KINGDOM OF LESOTHO
Lesotho Highlands Development Authority

LESOTHO HIGHLANDS WATER PROJECT

Phase 1B

Environmental Impact Assessment

EXECUTIVE SUMMARY

May 1997

The environmental impact assessment for Phase 1B of the Lesotho Highlands Water Project is dedicated to the late Dr. M. Maema, former manager of the Environment Division, LHDA, and a strong supporter of the environmental assessment process in Lesotho.

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Acronyms

CALC	Combined Area Liaison Committee
CLA	Community Liaison Assistants
CLC	Community Liaison Coordinator
DWAF	Department of Water Affairs and Forestry
DDC	District Development Council
EA	Environmental Assessment
EAP	Environmental Action Plan
EIA	Environmental Impact Assessment
EPP	Emergency Preparedness Plan
FOT	Field Operations Team
FSL	Full Supply Level
GOL	Government of Lesotho
HIV	Human Immune Deficiency Virus
HSG	Highlands Services Group
IUCN	International Union for the Conservation of Nature and Natural Resources
JPTC	Joint Permanent Technical Commission
LHDA	Lesotho Highlands Development Authority
LHWP	Lesotho Highlands Water Project
LSA	Later Stone Age
MNR	Ministry of Natural Resources
NES	National Environment Secretariat
PHC	Primary Health Care

RIS	Reservoir Induced Seismicity
RSA	Republic of South Africa
TBM	Tunnel Boring Machine
STD	Sexually Transmitted Disease
TCTA	Trans Caledon Tunnel Authority
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Program
VAPS	Vaal Augmentation Planning Study
VDC	Village Development Council
WAR	Western Access Road
WDC	Ward Development Council

BACKGROUND

Statement of Purpose

The purpose of this environmental impact assessment (EIA) is to identify and describe the positive and negative effects of the Phase 1B component of the Lesotho Highlands Water Project (LHWP) on the Project Area, on Lesotho and on rivers in the Republic of South Africa (RSA) downstream of the proposed development. The EIA describes the relative importance of the various negative impacts and recommends mitigative solutions. The report provides an introduction to the environmental action plan (EAP) that will provide the detailed blueprint for impact mitigation and compensation as well as social and environmental enhancement.

RSA Water Requirements

Anticipated water shortages in the Gauteng area in the RSA as a result of an annual water demand increase of 3.8 percent due to projected population growth, led to the commencement of discussions between the RSA and Lesotho in the mid 1960s, regarding the sale and transfer of Lesotho water. Recent projections to the year 2000 indicate that Gauteng Province will accommodate nearly 42 percent of the urban population of the RSA and will generate 56 percent of all industrial and 79 percent of all mining output in the RSA.

Treaty Agreement

After evaluation of more than 2,000 variations amongst several main alternatives[9,20], proposals for the transfer of water from Lesotho to supplement the Vaal Dam were endorsed in 1986, and the LHWP came into existence through the signing of a treaty on 24 October 1986 between the two governments. The designed project consists of a large and complex water transfer scheme that will alter the course of water flow and deliver water from Lesotho to RSA by way of dams and tunnel systems. The Treaty covers only the first two phases of a multi-phased scheme. Phase 1A is currently under construction. The subject of this EIA is Phase 1B, currently in the planning and design stage. Map A-1 shows the regional setting.

The Treaty provides for the establishment, implementation, operation and maintenance of the project. The designated authority for Lesotho is the Ministry of Natural Resources (MNR); for RSA it is the Department of Water Affairs and Forestry (DWAF). These authorities have jointly established the Joint Permanent Technical Commission (JPTC) which is comprised of a delegation from each Party. The Treaty provides for the JPTC to monitor, advise and give priority agreement on matters relating to the Project.

Both the RSA and Lesotho will benefit directly from the project. While the RSA will receive a much needed reliable supply of high quality water, Lesotho will benefit financially from the royalties received through the provision of the water, and the money saved through the production of its own electricity supply.

Institutional and Legal Framework

The implementing agency at the operational level for Lesotho is the Lesotho Highlands Development Authority (LHDA), an autonomous statutory body corporate with perpetual succession and established by legislation (*Lesotho Highlands Development Authority Order No. 23 of 1986*). The LHDA is entrusted with the responsibility for the implementation, operation and maintenance of that part of the project situated in the Kingdom of Lesotho, and is controlled by a Board of Directors whose members are appointed by the Minister of Natural Resources. For the RSA the implementing agen-

cy is the Trans-Caledon Tunnel Authority (TCTA) which has a similar organizational structure and operational procedures to those of LHDA.

The Parties agree to take all reasonable measures to ensure that the implementation, operation and maintenance of the project are compatible with the protection of the existing environment and, in particular, agree to address the maintenance of the welfare of persons and communities immediately affected by the project.

EIA Requirements

As a major project, the LHWP is required to be subjected to an environmental impact assessment. Lesoth [illegible] rently developing the environmental le[illegible] e framework required to effectively deal with environmental and natural resources issues, and the Treaty between Lesotho and the RSA requires that the LHWP be implemented to "international standards". The LHDA has adopted World Bank EIA guidelines for EIA.

Lessons Learned fro[illegible] Phase 1A

A number of en[illegible] ntal issues surfaced during implementation of Phase 1A. When the various components of Phase 1A were being planned, only minimal consideration was given to the environmental and social aspects of the project. In examining the experiences from Phase 1A, LHDA has been able to avoid a number of problems in the design, planning and implementation of Phase 1B. The following describes the most important Phase 1A issues and problems related to the environment and how the experiences gained will lead to a more comprehensive and effective program for the environmental management of Phase 1B.

The lessons learned are discussed in the context of six main themes: management, local people, socio-economic concerns, compensation, environment, and rural development.

Management

The environmental and social consequences of a large project such as the LHWP are extensive and varied. In its formative years LHDA was not customer focused and service oriented, nor was it proactive. The ineffectiveness of management in Phase 1A was reflected in responses of the people of the area, many of whom indicated that LHDA provided them with no forum in which they could take part in discussions relating to the project. Recognition of management short comings has led to a much improved and functional management system that continues to evolve. The Highlands Services Group (HSG), formerly known as the Environment Division, is currently much more responsive to people's needs, has the ability to identify issues at an early stage, is more adept at problem solving, and is proactive. The preparation of a timely and comprehensive EIA and EAP, staffing dedicated to public participation, the development of a detailed resettlement plan with and for the people to be affected; the decentralization of the Division through the field operating teams (FOTs), and the recent restructuring plan all provide evidence of improved management.

Monitoring plays an important role in environmental management. Not only does it ensure that construction activities are carried out in an environmentally effective manner but it also provides a feedback mechanism for management for deciding on modifications and more efficient and effective means of achieving environmental objectives. In addition, to those produced by consultants, the HSG has its own team of monitors who regularly inspect construction works. However, much is still required to ensure that monitoring is effective and that monitoring is adapted as a significant and effective management tool. To this end the new structure of the Highlands Services Group includes a monitoring and evaluation section.

Local Communities

In the early stages of Phase 1A, little consideration was given to local people who would be most affected by the project and little was done to alleviate project impacts on the people of the area. The people of the area were never kept informed, there was no forum in which they could express their views, and no opportunity to meaningfully participate. Their importance as stakeholders was not recognized. As a result, people became distrustful of the LHDA.

In Phase 1B the local people have had full opportunity to provide input. The results of the component environmental assessments (EAs) reflect people's concerns. Local people, including those of the host communities have had full participation in the preparation of the resettlement and development plan and a structure has been put in place to ensure that active participation continues. As a result of the participation program, people are aware of what will be taking place, they are well prepared, and do not have the same worries, insecurity, feelings of despair, and hostility towards LHDA as people did in Phase 1A.

Socio-economic Concerns

Phase 1A experienced a population flux as people from outside migrated to the project sites for jobs, and to establish other secondary economic activities. This resulted in uncontrolled and disorganized development. The problems associated with population influx are recognized and are being addressed in Phase 1B. Where possible, camps will be located away from the construction sites and local communities; and an employment and informal settlement avoidance strategy has been prepared to address the general problem. Early experiences in Phase 1A showed that a public health program is well justified and currently health care for the Phase 1A area is being carried out in a comprehensive manner. Similar public health programming and facilities will be provided in Phase 1B.

The greatest concern of local people of Phase 1A was the lack of project jobs available to them. For all the disruption that the project causes to their lives, they felt that the provision of jobs would be just compensation. This issue is being addressed seriously in Phase 1B and all contractors will be obligated to give priority to hire local people for semi-skilled and unskilled jobs.

Compensation

The compensation program for Phase 1A was slow in delivery of its services and lacked a direct service for the processing of claims. To address this issue, FOTs have recently been established to provide a front line response function. One of their responsibilities is to provide *on the spot* compensation claims to a designated maximum amount. Cash instead of commodities is now given for compensation which speeds up the process and is generally more acceptable. Record keeping in the past had been ineffective but now all claims are meticulously kept and the values of all resources are determined to ensure fair compensation. Unlike Phase 1A, Phase 1B compensation policy for lost land will be flexible and will offer a choice of types of compensation including 'land for land', cash or grain, or a combination of these.

To ensure that compensation is timely for Phase 1B, the resettlement and development program will be implemented in advance of the beginning of construction.

Environment

Planning, design and construction of Phase 1A proceeded without individual environmental assessments for each of the main components and without an overall environmental impact assessment. Baseline studies were carried out quite late and one critical baseline study - erosion and sedimentation - was only initiated in 1996. The EAP was prepared before baseline studies were made available and was prepared in the absence of an EIA.

Individual environmental assessments were conducted for each of the main project components in Phase 1B as part of the engineering design contracts. Baseline studies were initiated at about the same time as the individual EAs and most of the baseline data were available to be used as a foundation for the preparation of the EIA. An EIA process was established for all of Phase 1B and an EIA was prepared in advance of design and tender document completion.

During Phase 1A much of the responsibility for environmental matters was given to the engineers responsible for project component implementation. Infrastructure impacts were not completely addressed as a result of weak tender documents. To some degree, noise, dust, unnecessary land loss, and a diminishing of aesthetic values resulted. Tender documents in Phase 1B include comprehensive environmental guidelines for the contractor.

Rural Development

Planning of Phase 1A rural development program was late, it was implemented centrally and the program has been slow to show meaningful progress. The initial planning of the program was unrealistic, and LHDA staff lacked the understanding of the required implementation mechanisms. A rural development program requires strong integrated planning, the selection of appropriate and capable implementing agencies, and effective management. The planning of the rural development program for Phase 1B is currently underway. The Phase 1B rural development program is currently being planned and it will be implemented in co-operation with the people of the area.

Significant Environmental Changes Expected as a Result of Phase 1B

The alpine and sub-alpine region of Lesotho is unique in southern Africa, and is only one of a small number of such eco-regions on the African continent. Highlands people of Lesotho are unique, perhaps in all of Africa[6]. They are a proud people who have always considered themselves different from their fellow countrymen in the Lowlands. They have a unique culture developed as a result of the harsh physical conditions of the Highlands.

The LHWP will bring a number of irreversible changes to the region. The effects of the project will be most evident throughout the immediate Project Areas, and less so, but still significant, throughout most of the Highlands. The people of the mountains will not go untouched as a result of the project. With the advanced stages of Phase 1A, changes to the socio-economic fabric of the Highlands are already being observed.

Another significant change to be expected will be the loss of aquatic habitat as a result of the flooding of 25km of the Senqunyane River and the operation of the Mohale Dam that will affect water releases and downstream habitat conditions. Rare and endangered species will be affected.

Resettlement

The LHDA recognizes that the effect that Phase 1B will have on the people of the Highlands is the most important impact of the project. Accordingly, the LHDA is taking great effort to ensure that highland communities are not adversely affected by the development. Resettlement is either mandatory or a recommendation for 387 households as a result of the Phase 1B scheme. For those who will be displaced, and others who will be directly affected, the LHDA has developed a comprehensive and in-depth resettlement and development program that will ensure that these people will beat least as well off, if not better off, socio-economically than they are currently. The program has included a detailed socio-economic analysis of the people's current situation. In the process of formulating the program, active and full participation through a number of appropriate mechanisms has been carried out. Most importantly, the people to be affected have been allowed to make

choices for their own future. Almost half, given the opportunity to resettle in the Lowlands, have chosen to remain in their home area.

The resettlement program also includes a development component that will benefit those to be resettled, the host communities, and those who will be indirectly affected by the project. In recognizing that one of the people's primary concerns is job opportunities, LHDA is ensuring that all contract work associated with Phase 1B includes to the greatest extent possible, the hiring of local labor.

METHODS

General

The EIA has been based on a number of studies specific to Phase 1B. The preparation of the EIA has been carried out concurrently with the early detailed design stages of the various engineering components. It has been prepared on the basis of World Bank guidelines and has been reviewed at various stages by the National Environment Secretariat (NES) with the technical assistance of UNESCO/UNDP, by the JPTC and by a number of other agencies including the World Bank and the Southern African Development Bank. Due to the complexity of Phase 1B it was necessary to develop the EIA through the separate examination of its individual components (Mohale Dam, Mohale Tunnel, Matsoku Diversion and infrastructure - main access roads, rural access roads, transmission network, communications network] and resettlement and development). Impacts that would occur at different stages of development including pre-construction, construction, operation and maintenance, and decommissioning were considered.

Scoping and Selection of Important Environmental Components

Important environmental components (IECs) are those features and values of an area for which an EIA is being carried out. The IECs provide focus for the EIA. The extent to which each of the IECs was investigated, either through the project component environmental examinations or through the various background studies, was based on the relative importance of each of the IECs and the minimum information required for each in order to make an informed judgment as to the impact that the IEC will receive from the project.

Data Collection and Analysis

Much of the socio-economic data used has been based on a 1994 social survey[11] of the Mohale area and on additional information collected through the resettlement and development study[7]. The epidemiology study[18] collected detailed information on various aspects of public health. Water quality and aquatic communities data were collected through the water quality study[4]; fauna and flora data was collected through the biological baseline study[1]; erosion data were provided by a watershed analysis[3] and modelling study[21] and other background data and information were sourced from various LHDA documentation[8,12,16] and the environmental assessments carried out for the various project components[10,17,19].

Impact Assessment Methods - Mohale Catchment

Different approaches were used for the determination of impacts. Many of the socio-economic impacts identified and predicted are based on previous studies and on experiences from Phase 1A. Observations from other projects in Lesotho and elsewhere (e.g. increase in STD incidence with an increase in outside worker population) were also used to develop impact statements.

Impact statements on reservoir water quality have been based on modeling results and experiences from other areas where large reservoirs have been created. Generally, water quality impacts, particularly those caused by various construction activities, are based on statistical analyses and past experiences. Impacts on aquatic and terrestrial fauna, flora and other resources

have been described on the basis of results of the various EAs conducted, on observation and on other experiences.

A number of the socio-economic impacts described have been based on results from the resettlement and development study. Other impacts have been described on the basis of Phase 1A experiences.

Impact Assessment Methods - Downstream
Detailed data such as that made available through the Mohale catchment studies were not available for the downstream areas. In the cases of the Senqunyane River below the Mohale dam wall, the Senqu River downstream to the Lesotho border, the Orange River within South Africa and downstream to its outlet, and the Ash River downstream to Saulspoort dam, information available from various non-EIA related documentation was used[2,13,14]. These assessment studies have been summarized and incorporated into the overall EIA for Phase 1B. The Matsoku River downstream impacts have been based on studies carried out as part of the Matsoku Diversion EA. Map A-2 shows the Senqunyane and Senqu river systems and Map A-3 shows part of the Ash River system.

Defined Study Areas
Most impacts will occur within the Project Area centered around the main construction sites. Impacts will extend to the regional area within central Lesotho, and some will be manifested at a national level. The socio-economic effect within Lesotho will be nation wide. Construction activities have been assessed in the immediate vicinity of the various project components. In addition, the impacts to occur in the area to be occupied by the reservoir to the full supply level and the associated safeline have been examined. Downstream, the Senqu system down to the Orange River mouth has been included, along with a land base within 1 km of the river. Similarly the Ash River that will receive the delivery tunnel water, has been included in the assessment as far as the Saulspoort dam in RSA. The Matsoku River has been examined downstream to where the Matsoku River meets the Malibamats'o River. The areas to be subjected to resettlement have also been addressed.

Impact Significance
The impacts of each IEC have been scored according to four criteria: duration (short term, medium term or permanent), scale (local, watershed wide, regional, national or international), severity (including irreversibility) and certainty of occurrence. The sum of individual scores for each IEC has provided a numerical index of impact significance. Overall scores for each IEC naturally vary according to the project component involved (dam, tunnel, infrastructure, etc.). The highest severity rating of any IEC for any project component has been taken to be the prevailing impact for all of Phase 1B.

A very high level of significance will have the consequence of major losses or system disruption; the system will be unable to function without mitigation or major compensation programs; and/or the impact may be irreversible. A high level of significance will have the consequence of substantial losses or system disruption: the system will probably still function, albeit at a lower level, and the impact may be irreversible. A level of moderate significance will show measurable losses or system disruption. A low level of significance will result in small changes, possibly measurable. The scoring system has been developed specifically for application to Phase 1B. It is a simple system using limited criteria, but essential criteria that will result in an appropriate ranking system of the various impacts.

PROJECT DESCRIPTION

General
The LHWP is a multi-phased water transfer and hydropower generation scheme that will include a number of impoundments linked by a series of

tunnels that will ultimately deliver water to the Vaal River System in South Africa.

Phase 1A is under construction and consists of Katse Dam on the Malibamats'o River, a transfer tunnel and delivery tunnel, and a reservoir and hydropower plant at Muela. This phase of the project started in 1986 and is scheduled for completion in 1997. Phase 1B of the LHWP consists of the Mohale Dam on the Senqunyane River, a diversion weir on the Matsoku River and transfer tunnels delivering water into Katse Reservoir. This phase will also include the upgrading of existing roads and the development of new roads, the development of construction camps, and the provision of power transmission and telecommunications. Map A-4 shows the Phase 1A and 1B Project Areas.

Phases 2, 3, and 4 (Lesotho Highlands Further Phases) as envisaged will include additional impoundments on the Senqu River and linking tunnels into the Katse reservoir.
Basic statistics for Phase 1A and Phase 1B of the project are provided in Table B-3.

Project Alternatives
The various project layouts suggested during the pre-feasibility study were used as a basis for generating a number of layouts. This study identified nineteen possible layouts for conveying water from the Highlands of Lesotho to South Africa. The report recommended the phased construction of a layout consisting of reservoirs at Oxbow, Pelaneng, Soai, Polihali and Taung, with approximately 102 km of tunnels to transfer the water via a hydropower station on the Hololo River at Tlhaka to the Kroonspruit River in South Africa.

Limited further studies were undertaken and the recommended layout was adjusted. The Lesotho and South African governments agreed that the adjusted layout should form the basis for the feasibility study that was carried out to investigate the scheme as it is known today.

The Vaal Augmentation Planning Study of 1995 (VAPS) examined several options for the water supply shortage in the Johannesburg area that will be experienced after 2006 and after Phase 1A and 1B have been completed. These options included water transfer from the Zambezi River, water from the Tugela River, desalinization of sea water, reduced irrigation, converting power stations from wet-cooled to dry-cooled, and non-augmentation. This last option would force industry to move to where water would be more freely available.

Phase 1B - General Description
Phase 1B consists of several distinct but interrelated components. It is intended to capture water from the upper Senqunyane River through the construction of a concrete faced rockfill dam at Mohale and deliver this water through a tunnel to the Katse reservoir. This aspect of the project will divert 300 million m3 of water annually. A weir on the Matsoku River is intended to divert water into a tunnel connected to the Katse reservoir. This aspect will deliver 60 million m^3 of water annually. Map A-5 shows the location of the main activities of Phase 1B.

Mohale Dam and Associated Infrastructure
The main component of the project consists of a concrete-faced rockfill dam, located at Mohale immediately downstream of the confluence of the Senqunyane and Likalaneng rivers. The dam complex will consist of an embankment 145m high, an ungated spillway on the left abutment, and an outlet facility. In addition to these permanent structures, construction of the dam will require a diversion tunnel, quarries and borrow areas, a stockpile area for tunnel spoil, temporary access roads and bridges, and a contractor's camp and works areas. To the extent possible, these temporary works will be located within the reservoir inundation area, below FSL 2075m asl. To facilitate construction of the dam and its ongoing operation and maintenance, supporting components including roads, offices and shops, construc-

tion camp and residential areas will also be provided.

