CHAPTER 2

The Klip River Catchment (Gauteng) and Study Area.

2.1 GENERAL DESCRIPTION OF THE CATCHMENT

A catchment is defined as all the land from mountain to sea, drained by one river system. The physical, chemical and biological characteristics of any river are determined almost entirely by the nature of the catchment, and activities –anthropogenic and natural- that take place in it (Davies & Day, 1998). Rivers reflect the health or ill-health of the catchment, and it is therefore of cardinal importance to monitor.

The Klip River catchment is situated in the Gauteng province of South Africa, and drains the southern Witwatersrand region. It flows primarily southwards until it joins the Vaal River at Vereeniging (Figure 2.1). The Vaal-Orange system then flows westward terminating in the Atlantic Ocean. The Klip River catchment incorporates the southern part of Johannesburg, one of the most developed urban complexes in Africa. This river is seen as one of the most heavily impacted river systems in South Africa and is subjected to almost every conceivable type of pollution (DWAF, 1999). Two of its major tributaries, the Klipspruit and Rietspruit, are also considered to be highly impacted rivers. The Klip River must, however, still serve all recognised user groups as identified by the Department of Water Affairs and Forestry (i.e. domestic, agricultural, industrial and recreation).

Topography

The Klip River originates in the Witwatersrand range of hills, which runs across the Witwatersrand urban complex in an east-west alignment (Krugersdorp to Springs). This ridge also forms the drainage border between the larger Vaal River Catchment (to the south) and the Crocodile River catchment (to the north). The altitute of the study area ranged from approximately 1 800m above mean sea level (a.m.s.l.) at the source, to 1 420m a.m.s.l. at the confluence with the Vaal River.

The natural topography of the upper catchment is largely modified by mine dumps. Steep rocky ridges are found in the upper Klip River catchment. The Klipriviersberg, the

Gatsrand and a range of hills to the north of Ennerdale and Walkerville are prominent topographic features in this upper segment. The Suikerbosrand range of hills (highest in Gauteng) form the watershed divide between the Rietspruit (major tributary of the Klip River) and the Suikerbosrand River catchment in the south east of the area. Topographically, the lower Klip River area is fairly featureless as the flood plain widens and as the catchment area narrows towards the confluence with the Vaal River (Otto, 1996; DWAF, 1999).

Regional Climate

A typical Highveld climate, with warm to hot summers (October to March), and cool days with cold nights during winter, exists in the Klip River catchment. Rainfall is mainly in the form of showers and thunderstorms, which occur mainly during the summer, with maximum falls usually occurring from December to January. The average annual rainfall ranges from 650mm near the Vaal Barrage, to 750mm on the Witwatersrand hills in the north. Winter months are usually dry and periodic droughts common in the area.

Average daily temperatures range from approximately 15 to 27 °C in January (summer) to 5 to 17 °C in July (winter). Extremes can range from 1 to 38 °C in the summer months to –13 to 17 °C in the winter months. Wind speed is generally light in the area (average of 4m/s) and winds mainly blow in a north-westerly direction. Exceptions occur sometimes with turbulent high velocity winds, especially during thunderstorms. The average evaporation rate for the region ranges between 109 to 246 mm/month and this exceeds the annual average rainfall. Heavy rains occasionally fall within short periods during the summer, causing localised flooding. Severe electrical storms, accompanying rainstorms, and hail and frost are common, while snow is an exceptional occurrence (Otto, 1996; DWAF, 1999).

