REPORT

The Mount Edgecombe Partial Interchange and Link Road at km 8,0 on Main Road 2, Section 1: Stormwater Management Plan

Client: KwaZulu Natal Department of Transport

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1 Introduction

1.1 Background

The existing Main Road 2/1 is a single carriageway arterial road which commences at the Duff's Road Interchange at Main Road 25 (P93), viz. Kwa Mashu Highway, and ends at the Umdloti River Bridge in Verulam.

The proposal by the Province of Kwazulu-Natal Department of Transport is to upgrade Main Road 2/1 by constructing a grade separation at the Phoenix Highway intersection and constructing a new partial directional interchange bypassing the existing Mount Edgecombe Interchange together with an underpass link road to Main Road 79. This interchange will provide continuity and free-flow on Main Road 2/1 and forms part of the overall upgrading of the R102 corridor to the new King Shaka International Airport.

There are two grade separations and one underpass on this portion of Main Road 2/1. The first grade separation is the existing Phoenix Highway intersection which is to be upgraded with additional turning lanes where required. This signalised grade separated intersection will tie-in with the proposed cross-section for the future upgrading to 4 lanes of Main Road 2/1 South of this intersection through Mount Edgecombe and will allow free-flow for the Go Durban Bus Rapid Transit corridor which is to be constructed along the Phoenix Highway.

Mt Edgecombe Grade Separation is a new bridge required to form part of the proposed Mt Edgecombe partial interchange, which will provide a link from the future south bound carriageway of the Main Road 2 from Verulam, over the M41, en route to Mt Edgecombe and Durban. This grade separation is located at km 0,800 on the Southbound Offramp of the partial interchange. The underpass will form part of the Main Road 79 link to Main Road 2/1.

No major cross-drainage structures are required on this portion of Main Road 2/1, and all cross drainage is classified as minor and will be accommodated using standard pipe culverts.

1.2 Site locality and description

Figure 1 shows the locality plan for the upgrade of Main Road 2/1.

The portion of Main Road 2 under consideration is located in the Mount Edgecombe / Phoenix area North of Durban. The partial interchange commences at the Phoenix Highway intersection and terminates at the Trenance overpass. These limits of construction are 1,8 km apart.

2 OBJECTIVE

The primary objective of the report is to outline the Stormwater Management Plan for the upgrade of Main Road 2/1. The objectives include the following:

- Protecting all life and property from damages by floods and stormwater.
- Protecting the water resources in the catchment areas from pollution and siltation.
- Protecting and enhancing the watercourses locally and downstream.
- Conserving the natural flora and fauna in the environment.
- Preventing soil erosion by wind and water.

This report has been prepared to provide details of the analysis to ensure that adequate drainage measures are implemented to promote the dissipation of stormwater run-off, during and after construction.