The reservoir created by the Mohale Dam will be 22.8km^2 in area and will run up river for approximately 25km. The reservoir, when full, will contain 947 million m^3 of water of which 857 million m^3 will be available for transfer and the remainder will be dead storage. Map A-6 shows details of the Mohale Dam construction site.

Mohale Tunnel

The Mohale tunnel will connect Mohale reservoir to Katse reservoir. The tunnel intake will be located 4.5km upstream of the Mohale dam wall and the outlet some 8.0km upstream of the confluence between the Bokong and Malibamats'o rivers. The tunnel will have a length of approximately 32km in a straight line between the intake and the outlet and it will be on a downward sloping gradient of approximately 1:3,300. A lined tunnel diameter of 4.0m has been specified. Average water velocity in the tunnel at normal discharge will be approximately 0.7m/s.

The construction of the tunnel will be undertaken with two tunnel boring machines (TBMs). The intake site will require a works area of approximately 60ha and the site establishment at the outlet will require an area of approximately 11ha. Map A-7 shows details of the Mohale tunnel intake site.

Matsoku Diversion

The Matsoku tunnel intake and weir will be located on a westward loop of the Matsoku River immediately upstream of the confluence of a small tributary stream (Tlopa) and south of the village of Ha Mahlomola. The tunnel outlet site is located north of Kutu-Kutu village on the eastern side of an oxbow bend in the Katse Reservoir. This project component is designed to operate as a run of river diversion, with no capacity for storage or regulation.

The free flow tunnel will be partially lined and will be 5.7km long. The weir will be approximately 10m high and 180m long and will be a mass gravity structure constructed either of mass concrete or of uncut grouted stone masonry. The tunnel will have an excavated span of approximately 4.0m with concrete lining thickness nominally 300mm. The excavation of the tunnel will be with drill and blast methods from two headings. The tunnel will commence at the intake located immediately upstream of the weir, and will follow a westerly direction at a slope of approximately 0.5 percent to discharge into the Katse reservoir marginally above full supply level. A works area of approximately 1.9ha at the weir/intake site will be required. A 5.0km access road from the existing road will be constructed into the works area site at the inlet. A 1.0km access road will be constructed to provide access to the outlet. Map A-8 shows the Matsoku weir location and tunnel alignment.

Supporting Infrastructure

Three major roads will be provided to give access to the Mohale dam and tunnel sites. The Maseru bypass will be built around Maseru to avoid congestion in the city centre. It will consist of the upgrading of 6.5km of road and the construction of 19.7km of new road. The Western Access Road (WAR) will be upgraded from St. Michael's for a distance of 60.4km until the turn-off to the Mohale Dam at Patiseng. This road forms part of the Lesotho trunk road system linking Maseru and Thaba-Tseka. The Mohale Dam access road will require 22km of new construction to reach the dam site and tunnel intake. The road will be a sealed surface capable of handling large volumes of construction related traffic.

The Mohale Dam, Mohale Tunnel and the Matsoku Diversion will all require a power supply for construction purposes. The optimal supply voltage for transmitting electrical energy from Maseru to Mohale and beyond is 132kV. The power line will run from Mazenod up to Bush-

men's Pass at an altitude below 2.100m, and from Bushmen's Pass up to the Mohale Dam and the associated tunnel inlet.

The project will use a microwave point to multi-point communications system. This type of network will consist of a central station, six repeater stations, and terminal stations. The terminal stations will be connected by microwave transmission to the central station either by a direct hop or via a number of hops using repeater stations.

Development Stages

For environmental purposes the project is comprised of several distinct stages including design, pre-construction, construction, operation and maintenance, and decommissioning (Table B-7). provides a list of the general concerns for each of the major project components in each of the stages.

Development Program

The overall Phase 1B program has a target date of 01 January 2003 for the first water flow from the Mohale reservoir through the Mohale Tunnel and into the Katse reservoir. Mohale reservoir impoundment will begin on 1 October 2001. Matsoku Diversion water will be delivered to the Katse reservoir on 1 January 2001.

DESCRIPTION OF THE EXISTING ENVIRONMENT

Physical Environment

Topography and Drainage

The highlands of Lesotho, known as the *Maloti*, consist of an elevated and dissected plateau, with much of it above 2000m. The general landscape exhibits a high to very high relief. The project area is characterized by a dendritic drainage pattern focusing on the Senqunyane River. Narrow river valleys have been incised with depths of up to 500m and they are steep to very steep sided. The general landscape exhibits high to very high relief. A prominent pediment occurs at approximate elevation of 2.500m and this probably represents a former erosion surface. Previous base levels of erosion are indicated by raised terraces consisting of bedrock ledges or abandoned flood plains and oxbows. Oxbows occur up to 15-20m above existing river elevation. Waterfalls occur in the main rivers and their tributaries, and these represent knick-points between former and more recent levels of erosion.

Climate

The climate of the Mohale area is generally sub-humid, with about 85 percent of the precipitation occurring in the summer season from October to March when 10 to 12 rain days per month can be expected. In the Mohale area the mean annual precipitation ranges from 1,000mm to 664mm in the northern part of the Malibamats'o catchment to 1,200mm in the higher peaks of the upper Bokong catchment. Winters are normally dry but snow is common at higher elevations and may fall in any month of the year. Hail is a common occurrence. Sudden weather changes are common, with temperatures falling rapidly within a few hours. Frosts are severe in winter and can occur from May to October. Minimum temperature for the winter period is typically around -10oC.

Geology

The regional geology of the Lesotho Highlands comprises horizontally-layered basaltic lavas. The basaltic lavas were deposited in the form of horizontal flows typically 0.5 to 10m thick with occasional thicker flows of up to 70m. Structural discontinuities, especially major joints and fractures or faults, appear to have significantly controlled the development of the topography. Surficial deposits in the Lesotho Highlands are generally of very limited thickness. Exceptions to this occur where there are alluvial and colluvial deposits along river courses or where residual soils overlain by colluvium are developed in abandoned oxbows and raised plateaux lying

above river level. Raised plateaux make up much of the higher ground in areas with contrasting weaknesses. The topography that is developed is typically gently undulating and well drained. Residual soils are seldom developed to a thickness in excess of 3m. The lack of depth of weathering is probably a consequence of the temperate climate of the Highlands.

Seismicity

Lesotho and the surrounding area have experienced a relatively low level of seismicity. While the general distribution of earthquakes appears random, some patterns are evident. No direct relationship with known tectonic features which are exposed at the surface has yet been determined for any recorded earthquakes.

There are few major fault systems evident in Lesotho. The ones that do exist are of the same age or older than the volcanic strata and are believed to be inactive. There is no known volcanic activity in the area and the last known volcanic events were the emplacement of kimberlite pipes and dykes during the Cretaceous Period.

Reservoir Induced Seismicity (RIS) has recently occurred at Mapeleng in the Phase 1A area and earthquakes and tremors of magnitude 1.5 to 3.0 were felt in twelve villages. RIS is a common phenomenon which occurs under some new reservoirs. When a reservoir fills, an earthquake may be prematurely triggered by either the change in stress within the earth due to the weight of the water, or by the weakening of the ground due to the increased groundwater pressures. RIS earthquakes have been known to have occurred in more than 200 reservoirs throughout the world. In most cases the earthquakes are very small and cause no damage. Many are so small that they can only be detected by very sensitive seismometers. Elsewhere in the world large RIS earthquakes have occurred which have caused significant damage and even loss of life.

The tremors at Katse present no danger to the dam[5] which has been designed to resist much larger earthquakes as large as Richter Magnitude 6.5. They do, however, pose future risks to any local villages. The traditionally constructed dwellings in this region are structurally weak and vulnerable to even small earthquake ground motion. Continued monitoring of the situation will be necessary to ensure that appropriate action can be taken to ensure the safety of the inhabitants of the region. Map A-9 shows Katse area and seismic activity.

River Morphology- Senqunyane and Senqu Rivers

The Senqunyane River flows almost due south from the Mohale dam site for a distance of 120km to meet the Senqu near Ha Nkau. Most reaches of the river are fairly uniform and consist of long runs over bedrock or thin gravel/silt substrates. Sand and gravel are the major components of most of the Senqunyane River banks that are formed primarily as a result of deposition during the rapid fall in water velocities and levels following a flood surge. Substrates along the length of the Senqu River consist of coarse gravel and occasional cobbles, but there are frequent reaches where the river appears to flow directly over bedrock. Boulders are common along the banks, and sometimes in the main river channel.

Both the Senqunyane and Senqu rivers are in a highly dynamic state of seasonal and possibly multiseasonal flux, involving the deposition of large quantities of sediment from erosive flooding events upstream, followed by subsequent and more gradual erosion of the deposits by flows with low suspended material contents. The Senqu is a characteristic muddy colour, typical of rivers flowing through erodible sandstone formations compared to the much clearer water in the Senqunyane.

Hydrology

The hydrology of both the Mohale and Bokong areas is characterized by dendritic drainage patterns with high yields due to rapid runoff from steep slopes, and a highly variable flow

regime. The areas of the catchment that have the highest mean annual precipitation also have the highest mean annual runoff. Rainfall occurs predominantly as high intensity and short duration thunderstorms. The nature of the rainfall, the rapid movement of water off the steep slopes and thin soils, results in a quick drainage reaction time in relation to surface runoff. The wet/rainy season extends from October to March and runoff occurring during the dry or transitional months is often the result of snow melt.

The Senqu River has a relatively greater base flow in relation to its flood peaks than the smaller Senqunyane, which has a smaller and less altitudinally diverse catchment. Flows in both rivers decline to very low levels in the dry seasons of most years. Some large flood peaks in the lower Senqu have no corresponding flood peak in the Senqunyane as a result of localized rainfall over the upper Senqu and Malibamats'o (Phase 1A) catchments. On a long-term average basis, the Senqunyane River contributes about 16.5 percent of the Senqu River's flow at the confluence of the two rivers. The monthly contribution ranges from 8 to 19 percent. Figure C-1 shows typical hydrographs for Senqunyane and lower Senqu gauging stations.

Soils and Land Suitability

The homogeneity of the parent material in the Mohale area leads to soil properties that tend to differ by degree (i.e. texture, depth and drainage) rather than type. The mountainous nature of the terrain determines that large areas are steep and rocky with limited agricultural potential. Variations in soil type occur in limited areas in depositional depressions, footslope concavities and along the main river courses, i.e. land which will ultimately be inundated. There are five broad geomorphic groupings. Soils with agricultural potential include the recent riverine alluvial, colluvial and the deeper of the residual soils. Of these the riverine and colluvial soils form the most important arable land. The residual soils on side and upper slopes are highly variable in depth and degree of stoniness and are more marginal for agriculture. The hydromorphic soils are occupied by marshlands which are heavily grazed by local livestock. In general terms, the best of the arable soils are suitable for wheat but the area is not well suited for maize production because of climatic constraints mainly due to the incidence of frost.

Sediment Sources

Basaltic regions of Lesotho have a sediment yield measured at values from 10 to more than 500t/km2 per year. The yield from adjacent basaltic areas has been estimated at 350 to 400t/-km^2. Sandstone regions have significantly higher sediment yields, partly due to geology and soil structure and partly due to more intensive land use at lower elevations. Estimated sediment yields range from ~800 to more than 2,000t/-km^2 per year. The sediment yield of the Senqu River below the Senqunyane confluence is likely to be somewhat higher than that of the Senqunyane River because of the greater proportion of sandstone formations in its catchment. The long-term mean contribution of the Senqunyane River flows to the Senqu River flows is about 17 percent, and hence the long-term sediment contribution of the Senqunyane to the lower Senqu is likely to be less than this, possibly of the order of 10 percent or less.

Soil Erosion

The erosion levels throughout the catchment are generally low to moderate with areas of moderate to high erosion occurring in, and adjacent to, communities, and where concentrations of tracks occur. The widespread low to moderate erosion is the result of localized grazing. The main factors affecting soil erosion are the influence of aspect on vegetation, and soil type and slope. Basalt derived soils, although generally shallow, are particularly stable. Long steep slopes render the land extremely susceptible to erosion once the vegetative cover is seriously weakened or lost. The effect of raindrop splash effects, rill

erosion and gravity are seriously aggravated by steep slopes. High soil losses currently occur in cultivated and settlement areas. For almost all of the sub-catchment areas the average annual soil loss rates that are predicted exceed the proposed soil loss tolerances of 3 to 10t/ha/yr. Four of the sub-catchments of Mohale area and the catchment of Matsoku have badly degraded land facets for which soil loss rates exceed 100t/ha/-yr. These excessive rates are due to severe vegetation deterioration within these catchments.

Terrestrial Environment

Land Resources and Rangelands

The Mohale catchment contains 71,473ha of grassland, 50 percent of which is comprised of *Themeda triandra* type. In addition, the catchment contains 15,083ha of shrubland, 990ha of wetlands, 4,914ha of cultivation and 539ha of settlement. Sustainable carrying capacity estimated for the Mohale study area varies between 8ha and 12ha/Large Stock Unit (LSU) but the current livestock densities exceed the carrying capacity significantly. The major constraints to range production include the harsh climatic conditions, shallow soils, rugged terrain, and the fact that all grazing land is communal so that no one individual has responsibility towards the management of the resource.

Livestock

The average herd size of the 75 percent of all households that keep cattle is 6.9 head. Other livestock maintained include goats, sheep, swine, poultry, horses and donkeys. Livestock are intimately bound up with the lifestyle and culture of the community. They provides the second largest source of household income, after remittances.

Field Crops and Horticulture

The main crops grown in the study area include maize, wheat, peas, beans and oats. About 50 percent of households produce vegetables with the most important ones being cabbage, spinach/kale, onion, potato, tomato and a variety of others including *sepaile*, radish, peas and beans. Marijuana (*matekoane*) is the most important (though illegal) cash crop in the study area. It is mainly interplanted with maize and is grown by about 70 percent of all farmers.

Manure is used more frequently and in greater concentrations than on field crops because of the smaller areas involved and the generally close proximity to cattle kraals. Very little use is made of plant protection chemicals or inorganic fertilizers. All produce is either consumed by the household, sold to neighbors or bartered for other products. Despite a low level of productivity, agriculture plays a critically important role in the economy of the communities.

Forests and Village Orchards

There are no woodlots or orchards greater than 30m^2 in area in the catchment. Most villages have a few small trees and individual homesteads may have a tree or two. Household fuelwood is generally derived from poplar and willow species and a small amount of firewood comes from the die-back of peach trees, but there is no systematic pruning to produce firewood as a by-product. In the inundation area an estimate of 200kg per household per year of firewood is used from local sources.

Fauna

There are 52 mammal species in Lesotho (historically approximately 70 species), giving the country, by comparison, possibly the lowest mammal species diversity in the southern African Region. Historically, the possible reasons for this are extreme living conditions, a habitat of uniform topographic relief, homogeneous vegetation, human habitation and activity. In the Mohale area low trapping success rates indicate small animal densities. The Highlands support a relatively low diversity of bird species with 106 species recently recorded. Nevertheless, there are several species of conservation concern that have major strongholds in the region, both

relative to southern Africa and globally. The area's avifauna is also characterized by a high proportion of species endemic to the distinct biogeographical region encompassed by southern Africa south of the Zambezi and Kunene rivers and, even more specifically, to the region encompassed by Lesotho, South Africa and Swaziland. Globally threatened bird species in the area include bald ibis, Cape vulture, lesser kestrel, and yellow-breasted pipit.

Four lizard species and five frog species have recently been recorded with the most important of these being the umbraculate frog, *Rana vertebralis*. It is a species not tolerant of poor water quality and as such is not likely to survive in those areas where water quality will be affected as a result of the dam.

Flora

The flora of the area is typical Eastern Mountain Region flora which covers the whole of the basaltic area. Most of the highland vegetation has been disturbed. River valleys, where soil is suitable, have been converted to agricultural production. Many steep sided slopes have lost their original vegetation and are now being cultivated. Throughout the Highlands the natural vegetation is relied upon for grazing, and it is unlikely that any of the Highlands has escaped the demands of grazing cattle and sheep. Frequent and deliberately set fires are another important disturbance factor. Vegetation zones are not pronounced within the project area, primarily due to the narrow altitudinal range (between 2,500 and 2,750m asl) The area is characterized by three zonal communities (*Themeda* grassland, Sub-alpine and alpine grasslands, and summit community and *Helichrysum-Erica* heath) and six other azonal communities, the most important being the wetland azonal community. This latter community is of particular importance due to its function of regulating water flows.

The riverine (lower Senqunyane and Senqu rivers) azonal community will be most directly affected by the project as water flows downstream will be altered.The only species of plant which is endangered in Lesotho, and which is likely to be threatened in Mohale, is the spiral aloe, *Aloe polyphylla*. The greatest threat to the survival of the spiral aloe is increased access through road construction and increased tourism. Map A-11 shows Mohale catchment land cover.

Freshwater Environment

Habitats and Fauna

Freshwater habitats are determined by a number of physical and biological factors including geology, sedimentation, climate, flow rates, water quality, overall vegetation cover, and riparian vegetation. Human influence on the surrounding landscape contributes to the modification of water quality and sediment loading.

The habitat quality in the Senqunyane River is rated good to moderate. The relatively higher abundance of *Austroglanis sclateri* (rock catfish) in the Senqunyane system is indicative of clear fast-flowing well-oxygenated water. High water temperatures are probably a constraint on most fish populations in the lower Senqunyane River during the dry season and, possibly, in the Senqu during the same period when the rivers are reduced to small flows and fish are forced into available backwaters. The upper Senqunyane River is described as pristine with little to no overgrazing in the upper catchment, resulting in clear substratums with little or no silt. The benthic quality is considered intermediate for an unpolluted system such as the Senqunyane River. Benthic abundance and diversity is lower in the Senqu River than in the Senqunyane River because of higher suspended sediment concentrations.

Sixteen indigenous and seven exotic fish species are known to occur in the entire Orange/Vaal River system. Six of the indigenous species

occur in the headwater tributaries of the Lesotho Highlands above 1,500m asl. and two introduced trout species (*Salmo trutta* and *Oncorhynchus mykiss*). The Maloti minnow *Pseudobarbus quatlambae* is an ecological specialist confined to the uppermost streams of the Orange River system. It is listed as rare and endangered in the IUCN Red Data Book. Its vulnerability is emphasized by its specialized niche, its evolution in isolation from major predators over a long period of time, its physiological and anatomical specialization, its low recruit survival and sensitivity to environmental changes and degradation, its severely fragmented, isolated populations with substantially different pigmentation and possibly genetic variation and its disappearance from the Umkomazana River in RSA. The entire distribution of the minnow is restricted to the Highlands of Lesotho. Isolated populations of minnows are currently known to occur in specific sites in nine rivers in Lesotho: the Tsoelikane, Moremoholo, Upper Senqu, Senqunyane (Mohale catchment, Bokong, Jorodane, Boloaneng, Matsoku and Sani rivers. The extent of occurrence of the Maloti minnow, for those areas that have been sampled, in the Phase 1 B area is calculated at 4.78km2, on which basis the minnow is categorized by IUCN as critically endangered.

Water Quality

Water throughout the Senqunyane catchment has a low alkalinity and a correspondingly weakly alkaline to neutral pH. Total dissolved solids are low. Calcium and magnesium are the dominant cations, with some stations showing moderately high levels of iron. Dissolved nitrogen levels are low, as are the other nutrient parameters, including total organic carbon and phosphorous.

For many chemical parameters downstream sampling has shown statistically significant higher concentrations or index values than the stations above the Mohale dam site. A trend towards higher dissolved solids with distance downstream is continued in the Senqu River. Calcium, magnesium and chlorides are significantly higher in the Senqu than in the Senqunyane, and the associated parameters of total alkalinity and electrical conductivity are also significantly higher. A characteristic of both rivers, although more marked in the Senqu than in the Senqunyane, is the high variability in water quality parameters. For some this can be demonstrated to be seasonal, with higher levels of total dissolved solids and some cations and anions occurring in the peak flow seasons. Figure C-3 indicates the pre-project (measured) and post-project (predicted) water temperatures of the Senqunyane River.

