

8.4. ENVIRONMENTAL BASELINE - ZAMBIA

The main environmental constraints for the Zimbabwe and Zambian sides of the river are shown in Figure 8.3.

8.4.1. SITE LOCATION AND INTRODUCTION

Chirundu is a southern border post for Zambia, located 136 km from the capital Lusaka. It was established in July 1912 by the colonial government originally as an out station for administration, along the northern banks of the River Zambezi. The township falls within the jurisdiction of Siavonga District Council. Land outside the township is traditional land and falls under Chief Sikoongo.

8.4.2. GENERAL SITE DESCRIPTION/TOPOGRAPHY

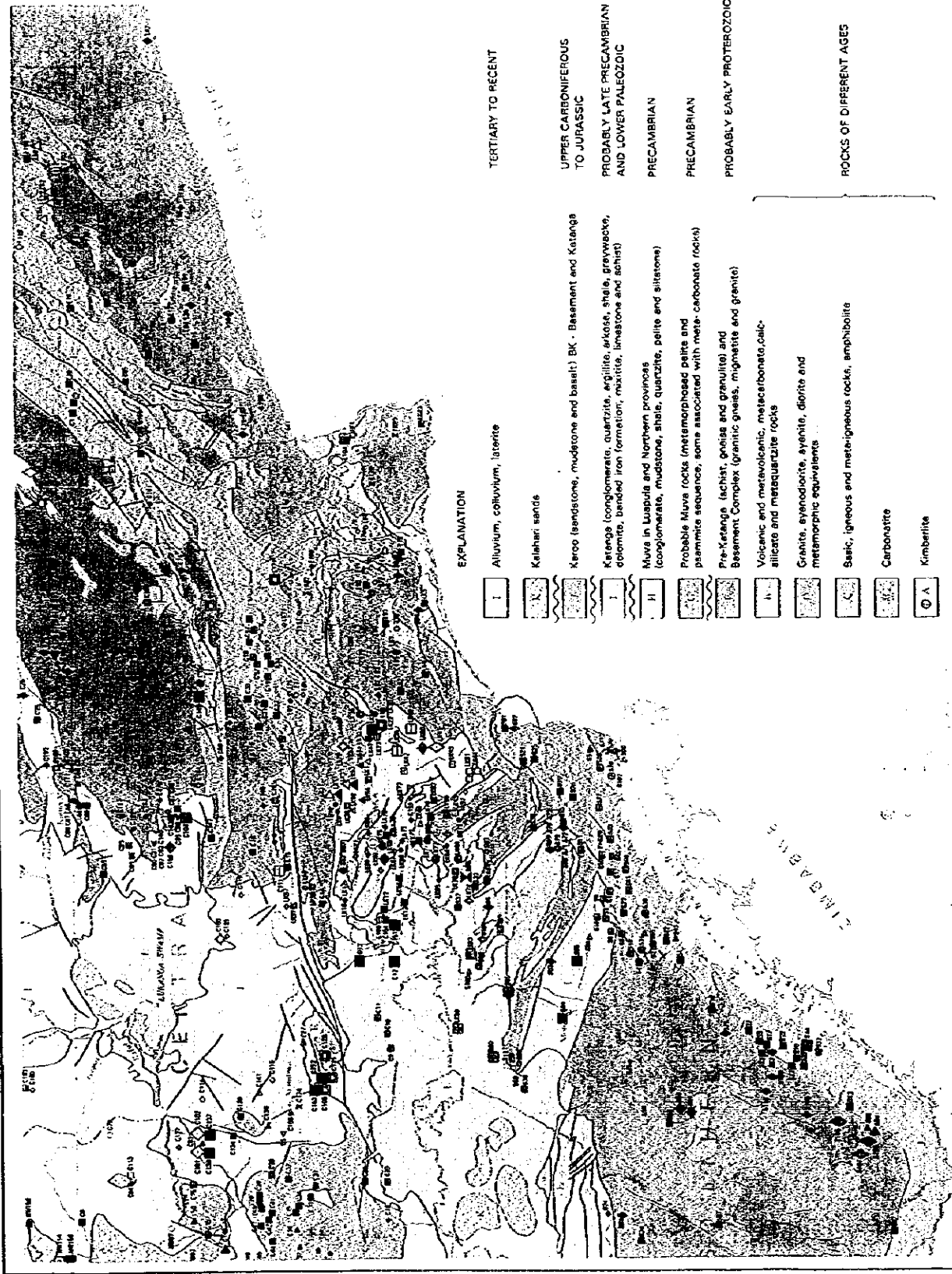
There are steep wooded cliffs along the Zambian riverbank, especially on the section upstream of the existing bridge. Approximately 350 m inland from the river bank there is a marked ridge roughly parallel to the river as the land falls away steeply to the north-west. This ridge roughly marks the northern boundary of the existing settlement of Chirundu. Land use consists of urban settlement and cleared bush/abandoned agricultural land. Immediately downstream of the existing bridge is an area of relatively good quality housing. Upstream of the bridge is the police and customs housing and a market, which are due for relocation. The land to the north of the township is gently sloping with areas of more traditional housing. There is a distinctive valley, which leads away from the river downstream of the bridge, which is used for growing subsistence crops during the wet season. The land in this area and on the valley sides and hill tops has been divided into building plots and several new houses were under construction during the survey period.

8.4.3. CLIMATE

Zambia's climate can be divided into three main periods. From December to April it is hot and wet with torrential downpours often in the late afternoon. From May to August it is dry and fairly cool, and from September to November it remains dry, becoming progressively hotter. The climate in the study area around Chirundu, is the same as that for the Zimbabwe side of the River Zambezi, with approximately 600 mm of rainfall per annum, although the rainfall is unpredictable, with up to 1 143mm recorded in a single year. The direction of the prevailing winds is from the south-east.

8.4.4. GEOLOGY, SOILS AND AGRICULTURAL CAPABILITY

The geology around Chirundu consists of the Karoo system, made up of basal sandstone conglomerates, overlain by Madumabisa Mudstone and Red Mudstone, overlain by the Upper Karoo Sandstone. This in turn is overlain by basalts (Batoka basalts). Between the basal sandstone conglomerates and the Madumabisa mudstones the Gwembe coal formations can be found. The Geological and Mineral Occurrence map for Zambia (Scale 1:2 000 000, 1994) (Figure 8.4) indicated the presence of mica at Siakalindi, Barite (Barium Sulphate) at Chirundu and coal nearby Chirundu, although none of these deposits would be affected by the



EXPLANATION

- T Alluvium, colluvium, laterite
 - K Kalahari sands
 - Ker Kerop (sandstone, mudstone and basalt) BK - Basement and Katanga
 - K Katanga (conglomerate, quartzite, argillite, arkose, shale, greywacke, dolomite, banded iron formation, muscovite, limestone and schist)
 - M Muva in Lusitania and Northern provinces (conglomerate, mudstone, shale, quartzite, pelite and siltstone)
 - M Probable Muva rocks (metamorphosed pelite and psammite sequences, some associated with meta-carbonate rocks)
 - P Pre-Katanga (schist, gneiss and granulite) and Basement Complex (granitic gneiss, migmatite and granite)
 - V Volcanic and metavolcanic, metacarbonate, calc-silicate and metaquartzite rocks
 - G Granite, syenodiorite, syenite, diorite and metamorphic equivalents
 - S Basic, igneous and met-igneous rocks, amphibolite
 - C Carbonatite
 - K Kimberlite
-
- Geological boundary, observed
 - Geological boundary, inferred
 - Fault, with downthrow
 - Fault, inferred
 - Thrust or reverse fault

TERTIARY TO RECENT

UPPER CARBONIFEROUS TO JURASSIC

PROBABLY LATE PRECAMBRIAN AND LOWER PALEOZOIC

PRECAMBRIAN

PRECAMBRIAN

PROBABLY EARLY PROTEROZOIC

ROCKS OF DIFFERENT AGES

Geology Map - Zambia

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<p>Project: Chriundu Bridge</p>	<p>Client: Ministry of Works & Supply Government of Zambia</p>
<p>Scale: 1:2,000,000</p>	<p>Figure 8.4</p>

