PART 1: INTRODUCTION

1.1 BACKGROUND TO STUDY

The present situation of water quality management in the world is far from satisfactory due to the pressure of increasing population growth and fast developing economy (Biswas, 1991; Haimes, 1992; Palte, 1993; Simonvic, 1996a,b; Falkenmark, 1997; Loucks, 1997 and Kundzewics, 1997 as quoted in Huang & Xia, 2001). Worldwide, tremendous pressure is being placed on water resources by increasing volumes of domestic, industrial and agricultural wastes (DWAF, 1998a). At present water quality in various water resources around the world, including surface water, groundwater and seawater are deteriorating, particularly in crowded communities where development activities are taking place due to contamination of toxic substances from human activities, as well as community activities as a result of economic growth and industrial, agriculture, and tourism developments. In particular the physical and biological characteristics of water resources and the ecological balance of the water resource system have been changed, resulting in impacts on resource utilization, pollution or other deterioration of resources (PCD, 2004). The lack of adequate water of good quality is probably the most serious environmental problem experienced in developing countries (Markandya, 2004).

Various activities of an anthropogenic nature take place in South Africa's riverine environments. In various parts of South Africa, water quality is impaired by industrial or mine effluents, sewage or sewage return flows, runoff of nutrients and pesticides from farmlands, and salinization as a result of inappropriate spray irrigation (Day, date unknown). As custodian of the natural water resources, it is an integral function of the Department of Water Affairs and Forestry (DWAF) to manage the effects of these activities on the country's water Resources (Clean Stream Environmental Services, 2005). The challenge that faces South Africa is to promote socio-economic development while maintaining a water quality that is at all times still fit for use by specified users and for proper ecological functioning of ecosystems (DWAF, 2004a). Water quality management in South Africa is based on the receiving water quality standards (Barnard, 1999). For this purpose the Department of Water Affairs and Forestry has developed the South African Water Quality Guidelines (Barnard, 1999). The water quality guideline approach is based on the principle that receiving waters have a capacity to assimilate pollution up to a point at which it becomes detrimental towards specified water users (Fuggle and Rabie, 2003).

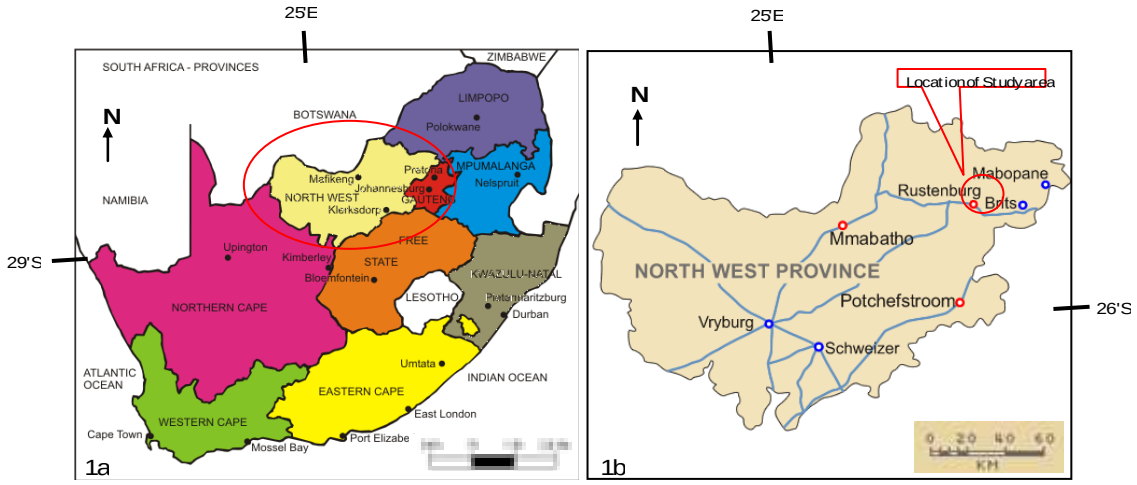

Figure 1: Regional setting of study area in relation to South Africa (a) and the North West province (b) (ANC, 2004 and Technikon South Africa, 2003).