Socio-Economic Environment

Administration

The Phase 1B Project Area is situated in the central Lesotho Highlands on land under the custodianship of two Chieftainships (Thaba-Bosiu and Matsieng), and spanning three Districts (Berea, Maseru and Thaba-Tseka). The jurisdiction of both Principal Chiefs overlaps district boundaries. The Mohale dam inundation area is situated in Maseru and Thaba-Tseka districts. There is a three tiered development council structure consisting of a village development council (VDC), a ward development council (WDC), and a district development council (DDC). This structure as well as the Chieftainship structure comes under the Ministry of Home Affairs and Local Government, but under different departments. The District Secretaries (Department of Local Government) perform an important administrative role in integrating the activities of the Chieftaincy and the Development Councils.

The Matsoku Diversion scheme is situated in two districts of Lesotho, namely Leribe and Mokhotlong. Villages on the east of the weir site are situated in Mokhotlong District (in the ward of the Principal Chief of Tlokoeng), while villages on the west of the weir and those at the tunnel outlet are situated in Leribe District (in the ward of the Principal Chief of Leribe). The

administrative structure includes four chiefs administering 11 villages.

Population and Settlements

Household sizes in the Mohale area range between 1 and 21, with an average household size of 5.6. 76 percent of the population is classified as nuclear family members. The population in Mohale catchment resides in a large number of villages, most of which are very small. The total population of Mohale catchment in 1993 was 7,435 living in 1,323 households and residing in 75 villages.

The age distribution indicates that the population of Mohale catchment is very young with a broad based pyramid, tapering sharply towards the top. The proportion and numbers of males is consistently higher than that of females up to the age of 34. From 35 years of age the proportion and number of females is consistently higher than that of males, an indication that more males than females are born but they die earlier than females.

Over the past five years there has been a net loss of 84 (6.4 percent) households from the catchment with the majority of the emigrants going to the Lowlands. This reflects the move from remote areas to areas with better access to services. However, immigration from other mountain regions into the catchment (also mountains, but more accessible) and from mountains to Lowlands reflects differences in perceptions of accessibility.

The population of the villages proximate to the Matsoku scheme is estimated at 2355. Ha Mahlomola, the village from where the access road to the weir construction area will run, will probably experience something of a boom with the advent of construction. Within the sub-region, the village of Ha Seshote (about 6km from Ha Makopela, on the Northern Access Road) is the most developed. While Ha Makopela and Ha Leohla have primary schools, the nearest secondary school is in Ha Seshote. The population of the directly affected households of the diversion scheme is 2811.

Land Tenure, Culture, Society and Community Resources

Arable land is a national asset, held in trust for the nation by the King. The rights to the use of this land were formerly exercised by the chiefs, on behalf of the King, to farmers. These rights were later transferred to the Land Allocation Committees, chaired by the Chief. Compensation for the loss of these rights is payable to the farmers who hold rights of cultivation over the land. An important community resource is summer grazing land because of the transhumance system of livestock grazing. Besides local grazing, livestock owners use distant cattle post areas in the high mountains during the summer months. Traditionally the cattle posts are controlled by the Principal or Ward Chief, however, it is common to the residents of adjacent villages who have preferential access.

The primary unit of village society is the household and the household head is the legal and customary representative. The household is also an economic unit, with its own land rights and livestock. The extended family/homestead is the building block and fundamental social unit.

Livelihood and Subsistence

The average reported annual cash income in the Mohale catchment is M3,400 per household, with a range of M20 to M59,700 and a median of M2,400. Households depend on multiple sources of cash income. The top five sources are: i) remittances from RSA (30 percent total reported annual cash income); ii) local wages/salaries (12 percent); iii) sale of livestock (11 percent); iv) sale of home made beer (5 percent); and, v), remittances from Lesotho (3 percent). Land based incomes (mainly agriculture) account for 19 percent of the total annual cash income of households. Most households depend on other income in kind, particularly

their own produce and communal resources such as wood. It is known that a substantial cash income is derived from the illegal growing and sale of marijuana but no information is available on the amounts grown or the incomes realized.

In the Matsoku area, the most important economic activity is agriculture. Although essential, it is not a sufficient condition for survival. Most households are dependent on access to a cash income to secure items other than food for their livelihood. A system of subsistence production therefore coexists with a market economy.

Local resources are an important source of building materials, craft materials, medicines, fuelwood and nutrition. Communities also collect and sell these resources to supplement their incomes.

Transportation and Access

The Western Access Road (WAR) was the closest road to the project area prior to the building of the Mohale dam and tunnel access road. The WAR passes through Likalaneng. From here the dam access road has been built to the dam site and extended further to the tunnel site. All other access throughout the study area is by mountain track, passable only by horse or on foot.

Two river bridges are located within the reaches downstream of Mohale Dam - one at Marakabei on the Senqunyane River and another at Seaka on the lower Senqu River near the international border. A number of drifts exist along the lower Senqu River where crossings are made during periods of low flows.

Health

Under-nutrition is dominant throughout the project area. Stunting is of particular concern in children, even from the first year of life. Adolescent boys are more under-nourished than girls and this pattern continues into early adulthood. In marked contrast, almost half of the older women are overweight. Mild to moderate levels of endemic goitre in school aged children and adult women is the only significant clinical sign of nutritional deficiency observed in the area's population. Iron deficiency occurs in about one in every five non-pregnant women.

Asymptomatic carriage of the important STDs are widespread in the area surveyed Seven percent of serum specimens have been found to be positive for HIV antibodies and HIV infection was detected exclusively in those who resided along the main road. The majority of chlamydial infections are detected in association with gonococcal infections. Syphilis remains a major public health problem and it is a major cause of foetal wastage, infant mortality and morbidity in southern Africa and it is a potential health problem in the study area. Hepatitis B is endemic in the area. The rates of incubating or chronic carriage of hepatitis B reveals a small but potentially infectious group within the community.

Health Services

The common health care facilities accessed by the population include professional medical practitioners (hospitals and clinics), traditional healers and spiritual healers. A high proportion of households send ill members to a professional medical practitioner for treatment while others use traditional doctors and traditional healers. The existing facilities in Phase 1B consist of clinics at Likalaneng and Marakabei, and the St. James Hospital at Mantsonyane. Existing facilities in the Phase 1B area as well as surrounding hospitals, do not match certain critical criteria of infrastructure and/or equipment for the provision of primary health care (PHC). This results in shortcomings in the quality of the services and disqualifies the hospitals for the effective provision of the intensive and urgent care that will be required by a number of industrial accidents.

Education

Educational attainment in the Project Area is generally low. A much higher proportion of males (43 percent), five years of age and above, have no formal education compared to females (13 percent). On the other hand a much higher proportion of females, in the same age group, have completed seven years of primary education (36 percent) compared to males (13 percent). Educational attainment of females is consistently higher up to high school (Form 4-5). The literacy rate is 65 percent for those 10 years of age and above and this is lower than the national average.

Water Supplies and Sanitation

Natural springs are the source of mountain community drinking water. There are no piped water systems in the project area and there are only 74 toilets in the catchment for 2,966 households. Common ailments of diarrhoea and stomach ache could be indicative of water borne diseases. An epidemiology survey carried out in Phase 1A showed that all semi-protected and unprotected springs were contaminated with *Escherichia coli* and total coliform count suggested faecal contamination.

Energy and Telecommunications

Energy sources in the project area are primarily gained from biomass and other non commercial fuels. Main sources of energy include dung, shrubs, firewood, crop residues, annual weeds, paraffin, and candles. The people's first preference is firewood and the average annual consumption per household is 0.2 tons. Coal and gas are scarcely used in the project area.

Telecommunications in the area are non-existent.

Gender Issues

The typical Basotho village is divided spatially into two realms: a) that of the women (the houses); b) that of the men (the cattle kraals). Traditionally, they were not allowed into each other's realms. The men are involved in politics and work for the chief. The women's responsibilities were, and to a great extent still are, for agriculture, cooking, collecting water and raising children, making crafts, plastering houses, and making beer. With regard to agriculture, men have the responsibility for ploughing planting and harvesting. The women rule the house but men make the decisions. Men play a dominant role in matters of government and ownership of wealth.

Aesthetics

The Project Area is located in the Lesotho Highlands, much of which is very remote and characterized by rugged mountain topography, grassland and small scattered settlements. The remoteness and underdevelopment of the area provides high aesthetic quality for visitors to the area. This quality will provide the basis for any tourism that may be developed for the area.

Tourism

Nationally, tourism is a major source of foreign exchange within a limited economy, with exports totally an estimated M186 million in 1991. However, tourism has significantly declined over the past two to three years and, according to the estimated figures, reached its lowest level for ten years in 1994. The number of leisure travellers is very limited with less than 23,000 in 1993. Tourism in the project area is currently limited to small pony trekking operations and limited quality accommodation. There is no coordinated effort to develop tourism in the Highlands, yet the region has many of the features to attract outdoor enthusiasts and eco-tourists.

Cultural Heritage

Two LSA workshop/quarry sites, three LSA rock painting sites, and one LSA rock shelter are located within the Phase 1B study area. In addition there are four other but there is no evidence of archaeological debris or evidence of archaeological occupation for these shelters.

Natural Hazards

There are a number of natural hazards that can threaten the lives of the people of the mountains and their property. These hazards include exposure to harsh elements including snow, severe cold, hail, high winds, lightning, which occurs frequently during the summer months, veld fires, and flooded waterways.

PEOPLE'S PARTICIPATION AND SCOPING OF PUBLIC OPINION

Within the framework of an environmental impact assessment, local participation is vital for the following reasons:

- people are informed of all of the issues;
- it helps to address feelings of insecurity, fears and mistrust;
- it assists in identifying the real concerns of the public, particularly those who will be directly affected by the project;
- it is the essential element to any scoping exercise that attempts to focus on the most important issues and by doing so, maintains the EIA process at a manageable level;
- it assists in identifying practical and cost effective mitigative measures that will result in the smallest of residual impacts;
- it allows the community (the public) to become involved and take on ownership of the assessment and subsequently, ownership of the activities to be carried out to mitigate the impacts; it provides a level of self-importance;
- it provides valuable resource, socio-cultural and economic information that normally would not be available otherwise;
- it sets the way for subsequent stages of the development program and establishes the basis for a strong and understanding relationship between the project proponents and the other stakeholders.

The preparation of EAs for each of the project components involved the participation of the local community. The results from the participation exercises provided valuable input to the scoping for each of the individual assessments. Although the IECs were identified by a technical working group, the scoping of the individual assessments helped to provide a true focus on the IECs and ultimately to develop a strong effective scoping for the overall EIA program. A comprehensive public participation program was carried out as an integral part of the resettlement and development study. This program provided valuable input to the EIA. Two workshops, one internal to LHDA, and the other open to all interested parties, not only served to provide information on the impacts, but provided valuable feedback. A summary EIA in Sesotho was presented to the people of the project area.

PROJECT BENEFITS

Phase 1B will bring a number of benefits to the people of Lesotho and beyond. The major benefit to local residents will be the creation of some 10,000 person years of jobs at the various construction sites. In addition to these, the informal and informal sectors will expand to provide a variety of services to the jobs provided through the project. Additional benefits provided include:

- Training and skills transfer
- Tourism development
- Improved transportation facilities
- Improved domestic water supplies and sanitation facilities
- Improved medical facilities
- Improved access
- Improved local institutional and organizational capacity
- General improved village services
- Community empowerment

Regionally, electrical energy, transportation and communication services will be improved and these will provide the thrust required for subsequent economic activity and the provision of improved social services.

The rural development component of the project will improve rural socio-economic conditions throughout the general area. This component extends beyond the meeting of mitigation requirements of the various impacts.

Nationally, Lesotho will gain some M56 million annually from sale of water to RSA. Internationally, RSA will receive the much needed water supplies required to meet the rapidly growing economic and social demands of its industrial heartland.

IMPACT ASSESSMENT

Important Environmental Components The focus of the EIA has been the important environmental components (IECs). IECs are those components of the environment that are essential for functioning and maintaining the integrity of ecosystems and/or the socio-economic fabric of the area/communities. IECs are perceived as being important, either in a positive or negative manner, in an ecological, socio-economic and cultural context. An IEC is one upon which the project will have an impact or a potential impact, and also something that society is generally concerned about and is willing to invest money and resources to conserve and enhance.

The group discussions that resulted in a list of IECs have been supplemented and supported by the input provided by local communities where their concerns have been expressed and recorded. In all, a provisional list of 79 IECs was identified. The original identified IECs are indicated in Table B-4.

Phase 1B will result in a number of environmental impacts, most of which will be mitigated either during the construction stage of the project or following the completion of construction and as part of an ongoing environmental management program. The major impact, dislocation of people as a result of reservoir filling, will be addressed well in advance of project completion.

A total of 130 impacts were identified for the various components to the project. Table B-8 provides a summary of each of the impacts identified for each project component. The following descriptions are only for those impacts that have either high or very high levels of significance rating for individual or groups of IECs. Residual impacts are described in Table B-10.

Impacts on the Socio-economic Environment

General

There are many socio-economic IECs that when considered collectively, express the overall serious impact on the people of the area. There is not one single IEC that focuses on resettlement as such, although resettlement, or rather the impact (dislocation) that leads to resettlement is implied. Cultural identity loss, social infrastructure impact, community relationships, access (or lack of) and the loss of subsistence opportunities, particularly through the loss of agricultural land, together lead to a mitigative action of resettlement.

As a result of inundation and other construction activities associated with the reservoir, people in the Project Area will be faced with situations which seriously affect their lives. These include the loss of housing and infrastructure, arable and winter grazing land, and the access to existing resources and amenities. The reservoir will seriously restrict movement through the Project Area. A major impact will be the reduction of total households in the area from 1,500 to 1,280

(15 percent reduction). However, there will be local movement of households relocating within the Project Area and this will increase the pressure on certain parts of the area, notably surrounding Ha Koporale.

The two major areas where access will be most constrained by the reservoir are the NE area between the Bokong and Senqunyane rivers, and the Northern area between the Bokong and Jorodane rivers. Access across the river at the Mohale tunnel site will be lost to the people of Ha Tsapane.

The majority of affected households in the Mohale area that are eligible for resettlement have indicated the foothills area as their preferred relocation area.

There will continue to be strong links between the settlers in the foothills area and those who remain in the Project Area. Regional planning will necessarily have to take this into consideration, especially in respect of access to existing communal assets such as summer grazing areas and associated cattle posts. Movement of livestock will form a major element of plans to organize Range Management Associations for improved utilization or rangeland resources.

There are 83 villages in the Project Area of which 46 contain households affected directly by inundation or construction activities associated with the Mohale Dam. Other villages may be affected to a lesser extent by various aspects of the project. A major impact upon this latter group of villages will primarily be restricted access.

Within the 916 households of the Mohale area there are 583 households losing physical structures and/or arable land..

Every effort will be made to encourage villages which are not seriously affected (less than 50 percent of the households losing less than 50 percent of their arable land) to remain in the Project Area and preferably at their present location. Only 13 villages have been recommended for resettlement or relocation: nine villages are recommended to remain, subject to the provision of adequate access; and the other 24 marginally affected villages should preferably remain in their present location.

People will be resettled in three groups. The stage 1 group includes 85 households affected by construction activities associated with the dam and the tunnel. The stage 2 group includes those primarily affected by inundation. Should the necessary infrastructure not be in place the stage 3 group of 168 households could be eligible for resettlement.

Seven key destination areas have been identified and these are indicated in Table B-5. If all people are resettled and / or compensated as per the resettlement and development plan there will be no residual impact. Map A-10 shows the potential resettlement receiving areas.

Housing and villages infrastructure

The villages of Ha Tsapane, Maetsisa, Ha Ralifate ad Mamokoluoa will be inundated. Eight other villages are all dangerously situated *vis a vis* the planned reservoir. The villages to be inundated or partially inundated accommodate 136 households containing 680 people. Villages that are proximate to the full supply level accommodate 111 households with a population of 630. Eight villages identified to be most at risk from the construction include 290 households and estimated population of 1595.

Mitigation of inundated villages and homes will include full resettlement. Where houses have been disturbed by the upgrading of the Western Access Road, they have been set back from the road or replaced. Any house and village infrastructure affected by blasting will be repaired.

Land Tenure
Those who are displayed from their land and relocated as a result of project activities will be given arable land as compensation. However, the authorities in the receiving villages have an obligation to provide every male resident of the village with land for farming. This obligation may be difficult to meet if those being resettled have taken all or most of the arable land available. Mitigation could include job training and other income generating approaches. The residual impact will be the loss of tenure rights for young men, and the loss of these men from the village as they go elsewhere in search of land or other forms of income.

Livelihood and Subsistence
Almost half of all of the people residing within the proposed reservoir rely on agriculture for their main occupation. Inundation will remove the livelihood of a large number of people. Many are subsistence farmers but many also earn a very substantial income from the growing of marijuana. This income will be lost. For those who will be inundated, resettlement, as one choice for compensation, will provide conditions under which traditional agricultural livelihood could be continued.

Although this traditional livelihood may be affected overall, the increased cash economy created through the provision of job opportunities will provide a substitute and improved livelihood. The introduction of various income generating activities will partially provide a substitute for the loss of income as a result of no longer being able to grow marijuana. For those who grow marijuana, this lost income will not be replaced and thus the residual impact for those people will be significant.

Informal Sector
The informal sector will expand and although this expansion will economically benefit the local community, it will bring with it some of the social ills normally associated with construction areas. Commercial sex and increased sales of both commercial beer and home brew will occur. Commercial sex can lead to an increase in STDs and in particular, increased incidence of HIV positive status. Substance abuse frequently leads to crime, fighting, injury, family quarreling and spousal abuse. Effective policing, health education and counseling will mitigate the impacts to some degree.

Short Term Employment
People who gain employment with the project will develop a lifestyle consistent with income earned. Approximately 10,000 person years of semi -skilled and labor jobs will be available at the various project sites. Some local people may abandon stable work to take up employment with the project. However, project jobs are not permanent and eventually people will have to return to their former employment (or unemployment) and will be required to curtail a lifestyle designed on the basis of a steady income. This often leads to social difficulties, particularly within the family.

Rural development activities will be introduced that will provide long term employment and income generation. The project will introduce training programs that will provide useful and lasting skills that can be applied elsewhere.

Food Security
Most agricultural activities in the area are either subsistence or of a complimentary nature to remittances. The most immediate consequences of the loss of arable land will be the reduction in food security for households partly or wholly dependent on the affected fields. The loss of arable land will affect some 3000 people that rely on food grown in the Mohale inundation area. Those who lose their ability to grow their own food will be compensated and one choice of compensation will be replacement arable land. Crop production improvements will be introduced to the general area to increase crop pro-

duction on those lands in the area that are not affected by the project.

Biomass Fuels

Biomass fuel in the highlands is a scarce commodity and people rely on it to meet much of their cooking and heating requirements. A significant amount of biomass in the Mohale area will be lost as a result of inundation. This biomass is not only available to those who have to be resettled to other areas but it also is used by others living beyond the FSL. Mitigation for the loss of biomass fuel will include the establishment of appropriate vegetation (e.g. afforestation) for fuel on suitable sites, and the introduction of paraffin and paraffin stoves.

Cultural Identity

The people of the Project area have been shaped by the harsh climate, difficult terrain and remoteness from modern facilities, services and amenities. Economic independence and self reliance are strong characteristics. Many people will abandon a traditional lifestyle for the sake of project jobs. Social interactions will change and cultural identity will erode. Those who will be inundated will be resettled, in some instances to the Lowlands where the lifestyle and culture are be different. Mitigation for a number of socio-economic impacts must include compensation that extends beyond Hand-outs@ and will be a type that promotes self-reliance, initiative and capacity of the mountain people to survive under the prevailing harsh conditions. There is no mitigation for the loss of a culture.

Health

With the loss of a substantial area of cropland including vegetable gardens and fruit trees, as a result of inundation, a variety of crops required to maintain nutritional levels will no longer be available. The assumption is that the crops grown in the area to be inundated will normally be available to an area population considerably greater than the population that will have to be resettled as a result of inundation. With the influx of a large construction workforce, both formal and informal business will be established to sell to the expanded population. Non-nutritional foods will be made available and sold to local people with more income available for discretionary spending. Nutritional levels may decrease.