Geology and Soils

The general geology of especially the upper reaches of the Klip River catchment is complex. It comprises a succession of formations dipping steeply towards the south and striking in a roughly east-west direction. The Basement Complex granites in the north are

overlain by the Hospital Hill Sequence of interbedded quartzites and shales. In turn, they are again covered by the Witwatersrand Sequence shales, quartzites and conglomerates containing the gold-bearing reefs. The Ventersdorp Supergroup lavas of the Klipriviersberg follow to the south and are overlain by the younger Malmani Dolomites, with the Black Reef Formation quartzites occurring on the interface. All of the above formations may be intruded by diabase dykes. Fresh, hard rock dolomite is encountered at depths ranging from 0 to 50 meters below the ground level throughout much of the catchment. The level and chemistry of the groundwater affects the nature and weathering of these rocks. This can lead to the creation of sub-surface cavities which can, under certain conditions, develop as surface subsidence or appear as sinkholes (DWAF, 1999).

In the sub-humid climatic zone (annual rainfall 500mm to 750mm such as in Klip River catchment) the underlying geology has been subjected to differential weathering. This gave rise to residual soils, which may vary significantly over short horizontal distances. The soil profile may range from large rock pinnacles to either soft or firm clayey silts of low permeability, and which are often volumetrically unstable. Soils in the upper reaches are predominantly sandy loams and those of the lower reaches predominantly clayey loams. Both soil types are derived mainly from the weathering of dolomites and sandstone (DWAF, 1999).

Differential weathering has also resulted in the formation of large hard rock corestones in a matrix of completely decomposed softer material. Underlying rocks are blanketed by either a thin horizon of gravity transported, gravelly colluvium, or in the vicinity of watercourses, by clayey water transported alluvium. These transported soils are seldom more than two meters thick. The alluvial clays are generally highly potentially expansive. The degree of weathering generally reduces with depth, the reddish clayey material grading into firm, brownish silts, which in turn change to stiff or very stiff, highly joined silts and soft rocks (Otto, 1996; DWAF, 1999).

Hydrology

The uppermost reach of the Klip River (first 10 kilometres running southwards) has a steep gradient of more than 4 m/km. Thereafter, the gradient flattens continuously after the rivers eastward turn, and the gradient is especially low (<2 m/km) in the lower section of

the river (from Rietspruit confluence). The natural mean annual runoff (MAR) of the Klip River catchment is estimated to be in the vicinity of 111 x $10^6 m^3$/annum (Stewart Scott *et al*, 1996). The average returns are in excess of 200 x $10^6 m^3$/annum, showing how dominant effluent return flows are in the catchment. Although more water is generally seen as a good thing, there are various negative connections to this increased amount of water being transported to the Klip River. The most important being reduced water quality, and reduction in natural habitats for biota, increased bank erosion and lack of naturally occurring floods as stimuli for fish migration. On the positive side, the return flow ensures the river to be perennial, permitting year round recreational activities, irrigation and also provides a permanent source of water for wildlife (DWAF, 1999).

The urban areas cover approximately 20% of the surface area in the catchment. The paved surfaces of urban areas cause an increase in surface run-off during the wet summer months and a decrease in sub-surface flow during the winter months (Stewart Scott *et al*., 1996). Dams and impoundments occurring in the catchment are primarily structures associated with mining (especially in the upper catchment). Only two impoundments occur in the mainstream, namely at Olifantsvlei Waste-water Treatment works (WWTW) and a weir at Henley-on-Klip. The present use of impoundments is predominantly for recreational activities, although the quality of the water is not always within limits for this use.

Flora

The vegetation of most of the Klip River catchment falls within the Bankenveld (Acocks veld type 61) and *Cymbopogon – Themeda* Veld (Acocks veld type 48; Acocks, 1988). The Climax of the Bankenveld type is *Acacia caffra* in parts along its northern margin, with sour bushveld regularly occurring on rocky outcrops and hills. These habitats carry bushveld vegetation dominated by *Protea caffra, Acacia caffra, Celtis africana* and sometimes *Protea welwitchii* subsp. g*labrescens*. In sheltered valleys and sinkholes there are traces of temperate or transitional forest with species such as *Celtis africana, Kiggelia africana, Halleria lucida, Leucosidea sericea, Buddleia salviifoli*a *and Cassinopsis ilicifolia* occurring. Typical grassveld species include, among others, *Trachypogon spicatus, Tristachya hispida, Heteropogon contortus, Panicum natalensis, Loutetia simplex, Digutaria monodactyla, Digutaria tricholaenoides, Setaria flabellata, Eragrostis racemosa* and *Thameda triandra*. Combined with regular burning, the veld is a

