Report 115/RING-F1

SPECIALIST GROUNDWATER STUDY

POTENTIAL IMPACT OF THE PROPOSED N21 (R300) CAPE TOWN RING ROAD

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EXECUTIVE SUMMARY

As part of the Environmental Impact Assessment, Parsons and Associates Specialist Groundwater Consultants were appointed by Chand & Ecosense Joint Venture to assess potential impacts to groundwater from the proposed N21 (R300) Cape Town Ring Road. The assessment was based on two reconnaissance drives along the proposed route, available geological and geohydrological information and geohydrological experience gained by the author whilst undertaking consulting and research projects in the general area adjacent to the planned route.

The proposed ring road traverses the major primary aquifer system comprising unconsolidated sands and the minor fractured and weathered aquifer system comprising rocks of the Malmesbury Group and Cape Granite Suite. In the vicinity of the Philippi Horticultural Area the primary aquifer is used extensively, but elsewhere groundwater abstraction is limited. Many of the wetlands on the Cape Flats are groundwater-fed systems.

Potential impacts from the proposed development could result from blasting, groundwater abstraction, modification to groundwater flow, accidental spills and sewage and waste generated from the toll plazas. Assessment of these impacts and possible mitigation measures suggests all are of low significance, expect at the Strandfontein WWTW, where installation of an agricultural drain alongside the road could have a high positive significance with respect to the state of Zeekoevlei. Based on assumed groundwater flow directions, alignment of the road 250 m south of Bloubergsvlei should not impact groundwater discharge to the vlei.

Important mitigation measures include identification of boreholes likely to be impacted by blasting, controlled blasting to limit impacts, acceptable groundwater abstraction rates (if used), ensuring adequate movement of surface and subsurface flow through the use of culverts at appropriate places and having emergency response plans in place in the event of accidental chemical spills.

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1 INTRODUCTION

1.1 Background

The South African National Roads Agency Limited (SANRAL) awarded Scheme Developer status to the Peninsula Expressway Consortium (Penway) in January 2000 to develop Penway's unsolicited proposal for the N21 (R300) Cape Town ring road toll project. The proposal included the private financing of the project, construction of new sections, upgrade of the existing road and maintenance, operations and tolling of the entire route. The proposed route is indicated in Figure 1.

Penway and SANRAL have entered into a Public Private Partnership to develop this scheme and concluded a formal agreement in January 2000. In terms of the agreement, both parties are jointly responsible for the transparent development of the scheme. The initial Phase of Scheme Development was completed in December 2001 and included a Scoping Study, undertaken by Chand/Ecosense Joint Venture (CEJV), from February to November 2000 (CEJV, 2000). It was recommended groundwater be one of the issues to be addressed in the Environmental Impact Assessment (EIA). This specialist study describes geohydrological conditions encountered along the proposed route and assesses potential impacts that may result from construction of the N21 (R300) Cape Town ring road.

1.2 Terms of Reference

The Terms of Reference for the specialist groundwater study set by CEJV were as follows:

- Identify the geohydrological aspects that will be affected by the N21(R300) road proposal.
- Make recommendations towards avoiding or mitigation of potential impacts, whether related to route alignment, road design, construction or operation, including recommendations regarding post construction rehabilitation.
- Field and desktop assessment of any impacts that may be identified, without and with proposed avoidance/mitigation measures, using the assessment method provided.
- Assess the road design to ensure implementation of recommendations or concerns. This would be in the form of both desktop assessment and a workshop with the engineers and other specialists.
- Provide a detailed description of construction phase mitigation requirements/recommendations and rehabilitation requirements for inclusion into the construction phase management plan.

2 APPROACH TO STUDY

2.1 Information Used

The study was based on two reconnaissance drives along the proposed toll road, available geological and geohydrological information (Abbott Grobicki, 2001; Bertram, 1989; Henzen, 1973; Jolly, 1996; Rosewarne, 1999; Theron, 1984; Wright and Conrad, 1995; Meyer, 2000) and geohydrological experience gained by the author whilst undertaking consulting and research projects in the general areas adjacent to the planned route. This includes investigations at Zeekoevlei and the Cape Flats wastewater treatment works (WWTW), Bellville, Brackenfell, Vissershok and Atlantis (Parsons, 1991, 1999, 2000a, 2000b, 2000c, 2000d, 2002).