Construction workers will attract the establishment of a commercial sex trade. Sex, both commercial and non-commercial, will result in an increase in the levels of STDs including HIV positive status. Those living in the vicinity of construction activities will be subject to noise, dust and vibrations, all of which could affect their physical and mental well being. A number of people in the area will always be living in concern for the future and the unknown as the project proceeds. They will have the feeling of loss of power and control, and unfulfilled rising expectations.

Many of the occupational hazards related to traffic and machinery will apply to the residents of the area. Through curiosity of lack of understanding, local residents could find themselves in dangerous situations near heavy machinery. A major safety concern is for children, who are unable to swim, who could slip into the reservoir and drown. At Kutu Kutu the tunnel outlet for the Matsoku Diversion will be a temptation for local people as a convenient access to the shops at the tunnel entrance area. Such an unwise decision to walk the tunnel will result in death if the diversion was put into full operation during the traverse through the tunnel.

A number of mitigation measures will be undertaken to avoid the above health impacts, crop production improvements will be introduced to the remaining arable areas and general public education will include instruction on good nutrition. Sex education will be provided in the schools and in the construction camps and villages. Condoms will be distributed freely. The dangers of HIV positive will be well expressed

and illustrated. To minimize the mental anguish of noise, dust, the unknown, etc. local people will be well informed of construction scheduling, particularly of a major event taking place such as blasting, road closures, particularly heavy traffic, etc. Contractors will operate within an agreed daily time frame and they will ensure that minimal noise (e.g. properly maintained vehicles) and that roads are watered to control dust. On the matter of reservoir induced seismicity, local residents will be well informed of what to expect, and compensation for damages incurred will be swift and fair.

Regarding public safety, the public will be educated in terms of what to expect an the danger to be avoided. All vehicles will have properly maintained warning devices (lights, horns and reverse audio devices) and construction sites will be fenced and posted with warning signs. Speed limits will be fenced and posted with warning signs. Speed limits will be strictly enforced. The tunnel outlet at Kutu Kutu will be designed to prevent unofficial pedestrian access. A public health program will be introduced to the area.

Access

Impoundment of the reservoir will remove easy access from one side of the reservoir to the other. Families and entire villages that have social, cultural and economic contacts with one another will be physically separated by the reservoir. Traditional and easy access to resources upstream would be denied. Easy year round access across the Matsoku upstream in the vicinity of the weir will be difficult. People of the village of Ha Tsapane to Ha Koporale due to tunnel construction activities.

Access roads around the reservoir will be built, ferry landings will be established on the reservoir shoreline, and footbridges will be built over the Matsoku River and over the Senqunyane River downstream of the Mohale tunnel inlet.

Impacts on the Aquatic Environment

Stream and River Flows

The Mohale reservoir will eliminate 25km of the Senqunyane River. The river flow downstream of the dam will be affected significantly for its entire length. The flow of the Senqu will be affected marginally. Downstream flow of the Matsoku River will be affected for approximately 1km. The Ash River flow will be augmented by delivery waters from both Phase 1A and 1B. Compensation flows at Mohale and at the Matsoku weir will minimally offset downstream flow impact. Figure C-2 indicates average monthly flows, with and without Phases 1A and 1B.

Natural Springs

Springs are important sources of domestic water. They could be altered or destroyed during construction, and the tunnels could pose a threat to springs through underground drainage. Springs will be avoided wherever possible, tunnels will be lined where drainage into the tunnel from springs is a threat. Where domestic water supplies are lost, alternative sources of domestic water will be provided.

Water Quality

During construction of the various project components, spillage and runoff water with contaminants (e.g. oil, cement, chemicals) will threaten downstream water quality, and subsequently, downstream users and aquatic communities. Informal settlements without adequate sanitation facilities will affect water quality as will activities causing erosion and subsequent sedimentation. Appropriate precautions including containment, storage and disposal at construction sites could prevent contaminant runoff. Random settlement will be controlled, particularly where contamination risks are high. Undoubtedly there will be accidents and some neglect that will lead to some contamination of soil and water quality.

Modeling indicates that water near the dam wall, from which the downstream releases will be

drawn, will be clear, with low dissolved solids content and very low to negligible suspended material content. Released water will be cooler than river water in the summer by several degrees, depending on the depth of reservoir withdrawals, and will be substantially warmer in the winter months. Dissolved oxygen will be reduced in concentration. pH of released water will probably be similar to natural river water prior to the project. Figure C-3 shows pre- and post-water temperatures.

Aquatic Habitats and Fish

About 25km of the Senqunyane River above the Mohale Dam will have its aquatic habitat replaced by a large and, in the beginning, relatively sterile lake. Downstream of the dam and the Matsoku Diversion, changes in water quality in terms of chemistry, turbidity and siltation could have an effect on existing aquatic habitats. Reduced downstream flows will have an adverse effect on existing habitats. Fish and invertebrate communities currently found in the Senqunyane River will be lost above the dam for a distance of 25km, assuming the new habitats developed will not be suitable for current riverine species. Populations downstream will be adversely affected.

There is no mitigation for the loss of aquatic habitat. The reservoir will replace the river habitat with a lake habitat. Downstream compensation flows will only partially mitigate downstream aquatic habitat losses. New population mixes and numbers will develop as habitats change.

Rare and Endangered Species

The Maloti minnow, a rare and threatened species which is found only in the Lesotho Highlands, could lose two of the nine currently known habitat locations, thus placing further pressure of extinction on this species. In addition to habitat losses, if trout were intentionally introduced to the reservoir, an additional three locations (Senqunyane River tributaries) of the Maloti minnow will be lost.

Maloti minnow research, investigation into other possible highland habitat locations, habitat protection, species assessment, and artificial breeding and reintroduction into the Highlands, will all contribute to the protection of the species. In the three Senqunyane River tributaries and in the Senqunyane River above the reservoir, barriers could be erected to restrict the movement of trout upstream.

Impacts on the Terrestrial Environment

Soil Erosion

Potential for soil erosion during the construction stage of all project components is high. The increased pressure on grazing lands as a result of the loss of grazing lands due to inundation could lead to increased soil erosion. The project will attract outside people and livestock populations could increase, thus placing increased pressure on the remaining grazing lands. Increased soil losses will lead to a loss in biological productivity and a decrease of natural water flow regulation.

During construction, guidelines will be followed to ensure minimal soil erosion (e.g. rehabilitation of spoil dumps). To protect rangelands from overgrazing, range management programs will be introduced, and there will be strict control of livestock populations from the outside.

Woodland and Orchards

Single trees and micro-woodlot will be lost in the inundation area. These are important resources for local people and are used for firewood and building materials. Peach trees will also be lost and these provide an important source of income and well as nutrition. Individual trees could be damaged during construction.

Trees that are lost to inundation will be salvaged prior to inundation. Care will be taken not to

unnecessarily damage trees during construction. Individual trees and micro-woodlots will be established in appropriate areas. Compensation will be paid to all of those who lose trees.

Rangelands and Livestock
A total of 1635ha of primarily winter grazing land will be inundated. This will place pressure on the remaining winter grazing lands which could result in a decrease in grass productivity and an increase in erosion. Grazing pressure in the vicinity of Mohale New Town will likely occur. Construction activities, and improved access to the area, will lead to increased stock theft.

Decreased rangeland and animal productivity could be mitigated through the implementation of efficient rangeland and livestock management programs. Effective rangeland management could result in a nil residual impact.

Cropland and Crop Production
A total of 700ha of arable land will be lost to inundation, along with an additional 66 fields as a result of dam construction activities, and 16ha at the Matsoku weir site. Another 6.7ha will have been lost as a result of the WAR upgrading. The loss of arable land is a loss of livelihood and the source for family nutrition. There will be some temporary losses of arable land during the construction phase.

Loss of arable lands will be compensated and in the case of lands lost to inundation, at least some of these landowners will have the opportunity for resettlement. All construction activities will consider the quality of land to be used and prime agricultural land will be avoided wherever possible. Where agricultural lands are required, topsoil will be removed and stockpiled, to be used for site rehabilitation following construction. Where possible, arable land will be created using topsoil removed from construction sites. Effective extension with remaining area farmers could improve their productivity and make up for some of the production losses as a result of lost croplands.

Fauna (Birds)
The reservoir will effect the habitat and food source of eight of 16 water bird species as river flow is reduced and food sources and habitat are also reduced. A few cliff nesting species will lose habitats as cliffs are submerged. A total of 59 species of birds exploit the artificial habitat of the cultivated field and thus inundation will affect these species. Cliff nesting raptures will lose prey as the prey habitat is drowned. Transmission lines will take their toll on birds, particularly water birds. An increase in the population of people in the area will also place additional hunting pressure on bird populations.

Of the rare and endangered species, the greatest threat to the globally threatened and globally near threatened bird species will be the increased human population expected as a result of the construction and follow-on development activities.

Water birds may move into the area that will have been formerly occupied by the birds using field habitats. Bird guards will be installed on transmission lines and environmental education will contribute to the conservation of bird species.

Fauna (Reptiles and Amphibians)
Rana vertebralis (umbraculate frog) is an important indicator species of water quality. It is unlikely that the species will survive along the water edge or in any other part of the reservoir. Sub-populations in the Senqunyane tributaries will be isolated from one another. The species could disappear from the catchment area. There is no mitigation for the loss of this important species.

Flora
The spiral aloe is a rare and endangered species currently under threat of loss from the area due

to illegal collecting. Increased pressure on the plant=s survival will occur as the human population of the area increases as a result of the dam construction activities and the heavy traffic between Ha Mohale and Maseru. There are localities near the WAR where the spiral aloe is known to occur.

Wetlands have an important water regulation function to perform. They are continually under pressure from grazing and this pressure will increase as the population of the area increases and livestock numbers increase.

Mitigation will focus on public education, protection under law with effective prosecution, protection by communities, and propagation of the plant to build up the population and to provide specimens for commercial sale. Public education and livestock management programs will contribute to the protection of wetlands.

Cumulative Impacts

Cumulative impacts are impacts on the environment which result from the incremental impact of an action when added to other past, present and reasonably foreseeable future actions, regardless of whatever agency or other person undertakes such action. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

An impact that may have a low significance rating on its own, could contribute with other similar impacts, or totally different impacts, to a much greater impact on the IEC than the sum of all of the individual impacts. For example, the loss of water from the Senqu River as a result of the Mohale Dam may only be a moderate impact on its own. The impact of the loss of water from the Matsoku on the Senqu River, could be very low and the impacts of individual future phases on the Senqu River could be moderate. However, when all of the individual impacts, none of which may be very serious, are examined, the cumulative impact on the Senqu River could be high or very high. Cumulative impacts are provided in Table B-9.

ENVIRONMENTAL MANAGEMENT

General

An environmental action plan (EAP) is being prepared on the basis of the results of the environmental impact assessment. The purpose of the plan will be to

- provide the blueprint for clear and timely actions that will be required to mitigate and compensate for the impacts that have been identified through the EIA;
- to provide details of other actions necessary to ensure the sustainable economic development and management of the resources of the Mohale catchment.

Three approaches will be used for implementing mitigative measures:

- contractors will be required to take a number of actions during the pre-construction and construction phases to ensure that certain impacts are avoided and towards the end of the construction phase they will also be required to rehabilitate all the construction sites;
- the LHDA will be required to operate the water transfer facility in a manner that will minimize certain impacts that have been identified to occur during the operational phase;
- the LHDA will implement sectoral programs (natural environmental and heritage, public health, rural development, resettlement and compensation) that will mitigate the impacts of the project and also contribute to the enhancement of the people's standard of living.

The environmental protection requirements for contractor activities will be specified in the

engineering tender documents. The operational guidelines for LHDA that will be required to address certain impacts are yet to be developed. These will include such activities as water regulation and release schedules, maintenance activities, etc.

Construction Mitigation

Each of the main project components including Mohale Dam, advanced infrastructure, Mohale Tunnel, Matsoku Diversion, and telecommunications, was subjected to an environmental assessment and these assessments have provided major input to the preparation of the overall Phase 1B EIA. Along with the engineering aspects of the respective component designs that have been prepared, mitigative measures to address the identified environmental impacts to be expected from construction activities have been built into the project component tender documents. Once the contractors have been selected their individual contracts will specify environmental management activities to be carried out. The engineering staff of each component will employ an environmental monitor to ensure that the environmental responsibilities of each contractor are carried out in the manner described and that the results obtained are those expected in terms of impact mitigation. Contractors= responsibilities will also include environmental responsibilities during decommissioning following completion of construction.

The environmental action plan will include detailed descriptions of the contractors' environmental management responsibilities for each of the project components.

Operational Environmental Programs

The operational phase of the LHWP will be extensive and complex, and will include many aspects from maintenance of simple machinery to the operation of reservoir schedules. Of particular concern will be the downstream effects that water releases (through reservoir operating schedules) will have on various aspects of the environment. Until instream flow requirements (IFR) analysis have been determined and until final operating schedules have been determined, it is difficult to finalize the determination of downstream impacts and the mitigative measures that will be required to address these impacts. The design teams which are currently developing the design and tender documents will be responsible for the development of procedural manuals for the operation and maintenance of LHWP. The Highlands Services Group will ensure, during the preparation of the procedural manual, that adequate environmental management procedures are included.

Environmental Sectoral Programs

Each of four HSG sectors (although the natural environment and heritage sector under the new structure is part of the advisory group) will provide components to the EIA. Each component will be comprised of one or more programs. Within each program there will be a number of projects and each of these will be designed to address a particular impact or group of impacts. There will be one development program that will address environmental enhancement only. Each project in the EAP will be in terms of, background, rationale, objectives, and strategies for achievement of objectives.

The project will outline specific tasks to be achieved, outputs to be reached, expected results, costs, responsibilities and scheduling. Monitoring requirements for each program will be included in the EAP. Table B-6 provides a list (tentative at the time of the EIA preparation) of the programs and projects for each of the four sectors.

Monitoring

Monitoring is necessary to ensure:

- that predicted impacts are addressed effectively and efficiently through the mitigative measures indicated;

- that any additional impacts not identified in the EIA document are addressed appropriately;
- that the mitigative actions (targets indicated) are appropriate for addressing the impacts;
- to feed information back to management in order that appropriate modifications can be made either to the construction, operational or environmental programming activities, or to the EAP in terms of mitigative measures to be applied.

People's Participation

One of the most important lessons learned from Phase 1A was the need to keep the people of the area continually informed about the project and its progress. During the design stage of Phase 1B the people of the respective areas where construction activities will take place have been kept informed of the activities that will take place and they have been given the opportunity to provide input in terms of their concerns and wishes as these relate to the project. Liaison with the people of the project area has been carried out primarily as the basis of the environmental assessments in each of the project component areas. In-depth participation has taken place in the Mohale area, particularly with those households which will have to be relocated as a result of inundation. In this particular case the people of the inundation area have been well informed in advance and they have had the opportunity to contribute to the decisions regarding their relocation.

Participation which has commenced with the planning and design stages of the project will continue into the construction phases. The people living in the construction areas will have the opportunity to speak freely about the project and problems encountered as a result of construction activities. Those affected by the inundation will be able to participate through the Area Liaison Committees (ALCs) and the Combined Area Liaison Committee (CALC) which are already established. A system of Community Liaison Assistants (CLAs), supervised by a Community Liaison Coordinator (CLC), will support the affected individuals, households, institutions and organizations. It is planned that this type of institutional arrangement will be developed for all areas of Phase 1B where local residents will be affected by the project component construction activities.

In addition, and mainly as a result of recognizing that the people of Phase 1A had little opportunity for participation, particularly with regard to grievances, the Environment Division's FOTs will contribute significantly in providing a *front line* opportunity for communication and participation.

A third participatory mechanism with be provided through the system of monitoring and control that LHDA will provide for various aspects of the project. Since many of the project impacts can potentially affect the socio-economic welfare of the people of the project area, project activity monitors will, as part of their duties, provide the opportunity for local people to be heard.

Emergency Preparedness Plan

An emergency preparedness plan (EPP) has been developed for implementation in the event of controlled and uncontrolled releases of water from the Mohale Dam. The EPP includes dam break analysis and inundation mapping. It describes the actions to be taken by National (including LHDA) and local authorities and other agencies if an emergency arises. The EPP extends to the border of Lesotho with RSA. Data assembled in the preparation of the plan (e.g. results of the dam break analysis and the inundation mapping) and the plan itself will be communicated to DWAF (RSA) such that this agency will be able to extend the study results to its own structures.

Residual Impacts

The EAP will describe in detail the actions to be taken in order to address the various impacts identified. However, not all impacts can be mitigated. Some impacts will be mitigated fully, some partially and some not at all. A summary of the probable residual impacts, following mitigation is given in Table B-10 for some of the major impacts. These are only probable at this stage since the EAP, has yet to be finalized.

SUMMATION

Phase 1B of the LHWP is large and complex and as a result it will have a number of impacts on the environment. Many of the impacts can be mitigated through sound management practices, particularly at the construction sites. Many others can be mitigated entirely or partially through good operational procedures and through the effective implementation of appropriate actions to address the impacts. The majority of these latter actions will be the responsibility of the Highlands Services Group (HSG). Currently, the HSG is preparing a detailed EAP that will describe in detail the various actions to be taken by all LHDA groups and by the contractors.

There will be a number of residual impacts. People will be displaced, despite being resettled and compensated for in a fair and equitable manner. People will become ill, some critically with the HIV virus. The Highlands culture will be eroded. Aquatic habitat will be permanently modified downstream and lost upstream but replaced with a different habitat and set of biological communities. Regionally and world wide, the project contributes to the growing loss (the cumulative effect) of natural habitats. There is the strong possibility that the Maloti minnow may become extinct as a result of the project. The loss of a species weakens the country's and the world's biodiversity. Water quality is moderately threatened downstream, and erosion throughout the Highlands could increase.

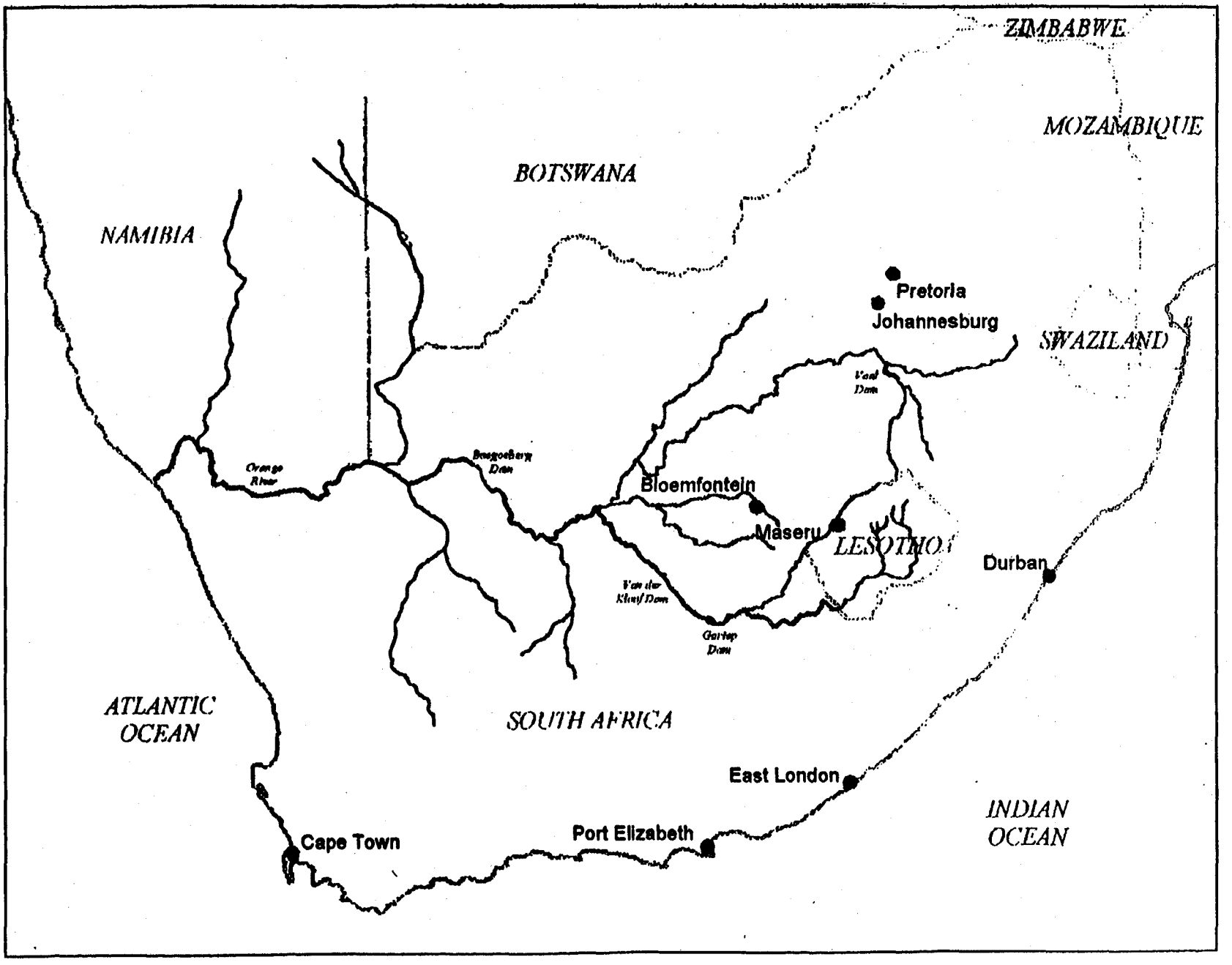
The benefits of the project have to be weighed against the residual impacts. These include the royalties to the GOL, some of which will be redirected for development in the Highlands. The people of the Highlands will receive an infrastructure that will not normally be made available. Economic spin-offs of the project will be large and many, for the country and for the Highlands people.

