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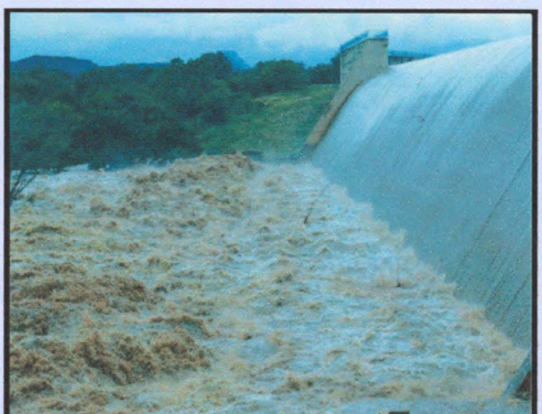
DEPARTMENT: WATER AFFAIRS AND FORESTRY

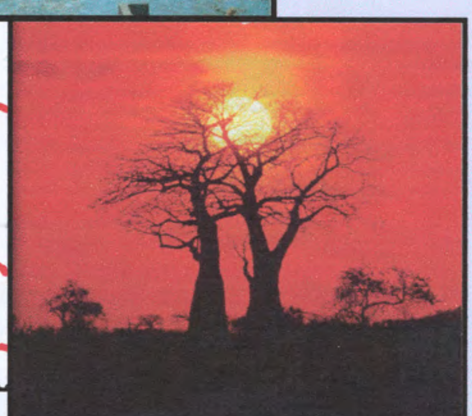
Directorate: Water Resources Planning

LIMPOPO WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT
JULY 2003





COMPILED BY:

CIVIL ENGINEERS, HYDROLOGISTS & PROJECT MANAGERS

ASSISTED BY:

NINHAM SHAND

PARSONS & ASSOCIATES

MARITZA UYS

GIS PROJECT SOLUTIONS

Title:	**Limpopo Water Management Area: Water Resources Situation Assessment – Main report**
Authors:	A JANSEN VAN VUUREN (WSM) H JORDAAN (WSM) E VAN DER WALT (WSM)
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Approved for Study Team:

....

A JANSEN VAN VUUREN
WSM (Pty) Ltd.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Directorate: Water Resources Planning

Approved for the Department of Water Affairs and Forestry by:

....

CFB HAVENGA
Chief Engineer
(Project Manager)

....

JA VAN ROOYEN
Director

LIMPOPO WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT

OVERVIEW

The water resources of South Africa are vital to the health and prosperity of its people, the sustenance of its natural heritage and to its economic development. Water is a national resource that belongs to all the people who should therefore have equal access to it, and although the resource is renewable, it is finite and distributed unevenly both spatially and temporally. The water also occurs in many forms that are all part of a unitary and inter-dependent cycle.

The National Government has overall responsibility for and authority over the nation's water resources and their use, including the equitable allocation of water for beneficial and sustainable use, the redistribution of water and international water matters. The protection of the quality of water resources is also necessary to ensure sustainability of the nation's water resources in the interests of all water users. This requires integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level where all persons can have representative participation.

This report is based on a desktop or reconnaissance level assessment of the available water resources and quality and also patterns of water requirements that existed during 1995 in the Limpopo Water Management Area, which occupies a portion of the Northern Province. The report does not address the water requirements beyond 1995 but does provide estimates of the utilisable potential of the water resources after so-called full development of these resources, as this can be envisaged at present. A separate national study has been conducted to consider future scenarios of land use and water requirements and the effects of water conservation and demand measures on these requirements and to identify alternative water resource developments and water transfers that will reconcile these requirements with the supplies.

The main purpose of this report is to highlight the principal water related issues, to identify existing water shortages, to provide information that is necessary to formulate future strategies such as the national water resources strategy and catchment management strategies and to stimulate initial actions to ensure the best overall sustainable utilisation of the water, with minimal waste and harm to the aquatic ecosystems.

The National Water Act (No. 36 of 1998), requires that a national water resources strategy (NWRS) be established that sets out the policies, strategies, objectives, plans, guidelines and procedures and the institutional arrangements for the protection, use, development, conservation, management and control of water resources for the country as a whole, and establish and define the boundaries of water management areas taking into account catchment boundaries, socio-economic development patterns, efficiency considerations and communal interests. This strategy is binding on all authorities and institutions exercising powers or performing duties under the National Water Act.

The national water resources strategy will, *inter alia*, provide for at least the requirements of the Reserve, international rights and obligations, actions required to meet projected future water needs and water use of strategic importance. Furthermore, it will contain estimates of present and future water requirements, set out principles relating to water conservation and demand management, give the total quantity of water available within each water management area, state the surpluses or deficits, provide for inter-catchment water transfers required to balance the supply with the requirements and state the objectives in respect of water quality to be achieved through the classification system to be provided for the water resources.

A catchment management agency established in terms of the National Water Act (No. 36 of 1998), must progressively develop a catchment management strategy, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of water resources within its water management area. Such a strategy must not be in conflict with the national water resources strategy, must take into account the class of water resource and resource quality objectives, the requirements of the Reserve and any applicable international obligations, the geology, land use, climate, vegetation and waterworks within its water management area. The strategy shall contain water allocation plans, take account of any relevant national or regional plans prepared in terms of any other law; enable public participation and take into account the needs and expectations of existing and potential water users. This report provides the initial baseline data that can be used by the catchment management agency to develop its catchment management strategy, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of the water resources in its area of responsibility.

The national water resources strategy will be reviewed and published at five-yearly intervals, with Addenda being issued in the interim, when required. The strategy will give guidance to the Department of Water Affairs and Forestry in respect of the protection, use, development, conservation, management and control of water resources and will also serve as a very important means of communication with all the stakeholders. The overall responsibility for the compilation of the national water resources strategy rests with the Directorate: Strategic Planning of the Department of Water Affairs and Forestry, while the Directorate: Water Resources Planning is responsible for:

- Identification of water resources to meet particular requirements
- Identification of international rights and obligations
- Identification of water use of strategic importance
- Calculating water balances
- Developing plans to reconcile water requirements and resources.

A number of inter-related studies have therefore been included by the Directorate: Water Resources Planning of the Department of Water Affairs and Forestry in the national future scenario study that will supply the information required for formulating the strategies, as given above.

The main objective of this water resources situation assessment has been to determine the water requirements of all the user sectors (including those of the riverine and estuarine ecosystems) and the ability of the available water resources to supply these requirements. However, other aspects such as water quality, legal and institutional aspects, macro-economics, existing infrastructure and international requirements have also been addressed. This report outlines the 1995 water resources situation, using information obtained from previous study reports to identify the main water related issues of concern. The large body of information available in the Department of Water Affairs and Forestry and from other sources has also been collated and presented in this assessment. This has been collected on a catchment basis at the quaternary catchment level of resolution.

The levels of confidence that can be attached to the data on land use, water requirements and surface water and groundwater resources have however, been found to vary considerably because of the desktop nature of the study. This has therefore also provided a basis for identifying where improvements need to be made to the data in future and to prioritise such studies. It is also important to note that where information on land and water use and sensitive ecosystems is not given, this could be due to the fact that it does not exist or because it has not been documented in a format or source that is readily accessible.

The larger inter-related studies that have supported this water resources situation assessment have been the following:

- Development of a computerised database

    Data collected in this water resources situation assessment has been used to populate the database of the Chief Directorate: Planning of the Department of Water Affairs and Forestry. The database design has mainly been based on the requirements of a water balance model that has been developed to compare the water requirements with the available water resources.

- Demographic study

    An important part in the development of the national water resources strategy is the future scenarios. Since water use is mainly driven by the requirements of the various socio-economic groupings of the population, a national demographic study was initiated. An important part of the study was an estimate of the base year (1995) population. The study has also associated the population with defined water user categories to facilitate estimating existing and future water requirements. These categories have *inter alia* been defined on the basis of reports on urban water supplies and questionnaires completed by local authorities.

- Macro-economic study

    Economic activity and its effects on the spatial distribution of the population and vice versa is an important determinant of water use. With the ever-increasing need for water for domestic use and protection of the water resources, water availability is already becoming a limiting factor in various regions of the country. The economic viability of continuing to supply water for existing sectors, such as irrigation and also of expanding such activities to satisfy socio-economic aspirations will need careful consideration. A national macro-economic study has therefore been undertaken to provide basic economic data for use in the demographic study and to provide macro-economic overviews for each water management area.

- Formulation and development of a water situation assessment model

    The primary function of the water situation assessment model is to reconcile water supply and water requirements by quantifying the surplus or deficit per catchment area. Water balances are compiled from the quaternary catchment level of resolution of the data, which can then be aggregated to suite any desired predetermined catchment boundaries. The water situation assessment model is nevertheless only a coarse planning tool and does not replace the detailed hydrological studies that are required for basin studies or project investigations.

- Water requirements for the ecological component of the Reserve

  The National Water Act (No. 36 of 1998) requires that water be provided for the Reserve, which is the quantity and quality of water required to satisfy basic human needs and to protect the aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant resource. The ecological sensitivity and importance of the rivers in South Africa and the present ecological status class was therefore established at the quaternary catchment level of resolution, using available data and local knowledge. At the same time the results of previous field assessments of the water requirements of the aquatic ecosystems at selected sites in South Africa were used in a separate study to develop a model for estimating the water required for the ecological component of the Reserve for various ecological management classes that correspond to those determined previously for the rivers throughout the country.

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ACRONYMS

AEMC	Suggested future ecological management class
AR	Area Rating
ARDC	Agriculture and Rural Development Corporation
CB	Consultburo (now BKS)
CCWR	Centre for Computing Water Research
CMA	Catchment Management Agency
CMIP	Consolidated Municipal Infrastructure Programme
CSIR	Council for Scientific and Industrial Research
CWSS	DWAF: Sub-directorate: Community Water Supply and Sanitation
DBSA	Development Bank of Southern Africa
DCD	Department of Constitutional Development
DEMC	Default ecological management class
DESC	Default Ecological Status Class
DOC	Dissolved Organic Carbon
DRASTIC	Software, where D = Depth to Water R = (Net) Recharge A = Aquifer media S = Soil media T = Topography (slope) I = Impact of the vadose zone media C = Conductivity (hydraulic) of the aquifer
DWAF	Department: Water Affairs and Forestry
DWAF:WS	Department: Water Affairs and Forestry: Directorate Water Services
EA	Enumerator Area
EC	Electrical conductivity
EISC	Ecological importance and sensitivity class
ELSU	Equivalent live stock unit.
ESCOM	Electricity Supply Commision
EVT	Evapotranspiration (A-pan equivalent in mm/m)
FFC	Financial and Fiscal Commission
GGP	Gross Geographic Product
GIS	Geographic Information System
GWS	Government Water Scheme

HIS	Hydrological Information Services (of DWAF)
HKS	Hill Kaplan Scott (Now Gibb Africa)
IFR	Instream flow requirement
IRP	Integrated Resource Planning
IWQS	Institute for Water Quality Studies
KNP	The Kruger National Park
LDC	Consortium Comprising Consultant Buro (now BKS), HRS and Loubscher Smith
LSU	Live Stock Unit
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MD	Magisterial District
MSL	Mean sea level
NGO	Non-Governmental Organisation
NMMP	National Microbiological Monitoring Programme
NPLGA	The Northern Province Local Government Association
NSTT	The National Sanitation Task Team
NWA	National Water Act
NWRS	National Water Resources Strategy
NWSR	National Water Supply Regulation
OD	Outside Diameter
PESC	Present ecological status class
PGRWS	The Pietersburg Governmental Regional Water Supply Scheme
RDP	Reconstruction and Development Programme.
RI	Relative Index
RWS	Regional Water Scheme
SABS	South African Buro of Standards
SALGA	South African Local Government Association
SAR	Sodium Adsorption Ratio
SRK	Steffen Robertson Kirsten
TDS	Total Dissolved Solids
THM	Trihalomethane
TLC	Transitional Local Council

TOR	Terms of Reference
TRC	Transitional Rural Council
VAT	Value Added Tax
VIP	Ventilated pit-latrine
WMA	Water Management Area
WR 90	Refer to References, Midgley (1994)
WRC	Water Research Commission
WRM	Water Resource Management
WRSA	Water Resources Situation Assessments
WS	Water Scheme
WSAM	Water Situation Assessment Model
WTW	Water Treatment Works
WUA	Water User Association

SYMBOLS

AIR	Irrigation Area (km^2)
BFI	Base Flow
CLI	Irrigaton conveyance loss
CRC	Crop factor
CV	Coefficient of variation
ECA	Total catchment area (minus) catchment area of next major dam upstream
fBML	Mining Losses (factor)
fBOL	Other industrial losses (factor)
fBSL	Strategic losses (factor)
fIHC	Irrigaton conveyance losses – High category irrigation
fILC	Irrigaton conveyance losses – Low category irrigation
fIMC	Irrigaton conveyance losses – Medium category irrigation
fIPH	Irrigation efficiency – High category irrigation
fIPL	Irrigation efficiency – Low category irrigation
fIPM	Irrigation efficiency – Medium category irrigation
IRC	Irrigation efficiency
IRR	Irrigation water requirements ($10^6m^3/m^2$)
LER	Leaching factor
LU	Land use rating per settlement
LUn	Land use rating for n settlements, per quaternary
oRTL	Rural losses (factor)
PD	Population Density rating
REF	Effective rainfall(mm/m)
SA	No/poor Sanitation Rating
TLU	Total land use rating for area
TLU	Total land use rating per quaternary catchment
TWU	Total water use rating for area
V_T	Sediment volume at end of period
V_{50}	Estimated sediment volume after fifty years at the same average yeild
$10^6m^3/a$	million cubic metres per annum
mg/ℓ	milligram per litre
Mℓ/day	megalitre per day
$t/km^2.a$	ton per square kilometre per annum

GLOSSARY OF TERMS

ANASTOMOSED	A river made up of multiple channels with stable islands, usually with a bedrock substrate.
ASSURANCE OF SUPPLY	The reliability at which a specified quantity of water can be provided, usually expressed either as a percentage or as a risk. For example "98% reliability" means that, over a long period of time, the specified quantity of water can be supplied for 98% of the time, and less for the remaining 2%. Alternatively, this situation may be described as a "1 in 50 year risk of failure" meaning that, on average, the specified quantity of water will fail to be provided in 1 year in 50 years, or 2% of time.
BASIN	The area of land that is drained by a large river, or river system.
BIOTA	A collective term for all the organisms (plants, animals, fungi. bacteria) in an ecosystem.
CAIRN	Mound of rough stones packed as a monument or landmark.
CATCHMENT	The area of land drained by a river. The term can be applied to a stream, a tributary of a larger river or a whole river system.
COMMERCIAL FARMING	Large scale farming, the products of which are normally sold for profit.
COMMERCIAL FORESTS	Forests that are cultivated for the commercial production of wood or paper products.
CONDENSED AREA	The equivalent area of alien vegetation with a maximum concentration/density that represents the more sparsely distributed alien vegetation that occurs over a large area.
DAM	The wall across a valley that retains water, but also used in the colloquial sense to denote the lake behind the wall.
DEFICIT	Describes the situation where the availability of water at a particular assurance of supply is less than the unrestricted water requirement.

DEFAULT ECOLOGICAL MANAGEMENT CLASS (A-D).

A class indicating the ecological importance and sensitivity of an area, as it is likely to have been under natural (undeveloped) conditions, and the risks of disturbance that should be tolerated. Values range from Class A (highly sensitive, no risks allowed) to Class D (resilient systems, large risk allowed).

DRAINAGE REGION

The drainage regions referred to in this document are either single large river basins, or groups of contiguous catchments or smaller catchments with similar hydrological characteristics. They follow the division of the country into drainage regions as used by the Department of Water Affairs and Forestry.

ECOLOGICAL IMPORTANCE

A measure of the extent to which a particular species, population or process contributes towards the healthy functioning of an ecosystem. Important aspects include habitat diversity, biodiversity, the presence of unique, rare or endangered biota or landscapes, connectivity, sensitivity and resilience. The functioning of the ecosystem refers to natural processes.

ECOSYSTEM HEALTH

An ecosystem is considered healthy if it is active and maintains its organisation and autonomy over time, and is resilient to stress. Ecosystem health is closely related to the idea of sustainability.

EDAPHIC

Pertaining to the influence of soil on organisms.

or

Resulting from or influenced by factors inherent in soil rather than by climatic factors.

ENDANGERED SPECIES

Species in danger of extinction and whose survival is unlikely if the causal factors bringing about its endangered status continue operating. Included are species whose numbers have been reduced to a critically low level or whose habitat has been so drastically diminished and/or degraded that they are deemed to be in immediate danger of extinction.

ENDEMIC

Occurring within a specified locality; not introduced.

ENDOREIC	Portion of a hydrological catchment that does not contribute towards river flow in its own catchment (local) or to river flow in downstream catchments (global). In such catchments the water generally drains to pans where much of the water is lost through evaporation.
ENVIRONMENTALLY SENSITIVE AREA	A fragile ecosystem which will be maintained only by conscious attempts to protect it.
EPHEMERAL RIVERS	Rivers where no flow occurs for long periods of time.
FORMAL IRRIGATION SCHEME	The term applies to a scheme where water for irrigation purposes is stored in a dam controlled by DWAF or an Irrigation Board and supplied in predetermined quotas to irrigators registered under the scheme.
GIS	A computer system which enables data to be stored, manipulated and presented visually, in a geographically located or spatially distributed format.
HISTORICAL FLOW SEQUENCE	A record of river flow over a defined period and under a defined condition of catchment development in the past, calculated from a record of observed flow corrected for inaccuracies, or from records of observed rainfall, or a combination of the two.
HYDROLOGICAL YEAR	The twelve-month period from the beginning of October in one year to the end of September in the following year.
INVERTEBRATE	An animal without a backbone - includes insects, snails, sponges, worms, crabs and shrimps.
IRRIGATION QUOTA	The quantity of water, usually expressed as m^3/ha per year, or mm per year, allocated to land scheduled under the scheme. This is the quantity to which the owner of the land is entitled at the point at which he or she takes delivery of the water and does not include conveyance losses to that point.
LOTIC	Flowing water.
MANAGEMENT CLASS	management objectives of an area which could possibly be attained within 5 years. Values range from Class A (largely natural) to Class D (largely modified).

MEAN ANNUAL RUNOFF	Frequently abbreviated to MAR, this is the long-term mean annual flow calculated for a specified period of time, at a particular point along a river and for a particular catchment and catchment development condition. In this report, the MARs are based on the 70-year period October 1920 to September 1990 inclusive.
OPPORTUNISTIC IRRIGATION	Irrigation from run-of-river flow, farm dams, or compensation flows released from major dams. As storage is not provided to compensate for reduced water availability in dry years, areas irrigated generally have to be reduced in dry years.
PETROGLYPH	A carving or inscription on a rock.
PRESENT ECOLOGICAL STATUS CLASS	A class indicating the degree to which present conditions of an area have been modified from natural (undeveloped) conditions. Factors that are considered in the classification include the extent of flow modification, inundation, water quality, stream bed condition, riparian condition and proportion of exotic biota. Values range from Class A (largely natural) to Class F (critically modified).
QUATERNARY CATCHMENT	The basic unit of area resolution used in the WR90 series of reports published by the Water Research Commission and also in this report. The primary drainage regions are divided into secondary, tertiary and quaternary catchments. The quaternary catchments have been created to have similar mean annual runoffs: the greater the runoff volume the smaller the catchment area and vice versa. The quaternary catchments are numbered alpha-numerically in downstream order. A quaternary catchment number, for example R30D, may be interpreted as follows: the letter R denotes Primary Drainage Region R, the number 3 denotes secondary catchment 3 of Primary Drainage Region R, the number 0 shows that the secondary catchment has not, in this case, been sub-divided into tertiary catchments, and the letter D shows that the quaternary catchment is the fourth in sequence downstream from the head of secondary catchment R30.

RARE	Species with small or restricted populations, which are not at present endangered or vulnerable, but which are at risk. These species are usually localised within restricted geographical areas or habitats, or are thinly scattered over a more extensive range. These may be species, which are seldom recorded but may be more common than supposed, although there is evidence that their numbers are low.
RED DATA BOOK	A book that lists species that are threatened with extinction. The concept was initiated by the International Union for the Conservation of Nature, and has since become adopted by many countries. The "Red" stands for "Danger". The categories reflect the status of the species only within the area under review, and it is sometimes the case that species, which are threatened in one region may have secure populations in other areas.
RELIABILITY OF SUPPLY	Synonymous with assurance of supply.
RESERVE	The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997) for people, who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No. 36 of 1998).
RESOURCE	Two kinds if water resources are recognised, namely surface water and groundwater, however these are often interdependent.
RESERVOIR	The lake formed behind a dam wall. In this report the colloquial term dam is generally used for reservoir.
RESILIENCE	The ability of an ecosystem to maintain structure and patterns of behaviour in the face of disturbance or the ability to recover following disturbance.

RESOURCE QUALITY	The quality of all the aspects of a water resource including: (a) the quantity, pattern, timing, water level and assurance of instream flow; (b) the water quality, including the physical, chemical and biological characteristics of the water; (c) the character and condition of the instream and riparian habitat; and (d) the characteristics, condition and distribution of the aquatic biota.
RESOURCE QUALITY OBJECTIVE	Quantitative and verifiable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection.
RIVER SYSTEM	A network of rivers ranging from streams to major rivers, and, in some cases, including rivers draining naturally separate basins that have been interconnected by man-made transfer schemes.
SCHEDULED LAND	Irrigable land to which a water quota has been allocated.
SETTLEMENT	smaller Centre of population, industry and services but still deemed to be of importance.
SPATIO — TEMPORALLY ROBUST	Does not change significantly with time in relation to spatial distribution.
STROMATOLITE	A rocky cushion-like growth formed by the growth of lime-secreting blue-green algae, thought to be abundant 200 million years ago, when blue-green algae were the most advanced form of life on earth.
SUB-CATCHMENT	A sub-division of a catchment.
SUBSISTENCE FARMING	Small-scale farming where almost all produce is consumed by the farmer's household or within the local community.
SUGGESTED ECOLOGICAL	A class of water resource indicating the suggested
SWALE	A small earth wall guiding surface runoff away from the stream back onto fields.

TAXON	A taxonomic group referring to the systematic ordering and naming of plants and animals according to their presumed natural relationships. For example, the taxa *Simuliidae, Diptera, Insecta* and *Arthropoda* are examples of a family, order, class and phylum respectively.
VADOSE ZONE	Relating to or resulting from water or solutions that are above the permanent groundwater level.
VULNERABLE	Species believed likely to move into the endangered category in the near future if the causal factors continue operating. Included are species of which all or most of the population are decreasing because of overexploitation, extensive destruction of habitat, or other environmental disturbance. Species with populations which have been seriously depleted and whose ultimate security is not yet assured, and species with populations that are still abundant but are under threat from serious adverse factors throughout their range.
WATER IMPORTS	Water imported to one drainage basin or secondary sub-catchment from another.
WATER TRANSFERS	Water transferred from one drainage basin or secondary sub-catchment to another. Transfers in are synonymous with water imports.
YIELD	The maximum quantity of water obtainable on a sustainable basis from a dam in any hydrological year in a sequence of years and under specified conditions of catchment development and dam operation.

LIMPOPO WATER MANAGEMENT AREA

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THE STUDY

The National Water Act No. 36 of 1998 requires the Minister of Water Affairs and Forestry to establish a national water resource strategy for the protection, use, development, conservation, management and control of water resources. To enable the strategy to be established, information on the present and probable future situations regarding water requirements and water availability is required, that is, a national water resources situation assessment providing information on all the individual drainage basins in the country.

The Department of Water Affairs and Forestry (DWAF) has appointed consulting engineers to undertake Water Resources Situation Assessments for the purpose of gathering information and using it to reconcile the present water requirements of all the user sectors with the presently available water resources. The information produced by all the studies will be consolidated by DWAF into a national database which will be used to establish the national Water Resource Strategy. Scenarios of future water requirements and water availability are being dealt with in a separate study. These scenarios will be taken up in the National Water Resource Strategy and will be reported on separately for each water management area.

As a component of the National Water Resource Strategy, the minister of Water Affairs and Forestry has established water management areas and determined their boundaries. The National Water Act provides for the delegation of water resource management from central government to the regional or catchment level by establishing catchment management agencies. It is intended that the documents produced in this study as well as in the subsequent scenario studies referred to above should, in addition to contributing to the establishment of the National Water Resource Strategy, provide information for collaborative planning of water resources development and utilization by the central government and the future catchment management agencies.

In order to facilitate use by future catchment management agencies, the information has been presented in the form of a separate report for each water management area. This report is in respect of the Limpopo Management Area, which occupies a portion of the Northern Province. A provincial water resources situation assessment can be derived by assembling the provincial data from each of those reports that describe the water management areas that occupy the province.

1.2 APPROACH TO THE STUDY

The study was carried out as a desktop investigation using data from reports and electronic databases, or supplied by associated studies, local authorities and DWAF. The study considered conditions as they were in the year 1995 and did not make projections of future conditions. Data at reconnaissance level of detail was collected on land-use, water requirements, water use, water related infrastructure, water resources and previous investigations of water supply development possibilities. Relevant data was used in a computerized water balance model, developed in a separate study (DWAF, February 2000) to calculate the yield of the water resources at development levels as they were in 1995, and the maximum yield that could be obtained from future development of these resources. The water balance (the relationship between water requirements and water availability) at selected points in each water management area was also calculated.

Information on urban water use and water related infrastructure was obtained from reports on urban water supplies and from questionnaires filled in by local authorities. The collected data on urban water use was supplied to consultants appointed to carry out a separate national demographic study, in relation to water requirements.

In that study, data from the 1996 census, and other sources, was used to derive demographic information for the whole country for the year 1995. In addition, the information on urban water use, that we supplied by the water resources situation assessment studies, was analyzed in the demographic study to derive typical unit water requirements. These were used, in conjunction with the demographic data, to estimate water requirements in 1995 for urban areas for which no recorded data was available.

Both the demographic data and the estimated water requirements in 1995, as supplied for the Limpopo Water Management Area by the national demographic study (DWAF, March 2000), are presented in this report. In addition to the separate studies on the water balance model and demography referred to above, separate studies were carried out to provide information on a national basis on:

- Macro-economic aspects. (Appendix B).
- Legal aspects of water resource management. (Section 3.4).
- Institutional arrangements for water supply. (Section 3.4).
- Effects of alien vegetation on runoff. (DWAF, 1998).
- Groundwater resources. (Appendix G).
- Bacteriological contamination of water resources. (Appendix E).
- Water requirements for irrigation
- Ecological classification of rivers
- Water requirements for ecological component of reserve. (Hughes, 1999).
- Effects of afforestation on runoff. (DWAF, 1998).
- Storage-yield characteristics of rivers. (Section 6.3.2).

Information from all the above studies, that is relevant to the Limpopo Water Management Area, is included in the appropriate sections of this report.

1.3 REPORT LAYOUT AND CONTENT

The findings of the study in respect of the Limpopo Water Management Area are presented in the nine chapters that make up the main body of this report, and a number of appendices containing mainly statistics for the quaternary hydrological sub-catchments that make up the water management area. (The system used to divide the area into hydrological sub-catchments is explained in section 2.1 of the report).

The chapter headings are:

Chapter 1:	Introduction
Chapter 2:	Physical features
Chapter 3:	Development status
Chapter 4:	Water related infrastructure
Chapter 5:	Water requirements
Chapter 6:	Water resources
Chapter 7:	Water balance
Chapter 8:	Costs of water resources development
Chapter 9:	Conclusions and recommendations

Chapter 2, 3 and 4 describe climatic and physical features, and land-uses that affect water resources or water supply. Chapter 5 describes the various water user sectors and their requirements. It includes information on water allocations, water conservation and demand management, and water losses and return flows. Chapter 6 describes the groundwater and surface water resources of the water management area, and Chapter 7 compares water requirements with the available resource. In Chapter 8, rough estimates are given of the cost of developing the portion of the total water resource that was not developed by 1995, and the conclusions and recommendations arising from the study are presented in Chapter 9.

Since the compilation of the majority of the report, including the GIS figures, a series of name changes occurred in the Northern (now Limpopo) Province, as listed below:

NORTHERN PROVINCE	**LIMPOPO PROVINCE**
Bochum	Senwabarwana
Dendron	Mowade
Ellisras	Lephalale
Louis Trichardt	Makhado
Messina	Musina
Naboomspruit	Mookgopong
Nylstroom	Modimolle
Pietersburg	Polokwane
Potgietersrus	Mokopane
Soekmekaar	Molemole

CHAPTER 2: PHYSICAL FEATURES

2.1 THE STUDY AREA

The Limpopo Water Management Area occupies the northwestern part of the Northern Province. Significant towns include Pietersburg, Potgietersrus, Naboomspruit, Nylstroom, Louis Trichardt, Messina and Ellisras. The Limpopo River watercourse forms the northern boundary of the WMA, and indeed of the country, and with its tributaries is shown in Figure 2.1.1. The Limpopo Water Management Area is shown in Figure 2.1.2. The WMA does not include the total catchment area of the Limpopo River, since the upper tributaries (the Marico and Crocodile Rivers) are included in the Crocodile West and Marico WMA, and the downstream tributaries (Luvuvhu and Mutale Rivers) are included in the Luvuvhu and Letaba WMA.

There are numerous tributaries that contribute to the Limpopo River within the WMA. The major tributaries, from the upstream end, are the Matlabas River, Mokolo River, Lephalala River, Mogolakwena River, Sand River and the Nzhelele and Nwanedi Rivers.

The Matlabas River drains the most western area of the Limpopo WMA. The catchment includes endoreic areas. The altitude in the Waterberge mountain range where the Matlabas River originates is in the order of 1 400 m and the altitude decreases to approximately 840 m where it flows into the Limpopo River.

The Mokolo River has various tributaries. Of these tributaries, namely the Sand River and the Grootspruit, originate in the Waterberge mountain range and flow into the Mokolo River upstream of the Mokolo Dam. Other tributaries are Tambotie River, Poer se Loop and Rietspruit River that join the Mokolo River downstream of the Mokolo Dam. The altitude varies from 1 700 m to 790 m at the confluence with the Limpopo River.

The Lephalala River originates in the Sandrivier Mountains that forms part of the Waterberge. The altitude varies from 1 700 m to 780 m. The area between the Mokolo River and Lephalala River is also an endoreic area.

The Mogalakwena River is known as the Nyl River in its upper reaches. The Nyl River originates north of Warmbad at an altitude of about 1 500 m. At Potgietersrus the name changes and it becomes the Mogalakwena River. The river flows northwards and joins the Limpopo River at an altitude of about 625 m.

The Sand River originates south of Pietersburg and drains the eastern part of the WMA.

The Nzhelele River and the Nwanedi River drains the most northeastern part of the WMA. These originate in the Soutpansberg and northern extremity of the Great Escarpment respectively.

There are also minor tributaries that drain directly into the Limpopo River, as well as the tributaries from the northern neighbouring countries. The major contributor from the north is the Sashe River from Botswana.

The basic unit of area used in this water resource situation assessment is the quaternary catchment. The quaternary catchments as used, were defined by Midley *et al* (1994) in their study of water resources in South Africa, generally referred to as the WR90 study.

The primary drainage regions throughout the country are divided into secondary, tertiary and quaternary catchments. The quaternary catchments have been selected to have similar runoffs. By definition, the greater the runoff volume the smaller the catchment area and *vice versa*. The quaternary catchments are numbered alpha-numerically in downstream order. A quaternary catchment number, for example A62B, may be interpreted as follows:

- the letter A denotes Primary Drainage Region A;
- number 6 denotes secondary catchment area number six of Drainage Region A;
- number 2 denotes the second tertiary catchment within the secondary catchment;
- the letter B shows that the quaternary catchment is the second in sequence downstream from the head of tertiary catchment area B62.

If a quaternary catchment number is, for example A50C, the number 0 shows that the secondary catchment has not been sub-divided into tertiary catchments.

The Limpopo River consists of portions of Primary Drainage Region A, as described above. The Water Management Area includes a total of 68 quaternary catchments. Figure 2.1.4 shows the numbered quaternary sub-catchments, as well as the hydrological sub-catchments grouped into so-called key points, as indicated by shading.

The data and results of this study are presented for the key points. Key points of interest were generally selected at existing large dams, possible future dam sites and at the confluences of important rivers. Table 2.1.1 lists the quaternary catchments within the selected key points.

TABLE 2.1.1: DESCRIPTION OF KEY POINTS

LOCATION OF KEY POINTS				DESCRIPTION
PRIMARY CATCHMENT		SECONDARY CATCHMENT NO.	QUARTERNARY CATCHMENT NO.'S	
NO.	NAME			
A	Limpopo River	A4	A41,1A,B,C,D	Matlabas
			A41E	Steenbokpan
			A42A,B,C,D,E,F	Mokolo (Upper)
			A42G,H,J	Mokolo (Lower)
		A5	A50A,B,C,D,E,F	Lephalala (Upper)
			A50G,H	Lephalala (Lower)
			A50J	Soutkloof
		A6	A61A,B,C	Nyl (Upper)
			A61D,E	Nyl (Middle)
			A61F,G	Mogalakwena (Upper)
			A61H,J	Sterk
			A62A,B,C,D,E,F,G,H,J	Mogalakwena (Middle)
			A63C	Doringfonteintjiespruit
			A63A,B,D	Mogalakwena (Lower)
			A63E	Kolope
		A7	A71A,B,C,D	Sand (Upper)
			A71E,F,G	Hout
			A72A,B	Brak
			A71H,J,K	Sand (Lower)
			A71L	Kongoloops/Soutsloot
		A8	A80A,B,C	Nzhelele (Upper)
			A80D,E,F,G	Nzhelele (Lower)
			A80H,J	Nwanedi

2.2 CLIMATE

The climatic conditions vary within the Limpopo Water Management Area, which ranges from the Waterberg Mountains in the south, northwards to the hot, dry Limpopo River valley on the border with Zimbabwe.

2.2.1 Temperature

The mean annual temperature ranges between 16°C in the south to more than 22°C in the north with an average of 20°C for the catchment as a whole. Maximum temperatures are usually experienced in January and minimum temperatures occur on average in July. The following Table 2.2.1 summarises temperature data for the Limpopo WMA for these two months (Schulze *et al*, 1997).

TABLE 2.2.1: TEMPERATURE DETAILS FOR THE WMA

Month	Temperature	Average (°C)
January	Mean Temperature Maximum Temperature Minimum Temperature Diurnal Range	22,6 30,0 17,5 12,5
July	Mean Temperature Maximum Temperature Minimum Temperature Diurnal Range	12,7 21,6 3,8 17,9

Frost seldom occurs with the average number of frost days per year amounting to about 3 days that is experienced mainly in the southern and western areas.

2.2.2 Precipitation

Rainfall occurs mainly in summer, (i.e. October to March). The Mean Annual Precipitation (MAP) is in the range 200 to 800 mm over most of the study area and is indicated on Figure 2.2.1. In general, the rainfall decreases from the southern part of the WMA (average about 650 mm) to the drier northern parts, where the lowest MAP of about 350 mm occurs along the lower part of the Limpopo River valley. For a small portion in the Soutpansberg the MAP is 1 000 mm and higher. The peak rainfall months are in January and February and rainfall occurs generally as thunderstorms.

During the driest year, the annual rainfall in the Limpopo WMA ranges generally between 100-200 mm in the extreme north with the majority of the catchment ranging between 200-400 mm increasing up to 600 mm in the south. Rainfall in the Soutpansberg watershed ranges between 800-1200 mm per annum.

In accordance with the rainfall patterns the relative humidity is higher in summer than in winter. Humidity is generally highest in February (the daily mean ranges from 64% in the west to above 70% in the east).

2.2.3 Evaporation

The mean annual gross evaporation (as measured by Symons pan) ranges between 1 600 mm in the southern region to 2 200 mm in the northern regions. Three evaporation zones are defined in the WR90 and are shown on Figure 2.2.2. The histogram shows the monthly evaporation as a percentage of the MAE.

In the Soutpansberg area the evaporation is lower, namely 1 600 mm/a in the foothills to only 1 300 mm/a in the highest region.

2.3 GEOLOGY

The Limpopo River Water Management Area is underlain by a wide variety of different lithologies.

In the north, the Limpopo Mobile Belt occurs with its southern margin bounded by down faulted basins containing upper Karoo strata and the Soutpansberg Mountains consisting of Soutpansberg Group rocks. Some Ecca shales also lie unconformably on the Limpopo Mobile Belt gneisses.

To the south west the Limpopo Mobile belt is truncated by large E-W trending faults with Waterberg Group strata and the northern lobe of the Bushveld Complex on the down faulted side of the faults. The Waterberg sandstone overlies predominantly Nebo Granite of the Lebowa Granite Suite and covers most of the western quadrant of the WMA.

The south central part of the WMA is underlain by basement gneisses i.e. the Houtriver and Goudplaats gneisses intruded by younger granite plutons e.g. the Matlala and Mashashane granites. Infolded into the basement are the low-grade metamorphic greenstone sequences, such as the Pietersburg Group and the high grade metamorphic Sandriver gneisses and the Bandolierkop Complex gneisses.

The south western quadrant of the study area is dominated by the northern lobe of the Bushveld Complex, which is intrusive into Transvaal Super Group strata and overlain by Waterberg sandstones. Karoo Super Group strata are preserved south of the Zebedelia fault in the Springbok flats basin and in the extreme west overlying Bushveld Complex and Waterberg Group strata.

A brief description of the various lithological groups, from oldest to youngest are as follows:

a) **The Greenstone Belts**

The Giyani, Pietersburg and Murchison greenstone belts are east north east striking sequences of volcano-sedimentary rocks infolded into the basement metamorphosed to green schist facies metamorphism. Only the Pietersburg Greenstone belt occurs in the basin. They are mapped as an assemblage of compact sedimentary and extrusive rocks.

All three Greenstone Belts can be modelled on the Barberton greenstone belt with basal ultra mafic strata grading into mafic and felsic strata interbedded with BIF, chert shales and greywackes. These are mapped as an assemblage of compact sedimentary and extrusive rocks.

b) **The Limpopo Mobile Belt**

The Limpopo Mobile Belt is a mega shear zone which strikes east north east and separates the Kaapvaal craton from the Rhodesian craton. It consists of gneissic granites, granulites, serpentenites, metapelites and horneblende gneisses with infolded supra crustal rocks such as the Sandriver Gneisses and Beit Bridge Complex.

The Sandriver Gneisses, Beit Bridge Complex and the Bandolierkop Complex are ancient supra-crustal sequences which have undergone high grade granulite metamorphism. The Sand River Gneisses and the Beit Bridge Complex consist of metaquartzites, calcsilicates, amphibolite, meta-pelites and pink hornblende gneisses. They are mapped as an assembleage of compact sedimentary extrusive and intrusive rocks.

The Bandolierkop Complex is infolded into the basement of the Houtriver and Goudplaats gneisses. It consists of ultramafic peridotite, pyroxenite lavas, mafic granulite, amphibolite, metapelite, pelitic gneisses, magnetite, quartzite and meta quartzite. It is mapped as acid, intermediate or alkaline intrusives.

c) **Intrusives**

The Houtrivier and Goudplaats gneisses consist of biotite muscovite granite, gneiss, leucogranite, migmatites, tonalite, quartz monzonite and quartz porphyries. They are mapped as acid, intermediate or alkaline intrusives.

d) **Transvaal Super Group**

Transvaal Super Group rocks occur in the south central part of the study area with the strata dipping towards the Bushveld Complex and truncated in the south by the Zebedelia fault. The following groups are represented in the study area;

i) The Wolkberg Group consists of quartzite shales and basalt with minor dolomite. It is mapped as an assemblage of compact sedimentary and extrusive strata.

ii) Chuniespoort Group consists of cherts, dolomites, banded iron formation with minor shales mapped as dolomite chert and minor limestone. It is mapped as dolomite chert and subordinate limestone.

iii) The Pretoria Group consists of interbedded quartzites and shales with two distinct volcanic horizons, in the middle and at the top of the Pretoria Group strata. It is mapped as compact sedimentary strata.

e) **The Bushveld Complex**

The northern lobe of the Bushveld Complex occurs in the study area. It is made up of two main phases:

i) The Lebowa Granite Suite is the acidic phase of the Bushveld Complex, consisting mostly of a red alkali feldspar granite and minor granophyre dykes. It is mapped as acid intermediate and alkaline intrusive.

ii) The Rustenburg Layered Suite is the mafic to ultra mafic phase of the Bushveld Complex and can be sub divided into:

- the upper zone consisting of titaniferous magnetites, magnetite gabbro, gabbro norite and anorthosites;
- the main zone consisting of gabbro;
- the critical zone consisting of pegmatitic pyroxenite;
- lower zone consisting of harzburgite, bronzetite, chrometite and pyroxenites.

The Rustenburg Layered Suite is mapped as Mafic/ultramafic basic, ultrabasic intrusives.

f) **The Soutpansberg Group and Waterberg Group**.

The Soutpansberg Group formed by the Blouberg and Soutpansberg mountain range. The rocks have suffered rift type faulting and generally dip northwards. It is mapped as an assemblage of compact sedimentary and extrusive rocks.

The sequence is made of a basal basalt layer overlain by quartzite, conglomerate and siltstone.

The Waterberg Group is formed by the Waterberg and Makgabeng mountains and is made up of red sandstone, conglomerate with minor trachyte and shale horizons. These strata are generally horizontal and undisturbed. It is mapped as compact, dominantly arenaceous strata.

g) **Karoo Super Group**

The Karoo Super Group rocks in the study area consist of the following;

i) Letaba Formation-consists of basalt
ii) Clarens Formation-consists of a fine pink sandstone
iii) Irrigasie Formation - consists of sandstone, shale, mudstone, grit and siltstone.
iv) Ecca Formation-consists of shale, shaley sandstone conglomerate with coal in places

Karoo Super Group rocks occurs in several localities throughout the study area namely:

- Within the valleys and north of the Soutpansberg mountains.(Letaba, Clarens, Irrigasie and Ecca Formations)
- In the Springbok flats basin in the south of the study area (Letaba and Clarens Formations)
- In the extreme west of the study area (Letaba, Clarens, Irrigasie and Ecca Formations).

A simplified geological map of rock types is shown in Figure 2.3.1. Information in Table 2.3.1 may be used to identify the stratigraphic units described above.

TABLE 2.3.1: DESCRIBING THE RELATION BETWEEN STRATIGRAPHY AND LITHOLOGY

Stratigraphy	Symbol	Rock Types
• Rooiberg Group		Acid and intermediate lavas
• Lebowa granite suite • Houtrivier, Mpuluzi, Gaborone and Cunning Moor intrusives • Mashashane, Hugomond, Matlala, Matok, Moletsi • Meinhardskraal and unnamed intrusives • Rashoop granophyre and Lebowa granite suite • Goudplaats and unnamed intrusives		Acid, intermediate or alkaline intrusives
• Soutpansberg Group and Blouberg Formation • Pietersburg Group		Assemblage of compact sedimentary and extrusive rocks
• Limpopo mobile belt, Sand River gneiss; Beit Bridge complex; Messina suite; Bulai gneiss		Assemblage of compact sedimentary extrusive and intrusive rocks
• Undifferentiated Karoo Super Group		Compact arenaceous and argillaceous strata
• Duitschland, Timeball Hill, Magaliehey Quartzite		Compact sedimentary strata
• Waterberg Group and Glentig Formation		Compact, dominantly arenaceous strata
• Black Reef Formations (except where the latter is included with Godwana Formation)		Dolimate, chert and subordinate limestone
• Letaba Formation		Mafic/basic lavas
• Rustenburg Layered Suite		Mafic/ulttramafic of basic/ultrabasic intrusives

2.4 SOILS

The soils in the Limpopo WMA are shown in Figure 2.4.1, which has been taken from the WR90 study (Midgley *et al*, 1994). This map is a simplified version of a more complete soil zone map developed by the University of Natal and reproduced in the South African Atlas of Agrohydrology and – Climatology (Schulze *et al*, 1997). The soil zones had been delimited by the Institute for Soil, Climate and Water, based on soil texture (i.e. clay, sand, silt, etc.), soil forms and series (i.e. Hu 18 for a Hutten soil form and 18 for the Balmoral series) and soil depth. In total, 84 zones had been identified in a coarse scale, regional zonation, originally mapped at 1:2 500 000 scale. Each of the 84 zones still displays a wide range of soil properties.

In the WR90 study, the soil types were further analysed according to features most likely to influence hydrological response, viz. depth of soil, soil texture and slope. Some 16 broad groupings were obtained, of which seven occur in the WMA.

In the northern regions of the WMA, up to the Limpopo River, the soil type is moderate to deep sandy soil. The relief is classed as steep.

In the central part of the WMA the soil is a sandy loam, moderate to deep with undulating relief.

In the most southern parts, sandy loam and clayey soil are intertwined with the relief varying from flat to steep.

In the Soutpansberg area and further south along the Escarpment, the soil type is clayey loam with a steep relief.

2.5 NATURAL VEGETATION

2.5.1 Introduction

Some 20 000 different plant species occur throughout South Africa. These are however not randomly distributed but are organised into distinct communities, largely dependent on the prevailing climatic (especially rainfall) and edaphic (soil) conditions. For the purposes of identifying and managing the heterogeneous range of vegetation within South Africa, it is necessary to be able to recognise relatively homogenous vegetation groups or types. Furthermore, for the recognised groups to be meaningful, it is essential that they are readily apparent and spatio-temporally robust.

Acocks (1988) introduced the concept of "Veld type", which he defined as: "a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming potentialities". Acocks (1988) identified a total of 70 veld types in South Africa (see Table 2.5.1.1), including 75 variations. These 70 veld types fall into 11 broad categories, ranging from various forest types to sclerophyllous (Fynbos) types (Table 2.5.1.1). These "simplified" Acocks veld type categories are used for the purposes of this report, and accordingly the description of the natural vegetation types occurring within the Water Management Area (WMA) is rather broad.

TABLE 2.5.1.1: A LIST OF THE DETAILED AND SIMPLIFIED ACOCKS VELD TYPES (Acocks, 1988)

Detailed Veld Types	No.	Simplified Veld Type
Coastal Forest and Thornveld	1	Coastal Tropical Forest
Alexandria Forest	2	
Pondoland Coastal Plateau Sourveld	3	
Knysna Forest	4	
'Ngongoni Veld	5	
Zululand Thornveld	6	
Eastern Province Thornveld	7	
North-eastern Mountain Sourveld	8	Inland Tropical Forest
Lowveld Sour Bushveld	9	
Lowveld	10	Tropical Bush and Savanna
Arid Lowveld	11	
Springbok Flats Turf Thornveld	12	
Other Turf Thornveld	13	
Arid Sweet Bushveld	14	
Mopani Veld	15	
Kalahari Thornveld	16	
Kalahari Thornveld invaded by Karoo	17	

Detailed Veld Types	No.	Simplified Veld Type
Mixed Bushveld	18	
Sourish Mixed Bushveld	19	
Sour Bushveld	20	
False Thornveld of Eastern Cape	21	False Bushveld
Invasion of Grassveld by Acacia Karoo	22	
Valley Bushveld	23	Karoo and Karroid
Noorsveld	24	
Succulent Mountain Scrub	25	
Karroid Broken Veld	26	
Central Upper Karoo	27	
Western Mountain Karoo	28	
Arid Karoo	29	
Central Lower Karoo	30	
Succulent Karoo	31	
Orange River Broken Veld	32	
Namaqualand Broken Veld	33	
Strandveld	34	
False Arid Karoo	35	False Karoo
False Upper Karoo	36	
False Karroid Broken Veld	37	
False Central Lower Karoo	38	
False Succulent Karoo	39	
False Orange River Broken Karoo	40	
Pan Turf Veld invaded by Karoo	41	
Karroid Merxmuellera Mountain Veld replaced by Karoo	42	
Mountain Renosterveld	43	
Highveld Sourveld and Dohne Sourveld	44	Temperate and Transitional Forest and Scrub
Natal Mist Belt 'Ngongoni Veld	45	
Coastal Renosterveld	46	
Coastal Fynbos	47	
Cymbopogon – Themeda Veld	48	Pure Grassveld
Transitional Cymbopogon – Themeda Veld	49	
Dry Cymbopogon – Themeda Veld	50	
Pan Turf Veld	51	
Themeda Veld or Turf Highveld	52	
Patchy Highveld to Cymbopogon – Themeda Veld Transition	53	
Turf Highveld to Highland Sourveld Transition	54	
Bakenveld to Turf Highveld Transition	55	
Highland Sourveld to Cymbopogon – Themeda Veld Transition	56	

Detailed Veld Types	No.	Simplified Veld Type
North-eastern Sandy Highveld	57	
Themeda – Festuca Alpine Veld	58	
Stormberg Plateau Sweetveld	59	
Karroid Merxmuellera Mountain veld	60	
Bankenveld	61	False Grassveld
Bankenveld to Sour Sandveld Transition	62	
Piet Retief Sourveld	63	
Northern Tall Grassveld	64	
Southern Tall Grassveld	65	
Natal Sour Sandveld	66	
Pietersburg Plateau False Grassveld	67	
Eastern Province Grassveld	68	
Fynbos	69	Sclerophyllous Bush
False Fynbos	70	False Sclerophyllous Bush

2.5.2 Natural Vegetation Types within the Limpopo WMA

Vegetation within the Limpopo WMA is dominated by Tropical Bush and Savanna, with areas of False Pure Grassveld around Pietersburg. Small scatterings of Inland Tropical Forest occur in the south and a relatively small area at the eastern boundaries of the WMA. The veld types that occur within the Limpopo WMA are described in more detail below and illustrated in Figure 2.5.2.1.

Tropical Bush and Savanna
This veld type dominates within the Limpopo WMA, occupying 85% of its area. Tropical trees and shrubs are common and the dominant grass is a tall form of Themeda Triandra which thrives on summer rainfall from 500–750 mm per annum. The tropical bush and savanna generally occurs at altitudes between 1 500 and 1 600 m above mean sea level.

False Grassveld
False Grassveld occurs in the southern regions which occurs at altitudes ranging from 1 450-1 750 m above sea level and rainfall from 700-750 mm per annum. Under these conditions combined with regular burning the veld is a particularly sour wiry grassveld.

Inland Tropical Forest
Occurs predominantly in the northeastern regions of the WMA. This vegetation dominates in the mountain ranges where high rainfall is experienced ranging on average from 900 to over 1950 mm per annum.

2.6 ECOLOGICALLY SENSITIVE SITES

2.6.1 Sensitive Ecosystems

The conservation of living resources is essential for sustaining development by; maintaining the essential ecological processes and life support systems, preserving genetic diversity and ensuring that utilisation of species and ecosystems is sustainable. However, for conservation to succeed it should be underpinned by two basic principles, namely the need to plan resource management (including exploitation) on the basis of an accurate inventory and the need to implement proactive protective measures to ensure that resources do not become exhausted. Accordingly, a vital component of ensuring sustainable conservation practices is the identification of conservation worthy habitats or sensitive ecosystems.

In terms of Section 2 (1) of the Environment Conservation Act (No. 73 of 1989), South Africa's schedule of protected areas was published in the Government Gazette 15726 in May 1994 (Notice 449 of 1994). This classification identifies the following sensitive or protected areas:

Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes, based on their location and the functions they fulfil.

South Africa has also recognised the importance of its wetlands as sensitive ecosystems which require conservation, and accordingly has become a signatory to the international Convention on Wetlands of International Importance especially as Waterfowl Habitat or RAMSAR Convention. In terms of this convention, signatories undertake to include wetland conservation considerations in their national land-use planning, and as far as possible to ensure the wise use of wetlands within their territory.
Before moving on to discuss ecosystems of concern to the study area it would be prudent to give some consideration to the definition of aquatic ecosystems, especially with respect to the National Water Act (No. 36 of 1998). In general terms an ecosystem may be defined as a community of organisms and their physical environment interacting as an ecological unit. Hence, aquatic ecosystems encompass the aquatic community and water resources necessary to sustain its ecological integrity. Within the National Water Act the water resource requirements of aquatic ecosystems are recognised and protected by the introduction of the concept of an ecological Reserve, viz. the water required to protect the aquatic ecosystem of the water resources. The Reserve refers to both the quantity and quality of the resource. Accordingly, development must take cognisance not only of the sensitivity of the receiving ecosystem but also of the resource requirements or ecological Reserve of the aquatic communities it supports.

2.6.2 River Classification

The water resources situation assessment has been performed at the quaternary catchment scale of resolution as described in Section 2.1. However, the delineation of these quaternary catchments was not based on ecological principles. In order to provide some ecological basis for the estimates of water requirements to maintain a particular class of river it was decided to base estimates of water requirements on an index of the ecological importance and sensitivity class (EISC) of the rivers in the quaternary catchment of concern. The ecological importance and sensitivity class of the rivers was used to derive the default ecological management class (DEMC), which relates to a default ecological status class (DESC). The default ecological status class and the present ecological status class (PESC) have been used to arrive at a suggested future ecological management class (AEMC) to be considered for the water resources. The default ecological status class would normally be assigned to a water resource on the basis of ecological sensitivity and importance. This methodology is based on the assumption that the ecological importance and sensitivity of a river would generally be closely associated with its default ecological management class and that its current ecological status and potential to recover from past ecological damage will determine the possibility of restoring it to a particular ecological management class.

This section describes the procedures and methods adopted to estimate the various status and management classes of the rivers that will be used to estimate the corresponding quantities of water required for that component of the Reserve that is necessary to protect the aquatic ecosystems according to the designated class.

The procedure that has been followed to determine the various classifications is illustrated in Diagram 2.6.2.1. The descriptions of the various ecological importance and sensitivity classes (EISC), default ecological management classes (DEMC), default ecological status classes (DESC), present ecological status classes (PESC) and the suggested future ecological management class (AEMC) are given in Diagram 2.6.2.2.

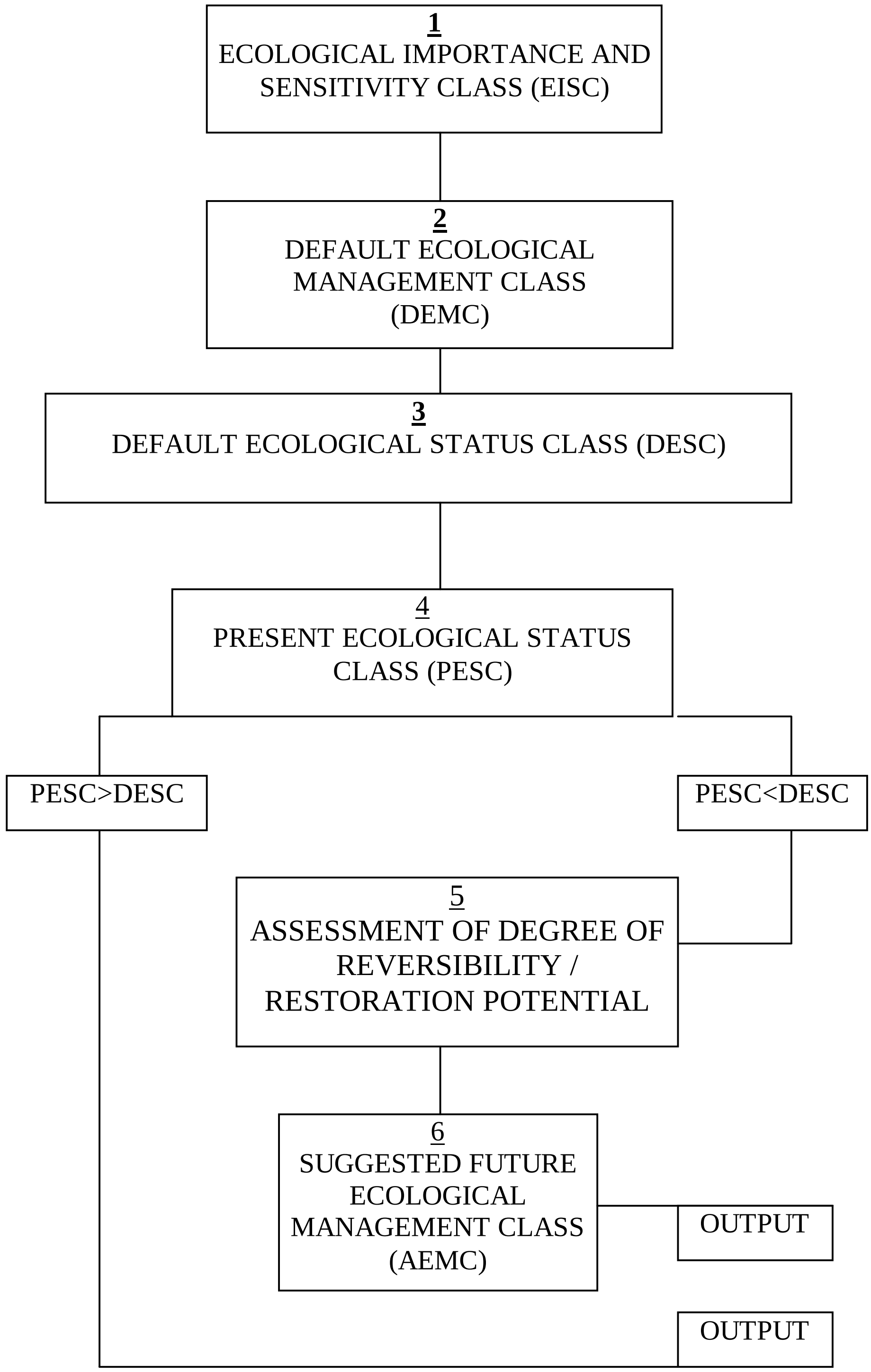
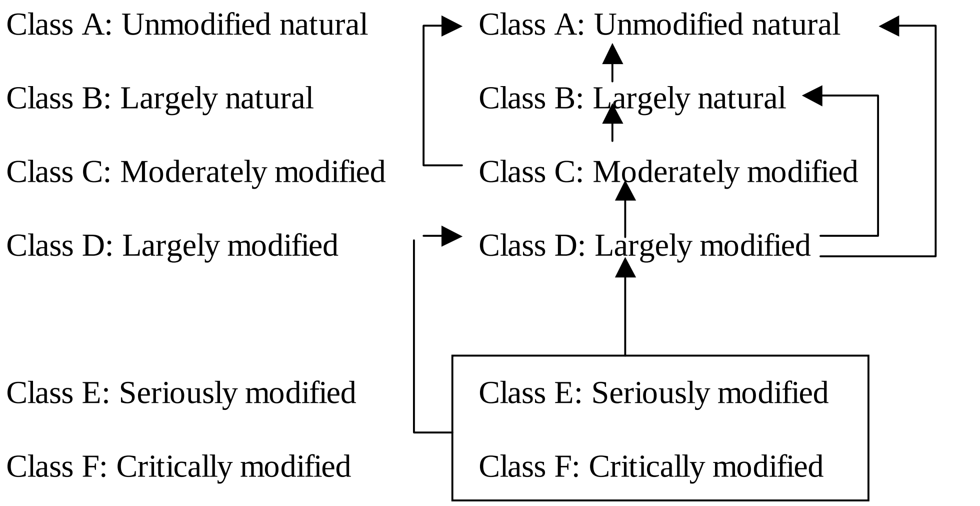


Diagram 2.6.2.1: Procedure followed to determine the river classifications

EISC		DEMC and DESC
Very high	→ No human induced hazards	→Class A: Unmodified natural
High	→ Small risk allowed	→Class B: Largely natural
Moderate	→ Moderate risk allowed	→Class C: Moderately modified
Low/marginal	→ Large risk allowed	→Class D: Largely modified

PESC — PESC: SUGGESTED ATTAINABLE IMPROVEMENT

Acceptable range of AEMC:



→ : indicates relationship.
⟶ : indicates possible direction of desirable change.

Diagram 2.6.2.2: Descriptions of EISC, DEMC DESC, PESC and AEMC.

Individual assessors familiar with the ecology of a particular area or a comparable area were engaged in discussions and workshops during which a number of biotic and habitat determinants considered important for the determination of ecological importance and sensitivity were quantified or scored. The procedure that was followed was considered to be suitable for the situation where the delineation of the quaternary catchment units was not based on ecological considerations. The approach may however, have a low ecological sensitivity because of the absence of an ecological typing framework. The median of the scores assigned by the assessors was calculated to derive the ecological importance and sensitivity class. The assessors were then required to compare this with their overall estimation of the ecological importance and sensitivity class of the mainstream river of the quaternary catchment of concern near its outlet.

The assessors were required to record and be able to substantiate their assessments to a reasonable degree for possible review in future.

The ecological importance and sensitivity classes were assessed during meetings or a workshop held during 1998. This was followed by a second workshop during 1999 that was primarily concerned with the assessment of the present ecological status class, the potential to improve the ecological status class and the suggested future management class. The second workshop however, also involved an overall review of the ecological importance and sensitivity assessments determined during the original workshop.

The procedure that was adopted to classify the rivers was qualified in the following respects:

- Only lotic systems (i.e. streams and rivers and associated habitats such as lotic wetlands) can be classified and the procedure is not meant to be applied to lakes, pans, impoundments or estuaries. Although several of the components considered in this assessment may be generally applicable, the application of the procedure to systems other than rivers and streams was not attempted.

- Where a quaternary catchment contained an estuary, this procedure was only applied to the riverine part of the catchment.

- Only the mainstem river in a quaternary catchment was considered in the assessment and therefore the management class must not be applied to any tributary streams in the quaternary catchment. These tributaries and their associated water requirements do however, become relevant when a water resources situation assessment is conducted at a sub-quaternary level.

- In cases where a dam wall was present at or relatively close to the outlet of a quaternary catchment, the assessments for that quaternary catchment were based on the river upstream of the dam (i.e. upstream of the backwater effect of the dam).

- In cases where degradation has occurred along certain sections of the mainstem of a quaternary catchment, but where there are still substantial less disturbed sections, the classification was based on those less disturbed areas.

  The intention of this was to ensure that the ecological component of the Reserve would provide for these less disturbed sections as if they were situated at the outlet of the quaternary catchment, where the ecological component of the Reserve will be estimated for the water resources situation assessments.

- The classifications were fundamentally considered from an instream and riparian zone perspective. Although the catchment in itself plays a major role in the condition and functioning of the rivers and streams in the catchment, the purpose of this procedure was not to provide an overall assessment of the condition of each catchment.

- The riparian zone was broadly been regarded as that part of the river bordering on the river channel. Usually characteristic plant species and/or vegetation structure provided an indication of the extent of the riparian zone.

  The specific aspects that were considered when classifying the rivers are described below.

Ecological Importance and Sensitivity Class (EISC)
The following ecological aspects were considered for the estimation of the ecological importance and sensitivity class:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, species intolerant to changes in flow regime or water quality and species diversity was taken into account for both the instream and riparian components of the river.

- Habitat diversity was also considered. This included specific habitats and river reaches with a high diversity of habitat types such as pools, riffles, runs, rapids, waterfalls and riparian forests.

- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species.

- The presence of conservation or relatively natural areas along the river section serving as an indication of ecological importance and sensitivity.

- The ecological sensitivity (or fragility) of the system to environmental changes. Both the biotic and abiotic components were included.

The ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and broader scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its resilience or capability to recover from a disturbance that has occurred.

The present ecological status was not considered when determining the ecological importance and sensitivity per se. The ecological importance and sensitivity that has been established for the water resources situation assessments is a general and unrefined estimate. It is strongly biased towards the potential importance and sensitivity of the mainstem river of the quaternary catchment under close to unimpaired conditions.

Present Ecological Status Class (PESC)

Habitat integrity i.e. ecological integrity, condition and change from the natural condition, was regarded as a broad preliminary indicator of present ecological status for the purpose of the water resources situation assessments.

Each of the above attributes that were used to estimate the present ecological status were scored, from which the mean was calculated. This mean was used to assign a present ecological status class to the mainstem river in the vicinity of the outlet of the quaternary catchment.

Suggested Future Ecological Management Class (AEMC)

The potential to improve the ecological conditions was assessed only in terms of the present flow regime. Degradation of the system purely because of non-flow related changes was ignored.

The practicality of improving an existing modified ecological system to arrive at the suggested future ecological management class was assessed on the basis of the changes that have occurred, by comparing the difference between the present ecological status class and the default ecological status. For the purpose of these water resources situation assessments restoration was accepted to be the "…re-establishment of the structure and function of an ecosystem, including its natural diversity". Generally, structure is the native or natural species diversity of the ecosystem, while function is its productivity in terms of growth of plant biomass as the basis for food webs and the functions of hydrology, tropic structure and transport. Restoration is to reverse the decline of the health of a degraded ecosystem towards its historic structure. In contrast, reclamation and rehabilitation are usually more local and site-specific, while habitat creation refers to the establishment of new habitat, without regard to historical conditions.

The water resources situation assessment is, inter alia, concerned with the quantity of water, and therefore particular emphasis was placed on flow modification. Where the impact on the biota and the habitats of the estimated present flow modification was less than can be inferred from the present ecological status, this was taken into account and specifically highlighted (emphasized or flagged). It is obvious that such a state of affairs needs more specific attention. This situation arose only in a limited number of cases and has been indicated in the assessment of both the present ecological status class and the suggested future ecological management class, but needs more specific attention in future.

2.6.3 Aquatic Ecosystem of Concern to the Study

It is important to recognise that within the context of the current report sensitive ecosystems refer specifically to ecosystems which are sensitive with respect to possible changes in water quantity and quality. Other sensitive ecosystems, specifically protected areas, are discussed in Section 2.6.4 below.

The Limpopo WMA contains several major tributaries namely Mokolo River, Lephalala River, Mogalakwena River, Sand River, Nzhelele River and the Nwanedi River. The rivers are all of regional significance and are subject to increasing water resource demands.

The Mokolo River drains the southwestern part of the WMA. The information base of the sensitive ecosystems of this river is outdated. As a consequence this catchment is now the focus of further study and assessment. Available information suggests that the Mokolo River and its tributaries are important from a conservation perspective in view of the occurrence of fish species particular to the highveld environment. Small scale yellow fish, which is specific to this environment, is found particularly in the upper reaches of the Mokolo River and its tributaries.

The Lephalala River is relatively undeveloped and traverses large wilderness areas. Numerous wetland areas also occur in this catchment. The Lephalala River and its tributaries are therefore of particular importance from a conservation perspective in view of:

- Numerous flow dependant species, many of which are red data species, occur along various reaches along the river.
- The short fin barb, which was recently declared as an international red data species, also occurs in this catchment.
- Several red data pool dependant species occur in this catchment due to wetlands and the nature of the river, particularly in the upper parts of the catchment.

The Mogalakwena River is characterized by certain reaches which have relatively little water resources development, but other reaches (particularly the Sterk River) have been highly developed in terms of construction of dams. Diversity of species has been lost in such instances. The river and its tributaries are however important from a conservation perspective due to:

- o Hot/cold flow environment created along the middle reaches of the Mogalakwena River by the cooler mountain streams which confluence with the Mogalakwena River along this reach.
- o Flow dependant species which occur downstream of the Glen Alpine Dam.

- o Refuge offered to numerous species by pool which occur at various points along the river system.
- o The short fin barb, which was recently declared and international red data species, occurs in the Mogalakwena River.

The Sand River, which rises in the Pietersburg area and traverses semi-arid terrain before passing through the gorge at the Soutpansberg mountains, has had little surface water resource development. Groundwater has, however, been extensively developed in large parts of the catchment and the flow regime has therefore been considerably modified.

Flow dependant species are not found in the Sand River. Wetland areas occur in the Soutpansberg area and have been identified with considerable bio-diversity. Mineral springs also occur in the northern section of the gorge in the Soutpansberg mountains. The springs introduce a constant flow of water to the Sand River which has created permanent pools and thus offers refuge to several fish species and invertebrates.

The Nhzelele River comprises a perennial reach upstream of the Nhzelele Dam with considerable water abstraction. The downstream reach has been highly modified by the construction of the Nhzelele Dam.

The upper reaches, which flow through forestry areas and steep mountainous areas, have several red data species. The waterfalls along several of the river reaches in the mountainous areas create breaks which prevent migration of fish species. Numerous flow dependant species occur in the upper Nzhelele and its tributaries. The Mutshedzi Dam in this reach is relatively small with probably minor impact.

The flow in the lower Nzhelele is highly modified by the releases made from the Nzhelele Dam for irrigation. The recent floods (2000) have, however, washed away the numerous weirs and small dams which were constructed along the lower reaches of the Nhzelele River. There are therefore no barriers between the Limpopo River and the Nzhelele River and this assists the migration of fish into the Nzhelele River.

The Nwanedi River drains a small catchment in the northeastern part of the WMA. This river is considered important from a conservation perpective due to the occurence of the endangered snake catfish in the river.

The ecological significance/conservation importance of the river systems falling within the Limpopo WMA, as exemplified by their Ecological Importance and Sensitivity Classes (EISC), are summarised in Figures 2.6.3.1 to 2.6.3.3. These show, respectively for each quaternary catchment, the default ecological management class, the present ecological status class, and the suggested future ecological management class. As outlined in Section 2.6.2 the EISC of a river is an expression of its importance to the maintenance of ecological diversity and functioning on a local and wider scale, as well as the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. As evident from Figure 2.6.3.1, a minority of the river reaches within the Limpopo WMA are classified as "Largely Natural". The largest number of quaternary catchments fall in the "Moderately Modified" category, with a significant portion classified as "Largely Modified". Developers should take cognisance of the significant risk of negative environmental impacts associated with the development of further water resources in areas that are ecologically important.

This overview of the ecological significance and conservation importance of the river systems within the Limpopo WMA is of necessity superficial. However, the assessment of the EISC and Default Ecological Management Class for the various Quaternary Catchments (outline in Section 2.6.2) involved the consideration of a range of ecological determinants, including: rare and endangered biota, unique biota, intolerant biota, species richness, diversity of habitat types or features, refuge value of habitat types, sensitivity to flow changes, sensitivity to water quality changes, migration route / corridor for instream and riparian biota and presence of conservation or natural areas. This information is summarised within the EcoInfo database, and accordingly this database should be consulted as a matter of course at the planning stage of any water utilisation and development projects, to provide insight into the ecological sensitivity of the environment which is likely to be impacted by the proposed project, particularly with respect to sensitivity habitats and rare and endangered species.

2.6.4 Natural Heritage Sites, Proclaimed Game and Nature Reserves, Wilderness Areas

These areas can be defined as areas of natural beauty and/or ecological importance that have been recognised as valuable and set apart to be protected and preserved.

As previously alluded to, the sensitive ecosystems outlined above only include those relevant to aquatic ecosystems. However, in addition to these ecosystems the Limpopo WMA contains other protected areas which may be impacted directly or indirectly upon by developments activities associated with water resources. These protected areas include Natural Heritage Sites as well as those areas listed in Section 2.6.1, viz. Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas, Protected Land Seascapes.

There are a number of conservation areas and nature reserves in the eastern regions with a few others scattered within the WMA. Kransberg in the southern region, Moepelplase in the central region and Messina in the northern region are the largest conservation areas in this WMA. There are many privately owned Game Reserves located in this WMA, as indicated in Table 2.6.4.1

A number of natural heritage sites are situated in the eastern region with a few others scattered within the WMA. Lapalala, Mosdene and Lesheba Wilderness areas are the large proclaimed heritage sites within the catchment. In the southern regions of the catchment Nylsvley is the only proclaimed RAMSAR site.

TABLE 2.6.4.1: PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES WITHIN THE LIMPOPO WMA [(1)]

Area Name	Category
Kransberg	Conservation Areas
Hans Strijdom	Conservation Areas
D Nyala	Conservation Areas
Moepelplase	Conservation Areas
Masebe	Conservation Areas
Wonderkop	Conservation Areas
Blouberg	Conservation Areas
Langjan	Conservation Areas
Happy Rest	Conservation Areas
Hang Klip	Conservation Areas

Area Name	Category
Honnet	Conservation Areas
Messina	Conservation Areas
Vembe	Conservation Areas
Turfloop	Conservation Areas
Machaka	Conservation Areas
Mothibaskraal	Conservation Areas
Pietersburg	Conservation Areas
Kuschke	Conservation Areas
Percy Fyfe	Conservation Areas
Witvinger	Conservation Areas
Zebediela	Natural Heritage Sites
Sterkriver	Natural Heritage Sites
Doorndraai	Natural Heritage Sites
Kurumakatiti	Natural Heritage Sites
Sterkfontein	Natural Heritage Sites
Mosdene	Natural Heritage Sites
Touchstone	Nature Reserves and Wilderness Areas
Laphalala	Nature Reserves and Wilderness Areas
Lesheba Wilderness	Nature Reserves and Wilderness Areas
Robertson en George	Nature Reserves and Wilderness Areas
Little Leigh	Nature Reserves and Wilderness Areas
Devils Gully	Nature Heritage Sites
Mmabolela Estates	Nature Reserves and Wilderness Areas
Breslau	Nature Heritage Sites
Vhembe Nature Reserves	Nature Reserves and Wilderness Areas
Nylsvley	RAMSAR Site

(1) Note: This list should only be viewed as a guide to the protected areas, since as the status of protected areas is constantly changing and new areas are receiving protection, the list cannot be comprehensive. It is the developer's responsibility to ascertain the location of any protected area adjacent to the development and to ensure that activities do not impact on the areas.

2.7 CULTURAL AND HISTORICAL SITES

Development of water supplies and services can have a negative impact on the archaeological and cultural heritage by way of development of dams, pipelines, canals, water services infrastructure and enterprises following on the provisions of water.

The National Monuments Act (No. 28 of 1969) provides for the protection and conservation of cultural resources including all archaeological sites. In addition, the Environment Conservation Act (No. 73 of 1989) provides for the integration of cultural resources into environmental management processes.

Any given development may have an impact on archaeological or cultural heritage sites. It is essential therefore that potential impacts of any water supply and services related development should be assessed at the earliest possible phase of project planning.

Permission for the development to proceed is granted by the National Monuments Council once it is satisfied that steps have been taken to safeguard archaeological or cultural heritage sites, or that they have been adequately recorded and/or sampled.

Sites of cultural and historical importance in the Limpopo WMA include:

- Moorddrif in the Lower Nyl catchment
- Makapansgat in the Upper Mogalakwena catchment
- Makgabeng in the Glen Alpine catchment with bushman paintings.

Other National Monuments occur in the catchment, but these are historical buildings in towns and should therefore not be influenced by development of water resources.

It is still the responsibility of any developer to liaise with the National Monuments Council and South African Museum to establish whether they are aware of any sites of cultural/historical/archaeological interest within any area earmarked for development. Moreover, it is the developer's responsibility to ensure that the development area is surveyed for archaeological sites or artifacts, and that necessary steps are taken to conserve them if they are present. To this end, the developer should be familiar with the relevant sections of the National Monuments Act and any other relevant legislation (e.g. National Parks Act (No. 57 of 1975)), and should consult with the National Monument Council on discovering sites or artifacts of paleontological, archaeological or historical significance. Also, developers should take cognizance of the fact that the National Heritage Act superseded the National Monuments Act in April 2000, and should undertake to familiarize themselves with the contents of the new Act.

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE

Water resources development and the development of related water supply infrastructure in the Limpopo WMA were driven by the following factors:

- Domestic water supply was driven by spatial and temporal demographic patterns. The area encompasses areas of traditional land (mainly parts of the former Lebowa and Venda area) and areas where population growth was stimulated by agricultural, industrial or mining activities.

- Irrigation water supply was driven by the development of irrigation schemes that were developed in the 1950's and1960's, e.g. Sterk River and Glen Alpine Irrigation Schemes.

- Mining and industrial water supply was driven by the discovery and exploitation of coal and minerals such as platinum and diamonds.

- Strategic water supply, driven by the establishment of a large coal-fired power station at Ellisras.

The Matlabas/Mokolo catchment, which is located in the south western part of the WMA, has a moderately high MAP in the upper reaches but is mostly in a semi-arid region and has a low population density.

The availability of especially surface water resulted in extensive irrigation development. This development has been enhanched by the construction of Mokolo Dam, which was developed mainly to support mining and thermal power generation. The associated infrastructure development was undertaken by the then parastatal organizations, Eskom and Yskor.

The Lephalala River catchment, which is located in the western part of the WMA, has a moderately high MAP in the upper reaches, and is semi-arid in the downstream areas. A large number of small farm dams have been constructed in the upper reaches by farmers for irrigation.

In the lower reaches, contribution to runoff is limited due to large endoreic areas occurring. As a consequence only limited irrigation development has occurred. This area does however have a relatively high concentration of people and numerous small local groundwater schemes have been developed by the state to meet basic domestic and stock water needs.

The **Mogalakwena River catchment,** which is located in the central portion of the WMA, is mostly semi-arid and is densely populated, particularly in the central parts of the catchment. A major platinum mine and other mines also occurs in the catchment.

Water resources development occurred mainly to allow irrigation and to meet domestic and urban water needs. The main development occurred during the 1950's and 1960's with the development of the Sterk River and Glen Alpine Irrigation Schemes by the state.

Domestic and urban water supply infrastructure was developed by the municipalities and the state in accordance with population growth. It involved the construction of several medium sized dams and development of wellfields.

Several small mines and one large mine (Potgietersrust Platinums Mine) were developed and utilized local groundwater resources and limited surface water resources.

Irrigation and mining development have been the main driver for economic development.

The **Sand River catchment,** which is located in the eastern part of the WMA, is semi-arid and has a high population concentration in the central and upper reaches of the catchment. Mining development occurs in the northern part of the catchment. Extensive irrigation occurs in the central parts of the catchment which is reliant on groundwater resources.

The initial water supply infrastructure was developed during the early 1900 by private developers for irrigation and mining and by municipalities for urban use. The state later constructed dams in the Luvuvuhu/Letaba WMA to augment water for urban use in the Limpopo WMA.

Mining, agriculture and industry are the main economic drivers in this catchment.

The Nzhelele/Nwanedi catchment, which is located in the north eastern part of the catchment, has high rainfall in the upper reaches of the catchment and is semi-arid in the central and lower reaches of the catchment.

The population density in the upper reaches of the Nzhelele River catchment is high.

Water supply infrastructure development was initially to support irrigation and this activity was significantly advanced by the construction of the Nzhelele and Nwanedi Irrigation Schemes during the mid 1900's by the state.

An extensive bulk water scheme was developed by the state in the upper reaches of the Nzhelele River catchment to meet domestic water needs.

3.2 DEMOGRAPHY

3.2.1 Introduction

A national study (Schlemmer *et al*, 2001) to develop water use projections to the year 2025 was undertaken for the Department of Water Affairs and Forestry, in order to support the development of the National Water Resource Strategy. This included the development of baseline 1995 population estimates. The work commenced well before the results of the 1996 census became available, and a number of sources were used to develop the baseline data set. The database developed was subsequently reconciled with the results of the census in areas where the census had provided superior information.

The study focused on so-called functional urban centres having or likely to have reticulated water supply systems in the future. In a number of instances, areas on the fringe of urban centres and classified as rural in the 1996 census were incorporated with the functional urban centres defined in the study, and urban populations identified in this study therefore differed from the urban populations enumerated in the census.

The regional weighting of census counts to compensate for undercounts was also identified as a factor distorting some urban populations in smaller centres reported in the census.

3.2.2 Methodology

Functional urban areas were identified within magisterial districts. Estimates were made of the 1995 population in these centres, while the populations outside of these urban areas were grouped together as a so-called rural remainder. The urban populations were further categorized in order to provide a basis for developing estimates of urban water use for the entire country (see section 5.3).

A number of sources and approaches were used to obtain baseline population data for the year 1995. These included projections and estimates made by the following institutions:

- The Development Bank of Southern Africa.
- The Demographic Information Bureau.
- The Bureau for Market Research.
- Local authority estimates, where available.

The data from the above sources were compared with extrapolations and estimates based on the following:

- Household counts from the sampling database held by one of the participating consultants.
- Previous census results from 1970 onwards, including former homeland censuses.
- Estimates obtained from very large surveys such as that of the SAARF.
- The database of villages of the Directorate: Water Services of the Department of Water Affairs and Forestry.

Discrepancies were reconciled on the basis of local knowledge and special enquiries directed at local authorities. The results of the 1996 census became available after this had been completed, and was used as an additional check on the database. Where discrepancies were significant these were investigated, and the database was revised where the 1996 census provided improved information.

As an overall check the population distribution database for 1995 that was developed as part of this study was projected for one year on the basis of a ruling population growth rate of 1,9 %. An effective population of 42 379 000 persons in 1996 for the whole of South Africa was arrived at in this way, which is only 1 % above the 1996 census population of 41 945 000 persons.

A reasonable estimate of the distribution of the rural population was made, using the census results for the rural population as a guideline, to develop a spatially distributed database.

3.2.3 Historical Population Growth Rate

The population in the Limpopo WMA comprises residents in urban centres including Ellisras, Nylstroom, Naboomspruit, Potgietersrus, Pietersburg, Louis Trichardt and Messina and of developing rural communities who are concentrated in the former Venda and Lebowa homeland areas.

A major part of the household economy in the rural areas is on survivalist level with some 70 % of the population living in poverty (DWAF: WS Planning, 1999).
Unemployment, which is in the order of 47 % (DWAF: WS Planning, 1999), is a major driver of **migration out** of the WMA to larger industrial centres and urban areas including Johannesburg/Pretoria and Middelburg/Witbank. Migration within the WMA from the rural areas to the urban centres also occurs. Assessments of the absenteeism of potentially economically active males in the WMA during the late 1980's found that some 50 % of males may be considered to be migrant workers (DBSA, 1993).

This situation is aggravated by the formal sectors of the provincial economy displaying a generally declining rate of labour absorption / employment creation relative to output and is also associated with increasing mechanisation.

Indications are that some 50 % of the population do not have access to water which meets RDP Standards. Health services are also poor and the literacy rate is about 53 % (DWAF: WS Planning, 1999). Population movement to areas having improved services have been experienced, but no statistics are available in this regard.

Illegal immigrants, who have migrated to South Africa from neighbouring countries, has occurred for the past several decades. Statistics from the Department of Interior for the late 1980's and early 1990's show a rising trend in the number of illegal aliens with some 2 000 repatriations occurring per week at that time (DBSA, 1993). It is almost impossible to obtain an estimate of the size of the influx of these people in view of the endeavours of such people to remain unidentified.

The historical population growth rate in the WMA is mainly a function of the population growth rate of communities in the former homeland areas.

The former Venda areas, which are located in the north eastern parts of the WMA, experienced a growth rate of between 3,4%/a and 4,5%/a in the period 1960 to 1991 (DBSA, 1993).

The former Lebowa areas, which are located in the central and western parts of the WMA, experienced a moderate to high population growth rate increasing between 1,1%/a and 7,8%/a for the period 1960 to 1991 (DBSA, 1993).

The average population growth rate for the Northern Province for the period 1985 to 1994 was about 3,9%/a (DBSA, 1998).

3.2.4 Population Size and Distribution in 1995

The population of the Limpopo WMA in 1995 is shown in Table 3.2.4.1.

Figure 3.2.4.1 shows the population per key area in scaled dots with the diameters related to the population.

The total population of the **Mokolo/Matlabas River catchment** amounts to about 47 800 and comprises 13 800 urban residents and 34 000 rural residents. The urban population is concentrated in the Ellisras area.

The total population of the **Lephalala River catchment** amounts to about 58 700, none of which are considered to be urban. The population is concentrated in the lower part of the catchment in the former homeland area.

The total population of the **Mogalakwena River catchment** is about 527 000 and comprises of about 73 700 urban residents and about 453 300 rural residents. The population is concentrated mainly in the urban centres of Nylstroom, Naboomspruit and Potgietersrus. Numerous villages occur in the central part of the catchment.

The Sand River catchment has a total population of about 652 000 and comprises about 487 000 urban residents and 165 000 rural residents. Urban residents are concentrated in Pietersburg and Louis Trichardt, while the rural population is settled mostly in the upper and central parts of the catchment.

The northern part of the catchment is sparsely populated in view of its remoteness and semi- arid nature.

The Nzhelele/Nwanedi River catchment has a total population of about 131 000 and comprises about 5 000 urban residents and 126 000 rural residents. The population is concentrated in the numerous villages located in the upper reaches of the catchment.

A detailed breakdown of the population is given in **Appendix A**.

TABLE 3.2.4.1: POPULATION SIZE AND DISTRIBUTION IN 1995

Catchment						Population		
Primary		Secondary		Tertiary				
No	Description	No	Description	No	Description	Urban	Rural	Total
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0	6 345	6 345
					Steenbokpan	0	3 698	3 698
				A42	Mokolo (Upper)	450	18 053	18 503
					Mokolo (Lower)	13 300	5 940	19 240
			Sub total			**13 750**	**34 036**	**47 786**
		A5	Lephalala	A50	Lephalala (Upper)	0	3 699	3 699
					Lephalala (Lower)	0	52 730	52 730
					Soutkloof	0	2 280	2 280
			Sub total			**0**	**58 709**	**58 709**
		A6	Mogalakwena	A61	Nyl (Upper)	33 100	6 525	39 625
					Nyl (Middle)	0	7 365	7 365
					Mogalakwena (Upper)	40 250	144 880	185 130
					Sterk	0	2 796	2 796
				A62	Mogalakwena (Middle)	0	222 722	222 722
				A63	Doringfonteintjiespruit	0	1 767	1 767
					Mogalakwena (Lower)	350	64 680	65 030
					Kolope	0	2 621	2 621
			Sub total			**73 700**	**453 356**	**527 056**
		A7	Sand	A71	Sand (Upper)	141 150	216 956	358 106
					Hout	350	117 120	117 470
					Sand (Lower)	23 450	52 338	75 788
					Kongoloops / Soutsloot	0	5 122	5 122
				A72	Brak	0	95 680	95 680
			Sub total			**164 950**	**487 216**	**652 166**
		A8	Nzhelele	A80	Nzhelele (Upper)	1 900	93 970	95 870
					Nzhelele (Lower)	0	17 858	17 858
					Nwanedi	3 250	13 636	16 886
			Sub total			**5 150**	**125 464**	**130 614**
Total WMA (All Northern Province)						**257 550**	**1 158 781**	**1 416 331**

3.3 MACRO-ECONOMIC INFLUENCES

3.3.1 Introduction

The purpose of this section is to provide an economic overview of the salient features of the Limpopo Water Management Area (WMA) in terms of the following aspects:

- The present economic development of the Limpopo WMA on a sectoral basis, taking into account the context of economic development in South Africa.
- The comparative advantages of the Limpopo WMA.

Selected graphs are included to illustrate the text and additional supporting information is given in **Appendix B**.

3.3.2 Data Sources

The information presented has been derived from a database of macro-economic indicators that was prepared by Urban-Econ: Development Economists from a number of sources, including the Development Bank of Southern Africa. **Appendix B.2** contextualises each WMA economy in terms of its significance to the national economy, as derived from the national economic database. Only gross geographic product (GGP) and labour data are analyzed. A brief description of the database of macro-economic indicators and associated economic information system is given in **Appendix B4**.

Gross geographic product is the total value of all final goods and services produced within the economy in a geographic area for a given period. GGP is the most commonly used measure of total domestic activity in an area and is also the basis for the national account. Changes in the local economy can therefore be expressed as an increase in GGP. Base GGP data for 1972, 1975, 1978, 1981, 1984, 1988, 1991, 1993 and 1994 were obtained from Statistics South Africa. Data for unknown years between 1972 and 1994 were interpolated applying a compound growth formula. The interpolated data was balanced with national account figures. Data for 1995 to 1997 is based on weighted least squares estimates of the long-term trend, taking into account the change in electricity consumed. The projected data was balanced with national account figures. The major limitation of GGP figures is that activities in the informal sector are largely unmeasured.

The **labour** distribution provides information on the sectoral distribution of formal economic activities, as do the GGP figures, but in addition, information is provided on the extent of informal activities, as well as dependency. Dependency may be assessed from unemployment figures, as well as by determining the proportion of the total population that is economically active. Total economically active population consists of those employed in the formal and informal sectors, and the unemployed. Formally employed includes employers, employees and self-employed who are registered taxpayers. Unemployment figures include people who are actively looking for work, but are not in any type of paid employment, either formal or informal. Active in informal sector includes people who are employers, employees or self-employed in unregistered economic activities, i.e. businesses not registered as such. The labour data was obtained directly from the Development Bank of Southern Africa (DBSA). The DBSA has utilized the 1980 and 1991 population censuses as the basis but has also updated the figures utilizing the 1995 October Household Surveys of Statistics South Africa (CSS statistical release P0317 for South Africa as a whole and P3017.1 to P0317.9 for the nine provinces).

The GGP and labour statistics are desegregated into the following major economic sectors:

- Agriculture
- Mining
- Manufacturing
- Electricity
- Construction
- Trade
- Transportation
- Finance
- Government and Social Services (Community Services).

Separate GDP figures for the government and social services are available. However, in the labour market these figures are combined into the community services sector. The nature and composition of each sector are described in Appendix B.3.

3.3.3 Methodology

Each sector of the economy was dealt with in an appropriate way to reflect a reasonable approximation of the spatial distribution of production and labour:

- **Agriculture**

The digitised geographic layer of WMAs was merged with the Magisterial District (MD) boundaries, and the surface area for each of the newly generated polygons was determined. The proportion of the surface area of each of the MD, which falls within each WMA, was calculated, and that proportion was used to allocate the part of a GGP figure that falls on each side of a WMA-boundary.