2.2 Assumptions

The following key assumptions were made during execution of the project:

- All bridges (and widening of bridges) and roads will be designed and constructed in an environmentally sensitive manner so flow (groundwater, river and storm water) will not be restricted and the area around the structure not damaged. If these principals are adhered to, restriction of flow is unlikely to be a ‘red-flag’ issue.
- All buildings and services will be constructed according to accepted standards and reasonable precautions taken to prevent environmental degradation.
- Local conditions will be considered in the final siting and design of all structures.

2.3 Limitations of the Study

The following limitations to the study were recognised:

- The study was based on a reconnaissance drive on the proposed toll road, available geohydrological information and geohydrological experience gained by the author whilst undertaking consulting and research projects in the general area. No fieldwork was undertaken as part of this study.
- Impacts of related activities (eg. establishment of petrol stations) were not considered.
- It was not possible to identify individuals or specific boreholes that could potentially be impacted by the proposed toll road project. This will be required at a later stage during detailed design.

2.4 Assessment Methodology

The assessment procedure followed during this specialist study was based on guidelines provided by CEJV in the project Terms of Reference.

3 DESCRIPTION OF AFFECTED ENVIRONMENT

3.1 Physiography and Climate

Much of the study area experiences a Mediterranean climate with hot dry summers and cool wet winters. Average rainfall varies between 400 mm/a to 600 mm/a.

The proposed ring road is situated on relatively flat land with low relief from the start in Muizenberg through to the N1 national road north of Bellville. From here through to the N7, the road passes over gently rolling hills where after it again traverses relatively flat land with low relief.

3.2 Geology

Topography along the proposed route is strongly controlled by geology. The gently rolling hills encountered along the north-eastern sections of the proposed ring road comprise rocks of the Malmesbury Group, and in places inliers of granites of the Cape Granite Suite. Younger unconsolidated sediments of Tertiary to Recent age underlie the flatter lying areas.

The Malmesbury Group was deposited some 800 Ma ago and predominantly comprises low-grade metamorphic rocks such as phyllitic shales, quartz and sericitic schists, greywacke and siltstones. The Group is relatively susceptible to weathering, resulting in low relief landforms. Various granitic plutons intruded the Malmesbury Group between 630 and 525 Ma ago (Theron, 1984). This was followed by a period of about 50 Ma during which much of the metamorphosed material overlying the Cape Granite Suite was removed by erosion.

Significantly younger unconsolidated sediments of Tertiary to Recent age are found on the coastal plains in the southern and northern sections of the proposed ring road. The nature, thickness and extent of these deposits vary significantly.

3.3 Aquifer Types

Based on lithostratigraphy considerations, two aquifer types are readily distinguished. Primary aquifers associated with unconsolidated deposits are generally classified as major aquifer systems (Parsons, 1995). It is recognised saturated thickness and hydraulic properties vary significantly throughout the study area. The primary aquifer in the vicinity of the Philippi Horticultural Area is used extensively while groundwater may be abstracted for small-scale garden irrigation elsewhere along the route. Groundwater levels are generally shallow (less than 2m below surface) while these aquifers are considered vulnerable to anthropogenic impacts (Parsons and Conrad, 1998).

Geological units of the Malmesbury Group and Cape Granite Suite are classified as minor aquifer systems that produce variable quantities of groundwater of variable quality. In general, aquifers of the Cape Granite Suite are low yielding and are known to produce poor quality groundwater in places. Aquifers of the Malmesbury Group also generally produce poorer quality groundwater, but high yields of good quality have been obtained. These aquifer systems are moderately vulnerable to anthropogenic impacts. Groundwater levels are variable, but are generally in the range of 5 to 30 m below surface, with deeper levels associated with elevated topography.