REFERENCES

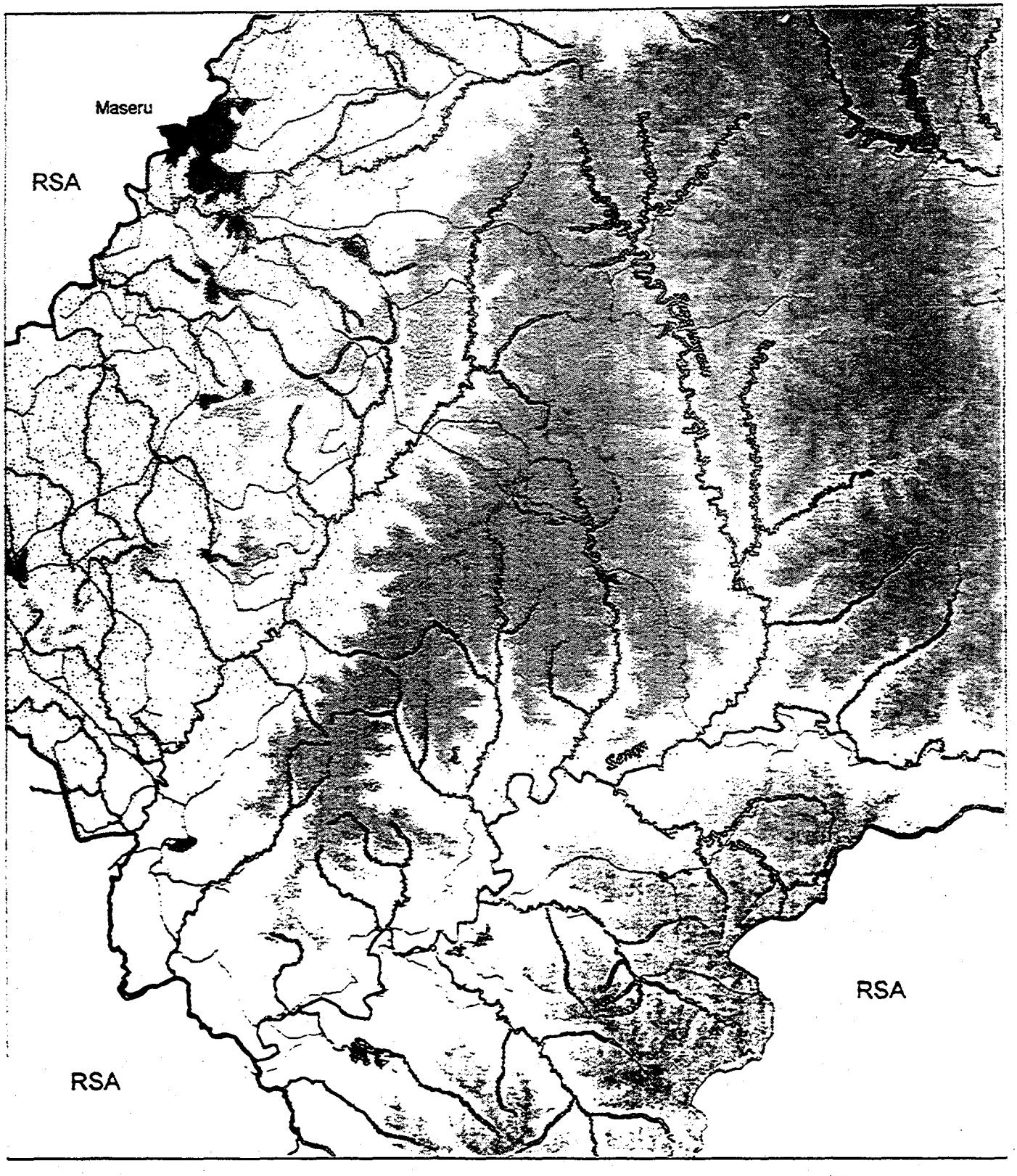
1. Afridev Consultants. 1996. *Baseline Biology Survey and Reserve Development, Phase 1B.* LHDA unpublished report.
2. Chutter, F. M. and P. J. Ashton. 1990. *Preliminary Report on the Impact of Lesotho Highlands Water Project on the Ash/Liebenbergsvlei/Wilge River Ecosystem.*
3. Consult 4. 1996. *Erosion and Sedimentation: Watershed Analysis.* LHDA unpublished report.
4. CSIR. 1997. *Baseline Water Quality and Aquatic Communities Studies Phase 1B.* LHDA unpublished report.
5. Gibson, G. and A. Hendron. 1996. Letter dated 21st February 1996, to Chief Executive, LHDA, Re: Seismic activity at Katse dam.
6. Gill, S. 1993. *A Short History of Lesotho.*
7. Hunting-Consult 4. 1996. *Resettlement and Development Study.* Draft Final Report Volumes 1-15. LHDA unpublished report.
8. Kaplan, J. 1994. *Archaeological Survey of the Mohale Inundation Area.* LHDA unpublished report.
9. Lahmeyer MacDonald Consortium and Olivier Shand Consortium. 1986. *Feasibility Study, Lesotho Highlands Water Project.* Main Report. LHDA unpublished report.
10. Lesotho Highlands Tunnel Partnership. 1996a. *Final Environmental Impact Assessment.* LHDA unpublished report.
11. LHDA. 1994. *Phase 1B Socio-economic Census Report: Mohale, 1993. Volume 1.* LHDA unpublished report.
12. LHDA. 1996a. *LHDA Employment and Informal Settlement Avoidance Strategy.* Environment Division.
13. LHDA. 1996b. *Impacts of the Lesotho Highlands Water Project Phases 1A and 1B on the Orange River System within South Africa.* LHDA unpublished report.
14. LHDA. 1996c. *Impacts of the Lesotho Highlands Water Project Phases 1B on the Senqunyane and Senqu Rivers.* LHDA unpublished report.
15. LHDA. 1996d. *LHDA Community Participation Strategy.* Environment Division. LHDA unpublished report.
16. LHDA. 1996e. *The Economics of Phase 1B.* November 1996. LHDA unpublished report.
17. Matsoku Diversion Partnership. 1996. *Environmental Impact Assessment.* LHDA unpublished report.
18. Medical Research Council, South Africa. 1996. *Baseline Epidemiology and Medical Services Survey.* LHDA unpublished report.
19. Olivier, Henry and Associates and Binnie and Partners. 1979. *Preliminary Pre-feasibility Report on the Lesotho Highlands Water Project.* LHDA unpublished report.
20. University of Pretoria. 1996. *Erosion and Sedimentation Studies. Erosion Modelling.* LHDA unpublished report.

ANNEX A: MAPS

Map A-1 Regional Setting



Map A-2 The Senqunyane / Senqu River System in Lesotho



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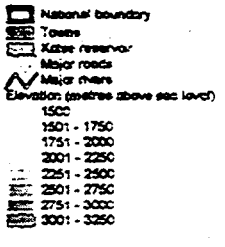
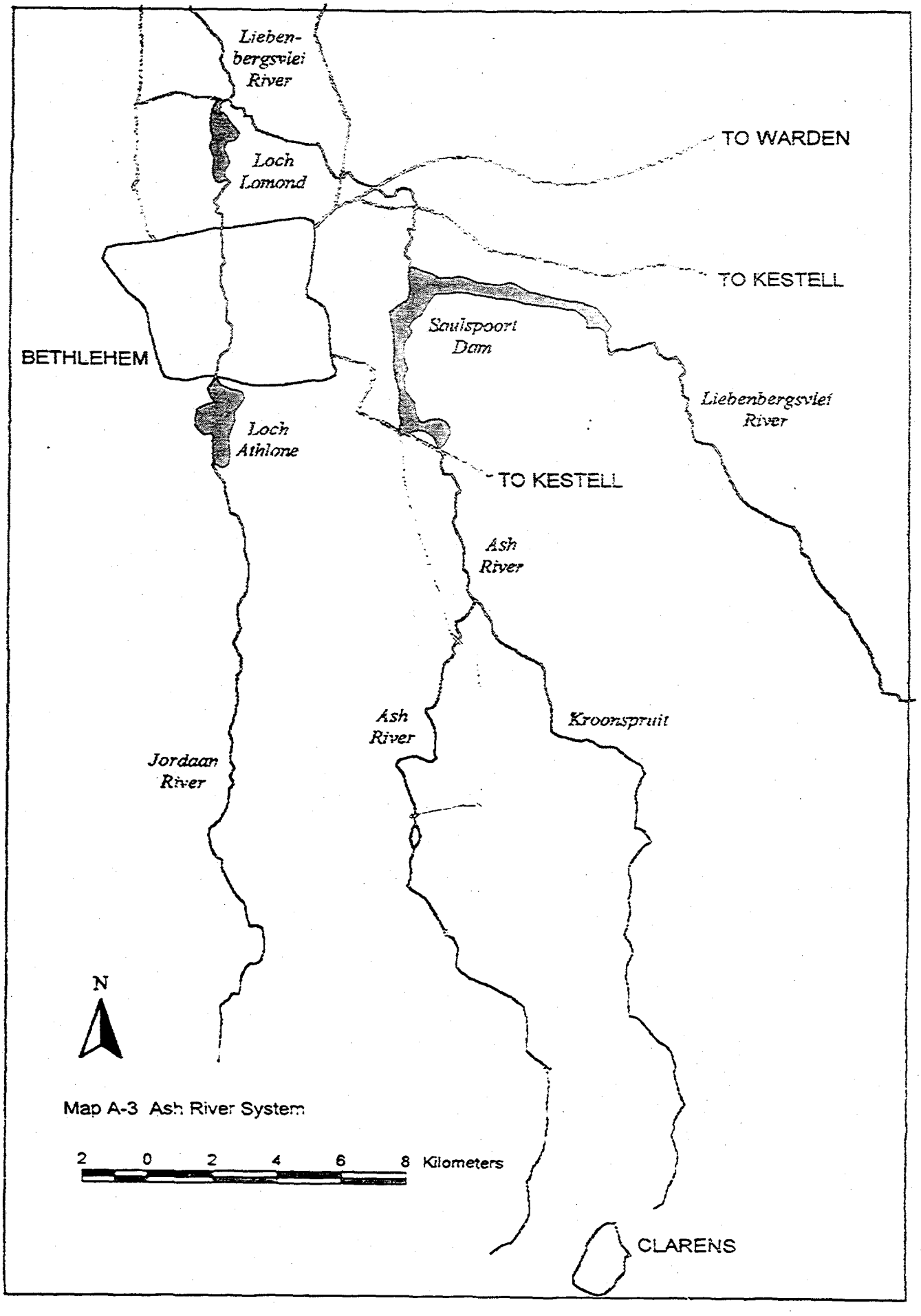
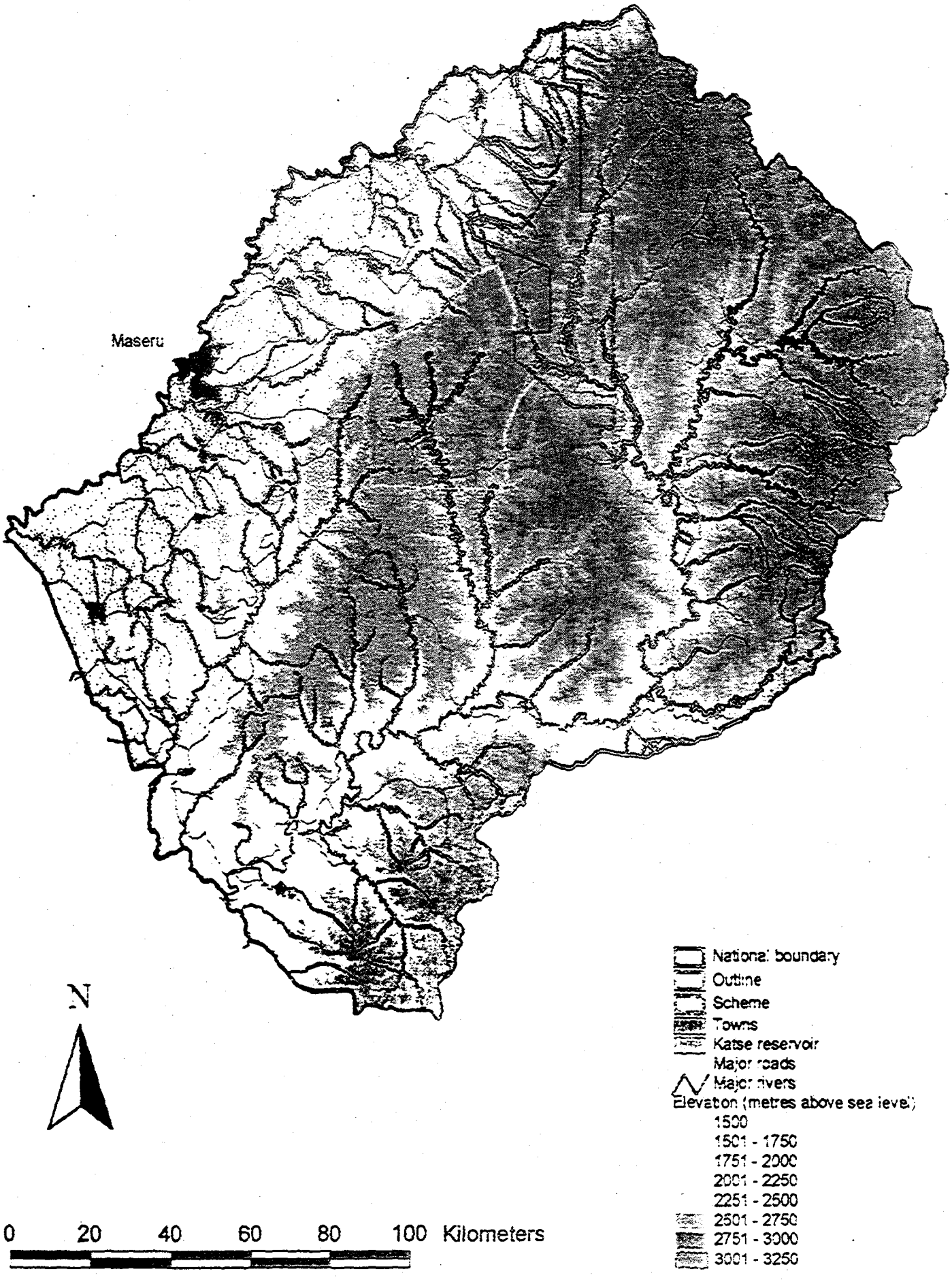