- **Trade and Community Services**

To take account of the subdivision of local authority areas by MD or WMA boundaries, the number of enumerator areas (EAs) falling within each subdivision of a local authority area, as a proportion of the total number of EAs in a local authority area, was determined. This proportion was applied to the latest population figure (1996 census) of each local authority area. As EAs are of approximately equal population size, these proportions were used to calculate the approximate population for that part of a local authority area which falls within each MD, as they are subdivided by WMA boundaries. The population of each MD segment, as a proportion of the total MD population, was used to calculate the proportion of a GGP figure which should be allocated to each segment of a MD, so that these figures could be totaled up within the WMA boundaries.

- **Other Sectors**

Historical factors such as the relocation of certain segments of the population to non-productive areas, and the immigration of mainly Mozambicans, especially to Mpumalanga and the Northern Province, had to be taken into account when allocating the GGP figure to the WMAs. Subsequently, for all the sectors apart from those discussed above, only the caucasion population was used to perform the calculations as described above.

Economic activities in these sectors are less dependent on population *per se*, but are dependent on the same factors which affect the kind of population distribution that is not distorted by government intervention or other external factors. The caucasion population has typically not been influenced by the latter factors, and its distribution is therefore a better guide for determining the distribution of economic activities in these sectors.

3.3.4 Status of Economic Development

The GGP of the Limpopo WMA was R7,2 bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

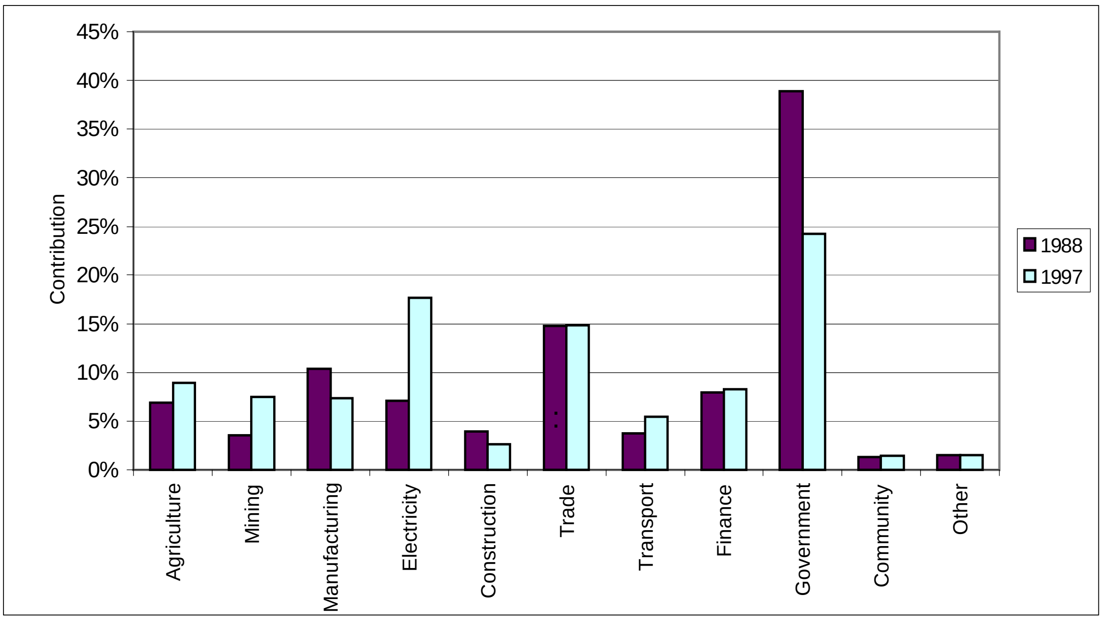
- Pietersburg 26,6 %
- Ellisras 19,8 %
- Potgietersrus 12,0 %
- Seshego 7,7 %
- Mokerong 7,2 %
- Other 26,7 %

❑ **Economic Profile**

The composition of the Limpopo WMA economy is shown in Diagram 3.3.1. Apart from Government expenditure and electricity production, the most important sectors in terms of contribution to GGP are shown below:

- Trade 14,9 %
- Agriculture 9,0 %
- Financial Services 8,3 %
- Mining 7,5 %
- Other 60,3 %

DIAGRAM 3.3.1: CONTRIBUTION BY SECTOR TO ECONOMY OF LIMPOPO WATER MANAGEMENT AREA, 1988 AND 1997 (%)



The significance of the Government sector (24,2% contribution to GGP) can be attributed to the large number of former homeland governing bodies that had to be absorbed into new Provincial and Local Government structures.

Electricity production is significant due to the presence of the Matimba Power Station at Ellisras. This is said to be the largest dry-cooled power station of its kind in the world. Hence, electricity is the second largest sector in the WMA economy, contributing 17,7% to GGP. This sector contributes 6,1% to the national electricity sector.

Agriculture is important as a result of cotton, grain sorghum and tobacco production. Apart from renowned high quality tobacco, the Bushveld Region, which is a sub-region of the Limpopo WMA, contributes 50% to annual national cotton production and 78% to provincial grain sorghum production.

Mining (7,5% contribution to GGP) is largely driven by Platinum Group Metals (PGMs) mines around Northam. These include the Amandelbult Platinum Mine, Union Platinum Mine and Northam Platinum Limited. There is also a PGM mine at Potgietersrus. Other major contributors include Iscor coal and iron ore mines at Ellisras and Thabazimbi.

Trade (14,9% contribution to GGP) and Financial Services (8,3% contribution to GGP) are fuelled by derived demand and, as such, is a function of population size. The high population concentration in this region is portrayed by the density of 45,6 persons/km², which is higher than the national average of 35,5 persons/km². The significance of these two tertiary sector activities (i.e. trade and financial services), can therefore be attributed to the population density in the area and also to the relatively high level of value added by these sectors in comparison to primary sector activities, e.g. agriculture and mining.

- **Economic Growth**

The average annual economic growth by sector is shown in Diagram 3.3.2. Between 1987 and 1997, the highest average growth rates were recorded in the following sectors:

- Agriculture : 0,8% per annum (1988-1997)
- Mining : 6,6% per annum (1988-1997)

The Limpopo WMA has a very small manufacturing base (0,4% contribution to GGP) and in addition negative growth (-5,6% per annum) does not suggest that the rate of economic diversification is likely to accelerate in the near future.

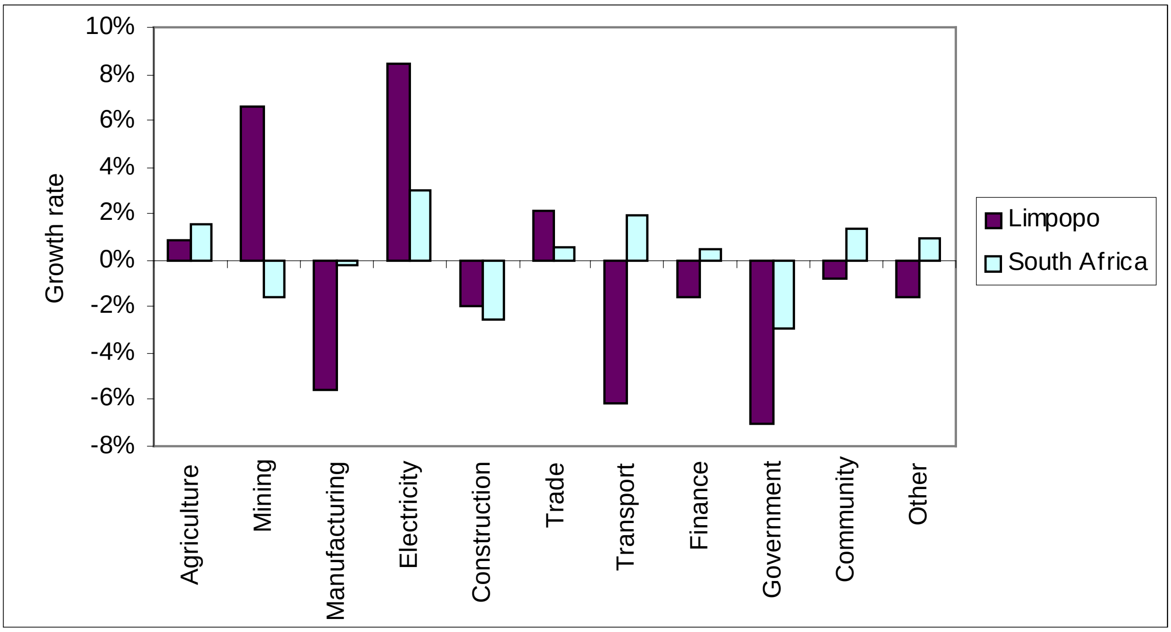
Significant growth in the electricity sector (8,4% per annum) may be attributed to expansion of activities at the Matimba Power Station. Growth in the trade sector (2,2% per annum) may be attributed to population growth and tourism activities (as shown in Appendix B.3, the trade sector comprises trade, catering and accommodation).

- **Labour**

Of the total labour force of 410 000 in 1994, 43,2% were unemployed, which is higher than the national average of 29,3%. Forty five percent (45,5%) are active in the formal economy. Forty four percent (44,5%) of the formally employed labour force work for government, while 21,4%, are involved in agriculture, and 11,1% in trade.

During the period 1980-1994 employment growth was recorded in the electricity sector (6,4% per annum); financial services (6,0% per annum); the government sector (4,8% per annum); and manufacturing (1,8% per annum).

DIAGRAM 3.3.2: AVERAGE ANNUAL ECONOMIC GROWTH BY SECTOR OF LIMPOPO WATER MANAGEMENT AREA
AND SOUTH AFRICA, 1988 - 1997



3.3.5 Comparative Advantages

A geographic area is said to have a comparative advantage in the production of certain goods and services if it can produce them at a lower cost per unit than another region while maintaining the same quality. When this is the case, production of such goods tend to become relatively more concentrated in the region which has the comparative advantage. The location quotient is a measure of the relative concentration of economic activities in a region as compared with another region, or as compared with a larger region of which it forms part. A location quotient for an economic sector with a value of more than one implies that the sector contributes a larger percentage to a sub-region's GGP than that sector contributes to the larger area of which the sub-region forms part. The location quotient can, however, not be equated with comparative advantage, and provides only an indication.

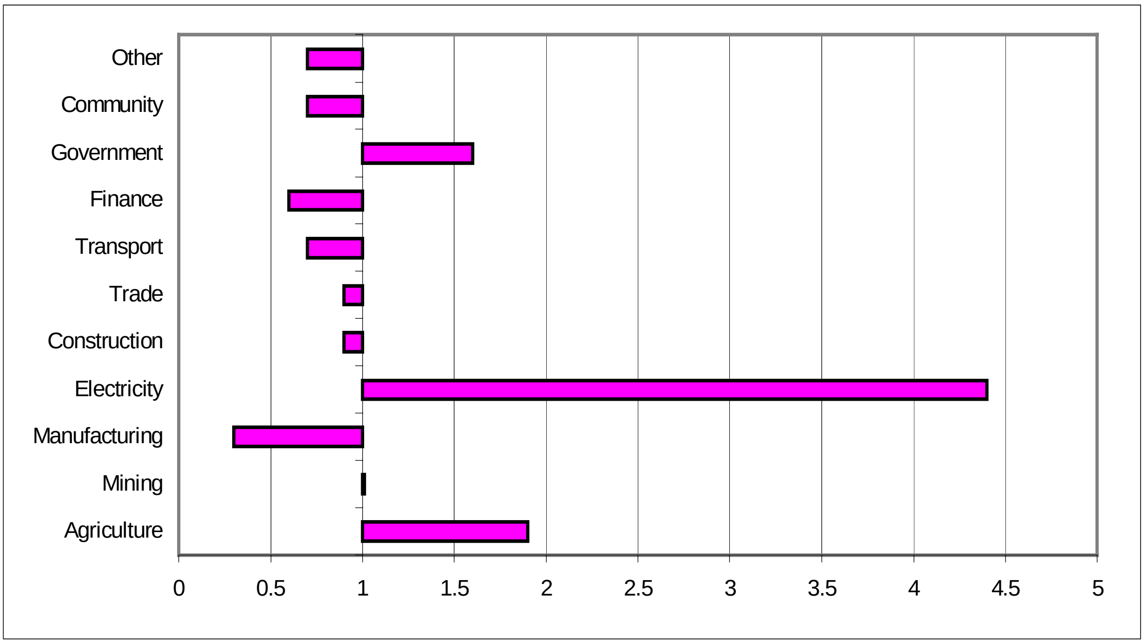
Diagram 3.3.3 shows the location quotients for the Limpopo WMA. The Figure shows that, based on the location quotients for 1997, the Limpopo WMA economy is relatively more competitive than the remainder of South Africa in the following economic activities (excluding Government expenditure and electricity):

- Agriculture : 1,9
- Mining : 1,0

This information affirms the primary nature and function of the Limpopo WMA as an agriculture and mining region.

Government expenditure is not considered to be a comparative advantage due to the fact that it is not an activity that drives economic development.

DIAGRAM 3.3.3: LIMPOPO GROSS GEOGRAPHIC PRODUCT LOCATION QUOTIENT BY SECTOR, 1997



Due to the existence of coal mines at Ellisras, this area has a comparative advantage in electricity production. Electricity production is largely accounted for by one power station: the Matimba Power Station. The high location quotient, however, is more a consequence of the relatively small economic base of the WMA than of the significance of this sector in a national context. In this regard, Mpumalanga Province has a comparative advantage.

The Limpopo WMA does not possess a comparative advantage in trade and tourism activities, seen within a national context, even though this sector is fairly important to the regional economy.

3.4 LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY

3.4.1 Background

The history of settlement in southern Africa is linked to the availability and supply of fresh water. From early times South African water law was based on the needs of white settlers who in colonizing the land promulgated a water law in which domestic and agriculture needs and later industrial needs played the major role (*res publica)* and the government had the function to regulate the use of water (*dominus fluminis*).

Initially Roman and Roman Dutch law had a strong influence in the shaping of South African water law and water running in rivers was regarded as common property. This changed in the latter half of the 19^{th} century, after the occupation of the Cape by the British. The judges trained by the British introduced the principle that owners of property riparian to a river became entitled to water from that river.

The first codification of water law in South Africa was in the Irrigation and Conservation of Waters Act of 1912. The emphasis was still on irrigation and carried down the riparian principle. This Act was repealed by the Water Act of 1956, which also placed a major emphasis on the use of water for irrigation, although other water uses, such as domestic, urban and industrial, also received recognition.

This remained the situation until the National Water Act (Act No. 36 of 1998) (NWA) was assented to by the President on 20 August 1998. As from 1 October 1999 the whole of the NWA came into full effect and is now the only Act dealing with water law.

3.4.2 National Water Act

The NWA does away with and introduces some far-reaching concepts. These concepts have both economic and social features. The former to address water management by conservation and pricing strategy and the latter by ensuring that past discriminatory principles are not continued in the NWA. The most important of these can be summarized as follows:

- The riparian principle is done away with. The nation's water resources become common property, belonging to the nation as a whole. Therefore the previous concept of private ownership in water is done away with;
- The national government, through the Minister of Water Affairs and Forestry, becomes responsible as the public trustee of all water resources to ensure that water resources are protected and water allocated equitably and used beneficially in the public interest. Therefore the NWA reflects the constitutional right of access to sufficient water (Section 27 of the Constitution);
- All right to use water derives from the NWA;
- Water must be available for the Reserve. The Reserve is a new concept and consists of two legs, namely the quantity and quality of water required to satisfy basic human needs as prescribed by the Water Services Act (Act No 108 of 1997) for people who now or will in future require water and to protect the aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. Thus environmental considerations are anchored in the NWA;
- Setting out in the purposes of the Act that institutions which have appropriate community, racial and gender representation must be developed to give effect to the NWA;
- Shifts the emphasis from the traditional "supply management" approach towards "demand management", that is conservation of the nation's water resources by lessening the demand and providing for an innovative pricing system.
- Providing for extensive public participation. Virtually no decision can be made without public participation;
- The abolishment of the Water Courts and introducing a Water Tribunal where administrative final decisions can be appealed to; and
- Recognition of international obligations.

3.4.3 Strategies

The NWA makes provision for establishment of two water management strategies. These are the National Water Resource Strategy and the Catchment Management Strategy. The National Water Resource Strategy is binding on the Minister of the Department of Water Affairs and Forestry, other organs of State and all water management institutions for anything contained therein, while the catchment management strategy is binding on the relevant catchment management agency and is more on a local level.

Water resource management will in future be based on the management strategies and the classification system for the protection of water resources provided for in the NWA. The contents of the National Water Resource Strategy are wide and included therein are the principles relating to water conservation and water demand management; the objectives in respect of water quality to be achieved through the classification system, as well as having to establish the future water needs. The National Water Resource Strategy will also provide for international rights and obligations.

3.4.4 Environmental Protection

Chapter 3 of the NWA deals with protection of the water resources.

The Minister must classify the nation’s water resources and then determine the class and resource quality objectives for each class. This will establish clear goals for resource protection and at the same time provide for a balance between the need to protect and sustain one’s water resources and the need to develop and use them on the other hand.

An important function is for the Minister to determine the Reserve, which as stated above, is closely linked to the Water Services Act (Act No. 108 of 1997).

Section 19 of the NWA provides *inter alia* that any person who is in control of land over which pollution is taking place or who causes pollution or potential pollution to take place, must take the necessary steps to prevent this from continuing. Should this not be done, the Minister shall have the right to take the necessary steps to recover the cost from the responsible person.

3.4.5 Recognition of Entitlements

The NWA abolishes the historical distinction between public and private water. There is no ownership in water and all water is subject to a licensing system, except for the following:

- Water use that is set out under Schedule 1 of the NWA;
- General authorizations issued under section 39 of the NWA; and
- Existing lawful use recognized under the NWA until such time as the person is required to apply for a license.

The statutory difference between water resources within an area proclaimed as a government water control area in terms of the Water Act of 1956 and areas outside a government water control area has now been done away with. In actual fact the whole of the country is a government water control area.

3.4.6 Licensing

Whereas the Water Act of 1956 divided water into different categories, in the NWA all water has the same status. Section 21 of the NWA sets out what is regarded as water use. These include, amongst other uses, taking water from a water resource, storage of water, diverting water, discharging waste into a watercourse, disposing of waste in a manner that may detrimentally impact on a water resource and recreational use.

Two new concepts of water use are created. The first is that the Minister can declare any activity to be a stream flow reduction activity, if that activity reduces the availability of water. Afforestation has already been declared a stream flow reduction activity. The second new concept is that the Minister can declare any activity to be a controlled activity if that activity impacts on a water resource. Activities such as irrigation on any land with waste, recharging of an aquifer are examples of activities that are already controlled activities.

All water use requires a license unless it falls into a Schedule 1 use (this deals with the *de minimus* use, such as water for reasonable domestic use, small gardening and animal watering (excluding feedlots); or was permissible as an existing lawful use (water use permitted under previous laws and which were exercised during the period of two years before the date that section 32 came into effect; namely 1 October 1998); and under a general authorization.

An important innovation is that a license can only be for a maximum period of 40 years and is subject to a review period, which may not be at intervals of more than five years. A license can be increased at each review period but not for more than the review period. This is known as the “revolving license”.

If a person who has an existing lawful use applies for a license under section 43 of the NWA (compulsory licensing), and the application has been refused or has been granted for a lesser amount which results in severe economic prejudice, the applicant may claim compensation. Compensation cannot be claimed if the reduction is to provide for the Reserve, rectify a previous over-allocation or a previous unfair allocation.

Compensation must be claimed from the Water Tribunal.

The Minister has the right to attach conditions to any license as well as to make regulations on various topics set out in section 26 of the NWA.

It is important to note that although the Water Services Act (Act No. 108 of 1997) deals with water services, the actual water use is controlled under the NWA.

3.4.7 Other Legislation

The NWA is aligned with other laws in order to prevent, for example, duplication of applications, unnecessary expenses and where possible, a “one stop” can be issued. Specific examples are as follows:

- Environment assessments in terms of the Environmental Conservation Act of 1989 can be taken into account by the responsible authority when issuing a license;
- If a license is issued under other acts that meet the purpose of the NWA, the responsible authority can dispense with the issuing of a license for water under the NWA; and
- Provisions in the Constitution of the Republic of South Africa must be complied with.

Further, there is a close connection between the Water Services Act (Act No. 108 of 1997) and the NWA.

The Abolition of Racially Based Land Measures Act repealed laws that previously restricted black persons from owning or occupying land.

These acts had the effect of preventing black persons from having any water rights or under certain circumstances, limited water entitlements.

Notwithstanding the NWA there are other acts to which a water user and indeed the State must comply.

These Acts are the following:

Physical Planning Act (Act No. 125 of 1991)
Under this act no land use, development or subdivision may be permitted unless in accordance with an approved plan.

Development Facilitation Act (Act No. 67 of 1995)
This act prescribes the set of principles with which all development projects and all land use and land use planning should comply, and which will serve as guidelines for the administration of land use and development schemes.

Restitution of Land Rights (Act No. 22 of 1994)
This act is aimed at the restitution of land to those who have been deprived thereof in terms of discriminatory laws. Claims are lodged with the Land Claims Commission. It is because of this act that when a transfer of water entitlements is approved in terms of the NWA an indemnity is required from the transferor that a claim was not lodged against the land in terms of the Restitution of Land Rights Act.

Environmental Conservation Act (Act No. 73 of 1989)
This act provides for the effective protection and control of the environment. It makes provision for the declaration of an environmental conservation policy.

In terms of this act the state has a responsibility to act as trustee of the natural environment and to consider all activities which may have an influence on the environment.

Activities, which may have a detrimental effect on the environment, have been published in terms of section 21 of this act. To undertake any of these activities, authorization is required, which can only be obtained from the Minister of Environmental Affairs and Tourism after the prescribed procedure has been complied with. The construction of various forms of water works (dams, water diversions, water transfer schemes, etc.) are subject to the new process.

Through a consultative process a White Paper for Sustainable Coastal Development in South Africa was prepared. In terms thereof it is the joint responsibility of the Departments of Water Affairs and Forestry and of Environmental Affairs and Tourism to protect the in-shore marine environment.

In terms of this act the Department of Environmental Affairs and Tourism is responsible for issuing waste permits under this act and has published a Government Notice 1986 of 24 August 1990 relating to the identification of waste. This government notice needs drastic amendment to bring it in line with the NWA.

In May 2000 the Department of Environmental Affairs and Tourism published a White Paper on Integrated Pollution and Waste Management for South Africa. Aspects included water pollution; diffuse water pollution, marine pollution; and land pollution.

National Environmental Management Act (Act No. 107 of 1998)
This act lays a new foundation for environmental management. The act includes 20 principles that serve as a general framework within which environmental management and implementation plans must be formulated and guide any other law concerned with the protection or management of the environment. Environment is defined as the natural environment and the physical chemical, aesthetic and cultural properties of it that influence human well being.

To give effect to these principles this act creates the National Environmental Forum and the Committee for Environmental Co-ordination and defines the procedure for the establishment of a Coastal Management Subcommittee of the Committee for Environmental Co-ordination in order to achieve better inter-governmental co-ordination of coastal management.

This act provides for the drawing up of environmental implementation plans by certain scheduled national Government Departments and the Provinces. In addition, environmental management plans are to drawn up by certain national Departments. The two sets of plans do not have to be drawn up by the private sector and may be consolidated. The purpose of the plans is set out in detail and must co-ordinate and harmonise environmental policies, plans, decisions of the three spheres to prevent duplication; give effect to co-operative governance and enable monitoring the achievement.

Chapter 7 of this act relates to environmental damage, duty of care, emergencies and remediation.

Conservation of Agriculture Resources Act (Act No. 43 of 1983)
This act is to provide for control over the utilisation of the natural agricultural resources in order to promote the conservation of the soil; the water resources and vegetation and the combating of weeds and invader plants. Except for weeds and invader plants, this act does not apply to land in an urban area.

3.4.8 Institutions Created Under the National Water Act

The NWA creates various institutions, some of which are listed below.

The first are Catchment Management Agencies (CMA) and one CMA will be established in each of the Water Management Areas that have been promulgated by Government Notice 1160 of 1 October 1999 (19 in total). These will have various functions either delegated or assigned to them, thus bringing the management of water resources to the regional or catchment level. A CMA will operate via a board along the lines set out in Schedule 4 to the NWA. The composition of the board is recommended by an Advisory Committee that is established by the Minister and has the important task to recommend to the Minister proposed members who are racially, gender and community representative.

A second institution, is that of Water User Associations (WUA) that will operate on a restricted local level and are in effect cooperative associations of individual water uses who wish to undertake related water activities for a mutual benefit. Irrigation Boards established under the Water Act of 1956 had until 29 February 2000 to transform into a WUA. All WUA’s must have a constitution based on the lines set out in Schedule 5 to the NWA, which must be approved by the Minister. The policy of the Department of Water Affairs and Forestry is that these must also as far as possible be racially, gender and community representative.

A third institution is bodies to implement international agreements. This can only be established by the Minister in consultation with the Cabinet.
A fourth body that the Minister can establish is Advisory Committees. These committees may be established for a particular purpose but can also have powers delegated to it by the Minister.

Lastly the NWA establishes a Water Tribunal where appeals against administrative decisions by the Department of Water Affairs and Forestry and CMA's can be heard. The question of compensation for loss of entitlements to use water is also to be heard in this Tribunal. Appeals on questions of law from the Tribunal are heard in the High Court.

Figure 3.4.8.1 shows the District Councils and Magisterial Districts. Figure 3.4.8.2 indicates the institutional boundaries related to water supply.

3.4.9 Institutional Arrangements

A distinction is made between those institutions that are directly involved, and those that are indirectly involved. A third category is also listed and includes all those forums and committees established to facilitate and co-ordinate the execution of certain initiatives or programmes. These forums and committees do not have any official administrative task or line function and have been established to fulfil a particular task. Similarly, such forums and committees may be disbanded upon completion of such task. Apart from these line departments, there are also political structures that play a vital role.

Institutional structures directly involved. The following structures are considered to be directly involved in the provision of water and sanitation services in the Northern Province (in order of hierarchy):

National level:
- Department of Water Affairs and Forestry (DWAF);
- Department of Constitutional Development (DCD);
- Department of Finance;
- Department of Health; and

Provincial level:
- Department of Housing and Water Affairs;
- Department of Local Government and Traditional Affairs;
- Department of Public Works;
- Department of Health and Welfare;
- Office of the Premier;
- Department of Agriculture, Land and Environment;
- Agriculture and Rural Development Corporation (ARDC).

Local level:
- Northern District Council;
- Bushveld District Council;
- Lepelle Northern Water Board;
- Magalies Water Board
- The various Irrigation Boards.

Institutions indirectly involved. The following are considered to be indirectly involved in the provision of water and sanitation services in the Northern Province (in hierarchical order):

National level:
- Development Bank of Southern Africa (DBSA);

Provincial level:
- Department of Education and Training.

Forums and committees. The following forums and structures have been established to perform specific tasks relating to the provision of water and sanitation in the Northern province (in hierarchical order):

National level:
- National Water Advisory Council;
- Advisory Committee of safety of dams;
- National Community Water and Sanitation Training Institution;
- Financial and Fiscal Commission (FFC); and
- The National Sanitation Task Team (NSTT).

Provincial level:
- Provincial Planning Forum;
- Provincial Liaison Committee;
- Northern Province Development Management Committee, and
- The Inter-departmental Water and Sanitation Planning Forum.

Local level:
- Northern Area Planning Forum;
- Western and Central Area Planning Forum.

Political structures. The following structures are predominantly political in their nature and are also involved in the provision of water and sanitation services, albeit indirectly: (in hierarchical order):

National level:
- National Council of Provinces; and
- South African Local Government Association (SALGA).

Provincial level:
- Northern Province Legislature (with portfolio committees);
- Northern Province Cabinet;
- EXECO: Infrastructure; and
- The Northern Province Local Government Association (NPLGA).

Local level:
- The various Transitional Local Councils (particularly their “Water Desks”).

Tasks and responsibilities. This sub-paragraph presents some perspective on the tasks and responsibilities of those structures that are directly involved. This perspective is presented as follows:

Table 3.4.1: Existing structures.
Table 3.4.2: Existing forums and committees (only those on provincial and local levels).

TABLE 3.4.1: TASKS AND RESPONSIBILITIES OF EXISTING STRUCTURES

Name	Tasks
National level	
DWAF (national and provincial)	Custodian of national water resources.
Department of Constitutional Development (DCD)	Financier of CMIP and BCIG.
Department of Health	Set national standards and priorities (also policy framework).
Department of Finance	Lead and facilitate Financial and Fiscal Commission (FFC) in its work concerning inter-governmental transfers.
Development Bank of Southern Africa (DBSA)	A possible source to finance bulk and reticulation projects.
Provincial level	
Department of Local Government and Traditional Affairs	Administers the CMIP.
Department of Housing and Water Affairs	Administers the BCIG.
Department of Agriculture, Land and Environment	Planning of agricultural projects and schemes, such as intensive irrigation schemes. Conservation of the natural resource base.
Agriculture and Rural Development Corporation (ARDC)	Detail design, implementation and operation of agricultural projects and schemes (i.e. the ARDC can be considered the "implementation arm" of the Department of Agriculture, Land and Environment).
Office of the Premier	Coordinator of all programmes.
Department of Health and Welfare	Procure the provision of water and sanitation services to health facilities. Implement the VIP toilet construction programme.
Department of Public Works	Project manager of the Public Works Programme, School Building Programme and the Clinic Building Programme.
Local level	
Water Boards: ▪ Lepelle Northern Water Board ▪ Magalies Water Board	Plan, implement, operate and maintain bulk water schemes. In extraordinary cases, a water board may also act as a water services authority.
District Councils: ▪ Northern District Council ▪ Bushveld District Council	In accordance with the provision of the Provincial Gazette Extraordinary, 31 July 1995 (No. 73), a district council is considered a local government in terms of the Local Government Ordinance (1939) and a TLC in terms of section 16 of the Local government Transition Act (No. 209 of 1993). As such, the district council has to provide services to a TLC falling in its area of jurisdiction until such time that a TLC has demonstrated that it has sufficient capacity to provide such services itself.
Mvula Trust	Finance and implement certain of the water and sanitation projects
The irrigation boards	In terms of the provisions of Section 89 of the Water Act (No 54 of 1956), the Minister may assign a number of functions, powers and duties to an irrigation board. (The existing irrigation boards will have to restructure themselves into water services authorities by drafting and adopting a Constitution, which has to be proved by the Minister).

TABLE 3.4.2: FORUMS AND STRUCTURES (Provincial and local levels)

Name	Composition	Function
Provincial level		
Provincial Planning Forum	▪ DWAF ▪ Relevant line departments of provincial government ▪ Consultants	To report progress on and discuss all matter relating to CWSS.
Northern Province Development Management Committee	All line departments of provincial government	To coordinate all development projects planned by government, parastatal organizations and community based organizations (also refer to paragraph 1.5.4 of the CWSS Strategic Study Report – p. 34).
Inter-department Development Management Committee	▪ DWAF ▪ All line departments of provincial government ▪ Consultants involved in the CWSS ▪ NGO's and parastatals water services institutions	To coordinate all development projects planned by government, parastatal organizations and community based organizations (also refer paragraph 1.5.4 of the CWSS Strategic Study Report - p. 34).
Provincial Liaison Committee	All line departments of provincial government	To discuss all matter relating to water supply and sanitation. For this purpose, the structure comprise three sub-committees namely: ▪ Water quality planning forum; ▪ Agriculture action commit-tee; and ▪ Disaster committee. (Refer to paragraph 1.5.4 of the CWSS Strategic Study Report – p. 35).
Local level		
Area Planning Form: ▪ Central, Western and Bushveld Districts ▪ Northern District	▪ TLC's ▪ Community representatives ▪ Other (e.g. Mvula, Metsico, etc)	To discuss progress made with CWSS and to assess needs and requirements relating to water and sanitation.
Water Committee(s)	Depends on local circumstances and project(s).	Act as discussion forum for particular project(s).
Reservoir Committees (where they have been established)	Depends on local circumstances.	To act as platform for the communities served by a particular reservoir and other role-players such as the TLC.

Local Government structures include:

Urban TLC's:

- Greater Louis Trichardt
- Greater Messina
- Greater Thohoyandou
- Greater Ellisras
- Greater Nylstroom
- Greater Thabazimbi
- Greater Warmbaths
- Pietersburg/Polokwane
- Naboomspruit
- Potgietersrus/Mahwelereng

Rural TLC's:

- Alldays/Louis Trichardt/Buysdorp
- Elim/Tshitale-Hlanganani/Levubu-Vuwani
- Levubu/Shingwedzi
- Mutale/Masisi/Vhutswema
- Nzhelele/Tshipise
- Ellisras/Marapong
- Northam-Leeupoort
- Vaalwater
- Bochum/My Darling
- Dendron
- Dikgale/Soekmekaar
- Maraba-Mashashane / Maja
- Moletje/Matala
- Mankweng
- Bakenberg
- Koedoesrand/Rebone
- Naboomspruit/Roedtan-Thusang

Irrigation Boards

Name	Nearest town	Number of board members	Total scheduled area (ha)
Bellevue	Potgietersrus	4	289,00
Mogol River	Ellisras	6	4 001,30
Warmbaths	Warmbaths	3	230,45
TOTAL			**4 520,75**

A large number of Tribal Authorities occur in the rural areas.

3.5 LAND USE

3.5.1 Introduction

The limited extent of the water resources has given rise to intense competition between the ever growing water and land use sectors, such as agricultural, industry, domestic and the environment. Figure 3.5.1.1 and Table 3.5.1.1 shows the extent and total area of land use in the Limpopo WMA.

TABLE 3.5.1.1: LAND USE BY DRAINAGE AREAS IN km^2

Catchment						Irrigation	Dryland sugar cane	Other dryland crops	Afforestation	Nature reserves*	Urban	Other**
Primary		Secondary		Tertiary								
No	Description	No	Description	No	Description							
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	9,2	0,0	33,5	0,0	387,3	0,0	3 664,0
					Steenbokpan	18,8	0,0	3,4	0,0	0	0,0	1 917,8
				A42	Mokolo (Upper)	97,6	0,0	604,1	0,0	42,4	0,0	3 574,9
					Mokolo (Lower)	2,0	0,0	129,0	0,0	89,0	0,0	3 856
			Sub total			**127,6**	**0,0**	**770,0**	**0,0**	**518,8**	**0,0**	12 992,6
		A5	Lephalala	A50	Lephalala (Upper)	37,6	0,0	136,0	0,0	198,7	0,0	2 331,7
					Lephalala (Lower)	24,7	0,0	209,4	0,0	0,0	14,4	2 517,5
					Soutkloof	14,4	0,0	26,4	0,0	0,0	0,0	1 214,2
			Sub total			**76,7**	**0,0**	**371,8**	**0,0**	**198,7**	**14,4**	**6 063,4**
		A6	Mogalakwena	A61	Nyl (Upper)	9,6	0,0	299,9	0,0	37,2	0,0	983,3
					Nyl (Middle)	15,1	0,0	281,9	0,0	49,26	0,0	656,74
					Mogalakwena (Upper)	18,6	0,0	393,8	0,0	91,8	0,0	898,8
					Sterk	15,6	0,0	241,6	0,0	105,5	0,0	1 715,3
				A62	Mogalakwena (Middle)	8,8	0,0	1 253,2	0,0	472,1	0,0	4 060,9
				A63	Doringfonteintjiespruit	2,5	0,0	2,4	0,0	0,0	0,0	1 318,1
					Mogalakwena (Lower)	13,4	0,0	409,5	0,0	74,2	0,0	4 254,9
					Kolope	19,1	0,0	2,4	0,0	100,3	0,0	1 870,2
			Sub total			**102,7**	**0,0**	**2 884,7**	**0,0**	**930,7**	**0,0**	15 757,9
		A7	Sand	A71	Sand (Upper)	27,2	0,0	282,2	2,0	96,5	22,8	3 818,3
					Hout	29,6	0,0	458,0	0,0	10,6	0,0	1 952,8
					Sand (Lower)	7,65	0,0	536,0	10,4	289,1	22,8	14 905,9
					Kongoloops / Soutsloot	0,0	0,0	52,0	0,0	20,4	0,0	1 692,6
				A72	Brak	11,6	0,0	1,9	0,0	145,3	0,0	3 303,2
			Sub total			**76,05**	**0,0**	**1 330,4**	**12,4**	**561,9**	**45,6**	25 672,55
		A8	Nzhelele	A80	Nzhelele (Upper)	2,3	0,0	182,0	24,3	0,3	0,0	617,8
					Nzhelele (Lower)	18,9	0,0	38,5	2,0	86,1	0,0	2 089,5
					Nwanedi	25,4	0,0	83,1	0,0	0,0	0,0	1 027,5
			Sub total			**46,6**	**0,0**	**303,6**	**32,6**	**86,4**	**0,0**	**3 733,8**
Total WMA (All Northern Province)						**429,65**	**0,0**	**5 660,5**	**44,0**	**2 296,5**	**60,0**	**64 221,3**

* Includes National parks, wilderness areas, etc.
** Includes all other areas.

Agriculture is the largest land use sector in the WMA with irrigation land covering some 450 km^2. Dry-land cultivation has increasingly been converted to pastures in the recent past. Large parts of the WMA are being used for game and stock farming. The whole area was fully stocked or over stocked but as a result of the drought in recent years stock numbers have decreased.

There are only a few forestry plantations in the high rainfall areas and the indigenous forests are not significant. A few proclaimed nature reserves exist.

Major industries are mainly situated within the urban areas except for the Matimba power station. A variety of products are mined mainly in the Mogalakwena catchment, however, there has been a decrease in mining activity in most instances.

TABLE 3.5.1.2: LAND USE BY DISTRICT COUNCIL AREA

Type of land use	**Areas in Northern Province**		
	Bushveld District Council Area (km^2)	**Northern District Council Area (km^2)**	**Total area (km^2)**
Irrigation	285,1	144,55	429,65
Dryland sugar cane	0,0	0,0	0,0
Other dryland crops	3 193	2 467,5	5 660,5
Afforestation	0,0	42,1	42,1
Nature reserves*	1 324,5	972	2 296,5
Urban areas	14,4	45,6	60,0
Other**	29 062,2	35 159,1	64 221,3
TOTAL	**33 879,2**	**38 830,85**	**72 710**

* Include National Parks, wilderness areas, etc.

** Includes all other areas. Thus the total area in the table equals the total drainage areas.

3.5.2 Irrigation

Irrigated Areas

The total irrigated area and various crop areas for each sub-catchment are shown in Table 3.5.2.1. A map depicting the extent of the existing irrigation is shown in Figure 3.5.1.1. The irrigated area has been accepted as the maximum of the mid-summer crop area and the mid-winter crop area. Considering the given full range of crops being irrigated, mid-summer has been defined as January/February while mid-winter was defined as July/August. This will account for double cropping, where appropriate, and thus shows the crop area, which is a larger area than the irrigated area shown in the land use table (Table 3.5.1.1).

The available information on irrigation methods only stipulates the dominant irrigation method per sub-catchment. The irrigation methods used for a specific crop type however do not vary significantly between different catchments. The methods used include the full range of flood irrigation, sprinkler systems, mechanical systems, micro systems and drip systems.

It is generally recognized that future growth in irrigation will be severely limited by the availability of water. In more water-scarce areas it may even become necessary to curtail some irrigation to meet the growing requirements of domestic and urban water use. In order to do this it will be necessary to base such decisions on sound economic principles that include the economic return per unit of water.

Although acknowledged to be fairly generalized, it is suggested that only three income categories of irrigated crops be used for the purpose of this study. These categories also represent an appropriate grouping for the purpose of assurance of irrigation water supply. Table 3.5.2.2 shows the typical crops within each category.

TABLE 3.5.2.2: ASSURANCE CATEGORIES FOR IRRIGATED CROPS

Category	Crop Examples
Low	Maize, wheat, Soya beans, dry bean, groundnut, lucerne and pasture (small stock). Includes for double cropping.
Medium	Vegetables, potatoes, tobacco, coffee, cotton, pineapple, seed production, sugarcane, lucerne and pasture for dairying and ostrich. Includes double cropping.
High	Citrus, deciduous fruit and nuts, sub-tropical fruit and nuts, grapes, tea, dates and speciality vegetables.

The above categories include for double cropping of the different crop types where appropriate.

3.5.3 Dryland Agriculture

Except for sugarcane, the water use of all the other dryland crops produced in South Africa has been considered to be adequately accounted for in the surface water runoff used to estimate the water resources. Because of the considerable annual variation in dryland cultivation (due to climatic conditions) reliable dryland data are also not always readily available. For completeness, total areas of dryland cultivation were obtained from the CSIR Landcover Spacemaps (CSIR, 1999) and are shown in Table 3.5.3.1. These values serve only to give an indication of the total areas of dryland cultivation and are not necessarily accurate.

No significant dryland sugarcane is being produced in the WMA.

3.5.4 Livestock and Game Farming

Cattle are the most popular form of livestock in the Limpopo WMA and are mainly reared for meat. Sheep and goats are kept in relatively small numbers, due to the hot climate, and the largest numbers are kept in the former Lebowa area, especially goats. Intensive sheep farming is practiced by very few farmers on artificial pastures and mainly for wool and meat. Large piggeries are located near Nylstroom, on the farm Rhenosterpoort 455 KR, near Naboomspruit and one near Gilead.

Game is farmed for hunting and meat production and this type of farming has gained popularity in recent years. The main game species are Impala, Kudu, Water Buck, Gemsbok and Rhino. The northern catchments are more popular for game farming as they are drier and less suitable for cattle. Table 3.5.4.1 gives the readily available numbers of livestock and game and ELSU per tertiary catchment. ELSU is the Equivalent Large Stock Unit of a specific livestock or game type (e.g. four pigs equal one large stock unit). Data for the former homeland areas are either not available or very approximate and therefore the table is incomplete.

A map depicting the extent of the existing livestock and game is shown in Figure 3.5.4.1.

TABLE 3.5.2.1: IRRIGATION LAND USE

Catchment						Irrigation area by crop category				
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description	Perennial	Summer	Winter	Undifferentiated	Total
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	9,2	0,0	0,0	0,0	9,2
					Steenbokpan	18,83	0,0	0,0	0,0	18,83
				A42	Mokolo (Upper)	6,01	49,63	10,09	57,23	122,96
					Mokolo (Lower)	0,09	1,05	0,21	1,17	2,52
			Sub total			**34,13**	**50,68**	**10,3**	**58,4**	**153,51**
		A5	Lephalala	A50	Lephalala (Upper)	6,69	2,71	1,77	24,92	36,09
					Lephalala (Lower)	10,47	7,45	1,02	5,7	24,64
					Soutkloof	1,61	4,07	2,62	10,72	19,02
			Sub total			**18,77**	**14,23**	**5,41**	**41,34**	**79,75**
		A6	Mogalakwena	A61	Nyl (Upper)	0,43	2,97	2,62	7,107	13,141
					Nyl (Middle)	0,68	4,70	4,13	11,194	20,698
					Mogalakwena (Upper)	2,36	5,21	3,78	4,248	15,6
					Sterk	0,3	9,81	6,44	10,73	27,28
				A62	Mogalakwena (Middle)	0,24	1,92	3,39	6,686	12,241
				A63	Doringfonteintjiespruit	0,97	0,27	0,0	1,43	2,67
					Mogalakwena (Lower)	1,73	8,74	2,92	8,149	21,535
					Kolope	2,71	13,66	10,06	4,34	30,77
			Sub total			**9,42**	**47,27**	**33,35**	**53,88**	**143,94**
		A7	Sand	A71	Sand (Upper)	6,18	14,68	0,0	43,75	64,61
					Hout	5,25	16,96	0,0	49,0	71,21
					Sand (Lower)	0,4	1,91	0,0	5,34	7,65
					Kongoloops / Soutsloot	0,0	0,0	0,0	0,0	0,0
				A72	Brak	1,42	7,06	0,0	19,8	28,28
			Sub total			**13,25**	**40,61**	**0,0**	**117,89**	**171,75**
		A8	Nzhelele	A80	Nzhelele (Upper)	5,0	0,0	0,0	5,0	10,0
					Nzhelele (Lower)	8,66	10,63	0,0	2,73	22,02
					Nwanedi	11,04	5,52	0,0	16,55	33,1
			Sub total			**24,70**	**16,15**	**0,0**	**24,28**	**65,12**
Total						**100,26**	**168,93**	**49,06**	**295,79**	**614,06**

TABLE 3.5.3.1: AREAS OF DRYLAND CROPS

Catchment						Dryland crops (km^2)	
Primary		Secondary		Tertiary			
No	Description	No	Description	No	Description	Sugar Cane	Other
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	33,5
					Steenbokpan	0,0	3,4
				A42	Mokolo (Upper)	0,0	604,1
					Mokolo (Lower)	0,0	129
			Sub total			**0,0**	**770,0**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	136
					Lephalala (Lower)	0,0	209,4
					Soutkloof	0,0	26,4
			Sub total			**0,0**	371,8
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	299,9
					Nyl (Middle)	0,0	281,9
					Mogalakwena (Upper)	0,0	393,8
					Sterk	0,0	241,6
				A62	Mogalakwena (Middle)	0,0	1 253,2
				A63	Doringfonteintjiespruit	0,0	2,4
					Mogalakwena (Lower)	0,0	409,5
					Kolope	0,0	2,4
			Sub total			**0,0**	**2 884,7**
		A7	Sand	A71	Sand (Upper)	0,0	282,2
					Hout	0,0	458,0
					Sand (Lower)	0,0	536,3
					Kongoloops / Soutsloot	0,0	52
				A72	Brak	0,0	1,9
			Sub total			**0,0**	**1 330,4**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	182,0
					Nzhelele (Lower)	0,0	38,5
					Nwanedi	0,0	83,1
			Sub total			**0,0**	**303,6**
Total WMA (All Northern Province)						**0,0**	**5 660,5**

TABLE 3.5.4.1: LIVESTOCK AND GAME

Catchment						Numbers of livestock and game				
Primary		Secondary		Tertiary		Cattle & horses	Small livestock	Large antelope	Small antelope	No of ELSU
No	Description	No	Description	No	Description					
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	17 624	6 551	1 254	6 267	23 740
					Steenbokpan	9 800	3 642	697	3 485	13 200
				A42	Mokolo (Upper)	18 433	6 851	1 311	6 555	24 830
					Mokolo (Lower)	23 608	8 775	1 679	8 396	31 800
			Sub total			**69 465**	**25 819**	**4 941**	**24 703**	**93 570**
		A5	Lephalala	A50	Lephalala (Upper)	34 443	24 964	2 224	11 119	48 540
					Lephalala (Lower)	n.a.	n.a.	n.a.	n.a.	n.a.
					Soutkloof	n.a.	n.a.	n.a.	n.a.	n.a.
			Sub total			**34 443**	**24 964**	**2 224**	**11 119**	**48 540**
		A6	Mogalakwena	A61	Nyl (Upper)	10 612	15 223	579	2 893	16 340
					Nyl (Middle)	12 353	17 719	674	3 368	19 020
					Mogalakwena (Upper)	7 787	11 170	425	2 123	11 990
					Sterk	12 489	17 915	681	3 405	19 230
				A62	Mogalakwena (Middle)	18 016	25 843	982	4 912	27 740
				A63	Doringfonteintjiespruit	n.a.	n.a.	n.a.	n.a.	n.a.
					Mogalakwena (Lower)	3 477	4 988	190	948	5 354
					Kolope	2 608	3 741	142	711	4 016
			Sub total			**67 342**	**96 599**	**3 672**	**18 360**	**103 690**
		A7	Sand	A71	Sand (Upper)	15 714	15 679	1 256	6 278	23 130
					Hout	14 661	14 629	1 171	5 857	21 580
					Sand (Lower)	58 102**	57 972**	4 642	23 212	85 520
					Kongoloops / Soutsloot	5 953	5 940	476	2 378	8 762
				A72	Brak	7 249	7 233	579	2 896	10 670
			Sub total			**101 679**	**101 453**	**8 124**	**40 621**	**149 662**
		A8	Nzhelele	A80	Nzhelele (Upper)	n.a.	n.a.	n.a.	n.a.	n.a.
					Nzhelele (Lower)	5 138	11 712	1 448	7 239	14 600
					Nwanedi	n.a.	n.a.	n.a.	n.a.	n.a.
			Sub total			**5 138**	**11 712**	**1 448**	**7 239**	**14 600**
Approximate Total for WMA (All Northern Province)						**278 067**	**260 547**	**20 410**	**102 042**	**410 062**

- Numbers of livestock and game are only an indication of the spatial distribution.

** Data as in WSAM: Need verifying.

3.5.5 Afforestation and Indigenous Forest

There are no large scale commercial forestry plantations within the Limpopo WMA. A relatively small section, approximately 4 200 ha, of exotic forest occur mainly in the mountainous high rainfall areas. Approximately 1 400 ha afforestation (pine) occur in the former Venda in the Tate – Vondo and Joubertstroom forests. Some 2 200 ha is situated in a section of the Entabeni State Forest and private forests in the Piesanghoek area and in the upper reaches of the Mutamba River. The Piesanghoek afforested area, as well as part of the Entabeni State Forest consists of 50% pine and 50% gum plantations. Afforestation in the Upper Mutamba River consists of 190 ha gum plantation and 30 ha of pine plantations.

Hangklip State forest covers approximately 1 000 to 1 500 ha and is situated on the southern slopes of the Soutpansberg north of Louis Trichardt.

There are two sections with some informal exotic plantations, having a negligible effect on the runoff:

a) Within the Nylstroom Municipal Boundary some 180 ha of Eucalyptus plantation are owned by the municipality in the Lower Nyl catchment.
b) Within Lebowa some 304 ha of land is designated for woodlots to provide the local community with building materials and fire wood.

Indigenous forest occurs only in a small area on the Blouberg range, west of the Soutpansberg in the Bochum magisterial district, on the farms The Glade 2 LS and Dantzig 3 LR. In the rest of the Limpopo WMA no significant indigenous forest occurs. The effect of indigenous forests on run-off is regarded as natural.

Table 3.5.5.1 gives areas of afforestation and indigenous forest per tertiary catchment.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST

Catchment						Areas of afforestation					Areas of indigenous forest (km^2)
Primary		Secondary		Tertiary		Eucalyptus (km^2)	Pine (km^2)	Wattle (km^2)		Total (km^2)	
No	Description	No	Description	No	Description						
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0,0	0,0	0,0	0,0
					Steenbokpan	0,0	0,0	0,0	0,0	0,0	0,0
				A42	Mokolo (Upper)	0,0	0,0	0,0	0,0	0,0	0,0
					Mokolo (Lower)	0,0	0,0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,0	0,0	0,0	0,0	0,0
					Lephalala (Lower)	0,0	0,0	0,0	0,0	0,0	0,0
					Soutkloof	0,0	0,0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	0,0	0,0	0,0	0,0	0,0
					Nyl (Middle)	0,0	0,0	0,0	0,0	0,0	0,0
					Mogalakwena (Upper)	0,0	0,0	0,0	0,0	0,0	0,0
					Sterk	0,0	0,0	0,0	0,0	0,0	0,0
				A62	Mogalakwena (Middle)	0,0	0,0	0,0	0,0	0,0	0,0
				A63	Doringfonteintjiespruit	0,0	0,0	0,0	0,0	0,0	0,0
					Mogalakwena (Lower)	0,0	0,0	0,0	0,0	0,0	0,0
					Kolope	0,0	0,0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
		A7	Sand	A71	Sand (Upper)	1,717	0,291			2,008	0,0
					Hout	0,0	0,0	0,0	0,0	0,0	0,0
					Sand (Lower)	3,574	4,816	0,004	0,125	8,519	3,775
					Kongoloops / Soutsloot	0,0	0,0	0,0	0,0	0,0	0,0
				A72	Brak	0,0	0,0	0,0	0,0	0,0	0,0
			Sub total			**5,291**	**5,107**	**0,004**	**0,125**	**10,52**	**3,775**
		A8	Nzhelele	A80	Nzhelele (Upper)	9,137	19,845		0,641	29,623	0,0
					Nzhelele (Lower)	0,154	1,818			1,972	1,121
					Nwanedi					0,0	0,0
			Sub total			**9,291**	**21,663**	**0**	**0,641**	**31,595**	**1,121**
Total						**14,582**	**26,77**	**0,004**	**0,766**	**42,122**	**4,896**

3.5.6 Alien Vegetation

The impacts of the widespread infestations by alien plants in South Africa are increasingly recognized. The total incremental water use of invading alien plants was estimated at 3 300 million m^3/a by Le Maitre *et al*. (1999) but this estimate is not widely recognized by the water resources planning community. This estimate is almost twice as high as the estimate for stream flow reduction resulting from commercial afforestation. Le Maitre *et al*. (1999) estimate that the impact will increase significantly in the next 5 to 10 years, resulting in the loss of much, or possibly even all, of the available water in certain catchment areas. Again, this is a debatable point requiring more research to verify these statements.

Much of the infested areas are in the riparian zones where the degree of infestation is largely independent of the rainfall in the surrounding areas. The acacias, pines, eucalyptus, and prosopis species and melia azedarachs are among the top ten invading aliens, which account for about 80 % of the water use by alien vegetation.

Commercial afforestation has been one of the major sources of alien vegetation in South Africa, largely as a result of poor past forestry management practices. The results of a recent national scale study (Nel et al., 1999) showed that about 44% of the area invaded by plantation trees (pine, eucalyptus and black wattle) overlaps with areas affected by commercial afforestation practices. The new commercial afforestation plantations generally tend to be well-managed, maximizing benefits of forestry and minimizing environmental impacts.

Alien vegetation infestations across South Africa were mapped under supervision of a CSIR (Environmentek) team using a "best expert knowledge" approach, supplemented by existing detailed localized maps and Geographic Information System (GIS) data sets obtained from certain specific authorities. The expert knowledge was gathered through workshops in different regions and the expert information was mapped directly onto overlays on 1:250 000 scale topographic maps. Data capture procedures were designed to standardize the approach and terminology and to ensure consistency and comparability in the inputs made by the wide range of people involved.

Areas invaded by alien vegetation were mapped as independent polygons with each polygon accompanied by attribute data regarding species and density. All polygons and attribute data were captured in a GIS (Arc/Info).

The following shortcomings and limitations of the CSIR data base on alien vegetation infestation have been highlighted by Görgens (1998):

- The quality of data gathered is known to be variable as it depended on the level of expert knowledge available, the nature of the terrain and the extent and complexity of the actual invasion.
- Mapping of alien vegetation ending very abruptly (and artificially) along some or other administrative boundary.
- Mapping of riparian infestations along rivers at the coarse scale of the available GIS coverages (generally, 1:500 000 with 1:250 000 for some areas) could have led to significant under-estimates of river lengths and, therefore, of infested riparian areas. For example, a pilot comparison by the CSIR of 1:50 000 scale (a suitable scale) and 1:500 000 scale maps yielded a river length ratio of 3,0 and greater.

- Riparian infestation identification in a particular catchment with the simple statement: "all rivers are invaded". In these cases, all the river lengths appearing in the particular coverages were assigned a uniform infested "buffer" strip of specific width, say 20 m.
- Small rivers not reflected on the smaller scale mapping were not accounted for and therefore infestation along these particular rivers was not mapped or quantified.

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION

Catchment						Alien vegetation
Primary		Secondary		Tertiary		
No	Description	No	Description	No	Description	Condensed Area (km^2)
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0
					Steenbokpan	0,0
				A42	Mokolo (Upper)	•
					Mokolo (Lower)	0,0
			Sub total			**0,0**
		A5	Lephalala	A50	Lephalala (Upper)	•
					Lephalala (Lower)	0,0
					Soutkloof	0,0
			Sub total			**0,0**
		A6	Mogalakwena	A61	Nyl (Upper)	155,1
					Nyl (Middle)	115,8
					Mogalakwena (Upper)	0,2
					Sterk	169,9
				A62	Mogalakwena (Middle)	45,3
				A63	Doringfonteintjiespruit	0,0
					Mogalakwena (Lower)	0,0
					Kolope	0,0
			Sub total			**486,3**
		A7	Sand	A71	Sand (Upper)	238,1
					Hout	39,5
					Sand (Lower)	0,0
					Kongoloops / Soutsloot	0,0
				A72	Brak	0,0
			Sub total			**277,6**
		A8	Nzhelele	A80	Nzhelele (Upper)	11,3
					Nzhelele (Lower)	0,6
					Nwanedi	•
			Sub total			11,9
Total in WMA (All Northern Province)						**775,8**

- Detailed information not available.

The condensed areas of infestation are shown in Figure 3.5.6.1.

3.5.7 Urban Areas

Urban areas are located throughout the study area and include residents in major and small towns as well as settlements and villages. The extent of the urban areas is shown in Figure 3.5.1.1. Major urban areas are Pietersburg, Louis Trichardt, Messina, Nylstroom, Naboomspruit, Potgietersrus, Ellisras and Vaalwater.

The population are mainly concentrated around these major urban areas. Large numbers of people have also settled on former Trust Land.

3.6 MAJOR INDUSTRIES AND POWER STATIONS

There are only a few major industries in the Limpopo WMA. They are mainly situated within the urban areas.

Silicon Smelter
A silicon smelter is located adjacent to Pietersburg and was commissioned in the early 1970's. The smelter anticipates that present production will be maintained for at least 20 to 30 years.

Some 600 (1990) persons are employed of whom most reside in Pietersburg and in the villages and settlements in the former Lebowa located in close proximity.

Pietersburg Industrial Area

The proclaimed industrial areas in Pietersburg are located to the west and north of the CBD. There are eight wet industries in Pietersburg, viz.:

- Development Board (beer brewing)
- Granor Passi (fruit juice production)
- SA Bottling (soft drink production)
- Kanhym (meat processing)
- Municipal Abattoir
- SA Brewery
- TAL Bakery
- Hospital Services (laundry)

Messina Industrial Area

Industries in Messina include service industries, a vegetable processing works and light manufacturing. Of these, the Langeberg vegetable processing factory is the most important and is considered to be a wet industry.

Potgietersrus Industrial Area

Nedan Edible Oils is the only wet industry in Potgietersrus.

Matimba is the only power station in the Limpopo WMA. Table 3.6.1 gives more detail on the power station.

TABLE 3.6.1: POWER STATIONS IN THE LIMPOPO WMA

Quaternary catchment	Name	Type	Generating capacity (MW)	Owner
A42J	Matimba	Coal	3 690	Eskom

As stated in Section 4.5, no hydro power stations have been developed in the WMA.

3.7 MINES

3.7.1 Introduction

Mining operations in South Africa encompass a wide range of activities, which include the dressing, and benefaction of naturally occurring minerals, whether in solid, liquid or gaseous form to render the material marketable or to enhance the market value of the material. Mining operations include underground and surface mines, quarries and the operation of oil and gas wells.

Products of the mining industry in the Limpopo Water Management Area include fluorspar, tin, chrome, diamonds, granite, silicon, bricks, sand, vanadium, platinum, manganese and aggregate, coal, graphite and copper.

All known operating mines in the Limpopo WMA are shown in Figure 3.7.1 and listed in Appendix D. Mines that have an impact on the hydrology and water quality of the river systems, and mines that impact significantly on the economy of a region or town are highlighted.

For summarising mining impacts the Limpopo WMA has been divided into five sub-catchments.

The sub-catchments are:

- Mokolo River
- Lephalala River
- Mogalakwena River
- Sand River
- Nzhelele River

The impact of mining activities on hydrology, water quality and on the economy is described in general terms for the WMA within the sub-catchment areas listed. Quantitative information is given in Chapter 5.

3.7.2 Mokolo River

Coal mining is the most important mining activity in this catchment as this supply Matimba power station with coal.

3.7.3 Lephalala River

No mining operations have been undertaken in this drainage region. The region does have some deposits of phosphates, coal, iron, vanadium and kieselguhr, which may be economical viable.

3.7.4 Mogalakwena River

Mining has in the past contributed significantly to the Gross Geographic Product of various magisterial districts partly or wholly located in the Mogalakwena River Basin. There has been, however, in most instances, a decrease in activity during recent years (pre-1995). Platinum and fluorspar is still mined. Mining contributes particularly to the economic productivity in the magisterial districts of Potgietersrus, Waterberg and Mokerong II.

3.7.5 Sand River

There are several mines located in this catchment. Most of the mines in the region are dry mines and therefore water use is mainly for domestic purposes. Several wet mines also occur. These include the Messina Copper Mine and Silicon Smelter.

3.7.6 Nzhelele River

Mining activities at the mines were at low intensity and have now ceased.

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW

Regional Water Supply Schemes, which have water sources located outside the Limpopo WMA, include the following:

- The Roodeplaat Dam Scheme (Magalies Water) supplying several centres in the Crocodile West and Marico WMA as well as Nylstroom in the Limpopo WMA.

- Olifants-Sand and Letaba Regional Water Supply Schemes, which supply water to Pietersburg, Seshego, Lebowakgomo, Mankweng, numerous villages and major industries. Water is drawn from the Olifants River (only since 1997), Ebenezer and Dap Naude Dams on the Letaba River, Seshego Dam on the Blood River (tributary of the Sand River) and several well fields in the Sand River Catchment.

- The Louis Trichardt Regional Water Supply Scheme, which draws water from Albasini Dam (Luvhuvhu River) and the Dorps River wellfield.

Regional Water Supply Schemes which lie within secondary sub-catchments of the Limpopo WMA, but which draws water from one or more sources and delivers water to one or more water user groups, includes the following:

- Mokolo Dam supplying Ellisras and irrigation along the Mokolo River.

- Greater Potgietersrus Regional scheme which supplies Greater Potgietersrus, irrigation and PPL Platinum mine. Water is obtained from Doorndraai Dam, four separate well fields and numerous dispersed boreholes. Doorndraai Dam also provides water to the Sterk River irrigation scheme.

- Nzhelele Regional Water Supply Scheme in which water is drawn from the Nzhelele River, Tshifire River and Mutshedzi Dam and delivered to 55 villages.

Other large bulk water supply schemes include the following:

- Glen Alpine irrigation scheme, which draws water from the Glen Alpine Dam and provides irrigation water along the Lower Mogalakwena River.

- Nzhelele irrigation scheme, which draws water from the Nzhelele Dam and provides irrigation water along the Lower Nzhelele River.

- Nwanedi irrigation scheme, with bulk water supplied by the Nwenadi-Luphephe Dams.

Several other towns and concentrations of villages have developed bulk water supply schemes and these include Naboomspruit, Messina and Sinthumule/Kutama villages.

Venetia diamond mine draws water from a wellfield on the Limpopo River. The mine also has an off-channel storage dam fed by flood water.

Some 660 villages obtain water supplies from dispersed boreholes. Groundwater is also used to meet irrigation water needs in certain areas particularly in the Sand River catchment.

More than 600 minor dams have been constructed to improve the assurance of irrigation water supplies and for stock and game watering.

Plans have been drafted to supply numerous villages located in the northern parts of the Luvuvhu/Letaba WMA with water from the Nwanedi Dam on the Nwanedi River.

The Limpopo WMA is semi arid and the topography is relatively flat. The construction sites for major dams are therefore limited and water from possible new dams will be expensive. Bulk water is conveyed over relatively long distances from existing dams to the major towns. Possible major dams may be constructed on the Sterk River (at Groenvley) and the upper Lephalala River. The Glen Alpine, Nzhelele and Mutshedzi Dams may be raised in future.

Groundwater is extensively used in view of the scarcity of surface water, limited suitable dam sites and the low population of the large number of scattered villages (average population only 1 300).

Hydro electric or pumped storage power stations have not been constructed, nor is any being planned.

Table 4.1.1 shows the combined capacities of individual town and regional potable water supply schemes by key area.

TABLE 4.1.1: COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL POTABLE WATER SUPPLY SCHEMES BY KEY AREA

Catchment						Area (km^2)	Population	Town and Regional Water Supply Schemes			
Primary		Secondary		Tertiary				No of people supplied	% Of key area population	Capacity	
No	Description	No	Description	No	Description					(10^6 m^3 /a)	(ℓ/c/d)
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	18,4	6 347				
					A41E	37,7	3 698				
				A42	Mokolo (Upper)	220,5	18 500				
					Mokolo (Lower)	4,5	19 240				
			Sub total			**281,1**					
		A5	Lephalala	A50	Lephalala (Upper)	73,7	3 699				
					Lephalala (Lower)	63,7	52 730				
					Soutkloof	33,4	2 280				
			Sub total			**170,8**					
		A6	Mogalakwena	A61	Nyl (Upper)	177,8	39 625	23 800			
					Nyl (Middle)	151,6	7 365	8 700		1,2	378
					Mogalakwena (Upper)	46,1	185 130	89 300		4,55	140
					Sterk	213,9	2 796				
				A62	Mogalakwena (Middle)	66,4	222 722				
				A63	Doringfonteintjiespruit	5,2	1 767				
					Mogalakwena (Lower)	34,9	65 030				
					Kolope	49,9	2 621				
			Sub total			**745,8**					
		A7	Sand	A71	Sand (Upper)	354,7	358 106	117 000		15,4	360
					Hout	140,3	117 470				
					Sand (Lower)	555,5	75 788	20 000			
					Kongoloops / Soutsloot	0,0	5 122				
				A72	Brak	39,8	95 680				
			Sub total			**1090,3**					
		A8	Nzhelele	A80	Nzhelele (Upper)	42,9	95 870	90 000		3,8	116
					Nzhelele (Lower)	43,5	17 860				
					Nwanedi	58,5	16 886				
			Sub total			**144,9**	**1 416 332**				
Total WMA											

4.2 REGIONAL WATER SUPPLY SCHEMES WHICH EXTEND OVER THE LIMPOPO WMA BOUNDARY

4.2.1 Magalies Roodeplaat Dam Scheme

This scheme supplies treated water to residents in the Hammanskraal area, north of Pretoria, as well as Warmbad and Nylstroom, the latter being located in the Limpopo WMA. The scheme is owned and operated by Magalies Water.

Raw water is drawn from Roodeplaat Dam located on the Pienaars River. The water is treated at Klipdrift raw water works, which is located near Hammanskraal.

Water is pumped at a rate of 75 ℓ/s through a 350 mm diameter pipeline to Warmbad/Nylstroom (See figure 4.1.1). It is anticipated that the design capacity of the pipeline (85 ℓ/s) will be reached by about 2003 (Magalies Water, 1999). The relatively high tariff (R2-20/kℓ) of this water has resulted in a drastic drop in water use in Nylstroom. As a consequence, Nylstroom's own water source, Donkerpoort Dam, is practically not used.

4.2.2 Olifants-Sand-Letaba System

The Olifants-Sand-Letaba system supplies water to the Pietersburg area. It has developed from several separate schemes that have become interlinked. The main components of the system area are shown on Diagram 4.2.2.1. Details of the dams and water treatment works associated with the system are given in Table 4.2.2.1. The system draws water from the Olifants River (Olifants WMA), Letaba River (Luvuvhu/Letaba WMA), Blood River (Sand River catchment in the Limpopo WMA) and several wellfields. Details of the various components of the Olifants-Sand-Letaba system are as follows:

(i) **Dap Naude Water Supply Scheme** draws water from the Dap Naude Dam on the Broederstroom, tributary of the Great Letaba River. The dam, which is owned by the Pietersburg/Polokwane TLC, has a gross storage capacity of $2,08x10^6 m^3/a$ and a firm yield of $5,6x10^6 m^3/a$ and an estimated yield of $3,8x10^6 m^3/a$ at 98% assurance (Steffen, Robertson & Kirsten, 1990). Raw water is conveyed over a distance of about 60 km through a 572/419 mm OD steel pipeline to Pietersburg. The water is treated in a 18,0 Mℓ/d treatment works. The pipeline requires refurbishment and can presently only convey $3,6 \times 10^6 m^3/a$.

(ii) **Pietersburg Government Regional Water Supply Scheme (PGRWS)** draws bulk water from Ebenezer Dam, which is downstream of the Dap Naude Dam in the Luvhuvhu Letaba WMA. Ebenezer Dam has a gross storage capacity of $70,12x10^6 m^3/a$ and firm yield $21,9 \times 10^6 m^3/a$. Water is purified at a 42 Mℓ/d raw water treatment works located immediately downstream of the dam. Treated water is pumped through two 600 mm diameter pipelines (each 428 ℓ/s capacity - Lepelle Northern Water, 1999) to Mankweng, 20 km distant. From Mankweng water is pumped a further 22 km through a 600 mm diameter pipeline to Pietersburg.

This scheme is operated by Lepelle Northern Water and delivers water to Pietersburg, Seshego, Haenertsburg, Dalmada plots, Mankweng and numerousvillages in the Mankweng TLC area. The allocation from Ebenezer Dam for this scheme is 18,53 x $10^6 m^3/a$. Due to the fact that the infrastructure is not fully developed, only 15 x $10^6 m^3/a$ can be supplied. The remaining water in the dam is allocated for irrigation along the Groot Letaba River downstream of the dam.

(iii) **Olifants-Sand Water Supply Scheme** draws water from the Olifants River at a weir at Olifantspoort. Water is treated at this point in a 38 Mℓ/d raw water treatment works before being pumped to Pietersburg (allocation $5{,}4x10^6 m^3/a$), via Lebowakgomo (allocation $7{,}6x10^6 m^3/a$). The conveyance system after Lebowakgomo has a capacity of 27 Mℓ/d.

Treated water from this scheme is delivered to Pietersburg, Seshego, Perskebult adjacent to Seshego and numerous villages in the Groothoek-Lebowakgomo area. Water can also be supplied to the Klipspringer mine located near Zebediela Estates, west of Lebowakgomo.

Plans have been drafted to significantly increase water availability in the Olifants River by raising Arabie Dam and/or constructing Rooipoort Dam. The associated treatment and conveyance systems will be upgraded.

(iv) **Blood River Dam Scheme** is located on the Blood River adjacent to Seshego. The dam has a gross capacity of 2,38 x $10^6 m^3$ and yields about 1,4 x $10^6 m^3/a$ (De Wet Shand, 1992). Water gravitates from the dam through a 200 mm diameter AC pipe to a raw water treatment works (3,95 Mℓ/d) located a short distance from the dam. Water from five boreholes is combined with this water and delivered to domestic users in Seshego.

(v) **Pietersburg wellfields** comprise several separate concentrations of boreholes viz.:

- Sand River North boreholes, which are located downstream of the sewage purification works on the banks of the Sand River. This well field comprises 22 production boreholes and has a sustainable yield of 12,3 Mℓ/d.

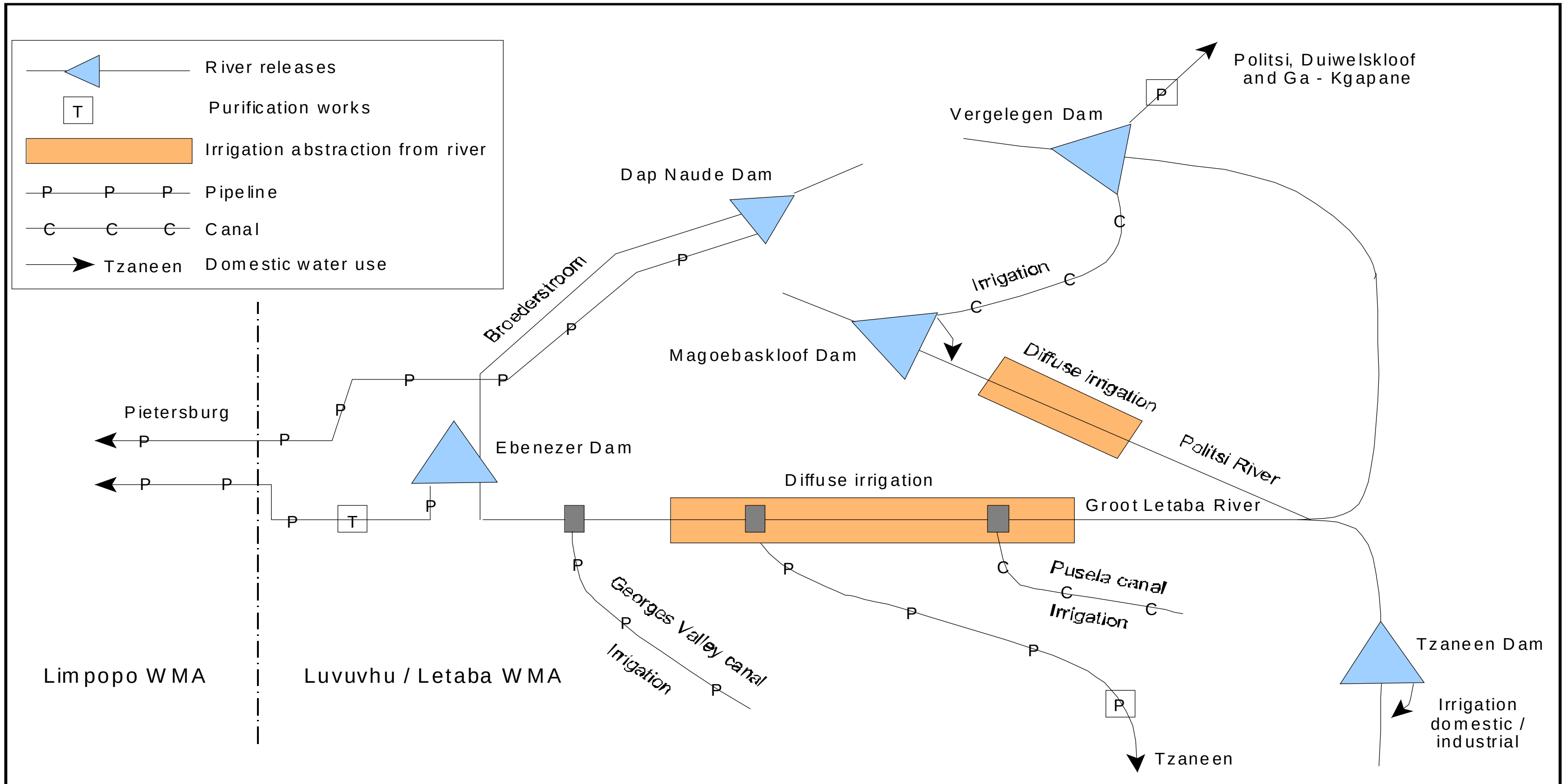
  Discharge from the Pietersburg sewage effluent treatment works recharges the aquifer.

- Sand River borehole scheme is located between Pietersburg and the Sand River. This scheme is no longer in use due to vandalism.

- The Penina Park and Marshall Street boreholes are located along the Sterkloop River adjacent and in Pietersburg. The scheme consists of six production boreholes and has a sustainable yield of 2,0 Mℓ/day.

- The Westenburg borehole scheme is located west of Pietersburg, but is no longer in production.

DIAGRAM 4.2.2.1: SCHEMATIC LAYOUT OF LETABA SYSTEM



DAP NAUDE / EBENEZER / MAGOEBASKLOOF / FANIE BOTHA SYSTEM: SCHEMATIC LAYOUT

DIAGRAM 4.2.2.1

TABLE 4.2.2.1: REGIONAL WATER SUPPLY SCHEMES WHICH EXTEND OVER THE LIMPOPO WMA BOUNDARY

Treatment works			Raw water works					
Name	**Capacity (Ml/d)**	**Owner / operator**	**Name**	**Yield**		**Additional yield allocated to other users ($10^6m^3/a$)**	**Owner**	**Operator**
				$10^6m^3/a$	**(Ml/d)**			
Magalies Roodeplaat Dam System								
Wallmannstal	?	Magalies Water	Roodeplaat Dam	?	?		DWAF	Magalies
Donkerpoort	3,4	Nylstroom TLC	Donkerpoort Dam	0,6	1,6	0	Nylstroom TLC	Nylstroom TLC
Olifants-Sand-Letaba System								
Olifants Poort	38	Lepelle Northern Water	Olifants River	7,66	21,0	Irrigation: Environment: Other domestic:	DWAF	DWAF
Ebenezer Dam	42	Lepelle Northern Water	Ebenezer Dam	21,9	50,8	Irrigation:	DWAF	DWAF
Dap Naude	18	Pietersburg TLC	Dap Naude Dam	5,6	15,3	0	Pietersburg TLC	Pietersburg TLC
Seshego	3,95	Pietersburg TLC	Blood River Dam	1,4	3,8	0	Pietersburg TLC	Pietersburg TLC
Pietersburg wellfield	-	Pietersburg TLC	Sand River North wellfield Penina Park & Marshall Street	4,49 0,73	12,3 2,0	0	Pietersburg TLC	Pietersburg TLC
Louis Trichardt Water Supply System								
Albasini	5,7	Louis Trichardt TLC	Albasini Dam	3,58	9,82	Irrigation:	DWAF	DWAF
Louis Trichardt wellfield	-	Louis Trichardt TLC	Louis Trichardt wellfield	0,24	0,7	0	Louis Trichardt TLC	Louis Trichardt TLC

4.2.3 Louis Trichardt Regional Scheme

This scheme draws water from the Albasini Dam and a wellfield located adjacent to Louis Trichardt.

(i) **The Albasini dam** in the Luvuvhu River is located in the Luvuvhu/Letaba WMA some 25 km east of Louis Trichardt and has a capacity of 29,7 x $10^6 m^3$. The dam delivers water to Louis Trichardt/Tshikota (allocation 9,82 Mℓ/d). Water is treated at the dam in a 5,7 Mℓ/d treatment works before being pumped to Louis Trichardt. The pipeline has a capacity of 10 Mℓ/d. At present, about 2,2x10^6 m^3/a water is delivered to Louis Trichardt. Albasini Dam also provides water for irrigation downstream of the dam.

(ii) **The Louis Trichardt wellfield** comprises 12 production boreholes and has a sustainable yield of 0,24 x $10^6 m^3$/a.

4.3 REGIONAL WATER SUPPLY SCHEMES IN THE LIMPOPO WMA

Main Dams and Regional Schemes in the Limpopo WMA are shown in Table 4.3.1 and Table 4.3.2 respectively. Table 4.3.3 shows Potable Water Supply Schemes. A general overview of water related infrastructure (Source: DWAF Water Services) are given in Figure 4.1.1.

4.3.1 Greater Potgietersrus Regional water supply system

The Greater Potgietersrus system was developed as several separate schemes, that is becoming more linked due to the scarcity of water in the region.

The water sources are all located in the Mogalakwena River catchment and comprise Doorndraai Dam, several well fields and numerous dispersed boreholes. Water is supplied to Potgietersrus, Mahwelereng, several denser settlements, PPL platinum mine and irrigation on the Sterk River irrigation scheme. Details of the various components of the water supply system are given below:

(i) **Doorndraai Dam** is located on the Sterk River and has a storage capacity of 47,2 x 10 $^6 m^3$ and a firm yield of 8,6 x 10^6 m^3/a making no allowance for the reserve. The dam, which is owned by DWAF, provides water for irrigation and domestic use in Potgietersrus/Mahwelereng.

The Sterk River irrigation scheme receives water from Doorndraai Dam through an extensive canal system. Conveyance losses are in the order of 30% to 40%. Initially some 1966 ha were scheduled for irrigation, but water rights were purchased by the state during the early 1990's and the scheme now has 520 ha scheduled for irrigation. The water allocation is 7 200 m^3/ha/a.

Domestic water for Potgietersrus and numerous minor water users (allocation 4,38 x $10^6 m^3$/a) is treated in a raw water treatment works (8,2 Mℓ/d capacity) located near Doorndraai Dam. The treated water is pumped over a distance of 34 km to Potgietersrus. The pipeline capacity is limited to 2,63 x $10^6 m^3$/a (7,2 Mℓ/d) and needs refurbishment, particularly along certain sectors.

Plans have been drafted to construct a new pipeline from Doorndraai Dam to Potgietersrus, which would allow conveyance of the full allocation of water from Doorndraai Dam.

Capacity would also be available to convey irrigation water entitlements, which would be purchased for domestic use. The potable domestic water supply system is owned by DWAF and operated by Lepelle Northern Water.

(ii) **Planknek wellfield** is located in the Dorps River catchment and comprises 19 production boreholes. The sustainable yield of the boreholes is 1,6 x 10^6 m^3/a. The scheme is owned by the Potgietersrus TLC and the water is used to meet consumer's needs in Potgietersrus and Mahwelereng.

(iii) **Treated sewage effluent** from Potgietersrust and Mahwelereng is fully reused in the process plant of PPL platinum mine, to irrigate sports fields and the golfcourse, and to produce lucerne for the zoological gardens.

Sewage effluent from Potgietersrus is treated in a 3,4 Mℓ/d works located adjacent to the Nyl River. Treated sewage effluent is pumped to maturation ponds before being pumped to the various users mentioned above. At present (1995) some 2,0 Mℓ/d treated sewage effluent is recovered from the plant. Water losses are estimated to be about 1,4 Mℓ/d.

Sewage effluent from Mahwelereng is treated in two separate sets of oxidation ponds before being routed through the Potgietersrus sewage treatment works and then pumped to the maturation ponds for reuse. Some 1,0 Mℓ/d sewage effluent is produced.

Plans have been drafted to extend the Potgietersrus sewage treatment works to accommodate sewage effluent from Mahwelereng and extensions in Potgietersrus.

(iv) **Dispersed boreholes**

More than 50 production boreholes have been developed in Mahwelereng and the denser settlements by DWAF and private organisations to meet critical water shortages which have occurred in this area during the past decade. These boreholes deliver about 2,1 Mℓ/d.

The Rooisloot wellfield, which lies within this area, is out of production due to vandalism and over exploitation of the catchment groundwater.

(v) **PPL well fields** comprise separate groundwater developments at Zwartkop, Blinkwater and Commandodrift. The well fields are owned and operated by PPL. The combined sustainable yield of the well fields amounts to about 4,3 Mℓ/d (1,57 x $10^6 m^3$/a).

TABLE 4.3.1: MAIN DAMS IN THE LIMPOPO WMA

Name	Live storage capacity (10^6 m^3)	Firm yield [1]			Owner	1:50 Yr yield from Water Balance Model (10^6 m^3)
		Domestic supplies (10^6 m^3)	Irrigation (10^6 m^3)	Other (10^6 m^3)		
Mokolo River Catchment:						
Mokolo	146,0	1,0	10,4	17,2[2]	DWAF	
Mogalakwena River Catchment:						
Donkerpoort	2,38	0,6	-	-	Nylstroom TLC	
Welgevonden	0,92	0,6	-	-	Naboomspruit TLC	
Doorndraai	46,63	4,38	4,22		DWAF	
Glen Alpine	21,8	-	5,6	-	DWAF	
Sand River Catchment:						
Blood	2,36	1,4	-	-	Pietersburg TLC	
Hout	6,89	0,6	-	-	DWAF	
Spies	2,89		?		DWAF	
Nzhelele River Catchment:						
Mutshedzi	2,37	1,5			DWAF	
Nzhelele	55,4		7,8		DWAF	
Nwanedi River Catchment:						
Nwanedi	5,56		? [3]		DWAF	
Luphephi	15,02		? [3]		DWAF	

1) The allocation of water to irrigation is greater than the volume shown because water is supplied at a lower assurance.
2) Matimba power station and Grootegeluk Colliery.
3) Dams are operated as a system.

TABLE 4.3.2: REGIONAL SCHEMES WITHIN THE LIMPOPO WMA

Treatment works			Raw water works					
Name	Capacity (Mℓ/d)	Owner / operator	Name	Firm yield $10^6 m^3/a$	Firm yield (Mℓ/d)	Additional yield allocated to other users ($10^6 m^3/a$)	Owner	Operator
Greater Potgietersrus regional Water Supply Scheme								
Doorndraai Dam	8,2	DWAF/Lepelle Northern Water	Doorndraai Dam	4,38	12,0	4,22	DWAF	DWAF
			Planknek wellfield	1,6	4,4	0	Potgietersrus TLC	Potgietersrus TLC
			Treated sewage effluent			1,1(1)	Potgietersrus TLC	Potgietersrus TLC
			Dispersed boreholes	0,77	2,1	0	DWAF	DWAF
			PPL Wellfields	1,57	4,3	0	PPL	PPL
Nzhelele regional Water Supply Scheme								
Mutshedzi Dam	3,6	DWAF	Mutshedzi Dam	1,5	4,1	0	DWAF	DWAF
-	-	-	Nzhelele weir	2,0	5,5	Run-of-river for irrigation	DWAF	DWAF
Tshifire	1,73	DWAF	Tshifire River	0,6	1,7	Run-of-river for irrigation	DWAF	DWAF
Mokolo regional Water Supply Scheme								
Zandvlei	17,0	Iscor	Mokolo Dam	1,0	2,7	26,1(2)	DWAF	DWAF

1) Treated sewage effluent delivered to PPL platinum mine.
2) Raw water delivered to Grootegeluk Colliery, Matimba power station and irrigation

TABLE 4.3.3: POTABLE WATER SUPPLY SCHEMES

Scheme name	Raw water source	Population supplied	Scheme capacity		
			(10^6 m^3 / a)	(ℓ/c/d)	Limiting factor
Mokolo River catchment					
Mokolo	Mokolo Dam		1,0		None
Phalala River catchment					
Witpoort scheme	Boreholes				Source
Mogalakwena River catchment					
Nylstroom Water Supply Scheme	Magalies Roodeplaat Dam, Donkerpoort Dam	23 800			None
Naboomspruit Water Supply Scheme	Welgevonden Dam, boreholes	8 700	1,2	378	Source
Greater Potgietersrus	Doorndraai Dam, boreholes	10 300[(1)] 37 500[(2)] 41 500[(3)]	2,85 0,9 0,8	758[(4)] 65 52	 Source Source
Pietersburg/Polokwane	Dap Naude Dam, Ebenezer Dam, Olifants-Sand transfer, Blood Dam, boreholes	117 000	15,4	360[(4)]	None
Hout River scheme	Hout River Dam				
Louis Trichardt Water Supply Scheme	Albasini Dam, boreholes	20 000			Water source
Messina Water Supply Scheme	Limpopo well points				None
Nzhelele Water Supply Scheme	Nzhelele River, Mutshedzi Dam	106 000	3,8	98	Non-payment for services, water wastage
1) Potgietersrus 3) Mahwelereng 2) Denser settlements 4) All in water use					

4.3.2 Mokolo Regional Water Supply Scheme

The Mokolo Regional Water Supply Scheme comprises of the Mokolo Dam (gross capacity 146,0 x $10^6 m^3$, firm yield 27,1 x $10^6 m^3/a$) located in the middle reaches of the Mokolo River. The dam was constructed to assure water supply to the Matimba power station (allocation 7,3 x $10^6 m^3/a$), Iscor coal mine (allocation 9,9 x $10^6 m^3/a$), Ellisras and adjacent urban water users (allocation 1,0 x $10^6 m^3/a$) and irrigation (allocation 10,4 x $10^6 m^3/a$, at lower level of assurance).

Raw water is drawn from the dam and pumped through a 700 mm diameter steel pipeline to Ellisras via a balancing dam at Wolwefontein some 40 km from Mokolo Dam. Part of the water is treated in a 17 Mℓ/d raw water treatment works before being delivered through a 450 mm diameter pipeline to Ellisras. The scheme is owned and operated by Iscor.

Raw water is drawn from the balancing dam and delivered to Iscor and Matimba power station. Escom treats water for own use and also delivers potable water to Marapong of the Ellisras TLC.

Irrigation water is released from Mokolo Dam into the Mokolo River where it is abstracted by riparian irrigators as required.

4.3.3 Nzhelele Regional Water Supply Scheme

The Nzhelele Regional Water Supply Scheme comprises of abstraction weirs on the Nzhelele and Tshifire Rivers and the Mutshedzi Dam on the Mutshedzi River. These rivers all form part of the upper Nzhelele River system.

The Nzhelele government irrigation scheme draws water from Nzhelele Dam (storage capacity 57,2 x $10^6 m^3$, firm yield 7,8 x $10^6 m^3/a$). Some 2 100 ha is scheduled for irrigation with an allocation of 8 400m^3/ha/annum. Irrigation water is distributed to the irrigators through a canal system. Crops produced include mainly citrus and cash crops (20%).

The Nzhelele weir is located in the upper reaches of the Nzhelele River (capacity 2,0 x $10^6 m^3/a$). The abstracted water is conveyed under gravity in a pipe network to some 21 villages.

The Mutshedzi Dam scheme comprises of the Mutshedzi Dam having a capacity of 2,4 x $10^6 m^3$ and a firm yield of 1,5 x $10^6 m^3/a$. Raw water is treated a short distance downstream of the dam in a 3,6 Mℓ/d raw water treatment works. Treated water is delivered to 28 villages including Makhado (a proclaimed town) and the Makhado tomato-processing factory.

The Tshifire scheme comprises of two weirs, one on the Tshifire River and another on a tributary. The Tshifire River is a tributary of the Mutshedzi River, which in turn is a tributary of the Nzhelele River. Water is conveyed under gravity from the weirs, after rudimentary treatment, to some 6 villages. The capacity of the works is about 1,73 Mℓ/d.

More than 4 000 of the households in the 55 villages supplied have metered yard connections.

Some 18 villages located near the Nzhelele Dam comprising some 11 000 residents, obtain water supplies from dispersed boreholes. The water is reticulated to street taps.

The total population served by the Nzhelele scheme is about 90 000 people.

4.3.4 Nwanedi River catchment

Development in the Nwanedi River catchment is limited essentially to the Nwanedi irrigation scheme. This scheme obtains bulk water from the Nwanedi-Luphephe Dams, which has a combined storage capacity of 20,6 x $10^6 m^3$. Water is released form the dam into a canal system which distributes the water to the irrigators. The Cross Dam, located in the Nwanedi River and linked to the canal system, provides balancing storage.