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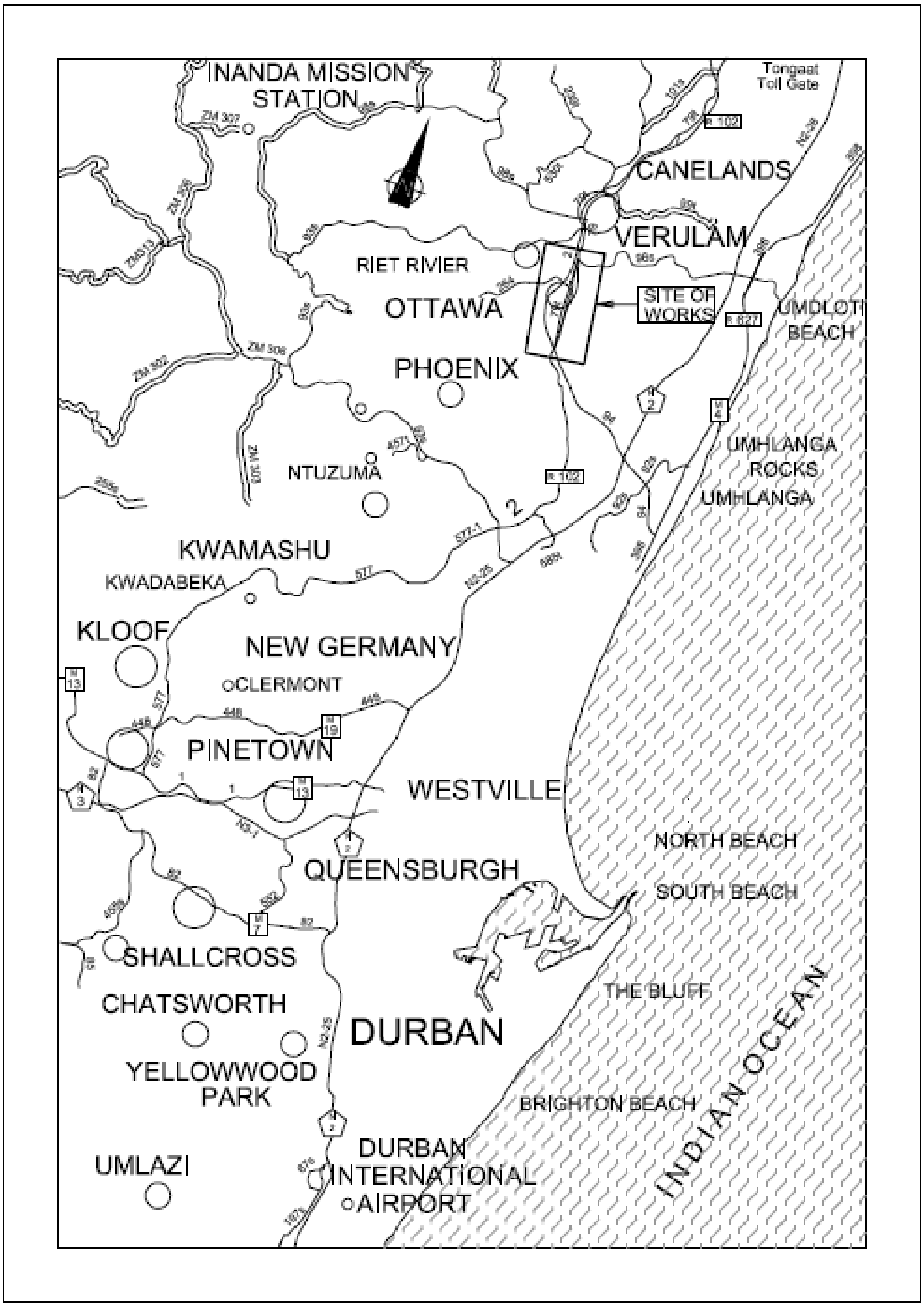

Figure 1: Locality plan.

3 METHODOLOGY

A stormwater system includes any measures provided to accommodate stormwater runoff and transport the runoff out of the system.

The existing stormwater system consists of natural water ways, including seasonal wetlands. Since this section of Main Road 2/1 is predominantly new construction, there are no existing devices constructed to control the stormwater.

The management of the stormwater runoff has been planned to mitigate against the effects of increased water runoff from hardened areas and to control the movement of sand and silt.

Roads, platforms and associated embankments have been designed to ensure free surface drainage.
The proposed stormwater system will be dependent on factors such as the topography (natural and artificial slopes), the zoning of the site and the natural soil conditions.

Silt and trash traps will need to be provided within the stormwater system to ensure that the water quality is not compromised. Open ditches, drains and channels should be used instead of pipes, where conditions permit. To prevent erosion of the channels, where the flow velocities are high, an appropriate lining should be provided. Types of lining include natural vegetation, stone pitching and reinforced concrete lining.

The proposed development should not adversely impact the environment within its footprint and the surrounding areas by means of erosion and sediment deposition. The frequency of flooding and the runoff volume will increase unless adequate provisions are made to maintain the current natural rate of stormwater attenuation and infiltration in the catchment areas.

