Royal HaskoningDHV
Enhancing Society Together

P449 Rehabilitation
Stormwater Management Plan
June 2017

Royal HaskoningDHV
Enhancing Society Together

Document title: Stormwater Management Plan
Status: Rev 0
Date: June 2017
Project name: P449 Rehabilitation
Project number: MD1687
Client: The Province of KwaZulu-Natal: Department of Transport
Client contact: Mr. Mzokhanyayo Nkabini

Reference: MD1687/SWMP

Drafted by: Mr. Chris du Plessis
Checked by: Mr. Erik Bosman
Date/initials check: June 2017
Approved by: Mr. Rudi Von Fintel
Date/initials approval: June 2017

QUALITY VERIFICATION

This Report has been prepared under the controls established by a Quality Management System that meets the requirements of ISO9001: 2008:

VERIFICATION	CAPACITY	NAME	SIGNATURE	DATE
Checked by	Project Manager	E. Bosman		2017/06/22
Authorised by	Project Principal	R von Fintel		2017/06/22

Contents

List of tables

List of figures

1 INTRODUCTION

1.1 Background

Royal HaskoningDHV was appointed by the Province of KwaZulu-Natal: Department of Transport (hereafter referred to as KZN: DOT) to undertake the engineering studies, detailed design and the construction supervision for the rehabilitation of Main Road 449. After further investigation it was decided that the road required more extensive repair due to poor drainage and alignment conditions, therefore sections of the road need to be upgraded to better managed the stormwater.

The repair and upgrade of Main Road 449 comprises of bulk earthworks, layerworks, bituminous surfacing, drainage, ancillary works and major stormwater structures. The required roadworks starts at km 0,0 at the intersection with Main Road 522-1 and ends at Km 11,3 where it intersects Main Road 444.

This stormwater management plan will focus on the first phase of the upgrade from km 0,0 to km 6,0. This portion of the existing gravel road will be upgraded to a single carriageway 8,5 m wide surfaced road and related stormwater drainage, as well as three major structures that are required at stream crossings.

The three major structures are located at km 1,990 (STC3962), km 3.877 (STC3958) and km 4.445 (STC3959) and the widths of these structures are 6.50 m; 13.00 m; 13.00m respectively.

1.2 Site locality and description

Main Road P449 is situated within the uMkhanyakude district of the Jozini Local Municipality. It starts from its intersection with P522-1 in Jozini and ends at its junction with Main Road P444: The total length of the road is approximately 11.3 Km of which only the first 6.0 km will form part of this report. The road is classified as a class 3 road and forms part of the access route from Jozini to the community of Mbazwane.

The location of Main Road 449 is shown on Figure 1: Locality Plan.

2 OBJECTIVE

The primary objective of this report is to outline the Stormwater Management Plan for the upgrade of Main Road 449 from km 0,0 to km 6,0. 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.