Plans have been drafted to supply some 30 000 residents in 43 villages with treated water from the Luphephe/Nwanedi Dam.

4.4 OTHER WATER SUPPLY SYSTEMS

4.4.1 Lephalala River catchment

Water user groups in the catchment comprise essentially of:

- 58 000 residents in 37 villages located along the lower reaches of the Lephalala River.
- 5 400 ha diffuse irrigation located along the Lephalala River and the main tributaries.

The rural domestic water users obtain water supplies from groundwater. Eight villages are serviced by the Witpoort Regional scheme while individual borehole schemes, comprising one or more boreholes, a short rising main, reservoir and rudimentary reticulation, service the remaining villages.

Individual irrigators developed irrigation schemes where water is obtained mainly from more than 530 farm dams having a combined capacity of about 9,5 x $10^6 m^3$.

More than 20 of the irrigation dams have been registered with the dam safety office.

The potential exists to construct a large dam (capacity 63,6 x $10^6 m^3$) on the Lephalala River on the farm Doornkom LR 657 (WSM (Pty) Ltd, 2000).

4.4.2 Nylstroom water supply

Water is obtained from the Magalies Water Roodeplaat Dam scheme and Donkerpoort Dam.

The Donkerpoort Dam is located on the Klein Nyl River and has a gross storage capacity of 2,38 x $10^6 m^3$ with a firm yield of about 0,6 x $10^6 m^3/a$ (1,6 Mℓ/d). Raw water is treated in a 3,4 Mℓ/d treatment works.

As stated in section 4.2.1, water from the dam is not being utilized.

4.4.3 Naboomspruit water supply

Water is obtained from the Nyl wellfield and Welgevonden Dam. The Nyl wellfield comprises of 9 production boreholes and is located adjacent to Naboomspruit. Naboomspruit has an allocation of 1,0 x 10^6 m^3/a but the sustainable yield is about 0,75 x 10^6 m^3/a.

Welgevonden Dam has a capacity of 0,92 x 10^6 m^3/a and a firm yield of about 0,6 x 10^6 m^3/a. The total water use (1995) in Naboomspruit is about 1,1 x 10^6 m^3/a.

4.4.4 The Glen Alpine irrigation scheme

This scheme provides irrigation water from the Glen Alpine Dam (capacity 21,9 x 10^6 m^3, firm yield 5,6 x 10^6 m^3/a under present catchment conditions) to some 707 ha scheduled for irrigation. Some 251 ha was scheduled for irrigation in the former Lebowa but was never developed.

Irrigators have a quota of 6 200 $m^3/ha/a$ and the water is released about 3 times per year in slugs. Each release amounts to about 20% of the total storage capacity of the dam. The water is stored temporarily in dams constructed by irrigators in the river and on adjacent properties. About 70% of the water released are lost.

DWAF are considering the possible raising of Glen Alpine Dam in order to increase the yield, for, inter alia, supply to rural villages, although it has been shown conclusively that these villages can be supplied with groundwater.

4.4.5 Diffuse irrigation in the Mogalakwena River Catchment

The main concentrations of irrigation occur in the Moorddrift area near Potgietersrus, Gillimburg area in the central parts of the Mogalakwena River catchment and in the Glen Alpine Dam area. A summary of the irrigation developed is as follows (Steffen Robertson & Kirsten, 1992):

		Irrigation land use (ha)	**Irrigation water need ($10^6 m^3/a$)**	**Unit water need ($m^3/ha/a$)**
Region	Northern	5 800	54	9 400
	Central	7 400	57	7 800
	Southern	5 650	39	6 900
	TOTAL	**18 850**	**150**	**8 000**
Seasonal	Summer	11 600	92	8 000
	Winter	5 500	38	6 700
	Perennial	1 750	20	12 400

Water supply is obtained equally from surface water and groundwater sources. More than 700 farm dams have been developed to improve the level of assurance from surface water sources.

Privately developed Water Supply Schemes generally consist of a farm dam or system of boreholes as the developed water source, from where the water is pumped to the irrigation application systems. These systems usually comprise overhead sprinkler systems or drippers.

Smaller urban centres which obtain water supplies from locally developed groundwater sources include Alldays and Marken.

4.4.6 The Sand River Catchment

Major urban areas in the Sand River catchment include Pietersburg and Louis Trichardt. Major schemes have been developed to meet the urban and large industrial water requirements, as described previously. Major industrial water users include SA Breweries (SAB) and Silicon Smelters.

Smaller urban centres which obtain water supplies from locally developed groundwater sources include Soekmekaar, Dendron and Messina.

Some 466 000 residents located in about 350 rural villages obtain water supplies mainly from groundwater, excepting for the group of settlements located east of Pietersburg, which are becoming more and more dependent on bulk water from Ebenezer Dam.

There are no government developed irrigation developments in the Sand River catchment, but extensive privately developed irrigation occurs.

Venetia diamond mine is located near Alldays in the Mogalakwena River catchment. The mine's water requirements, which amount to about 2,5 x 10^6 m^3/a, are obtained from a wellfield developed along the Limpopo River (quaternary catchment A71L, Soutsloot Key Area).

Messina water supply is obtained from well points in the Limpopo River and on the banks of the river. A weir, some 2 m high, was constructed in the Limpopo River a short distance downstream of Beitbridge to provide additional storage.

Water is pumped from the Limpopo River through a 500 mm diameter steel pipeline to Messina. Present water use amounts to about 11,0 Mℓ/d (4,0 x 10^6 m^3/a).

The western Sand River catchment rural villages comprise approximately 170 villages in the former Seshego and Bochum districts of Lebowa. The population (1995) amounts to about 217 000.

Water supplies are obtained almost entirely from groundwater, excepting for 12 villages, which draw water from Hout River Dam. Hout River Dam has a storage capacity of about 7,49 x $10^6 m^3$ and a firm yield of about 0,6 x $10^6 m^3$/a. Water is treated at the dam before being reticulated.

Borehole schemes comprise concentrations of boreholes which supply several villages, or as in most cases, one or two boreholes which supply water to one village. The local schemes comprise a short rising main through which water is pumped to a reservoir located in or near the village. The water is usually distributed through street taps.

The Soutpansberg villages and settlements are concentrated at Buysdorp and Sinthumule/Kutama. Buysdorp is located about 60 km west of Louis Trichardt and comprises some 450 families. Water is drawn from two perennial streams (yield about 0,17 x $10^6 m^3/a$) and reticulated to 1 kℓ tanks at each house.

Sinthumule/Kutama comprises some 64 000 residents concentrated in 39 villages located some 20 km south west from Louis Trichardt. This area falls within the municipal boundaries of the Greater Louis Trichardt TLC. Water supplies are obtained from 19 production boreholes scattered throughout the area. The water is pumped to central reservoirs from where it is reticulated in the villages to street taps. A large number of illegal yard connections have been made.

Eastern Sand River catchment rural villages comprise concentrations of villages in the former Sekgosese and Thabamoopo district of the former Lebowa.

The Sekgosese area has some 60 000 residents concentrated in about 50 villages. Water supplies are obtained from dispersed boreholes.

The Thabamoopo area, which includes Mankweng and the University of the North, has some 130 000 residents concentrated in about 100 villages and settlements. This area is traversed by the Ebenezer Dam - Pietersburg pipeline (refer to section 4.2.2). Bulk water connector pipelines have been constructed from this pipeline to reticulate treated water to certain of the villages and settlements, including Mankweng. This scheme will be extended to ultimately service almost all the villages. Indications are that the full domestic allocation from Ebenezer Dam (18,53 x $10^6 m^3/a$) would be required to satisfy rural domestic needs.

Dispersed irrigation occurs throughout the Sand River catchment with the main concentrations occurring along the Sand River near Pietersburg and south and north of the Soutpansberg, in the vicinity of Dendron and Vivo in the western parts of the catchment, and along the Limpopo River. Some 8 600 ha have been developed for irrigation and water supplies are obtained almost entirely from groundwater. Approximately 125,5 x $10^6 m^3/a$ is used.

4.4.7 Nzhelele River Catchment

Nzhelele River catchment comprises some 113 700 people in the upper reaches of the catchment and irrigation throughout the catchment.

Irrigation occurs from run-of-river schemes in the upper Nzhelele River catchment and from a government water supply scheme downstream of Nzhelele Dam.

The run-of-river irrigation scheme draws irrigation water in most cases from weirs, which discharge into canal systems. Irrigation water application is almost in all cases by flood irrigation. The total area irrigated amounts to about 1 000 ha. Irrigation is very inefficient and the total water use amounts to about 21,3 x $10^6 m^3/a$.

According to the N'Jelele Act of 1948, irrigation water abstraction may only occur during the 12 daytime hours. This order is not adhered to and water abstraction occurs 24 hours/day. This negatively affects the yield of Mutshedzi Dam, used for domestic water supply, and Nzhelele Dam, used for irrigation.

Tshipise holiday resort, which can accommodate some 2 000 visitors, also obtains its water requirements from Nzhelele Dam. The resort has an allocation of 55 ha, which equals 0,5 x $10^6 m^3$/a.

Limited irrigation occurs in the Mutamba River catchment (100 ha), which is a tributary of the Nzhelele River. Groundwater is used to meet water requirements.

4.5 HYDRO-POWER AND PUMPED STORAGE

No hydro-power and pumped storage schemes exist in the Limpopo WMA.

CHAPTER 5: WATER REQUIREMENTS

5.1 WATER USE SUMMARY

Development and population growth have brought increasing pressure to bear on the water resources of the Limpopo WMA. The limited extent and uneven distribution of the water resources has given rise to intensive competition between the ever-growing water use sectors. The groups each have their own needs, norms and expectations and have for the most part, followed a course of independent and *ad hoc* water resource development.

Agriculture is by far the largest water use sector in the Limpopo WMA, followed by the requirements of the natural environment. The whole of the Limpopo WMA falls in the Northern Province. The water requirement per user group within the WMA is summarised in Table 5.1.1. Note that demands in the international catchments (see diagram 6.3.1), as well as local demands satisfied from the Limpopo River itself, have **not** been considered in the study. Distribution losses and conveyance losses are included in the values given for requirements, including water transfers, but return flows have not been subtracted. The water requirement for the ecological reserve is the requirement at the outlet of the tributaries of the Limpopo River. The different water user groups require water at different assurance of supply levels and the water use requirement is therefore also shown at an equivalent 98% assurance level.

Figure 5.1.1 shows all the water transfers to and from the WMA. Water requirements are shown both at the source of supply and at the point of use, or delivery. The water requirements at equivalent assurance per user sector in 1995 are shown in Figure 5.1.2.

TABLE 5.1.1: WATER REQUIREMENTS PER USER GROUP IN 1995

User Group	Estimated Water Requirement ($10^6\,m^3/a$)	Requirement/Use At 1:50 Year Assurance ($10^6\,m^3/a$)
Ecological reserve (1)	144,8	24,9
Domestic (2)	73,94	65,83
Bulk water use (3)	25,2	26,4
Neighbouring States	0,0	0,0
Agriculture (4)	286,9	332,2
Afforestation	2,2	1,0
Alien vegetation	25,7	6,07
Water transfers (5)	0,0	0,0
Hydropower	0,0	0,0
TOTALS	**558,74**	**456,4**

(1) For rivers in WMA at confluences with Limpopo River, excluding main stem.
(2) Includes urban and rural domestic requirements and commercial, institutional and municipal requirements.
(3) Includes thermal power stations, major industries and mines.
(4) Includes requirements for irrigation, dryland sugar cane, livestock and game.
(5) Only transfers out of the WMA are included.

5.2 ECOLOGICAL COMPONENT OF THE RESERVE

5.2.1 Introduction

The classification of the main stem rivers in the vicinity of the outlets of the quaternary catchments is described in Section 2.6.2. On the basis of this classification, a so-called desktop method has been developed (Hughes and Münster, 1999) to provide a low-confidence estimate of the quantity of water required for the ecological component of the Reserve, which is suitable for use in this water resources situation assessment.

The method involves the extrapolation of high confidence results of previous instream flow requirement (IFR) workshops, the use of a reference time series of monthly runoff at the outlet of the quaternary catchment and a number of hydrological indices or parameters that have been defined for 21 desktop Reserve parameter regions in South Africa. These desktop Reserve parameter regions are described and shown in Figure 5.2.1.1. The instream flow requirements that were determined previously were mostly based on the use of the Building Block Method (King and Louw, 1998). The monthly time series of natural flow that has been used is described in Section 6.3. The following are the two main hydrological parameters:

- a measure of the longer term variability, which is a combination of the coefficients of variation of winter and summer volumes (CV); and
- an estimate of the proportion of the total flow that occurs as base flow (BFI), which can be considered to be a measure of short-term variability.

The ratio of the above two indices (CV/BFI) has been used as an overall hydrological index of flow variability or reliability. Rivers with low variability and a high base flow response have very low hydrological indices of flow variability and vice versa.

A relationship has been found between the hydrological index of flow variability, the ecological status and the annual requirements for low and high flows for the so-called maintenance and drought periods of the modified flow regime for the river. The essence of the relationship is that for a particular ecological status or class, the water required for the ecological component of the Reserve will increase as the hydrological index of flow variability decreases, and vice versa. Furthermore, the water requirement will decrease as the ecological status is decreased.

The method that has been used is based on a series of assumptions, many of which have not yet been verified due to either a lack of information or of time since the method was developed. The following is a summary of the main limitations in order to provide an indication of the level of accuracy that can be expected:

- The extrapolations from past IFR workshops are based on a very limited data set, which does not cover the whole of the country. While some development work has been completed to try and extend the extrapolations and has improved the high flow estimations for dry and variable rivers, this has been limited.

- The extrapolations are based on a hydrological index and no allowance (in the desktop method adopted for this water resources situation assessment) has been made for regional, or site-specific ecological factors. It is unlikely that an index based purely on hydrological characteristics can be considered satisfactory but it represents a pragmatic solution in the absence of sufficient ecological data.

- The method assumes that the monthly time series of natural flows are representative of real natural flow regimes and many of the algorithms rely upon the flow characteristics being accurately represented. Should the data indicate more extended base flows than actually occur, the hydrological index of flow variability would be under-estimated and the water requirements for the ecological component of the Reserve would be over-estimated.

5.2.2 Quantifying the Water Requirements

A simulation model has been developed to simulate the relationships that were found to exist between the hydrological index of flow variability, the ecological status and the annual requirements for low and high flows and for so-called maintenance and drought flow periods (Hughes and Münster, 1999).

The simulation model provides annual maintenance and drought low flows and maintenance high flows (expressed as a proportion of the mean annual runoff). The model also provides for the seasonal distribution and assurances associated with the monthly flows on the basis of a set of default parameters that has been developed for each of the 21 desktop Reserve parameter regions of South Africa referred to in Section 5.2.1. The quaternary catchments in the Limpopo Water Management Area fall within the so-called Lowveld (18) and Eastern Foothills (19) regions.

The monthly time series of natural flows at the outlets of the quaternary catchments have been used to generate an equivalent time series of water requirements for the ecological component of the Reserve. This has been accomplished by relating the assurances of the natural flows in a particular month to the assurances of the flow required for the ecological component of the Reserve during the same month.

In the water balance model it is necessary to express the water requirements for the ecological component of the Reserve in terms of annual requirements that are directly comparable to those of any other sector. It therefore becomes necessary to reduce these water requirements to a common assurance and more specifically the effect that these requirements will have on the capacity of the river system to supply water at a specific assurance i.e. the effect on the yield of the river system.

The effects on the yield of the river system of the water required for the ecological component of the Reserve have been based on an analysis of the monthly time series of these water requirements for the same 70-year period as for the natural time series of flows that is described in Section 6.3. This has been estimated by establishing the average annual quantity of water required for the ecological component of the Reserve during the most severe or so-called critical drought that has determined the yield of the river system at a recurrence interval of 50 years. The duration of the critical drought can be approximated by the (inverse of) marginal rate of increase of the yield of the river system per unit increase in storage capacity i.e. the slope of the storage-yield curve at the storage capacity under consideration. The periods of high and low flows in the monthly time series of water requirements for the ecological component of the Reserve also mimic the periods of high and low flows in the monthly time series of natural flows used to establish the yield of the river system. Therefore, the portion of the yield of the system that is required for the ecological component of the Reserve can be estimated by finding the lowest average flow for all periods in the monthly time series of water requirements for the ecological component of the Reserve that are as long as the critical drought period.

The monthly time series of water requirements for the ecological component of the Reserve has been determined at the outlet of each quaternary catchment for each of the ecological status Classes A to D. These time series have been analyzed for various lengths of the critical drought to establish the system yield required for the ecological component of the Reserve. This has been done for a range of system capacities, from which the appropriate value corresponding to the storage capacity being considered has then been selected for use in the water balance.

The method that has been used to quantify the water requirements is based on a series of assumptions, many of which have not yet been verified due to either a lack of information or of time since the method was developed. The following is a summary of the main limitations in order to provide an indication of the level of accuracy that can be expected:

- The seasonal distributions of the annual estimates of water requirements are based on analyses of the base flow characteristics of some 70 rivers using daily data, the results of which were then regionalised. Some individual quaternary catchments that have been allocated to a specific region may however, have somewhat different characteristics.

- Similarly, the regional parameters for the assurance rule curves have been based on the duration curve characteristics of the natural flow regimes represented by the monthly time series of flow described in Section 6.3 and some experience of setting assurance rules used at past IFR workshops. Investigating a representative sample of quaternary catchments facilitated regionalising and it is therefore possible that some have been assigned to the wrong regions.

- The estimates of water required for the ecological component of the Reserve are the best estimates that can be given at this stage, but must be regarded as low confidence estimates. As more detailed estimates are made for a wider range of rivers, the estimates will be improved through modifications made to the delineation of the regions and the regional parameters that have been assigned. It is also anticipated that a better way of accounting for regional or site-specific ecological considerations will be added in due course.

5.2.3 Comments on the Results

The Limpopo WMA has 68 quaternary catchments of which two are considered to be of Present Ecological Management Class A, 17 of Management Class B, 28 of Management Class C and 21 of Management Class D.

The catchments having a Present Ecological Management Class A rating occur in the quaternary catchments containing Soutkloof River and Doringfonteintjiespruit joining the Limpopo River. The remainder of the ecological classes are distributed over the WMA. The Matlabas and Mokolo River Basins are mainly Class C and the Lephalala and Mogalakwena River Basins mainly Classes C and D. The Sand River Basin is mainly Class B and the Nzhelele and Nwanedi River Basins mainly Class D.

It is estimated that the ecological water requirement for PESC in Soutkloof, Upper Mokolo and Doringfonteintjiespruit key areas amounts to between 20% and 25% of the virgin MAR. The ecological water requirement for PESC in the remainder of the quaternary catchments varies from 8% to 20% of the naturalised MAR.

5.2.4 Presentation of Results

The water requirements for the Ecological Component of the reserve are shown in Table 5.2.4.1 and Figure 5.2.4.1. The considered key points coincide with catchment or sub-catchment outlets. The selection of these areas is listed in Chapter 2 (section 2.1). Intra-quaternary catchment variation in class and state is possible and there may be intra-tertiary or intra-key point variations. Appendix F1 of this report contains the quaternary information.

5.2.5 Discussion and Conclusions

There is a large variation in the Present Ecological Class throughout the Limpopo WMA. The Present Ecological Class in the Mokolo and most of the Mogalakwena secondary catchment is predominantly "moderately modified". The Lephalala and Nzhelele secondary catchments fall mainly in the "largely modified" class. The smaller Soutkloof and Doringfonteintjiespruit catchments fall in the "unmodified/natural" class. Conditions in the Sand River secondary catchment varies from slightly to largely modified.

TABLE 5.2.4.1: WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE

Catchment						Present Ecological Class	Ecological Water Requirements for PESC		
Primary		Secondary		Tertiary					
No	Description	No	Description	No	Description		% Virgin MAR	10^6 m^3 /a	Impact on 1:50 yr yield + (10^6 m^3 /a)
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	C	12,3	**6,7***	0,0
					Steenbokpan	C	12,2	1,4	0,0
				A42	Mokolo (Upper)	C	22,0	52,9	16,9
					Mokolo (Lower)	C	19,6	**61,8***	0,0
			Sub total						**16,9**
		A5	Lephalala	A50	Lephalala (Upper)	D	10,8	14,1	0,1
					Lephalala (Lower)	D	9,3	**13,4***	0,0
					Soutkloof	A	25,4	1,3	0,0
			Sub total						**0,1**
		A6	Mogala-kwena	A61	Nyl (Upper)	C	14,7	6,5	0,4
					Nyl (Middle)	C	13,4	8,9	0,0
					Mogalakwena (Upper)	C	16,5	20,0	2,2
					Sterk	D	13,8	7,7	0,0
				A62	Mogalakwena (Middle)	C	16,3	40,2	2,7
				A63	Doringfonteintjie-spruit	A	20,8	1,3	0,0
					Mogalakwena (Lower)	C	13,3	**37,3***	0,0
					Kolope	C	12,1	0,9	0,0
			Sub total						**5,3**
		A7	Sand	A71	Sand (Upper)	C	11,9	2,3	0,0
					Hout	D	8,0	0,9	0,2
					Sand (Lower)	B	16,1	**11,0***	0,0
					Kongoloops / Soutsloot	B	16,7	0,6	0,0
				A72	Brak	B	17,1	3,1	0,5
			Sub total						**0,7**
		A8	Nzhelele	A80	Nzhelele (Upper)	D	11,6	5,3	1,7
					Nzhelele (Lower)	D	9,7	**6,7***	0,0
					Nwanedi	D	9,7	**2,4***	0,2
			Sub total						**1,9**
Total Requirement for WMA								**144,8****	**24,9**

* Values for main tributaries at confluence with Limpopo River. + Values from WSAM: to be verified
** For all rivers and streams in WMA at confluences with Limpopo River, excluding main stem.

5.3 URBAN AND RURAL

5.3.1 Introduction

Domestic water users can be grouped into several categories, with the main categories being urban and rural communities. The urban population all have fully reticulated water supply systems with water borne sewage facilities and have a relatively high per capita water use. This group uses a significant percentage of the water for gardening purposes. Commercial and industrial activity is high in centres having first world residents.

The rural community, which comprises about 80% of the population, generally have rudimentary water supply systems and have a relatively low per capital water use. Water is, in most cases used only for basic needs. This population group is mostly residents in densely populated areas and has high population growth rates, in most cases, and have a high impact on the water resources in terms of use and water quality.

The domestic urban and rural water requirements in 1995 are shown in Table 5.3.1.1 and illustrated in Figure 5.3.1.1. It should be noted that the requirements per quaternary catchment area are shown in the figure. The urban water requirement is almost the same as the rural requirement. The Human Reserve is also shown in the table and it is less than the estimated water requirement. This portion of the Reserve is therefore not considered as a separate water demand. The urban water requirement amounts to about 14,1 x 10^6 m^3/a for the Limpopo WMA. The highest urban water use occurs in the Upper Sand River and Upper Nyl River sub-catchments.

5.3.2 Urban

Water Requirements

A study by Schlemmer *et al* (2001) in support of the development of the National Water Resource Strategy developed a methodology to provide a framework for estimation of both direct and indirect water requirements for the entire South Africa, as well as for the development of long-term projections. A framework methodology was developed on the basis of available information. Information collected in the field as part of the Water Resources Situation Assessments was used to refine the analysis, identify default values and where available update the default database figures.

Urban water requirements were classified into direct use by the population plus indirect use by commerce, industries, institutions and municipalities related to the direct use. These are dealt with below.

Direct Water Use: The following criteria were considered significant in identifying categories of direct water use:

- Economic strata.
- Types of housing.
- Levels of service provided.
- Extent of local authority records.

It was recognised that a critical factor to be considered was the dependence on data that was required from Local and Water Service Authorities. Generally many authorities have records of water supplied to different users, individual households, and at times to flats and multi-household complexes. Further detail is not common.

TABLE 5.3.1.1: URBAN AND RURAL DOMESTIC WATER REQUIREMENTS IN 1995

Catchment						Urban requirements (10^6 m^3 /a)	Rural requirements (10^6 m^3 /a)	Combined urban and rural domestic requirements (10^6 m^3 /a)	Requirement at 1:50 year assurance (10^6 m^3 /a)	Human reserve (10^6 m^3 /a)
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description					
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,13	0,13	0,13	0,06
					Steenbokpan	0,0	0,07	0,07	0,07	0,03
				A42	Mokolo (Upper)	0,0	0,36	0,40	0,40	0,17
					Mokolo (Lower)	1,1	0,12	1,18	1,16	0,18
			Sub total			**1,1**	**0,68**	**1,78**	**1,76**	**0,44**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,10	0,10	0,10	0,03
					Lephalala (Lower)	0,0	1,44	1,44	1,44	0,48
					Soutkloof	0,0	0,06	0,06	0,06	0,02
			Sub total			**0,0**	**1,60**	**1,60**	**1,60**	**0,53**
		A6	Mogala-kwena	A61	Nyl (Upper)	2,0	0,10	2,09	2,07	0,36
					Nyl (Middle)	0,0	0,11	0,11	0,11	0,07
					Mogalakwena (Upper)	0,0	0,04	0,04	0,04	0,03
					Sterk	1,4	0,04	1,47	1,47	1,69
				A62	Mogalakwena (Middle)	0,0	3,25	3,25	3,25	2,03
				A63	Doringfonteintjiespruit	0,0	0,03	0,03	0,03	0,02
					Mogalakwena (Lower)	0,0	0,94	0,94	0,97	0,59
					Kolope	0,0	0,04	0,04	0,04	0,02
			Sub total			**3,4**	**4,55**	**8,0**	**8,0**	**4,8**
		A7	Sand	A71	Sand (Upper)	8,1	3,17	11,29	11,20	3,27
					Hout	0,0	1,71	1,74	1,74	1,07
					Sand (Lower)	1,35	0,76	2,11	10,16	0,69
					Kongoloops / Soutsloot	0,0	0,07	0,07	0,07	0,05
				A72	Brak	0,0	1,40	1,40	1,40	0,87
			Sub total			**9,45**	**7,11**	**16,6**	**24,57**	**6,0**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	2,74	2,78	2,78	0,87
					Nzhelele (Lower)	0,0	0,52	0,52	0,52	0,16
					Nwanedi	0,1	0,40	0,48	0,48	0,15
			Sub total			**0,1**	**3,66**	**3,78**	**3,8**	**1,2**
Total WMA						**14,1**	**17,6**	**31,74**	**39.69**	**12,92**

Note: The values in this table do not include water losses.

Categories of direct water use were then identified in order to develop profiles of use per urban centre (see table 5.3.2.1.1 below). Schlemmer *et al* (2001) allocated the populations of the urban centers that had been determined, to these categories on the basis of the socio-economic category characteristics of each centre.

The study then proceeded to derive per capita water use for each of these categories using information from the South African Local Government Handbook, and the data collected as part of the Water Resources Situation Assessments from local authorities at the time. Where detailed data was not available, an estimation procedure was followed. The categories defined were associated with default unit water uses to generate overall water use estimates where hard data was not available. These categories and default unit water uses are listed in table 5.3.2.1.1.

TABLE 5.3.2.1.1: DIRECT WATER USE: CATEGORIES AND ESTIMATED UNIT WATER USE

Category		Water Use ℓ/c/day
1.	Full service : Houses on large erven > 500m^2	320
2.	Full service: Flats, Town Houses, Cluster Houses	320
3.	Full service : Houses on small erven <500m^2	160
4.	Small houses, RDP houses and shanties with water connection but minimal or no sewerage service	90
5.	Informal houses and shanties with service by communal tap only	10
6.	No service from any water distribution system	6
7.	Other/Miscellaneous	90

Indirect Water Use: Indirect water use was considered in terms of four categories, viz. commercial, industrial, institutional and municipal. Again, available information was complemented by data collected as part of the Water Resources Situation Assessments from local authorities at the time. Limited hard data was obtained at the level of detail sought.

In order to develop a comprehensive set of estimates, a standard table relating the components of indirect water use to the total direct water use of an urban centre was developed. The urban centres were first classified according to shared characteristics related to water use. The classification used is shown in table 5.3.2.1.2.

TABLE 5.3.2.1.2: CLASSIFICATION OF URBAN CENTRES RELATED TO INDIRECT WATER USE

Classification	Type of Centre	Perception
1.	Long established Metropolitan centres (M)	Large conurbation of a number of largely independent local authorities generally functioning as an entity.
2.	City (C)	Substantial authority functioning as a single entity isolated or part of a regional conurbation.
3.	Town: Industrial (Ti)	A town serving as a centre for predominantly industrial activity.
4.	Town: Isolated (Tis)	A town functioning generally as a regional centre of essentially minor regional activities.
5.	Town: Special (Ts)	A town having significant regular variations of population consequent on special functions. (Universities, holiday resorts, etc.).
6.	Town: Country (Tc)	A small town serving essentially as a local centre supporting only limited local activities.

New Centres		
7.	Contiguous (Nc)	A separate statutory authority, or number of authorities adjacent to, or close to, a metropolis or city and functioning as a component part of the whole conurbation.
8.	Isolated (Nis)	A substantial authority or group of contiguous authorities not adjacent to an established metropolis or city.
9.	Minor (Nm)	Smaller centres with identifiable new or older established centres not constituting centres of significant commercial or industrial activity.
10.	Rural (Nr)	All other areas not having significant centres.

Default profiles of indirect water use in relation to total water use were developed on the basis of available information for these classes, and are given in Table 5.3.2.1.3.

TABLE 5.3.2.1.3: INDIRECT WATER USE AS A COMPONENT OF TOTAL DIRECT WATER USE

Urban Centre Classification	Components of the water use			
	Commercial	Industrial	Institutional	Municipal
Metropolitan Cities Towns Industrial Towns Isolated	0,2	0,3	0,15	0,08
Towns Special	0,30	0,15	0,08	0,03
Towns Country	0,10	0,15	0,03	0,10
New Centres	0,15	0,08	0,08	0,08

Where detailed data was not available, table 5.3.2.1.3 was used as a basis for estimating the indirect water use.

Table 5.3.2.1.4 shows the estimated urban water requirements and return flows. The total urban water requirement at 98% assurance level for the Limpopo WMA (including losses) is estimated at 31,1 x 10^6 m^3 per annum. In view of the high per capita use (about 330 *l*/c/day on average) it should be possible to curtail water use under 1:50-year drought conditions. Note that the effluent produced in Pietersburg (quaternary catchment A71A) is discharged into the Sand River and therefore recharges the riverine aquifer.

TABLE 5.3.2.1.4: URBAN WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Urban water requirements (10^6 m^3 /a)							Total at 1:50 year assu=rance (10^6 m^3 /a)	Return flows (10^6 m^3 /a)			
Primary		Secondary		Tertiary		Direct	Indirect	Bulk conveyance losses		Distribution losses		Total		Ef=fluent	Imper=vious urban area	Total return flow	Return flow 1:50 year assu=rance
No	Description	No	Description	No	Description			(10^6 m^3/a)	%	(10^6 m^3/a)	%						
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
					Steenbokpan	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
				A42	Mokolo (Upper)	0,0	0,0	0,0	5	0,0	20	0,1	0,1	0,03	0,00	0,03	0,03
					Mokolo (Lower)	1,1	0,4	0,07	5	0,15	10	1,72	1,7	0,88	0,00	0,88	0,87
			Sub total			**1,1**	**0,4**	**0,07**		**0,15**		**1,73**	**1,8**	**0,91**	**0,0**	**0,91**	**0,90**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
					Lephalala (Lower)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,61	0,61	0,61
					Soutkloof	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
			Sub total			**0,0**	**0,0**	**0,0**		**0,0**		**0,0**	**0,0**	**0,00**	**0,61**	**0,61**	**0,61**
		A6	Mogalakwena	A61	Nyl (Upper)	2,0	1,2	0,16	5	0,48	15	4,00	4,0	1,91	0,00	1,91	1,91
					Nyl (Middle)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
					Mogalakwena (Upper)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,51	0,00
					Sterk	1,4	1,0	0,12	5	0,49	20	3,3	3,3	1,41	0,00	1,41	1,41
				A62	Mogalakwena (Middle)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
				A63	Doringfonteintjiespruit	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
					Mogalakwena (Lower)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,02	0,00	0,02	0,02
					Kolope	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
			Sub total			**3,4**	**2,2**	**0,28**		**0,97**		**7,3**	**7,3**	**3,34**	**0,00**	**3,84**	**3,34**
		A7	Sand	A71	Sand (Upper)	8,1	5,8	0,70	5	2,78	20	18,6	18,7	0,00	1,10	1,10	1,10
					Hout	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
					Sand (Lower)	1,3	1,0	0,81	5	3,25	20	7,8	3,1	0,00	1,10	1,10	1,10
					Kongoloops / Soutsloot	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
				A72	Brak	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
			Sub total			**9,4**	**6,8**	**1,51**		**6,03**		**25,4**	**21,8**	**0,0**	**2,20**	**2,20**	**2,20**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	0,0	0,0	5	0,0	20	0,1	0,1	0,02	0,00	0,02	0,02
					Nzhelele (Lower)	0,0	0,0	0,0	5	0,0	20	0,0	0,0	0,00	0,00	0,00	0,00
					Nwanedi	0,1	0,1	0,01	5	0,02	20	0,2	0,2	0,04	0,00	0,04	0,05
			Sub total			**0,1**	**0,1**	**0,01**		**0,02**	20	**0,3**	**0,3**	**0,06**	**0,0**	**0,06**	**0,07**
Total WMA						**14,1**	**9,5**	**1,87**		**7,17**		**35,7**	**31,1**	**4,31**	**2,81**	**7,63**	**7,12**

Water Losses

Water losses in urban areas can be broken down into three components:

Losses in the bulk supply system

Losses in the bulk supply system to an urban area typically range from 3% to 7% of the urban water use, and include losses at purification works due to backwashing of sand filters. The portion of urban water use lost in the bulk supply system is 5% of the urban water use within the WMA, which implies a total loss of 1,87 x 10^6 m^3/a for the WMA.

Losses in the water distribution system

Distribution losses include losses due to leaking pipes and reservoirs. Distribution losses can range from 10% of the urban water use to as high as 30% of the urban water use in places where proper maintenance is not done. The total loss in the distribution systems in the WMA is 7,17 x 10^6 m^3/a.

Other losses

Unauthorized connections and unmetered water supply can also be considered to be losses. It is difficult to estimate these “losses” because they would differ depending on each urban area. These losses are not included in the tables.

Return Flows

Return flows from urban areas can be broken down into two categories:

Effluent from residential and industrial areas

Effluent generated from residential and industrial areas is directly proportional to the water used. The water use is further dependent on the standard of living and type of industries. All these factors have been taken into consideration when estimating the return flow. The return flow from effluent has been estimated as 4,31 x 10^6 m^3 /a.

Return flow due to impervious urban areas

Additional rainfall run off is created due to impervious areas created in urban areas. On average one eighth of the urban areas in the WMA are effectively paved and it is assumed that 84% of rain falling on these areas runs off into the river system. The impervious areas in the WMA total 7,5 km^2 and thus the return flows generated from these areas are 2,8 x 10^6 m^3/a.

5.3.3 Rural

Water Requirements

Rural water users include domestic, subsistence farming, livestock and game users.

Domestic water requirements

Domestic water users are located throughout the area and include domestic users of villages, settlements, farming communities and mines.

The estimates of the water requirements of the rural population are based on estimates of the population and the unit water requirements, inclusive of allowances for other related uses such as schools, clinics, commercial activities, service industries, sports fields, etc. This procedure assumes that the water use by the rural population has generally not been measured in the past and has frequently been affected by inadequate infrastructure and / or inadequate measures to ensure that water is not used wastefully.

The rural population uses water mainly for hygiene, other in-house use, sanitation and gardening. Other users such as schools, clinics, etc. comprise a relatively small increment to the domestic component.

The water use is therefore related to the value orientation or level of living and development of the domestic water user. It has also been found that for the non-farming rural communities, community size correlates well with the level of living, as shown below:

Community characteristic	**Level of living**	**Typical description**
Rural	Low	Remote small rural villages or scattered homesteads
Advanced rural	Low to Moderate	Small rural villages
Developing urban	Moderate	Densely populated rural villages
Farming	Low to Moderate	Farming communities outside urban and rural residential areas

For each quaternary catchment the percentage of the rural population in each of the four community characterizations should therefore be estimated.

The unit water requirements were estimated for the conditions applicable in 1995 and that correspond to the levels of living that are typical of the community characteristics in the WMA.

The following typical unit water requirement allowances were considered applicable particularly where there is no other data available:

- Rural 30ℓ/c/day
- Advanced rural 75ℓ/c/day
- Developing urban 150ℓ/c/day
- Farming 175ℓ/c/day

The above allowances include a provision of about 15% for other users in the rural, advanced rural and developing urban communities.

The water requirements per capita are shown in Table 5.3.3.1.1, while Table 5.3.3.1.2 shows the rural domestic water requirements in 1995, amounting to 24,8x10^6 m^3/a for the WMA.

TABLE 5.3.3.1.1: PER CAPITA WATER REQUIREMENTS IN RURAL AREAS IN 1995

User Category	**Unit Water Requirements**			
	Direct use (ℓ/c/day)	**Distribution losses**		**Total (ℓ/c/day)**
		(ℓ/c/day)	**(%)**	
Rural	30	4	15	34
Advanced rural	75	11	15	86
Developing urban	150	22	15	172
Commercial farming	175	26	15	201

TABLE 5.3.3.1.2: RURAL DOMESTIC WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Rural water requirements (10^6 m/a)							Return flow	
Primary		Secondary		Tertiary		Domestic (10^6 m^3/a)[1]	Subsistence farming [1] (10^6 m^3/a)	Livestock & game [1] (10^6 m^3/a)	Losses		Total (10^6 m^3/a)	Total at 1:50 yr assurance (10^6 m^3/a)	Normal (10^6 m^3/a)	Total at 1:50 yr assurance (10^6 m^3/a)
No	Description	No	Description	No	Description				(10^6 m^3/a)	%				
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,13	0,00	0,35	0,10	20	0,58	0,62	0,00	0,0
					Steenbokpan	0,08	0,00	0,19	0,05	20	0,32	0,35	0,00	0,0
				A42	Mokolo (Upper)	0,38	0,00	0,36	0,15	20	0,89	0,93	0,00	0,0
					Mokolo (Lower)	0,12	0,00	0,46	0,12	20	0,71	0,75	0,00	0,0
			Sub total			**0,71**	**0.00**	**1,36**	**0,42**	**20**	**2,50**	**2,65**	**0,00**	**0,0**
		A5	Lephalala	A50	Lephalala (Upper)	0,11	0,00	0,71	0,16	20	0,98	1,04	0,00	0,0
					Lephalala (Lower)	1,50	0,00	0,00	0,30	20	1,80	1,94	0,00	0,0
					Soutkloof	0,07	0,00	0,00	0,01	20	0,08	0,08	0,00	0,0
			Sub total			**1,68**	**0.00**	**0,71**	**0,47**	**20**	**2,86**	**3,06**	**0,00**	**0,0**
		A6	Mogalakwena	A61	Nyl (Upper)	0,10	0,00	0,24	0,07	20	0,41	0,44	0,00	0,0
					Nyl (Middle)	0,11	0,00	0,28	0,08	20	0,47	0,51	0,00	0,0
					Mogalakwena (Upper)	0,04	0,00	0,18	0,04	20	0,26	0,27	0,00	0,0
					Sterk	2,22	0,00	0,28	0,50	20	3,00	3,27	0,00	0,0
				A62	Mogalakwena (Middle)	3,39	0,00	0,41	0,76	20	4,55	4,98	0,00	0,0
				A63	Doringfonteintjiespruit	0,03	0,00	0,00	0,01	20	0,03	0,03	0,00	0,0
					Mogalakwena (Lower)	0,98	0,00	0,08	0,21	20	1,27	1,37	0,00	0,0
					Kolope	0,04	0,00	0,06	0,02	20	0,12	0,13	0,00	0,0
			Sub total			**6,91**	**0.00**	**1,53**	**1,69**	**20**	**10,11**	**11,00**	**0,00**	**0,0**
		A7	Sand	A71	Sand (Upper)	3,30	0,00	0,34	0,73	20	4,36	4,86	0,00	0,0
					Hout	1,78	0,00	0,32	0,42	20	2,52	2,80	0,00	0,0
					Sand (Lower)	7,41	0,00	1,25	1,73	20	10,39	11,55	0,00	0,0
					Kongoloops / Soutsloot	0,08	0,00	0,13	0,04	20	0,25	0,27	0,00	0,0
				A72	Brak	1,46	0,00	0,16	0,32	20	1,93	2,15	0,00	0,0
			Sub total			**14,03**	**0.00**	**2,20**	**3,24**	**20**	**19,45**	**21,63**	**0,00**	**0,0**
		A8	Nzhelele	A80	Nzhelele (Upper)	1,59	0,00	0,00	0,32	20	1,91	2,11	0,00	0,0
					Nzhelele (Lower)	0,54	0,00	0,21	0,15	20	0,91	1,00	0,00	0,0
					Nwanedi	0,41	0,00	0,00	0,08	20	0,50	0,55	0,00	0,0
			Sub total			**2,54**	**0,00**	**0,21**	**0,55**	**20**	**3,32**	**3,66**	**0,00**	**0,0**
Total WMA						**24,8**	**0,00**	**6,01**	**5,3**	**20**	**38,24**	**34,73**	**0,00**	**0,0**

(1) Direct use excluding losses.

Livestock and game water requirements
Water requirements corresponding to the distribution of large stock units (livestock and game) are described in Section 3.5.4. The unit water requirement is 45 ℓ/LSU/day. A table showing the relationship between various livestock and game species and LSU is contained in Appendix F (water requirements).

While livestock farming is a significant activity within the WMA, it is an activity that derives much of its water mainly from groundwater and from small farm dams.

The available livestock data provided overall numbers for cattle (beef/milk), sheep, goats, horses, donkeys and mules on a primary catchment basis for magisterial districts. Game data was also provided per magisterial district according to species type.

The disaggregation of livestock and game from Magisterial District (MD) resolution to quaternary catchment resolution was based on the uniform spatial distribution of livestock and game within a MD. The actual disaggregation was carried out pro-rata to the area of the quaternary catchments within the MDs. However, where there was additional information available, the data was adjusted.

The LSU for each species was then combined per quaternary. The livestock and game requirement forms part of the rural consumption. The average water use by LSU was taken at 45 ℓ/LSU/day. Water consumption by livestock and game per quaternary catchment is obtained by multiplying the LSU's by 45 ℓ/LSU/day.

It was assumed that livestock data for 1990 can be used to represent 1995 figures as the general consensus is that agriculture has reached a threshold and numbers are unlikely to change much at present. Furthermore the 1990 data represent both mature and immature livestock and game numbers; therefore these numbers can be used to represent the mature livestock and game numbers for 1995.

The Central Statistical Services provided another source of data. They produced a "Census of Agriculture, 1988" on a magisterial district basis and is similar to that provided by the Department of Agriculture at Glen (near Bloemfontein). Data on pigs, horses etc. are defined. The main disadvantage of this data is that, unlike the Glen data, it is not presented per primary catchment and game is not broken down into species.

The estimated water requirement of livestock and game is shown in Table 5.3.3.1.2. and the total amounts to $6.01x10^6$ m^3/a for the WMA

Water losses

Bulk supply and distribution losses
The losses in the rural supply systems vary from 10% of the rural water use to 30% of the rural water use. The total losses in the bulk supply to the rural consumers and the losses in the distribution system are $5,3x10^6$ m^3/a for the WMA.

Return Flows

The return flow generated by rural consumers is minimal due to their low water use and can in most cases be taken as zero. The return flow for the WMA is estimated to be zero.

5.4 BULK WATER USE

5.4.1 Introduction

This section deals with industries, mines and thermal power stations having individual bulk raw water supplies, or direct supplies from water boards, or DWAF, as well as mines that receive water from local authorities or water boards. Industries and power stations supplied with potable water by municipalities are included in urban water requirements. Users in the bulk water use category are divided into "Strategic", "Mining" and "Other".

5.4.2 Strategic

Water Requirements

Only the requirements of thermal power stations are considered to be strategic water use. Matimba power station is the only power station in the Limpopo WMA with a water demand of 3,5 x 10^6 m^3/a. The strategic water requirements of the Limpopo WMA are shown in Table 5.4.2.1.

Water Losses

These losses include transmission and purification losses in privately owned bulk supply systems and losses by bulk suppliers of bulk users. Losses are similar to those in urban bulk supply systems. The proportion of bulk losses in this WMA is about 0,35x10^6 m^3/a. Losses are included in Table 5.4.2.1.

Return flows

Return flows generated by bulk users are directly proportional to the type of industry. Return flows are included in Table 5.4.2.1.

TABLE 5.4.2.1: STRATEGIC WATER REQUIREMENTS

Catchment						On-site strategic use (10^6 m^3 /a)	Conveyance losses		Total water requirement (10^6 m^3 /a)	Total water requirement at 1:50 yr assurance (10^6 m^3 /a)	Normal return flow (10^6 m^3 /a)	Return flow at 1:50 yr assurance (10^6 m^3 /a)
Primary		Secondary		Tertiary			(10^6 m^3 /a)	%				
No	Description	No	Description	No	Description							
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0	0,0	0,0	0,0	0,0
					Steenbokpan	0,0	0,0	0	0,0	0,0	0,0	0,0
				A42	Mokolo (Upper)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Mokolo (Lower)	3,5	0,35	10	3,9	4,1	0,0	0,0
			Sub total			**3,5**	**0,35**		**3,9**	**4,1**	**0,0**	**0,0**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Lephalala (Lower)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Soutkloof	0,0	0,0	0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**		**0,0**	**0,0**	**0,0**	**0,0**
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Nyl (Middle)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Mogalakwena (Upper)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Sterk	0,0	0,0	0	0,0	0,0	0,0	0,0
				A62	Mogalakwena (Middle)	0,0	0,0	0	0,0	0,0	0,0	0,0
				A63	Doringfonteintjiespruit	0,0	0,0	0	0,0	0,0	0,0	0,0
					Mogalakwena (Lower)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Kolope	0,0	0,0	0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**		**0,0**	**0,0**	**0,0**	**0,0**
		A7	Sand	A71	Sand (Upper)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Hout	0,0	0,0	0	0,0	0,0	0,0	0,0
					Sand (Lower)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Kongoloops / Soutsloot	0,0	0,0	0	0,0	0,0	0,0	0,0
				A72	Brak	0,0	0,0	0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**		**0,0**	**0,0**	**0,0**	**0,0**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Nzhelele (Lower)	0,0	0,0	0	0,0	0,0	0,0	0,0
					Nwanedi	0,0	0,0	0	0,0	0,0	0,0	0,0
			Sub total			**0,0**	**0,0**		**0,0**	**0,0**	**0,0**	**0,0**
Total WMA						**3,5**	**0,35**		**3,9**	**4,1**	**0,0**	**0,0**

5.4.3 Mining

Water Requirements

Mining activity requires a level of assurance better than 90%. This catchment has only a few mines. Appendix D1 lists all operating mines and highlights the important mines. Water requirements of mines are shown in Table 5.4.3.1.

During 1995 mines abstracted 22,3 x 10^6 m^3 water from the Limpopo WMA. Note that the water usage of Venetia Mine is excluded as it abstracts water from the Limpopo River main stem.

Water Losses

These losses include transmission and purification losses in privately owned bulk supply systems and losses by bulk suppliers of bulk users. Losses are similar to those in urban bulk supply systems. The proportional bulk losses in this WMA are about 0,2 x 10^6 m^3/a. Losses are included in Table 5.4.3.1.

Return Flows

Pumpage to river systems by mines are separated from return flows by other bulk users because of the impact that this pumpage can have on the quantity and quality of the river system. Some mines in this WMA pump out large quantities of groundwater, which is often re-used in the mining operation, for example by the PPL Mine near Potgietersrus.

5.4.4 Other Bulk Users

There are no other non-strategic bulk users in the Limpopo WMA.

5.5 NEIGHBOURING STATES

The right bank of the Limpopo River catchment falls within RSA boundaries up to the downstream end of the Limpopo WMA, while the coinciding left bank falls in Botswana and Zimbabwe. No agreement exists between the Republic of South Africa and Botswana or Zimbabwe about the required flow in this section of the Limpopo River.

The Minister of Water Affairs and Forestry would have to establish a body in consultation with the Cabinet to conclude and implement an international agreement.

TABLE 5.4.3.1: WATER REQUIREMENTS OF MINES

Catchment						Mines with individual bulk supplies*			Total water requirement (10^6 m^3/a)		Return flow (10^6 m^3/a)			
Primary		Secondary		Tertiary		On-site bulk use (10^6 m^3/a)	Conveyance losses (10^6 m^3/a)	Conveyance losses %	Nor-mal	At 1:50 yr assurance	Surface returns	Groundwater decanting	Total	Total at 1:50 yr assurance
No	Description	No	Description	No	Description									
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0	0,0	0,0			0,0	0,0
					Steenbokpan	0,0	0,0	0	0,0	0,0			0,0	0,0
				A42	Mokolo (Upper)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Mokolo (Lower)	3,5	0,35	10	3,9	4,1			0,0	0,7
			Sub total			**3.5**	**0,35**		**3,9**	**4,1**			**0,0**	**0,7**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Lephalala (Lower)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Soutkloof	0,0	0,0	0	0,0	0,0			0,0	0,0
			Sub total			**0,0**	**0,0**		**0,0**	**0,0**			**0,0**	**0,0**
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Nyl (Middle)	1,5	0,15	10	1,7	1,8			0,0	0,3
					Mogalakwena (Upper)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Sterk	4,2	0,42	10	4,6	4,8			0,0	0,9
				A62	Mogalakwena (Middle)	3,2	0,32	10	3,5	3,6			0,0	0,7
				A63	Doringfonteintjiespruit	0,0	0,0	0	0,0	0,0			0,0	0,0
					Mogalakwena (Lower)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Kolope	1,64	0,16	10	1,7	1,8			0,0	0,3
			Sub total			**10,54**	**1,05**		**11,5**	**12,0**			**0,0**	**2,2**
		A7	Sand	A71	Sand (Upper)	2,2	0,22	10	2,4	2,5			0,0	0,5
					Hout	0,0	0,0	0	0,0	0,0			0,0	0,0
					Sand (Lower)	3,2	0,3	10	3,5	3,7			0,0	0,7
					Kongoloops / Soutsloot	0,0	0,0	0	0,0	0,0			0,0	0,0
				A72	Brak	0,0	0,0	0	0,0	0,0			0,0	0,0
			Sub total			**5,4**	**0,5**		**5,9**	**6,2**			**0,0**	**1,2**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Nzhelele (Lower)	0,0	0,0	0	0,0	0,0			0,0	0,0
					Nwanedi	0,0	0,0	0	0,0	0,0			0,0	0,0
			Sub total			**0,0**	**0,0**		**0,0**	**0,0**			**0,0**	**0,0**
Total WMA						**19,44**	**0,19**		**21,3**	**22,3**			**0,0**	**4,1**

* Includes mines supplied individually by Water Boards or DWAF. Municipalities supply none of the mines.

5.6 IRRIGATION

5.6.1 General

Comprehensive, detailed, observed data on water use is not available at this stage of the investigation; therefore irrigation water requirements were estimated from available information on irrigated areas, typical quotas and assurances of supply.

The water requirement for irrigation in the WSAM was calculated by means of the irrigation pre-processor of the National Water Balance Model and was based on the following well-known equation.

IRR (1 - CLI) = AIR * (EVT * CRC – REF) * 0.001 * LER/IRC

Where:
IRR: Irrigation water requirement (10^6 m^3/m)
AIR: Irrigation area (km^2)
EVT: Evapotranspiration (A-Pan equivalent in mm/m)
CRC: Crop factor
REF: Effective rainfall (mm/m)
LER: Leaching factor
IRC: Irrigation efficiency
CLI: Irrigation conveyance loss (Proportion of IRR)

The processor calculates the irrigation water requirement for every crop separately for each of the 12 months, using the appropriate quaternary mean monthly data obtained from the CCWR. This seemingly detailed methodology is essential to eliminate considerable errors that can be made by combining crop factors. The final annual water requirements are then obtained by simple summation of the various crop water requirements.

5.6.2 Water User Patterns

The Limpopo WMA has a low Mean Annual Precipitation (MAP) and a high mean annual evaporation. An additional water source is thus important for successful crop farming. There are various irrigation schemes (government and private) throughout the WMA and farmers make use of drip, micro, sprinkler, center pivots and flood irrigation to irrigate their crops. Water is used from large dams (Nzhelele, Doorndraai, Glen Alpine, Mokolo Dam), smaller farm dams, weirs, canals, rivers and groundwater aquifers for the necessary crop demand.

Estimated irrigation water requirements in 1995 are shown in Table 5.6.2.1 and Figure 5.6.2.1. The irrigation areas are normally located along the main rivers or suitable low-laying areas.

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS

Catchment						Field edge water require-ment (10^6 m^3 /a)	Assumed canal or river losses**		On farm conveyance losses*		Total water require-ment (10^6 m^3 /a)	Total water requirement at 1:50 yr assurance (10^6 m^3 /a)	Return flows				
Primary		Secondary		Tertiary									Leaching beyond the root zone (10^6 m^3 /a)	Additional return flow from lands (10^6 m^3 /a)	From conveyance losses (10^6 m^3 /a)	Total return flow (10^6 m^3 /a)	
No	Descrip-tion	No	Description	No	Description		(10^6 m^3 /a)	%	(10^6 m^3 /a)	%						Normal	At 1:50 yr assurance
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	3,9	0,0	0	0,0	0	3,9	3,2	0,45	0,05	0,00	0,50	0,2
					Steenbokpan	7,9	0,0	0	0,0	0	7,9	5,9	0,85	0,09	0,00	0,94	0,3
				A42	Mokolo (Upper)	41,0	0,0	0	0,0	0	41,0	50,9	4,78	0,51	0,00	5,29	2,5
					Mokolo (Lower)	0,8	0,05	6	0,01	1,6	0,8	1,5	0,27	0,03	0,06	0,36	0,1
			Sub total			**53,6**	**0,05**		**0,01**		**53,6**	**61,5**	**6,35**	**0,68**	**0,06**	**7,09**	**3,1**
		A5	Lephalala	A50	Lephalala (Upper)	22,6	0,0	0	0,0	0	22,6	10,3	2,24	0,24	0,00	2,48	0,0
					Lephalala (Lower)	14,8	0,0	0	0,0	0	14,8	11,7	1,61	0,17	0,00	1,79	0,0
					Soutkloof	8,6	0,0	0	0,0	0	8,6	6,6	0,81	0,09	0,00	0,90	0,0
			Sub total			**46,0**	**0,0**		**0,0**		**46,0**	**28,6**	**4,66**	**0,50**	**0,00**	**5,17**	**0,0**
		A6	Mogalakwena	A61	Nyl (Upper)	5,6	0,0	0	0,17	3	5,8	5,3	0,58	0,06	0,09	0,73	0,3
					Nyl (Middle)	8,8	0,0	0	0,26	3	9,1	8,0	0,90	0,10	0,14	1,13	0,4
					Mogalakwena (Upper)	10,8	0,03	0,3	0,29	2,7	11,2	12,9	1,17	0,13	0,21	1,51	0,6
					Sterk	11,9	0,14	1,2	0,21	1,8	12,3	14,2	1,29	0,14	0,24	1,68	0,7
				A62	Mogalakwena (Middle)	5,1	0,02	0,3	0,14	2,7	5,3	9,4	0,52	0,06	0,17	0,75	0,5
				A63	Doringfonteintjiespruit	1,5	0,0	0	0,04	3	1,5	1,0	0,15	0,02	0,02	0,18	0,0
					Mogalakwena (Lower)	7,8	0,09	1,2	0,14	1,8	8,0	10,4	0,83	0,09	0,18	1,10	0,5
					Kolope	11,1	0,0	0	0,33	3	11,5	15,6	1,11	0,12	0,28	1,50	0,8
			Sub total			**62,6**	**0,28**		**1,58**		**64,7**	**76,8**	**6,55**	**0,72**	**1,33**	**8,58**	**3,8**
		A7	Sand	A71	Sand (Upper)	18,2	0,0	0	0,0	0	18,2	24,1	1,85	0,20	0,00	2,04	2,4
					Hout	19,8	0,0	0	0,0	0	19,8	27,0	2,01	0,21	0,00	2,22	2,7
					Sand (Lower)	47,8	0,0	0	0,0	0	47,8	64,8	4,81	0,52	0,00	5,32	6,5
					Kongoloops / Soutsloot	0,0	0,0	0	0,0	0	0,0	0,0	0,00	0,00	0,00	0,00	0,0
				A72	Brak	7,7	0,0	0	0,0	0	7,7	10,9	0,75	0,08	0,00	0,84	1,1
			Sub total			**93,5**	**0,0**		**0,0**		**93,5**	**126,8**	**9,42**	**1,01**	**0,00**	**10,42**	**12,7**
		A8	Nzhelele	A80	Nzhelele (Upper)	1,3	0,08	6	0,05	4	1,4	1,4	0,12	0,01	0,09	0,22	0,1
					Nzhelele (Lower)	10,7	0,32	3	0,75	7	11,8	20,7	0,83	0,09	1,14	2,06	2,1
					Nwanedi	14,4	0,72	5	0,72	3	15,9	16,4	2,00	0,21	0,97	3,18	1,6
			Sub total			**26,4**	**1,12**		**1,52**		**29,1**	**38,5**	**2,95**	**0,31**	**2,20**	**5,46**	**3,8**
Total WMA						**282,1**	**1,45**		**3,11**		**286,9**	**332,2**	**29,93**	**3,22**	**3,59**	**36,72**	**23,4**

* Conveyance losses from river or communal canal to field edge.

** River and communal canal losses where water is released from dams.

5.6.3 Water Losses

All the water losses associated with irrigation methods are included in the field edge water requirement shown in Table 5.6.2.1. Irrigation methods that are used in the WMA include, drip, micro, centre pivot, overhead sprinkler and flood irrigation.

Assumed canal or river losses include losses due to leaking of canals and normal losses from rivers for the bulk supply of water to farmers. Distribution losses can be very high in places where proper maintenance is not done. These losses can be as high as 6%. On-farm conveyance losses include conveyance losses from river, farm dam or communal canal to the field edge. These losses can be as high as 7% in the Limpopo WMA.

5.6.4 Return Flows

Return flows as a result of irrigation can be broken down into two components:

Return flow due to leaching beyond the root zone
Irrigation water not used by the plant is returned to the groundwater or streams due to leaching and is largely dependent on the soil characteristics and water quality. The total return flow due to leaching is estimated at 29,93 x 10^6 m^3/a for the WMA.

Additional return flow
The return flow from irrigation can further increase due to the increased rainfall run off due to the higher level of soil moisture when compared with the natural state. This increased return flow can be calculated for a seasonal or yearly crop. Based on the different crops under irrigation in the WMA the additional return flow generated is estimated at 3,22 x 10^6 m^3/a.

5.7 DRYLAND

Sugarcane
No sugarcane is grown in the WMA and therefore no streamflow reduction activities occur here.

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Water losses from rivers, wetlands and dams are shown in Table 5.8.1.

Rivers and wetlands
The losses in all the major wetlands and river channels given in WR90 were used unless more accurate data have come available. Losses due to aquifers are not considered to be a loss unless these occur where the surface water storage capacity is low. In this instance the aquifer recharge could impact on the total utilizable water resource at a specific point in time. Losses in rivers traversing arid areas are substantial especially if they are used to convey water to downstream users, as is the case in the lower Mogalakwena River where water is released in slugs down the river to irrigation farmers' weirs. These channel losses have been estimated separately if the losses given in WR90 were considered to be too low, by multiplying the net class A pan evaporation with the area of the riverine strip. Losses in the WMA due to wetlands are 40 x 10^6 m^3/a and due to channel losses are 46 x 10^6 m^3/a.

Dams

Evaporation losses from the reservoir surface depend on net evaporation rates and the surface area exposed. The critical evaporation losses occur during the critical drought, which establishes the yield of the system. The total net evaporation losses during this period for the 19 dams in the WMA have been estimated to be 57,4 x 10^6 m^3/a.

5.9 AFFORESTATION

Table 5.9.1 gives water use by afforestation at the selected key points.

The water use by commercial afforestation is based on the so-called CSIR curves (CSIR, 1995), which have replaced the Van der Zel curves that were used for the preparation of WR90 (Midgley, et al., 1994). The Van der Zel curves were considered to be too simplistic compared to the CSIR curves, which now take the species, age and site conditions into account in estimating the stream flow reductions. A study was undertaken (Ninham Shand, 1999) to provide adjusted naturalised flow sequences for the Water Situation Assessment Model (WSAM) (Department of Water Affairs and Forestry, 2000) based on the WR90 naturalised flow data. This now enables the CSIR curve-based stream flow reduction estimates to be used in the WSAM and these reduction estimates have been used in the WRSA reports. Details of the method of estimating the reduction in runoff by or water use of commercial afforestation are described in CSIR (1995).

The impact of the reduction in runoff due to afforestation on the yield of a catchment depends on the storage in that catchment. It was accepted that the storage/yield characteristics of a catchment with afforestation were similar to those of the natural catchment and that the latter characteristics could be used to estimate the yield of a catchment with afforestation. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transposed to its outlet and formed the basis for determining the incremental yield of the catchment under both natural conditions and the effects of only the afforestation. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The difference between the incremental yields under natural conditions and with only the effects of afforestation was the impact of the reduction in runoff due to afforestation in the incremental catchment on the yield of the catchment.

The average annual water use by afforestation in the Limpopo WMA is estimated at 2,2 x 10^6 m^3, causing a reduction of 1,0 x 10^6 m^3 in the 1:50 year system yield. Afforestation is concentrated largely in the Upper Nzhelele catchment, which uses about 91% of the abovementioned value. Table 3.5.1.1 contains areas of afforestation per key point area and Figure 3.5.1.1 depicts the land use categories.

TABLE 5.8.1: WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Catchment						Losses from rivers and wetlands (10^6 m^3 /a)	Evaporation losses from dams (10^6 m^3 /a)	Total (10^6 m^3 /a)
Primary		Secondary		Tertiary				
No	Description	No	Description	No	Description			
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,1	0,1
					Steenbokpan	0,0	0,0	0,0
				A42	Mokolo (Upper)	0,0	13,3	13,3
					Mokolo (Lower)	0,0	0,0	0,0
			Sub total			**0,0**	**13,4**	**13,4**
		A5	Lephalala	A50	Lephalala (Upper)	7,0	2,4	9,4
					Lephalala (Lower)	17,0	0,0	17,0
					Soutkloof	0,0	0,0	0,0
			Sub total			**24,0**	**2,4**	**26,4**
		A6	Mogalakwena	A61	Nyl (Upper)	20,0	0,8	20,8
					Nyl (Middle)	20,0	0,8	20,8
					Mogalakwena (Upper)	2,0	5,8	7,8
					Sterk	4,0	3,3	7,3
				A62	Mogalakwena (Middle)	7,0	6,3	13,3
				A63	Doringfonteintjiespruit	0,0	0,1	0,1
					Mogalakwena (Lower)	6,0	1,9	7,9
					Kolope	0,0	3,5	3,5
			Sub total			**59,0**	**22,5**	**81,5**
		A7	Sand	A71	Sand (Upper)	0,6	0,6	1,1
					Hout	0,4	3,8	4,2
					Sand (Lower)	2,0	9,6	11,5
					Kongoloops / Soutsloot	0,0	0,4	0,4
				A72	Brak	0,0	2,9	2,9
			Sub total			**3,0**	**17,3**	**20,1**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	0,1	0,1
					Nzhelele (Lower)	0,0	1,3	1,3
					Nwanedi	0,0	0,4	0,4
			Sub total			**0,0**	**1,8**	**1,8**
Total WMA						**86,0**	**57,4**	**143,2**

TABLE 5.9.1: WATER USE BY AFFORESTATION IN 1995

Catchment						Average water use		Reduction in system 1:50 yr yield	
Primary		Secondary		Tertiary		(10^6 m^3/a)	(mm/a)	(10^6 m^3/a)	(mm/a)
No	Description	No	Description	No	Description				
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0,00	0,00
					Steenbokpan	0,0	0,0	0,00	0,00
				A42	Mokolo (Upper)	0,0	0,0	0,00	0,00
					Mokolo (Lower)	0,0	0,0	0,00	0,00
			Sub total			**0,0**	**0,0**	**0,00**	**0,00**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,00	0,00	0,00
					Lephalala (Lower)	0,0	0,00	0,00	0,00
					Soutkloof	0,0	0,00	0,00	0,00
			Sub total			**0,0**	**0,0**	**0,00**	**0,00**
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	0,0	0,00	0,00
					Nyl (Middle)	0,0	0,0	0,00	0,00
					Mogalakwena (Upper)	0,0	0,0	0,00	0,00
					Sterk	0,0	0,0	0,00	0,00
				A62	Mogalakwena (Middle)	0,0	0,0	0,00	0,00
				A63	Doringfonteintjiespruit	0,0	0,0	0,00	0,00
					Mogalakwena (Lower)	0,0	0,0	0,00	0,00
					Kolope	0,0	0,0	0,00	0,00
			Sub total			**0,0**	**0,0**	**0,00**	**0,00**
		A7	Sand	A71	Sand (Upper)	0,0	0,0	0,00	0,00
					Hout	0,0	0,0	0,00	0,00
					Sand (Lower)	0,1	0,0	0,01	0,00
					Kongoloops / Soutsloot	0,0	0,0	0,00	0,00
				A72	Brak	0,0	0,0	0,00	0,00
			Sub total			**0,1**	**0,0**	**0,01**	**0,00**
		A8	Nzhelele	A80	Nzhelele (Upper)	2,0	6,8	0,97	3,39
					Nzhelele (Lower)	0,1	0,0	0,01	0,01
					Nwanedi	0,0	0,0	0,00	0,00
			Sub total			**2,1**	**6,8**	**0,99**	**3,40**
Total WMA						**2,2**	**6,8**	**1,00**	**3,40**

5.10 HYDROPOWER AND PUMPED STORAGE

There are no hydropower or pumped storage schemes in the Limpopo WMA and therefore the associated water requirements are zero.

5.11 ALIEN VEGETATION

The extent of Alien Vegetation is shown in Figure 5.11.1 and their reducing effects of the normal run-off is shown in Table 5.11.1.

Tertiary and quaternary catchment information on condensed areas of infestation by alien vegetation and stream flow reductions was obtained from the CSIR (Environmentek) (Versfeld, et al. 1997).

It has been assumed that water consumption of alien vegetation outside of the riparian zone cannot exceed the natural runoff and water use inside and outside of the riparian zone has been estimated separately wherever possible. In the absence of any better information, it was assumed that 10 % of the condensed area under alien vegetation is riparian. The reduction in runoff due to alien vegetation was taken from WSAM using the above assumptions. The impact of this reduction in runoff on catchment yield was determined in the same manner as for afforestation.

5.12 WATER CONSERVATION AND DEMAND MANAGEMENT

5.12.1 Introduction

The Department of Water Affairs and Forestry is entrenching and insisting on efficient water management and use. This concept has been strongly emphasized, both in legislation and through key demonstration water conservation and water demand management projects. The Department of Water Affairs and Forestry is therefore developing a National Water Conservation and Demand Management Strategy, which is aimed at the water supply industry and South African society at large and aims to cover all water use sectors including agriculture, forestry, industry, recreational, ecological, and water services.

Evidence of inefficient water usage can be found in all water use sectors throughout the country and the value of water seems largely unrecognized by many water users. South Africa is a developing country that is water stressed and requires improved management of its limited water resources.

The implementation of water conservation and demand management principles is essential in meeting the national goals of basic water supply for all South Africans and the sustainable use of water resources.

TABLE 5.11.1: WATER USE BY ALIEN VEGETATION IN 1995

Catchment						Average reduction in runoff		Reduction in system 1:50 yr yield	
Primary		Secondary		Tertiary		(10^6 m^3/a)	(mm/a)	(10^6 m^3/a)	(mm/a)
No	Description	No	Description	No	Description				
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0,0	0,00
					Steenbokpan	0,0	0,0	0,0	0,00
				A42	Mokolo (Upper)	0,0	0,0	0,0	0,00
					Mokolo (Lower)	0,0	0,0	0,0	0,00
			Sub total			**0,0**	**0,0**	**0,0**	**0,00**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,0	0,0	0,00
					Lephalala (Lower)	0,0	0,0	0,0	0,00
					Soutkloof	0,0	0,0	0,0	0,00
			Sub total			**0,0**	**0,0**	**0,0**	**0,00**
		A6	Mogalakwena	A61	Nyl (Upper)	8,0	6,0	1,84	1,38
					Nyl (Middle)	4,3	4,3	1,04	1,03
					Mogalakwena (Upper)	0,0	0,0	0,0	0,01
					Sterk	4,7	2,3	1,64	0,79
				A62	Mogalakwena (Middle)	0,6	0,1	0,24	0,04
				A63	Doringfonteintjiespruit	0,0	0,0	0,0	0,00
					Mogalakwena (Lower)	0,0	0,0	0,0	0,00
					Kolope	0,0	0,0	0,0	0,00
			Sub total			**17,6**	**12,7**	**4,76**	**3,25**
		A7	Sand	A71	Sand (Upper)	2,7	0,6	0,26	0,06
					Hout	0,4	0,2	0,18	0,07
					Sand (Lower)	3,1	0,2	0,01	0,00
					Kongoloops / Soutsloot	0,0	0,0	0,0	0,00
				A72	Brak	0,0	0,0	0,0	0,00
			Sub total			**6,2**	**1,0**	**0,45**	**0,13**
		A8	Nzhelele	A80	Nzhelele (Upper)	1,9	6,6	0,86	2,99
					Nzhelele (Lower)	0,0	0,0	0,0	0,00
					Nwanedi	0,0	0,0	0,0	0,00
			Sub total			**1,9**	**6,6**	**0,86**	**2,99**
Total WMA						**25,7**	**20,3**	**6,07**	**6,37**

Water conservation and water demand management is not synonymous. The following meanings are therefore assigned to these terms in this report:

- Water conservation is the minimization of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water. Water conservation should be both an objective in water resource and water services management as well as a strategy.
- Water demand management is the adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water requirements and use of water in order to meet any of the objectives of economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services and political acceptability. Water supply institutions should set water demand goals and targets by managing the distribution systems and consumer requirements in order to achieve the above objectives.

Water demand management is deemed to include the entire water supply chain - from the point of abstraction at the source to the point of use. This includes all levels of water distribution management and consumer demand management. The conservation measures related to the water resources and return flow are part of water resource management and return flow management respectively.

Various obstacles and constraints have to be overcome before the full potential of water conservation and demand management can be achieved.

This section describes the National Water Conservation and Demand Management Objectives that will lead to the development of action plans to be implemented by the various water institutions. The needs and opportunities for the implementation of water conservation are described, as are some of the important principles on water conservation and demand management. This section also describes the platform on which the National Water Conservation and Demand Management Strategy will be based. This National Strategy Framework will also be used to develop the functions of the Directorate: Water Conservation within the Department of Water Affairs and Forestry and the functions of other departments and other water institutions. It is also intended that those principles will assist the water industry to comprehensively implement water conservation and demand management.

5.12.2 Background

Water resources and supply

The sustainability of the limited water resources is threatened in terms of quantity and quality. Unless the current water use pattern is changed, future water requirements will greatly exceed existing available fresh water resources. Frequently the water supply and quality are unreliable or improperly managed, leading to the wasteful use of water by consumers in anticipation of possible supply failures.

Environment

Environmental degradation and the prevention thereof are a key focus in the current policy and legislation. Measures such as providing for water of suitable quality in sufficient quantity in the Reserve to protect the integrity, health and productivity of the rich and diverse ecosystems have become necessary.

Neighbouring states

South Africa and the neighbouring states of Botswana, Lesotho, Mozambique, Namibia, Swaziland and Zimbabwe have certain common water resources and must collaborate to achieve the optimal use of these resources. Except for Lesotho all of these countries are water scarce and it is imperative that none of them should allow the wastage of water resources to the detriment of the other countries.

Basic water supply needs

By the application of water demand management measures to existing water services, water resources and bulk infrastructure can be reallocated for the provision of new services where adequate services do not yet exist. Water demand management is also essential in ensuring the sustainability of the new water service delivery projects and can help to ensure that water remains affordable.

Existing water services

It is estimated that up to 50% of the total quantity of water that is supplied is not accounted for in many of the urban areas. This unaccounted for water consists of a combination of reticulation system leaks, unauthorized water connections, faulty water meters and domestic plumbing leaks. These factors, combined with the low levels of payment and institutional problems of local authorities, affect the sustainability of water services. Current indications are that levels of unaccounted for water are growing despite the formulation of several water conservation strategies in the past.

Irrigation

Irrigation accounts for an estimated 51% of total water use in the Limpopo Water Management Area. Irrigation losses are often quite significant and it is estimated that often no more than 80% of water abstracted from water resources is correctly applied to the root systems of plants. Some irrigation system losses return to the river systems but this return water can be of reduced quality. Irrigation methods, irrigation scheduling, soil preparation, crop selection, crop yield targets and evaporation all affect the efficient use of water.

Forestry

Forestry accounts for an estimated 0,2% of total water use in the Limpopo Water Management Area. Issues such as site selection and preparation, species selection, rotation periods and plantation management all affect the efficient use of water.

Industry, mining and power generation

Industry is expected to be the biggest contributor to future economic growth in South Africa. The industrial sector is projected to have the greatest growth in water requirements. Much of this growth will occur in major urban centres that only have limited water resources nearby. It is imperative to have assured water supplies at a reasonable cost to support the industrial development and for the industrial sector to improve its efficiency of water use and to minimize waste.

5.12.3 Legal and Regulatory Framework

General

The Water Services Act (No. 108 of 1997) and the National Water Act (No. 36 of 1998) variously require and provide for the implementation of water conservation and demand management measures. One of the functions of the National Water Conservation and Demand Management Strategy is to fulfill the requirements made through the legislation and to utilize the opportunities created through the legislation to develop comprehensive policies and to identify and develop regulations.

Complimentary to the regulations promulgated in terms of the above two Acts are codes of practice that present guidelines for the maintenance of uniform standards within the water supply industry.

Water Services Act

The Water Services Act (No. 108 of 1997) sets out a framework to ensure the provision of basic water supply and sanitation and a regulatory framework for water services institutions. All water services institutions are required to develop conditions for the provision of water services that must include for measures to promote water conservation and demand management.

National Water Act

The purpose of the National Water Act (No. 36 of 1998) is to *inter alia* ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways that, amongst others, promote efficient, sustainable and beneficial use of water in the public interest.

Codes of Practice

The SABS Code of Practice 0306:1998 titled *The Management of Potable Water in Distribution Systems* has been drafted to establish the management, administrative and operational functions required by a water services institution to account for potable water within distribution systems and apply corrective actions to reduce and control unaccounted for water.

5.12.4 The Role of Water Conservation and Demand Management

Security of supply

The role of water conservation and demand management in ensuring security of supply can be divided into short-term rationing measures during droughts, which amount to a reduction in assurance of supply in respect of some of the water, and sustainable long-term functions.

With the current growth of water requirements it is estimated that unless water conservation and sustainable development policies are implemented, South Africa will utilize all its natural fresh water resources within 30 years. Possible alternative water resources such as importation of water from neighbouring states, desalination and harvesting icebergs are considered to be too expensive.

Protection of the aquatic environment

Aquatic ecosystems are under threat from current land use practices and over-utilization of water resources. Reducing water requirements reduces water abstractions that affect the aquatic environment and results in increased stream flows and/or decreased demand on groundwater sources and also reduces or defers the need for dams that have their own impacts on the environment.

Protection of existing water resources

The protection of water resources through water conservation measures can be achieved as follows:

- The removal of alien invading plants, which reduce surface runoff and the yield of existing resources.
- Rehabilitation of wetlands.
- Protection of groundwater resources by limiting abstraction to the sustainable yield.
- Minimizing pollution of water resources.

Economic efficiency

One of the main objectives of water demand management is economic efficiency through the entire water cycle.

In the potable water services sector, economic efficiency may often be a more important objective than water resource considerations. A certain measure that may be economically efficient from the perspective of society may not be economically efficient from the perspective of a specific water institution or user, which can be a major constraint on water demand management. However, the perspective of society needs to have priority over the economic efficiency perspective of the various water institutions or users.

Reducing the growth in water requirements can postpone large infrastructure development costs.

Social development, equity and accountability

Water demand management can enhance the objectives of social development and equity in a number of ways, some of which are given below:

- To promote maintenance, management and prevention of abuse of water infrastructure.
- To reduce domestic water consumption and waste and the cost of potable water services.
- To provide new services to people by using existing resources and bulk infrastructure.
- To offer more employment opportunities to the community.
- To make water institutions accountable to the public and understand the consumers and their needs.

5.12.5 Planning Considerations

Water conservation and demand management initiatives are not only strategies associated with environmental or communications initiatives but must be integrated into the water resource planning process as potential alternatives to increasingly expensive supply side management options.

All water demand management activities that decrease the water requirement tend to affect supply management because existing system capacity is released for other users.

The opportunities for water demand management exist where there are high levels of loss and inefficient use, particularly where water is used for the service that is derived from it and not for the water itself.

5.12.6 Water Conservation and Demand Management Measures

There are a number of categories of water conservation and demand management measures and initiatives that can be implemented. The following categories are general for all water sectors and are according to the different components of the water supply chain:

- Water conservation measures in resource management.
- Water demand management in distribution of supply management.
- Water demand management measures of customer or end user.
- Water conservation measures for return flow management.

5.12.7 Objectives of the National Water Conservation and Demand Management Strategy

The objectives of the National Water Conservation and Demand Management Strategy are as follows:

- Create a culture of water conservation and demand management within all water management and water service institutions in South Africa.
- Support water management and water services institutions to implement water demand management and water conservation.
- Create a culture of water conservation and demand management for all consumers and users in South Africa.
- Promote international co-operation and participate with other Southern African countries, particularly co-watercourse states, to develop joint water conservation and demand management strategies.
- Enable water management and water resources institutions to adopt integrated resource planning.
- Promote social development and equity in South Africa.
- Contribute to the protection of the environment, ecology and water resources.
- Contribute the parameters of water economics to development planning processes.

5.12.8 Water Conservation in South Africa

History

Since 1982 the droughts have accentuated the awareness of the need to conserve water.

In 1985 the Water Research Commission initiated a process to establish the National Water Supply Regulation (NWSR), which was proposed to be promulgated under the then Water Act. Participating local authorities were however, encouraged to promulgate the NWSR as their own Water Regulations (by-laws). Port Elizabeth Municipality was the first to adopt the NWSR in 1987. However, in 1992 the Department of Water Affairs and Forestry indicated it would not be involved with the administration of the (then) proposed NWSR and although the United Municipal Executive resolved in 1993 that local authorities should adopt the NWSR, little progress was made.

The proceedings of the National Water Supply and Sanitation Policy Conference of 1994 included an estimate of the extent of the problem of water losses due to leakage at 330×10^6 m^3/a and proposed a policy of water demand management. The subsequent Water Supply and Sanitation Policy White Paper published in 1994 referred to water conservation and demand management and encouraged a culture of water conservation and the introduction of stringent water demand management strategies to reduce water usage and the stress on resources.

The Working for Water Programme

The Working for Water Programme is part of the National Water Conservation Campaign and is based on the key assumption that invading alien plants pose a considerable threat to South Africa’s extremely rich biological diversity, and to the ecological functioning of its natural systems. Also provided by the campaign is a catalogue of devices that can contribute to the efficient consumption of water.

Water restrictions

Restricting water use during extreme droughts through the imposition of conservation measures on consumers is an intermittent form of water demand management. The effects of past water restrictions give an indication of the extent and direction that future water conservation strategies could have.

Overall savings in water use (median estimates) achieved through water restrictions were found to vary according to region and severity of restriction. In the Rand Water area of supply mild restrictions saved about 15% whereas stringent restrictions saved about 27%. For the rest of Gauteng, Free State and Northern Cape these savings were about 19% (mild) and 34% (stringent). In the Umgeni Water area of supply mild restrictions saved only 1% to 5%, whereas stringent measures saved as much as 50%. For the rest of KwaZulu/Natal these savings were 29% (mild) and 46% (stringent).

It was difficult to determine the financial effects of water restrictions. In the Vaal River Supply Area the reduction in water requirements due to water restrictions for the Rand Water, Goldfields and Vaal River supply areas for the period 1982 to 1984 was almost 240×10^6 m^3 of water or 22,5% of the requirement for the year 1982. The greatest total direct tangible financial impact was on public institutions such as the Department of Water Affairs and Forestry, Water Boards, Local Authorities and Eskom. Private households also bore a large financial impact of water restrictions. Mining had the least financial burden to bear because of water restrictions, yet achieved a net saving in water use of almost 32% in the same period. The greatest reduction in water use was for the agricultural sector, which had the second lowest direct financial impact.

From analyses of return flows in Gauteng it is concluded that the ratio of return flow to water use is not materially altered by the imposition of water restrictions. In other words, if the supply is reduced by (say) 20%, it can be assumed that the return flow will also be reduced by 20%.

Experience from past water restrictions that have proved to be the most effective during times of drought, which are relevant to future water conservation efforts are:

- The overall reduction in water use depends on a number of factors. However, when water use is reduced beyond 30% it can be detrimental to the user from a financial and motivational perspective.
- Voluntary reduction in water use fails to achieve the savings possible with mandatory steps.
- The most effective methods of reducing water use are higher tariffs, restriction of garden watering times, the banning of domestic hosepipe usage and allotting quotas to industry, bulk consumers and irrigators.
- The most effective motivations are pamphlets/newsletters, higher tariffs and punitive measures.
- The major interventions required to reduce both physical and non-physical losses from pipe networks are leak detection/monitoring, replacing old plumbing and the repair/monitoring of meters.
- The most effective methods of saving water used by commerce and industry are technical adjustments, recycle/re-use and promotion campaigns.
- The ratio of return flow to water use is not materially changed by changes in water use.

The measures implemented during the drought in the mid-1980's reduced water use and the growth rate in water usage after the drought had ended. However, there is little or no incentive for existing or new consumers to continue to retain or to adopt the water saving measures when there is no drought.

5.12.9 Water Conservation in the Limpopo Water Management Area

Based on experience elsewhere in South Africa an overall sustainable reduction in water use of up to 25% can be expected without having a detrimental effect on users. Return flows could be reduced by up to 10% of total water use.

5.13 WATER ALLOCATIONS

5.13.1 Introduction

As described in Section 3.4 of the report, numerous allocations in terms of the previous water act have been made in the past. The available information was collected and are given below.

5.13.2 Allocations and Permits Issued Under the Old Water Act

Each of the centres in an area, which abstract water for commercial and industrial water use, had to obtained the necessary permits to abstract and store water from a source. In some instances however, the volume of water allowed for abstraction greatly exceeds the yield of facilities.

Table 5.13.4.1 shows irrigation scheduling and quotas from Government Water Schemes (Article 63). Note that most of the schemes shown was not regulated in terms of the Old Water Act, since it is located in the former homeland areas. Table 5.13.4.2 shows Article 56(3) allocation from government water schemes.

TABLE 5.13.4.1: ARTICLE 63 - SCHEDULING AND QUOTAS FROM GOVERNMENT WATER SCHEMES

Scheme	Quaternary * Catchments	Scheduling **	Quota	Allocation
			(m^3 /ha/a)	(10^6 m^3/a) **
Sterk River	A61H, A61J	1 645	9 000	14,8
Nzhelele	A80F, A80G, A80C	2 914,3	8 400	26,0
Garside	A80G	30	-	-
Dopeni Scheme	A80A	170	-	-
Mpefu Scheme	A80A	112	-	-
Raliphaswa, Mandiwane and Mamuhoyi Scheme	A80B	145	-	-
The Mpaila Scheme	A80A	70	-	-
Beaconsfield Scheme	A80A	39	-	-
Deepkloof Scheme	A80A	40	-	-
Mpzena Scheme	A80A	136	-	-

* List all quaternaries in which the scheme lies.
** Totals for the whole scheme only.

TABLE 5.13.4.2: ARTICLE 56(3)-ALLOCATIONS FROM GOVERNMENT WATER SCHEMES

Scheme	Quaternary catchments*	Allocation (10^6 m^3/a)**					
		Household & Stock Watering	Munici-palities	Bulk Strategic	Bulk Mining	Irriga-tion	Total
Potgietersrus – Doorndraai Dam	A61H A61F	0,094	2,380	-	-	-	2,474
Mokolo Dam	A42F, A42J	0,057	0,465	-	-	-	0,522
Susandale Dam and Visgat Weir	A50E	0,464	2,470	-	-	-	2,934
Sterk River – Doorndraai Dam	A61H	0,023	4,672	-	-	-	4,695

* All quaternaries in which the scheme lies.
** Total for whole scheme only.

5.13.3 Water Control Areas in the Water Management Area

A Government Water Control Area is an area, which has been identified as such in the Government Gazette. The purpose of declaring an area as a water control area is to ensure an equitable distribution of water between all the users. Usually, in such cases, a full list of the farms or farm portions and the scheduled areas for each, as well as the rate of water allocation per unit area per year, is published in the Government Gazette. Scheduling and quotas from Government Water Control Areas are shown in Table 5.13.4.3. Table 5.13.4.4 shows scheduling and quotes from Government Underground Water Control Areas.

TABLE 5.13.4.3: ARTICLE 62 – SCHEDULING AND QUOTAS IN GOVERNMENT WATER CONTROL AREAS

Water Control Area	Quaternary * Catchments	Scheduling ** (Ha)	Quota (m^3 /ha/a)	Allocation ($10^6 m^{3/}a$) **
Doorndraai Dam	A61H	500	7 200	3,6
Magalakwin River (Glen Alpine Irrigation Scheme)	A63A, A63B, A63C, A63D	958	6 200	5,9
Ngotwani – Marico – Limpopo River	A63C, A63D, A63E		9 100	
Mokolo	A42F			28,6+

* List of all quaternaries in the GWCA.
** Totals for the whole area.
\+ Includes irrigation allocation at a lower assurance level

TABLE 5.13.4.4: ARTICLES 32A AND 32B - ALLOCATIONS IN SUBTERRANEAN WATER CONTROL AREAS

Subterranean Water Control Area	Quaternary Catchments*	Irrigation			Other Water Use (m^3 /ha/a)
		Scheduling** (ha)	Quota (m^3 /ha/a)	Allocation ($10^6m^3/a$) **	
Nyl Valley	A61B, A61C, A61D, A61E, A61F	1 070	6 542	7	-
Dorps River	A61F	359	8 000	2,87	2,9

* List all quaternaries that the area covers.
** Totals for the whole area only.

5.13.4 Permits and Other Allocations

Industrial, mining and effluent permits including Articles 12, 12B and 21 are shown in Table 5.13.4.5.

TABLE 5.13.4.5: INDUSTRIAL, MINING AND EFFLUENT PERMITS (INCLUDING ARTICLES 12, 12B AND 21)

Town / Centre	Source	Permit No	Date	Allocation (10^6 m^3)	Remarks
Nylstroom	Donkerpoort Dam	190/1/15	1970	N/A	Storage limit increased from 1,7 to 2,58 x 10^6 m^3
Naboomspruit	Frikkie Geyser Dam			0,75	Includes 0,33 to Buffalo Fluorspar
	Nylsvlei boreholes			1,00	
Potgietersrus	Planknek boreholes			2,11	Exceeds yield
	Combrink Dam			0,70	Decommissioned
	Volspruit boreholes			0,50	Not developed
Buffalo Fluorspar	Sandsloot effluent re-use	661 708 B	1977	0,55	Exceeds yield
	Frikkie Geyser Dam	540 N	1979	0,33	

Town / Centre	Source	Permit No	Date	Allocation (10^6 m^3)	Remarks
Zaaiplaats	Sterk River	510 N	1978	1,10	Flow often insufficient
Union Tin mine	Waterberg River		1966	0,10	Mine closed
Grass Valley	Nyl River				
Chrome mine	Boreholes		1979	0,00	Mine closed
Pietersburg	Dap Naude Dam				
	Ebenezer Dam wellfield	AV08/8	1974	6,61	
Louis Trichardt	Albasini Dam wellfield				
Messina	Limpopo River				
Seshego	Ebenezer Dam	AV08/8	1974	2,30	
Mankweng / Univ of the North	Ebenezer Dam	76/112	1978		
Perskebult*	Wellfield				
Silicon Smelters	Pietersburg Municipality				Permit applied for
Messina Copper Mine	Limpopo River				
RSA users on Ebenezer pipeline	Ebenezer Dam	Refer DWA	1971 – 1986	0,319	
Lebowa users on Ebenezer pipeline	Ebenezer Dam	Refer DWA	1976 - 1985	0,232	

* Perskebult/Bloedrivier is a rapidly growing, densely populated settlement adjacent to Seshego in Seshego district.

5.13.5 Allocations in Relation to Water Requirements and Availability

When comparing the above allocation to the developed yields in Table 6.1.1, the following observations can be made:

- Allocations from the Mokolo Dam are approximately in balance with the firm yield.
- Allocations in the Lephalala catchment seem to exceed the available yield.
- Allocations in the Glen Alpine Irrigation Scheme seems to be in balance with the firm yield, but considering that about 70% more water has to be released, the actual usage is somewhat higher than the yield.
- The Article 63 allocation in the Nzhelele catchment exceeds the yield of the Nzhelele Dam.