3.4 Groundwater Users

Large-scale groundwater abstraction for irrigation purposes takes place in the Philippi Horticultural Area. Groundwater is abstracted from the extensive primary aquifer system by means of both conventional boreholes and pits. Cave and Weaver (2000) estimated abstraction from this area to amount to some 20 Mm^3/a.

Small-scale abstraction for garden irrigation is expected elsewhere along the route. Shallow, small diameter wellpoints are widely used on the Cape Flats for garden irrigation. However, this study did not allow for the identification of individual groundwater users or the quantification of groundwater use.

No large-scale groundwater abstraction from Malmesbury Group aquifers adjacent to the proposed route is known. Small-scale abstraction for domestic use or stock watering may take place, but individual groundwater users have not been identified.

Local groundwater users potentially threatened by the proposed toll road proposal may need to be identified during the detailed design stage of the project.

3.5 Ecosystems

Many of the wetlands on the Cape Flats are groundwater-fed systems with groundwater being the sole source of water during dry summer months. The proposed ring road passes directly north of the Westlake wetland, south of Zeekoevlei and in the vicinity of Varkensvlei and Bloubergsvlei. Numerous other small-scale, local groundwater-fed rivers, wetlands and terrestrial ecosystems will also be traversed.

3.6 Value of Groundwater

The viability of the Philippi Horticultural Area is entirely dependant on the availability of groundwater. Similarly, most wetland systems are groundwater-dependant. Groundwater is hence considered to be regionally significant and have a high value in areas underlain by the primary aquifer system.

On a more local scale, groundwater is used for domestic supply, garden irrigation and stock watering. As potential impacts could affect local users, both the extent of impact and significance of impact need to be considered in this assessment. This is particularly true where users do not have ready access to other safe and reliable potable water supplies.

4 IDENTIFICATION OF RISK SOURCES

The N21 (R300) proposal aims to link new sections of road to the existing R 300 west of Mitchells Pain and north of the N1 national road. The central section of the proposed ring road hence makes use of existing infrastructure, with new infrastructure being required along the southwestern and northern sections. Interchanges and toll plazas will be added to existing sections of road.

In general terms, geohydrological considerations are unlikely to govern road alignment, road widening and rehabilitation, toll plaza placement and the position of interchanges. Further, threats posed by roads to underlying aquifers are considered small. However, at a local scale geohydrological criteria may be important because of the consequence of impacts to groundwater users and groundwater dependant ecosystems.

Five potential risk sources were identified for the construction and operation of the proposed N21 (R300) ring road around Cape Town, including blasting, groundwater abstraction during construction, modification of flow (both recharge and subsurface flow), accidental spills and sewage and waste from the toll plazas.

4.1 Impacts of Blasting

Inappropriate blasting in sensitive environments could result in changes to aquifer properties and borehole performance and structure. The impact of blasting and extent thereof is governed by the size and timing of the charge and the nature of the material being blasted. It is unlikely significant blasting will be required in areas underlain by the primary aquifers while the impact in weathered Malmesbury and Granitic aquifers is expected to remain localised.

Expert opinion and consideration of local conditions is required to address this issue adequately. By considering local conditions, proximity to boreholes, site blast characteristics and controlled blasting, the impacts of blasting can be mitigated. As a result, blasting can be of low to very low significance in the decision-making process.

4.2 Groundwater Abstraction

It is likely groundwater will be used during construction of the road, interchanges and toll plazas. The good groundwater potential of the primary aquifer system and the fractured and weathered nature of the sedimentary and granitic rocks suggest groundwater resources could be invaluable during this phase. As the volume of groundwater abstracted is expected to be relatively small and abstraction performed during working hours only, the impact of groundwater abstraction is expected to be insignificant. Again, local conditions need to be taken into account when developing groundwater supplies during construction.