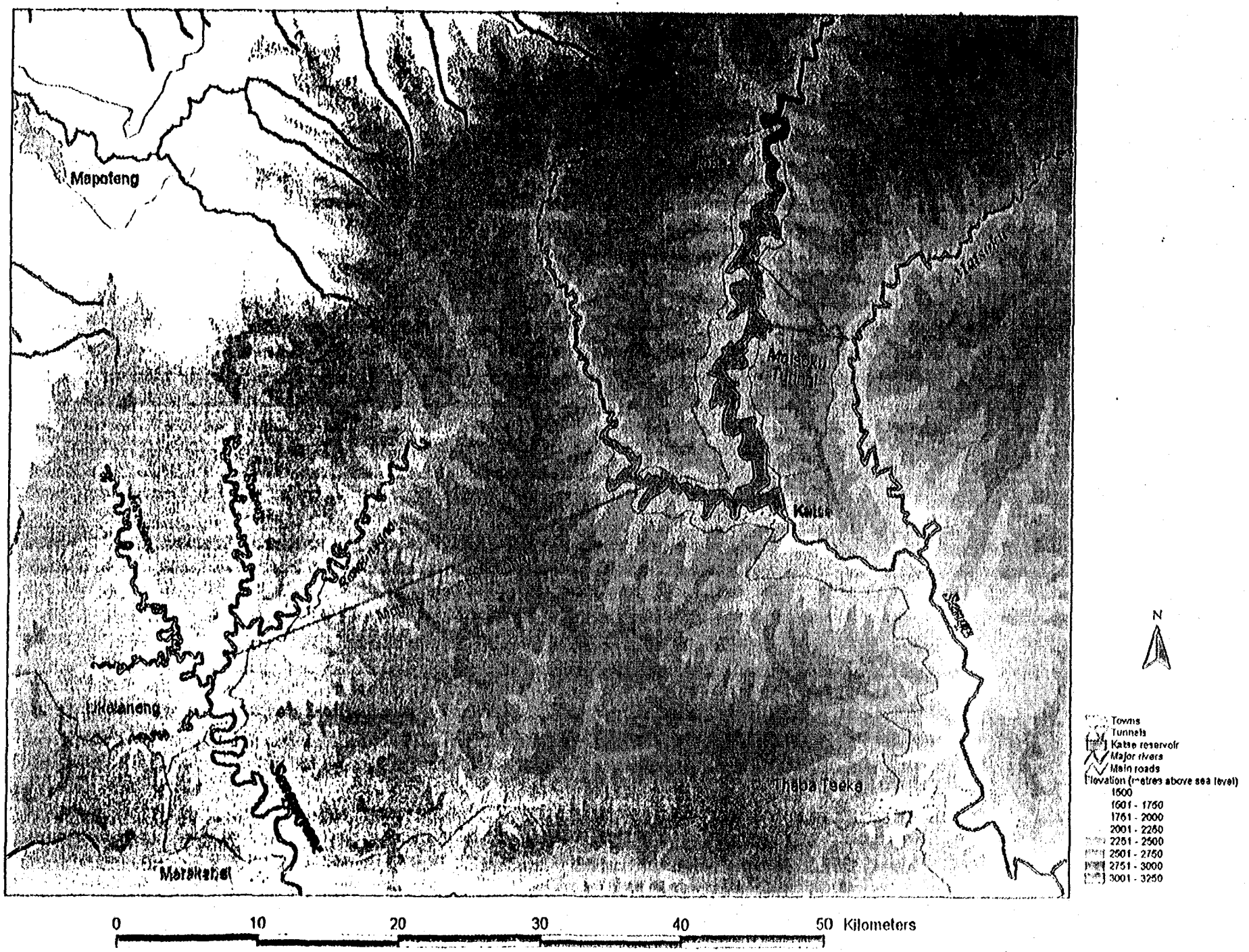


Map A-3 Ash River System

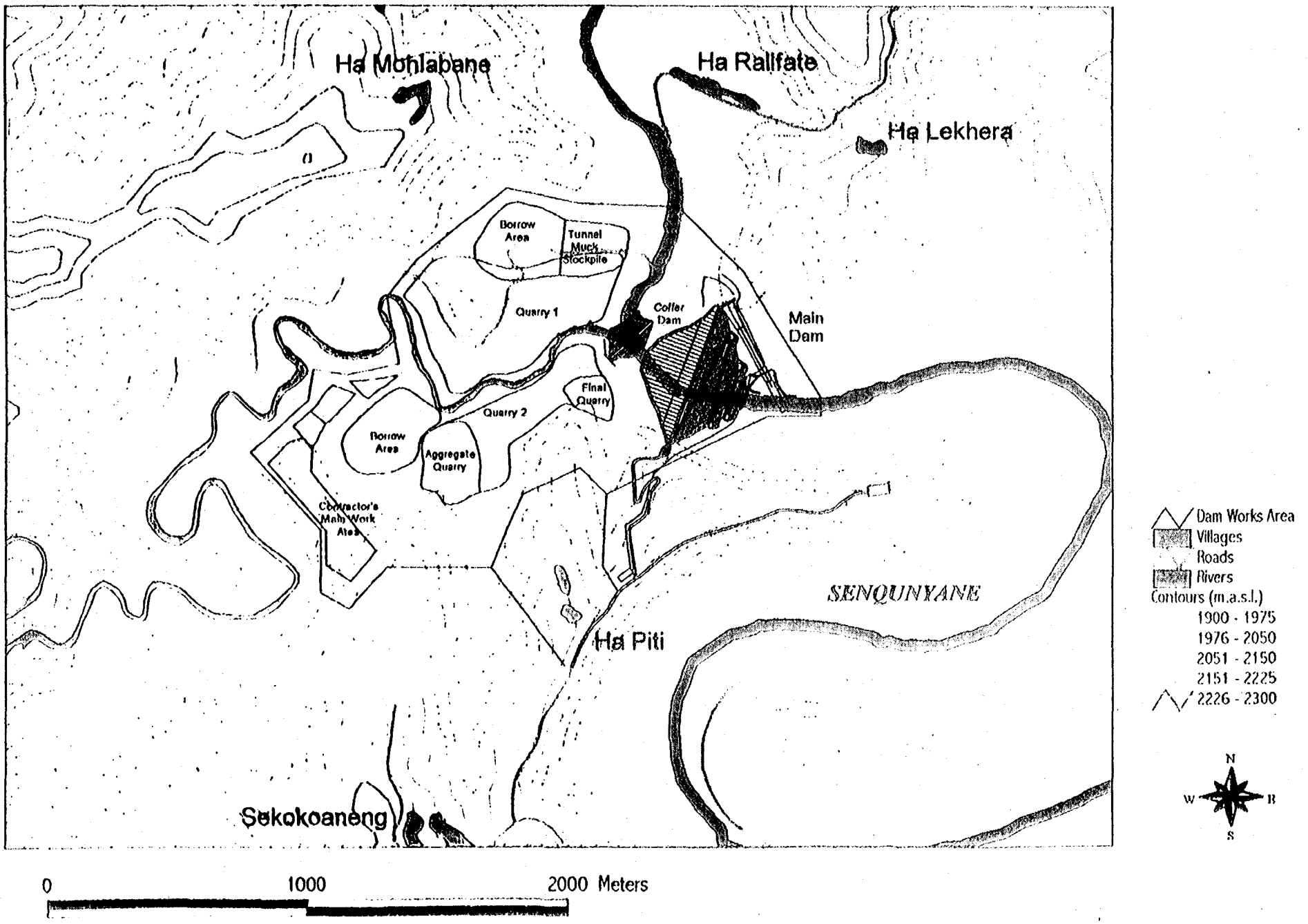
Map A-4 National Map of Lesotho showing Phase 1A and Phase 1B Scheme Areas



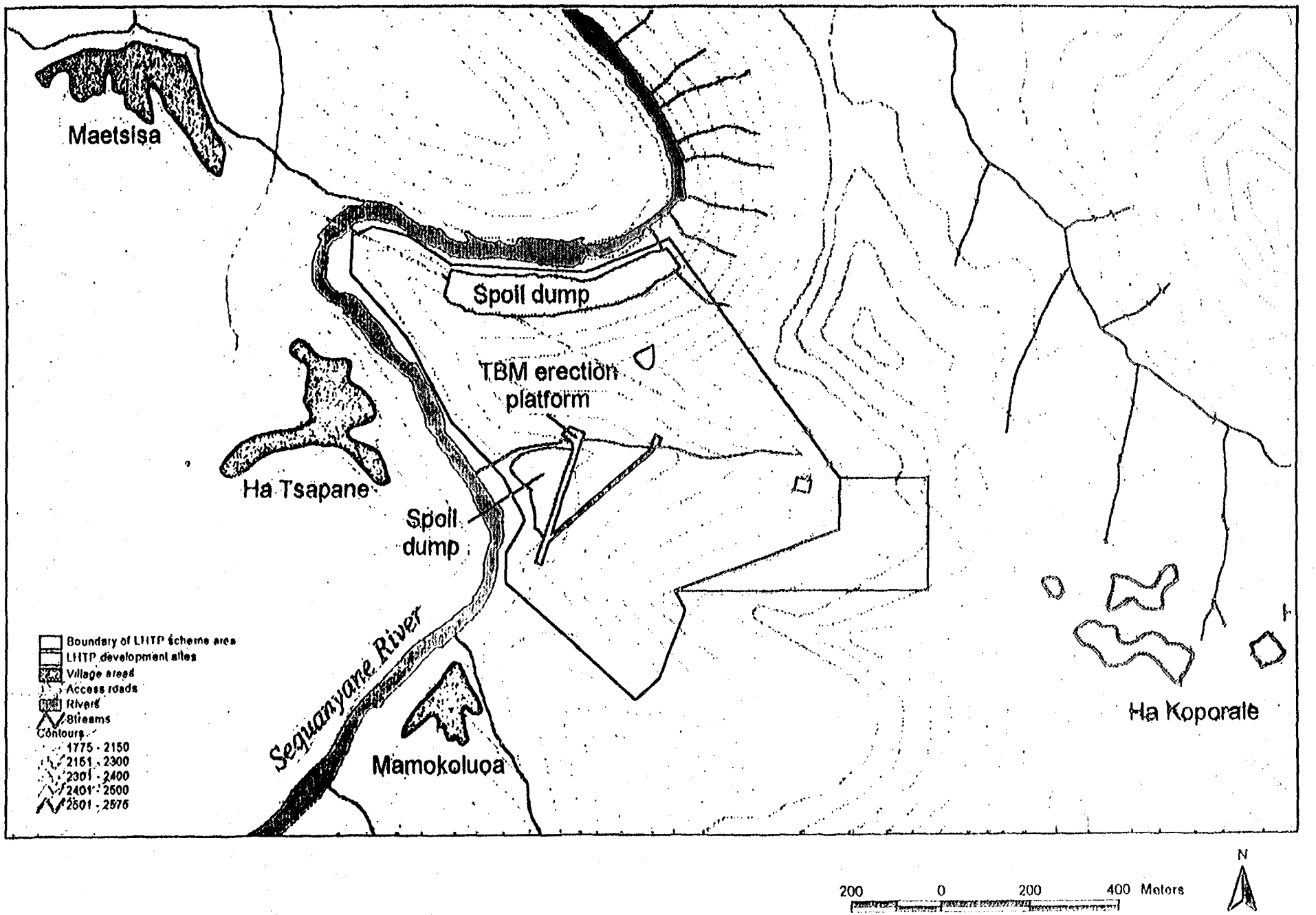
Map A-5 Extent of Main Activities of Phase 1B of the LHWP