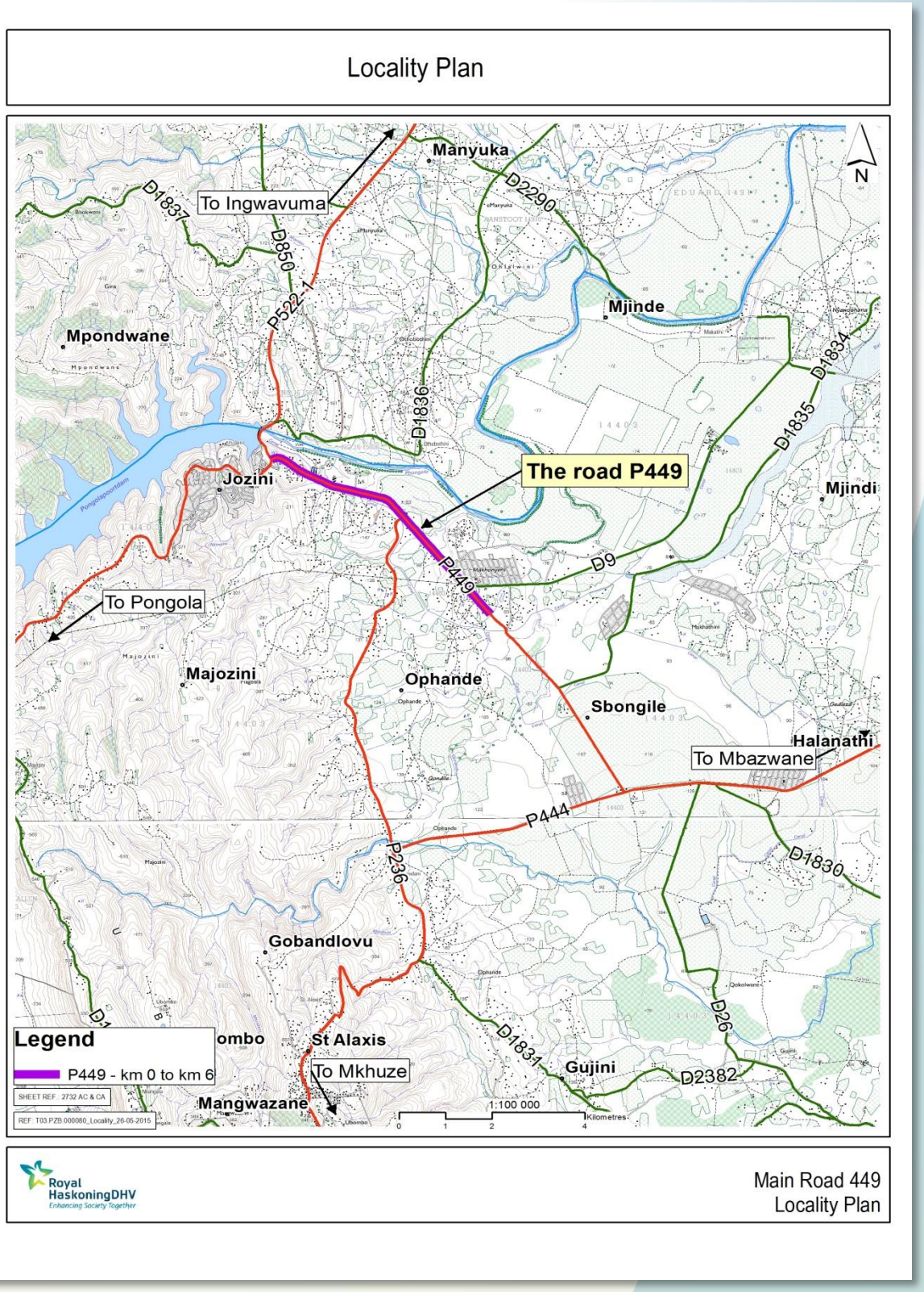

Figure 1: Locality plan.

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 streams, rivers and seasonal wetlands. The system includes existing infrastructure to control the stormwater. The existing road has drainage structures that form part of the stormwater system.

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 depends 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 linings.

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 KZN: DOT Standard Specifications, KZN: DOT Drainage Manual and KZN: DOT Standard Drawings.

The Rational Method (SANRAL Drainage Manual 6th Edition) was 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.**(largest pipe is under 10 hectares)**

The road is classified as a Type 3 road.

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 Main Road 449 (km 0,0 to km 6.0) has three major structures in the form of culverts. All these structures have sufficient slopes to allow for the surface water to runoff towards the catchment and stormwater discharge positions.

The culverts were designed to ensure that the capacity of the culvert does not exceed the pre-development stormwater flow at that point and attenuation storage was provided on the road and upstream of the stormwater culvert.

Outlet structures at a culvert or a natural watercourse were designed to dissipate the flow energy and unlined downstream channels will be 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.

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, onto gabion mattress structures or into catchpits with cross drainage pipes, depending on the discharge velocities and topography.

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 the entire 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, road surface and general up-sloping terrain. These drains will have sufficient capacity to handle all the water that flows towards it, hence catch water banks will not be used.

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 will be installed in cut situations to collect any groundwater that may potentially damage the structural layer works of the roadway. This will be discharge into the stormwater manholes or appropriate areas where the subsoil pipes can daylight.

3.3 Stormwater Management

Stormwater Management encourages the developer, professional teams and contractor to consider 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 of which the natural ground can safely accommodate.
- Ensuring that the construction of the stormwater infrastructure is carried out in safe and aesthetic manner.
- Preventing pollution of water ways and water features.
- Preventing 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 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 like 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 to minimise erosion and the discharge of contaminated storm water runoff into water courses.

3.3.2 Pollution

Pollution and or contamination of the surface water and stormwater shall 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 may cause localised flooding.

3.3.3 Flooding

The proposed repair and upgrade activities will not increase the stormwater runoff significantly as it is an existing road that has been in operation for many years without major stormwater related incidents. Adequate attenuation of flood runoff will be provided as the latter may increase downstream flows that may cause erosion.

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.

4 CALCULATIONS

4.1 Pre-construction

The water catchment areas along the first six kilometres of Main Road 449 is divided into fifteen (14) catchment areas. The schedule of the catchment areas is listed in Table 2.

Table 2: Schedule of catchment areas.