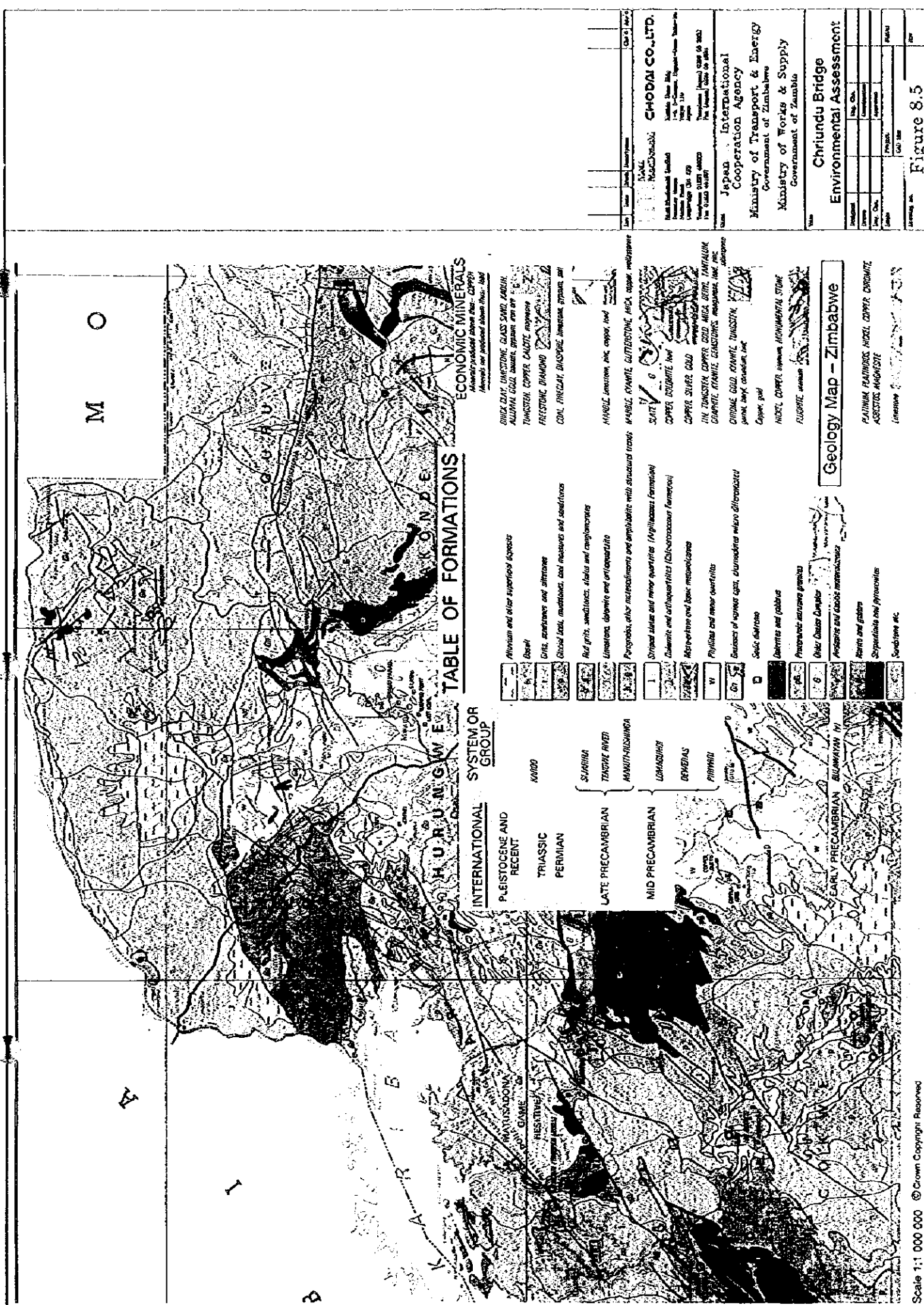


TABLE OF FORMATIONS

INTERNATIONAL SYSTEM OR GROUP	DESCRIPTION
PLEISTOCENE AND RECENT	Alluvium and other superficial deposits
TRIASSIC	Dolerite dykes and sills
PERMIAN	Dolerite dykes and sills
LATE PRECAMBRIAN	Red gneiss, amphibolites, chlorite schists and metapelites
MID PRECAMBRIAN	Granite, orthogneiss and amphibolite with staurolite zones
EARLY PRECAMBRIAN	Orthogneiss and minor quartzites (Mg-rich mafic gneiss)
	Quartzite and orthoquartzites (Chloritaceous mafic gneiss)
	Acroterite and basic metapelites
	Phyllites and minor quartzites
	Gneisses of various ages, chloritoides and orthoquartzites
	Schists
	Quartzites and gabbros
	Metavolcanic and granitic gneisses
	Other Quartz Complex
	Amphibolite and basic metapelites
	Metals and gabbros
	Stratolite and pyroclastics
	Sandstone etc.

ECONOMIC MINERALS

BRICK CLAY	SHALE	SLATE	GRAPHITE
LIMESTONE	TRAP	DIAMOND	COAL
IRON ORE	COPPER	PLATINUM	ASBESTOS
CHROMIUM	NICKEL	COBALT	URANIUM
ANTHRACITE	BITUMEN	OPAL	AGATE
EMERALD	AMETHYST	QUARTZ	TOPAZ
SPINEL	PERidot	DIOPHANE	TRIPHYLITE
TRIPHYLITE	TRIPHYLITE	TRIPHYLITE	TRIPHYLITE

Geology Map - Zimbabwe

PLATINUM	ASBESTOS	COBALT	URANIUM
ANTHRACITE	BITUMEN	OPAL	AGATE
EMERALD	AMETHYST	QUARTZ	TOPAZ
SPINEL	PERidot	DIOPHANE	TRIPHYLITE
TRIPHYLITE	TRIPHYLITE	TRIPHYLITE	TRIPHYLITE

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PROJECT NAME	International Cooperation Agency
PROJECT NO.	Ministry of Transport & Energy
PROJECT DATE	Government of Zimbabwe
PROJECT LOCATION	Ministry of Works & Supply
PROJECT STATUS	Government of Zimbabwe
PROJECT TYPE	Environmental Assessment
PROJECT NO.	Chirundu Bridge
PROJECT DATE	Environmental Assessment
PROJECT STATUS	Environmental Assessment
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project. Basalt deposits are also found at the confluence of the Zambezi and Kafue Rivers. The soils are shallow sands, prone to drought and of marginal agricultural value.

Zambia is subdivided into 36 agro-ecological zones, which have been grouped into 3 main regions, on the basis of rainfall. Chirundu lies within Region 1 which is characterised by high temperatures, high evaporative losses and a short crop growing season due to low and poorly distributed rainfall of less than 800 mm per annum. The land is extremely poor and appears incapable of growing significant crops without irrigation. Even with irrigation there are potential problems of salinity since the sandstone deposits of the region were originally marine. The squatters apparently make a living partly by servicing the border post and partly by selling food. The only crop seen was some okra, *Hibiscus esculentus*, not growing but dropped on the path and some sweet potato, *Ipomoea batatas*. However, in the wet season there are important subsistence crops of maize and finger millet, especially in the valley immediately downstream of the main Chirundu settlement. The fruits of the mature tamarind trees along the riverbank are used. Bananas and pawpaws are also grown. Figure 8.6 shows the land use classification.

8.4.5. ECOLOGY

(1) General Background

The vegetation around the most closely settled areas consists of urban weeds and low scrub typical of disturbed urban land. Weed species include dark-eyed hibiscus *Hibiscus caesius*, dongolo hibiscus *Hibiscus dongolensis*, castor oil *Ricinus communis*, yellow cleome *Cleome diandra*, sticky purple cleome *Cleome hirta*, kitui morning glory, *Ipomoea kituensis*, lantana, *Lantana camara*, bells of St Mary, *Trichodesma physaloides*, Leonitis *Leonitis nepetifolia*, and fish-tail creeper *Momordica kirkii*. Wild tree and shrub species include *Acacia* sp, *Ziziphus mucronata*, and *Ficus* sp. Planted or naturalised tree and shrub species include milkweed *Calatropis procera*, tamarind, *Tamarindus indica*, and mango, *Mangifera indica*.

(2) Vegetation

The vegetation within the study area in Zambia falls largely into 3 distinct zones, the river cliff vegetation dominated by *Acacia* sp and *Tamarindus indica*. The dry scrub vegetation dominated by *Acacia* sp and 'cultivated' vegetation comprising *Ziziphus* sp, mango and pawpaw.

The 'cultivated' vegetation is confined to the shallow valley and in the vicinity of the police housing upstream of the existing bridge. Species include tamarind, marula, *Sclerocarya birrea* and *Ziziphus mucronata*.

The river edge and cliffs are dominated by mature tamarinds and acacia which form a strong linear habitat allowing animals to move undetected. Other species include *Casia abbreviata*, *Sclerocarya birrea*, *Ziziphus mucronata*, *Markhamia acuminata*, *Acacia polyacantha* *Acacia Schweinfurthii*, winter cassia *Cassia sinqueana* and pencil bush *Euphorbia tirucalli*.

(3) Butterflies

Due to the undeveloped riverine nature of the Zambian site there is an abundance of butterflies. During three site surveys the following species were observed.

The Guinea fowl *Hamanumida daedalus*, *Colotis danae*, *Papilio democus*, *Colotis evagore*, *Belenois* sp, *Acraea* sp, *Junonia oenore*, and the common barred sailor *Neptis alta*.

(4) Dragonflies

Probably due to the emergent vegetation along the Zambian bank, affording breeding habitat, there was an abundance of dragonfly species. These have not been formally identified.

(5) Reptiles

Along the entire study area snakes were observed in the undergrowth of the riverbanks, the most common being the stripe bellied sand snake *Psammodphis subtaeniatus*. A single black mamba *Dendroaspis polylepis polidepis* was observed.

Skinks were extremely abundant along the riverine cliffs downstream of the bridge (access prevented a detailed study upstream). The species present were mainly rainbow skink *Mabuya quinquetaeniata*. Crocodiles are reported as abundant in the river.

(6) Animals

Vervet monkeys are present, as well as elephants, crocodiles and hippos. Animals which conflict with humans are likely to be shot, and elephant skin was observed on site. There is also potential conflict between hippos and riverside crops.

(7) Birds

The study area was surveyed for bird species on three occasions, on different days and at different times of the day to provide an accurate indication of those birds found in the area. Both the actual number of birds recorded and also the number of species present was notably scarce, probably as a result of degraded habitat combined with disturbance from the existing bridge and the villagers. During two of the survey visits to the study area children were observed wielding catapults and the targets were obviously the bird population. This may also account for the low numbers of birds present. The total number of species recorded was 8, these being as follows: pied crow *Corvus albus*, blue waxbill *Araegithus ongolensis* Jameson's firefinch *Lagonostiza rhodoparera*, house sparrow *Passer domesticus*, longtailed starling *Lamprotornis mevesii*, paradise flycatcher *Terpsiphone viridis*, red billed hornbill *Tockus erythrorhynchus* and Meyer's parrot *Procephalus meyeri*.with disturbance from the existing bridge and the villagers. During two of the survey visits to the study area children were observed wielding catapults and the targets were obviously the bird population.

8.4.6. SOCIO-ECONOMIC PROFILE

(1) General

Chirundu, Zambia, lies within Siavonga District which covers a relatively large area of southern Zambia and has a district population of between 65 000 and 70 000 people. The major occupation in the region is subsistence farming and fishing, the latter notably on Lake Kariba. Within the immediate region of Chirundu, the only significant farming is subsistence farming during the wet season. The population of the township at present is estimated to be 10000, with large numbers of squatters in unplanned settlements. The growth rate of the town is high. In

1980 the population was only 1513, rising to 5338 in 1990 (growth rate of 13.4%). The high growth rate is accounted for by:

- The opening of the border between Zambia and Zimbabwe after Zimbabwe's independence.
- The establishment of several freight companies at Chirundu border post.
- Immigration of local people from other towns and districts (especially smugglers, poachers and fishermen).
- Natural birth rate.