4.3 Modification of Flow

Road construction will modify surface and near-surface geohydrological properties. This, in turn, could impact both vertical and horizontal flow conditions. Recharge to both aquifers occurs as a result of infiltration of rainfall into the subsurface. Reducing the hydraulic conductivity of the natural surface will result in increased run-off within the footprint of the road. This is unlikely to influence aquifer recharge (and hence the available groundwater resource) as the water will move off the road and infiltrate in areas unaffected by road construction. However, this could induce localised flooding in areas directly adjacent to the road where the volume of run-off is greater than the infiltration capabilities of the adjacent area.

Road construction may retard or restrict surface and near-surface subsurface lateral flow toward wetlands. Surface run-off patterns could also be altered. Though this will occur during rainfall events (and directly thereafter), impacts are expected to be transient and remain localised.

4.4 Accidental Spills

Contamination of surface and groundwater during road construction and operation can occur as a result of accidental spills (Eklund and Rosen, 2000) and always remains a possibility. This applies to both existing and new road infrastructure. By constructing a safer road (as is intended), it could be argued the proposed ring road could reduce the likelihood of spills and thus have a positive impact.

Because ongoing protection measures against groundwater contamination from accidental spills are costly (Eklund and Rosen, 2000), prompt implementation of effective remedial actions is considered the only viable means of addressing this issue from a geohydrological perspective. Groundwater contamination and potential impacts to local users thus need to be included in disaster management plans.

4.5 Sewage and Waste from Toll Plazas

The potential threat posed by sewage and waste generated by the control building at toll plazas is expected to be of a similar order of magnitude of that of a residential house. Sewage disposal by means of a reticulated system, conservancy tank or soakaway and removal of waste will significantly reduce the threat and result in this issue being of very low significance in the decision-making process.

5 IMPACT DESCRIPTIONS AND ASSESSMENT

Given the above threats, the following impacts may be expected:

- Reduction of available water resources as a result of road construction
- Impact to aquifer properties and borehole yield and structure
- Localised over-exploitation of the resource
- Restriction of localised surface and subsurface flow by road
- Contamination of groundwater

Before addressing these impacts in further detail below, it needs to be highlighted all potential impacts are expected to remain localised while the duration of impact invariably is long-term. As groundwater moves slowly (tens of metres a year), changes are slow to manifest themselves and remain for years or decades longer than in the case of faster moving surface water. This sometimes results in the consequence of an impact being assigned a medium score instead of a low score (Table 1).

5.1 Reduction of Available Water Resources

It is improbable the construction of the Cape Town ring road will impact the availability of groundwater resources, even at a local scale. Such impacts have not been reported in either international or local literature. Consequently, this impact is assigned a low significance with no mitigatory actions required.

5.2 Impact to Aquifer Properties and Boreholes

It is possible blasting could impact aquifer properties and borehole performance and structure (Table 1). These impacts may be of significance in the northeastern section where the proposed ring road traverses hard rock formations and blasting is required.

Blasting could either create new fractures or close existing fractures, thereby affecting the ability of water to be transmitted in the subsurface. Similarly blasting could induce subsurface movement and result in rocks being displaced. This could cause a borehole to collapse or prevent the removal of pumps.

Proper blast site characterisation and consideration of proximity to water supply boreholes could mitigate against potential impacts. This requires appointment of an appropriately qualified and experienced blast expert and identification of boreholes in proximity to blast areas. A hydrocensus in the vicinity of blast areas will hence be required, with the extent of the hydrocensus being guided by the blast expert.

5.3 Impacts Resulting from Abstraction

The impact of abstracting groundwater during construction is unlikely to be of major concern (Table 1). Because of the relatively small volume to be abstracted and the short duration of pumping, impacts will remain localised.

Groundwater abstraction results in a lowering of the water table in the vicinity of the pumped borehole. The extent and degree of lowering is governed by the geohydrological properties of the rock and the rate and duration of abstraction. On cessation of abstraction, the groundwater level recovers to its former position.

Appointment of an appropriately qualified geohydrologist to control pumping rates and volumes could prevent local landowners being impacted. In instances where feasible, contractors may find it more economical to buy water from landowners instead of developing their own supplies.