particularly sour and wiry grassveld, which is not very palatable in winter. A great wealth of forbs occurs within this variation of Bankenveld, including *Spenostylis angustifolia, Senecio coronatus, Helichrysum acutatum, Indigofera hilaris, Jusicia anagalloides, Veronia natalensis*, and many others.

The lower Klip River reaches are dominated by the *Cymbopogon – Themeda* Veld type. A mixed to sour grassveld is the climax. The northern variation of the veld type is a sparser more tufted veld and *includes Setaria flabellata, Themeda triandra, Heteropogon contortus* and *Eragrostis* species.

A large amount of the natural veld types of the Klip River have been either cultivated or disturbed to enable urban development. Intensive farming takes place in most of the rural areas of the catchment, and more so in the lower reaches of the river. Irrigation also occurs from the Klip River and its tributaries. The rocky ridges and low hills which flank the catchment in the north west and south east protect the few remaining natural veld habitats where a number of Red Data (rare or endangered) flora species are known to occur (Otto, 1996; DWAF, 1999).

Exotic vegetation encroachment is common along many parts of the river. *Acacia mearnsii* (Black wattle) is very common in the upper reaches while *Eucalyptus grandis* (Blue gum) is found along most of the river.

Wetlands

Wetlands are found in landscapes that are neither fully terrestrial nor fully aquatic, particularly where there is a moisture surplus or poor surface drainage, or adjacent to water bodies where waterlogged conditions are maintained. In such areas, the ground water table remains near or above the soil for most of the growing season and the dominant vegetation is adapted to wet environments (Williams & Feltmate, 1992).

The Klip River, and its tributary, the Rietspruit, have numerous small wetlands in their headwaters, but more importantly, have substantially larger areas in their middle reaches. Most of the wetlands are dominated by emergent reeds of the *Phragmites spp*. (Rand Water, 1998). Although generally seen as useless areas by the uninformed, wetlands perform vital functions, most of which depend on the presence of dense stands of reeds,

rushes and other large emergent plants. Firstly these wetlands are remarkably effective flood-control agents, forcing water to spread and reduce their damaging effects. It also ameliorates the impacts of floods by storing and slowly releasing floodwater to river channels. This feature reduces flood peaks and extends time taken for floodwater to drain to rivers. Probably the most important feature of wetlands is their ability to act as natural filters, trapping sediment, nutrients and even pathogenic bacteria (Davies & Day, 1998; Rand Water, 1998). This action is brought about by the plants causing the water to flow much slower and thus drop its silt, and at the same time, the plants and microbes associated with them extract nutrients for their own growth. The wetlands furthermore provide vital habitat, food and shelter for an enormous variety of plants and animals, both terrestrial and aquatic. Hundreds of waterfowl have been observed in the wetland areas during the study period, emphasising their importance in refuge areas even more.

Fauna

Most of the natural fauna that used to occur in the Klip River catchment has disappeared as a result of man's activities. Hunting, farming and the rapid urban development over the past decades can be seen as the most important impact on the natural fauna (DWAF, 1999). The faunal composition present in the Suikerbosrand Nature reserve would be a good indication of the natural terrestrial fauna that occurred in the Klip River catchment historically. One rare fish species, the Rock catfish (*Austroglanis sclateri*) is expected to occur in the Klip River system (Skelton, 1993).