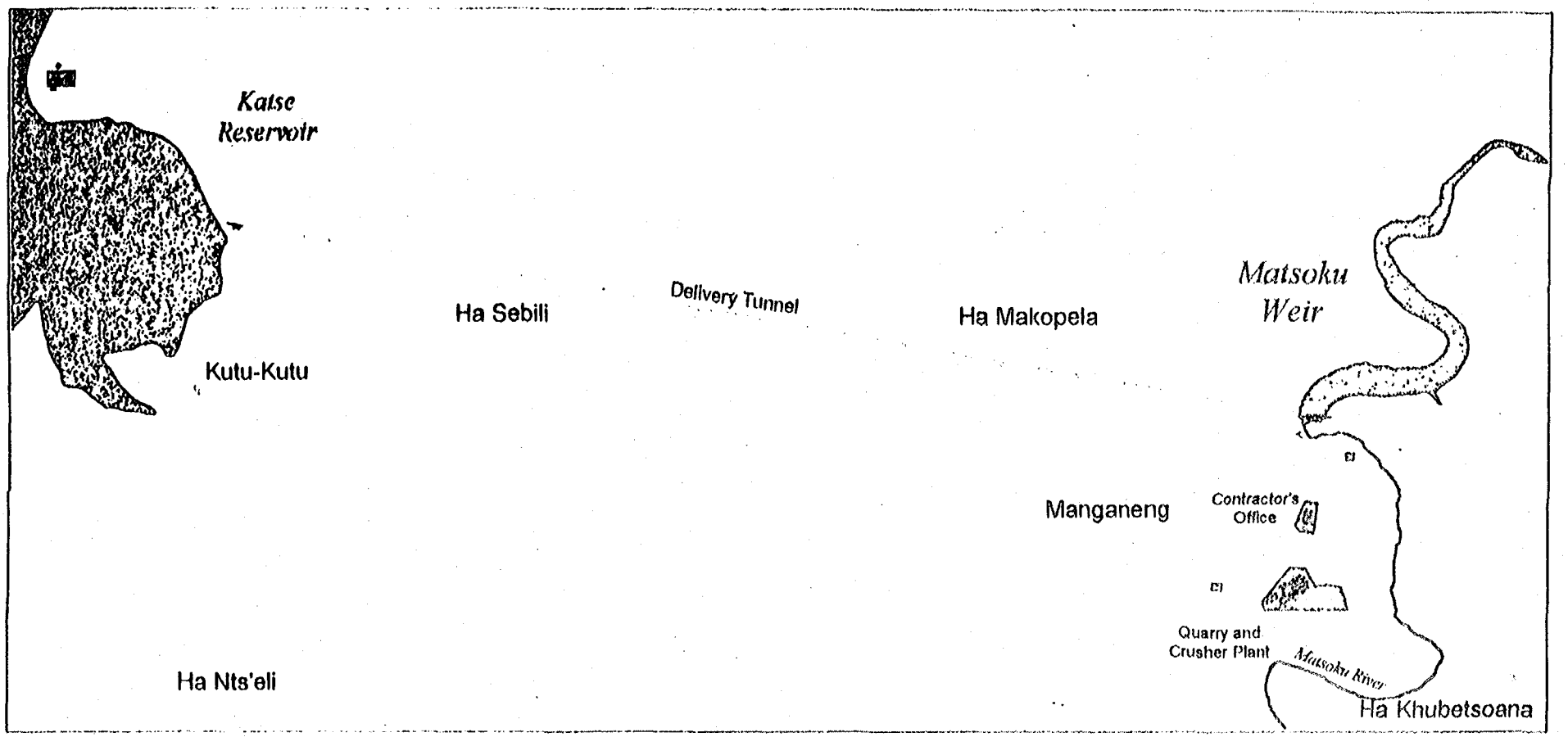
Map A-6 Mohale Dam Works Site

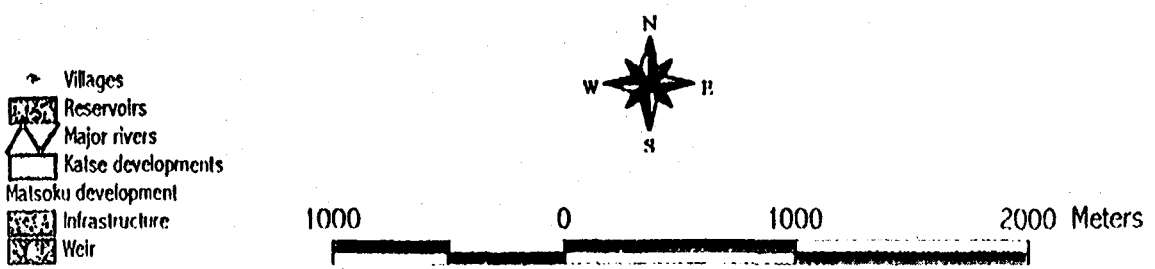


Map A-7 Mohale Tunnel Intake Location

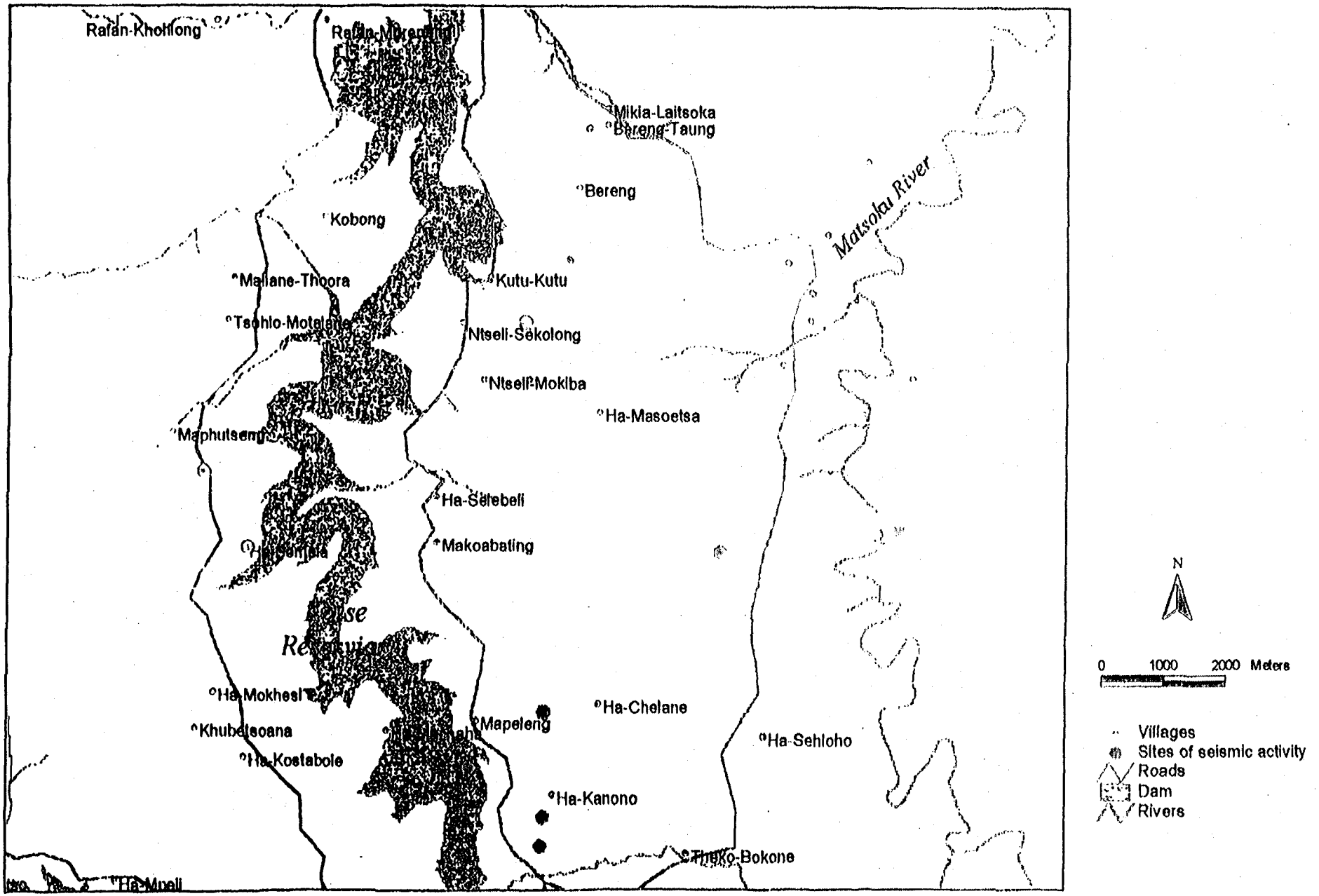


Map A-8 Overview of Matsoku Weir showing tunnel alignment

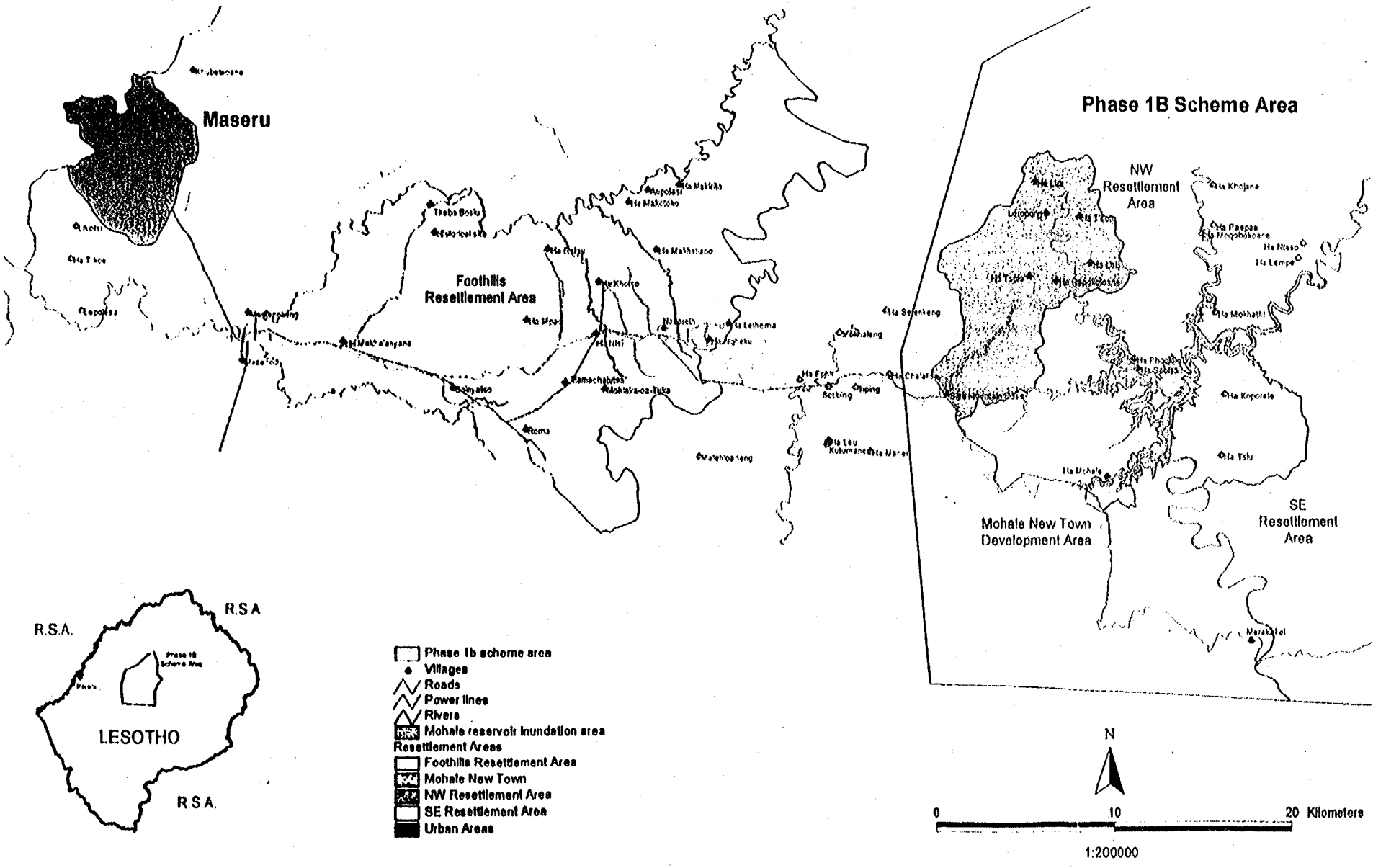




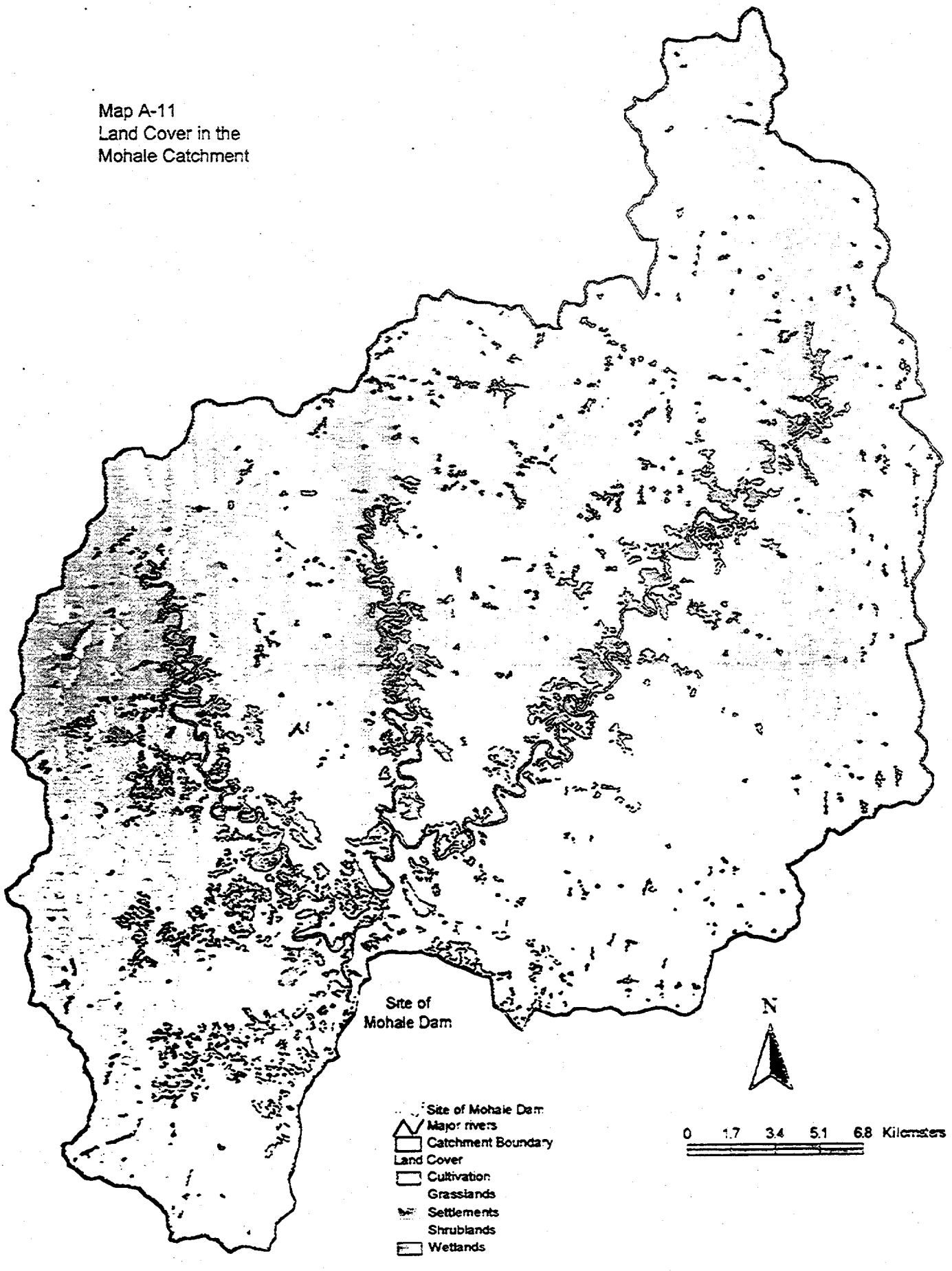
Map A-9 Katse Reservoir area showing sites of seismic activity



Map A-10 Potential Resettlement Receiving Areas



Map A-11
Land Cover in the
Mohale Catchment



ANNEX B: TABLES

Table B-1: Main Source Reports for the Preparation of the Phase 1B EIA

Study	Contract No.	Primary Consultant(s)	Completion Date (Env. Component)
Mohale Access Roads (Planning, Design and Supervision	1000	Gibb (Lesotho) Bergerman (RSA)	May 1993
Mohale Advanced Infrastructure (Planning, Design and Supervision	1001	HH Moteane (Lesotho) Bouwer Viljoen (RSA)	Nov 1995
Maseru Bypass (Design and Supervision)	1002	Van Wyk and Louw (RSA) Litsebi (Lesotho)	Oct 1995
Mohale Tunnel (Stage 1) Design and Tendering	1009	LHTP Lescon (Lesotho)	June 1996
Matsoku Diversion (Stage 1) Design and Tendering	1013	Consult 4 (RSA) Lescon (Lesotho)	Jan 1996
Power Supplies, Design and Supervision	1014	Plantech (RSA) SM (Lesotho)	Dec 1995
Mohale Dam (Stage 1) Design and Tendering	1017	SMEC (Australia) Harza (USA) HEC (RSA) SM (Lesotho)	June 1996
Maloti Minnow Conservation	170	RAU (RSA)	Sept 1997
Baseline Water Quality Studies	1007	CSIR (RSA)	Jan 1997
Baseline Biology Survey	1008	Afridev (RSA) Sechaba (Lesotho)	Nov 1996
Baseline Epidemiology and Medical Services	1010	MRC (RSA) Sechaba (Lesotho)	May 1996
Resettlement and Development	1012	Hunting (UK) Consult 4 (RSA)	Dec 1996
Baseline Archaeology Survey	1016	Kaplan (RSA)	Sept 1995
Downstream Impact Assessment	-	LHDA Environment Division	Sept 1996

Table B-2: Scoring System for Determining Significance of Impacts

Variable	Ratings				
Duration	short 1	medium 3	long 5		
Scale (area extent)	site 1	watershed 2	regional 3	national 4	international 5
Severity	low 1	moderate 2	high 3	very high 4	
Certainty	possible 1	probable 2	definite 3		
Impact Significance	low < 7	medium 7-11	high 12-15	very high > 15	

Table B-3: Basic Statistics for Phase 1A and 1B

	Phase 1A (under construction)		Phase 1B (subject of EIA)	
DAM	**Katse**	**Muela**	**Mohale**	**Matsoku**
Type of dam	conc. arch	conc. arch	rockfill	weir
Elevation at crest (m asl)	2060	1778	2085.5	——
Height above foundation (m)	180	55	145	12
Length (m)	710	180	600	——
Catchment area (km2)	1866		874	580
RESERVOIR	**Katse**	**Muela**	**Mohale**	**Matsoku**
Yield (m^3/s)	16.8	——	9.6	2.2
Extreme water level (m asl)	2060.2	1782.5	2084	——
Full supply level (m asl)	2053.0	1775.0	2075.0	2090.5
Minimum operating level (m asl)	1989.0	1760.0	2005.0	N/A
Reservoir area at FSL (km^2)	35.8	0.4	22.8	N/A
Storage capacity at FSL ($m^3 x 10^6$)	1950.0	5.9	947.0	N/A
Live storage capacity ($m^3 x 10^6$)	1519.0	3.9	857.0	N/A
Compensation flow discharge (m^3/s)	0.5*	——	0.3*	1.7**

**set by LHWP Treaty *available for baseflow releases, provision available for additional flood releases

Table B-4: Important Environmental Components

Physical Environment	Socio-economic Environment
mesoclimate	housing
microclimate	village infrastructure
stream and river flows	land tenure
Aquatic Environment	agriculture livelihood
natural springs	migrant labor
domestic water	informal sector
water quality	commercial ventures
aquatic habitats	short term employment
fish	tourism related employment
aquatic invertebrates	food security
aquatic vegetation	roads and bridges
rare and endangered species	schools and clinics
Terrestrial Environment	communications
soil types	biomass fuels
soil fertility	fossil fuels
soil erosion	other energy
grazing/livestock production	cultural identity
croplands/crop production	community interactions
woodlands/orchards	family social structure
wetlands	traditional activities
mammals	gender issues
invertebrates	literacy
birds	school attendance
reptiles/amphibians	adult education
medicinal/other useful plants	occupational health
commercial plants	nutrition
rare/endangered habitats	STDs
rare/endangered species	substance abuse
biodiversity	communicable diseases
disease vectors	other health problems
pest species	access
	communications
	archaeological sites
	aesthetics

Table B-5: Destinations for relocation and resettlement

Vill no	Village name	RDS Total Hh	Total Hh eligible	Destination areas: Scheme Area: Ts'ju	Kop	Rap	Moh	Foothills area	Lowlands: LL	MSU	Resettlement recommendations for each village
57	Maetsisa	29	27		5			16	3	5	Priority reloc./reset
58	Tsapane	26	24		9			11	5	1	Priority reloc./reset
70	Ha Piti	6	6				6	0			Priority reloc./reset
79	Mamokoluoa	9	9		9			0			Priority reloc./reset
80	Ha Ralifate	12	12	12				0			Priority reloc./reset
380	Ha Lekhera	3	1	3				0			Priority reloc./reset
28	Kolotsane	7	4		3			3	1		Reloc./reset
55	Ha Seotsa	45	45			6		32	5	1	Reloc./reset
56	Ha Phoofolo	12	12			4		8		1	Reloc./reset
59	Matebeleng	10	10					10			Reloc./reset
61	Ha Takatso	25	23				3	20	2		Reloc./reset
62	Mohlabane	14	10				6	8			Reloc./reset
97	Lumapong	21	20		21			0			Reloc./reset
29	Ha Mokhathi	41	19				2	6	10	4	Encourage stay
43	Ponts'eng	24	21					0			Encourage stay
60	Ha Monts'i	27	20					5	4		Encourage stay
64	Phomolo	17	15					0			Encourage stay
65	Lebiletsa	13	13					0		1	Encourage stay
96	Raboshabane	3	3					1	1		Encourage stay
98	Kamolane	16	13		16			0			Encourage stay
102	Masaleng	12	12	2				0	1		Encourage stay
379	Letsatseng	15	8					2			Encourage stay
	Other villages	529	123								Remain
	Stage 1	85	79	15	23	0	6	27	8	6	Priority reloc./reset.
	Stage 2	134	124	0	24	10	9	81	8	2	Reloc./reset.
	Stage 3	168	124	2	16	0	2	14	16	5	Encourage stay
	Other villages	529	123	0	0	0	0	0	0	0	Remain
	Total	916	450	17	63	10	17	122	32	13	

Table B-6: Environmental Action Plan Programs

Component			
Natural Environment and Heritage	**Public Health**	**Resettlement and Compensation**	**Development**
Conservation and Biodiversity:	**Workforce Health Care:**	**Resettlement:**	**Mitigative Development:**
Biosphere conservation		Resettling of families inundated by reservoir	Crops and livestock
Germ plasm conservation	**Local Community Health Care:**		Forestry
Soil conservation			Energy
Wetland conservation	**Local Capacity Building:**		Tourism
Biology monitoring			Training/income restoration
			Infrastructure
Rare and Endangered Species:	**Special Needs.**	**Compensation:**	**Enhancement Development:**
Maloti minnow protection	**MHSW Capacity Building:**	Replacement housing	(projects have not yet been identified)
Spiral Aloe protection		Commodities for loss of agricultural property	
Umbraculate frog protection		Replacement of water and other infrastructure	
Water Resources:			
Water quality monitoring			
Instream flow requirements			
Environmental Awareness:			

Table B-7: Development Stages and Environmental Concerns

Project Component	Development Stage	Activity	Environmental Concerns
Mohale dam and associated structures	Design	Type of dam, size of dam, determination of FSL, location of dam, location of work areas, location of quarries and access roads, location of camps and offices, hiring policies	Loss of land from other uses, displacement of people, aquatic habitats, terrestrial habitats, social interaction, local jobs, water quality, health, social insecurity
	Pre-construction	Surveying, geotechnical investigations, soil stripping, fencing.	Social interaction, water quality, health, erosion, loss of land, water quality, access
	Construction	River dewatering, materials handling, drilling and blasting	Water quality, health, safety, aesthetics, aquatic habitats, social insecurity
	Operation and Maintenance	Reservoir filling, flow regulation	Aquatic ecosystems, rare and endangered species, safety
	Decommissioning	Removal of materials, wastes, buildings, rehabilitation	Aesthetics, erosion, water quality
Mohale Tunnel	Design	Tunnel alignment, location of inlet and outlet, location of works area, quarries, spoil dumps, access roads, location of camps and offices, hiring policies	Natural springs, loss of land from other uses, displacement of people, water quality, social interaction, terrestrial and aquatic habitats
	Pre-construction	Surveying, geotechnical investigations, fencing	Social interaction, water quality, health, access
	Construction	Drilling and blasting, drainage, materials handling, spoil dumps	Social interaction, water quality, health, safety, erosion
	Operation and Maintenance	Water flow regulation	Aquatic ecosystems, rare and endangered species
	Decommissioning	Removal of materials, wastes, buildings, rehabilitation	Aesthetics, erosion, water quality
Matsoku Diversion	Design	Type of weir construction, size of weir, flow regime, location of weir , location of work areas, location of quarries and access roads, tunnel construction methods, safety features, location of camps and offices, hiring policies	Loss of land from other uses, displacement of people, aquatic habitats, social interaction, local jobs, water quality, safety, health
	Pre-construction	Surveying, geotechnical investigations, soil stripping, fencing	Social interaction, water quality, health, erosion
	Construction	Materials handling, drilling and blasting, tunnelling	Water quality, health, safety, aesthetics, aquatic habitats
	Operation and Maintenance	Flow regulation	Aquatic habitat, health (safety)

Project Component	Development Stage	Activity	Environmental Concerns
	Decommissioning	Removal of materials, wastes and buildings, rehabilitation	Aesthetics, erosion and water quality
Infrastructure	Design	Location of roads and towers, location of work areas	Aesthetics, avian fauna, vegetation, rare and endangered species, loss of cropland and livelihood
	Pre-construction	Surveying, soil stripping	Social interaction, water quality, health, erosion
	Construction	Drilling and blasting, spoil removal	Safety and health, loss of crop land, erosion, water quality, terrestrial habitat
	Operation and Maintenance	Surfacing of roads, line maintenance, repeater station maintenance	Water quality (roads), erosion
	Decommissioning	Camps, materials, waste, rehabilitation	Aesthetics, erosion, water quality

Table B-8: Impact Significance by IEC for Each Project Component

IEC	Mohale Dam and Reservoir	Mohale Tunnel	Matsoku Diversion	Roads	Trans-mission System	Telecom-munica-tions
mesoclimate	*	-	-	-	-	-
microclimate	**	-	-	-	-	-
commercial deposits	-	-	-	-	-	-
stream/river flows	***	*	***	*	-	-
natural springs	**	***	***	***	*	-
domestic water sup-plies	**	-	-	**	-	-
water quality (reser-voir)	*	-	-	-	-	-
water quality	***	**	**	**	*	-
aquatic habitats	***	**	***	**	-	-
fish	***	-	-	-	-	-
aquatic invertebrates	***	-	-	-	-	-
aquatic vegetation	**	-	-	-	-	-
rare/endangered species	****	***	****	-	-	-
soil types	-	-	-	-	-	-
soil fertility	-	-	**	-	-	-
soil erosion	***	*	**	***	*	*
woodlands and orchards	***	-	**	**	**	-
irrigable land	-	-	-	-	-	-
wetlands	**	-	-	**	*	-
drawdown zones	-	-	-	-	-	-
rangelands/livestock production	***	*	**	-	**	**
croplands/crop pro-duction	***	*	***	**	**	-
land access	-	-	-	-	-	-
mammals	**	*	*	*	*	-
insects	-	-	-	-	-	-
birds	***	-	-	-	***	-
reptiles and amphibi-ans	***	-	-	-	-	-
medicinal/other useful plants	***	-	**	-	-	-
commercial plant spe-cies	-	*	**	-	-	-
rare and endangered habitats	***	-	-	-	-	-

rare and endangered species	***	-	-	****	*	**
biodiversity	**	-	-	***	-	*
disease vectors	**	-	-	-	-	-
pest species	-	-	-	-	-	-
housing	***	-	-	**	-	-
village infrastructure	***	-	-	-	-	-
land tenure	***	-	-	-	-	-
agriculture based livelihood	***	**	**	***	-	-
migrant labour	-	-	-	-	-	-
informal sector	***	**	*	**	*	-
commercial ventures	-	-	-	-	-	-
short term employment	**	**	**	-	-	-
tourism related employment	-	-	-	-	-	-
food security	***	-	***	-	-	-
biomass fuels	***	-	-	-	-	-
fossil fuels	-	-	-	-	-	-
electrical/other energy	-	-	-	-	-	-
cultural identity	***	-	-	-	-	-
community social interactions	**	-	-	-	-	-
family social structure	*	-	-	-	-	-
traditional activities	*	-	-	-	-	-
gender issues	**	-	**	-	-	-
community admin structures	***	-	**	-	-	-
community capacity	**	-	*	-	-	-
schools	**	-	**	-	-	-
literacy/numeracy	-	-	-	-	-	-
school attendance	-	-	-	-	-	-
adult education/skills training	-	-	-	-	-	-
clinics	-	-	**	-	-	-
occupational health	**	**	**	**	-	**
public safety	**	**	**	***	-	-
nutrition	***	-	-	-	-	-
STDs	****	***	***	****	**	-
substance abuse	**	-	-	**	-	-
other health problems	*	**	*	-	***	-
access	***	**	**	-	-	-
communications	-	-	-	-	-	-

archaeological sites	**	-	-	**	*	*
aesthetics	**	**	**	**	***	**
other cultural resources	***		-	-	-	-

- no impact

* impact of low significance

** impact of moderate significance

*** impact of high significance

**** impact of very high significance

Rare and endangered species	**Two of nine locations of Maloti minnow habitat will disappear and three others will be drastically affected; increased population and improved access will place additional pressure on spiral aloe; increased pressure will be placed on threatened bird species.**	It is probable that the Maloti minnow habitat and populations exist in other parts of the Highlands. The development of future phases will probably eliminate more isolated populations of the minnow and further threaten the species existence. Opening up remote areas and increased human populations to the area will place additional pressure on spiral aloe, assuming it exists throughout the Highlands, and other rare and endangered species possibly existent in other phase areas. Secondary and tertiary development will place increased pressure on the these species. Tourism related to a series of lakes and the introduction of trout for sport fishing will place additional pressure on the Maloti minnow. The CE on rare and endangered species could be **very highly significant.**	High (in the absence of national data on Maloti minnow habitat and spiral aloe distribution)
Soil erosion	**Construction sites will cause some erosion; increased grazing pressure on upslope lands will increase erosion to some extent.**	Phase 1A and further phases will result in considerable erosion. Additional pressure from a larger population will lead to an increase in erosion. The CE could be **moderately significant.**	Low - Moderate
Grazing and livestock production	**Winter grazing lands will be reduced as a result of inundation; pressure will be placed on other winter grazing areas; livestock production could increase with increased human population into area.**	Phase 1A has reduced winter grazing and further phases will likely decrease further this scarce resource. Livestock production could decrease significantly and/or erosion could increase significantly. The CE will be **moderately significant.**	Low - Moderate
Croplands and crop production	**700ha of croplands lost and overall crop production will be diminished.**	Valuable river bottom areas will be lost in different catchment areas as a result of future phases, increasing the loss of crop production land. Crop production will increase on steep slopes, promoting further erosion. The CE will be **highly significant.**	Moderate
Wetlands	**Wetlands lost through inundation; wetlands further damaged with increased pressure on upslope grazing; wetlands dried up through tunnelling.**	Further wetlands could be destroyed through development of future phases. Important habitats could be lost and village water supplies affected. The CE will be **moderately significant.**	Low
Medicinal and other plants	**Inundation and construction activities will destroy medicinal and other community valued plants.**	Phase 1A, development of further phases and other developments introduced to the Highlands, will place heavy pressure on these valuable community resources. The CE could be **highly significant.**	Low-Moderate
Biodiversity	**Biodiversity of the Mohale scheme will change as a result of inundation. Animal and plant species will be lost but others will migrate to adapt to the lake conditions developed by the reservoir.**	Reservoirs change the composition of the biodiversity. The unique biodiversity of the Highlands (found nowhere else in southern Africa) could be partially lost with the development of further phases. The CE could be **moderately significant.**	Low