5.4 Restriction of Surface and Subsurface flow

Road construction could impact surface and subsurface flow, which in turn could impact drainage and flow to wetlands. Without mitigation, such impacts could be of medium significance. Though such impacts usually remain localised and can readily be mitigated against, three special cases were identified along the proposed route:

- Strandfontein WWTW: Subsurface seepage from the Strandfontein WWTW into Zeekoevlei contributes significantly to the hypertrophic state of the vlei. Installation of an agricultural drain has been proposed as an effective remedial action (Parsons, 2001). Alignment of the ring road across the land between the WWTW and the vlei provides an opportunity to address this problem.
- Flooding: Increased run-off from the road during high intensity rainfall events could induce transient flooding directly adjacent to the road. As flooding of low lying areas in the Cape Flats as a result of shallow water tables is already a problem, localised flooding could exacerbate the problem. However, the impact is expected to remain localised.
- Bloubergsvlei: Little is known about the ecohydrological functioning of Bloubergsvlei (also referred to as the Blaauwberg Vlei), but it appears to be a unique and sensitive wetland on the sand deposits north of Cape Town. Construction of a major road in the immediate vicinity could negatively impact the wetland system. van den Honert (2001) recommended a minimum buffer of 100 m around the vlei and associated temporary pools while Harding (2002) felt 500 m would be more appropriate. He based this on local vegetation patterns and the fact so little is known about the vlei system which has a high botanical, ecological and historic significance. The developers have since proposed the road be aligned 250 m south of the vlei. On the assumption that groundwater flows toward the southeast, it is unlikely that the road will impact groundwater flow to the spring nor its expected recharge area. However, this assumption needs to be checked with appropriate fieldwork.

5.5 Groundwater Contamination

It is not possible to predict or protect against accidental spills caused by accidents. Because of the relatively slow rate of groundwater movement, spills of hazardous and other chemicals are expected to remain localised (Table 1). Where groundwater users or groundwater-dependant ecosystems are affected, impacts may be of medium significance. Experience has shown the remediation of contaminated aquifers is technically difficult and generally expensive. However, quick response to spills increases the success of remedial actions considerably.

Rapid response to accidents and timeous implementation of remedial measures is the most practical mitigatory means of addressing this issue. Potential for groundwater contamination must hence be included in disaster management plans.

Similarly, the contamination threat posed by sewage and waste disposal at toll plazas is expected to be no more than that of a residential house. These impacts are expected to be small and of low significance, even without mitigation.

Table 1: Assessment of impacts without mitigation

POTENTIAL IMPACT	**IMPACT ASSESSMENT CRITERIA**										
	Extent	Duration	Intensity			Probability	Status	Consequence	Significance	Confidence	Applicable Legislation
			Qualitative	Quantitative	Community response						
Reduction of available water resources as a result of road construction	L	H	L-	L-	L-	L	-	M	L	H	ECA / NWA
Impact to aquifer properties and borehole yield and structure as a result of blasting	L	H	L-		L-	L	-	M	L	M	ECA / NWA
Localised over-exploitation of the resource as a result of groundwater abstraction during construction	L	L	L-			L	-	L	L	H	ECA / NWA
Restriction of localised surface and subsurface flow by road	L	H	M-	M-	L-	M	-	M	M	M	ECA / NWA
Modification of subsurface seepage at Standfontein WWTW by road	L	H	L-	L-		M	+	M	M	H	ECA / NWA
Increased flooding of low lying areas in the Cape Flats due to increased run-off	L	L	M-	M-	M-	L	-	L	L	H	ECA / NWA
Potential modification to subsurface flow at Bloubergsvlei by road alignment and construction	L	H	M-	M-		L	-	M	L	M	ECA / NWA
Groundwater contamination caused by accidental spills	L	H	H-	H-	H-	L	-	H	M	H	ECA / NWA
Groundwater contamination caused by sewage and waste generated by the toll plazas	L	H	L-	L-		L	-	M	L	H	ECA / NWA

6 RECOMMENDED MITIGATION MEASURES

At this stage it is only possible to submit a set of generic mitigation measures. Assessment of the impacts with mitigation measures is presented in Table 2. Most of the identified impacts can readily be mitigated so the impacts are of low significance. These include:

- Controlled blasting in potentially sensitive areas is to be preceded by blasting site characterisation and identification of water sources that could be impacted. This would be done by means of a hydrocensus. Contingency plans need to be put in place should water supplies be disrupted, while replacement of boreholes may be required if borehole performance and / or structure are negatively impacted.
- If used, groundwater abstraction during construction is unlikely to impact adjacent groundwater users. However, the possibility for impact must be recognised and rates of abstraction must be set with proximity to groundwater users being considered.
- In the design phase of the proposed development, cognisance of surface and subsurface flows must be taken. Adequate culverts are to be used to prevent the restriction of flow as much as possible.
    - installation of a subsurface agricultural drain between the WWTW and Zeekoevlei was identified as an opportunity arising from the ring road proposed and could have a high positive significance with respect to the state of Zeekoevlei.
    - an appropriate buffer zone must be maintained around Bloubergsvlei, with the aquatic ecosystem specialist setting this at 500 m (Harding, 2002).
    - any measures to reduce the likelihood of accidents and spills will reduce the risk of groundwater contamination. However, emergency response plans for accidents and spills of hazardous and other chemicals are required to ensure the impact thereof remains localised and of very low significance. The provision of alternative water supplies may be required if existing potable supplies are threatened.
- Toilets at toll plazas can either be linked to sewer system or septic tanks. If septic tanks are used, these should be properly maintained and no boreholes used for potable supply located within 50 m of the septic tank system.

Table 2: Assessment of impacts with mitigation

POTENTIAL IMPACT	**IMPACT ASSESSMEN CRITERIA**									
	Extent	Duration	Intensity			Probability	Status	Consequence	Significance	Confidence
			Qualitative	Quantitative	Community response					
Reduction of available water resources as a result of road construction	L	H	L-	L-	L-	L	-	M	L	H
Impact to aquifer properties and borehole yield and structure as a result of blasting	L	H	L-		L-	L	-	M	L	H
Localised over-exploitation of the resource as a result of groundwater abstraction during construction	L	L	L-			L	-	L	L	H
Restriction of localised surface and subsurface flow by road	L	H	L-	L-	L-	L	-	L	L	H
Modification of subsurface seepage at Standfontein WWTW by road	L	H	H+	H+		H	+	H	H	H
Increased flooding of low lying areas in the Cape Flats due to increased run-off	L	L	L-	L-	L-	L	-	M	L	H
Potential modification to subsurface flow at Bloubergsvlei by road alignment and construction	L	H	L-	L-		L	-	M	L	H
Groundwater contamination caused by accidental spills	L	H	L-	L-	L-	L	-	L	L	H
Groundwater contamination caused by sewage and waste generated by the toll plazas	L	H	L-	L-		L	-	L	L	H

7 CONCLUSIONS

The proposed N21 (R300) Cape Town ring road traverses the major primary aquifer system comprising unconsolidated sands and the minor fractured and weathered aquifer system comprising rocks of the Malmesbury Group and Cape Granite Suite. In the vicinity of the Philippi Horticultural Area the primary aquifer is used extensively, but elsewhere groundwater abstraction is limited. Many of the wetlands on the Cape Flats are groundwater-fed systems.

Potential impacts from the proposed development could result from blasting, groundwater abstraction, modification to groundwater flow, accidental spills and sewage and waste generated from the toll plazas. Assessment of these impacts and possible mitigation measures suggests all are of low significance, expect at the Strandfontein WWTW where installation of an agricultural drain alongside the road could have a high positive significance with respect to the state of Zeekoevlei. Based on assumed groundwater flow directions, alignment of the road 250 m south of Bloubergsvlei should not impact groundwater discharge to the vlei.

Important mitigation measures include identification of boreholes likely to be impacted by blasting, controlled blasting to limit impacts, acceptable groundwater abstraction rates (if used), ensuring adequate movement of surface and subsurface flow through the use of culverts at appropriate places and having emergency response plans in place in the event of accidental chemical spills.