Being a generally arid province, the North West province (Figure 1a) experience the same water constraints as discussed for South Africa. The scarcity of water within the Hex River is compounded by the deterioration in quality as a result of water pollution. According to Howard, Mangold & Mpambane (2002) the North West province surface water comprises rivers, dams, pans, wetlands and dolomitic eyes fed by underground water sources. In the North West province ground and surface water are integrated and interdependent as dolomitic eyes or springs are the sources of several major rivers which rise within the boundaries of the province, such as the Groot Marico, Mooi and Molopo Rivers. The North West province has four Water Management Areas (WMAs) within its provincial boundaries: Crocodile (West) and Marico, Upper, Middle and Lower Vaal Water Management Area. This specific research, however, will focus on the water quality of the Hex River catchment (Figure 1b). According to Burke & Shepherd (2004) typical point-source pollution in the North West Province includes domestic sewage, industrial effluents and acid mine drainage while non-point source pollution includes agricultural runoff of fertilizers, insecticides and herbicides from agricultural land and storm water runoff from urban surfaces such as roads.

The Hex River forms part of the Limpopo River System draining in a northern direction towards the Crocodile River (West). The study area falls within the water drainage area (water management area) A, and more specific in quaternary catchment A22H. By assessing the water quality of the Hex River catchment its degradation is determined and from this rehabilitative and mitigatory measures are anticipated. Smallholdings and cultivated land (mainly tobacco, wheat, dunflowers, cotton and chillies) characterize the upstream area of the Hex River. Downstream the land is predominately rural with

some agricultural and scattered formal and informal settlements. In close proximity to the study area the town of Rustenburg has both residential and industrial areas. Urban development has taken place in the town of Rustenburg, and extensive informal settlements further exist within the Hex River catchment (Burke & Shepherd, 2004). The different land uses and activities occurring within the catchment are responsible for a variety of pollutant influxes into the Hex River and its associated tributaries.

1.2. PURPOSE OF THIS STUDY

The South African Constitution states that every South African inhabitant has the right to a clean and healthy environment and to have the environment protected for the benefit of present and future generations [Section 24 of the Bill of Rights, Constitution of the Republic of South Africa (Act No. 108 of 1996)]. The National Water Act, 36 of 1998 recognizes that the ultimate aim of water resource management is to achieve sustainable use of water for the benefit of all users. The Act also recognizes that the protection of the quality of water resources is necessary to ensure sustainability of the nation's water resources in the interest of all water users. The Act requires that water quality be managed in an integrated manner at national level in terms of the National Water Resource Strategy, and at regional or catchment level in terms of Catchment Management Strategies. The main reason for the assessment of the quality of the aquatic environment has been, traditionally, the need to verify whether the observed water quality is suitable for intended uses (Meybeck, Kimstach & Helmer, 1992).

This study is focused on the Hex River catchment, located in the North West province of South Africa, upstream of the Bospoort Dam. The anthropogenic activities impacting on the water quality of the Hex River include mining; storm water runoff; use of fertilizers, pesticides, herbicides in agriculture; uncontrolled dumping of wastes close to and in water resources (especially in informal settlements); sewage as well as leachate from waste disposal facilities. Because of these impacts it is deemed necessary to determine the current state of the water quality of the Hex River to ensure the suitability thereof for identified water users.

1.2.1. MAIN AIM OF THE STUDY

The main aim of this study is to determine the present day physical, chemical and biological water quality of the Hex River catchment. Water quality data for various surface water monitoring localities along the Hex River upstream of the Bospoort Dam will be collected and analyzed. The water quality of upstream and downstream localities will be compared to identify the influx of impacted water quality into the Hex River from various activities situated within the catchment. Specific emphasis is placed on the identification of the fitness of use of the resource by identified downstream water users (Hex River and Bospoort Dam). To meet this aim it is important to further determine the water quality status of the principal tributaries. The concentrations of various constituents will be compared with the Target Water Quality Guideline Ranges (TWQGR) as specified by the Department of Water Affairs and Forestry for domestic use, irrigation, livestock watering as well as the aquatic environment. The study will determine the assimilative capacity of the downstream Bospoort Dam acting as the receiving water body. It is essential to establish the current status of the water quality in the Hex River to facilitate management decisions to maintain the requirements of the resource downstream from impacted areas.