Land use and Socio-Economic Environment

The city of Johannesburg was born in the 1880s when gold deposits were discovered in the hills of the Witwatersrand. It expanded both easterly and westerly, and consequently towns developed around the pitheads. The growth of mining and its supporting industries and services led to Johannesburg becoming South Africa's, and the sub-continent's premier city in terms of size and diversity. Most of the mining activities in the area are to the south of the watershed divide, therefore falling within the upper reaches of the Klip River catchment. A gradual decrease in gold mining activities has been witnessed over the past few decades. Currently, there are only two operating underground mining companies

in the Klip River catchment (Durban Roodepoort Deep and ERPM). Many old gold dumps are, however, being reworked as surface operations all along the gold bearing reef.

Despite the decline in gold mining, the Witwatersrand continues to thrive on expanding manufacturing and service industries. Another important area in the Klip River catchment is the Vereeniging district in the lower reaches of the river, close to its confluence with the Vaal Barrage. This town was established on the coal mining and steel industries, and also plays an important role in water supply, hosting Rand Water's purification works. Throughout the catchment lie various agricultural communities, the industrial town of Meyerton, and some small villages that act as remote dormitory suburbs to the metropolitan areas. There is also an increase in growth of formal residential areas serving the lower income groups, as well as rapid growing informal settlements (Otto, 1996; DWAF, 1999).

2.2 WATER USERS AND OTHER ANTHROPOGENIC IMPACTS ON THE KLIP RIVER

Domestic users

Most domestic water users in the Klip River catchment are supplied with potable water by Rand Water. They are responsible for providing drinking water to more than ten million people in Gauteng and its surrounding areas. In the lower Klip River catchment, a few individuals and small communities are reliant on the extraction of groundwater via boreholes. In the west of the upper Klip River catchment, Rand Water also extracts groundwater from the Zuurbekom underground water compartment for domestic use. Otherwise, the urban use of borehole water is chiefly limited to watering of gardens.

Generally Rand Water supplies potable water to a local authority which then distributes that water to end users. Rand Water is, however, increasingly supplying water to previously unserved end users, especially those living in informal settlements. Their area of supply stretches much further than just the Klip River catchment, and goes as far as Rustenburg, Pretoria, Bethal and Heilbron. Present and future growth in the large area covered will cause increased water demands and therefore also increase the pressure on Rand Water to meet these demands (DWAF, 1999).

In especially the informal settlements of the Klip River catchment, water is used directly from the river for domestic purposes (drinking, washing clothes, etc.). One can expect this user group to be increasing as the number and extent of informal settlements in the catchment increases. These informal areas are generally supplied with potable water in tankers or stand pipes. Experience and community knowledge of the potential health risk associated with drinking water from the Klip River seems to be relatively good and has prevented widespread use of the water for drinking purpose. If their needs are, however, not met and their education not satisfactory, one can expect the direct use of water from the river to increase. Poor water quality in the river can therefore severely impact domestic users if not monitored and kept within limits.

Industrial users

Similar to the case with domestic water users, industrial water users in the Klip River catchment are supplied with water by Rand Water, either directly or via local authorities. A few industrial users abstract water directly from the river system (Hippo Quarries in upper Klip River), make use of groundwater (Glen Douglas Dolomite Mine in lower Klip River), or use purified sewage effluent. A number of industries (e.g. Nampak and Everite in the upper Klip river) used to abstract river water in the past for their industrial processes, but now also rely on Rand Water for water supplies. In general, the direct use of river water for industrial use has declined over the past few years due to declining water quality and the increased accessibility to potable water (DWAF, 1999).