The areas of land outside Chirundu, and outside the Plan area are Traditional Lands controlled by Chief Sikoongo (Chief Mandemnga is the village headman), although these areas are still subject to Town and Country Planning for any new permanent structures. The local languages in the area are Bemba and Nyanja.

The urban settlements upstream of the bridge consist of a market (scheduled to move to a new site downstream) and housing for junior police and customs officials (a total of 40 houses with approximately 7 family members per housing unit). Downstream of the bridge are the customs and immigration offices, a fast expanding private housing development where the senior officers live and a half-built motel. Squatters' huts exist on the most downstream area. The squatters are steadily being moved away to a resettlement area elsewhere and some of the local people, the Gobas, feel they are being unfairly moved as they were the original inhabitants of this area. The largest employer at Chirundu is the government, with a staff of approximately 65 employees. As with the Zimbabwean side prostitution and currency exchange are major elements of employment.

There is a chronic shortage of housing in the township. From a total estimated labour force of 129 (employed) only 61 are properly housed, with the remaining living in nearby villages. An estimated 318 plots are needed. The proposed layout plan for the township designates large areas of land for proposed new housing. In particular the valley, immediately downstream of the existing bridge has already been divided into plots, and building is currently taking place on a number of these. Service charges for the plots range between 250 000 and 800 000 Kwacha.

(2) Health

The Mitendere Mission hospital is a large hospital 3km downstream of the bridge. The hospital is currently funded partly by the Zambian Government, and from donations. There are 110 beds in the hospital and 24 members of staff, with 2 doctors. Staffing levels are already low, and a shortage of accommodation is the main reason why additional staff cannot be employed. Although land is available for such housing, there are inadequate funds for construction. Health reforms are being carried out in Zambia at present, and from 1 January 1998 the hospital will be de-linked from central government funding, and given grants from the newly created Local Health Boards. The grant will be based on a per capita basis for the catchment area, which is officially recorded at 34 000 people, although more realistic figures suggest that the actual population is closer to 60 000. The hospital is therefore, already running on less than the required budget, and this is exacerbated by an influx of patients from outside the catchment area. Health care is free in Zambia at present, although there is concern that once hospitals are made to operate on a profit basis, free health care will no longer be possible.

Current health problems in Chirundu are:

AIDS, with a large number of prostitutes living on the western side of town; and Cholera, which is a problem during the rainy season from December to March.

The water supply is also a problem at the hospital, with poor water quality during the rainy season when the turbidity is high and fluctuating levels in the river cause the pump to suck in air and the motor to burn out.

(3) Education

The Mandenga School is the only school in the area. There are presently 700 children at the school (with an even balance between boys and girls), although there is officially only space for 450 children, and each year additional children are turned away due to lack of space. There are 17 teachers, although 25 are required, with accommodation shortages restricting the appointment of further staff. There are 7 classrooms, which means that on average there are 100 pupils per class. A Five Year Plan (1994 to 1999) was developed for the school, which recommends that a further 3 classrooms should be built, 4 flats for teachers, a toilet block, library and staff room. There are currently 2 toilets (with septic tanks) for 700 children.

The school accepts pupils from grades 1 to 9. At the end of Grade 4 there is a national examination when some pupils are retained, and some go to other schools. At Grades 8 to 9 the school receives pupils from 5 feeder schools (ages 14 to 17). For the final stage of education (Grades 10 to 12) the pupils must go to another school. The closest suitable school is in Siavonga, but is not a boarding school.

Schooling in Zambia is currently free, although many schools (including Mandenga School) ask parents to make small contributions to pay for the basic requirements. The local Plan makes provision for the construction of another secondary and primary school, although lack of funds may prevent any such developments in the near future.

(4) Road Safety

It was reported by the customs officials that road safety between Chirundu and Lusaka is an issue, with a poor, narrow and in some places steep road connecting the border post with the capital city. There are the remains of several accidents evident by the road side.

(5) Other Services

There is a hotel in Chirundu immediately adjacent to the Otto Beit Bridge, and a motel, which is currently being refurbished, on the riverbanks. There is a small market which operates selling fruit and vegetables, as well as clothing and other household items. There is also a grocery shop and a small café serving local and transit travellers. There is another shop located on the junction of the Chiawa and main Lusaka-Harare road. Neither of these shops sell essential commodities such as sugar or mealie-meal, which have to be purchased from Lusitu. There are also three approved licensed premises.

8.4.7. TOURISM

Tourist facilities are not well developed, with most tourists just passing through either to or from Zimbabwe. The Lower Zambezi National Park is located approximately 60 km down river from Chirundu. The Gwabi Lodge hotel is situated a short distance from Chirundu on the Kafue River, and is used by canoe parties as well as independent tourists.

8.4.8. FISHERIES

There are over 120 species of fish occurring within the Chirundu reach of the Zambezi. Major species caught are chessa *Distichodus shenga*, nukupi *Distichodus mossambicus*, purple labeo *Labeo congoro*, cornish jack *Mormyrops anguilloides*, butter barbel *Schilbe intermedius*, brown squeaker *Syodonotis zambezensis*, vundu *Heterobranchus longifilis* and bream or green happy *Sargochromis codringtonii*. Other species present which are important for fisheries are redbreast tilapia *Tilapia rendalli*, nembwe, *Serranochromis robustus*, manyame labeo *Labeo altivilis* and straightfin barb *Barbus paludinosus*.

While fishing certainly takes place downstream of the bridge, the cliffs are too steep and the current too fast for fishing immediately beside the bridge and along the upstream section. A lot of netting is done in Zambia but there are tight controls. In contrast to the Zimbabwean side there is a closed season for four months from December to March. Licenses are also tied to the size of net mesh and policing is fairly good with canoes marked with yellow tags. A small amount of fish is caught for sale within and outside Chirundu, although this is diminishing due to the restrictions on fishing to control cross-border poaching of animals.

8.4.9. HISTORIC/CULTURAL/ARCHAEOLOGICAL

There are no known sites of historic significance in the area. An archaeological study covering the archaeology, history and ethnography of the study area was commissioned as an additional part of the EIA.

8.4.10. MINERALS

Mining activities are very important for the Zambian economy, with large deposits of copper, cobalt, coal, lead and zinc. Until recently metal mining was the most important economic activity in the country. Other metals such as gold and silver are produced as a by-product of copper and lead/zinc mining. Zambia currently produces small quantities of other metals, including selenium, cadmium, manganese and tin. Iron ore and uranium are present in Zambia and plans to begin extraction of these metals will soon be implemented. Non metallic minerals such as emerald and other precious stones have also been mined on a small scale by the private sectors. Limestone and dolomite are quarried for the local building industry and several other minerals are produced in smaller quantities. Graphite, marble, sulphur, phosphate, gypsum and asbestos are also present. Minor natural gas deposits have been discovered and the search for oil continues. There are no known major deposits of these minerals close to the study area, although as noted in Section 8.4.4 there are deposits of Mica, Barite and Coal further away from Chirundu.

8.4.11. NOISE AND AIR QUALITY

Chirundu is a busy border post, with resultant traffic noise. However, noise levels in the residential areas are generally low, and the impact of lorries is only significant during periods when trucks are passing by. There are no major industries or other activities which produce significant quantities of air pollution. Dust is the major cause of air pollution, and only the main road to Lusaka has a tarmac surface.

8.4.12. WATER RESOURCES

There is a small water treatment plant which pumps water from the Zambezi River, just upstream from the Otto Beit Bridge. The water is dosed with alum and chlorine as part of the treatment process. It was reported that although the system is not very old, it is not very effective, and water quality is poor. In addition, water from this source only serves the police and customs houses upstream from the bridge, which are due for relocation in any case. The hospital has a water pump to supply its needs, and the water is filtered before use. It was reported that water from this source is of poor quality during the rainy season, with a lot of sediment. The main population of the town draws its water supply directly from the Zambezi or through water collection from the hospital taps or the police/customs supply.

Chirundu layout plan proposes to move the present water intake and treatment works to a new site further upstream. This project will be undertaken as part of the "Nine Towns Project" funded by NORAD. Two sites are reserved in the Plan for water storage tanks. It is proposed that the existing storage tank should supply water to the area enclosed by the powerline, the mission access road and Chiawa Road, and the area west of Chirundu-Lusaka Trunk Road. The new proposed storage tank should supply the remaining areas of the township.

Existing sewage facilities in the township are provided by septic tanks, soakaways and pit latrines. Sewage stabilisation ponds are proposed to serve the proposed primary and secondary schools, the central business area, and residential areas north and south of Chiawa roads.

8.4.13. EXISTING LANDSCAPE CHARACTER

The landscape character of the study area is dominated by the Zambezi which serves to draw the views up and down the wide valley flood plain. The existing bridge acts as a focal focus and provides an attractive man made landmark feature in the area. Distant views of the Zambezi escarpment both in Zambia and Zimbabwe provide a backdrop to the whole picture.

Views from Chirundu close to and upstream of the bridge are generally partially obscured and filtered by large trees and housing, providing the whole area with a more enclosed feeling. Downstream is the higher income, and rapidly expanding, part of Chirundu where views are expansive across the Zambezi Valley. A large part of Chirundu lies in a shallow valley where the landscape is an intimate mosaic of small settlements and subsistence crops. Views are confined by scrub vegetation. Settlements are generally set back from the rivers edge in the study area due to the steep river cliffs and there being less tourist developments within the area.

The existing bridge built in 1939 is an elegant riveted steel suspension bridge spanning the 370m wide Zambezi between the narrowest part of the river cliffs. It appears visually to be in good condition and the pronounced contrast between the white steel and black suspension cables is an attractive sight in the early morning or late day sun. The simplicity of design and flowing lines complement the river landscape and serves to visually link Zimbabwe and Zambia.

8.5. ENVIRONMENTAL BASELIN - ZIMBABWE

The main environmental constraints for both the Zimbabwe and Zambian sides of the river, are

shown in Figure 8.3.

8.5.1. SITE LOCATION AND INTRODUCTION

Chirundu is located in the Zambezi River Valley, in the province of Mashonaland West on the Zimbabwe-Zambia Border. The Capital City, Harare is located 350 km to the east, and the provincial capital, Chinoyi, is 269 km to the east. The nearest major urban centre is Karoi, which is at a distance of 120 km. Chirundu is surrounded by the Hurungwe Wildlife Safari Area, with excellent access to the Mana Pools National Park, and the Sapi and Chewore Safari Areas.