5.14 EXISTING WATER TRANSFERS

5.14.1 Introduction

Water transfers out of a quaternary catchment are a water requirement from the catchment, while water transfers into a catchment represent a resource or source of supply for the catchment. Water transfers to augment the supply of water for urban, industrial and agricultural use are categorized as follows:

- Transfers to and from neighbouring states.
- Transfers between Water Management Areas (e.g. Letaba River–Sand River transfer).
- Transfers within WMAs are transfers between and within quaternary catchments within a WMA.

The Limpopo WMA receives water from the following WMA's:

- Olifants
- Luvuvhu / Letaba
- Crocodile West and Marico

The WMA does not transfer any water to other WMA's.

5.14.2 Transfers to and from Neighbouring States

There are no transfers to and from neighbouring states.

5.14.3 Inter-WMA Transfers

The major schemes have been previously briefly described in section 4.2 and all transfers for 1995 are listed in Table 5.14.3.1.

During 1995 approximately 14,869 x 10^6 m^3 of water was imported from various WMA's to augment the water resources of the Limpopo WMA. The most significant imports were the following:

- Magalies Water transfer from Klipdrift Water Treatment Works to Nylstroom.
- Dap Naude and Ebenezer Dams to Pietersburg.
- Albasini Dam to Louis Trichardt.

Future inter-catchment transfers being planned, include:

- Transfers from the Olifants River to the Sand River (for Pietersburg, Lebowakgomo and Groothoek area)
- Nandoni Dam to Louis Trichardt.

TABLE 5.14.3.1: INTER-WMA TRANSFERS UNDER 1995 DEVELOPMENT CONDITIONS

Description Of Transfer	Source WMA And Quaternary	Receiving WMA Key Point catchment Quaternary catchment	Transfer Quantity Receiving WMA ($10^6m^3/a$)	Transfer Quantity Source WMA ($10^6m^3/a$)		
				Transfer	Losses	Total
Inter-WMA transfer into WMA :						
Magalies Roodeplaat Dam Scheme	Crocodile West and Marico Roodeplaat Dam A23F	Limpopo Upper Nyl Nylstroom A61A	-3	n.a.	n.a.	n.a.
Sand–Letaba System	Luvuvhu and Letaba Dap Naude and Ebenezer Dam B81A	Limpopo Upper Sand Pietersburg A71A	-10,1	n.a.	n.a.	n.a.
Louis Trichardt Regional Scheme	Luvuvhu and Letaba Albasini Dam A91B	Limpopo Lower Sand Louis Trichardt A71H	-1,8	n.a.	n.a.	n.a.
Total water imports in 1995 :			-14,869	n.a.	n.a.	n.a.
Total water exports in 1995 :			0,0	0	0	0

Note: A [+] in the transfer column indicates a surplus for the receiver quaternary that is routed through the system; while a [–] symbol represents the supply of a requirement in the receiving quaternary.

5.14.4 Transfers within the WMA

Within the Limpopo WMA there are numerous in-basin transfers that include transfers between quaternaries and even within quaternaries. Significant transfers by urban users (including water boards), bulk users (industry & mines) and agriculture (for irrigation) are listed in Table 5.14.4.1.

The most significant urban transfers are to Potgietersrus. The most significant bulk user is the Grootgeluk mine.

TABLE 5.14.4.1: SIGNIFICANT TRANSFERS WITHIN THE WMA IN 1995

Description Of Transfer	Source & Quaternary	Destination & Quaternary	Quantity ($10^6 m^3/a$)
Urban users:			
Doorndraai Dam to Potgietersrus water supply system			
	Doorndraai Dam A61H	Potgietersrus A61F	2,63
Bulk users:			
Mokolo Regional Water Supply Scheme			
	Mokolo Dam A42F	Grootgeluk Mine & Matimba Power Station A42J	17,2
	Mokolo Dam A42F	Ellisras A42J	1,0

The most significant in-basin transfer scheme being planned is the transfer of treated sewage effluent from the Sand River (Pietersburg) to Mogalakwena (PPL Mine).

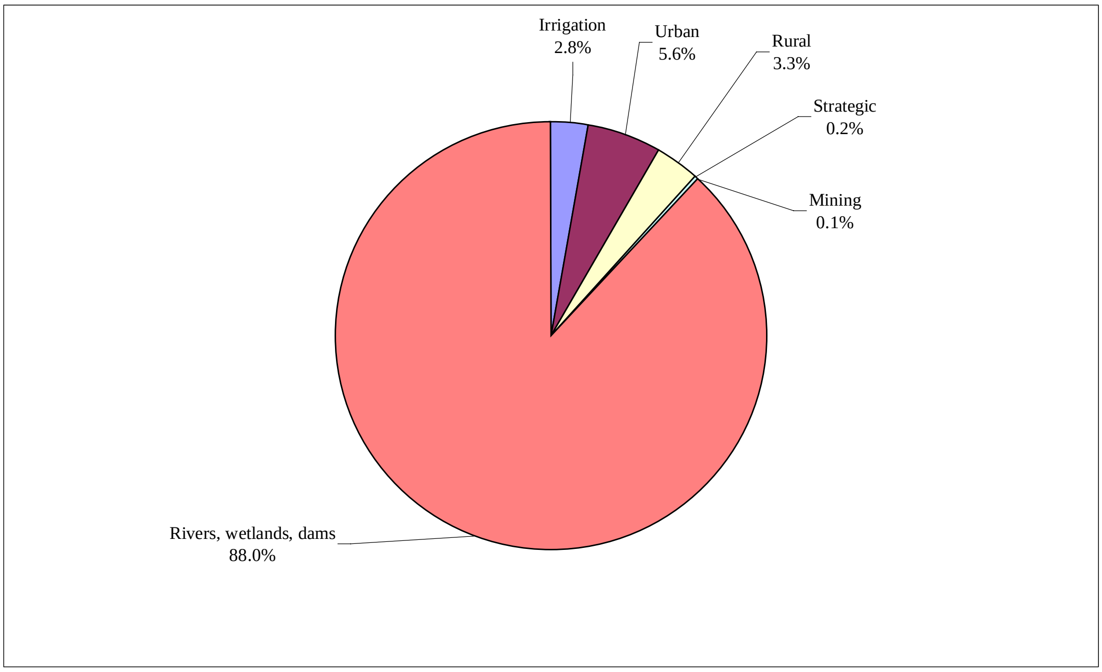
5.15 SUMMARY OF WATER LOSSES AND RETURN FLOWS

A summary of the water requirements, losses and return flows are shown in Table 5.15.1. Diagram 5.15.1 shows the portion of total losses contributed by each of the five categories considered. Diagram 5.15.2 shows the portion of total return flow contributed by each of the six categories considered.

TABLE 5.15.1: SUMMARY OF WATER REQUIREMENTS, LOSSES AND RETURN FLOWS

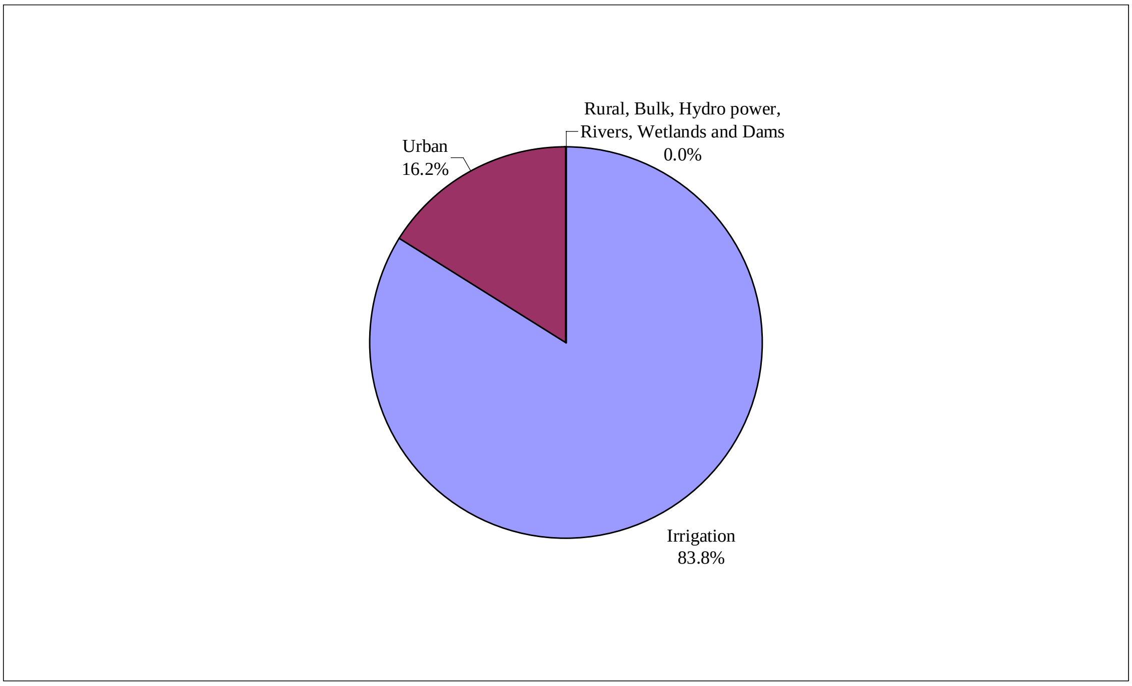
Category		On-Site Water Requirements ($10^6 m^3/a$)	Losses		Return Flow ($10^6 m^3/a$)
			($10^6 m^3/a$)	(%)	
Irrigation		282,34	4,56	1,6	36,72
Urban		35,7	9,04	25,3	7,12
Rural		30,81	5,3	17,2	0
Bulk	a) Strategic	3,55	0,35	9,9	0
	b) Mining	21,3	0,19	0,9	0
	c) Other	0	0	0	0
Hydro-power		0	-	-	-
Rivers, wetlands, dams		164,90	143,2	86,8	-
TOTAL		**538,6**	**162,64**	**30,2**	**43,84**

Diagram 5.15.1: Category loss as a portion of the total losses



NOTE : "Bulk" is bulk industrial, mining and thermal power stations.

Diagram 5.15.2: Category return flow as a portion of the total return flow in the WMA losses in the WMA



NOTE : "Bulk" is bulk industrial, mining and thermal power stations.

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF THE WATER RESOURCES

The total natural MAR of the Limpopo WMA, excluding the Limpopo River, is about 990 x 10^6 m^3/a. The Limpopo WMA is in a mostly semi-arid region, with significant runoff occurring only in the mountainous area. The Limpopo River is a major resource, lacking suitable dam sites and since development of major dams would involve neighbouring states, the present usage is limited to small weirs or well fields. The total Limpopo River system runoff at the WMA outlet is estimated at 2 008 x 10^6 m^3/a.

In the WMA, the largest contribution to runoff is from the Mokolo Secondary Catchment with 38% or 381,7 x 10^6 m^3/a. The potential surface water resources are nearly fully developed with major dams and a host of smaller dams existing in the WMA. Only the upper Lephalala River and Mokolo River have significant potential for surface water development. The existing Mokolo Dam can be raised 15 m and a number of dam sites have been investigated in the Lephalala River. The developed yield from surface water in 1995 is about 262 x 10^6 m^3/a.

Regarding groundwater resources, some 98 x 10^6 m^3/a of the potential groundwater is exploited. The exploitation potential not contributing to base flow is estimated as 240 x 10^6 m^3/a and the surplus of about 140 x 10^6 m^3/a is mainly within the Mokolo and Mogalakwena secondary catchments.

Figure 6.1.1 shows the 1:50 year yield of the total water resources as developed in 1995.

The full potential yield in the WMA, excluding the Limpopo River, was determined by adding to the water resources (surface and groundwater) as developed in 1995, the unused exploitable groundwater potential, not contributing to base flow, and the theoretically utilisable surface water yield. The surface water potential was determined using a regionalised approach, based on the creation of storage. The size of storage required depended on the variability of the river system, i.e. in regions with high variability, larger storage, relative to the MAR, is required. No provision was made for the ecological reserve in the yield calculation.

Figure 6.1.2 shows the 1:50 year yield of the total water resources if developed to full potential.

TABLE 6.1.1: WATER RESOURCES

Catchment						Surface Water Resources (10^6 m^3 /a)			Sustainable groundwater exploitation potential not linked to surface water (10^6 m^3 /a)		Total water resources (10^6 m^3 /a)	
Primary		Secondary		Tertiary								
No	Description	No	Description	No	Description	Nat – MAR	1:50 Yr Developed yield in 1995*	1:50 yr Total potential yield	Developed in 1995	Total potential	1:50 yr Developed in 1995	1:50 yr Total potential
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	54,8	17,7	21,4	4,2	20,8	21,9	42,2
					Steenbokpan	11,4	0,0	4,4	1,8	6,5	1,8	10,9
				A42	Mokolo (Upper)	240,4	50,7	134,4	0,2	-12,0	50,9	122,0
					Mokolo (Lower)	75,1	10,4	29,3	0,4	16,9	10,8	46,2
			Sub total			**381,7**	**78,80**	**189,5**	**6,6**	**32,2**	**85,4**	**221,3**
		A5	Lephalala	A50	Lephalala (Upper)	131,0	4,8	64,3	1,7	5,7	6,5	70,0
					Lephalala (Lower)	13,5	6,1	4,3	1,8	11,5	7,9	15,8
					Soutkloof	5,0	18,7	1,6	0,6	6,8	19,3	8,4
			Sub total			**149,5**	**29,6**	**70,2**	**4,1**	**24,0**	**33,7**	**94,2**
		A6	Mogalakwena	A61	Nyl (Upper)	44,1	7,2	15,9	3,1	8,6	10,3	24,5
					Nyl (Middle)	22,6	1,2	8,8	2,0	12,1	3,2	20,9
					Mogalakwena (Upper)	54,5	13,3	15,8	2,4	10,0	15,7	25,8
					Sterk	55,7	14,8	35,9	2,0	-2,0	16,8	33,9
				A62	Mogalakwena (Middle)	69,9	9,2	29,4	2,2	31,1	11,4	60,5
				A63	Doringfonteintjiespruit	6,1	0,3	2,0	0,1	7,4	0,4	9,4
					Mogalakwena (Lower)	33,3	4,3	11,8	2,4	21,0	6,7	32,8
					Kolope	7,6	15,4	2,4	0,9	5,8	16,3	8,2
			Sub total			**293,8**	**65,7**	**122,0**	**15,1**	**94,2**	**80,8**	**216,0**
		A7	Sand	A71	Sand (Upper)	19,2	15,3	6,8	21,3	29,1	36,6	35,9
					Hout	10,8	0,1	3,9	28,2	17,9	28,3	21,8
					Sand (Lower)	20,3	47,8	7,0	6,4	14,8	54,2	21,8
					Kongoloops / Soutsloot	3,3	1,9	1,3	0,6	2,6	2,5	3,9
				A72	Brak	18,3	0,0	6,3	15,2	20,0	15,2	26,3
			Sub total			**71,9**	**65,1**	**25,3**	**71,7**	**84,7**	**136,8**	**109,7**
		A8	Nzhelele	A80	Nzhelele (Upper)	45,4	22,1	25,6	0,7	-0,9	22,8	24,7
					Nzhelele (Lower)	23,2	0,0	10,2	0,1	6,0	0,1	16,2
					Nwanedi	24,5	1,1	9,6	0,2	0,8	1,9	10,4
			Sub total			**93,1**	**23,2**	**45,4**	**1,0**	**5,9**	**24,8**	**51,3**
Total WMA						**1041,6**	**262,4**	**452,4**	**98,5**	**241,0**	**361,5**	**692,5**

* From WSAM . to be verified.

6.2 GROUNDWATER

Groundwater is an important part of the total water resources of South Africa and must be seen as part of the total hydrological cycle. The information provided here gives an overview of the groundwater resources, its interaction with surface water, the present use, (1995) and its potential for further development.

It must be noted that this information is intended for regional strategic planning and is not suitable for local site evaluations. More detailed information on the approach and methodology can be obtained in Appendix G. All information was collated on a quaternary catchment basis.

The Ground Water Harvest Potential (Seward and Seymour, 1996) was used as the basis for the evaluation. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods (see Figure 6.2.1).

The Harvest Potential was then reduced by an exploitation factor, determined from borehole yield data to obtain an exploitation potential, i.e. the portion of the Harvest Potential which can practically be exploited (see Table 6.2.1 and Figure 6.2.2).

Groundwater and surface water interaction was determined by evaluating the base flow or more specifically the contribution of Harvest Potential to the base flow. This contribution can be seen as water that can either be abstracted as groundwater or surface water. From this, the extent to which groundwater abstraction will impact on surface water has been qualitatively evaluated (see Figure 6.2.3), i.e. where the contribution is nil the impact will be negligible; where the contribution is ≤30% of the base flow the impact will be low; where the contribution is 30% - 80% of the base flow, the impact will be moderate and a high impact has been evaluated where the contribution to base flow is >80%.

Baron and Seward (2000) determined the existing groundwater use. The information was then verified at a workshop held in the WMA by the Water Resources Situation Assessment team. This provided local input to the groundwater use numbers provided by Baron and Seward, which were then adjusted accordingly (see Table 6.2.1 and Figure 6.2.4).

The groundwater balance then compares existing groundwater use to Harvest and Exploitation Potential to determine the extent to which the groundwater resources are utilized (see Figure 6.2.5). Therefore, if the total use was greater than the Harvest Potential, the catchment was considered over-utilized, if the total use was greater than the exploitation potential but less than the Harvest Potential, the catchment was considered heavily utilized. If the total use was more than 2/3 of the Exploitation Potential the catchment was considered moderately-utilized and if the total use was less than 2/3 of the Exploitation Potential the catchment was considered under-utilized.

The following figures are included:

- Figure 6.2.1 Groundwater Harvest Potential and
- Figure 6.2.2 Groundwater Exploitation Potential;
- Figure 6.2.3 Groundwater Use in 1995 and
- Figure 6.2.4 Remaining Groundwater Exploitation Potential in 1995

Table 6.2.1 indicates groundwater resources at 1 in 50 year assurance of supply.

TABLE 6.2.1: 1995 GROUNDWATER RESOURCES AT 1 IN 50 YEAR ASSURANCE OF SUPPLY

Catchment						Ground water exploitation potential (10^6 m^3 /a)	Ground water use (10^6 m^3/a)	Unused groundwater exploitation potential (10^6 m^3 /a)	Groundwater contribution to surface water baseflow (10^6 m^3 /a)	Portion of ground water exploitation potential not contributing to base flow (10^6 m^3/a)
Primary		Secondary		Tertiary						
No	Description	No	Description	No	Description					
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	21,7	4,2	17,4	0,9	20,8
					Steenbokpan	6,4	1,8	4,7	0,0	6,5
				A42	Mokolo (Upper)	28,6	0,2	28,3	40,5	-12,0
					Mokolo (Lower)	18,1	0,4	17,8	1,2	16,9
			Sub total			**74,8**	**6,6**	**68,2**	**42,6**	**32,2**
		A5	Lephalala	A50	Lephalala (Upper)	17,3	1,7	15,7	11,6	5,7
					Lephalala (Lower)	11,6	1,8	9,8	0,0	11,5
					Soutkloof	6,8	0,6	6,2	0,0	6,8
			Sub total			**35,7**	**4,1**	**31,7**	**11,6**	**24,0**
		A6	Mogalakwena	A61	Nyl (Upper)	12,8	3,1	9,7	4,1	8,6
					Nyl (Middle)	14,4	2,0	12,3	2,2	12,1
					Mogalakwena (Upper)	15,6	2,4	13,2	5,6	10,0
					Sterk	11,9	2,0	9,9	13,9	-2,0
				A62	Mogalakwena (Middle)	35,9	2,2	33,7	4,9	31,1
				A63	Doringfonteintjiespruit	7,4	0,1	7,3	0,0	7,4
					Mogalakwena (Lower)	21,0	2,4	18,7	0,0	21,0
					Kolope	5,8	0,9	5,0	0,0	5,8
			Sub total			**124,8**	**15,1**	**109,8**	**30,7**	**94,0**
		A7	Sand	A71	Sand (Upper)	29,1	21,3	7,9	0,0	29,1
					Hout	17,9	28,2	-10,2	0,0	17,9
					Sand (Lower)	14,8	6,4	8,5	0,0	14,8
					Kongoloops / Soutsloot	2,7	0,6	2,1	0,0	2,6
				A72	Brak	20,1	15,2	4,9	0,0	20,0
			Sub total			**84,6**	**71,7**	**13,2**	**0,0**	**84,4**
		A8	Nzhelele	A80	Nzhelele (Upper)	3,7	0,7	3,0	4,6	-0,9
					Nzhelele (Lower)	7,7	0,1	7,6	1,7	6,0
					Nwanedi	2,6	0,2	2,3	1,8	0,8
			Sub total			**13,9**	**1,0**	**12,9**	**8,1**	**5,9**
Total WMA						**333,8**	**98,5**	**235,8**	**93,0**	**240,5**

6.3 SURFACE WATER RESOURCES

6.3.1 Stream Flow Data

The basis for the analysis of surface water resources for all WMAs was the synthesized streamflow data at quaternary catchment level developed for the Water Research Commission funded study of the water resources of South Africa (Midgley et al, 1994), which is commonly referred to as WR90. Certain adjustments, as described below, were made to these flow sequences.

The WR90 naturalized flows have taken account of afforestation-related streamflow reductions according to the "Van der Zel curves". Recently these curves have been seen as too simplistic, and have been superseded by the "CSIR curves". These curves allow the species, age and site conditions of the afforested area to be taken into account in estimating the streamflow reduction, and are currently the preferred estimation method.

For the purpose of the Water Situation Assessment Model (WSAM) it was decided to adjust the WR90 quaternary naturalized flows to reflect the CSIR afforestation-related streamflow reduction effects. An investigation to determine a method of making the adjustments without serious time or cost implications was conducted (Ninham Shand, 1999). The selected method consisted of the following steps:

(1) The afforestation water use time series based on the Van der Zel 15-year rotation curve was generated
.

(2) This time series (the result of (1)) was then subtracted from the Van der Zel-based naturalized flow time series generated for the whole calibration catchment.

(3) The naturalized flow from the afforested portion of the catchment (Van der Zel-based) was used to obtain an afforestation water use time series based on the CSIR curves. This result was added to the result of (2), yielding a time series of adjusted (CSIR-based) naturalized flows.

These adjusted flows have been used for the catchments that contain afforestation.

A validation of this adjustment method was carried out for five gauged catchments from three geographically different regions, which had full hydrological studies available from recent basin studies. Calibration configurations were obtained from these studies. An identical configuration was set up to include the CSIR afforestation-related flow reduction function, and the Pitman model was recalibrated. This resulted in two "calibrated" sets of Pitman model parameters for each catchment, the one using the Van der Zel, and the other using the CSIR afforestation-related streamflow reduction functions.

Monthly naturalized flows were simulated using the two calibrated parameter sets. The CSIR series was used as the "true" series for validation and compared with the Van der Zel time series after it was adjusted as described above.

Differences between the MARs of the adjusted (CSIR-based) naturalized flows and the re-calibrated "true" naturalized flows were within 5%, which was considered to be acceptable.

Based on the three steps described above, the WR90 naturalized flow series were then adjusted for all the afforested quaternary catchments in the country. If the runoff reduction due to afforestation estimated by means of the CSIR curves was lower than the runoff reduction estimated by means of the Van der Zel curves, the virgin runoff of WR90 would have been reduced and *vice versa*. The difference between the adjusted MARs and the original WR90 values ranges between a reduction of 18% and an increase of 28%. For most of the catchments the difference varies between zero and an increase of 7%.

The proposed methodology ensures that the calculated runoff from an afforested catchment (which would be observed at a streamflow gauge) is the same, irrespective of the afforestation water use model that has been used.

The most important limitations of the method described above are:

- The updated afforestation water use was estimated by means of the CSIR curves (as described in (3)), but the uncorrected naturalized flows based on the original Van der Zel curves were used as input into this calculation. As a refinement, one could consider the possibility of repeating the process, but this time estimating afforestation water use, not using the original WR90 naturalized flows, but rather the newly adjusted ones. This could then be used to make a second estimate of the CSIR-based natural flows. Further re-iterations of this process might improve the accuracy.

- Catchments upstream of some calibration gauges contained quaternaries with and without afforestation. Changing the MARs of only afforested quaternary catchments therefore made the naturalized MAR of the total catchment less accurate, as the MARs of unafforested catchments were not adjusted.

The perfect solution is to re-calibrate all affected catchments. However, as was explained above, at this stage it was considered inappropriate. It is recommended that a sensitivity analysis be done in order to determine whether these limitations have a significant effect on the results.

Table 6.3.1.1 gives values of the surface water resources in the Limpopo WMA (excluding the main stem of the Limpopo River). It should be noted that the gross catchment areas have been entered into the database. However, in some of the western sub-catchments, endoreic areas occur and the actual area contributing to runoff is smaller. Similarly, the gross mean annual runoff (from WR90) is shown. The net runoff for the WMA is 935,3 million m^3/a, which is 6% less than the gross MAR of 990,1 million m^3/a shown in the table.

Figure 6.3.1 shows the mean annual naturalised runoff for the different quaternaries.

TABLE 6.3.1.1: SURFACE WATER RESOURCES

Catchment						Gross Catch-ment area (km^2)	Mean annual precipitation (mm/a)	Mean annual evaporation (mm/a)[(2)]	Naturalised Gross MAR		Yield (1:50 yr)[(1)]	
Primary		Secondary		Tertiary					Incremental (10^6 m^3/a)	Cumulative for tributaries of Limpopo (10^6 m^3/a)	Developed in 1995 (10^6 m^3/a)	Total potential (10^6 m^3/a)
No	Description	No	Description	No	Description							
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	4 074,0	528,4	1 912,0	54,8	**54,8**	17,7	21,4
					A41E	1 940,0	438,0	1 950,0	11,4	All to Limpopo	0,0	4,4
				A42	Mokolo (Upper)	4 319,0	625,0	1 753,0	240,4	240,4	50,7	134,4
					Mokolo (Lower)	4 076,0	487,8	1 922,0	75,1	**315,5**	10,4	29,3
			Sub total			**14 409,0**	**519,8**	**1 860,0**	**381,7**	n.a.	**78,3**	**189,5**
		A5	Lephalala	A50	Lephalala (Upper)	2 704,0	561,4	1 771,0	131,0	131,0	4,8	64,3
					Lephalala (Lower)	2 766,0	415,3	1 950,0	13,5	**144,5**	6,1	4,3
					Soutkloof	1 255,0	391,0	2 000,0	5,0	All to Limpopo	18,7*	1,6
			Sub total			**6 725,0**	**455,9**	**1 908,0**	**149,5**	n.a	**29,6**	**70,2**
		A6	Mogalakwena	A61	Nyl (Upper)	1 330,0	616,7	1 718,0	44,1	44,1	7,2	15,9
					Nyl (Middle)	1 003,0	601,6	1 736,0	22,6	66,7	1,2	8,8
					Mogalakwena (Upper)	1 716,0	633,1	1 705,0	54,5	121,2	13,3	15,8
					Sterk	1 403,0	590,9	1 795,0	55,7	55,7	14,8	35,9
				A62	Mogalakwena (Middle)	5 795,0	478,4	1 884,0	69,9	246,8	9,2	29,4
				A63	Doringfonteintjie-spruit	1 323,0	378,0	2 050,0	6,1	All to Limpopo	0,3	2,0
					Mogalakwena (Lower)	4 752,0	414,8	1 991,0	33,3	**280.1**	4,3	11,8
					Kolope	1 992,0	358,0	2 050,0	7,6	All to Limpopo	15,4*	2,4
			Sub total			**19 314,0**	**508,9**	**1 898,0**	**293,8**	n.a.	**65,7**	**122,0**
		A7	Sand	A71	Sand (Upper)	4 249,0	432,2	1 720,0	19,2	19,2	15,3	6,8
					Hout	2 451,0	417,3	1 822,0	10,8	10,8	0,1	3,9
					Sand (Lower)	3 842,0	396,7	1 879,0	20,3	**68,6**	47,8	7,0
					Kongoloops / Soutsloot	1 765,0	288,0	2 050,0	3,3	All to Limpopo	1,9	1,3
				A72	Brak	3 462,0	410,7	1 900,0	18,3	18,3	0,0	6,3
			Sub total			**15 769,0**	**387,0**	**1 840,0**	**71,9**		**65,1**	**25,3**
		A8	Nzhelele	A80	Nzhelele (Upper)	832,0	938,0	1 400,0	45,4	45,4	22,1	25,6
					Nzhelele (Lower)	2 235,0	397,0	1 851,0	23,2	**68,6**	0,0	10,2
					Nwanedi	1 136,0	369,0	1 750,0	24,5	**24,5**	1,1	9,6
			Sub total			**4 203,0**	**568**	**1 746,0**	**93,1**	n.a.	**23,2**	**45,4**
Total WMA						**60 420,0**	**485,5**	**1 864,0**	**990,1**		**261,9**	**452,4**

(1) The Ecological Reserve has not been deducted from the yields shown. (2) Class A-pan * Includes Limpopo River yield (from WSAM)

The total potential surface water yield in the WMA was determined by the methodology described in section 6.3.2, while the current developed yield was based on information generated in WSAM. It should be noted that the yield model was probably not yet capable of determining realistic yields for the highly non-perennial rivers in the drier western parts of the WMA, where there is little or no storage. The estimated 1995 developed yield is only about 60% of the potential surface water yield. Although apparent further development potential exists in the Upper Lephalala, Mokolo, Sterk and Middle Mogalakwena areas, the cost effectiveness of the schemes may be low due to difficult dam sites leading to costly dams, expensive relocations required or distance from water demand nodes.

Table 6.3.1.2 shows the MAR for the main stem of the Limpopo River up to the outlet of the WMA, including the contribution of the upstream Crocodile and Marico Rivers, as well as its tributaries outside of the borders of the RSA. The international catchments considered are shown in Diagram 6.3.1. At the outlet, the estimated MAR of the Limpopo River system totals 2 008,7 million m³/a.

TABLE 6.3.1.2: MEAN ANNUAL RUNOFF OF MAIN STEM OF LIMPOPO RIVER

LOCALITY ON MAIN STEM	MAR (10^6 m^3/ a)
Downstream of Crocodile & Marico River confluence	741,5
Downstream of Matlabas River confluence	860,8
At downstream boundary of A41E (Steenbokpan)	985,6
Downstream of Mokolo River confluence	1297,9
Downstream of Lephalala River confluence	1435,5
At downstream boundary of A50J (Soutkloof)	1429,5
At downstream boundary of A63C (Doringfonteintjiespruit)	1435,6
Downstream of Mogalakwena River confluence	1676,9
At downstream boundary of A63E (Kolope)	1808,0
At downstream boundary of A71L (Kongoloops / Soutsloot)	1819,5
Downstream of Sand River confluence	1880,5
Downstream of Nzhelele River confluence	1969,2
Downstream of Nwanedi River confluence	1993,7
At outlet of WMA	2008,7

6.3.2 Yield Analysis

In order to estimate the total potential yield available from the catchments within the Water Management Area, future storage dams of a particular maximum net storage capacity have been postulated. The net incremental storage capacities that have been adopted within the Water Management Area are given in Appendix G for each group of quaternary catchments that falls within the same hydrological zone, as defined in WR90 (Midgley, et al., 1994). These range from 300% of the MAR in the higher rainfall quaternary catchments to 200% of the MAR in the drier quaternary catchments within the Water Management Area.

Dams that will capture and regulate all the runoff from a catchment are not economical to build. In the drier areas where the runoff is more variable the sizes of such dams also become prohibitive.

A simple technique, based on past experience, has therefore been developed whereby plausible estimates of maximum feasible dam size have been derived for the entire South Africa and which will provide consistent results throughout the country. The water balance model will however, be enhanced in future to contain additional functionality to allow users to optimize the likely maximum storage capacity.

The technique that was adopted introduces a limit line to the net storage-gross yield relationship for a 50-year recurrence interval, as shown in Diagram 6.3.1. The net total incremental quaternary catchment storage capacity used to estimate the potential contribution to the yield by a quaternary catchment has been determined from the intersection of the net storage–gross yield relationship for a 50-year recurrence interval for a particular hydrologic zone, and the limit line shown in Diagram 6.3.1. This is illustrated by means of the typical net storage-gross yield relationships shown in Diagram 6.3.1 for rivers of low, moderate and high flow variability, which generally correspond to rivers draining high, moderate and low rainfall catchment areas respectively. The net total incremental storage capacities derived by means of this method have been rounded off to 200%, 250% or 300% of the MAR as appropriate. In this method, the variability of the rivers were classified, and the storages assumed for the calculation of the dam yield were the following:

- Dams in rivers with low variability: capacity 100% of MAR
- Dams in rivers with medium variability: capacity 150% or 200% of MAR
- Dams in rivers with high variability: capacity 250% or 300% of MAR.

The detail calculations are shown in Appendix I, while Figure 6.3.2 shows water resource development potential according to drainage areas.

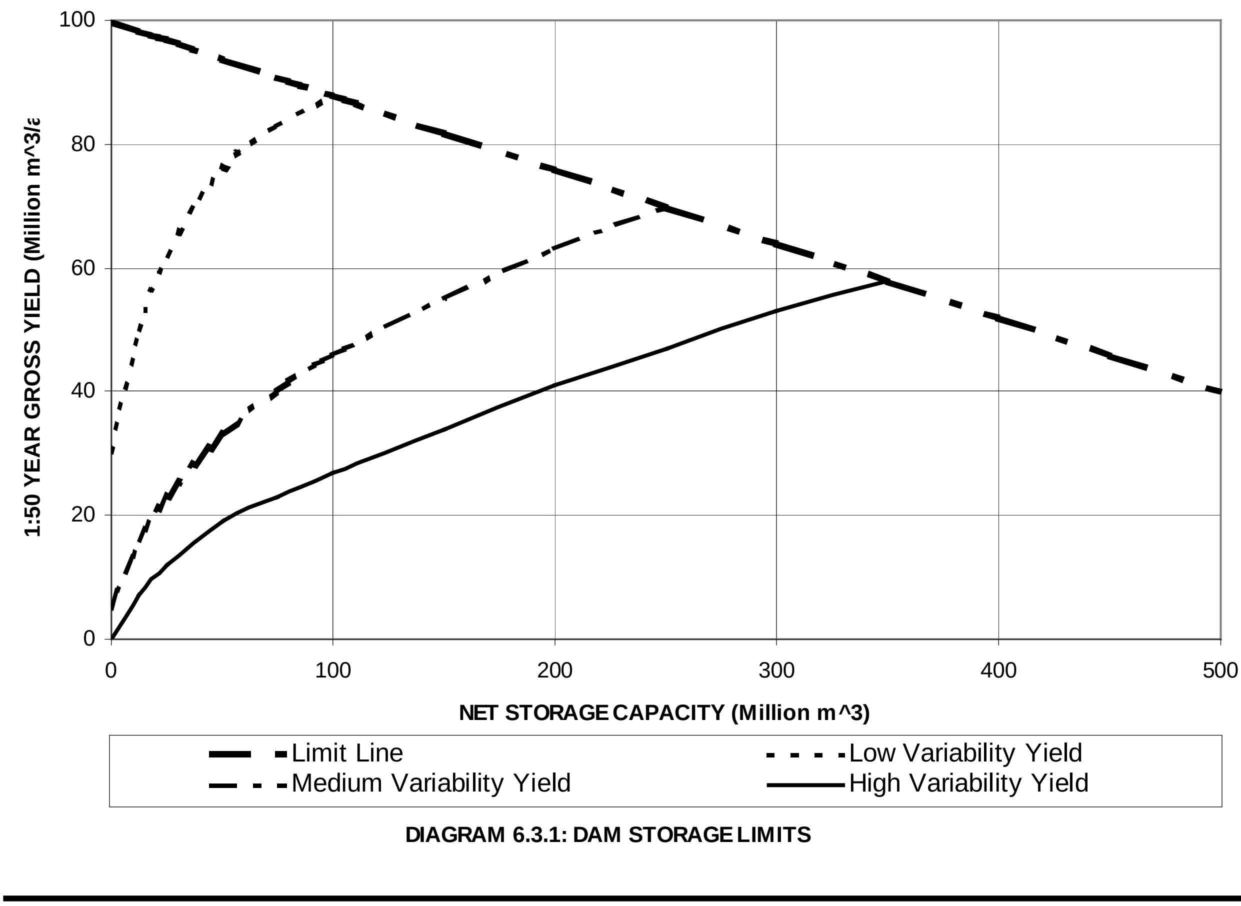


DIAGRAM 6.3.1: DAM STORAGE LIMITS

6.4 WATER QUALITY

6.4.1 Mineralogical Surface Water Quality

The purpose of this assessment is to provide an indication of where water quality problems can be expected rather than provide a comprehensive overview of water quality in the Water Management Area.

The mineralogical water quality of the surface water bodies is only described in terms of total dissolved salts (TDS). Data for the assessment were obtained from the water quality database of the Department of Water Affairs and Forestry.

The surface water quality monitoring stations that were used to provide the data are located along major rivers, usually at hydrological measuring stations and are therefore limited in number and spatial distribution. The Mogalakwena catchment has water quality monitoring stations mainly on the Nyl River, with some information from downstream. The Lepahalala River has four monitoring stations which covers the whole river. The Nzhelele River has monitoring stations at the Mushedzi and Nzhelele Dams as well as at the Kranspoort and Bosbokpoort canals and at the weir downstream of the Nzhelele Dam.

Only data sets that had data for the last five years were used. The data sets were filtered to monthly data, and various techniques were used to fill in missing values where possible. Only those data sets that spanned at least two years and contained at least 24 data points were eventually selected for analysis. These were used to derive the mean and maximum TDS concentrations.

It should be noted that the methodology is less suitable for the assessment of water quality in ephemeral rivers where no flows occur for long periods of time, resulting in a low frequency of sampling.

The water quality is described in terms of a classification system developed for the Water Resources Situation Assessments. The uses that were taken into account were domestic use and irrigation. It was assumed that if the water quality met the requirements for domestic and irrigation use it would in most cases satisfy the requirements of other uses. The South African Water Quality Guidelines of the Department of Water affairs and Forestry (1996) for these two uses were combined into a single classification system as shown in table 6.4.1.1.

TABLE 6.4.1.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY

Class	Colour Code	Description	TDS Range (mg/ℓ)
0	Blue	Ideal water quality	<260
1	Green	Good water quality	260 - 600
2	Yellow	Marginal water quality	601 – 1 800
3	Red	Poor water quality	1 801 – 3 400
4	Purple	Completely unacceptable water quality	>3 400

Where water quality data were available, water quality was assessed at a quaternary catchment level of resolution. The final classification of the mineralogical surface water quality of a quaternary catchment should be based on both average conditions and extreme conditions. For this purpose the data set is inspected for the worst two-year period observed. The average concentration and the maximum are then used to determine the class of the water as shown in Table 6.4.1.2.

TABLE 6.4.1.2: OVERALL CLASSIFICATION

Average Concentration Class	Maximum Concentration Class	Overall Classification
Blue	Blue Green Yellow Red Purple	Blue Green Green Yellow Purple
Green	Green Yellow Red Purple	Green Yellow Yellow Purple
Yellow	Yellow Red Purple	Yellow Red Purple
Red	Red Purple	Red Purple
Purple	Purple	Purple

The water quality of the Limpopo Water Management Area is summarized in Table 6.4.1.3 and shown in Figure 6.4.1.1. It should be noted that only average values were available for the evaluation.

TABLE 6.4.1.3: SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE LIMPOPO WATER MANAGEMENT AREA

Secondary Catchment	Number of Quaternary Catchments	Number of Quaternary Catchments in each Class				
		Class O: Blue	Class 1: Green	Class 2: Yellow	Class 3: Red	Class 4: Purple
A4	14	0	10	4	0	0
A5	9	0	6	3	0	0
A6	23	0	15	8	0	0
A7	13	0	0	13	0	0
A8	9	0	6	3	0	0

The mineralogical surface water quality of the Limpopo Water Management Area is generally good. The only exception to this occurs in the Sand River catchment (A7) which is relatively highly urbanized upstream of Messina and receives large quantities of industrial and domestic effluent. As can be seen from the table above, no Class 1 water quality samples were obtained in this catchment area.

6.4.2 Mineralogical groundwater quality

The ground water quality is one of the main factors affecting the development of available ground water resources. Although there are numerous problems associated with water quality, some of which are easily remedied, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (M Simonic, 2000). The mean TDS together with the highest value, lowest value and range is given for each catchment where analyses were available. Where no analyses were available an estimate of the mean was made using Vegters Maps (Vegter, 1995). The potability evaluation done by Simonic (M Simonic, 2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The portion of the ground water resources considered potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) and according to Quality of Domestic Water Supplies, Volume I (DWAF, 1998). Water classified as poor and unacceptable (Class 3 and 4) has been considered **not** potable.

In catchments where no information was available estimates of the portion potable were made using Vegters maps (Vegter 1995).

Figure 6.4.2.1 gives an evaluation of the mean TDS per quaternary catchment and Figure 6.4.2.2 gives an estimate of the percentage potable water per quaternary catchment.

Estimated overall groundwater quality class and areas with high fluoride or nitrate concentrations are shown in Figure 6.4.2.1.

6.4.3 Microbiological (or microbial) water quality

Background

A method was developed and applied to assess the risk of microbial contamination of surface water and groundwater resources in South Africa. (Refer to Appendix G2 for details of the study). Maps depicting the potential vulnerability of surface water and groundwater to microbial contamination were produced at a quaternary catchment resolution. The maps provide a comparative rating of the risk of faecal contamination of the surface water and groundwater resources. The microbial information that has been provided is, however, intended for planning purposes only and is not suitable for detailed water quality assessments.

Mapping microbial contamination of surface water resources

As part of the National Microbiological Monitoring Programme a screening method was developed to identify the risk of faecal contamination in various catchments. This screening method uses a simple rule based weighting system to indicate the relative faecal contamination from different land use areas. It has been confirmed that the highest faecal contamination rate is derived from high population densities with poor sanitation services. The Programme produced a map, at quaternary catchment resolution, showing the potential faecal contamination in the selected catchments. Unfortunately, the map did not cover the entire country.

As part of this study, the same screening method was applied to produce a potential surface faecal contamination map for the whole of South Africa using national databases for population density and degree of sanitation. The portion applicable to the Limpopo WMA is given in Figure 6.4.3.1.

Mapping aquifer vulnerability of groundwater resources

Certain aquifers are more vulnerable to contamination than others. The DRASTIC method used in this study is an acknowledged method for assessing aquifer vulnerability to contamination. The method is a weighting and rating technique that considers up to seven geologically and geohydrologically based factors to estimate groundwater vulnerability. The magnitudes or severities of pollution sources are, however, not considered. Three of the above factors were used in this study to estimate the vulnerability of groundwater to microbial contamination.

Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider groundwater depth, soil media and impact of the vadose zone media. Comparison of the different maps showed remarkable similarity and confirmed that the vulnerability is largely controlled by the selected three parameters. This similarity promotes confidence in the resultant microbial contamination vulnerability map.

A GIS model, which considered the three factors, was developed and a vulnerability rating of low, medium and high was calculated for each grid element in the GIS coverage. A numerical control was included to account for deep groundwater below 35 metres. At this depth it was assumed that the surface contamination rate would be low, irrespective of the other two factors.

Mapping microbial contamination of groundwater resources

The potential surface faecal contamination and aquifer vulnerability maps were then intersected to derive a potential groundwater faecal contamination map for South Africa at a quaternary scale. The portion applicable to the Limpopo WMA is given in Figure 6.4.3.2. This map shows the degree of potential faecal contamination in groundwater using a rating scale, which ranges from low to medium to high.

Conclusions and recommendations

A limitation of the study was the inability to validate results due to the limited information on groundwater contamination resulting from human wastes.

Once sufficient microbial data becomes available, the numerical methods and associated assumptions should be validated and the maps replotted. Monitoring data from selected areas should also be collected to assess the validity of the vulnerability assessment presented in this report.

6.4.4 Water Quality Issues

The existing status of the surface water quality of the Limpopo WMA is generally good.

It is suitable for domestic use after conventional treatment processes, particularly disinfection. Its suitability for irrigation should be investigated further and relates to specific crops in some areas, but is generally acceptable. Surface water quality tends to deteriorate downstream in most of the rivers.

Data on the quality of the groundwater is limited in some areas of the WMA. The quality is largely dependent on the interaction of the water with its geological environment and leads to high fluoride, high boron and elevated sodium levels in specific geological formations. Tests on groundwater from the Swartwater and Beauty areas revealed that concentrations of total dissolved solids, nitrates and fluorides often exceed the maximum recommended levels for human consumption.

North of the Soutpansberg in the Nzhelele catchment, the quality of the groundwater will have localized influence on both domestic and agricultural use.

In high-density population areas, groundwater with unacceptable E-coli levels occurs. Figure 6.4.4.1 shows water quality issues regarding polluted urban, industrial and agricultural runoff and natural dissolution of salts and suspended solids influences on agriculture.

6.5 SEDIMENTATION

Sedimentation has a significant impact on water resources development as well as riverine ecology.

The majority of catchments with sediment yield information are situated in the upper regions of the Marico, Olifants and Crocodile River. Little data is available for areas in the far Northern Province, especially closer to the Limpopo River.

Despite the fact that the overall WMA is geologically diverse, the measured sediment yield values show a strong tendency to converge to the regional mean value with increase in catchment size. The recorded sediment yield in a dam can be affected by the creation of additional storage in the upstream catchment.

Table 6.5.1 shows observed sedimentation rates and total decreases in capacity of existing reservoirs within or adjacent to the Limpopo WMA.

The sediment production per quaternary and the 25-year sediment volume are tabulated in Appendix G of this report. Figure 6.5.1 shows the variation in sediment yield per quaternary.

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE LIMPOPO WMA

Quaternary Catchment No.	River	Dam Name	ECA (km^2)	Period	V_T ($10^6 m^3$)	V_{50} ($10^6 m^3$)	Sediment Yield ($t/km^2.a$)
A42F	Mokolo	Mokolo	4 319	1975 - 1988	1,762	1,762	11
A61H	Sterk	Doorndraai	579	1953 – 1979	1,582	2,098	98
A61KJ	Mogalakwena	Glen Alpine	10 713	1967 - 1979	1,868	4,031	10
A61F	Dorps	Combrink*	174	1964 - 1978	0,049	0,094	15
A61H	Sterk	Welgevonden	166	1954 - 1977	0,026	0,037	6
A80C	Nzhelele	Nzhelele	842	1948 - 1979	3,050	3,718	119
A80H	Nwanedi	Nwanedi	109	1963 - 1979	0,032	0,056	14
A80H	Luphephi	Luphephi	150	1963 - 1979	0,115	0,201	36

ECA = Total catchment area – catchment area of next major dam upstream
V_T = Sediment volume at end of period
V_{50} = Estimated sediment volume after fifty years at the same average yield
* Dam not shown as existing infrastructure since it had been breached

CHAPTER 7: WATER BALANCE

7.1 METHODOLOGY

7.1.1 Water Situation Assessment Model

The Water Situation Assessment Model (WSAM) was developed with the purpose of providing a reconnaissance level decision support tool. The model is intended to provide a broad overview of the water situation in South Africa taking into account all significant water uses and resources. The model can produce output at a variable resolution, down to quaternary catchment scale.

Various organisations and individuals gathered data input, but the Water Resources Situation Assessments (WRSA) were the main vehicle for providing data for the model. Appendix H lists the organisations responsible for the various components of the data. This list also gives the reader a good indication of the type of data in the database.

The intention was to use the WSAM to determine the water balance for the WRSA reports and also to use the WSAM reporting tools to produce as many of the tables in the WRSA reports as was practical. However, due to various unresolved developmental problems with the WSAM, another approach was adopted, as described in this section. For this reason, the WSAM is not described in any detail in this report. The reader is referred to the WSAM user manual for more information on this model.

7.1.2 Estimating the water balance

The water balance produced by the WSAM is not yet correct in all cases due to the following unresolved problems:

- The Ecological Reserve has spurious impacts on the water balance, which do not appear to be correct;
- The impacts of afforestation and alien vegetation, as reported on the balance do not appear to be correct;
- It is not possible to model actual known river losses; and
- Return flows from irrigation are not modeled correctly.

The approach taken to determine the water balance was therefore to remove the above questionable components out of the WSAM modeling procedure. This is done relatively easily. The above impacts (Ecological Reserve, etc.) were then determined external to the model and added or subtracted from the WSAM water balance as appropriate. This procedure achieved a resultant water balance that seemed to be in reasonable agreement with other estimates in most cases.

7.1.3 Estimating the water requirements

The water requirements determined by the WSAM are mostly accepted to be correct. In order to facilitate the production of the WRSA reports, this data was abstracted from the WSAM into a spreadsheet and various worksheets set up, which reference this abstracted data. These worksheet were structured so a to present most of the information contained in the tables of this report. This is not only limited to water requirements but also lists land uses such as irrigated areas, afforested areas, etc.

The data was abstracted in two different formats: at key area resolution (incremental between key points) and at quaternary catchment resolution. The key area data has been aggregated by the WSAM except for a few parameters relating mainly to irrigation, which the WSAM did not aggregate correctly. In these cases, default values were used. A list of these parameters and the default values is attached as Appendix H. The data at quaternary catchment resolution was abstracted for information purposes only. It is attached in the Appendices to this report.

Water requirements or gains that the WSAM could not calculate were determined as follows:

Ecological Reserve

The impact of the Ecological Reserve on the yield of a catchment depends on the storage in that catchment. It was accepted that the water required for the Ecological Reserve follows the same general pattern of (i.e. mimics) the natural flow and that the storage/yield characteristics of the natural catchment could therefore also be used to estimate the yield of the catchment after allowing for the water requirements of the Ecological Reserve. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transposed to its outlet and formed the basis for determining the incremental yield of the catchment under natural conditions, both with and without provision for the Ecological Reserve. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The incremental impact of the Ecological Reserve on the water resources of a particular key area was taken to be the difference between the impact at the downstream key point and the impact at the upstream key point.

The impact of the Ecological Reserve on the run-of-river yield was accepted to be the annual equivalent of the lowest 4-month water requirement for the Ecological Reserve. This value was used to establish the incremental impact of the Ecological Reserve on the yield at a key point at which there was no significant storage in the incremental catchment.

Using the above method, negative impacts are sometimes possible. The reason for this is that the water required for the Ecological Reserve at an upstream point may become available for use further downstream, if the Ecological Reserve is less at the downstream point.

Water losses

The WSAM models losses as a function of the flow in the river. The water loss under natural flow conditions is used in the WSAM to calculate the water loss under the altered flow conditions. While this is conceptually correct, it is found to be very difficult to model the known loss under current conditions. For this reason, the WSAM was run with zero losses and the known losses taken into account external to the model when determining the water balance.

Irrigation return flows

The average return flow from irrigation in South Africa according to the WSAM is in the order of 3%. This is clearly erroneous and not in accordance with the 10% to 15% default agreed upon at various workshops. Irrigation return flows were therefore calculated external to the model and were usually assumed to be 10%. Where the consultant and/or other persons had more detailed information of the return flows that could be expected these were adopted instead.

7.1.4 Estimating the water resources

The WSAM does not report directly on the available water resource, as required for this WRSA report. This was therefore calculated external to the model as follows:

- The water balance produced by the WSAM, as described in paragraph 7.1.2 above, was mostly deemed to be correct. A few adjustments were made to the model to allow for the following:
  - Runoff into minor dams
    It appears as if the WSAM assumes that the runoff into minor dams is equal to the entire incremental flow generated within a quaternary catchment. Considering the definition of a minor dam, i.e. a dam that is not situated on the main stream of the catchment, this is not possible. An assumption was made that only 50% of the runoff of a catchment flows into minor dams and this assumption was applied throughout the WMA.
  - Impact of afforestation and alien vegetation on catchment yield
    The WSAM seems to determine the impact of afforestation and alien vegetation on yield in a realistic manner. However, it does not report correctly on what this impact is. This problem was resolved by adopting zero afforestation and alien vegetation in the catchments when running the WSAM and calculating these impacts external to the model. The impacts on the yield of the catchments were then accounted for external to the model when determining the water balance.

- The available water resource was then assumed to be the difference between the water balance and the water requirements that are supplied from the catchment.
- In some cases, there are negative balances within the quaternary catchments making up a key area. These negative balances are not routed through the system, and it was therefore necessary to sum these negative balances and subtract them from the water resource.
- In some cases the WSAM did not model the yield of major dams correctly and the yield curves were adjusted to approximate the yield as obtained from more detailed studies.

DIAGRAM 7.1.1: WATER BALANCE MODEL CONCEPTUAL LAYOUT

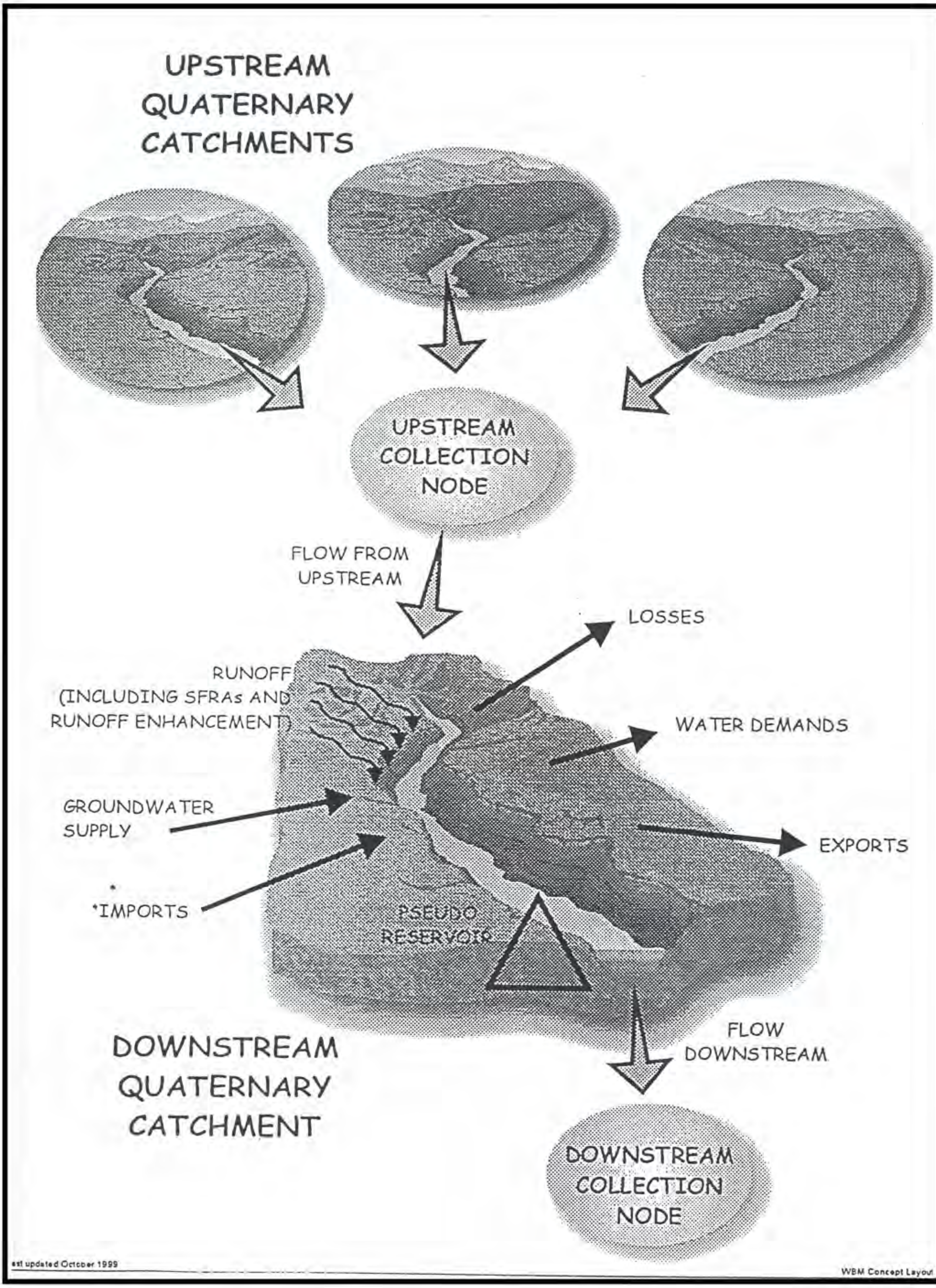
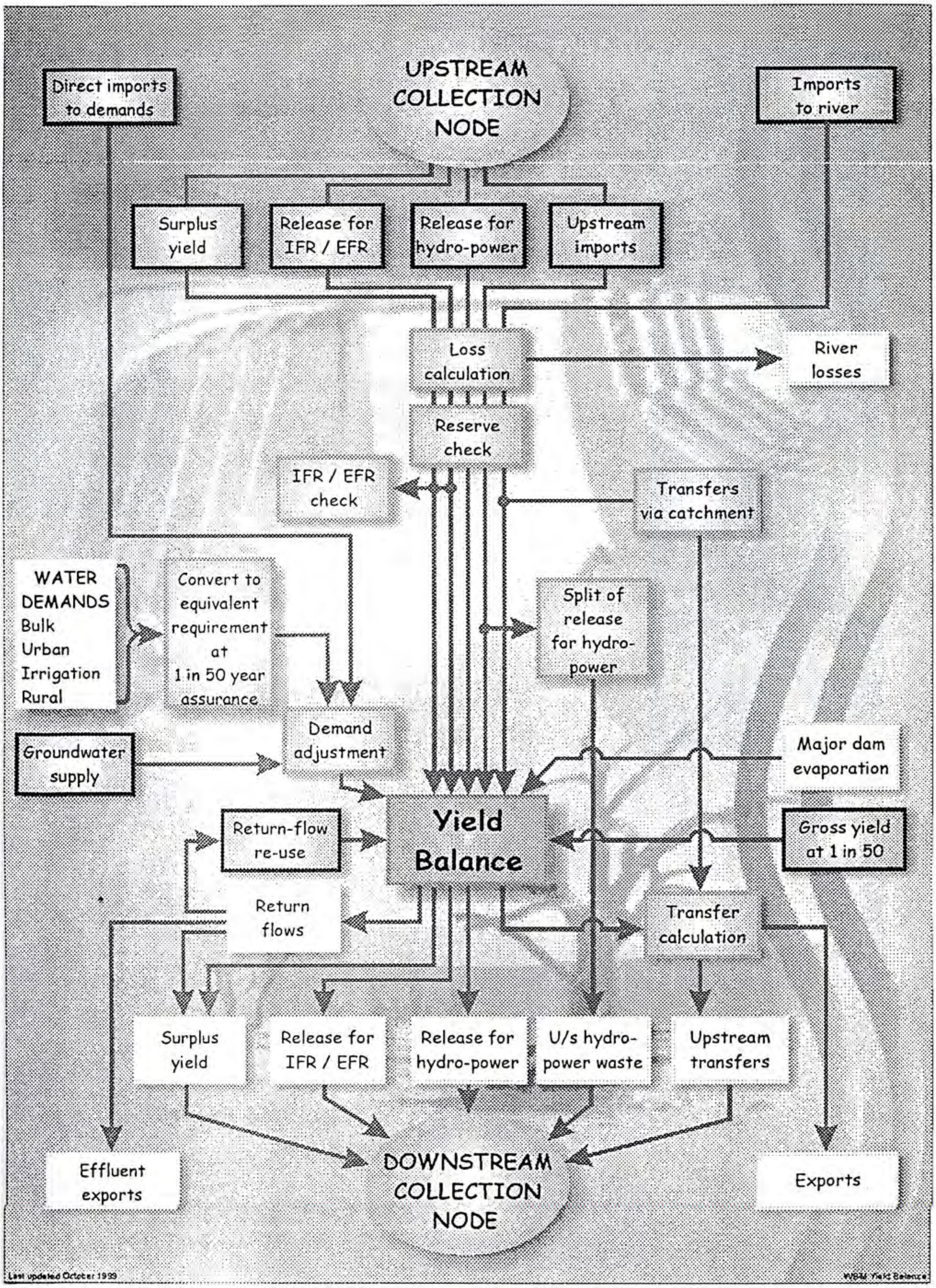


DIAGRAM 7.1.2: WATER BALANCE MODEL YIELD BALANCE ALGORITHM



7.2 OVERVIEW

Key points of interest were selected as the reporting level for the results of the study. The selection of these points and the list of quaternary catchment areas included at each key point are described in Chapter 2 (section 2.1).

In summary, Table 7.2.2 indicates the water requirements in 1995 at the different keypoints. The water balance is indicated in Table 7.2.3, where the water requirements and availability are compared. Figure 7.2.1 gives a water balance overview.

TABLE 7.2.2: WATER REQUIREMENTS BY DRAINAGE AREA IN 1995

Catchment						Stream flow reduction activities		Water use		Water requirement						Ecological reserve (10^6 m^3/a)	Total (10^6 m^3/a)
Primary		Secondary		Tertiary		Affore-station (10^6 m^3/a)	Dryland sugar cane (10^6 m^3/a)	Alien vegetation (10^6 m^3/a)	River losses (10^6 m^3/a)	Bulk[(1)] (10^6 m^3/a)	Irrigation[(2)] (10^6 m^3/a)	Rural[(3)] (10^6 m^3/a)	Urban[(4)] (10^6 m^3/a)	Hydro-power (10^6 m^3/a)	Water transfers out of WMA (10^6 m^3/a)		
No	Description	No	Description	No	Description												
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	0,0	0,0	0,0	0,0	3,2	0,6	0,0	0,0	0,0	0,0	3,8
					Steenbokpan	0,0	0,0	0,0	0,0	0,0	5,9	0,4	0,0	0,0	0,0	0,0	6,3
				A42	Mokolo (Upper)	0,0	0,0	0,0	0,0	0,0	50,9	0,9	0,1	0,0	0,0	16,9	68,8
					Mokolo (Lower)	0,0	0,0	0,0	0,0	8,2	1,5	0,8	1,7	0,0	0,0	0,0	12,2
			Sub total			**0.0**	**0.0**	**0,0**	**0,0**	**8,2**	**61,5**	**2,7**	**1,8**	**0,0**	**0,0**	**16,9**	**91,1**
		A5	Lephalala	A50	Lephalala (Upper)	0,0	0,0	0,0	7,0	0,0	10,3	1,0	0,0	0,0	0,0	0,1	18,4
					Lephalala (Lower)	0,0	0,0	0,0	17,0	0,0	11,7	1,9	0,0	0,0	0,0	0,0	30,6
					Soutkloof	0,0	0,0	0,0	0,0	0,0	6,6	0,1	0,0	0,0	0,0	0,0	6,7
			Sub total			**0,0**	**0,0**	**0,0**	**24,0**	**0,0**	**28,6**	**3,1**	**0,0**	**0,0**	**0,0**	**0,1**	**55,8**
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	0,0	1,8	20,0	0,0	5,3	0,4	4,0	0,0	0,0	0,4	31,9
					Nyl (Middle)	0,0	0,0	1,0	20,0	1,8	8,0	0,5	0,0	0,0	0,0	0,0	31,3
					Mogalakwena (Upper)	0,0	0,0	0,0	2,0	0,0	12,9	0,3	0,0	0,0	0,0	2,2	17,4
					Sterk	0,0	0,0	1,6	4,0	4,8	14,2	3,3	3,3	0,0	0,0	0,0	31,2
				A62	Mogalakwena (Middle)	0,0	0,0	0,2	7,0	3,6	9,4	5,0	0,0	0,0	0,0	2,7	27,9
				A63	Doringfonteintjiespruit	0,0	0,0	0,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	1,0
					Mogalakwena (Lower)	0,0	0,0	0,0	6,0	0,0	10,4	1,4	0,0	0,0	0,0	0,0	17,8
					Kolope	0,0	0,0	0,0	0,0	1,8	15,6	0,1	0,0	0,0	0,0	0,0	17,5
			Sub total			**0,0**	**0,0**	**4,6**	**59,0**	**12,0**	**76,8**	**11,0**	**7,3**	**0,0**	**0,0**	**5,3**	**176,0**
		A7	Sand	A71	Sand (Upper)	0,0	0,0	0,3	0,6	2,5	24,1	4,9	18,7	0,0	0,0	0,0	51,1
					Hout	0,0	0,0	0,2	0,4	0,0	27,0	2,8	0,0	0,0	0,0	0,2	30,6
					Sand (Lower)	0,0	0,0	0,0	2,0	3,7	64,8	11,6	3,1	0,0	0,0	0,0	85,2
					Kongoloops / Soutsloot	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,3
				A72	Brak	0,0	0,0	0,0	0,0	0,0	10,9	2,2	0,0	0,0	0,0	0,5	13,6
			Sub total			**0,0**	**0,0**	**0,5**	**3,0**	**6,2**	**126,8**	**21,6**	**21,8**	**0,0**	**0,0**	**0,7**	**180,8**
		A8	Nzhelele	A80	Nzhelele (Upper)	1,0	0,0	0,9	0,0	0,0	1,4	2,1	0,1	0,0	0,0	1,7	7,2
					Nzhelele (Lower)	0,0	0,0	0,0	0,0	0,0	20,7	1,0	0,0	0,0	0,0	0,0	21,7
					Nwanedi	0,0	0,0	0,0	0,0	0,0	16,4	0,6	0,2	0,0	0,0	0,2	17,4
			Sub total			**1,0**	**0,0**	**0,9**	**0,0**	**0,0**	**38,5**	**3,7**	**0,3**	**0,0**	**0,0**	**1,9**	**46,3**
Total WMA						**1,0**	**0,0**	**6,0**	**86,0**	**26,4**	**332,2**	**42,0**	**31,1**	**0,0**	**0,0**	**24,9**	**550,0**

(1) Requirements of wet industries, mines, thermal power stations and any other bulk users supplied individually by a water board or DWAF.
(2) Includes conveyance and distribution losses.
(3) Requirements for rural household use, livestock and game watering, and subsistence irrigation, including losses.
(4) Requirements for urban residential, commercial, municipal and institutional use, and requirements of industries supplied by local authorities, all including water losses.

TABLE 7.2.3: WATER BALANCE: REQUIREMENTS AND AVAILABILITY

Catchment						Available 1:50 yr yield in 1995			Water transfers at 1:50 yr assurance		Return flows at 1:50 yr assurance		Water requirement at 1:50 yr assurance(1) (10^6 m^3/a)	Water balance at 1:50 yr assurance (10^6 m^3/a)
Primary		Secondary		Tertiary										
No	Description	No	Description	No	Description	Surface water (10^6 m^3/a)	Ground water not linked to surface water (10^6 m^3/a)	Total (10^6 m^3/a)	Imports (10^6 m^3/a)	Exports (10^6 m^3/a)	Re-usable (10^6 m^3/a)	To sea (10^6 m^3/a)		
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	17,7	4,2	21,9	0,0	0,0	0,2	0,0	3,8	18,3
					Steenbokpan	0,0	1,8	1,8	0,0	0,0	0,3	0,0	6,3	-4,2
				A42	Mokolo (Upper)	50,7	0,2	50,9	0,0	24,0	2,6	0,0	68,8	-39,3
					Mokolo (Lower)	10,4	0,4	10,8	24,0	0,0	1,7	0,0	12,2	24,3
			Sub total			**78,8**	**6,6**	**85,4**	**24,0**	**24,0**	**4,8**	**0,0**	**91,1**	**-0,9**
		A5	Lephalala	A50	Lephalala (Upper)	4,8	1,7	6,5	0,0	0,0	0,0	0,0	18,4	-11,9
					Lephalala (Lower)	6,1	1,8	7,9	0,0	0,0	0,6	0,0	30,6	-22,1
					Soutkloof	0,0*	0,6	0,6	0,0	0,0	0,0	0,0	6,7	-6,1
			Sub total			**10,9**	**4,1**	**15,0**	**0,0**	**0,0**	**0,6**	**0,0**	**55,8**	**-40,2**
		A6	Mogalakwena	A61	Nyl (Upper)	7,2	3,1	10,3	3,0	0,0	2,2	0,0	31,9	-16,4
					Nyl (Middle)	1,2	2,0	3,2	0,0	0,0	0,7	0,0	31,3	-27,4
					Mogalakwena (Upper)	13,3	2,4	15,7	0,0	2,9	0,6	0,0	17,4	-4,0
					Sterk	14,8	2,0	16,8	2,9	0,0	2,9	0,0	31,2	-8,6
				A62	Mogalakwena (Middle)	9,2	2,2	11,4	0,0	0,0	1,1	0,0	27,9	-15,4
				A63	Doringfonteintjiespruit	0,3	0,1	0,4	0,0	0,0	0,0	0,0	1,0	-0,6
					Mogalakwena (Lower)	4,3	2,4	6,7	0,0	0,0	0,5	0,0	17,8	-10,6
					Kolope	0,0*	0,9	0,9	0,0	0,0	1,1	0,0	17,5	-15,5
			Sub total			**50,3**	**15,1**	**65,4**	**5,9**	**2,9**	**9,1**	**0,0**	**176,0**	**-98,5**
		A7	Sand	A71	Sand (Upper)	15,3	21,3	36,6	10,1	0,0	3,9	0,0	51,1	-0,5
					Hout	0,1	28,2	28,3	0,0	0,0	2,7	0,0	30,6	0,4
					Sand (Lower)	47,8	6,4	54,2	1,7	0,0	8,2	0,0	85,2	-21,1
					Kongoloops / Soutsloot	1,9	0,6	2,5	0,0	0,0	0,0	0,0	0,3	2,2
				A72	Brak	0,0	15,2	15,2	0,0	0,0	1,1	0,0	13,6	2,7
			Sub total			**65,1**	**71,7**	**136,8**	**11,8**	**0,0**	**15,9**	**0,0**	**180,8**	**-16,3**
		A8	Nzhelele	A80	Nzhelele (Upper)	22,1	0,7	22,8	0,0	0,0	0,2	0,0	7,2	15,8
					Nzhelele (Lower)	0,0	0,1	0,1	0,0	0,0	2,1	0,0	21,7	-19,5
					Nwanedi	1,1	0,2	1,3	0,0	0,0	1,7	0,0	17,4	-14,4
			Sub total			**23,2**	**1,0**	**24,2**	**0,0**	**0,0**	**4,0**	**0,0**	**46,3**	**-18,1**
Total WMA						**228,3**	**98,5**	**326,8**	**41,7**	**26,9**	**34,4**	**0,0**	**550,0**	**-174,0**

(1) To avoid double accounting, water exports within the WMA are not included in the “Water Requirements” column. Water losses and water exports from the WMA are included.
(2) Surpluses indicated by a + and deficits by a -.

7.3 THE LIMPOPO WATER MANAGEMENT AREA

The Limpopo WMA excludes the upper tributaries of the Crocodile and Marico Rivers and the downstream border is at the confluence of the Nwanedi and Limpopo Rivers. The study focussed on the water requirements and potential water resources of the catchment areas within the WMA. Because the Limpopo River system is much wider than the RSA and the quaternary areas are not delineated to include the main stem, the ultimate water balance excluded the main stem. Water requirements that are met from the Limpopo River were also not considered as part of the balance within the WMA.

All the different water users were identified within each quaternary catchment. The total water requirement was determined and is shown in Table 7.2.2. The total water requirement, including an estimate of the ecological reserve, is 550 x 10^6 m^3/a.

The available surface and groundwater sources were determined and are shown in Table 7.2.3. The total developed (1995) water sources within the WMA are 327 x 10^6 m^3/a. About 34 x 10^6 m^3/a water is re-used and because of the high water requirement and scarce water resources, there are no transfers out of the WMA. The total water transfer into the WMA is 14,8 x 10^6 m^3/a.

All of the above results in an estimated water shortage of 174 x 10^6 m^3/a in the Limpopo WMA, excluding the Limpopo River as a source.

7.4 THE MOKOLO AREA

The Mokolo Area includes the Mokolo and Matlabas Catchment.

The only major dam in the area is the Mokolo Dam with a yield of 28,6 x 10^6 m^3/a. The total yield of the area is 85,4 x 10^6 m^3/a. The water requirement of 91,1 x 10^6 m^3/a in this area is nearly balanced by the estimated yield.

7.5 THE LEPHALALA AREA

This area includes the Lephala catchment and the Soutkloof catchment area, a collection of tributaries of the Limpopo River.

There are no major dams in the catchment and the run of river yield is about 10,9 x 10^6 m^3/a. Groundwater usage amounts to 4,1 x 10^6 m^3/a.

The water requirement of the area is 55,8 x 10^6 m^3/a and the area thus have a negative balance of 40,2 x 10^6 m^3/a.

7.6 THE MOGALAKWENA RIVER AREA

The Mogalakwena area includes the Mogalakwena River catchment as well as the Kolope catchment area, a collection of tributaries of the Limpopo River.

There are a number of major dams in the area and the surface water yield amounts to 50,3 x 10^6 m³/a.

The total yield of the area is 65,4 x 10^6 m³/a. The water requirement in this area exceeds the yield by 98,5 x 10^6 m³/a.

7.7 THE SAND RIVER AREA

The Sand Area includes the Sand River and Brak River catchments. There are no major dams in this area and the 1995 groundwater developed source is 71,7 x 10^6 m³/a. The total water source development, including water imports, amounts to 164,5 x 10^6 m³/a. The water requirement is 180,8 x 10^6 m³/a and thus exceeds the available yield by 16,3 x 10^6 m³/a.

7.8 THE NZHELELE AREA

The Nzhelele River and Nwanedi River catchment form part of the Nzhelele Area. The surface water and groundwater yield is 23,2 x 10^6 m³/a and 1,0 x 10^6 m³/a respectively. This area has a short fall of 18,1 x 10^6 m³/a.

CHAPTER 8: COSTS OF WATER RESOURCE DEVELOPMENT

8.1 METHODOLOGY

The methodology used to estimate the cost of harnessing the potential maximum yield of the water resources in the Limpopo WMA is described below.

Table 8.1.1 indicates the costs of water resource development in the Limpopo WMA. It only summarises the theoretically possible water resource development as calculated in Appendix G3, but does not take into account feasibility of individual projects.

8.1.1 Capital Cost of Dams

Diagram 8.1.1 shows a proposed relationship between the gross storage capacity of a dam (at full supply level) and the capital cost at year 2000 prices including 14% VAT. The cost is not in a direct linear relationship with the storage capacity. Separate costs therefore need to be derived for each likely future dam, and not on the basis of the aggregate of the additional storage capacity required in the catchment. The cost function shown in Diagram 8.1.1 was used only in those cases where more detailed previous cost estimates are not available or if there is a reason to discard the previous cost estimates.

8.1.2 Capital Cost of Wellfields

The cost to develop groundwater has been estimated and is expressed as cost per unit of yield developed.

The costs include all evaluations, borehole siting, drilling, test pumping and equipping of the boreholes with positive displacement pumps and electrically driven motors.

The cost will however vary from area to area depending mainly on the following factors, viz.:

- Availability of existing information
- Borehole yield obtainable
- Drilling depth
- Drilling success rate
- Drilling conditions

The biggest influence on the cost was however found to be the borehole yield.

Diagram 8.1.2 gives the estimated development cost for different borehole yields with an upper and lower range. The costs are at 2000 prices. The estimated development cost shown on Diagram 8.1.2 is in Rand per kℓ/annum of water produced.

TABLE 8.1.1: COSTS OF WATER RESOURCE DEVELOPMENT

Catchment						Net storage volume to be supplied (10^6 m^3 /a)	Well field yield to be developed	Estimated cost (R x 10^6)
Primary		Secondary		Tertiary				
No	Description	No	Description	No	Description			
A (Part)	Limpopo	A4	Mokolo	A41	Matlabas	0,0	6,6	46,2
					A41E	0,0	1,4	9,8
				A42	Mokolo (Upper)	21	14	98
					Mokolo (Lower)	21	8,7	180,9
			Sub total			**0,0**	**30,7**	**334,9**
		A5	Lephalala	A50	Lephalala (Upper)	65,0	1,0	144
					Lephalala (Lower)	0,0	2,2	15,4
					Soutkloof	0,0	2.2	15,4
			Sub total			**65,0**	**5,4**	**174,8**
		A6	Mogalakwena	A61	Nyl (Upper)	0,0	1,8	12,6
					Nyl (Middle)	0,0	3,8	26,6
					Mogalakwena (Upper)	0,0	0	0
					Sterk	82,9	2,6	110,4
				A62	Mogalakwena (Middle)	?	13,9	117,3
				A63	Doringfonteintjie spruit	0,0	3,5	24,5
					Mogalakwena (Lower)	0,0	3,8	26,6
					Kolope	0,0	0,0	0,0
			Sub total			**?**	**29,4**	**318**
		A7	Sand	A71	Sand (Upper)	0,0	0,0	0,0
					Hout	0,0	0,0	0,0
					Sand (Lower)	0,0	0,0	0,0
					Kongoloops/ Soutsloot	0,0	0,9	6,3
				A72	Brak	0,0	0,0	0,0
			Sub total			**0,0**	**0,9**	**6,3**
		A8	Nzhelele	A80	Nzhelele (Upper)	0,0	0,0	0
					Nzhelele (Lower)	0,0	0,0	0
					Nwanedi	0,0	2,6	18,2
			Sub total				**2,6**	**18,2**
Total WMA							**69**	**851,3**

DIAGRAM 8.1.1: CAPITAL COST OF DAMS

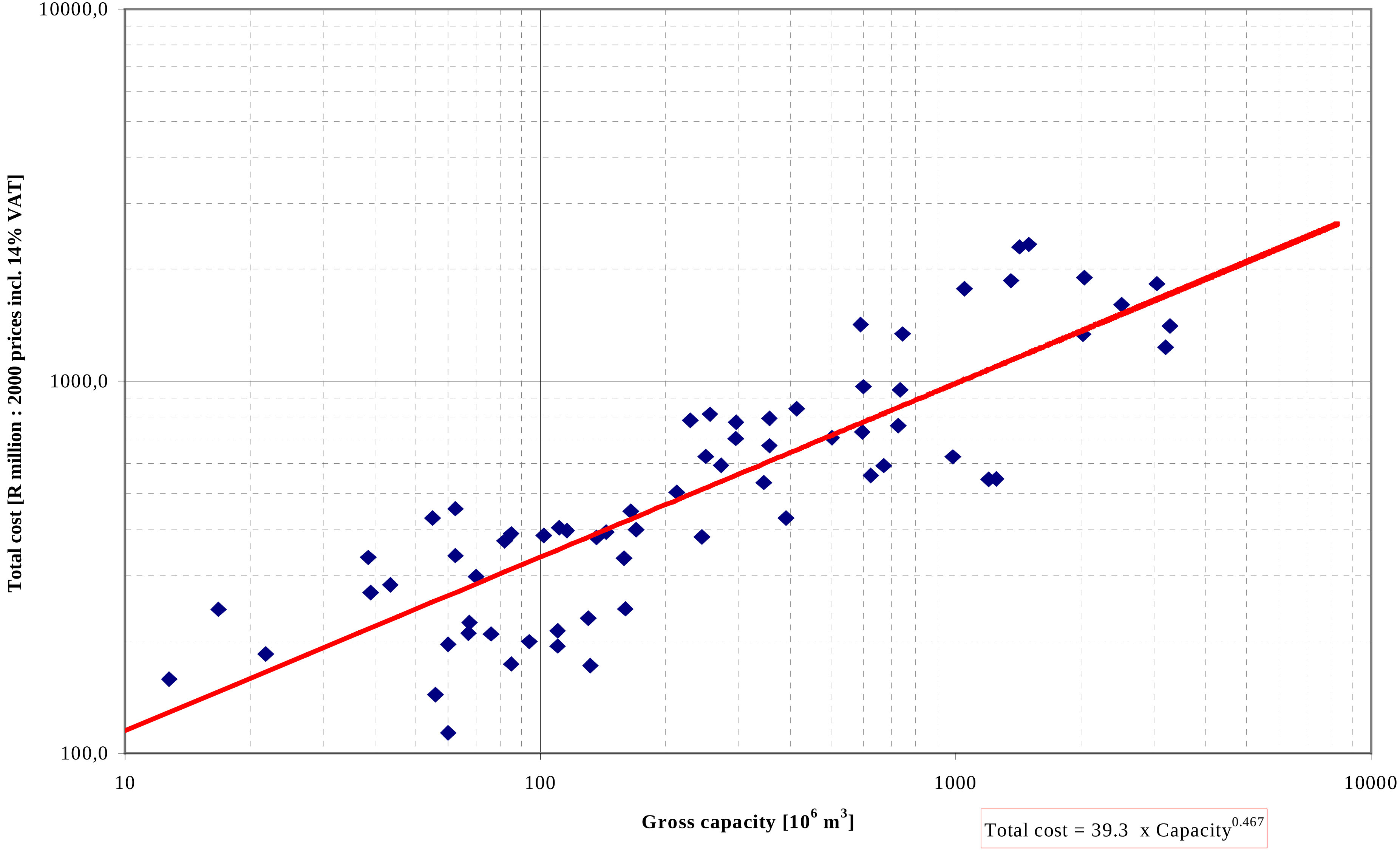
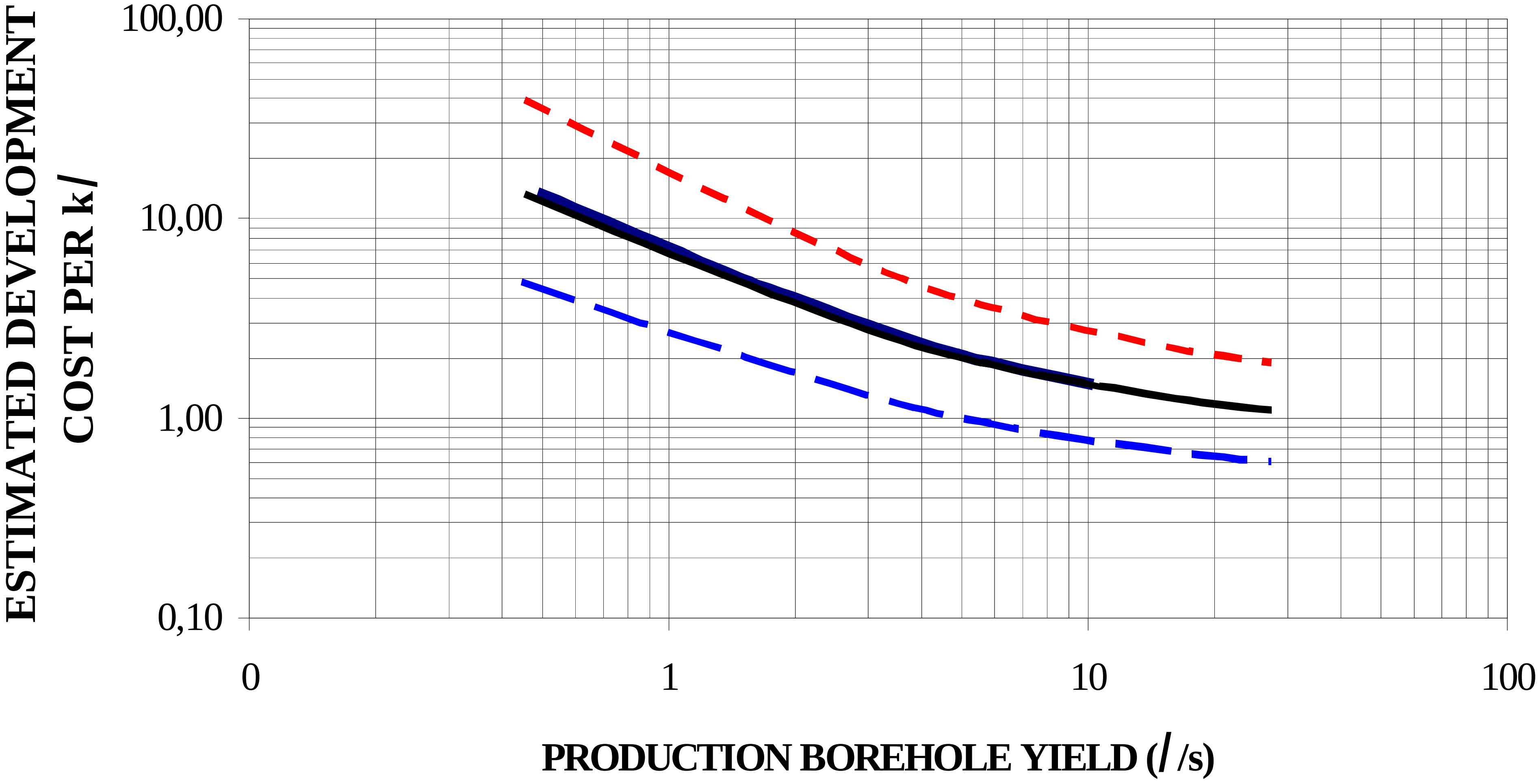


DIAGRAM 8.1.2: GROUNDWATER DEVELOPMENT COST



8.2 MOKOLO RIVER CATCHMENT

Since the storage capacity of the Mokolo Dam is significantly less than the MAR, it is possible to greatly increase the water availability from the catchment by further water resources development.

DWAF have investigated the feasibility of raising the Mokolo Dam. Indications are that the dam may be raised by some 15 m to have an ultimate storage capacity of about 303 x $10^6 m^3$. The cost is estimated at R120 million.

Potential dams according to maximum dam size are shown in Appendix G3.

Well fields with a capacity of 30,7 x $10^6 m^3$ /a could be developed in the Mokolo River catchment for an estimated cost of R214,9 million.

Costs of future water resource development are summarised in Table 8.2.1.

TABLE 8.2.1: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT IN MOKOLO RIVER CATCHMENT

Catch-ment No.	Scheme No.	Storage Volume ($10^6 m^3$)	Incremental Surface Water Yield ($10^6 m^3$/a)	Wellfield Yield ($10^6 m^3$/a)	Costs		
					Dams (R x 10^6)	Wellfields (R x 10^6)	Totals (R x 10^6)
A42F	Raise Mokolo Dam	Increase by 156,5	Increase by 12,21	-	120	-	120
A41	Fully developed	-	-	8	-	56	56
A42	Fully developed	-	-	22,7	-	158	158
TOTALS		**156,.5**	**12,0**	**30,7**	**120**	**214,9**	**334**

8.3 LEPHALALA RIVER CATCHMENT

Potential dams according to maximum dam size are shown in Appendix G3.

A reconnaissance level investigation was undertaken of a dam on Doornkom 657 LR (A50B) having storage capacity 65 x $10^6 m^3$/a, and yield 10,2 x $10^6 m^3$/a making allowance for releases to maintain the ecology of the river. The estimated capital cost of the dam amounts to R137 million (1995).

Well fields with a capacity of 5,4 x $10^6 m^3$/a could be developed for an estimated cost of R37,8 million.

Costs of future water resource development are summarized in table 8.3.1.

TABLE 8.3.1: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT IN THE LEPHALALA RIVER CATCHMENT

Catch-ment No.	Scheme No.	Storage Volume ($10^6 m^3$)	Incre-mental Surface Water Yield ($10^6 m^3/a$)	Wellfield Yield ($10^6 m^3/a$)	Costs		
					Dams (R x 10^6)	Wellfields (R x 10^6)	Totals (R x 10^6)
A50B	Doornkom Dam	65	10.2	-	137	-	137
A50	Fully Developed	-	-	5,4	-	37,8	37,8
TOTALS		**65**	**10,2**	**5,4**	**137**	**37,8**	**174,8**

8.4 THE MOGALAKWENA RIVER CATCHMENT

RDP schemes have been planned to benefit some 70 000 residents (A61G, A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J, A63A, A63B, A63D) in the period 2000 to 2010.

Water will mainly be obtained from groundwater although the raising of Glen Alpine Dam (A62J) is being considered. Alternatives to the raising include different operating rules in terms of water releases into the river, or the reallocation of irrigation entitlements. Water from Glen Alpine Dam may augment water supply to villages in quaternary catchments A62J, A72A, A62A and A63D.

Greater Potgietersrus experienced exceptional population growth in the period 1995-2000, partly due to a R120 million urban renewal programme.

A pre-feasibility study (1996) into possible options to augment bulk water supply to Greater Potgietersrus identified the following options:

- Reallocation of irrigation water entitlements from the Doorndraai Dam (3,4 x $10^6 m^3/a$).
- Construction of a 82,9 x $10^6 m^3/a$ dam at Groenvley 224KR (A61J) having a firm yield of 5,5 x $10^6 m^3/a$. The estimated capital cost (1995) for the dam is only R92,2 million.

A feasibility study (2000) confirmed the viability of reallocation of the irrigation entitlements. The construction of the Groenvley Dam was considered not to be affordable by resident in Greater Potgietersrus, due to the expensive infrastructure required.

The option to import water from the Olifants River was also considered and found to be possible for implementation after 2010. Increased mining and agricultural water needs in the adjacent Olifants WMA may dictate otherwise and a feasibility study in this regard was recently (2000) commissioned.

Potential dams according to maximum dam size are shown in Appendix G3.

Costs of future water resource development are summarized in table 8.4.1.