Agricultural users

Crop irrigation and livestock watering are the main agricultural users of water in the Klip River catchment. It is confined to the rural and peri-urban areas between Johannesburg and Vereeniging. Surveys conducted by the Department of Water Affairs and Forestry (DWAF) revealed that approximately 4 400ha of land could potentially be irrigated in the catchment (DWAF, 1999). It is furthermore estimated that the actively irrigated land is presently consuming just over 11 000 000m^3/annum. The main irrigated crops grown in the Klip River catchment are maize, fodder crops, vegetables (especially carrots, spinach, cabbage, onions, potatoes and salad greens), instant lawn, nursery plants and private

gardens. Livestock watering for dairy and beef cattle, sheep and pigs is also undertaken using river water. The irrigation of crops in the catchment plays an important role in the economy of the area and constitutes part of the market gardening belt surrounding and supplying Johannesburg. Treated sewage effluent from Johannesburg's southern wastewater treatment works is used to irrigate crops and also for livestock watering in the upper Klip River, while East Rand Water Care Works (ERWAT) irrigates land in the area of the Klip River-Rietspruit confluence with sewage sludge.

Recreational users

Various recreational activities commonly take place in the Klip River catchment. These include non-contact, intermediate contact and full contact recreation such as riparian home ownership, picnicking, fishing, birdwatching, nature walks, boating/canoeing, swimming, windsurfing and water-skiing. Most of these activities occur mainly in impoundments in the urban areas, but is also often observed in the Klip River itself. The human health aspect of the consumption of fish from this system has been raised in the past (Stewart Scott *et al.*, 1996; Du Preez, 2000).

The Vaal Barrage into which the Klip River flows is also a key recreational area both for permanent residents and weekend visitors, with full contact activities being common. The number of people regularly using the Vaal Barrage as a recreational facility heightens any risk associated with poor water quality. These activities are of significant economic value to the area, generating income that could be jeopardised by significant changes in water quality.

A number of small holiday resorts are situated on the banks of the middle Klip River. Additionally, existing and proposed hotels, riparian homes and commercial centres throughout the Klip River catchment, view the proximity to a water resource as being of economic and aesthetic importance. In particular, the Henley-on-Klip community in the lower Klip River is very active in promoting and protecting the Klip River as a recreational resource. Although not strictly identified as recreational activities, certain cultural practices of town ownership dwellers also rely on the Klip River system. These include church baptisms and the use of river water in traditional medicine.

Natural Environment

Water quality, biodiversity and recreational activity are inextricably linked so that changes in water quality in one river reach can result in significant changes in biodiversity and recreation potential over a much larger scale downstream. The natural environment is heavily impacted upon by anthropogenic activities in the Klip River catchment. Alien flora and fauna have established themselves in the river system and on its banks. Deteriorating water quality and an altered flow regime has also resulted in decreased ecological diversity of aquatic life in the river system. Presently, there are no areas in the Klip River catchment that can be considered pristine and therefore sensitive. There are also few officially declared nature reserves in the catchment. The Klipriviersberg Nature Reserve offers some protection to the headwaters of a number of tributaries (e. g. Bloubosspruit) of the Klip River in the upper catchment. No threatened fauna or flora is known to occur in the Klip River catchment. The rare rock catfish, *Austroglanis sclateri* has, however, been observed in the system.

Aesthetics form an important component of the environment, and river courses are being increasingly recognised as green belts. With this in mind, the Department of Water Affairs and Forestry (DWAF) treats rivers as an integrated system and therefore as part of the wider environment in the catchment. Although the banks of many areas of the Klip River have been degraded by human activities, it forms a high priority area in some areas such as Henley-on-Klip.

The Vaal Barrage Conservancy has been established by landowners adjacent to the Vaal Barrage at the foot of the Klip River. This organisation has been established to promote the protection of fauna and flora of the Vaal Barrage. This initiative was also followed by landowners in the Henley-on-Klip area, where a similar organisation was recently formed. Other forums also exist for the Klip River and some of its main tributaries.

Anthropogenic activities have shaped and continue to alter the ecological integrity of the Klip River system. Treated effluent discharges enrich the system and cause increased growth of reedbeds. Exotic plants have established themselves in the river system. Water abstraction, effluent discharges and urban run-off change flow patterns and nutrient levels. Siltation from construction sites and mine dumps modifies soil chemistry and affects the

sediment composition of rivers. Weirs and bridges locally modify water depths and flow patterns, whilst discharges and urban run-off are maintaining water chemistry at levels different to natural conditions.