3.1 Stormwater Design Philosophy

The design methodology used for the stormwater is in accordance with The South African National Roads Agency SOC Limited (SANRAL) Drainage Manual 6th Edition. The stormwater design complies with the KZN: DOT Standard Specifications, KZN: DOT Drainage Manual and KZN: DOT Standard Drawings.

The Rational Method (SANRAL Drainage Manual 6th Edition) will be used to calculate the flood peaks for the stormwater design as the individual catchment areas for the road and minor culvert structures are less than 15 km^2.

The road is classified as a Class U2 road (Dual carriageway expressway).

3.2 Stormwater Design Considerations

3.2.1 Structures

The flow depth of surface run-off across road and bridge surfaces is not a primary design variable due to normal design standards ensuring that this depth remains within the acceptable limits.

The portion of Provincial Road R102 (km 6,0 to km 8,0) has two major structures in the form of an underpass bridge and culvert. Both of these structures are road over road structures and have slopes to allow for the surface water to flow towards the stormwater discharge positions.

Outlet structures at a culvert or a natural watercourse were designed to dissipate the flow energy and unlined downstream channels were adequately protected against soil erosion.

3.2.2 Roads

The proposed road was designed and graded to avoid the concentration of water flow along and off the road. Where the flow concentration is unavoidable, measures were incorporated in the road and stormwater system at suitable points.

Unlined and concrete lined v-drains were provided along the edge of the road as necessary. These drainage facilities will serve to channel the stormwater to the predetermined discharge positions. Stormwater will either be discharged directly onto the grassland or onto the gabion mattress structures, depending on the discharge velocities.

The flow depth along these side drains is designed to satisfy Figure 5.2 of the SANRAL Drainage Manual 6th edition.

The applicable KZN: DOT standard details for al the drainage elements are from SD0406 to SD0702/A. Table 1, below, outlines the options adopted for use as side drain outlets.

Table 1: Options adopted for use as side drain outlets.

Discharge Type	Standard Detail Name	Condition for use
Kerb and channel grid inlet	SD 0702/A	Deep fill > 3 m
Kerb and channel chute	SD 0603/3	Shallow fill < 3 m
1,5 m / 2,4 m v-drain grid inlet	SD 0602/B	In cuttings
1,5 m / 2,4 m v-drain chute	SD 0603/1	Shallow fill < 3 m
1,5 m / 2,4 m v-drain chute	SD 0604/A	Deep fill > 3 m

Side drains will collect water from the cut slopes and road surface. Catchwater banks will be used as required, to eliminate any erosion on the cut banks due to excessive amounts of water occurring on the slopes. These banks will channel the water towards the nearest natural watercourse.

All the grid inlets will lead to cross-road drainage pipes. Other stormwater drainage pipes will be installed at high fills to prevent the ponding of water.

Scour on high fill banks (height greater than 3 m) shall be prevented by using kerb and channel side drains to collect water and discharge it at predetermined positions via appropriate inlets.

Subsoil pipe systems were installed in cut situations to collect any groundwater and the system will discharge into the stormwater manholes.

3.3 Stormwater Management

Stormwater Management encourages the developer, professional teams and contractor to conduct the following aspects:

- Maintaining adequate ground cover at all times and in all areas to negate erosion caused by wind, water and vehicular traffic.
- Preventing the concentration of stormwater flow where the soil is susceptible to erosion.
- Adding devices to reduce the stormwater flows to acceptable levels.

- Ensuring that the development does not increase the stormwater flow above that which the natural ground can safely accommodate.
- Ensuring that the construction of the stormwater devices is carried out in safe and aesthetic manner.
- Preventing pollution of water ways and water features.
- Containing soil erosion during construction.
- Avoiding conditions where the embankments may become saturated and unstable.

Poor stormwater management can result in the stormwater becoming contaminated and can also result in erosion, pollution and flooding. These issues are discussed further in the following sub items.