1.2.2. IMPORTANCE OF THE STUDY

According to Fuggle and Rabie (2004, p. 277): “the golden rule for the management of freshwater ecosystems is to remember that the conditions, water quality and biota of any body of freshwater are the products and reflection of events and conditions in its catchment.” According to the Department of Water Affairs and Tourism (as quoted in Fuggle and Rabie, 2004) the quality of many water resources in South Africa is declining. This is of utmost concern as South Africa is located in a semi-arid part of the world, and thus has scarce water resources. According to Godfrey *et al* (2002) changing water quality results in impacts upon the effectiveness of use of the water body, as well as upon ecosystem integrity. With the limited water resources available, efficiency of use and the management of impacts upon the quality of water resources are essential (Godfrey *et al*, 2002). Various studies in relation to the assessment of regional water quality have been undertaken. Nawn (2004) established the present day water quality conditions of the Hennops River in terms of water quality and the hydrological status. Bridgett (2003) studied the quality of the surface water for the Horn- as well as Ngagane Rivers in the vicinity of a coalmine. Ravengai, *et al* (2005) looked at the water quality of the Mupfure River and it tributaries in an abandoned gold mining belt in the Sanyati Valley in Zimbabwe. Aston and van Zyl (1995) used a Geographic Information Systems (GIS) to display specific catchment characteristics and

land uses, supplemented with overlays depicting land-use impacts on surface water resources in the Crocodile River. Venter (2004) conducted a study on the water quality of the Rustenburg Dorpspruit from 1995 to 2000.

In South Africa the need for effective management of catchment and river basins were identified a while back with the Promulgation of the National Water Act 36 of 1998 (Jansen, 2000). The Department of Water Affairs and Forestry (DWAF) retains a central role in the management of South Africa's water resources, and particularly the licensing of water uses and pollution control (SRK consulting, 2002). The Key to sustainability of resource is to ensure that the quality of water resources is suitable for their intended uses. In order for DWAF to fulfill its role it must have appropriate information and commitment from water users. DWAF requires the bulk water users, to comply with conditions and requirements set out in existing water use permits, and demonstrate effective water management, particularly with respect to monitoring of water quality and quantity used and/ or discharged by permitted business units, and pollution control management (SRK consulting, 2002).

The Hex River catchment is impacted on by a variety of including formal (Rustenburg) as well as informal settlements, agricultural impacts, industrial impacts from Rustenburg, influx of water from waste water treatment plants as well as various mining operation. This study is important because the impacts on the water quality of the Hex River will be determined in order to propose mitigatory actions as well as rehabilitative measures. The determination of long-term as well as current water quality conditions is important to indicate if previous management actions were appropriate in safeguarding the resource for the water users situated within the catchment as well as the receiving environment, the Bospoort Dam. These management actions are important as the Hex River is situated within a severely impacted area with high economic growth and thus has become less suitably for use for domestic purposes, irrigation, livestock watering and less suitable for the survival of aquatic ecosystems. The vital nature of water as a developmental resource has resulted in the government passing laws and regulations aimed at protecting the resource. The National Water Act (Act No. 36 of 1998) states that 'to balance long-term protection of water resources with short- and medium-term demands for using them'. Thus the challenge is to obtain the right balance between the impacts pertaining from economic and social development on the water quality of the Hex River catchment and the equity and sustainability of the resource. In order to ensure sustainable use of the Hex River as water resource local authorities need to be aware of the associated water quality problems experienced within the Hex River catchment.