The area was originally settled by the Tonga Tribe, who were hunters and fishermen. When the land was designated as a Safari Area during the 1950s the Tonga moved away, and the area experienced an influx of riverine activities designed to cater for tourists.

8.5.2. GENERAL SITE DESCRIPTION/TOPOGRAPHY

The section of the River Zambezi affected by the proposals is relatively fast flowing and narrow (370 m wide) with wooded riverside cliffs on the upstream of the existing bridge and wooded, gentle slopes on the downstream side. On the upstream side of the existing bridge, the land rises steeply to the escarpment edge where some private and senior officials housing and the home of the chief of police command wide views of the Zambezi. On the downstream side, relatively shallow slopes ascend from the river edge to the main road. Low level housing and development, interspersed with secondary bush dominate the upstream section. There is a pronounced valley, which divides the grouping of the police and official's housing. The urban areas include the water treatment works and Meteorological station (no longer operational), the police headquarters, the police and customs officials housing and further inland from the river, the Vehicle Inspection Depot, town board offices, clinic, hotel and the high density unofficial "squatter" settlement known as Baghdad.

On the downstream side of the bridge and between the river and the road the land is relatively thick bush, the only developments being the customs point, the floating police jetty, and the public boat launching pad. Further downstream from the route corridor are a camping site, a number of private houses, and further bush extending to the Hapabvumidze Fish Farm. The bush within the study area lies within the enclave just outside Hurungwe Safari Area but as contiguous habitat is regularly visited by game and is effectively part of it, especially since hunting is not allowed within the Chirundu enclave in contrast with the surrounding area. This is state land administered by the Department of Parks and Wildlife although some private plots are on 35-year leases. The bush immediately downstream of the existing bridge is zoned as an area to be excluded from any urban development under the most recent local plan.

8.5.3. CLIMATE

Zimbabwe lies within the tropics, extending from 15° 30'S to 22° 30'S, and lies between 25° E and 33° E. The effect of relief results in a sub-tropical climate. The country has three distinct relief and climatic regions, on the basis of their general elevation. These are the Lowveld (below 900 m above sea level), the Middleveld (900 to 1 200 m) and the Highveld (1 200 to 2 000 m). The Study area lies within the Zambezi valley, and is therefore classified as Lowveld. The Lowveld is characterised by high temperatures (over 40° in extremes between

October and December) and low rainfall (less than 650mm/year). The country receives almost all of its rain during the five summer months between November and March. The start of the rain season is unreliable in terms of both amount and duration. The variation from year to year means that in some years as little as one quarter of the arithmetic mean falls, while in other years 200 to 300% of the mean may fall. The areas of lowest rainfall, such as at Chirundu, are also the areas of least rainfall reliability. During the dry season, from May to October, there may be a few showers of rain, but the temperatures and evapo-transpiration rates are sufficiently high to result in virtually no effective rainfall.

8.5.4. GEOLOGY, SOILS AND AGRICULTURAL CLASSIFICATION

The site is typical of the middle Zambezi Valley, lying within the Karoo series and consisting of grits, sandstones and siltstones laid down as marine deposits in the Triassic period (Figure 8.5). The soils consist in general of fine to medium grained sands, overlaying compact sodic horizons, which are usually almost impervious.

Siallitic soils are also found in the study area. Due to the high temperatures and clear skies for most of the year, high evaporation mitigates against accumulation of moisture in the soil. Weathering intensity is therefore very low, and there is generally insufficient moisture for extensive leaching to take place. Despite the low rainfall there are times during the year when rainfall intensity is so high that the amount of water falling on the surface far exceeds the rate of infiltration, thus giving rise to considerable run-off, which in turn results in sheet erosion and loss of topsoil.

The site lies within Agro-ecological Region V under the Zimbabwean classification system (classes I to V, with I being the highest grade, recommended for specialised farming and intensive cropping). Grade V soils are extremely poor and are inappropriate for agriculture except for very extensive ranching, although sugar cane was grown in the region, until the Tate and Lyle Estate closed in 1969. Bananas are currently grown, with the help of irrigation, about 4 km downstream of the site, for export to Zambia. Even household vegetable plots are very hard to maintain because of damage by baboons and elephants. Most of the area consists of bush savannah (mopane scrub).

The Chirundu-Harare road crosses some of the best land in the country, Agro-ecological Region IIA on the Highveld, where maize, tobacco and some cotton and wheat are grown and fine beef cattle are raised. General land classification is shown in Figure 8.7, locating communal and forest land, as well as national parks and safari areas.

8.5.5. ECOLOGY

(1) General background

The River Zambezi, 2 700 km from south to north is Africa's fourth longest river and arguably the least spoilt. The middle Zambezi, between Zambia and Zimbabwe, despite the two large dams at Kariba and Kaboro Basso, comprises perhaps the wildest river valley, with the greatest resources of game of any in central Africa. A chain of Reserves, National Parks and World Heritage sites extends from Victoria Falls at the western Zimbabwean end to Mana Pools in the east. The middle Zambezi has also been the subject of a number of recent controversies, concerning new dams and navigation proposals. Alien aquatic weeds, Kariba weed *Salvinia molesta*, water hyacinth *Eichornia crassipes* and water fern *Azolla* present potential ecological

problems on the Zambezi, sometimes being transported by boats from the major reservoirs. However, in the Chirundu region they tend to be confined to relatively still backwaters. Heavy siltation affects the river seasonally and may be linked to maize cultivation on the Zambian side.

The road between Makuti and Chirundu descends the Zambezi escarpment, which is very rich in game and birdlife within the Hurungwe Safari area. This area is also of great ecological interest, since it is the interface between the miombo woodland of the Highveld and the mopane woodland of the Lowveld (Figure 8.8).

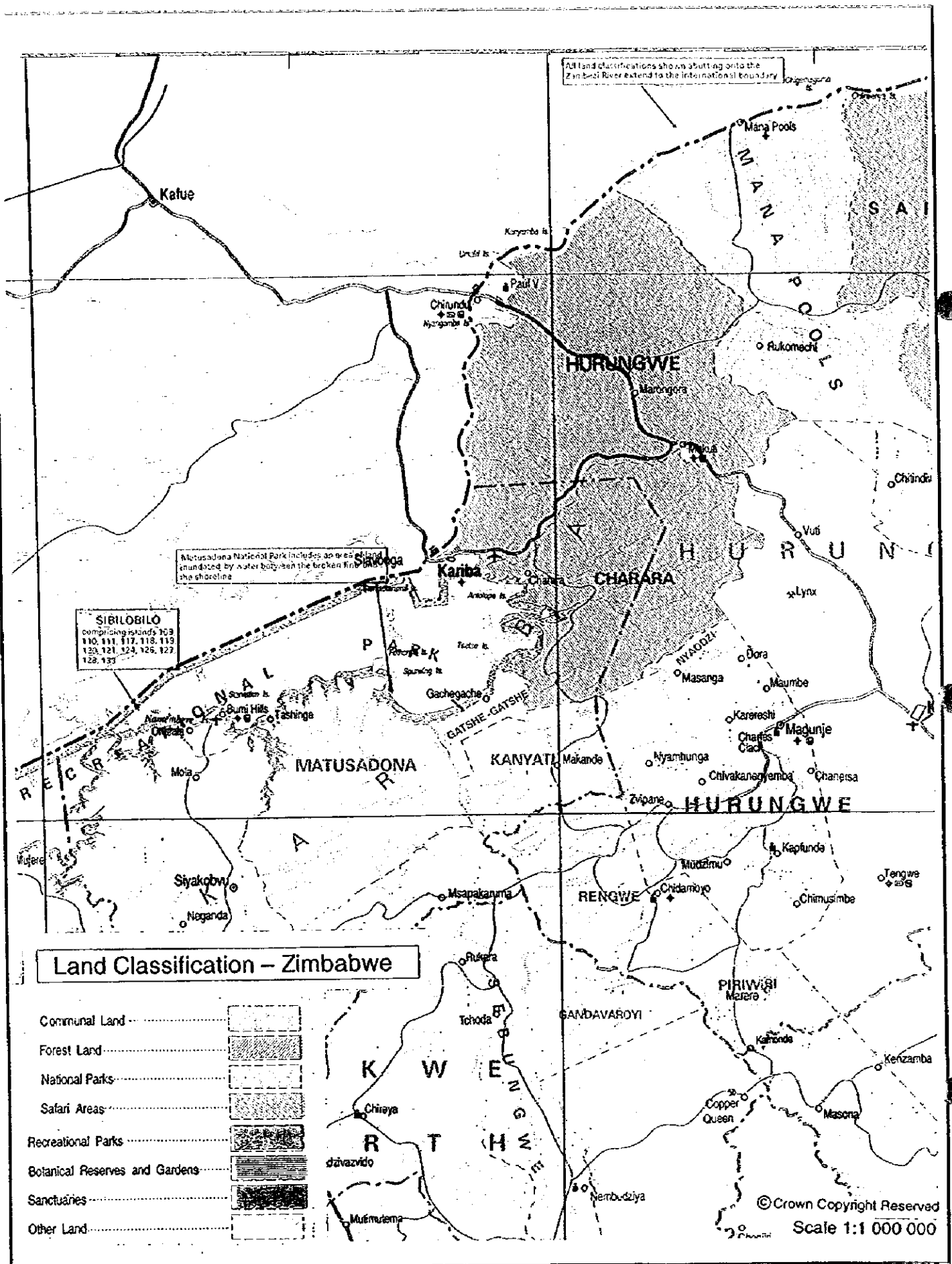
(2) Vegetation

Figure 8.8 shows the vegetation classification. The study area lies within the Lowveld of the Zambezi Valley, the less disturbed vegetation consisting of mopane, *Colophospermum mopane*, which forms tall dense stands especially downstream of the existing bridge. The elements of vegetation are similar to those found upstream and downstream within the Hurungwe Reserve proper, but there is less open grass due to reduced grazing pressure by buck and some mopane trees are taller due to less regular damage by elephants. Other shrub and tree species present include baobab, *Adansonia digitata*, purple pod terminalia *Terminalia prunioides*, tree buckthorn *Berchemia discolor*, white syringa *Kirkia acuminata*, sweet thorn *Acacia karroo*, buffalo thorn *Ziziphus mucronata*, wild fig, *Ficus burkei*, *Salvadora persica*, *Grewia sp*, *Combretum sp* and *Balanites maughamii*. A rare tree within the Zambezi valley, which is especially well represented on the site along the river edge downstream of the existing bridge is the Lebombo wattle *Newtonia hildebrandtii*. This tree is largely confined to the lower Limpopo valley in Mozambique. It is a protected tree in South Africa. Along the river's edge are many large specimen tamarind trees, *Tamarindus indica*, presumably originally planted. Herb species occurring on site include *Crossandra mucronata*, *Leonotis nepetifolia*, *Trichodesma zeylanica* and *Melhania acuminata*.