The wetlands in the upper catchment are of great value to the system as they sustain biodiversity, improve water quality and provide recreation opportunities. Their purification abilities help attenuate pollution, although they may also become a trap for wastes and suspended solids. They are also frequently viewed by residents of nearby communities as a health hazard or a haven for vagrants and criminals. The dominant vegetation in the wetlands is reedbeds (*Phragmites communis* and *Typha capensis*) that are expanding because of the nutrient enrichment and bank alterations of this river. Many of the wetlands are therefore artificially created as a result of man's activities. They do, however, provide a sanctuary for birdlife, small animals and aquatic life.

The biological integrity of the Klip River system is considerably impaired. This is partially expected since the Klip River is an extremely altered system. Alterations to the system include:

- a completely modified hydrological regime – strong seasonality of rainfall in this area is cancelled by more constant contribution from treated wastewater;
- a change in the chemical composition of the water – rain water largely reaches the river via urban run-off, effluent discharge and mine drainage;
- changes instream morphology brought about by the building of weirs, bridges, recreational facilities etc.; and
- degradation and destruction of natural riparian habitats as a result of formal and informal urbanisation, and industrial, agricultural and domestic activities close to the river bank.

Potential Anthropogenic Induced Sources of Pollution in the Klip River Catchment

The Klip River is exposed to various anthropogenic activities from its source to its confluence with the Vaal River. The type of stressors on the system vary to some extent between the different areas of the river (Table 2.1). The primary point sources of pollution include gold mining activities and waste water treatment work (WWTW) effluents. Diffuse pollution sources originate primarily from slimes dams, rock dumps, degraded

sewerage networks, industries, solid waste disposal sites, informal settlements and agricultural activities (Table 2.1).

Table 2.1: Potential point and diffuse sources of pollution in different sections of the Klip River (from DWAF, 1999).

Klip River upstream of the Klipspruit confluence (Localities 1 to 3)	
Point sources	- Durban Roodepoort Deep Gold Mine (ceased pumping end June 1998).
Diffuse sources	- Slimes dams / rock dumps and old waste sites on mine properties. - Informal settlements near Kagiso, Durban Roodepoort Deep and western Soweto including extensive Doornkop informal settlements. - Leaking sewers, especially in Soweto area. - Industrial areas of Chamdor & Factoria/Manufacta. - Closed solid waste at Dobsonville.
Klipspruit Tributary	
Point sources	- Orlando Power Station (ceased operations in September 1998)
Diffuse sources	- Slimes dams / rock dumps and old waste sites on mine properties. - Central Gold Recovery slimes dam reclamation - Informal settlements in the CBD and Soweto. - Leaking sewers, especially in the CBD and Soweto. - Industrial areas of Main Reef Road, Industria, Newtown, Selby, Ophirton area. - Marie Louise & Robinson Deep solid waste sites & the now closed waste site near Meredale.
Klip River between Klipspruit & Rietspruit confluenses (Localities 4 & 5)	
Point sources	- Goudkoppies, Olifantsvlei, Bushkoppies & Waterval WWTW's
Diffuse sources	- Informal settlements near Eldorado Park, Lenasia and Eikenhof. - Leaking sewers in the Eldorado Park Area. - Industrial areas of Kliprivier. - Goudkoppies solid waste site. - Agricultural run-off.

Table 2.1 (Continue): Potential point and diffuse sources of pollution in different sections of the Klip River (from DWAF, 1999).