TABLE 8.4.1: COSTS OF FUTURE WATER RESOURCE DEVELOPMENT IN THE MOGALAKWENA RIVER CATCHMENT

Catch-ment No.	Scheme No.	Storage Volume (10^6 m^3/a)	Incremen-tal Surface Water Yield (10^6 m^3/a)	Wellfield Yield (10^6 m^3/a)	Costs		
					Dams (Rx$10^6$$m^3$)	Wellfields (Rx$10^6$$m^3$)	Totals (Rx$10^6$$m^3$)
A61J	Groenvley Dam	82,9	5,5	-	92,2	-	92,2
A62J	Raise Glen Alpine	?	Additional 5,5	-	20	-	20
A61	Fully Developed	-	-	8,2	-	57,4	57,4
A62	Fully Developed	-	-	13,9	-	97,3	97,3
A63	Fully Developed	-	-	7,3	-	51,1	51,1
TOTAL			**11**	**29,4**	**112,2**	**205,8**	**318**

8.5 THE SAND RIVER CATCHMENT

The surface water resource of the Sand River catchment is considered to be fully exploited. Plans have been drafted to augment the Sand River catchment from other catchments.

Pietersburg/Seshego/Mankweng is a major growth node in the Northern Province. Plans have been drafted to augment water supply from the adjacent Olifants WMA and Luvuvhu/Letaba WMA, in view of the scarcity of local water resources.

The Olifants-Sand pipeline and its upgrading will allow import of water from the Olifants River amounting to about 5,1 x $10^6$$m^3$/a in 2005 and about 11,0 x $10^6$$m^3$/a in 2010.

The Pietersburg Government Regional water supply scheme will transfer increasing amounts of water from Ebenezer Dam on the Groot Letaba River to Pietersburg, Mankweng and numerous rural villages along the pipeline.

Indications are that about 15,2 x $10^6$$m^3$/a will be delivered by the scheme (2000) and would increase to about 18,53 x $10^6$$m^3$/a (2003) which is the full allocation from the dam.

Louis Trichardt is a service center for areas in the northern parts of the Limpopo WMA. Water is already imported from Albasini Dam in the Luvuvhu/Letaba WMA (A91B). Plans have been drafted to import additional water from the Nandoni Dam now under construction on the Luvuvhu River (A91F).

Some 40 RDP water projects were undertaken during the period 1995–2000 in the western half of the Sand River catchment benefiting a population about 50 000.

Water source development in practically all cases involved groundwater, excepting for the small extensions to the Hout River scheme, which draws water from Hout River Dam (A71E).

Some 15 villages in the Sand River catchment would benefit from the proposed Glen Alpine water supply scheme, which will probably be commissioned in the period 2000–2005. Groundwater will be used extensively with possible augmentation from Glen Alpine Dam. Refer to section 8.4.)

The Mankweng area in the Dwars River catchment, a tributary of the Sand River, is supplied with water from boreholes (pre 1995), but Mankweng is supplied from the Ebenezer Dam - Pietersburg pipeline.

During the period 1995–2000 some 100 000 people were supplied with water from Ebenezer Dam and this scheme will be extended to supply water to about 190 000 by 2010.

Sinthumule/Kutama, which has a population of some 60 000, was supplied with water from local borehole schemes, using hand pumps and diesel driven pumps.

A new scheme was developed during the period 1995–2000, which supplies RDP level water to all residents.

The groundwater aquifer in the Sand River Catchment is generally over developed. Potential wellfields to be develop only exists in the Kongoloops/Soutkloof key area with a capacity of 0,9 x 10^6 m^3/a at a estimated cost of R6,3 million.

Table 8.5.1 shows the costs for future water resource development.

TABLE 8.5.1: COSTS FOR FUTURE WATER RESOURCE DEVELOPMENT IN THE SAND RIVER CATCHMENT

Catch-ment No	Scheme No	Storage Volume (10^6 m^3)	Incremental Surface Water Yield (10^6 m^3/a)	Wellfield Yield (10 m^3/a)	Costs		
					Dams (10 m^3/a)	Wellfields (10 m^3/a)	Totals (10 m^3/a)
A71	Fully Developed	-	-	0,9	-	6,3	6,3
TOTALS		-	-	0,9	-	6,3	6,3

8.6 THE NZHELELE RIVER CATCHMENT

The surface water resource of the Nzhelele River Catchment is considered to be fully exploited. The Nwanedi key area has some potential well field to develop. An estimated cost of R18,2 million is needed to develop the area to its full potential.

Table 8.6.1 shows the costs for future water resource development.

TABLE 8.6.1: COSTS FOR FUTURE WATER RESOURCE DEVELOPMENT IN THE NZHELELE RIVER CATCHMENT

Catch-ment No	Scheme No	Storage Volume (10^6 m^3)	Incremental Surface Water Yield (10^6 m^3/a)	Wellfield Yield (10 m^3/a)	Costs		
					Dams (10 m^3/a)	Wellfields (10 m^3/a)	Totals (10 m^3/a)
A80	Fully Developed	-	-	2,6	-	18,2	18,2
TOTALS		**-**	**-**	**2,6**	**-**	**18,2**	**18,2**

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 AVAILABLE DATA

Data that should be investigated further for the purpose of proper management of the Limpopo WMA include:

- Monitoring of **large water abstractions** from both surface and ground water resources and the recording of these in a data base. The agricultural sector is the largest water user in the Limpopo WMA, yet only highly incomplete information exists about the water use on individual farms. There are still many uncertainties in this field, like crop areas and crop factors. More work needs to be done to verify crop areas. Best management practices needs to be implemented by the service providers to encourage responsible water use on farm level. It will be only then that crop factors will start to make sense as crop factors are derived from crop water use.

- The quantity and quality of **effluent discharge** streams from towns, industries and other sources should be monitored and the information kept in data base.

- Information on **slit loads** should be collected.

- Overgrazing should be discouraged to improve the erosion of such areas.

- Outstanding information on **population** statistics and water supply infrastructure, especially in rural villages, could be collected to enable a better estimate of water requirements.

- The **river flow gauging network** should be improved with new gauges at strategically important points in the basin. Existing gauges should be checked for accuracy and reliability.

- Information on **infiltration and seepage losses** from rivers and canal distribution systems is unavailable and is required for the optimizing of water supply systems.

- A sensitivity analyses should be done on the influence of **afforested areas** on stream flows. This would show how significant the effect is on the results.

- **Water quality** should be investigated and monitored. Water quality monitoring stations are insufficient.

- Information regarding **groundwater contamination** resulting from human wastes should be collected. Once sufficient microbial data becomes available, the numerical methods and associated assumptions discussed in section 6.4.3 should be validated and the maps replotted. Monitoring data from selected areas should also be collected to assess the validity of the vulnerability assessment presented in this report.

Many of the issues listed above would probably be taken care of in the WSDP plans and monitoring required of water service providers by DWAF, as well as in the water use registration and ultimate licencing process.

9.2 LIMPOPO WMA

As described above, this assessment did not include either the Limpopo River as a water resource or the requirements being presently met directly from the river. Since it is an international river, an estimate of its total resources and current utilization is required to enable proper management of the river. Such studies will encompass a large area and will probably have to rely on scant information.

9.3 MOKOLO SECONDARY CATCHMENT

The future water requirements from the existing Mokolo Dam should be investigated. The Matimba Power Station usage is apparently at a constant level, while the Grootegeluk Coal Mine uses less water. This decrease is because the mine utilizes water from the pit and from an adjacent wellfield.

Since the storage capacity of the Mokolo Dam is significantly less than the MAR, it is possible to greatly increase water availability from the catchment by further water resources development. Several options are available and include:

- Raising Mokolo Dam.
- Constructing of a dam in the upper reaches of the Mokolo River.
- Diverting surplus water from the Mokolo River to demand centers.

9.4 LEPHALALA SECONDARY CATCHMENT

It is recommended that consideration be given to the construction of a new river flow gauging station in the Lephalala River near the northern border of the Lapalala Wilderness.

The feasibility of the Phalala Dam should be further investigated.

9.5 MOGALAKWENA SECONDARY CATCHMENT

The hydrometeorological data network should be improved. Rain gauges should be installed to improve the spatial coverage and the flow-gauging network should be expanded by constructing additional stations. The operation of existing river flow gauging stations should be improved.

Operating rules for water supply schemes in the Basin should be refined and these should be implemented in order to optimize the supply of water to all users.

Water quality management objectives should be set for all rivers in the basin.

The data compiled in this study should be fully integrated onto the Geographic Information System of the Department of Water Affairs and Forestry and the system should be utilized for the management of the water resources.

The impact of changing land use and water utilization should be monitored and evaluated on an ongoing basis. This will give effect to accepted DWAF policy with regard to its role as custodian of the nation’s water resources.

Detailed studies of development possibilities should be undertaken for the following:

- Dam management and operation of Glen Alpine, Frikkie Geyser and Doorndraai Dams.

- Groundwater supply at Melinda fault, Potgietersrus area and local/regional schemes.

Institutional arrangements should be initiated to achieve ongoing co-operation between the various regional authorities and interest groups that deal with water resource development and management.

9.6 SAND SECONDARY CATCHMENT

Louis Trichardt should undertake the necessary studies, acquire the necessary water rights, and develop the following:

- Extensions to the existing wellfield
- Albasini wellfield
- Welgevonden wellfields
- Nooitgedacht wellfield
-

A feasibility study of the proposed Sand River wellfield at Louis Trichardt and Kutama/Sinthumule should be commissioned considering water rights, aquifer yield, and wellfield and pump system design. If not found to be feasible, water from Elim, and a feasibility study/preliminary design should be commissioned.

Monitoring of groundwater quality of the entire study area should be co-ordinated and rationalized, and the results should be entered into a single data base for continuous comparison with health criteria for human consumption. The effects of water quality and in particular high nitrate concentrations, on public health should be monitored throughout the area, but particularly in the Kutama/Sinthumule district.

A feasibility study of the proposed Mapungubwe Dam (and possibly of the alternative Vryheid Dam) should be commissioned.

9.7 NZHELELE SECONDARY CATCHMENT

Measures that would increase irrigation efficiency in the former Venda should be identified. These may include additional extension work, using a pilot project as an example and attending to landownership and credit facilities.

DWAF should initiate a study to establish the desirability and feasibility of making additional water available to the irrigators both upstream and downstream of the Nzhelele Dam by raising the Nzhelele Dam, constructing the Wyllies Poort Dam or constructing the Tshipise Dam.

A study should be commissioned to establish the cause of water shortages in villages in the Nzhelele River valley – be it water losses, higher than anticipated per capita water use or inadequacy of the bulk water infrastructure.

Measurements should be implemented to reduce losses and conserve the resource. This may involve punitive tariff policy measures.

A study should be commissioned to find additional water supplies for industrial water use, such as developing the Makhado wellfield.

A study should be commissioned to establish the feasibility of importing water from the Mutale River or the Vondo Dam to the Nzhelele River valley, considering the long-term requirement in the donor catchments.

The relevant authority should develop a database containing water-related information for all villages, settlements and industry in the Nzhelele River catchment.

DWAF should improve the hydrological monitoring system for the valley and investigate the feasibility of constructing flow-gauging stations at suitable sites on the Mutamba near the confluence of the Mutamba and Nzhelele Rivers as well as constructing a gauging station on the Nzhelele River near the confluence of the Nzhelele and Limpopo Rivers.

DWAF should reopen evaporation stations at Macaoville (A7E006) and Luphephi Dam (A8E002) and establish a new station in or near Vondo Forest in the upper reaches of the Nzhelele River valley.

A readily accessible database should be established of groundwater levels and borehole statistics pertaining to the areas where development is likely to occur, including the Makhado wellfield area, Mufungudi River valley and the eastern escarpment areas.

DWAF should develop a water quality management programme for the Nzhelele River basin that will deal with agricultural land-use and waste-water management to control seepage from pit latrines, oxidation ponds and solid-waste disposal sites.

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APPENDICES

APPENDIX A:	**DEMOGRAPHIC DATA**
APPENDIX B:	**MACRO-ECONOMIC DATA**
APPENDIX C:	**LEGAL ASPECTS**
APPENDIX D:	**LAND-USE DATA**
APPENDIX E:	**WATER RELATED INFRASTRUCTURE**
APPENDIX F:	**WATER REQUIREMENTS**
APPENDIX G:	**WATER RESOURCES**
APPENDIX H:	**WATER BALANCE**

NOTE: BLANKS INDICATE THAT DATA WAS NOT READILY AVAILABLE

APPENDIX A

DEMOGRAPHIC DATA

APPENDIX A

WMA 1: LIMPOPO Version 2: June 2001 Quaternary Catchment	Urban Population	Rural Population
A41A	0	1,116
A41B	0	829
A41C	0	1,227
A41D	0	3,173
A41E	0	3,698
A42A	0	3,886
A42B	0	2,043
A42C	450	2,682
A42D	0	2,153
A42E	0	5,382
A42F	0	1,907
A42G	0	1,773
A42H	13,300	1,714
A42J	0	2,453
A50A	0	718
A50B	0	577
A50C	0	961
A50D	0	599
A50E	0	483
A50F	0	362
A50G	0	23,580
A50H	0	29,150
A50J	0	2,280
A61A	33,100	2,948
A61B	0	1,737
A61C	0	1,840
A61D	0	6,854
A61E	0	511
A61F	40,250	55,770
A61G	0	89,110
A61H	0	1,748
A61J	0	1,048
A62A	0	12,640
A62B	0	41,440
A62C	0	11,000
A62D	0	9,179
A62E	0	50,870
A62F	0	32,790
A62G	0	19,740
A62H	0	38,030
A62J	0	7,033
A63A	0	22,030
A63B	0	21,110
A63C	0	1,767
A63D	350	21,540
A63E	0	2,621
A71A	125,300	23,040
A71B	14,600	111,200
A71C	1,250	81,070
A71D	0	1,646
A71E	350	50,640
A71F	0	47,560
A71G	0	18,920
A71H	11,300	45,850
A71J	0	2,658
A71K	12,150	3,830
A71L	0	5,122
A72A	0	94,200
A72B	0	1,480
A80A	1,900	52,210
A80B	0	32,020
A80C	0	9,740
A80D	0	138
A80E	0	8,101
A80F	0	3,100
A80G	0	6,519
A80H	0	3,744
A80J	3,250	9,892

APPENDIX B

MACRO-ECONOMIC DATA

APPENDICES

SUPPLEMENTARY ECONOMIC INFORMATION

APPENDIX B.1

GRAPHS: GROSS GEOGRAPHIC PRODUCT, LABOUR AND SHIFT-SHARE

APPENDIX B.1
DESCRIPTION OF GRAPHS

Diagram No	Graphic Illustration	Description
	• **Gross Geographic Product**:	
B.1	⇨ Contribution by Magisterial District to Berg Economy, 1997 (%)	Each WMA comprises a number of Magisterial Districts. This graph illustrates the percentage contribution of each MD to the WMA economy as a whole. It shows which are the most important sub-economies in the region.
B.2	⇨ Contribution by sector to National Economy, 1988 and 1997 (%)	This graph illustrates the percentage contribution of each sector in the WMA economy, e.g. agriculture, to the corresponding sector in the national economy.
	• **Labour Force Characteristics**:	
B.3	⇨ Composition of Berg Labour Force 1994 (%)	The total labour force may be divided into three main categories, namely formal employment, informal employment and unemployment, as outlined in this graph.
B.4	⇨ Contribution by Sector to Berg Employment, 1980 and 1994 (%)	Shows the sectoral composition of the formal WMA labour force.
B.5	⇨ Contribution by Sectors of Berg Employment to National Sectoral Employment, 1980 and 1994 (%)	Similar to the production function (i.e. GGP), this graph illustrates the percentage contribution of each sector in the WMA economy, e.g. mining, to the corresponding sector in the national economy.
B.6	⇨ Compound Annual Employment Growth by Sector of Berg versus South Africa, 1988 to 1994 (%)	Annual compound growth by sector is shown for the period 1980 to 1994.
	• **Shift-Share**:	
B.7	⇨ Shift-Share Analysis, 1997	Compares the contribution of each sector in the WMA economy to its recent growth performance. This serves as an instrument to identify sectors of future importance (towards top right hand side of the graph) and sectors in distress (towards the bottom left hand side of the graph).

Figure B.1: Contribution by Magisterial District to Limpopo economy, 1997 (%)

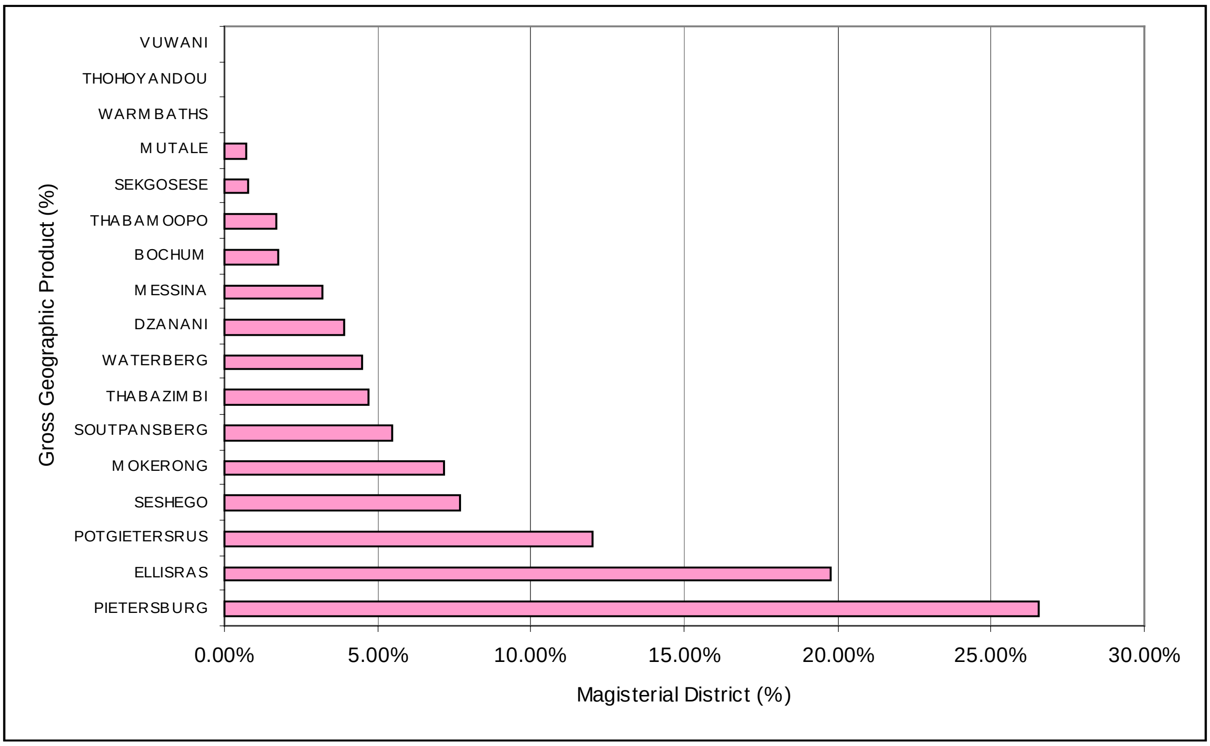


Figure B.2: Contribution by Sector to National Economy, 1988 and 1997 (%)

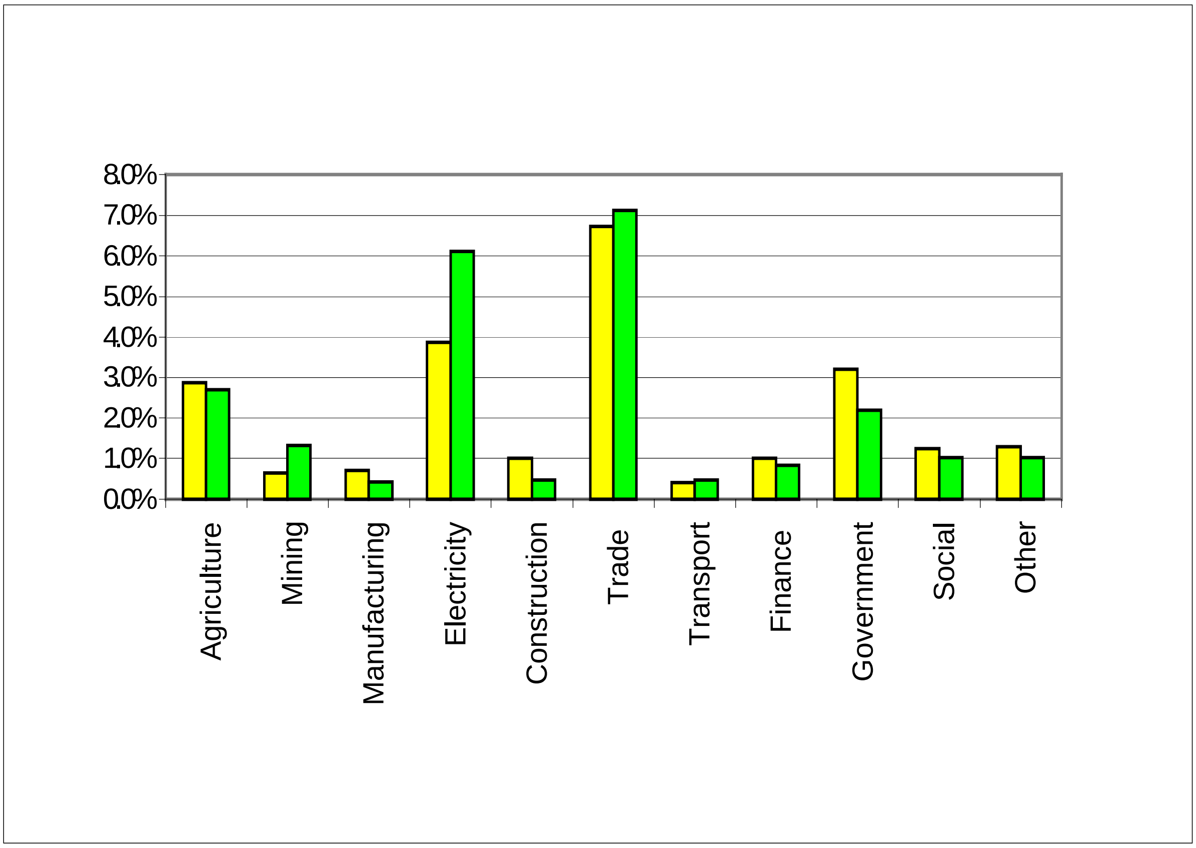


Figure B.3: Composition of Limpopo Labour Force, 1994 (%)

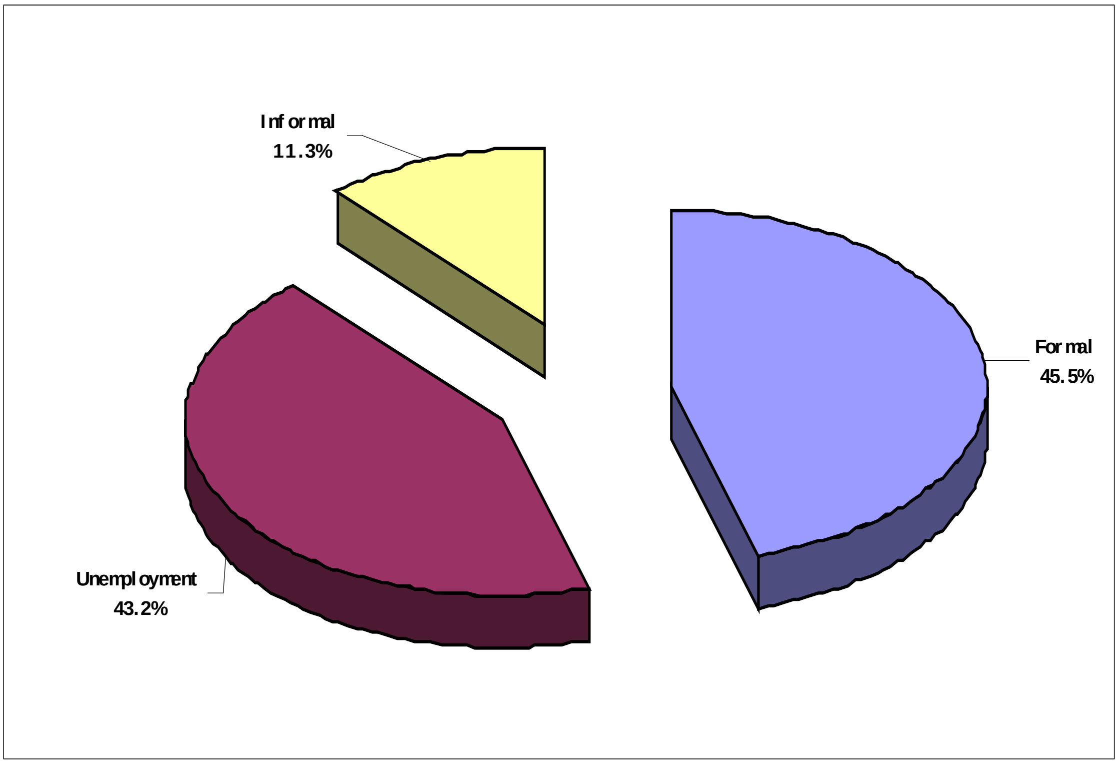


Figure B.4: Contribution by Sector to Limpopo Economy, 1980 and 1994(%)

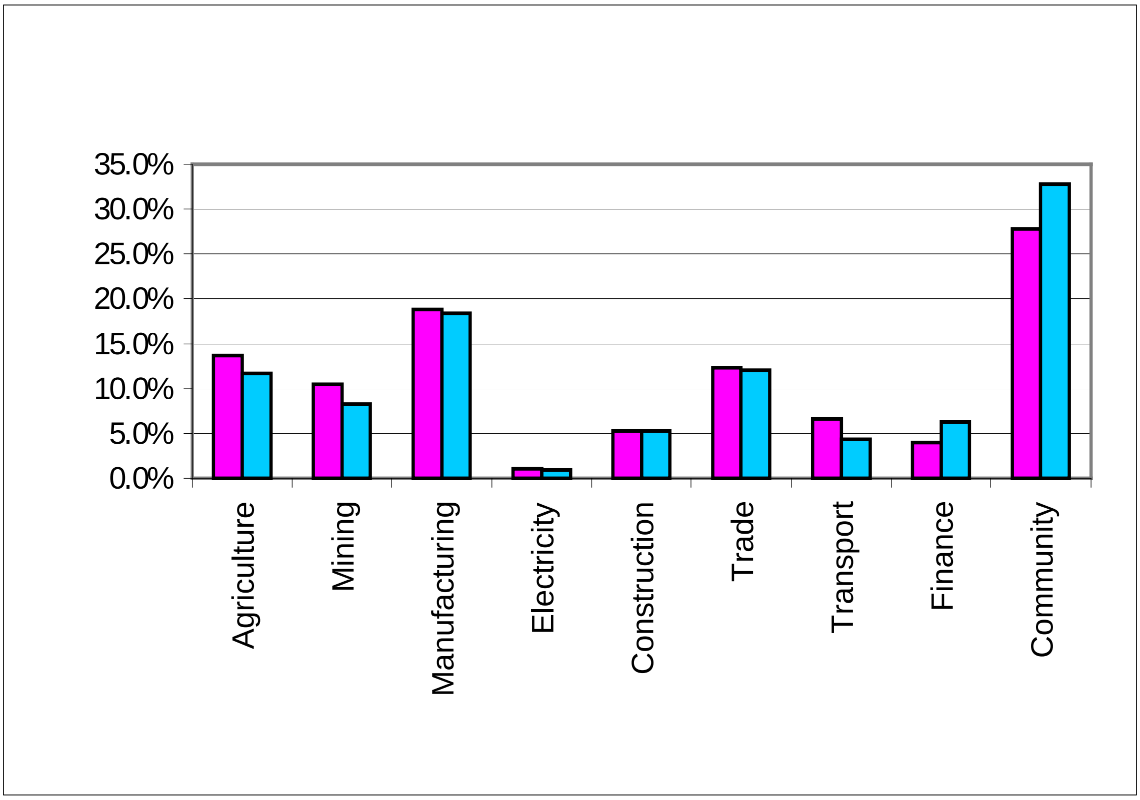


Figure B.5: Contribution by Sectors of Limpopo Employment to National Sectoral Employment, 1980 and 1994 (%)

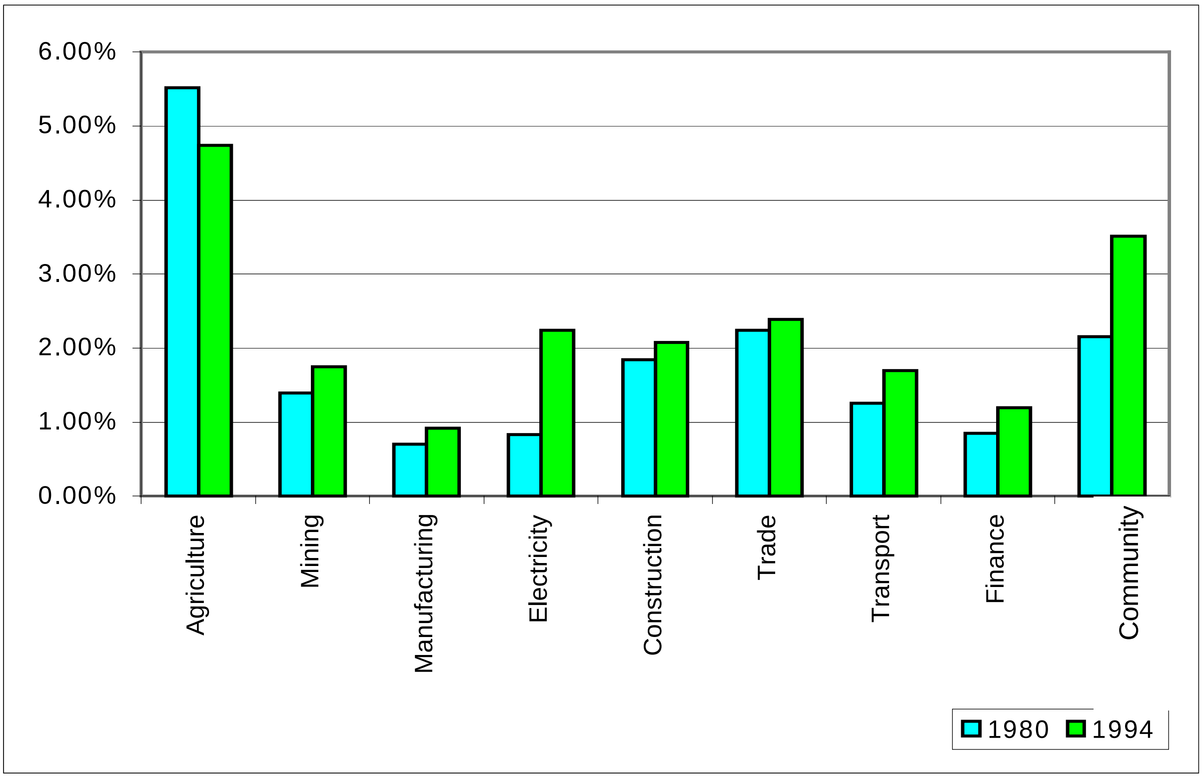


Figure B.6: Average Annual Employment Growth by Sector of Limpopo versus South Africa, 1980 to 1994 (%)

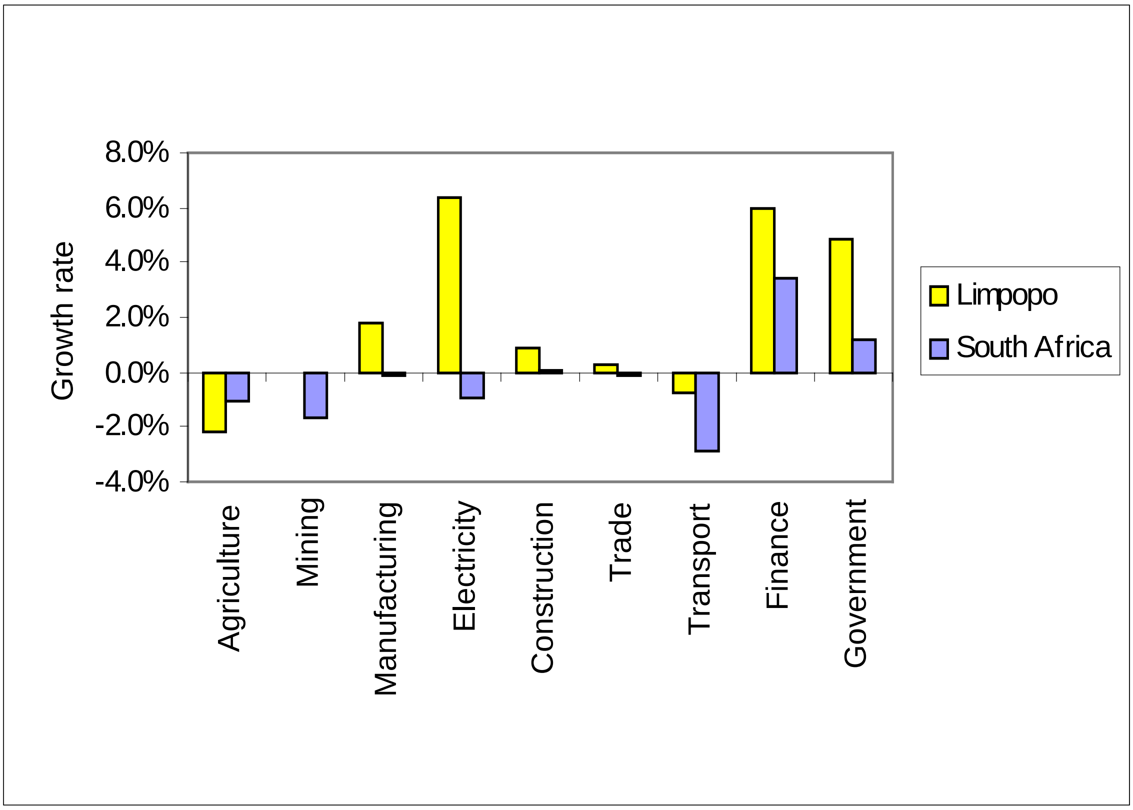
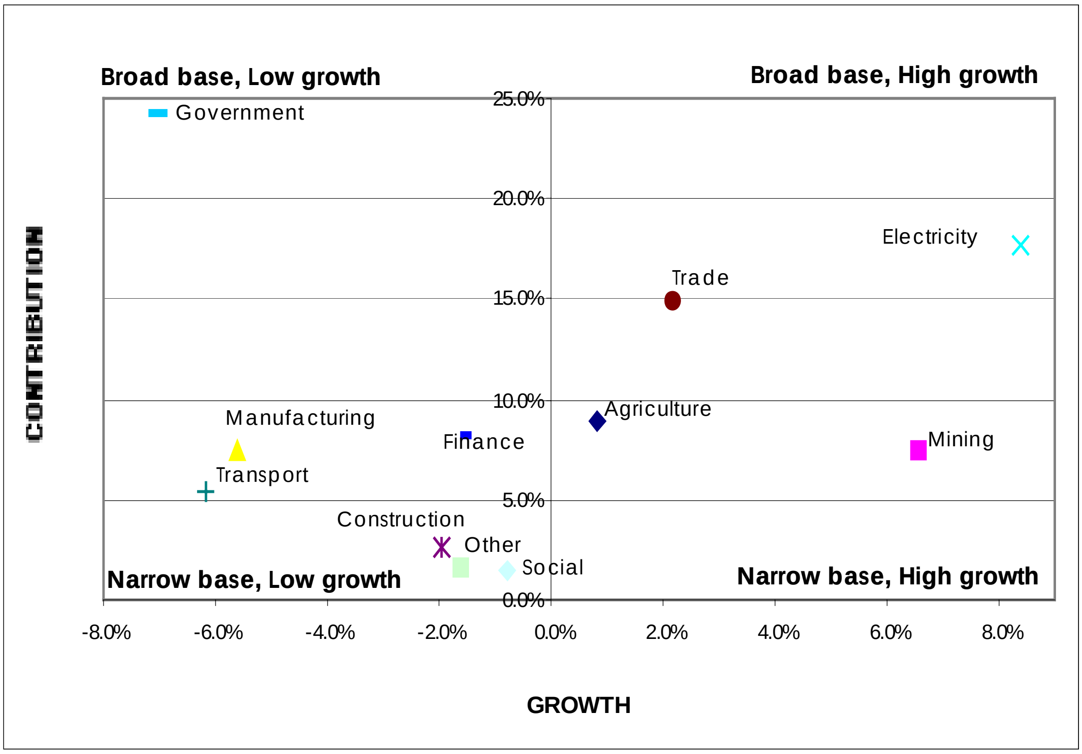


Figure B.7: Shift-Share Analysis, 1997



APPENDIX B.2

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

B.1 INTRODUCTION

The purpose of this section is to illustrate the relative importance of the nineteen different water management areas (WMAs) in South Africa. The following aspects are outlined:

- Contribution by WMA to national economy
- Contribution by WMA to formal employment
- Economic growth by WMA.

B.2 CONTRIBUTION BY WATER MANAGEMENT AREA TO NATIONAL ECONOMY

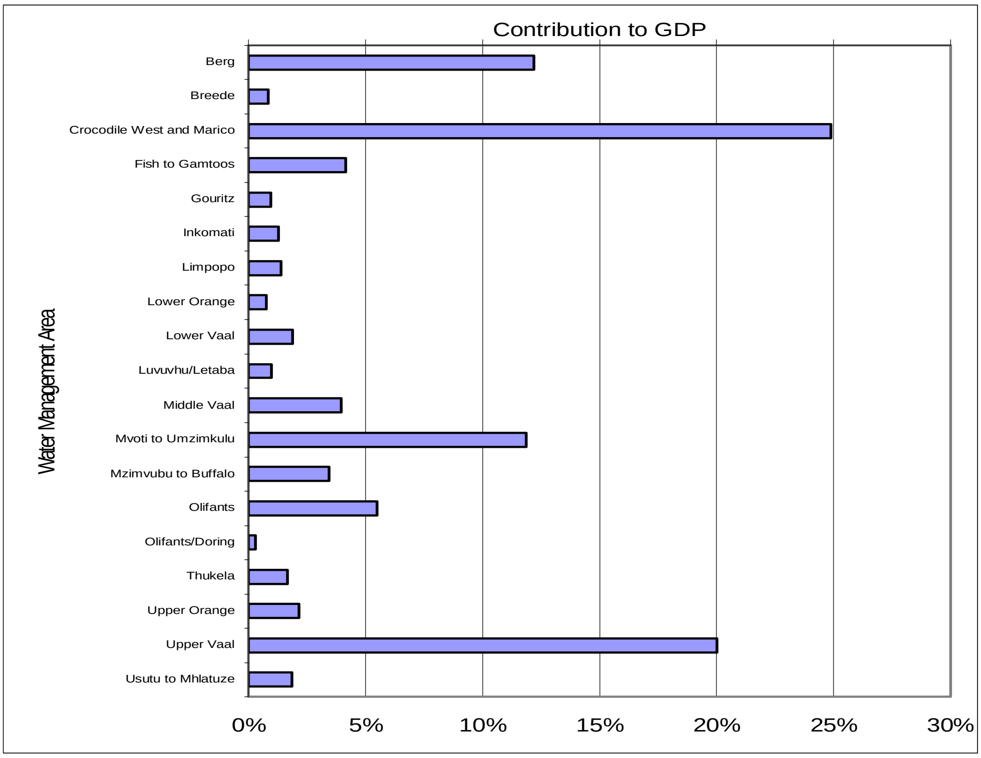
- The largest contribution to the national economy is made by the Crocodile West and Marico WMA which contributes (19.1%) to GDP. This WMA comprises, inter alia, magistrates districts of Pretoria, Johannesburg, Germiston, Kempton Park, Benoni, Thabazimbi and Lichtenburg.

- The second largest WMA to the national economy, is the Upper Vaal, which contributes 16.6% to GDP. This WMA comprises mainly portions of Johannesburg, Vereeniging and Vanderbijlpark.

- The Berg WMA contributes 11.25% to the GDP of the national economy and comprises mainly the Cape Metropolitan Area (CMA).

- Mvoti to Umzimkulu WMA makes the fourth largest contribution of 10.72% to the GDP of the national economy. This WMA includes the Durban-Pinetown Metropolitan Area.

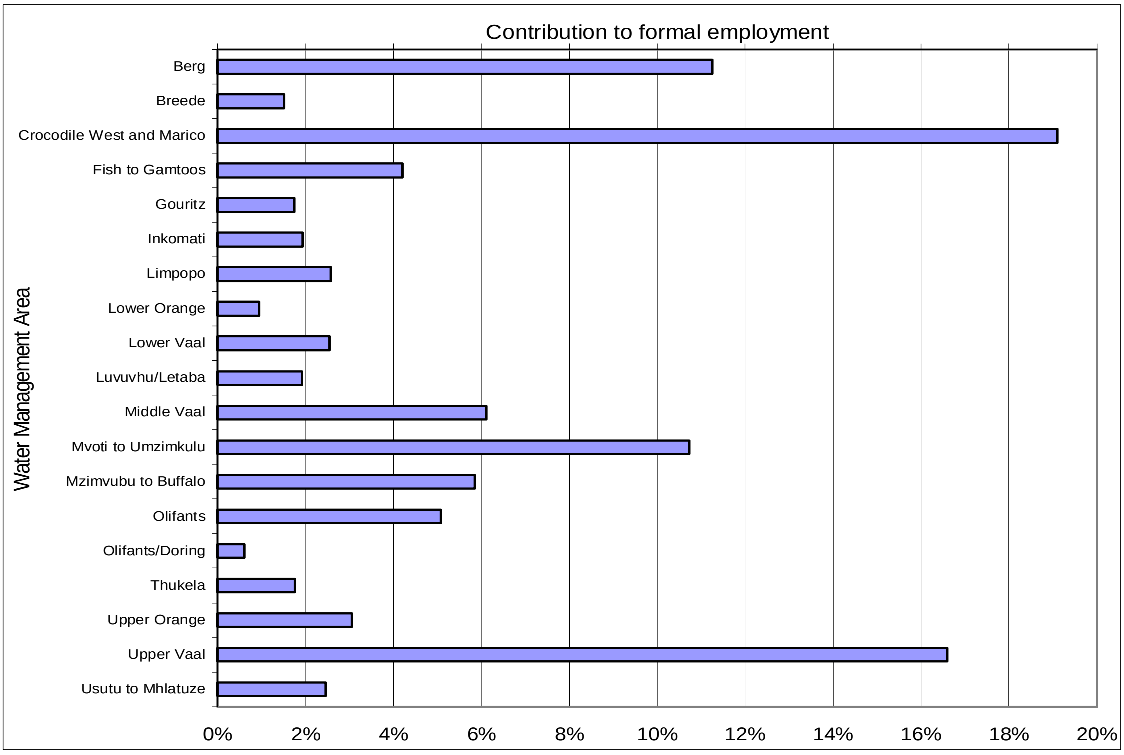
Figure B.1: Total GGP by Water Management Area (% of Country)



B.3 CONTRIBUTION BY WATER MANAGEMENT AREA TO NATIONAL EMPLOYMENT

- Contribution to formal employment corresponds to economic production and is mainly concentrated in the four dominant WMAs.

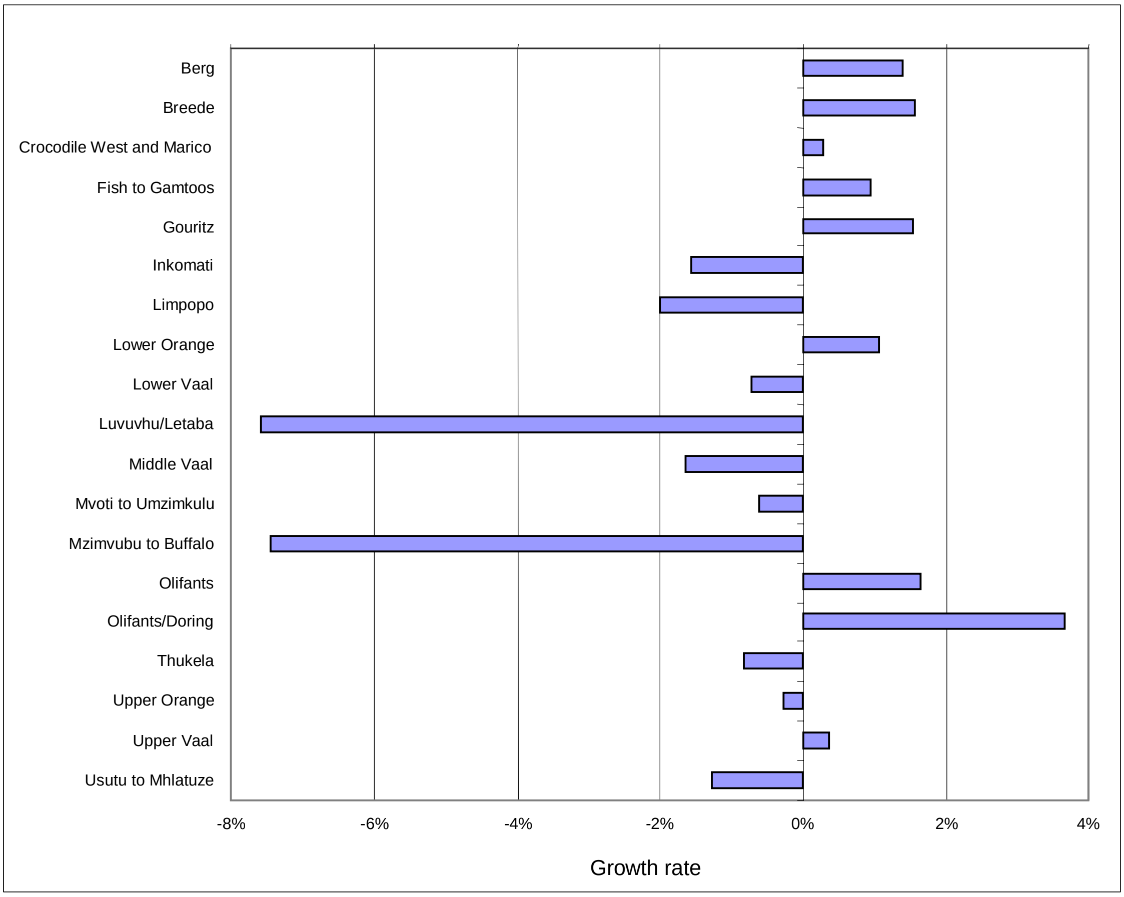
Figure B.2: Formal Employment by Water Management Area (% of country)



B.4 ECONOMIC GROWTH BY WATER MANAGEMENT AREA

- In terms of economic growth, three of the dominant four WMAs recorded positive economic growth between 1988 and 1997: the Berg grew at 1.4% per annum, Crocodile West and Marico at 0.28% per annum and Upper Vaal at 0.36% per annum. Marginal negative growth was recorded over the nine year period in the Mvoti to Umzimkulu WMA: -0.62% per annum.

Figure B.3: Average Annual Economic Growth by Water Management Area, 1988-1997 (%)



APPENDIX B.3
ECONOMIC SECTOR DESCRIPTION

ECONOMIC SECTOR DESCRIPTION

- **Agriculture:** This sector includes agriculture, hunting and related services. It comprises activities such as growing of crops, market gardening, horticulture, mixed farming, production of organic fertiliser, forestry, logging and related services and fishing, operation of fish hatcheries and fish farms.

- **Mining:** This section entails the mining and quarrying of metallic minerals (coal, lignite, gold, cranium ore, iron ore, etc); extraction of crude petroleum and natural gas, service activities incidental to oil and gas extraction; stone quarrying; clay and sand pits; and the mining of diamonds and other minerals.

- **Manufacturing:** Manufacturing includes, inter alia, the manufacturing of food products, beverages and tobacco products; production, processing and preserving of meat, fish, fruit, vegetables, oils and fats, dairy products and grain mill products; textile and clothing; spinning and weaving; tanning and dressing of leather; footwear; wood and wood products; paper and paper products; printing and publishing; petroleum products; nuclear fuel; and other chemical substances.

- **Electricity, Water and Gas:** Utilities comprise mainly three elements, namely electricity, water and gas. The services rendered to the economy include the supply of electricity, gas and hot water, the production, collection and distribution of electricity, the manufacture of gas and distribution of gaseous fuels through mains, supply of steam and hot water, and the collection, purification and distribution of water.

- **Construction:** This sector includes construction; site preparation building of complete constructions or parts thereof; civil engineering; building installation; building completion; and the renting of construction or demolition equipment with operators all form part of the construction sector.

- **Trade:** Trade entails wholesale and commission trade; retail trade; repair of personal household goods; sale, maintenance and repair of motor vehicles and motor cycles; hotels, restaurants, bars canteens, camping sites and other provision of short-stay accommodation.

- **Transport:** The transportation sector comprises land transport; railway transport; water transport; transport via pipelines; air transport; activities of travel agencies; post and telecommunications; courier activities; and storage.

- **Business and Financial Services:** The economic activities under this category include, inter alia, financial intermediation; insurance and pension funding; real estate activities; renting of transport equipment; computer and related activities; research and development; legal; accounting, book-keeping and auditing activities; architectural, engineering and other technical activities; and business activities not classified elsewhere.

- **Government and Social services (Community Services)**: This sector includes public administration and defence, social and related community services (education, medical, welfare and religious organisations), recreational and cultural services and personal and household services.

- **Other:** Private households, extraterritorial organisations, representatives of foreign governments and other activities not adequately defined.

APPENDIX B.4
ECONOMIC INFORMATION SYSTEM

ECONOMIC INFORMATION SYSTEM
For Department of Water Affairs and Forestry

1. Background

The Economic Information System was developed for the Department of Water Affairs and Forestry due to a need for a comprehensive source of readily available economic data that can be utilised as a management tool for decision making.

Relevant information required for planning the allocation and utilisation of scarce resources such as water has always been a difficult process due to:

- **Inaccessibility of information**
- **Incompatibility of information**
- **No framework of reference for analysis**

The purpose of the Economic Information System was thus to combine all readily available economic information into a single computer package that would be readily accessible, easy to use and could be distributed without restrictions.

2. The System

The characteristics of the Economic Information System can be summarised as follows:

- Provides immediate access to a comprehensive economic database.
- Stand alone software programme that can be loaded onto a personal computer.
- System provides not only the existing data but also allows first degree transformation of data both geographically and functionally.
- Allows multidimensional access and presentation of information, that is, on a sectoral, geographical and functional basis.
- Provides time series information to enable users to determine trends and make projections.

Urban-Econ collected existing data from a range of secondary sources. The following data were combined in a single database which can be queried spatially, thematically and temporally *via* a user-friendly computer interface.

Diagram 1 depicts the economic information system in a flow chart format. It is possible to display the data in:

- Tables
- Graphs
- Thematic maps (this provides a better perspective of the spatial context and significance of other spatial features relevant to the data.

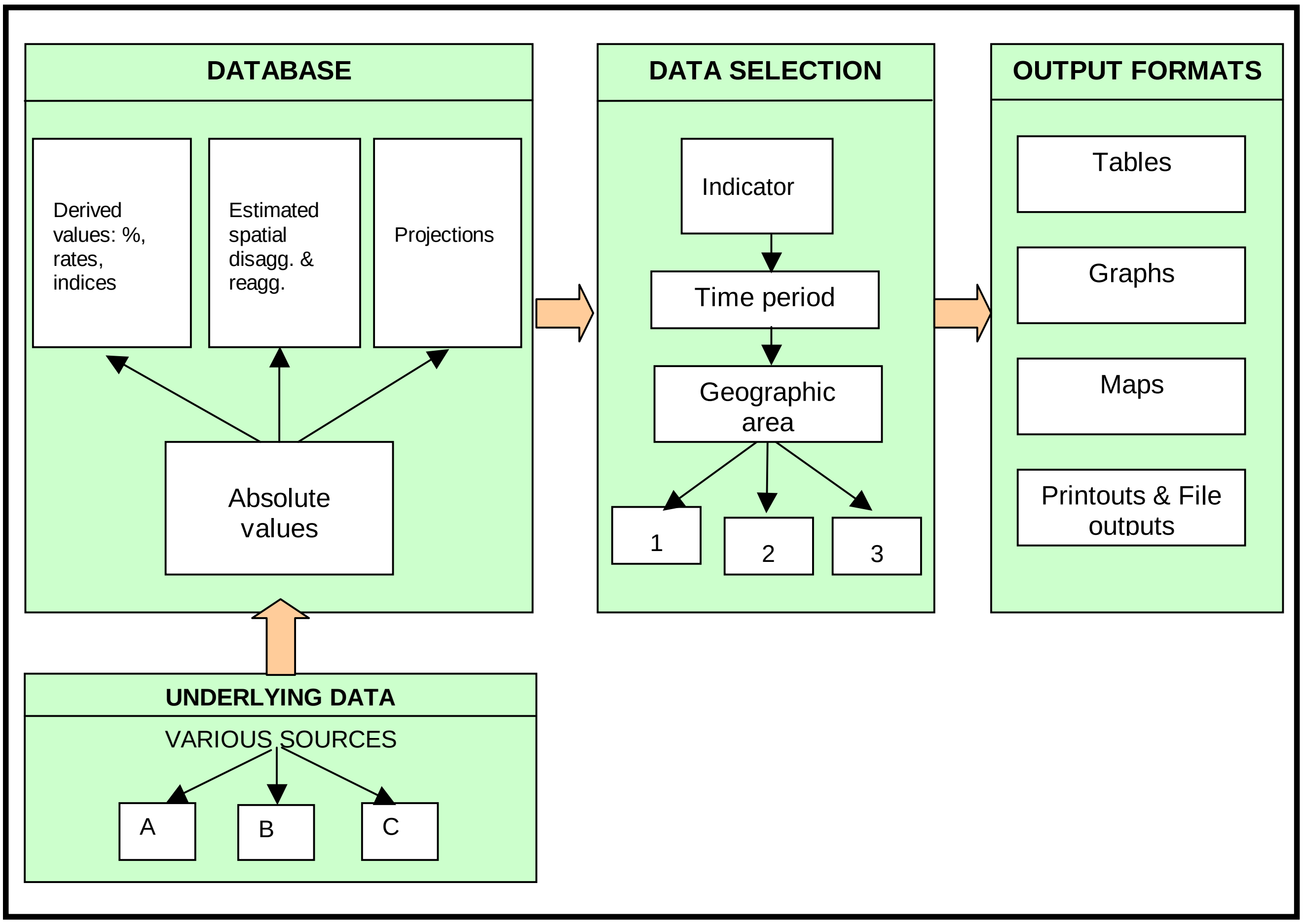
Indicator	Categories	Timespan	Geographic detail
Gross geographic product	Major sectors	1972-1997	Magisterial districts
Labour distribution	Employment/un-employment Major sectors	1980, 1991, 1994	Magisterial districts
Electricity consumption	Economic sectors, domestic	1988-1997	Local authority area, service council area
Electricity connections	Economic sectors, domestic	1988-1997	Local authority area, service council area
Remuneration*	Economic sectors	1993-1998	Magisterial districts
Turnover*	Economic sectors	1993-1998	Magisterial districts
Number of firms*	Economic sectors	1992-1998	Magisterial districts
Tax revenue	Company, Personal, VAT	1992-1997	Tax office area
Buildings completed	Residential, office, shops, industrial	1991-1996	Local authority area, service council area
Telephone connections	Business, residence	1998 1976-1997	Magisterial district Province
Vehicle sales	Commercial, passenger	1980-1997	Towns

* Figures complete for totals, but incomplete for economic sectors

On-line documentation is provided which gives information on:

- The definition of an indicator
- How the figures were obtained
- How reliable the figures are
- How complete the figures are
- To what detail the figures are available
- What the relevance or limitations of the figures are for analytical purposes.

Diagram 1: Overview of Economic Information System



3. Examples of utilisation

- A user can select a main area for analysing the spatial variations of an indicator. Within that area, any level of geographic detail, i.e. magisterial district level or town level in the case of data relating to a local authority area can be assessed.
- It is possible to compare changes over time between different areas. This may indicate whether patterns of economic activity are changing, for example that it is growing in one area and declining in another area, which will have an impact on, for example, human settlement and the demand for water.
- A user can select more than one indicator to ascertain how the trends of the different indicators are correlated in different areas or over time. If indicators are correlated, there may be a causal relationship between the two, or it may reveal that changes in both indicators are a consequence of some other factor. If these causal relationships can be determined, it may also become known whether the causal factors are changing permanently or temporarily, which will inform the user whether there should be a long-term planning response or not.

APPENDIX C

LEGAL ASPECTS

APPENDIX D

LAND-USE DATA

D1. MINES WITHIN THE LIMPOPO WMA

ALL KNOWN OPERATING MINES

Activity	Product
Groote Geluk Collery	Coal
Messina Copper Mine	Copper
Silicon Smelter	Silicon
PPL Mine	Platinum
Union Tin Mines Ltd	Tin
Buffalo Fluorspar	Flourspar
Grass valley	Chrome
Zaaiplaats	Tin
Valley Enterprises	Tin
Samancor / LDC	Vanadium
Lebowa Granite	Granite
Aurora Granite	Granite
Kudu Granite	Granite
Holding	Granite
South Wits	Platinum
Overysel	Platinum
Northern Prospecting	Platinum
Venetia	Diamonds
Weenen Brickworks	Bricks
Potgietersrus Brickworks	Bricks
Franet Sand	Sand
Ruytenberg Sand	Sand
De Kock Sand	Sand
Steenkamp Sand	Sand
Corea	Sand
Bridgewater	Sand
Graphite	Graphite
Bestegrondwerk	
Pruizen Stone	Crushed stone
Naboomspruit crusher	Felsite (riolite)
Cyferfontein	Clay / Fireclay
Bridgewater	Anthophylite

Note: Mines that has an impact on the hydrology and water quality of the river systems, and mines that impact significantly on the economy of a region or town are highlighted.

APPENDIX E

WATER RELATED INFRASTRUCTURE

Scheme Name	Water Source				Water User				Treatment Works	Reservoir Capacity	Sewage Disposal
	Dam	Combined farm dams	Boreholes	Run-of-river	Domestic	Major industry	Mines	Irrigation			
Phalala River											
Phalala irrigation		Quaternary: A50A, A50B, A50C, A50D, A50E, A50F, A50G, A50H River: Lephalala & tributaries Gross storage capacity (Mm^3) 9.53 Dead storage capacity (Mm^3) #530 farm dams	Quaternary: A50A, A50B, A50C, A50D, A50E, A50F, A50G, A50H Diesel: Electric: Wind/hand Yield (M^3/d): Limited use	Quaternary: A50A, A50B, A50C, A50D, A50E, A50F, A50G, A50H River: Abstraction: pumps: canals: Used in combination with dams				Quaternary: A50A, A50B, A50C, A50D, A50E, A50F, A50G, A50H Area (ha): 5433 Allocation (M3/ha/a): Use (Mm3/a) 45 Water shortfall: Frequent especially in A50E, A50F, A50G, A50H			
Witpoort scheme			Quaternary: A50H Diesel: Electric: Witpoort well field Wind/hand Yield (M^3/d):		Quaternary: A50H Name: 8 Villages Population (1995) Use 1995 (Mm3/a)						
Village boreholes			Quaternary: A50, A50H Diesel: Electric: Wind/hand Yield (M^3/d):		Quaternary: A50G, H50H Name: 28 Villages Population (1995) Use 1995 (Mm3/a)					Quaternary: Number: Combied Capacity (Ml):	
Mogalakwena River											
Donkerpoort scheme	Quaternary: A61A Name: Donkerpoort River: Klein Nyl Gross storage capacity (Mm^3) 2.38 Dead storage capacity (Mm^3) 0				Quaternary: A61A Name: Nylstroom Use 1995 (Mm3/a) Population (1995) 23800				Quaternary: A61A Capacity (Ml/d): 3.4 Process: Sand filter	Quaternary: Number: Combied Capacity (Ml):	Quaternary: A61A Capacity (Ml/d) 3.4 Process: Activated sludge
Magalies (import)	Quaternary: A23B Name: Roodeplaat Dam River: Pienaars Gross storage capacity (Mm^3) Dead storage capacity (Mm^3)				Quaternary: A61A Name: Nylstroom Use 1995 (Mm3/a) Contract (Mm3/a)					Quaternary: A61A Name: Nylstroom Number: Combied Capacity (Ml): Comment: Included in Donkerpoort scheme	Quaternary: A61A Name: Nylstroom Capacity: Process: Comment: Included in Donkerpoort scheme
Nyl River irrigation		Quaternary: A61A, A61B, A61C A61D, A61E Name: River: Nyl and tributaries Gross storage capacity (Mm^3) 6.57 Dead storage capacity (Mm^3) # 208 farm dams	Quaternary: A61A, A61B, A61C A61D, A61E Diesel: Electric: Wind / hand Yield (M^3/d): 1626ha irrigated					Quaternary: A61A, A61B, A61C A61D, A61E Area (ha): 3383 Allocation (m3/ha/a): Use (Mm3/a) 23.02 Produce mainly maize, tabacco, wheat, cotton			
Naboomspruit water supply scheme	Quaternary: A61H Name: Welgevonden Dam River: Sterk River Gross storage capacity (Mm^3) 0.92 Dead storage capacity (Mm^3) 0 Yield (firm) (Mm3/a) 0.6 Allocation (Mm3/a) 0.72		Quaternary: A61D Diesel: Electric No: 9 Wind / hand Yield (M^3/d): 0.75 Permit (Mm^3/a) 1.0		Quaternary: A61D Name: Naboomspruit, Mookgophong Use 1995 (Mm3/a) 1.2 Population (1995): 8700				Quaternary: A61D Name: Naboomspruit Capacity (Ml/d): 4.4 Process: Slow sand filter	Quaternary: A61D Number: 2 Combied Capacity (Ml):	Quaternary: A61D Capacity: Process: Activated sludge
Potgietersrus water supply scheme	Quaternary: A61H Name: Doorndraai Dam River: Sterk River Gross storage capacity (Mm^3) 47.2 Dead storage capacity (Mm^3) 0.57 Firm yield (Mm3/a): 8.6		Quaternary: A61F Name: Planknek well field Diesel: Electric No: 14 Wind/hand: Yield (Mm^3/a): 1.6 Quaternary: A61F Name: Dispersed Diesel No: Electric No: Wind/hand No: Yield (Mm^3/a):		Quaternary: A61F Name: Potgietersrus, Mahwelereng, settlement Population (1995): 89300 Use 1995 (Mm3/a) 4.53			Quaternary: A61J Area (ha): 520 Allocation (m3/ha/a): 7200 Use (mm3/a) 4.87	Quaternary: A61H Capacity (Ml/d): 8.2 Process: Sand filter	Quaternary: A61F Number: 11 Combied Capacity (Ml): 50.9	Quaternary: A61F Capacity (Ml/d): 3.4 Process: Activated sludge Disposal: PPL mine irrigation Nyl River Quarternary: A61F Capacity (Ml/d): Process: Oxidation ponds Disposal: PPL mine Evaporation
Sterk River catchment irrigation		Quaternary: A61H, A61J River: Sterk River and tributaries Gross storage capacity (Mm^3) 6.54 Dead storage capacity (Mm^3) # 99 dams	Quaternary: A61H, A61J Diesel: Electric: Wind/hand No: Water use (Mm^3/a): 3.52	Quaternary: A61H, A61J River: Abstraction: pumps: canals: Limited use				Quaternary: A61H, A61J Area (ha): 4319 Allocation (m3/ha/a): Use (Mm3/a) 33.47 * Excludes Sterk River irrigation scheme			
Upper and Middle Mogalakwena irrigation		Quaternary: A61F, A61G, A62A, A62B, A62C, A62D, A62E, A62F A62G, A62H, A62J River: Mogalakwena & tributaries Gross storage capacity (Mm^3) 12.72 Dead storage capacity (Mm^3)	Quaternary: A61F, A61G, A62A, A62B, A62C, A62D, A62E, A62F A62G, A62H, A62J Diesel: Electric: Wind/hand No: Yield (Mm^3/a): Water use (Mm^3/a): 14.38					Quaternary: A61F, A61G, A62A, A62B, A62C, A62D, A62E, A62F A62G, A62H, A62J Area (ha): 3350 Allocation (m3/ha/a): Use (Mm3/a) 24.82			
Glen Alpine irrigation scheme	Quaternary: A62J Name: Glen Alpine Dam River: Mogalakwena Gross storage capacity (Mm^3) 21.9 Dead storage capacity (Mm^3) 0.1 Yield (firm) (Mm3/a) 5.6	Quaternary: A63A, A63B River: Mogalakwena & tributaries Gross storage capacity (Mm^3) 2.3 Dead storage capacity (Mm^3) # 127 dams	Quaternary: A63A, A63B Diesel: Electric: Wind/hand No: Yield (Mm^3/a): Water use (Mm^3/a): 13.75	Quaternary: A63A, A63B River: Mogalakwena Abstraction: pumps: Spillage from Glen Alpine Dam				Quaternary: A63A, A63B Area (ha): 2429 Allocation (m3/ha/a): 6200 Use (Mm3/a)			
PPL mine scheme			Quaternary: A61G Name: PPL, Blinkwater, Commandodrift well fields Electric: Yield (Mm^3/a): 1.3	Sewage effluent Quaternary: A61F Contract with Potgietersrus to use 1.3Ml/d Average delivery (Ml/d): 2.6			Quaternary: A61F Name: Potgietersrust Platinums Ltd Use 1995 (Mm3/a): 2.19				
Lower Mogalakwena irrigation		Quaternary: A63C, A63D, A63E, A71L River: Tributaries of Limpopo Gross storage capacity (Mm^3) 5.51 Dead storage capacity (Mm^3)	Quaternary: A63C, A63D, A63E, A71L Diesel: Electric: Wind/hand No: Yield (Mm^3/a): Water use (Mm^3/a): 32.02	Quaternary: A63C, A63E, A71L River: Limpopo Abstraction: pumps: Unknown				Quaternary: A63.C, A63D, A63E, A71L Area (ha): 3390 Allocation (m3/ha/a): Use (Mm3/a) 32.02			
Middle and Upper Mogalakwena village water supply			Quaternary: A61G, A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J Diesel: Electric: Wind/hand No: Yield (Mm^3/a):		Quaternary: A61G, A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J Name: 23 villages Population (1995): 370000 Use 1995 (Mm3/a) 2.3					Quaternary: A61G, A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J Number: Combied Capacity (Ml):	Quarternary: A62G Name: Rebone Capacity (Ml/d): Process: Oxidation ponds
Venetia mine water supply			Quaternary: A63E Electric: Yield (Mm^3/a):				Quaternary: A63E Name: Venetia Use 1995 (Mm3/a): 2.5			Quaternary: Number: Combied Capacity (Ml):	Quarternary: Capacity (Ml/d): Process:
Lower Mogalakwena village water supply			Quaternary: A63A, A63B, A63C, A63D, A63E Diesel: Electric: Wind/hand No: Yield (Mm^3/a):		Quaternary: A63A, A63B, A63C, A63D, A63E Population (1995): 64000 Name: 50 villages Use 1995 (Mm3/a) 0.34			Quaternary: A63A, A63B Area (ha): 2429 Allocation (m3/ha/a): 6200 Use (Mm3/a)		Quaternary: Number: Combied Capacity (Ml):	
Nzhelele River											
Nzhelele village water supply scheme	Quaternary: A80A Name: Mutshedzi River: Mutshedzi Gross storage capacity (Mm^3) 2.4 Dead storage capacity (Mm^3) 0.03		Quaternary: A80A, A80B Diesel: Electric: Wind/hand No: Yield (Mm^3/a):	Quaternary: A80A River: Nzhelele Abstraction: Weir into pipeline under gravity Water delivery (Mm3/a): 2.0	Quaternary: A80A, A80B Name: 55 villages Use 1995 (Mm3/a) 4.4 Population (1995): 101600	Quaternary: A80A Name: Makhado tomato factory Use 1995 (Mm3/a): 0.5			Quaternary: A80A Name: Mutshedzi Capacity (Ml/d): 3.6 Process: Gravity sand filter	Quaternary: A80A, A80B Number: 48 Combied Capacity (Ml): 33.9	Quaternary: A80A Name: Siloam Hospital Capacity (Ml/d): 120m3/d Process: Oxication ponds

Scheme Name	Water Source				Water User				Treatment Works	Reservoir Capacity	Sewage Disposal
	Dam	Combined farm dams	Boreholes	Run-of-river	Domestic	Major industry	Mines	Irrigation			
	Firm yield (Mm3/a) 1.5		Limited use								
				Quaternary: A80A River: Tshifire Abstraction: Weir into pipeline under gravity Water delivery (Mm3/a): 0.58					Quaternary: A80A Name: Tshifire Capacity (Ml/d): 1.6 Process: Chlorinator		Quarternary: A80B Name: Makhado Capacity (Ml/d): 2.3 Process: Activated oxidation ponds Discharge to Nzhelele River
Nzhelele north borehole schemes			Quaternary: A80B, A80C Diesel: 18 Electric: Wind/hand No: 6 Yield (Mm^3/a):		Quaternary: A80B, A80C Name: 19 villages Population (1995): 11100 Water need (Mm3/a): 0.19					Quaternary: A80B, A80C Name: 15 Combied Capacity (Ml): 1.07	
Venda irrigation				Quaternary: A80A, A80B, A80C River: Nzhelele & tributaries Abstraction: pumps (Mm3/a): 1.73 canals (Mm3/a): 19.57				Quaternary: A80A, A80B, A80C Area (ha): 1000 Allocation (m3/ha/a): Run-of-river during 12 hours day time Use (Mm3/a): 21.3			
Nzhelele irrigation scheme	Quaternary: A80C Name: Nzhelele River: Nzhelele Gross storage capacity (Mm^3) 57.2 Dead storage capacity (Mm^3) 1.8 Firm yield (Mm3/a) 7.8		Quaternary: A80F, A80G Diesel: Electric: Wind/hand No: Yield (Mm^3/a): Limited use only		Quaternary: A80G Name: Tshipise Use 1995 (Mm3/a) 0.47			Quaternary: A80F, A80G Area (ha): 2100 Allocation (m3/ha/a): 8400 Use (Mm3/a): 26.0			Quarternary: A80G Capacity (Ml/d): 0.2 Process: Oxication ponds
Mutamba irrigation			Quaternary: A80F Diesel: Electric: Wind/hand No: Yield Water use (Mm^3/a): 0.5					Quaternary: A80F Area (ha): 100 Allocation (m3/ha/a): Use (Mm3/a): 0.5			
Sand River											
Seshego water supply scheme	Quaternary: A71A Name: Blood River Dam River Blood River Gross storage capacity (Mm^3) 2.36 Dead storage capacity (Mm^3) Firm yield (Mm3/a)		Quaternary: A71A Name: Seshego well field Electric: 10 Yield (m^3/d) 3000		Quaternary: A71A Name: Seshego Population (1995): 66000 Use 1995 (Mm3/a) Approx 4.0				Quaternary: A71A Name: Seshego Capacity (Ml/d): 3.95 Process: Sand filter	Quaternary: Number: Combied Capacity (Ml):	Quarternary: A71A Name: Seshego Capacity (Ml/d): Process: Sludge digester
Pietersburg well fields			Quaternary: A71A Name: Sand River North Electric: 22 Yield (m^3/d) 12300 Quaternary: A71A Name: Penina Park & Marshall Street Electric: 12 Yield (m^3/d) 7000		Quaternary: A71A Name: Pietersburg Use 1995 (Mm3/a) 12.12 Population (1995): 51000	Quaternary: A71A Name: SAB Use 1995 (Mm3/a): 3.08	Quaternary: A71A Name: Silicon smelters Use 1995 (Mm3/a): 0.28		Quaternary: A71A Name: Dap Naude Capacity (Ml/d): 18.0 Process: Rapid gravity sand filters	Quaternary: A71A Number: Combied Capacity (Ml):	Quarternary: A71A Name: Pietersburg Capacity (Ml/d): 19.4 Process: Activated sludge
Hout River scheme	Quaternary: A71E Name: Hout River Dam River: Hout River Gross storage capacity (Mm^3) 7.49 Dead storage capacity (Mm^3/a) 0.6		Quaternary: A71E Diesel: Electric: Wind/hand No: Yield Water use (Mm^3/a): 700		Quaternary: A71E Name: 12 villages Population (1995): Use 1995 (Mm3/a)				Quaternary: A71E Capacity (Ml/d): Process:	Quaternary: A71A Number: 6 Combied Capacity (Ml): 1.6	
Sand River West village water supply			Quaternary: A71A, A71E, A71F, A71G, A72A Diesel: Electric: Wind/hand No: Yield (m^3/d)		Quaternary: A71A, A71E, A71F, A71G, A72A Name: 170 villages Population (1995): 217000 Use 1995 (Mm3/a) 1.44					Quaternary: A71A, A71E, A71F, A71G, A72A Number: Combied Capacity (Ml):	
Buysdorp regional scheme			Quaternary: A71G Diesel: Electric: Wind/hand No: Yield (m^3/d)	Quaternary: A71G River Tributary Dorps River Abstraction: weirs: canals: Min yield (Mm3/a): 0.17	Quaternary: A71G Name: Buysdorp Population (1995): 1600 Use 1995 (Mm3/a)			Quaternary: A71G Area (ha): Allocation (m3/ha/a): Use (Mm3/a):	Quaternary: Capacity (Ml/d): Process:	Quaternary: Number: Combied Capacity (Ml):	
Spies Dam irrigation scheme	Quaternary: A71G Name: Spies Dam River Dorps River Gross storage capacity (Mm^3) 2.89 Dead storage capacity (Mm^3/a) Firm yield (Mm3/a)							Quaternary: A71G Area (ha): Allocation (m3/ha/a): Use (Mm3/a):			
Sinthumule/Kutama water supply			Quaternary: A71H Electric: 19* Water use (Mm^3/a): 0.94 * Developed in 1998		Quaternary: A71H Name: 39 villages Population (1995): 64000 Use 1995 (Mm3/a) 0.3					Quaternary: Number: Combied Capacity (Ml):	
Sand River East village water supply			Quaternary: A71B, A71C Diesel: Electric: Wind/hand No: Yield (m^3/d):	IMPORT Quaternary: B81A River: Letaba Name: Ebenezer Dam	Quaternary: A71B, A71C Name: 140 villages Population (1995): 185000 Use 1995 (Mm3/a) 1.65					Quaternary: A71B, A71C Number: Combied Capacity (Ml):	Quarternary: A71B Capacity (Ml/d): Process:
Louis Trichardt water supply			Quaternary: A71H Electric: Yield (Mm^3/a): 0.59	Quaternary: A91B Name: Albasini Dam River: Luvuvhu Water allocation (Mm3/a): 2.41	Quaternary: A71H Name: Louis Trichardt Population (1995): Use 1995 (Mm3/a)					Quaternary: A71H Number: Combied Capacity (Ml):	Quarternary: A71H Capacity (Ml/d): Process:
Messina water supply			Quaternary: A71K Electric: Yield (Mm^3/a):	IMPORT Quaternary: A71K River: Limpopo Abstraction: weir: pumps:	Quaternary: A71K Name: Messina Population (1995): 8300 Use 1995 (Mm3/a) 2.2				Quaternary: A71K Capacity (Ml/d): Process:	Quaternary: A71K Number: Combied Capacity (Ml):	Quarternary: A71K Capacity (Ml/d): Process:
Ground water irrigation			Quaternary: A71A, A71B, A71C, A71D, A71E, A71F, A71G, A71H, A71J, A71K, A71L, A72A, A72B Diesel: Electric: Yield (m^3/a):					Quaternary: A71A, A71B, A71C, A71D, A71E, A71F, A71G, A71H, A71J, A71K, A71L, A72A, A72B Area (ha): 8586 Allocation (m3/ha/a): Use (Mm3/a): 125.5			
Mokolo River catchment											
Mokolo Dam scheme	Quaternary: A42F Name: Mokolo Dam River Mokolo Gross storage capacity (Mm^3) 146.0 Dead storage capacity (Mm^3/a) Firm yield (Mm^3/a) 21.7	Quaternary: A42G, A42H, A42J Name: River Mokolo & tributaries Gross storage capacity (Mm^3) Dead storage capacity (Mm^3)	Quaternary: Diesel: Electric: Yield (m^3/a):	Quaternary: River Abstraction: pumps: canals:	Quaternary: A42H Name: Ellisras, Marapong Population (1995): Use 1995 (Mm3/a) 4.21	Quaternary: A42J Name: Matimba power station Use 1995 (Mm3/a): 6.5	Quaternary: A42J Name: Grootegeluk colliery Use 1995 (Mm3/a): 4.04	Quaternary: A42G, A42H, A42J Area (ha): 2000 Allocation (m3/ha/a): Use (Mm3/a): 10.4	Quaternary: Capacity (Ml/d): Process:	Quaternary: Number: Combied Capacity (Ml):	Quarternary: Capacity (Ml/d): Process:
Mokolo diffuse irrigation		Quaternary: A42A, A42B, A42C, A42D, A42E, A42F, A42G, A42H, A42J Name: River: Mokolo & tributaries Gross storage capacity (Mm^3) Dead storage capacity (Mm^3)	Quaternary: Diesel: Electric: Yield (m^3/a):	Quaternary: River: Abstraction: pumps: canals:				Quaternary: A42A, A42B, A42C, A42D, A42E, A42F, A42G, A42H, A42J Area (ha): 12550 Allocation (m3/ha/a): Use (Mm3/a):			

APPENDIX F

WATER REQUIREMENTS

F1. ECOLOGICAL CLASSES PER QUATERNARY CATCHMENT FOR THE OLIFANTS WMA

QUATERNARY	PROVINCE	RIVERS	EISC	DEMC	PESC	BEST AEMC	cEPCo
A41A	NORTHERN PROVINCE	Mathlabas (main)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A41B	NORTHERN PROVINCE	Mathlabas	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A41C	NORTHERN PROVINCE		LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A41D	NORTHERN PROVINCE	AB	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A41E	NORTHERN PROVINCE	Limpopo	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A42A	NORTHERN PROVINCE	KLEIN SAND ?	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A42B	NORTHERN PROVINCE	GROOTSPRUIT	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A42C	NORTHERN PROVINCE	MOKOLO	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A42D	NORTHERN PROVINCE	GROENSPRUIT?	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A42E	NORTHERN PROVINCE	MOKOLO	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A42F	NORTHERN PROVINCE	MOKOLO	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A42G	NORTHERN PROVINCE	MOKOLO	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A42H	NORTHERN PROVINCE	MOKOLO	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A42J	NORTHERN PROVINCE	MOKOLO	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A50A	NORTHERN PROVINCE	Palala	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A50B	NORTHERN PROVINCE	Palala	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A50C	NORTHERN PROVINCE	Melk	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A50D	NORTHERN PROVINCE	Palala	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A50E	NORTHERN PROVINCE	Palala	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A50F	NORTHERN PROVINCE	Palala	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A50G	NORTHERN PROVINCE	Palala	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A50H	NORTHERN PROVINCE	Palala	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A50J	NORTHERN PROVINCE		LOW	CLASS D: LARGE RISK ALLOWED	CLASS A: UNMODIFIED, NATURAL	CLASS A: UNMODIFIED, NATURAL	1.1
A61A	NORTHERN PROVINCE	KLEIN NYL	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A61B	NORTHERN PROVINCE	NYL	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED	4.1
A61C	NORTHERN PROVINCE	NYL	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A61D	NORTHERN PROVINCE	NYL	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A61E	NORTHERN PROVINCE	NYL	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A61F	NORTHERN PROVINCE	NYL	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A61G	NORTHERN PROVINCE	NYL	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A61H	NORTHERN PROVINCE	STERK RIVER	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED	4.1
A61J	NORTHERN PROVINCE	STERK RIVER	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A62A	NORTHERN PROVINCE	MOKAMOLE	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A62B	NORTHERN PROVINCE	MOGALAKWENA	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A62C	NORTHERN PROVINCE	MOGALAKWENA	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A62D	NORTHERN PROVINCE	RIETSPRUIT	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A62E	NORTHERN PROVINCE	SEEPABANA	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A62F	NORTHERN PROVINCE		LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A62G	NORTHERN PROVINCE	MOGALAKWENA	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A62H	NORTHERN PROVINCE		LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A62J	NORTHERN PROVINCE	MOGALAKWENA	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A63A	NORTHERN PROVINCE	MOGALAKWENA	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A63B	NORTHERN PROVINCE	MOGALAKWENA	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED	4.1
A63C	NORTHERN PROVINCE		LOW	CLASS D: LARGE RISK ALLOWED	CLASS A: UNMODIFIED, NATURAL	CLASS A: UNMODIFIED, NATURAL	1.1
A63D	NORTHERN PROVINCE	MOGALAKWENA	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A63E	NORTHERN PROVINCE	KOLOPE	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL	3.1

QUATERNARY	PROVINCE	RIVERS	EISC	DEMC	PESC	BEST AEMC	cEPCo
A71A	NORTHERN PROVINCE	SAND	LOW	CLASS D: LARGE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED	4.1
A71B	NORTHERN PROVINCE	SAND	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A71C	NORTHERN PROVINCE	SAND	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS A: UNMODIFIED, NATURAL	3.1
A71D	NORTHERN PROVINCE	SAND	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS A: UNMODIFIED, NATURAL	3.1
A71E	NORTHERN PROVINCE	HOU RIVIER	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A71F	NORTHERN PROVINCE	STRYDOMLOOP	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A71G	NORTHERN PROVINCE	HOUT	LOW	CLASS D: LARGE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS A: UNMODIFIED, NATURAL	4.1
A71H	NORTHERN PROVINCE	SAND	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A71J	NORTHERN PROVINCE	SAND	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A71K	NORTHERN PROVINCE	SAND	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A71L	NORTHERN PROVINCE		LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS A: UNMODIFIED, NATURAL	2.1
A72A	NORTHERN PROVINCE	Brak	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED	4.1
A72B	NORTHERN PROVINCE	BRAK	LOW	CLASS D: LARGE RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL	2.1
A80A	NORTHERN PROVINCE	Nzehele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A80B	NORTHERN PROVINCE	Nzehele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A80C	NORTHERN PROVINCE	Nzehele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED	4.1
A80D	NORTHERN PROVINCE	Nzehele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A80E	NORTHERN PROVINCE	Nzehele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED	3.1
A80F	NORTHERN PROVINCE	Nzhele	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT	4.1
A80G	NORTHERN PROVINCE	Nzhele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT	4.1
A80H	NORTHERN PROVINCE	Nzehele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED	4.1
A80J	NORTHERN PROVINCE	Nzhele	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT	4.1

EISC	Ecological importance and sensitivity class
DEMC	Default ecological management class
PESC	Present ecological status
BEST AEMC	Future ecological management class
cEPCo	Present ecological management class index

F2. RELATIONSHIP BETWEEN LIVESTOCK AND GAME SPECIES AND ELSU

CONVERSION OF MATURE LIVESTOCK AND GAME POPULATIONS TO EQUIVALENT LARGE STOCK

Units (ELSU)

Species	Group *	Number per Elsu
Livestock:		
Cattle	L	0,85
Sheep	S	6,5
Goats	S	5,8
Horses	L	1
Donkeys / mules	S	1,1
Pigs	S	4
Game:		
Black Wildebeeste	LA	3,3
Blesbuck	SA	5,1
Blou Wildebeeste	LA	2,4
Buffalo	BG	1
Eland	BG	1
Elephant	BG	0,3
Gemsbok	LA	2,2
Giraffe	BG	0,7
Hippopotamus	BG	0,4
Impala	SA	7
Kudu	LA	2,2
Nyala	SA	3,3
Ostrich	-	2,7
Red Hartebeest	LA	2,8
Roan Antelope	LA	2
Sable Antelope	LA	2
Southern Reedbuck	SA	7,7
Springbok	SA	10,3
Tsessebe	LA	2,8
Warthog	O	5
Waterbuck	LA	2,4
Rhinoceros	BG	0,4
Zebra	O	1,6

Groups (in terms of water consumption) : L = cattle and horses; S = small livestock; LA = large antelope; SA = small antelope; BG = big game; O = other game,

The livestock and game figures per category are not shown per quaternary due to a lack of information.

F3. PERMITS AND OTHER ALLOCATIONS

MOGOL RIVER (HANS STRYDOM DAM) (MAKOLO DAM)				
Consumer	**Authorization No**	**Quantity /m³/year**	**Usage code**	**Date**
Mnre ML Vosloo Boerdery (Edms) Bpk	30/144/79	6 209	vs	12/2/70
Mr A Vermooten	30/144/81	3 900	vs	14/5/79
Ellisras Steenmakery	35/144/81	24 548	st + ny	18/5/81
Transvaalse Werkedepartement	36/144/81	200 000	st + ny	18/5/81
Messrs PI Fourie, NP J van Rensburg, HJ Oberholzer & JA Oberholzer	37/144/81	58 400	st + ny	18/5/81
TPA – Afdeling Natuurbewaring	166/144/81	23 000	vs	6/1/82
Murray & Roberts Quarries	137/144/82	2 500	h + ny	7/12/82
E Marais	28/144/86	720	h	28/4/86
Mr JJ Olivier	12/144/90	7 000	h + vs	20/2/90
Yskor Beperk	89/144/90	16 000		5/12/90
Zoetleegte Boerdery (Edms) Bpk	64/144/92	10 000		3/8/92
D du P de Beer	72/144/93	6 000		9/11/93
Mr GJR Louw (Wolwefontein Twee Wildsplaas BK)	8/144/96	200	vs	13/2/96
TPA Louis Trichardt	113/62/76	163 200	Pb	14/12/76

PHALALA RIVER (SUSANDALE DAM AND VISGAT WEIR)				
Consumer	**Authorization No**	**Quantity /m³/year**	**Usage code**	**Date**
Distrik Potgietersrus (SAOT)		49 779	h	15/12/6
Haenertsburgdorp		9 792	st + ny	2/3
Mr LK de Jager (Ebenezer View (Edms) Bpk))		3 650	h	21/5
Messrs De Hoek Saw Mills	31/112/76	19 908	h + i	1/7/76
The Zion Christian Church	48/112/77	2 280	bou + h + vs	10/5/77
Departement Landbou & Bosbou, Lebowa	80/112/78	60 000	h	20/9/78
De Hoek Saw Mills	51/112/79	150 brand		27/9/79
Dalmada Waterkooperasie Bpk	63/112/79	180 000	h	15/10/79
Departement van Werke (Lebowa) Universiteit van die Noorde	76/112/82	2 300 000	st + ny	11/8/82
Departement van Landbou (Lebowa)	75/112/82	97 920	st + ny6	11/8/82
Boyne Roller Mills	34/112/83	39 000	h	28/1/83
Scatch Mist Saagmeule	67/112/83	42 960	h + i	11/4/83
Mrs SMM Dique	S5/112/83	8 600	h + vs	13/6/83
Departement Paaie	S4/112/84	3 600	h	5/12/84
Frans Motimela	S1/112/85	3 600	h	25/7/85
Mountain Yacht Club	S2/112/80	3 600	h	24/3/80
RW Anderson	S6/112/86	3 600	h	2/4/86
Pretoria Industrial Equipment	S7/112/86	3 600/	h	2/12/86
Mr AT Brett	81/112/87	3h 600	h	10/7/87
Paul Hans Spahn	S1/112/88	3 600	h	19/2/88
Mr C Jackson	39/112/88	600	h	18/3/88
Makgoka High School	40/112/88	9 600	h	18/3/88
Haenertsburg Primary School	S6/112/79	21 000	h	-
AS Thopmson	S1/112/80	3 600	h + vs	19/5/80
WL Lee	S4/112/80	2 760	h	24/3/80
Steven Lumber Saw Mill (Lebowa)	S6/112/80	3 600	h	24/3/80
EM van Schalkwyk	S8/112/80	3 600	h	24/3/80
CJ Labuschagne	S12/112/80	3 600	h	24/3/80
JH de Kock	S14/112/80	1 620	h	24/3/80
WSJ Dickenson	S15/112/80	3 600	h	24/3/80
SP Render	S2/112/82	3 600	h	

PHALALA RIVER (SUSANDALE DAM AND VISGAT WEIR)				
Consumer	**Authorization No**	**Quantity /m³/year**	**Usage code**	**Date**
Draken Industries (Pty) Ltd	S3/112/82	3 600	h	
TG Wiggill	S4/112/82	2 400	h	
M Gowans				
JGG Smit	S1/112/86	3 600	Vs	
RW Anderson	S4/112/86	3 600	h	
Mrs FAM Stumbles	S6/112/86	3 600	h	
FR van Rooyen	S2/112/88	3 600	h	28/9/88
WJ Roux	S4/112/88	3 600	h	
JS Grove	S2/112/89	3 600	h	
Johen Trust	S1/112/89	3 600	h	
Portion 22 Properties, BK	S55/112/91	3 600	h	4/4/91
	S56/112/91	3 600	h	4/4/91

POTGIETERSRUS				
Consumer	**Authorization No**	**Quantity /m³/year**	**Usage code**	**Date**
Municipality of Potgietersrus	281/127/77	2 380 000		23/9/77
AM Meiring	S2/127/83	3 600	H	1/2/83
WA Vermaak	S2/12/84	3 600	vs	25/9/84
DS Cuyler	S1/127/85	3 600	H + vs	24/6/85
WA Vermaak	S4/127/83	3 600	vs	28/7/83
AM Meiring	S6/127/86	3 600	H	30/7/86
WA Smit	S1/127/84	3 600	h	2/6/84
WA Smit	S1/127/87	8 300	H + ny	11/2/8
Doorndraai Dam - Natuurreservaat	106/127/76	24 000	h	3/12/76
Mrs S Dippenaar	31/127/80	3 600	vs	24/3/80
JFW Herbst	S3/127/80	3 600	vs	24/3/80
JFW Herbst	S1/127/83	300	h	1/2/83
Herbskof (Edms) Bpk	S4/127/86	3 600	vs	21/3/86
JT & Mrs HCMI Beaurian	S109/127/92	3 600	Vs + h	8/5/92
NJ Swart	S129/127/92	3 600	Vs + h	12/8/92
JT Beaurian & Mrs HCMI Heaurian	S151/127/92	1 638	Vs + h	6/10/92
AP van Rooyen	S152/127/92	3 600	Vs + hh	6/10/92
MSA Mong	S201/127/93	3 600		1/10/93
Herbskof		9 000	H + v	15/12/93
AM Meiring	S226/127/94	300		16/3/94
Will Kersten Max	S230/127/94	3 600		5/4/94

STERKRIVIER (DOORNDRAAI DAM)				
Consumer	**Authorization No**	**Quantity /m³/year**	**Usage code**	**Date**
a) NG Kerk en	a) 3/27/76	27		26/176
b) Boerevereniging	b) 4/27/76	27		26/1/76
Sterkrivier Laerskool		16 000	T	10/8/
Sterkrivier Boerevereniging	184/27/77	150	H	5/7/77
NG Gemeente, Potgietersrust	185/27/77	50	H	5/7/77
Grootrivier Suppermark	183/27/77	272	H	5/7/77
Zaaiplaats Tin Mining Co Ltd	127/27/85	292 000	H + I	1/10/85
Mr GMB Turvey	180/27/86	3 000	H + vs	19/1/8
JA Boulton	S128/127/92	3 600		16/7/92
Bosveld Water	6/27/96	4 380 000		2/2/96

APPENDIX G

WATER RESOURCES

G1. DETAILED INFORMATION ON GROUNDWATER

GROUND WATER RESOURCES OF SOUTH AFRICA

1. BACKGROUND

The Department of Water Affairs and Forestry (DWAF) has decided to conduct a Water Situation Assessment Study for South Africa to give a broad overview of national water requirements and water resources. These studies will enable the DWAF to utilize the Water Situation Assessment Model (WSAM), to assist in the decision making process when doing long term water resources planning.