(3) Animals

The site lies on the edge of the Hurungwe Safari area and game is abundant, especially in the dense bush downstream of the bridge. This is especially so during the hunting season, May to September, when more game, notably elephants, migrate away from the downstream hunting reserve towards Chirundu. Species present within the Hurungwe Reserve include elephant, lion, zebra, bushbuck, waterbuck, impala, hyena, warthog, vervet monkey, baboon, gennet, painted hunting dog, stembuck, leopard, kudu and buffalo. There are 7 resident elephants regularly beside the bridge during the hunting season, a group of 5 and a group of 2. Other species regularly seen within the immediate area directly impacted by the bridge proposals include bushbuck, warthog, baboon, wild dog and gennet.

Painted hunting dogs, *Lycaon pictus* are reported as breeding and hunting within the area immediately downstream of the existing bridge. The painted hunting dog is now extremely endangered, with a smaller population than the white rhino. There is a total African population of between 2 000 to 3 000, with only 4 countries containing viable populations, of which an estimated 400 occur in Zimbabwe. The Zimbabwe populations are found at Hwange, Gonarezhou and the Zambezi valley. The factors affecting the survival of the current populations are numerous and varied. Impacts include natural predation by lions and hyenas directly on the dogs, and also through stealing their kill. Increasingly, however, it is the conflict



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Government of Zimbabwe

Ministry of Works & Supply
Government of Zambia

Chirundu Bridge Environmental Assessment

Category	Impact	Significance	Mitigation

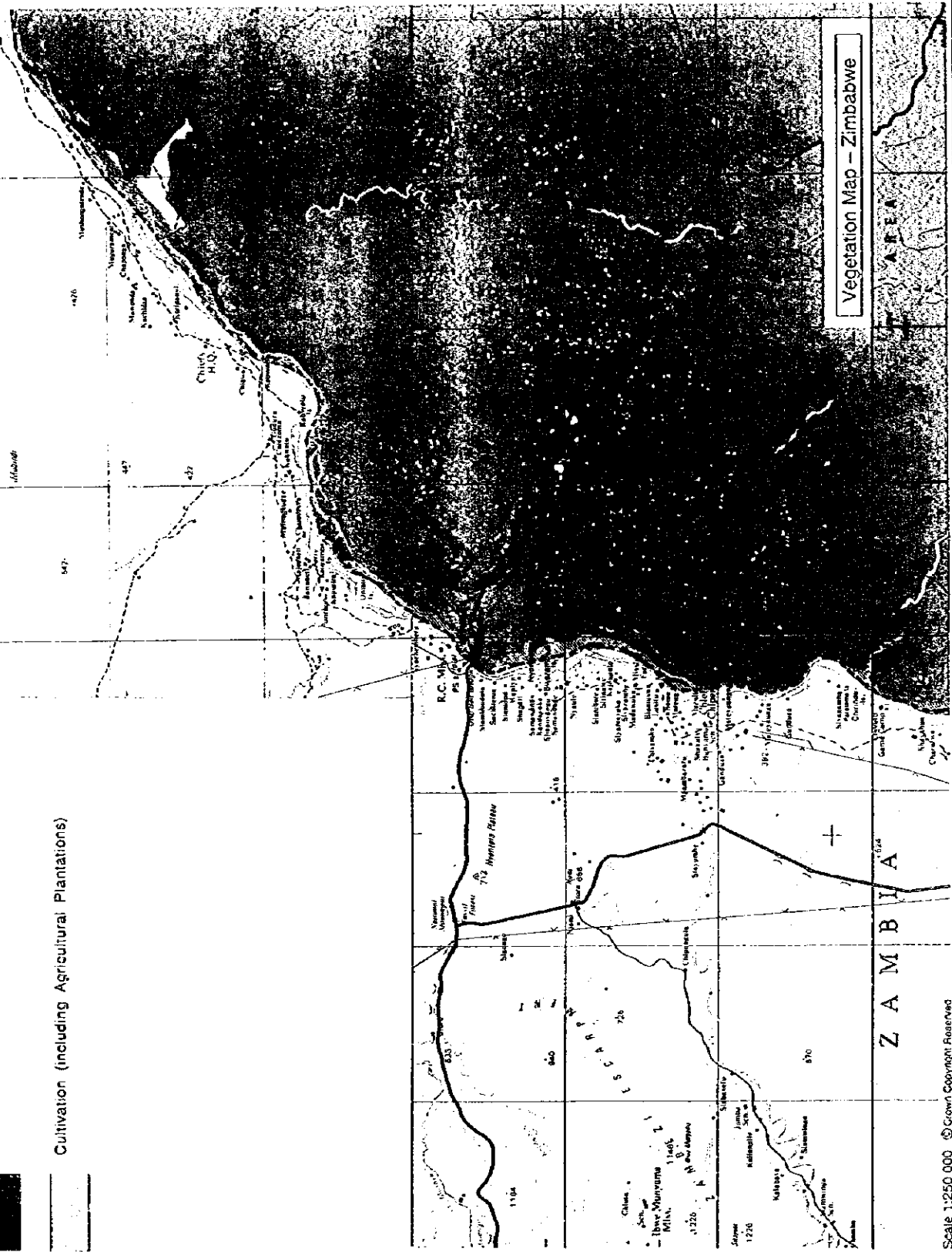
Project: Chirundu Bridge
Date: 1997

Figure 8.7

Woodland (Canopy Cover 20-80%, Tree Height 5-15m)

Bushland (Canopy Cover 20-80%, Height 1-5m)

Cultivation (including Agricultural Plantations)



Vegetation Map - Zimbabwe

Scale 1:250 000 © Crown Copyright Reserved

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<p>Title Chirundu Bridge Environmental Assessment</p>	
<p>Location</p>	<p>Proj. No.</p>
<p>Agency</p>	<p>Contract</p>
<p>Proj. No.</p>	<p>Assessment</p>
<p>Phase</p>	<p>Project</p>
<p>Approval No.</p>	<p>Scale 1:50,000</p>

Figure 8.8

with man that has a profound effect. Dogs are killed because they are perceived as vermin. With increasing volumes of traffic the numbers killed on the roads is also increasing.

Hippo and crocodile are abundant on the Zambezi within the study area. Along the wooded cliff edge upstream of the bridge, the species present are baboon, leopard, hिरax, black mamba and buck. Elephant and buffalo frequently use the densely vegetated valley to gain access to the river edge.

(4) Birds

Bird species present include crested barbet *Trachyphorus vaillantii*, longtailed starling *Lamprolornis mevesii*, red billed hornbill *Tockus erythrorhynchus*, white browed sparrow weaver *Plocepasser mahali*, Lilian's lovebird *Agapornis lilianae*, cardinal woodpecker *Dendropicos fuscense*, tropical boubou *Laniarius aethiopicus*, blue waxbill *Uraeginthus angloensis* and white helmet shrike *Prionops plumatus*.

(5) Game Corridors

There is an important game corridor, which lies between the bottom of the hill at the back of Chirundu and the border post at the bridge (Figure 8.3). This has been squeezed by developments and now consists of the gap between the hotel/Baghdad area and the main customs development. Elephants and buffalo regularly cross the urban areas at this point and the vehicle inspection depot, right in the middle of the gap, is especially badly placed. Its fences have been knocked down by elephants, which come inside to search for marula fruit and then are stampeded by the truck drivers. Elephants also enter the grounds of the hotel and drink from the swimming pool. Great care will be needed in planning the future growth of Chirundu to avoid the serious conflicts between game and urban development which now occur at Kariba. There are occasional fatalities. A man was trampled to death by an elephant in Chirundu two years ago and a bus driver was gored to death by an elephant in Kariba early in 1997. These events, a total of 4 fatalities in 14 years, need to be seen in the context of the far greater problems of malaria, AIDS and traffic accidents. Game is often killed or injured by vehicles and also develops a cycle of dependency through feeding.

(6) Poaching

Poaching, reported to be largely from the Zambian side, is much reduced. In 1996, there were 50 elephant carcasses of which 10 were legitimate culls. This can be compared with the late 1980s when on average 150 elephants were poached in the vicinity every year. However, an elephant was poached close to Chirundu on 4 July 1997. With the planned growth and economic development of Chirundu (Zambia) and the partial lifting of the ban on sales of ivory, it is hoped the poaching pressures will be reduced.

(7) Fish Species

There are over 120 species of fish occurring within the Chirundu reach of the Zambezi. Major species caught are chessa *Distichodus shenga*, nukupi *Distichodus mossambicus*, purple labeo *Labeo congoro*, cornish jack *Mormyrops anguilloides*, butter barbel *Schilbe intermedius*, brown squeaker *Syodonotis zambezensis*, vundu *Heterobranchus longifilis* and bream or green happy *Sargochromis codringtonii*. Other species present which are important for fisheries are redbreast tilapia *Tilapia rendalli*, nembwe *Serranochromis robustus*, manyame labeo *Labeo altivilis* and straightfin barb *Barbus paludinosus*.