Rietspruit tributary	
Point sources	- ERPM Gold Mine - Rondebult, Dekema & Vlakplaats WWTW's.
Diffuse sources	- Slimes dams / rock dumps and old waste sites on mine properties. - ERGO & Central Gold Recovery slimes dam reclamation. - Informal settlements in central Johannesburg, along Main Reef Road in Germiston, in Katorus, Kwa-Thema & Zonkiziswe. - Leaking sewers, especially in Katorus area. - Industrial areas of Village Deep, Germiston, Alrode, Boksburg, etc. - Active and closed solid waste sites in the area. - Agricultural run-off.
Klip River between the Rietspruit confluence and the Vaal Barrage (Localities 6 to 9)	
Point sources	- Meyerton WWTW - Glen Douglas Dolomite Mine
Diffuse sources	- Industrial areas of Daleside, Meyerton and Iscor. - Old Springfield Colliery. - Solid waste sites at Henley-on-Klip, Walkerville & Waldrift, and closed site near Meyindustria. - Agricultural run-off.

2.3 THE STUDY AREA

Sampling Localities

At the commencement of the study, the river was visited using a vehicle to get first hand experience of its condition. A helicopter flight, over the total river from its origin to the confluence with the Vaal River, was undertaken and recorded on video during June 1997. This video was studied intensively and after careful considerations, nine localities were selected over the entire length of the river. Localities were selected considering criteria such as accessibility, variety of habitats present at a site, to measure possible impacts in the vicinity of the locality as well as to cover the whole of the river (Figure 2.1 and Table 2.2). One sampling site was also selected in the Suikerbosrand River, which has the closest to natural conditions of all rivers in the region. This site served as a reference or control site, giving an indication of how the Klip River would have been under natural conditions.

The following sites were then selected (Figure 2.1):

Locality 1: This site is in the upper catchment, close to the origin of the river. It is situated below two dams (Skinners and Princess) in a primarily built-up area, with some informal housing occurring on small scale.

Locality 2: This site was included to investigate the possible impact of gold mining activities and informal settlements in the upper catchment of the Klip River.

Locality 3: It is located in the main stream of the upper Klip River after the river flows through a wetland area and western Soweto formal and informal settlements.

Locality 4: This locality is situated in the middle reaches of the Klip River, downstream of its confluence with the highly polluted Klip Spruit and the effluent discharge of the Olifantsvlei WWTW.

Locality 5: This site is also located in the middle reaches of the catchment, after the river flows through extensive wetland areas, and an area where agricultural activities occur.

Locality 6: This locality is situated in the lower catchment of the Klip River, directly downstream of the Rietspruit confluence with the Klip River.

Locality 7: It is located in the lower catchment, directly downstream of an obstruction, namely the Henley-on-Klip weir.

Locality 8: This site was included to investigate the impact of the town of Meyerton and it's associated industrial areas.

Locality 9: This locality is approximately 2 km before the Klip River confluence with the Vaal River Barrage, to give an indication of the aggregate effect of impacts on this river system, and to evaluate the quality of water contributed to the barrage.

Locality 10-(Reference Site): This site was selected in the Suikerbosrand River, upstream of its confluence with the polluted Blesbokspruit, The only visible anthropogenic activities impacting at this site was agricultural practices and flow modification by an upstream dam.