Agriculture based livelihood	**Inundation of Mohale and loss of farm land at Matsoku will affect agricultural livelihood for a number of farmers.**	Further phase development will cause inundation of bottomlands, and much of the Highlands agriculture will be lost. Livelihoods will change dramatically. Secondary and tertiary developments will bring a shift in the economic base from at least partially agrarian to service industry. The CE will be **highly significant.**	Low-Moderate
Food security	**Loss of crop land primarily as a result of inundation will place more dependency on importing food into the area from the Lowlands.**	Further phase development will ensure that increasingly more food will have to be brought from the Lowlands as populations increase and cropland is reduced. Local food security will be threatened and it could begin to threaten national food security. The CE will be **moderately significant.**	Moderate
Biomass fuels	**Inundation will cause the loss of biomass fuels as will the removal of some bank vegetation along the Matsoku River. Increased human population into the area will place pressure on remaining biomass fuels.**	Existing development (Phase 1A) and further phase development with increased populations will place severe pressure on remaining fossil fuel resources. CE could be **highly significant.**	High
Culture	**Physical disruption, resettlement for some to the Lowlands, outsiders migrating into the area, jobs and cash available, prostitution and alcohol availability will all contribute to a modified mountain culture.**	With Phase 1A, along with further phase development and other developments that will follow, the unique mountain culture will be transformed and eventually lost as it is known today. The CE will be **highly significant.**	High
STDs	**Outside construction workers, construction camps, discretionary spending and prostitution will lead to sexual activity and increased incidence of STDs, including HIV+.**	STD incidence has increased since Phase 1A development. With further phase development it will be unlikely that many relatively STD free isolated pockets in the Highlands will remain. The CE will be **very highly significant.**	High
Other health	**Respiratory diseases, diarrhoea, hearing problems from noise, stress from the unknown, and stress for those who will have to move and for those awaiting compensation.**	With further phase development the percentage of people experiencing other health problems will probably remain the same but the total number within the Highlands will increase. The CE will be **moderately significant.**	Low
Archaeological features	**Six sites containing archaeological features will be inundated.**	Archaeological resources are limited. Further phase development that could eliminate more sites will diminish the total inventory within the Highlands. The CE will be **highly significant.**	High (assuming that archaeological features are not numerous or significant in more remote areas)

Aesthetics	**During construction, aesthetics at each of the sites will be temporarily affected. After construction, transmission lines and towers could interfere with scenic views.**	Tourism will develop in the Highlands. Phase 1A and 1B provide interesting features to complement the natural beauty of the area. Further phase development with roads, dams, transmission lines, etc. will detract from the overall area. The CE will be **highly significant.**	Low

Table B-10: Residual Impacts

Impact on IEC	Mitigation	Probable Residual Impact
River flows on the Senqunyane downstream will be greatly reduced	Compensation flows	Greatly reduced downstream river flow
Water quality of Matsoku and Senqunyane rivers during construction contaminated by construction	Contractual requirements for containment of toxic substances and strict control of runoff	Little or no residual impact
Water quality downstream of Mohale deteriorates,.particularly in proximity to the dam	Operational procedures to ensure anoxic substances not released downstream	Low DO and low sediments in released water: moderate residual impact
Aquatic habitats destroyed upstream and greatly modified downstream	Man made lake aquatic habitat replaces natural fast flowing sub-alpine river habitat; compensation flows provides little to support aquatic habitat proximal to dam	Natural aquatic habitat permanently lost and downstream habitat proximal to dam greatly modified: high residual impact
Rare and endangered aquatic species, particularly the Maloti minnow, greatly threatened	Comprehensive Maloti minnow conservation program to inventory possible other habitats, to breed in captivity and to re-introduce to suitable habitats; construction of barriers to prevent trout invasion of remaining habitats	Five of nine known locations will be seriously affected and chance species could become extinct; residual impact is very high
Soil erosion will be serious at construction sites; is a potentially serious problem throughout the catchment	Contractual obligations require that work site areas be managed in a way to prevent erosion; rangeland management associations to be established, public awareness and controls on cattle brought in to the area	Minimal residual impacts at work sites; if Highland erosion increases, after mitigation, low to moderate residual impacts
Rangeland/livestock production will be reduced	Formation of rangeland management associations leading to effective rangeland management	Grazing land is lost; moderate residual impact
Cropland and crop production will be reduced as a result of inundation	Improved crop production methods on remaining cropland	Low to moderate residual impacts
Easy land access will be lost	Rural access roads, bridges and ferry facilities	Low to moderate residual impacts
Rare and endangered terrestrial species reduced through collection and sale	Public awareness and the a propagation program for the Spiral aloe	Some remaining plants will probably still be taken: moderate residual impact
Housing will be lost as a result of inundation	New houses will be provided through the resettlement program	No residual impact

Agriculture based livelihood will be lost as a result of inundation	Through resettlement program those who lose agricultural land have the option of compensation packages, one of which includes resettlement to other agricultural lands; other income generating opportunities will be offered	All those who want to continue agriculture will have the opportunity; others will be provided with alternatives; no residual impact
Biomass fuels will be lost as a result of inundation	Establishment of vegetation through woodlot program; introduction of paraffin stoves	No residual impact
Cultural identity will erode as project enters the area	No mitigation but project will avoid giving handouts whereby people lose their independence	Cultural identity will erode to a degree; moderate to high residual impact
Traditional activities diminished such as collection of plants for various uses	Re-establishment of plants lost through inundation or downstream flow changes	Low residual impact
STD incidence in the area will increase	Public awareness, free condoms and improved public health services will be provided	AIDS will increase and people will ultimately die as a result, and as result of the project; very high residual impact
Other health problems including mental stress, substance abuse, communicable diseases and malnutrition will occur	Improved public health services including health clinics and public awareness	Most health problems brought directly or indirectly by the project can be avoided; moderate residual impact
Archaeological sites will be destroyed by inundation	Recording of sites	Sites will be lost permanently; high residual impact

ANNEX C: FIGURES

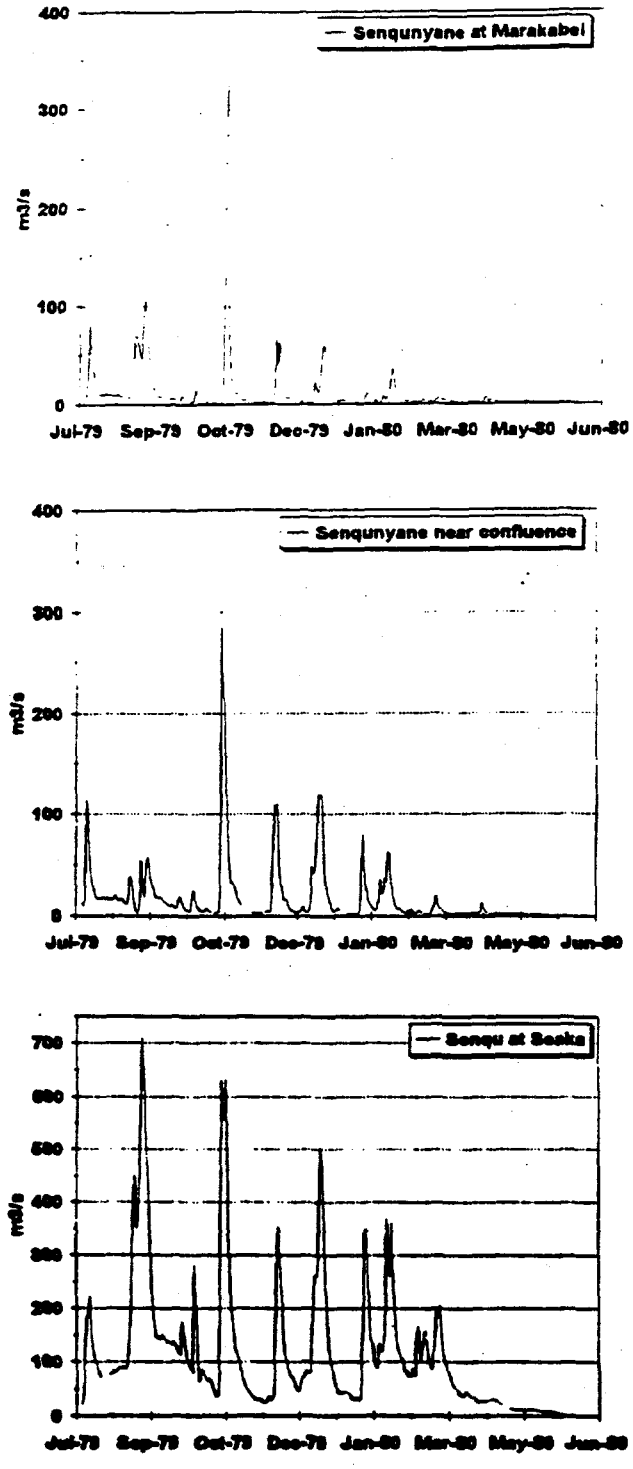


Figure C-1. Typical hydrographs for gauging stations on the Senqunyane and lower Senqu rivers.

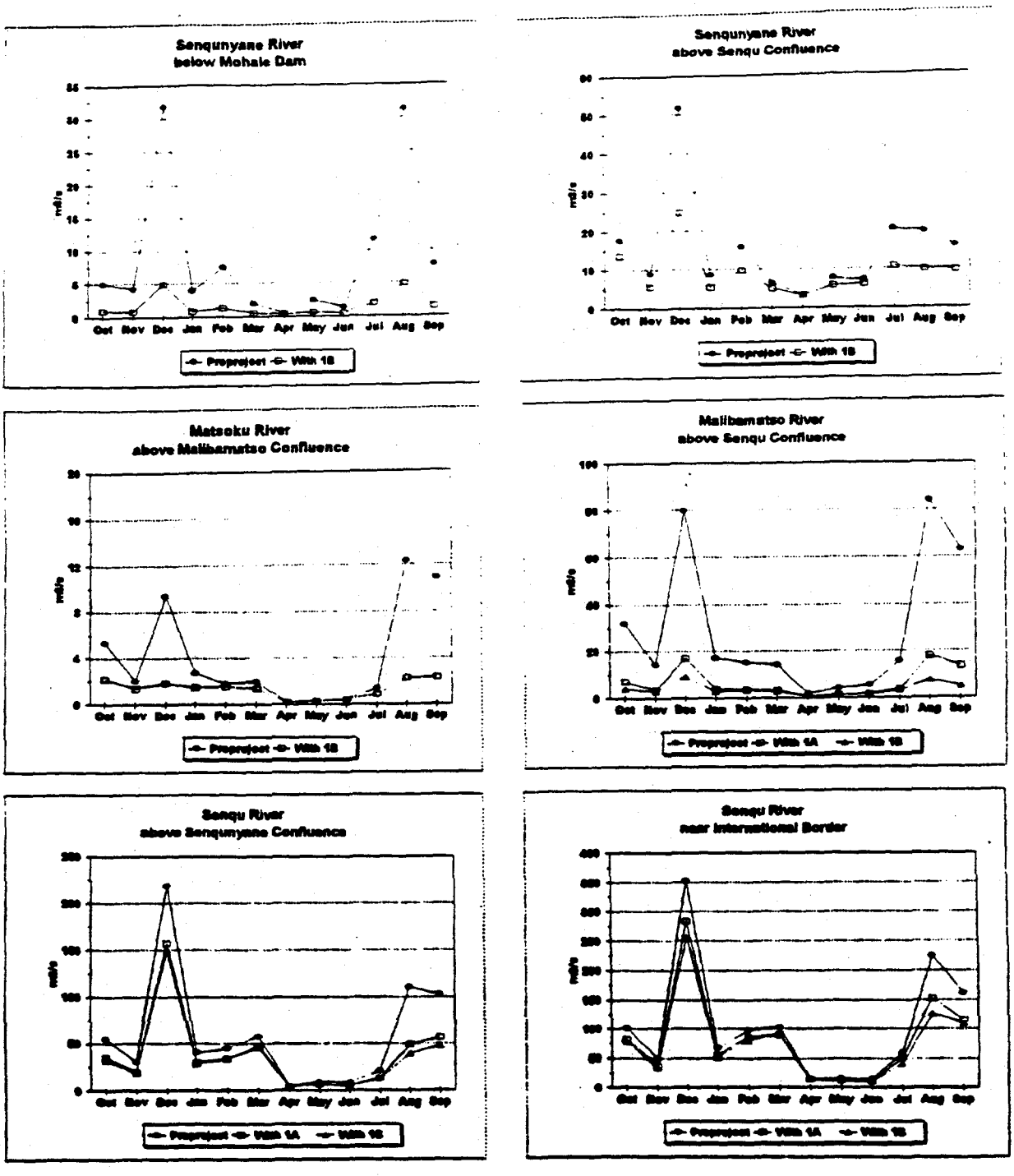


Figure C-2. Comparison of monthly average flows, with and without the LHWP Phase 1, at various locations in the rivers downstream of the dam and weir sites within Lesotho.

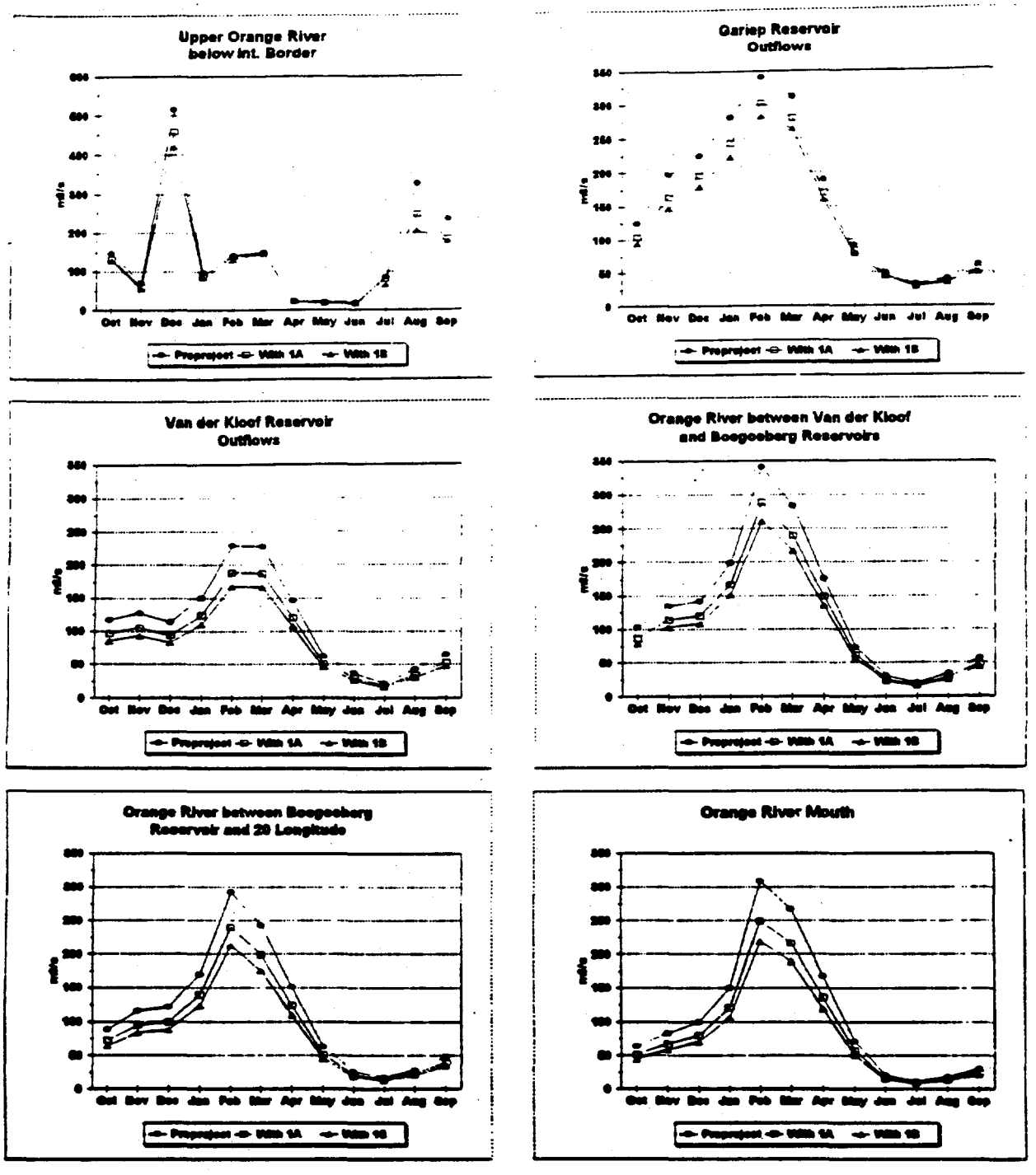


Figure C-2 continued. **Comparison of monthly average flows, with and without the LHWP Phase 1, at various locations in the Orange River within South Africa**

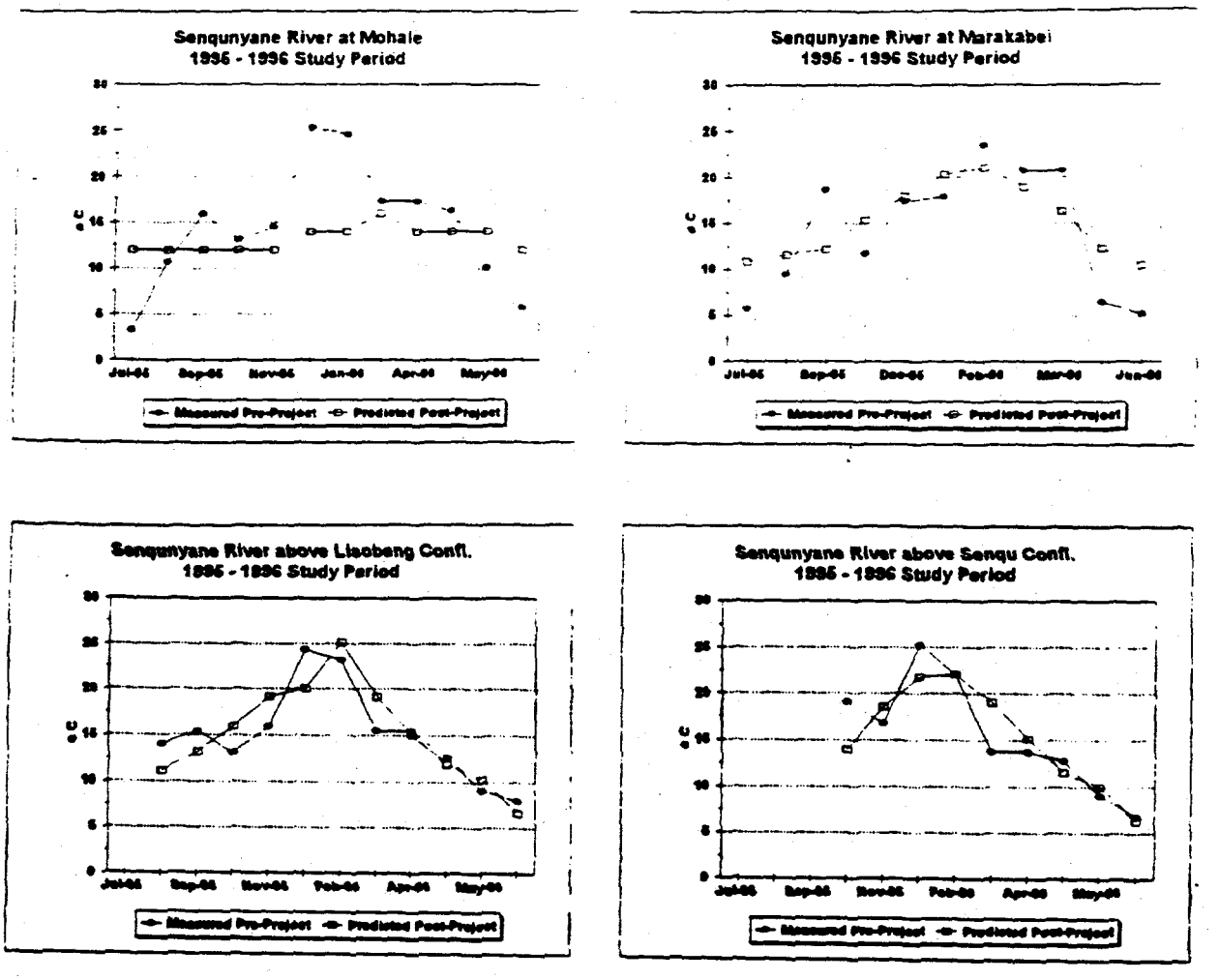


Figure C-3. Comparisons of pre-project (measured) and post-project (predicted) water temperatures at four locations in the Senqunyane River below Mohale Dam. Post-project temperatures predicted from mass balance computations.