The main attraction for tourist fisheries is the tigerfish *Hydrocynus vittatus*, which breeds during the summer, spawning along flooded riverbanks. Little is known about the specific breeding habits and locations of the local tigerfish population. Tagging of vundu has demonstrated that they migrate over a 40 km reach in the Zambezi. Although the local populations seem healthy, tigerfish are vulnerable to pollution, water abstraction and obstructions like weirs and dams. The main tourist fishery, Tiger Safaris, practises sustainable fishing, with catch and release for all but trophy specimens. Bream ponds, within the river system, upstream and around the bend from the existing bridge are especially important for spawning bream.

8.5.6. SOCIO-ECONOMIC PROFILE

(1) General

The 1992 census recorded 1 243 people living in the Chirundu area, 765 male and 478 female. (Government statistics report). It is usual to estimate a 3% annual growth rate in Zimbabwe. The Chirundu Town Board estimates that in 1994/95 there were 3 000 people living in the Chirundu area, which includes the outlying regions of Mana Pools. Most of the non-government population of Chirundu is said to have arrived there during the 1991 to 1993 period of drought.

Most of the population of Chirundu consists of government and police officials and their families, whose work is linked to the border post. In addition there is a small number of people employed for tourism, notably at the hotel, together with the work force for the fish farm (140 people) and the banana plantation (150 people) downstream. These are housed on their respective sites.

Finally there is the high-density village settlement known as 'Baghdad' which lies behind the hotel and supports a semi-transient population dependent chiefly on the truckers. The prostitutes who live in this area are reported to migrate from Harare and Chinhoyi. Major proposals to build over 500 housing units to replace Baghdad were drawn up by the Department of Physical Planning at Chinhoyi in 1992. However these proposals have substantially been abandoned in favour of more modest proposals. It is felt that many of the present inhabitants of Baghdad would be unable to afford any official high-density housing which might replace it. Final designs await the detailed decisions on the new bridge and associated infrastructure.

The view of the Senior Administrator in Chinhoyi is that Chirundu is expanding and must attract investment. While the urgent need to improve health and education facilities is undeniable, the employment base for expanding settlement seems limited. In Chirundu itself, apart from customs and police the main employment appears to be the black market and prostitution. With recent changes in Zimbabwean import law, the thriving market in second hand clothes from Zambia has evaporated.

There are some very serious social problems in Chirundu and its outlying districts, including crime and traffic accidents but especially health and education.

(2) Health

The Chirundu clinic has two qualified senior members of staff, serving an estimated population of about 3 000 people, including the fishing camps. On an average day about 45 people visit

the clinic. The clinic is very under-resourced with a shortage of drugs, and lacks even basic necessities such as adequate sheets, blankets and stretchers. There is no ambulance, and the nearest hospital is in Karoi. This has serious consequences for patients who require hospital treatment, since an ambulance has to be called from Karoi, which is a drive of about two hours. There are no kitchen facilities to provide food for patients.

Most Common Conditions 1996 above 5 years			Most Common Conditions 1996 under 5 years		
1	Malaria	2168	1	Malaria	304
2	STIs	938	2	ARI	440
3	ARI	677	3	Skin Diseases	48
4	Skin Diseases	271	4	Diarrhoea	83
5	Diarrhoea	253	5	Burns	14

Year	Number of STI Cases
1992	611
1993	740
1994	757
1995	961
1996	938

Malaria and AIDS are especially serious in the study area. There is a bad strain of malaria, which came from Mozambique, and originated in SE Asia. It is prevalent during the wet season (November/ December to March/June) and is generally at its worst between February and April at which time the workforce in the banana plantation goes down by approximately 50%. There were more than 2 400 reported cases during 1996. Malaria accounts for approximately 6 deaths a year, as reported by Mr Van der Reijt of the banana plantation. It is estimated that 30% of the workforce at the fish farm have malaria in the wet season, although hut spraying is regularly carried out. Mosquito nets are relatively unusual in Chirundu, as they are expensive. Cholera is also present though less serious than on the Zambian side.

AIDS in Zimbabwe is estimated as causing around 1 000 deaths a week. This can be seen in context of a total population of 11 million. It is estimated that by December 1995, 10% of Zimbabwe's population was infected with HIV. Within the sexually active age group it is estimated that 20 to 25% are infected. As a major stopping point for trucks, Chirundu is very seriously hit by AIDS and is also a major source of contagion for other areas. Prostitutes stay at Baghdad for specific periods and regularly return. No survey has been carried out but it is estimated that as many as 70 to 80% may be infected. Some of the prostitutes are as young as 14 or 15 years old. It is always difficult to establish very specific statistics on AIDS in the community, but at the fish farm for example, it is estimated that within the extended families of the 140 man workforce, approximately 1 to 2 people a week die of AIDS. There is a little AIDS education and condoms are sometimes available but local health resources are very limited. The Sister at the clinic said that although some people do come to the clinic for condoms, truck drivers are generally unwilling to use them. No AIDS tests are carried out at

the clinic, but it was reported that approximately 4 to 5 truck drivers visit the clinic every day showing symptoms which are sometimes an early indication of HIV.

(3) Education

Education levels are very poor. There is no school as yet, although the first building block of a new school is virtually completed and is being funded by the Apostolic Faith Mission in Zimbabwe. There are no teachers or other facilities as yet. The nearest school is at Marongora, 15 km away, so many children in Chirundu and its outlying settlements never go to school. The nearest senior schools are at Magunge near Karoi and Nyamakadi near Makuti. The lack of schooling is a factor dictating the difficulty in attracting staff to customs and police offices at the border post.

The RIFA Educational camp is situated in the Hurungwe Hunting area about 5 km upstream of Chirundu. The Zimbabwe Hunters Association, who created the camp in 1980 to promote the appreciation of Zimbabwe's wilderness areas, leases the area from the department of National Parks and Wildlife Management. During term time the camp is used by visiting groups of primary school children with 'O' and 'A' level students occupying it during the vacations.

(4) Road Safety

The Chief of the Chirundu police has full details and locations of traffic accidents in the recent past. There are many minor accidents near the bridge, which are concentrated around the customs buildings, and mainly a result of congestion and the large turning circle required for trucks. Forty-two accidents were recorded in Chirundu for the last 12 months (August 1996 to July 1997). Much more serious accidents occur on the bending road down the Zambezi escarpment from Makuti. These sometimes arise as a result of animals being hit during the night but more commonly they are a consequence of bad vehicle and brake maintenance.

(5) Crime

House raids and thefts from trucks are prevalent in Chirundu and are generally blamed on Zambians crossing the river at night. Poor street lighting also contributes to the problem. Smuggling appears to be increasing, with trafficking in illegal tape cassettes, clothes and skin lightening cream. Possession of skin lightening cream is an offence in Zimbabwe since it causes long-term skin damage and mental deterioration. Poaching is also a problem in the area. An elephant was poached on 4 July 1997, and the evidence pointed to poachers crossing from Zambia, since it took place near the river, a long way from any Zimbabwean settlements (at least 85 km), but only a short distance from Zambian settlements on the other side of the River Zambezi.

(6) Other Services

There is a general lack of shopping facilities and a great need for a bank. Final planning permission for the Take-Away has been withheld, pending detailed bridge design and subsequent development proposals.

8.5.7. TOURISM

Chirundu is a transit stop for tourists rather than a specific objective. Tourists coming from the south, who stay in Zimbabwe tend to turn off to Mana Pools or Kariba rather than go on to Chirundu. Many tourists travelling to Zambia choose to go via Kariba rather than Chirundu

since there are more facilities and attractions in Kariba, although it is a longer way round. However, in Chirundu there is fishing and boat hire on the river. Fishermen come from Harare and South Africa, and on a good day there may be 20 boats on the river. There is little fishing in the winter season when the water is too cold. Tourists using boat hire between Kariba and Mana Pools and beyond are generally only passing through and there are no overnight facilities for these tourists in the form of campsites. There are on average 6 outboard motorboats a day on the water. The hotel runs one boat. There are approximately 10 operators for canoe safaris, and each operator is allowed up to 10 canoes on the river, although they are phased so that no two groups ever see each other. Unfortunately there is no co-ordination with the Safaris operating along the Zambian shoreline.

The major permanent tourist enterprise within the study area is Tiger Safaris which is approximately 500 m downstream from the existing bridge. It is primarily a game fishing operation and also organises boat hire and photography. Tiger Safaris also own and run 5 chalets, employing 14 permanent staff and 12 - 13 casuals. It has been operating since 1980, and attracts tourists from South Africa, UK and USA, especially since the tigerfish has been declared an international game fish. It accommodates on average 340 visitors a month (1 697 for the first 5 months of 1997), with the addition of half as many again from the fishing clientele.

At the hunting Safari Camp in Hurungwe, hunting is auctioned out every year for the hunting season between May and September. This is co-ordinated by an organisation known as Campfire, which is an organisation to aid sustainable rural development and conservation. Rural communities are given legal authority to manage wildlife resources, including the selling of photographic or hunting concessions to tour operators, under rules and hunting quotas established in consultation with the wildlife department. Sports hunting provides over 90% of rural district funds under the campfire system, 65% of which is from elephant alone. The total revenue in 1996 was Z\$1 222 574 from consumptive tours, and a further Z\$22 150 from non-consumptive tours (ie photo-safaris and game viewing). At present there are two safari operators, and hunting takes place between July and December, although wet season hunting may also be carried out in February to April to keep animals away from crops.

Species	Approved Quota for 1997	
	Chewore/Mukwichi	Charara/Nyaodza
Elephant (M)	7	2
Elephant (F)	20	0
Buffalo (M)	35	2
Buffalo (F)	10	0
Lion	1	0
Lioness	0	0
Leopard	12	2
Hyena	3	5
Hippo	3	2
Crocodile	4	1
Sable	10	1
Eland	4	1
Kudu	3	2
Bushbuck	14	4
Waterbuck	4	1
Zebra	5	2

8.5.8. FISHERIES

The Zambezi, within the immediate study area, supports an important subsistence and tourist fishery while 3 km downstream from the bridge, is the Hapabvumidze Fish Farm on an old arm of the river, which provides a major source of revenue and employment.