WSM (Pty) Ltd was appointed to undertake the Situation Assessment Study of the Ground Water Resources of South Africa. This study took the form of a desk study evaluating all relevant existing data and reports at a reconnaissance level. The study area consists of all the quaternary sub-catchments of South Africa and the adjoining sub-catchments of the neighbouring states.

This report gives the findings of the study.

2. STUDY OBJECTIVES

The objective of the study is mainly to provide quantitative information on the Ground Water Resources on a quaternary catchment basis for the whole of South Africa for input into the WSAM. The information provided will consist of the following, viz :-

- ground water resource potential or harvest potential
- ground water resources available to be exploited or exploitation potential
- interaction between ground water and surface water ie the portion of ground water that contributes to stream flow (base flow)
- present ground water use
- a ground water balance identifying quaternary catchments where over exploitation occurs as well as catchments having a potential for increased ground water development
- ground water quality evaluation, determining the portion of ground water which is potable

3. METHODOLOGY

This study is a reconnaissance study making use of existing available information.

The quantification of the ground water resources is probably one of the most difficult aspects of ground water to access. Information on recharge to the ground water systems, storage capacity of the ground water systems, the hydraulic conductivity and thickness of these ground water systems, the interaction with surface water and water quality is required. Once the ground water resources are quantified a ground water balance is set up, comparing the resource with the existing use, to determine areas of over exploitation and identify areas which have a potential for further ground water exploitation. These parameters have been evaluated and the methodology is given below.

3.1 Harvest Potential

The evaluation of the mean annual recharge and storage on a national scale has been done by Vegter, 1995. This information together with a rainfall reliability factor (20th percentile precipitation divided by the median precipitation), which gives an indication of the possible drought length, has been utilized by Seward and Seymour, 1996, to produce the Harvest Potential of South Africa.

The Harvest Potential is defined as the maximum volume of ground water that may be abstracted per area without depleting the aquifers. The Harvest Potential as determined by Seward and Seymour, 1996 has been used as the starting point for the determination of the Ground Water Resources of South Africa.

3.2 Exploitation Potential

It is however not possible to abstract all the ground water available. This is mainly due to economic and/or environmental considerations. The main contributing factor is the hydraulic conductivity or transmissivity of the aquifer systems. As no regional information is available, a qualitative evaluation has been done using available borehole yield information, as there is a good relationship between borehole yield and transmissivity.

The average borehole yield was determined for each quaternary catchment using information available from the National Ground Water Database and the borehole database of the Chief Directorate Water Services. Where no information was available, the average of the tertiary catchment was used. The average yields were then divided into 5 groups and an exploitation factor allocated to each group as follows, viz: -

AVERAGE BOREHOLE YIELD	EXPLOITATION FACTOR
>3.0 ℓ/s	0.7
1.5 - 3.0 ℓ/s	0.6
0.7 - 1.5 ℓ/s	0.5
0.3 - 0.7 ℓ/s	0.4
<0.3 ℓ/s	0.3

This factor was then multiplied by the Harvest Potential of each quaternary catchment to obtain the exploitation potential. The exploitation potential is considered to be a conservative estimate of the groundwater resources available for exploitation.

3.3 Ground Water, Surface Water Interaction

In order to avoid double counting the water resources, the interaction between Surface and Ground Water needs to be quantified. At a workshop held at the DWAF where ground and surface water specialists were represented, it was agreed that the baseflow, be regarded as the portion of water common to both ground and surface water for the purposes of this study.

- ***Baseflow***

  The baseflow has been considered as that portion of ground water which contributes to the low flow of streams. Baseflow can therefore be regarded as that portion of the total water resource that can either be abstracted as ground water or surface water. The baseflow in this study is defined as the annual equivalent of the average low flow that is equaled or exceeded 75% of the time during the 4 driest months of the year. The baseflow has been calculated by Schultz and Barnes, 2001.

- ***Baseflow factor***

  The baseflow factor gives an indication of the portion of ground water which contributes to base flow and has been calculated by dividing the baseflow by the Harvest Potential.

  If baseflow = 0, then ground water does not contribute to baseflow and the baseflow factor is therefore also = 0.

  If baseflow ≥ harvest potential then all ground water can be abstracted as surface water and the baseflow factor is therefore ≥ 1. As the contribution of the Harvest Potential to baseflow cannot be greater than the Harvest Potential, the baseflow factor has therefore been corrected to equal 1 where it was > 1.

- ***Impact of Ground Water Abstraction on Surface Water Resources***

  The impact that ground water abstraction will have on surface water resources has been evaluated qualitatively by using the corrected baseflow factor ie,

  - negligible where corrected baseflow factor is = 0
  - low where the corrected baseflow factors is ≤ 0.3
  - moderate where the corrected baseflow factor is ≤ 0.8
  - high where the corrected baseflow factor is > 0.8

- ***Contribution of Ground Water to the Total Utilization Water Resource***

  This assessment of the interaction of groundwater and the base flow component of the surface water can however, not be used directly to determine the additional contribution of groundwater abstraction to the total utilizable water resource without also taking account of the effect of surface water storage capacity and the reduction in surface water runoff that is caused by the increase of groundwater recharge (induced recharge) that results from groundwater abstraction.

For the purpose of this water resources assessment the proportion of the utilizable groundwater not contributing to the base flow of the surface water that can be added to the utilizable surface water to estimate the total utilizable resources has therefore been ignored.

3.4 Existing Ground Water Use

Data on existing ground water use was not readily accessible especially the main use sectors, viz agriculture and mining. Available borehole information was thus utilized to give a first estimate.

This was done by adding all the estimated yields or blow yields of all the boreholes for an 8 hr/day pumping period, 365 days per year.

Ground Water use was also evaluated from work done by Jane Baron (Baron and Seward, 2000). The use was evaluated for the following sectors, ie

- Municipal Use

  This data was obtained from a study done by DWAF in 1990 with additional information obtained from DWAF hydrogeologists and town clerk /engineers.

- Rural Use

  Rural use was estimated from the DWAF, Water Services Database linking water source to population and allowing for 25 ℓ/capita/day.

- Livestock use

  The number of equivalent large livestock units per quaternary catchment was taken from the WSAM and multiplied by 45 ℓ/day and then multiplied by the % reliance on ground water obtained from the Glen College Food Survey (1990).

- Irrigation Use

  The total irrigation use per quaternary catchment was taken from the WSAM. This use was then multiplied by the % reliance on ground water obtained from the Glen College Food Survey (1990).

The total use was determined by summation of the municipal, rural, livestock and irrigation use. It must be noted that information on mining and industrial use was not available and has not been included in the total use.

Workshops held in each of the Water Management Area's by the Water Resources Situation Assessment teams, provided local input to the water use numbers. These numbers were then adjusted by applying a factor to the Baron & Seward (2000) number to give the final ground water use figures.

3.5 Ground Water Balance

The Ground Water Balance was calculated for each quaternary catchment to determine the extent to which the ground water resources have been developed. This was done by means of comparing the values of Harvest Potential and Exploitation Potential with adjusted ground water use (as determined by Baron and Seward, 2000).

The following scenario's were mapped, viz: -

- If the total use was greater than the Harvest Potential then the catchment was considered to be over utilized.

- If the total use was greater than the Exploitation Potential but less than the Harvest Potential then the catchment was considered to be heavily utilized.

- If the total use was less than the Exploitation Potential but greater than 66% of the Exploitation Potential then the catchment was considered to be moderately utilized.

- If the total use was less than 66% of the Exploitation Potential the catchment was considered under utilized.

3.6 Water Quality

The ground water quality is one of the main factors affecting the development of available ground water resources. Although there are numerous problems associated with water quality, some of which are easily remediated, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (M Simonic 2000). The mean TDS together with the highest value, lowest value and range is given for each catchment where analyses were available. Where no analyses were available an estimate of the mean was made using Vegters Maps (Vegter, 1995). The potability evaluation done by Simonic (M Simonic, 2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The TDS is described in terms of a classification system developed for this water resources situation assessment. The uses that were taken into account were domestic use and irrigation. It was assumed that if the water quality met the requirements for domestic and irrigation use it would in most cases satisfy the requirements of other uses. The South African Water Quality Guidelines for the Department of Water Affairs and Forestry (1996) for these two uses were combined into a single classification system as shown in Table 3.6.1

TABLE 3.6.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY

Class	Colour Code	Description	TDS Range (mg/l)
0	Blue	Ideal water quality	<260
1	Green	Good water quality	260 – 600
2	Yellow	Marginal water quality	601 – 1800
3	Red	Poor water quality	1801 – 3400
4	Purple	Completely unacceptable water quality	>3400

The portion of the ground water resources considered potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) according to the Quality of Domestic Water Supplies, Volume I (DWAF, 1998). Water classified as poor and unacceptable has been considered **not** potable.

In catchments where no information was available estimates of the portion potable were made using Vegters maps (Vegter 1995).

4. DATA LIMITATIONS

It must be noted that this evaluation was done using existing available information. The evaluation is based on the harvest potential map which was derived from interpretations of limited existing information on recharge and a very broad qualitative assessment of storage capacity. The comparison of base flow with the harvest potential indicates that the harvest potential could be significantly underestimated in the wetter parts of the country. It is thought that this is due to an under estimation of the storage capacity.

Although yield data on some 91000 boreholes was used the accuracy of this data in some instances is questionable, as it was not known whether the yield was a blow yield estimated during drilling, or a yield recommended by a hydrogeologist from detailed pumping test results. In general, however, the yields do highlight areas of higher and lower yield potential such as the dolomite areas but in some areas such as catchment W70 appear to grossly underestimate the yield. Underestimation of the yield would negatively impact on the calculation of exploitation potential.

Information on ground water use was obtained mainly from indirect qualitative evaluations. Further, mining and industrial use was not available and was therefore not included in the total usage. This could have a significant effect on the ground water balance in specifically the gold mining areas.

Water quality data should also only be used to give regional trends. In many catchments data at only a few sample points were available. As a catchment could be underlain by numerous different lithologies, a large range in water quality can occur. The samples used in the analysis could thus be non representative of the catchment as a whole.

In general this study should be seen as a first quantitative estimate of the ground water resources of South Africa.

5. OVERVIEW OF THE GROUND WATER RESOURCES OF SOUTH AFRICA

In over 90% of the surface area of South Africa, ground water occurs in secondary openings such as pores in weathered rock and faults, fractures, fissures and dissolution channels in so-called hard rock. These rocks consist of igneous, metamorphic and sedimentary rocks and range in age from Jurassic (± 140 x 10^6 yrs) to Swazian (3750 x 10^6 yrs).

In the remaining 10% of the surface area of South Africa ground water occurs in primary openings ie intergranular pores in mainly unconsolidated classic rocks. These rocks are generally recent in age (< 65 x 10^6 yrs) and consist of the Kalahari beds, the alluvial strip along some rivers and cenozoic deposits fringing the coast line, mainly in Northern Kwa Zulu Natal and the Southern and Western Cape.

The total Harvest Potential for South Africa has been calculated as 19100 x $10^6 m^3$/annum and varies from less than 0.5 mm/annum in quaternary catchment D82J to more than 352 mm/annum in quaternary catchment W12J.

Borehole yields vary considerably. The highest boreholes yields (up to 100 ℓ/s) have been found in the Malmani Dolomites. Other high borehole yielding (> 10 ℓ/s) lithostratigraphic units include the Table Mountain Quartsites of the Southern Cape, Basement Granites in the Pietersburg Dendron and Coetzerdam area, coastal deposits along Northern Natal, the eastern southern and western Cape, and alluvial deposits along certain sections of some of the major rivers such as the Limpopo River.

Moderate to good yields (> 5 ℓ/s) are found in the Letaba Basalt formation and where the Ecca has been intruded by dolerite dykes and sheets.

The total exploitation potential for South Africa has been calculated as 10100 x $10^6 m^3$/annum and varies from less than 0.2 mm/annum in quaternary catchment D82G to more than 211 mm/annum in quaternary catchment W12J.

The ground water use, excluding mines and industries, has been estimated to be some 1040 x $10^6 m^3$/annum and is concentrated in a few isolated areas.

The ground water balance shows that in general ground water is underutilized except for a few areas where over or heavy utilization occurs.

The extreme north western parts of South Africa show the poorest quality with TDS > 20000 mg/ℓ. The higher rainfall eastern parts have the best water quality, TDS < 100 mg/ℓ. The potability ranges between 0% in the extreme north-western parts of South Africa and 100% in the central and eastern areas. The main problems being brackish water and high nitrates and fluorides.

G2. POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

WATER RESOURCES SITUATION ASSESSMENTS

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCE PLANNING

POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

AUGUST 2001

Parsons & Associates	IWQS	Ninham Shand
P O Box 2606 SOMERSET WEST 7129	Private Bag X313 PRETORIA 0001	P O Box 1348 CAPE TOWN 8000

SUMMARY

This report forms part of the Water Resources Situation Assessments undertaken for the Department of Water Affairs and Forestry. Information is provided on the potential microbial contamination of surface water and groundwater resources in South Africa.

For surface water, initial mapping information was taken from the National Microbiological Monitoring Program where priority contaminated areas were identified and mapped. As part of this project, it was necessary to produce a surface contamination map for the whole country. A national surface faecal contamination map was produced using population density and sanitation type available from DWAF databases. A three category rating system was used (low, medium and high) to describe the surface faecal contamination. This information was delineated on a quaternary catchment basis for the whole country.

For groundwater, the first step involved the development of a groundwater vulnerability map using the depth to groundwater, soil media and impact of the vadose zone media. A three category rating system was used (least, moderate, most) to describe the ease with which groundwater could be contaminated from a source on the surface. The second step involved using the surface contamination and aquifer vulnerability maps to derive a groundwater contamination map. The derived map shows the degree of faecal contamination that could be expected of the groundwater for all areas in South Africa.

Conclusions and recommendations

- Maps were produced that provide an overall assessment of potential microbial contamination of the surface water and groundwater resources of South Africa.

- Spatial resolution of the maps is based on a quaternary catchment scale. It is recommended that these maps are not used to derive more detailed spatial information.

- Once sufficient microbial data are available, it is recommended that the numerical methods, and their associated assumptions, be checked, and the maps replotted where necessary.

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ACKNOWLEDGEMENT

The support of Mr Julian Conrad of Environmentek, CSIR for providing the GIS DRASTIC coverages. His help is fully acknowledged and appreciated.

GLOSSARY

Aquifer	Strata, or a group of interconnected strata, comprising of saturated earth material capable of conducting groundwater and of yielding usable quantities of groundwater to boreholes
Contamination	Introduction into the environment of an anthropogenic substance
DRASTIC	Numerical method that describes groundwater characteristics, using: water depth, recharge, aquifer media, soil media, topography, impact on vadose zone, and conductivity
Faecal	Material that contains bodily waste matter derived from ingested food and secretions from the intestines, of all warm-blooded animals including humans
Fitness for use	Assessment of the quality of water based on the chemical, physical and biological requirements of users
Groundwater	Subsurface water occupying voids within a geological stratum
Microbial	Microscopic organism that is disease causing
Ratio	Mathematical relationship defined by dividing one number by another number
Rating	Classification according to order, or grade
Vadose zone	Part of the geological stratum above the saturated zone where voids contain both air and water
Vulnerability	In the context of this report, it is the capability of surface water or groundwater resources to become contaminated

1. INTRODUCTION

The purpose of the Water Resources Situation Assessments is to prepare an overview of the water resources in South Africa. This will take account of the availability and requirements for water, as well as deal with issues such as water quality. The country has been divided into nineteen water management areas. Eight separate studies are being carried out within catchment boundaries that roughly approximate provincial borders. Once these studies have been completed, all information will also be synthesized into a single report for the whole country.

This report describes the method used to prepare a series of maps that show the microbial rating of surface water and groundwater resources in South Africa. Maps are produced at a quaternary catchment scale. It is intended that the appropriate portions of the maps be incorporated into each of the Water Management Area reports.

The microbial information provided in this report is intended for planning purposes, and is not suitable for detailed water quality assessment. The maps provide a comparative rating of the faecal contamination status of the surface water and groundwater resources in South Africa.

This report contains five sections:

- Section One: Introduction
- Section Two: Mapping of surface contamination
- Section Three: Mapping of Groundwater Resources
- Section Four: Conclusions and Recommendations
- Section Five: References

2. MAPPING SURFACE WATER RESOURCES

2.1 Background

The water resources of South Africa have come under increasing influence from faecal contamination as a result of increased urban development and lack of appropriate sanitation. Due to increased use of contaminated water for domestic consumption, people are at serious risk of contracting water-borne disease (e.g. gastroenteritis, salmonellosis, dysentery, cholera, typhoid fever and hepatitis). The Department of Water Affairs and Forestry (DWAF) is the custodian of the national water resources and should ensure *fitness for use* of the water resources. Thus, the Department has developed a monitoring system to provide the necessary management information to assess and control the health hazard in selected areas. This project is called the National Microbiological Monitoring Programme (NMMP).

As part of the NMMP, a screening exercise was carried out to determine the number of catchments that experience faecal contamination. A short-list of tertiary catchment areas was compiled. Data from the database of the Directorate: Water Services Planning of DWAF was used to prioritize catchments to assess the overall health hazard (see Figure 1).

Ratings for land use activity were assigned using the method developed by Goodmin & Wright (1991), IWQS (1996), and Murray (1999). Ratings for land and water use were combined to establish an overall rating. Water use was considered to have a higher effect than the land use so that a 60:40 weighting was used (see Equation 1).

$$OR = 0.4\ TLU + 0.6\ TWU \qquad \text{........ (1)}$$

Where OR = Area Rating (no units)
TLU = Total land use rating for area (no units)
TWU = Total water use rating for area (no units)

Each area was assigned a rating to indicate low (1), medium (2) or high (3) potential risk to users in the catchment area. The following values were used to designate each class:

Low	OR = 0 to 1000	
Medium	OR = 1001 to100 000	
High	OR > 100 000	.......(2)

Figure 1 shows the surface faecal contamination map for priority rated catchments in South Africa.

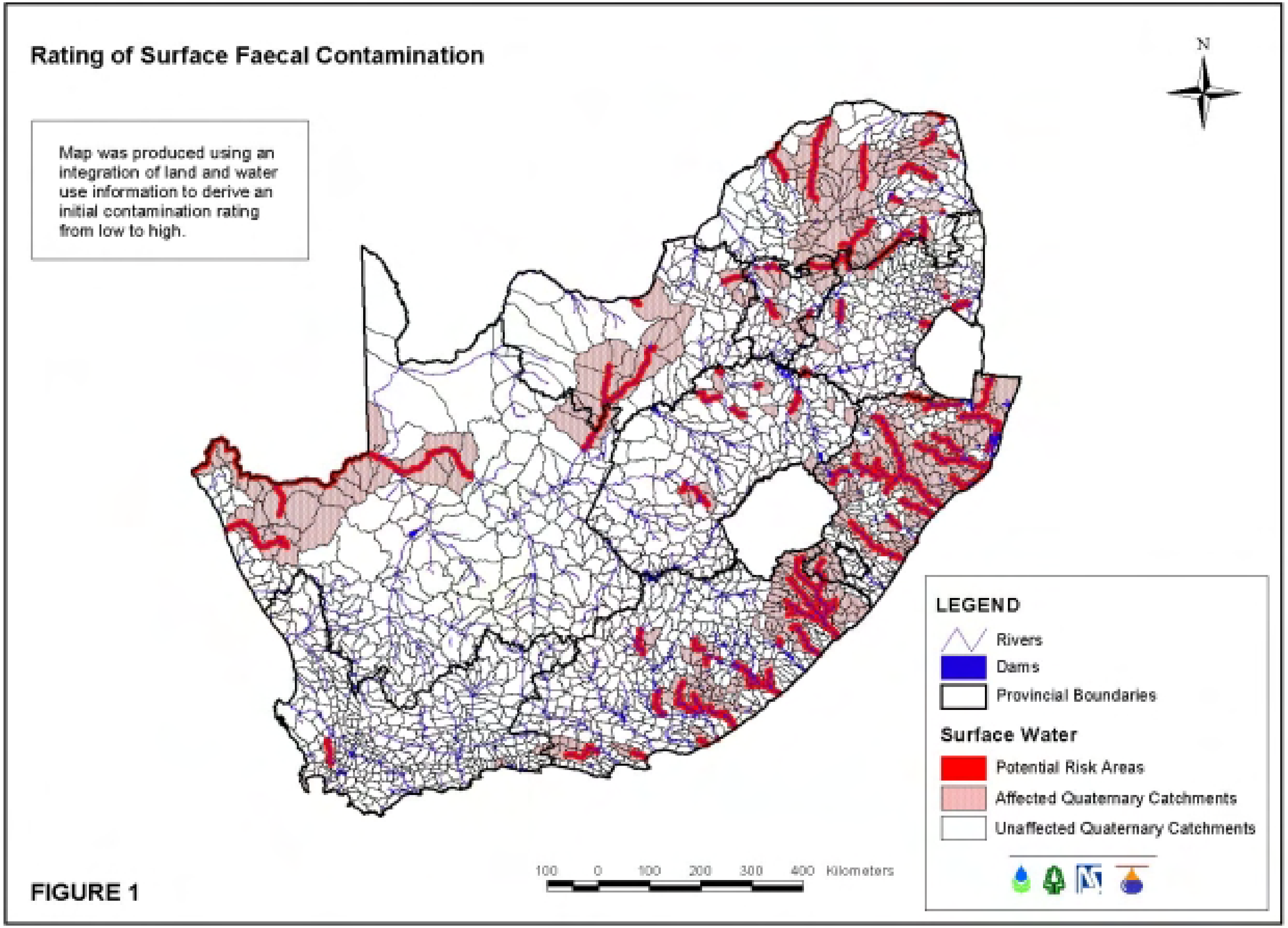

Rating of Surface Faecal Contamination
Map was produced using an integration of land and water use information to derive an initial contamination rating from low to high.
N
LEGEND
Rivers
Dams
Provincial Boundaries
Surface Water
Potential Risk Areas
Affected Quaternary Catchments
Unaffected Quaternary Catchments
100 0 100 200 300 400 Kilometers

FIGURE 1

2.2 Surface faecal contamination

Figure 2 shows the potential surface faecal contamination map, developed using average population density (for a quaternary) and degree of sanitation (Venter, 1998). The land use rating is given by:

$$LU = SA + PD \quad \text{........ (3)}$$

Where LU = Land use rating per settlement (no units)
SA = No/poor sanitation rating (no units)
PD = Population Density rating (no units)

Land use rankings for quaternary catchments were determined by calculating the total ratings of all settlements within a particular quaternary catchment, given by:

$$TLU = (LU_n) \quad \text{........ (4)}$$

Where TLU = Total land use rating per quaternary catchment
LU_n = Land use rating for n settlements, per quaternary

Each quaternary catchment was allocated a low (1), medium (2) and high (3) priority rating used to map the information using GIS. Classes were designated by the following values:

Low	=	$TLU < 1000$	
Medium	=	$1000 < TLU < 3000$	
High	=	$TLU > 3000$	.... (5)

2.3 Results: GIS Surface Water Mapping

Figure 1 was plotted on GIS by firstly assembling the national coverages for the quaternary catchments, rivers and dams. The data described above were processed using the following method:

> The quaternary catchments were shaded according to whether they were considered potential risk areas or not (refer to Equations 1 & 2).
>
> Within the quaternaries at risk, the rivers were buffered and shaded red to indicate the risk to potential surface water users.

Figure 2, the potential surface faecal contamination map, was produced as follows:
The ratings (TLU) were distributed into intervals (refer to Equations 5 and 6).

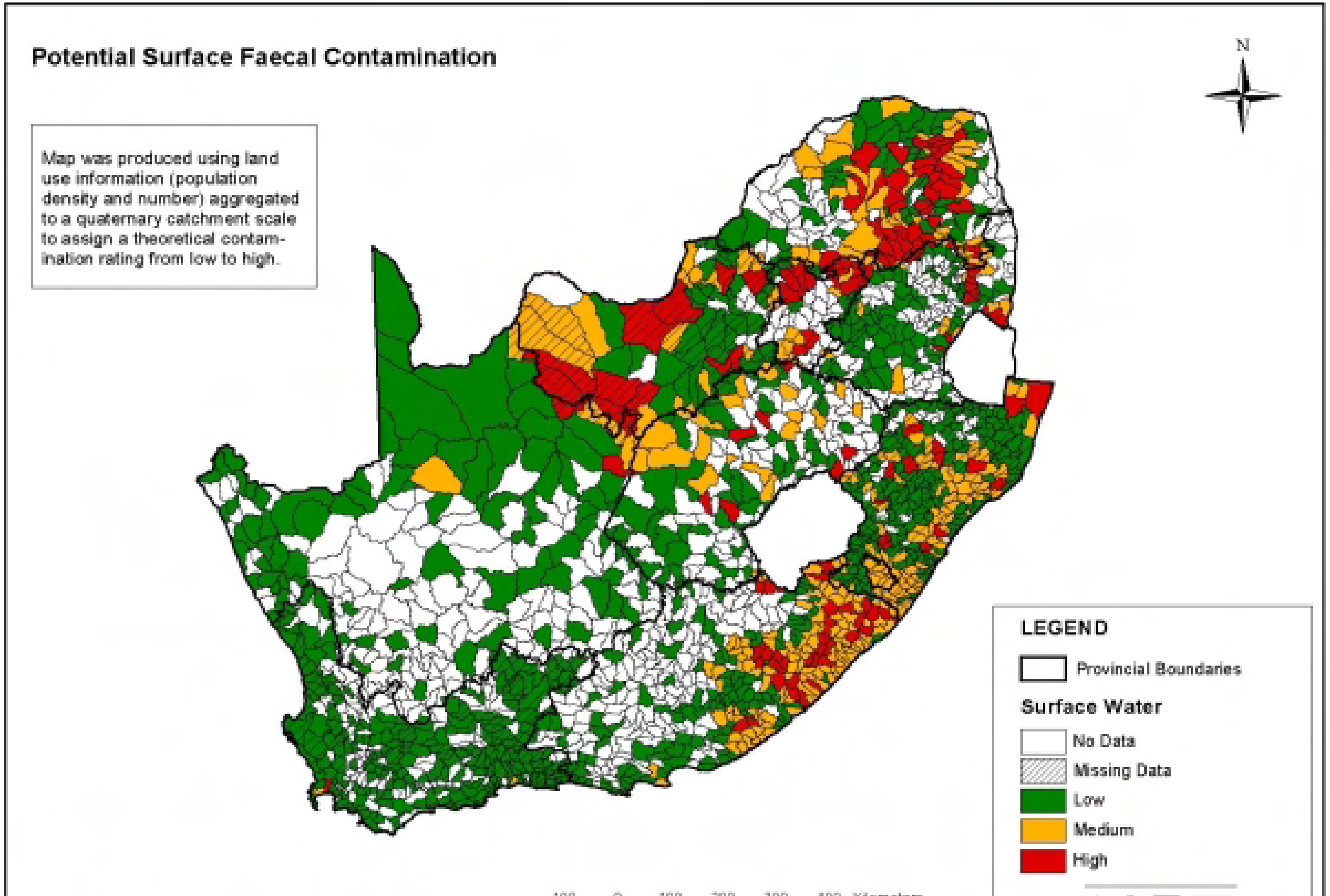

Potential Surface Faecal Contamination
N
Map was produced using land use information (population density and number) aggregated to a quaternary catchment scale to assign a theoretical contamination rating from low to high.
LEGEND
Provincial Boundaries
Surface Water
No Data
Missing Data
Low
Medium
High
100 0 100 200 300 400 Kilometers

FIGURE 2

3. MAPPING GROUNDWATER RESOURCES

3.1 Background

Groundwater is an important national water resource that plays an important role in meeting water requirements in remote areas. This is particularly true in areas where rainfall is low and surface water resources are scarce.

Microbial contamination of groundwater increases in high population density areas and areas with inadequate sanitation. Approximately three quarters of the population of South Africa do not have access to adequate sanitation.

Considerable work has already been carried out to map the groundwater resources in South Africa. Examples include: the national Groundwater Resources of the Republic of South Africa map produced by Vegter (1995) for the Water Research Commission (WRC), regional 1: 500 000 scale hydrogeological maps produced by DWAF, the national groundwater vulnerability map prepared by Reynders & Lynch (1993) and the aquifer classification map of Parsons & Conrad (1998). Figure 3 shows the vulnerability map used by Parsons & Conrad (1998). The existing work, particularly the vulnerability map (Figure 3), has therefore been used as a basis for assessing the potential of microbial contamination of groundwater systems.

3.2 Method

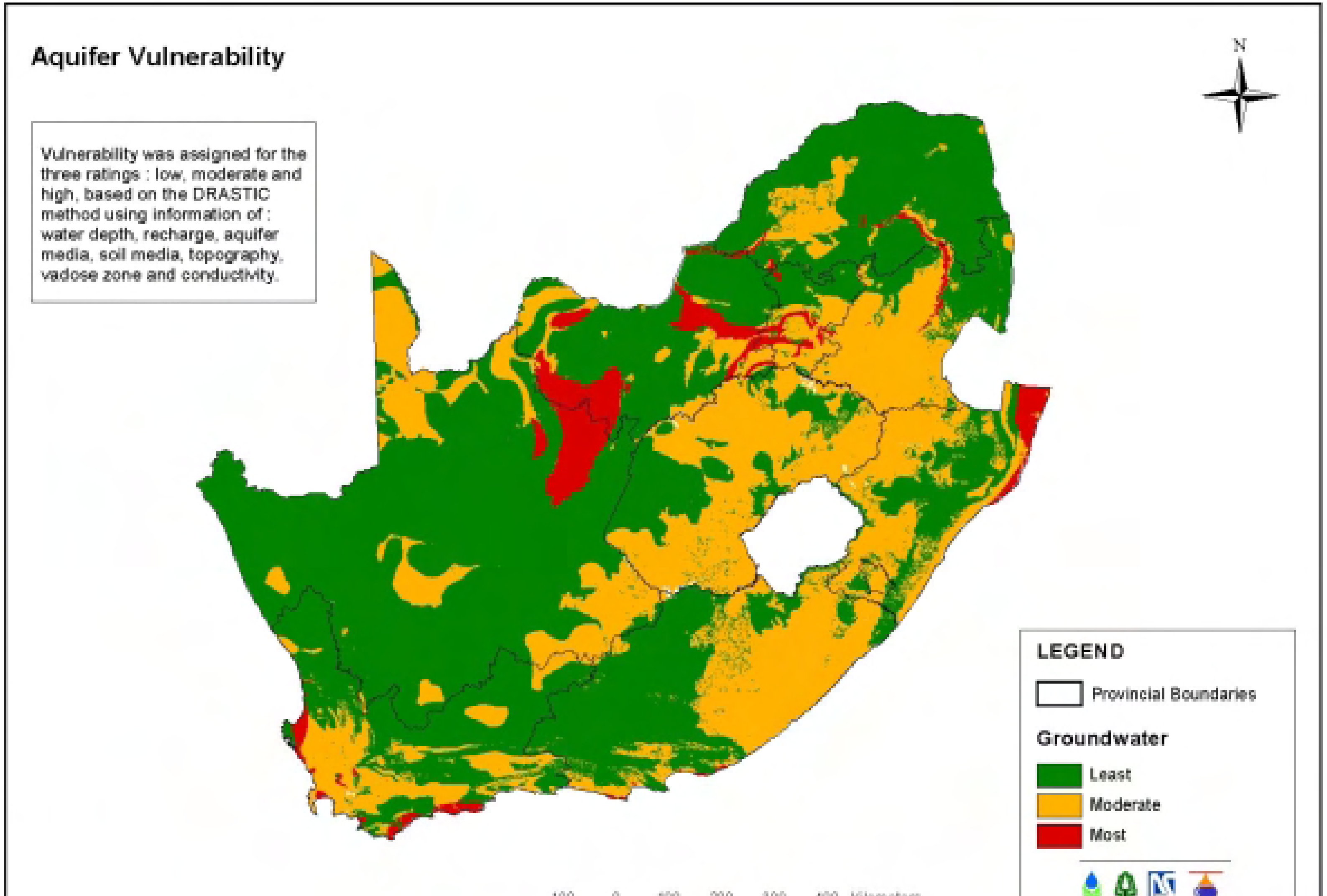
It is recognised that certain aquifers are more vulnerable to contamination than others. The DRASTIC method (Aller *et al.*, 1985) is a well-known and studied method of assessing aquifer vulnerability to contamination. Reynders & Lynch (1993) and Lynch *et al.* (1994, 1997) prepared a national scale aquifer vulnerability map using DRASTIC that was revised by Parsons & Conrad (1998) using additional data (see Figure 3).

DRASTIC is a weighting, and rating, technique that considers seven factors when estimating the groundwater vulnerability. Factors are geologically and geohydrologically based. Controls relating to the magnitude or severity of the pollution source are not considered. DRASTIC factors are shown in Table 1.

The quaternary catchments were then shaded according to these rating intervals indicating areas of Low, Medium or High Risk, see below.

Low	Green	TLU < 1000	
Medium	Yellow	1000 < TLU < 3000	
High	Red	TLU > 3000	........(6)

Quaternary catchments with no data were unshaded.
Quaternary catchments containing missing data were hatched.



Aquifer Vulnerability
Vulnerability was assigned for the three ratings : low, moderate and high, based on the DRASTIC method using information of : water depth, recharge, aquifer media, soil media, topography, vadose zone and conductivity.
N
100 0 100 200 300 400 Kilometers
LEGEND
Provincial Boundaries
Groundwater
Least
Moderate
Most
(Parsons and Conrad, 1998)

FIGURE 3

TABLE 1: FACTORS USED BY DRASTIC

D	Depth to water
R	(net) Recharge
A	Aquifer media
S	Soil media
T	Topography (slope)
I	Impact of the vadose zone media
C	Conductivity (hydraulic) of the aquifer

Each factor was weighted according to its relative importance (Aller *et al.*, 1985). Using a set of tables, a rating is assigned based on prevailing conditions. A relative DRASTIC index (I) is derived using the following formula, with higher index values showing greater groundwater vulnerability:

$$I = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W \quad ..... (7)$$

where: I = index rating

$_R$ is the rating for each factor, and

$_W$ is the weighting for each factor.

DRASTIC was also developed to assess the vulnerability to pesticide contamination (Aller *et al.*, 1985). In this case, those factors that play an important role in defining vulnerability to pesticide contamination are assigned higher weights.

In the case of microbial contamination, other factors are more important in terms of aquifer vulnerability to microbial contamination. Travel time in the vadose zone is recognised as an important control in this regard (Xu & Braune, 1995; Wright, 1995; DWAF, 1997). It was hence decided to assess aquifer vulnerability to microbial contamination in terms of D, S and I (i.e. all factors that relate to the vadose zone). [1]

The weighting and rating technique used by DRASTIC was followed in the current study, adopting the weights used by the pesticide DRASTIC. Using the following formula, the highest possible index value is 140 and the lowest value is 14,

$$\text{Index} = 5\ D_R + 5\ S_R + 4\ I_R \quad .... (8)$$

[1] A similar approach was used by Xu & Braune (1995) where they used the factors D, A and S, and used the weightings assigned by DRASTIC and not Pesticide DRASTIC.

It must be noted that (1) the value of the index is relative, (2) the factors used in the index were considered by the team to have the greatest influence in assessing the potential for microbial contamination at the surface entering underlying aquifers.

3.3 Aquifer vulnerability map

Three DRASTIC groundwater coverages were used to produce an indication of vulnerability of groundwater contamination, namely, depth to groundwater, soil media and vadose.

Each grid element on the DRASTIC coverages was allocated a rating, that was multiplied by a weighting factor (Depth = 5, Soil = 5, Vadose = 4) to produce a score. These three coverages were intersected and their scores added to produce a relative index for each point on the resulting coverage. An additional assumption was applied that assigned a low vulnerability to all areas with a Depth score of less than or equal to 2. This was used to account for deep infiltration of groundwater (over 35 metres) where long residence time and filtration will reduce the degree of contamination.

The relative index (RI) obtained for each grid allowed for grouping into high, medium and low categories. However, setting the intervals for the three categories proved difficult because of sensitivity to the interval chosen. A large percentage of indices fell in the interval of 60 to 80. It was thus decided to use the interval of 70 to 85 to allow for equal distribution between high, medium and low vulnerability areas (see Figure 4), namely:

Low	Green	$RI < 70$	
Medium	Yellow	$70 < RI < 85$	
High	Red	$RI > 85$	.... (9)

To illustrate the sensitivity to the interval chosen the map was replotted using two further intervals of 60-90 and 65-90 (see Figure 5).

Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider D, S and I. Comparison of Figures 3 and 4 shows remarkable similarity and confirms that the vulnerability *per se* is largely controlled by the three factors (D, S and I), which promotes confidence in the resultant microbial contamination vulnerability map.

A limitation of the study is the inability to validate results obtained. Little information is available regarding groundwater microbial contamination. Monitoring data, from selected areas, should be collected to assess the validity of the vulnerability assessment presented in this report.

3.4 Groundwater faecal contamination

Figure 2 (*Potential Surface Faecal Contamination)* and Figure 4 (*Aquifer vulnerability to Faecal Contamination)* maps were intersected to produce a combined *Risk of Faecal Contamination of Aquifers* map on a quaternary basis, see Figure 6.

A total rating score was calculated for each quaternary (e.g. two medium risk areas and one high risk area gives 2 + 2 + 3). This total was then divided by the total number of different risk areas present in each quaternary to produce an average risk value. Each quaternary catchment was shaded according to this average risk value.

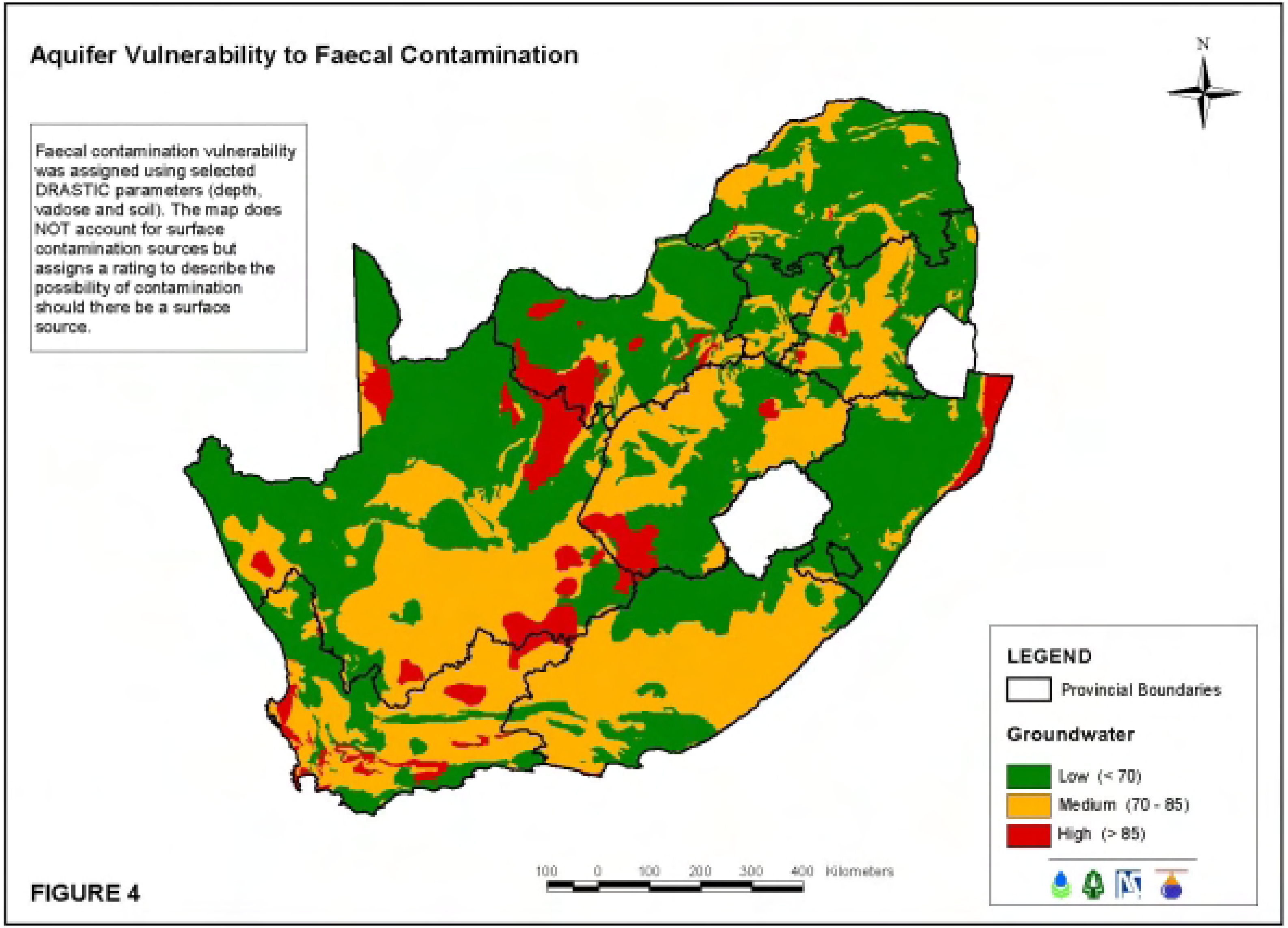
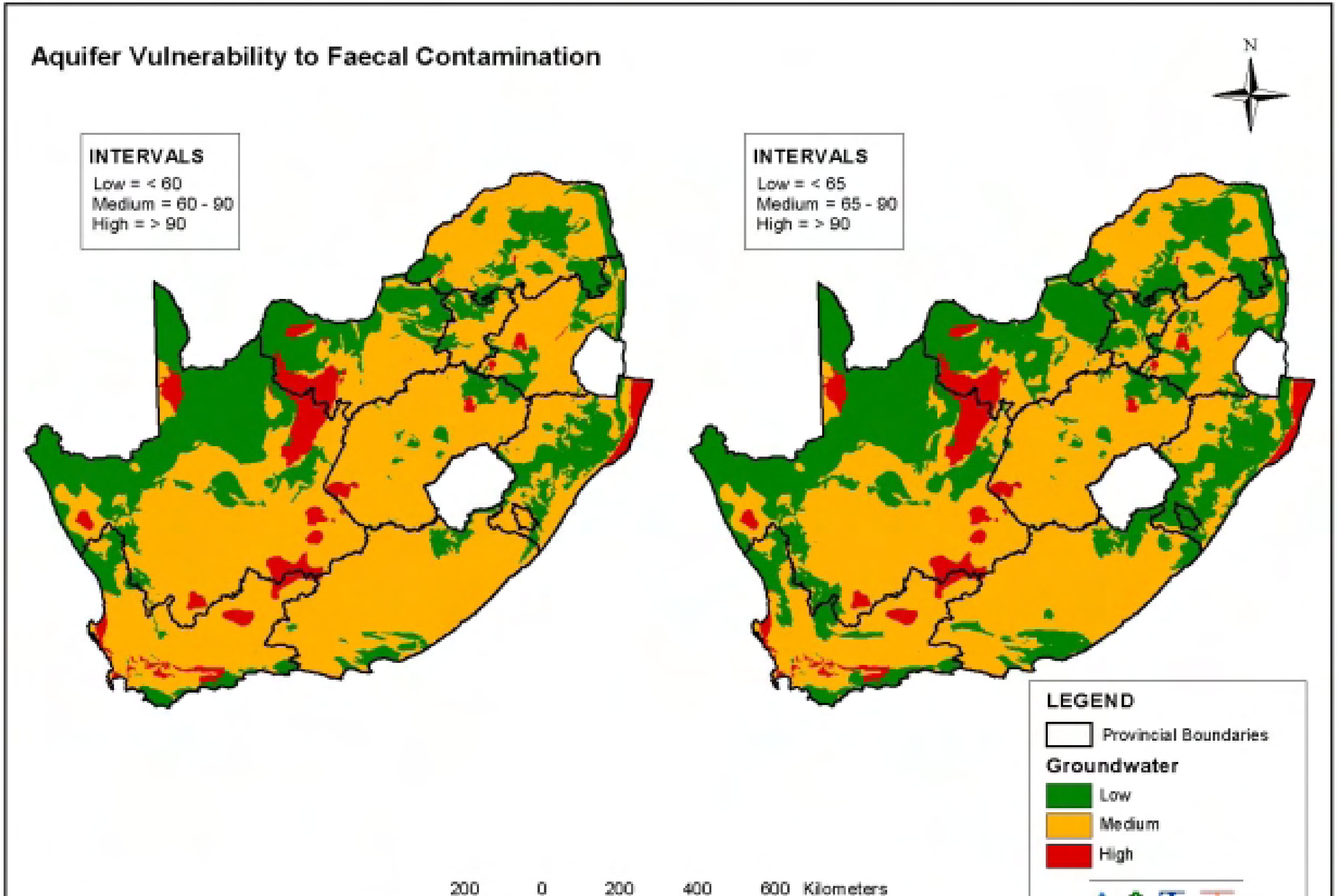
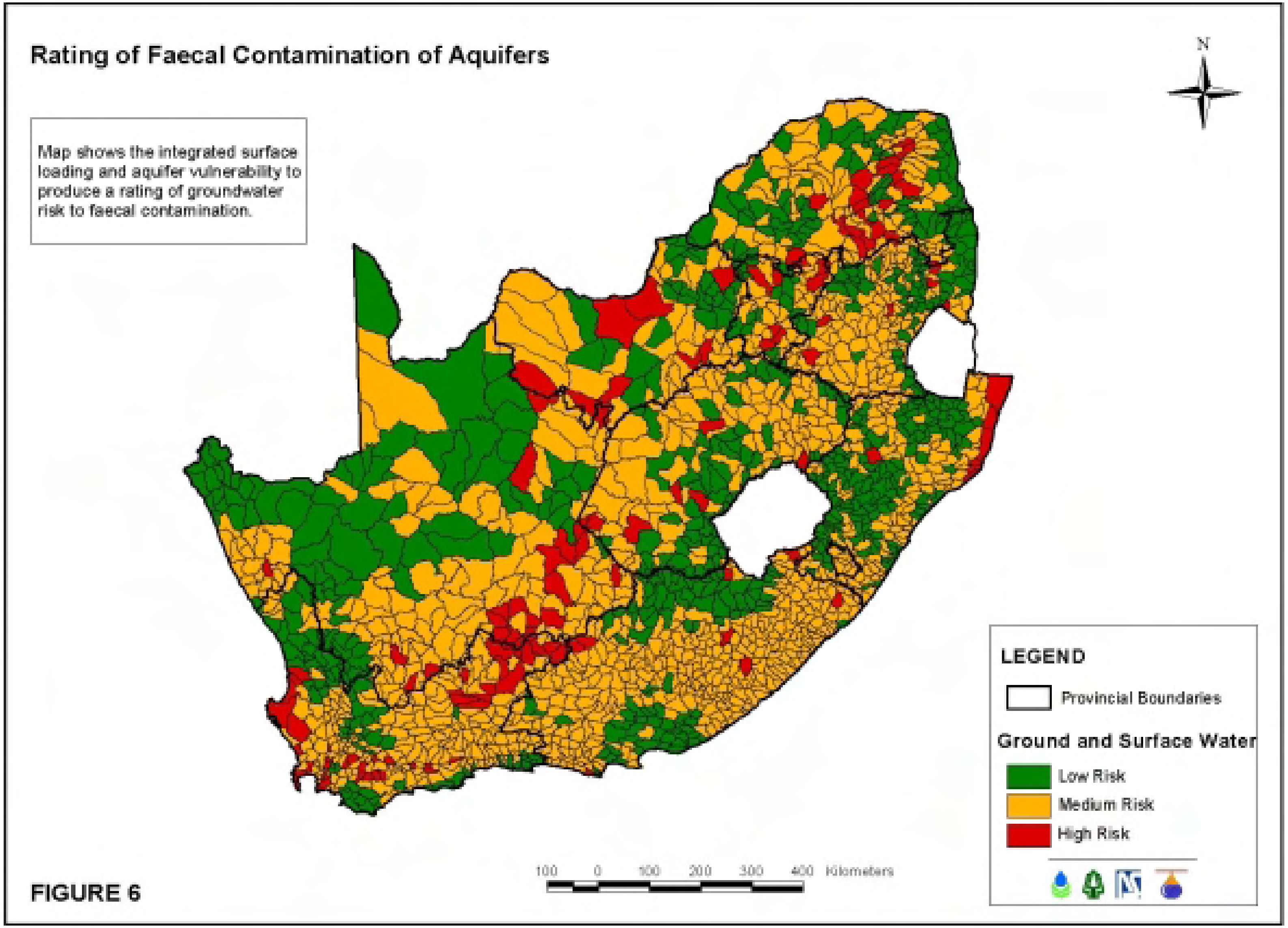

Aquifer Vulnerability to Faecal Contamination
Faecal contamination vulnerability was assigned using selected DRASTIC parameters (depth, vadose and soil). The map does NOT account for surface contamination sources but assigns a rating to describe the possibility of contamination should there be a surface source.
N
LEGEND
Provincial Boundaries
Groundwater
Low (< 70)
Medium (70 - 85)
High (> 85)
100 0 100 200 300 400 Kilometers

FIGURE 4



Aquifer Vulnerability to Faecal Contamination
N
INTERVALS
Low = < 60
Medium = 60 - 90
High = > 90
INTERVALS
Low = < 65
Medium = 65 - 90
High = > 90
LEGEND
Provincial Boundaries
Groundwater
Low
Medium
High
200 0 200 400 600 Kilometers

FIGURE 5


Rating of Faecal Contamination of Aquifers
Map shows the integrated surface loading and aquifer vulnerability to produce a rating of groundwater risk to faecal contamination.
N
LEGEND
Provincial Boundaries
Ground and Surface Water
Low Risk
Medium Risk
High Risk
100 0 100 200 300 400 Kilometers
FIGURE 6

4. CONCLUSIONS & RECOMMENDATIONS

- A series of maps (and their associated GIS coverages) have been produced to show the potential microbial contamination of surface water and groundwater resources in South Africa.

- Maps are produced on a quaternary catchment scale. Where more detailed spatial information is required, alternative methods should be used.

- Once sufficient microbial data are available, it is recommended that the numerical methods are calibrated, and the maps replotted.

- The surface water and groundwater maps should be used in the assessments of water quality for each water management area.

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G3. POTENTIAL DAMS

LIMPOPO								
Quat	**Zone**	**Maximum Feasible Storage**	**MAR**	**Maximum Storage**	**KEY POINTS**	**Maximum Cumulative Storage**	**Existing Dam Storage**	**Potential New Dams**
		(%MAR)	**(10^6 m^3)**			**(10^6 m^3)**	**(10^6 m^3)**	**(10^6 m^3)**
A41A	Q	250	23,91	59,775				
A41B	Q	250	9,96	24,9				
A41C	V	300	8,71	26,13				
A41D	V	300	12,25	36,75	**Matlabas**	147,56		**147,56**
A41E	U	250	11,36	28,4	**A41E**	28,40		**28,40**
A42A	H	200	25,89	51,78				
A42B	H	200	25,97	51,94				
A42C	H	200	34,06	68,12				
A42D	M	200	46,51	93,02				
A42E	M	200	71,18	142,36				
A42F	R	250	36,79	91,975	**Mokolo (Upper)**	499,20	146,00	**353,20**
A42G	R	250	39,97	99,925				
A42H	R	250	27,74	69,35				
A42J	U	250	7,42	18,55	**Mokolo (Lower)**	187,83		**187,83**
A50A	M	200	27,93	55,86				
A50B	M	200	28,65	57,3				
A50C	M	200	24,84	49,68				
A50D	R	250	23,8	59,5				
A50D	R	250		0				
A50E	R	250	17,14	42,85				
A50F	R	250	8,63	21,575	**Lephalala (Upper)**	286,77		**286,77**
A50G	U	250	4,71	11,775				
A50H	U	250	8,83	22,075	**Lephalala (Lower)**	33,85		**33,85**
A50J	U	250	4,96	12,4	**Soutkloof**	12,40		**12,40**
A61A	N	250	18,69	46,725				
A61B	N	250	12,74	31,85				
A61C	N	250	12,62	31,55	**Nyl (Upper)**	110,13		**110,13**
A61D	N	250	11,43	28,575				
A61E	N	250	11,18	27,95	**Nyl (Middle)**	56,53		**56,53**
A61F	N	250	14,9	37,25				
A61G	N	250	15,99	39,975	**Mogalakwena (Upper)**	77,23		**77,23**
A61H	H	200	22,61	45,22			46,63	
A61J	H	200	31,85	63,7	**Sterk**	108,92		**62,29**
A62A	M	200	17,4	34,8				
A62B	R	250	15,84	39,6				
A62C	R	250	5,92	14,8				
A62D	R	250	10,02	25,05				
A62E	U	250	3,81	9,525				
A62F	U	250	4,45	11,125				
A62G	U	250	3,07	7,675				
A62H	U	250	4,35	10,875				
A62J	U	250	5,08	12,7	**Mogalakwena (Middle)**	166,15	21,80	**144,35**
A63A	V	300	16,48	49,44				
A63B	V	300	8,15	24,45				
A63C	V	300	6,11	18,33	**Doringfonteintjiespruit**	18,33		**18,33**
A63D	V	300	8,66	25,98	**Mogalakwena (Lower)**	99,87		**99,87**
A63E	V	300	7,63	22,89	**Kolope**	22,89		**22,89**

A71A	U	250	6,78	16,95				
A71B	U	250	4,6	11,5				
A71C	U	250	5,21	13,025				
A71D	U	250	2,64	6,6	**Sand (Upper)**	48,08		**48,08**
A71E	U	250	4,04	10,1				
A71F	U	250	2,54	6,35				
A71G	U	250	4,25	10,625	**Hout**	27,08		**27,08**
A71H	U	250	8,28	20,7				
A71J	V	300	8,06	24,18				
A71K	X	300	3,85	11,55	**Sand (Lower)**	56,43		**56,43**
A71L	X	300	3,34	10,02	**Kongoloops / Soutsloot**	10,02		**10,02**
A72A	U	250	12,54	31,35				
A72B	V	300	5,78	17,34	**Brak**	48,69		**48,69**
A80A	P	300	45,43	136,29				
A80B	P	300	12,21	36,63				
A80C	P	300	8,01	24,03	**Nzhelele (Upper)**	196,95	55,4	**141,55**
A80D	P	300	5,15	15,45				
A80E	P	300	9,9	29,7				
A80F	V	300	3,84	11,52				
A80G	X	300	4,3	12,9	**Nzhelele (Lower)**	69,57		**69,57**
A80H	P	300	22,63	67,89			5,56	
A80J	X	300	1,86	5,58	**Nwanedzi**	73,47		**67,91**

G4. SEDIMENT YIELD

Sediment Yield per Quaternary		
Quaternary	Tonnes / annum (x10^6)	25 Year Sediment Volume (x106)
A41A	34	931,6
A41B	18	493,2
A41C	54	1479,6
A41D	94	2575,6
A41E	95	2603
A42A	28	767,2
A42B	26	712,4
A42C	34	931,6
A42D	24	657,6
A42E	49	1342,6
A42F	50	1370
A42G	59	1616,6
A42H	52	1424,8
A42J	89	2438,6
A50A	15	411
A50B	20	548
A50C	18	493,2
A50D	31	849,4
A50D-		
A50E	31	849,4
A50F	18	493,2
A50G	40	1096
A50H	95	2603
A50J	72	1972,8
A61A	19	520,6
A61B	18	493,2
A61C	38	1041,2
A61D	34	931,6
A61E	37	1013,8
A61F	69	1890,6
A61G	84	2301,6
A61H	29	794,6
A61J	40	1096
A62A	21	575,4
A62B	35	959
A62C	19	520,6
A62D	30	822
A62E	50	1370
A62F	32	876,8
A62G	31	849,4
A62H	51	1397,4
A62J	46	1260,4
A63A	94	2575,6
A63B	74	2027,6
A63C	121	3315,4
A63D	65	1781
A63E	98	2685,2
A71A	124	3397,6
A71B	96	2630,4
A71C	145	3973

Quaternary	Tonnes / annum (x10^6)	25 Year Sediment Volume (x106)
A71D	97	2657,8
A71E	78	2137,2
A71F	75	2055
A71G	59	1616,6
A71H	90	2466
A71J	61	1671,4
A71K	115	3151
A71L	89	2438,6
A72A	93	2548,2
A72B	77	2109,8
A80A	17	465,8
A80B	13	356,2
A80C	14	383,6
A80D	6	164,4
A80E	12	328,8
A80F	39	1068,6
A80G	109	2986,6
A80H	13	356,2
A80J	65	1781

APPENDIX H

WATER BALANCE

H1. DATA SOURCES

DATA SOURCES

Data type	Responsible organization
Afforestation	CSIR
Alien vegetation	CSIR
Industrial, urban and strategic water use	WRSA consultants
Ground water	WSM Civil Engineers
Dams	DWAF
Transfer schemes	WRSA consultants
Run-of-river yields	Arcus Gibb
Population	Markdata
Ecological Reserve	IWR, Prof Hughes
Irrigation	
▪ Areas and crop types	WRSA consultant
▪ Efficiency and losses	WRSA consultant
▪ Evapotranspiration and crop factors	WRP
Storage-draft-frequency curves	WRP

H2. DATA DEFAULT VALUES USED IN THE WRSA REPORT

DATA DEFAULT VALUES USED IN THE WRSA REPORT

Parameter	Description	Default value
fBMLi	Mining losses (factor)	0,1
fBOLi	Other industrial losses (factor)	0,1
fBSLi	Strategic losses (factor)	0,05
fIHCi	Irrigation conveyance losses – High category irrigation (factor)	0,1
fIMCi	Irrigation conveyance losses – Medium category irrigation (factor)	0,1
fILCi	Irrigation conveyance losses – Low category irrigation (factor)	0,1
fIPLi	Irrigation efficiency – Low category irrigation (factor)	0,75
fiIPMi	Irrigation efficiency – Medium category irrigation (factor)	0,75
fiIPHi	Irrigation efficiency – High category irrigation (factor)	0,75
oRTLi	Rural losses (factor)	0,2

THE DATA AT QUATERNARY CATCHMENT RESOLUTION

For the record – not part of appendix

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D11A	278	278	7	10	203	56434	0.0565	0.0426	255	71024	0.0712	0.0536
D11B	236	236	7	10	203	47908	0.0480	0.0589	255	60294	0.0604	0.0741
D11C	292	292	7	10	203	59276	0.0594	0.0549	255	74601	0.0748	0.0691
D11D	319	319	7	10	203	64757	0.0649	0.0774	255	81499	0.0817	0.0975
D11E	322	322	7	10	203	65366	0.0655	0.1018	255	82266	0.0824	0.1281
D11F	413	413	7	10	203	83839	0.0840	0.0749	255	105514	0.1057	0.0943
D11G	320	320	7	10	203	64960	0.0651	0.1368	255	81755	0.0819	0.1722
D11H	359	359	7	10	203	72877	0.0730	0.1420	255	91718	0.0919	0.1787
D11J	440	440	7	10	203	89320	0.0895	0.1485	255	112412	0.1126	0.1869
D11K	381	381	7	10	203	77343	0.0775	0.1565	255	97339	0.0975	0.1970
0	**3360**	**3360**				**682080**	**0.6834**	**0.0863**		**858423**	**0.8601**	**0.1087**
D12A	369	369	6	13	335	123615	0.1239	0.2878	422	155574	0.1559	0.3622
D12B	385	385	6	13	335	128975	0.1292	0.1969	422	162320	0.1626	0.2478
D12C	343	343	6	13	335	114905	0.1151	0.5597	422	144612	0.1449	0.7044
D12D	355	355	6	12	335	118925	0.1192	0.6649	422	149671	0.1500	0.8368
D12E	712	712	6	12	335	238520	0.2390	0.7200	422	300186	0.3008	0.9062
D12F	803	803	6	13	335	269005	0.2695	0.9797	422	338553	0.3392	1.2330
0	**2967**	**2967**				**993945**	**0.9959**	**0.4791**		**1250916**	**1.2534**	**0.6030**
D13A	475	475	6	13	335	159125	0.1594	0.2239	422	200265	0.2007	0.2817
D13B	533	533	6	13	335	178555	0.1789	0.2420	422	224718	0.2252	0.3046
D13C	517	517	6	13	335	173195	0.1735	0.3160	422	217972	0.2184	0.3977
D13D	635	635	6	13	335	212725	0.2132	0.3679	422	267722	0.2683	0.4630
D13E	1031	1031	6	13	335	345385	0.3461	0.2673	422	434680	0.4355	0.3364
D13F	970	970	6	13	335	324950	0.3256	0.3358	422	408961	0.4098	0.4226
D13G	1125	1125	6	13	335	376875	0.3776	0.7118	422	474311	0.4753	0.8958
D13H	1144	1144	6	13	335	383240	0.3840	1.2843	422	482322	0.4833	1.6163
D13J	1167	1167	6	13	335	390945	0.3917	1.1828	422	492019	0.4930	1.4886

Quat. Number	**Gross area (km2)**	**Net area (km2)**	**Sediment region**	**Erodibility index**	**Sediment (t/km2/a)**	**Sediment yield (t/a)**	**Sediment vol(MCM)**	**Volume (%MAR)**	***Sediment (t/km2/a)***	***Sediment yield (t/a)***	***Sediment vol(MCM)***	***Volume (%MAR)***
D13K	397	397	6	13	335	132995	0.1333	0.2641	422	167379	0.1677	0.3324
D13L	682	682	6	13	335	228470	0.2289	0.9037	422	287538	0.2881	1.1373
D13M	678	678	6	13	335	227130	0.2276	1.0546	422	285851	0.2864	1.3272
0	**9354**	**9354**				**3133590**	**3.1399**	**0.4499**		**3943737.7**	**3.9516**	**0.5662**
D14A	764	764	6	12	335	255940	0.2565	1.0205	422	322110	0.3228	1.2843
D14B	324	324	6	13	335	108540	0.1088	1.3492	422	136602	0.1369	1.6981
D14C	722	722	6	13	335	241870	0.2424	1.3106	422	304402	0.3050	1.6494
D14D	680	680	6	13	335	227800	0.2283	1.9450	422	286695	0.2873	2.4479
D14E	663	663	6	13	335	222105	0.2225	2.1580	422	279527	0.2801	2.7159
D14F	541	541	6	13	335	181235	0.1816	1.2767	422	228091	0.2285	1.6067
D14G	605	605	6	13	335	202675	0.2031	1.0383	422	255074	0.2556	1.3068
D14H	697	697	6	13	335	233495	0.2340	1.5790	422	293862	0.2944	1.9872
D14J	515	515	6	13	335	172525	0.1729	1.5681	422	217129	0.2176	1.9735
D14K	634	634	6	13	335	212390	0.2128	1.6937	422	267301	0.2678	2.1316
0	**6145**	**6145**				**2058575**	**2.0627**	**1.4136**		**2590792**	**2.5960**	**1.7790**
D15A	437	437	7	10	203	88711	0.0889	0.0749	255	111646	0.1119	0.0942
D15B	393	393	7	10	203	79779	0.0799	0.0773	255	100405	0.1006	0.0973
D15C	276	276	7	10	203	56028	0.0561	0.1036	255	70513	0.0707	0.1304
D15D	437	437	7	12	203	88711	0.0889	0.0842	255	111646	0.1119	0.1060
D15E	619	619	7	12	203	125657	0.1259	0.1097	255	158144	0.1585	0.1380
D15F	352	352	7	12	203	71456	0.0716	0.2366	255	89930	0.0901	0.2978
D15G	485	485	7	12	203	98455	0.0987	0.3474	255	123909	0.1242	0.4372
D15H	361	361	7	12	203	73283	0.0734	0.4943	255	92229	0.0924	0.6221
0	**3360**	**3360**				**682080**	**0.6834**	**0.1199**		**858422.63**	**0.8601**	**0.1509**
D16A	159	159	7	10	203	32277	0.0323	0.0762	255	40622	0.0407	0.0960
D16B	249	249	7	10	203	50547	0.0506	0.0925	255	63615	0.0637	0.1164
D16C	438	438	7	10	203	88914	0.0891	0.2732	255	111902	0.1121	0.3438
D16D	339	339	7	10	203	68817	0.0690	0.1114	255	86609	0.0868	0.1402
D16E	434	434	7	10	203	88102	0.0883	0.1763	255	110880	0.1111	0.2219
D16F	277	277	7	10	203	56231	0.0563	0.1105	255	70769	0.0709	0.1391
D16G	290	290	7	10	203	58870	0.0590	0.1269	255	74090	0.0742	0.1597
D16H	345	345	7	10	203	70035	0.0702	0.2191	255	88142	0.0883	0.2758

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D16J	374	374	7	10	203	75922	0.0761	0.1584	255	95551	0.0957	0.1993
D16K	329	329	7	10	203	66787	0.0669	0.1116	255	84054	0.0842	0.1404
D16L	533	533	7	10	203	108199	0.1084	0.1819	255	136172	0.1364	0.2290
D16M	753	753	7	10	203	152859	0.1532	0.1152	255	192379	0.1928	0.1450
0	**4520**	**4520**				**917560**	**0.9194**	**0.1369**		**1154782.8**	**1.1571**	**0.1722**
D17A	638	638	7	10	203	129514	0.1298	0.0629	255	162998	0.1633	0.0791
D17B	442	442	7	10	203	89726	0.0899	0.0710	255	112923	0.1131	0.0894
D17C	525	525	7	10	203	106575	0.1068	0.1379	255	134129	0.1344	0.1735
D17D	748	748	7	10	203	151844	0.1521	0.1356	255	191101	0.1915	0.1707
D17E	605	605	7	10	203	122815	0.1231	0.1276	255	154567	0.1549	0.1606
D17F	582	582	7	10	203	118146	0.1184	0.2451	255	148691	0.1490	0.3084
D17G	849	849	7	10	203	172347	0.1727	0.1584	255	216905	0.2173	0.1994
D17H	852	852	7	10	203	172956	0.1733	0.1701	255	217671	0.2181	0.2140
D17J	437	437	7	10	203	88711	0.0889	0.0890	255	111646	0.1119	0.1120
D17K	383	383	7	10	203	77749	0.0779	0.1533	255	97850	0.0980	0.1929
D17L	590	590	7	10	203	119770	0.1200	0.1611	255	150735	0.1510	0.2027
D17M	528	528	7	10	203	107184	0.1074	0.1475	255	134895	0.1352	0.1857
0	**7179**	**7179**				**1457337**	**1.4603**	**0.1241**		**1834111.9**	**1.8378**	**0.1562**
D18A	599	599	7	10	203	121597	0.1218	0.1259	255	153034	0.1533	0.1584
D18B	327	327	7	10	203	66381	0.0665	0.1668	255	83543	0.0837	0.2100
D18C	466	466	7	12	203	94598	0.0948	0.1972	255	119055	0.1193	0.2482
D18D	766	766	7	10	203	155498	0.1558	0.1393	255	195700	0.1961	0.1753
D18E	376	376	7	10	203	76328	0.0765	0.1376	255	96062	0.0963	0.1731
D18F	446	446	7	12	203	90538	0.0907	0.2071	255	113945	0.1142	0.2607
D18G	492	492	7	13	203	99876	0.1001	0.1160	255	125698	0.1259	0.1460
D18H	384	384	7	13	203	77952	0.0781	0.1551	255	98105	0.0983	0.1952
D18J	859	859	7	12	203	174377	0.1747	0.1561	255	219460	0.2199	0.1964
D18K	935	935	7	13	203	189805	0.1902	0.1290	255	238877	0.2394	0.1623
D18L	610	610	7	12	203	123830	0.1241	0.1919	255	155845	0.1562	0.2415
0	**6260**	**6260**				**1270780**	**1.2733**	**0.1486**		**1599323.1**	**1.6025**	**0.1871**
D21A	309	309	6	10	335	103515	0.1037	0.1688	422	130277	0.1305	0.2124
D21B	394	394	6	10	335	131990	0.1323	0.1495	422	166114	0.1664	0.1882

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D21C	212	212	6	9	335	71020	0.0712	0.2287	422	89381	0.0896	0.2878
D21D	252	252	6	9	335	84420	0.0846	0.2762	422	106246	0.1065	0.3476
D21E	268	268	6	9	335	89780	0.0900	0.3430	422	112991	0.1132	0.4317
D21F	480	480	6	9	335	160800	0.1611	0.4945	422	202373	0.2028	0.6223
D21G	278	278	6	9	335	93130	0.0933	0.4354	422	117208	0.1174	0.5480
D21H	381	381	6	9	335	127635	0.1279	0.3292	422	160633	0.1610	0.4143
D21J	359	359	6	10	335	120265	0.1205	0.1620	422	151358	0.1517	0.2039
D21K	326	326	6	10	335	109210	0.1094	0.1772	422	137445	0.1377	0.2230
D21L	304	304	6	9	335	101840	0.1020	0.2519	422	128169	0.1284	0.3170
0	**3563**	**3563**				**1193605**	**1.1960**	**0.2357**		**1502195.6**	**1.5052**	**0.2967**
D22A	636	636	6	9	335	213060	0.2135	0.5977	422	268144	0.2687	0.7522
D22B	457	457	6	9	335	153095	0.1534	0.4794	422	192676	0.1931	0.6033
D22C	486	486	6	9	335	162810	0.1631	0.3321	422	204902	0.2053	0.4180
D22D	628	628	6	9	335	210380	0.2108	0.5729	422	264771	0.2653	0.7211
D22E	498	498	6	10	335	166830	0.1672	0.3266	422	209962	0.2104	0.4111
D22F	633	633	6	9	335	212055	0.2125	0.4105	422	266879	0.2674	0.5166
D22G	969	969	6	9	335	324615	0.3253	0.6144	422	408540	0.4094	0.7733
D22H	541	541	6	9	335	181235	0.1816	0.5043	422	228091	0.2285	0.6347
D22J	652	652	6	10	335	218420	0.2189	0.3533	422	274890	0.2754	0.4447
D22K	324	324	6	10	335	108540	0.1088	0.3859	422	136602	0.1369	0.4857
D22L	376	376	6	11	335	125960	0.1262	0.5836	422	158525	0.1588	0.7345
0	**6200**	**6200**				**2077000**	**2.0812**	**0.4551**		**2613980.5**	**2.6192**	**0.5728**
D23A	608	608	6	12	335	203680	0.2041	0.5334	422	256339	0.2569	0.6713
D23B	597	597	6	12	335	199995	0.2004	0.4911	422	251701	0.2522	0.6181
D23C	861	861	3	12	82	70602	0.0707	0.1730	103	88855	0.0890	0.2177
D23D	565	565	6	12	335	189275	0.1897	0.8614	422	238210	0.2387	1.0841
D23E	702	702	6	12	335	235170	0.2356	0.8219	422	295970	0.2966	1.0343
D23F	352	352	6	12	335	117920	0.1182	0.6037	422	148407	0.1487	0.7598
D23G	512	512	6	12	335	171520	0.1719	0.6553	422	215864	0.2163	0.8248
D23H	776	776	6	12	335	259960	0.2605	1.3243	422	327169	0.3278	1.6667
D23J	534	534	6	12	335	178890	0.1792	1.1169	422	225140	0.2256	1.4057

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
0	**5507**	**5507**				**1627012**	**1.6303**	**0.6465**		**2047654.1**	**2.0517**	**0.8136**
D24A	310	310	6	12	335	103850	0.1041	0.5452	422	130699	0.1310	0.6862
D24B	470	470	6	12	335	157450	0.1578	0.6896	422	198157	0.1986	0.8679
D24C	398	398	6	12	335	133330	0.1336	0.9886	422	167801	0.1681	1.2442
D24D	598	598	6	12	335	200330	0.2007	1.3334	422	252123	0.2526	1.6781
D24E	489	489	6	12	335	163815	0.1641	1.3315	422	206167	0.2066	1.6757
D24F	567	567	6	12	335	189945	0.1903	1.0849	422	239053	0.2395	1.3653
D24G	626	626	6	13	335	209710	0.2101	0.9379	422	263928	0.2645	1.1804
D24H	736	736	6	12	335	246560	0.2471	1.3026	422	310305	0.3109	1.6394
D24J	1032	1032	6	12	335	345720	0.3464	1.6795	422	435101	0.4360	2.1137
D24K	877	877	6	12	335	293795	0.2944	1.7489	422	369752	0.3705	2.2011
D24L	511	511	6	12	335	171185	0.1715	1.8793	422	215443	0.2159	2.3651
0	**6614**	**6614**				**2215690**	**2.2201**	**1.1787**		**2788526.9**	**2.7941**	**1.4834**
D31A	1160	1160	5	12	30	34800	0.0349	0.2128	38	43797	0.0439	0.2678
D31B	996	757	5	13	30	22710	0.0228	0.5438	38	28581	0.0286	0.6844
D31C	677	677	5	12	30	20310	0.0204	0.4541	38	25561	0.0256	0.5715
D31D	1108	833	5	12	30	24990	0.0250	0.2575	38	31451	0.0315	0.3241
D31E	969	969	5	12	30	29070	0.0291	0.3395	38	36586	0.0367	0.4273
0	**4910**	**4396**				**131880**	**0.1321**	**0.3048**		**165975.8**	**0.1663**	**0.3836**
D32A	716	716	5	12	30	21480	0.0215	0.5253	38	27033	0.0271	0.6611
D32B	582	582	5	13	30	17460	0.0175	0.3693	38	21974	0.0220	0.4648
D32C	850	850	5	12	30	25500	0.0256	0.5117	38	32093	0.0322	0.6440
D32D	851	851	5	12	30	25530	0.0256	0.5400	38	32130	0.0322	0.6796
D32E	1157	1157	5	13	30	34710	0.0348	0.9054	38	43684	0.0438	1.1395
D32F	1443	1443	5	13	30	43290	0.0434	0.5841	38	54482	0.0546	0.7351
D32G	1045	1045	5	12	30	31350	0.0314	0.4304	38	39455	0.0395	0.5417
D32H	572	572	5	12	30	17160	0.0172	0.4476	38	21596	0.0216	0.5634
D32J	1114	1041	5	12	30	31230	0.0313	0.5128	38	39304	0.0394	0.6454
D32K	824	824	5	12	30	24720	0.0248	0.4606	38	31111	0.0312	0.5797
0	**9154**	**9081**				**272430**	**0.2730**	**0.5204**		**342863.12**	**0.3435**	**0.6550**
D33A	593	472	5	12	30	14160	0.0142	0.9903	38	17821	0.0179	1.2463
D33B	1018	323	5	12	30	9690	0.0097	1.1770	38	12195	0.0122	1.4813

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D33C	805	520	5	12	30	15600	0.0156	0.9679	38	19633	0.0197	1.2182
D33D	952	311	5	12	30	9330	0.0093	1.4309	38	11742	0.0118	1.8008
D33E	1554	343	5	12	30	10290	0.0103	1.3347	38	12950	0.0130	1.6797
D33F	863	77	5	12	30	2310	0.0023	1.7295	38	2907	0.0029	2.1766
D33G	1406	400	5	12	30	12000	0.0120	1.7610	38	15102	0.0151	2.2163
D33H	1054	468	5	7	80.7	37767.6	0.0378	4.0585	102	47532	0.0476	5.1077
D33J	865	200	5	12	30	6000	0.0060	2.1668	38	7551	0.0076	2.7270
D33K	488	290	5	12	30	8700	0.0087	1.6299	38	10949	0.0110	2.0513
0	**9598**	**3404**				**125847.6**	**0.1261**	**1.6044**		**158383.81**	**0.1587**	**2.0191**
D34A	794	794	5	12	30	23820	0.0239	0.2193	38	29978	0.0300	0.2760
D34B	706	706	5	12	30	21180	0.0212	0.2960	38	26656	0.0267	0.3725
D34C	760	760	5	12	30	22800	0.0228	0.3641	38	28695	0.0288	0.4583
D34D	599	599	5	12	30	17970	0.0180	0.3348	38	22616	0.0227	0.4214
D34E	519	519	5	12	30	15570	0.0156	0.2834	38	19595	0.0196	0.3566
D34F	692	692	5	12	30	20760	0.0208	0.3868	38	26127	0.0262	0.4868
D34G	950	950	5	12	30	28500	0.0286	0.2593	38	35868	0.0359	0.3264
0	**5020**	**5020**				**150600**	**0.1509**	**0.2924**		**189535.61**	**0.1899**	**0.3680**
D35A	254	254	6	12	335	85090	0.0853	1.9440	422	107089	0.1073	2.4465
D35B	260	260	6	13	335	87100	0.0873	2.1655	422	109619	0.1098	2.7253
D35C	943	943	6	13	335	315905	0.3165	2.9344	422	397578	0.3984	3.6931
D35D	586	586	6	13	335	196310	0.1967	3.5307	422	247063	0.2476	4.4435
D35E	312	312	6	13	335	104520	0.1047	2.6773	422	131542	0.1318	3.3695
D35F	557	557	6	12	335	186595	0.1870	2.1607	422	234837	0.2353	2.7193
D35G	552	552	6	13	335	184920	0.1853	3.7217	422	232729	0.2332	4.6839
D35H	498	498	6	12	335	166830	0.1672	2.7651	422	209962	0.2104	3.4800
D35J	1002	1002	5	12	30	30060	0.0301	0.3909	38	37832	0.0379	0.4920
D35K	674	674	5	12	30	20220	0.0203	0.2947	38	25448	0.0255	0.3709
0	**5638**	**5638**				**1377550**	**1.3803**	**2.1929**		**1733697.1**	**1.7372**	**2.7599**
0	0	0										
TOTALS	**99349**	**92568**				**20367562**	**20.4083**	**0.3027**		**25633321**	**25.6846**	**0.3810**

FIGURES

LOCALITY MAP:

LEGEND:

GIS COV:

- WMA Boundaries
- International Border
- Provincial Boundaries
- Towns
- Rivers
- Dams
- Secondary Catchment
- Primary Catchment

PREPARED BY:

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HYDROGEOLOGISTS
PROJECT MANAGERS

GIS Project Solutions

CLIENT:

DEPT: WATER AFFAIRS AND FORESTRY

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1 : 1 500 000

10 0 10 20 30 40 Km

TITLE:

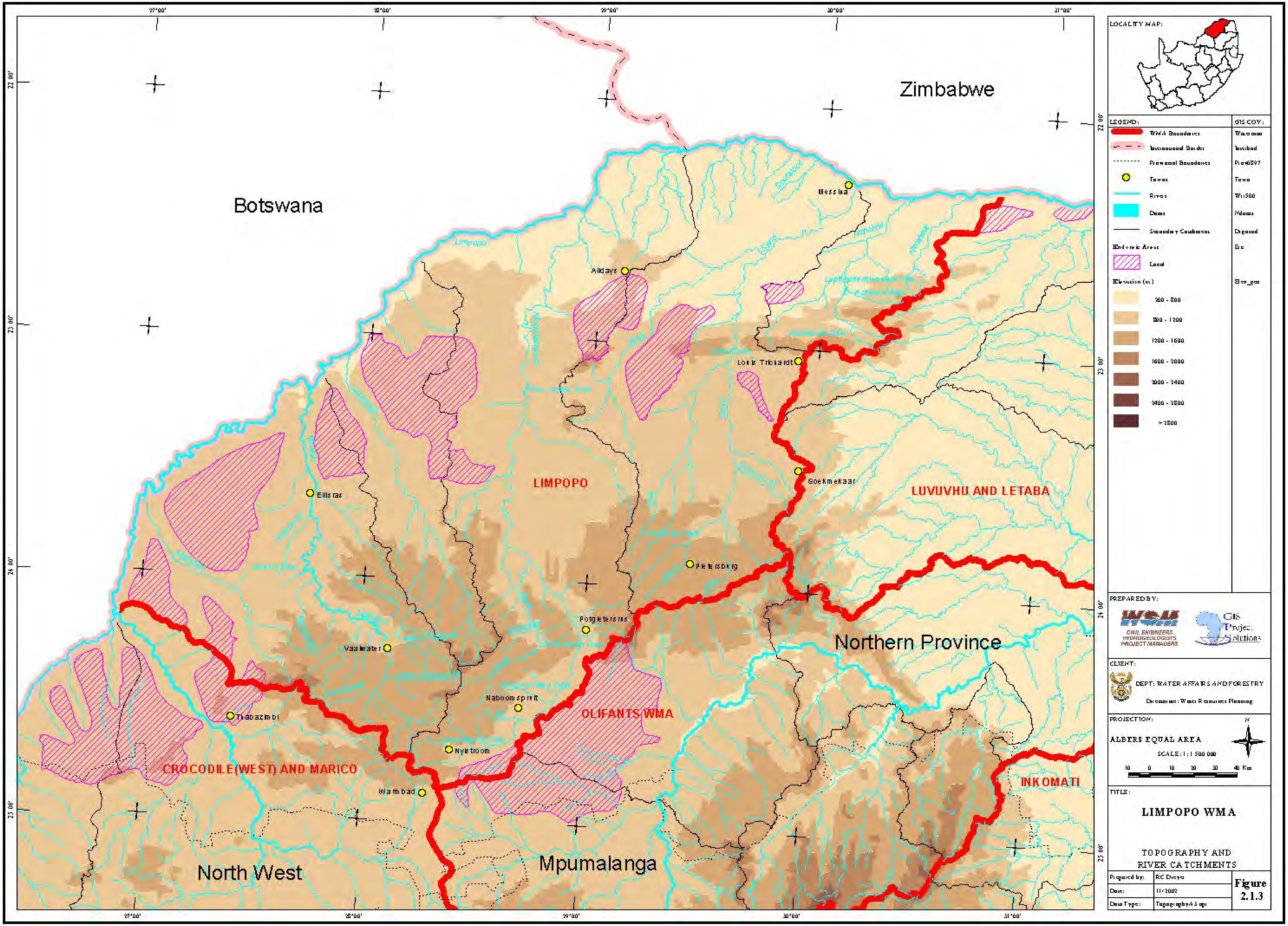
LIMPOPO WMA

LIMPOPO RIVER WATERCOURSE

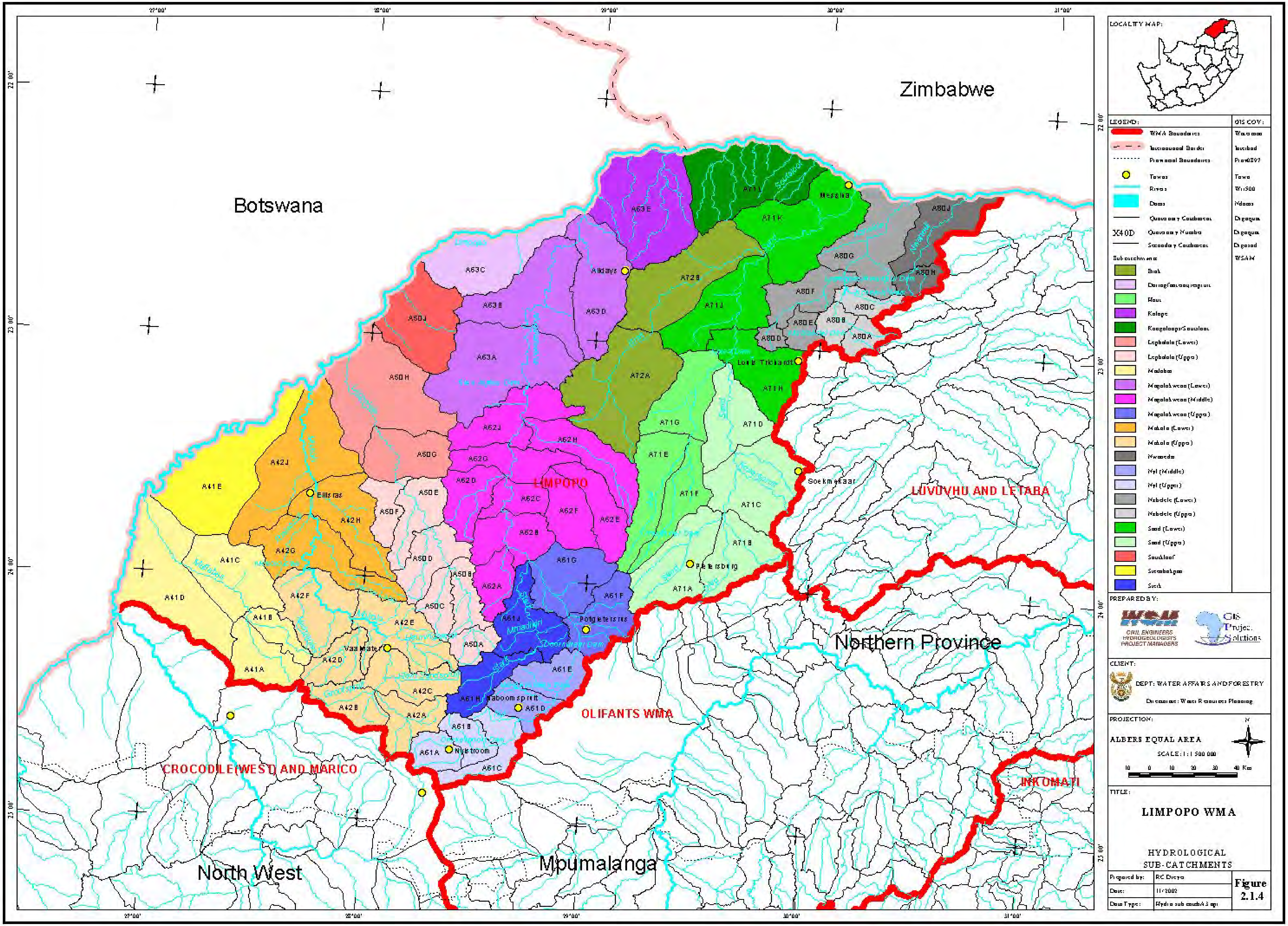
Prepared by:	RC Dreyer
Date:	11/2002

Figure 2.1.1

LOCALITY MAP:
BASE MAP LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Secondary Catchments
Nature Reserve Boundaries
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
THE STUDY AREA
Figure 2.1.2
Botswana
Zimbabwe
Northern Province
North West
Mpumalanga
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
A4
A5
A6
A7
A8
VEMBE
MESSINA
WONDERKOP
LAPALALA
MOEPELPLASE
PERCY FYFE
MARAKALE
NYLSVLEY
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
Limpopo
Sand
Hout
Brak
Mogalakwena
Mokolo
Lephalala
Klein Sandspruit
Grootspruit
Nyl
Glen Alpine Dam
Doorndraai Dam
Welgevonden Dam
Donkerpoort Dam
Mokolo Dam
Houtrivier Dam
Spies Dam
Mutshedzi Dam
Nzhelele Dam
Nzhelele
Nwanedi
Koudspruit
Diep



Zimbabwe
Botswana
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
Endoreic Areas
Elevation (m)
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
TOPOGRAPHY AND
RIVER CATCHMENTS
Figure
2.1.3



Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
A71L
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A71D
A71C
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A63E
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A42H
A42G
A42F
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A42D
A42C
A42B
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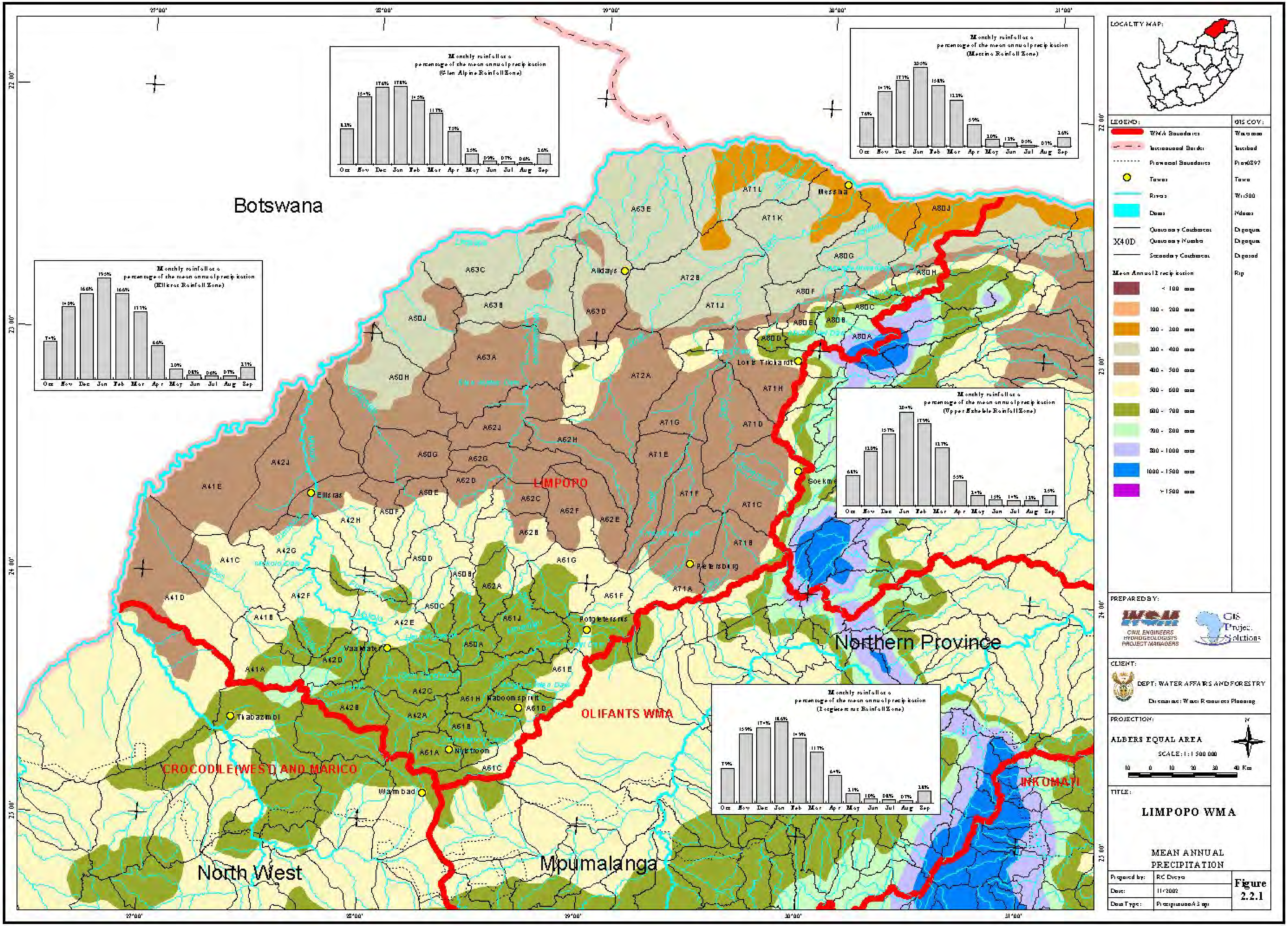
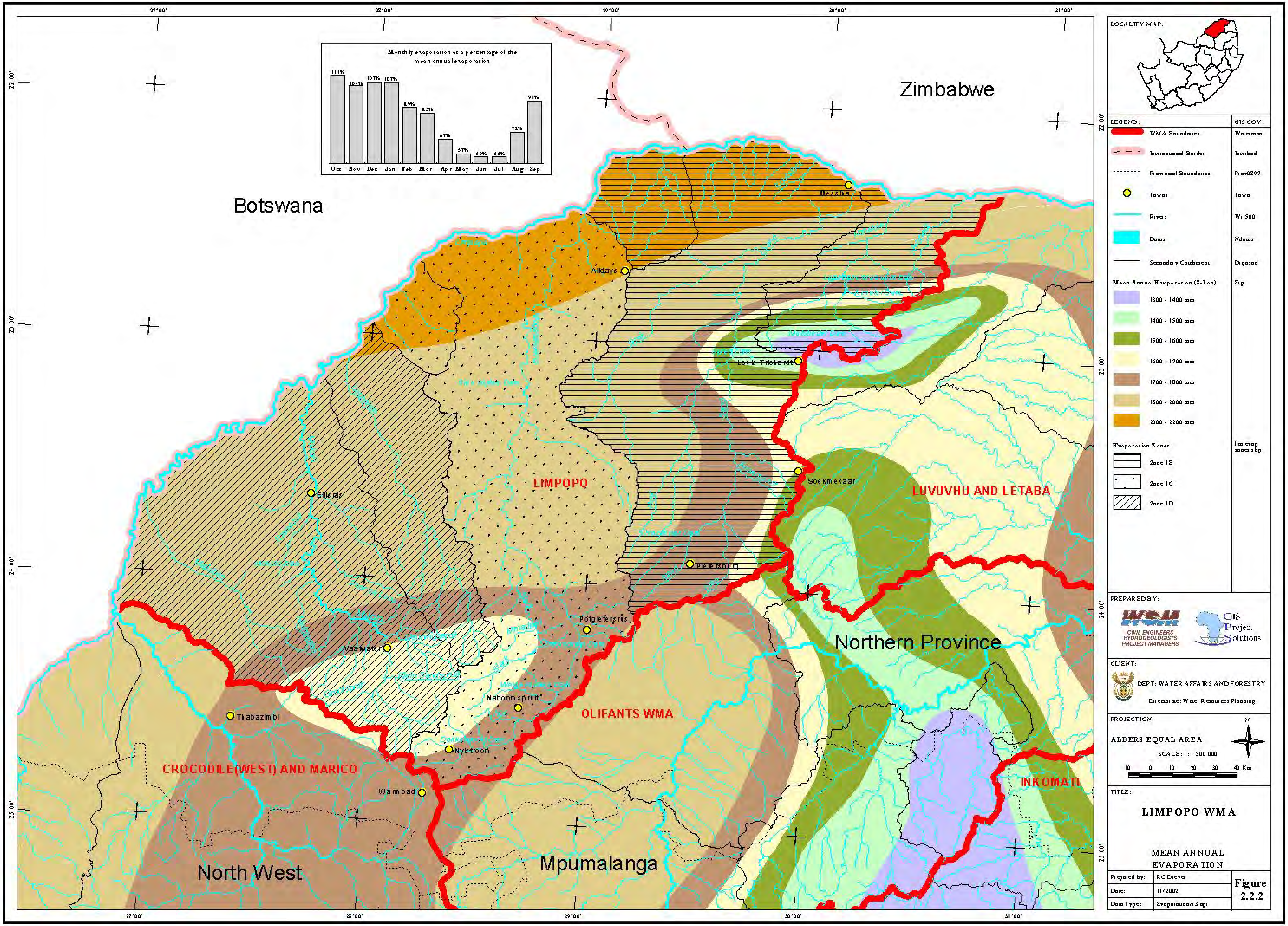
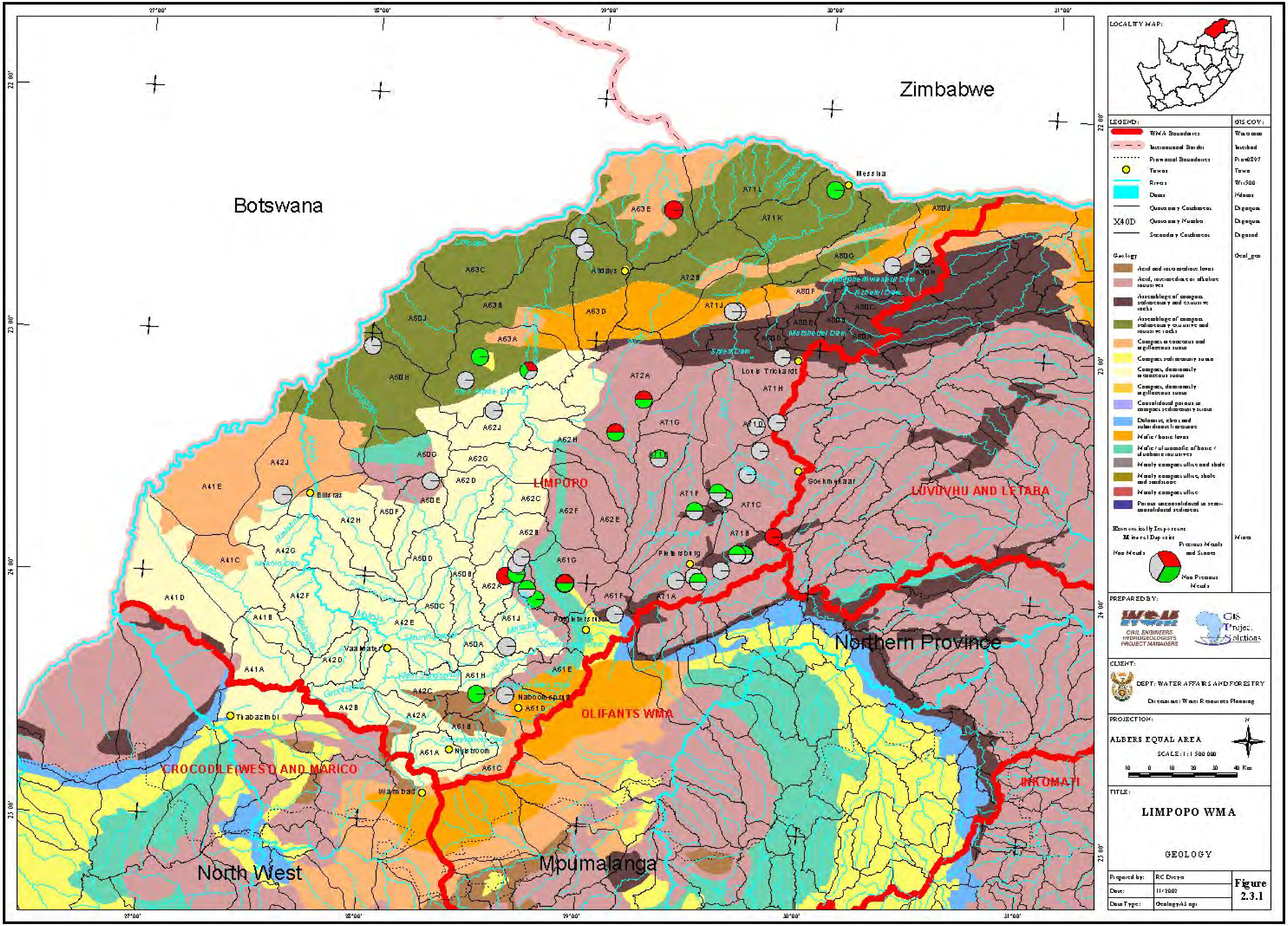
A41D
A41C
A41B
A41A
A80J
A80H
A80G
A80F
A80E
A80D
A80C
A80B
A80A
Doorndraai Dam
LOCALITY MAP:
LEGEND:
GIS COV:
Towns
X40D
Subcatchments
Kolope
Lephalala (Lower)
Lephalala (Upper)
Mogalakwena (Lower)
Mogalakwena (Middle)
Mogalakwena (Upper)
Mokolo (Lower)
Mokolo (Upper)
Nyl (Middle)
Nyl (Upper)
Sand (Lower)
Sand (Upper)
Soutkloof
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
HYDROLOGICAL SUB-CATCHMENTS
Prepared by:
Date:
11/2002

Figure 2.1.4

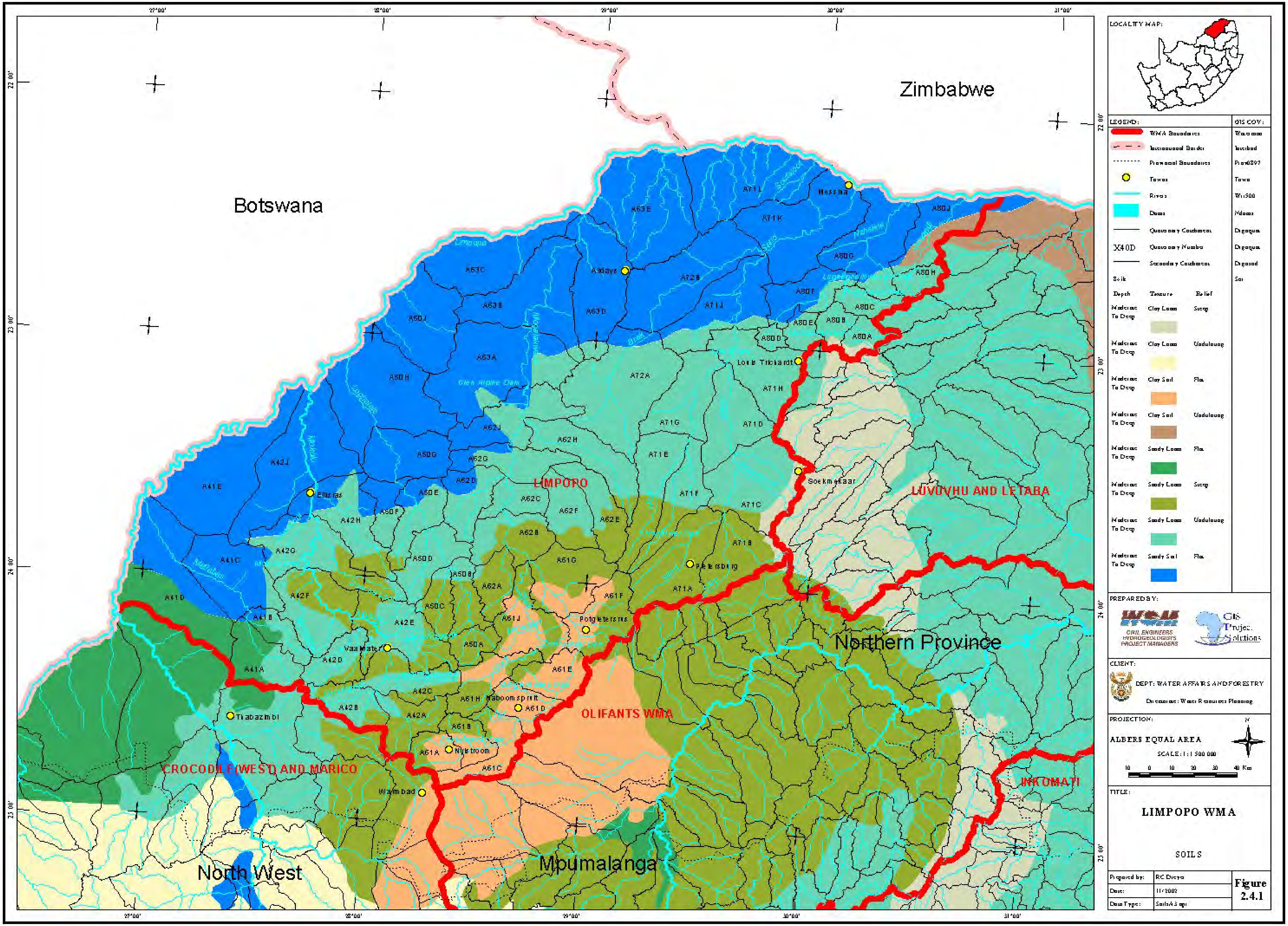


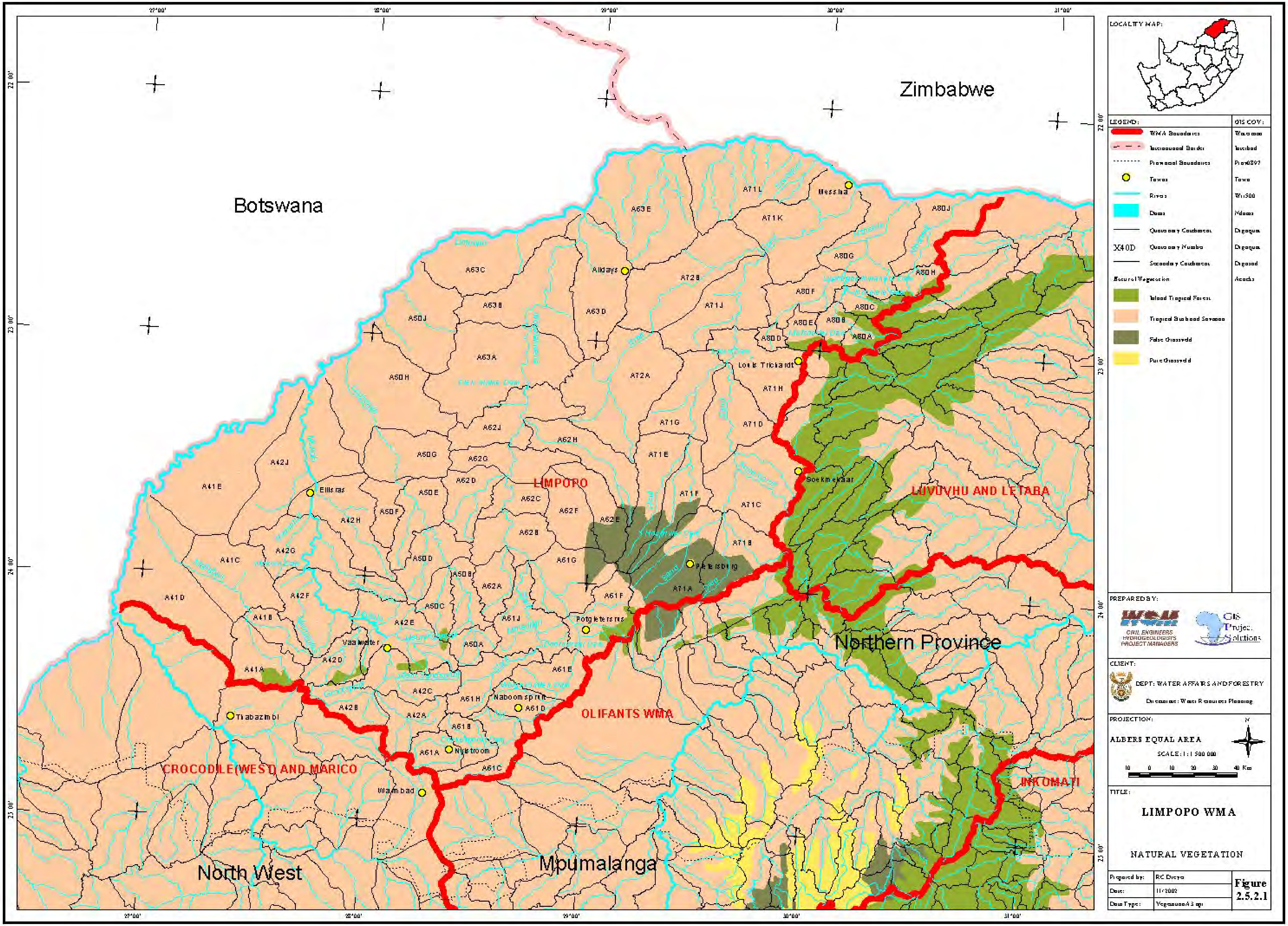
Botswana
Northern Province
North West
Mpumalanga
LIMPOPO
OLIFANTS WMA
CROCODILE (WEST) AND MARICO
INKOMATI
Messina
Alldays
Louis Trichardt
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Thabazimbi
Naboomspruit
Nylstroom
Warmbad
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
X40D
Mean Annual Precipitation
< 100 mm
100 - 200 mm
200 - 300 mm
300 - 400 mm
400 - 500 mm
500 - 600 mm
600 - 700 mm
700 - 800 mm
800 - 1000 mm
1000 - 1500 mm
> 1500 mm
GIS COV:
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
10 0 10 20 30 40 Km
N
TITLE:
LIMPOPO WMA
MEAN ANNUAL PRECIPITATION
Prepared by:
RC Dreyer
Date:
11/2002
Data Type:
Figure 2.2.1


Monthly evaporation as a percentage of the mean annual evaporation
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Zimbabwe
Botswana
Alldays
Messina
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Secondary Catchment
Mean Annual Evaporation (S-Pan)
1300 - 1400 mm
1400 - 1500 mm
1500 - 1600 mm
1600 - 1700 mm
1700 - 1800 mm
1800 - 2000 mm
2000 - 2200 mm
Evaporation Zones
Zone 1B
Zone 1C
Zone 1D
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
10 0 10 20 30 40 Km
TITLE:
LIMPOPO WMA
MEAN ANNUAL EVAPORATION
Prepared by:
RC Dicye
Figure 2.2.2



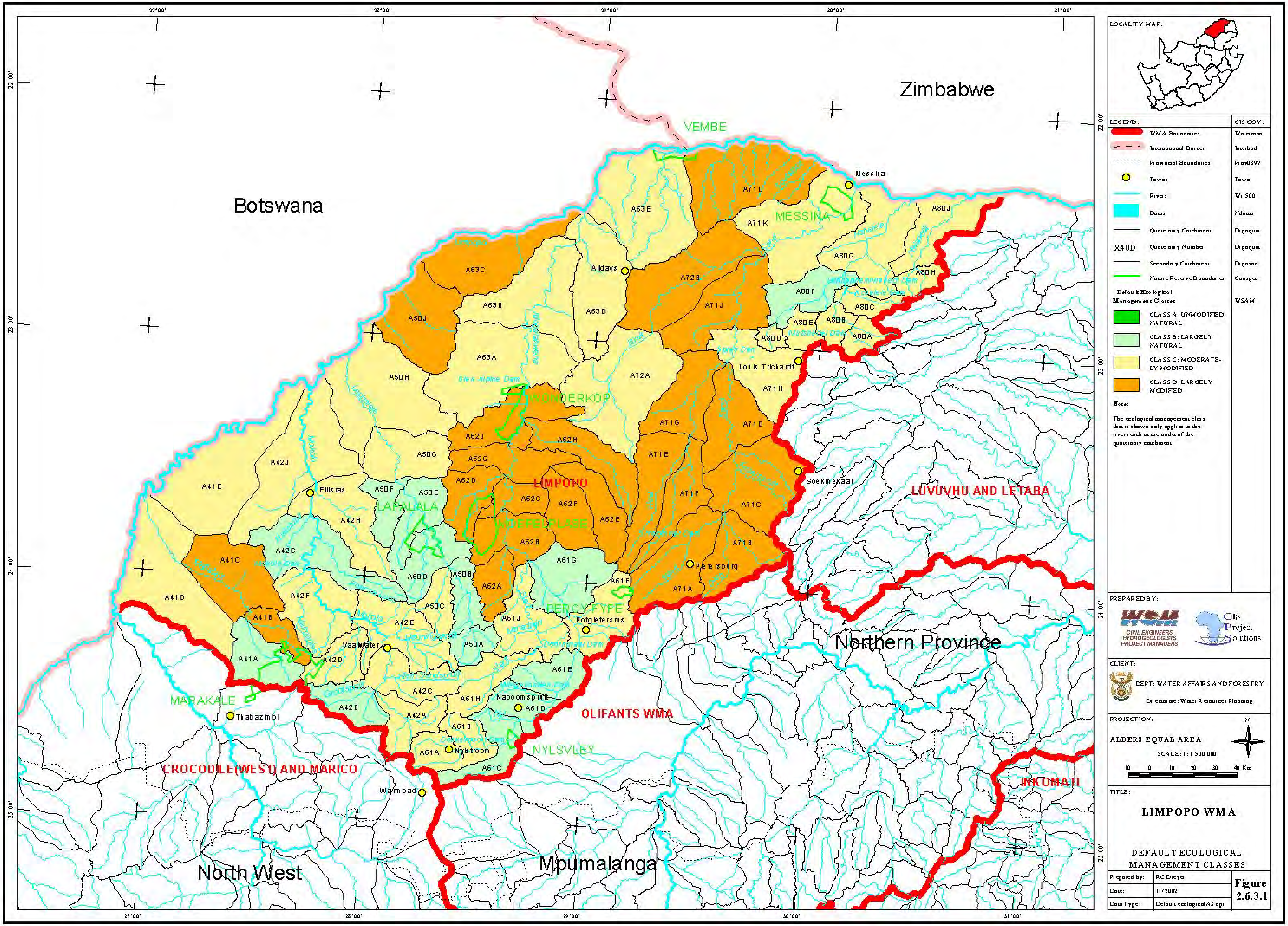
Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
LOCALITY MAP:
LEGEND:
GIS COV:
Geology
Economically Important Mineral Deposits
Precious Metals and Stones
Non Metals
Non Precious Metals
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
GEOLOGY
Prepared by: RC Dreyer
Date: 11/2002
Data Type: GeologyA3.apr
Figure 2.3.1


Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE (WEST) AND MARICO
INKOMATI
Northern Province
Mpumalanga
North West
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
Soils
Depth
Texture
Relief
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
LIMPOPO WMA
SOILS
Figure 2.4.1



Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Thabazimbi
Nylstroom
Warmbad
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS
Project
Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
N
TITLE:
LIMPOPO WMA
NATURAL VEGETATION
Prepared by:
Date:
Data Type:

Figure 2.5.2.1



Zimbabwe
Botswana
VEMBE
MESSINA
WONDERKOP
LIMPOPO
LAPALALA
DOORNDRAAI/WOLKBERG
PERCY FYFE
MARAKALE
NYLSVLEY
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
Mpumalanga
North West
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
A41A
A41B
A41C
A41D
A41E
A42B
A42C
A42D
A42E
A42F
A42G
A42H
A42J
A50A
A50B
A50C
A50D
A50E
A50F
A50G
A50H
A50J
A61A
A61B
A61C
A61D
A61E
A61F
A61G
A61H
A61J
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A62B
A62C
A62D
A62E
A62F
A62G
A62H
A62J
A63A
A63B
A63C
A63D
A63E
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A71B
A71C
A71D
A71E
A71F
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A71J
A71K
A71L
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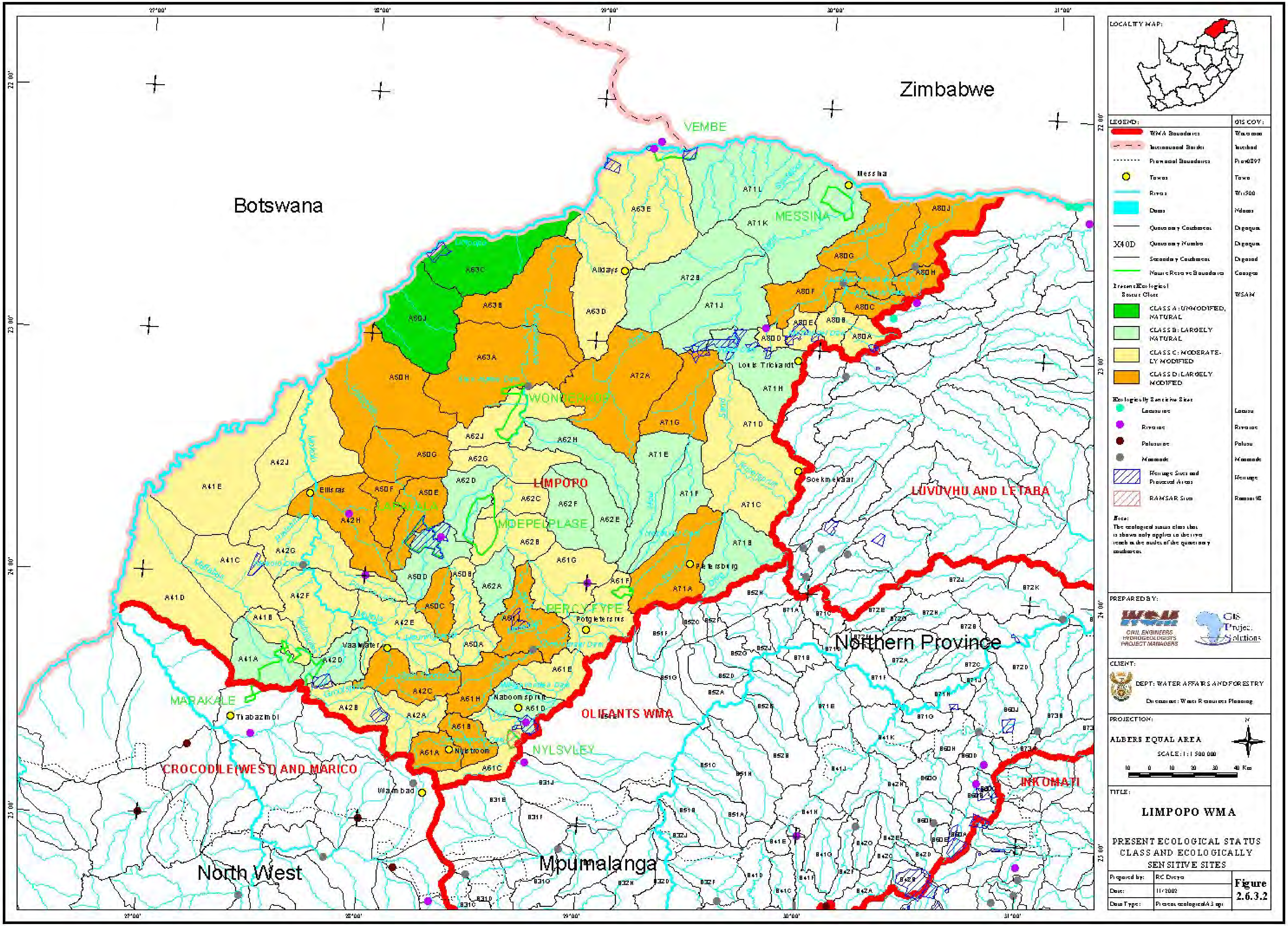
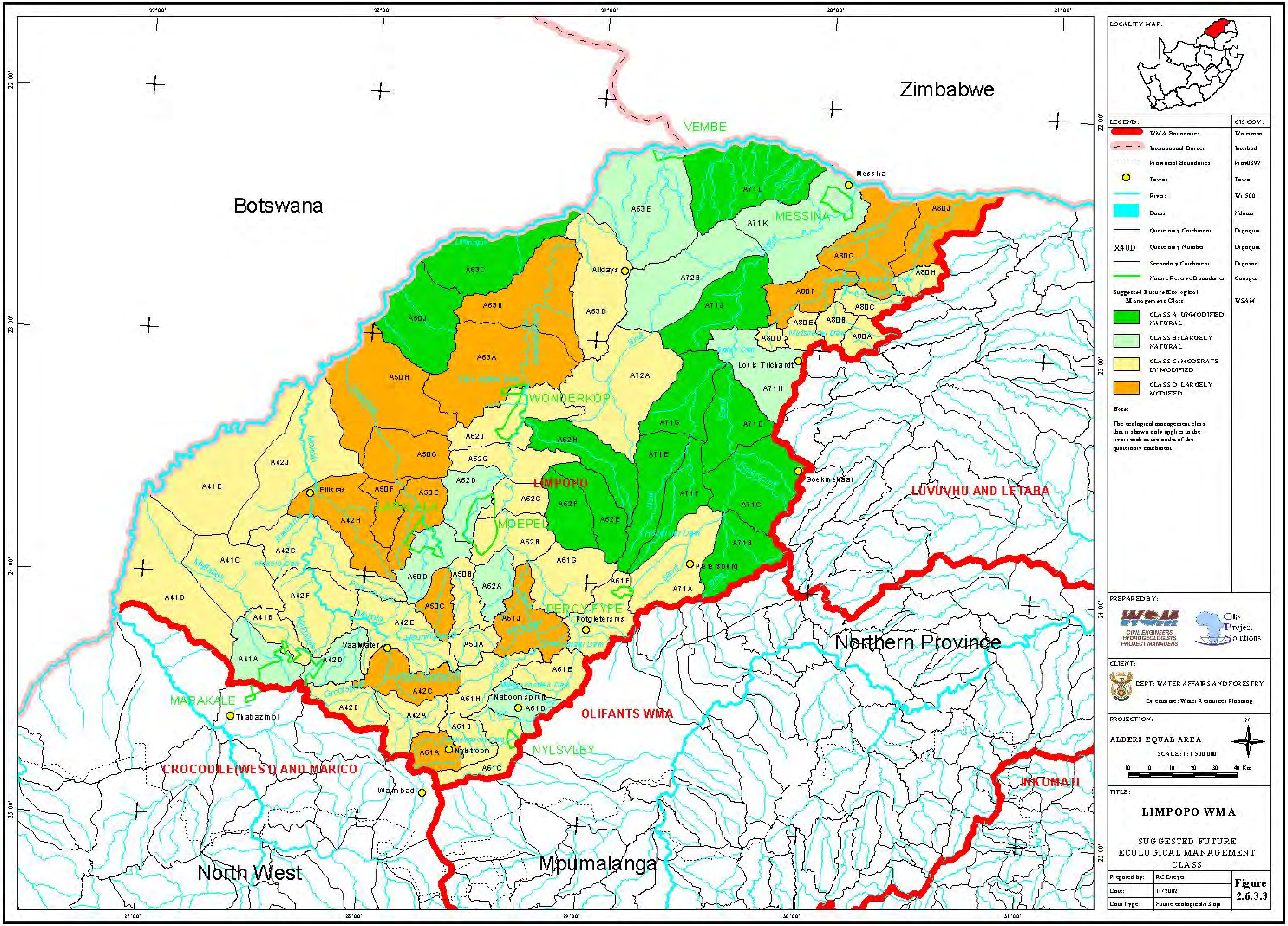
A72B
A80A
A80B
A80C
A80D
A80E
A80F
A80G
A80H
A80J
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
X40D
Default Ecological Management Classes
WSAM
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFIED
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
N
SCALE: 1 : 1 500 000
10 0 10 20 30 40 Km
TITLE:
LIMPOPO WMA
DEFAULT ECOLOGICAL MANAGEMENT CLASSES
Prepared by:
RC Dreyer
Date:
11/2002
Figure 2.6.3.1



Zimbabwe
Botswana
VEMBE
MESSINA
Messina
Alldays
WONDERKOP
LIMPOPO
Ellisras
LAPHALALA
MOEPELPLASE
Louis Trichardt
Soekmekaar
LUVUVHU AND LETABA
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
MARAKALE
Thabazimbi
Naboomspruit
Nylstroom
NYLSVLEY
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
Warmbad
Northern Province
INKOMATI
Mpumalanga
North West
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Secondary Catchment
Nature Reserve Boundaries
Present Ecological Status Class
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFIED
Ecologically Sensitive Sites
Heritage Sites and Protected Areas
RAMSAR Sites
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES
Prepared by:
RC Dreyer
Figure 2.6.3.2



Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Alldays
Louis Trichardt
WONDERKOP
LIMPOPO
Soekmekaar
LUVUVHU AND LETABA
Ellisras
MOEPEL
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
Northern Province
MARAKALE
Thabazimbi
Naboomspruit
OLIFANTS WMA
NYLSVLEY
Nylstroom
CROCODILE(WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
A63E
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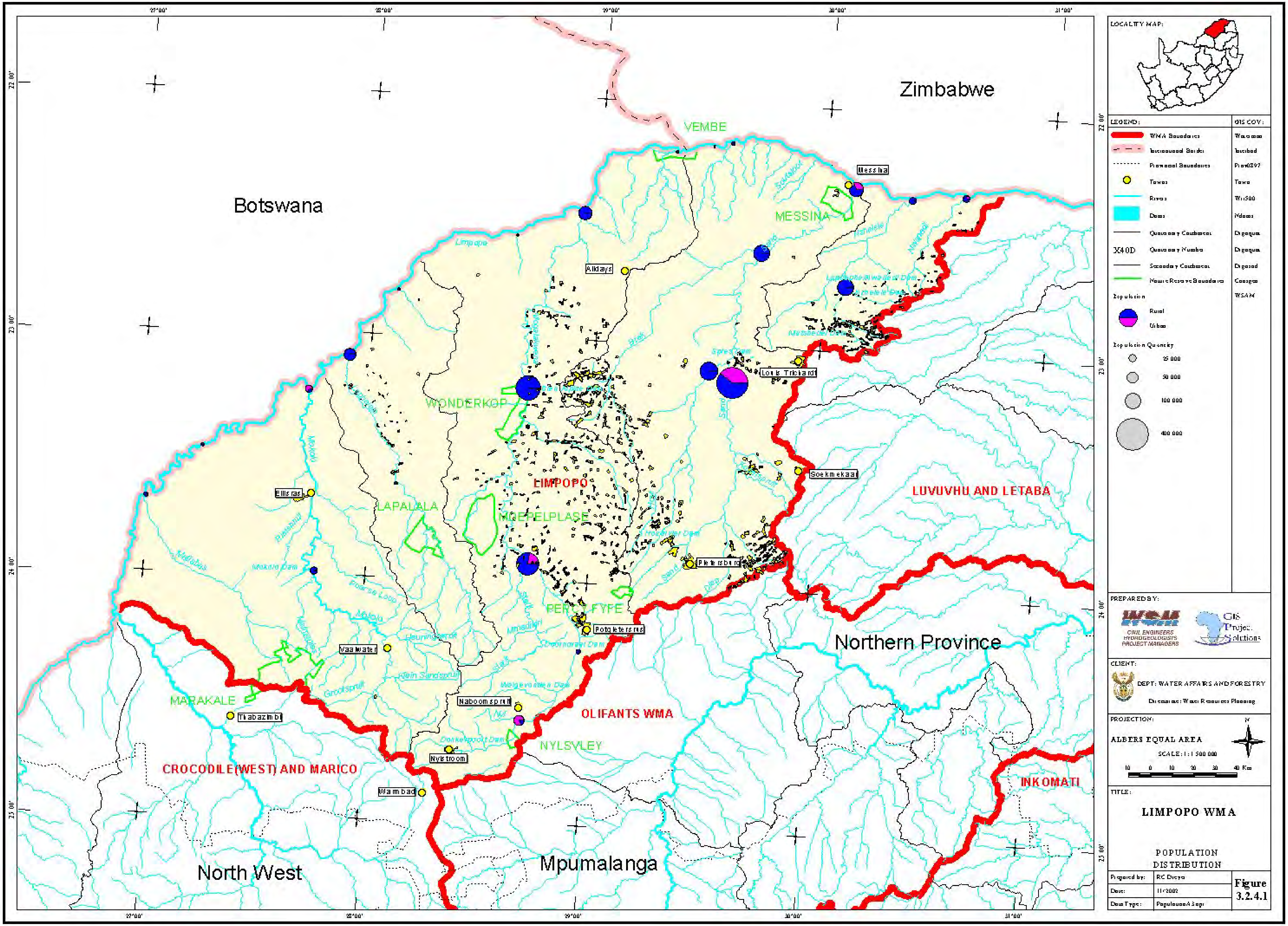
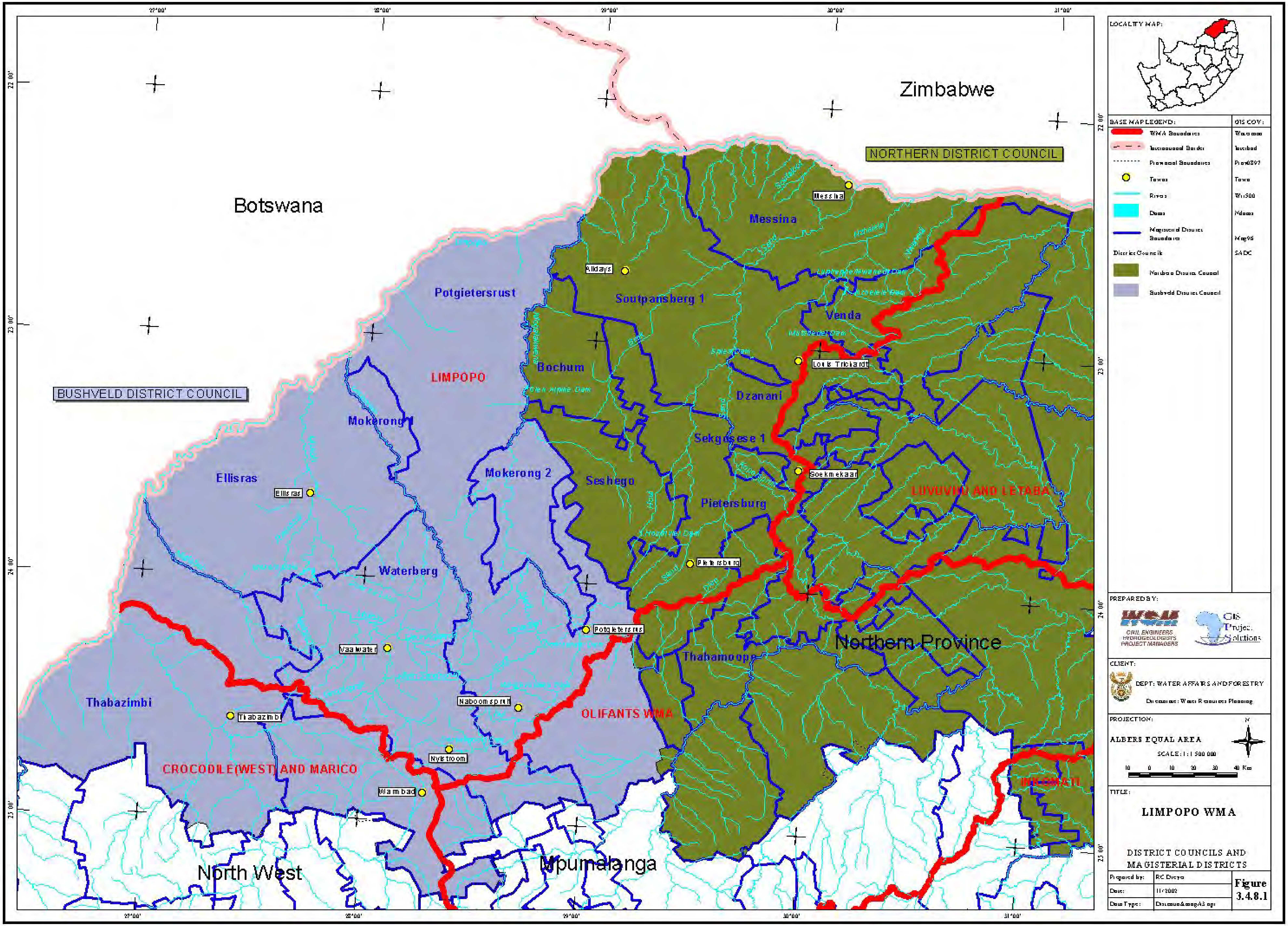
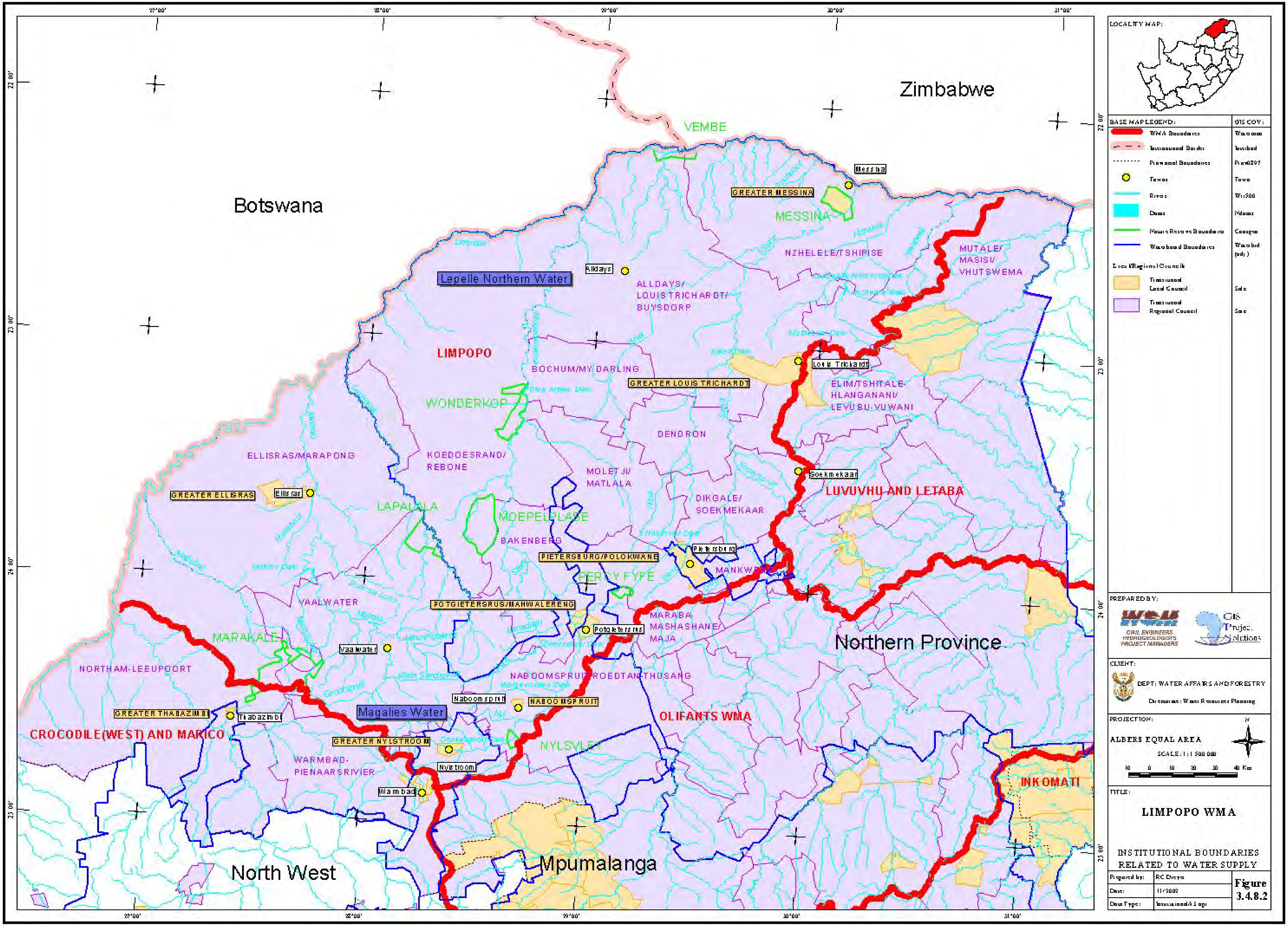
A80E
A80B
A80D
A80A
A50J
A63D
A63A
A72A
A71H
A50H
A62J
A62H
A71G
A71D
A50G
A62G
A71E
A42J
A62D
A41E
A50F
A50E
A62C
A62F
A71F
A71C
A42H
A62E
A42G
A62B
A71B
A41C
A61G
A50D
A50B
A62A
A61F
A71A
A41D
A42F
A50C
A41B
A42E
A61J
A50A
A41A
A42D
A61E
A42C
A42B
A61H
A61D
A42A
A61B
A61A
A61C
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
CLASS A: UNMODIFIED, NATURAL
CLASS B: LARGELY NATURAL
CLASS C: MODERATELY MODIFIED
CLASS D: LARGELY MODIFED
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
N
TITLE:
LIMPOPO WMA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASS
Prepared by:
RC Dreyer
Date:
11/2002
Figure 2.6.3.3


Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Alldays
WONDERKOP
LIMPOPO
LAPALALA
MOEPELPLASE
Louis Trichardt
Soekmekaar
LUVUVHU AND LETABA
Ellisras
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
Northern Province
MARAKALE
Thabazimbi
Naboomspruit
OLIFANTS WMA
NYLSVLEY
Nylstroom
CROCODILE(WEST) AND MARICO
INKOMATI
Warmbad
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
X40D
Rural
Urban
25 000
50 000
100 000
400 000
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
N
TITLE:
LIMPOPO WMA
POPULATION DISTRIBUTION
Prepared by:
Date:
Data Type:
11/2002
Figure 3.2.4.1

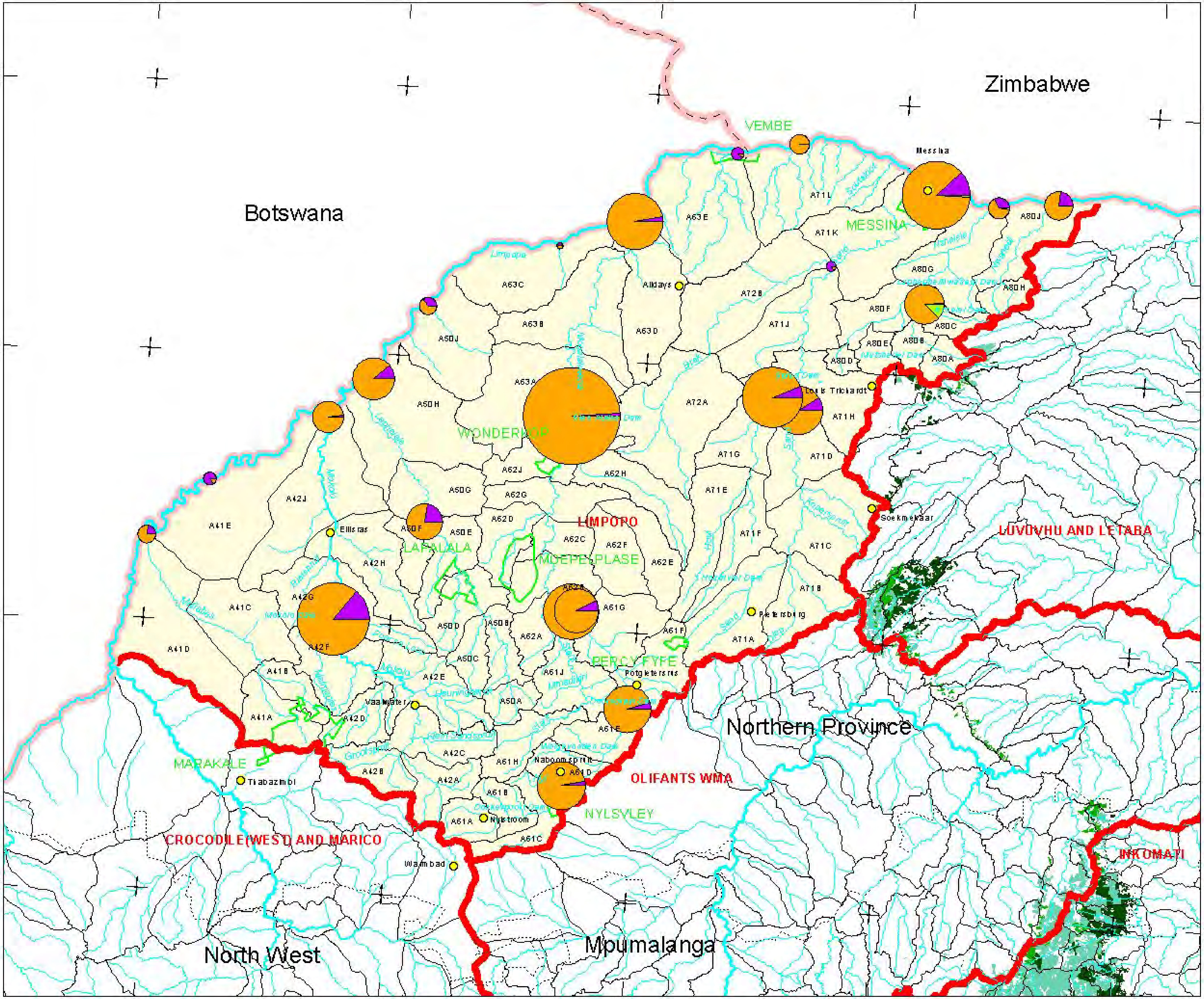


Zimbabwe
Botswana
NORTHERN DISTRICT COUNCIL
BUSHVELD DISTRICT COUNCIL
Messina
Alldays
Soutpansberg 1
Potgietersrust
Venda
Louis Trichardt
Bochum
LIMPOPO
Dzanani
Mokerong 1
Sekgosese 1
Mokerong 2
Soekmekaar
Ellisras
Seshego
Pietersburg
LUVUVHU AND LETABA
Waterberg
Potgietersrus
Vaalwater
Northern Province
Thabamoopo
Naboomspruit
Thabazimbi
OLIFANTS WMA
Nylstroom
CROCODILE(WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
BASE MAP LEGEND:
WMA Boundaries
Towns
Rivers
Dams
District Councils
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT. WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS
Prepared by:
Date:
Data Type:

Figure 3.4.8.1



Zimbabwe
Botswana
VEMBE
Messina
GREATER MESSINA
MESSINA
NZHELELE/TSHIPISE
MUTALE/
MASISI/
VHUTSWEMA
Lepelle Northern Water
Alldays
ALLDAYS/
LOUIS TRICHARDT/
BUYSDORP
LIMPOPO
BOCHUM/MY DARLING
Louis Trichardt
GREATER LOUIS TRICHARDT
ELIM/TSHITALE-
HLANGANANI/
LEVUBU-VUWANI
WONDERKOP
DENDRON
ELLISRAS/MARAPONG
KOEDOESRAND/
REBONE
MOLETJI/
MATLALA
Soekmekaar
LUVUVHU AND LETABA
GREATER ELLISRAS
Ellisras
LAPALALA
MOEPELPLASE
DIKGALE/
SOEKMEKAAR
BAKENBERG
Pietersburg
PIETERSBURG/POLOKWANE
PERCY FYFE
MANKWENG
VAALWATER
POTGIETERSRUS/MAHWALERENG
MARABA
MASHASHANE/
MAJA
Potgietersrus
Northern Province
MARAKALE
Vaalwater
NORTHAM-LEEUPOORT
NABOOMSPRUIT/ROEDTAN-THUSANG
Naboomspruit
NABOOMSPRUIT
GREATER THABAZIMBI
Thabazimbi
Magalies Water
OLIFANTS WMA
CROCODILE (WEST) AND MARICO
GREATER NYLSTROOM
NYLSVLEY
WARMBAD-
PIENAARSRIVIER
Nylstroom
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
BASE MAP LEGEND:
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
N
TITLE:
LIMPOPO WMA
INSTITUTIONAL BOUNDARIES
RELATED TO WATER SUPPLY
Prepared by:
RC Dreyer
Date:
11/2002
Figure
3.4.8.2



PREPARED BY:

CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS

GIS Project Solutions

CLIENT:

DEPT: WATER AFFAIRS AND FORESTRY

PROJECTION:

ALBERS EQUAL AREA

SCALE: 1 : 1 500 000

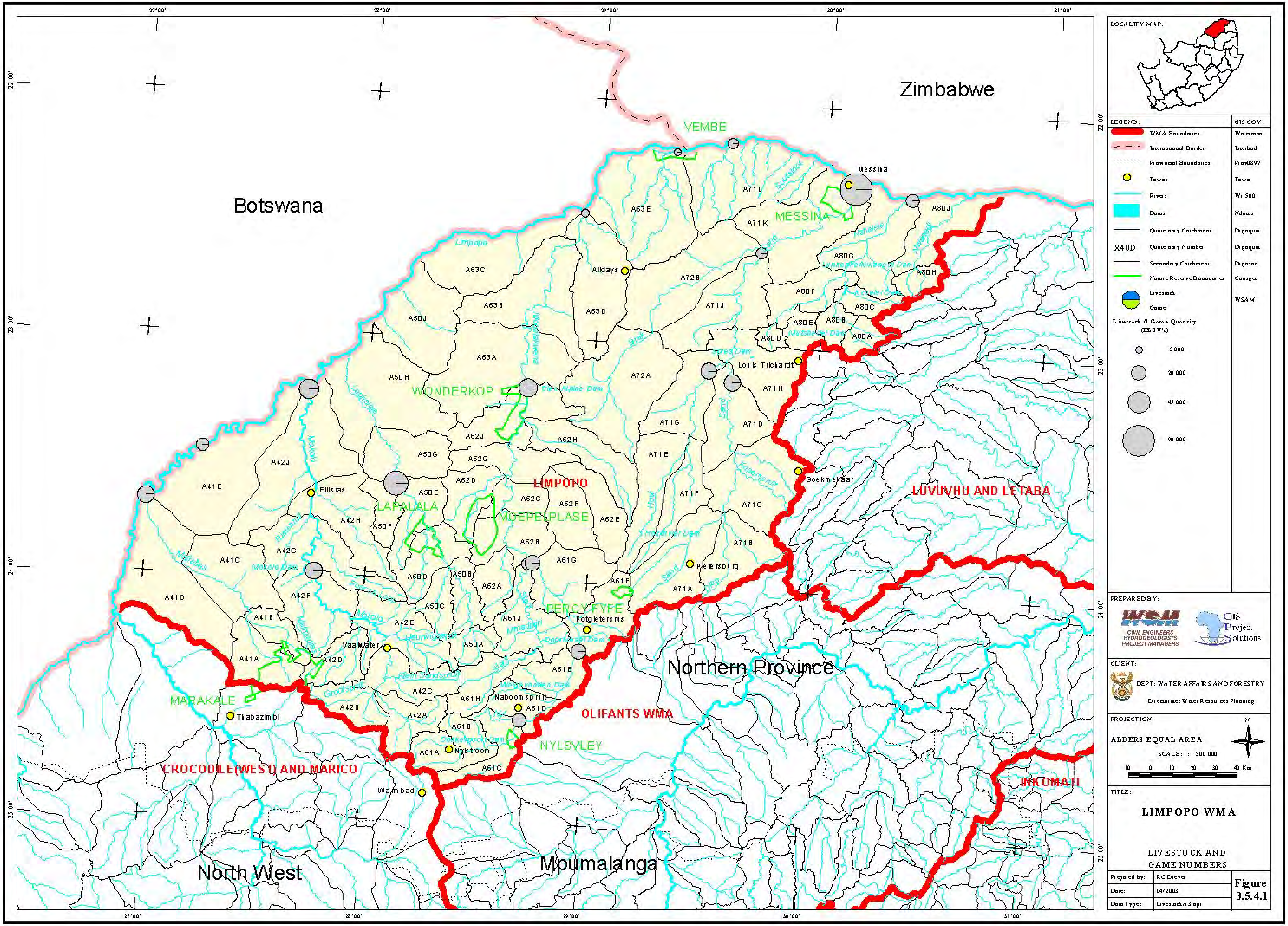
TITLE:

LIMPOPO WMA

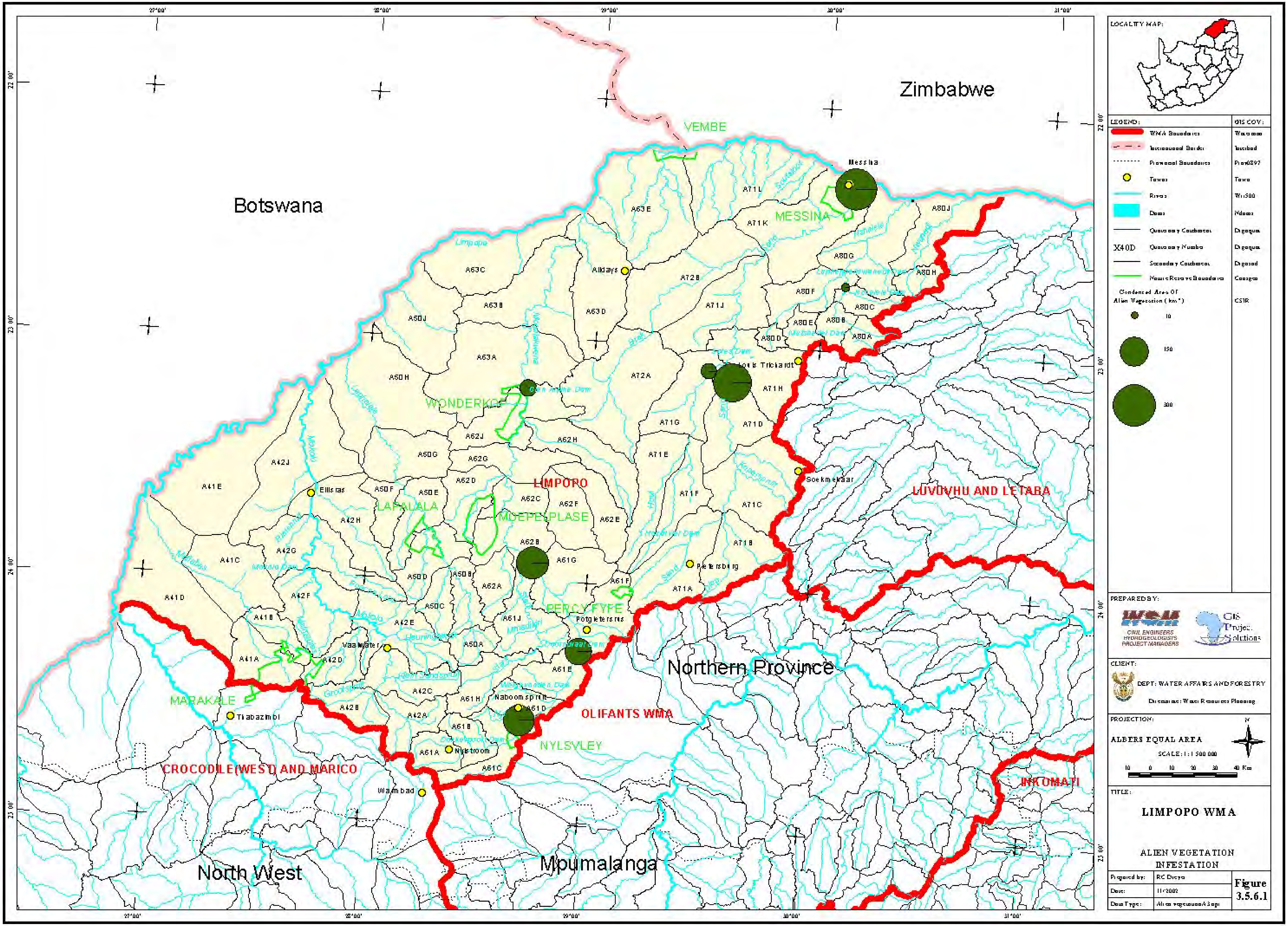
LAND USE

Prepared by:	RC Dicyo
Date:	04/2003

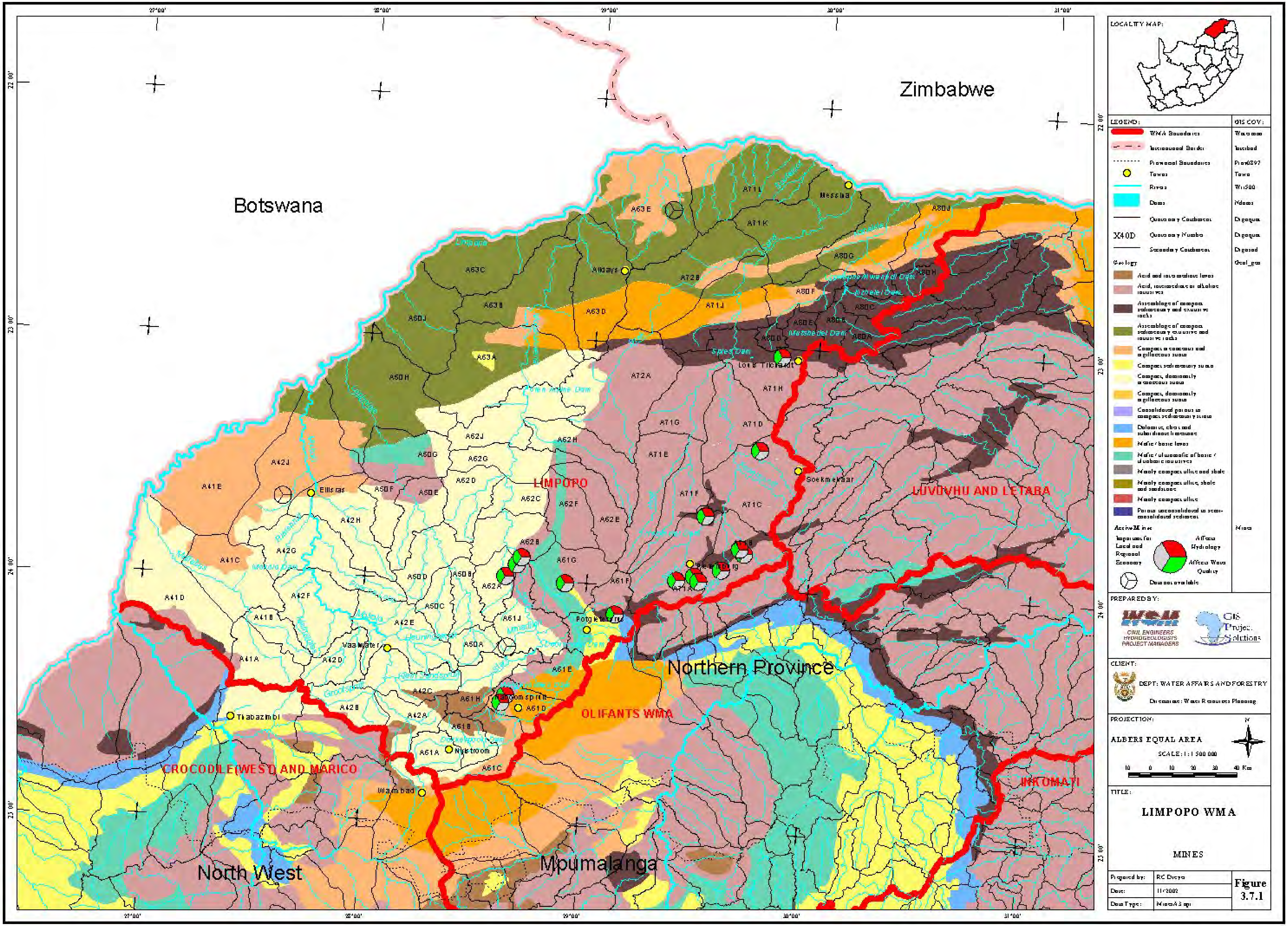
Figure 3.5.1.1



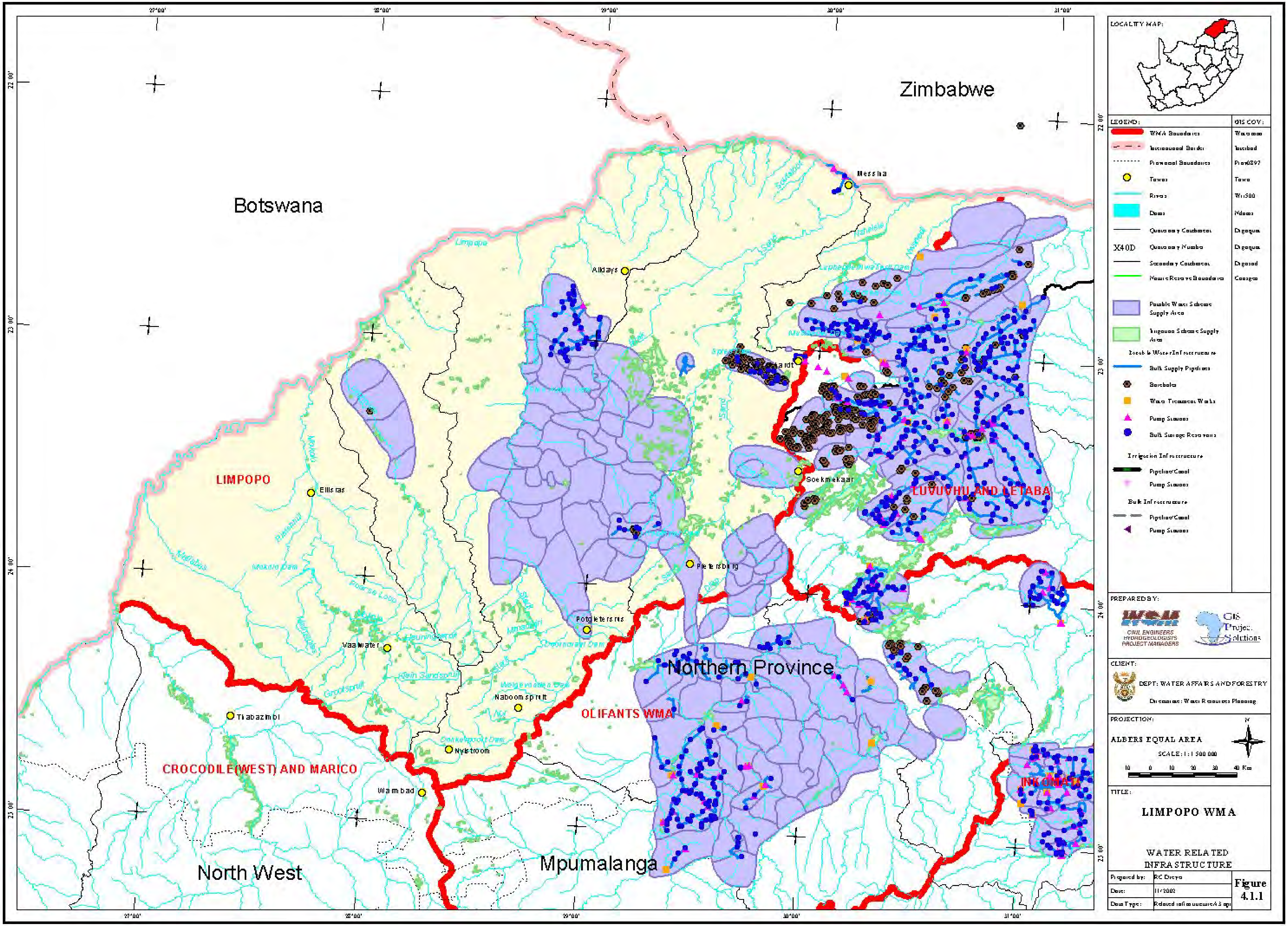
Zimbabwe
Botswana
VEMBE
Messina
MESSINA
A71L
A63E
A71K
A80J
Limpopo
A63C
Alldays
A72B
A80G
A80H
A80F
A63B
A63D
A71J
A80C
A50J
A80E
A80B
A80D
A80A
A63A
Louis Trichardt
A72A
A50H
WONDERKOP
A71H
A71G
A71D
A62J
A62H
A50G
A62G
A71E
A42J
A62D
LIMPOPO
Soekmekaar
A41E
Ellisras
A50E
A62C
A71F
LUVUVHU AND LETABA
LAPALALA
A62F
MOEPELPLASE
A71C
A42H
A50F
A62E
A62B
A71B
A42G
A41C
A61G
Pietersburg
A50D
A50B
A61F
A41D
A42F
A62A
A71A
PERCY FYFE
A50C
A61J
A41B
A42E
Potgietersrus
Vaalwater
A50A
A41A
A42D
Northern Province
A61E
A42C
A61H
Naboomspruit
MARAKALE
A42B
A61D
OLIFANTS WMA
Thabazimbi
A42A
A61B
NYLSVLEY
A61A
Nylstroom
CROCODILE (WEST) AND MARICO
A61C
Warmbad
INKOMATI
North West
Mpumalanga
LEGEND:
GIS COV:
X40D
WSAM
5 000
20 000
45 000
90 000
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
10 0 10 20 30 40 Km
TITLE:
LIMPOPO WMA
LIVESTOCK AND GAME NUMBERS
Figure 3.5.4.1



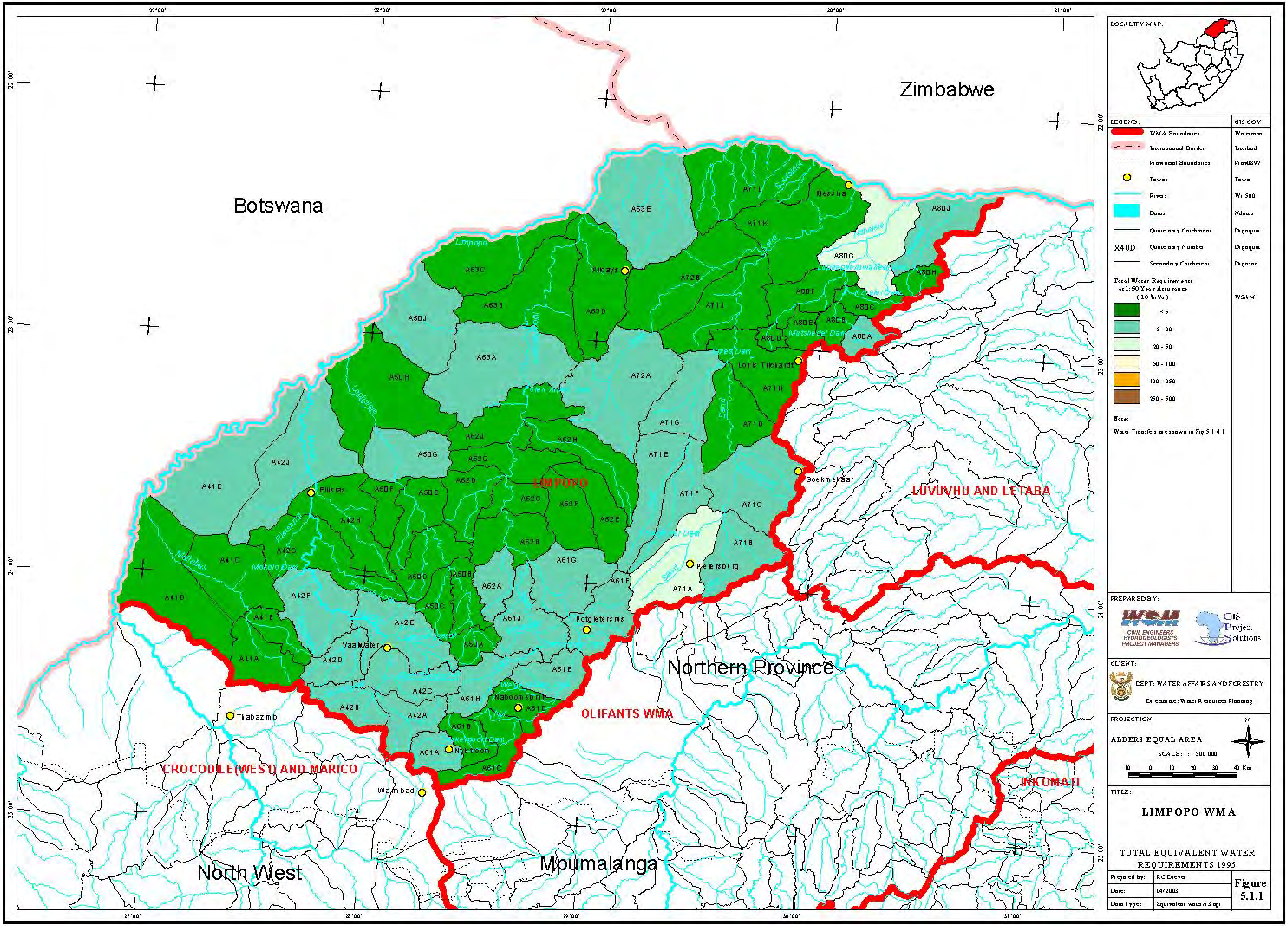
Zimbabwe
Botswana
VEMBE
MESSINA
WONDERKOP
LIMPOPO
LAPALALA
MOEPELPLASE
PERCY FYFE
MARAKALE
NYLSVLEY
OLIFANTS WMA
LUVUVHU AND LETABA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Ellisras
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
LOCALITY MAP:
LEGEND:
GIS COV:
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
ALIEN VEGETATION INFESTATION
Prepared by: RC Dreyer
Date: 11/2002
Figure 3.5.6.1



Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
Northern Province
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
North West
Mpumalanga
Alldays
Messina
Louis Trichardt
Soekmekaar
Ellisras
Vaalwater
Potgietersrus
Thabazimbi
Nylstroom
Warmbad
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
X40D
Geology
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
MINES
Figure 3.7.1



Zimbabwe
Botswana
Messina
Alldays
Limpopo
LIMPOPO
Ellisras
Pietersburg
Potgietersrus
Soekmekaar
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
X40D
Potable Water Scheme Supply Area
Bulk Supply Pipelines
Boreholes
Water Treatment Works
Pump Stations
Bulk Storage Reservoirs
Irrigation Infrastructure
Pipeline/Canal
Pump Stations
Bulk Infrastructure
Pipeline/Canal
Pump Stations
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
N
TITLE:
LIMPOPO WMA
WATER RELATED INFRASTRUCTURE
Prepared by:
Date:
Data Type:
Figure 4.1.1



Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
Towns
Rivers
Dams
X40D
< 5
5 - 20
20 - 50
50 - 100
100 - 250
250 - 500
WSAM
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
TOTAL EQUIVALENT WATER REQUIREMENTS 1995
Figure 5.1.1

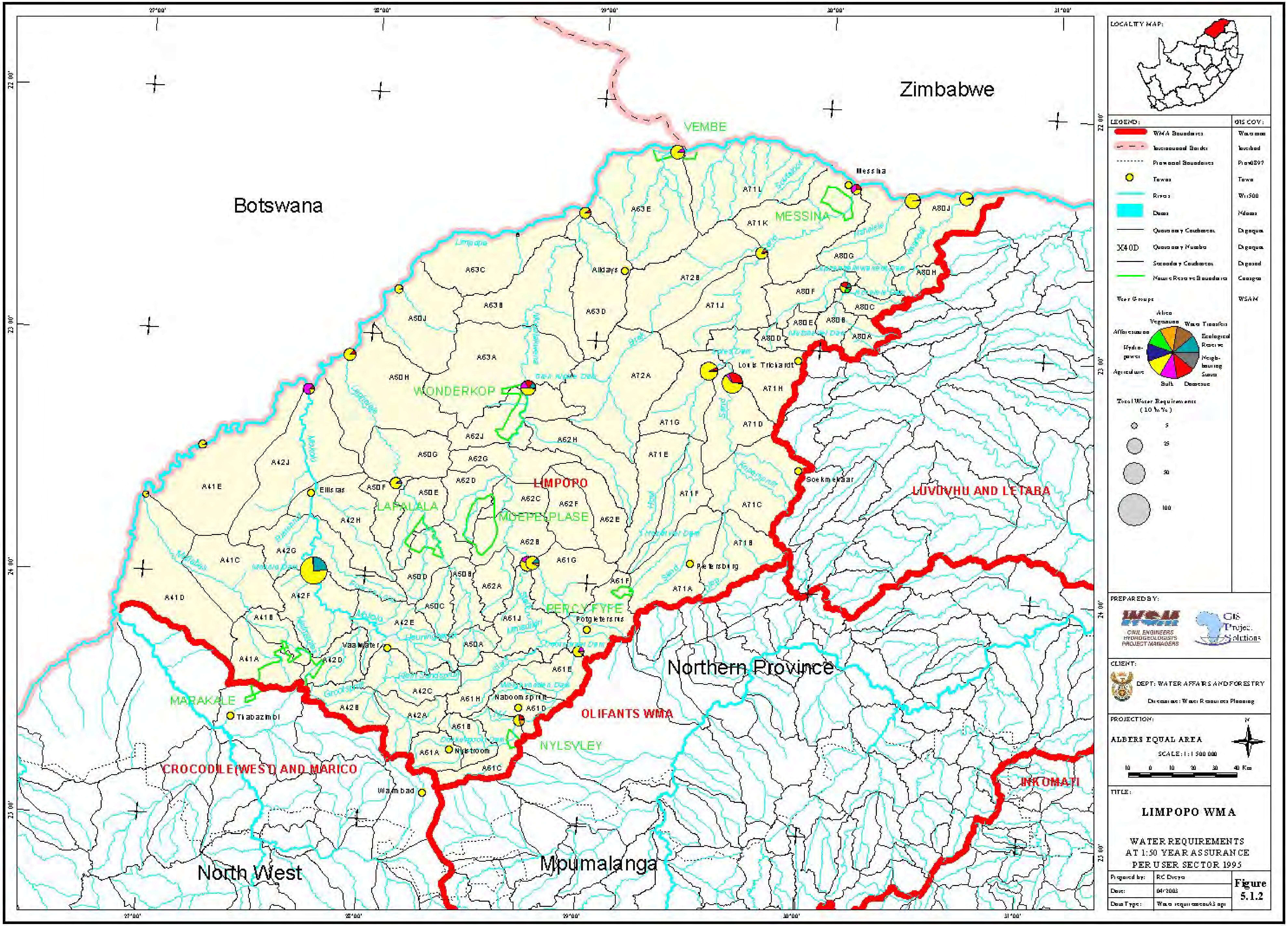
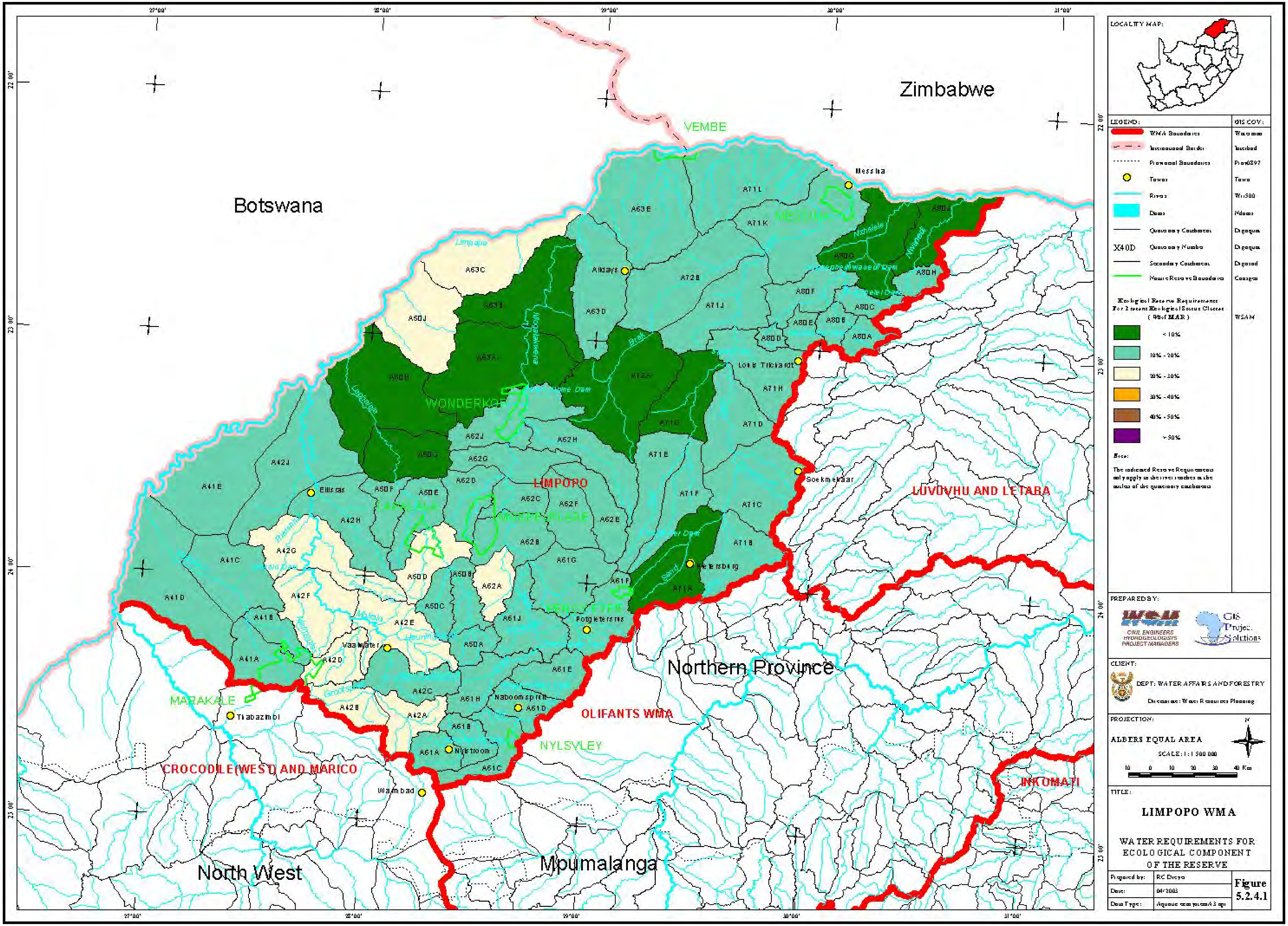

Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Alldays
Louis Trichardt
WONDERKOP
LIMPOPO
LAPALALA
MOEPELPLASE
Ellisras
Soekmekaar
LUVUVHU AND LETABA
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
MARAKALE
Northern Province
Naboomspruit
OLIFANTS WMA
Thabazimbi
NYLSVLEY
Nylstroom
CROCODILE (WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
Total Water Requirement
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE PER USER SECTOR 1995
Figure 5.1.2

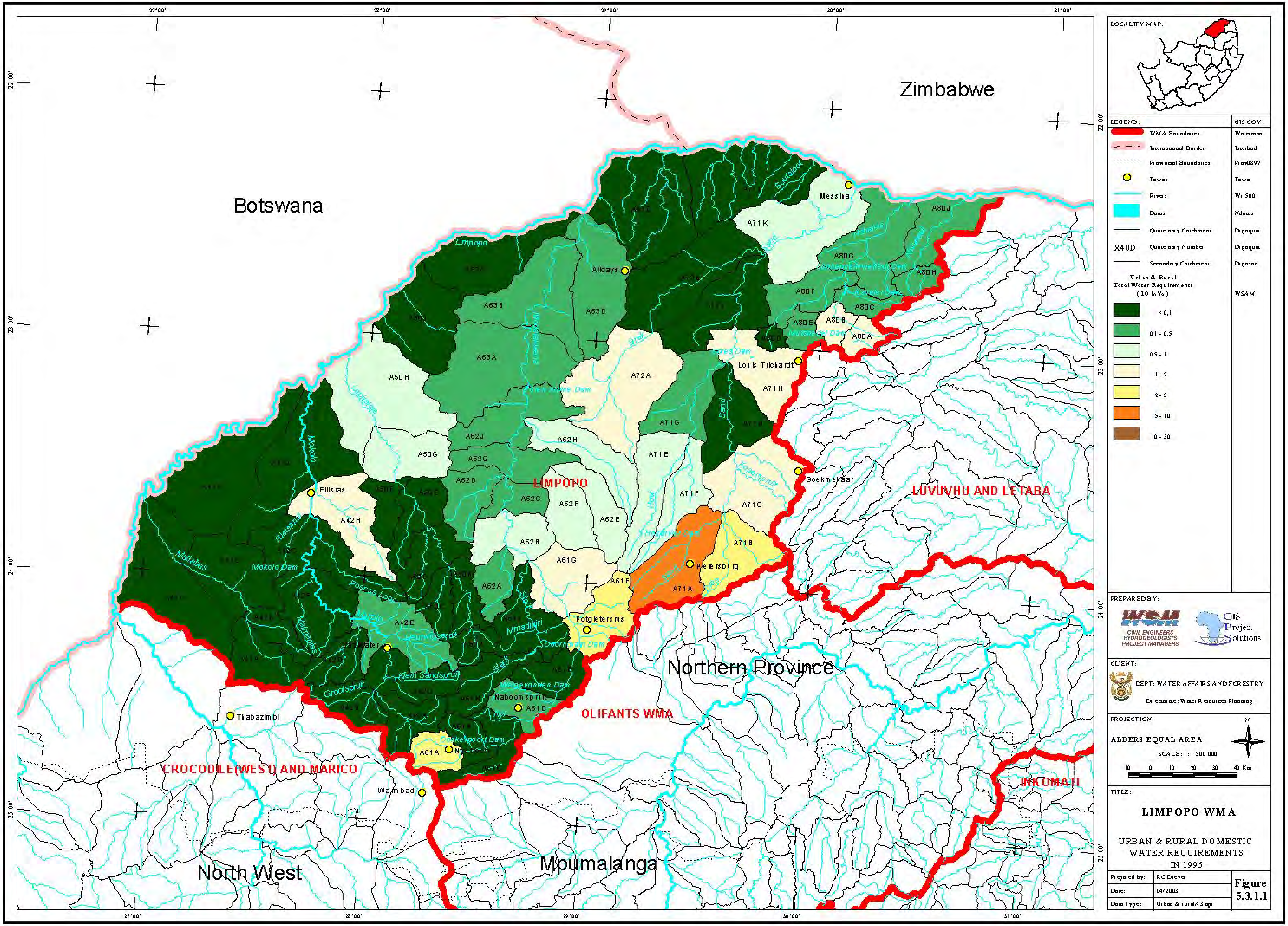
FIGURE 5.2.1.1: DESKTOP RESERVE PARAMETER REGIONS

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.