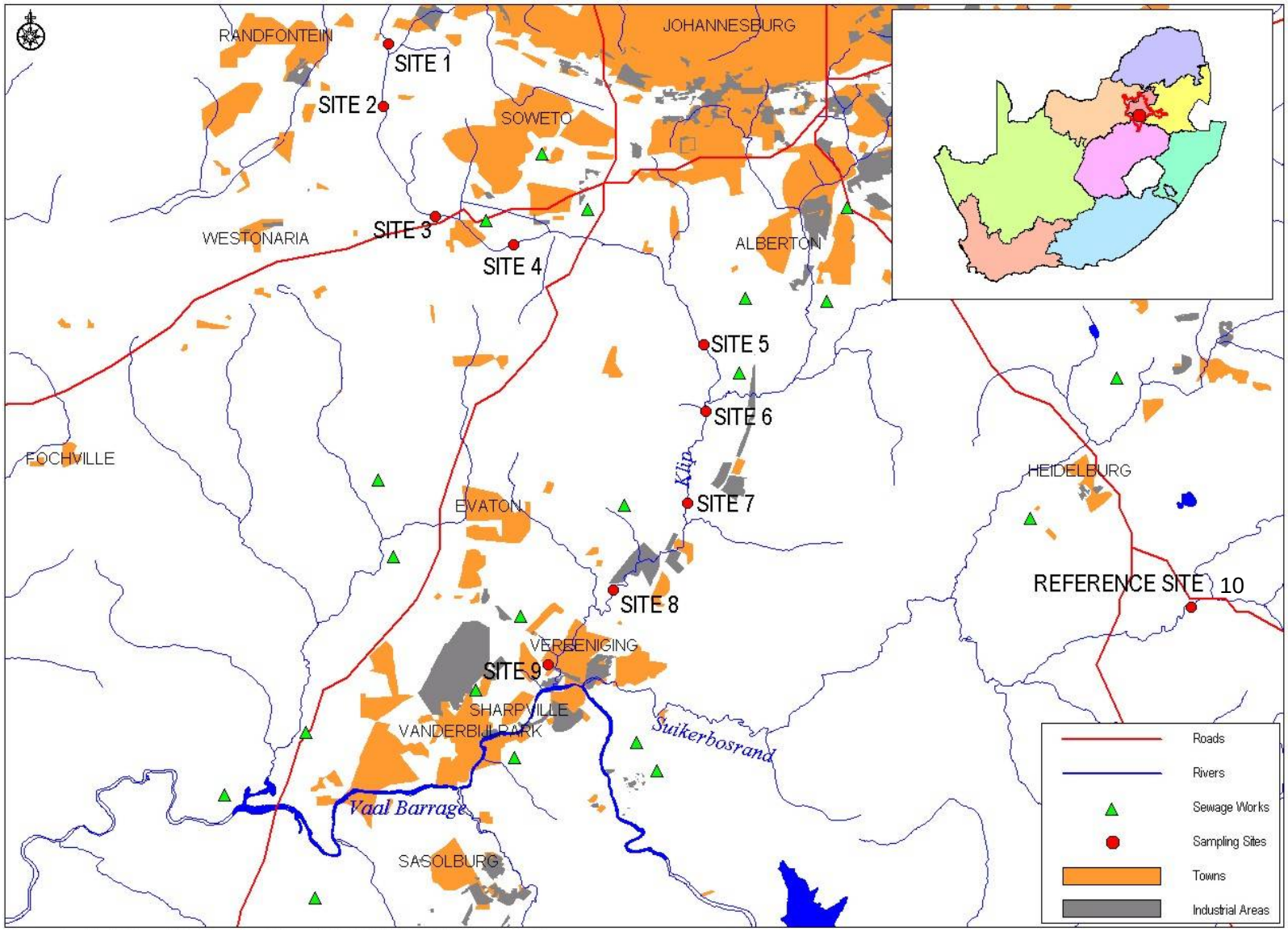

Figure 2.1: Map of the Klip River Catchment and selected sampling localities.

Table 2.2: Longitude and latitude of the sites selected for the purpose of this study.

LOCALITY NUMBER	RIVER	LATITUDE	LONGITUDE
1	Klip	26°10.154'	27°50.015'
2	Klip	26°12.837'	27°48.776'
3	Klip	26°17.912'	27°50.538'
4	Klip	26°20.234'	27°54.185'
5	Klip	26°22.855'	28°04.296'
6	Klip	26°27.396'	28°05.173'
7	Klip	26°33.000'	28°03.869'
8	Klip	26°36.608'	28°00.162'
9	Klip	26°38.965'	27°57.416'
10	Suikerbosrand	26°37.547'	28°27.927'

2.4 REFERENCES

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