There is concern that the overall fish catches along the Zambezi have been declining in recent years (IUCN, pers comm). However the local fishing operators in Chirundu maintain that the fishing is flourishing and the fish biomass within the river at Chirundu has been much boosted over the last 40 years by the upstream and downstream dams. Fishing in the river is supposed to be subject to ZWD \$20/permits, but a blind eye is turned to this and 80% of the local population supplement their food income by fishing. See also tourism section above.

The Hapabvumidze Fish Farm employs 140 people on its workforce and has been operating for 5 years. Tilapia are raised on a Zambezi backwater which would be very vulnerable to any change of flow level at the bridge crossing point. The river splits into two channels when the power generation at Kariba is down, well upstream of Umairi Island, and the lowest levels can generally be seen from the bridge on Monday afternoons. The fish farm enterprise is currently investing \$40 million ZWD over the next 12 months. The tilapia is exported to USA and Europe.

8.5.9. HISTORICAL/CULTURAL/ARCHAEOLOGICAL

The existing bridge, was designed by Sir Ralph Freeman, also responsible for the old Sydney harbour bridge and Birchenough Bridge over the Limpopo on the southern border of Zimbabwe. It was funded by the Beit Trust, whose origins were in gold and diamond mining in South Africa and copper mining in Zambia. The bridge was named after Alfred Beit's brother, Sir Otto Beit and was opened by his widow, Lady Lilian on 24 May 1939.

Near the floating police launch is a small concrete bunker for storing boat tackle, dated 1972 and initialled BSAP (British South African Police). As a small relic of the Rhodesian war it may have unhappy memories at present, but in time may come to be regarded as historically interesting.

Sacred trees and areas of local religious significance are a common feature of both miombo and mopane woodland. The vine nyafinya (*Combretum sp*) which is regarded as a powerful medicine, grows wild in the bush immediately downstream of the existing bridge. There are many baobab trees *Adansonia digitata* on site, and they are regarded as sacred in Zimbabwe. There are also *Kirkia acuminata* trees in the area which were once regarded as sacred in Rhodesia.

An archaeological study has been commissioned as an additional part of the EIA to assess the potential for the presence of any ancient remains or workings.

8.5.10. MINERALS

There are no significant mineral deposits within the immediate study area. Copper exported south from Zambia all crosses the Chirundu bridge. The Great Dyke gold fields lie across the Chirundu-Harare road. Chrome and other minerals are mined at Mhangura, copper at Shamrock Mine, and gold in the Chegutu area.

8.5.11. FUELWOOD/ENERGY ISSUES

The communal areas of Zimbabwe experienced a 50% denudation of woodland and other vegetative cover between 1966 and 1978 when colonial restrictions were at their height. By 1980 20% of the countries "communal areas" had chronic wood shortages. During the early 1990s more than 65% of communal areas were deforested and suffered chronic wood shortages. Removal of trees for building poles and thinning for fuelwood tend to reduce woodland quality and density more than creating complete deforestation.

Increased settlement along road corridors commonly creates major long-term impacts in terms of over-grazing, tree felling for fire wood and grass cutting for fodder and thatching, especially on the poor sands of the Zambezi and Limpopo Valleys Agro-ecological Region V. Because most of the study area on the Zimbabwe side is under the control of the Department of Parks and Wildlife and the Chirundu Town Council this problem is likely to be controlled and possibly limited. Nonetheless, there are potential problems around the existing expanding settlements, notably at Baghdad. Tiger Safaris estimate that for the hot water for their 5 chalets they need one trailer (about the size of a Land Rover) of wood per week and are currently changing to electric boilers due to shortage of readily available wood. Despite the proximity of Kariba Dam, there is frequently no electricity in Chirundu and distribution is confined to those in official housing in the higher income groups.

8.5.12. NOISE AND AIR QUALITY

Noise monitoring was carried out at five locations in the study area:

- 1 Residential quarter close the fish pond
- 2 Police officer's residential quarter 1
- 3 Police officer's residential quarter 2 (junior officers)
- 4 Road side opposite Chirundu Valley Hotel
- 5 Road side in cutting by Otto Beit Bridge

The noise measurements showed that environmental noise levels at monitoring points 1 and 2 were generally very low. Monitoring point 3 is affected by road traffic, with trucks approaching the customs area, although noise levels are generally low.

Monitoring of road traffic noise is generally very low, due to the low numbers of vehicles/trucks that use the road. However, when a lorry passes noise levels rise to between 75 and 85 dB(A).

There is no air quality monitoring data available for the study area. However, dust created by the passing lorries is an air pollution problem and smothers the vegetation in a fine coating of particles, which inhibits photosynthesis. There are no industries or related activities that contribute to significant air emissions in the area.

8.5.13. WATER RESOURCES

A water treatment plant, which serves the police and customs housing, and houses located further up the hill in Chirundu, is located immediately upstream of the Otto Beit Bridge, with the intake point directly under the bridge. The plant was built in 1980 and the water is treated by alum dosing, filtration and chlorination. The pH and chlorine levels of the water are checked every day. Water is pumped from the water treatment plant to a storage reservoir (1

500m³) located at a high point in the town, from where water is distributed. It is reported that chlorine levels in the water are generally too high.

The houses and tourist facilities, which are located downstream of the Otto Beit Bridge, draw their water directly from the River Zambezi through individually owned water pumps. The Local Subject Plan notes that this water is currently being drawn illegally since no property owners possess the rights to draw water. The potential for pollution of the river by oils, which may leak from the pumps, is a threat to the aquatic flora and fauna.

There are sewage ponds/soakaways located south-west of the high-density residential area of Baghdad, which are at present failing to meet demands. In other areas of town sewage is disposed of to septic tanks, soak-away pits and Blair latrines.

8.5.14. EXISTING LANDSCAPE CHARACTER

The Zambezi River serves to draw the views up and down the wide valley flood plain dominating the landscape character of the study area. The existing bridge acts as a local visual focus and provides an attractive man-made landmark feature in the area. Distant views of the Zambezi escarpment both in Zimbabwe and Zambia provides a backdrop to the whole picture.

Views from the road and lower elevation settlements in Chirundu are mostly confined to close horizons by the mopane vegetation and ridges of landform. View corridors along the main roads extend the views into the surrounding landscape. The "higher income" and holiday housing afford wide views both up and down the Zambezi Valley as they are located on the higher ground upstream of the existing bridge. This is behind and at a higher elevation than the majority of police officials' accommodation.

Views from the developments along the riverbank downstream of the existing bridge are across to the Zambian bank of the river. The bridge forms an important and attractive element in this view.

The bridge built in 1939 is an elegant riveted steel suspension bridge spanning the 370 m wide Zambezi between the narrowest part of the river cliffs. It appears to be in good condition and the pronounced contrast between the white steel and black suspension cables is an attractive sight. The simplicity of design and flowing lines complements the river landscape and serves to visually link Zimbabwe and Zambia.

8.6. INITIAL ENVIRONMENTAL EXAMINATION

Initial environmental examination was carried out for all the Alternative Routes -A, -B and -C (see Figure 5.5) during the first field reconnaissance survey from June to August 1997. Table 8.1 summarises the result of IEE.

Table 8.1 Summary of Initial Environmental Examination

ELEMENT	IMPACT	ZIMBABWE						ZAMBIA							
		Option A		Option B		Option C		Option A		Option B		Option C			
		Major ++	Minor +	Major ++	Minor -	Major ++	Minor -	Major ++	Minor -	Major ++	Minor -	Major ++	Minor -	Major ++	Minor -
1	Soils		*												*
2	Vegetation		*		*										*
3			*												*
4			*												*
5			*												*
6	Animals														*
7			*				*				*				*
8			*				*				*				*
9			*		*		*				*				*
10	Birds		*		*		*				*				*
11	Fish		*		*		*				*				*
12			*				*				*				*
13	Game Corridors		*				*				*				*
14	Poaching		*				*				*				*
15	Businesses		*				*				*				*
16	Land Take		*				*				*				*
17			*				*				*				*
18			*				*				*				*
19			*				*				*				*
20	Health		*				*				*				*

ELEMENT	IMPACT	ZIMBABWE												ZAMBIA												
		Option A				Option B				Option C				Option A				Option B				Option C				
		Major ++	Minor +	Major --	Minor -	Unknown	Major ++	Minor +	Major --	Minor -	Unknown	Major ++	Minor +	Major --	Minor -	Unknown	Major ++	Minor +	Major --	Minor -	Unknown	Major ++	Minor +	Major --	Minor -	Unknown
43				*																						
44	Landscape				*																					
45																										
46																										

8.7. EVALUATION OF ENVIRONMENTAL IMPACTS – ZAMBIA

8.7.1. SOILS

Owing to the nature of the soils, which consist of fine grained sand overlaying almost impervious sodic horizons the soils are liable to sheet erosion during periods of high rainfall intensity. During the construction period areas of vegetation will be cleared for the construction of housing for the workforce, and for the working site. It is therefore inevitable, that during the wet season there will be an increased risk from soil erosion, which could result in loss of topsoil and gulying. Mitigation measures include minimising the area of vegetation cleared as far as possible, and shallow grading to embankment slopes. Slopes should be replanted with good ground covering vegetation to reduce rainfall impact. Excavation and earthworks should be carried out during the dry season as far as possible.

8.7.2. VEGETATION, ECOLOGY AND WILDLIFE

(1) Vegetation

1) Loss of mature trees and bush vegetation

The loss of mature trees and bush vegetation on the Zambian side of the river will not be as severe as on the Zimbabwean side, since there is a smaller area of bush vegetation. However there will be the loss of some river edge cliff vegetation.

2) Loss of nationally rare species *Newtonia hildebrandtii*

Option A will not result in the loss of the rare *Newtonia hildebrandtii* trees, which occur in very small numbers along this length of the River Zambezi.

3) Destruction of river edge cliff vegetation

As noted above the project will result in the loss of some river edge cliff vegetation.

(2) Animals

1) Increased conflict between humans and animals

There are no particular game corridors on the Zambian side of the river, although elephants do pass through the township. It is, therefore, not considered that the location of the border facilities on this side of the river will have a significant effect.

(3) Birds

1) Disturbance to birds during construction

During construction, noise and dust will result from the movement of mechanical plant and any blasting or drilling activities. It is likely that any birds roosting or feeding in the area will move away to quieter areas. The return of birds to the area will depend on the scale of the border facilities and increased noise from greater numbers of trucks in the area, as well as the tolerance of the birds to repeated disturbance.

