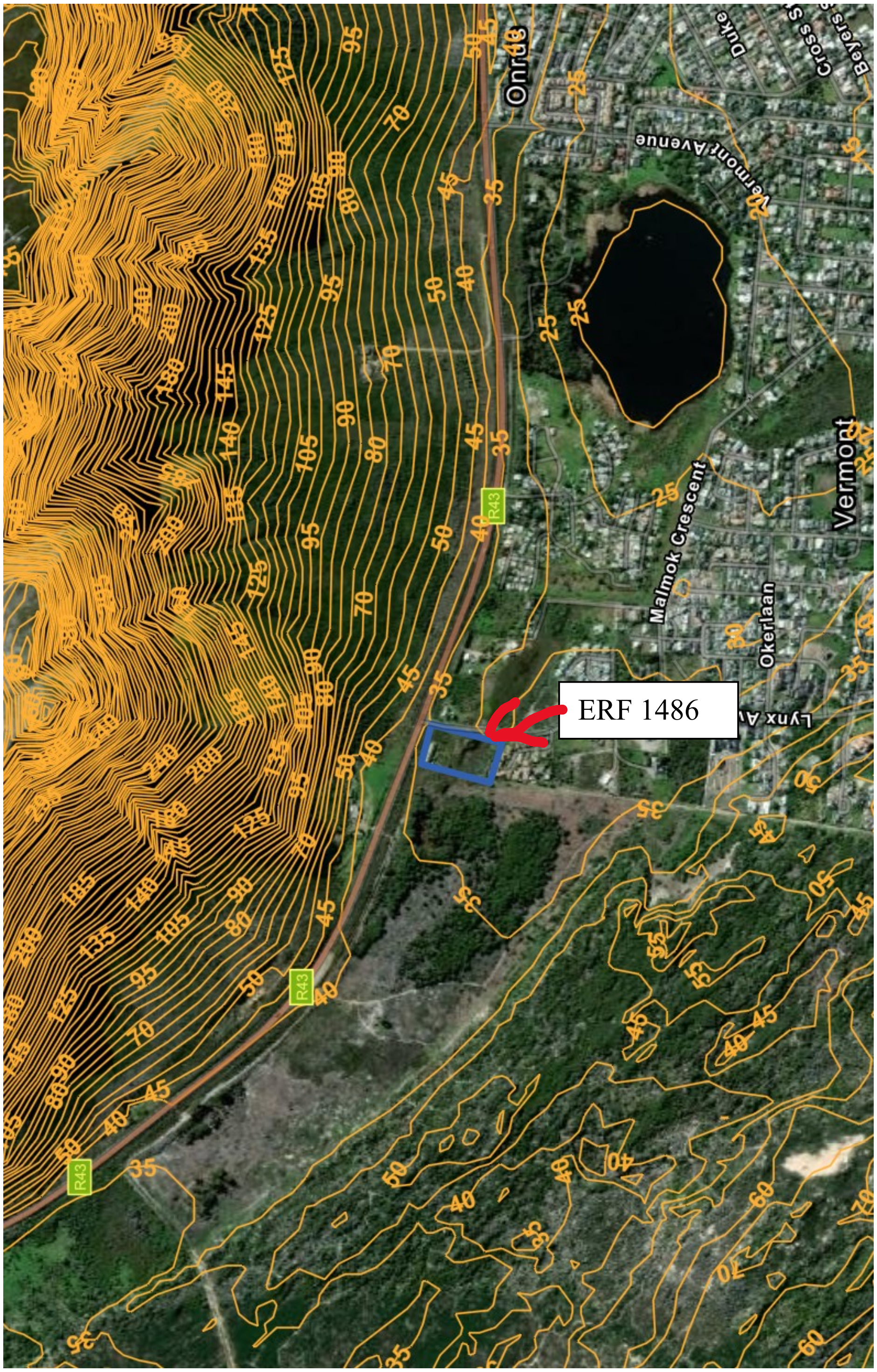
DECA

ANNEXURE A
LOCALITY PLAN


ERF 1486
Vermont Avenue
Malmok Crescent
Okerlaan
Vermont
Duke
R43

ANNEXURE B
Proposed SDP