IT IS AVAILABLE IN HARD COPY FROM:

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCES PLANNING


Zimbabwe
Botswana
Northern Province
Mpumalanga
North West
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
VEMBE
WONDERKOP
MOKOLOLA
MORIPEPLAAS
MARAKALE
NYLSVLEY
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
Vaalwater
Ellisras
LOCALITY MAP:
LEGEND:
GIS COV:
Ecological Reserve Requirements For Present Ecological Status Classes (% of MAR)
< 10%
10% - 20%
20% - 30%
30% - 40%
40% - 50%
> 50%
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE
Figure 5.2.4.1



Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Thabazimbi
Warmbad
Limpopo
Mokolo Dam
Doorndraai Dam
Welgevonden Dam
Klein Sandspruit
Grootspruit
Mogalakwena
Sand
A71K
A80J
A80G
A80H
A80F
A80C
A80E
A80B
A80A
A63B
A63D
A63A
A50H
A72A
A71H
A71G
A62H
A62J
A50G
A62G
A62D
A71E
A71F
A71C
A62C
A62F
A62E
A42H
A62B
A71B
A61G
A61F
A71A
A62A
A42E
A61D
A61A
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Urban & Rural Total Water Requirements
< 0,1
0,1 - 0,5
0,5 - 1
1 - 2
2 - 5
5 - 10
10 - 30
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
URBAN & RURAL DOMESTIC WATER REQUIREMENTS IN 1995
Prepared by: RC Dreyer
Date: 04/2003
Figure 5.3.1.1

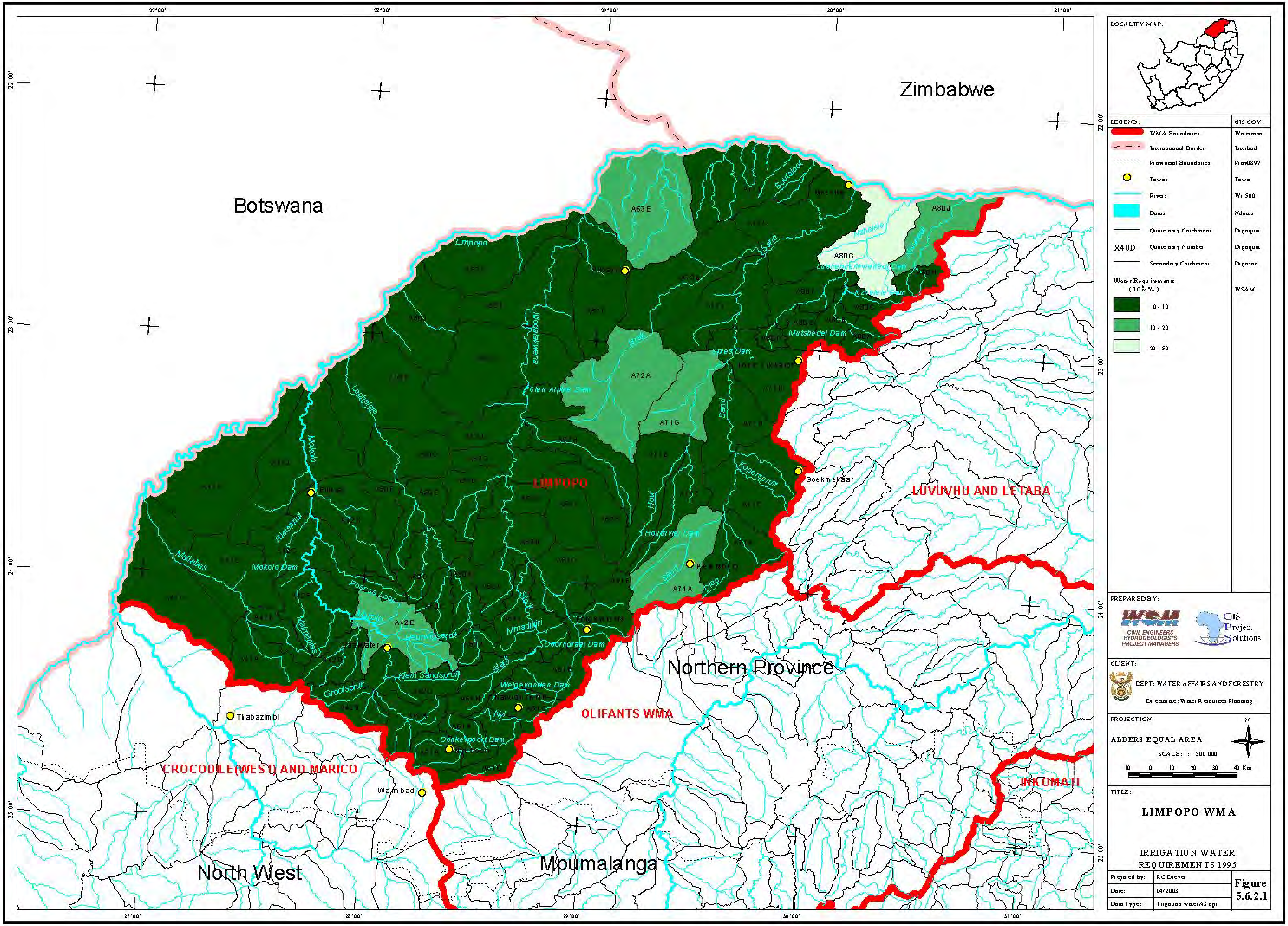
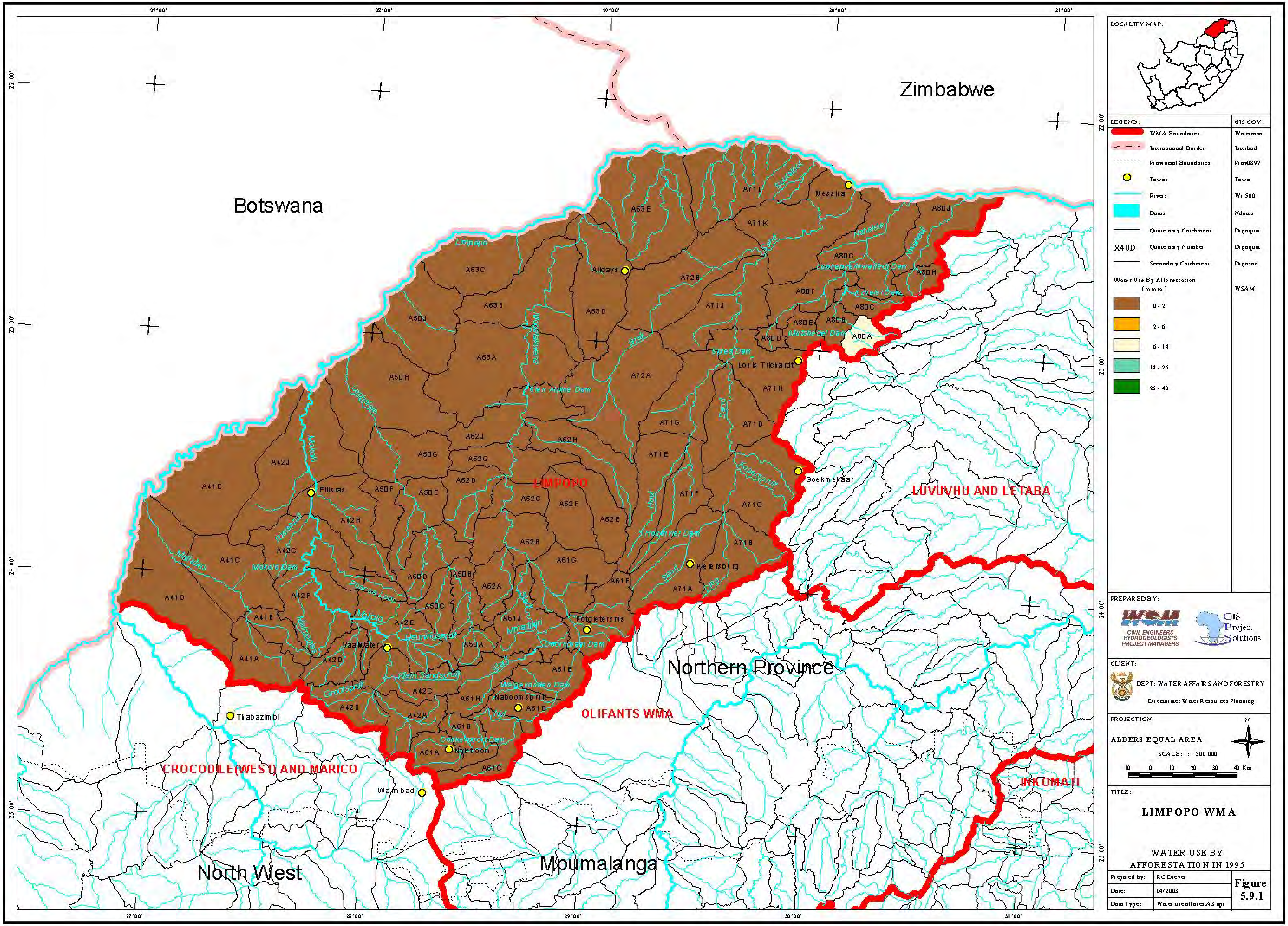
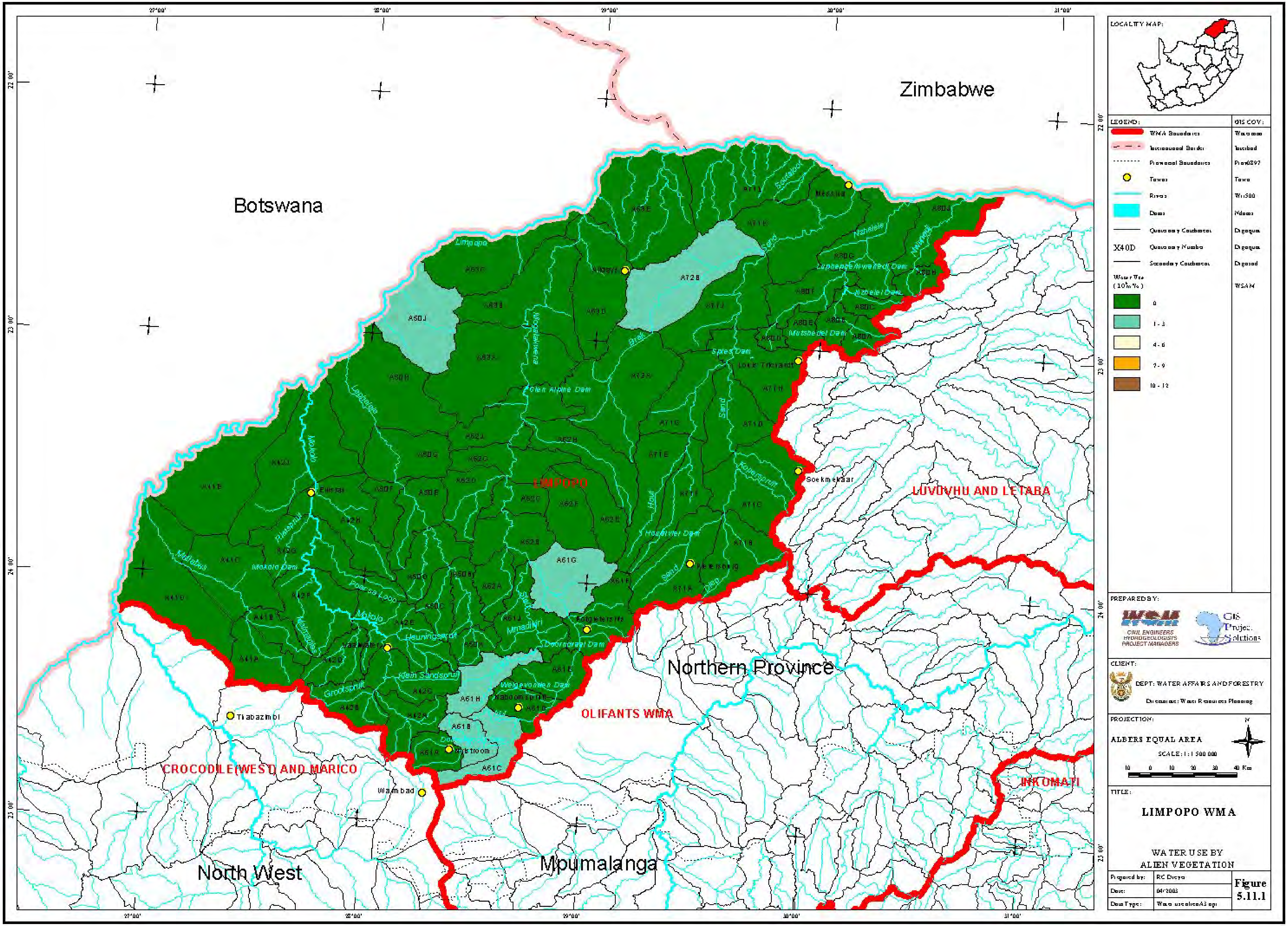
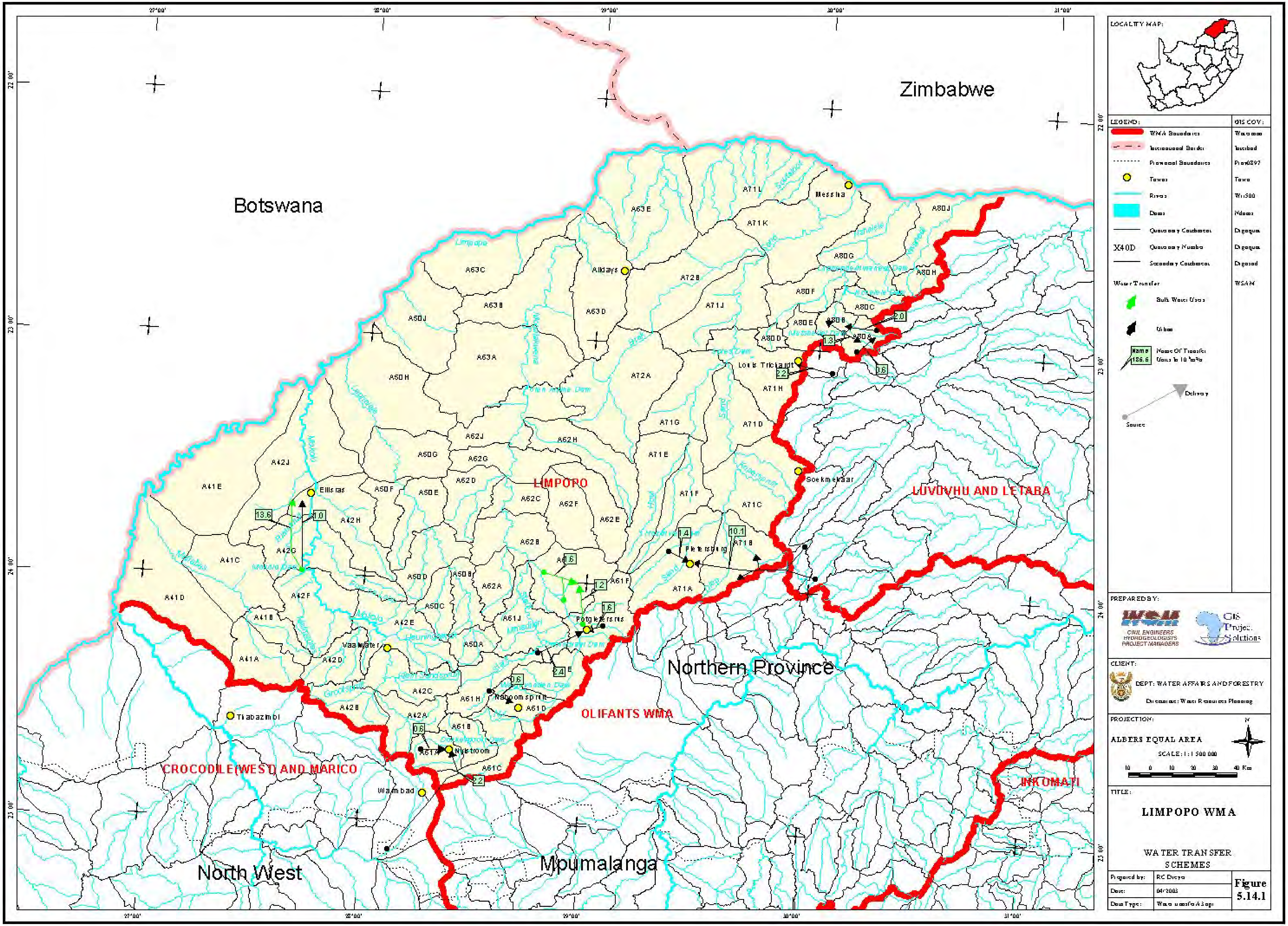

Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
Northern Province
OLIFANTS WMA
CROCODILE (WEST) AND MARICO
INKOMATI
North West
Mpumalanga
A63E
A72A
A71G
A80G
A80J
A42E
A71A
Limpopo
Mogalakwena
Mokolo
Lephalala
Sand
Hout
Kopersprut
Matlabas
Mokolo Dam
Glen Alpine Dam
Houtrivier Dam
Doorndraai Dam
Welgevonden Dam
Donkerpoort Dam
Klein Sandspruit
Grootspruit
Nyl
Mmadikiri
Soekmekaar
Thabazimbi
Warmbad
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Water Requirements
0 - 10
10 - 20
20 - 50
WSAM
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
IRRIGATION WATER REQUIREMENTS 1995
Prepared by:
Date:
Data Type:

Figure 5.6.2.1

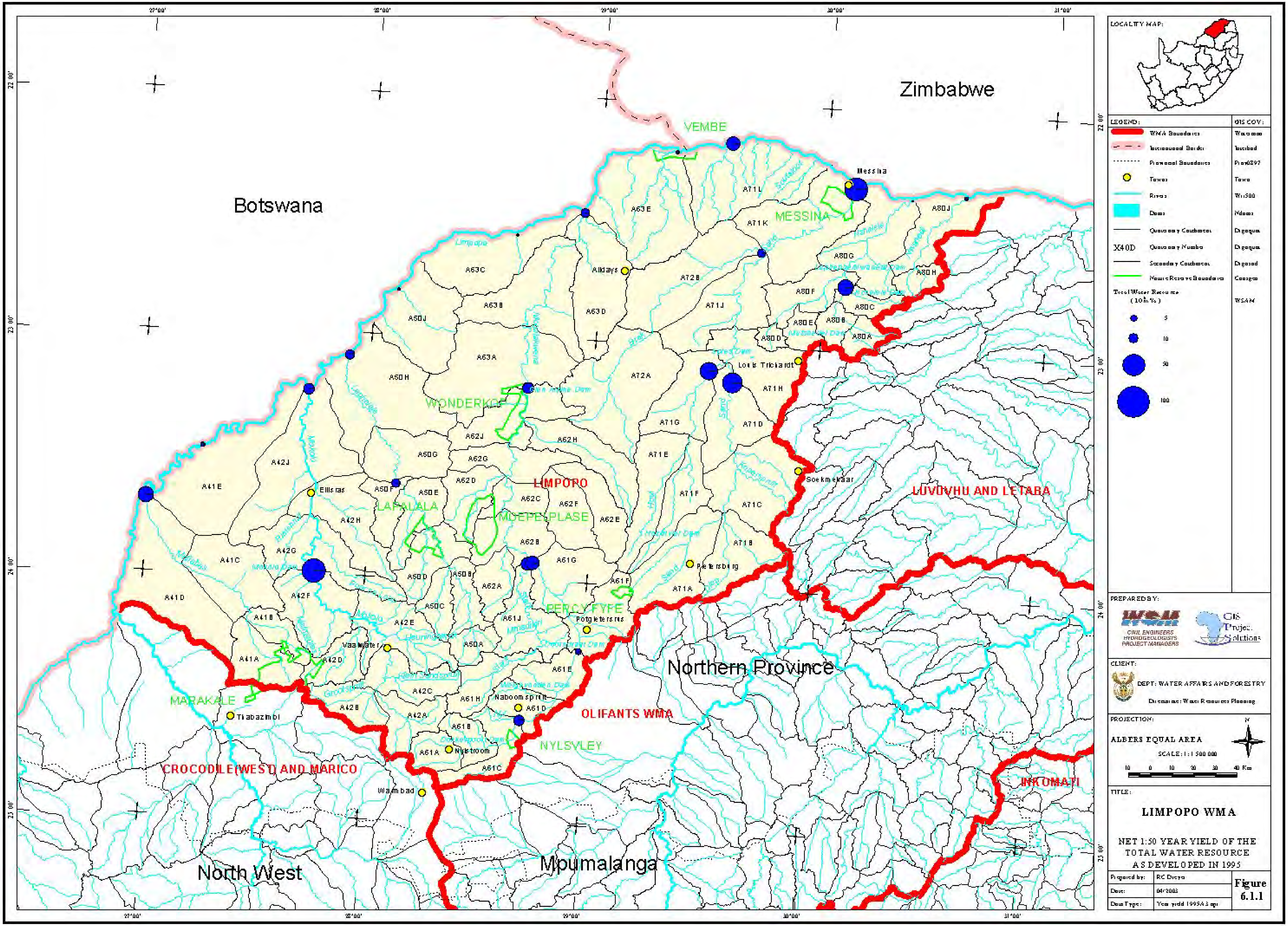


Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Thabazimbi
Naboomspruit
Nylstroom
Warmbad
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
WSAM
0 - 2
2 - 6
6 - 14
14 - 26
26 - 40
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
WATER USE BY AFFORESTATION IN 1995
Figure 5.9.1

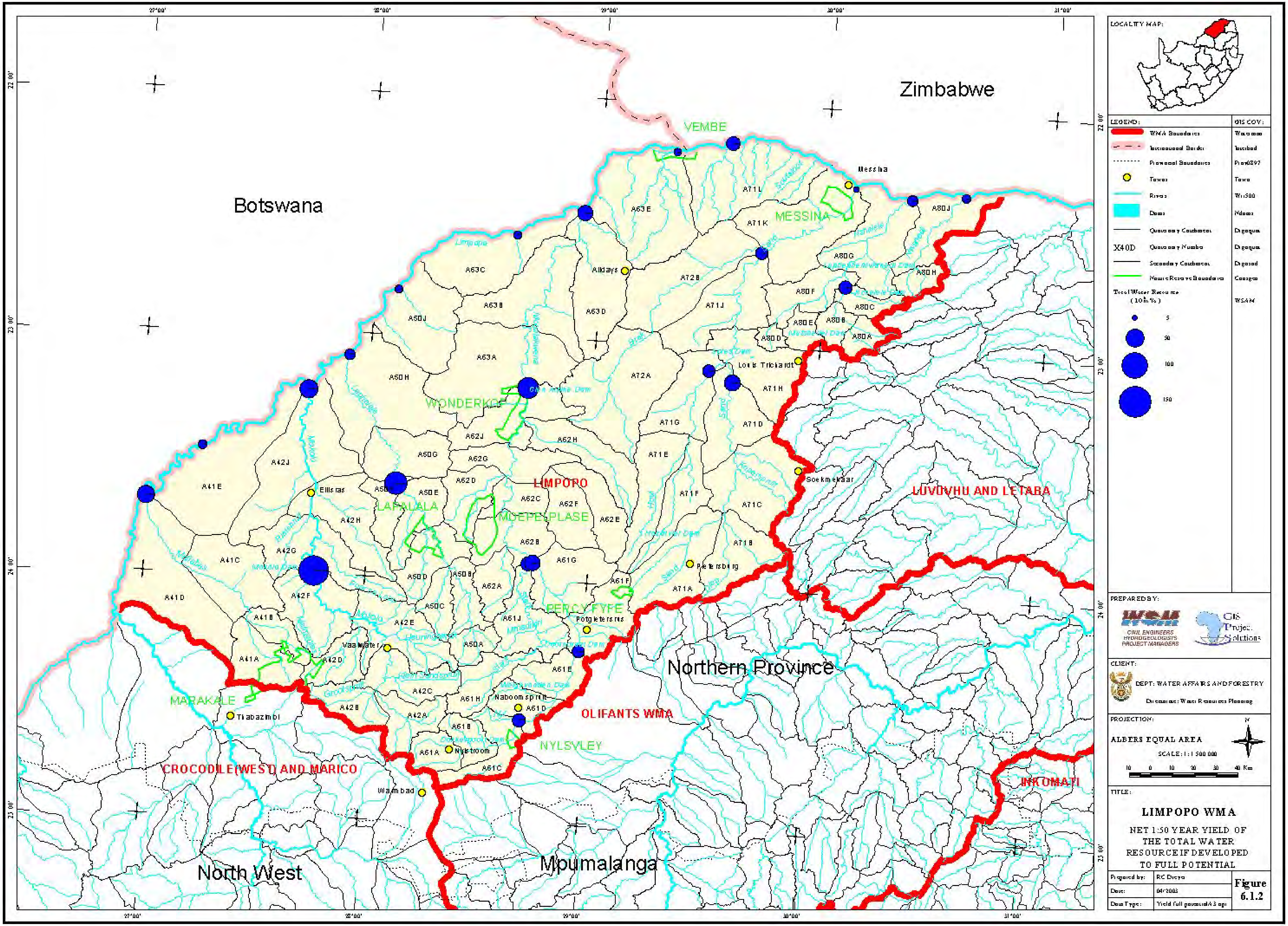

Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
Northern Province
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Tabazimbi
Warmbad
Mokolo
Mokolo Dam
Limpopo
Sand
Hout
Glen Alpine Dam
Houtrivier Dam
Doorndraai Dam
Welgevonden Dam
Klein Sandsoru
Groot spruit
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Water Use (10⁶m³/a)
0
1 - 3
4 - 6
7 - 9
10 - 12
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
WATER USE BY ALIEN VEGETATION
Prepared by: RC Drdya
Date: 04/2003
Figure 5.11.1

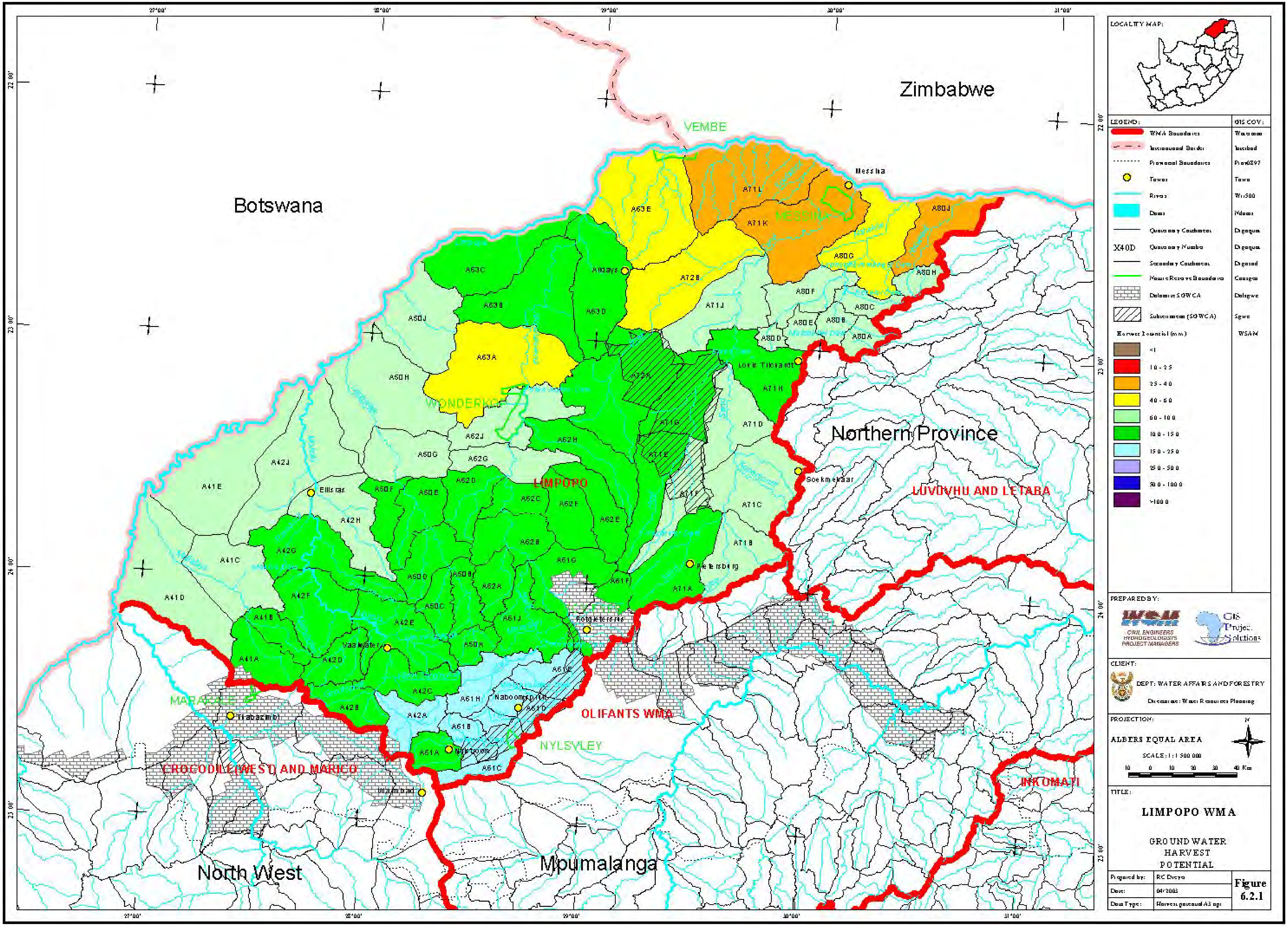


Zimbabwe
Botswana
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
Mpumalanga
North West
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Water Transfer
Bulk Water Users
Urban
Delivery
Source
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
WATER TRANSFER SCHEMES
Prepared by:
RC Dreyer
Date:
04/2003
Figure 5.14.1



Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Alldays
Louis Trichardt
WONDERKOP
LIMPOPO
Soekmekaar
LUVUVHU AND LETARA
Ellisras
LAPALALA
MOEPELPLASE
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
Northern Province
MARAKALE
Thabazimbi
Naboomspruit
OLIFANTS WMA
NYLSVLEY
Nylstroom
CROCODILE(WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
GIS COV:
Total Water Resource
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE AS DEVELOPED IN 1995
Prepared by: RC Dreyer
Figure 6.1.1


Zimbabwe
Botswana
VEMBE
MESSINA
Messina
Alldays
Louis Trichardt
WONDERKOP
LIMPOPO
LAPALALA
MOEPELPLASE
Soekmekaar
LUVUVHU AND LETABA
Ellisras
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
Northern Province
MARAKALE
Thabazimbi
Naboomspruit
OLIFANTS WMA
NYLSVLEY
Nylstroom
CROCODILE(WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
Total Water Resource
5
50
100
150
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE IF DEVELOPED TO FULL POTENTIAL
Prepared by: RC Dreyer
Date: 04/2003
Figure 6.1.2



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Northern Province
LIMPOPO
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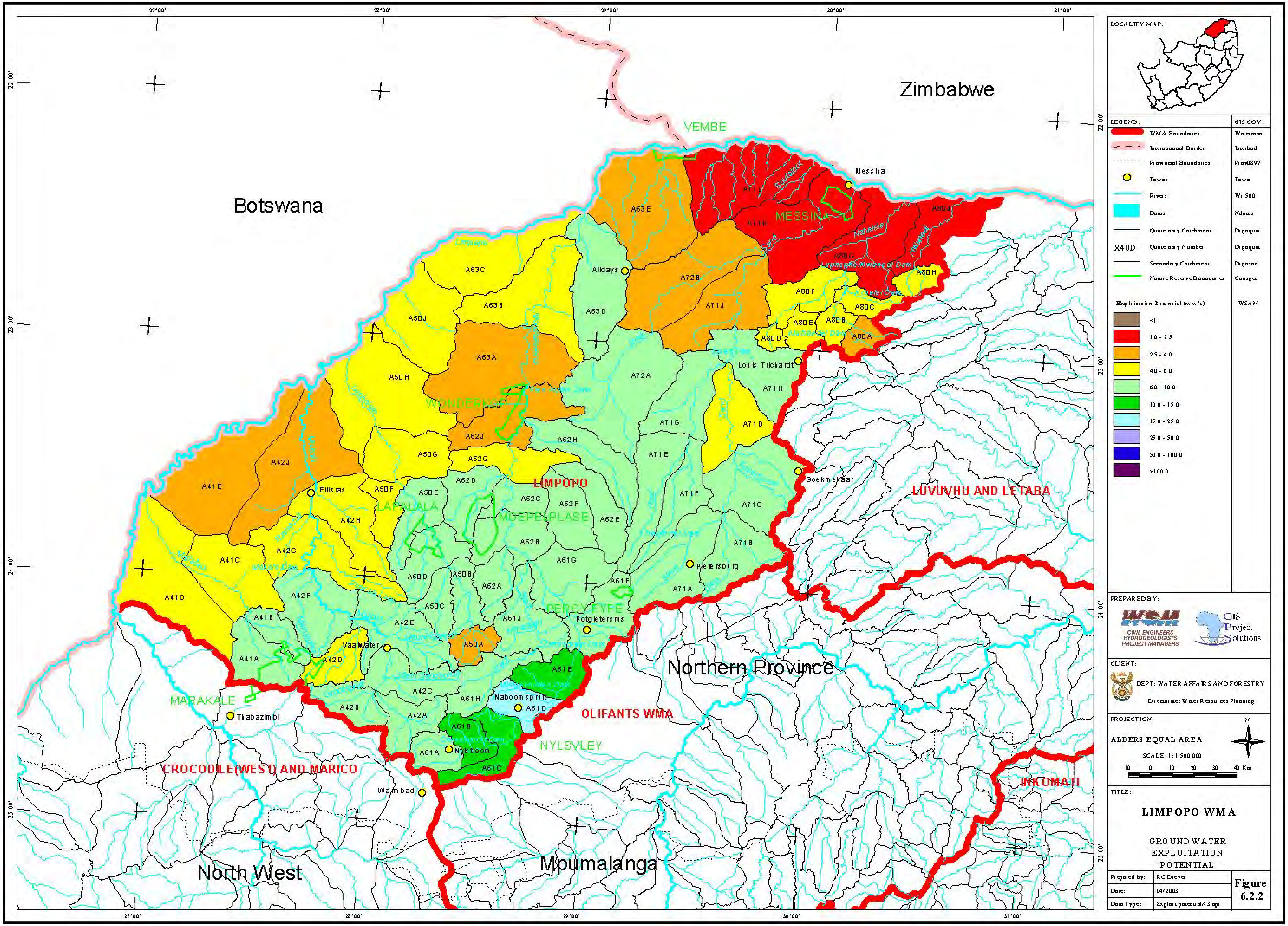
Soekmekaar
LUVUVHU AND LETABA
Pietersburg
Potgietersrus
Vaalwater
MARAKELE
Thabazimbi
Naboomspruit
OLIFANTS WMA
NYLSVLEY
Nylstroom
CROCODILE (WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
Towns
Rivers
Dams
X40D
Dolomite SOWCA
Harvest Potential (mm)
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
GROUND WATER HARVEST POTENTIAL
Prepared by:
RC Dreyer
Date:
04/2003
Figure 6.2.1



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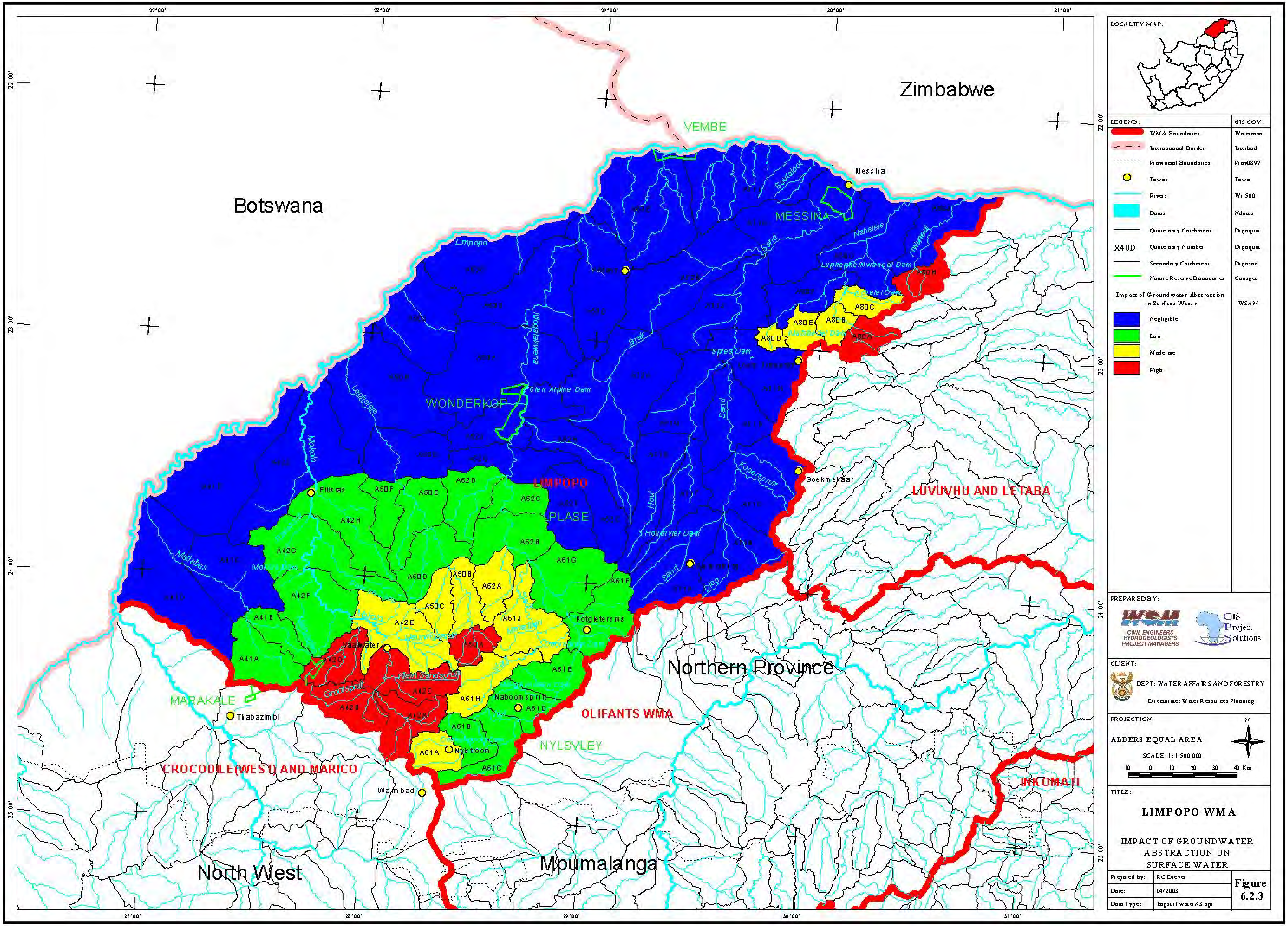
LIMPOPO
Pietersburg
Potgietersrus
PERCY FYFE
Vaalwater
Naboomspruit
Nylstroom
NYLSVLEY
MARAKALE
Thabazimbi
Warmbad
Northern Province
OLIFANTS WMA
LUVUVHU AND LETABA
CROCODILE (WEST) AND MARICO
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
GIS COV:
<1
10 - 25
25 - 40
40 - 60
60 - 100
100 - 150
150 - 250
250 - 500
500 - 1000
>1000
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
GROUND WATER EXPLOITATION POTENTIAL
Figure 6.2.2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VEMBE
MESSINA
WONDERKOP
PLASE
MARAKALE
NYLSVLEY
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Soekmekaar
Ellisras
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
Limpopo
Mogalakwena
Glen Alpine Dam
Sand
Nzhelele
Houtrivier Dam
Groot spruit
Klein Sandspruit
A80H
A80C
A80E
A80B
A80D
A80A
A50F
A50E
A62D
A62C
A42H
A42G
A62B
A61G
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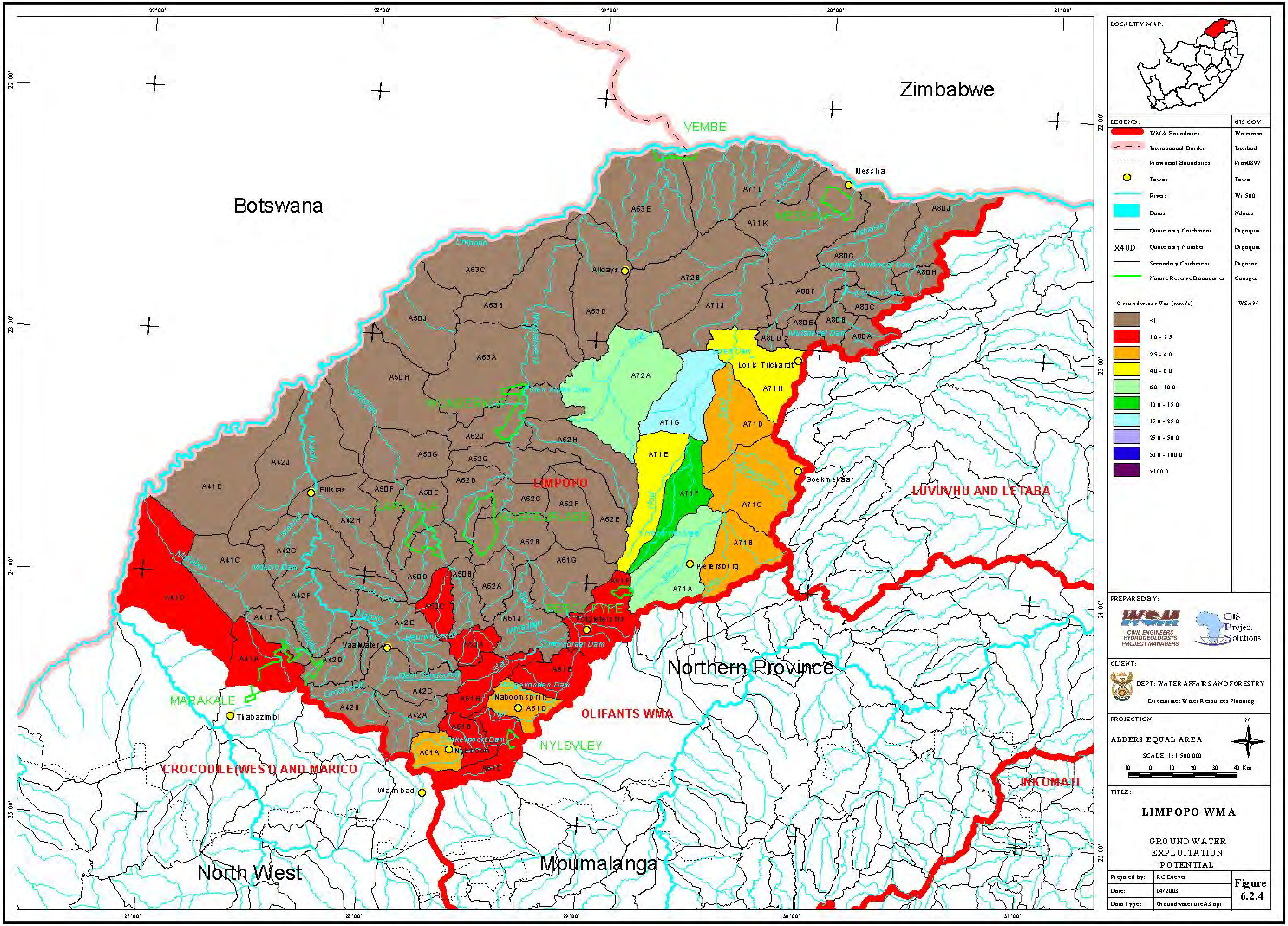
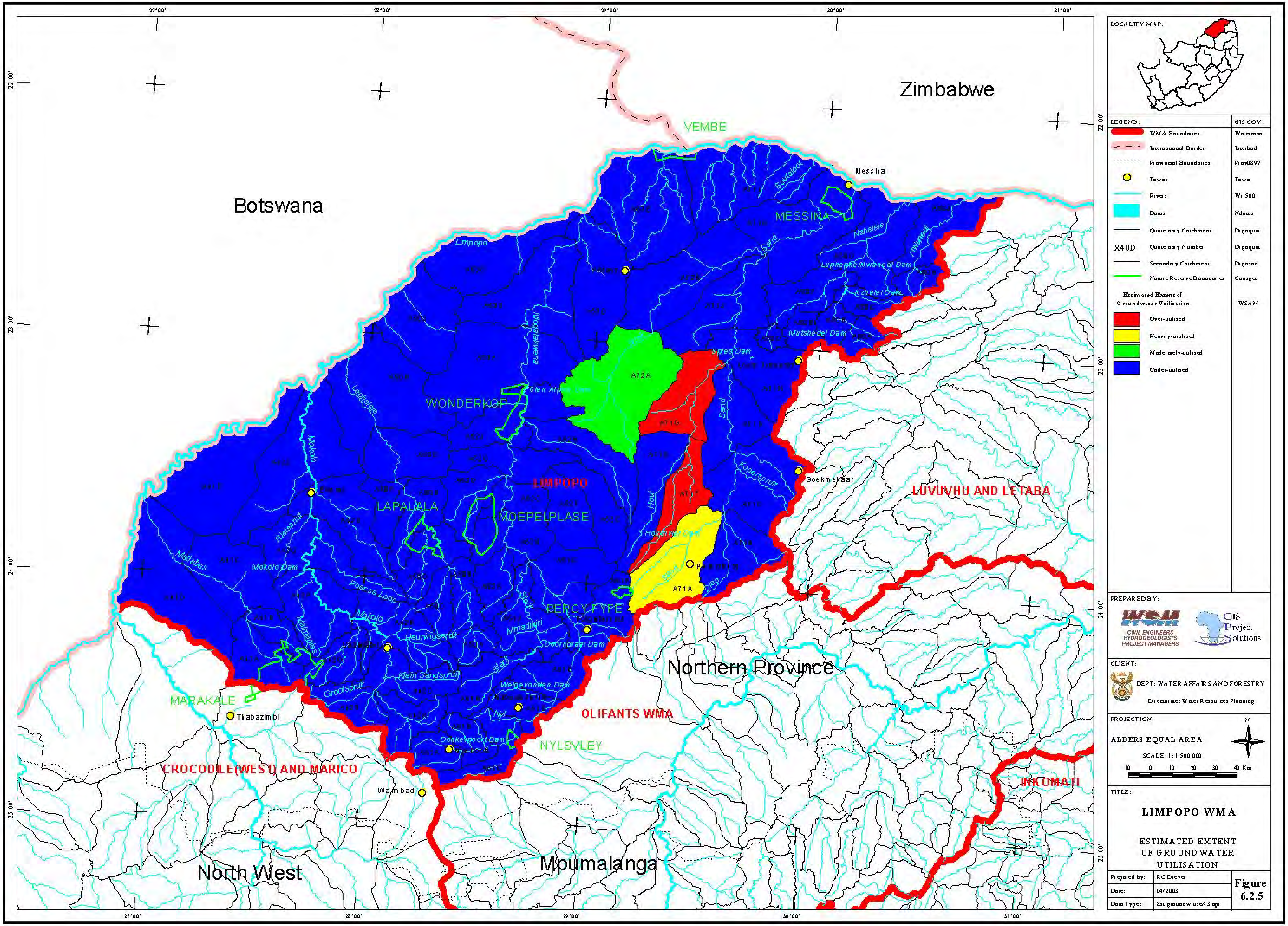
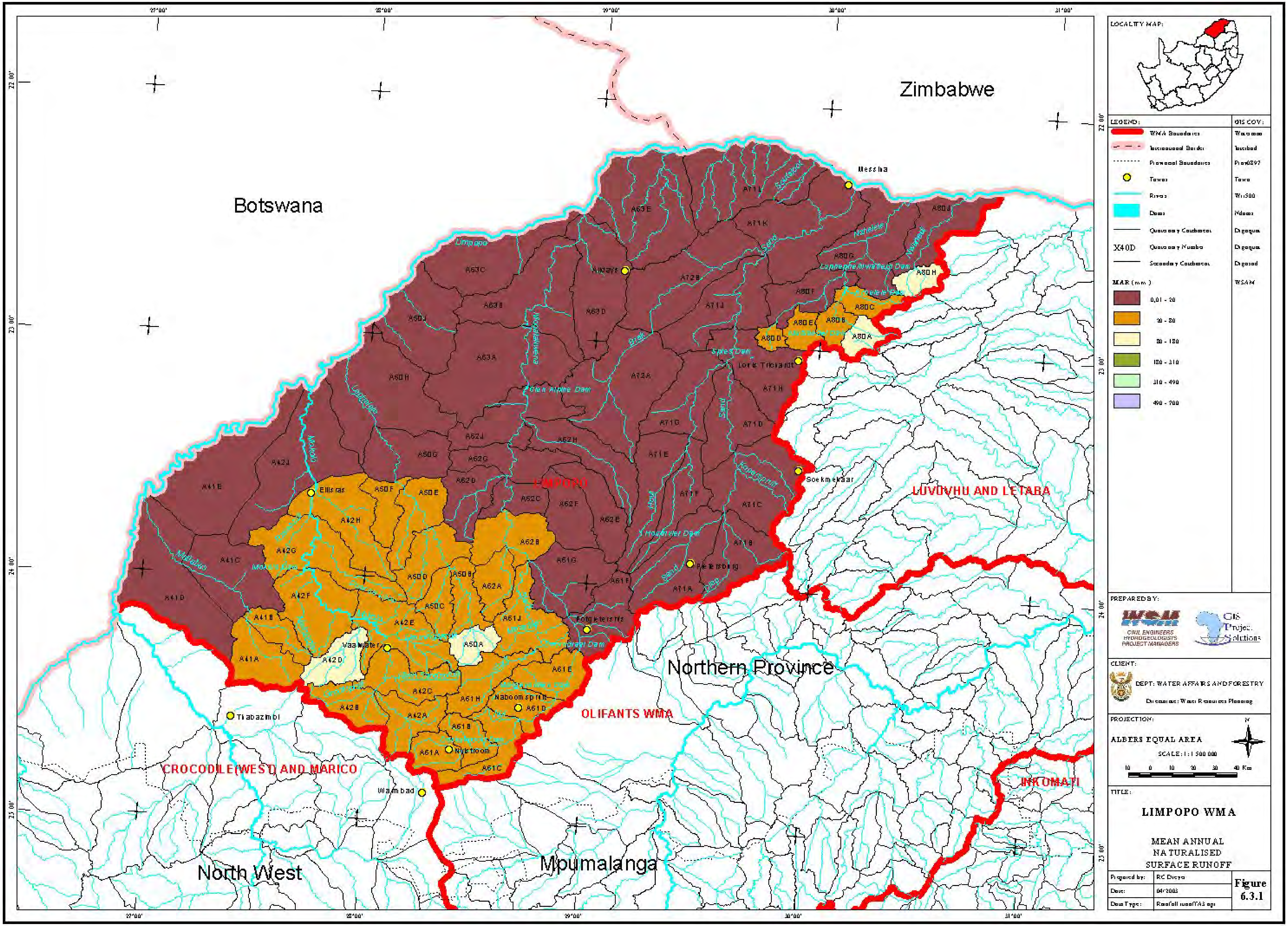
A50C
A42E
A61J
A41B
A41A
A42C
A61E
A61H
A61D
A42B
A61B
A61A
A61C
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
Negligible
Low
High
WSAM
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
TITLE:
LIMPOPO WMA
IMPACT OF GROUNDWATER ABSTRACTION ON SURFACE WATER
Figure 6.2.3


Zimbabwe
Botswana
VEMBE
Messina
LIMPOPO
LUVUVHU AND LETABA
Northern Province
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
North West
Mpumalanga
MARAKALE
NYLSVLEY
Louis Trichardt
Soekmekaar
Pietersburg
Alldays
Ellisras
Vaalwater
Thabazimbi
Naboomspruit
Nylstroom
Warmbad
Potgietersrus
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Groundwater Use (mm/a)
<1
1.0 - 2.5
2.5 - 4.0
4.0 - 6.0
6.0 - 10.0
10.0 - 15.0
15.0 - 25.0
25.0 - 50.0
50.0 - 100.0
>100.0
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
GROUND WATER EXPLOITATION POTENTIAL
Figure 6.2.4



Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Limpopo
WONDERKOP
LIMPOPO
LAPALALA
MOEPELPLASE
PERCY FYFE
MARAKALE
Thabazimbi
Warmbad
NYLSVLEY
OLIFANTS WMA
CROCODILE (WEST) AND MARICO
LUVUVHU AND LETABA
Northern Province
Mpumalanga
North West
INKOMATI
Soekmekaar
A72A
A71D
A71F
A71A
LOCALITY MAP:
LEGEND:
WMA Boundaries
Towns
Rivers
Dams
Estimated Extent of Groundwater Utilisation
Over-utilised
Heavily-utilised
Moderately-utilised
Under-utilised
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
ESTIMATED EXTENT OF GROUNDWATER UTILISATION
Figure 6.2.5


Zimbabwe
Botswana
Northern Province
Mpumalanga
North West
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
Limpopo
Mokolo
Mogalakwena
Sand
Nzhelele
Glen Alpine Dam
Houtrivier Dam
Mokolo Dam
Doorndraai Dam
Lupepe/Nwanedi Dam
Nzhelele Dam
Albasini Dam
Luvuvhu
Hout
Sand
Diep
A41A
A41B
A41C
A41D
A41E
A42A
A42B
A42C
A42D
A42E
A42F
A42G
A42H
A42J
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A71F
A71G
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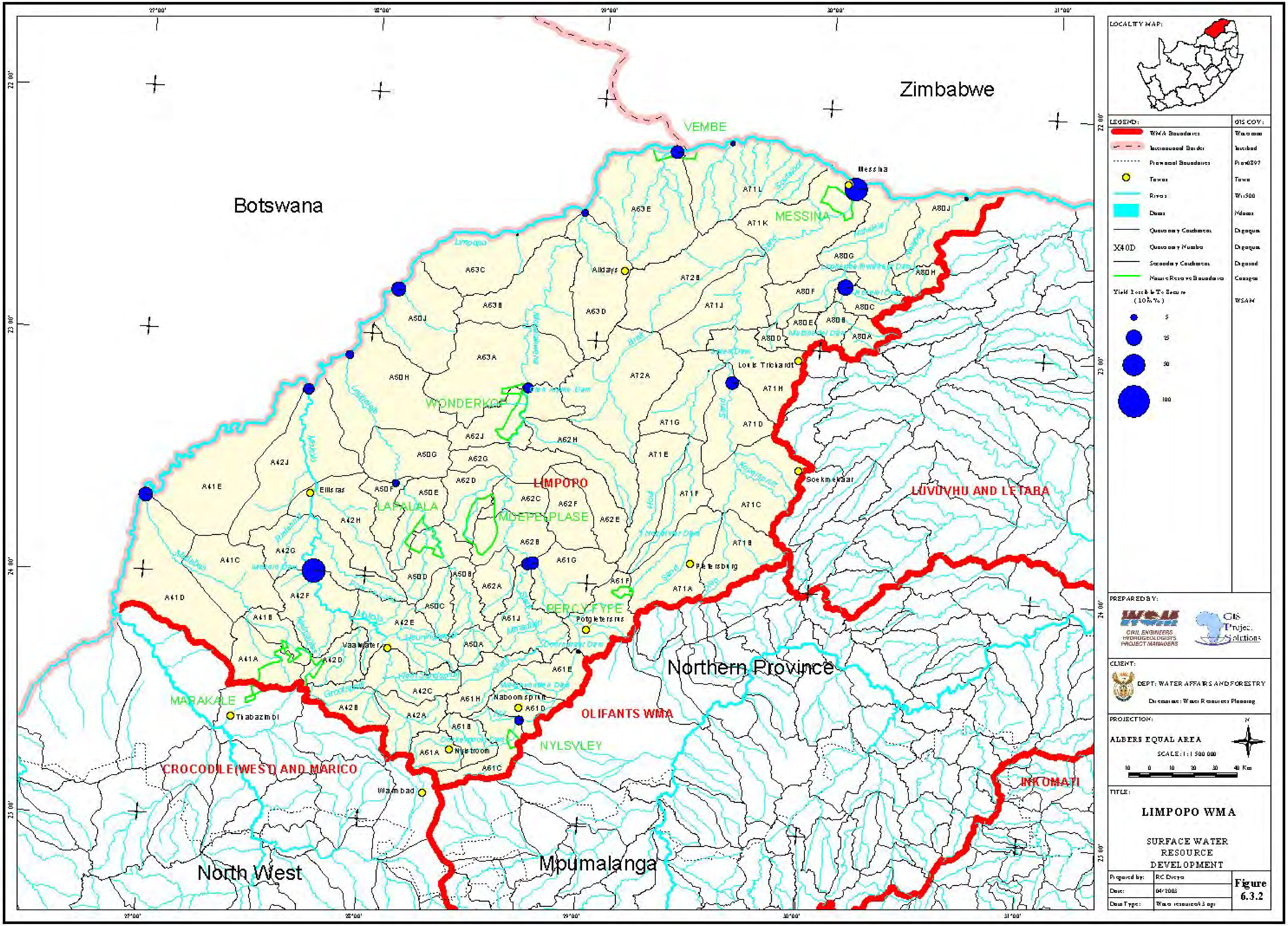
A71K
A71L
A72A
A72B
A80A
A80B
A80C
A80D
A80E
A80F
A80G
A80H
A80J
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
MAR (mm)
0,01 - 20
20 - 80
80 - 150
150 - 310
310 - 490
490 - 700
PREPARED BY:
WSM
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
MEAN ANNUAL
NATURALISED
SURFACE RUNOFF
Prepared by:
RC Dreyer
Date:
04/2003
Figure
6.3.1



Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Alldays
WONDERKOP
LIMPOPO
LUVUVHU AND LETABA
Louis Trichardt
Soekmekaar
Ellisras
LAPALALA
MOEPEL PLASE
Pietersburg
PERCY FYFE
Potgietersrus
Vaalwater
MARAKALE
Thabazimbi
Naboomspruit
Nylstroom
NYLSVLEY
OLIFANTS WMA
Northern Province
CROCODILE(WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
Limpopo
Mogalakwena
Mokolo
Sand
Hout
A41A
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A42D
A42E
A42F
A42G
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A80C
A80D
A80E
A80F
A80G
A80H
A80J
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
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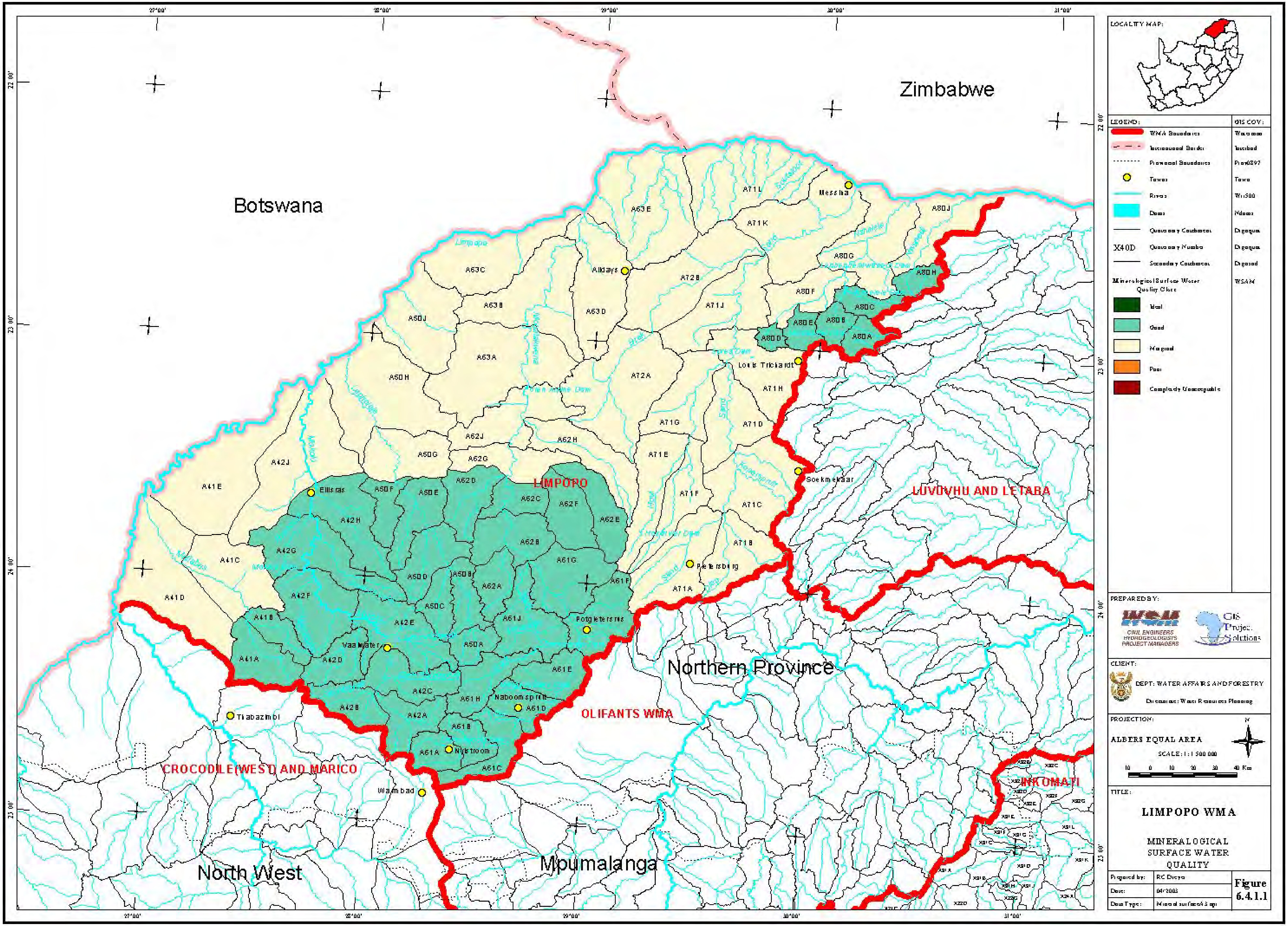
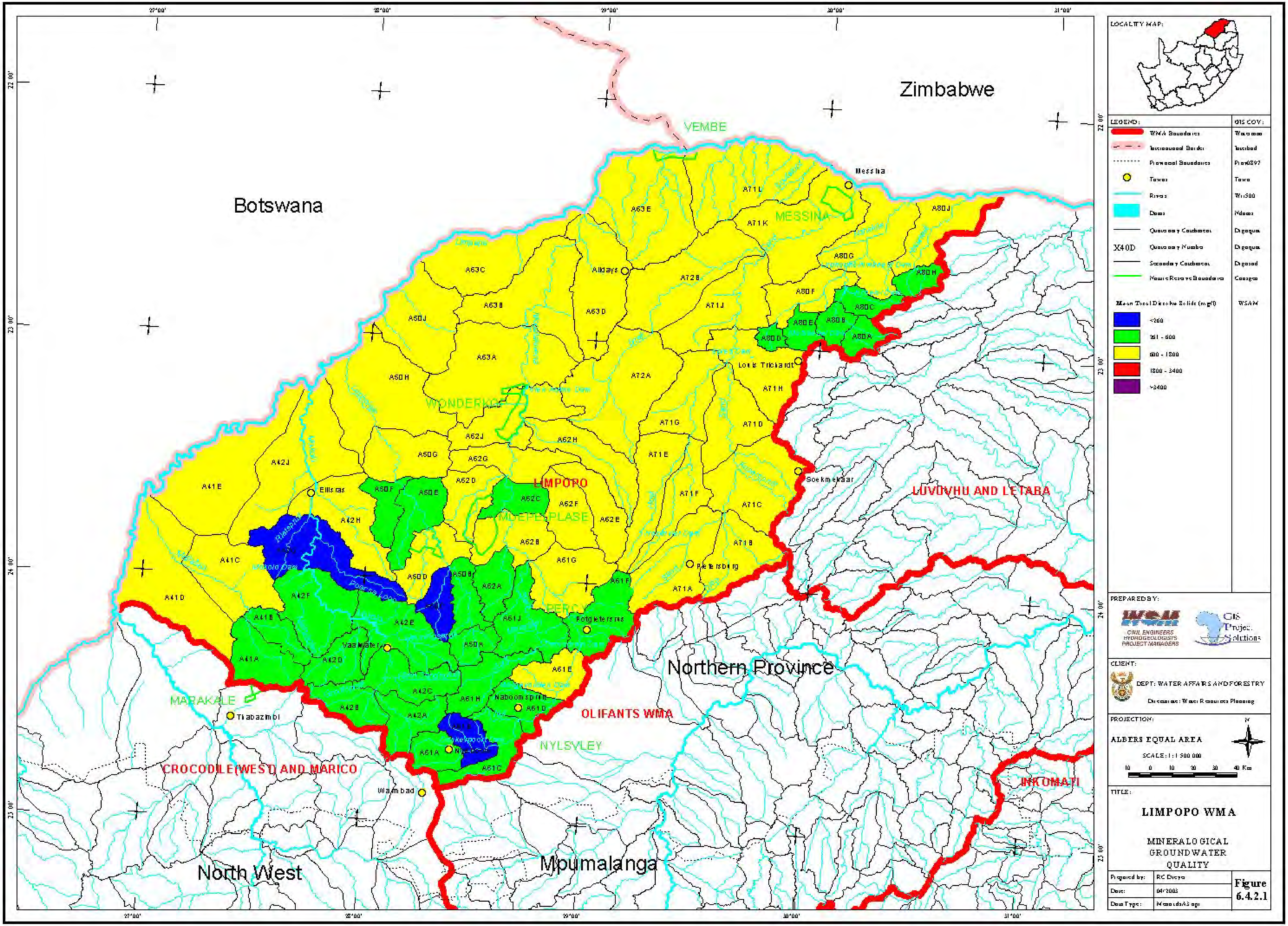
TITLE:
LIMPOPO WMA
SURFACE WATER RESOURCE DEVELOPMENT
Prepared by:
Date:
Data Type:
Figure 6.3.2


Zimbabwe
Botswana
Northern Province
Mpumalanga
North West
LIMPOPO
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
LOCALITY MAP:
LEGEND:
GIS COV:
Ideal
Good
Marginal
Poor
Completely Unacceptable
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
MINERALOGICAL SURFACE WATER QUALITY
Prepared by: RC Dreyer
Date: 04/2003
Figure 6.4.1.1



Zimbabwe
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LIMPOPO
LUVUVHU AND LETABA
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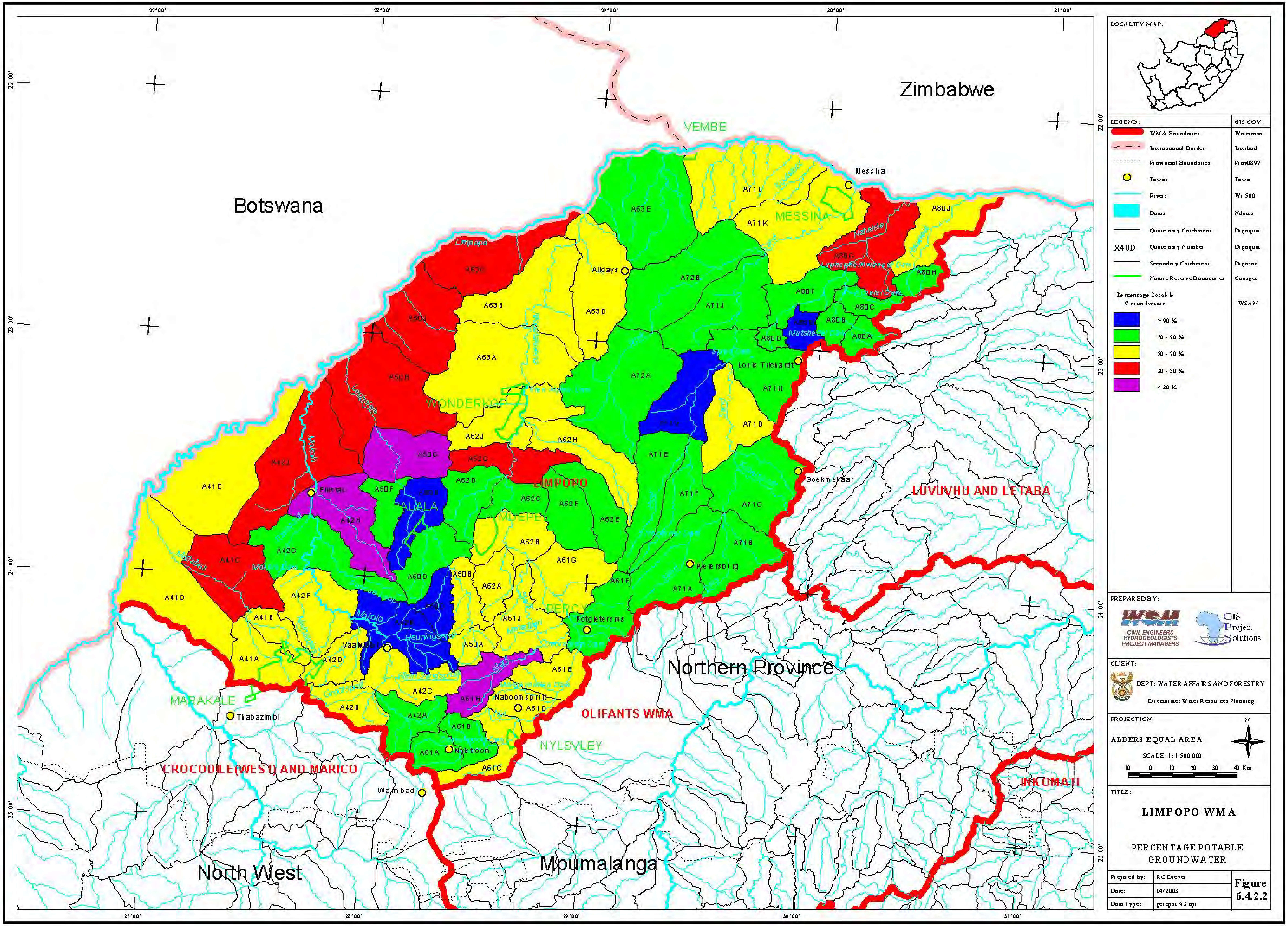
CROCODILE(WEST) AND MARICO
INKOMATI
VEMBE
MESSINA
WONDERKOP
MOEPEL PLASE
MARAKALE
NYLSVLEY
Messina
Alldays
Louis Trichardt
Soekmekaar
Ellisras
Pietersburg
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Warmbad
Thabazimbi
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
GIS COV:
WSAM
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
MINERALOGICAL GROUNDWATER QUALITY
Prepared by:
Date:
Data Type:
Figure 6.4.2.1



Zimbabwe
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MARAKALE
NYLSVLEY
LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
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Louis Trichardt
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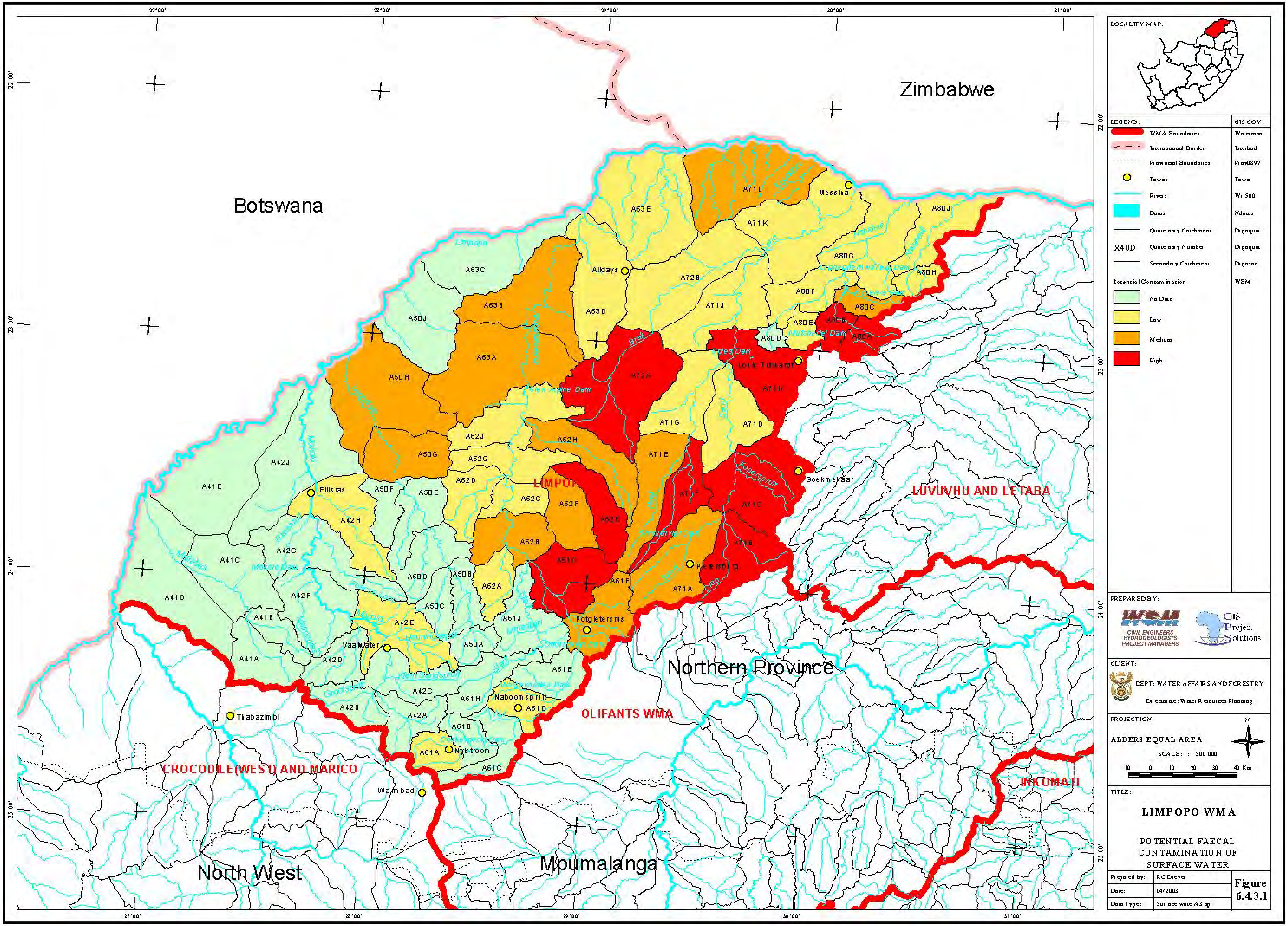
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
Quaternary Number
Secondary Catchment
Nature Reserve Boundaries
Percentage Potable Groundwater
> 90 %
70 - 90 %
50 - 70 %
30 - 50 %
< 30 %
PREPARED BY:
CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
PERCENTAGE POTABLE GROUNDWATER
Prepared by: RC Dreyer
Date: 04/2003
Figure 6.4.2.2



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North West
LIMPOPO
LUVUVHU AND LETABA
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CROCODILE(WEST) AND MARICO
INKOMATI
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Alldays
Louis Trichardt
Soekmekaar
Ellisras
Potgietersrus
Vaalwater
Naboomspruit
Nylstroom
Thabazimbi
Warmbad
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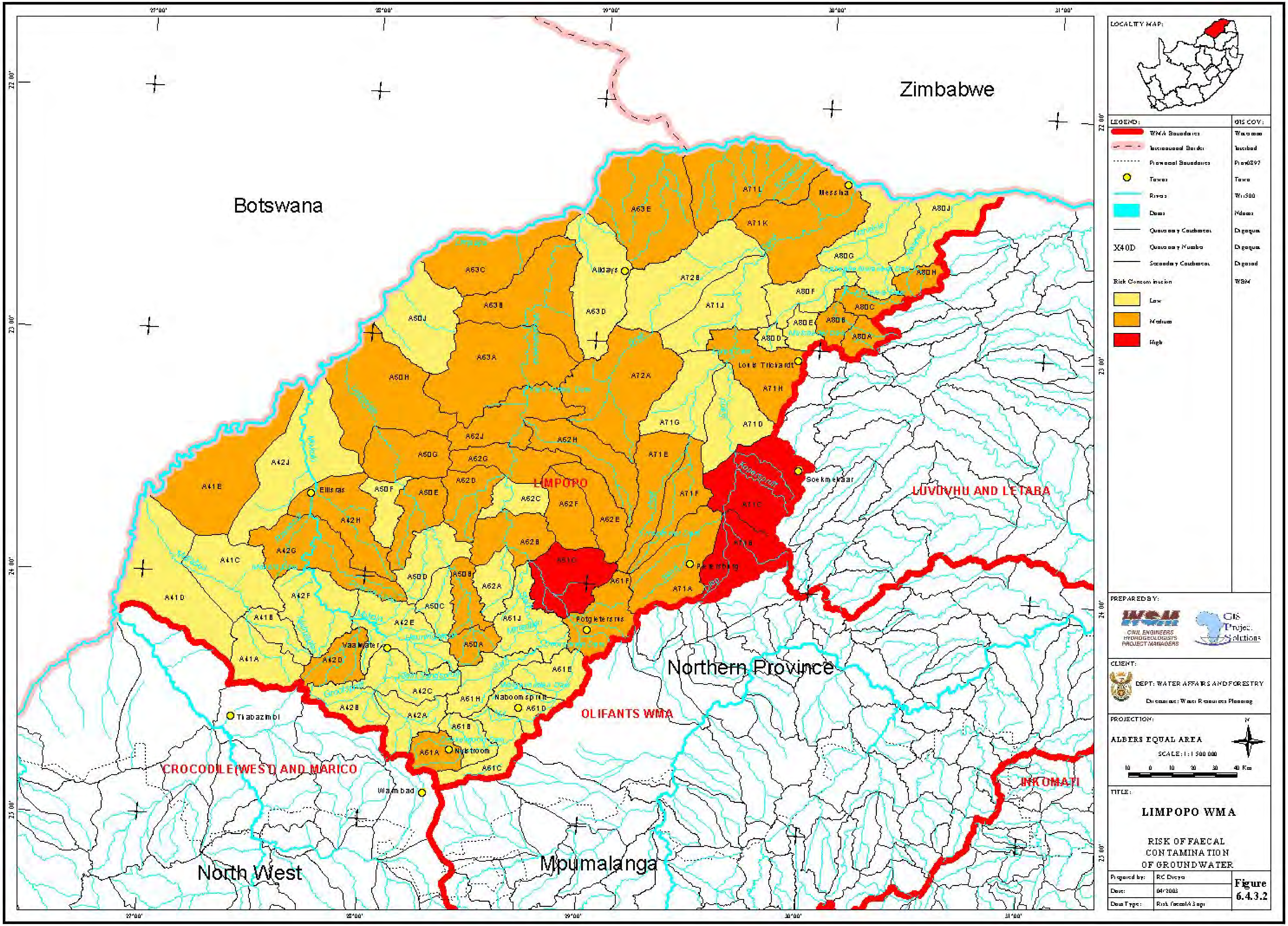
A61A
A61C
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Potential Contamination
No Data
Low
Medium
High
GIS COV:
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
TITLE:
LIMPOPO WMA
POTENTIAL FAECAL CONTAMINATION OF SURFACE WATER
Prepared by:
Date:
Data Type:
Figure 6.4.3.1



Zimbabwe
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LUVUVHU AND LETABA
OLIFANTS WMA
CROCODILE(WEST) AND MARICO
INKOMATI
Northern Province
North West
Mpumalanga
Messina
Alldays
Louis Trichardt
Soekmekaar
Pietersburg
Potgietersrus
Ellisras
Vaalwater
Naboomspruit
Nylstroom
Warmbad
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A50A
A41A
A42D
A61E
A42C
A61H
A42B
A61D
A42A
A61B
A61A
A61C
LOCALITY MAP:
LEGEND:
GIS COV:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
X40D
Risk Contamination
Low
Medium
High
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1 : 1 500 000
N
TITLE:
LIMPOPO WMA
RISK OF FAECAL CONTAMINATION OF GROUNDWATER
Prepared by:
Date:
Data Type:
04/2003
Figure 6.4.3.2

FIGURE 6.4.4.1: WATER QUALITY ISSUES

THIS FIGURE IS NOT ACCESSIBLE IN ELECTRONIC FORMAT.

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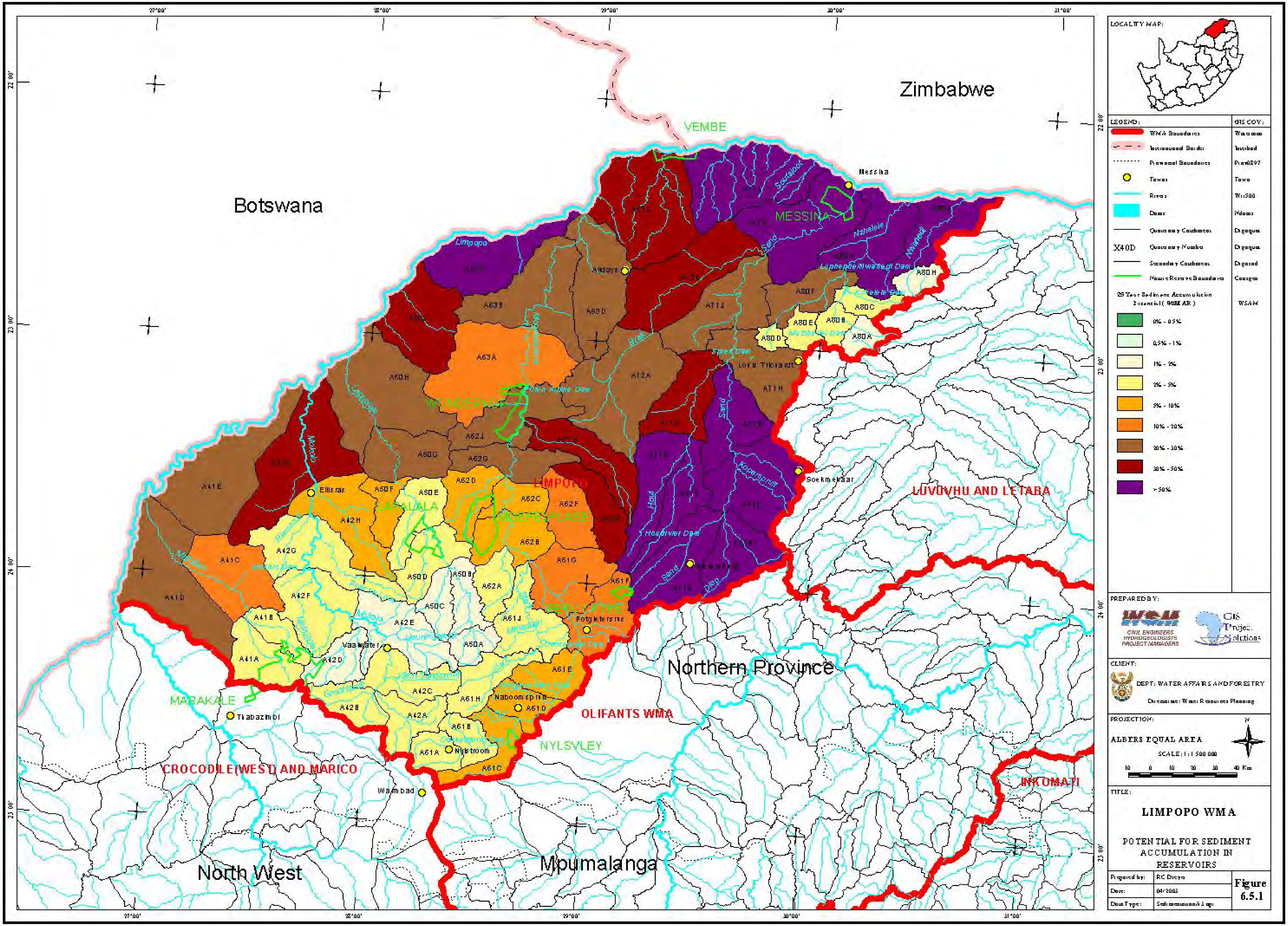
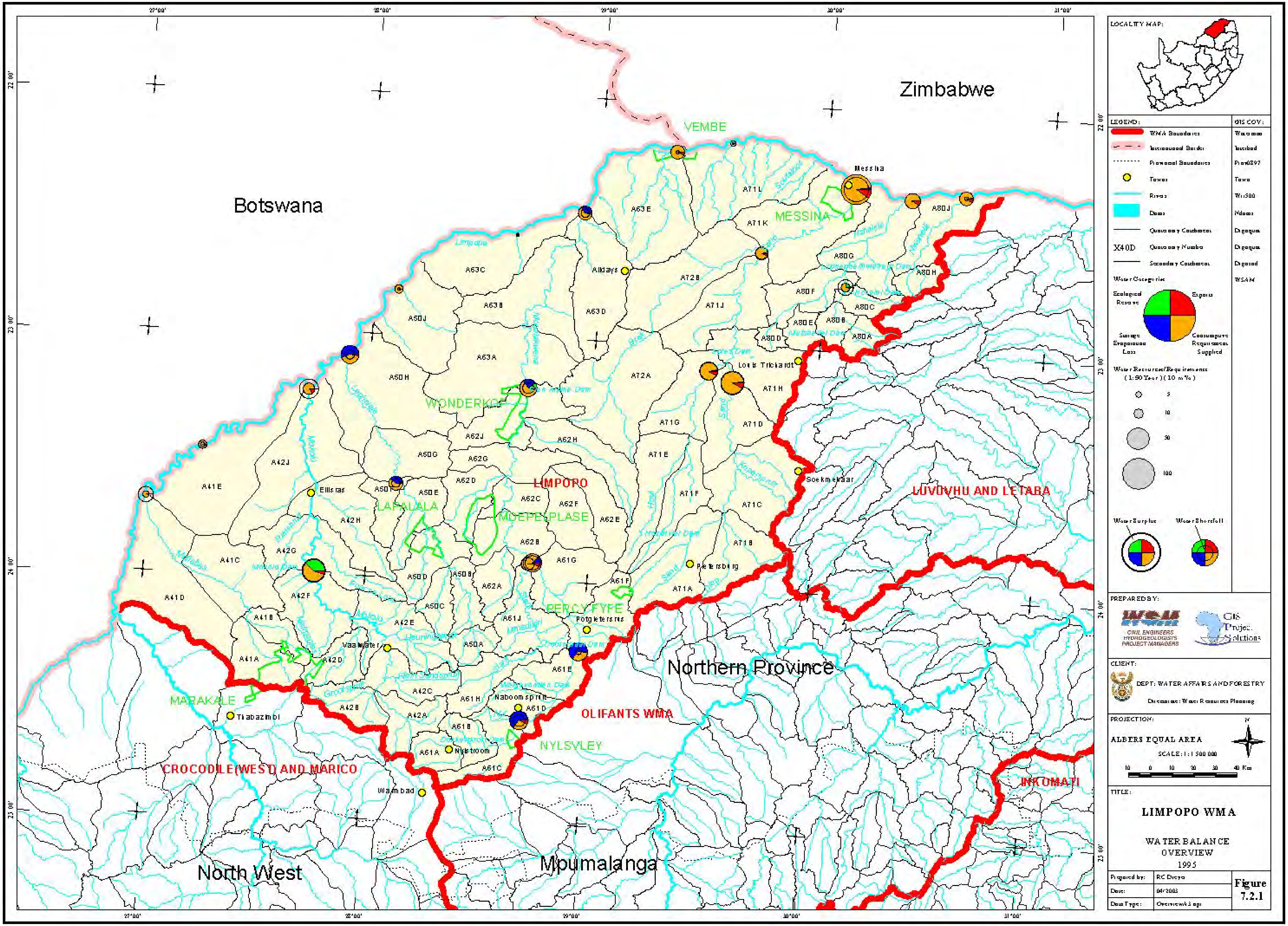
DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCES PLANNING


Zimbabwe
Botswana
VEMBE
Messina
MESSINA
Limpopo
Alldays
WONDERKOP
LAPALALA
LIMPOPO
MOEPELPLASE
Ellisras
Louis Trichardt
Soekmekaar
LUVUVHU AND LETABA
Potgietersrus
Vaalwater
Northern Province
Naboomspruit
OLIFANTS WMA
MARAKALE
Thabazimbi
NYLSVLEY
Nylstroom
CROCODILE(WEST) AND MARICO
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
GIS COV:
X40D
25 Year Sediment Accumulation
WSAM
0% - 0.5%
0.5% - 1%
1% - 2%
2% - 5%
5% - 10%
10% - 20%
20% - 30%
30% - 50%
> 50%
PREPARED BY:
CIVIL ENGINEERS
HYDROGEOLOGISTS
PROJECT MANAGERS
GIS Project Solutions
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
10 0 10 20 30 40 Km
N
TITLE:
LIMPOPO WMA
POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS
Prepared by: RC Dreyer
Date: 04/2003
Figure 6.5.1


Zimbabwe
Botswana
VEMBE
Messina
MESSINA
A71L
A63E
A71K
A80J
A80G
A80H
A80F
A80C
A80E
A80B
A80D
A80A
A63C
Alldays
A72B
A71J
A63B
A63D
A50J
A63A
A72A
Louis Trichardt
A71H
A50H
WONDERKOP
A71G
A71D
A62J
A62H
A50G
A62G
A71E
A42J
A41E
Ellisras
A62D
LIMPOPO
Soekmekaar
LUVUVHU AND LETABA
A50E
LAPALALA
A62C
A62F
A71F
A71C
MOEPELPLASE
A42H
A62E
A62B
A71B
A42G
A41C
A61G
Pietersburg
A50D
A50B
A62A
A61F
A71A
A41D
A42F
A50C
PERCY FYFE
A41B
A42E
A61J
Potgietersrus
Vaalwater
A50A
A41A
A42D
A61E
Northern Province
A42C
Naboomspruit
MARAKALE
A42B
A61H
A61D
A42A
OLIFANTS WMA
Thabazimbi
A61B
NYLSVLEY
A61A
Nylstroom
CROCODILE(WEST) AND MARICO
A61C
Warmbad
INKOMATI
North West
Mpumalanga
LOCALITY MAP:
LEGEND:
WMA Boundaries
International Border
Provincial Boundaries
Towns
Rivers
Dams
Quaternary Catchment
X40D
Quaternary Number
Secondary Catchment
Water Categories
Ecological Reserve
Exports
Storage Evaporation Loss
Consumptive Requirement Supplied
Water Surplus
Water Shortfall
PREPARED BY:
CLIENT:
DEPT: WATER AFFAIRS AND FORESTRY
Directorate: Water Resources Planning
PROJECTION:
ALBERS EQUAL AREA
SCALE: 1:1 500 000
TITLE:
LIMPOPO WMA
WATER BALANCE OVERVIEW
1995
Prepared by: RC Dreyer
Date: 04/2003
Figure 7.2.1