3.3.1 Erosion control

Suitable erosion control measures shall be implemented at stormwater discharge points, exposed areas and high embankments. These measures may include the following options:

- Sand bags on trenches (trench breakers).
- Bunds or grips adjacent to watercourses.
- Technologies similar to Soil Saver on embankments.
- Planting of indigenous vegetation on embankments.
- Minimise clearing and grubbing to necessary sections within the road reserve.
- Excavating borrow pit areas to ensure they are self-draining.
- Over-wetting, saturation and unnecessary runoff during dust control, curing and irrigation activities will be avoided.

Sandbag berms will be placed at regular intervals on all steep slopes and on the trench line before and after backfilling in order to minimise erosion and the discharge of contaminated storm water runoff into water courses.

The existing ground consists of sand with underlying clayey dolerite layers, which are not very susceptible to erosion.

3.3.2 Pollution

Pollution and or contamination of the surface water and stormwater must be well controlled. This can be achieved by managing activities such as:

- Mixing concrete on wooden boards in a plastic lined and leak-proof area.
- Removing all surplus material from the watercourse.
- Reducing spills of hazardous substances (e.g. Fuel).
- Opening of frequent chutes on long steep grades with unlined drains.
- Ensuring that banks are re-vegetated as soon as construction work is completed.
- Avoid water contamination by construction as well as general traffic.
- Containing the first-flush runoff, collectively or individually.

The stormwater system must be maintained to remove and reduce debris that may pose any pollution risk. The lack of maintenance will lower the transportation of the runoff to the existing watercourses and which may cause flooding.

3.3.3 Flooding

The proposed upgrade will not increase the stormwater runoff significantly as the area of the new road is only a small proportion of the entire catchment area.

The design of the stormwater system addresses the above issues and was designed as such that the post-development flood risks are not greater than the pre-development flood risks.

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4 CALCULATIONS

4.1 Pre-construction

Due to the size of the upgrade, it was decided to consider the entire catchment area along Main Road 2/1 as a single entity. The catchment area of the upgrade is 309,346 m^2.

4.2 Rainfall Return Period and Intensity

A rainfall intensity of 170 mm/hr was used to compute the road prism runoff for a 20 year flood with runoff coefficient (C) of 0,95.

4.3 Design principals

A 1:20 year flood was used to estimate the peak discharge for the catchment drainage. The depth of sheet flow on the road surface was limited to 6 mm during a 1:5 year storm. An intensity of 170 mm/hr was used to design the cutting side drainage system.

The stormwater drainage systems will be designed based on the following parameters:

- Mean Annual Rainfall = 951mm (> 900 mm)
- Site characteristics:
  - Pre-development: $C_{pre\text{-}dev} = 0{,}546$
  - Post-development: $C_{post\text{-}dev} = 0{,}604$
- Design used:
  - Rational Method: $Q = \frac{CIA}{3{,}6}$ (equation 3.8, SANRAL Drainage Manual 6th Edition)
- Flood duration:
  - Varies for each catchment and is three times the time of concentration i.e. $3T_c$.
- Stormwater pipe material:
  - For buried pipelines: Class 75D and Class 100D prefabricated concrete pipe culverts.
  - For subsoil drainage: 100 mm internal diameter perforated pipes.
- Stormwater pipe size:
  - Pipe sizes: minimum 450 mm diameter and maximum 1500 mm diameter
- Stormwater pipe gradient:
  - Minimum gradient of 2% for all prefabricated concrete pipe culverts.
- Stormwater inlets:
  - For roads: grid and kerb inlets.
- Stormwater manholes:
  - Materials: concrete foundation, 230 mm thick masonry walls.
  - Benching: smooth concrete channel formed to the soffit of the pipe.
- Stormwater headwalls:
  - Materials: concrete foundation, 230 mm thick masonry walls.

Manning's equation was used to compute the v-drain and median drain capacity by using a friction coefficient (n) of 0.015.

All the v-drains were designed to not flood above the concrete level. All the meadow drains are earth lined and are designed to accommodate flow velocities smaller than the scour velocity of gravel but great enough to avoid siltation.