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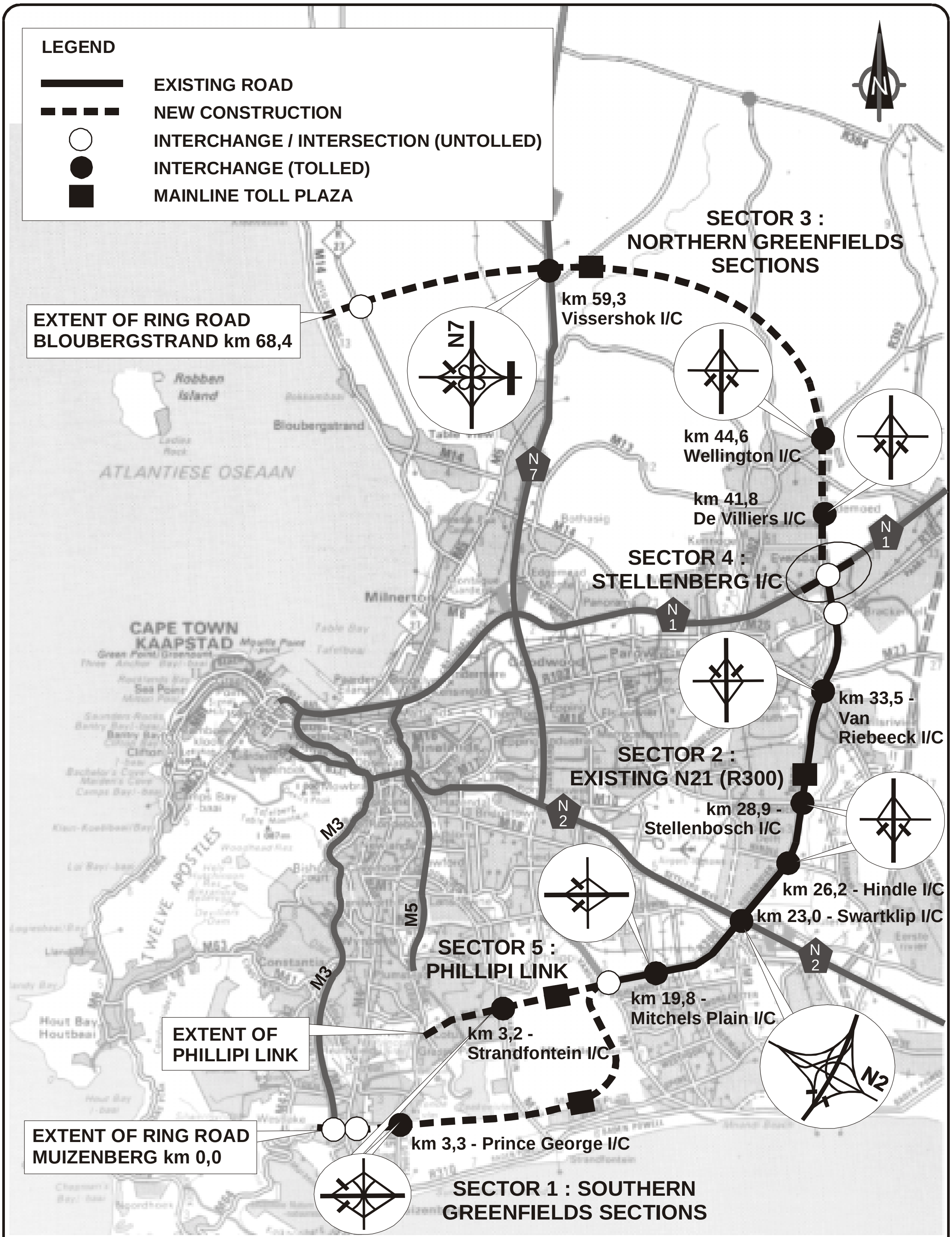

Locality Plan

N21 (R300) Cape Town Ring Road

NOT TO SCALE

Fig. 1