Catchment number	Area (m^2)	Catchment number	Area (m^2)
1	17 530	8	53 000
2	14 700	9	89 000
3	22 000	10	9 550 000
4	57 100	11	46 200
5	690 000	13	98 700
6	55 500	14	9 690 000
7	55 000	15	89 400

4.2 Rainfall Return Period

The return periods and peak flood volumes used for major stream crossing structures are listed in Table 3.

Table 3: Return periods and flow rates for the structures.

Structure number	Return period (years)	Mean annual rainfall (mm)	Design flow rate (m^3/s)
STC 3962 at km 1,990	10	890	17
STC 3958 at km 3,887	20	890	110
STC 3959 at km 4,445	20	890	111

The three major structures are located at km 1,990 (STC3962), km 3.877 (STC3958) and km 4.445 (STC3959) and the widths of these structures are 6.50 m; 13.00 m; 13.00m respectively.

4.3 Design principals

A 1:10 year flood was used to estimate the peak discharge for the smaller catchment drainage areas. The depth of sheet flow on the road surface is limited to 6 mm during a 1:5 year storm. An intensity of 150 mm/h was used to design the side drainage and cross drainage system.

The stormwater drainage systems was designed based on the following parameters:

- Mean Annual Rainfall > 700 mm
- Design used:
  - Rational Method: $Q = \frac{CIA}{3,6}$ (equation 3.8, SANRAL Drainage Manual 6th Edition)

- Time of concentration:
  - 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 900 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 capacity by using a friction coefficient (n) of 0.016.

All the v-drains were designed to not flood above the concrete level.

4.4 Hydrology

A summary of the hydrological calculations is listed in Table 4 below. It is evident from the hydrological calculations in the table that the water drainage requirements for most the catchments are reasonably low. Where the flow requirements have exceeded standard practical pipe crossing methods, adequate culvert structures have been designed as listed in Table 3 above.

Table 4: Hydrological Calculation Summary.

Catchment Number	Area (ha)	Average Rainfall (mm)	Return Period (yrs)	Longest Watercourse (km)	10/85 Hight Difference (m)	Slope (m/m)	Time of Concentra -tion (h)	Rainfall Intensity (mm/h)	Adjusted C (Rational Method)	Flow (m^3/s)
Catchment 1	1.75	700	10	0.255	17	0.067	0.342	81.815	0.312	0.124
Catchment 2	1.47	700	10	0.263	31	0.118	0.304	92.121	0.312	0.117
Catchment 3	2.20	700	10	0.290	50	0.172	0.291	96.184	0.312	0.183
Catchment 4	5.71	700	10	0.611	77	0.126	0.444	73.642	0.312	0.364
Catchment 5	69.00	890	10	0.91	30	0.006	0.21	N/A	0.440	17
Catchment 6	5.55	700	10	0.450	40	0.088	0.417	78.299	0.312	0.377
Catchment 7	5.50	700	10	0.580	40	0.069	0.498	75.911	0.312	0.357
Catchment 8	5.30	700	10	0.534	40	0.075	0.47	79.375	0.312	0.365
Catchment 9	8.90	700	10	0.800	42	0.053	0.617	68.047	0.312	0.525
Catchment 10	955.00	890	20	9.130	250	0.036	1.30	N/A	0.376	110
Catchment 11	4.62	700	10	0.741	7	0.009	0.888	63.003	0.312	0.252
Catchment 12	9.87	700	10	0.794	10	0.013	0.858	65.24	0.312	0.558
Catchment 13	969.00	890	20	6.550	90	0.015	1.32	N/A	0.376	111
Catchment 14	8.94	700	10	0.606	34	0.056	0.534	69.94	0.312	0.542

5 CONCLUSION

Table 4 summarizes the results of the hydraulic calculations for the first six kilometres of Main Road 449, which are proven to be quite low stormwater flow rates. 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. Gabions and Reno mattresses will be used to retard the velocity of the stormwater where applicable and will allow the ground water to recharge and prevent scouring.

Where possible, stormwater will be discharged into the nearest existing natural drainage path via open drains and headwalls. Soil erosion and scour will be prevented by providing gabions, reno mattresses at the inlet and out outlet structures. Splitter blocks will also be added at culvert outlet where high flow velocities are experienced.

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 indigenious plants will be carried out along the footprint of the development to ensure the stabilisation of the watercourses and embankments where applicable.

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 the contract document indicates the measures provided in the design to ensure that the Stormwater Management requirements are implemented.

The contractor shall prepare a Stormwaterwater Control Plan that will ensure that all the construction methods adopted on site do not cause soil erosion and stormwater damage. 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 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. 1 ed. Pietermaritzburg: Geometric Design Section, Provincial Roads Department.

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