4.4 Hydrology

From Table 3.7 (Recommended values of run-off factor C for use in the rational method) in the SANRAL Drainage Manual:

The pre-development run-off coefficient, $C_{pre\text{-}d.}$ = 0.191 (10% flat area and 90% hilly) + 0.2 (for semi-permeable soils) + 0.155 (30% thick bush, 35% light bush and 35% grasslands) = 0.546.

The post development run-off coefficient, $C_{post\text{-}d.}$ = 0.95 (streets). Thus the difference in runoff between pre- and post-development = 0.95 – 0.546 = 0.404.

For the purpose of this report, three rainfall intensities have been considered ie 1:5 year storm (I_5) of 110 mm/hr, 1:10 year storm (I_{10}) of 140 mm/hr and a 1:20 year storm (I_{20}) of 170 mm/hr.

For each of the ‘road catchment areas’, the increased runoff will affect downstream watercourses and wetlands. This increased flow is illustrated in Table 2 below.

Table 2: Hydrological calculations

Road Catchment Area	Area of change (m2)	Nett increased C value	Nett increase in Flow (Q)		
			I5= 110 mm/hr	I10= 140 mm/hr	I20= 170 mm/hr
			Q5 (m3/s)	Q10 (m3/s)	Q20 (m3/s)
NB Onramp	7264	0.404	0.090	0.114	0.139
SB Offramp	8440	0.404	0.104	0.133	0.161
R102 -1	3200	0.404	0.040	0.050	0.061
R102 -2	11300	0.404	0.139	0.178	0.216
Ramp A	4320	0.404	0.053	0.068	0.082
Ramp B	4000	0.404	0.049	0.063	0.076
Ramp C	3200	0.404	0.040	0.050	0.061
Ramp D	2800	0.404	0.035	0.044	0.053
		Total	**0.550**	**0.700**	**0.849**

It is evident from the hydrological calculations in Table 2 above, that there is only a 10% increase in the rate of runoff due to the proposed upgrade of Main Road 2/1 in the catchment area.

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5 CONCLUSION

Table 2 summarizes the results of the hydrologic calculations for the upgrade of Main Road 2/1. Based on these results, it is evident that there is a marginal increase in the rate of runoff due to the proposed upgrade of Main Road 2/1. The development of the road will increase the flow rate by 0,85 m^3/s.

The development will include hardened areas, reduced infiltration areas, loss of vegetation and evapo-transpiration potential. There will be a slight increase in surface runoff and peak flow rates.

Side drains will be used to channel the stormwater away from the road prism. Gabion boxes and Reno mattresses will be used to retard the velocity of the stormwater and will allow the ground water to recharge and prevent scour.

Where possible, stormwater will be discharged into the nearest existing natural drainage path via headwalls. Soil erosion and scour will be prevented by providing gabion boxes, Reno mattresses and/or splitter blocks at the inlet and outlet structures.

Siltation of the stormwater systems will be prevented by ensuring that the drainage facilities are built such that the flow velocity is greater than 0,25 m/s.

Landscaping and the planting of indigenous plants will be carried out along the footprint of the development to ensure the stabilisation of the watercourses and embankments.

Maintenance of the stormwater system must be carried out on a continuous basis to control pollution, blockages, siltation and scouring.

The detailed designed drawings and contract document indicates the measures provided in the design to ensure that the Stormwater Management requirements are implemented.

The contractor shall prepare a Stormwater Control Plan that will ensure that all the construction methods adopted on site do not cause, or precipitate, soil erosion. The contractor shall take adequate steps to ensure that the requirements of the Stormwater Management Plan are met before, during and after construction. The contractor shall ensure that that no construction activity commences before the Stormwater Control measures are in place and approved by the engineer on site.

6 REFERENCES

The Province of KwaZulu-Natal: Department of Transport, 1984. Drainage Manual. 1st ed. Pietermaritzburg: Geometric Design Section, Provincial Roads Department.

The South African Roads Agency SOC Limited, 2013. Drainage Manual. 6th ed. Pretoria: The South African Roads Agency SOC Limited.