(4) Fisheries

1) Disturbance to fisheries during construction

During the construction period the disturbance caused by any piling or activities which require plant to be in the water will result in fish moving elsewhere in the river. This will only be significant to local people who will be required to fish further up- or downstream from the works. The disturbance to the river bed will only be significant during the construction of the small cofferdams for the bridge piers. However, the area of riverbed to be affected is part of a bank of shifting sand that is highly mobile in any case. The natural increase in river turbidity may therefore be far greater than any increase caused by the building works.

It should also be noted that Tiger fish, which are the most significant fish caught in the area, prefer fast running "rapid" stretches of river, and are therefore unlikely to be found in the slower running sandy areas where the works will be taking place.

2) Risk from pollution during construction period

More significant than the risk of disturbance to fish is the risk of pollution to aquatic species (from oils or diesel for example) during the construction period. This could have a more long-term impact on fish populations, in particular the tiger fish which is an important game species. The findings indicate that water quality is generally good, and therefore pollution incidents could have a significant impact on aquatic fauna. In particular increases in turbidity, from discharges of sediment; or increases in pH from discharge of untreated water from the concrete batching plant could adversely affect flora and fauna.

The Environmental Management Plan detailed in the following chapters recommends that the Contractor should have tight controls on the storage and use of potentially polluting substances. Emergency procedures should be submitted for inspection by the project Engineer prior to the commencement of works, to ensure that the risk to fish populations is reduced to a minimum.

(5) Poaching

1) Risk of increased poaching as a result of improved access

Poaching is already known to occur in the area. Since there has been some relaxation of the ban on the trading of ivory and elephant products the demand for illegally poached sources should, hopefully, be reduced. As there is easy access across the river by boat, it is considered that the new bridge facilities will have no effect on any illegal activities.

8.7.3. SOCIO-ECONOMIC PROFILE

1) Land take as a result of the road alignment and border facilities

The area of land required for the border facilities is estimated to be approximately 5 hectares and the following buildings will be demolished:

- 1 No police station
- 1 No customs ancillary building
- 1 No filling station (privately owned)
- 2 No commercial buildings (privately owned)
- 1 No open market
- 50 No assorted houses for customs police and immigration

Five police/customs houses and the water treatment works will be demolished to accommodate the approach roads between the border facilities and the bridge. Compensation will be payable for the privately owned land and buildings. The remaining land is government land, and the existing houses are due for relocation in any case, as part of the development plan for the township. However, it is obviously essential that the new houses and water treatment works are built before demolition takes place.

2) Severance of township due to link road between bridge and border facilities

The township already extends on the up and downstream sides of the existing bridge. However, on the upstream side the housing is police and customs housing, which is due for relocation. The preferred route option will therefore not significantly sever the township, as long as these houses are moved as is planned.

3) Disruption to local development plan and compensation payable for land loss

The preferred route option concords with the local layout plan for Chirundu, which has advanced plans for land use zoning, water supply, sewage etc. (Figure 8.1).

4) Demolition of police housing

The preferred option will result in the demolition of 5 police houses, located upstream from the existing bridge. This housing is due for relocation under the Chirundu Layout Plan, and its demolition is therefore not considered to be a serious impact, providing the new houses are built prior to demolition of the old.

(2) Health

1) Spread of AIDS

The current delay at the border facilities, while truck drivers wait to clear customs and immigration, is an important factor in the transmission of AIDS. At present drivers may have to wait up to one week before clearing customs. The improved border facilities should allow 95% of drivers to proceed within 15 minutes to 1 hour, with the remaining 5% being required to undertake a full customs search, taking on average five to eight hours. These improved facilities should reduce the demand for prostitutes at the border post, which should in turn reduce the spread of AIDS amongst the population. However, although individual truck drivers will have reduced potential exposure periods, the predicted increase in traffic using the facilities will mean that increased number of drivers will be exposed to AIDS, for whatever period of time. Such effects are hard to quantify since at present no accurate statistics exist on the rate of infection in Chirundu. It should also be noted that improvements to the border facilities alone will not lead to a great decrease in the spread of AIDS, without a campaign of AIDS awareness and education leading to changes in lifestyle practices.

AIDS will also be a concern during the construction period, with a large influx of additional workers. Employment conditions should provide for the movement of families rather than individuals if possible, to reduce the demand for prostitutes, and thus control the spread of AIDS.

2) Increased pressure on hospital

The hospital is already operating with a shortage of staff and inadequate funds. During the construction period there will be an estimated additional 700 people in the township, who will

require medical facilities to be available, especially considering the increased risk of accidents on construction sites. It is therefore recommended that additional funds be made available to improve the services provided by the hospital, and also that the construction workforce should be given basic training in first aid and site safety before being allowed to start work on site.

3) Risk of malaria for the construction workforce, and resultant delays to construction

As already noted malaria is a significant problem during the wet season, with numerous pools of water providing ideal breeding habitats for mosquitoes. If the workforce is drawn from outside the area, the medical clinic in Chirundu (Zimbabwe) recommended that Malasone should be taken once a week, two weeks before moving to the area, during the stay and for four weeks after departing.

(3) Education

1) Increased pressure on existing school owing to population growth (especially during construction period)

The existing school in Chirundu currently takes 250 extra children, above the recommended maximum, with class sizes averaging 100 pupils. The influx of 100 workers and their families will only serve to exacerbate the problem, and it is likely that the majority of the additional children will be turned away from the school, as indeed some children already are. The provision of additional schooling facilities, in the form of a new school or additional classrooms, teachers and housing is therefore important for the successful completion of the project.

(4) Road Safety

1) Increased risk of accidents due to increased road traffic

A secondary impact from the improved border facilities will be the rise in road traffic, particularly trucks using the crossing. The steep narrow road which descends the Zambezi escarpment from Lusaka is already prone to traffic accidents. Traffic volumes are predicted to rise to 500 vehicles per day in 2010. This rise in traffic will inevitably lead to increased numbers of accidents.

(5) Crime

1) Increased security risk owing to long road link between bridge and border facilities

There will be no increased security risk as a result of the preferred route option. The improved facilities, in particular security arrangements should in fact greatly reduce the security risk which currently exists as trucks drive the considerable distance between the bridge and the temporary customs and immigration facilities.

2) Increased risk of crime owing to increase in population

At present the main crime in the area is smuggling and theft. With an increase in population, theft and petty crime are bound to increase.

(6) Other Services

1) Improvement in the local economy as a result of induced development

The Department of Planning already has elaborate plans for the development of Chirundu. It is envisaged that with the improvement of facilities at the border post new businesses will be

attracted to the area, such as banks, new hotels, shops and other activities. This should provide an important base to the local economy, and also provide much needed employment.

8.7.4. FISHERIES

1) Disruption to fishing during construction period

During the construction period two caissons will be constructed in the river bed, involving the construction of a temporary sheet pile cofferdam, excavation, de-watering, and concrete casting. These activities, which will take place in the river, are likely to result in significant disruption to the river bed and increases in the sediment load, as well as increasing the risk of pollution incidents. During this period there may be disruption to fishing immediately downstream from the bridge. Any fishing activities by local inhabitants will have to take place further up- or downstream.

8.7.5. HISTORIC/CULTURAL ARCHAEOLOGICAL

1) Conflict with the setting of the existing bridge

The existing bridge is an elegant riveted steel suspension bridge, and is an attractive sight in the early morning or late day sun. The simplicity of the design and flowing lines complement the river landscape. The location of the preferred route option is considered to be far enough away from the existing bridge not to detract from each other's setting. Although the chosen PC box girder bridge construction is not in itself very symbolic or attractive, this will mean that, when viewed from downstream, the setting of the existing bridge will be disturbed to the minimum extent.

2) Risk of damage to ancient sites or workings

An archaeological survey was commissioned as a separate part of the EIA, to determine the potential for ancient sites or workings along the alignment routes or on the site of the border facilities. The archaeological remains within the soil record in the township had been greatly disturbed by previous construction of the present buildings and military structures. Evidence to establish actual sites of settlements could, therefore, have been destroyed or scattered during construction. The results of this survey indicated that although test-excavation pits found evidence of Stone Age and Iron Age activities in the area, these finds were of little national significance, and the study concluded that the proposed bridge and border facility development could proceed. The full results of the archaeological survey are given in Appendix 5.

8.7.6. MINERALS

1) Increase in traffic levels during construction for the importation of aggregates

An estimated 15,000m³ of aggregates will be transported from Kafue in Zambia and Harare in Zimbabwe for the construction of the bridge, where impacts to environment is minimal (sites already developed). This will result in 1,500 additional vehicle journeys (assuming a minimum of 10m³ for each load). If deliveries are spread throughout the project this will not result in significant increases in road traffic.

2) Borrow pits as potential source of disease vectors

If local sources of sand are used for construction, the borrow pits could pond water and provide ideal habitats for disease vectors, in particular mosquitoes carrying malaria. However, malaria

is already a significant problem during the wet season. It is not considered that the increase in standing water will have a significant effect on the spread of the disease, although the creation of additional mosquito habitats is obviously not desirable.

8.7.7. FUELWOOD/ENERGY

1) Increased demand for fuel wood during construction period

The construction workforce will require an energy source for cooking during the construction period. It is strongly recommended that electricity supplies or propane gas be provided, since supplies of fuel wood are already being depleted in Zambia at an alarming rate. If electricity is not supplied further deforestation will result.

8.7.8. NOISE AND AIR POLLUTION

1) Noise, dust and vibration during construction

It is inevitable that noise and dust will be considerable during the construction period. Noise measurements undertaken by the study team show that ambient noise levels are generally low, except when trucks are passing. Since construction activities will result in almost continuous noise from mobile mechanical plant, blasting and piling activities, noise levels will be significantly increased during this period. It is therefore recommended that work be restricted to daylight hours, and that the World Bank Standards for construction sites be adhered to.

Dust is already a cause of air pollution in the area, in particular during the long dry season. It is recommended that blasting activities should be restricted to the wet season as far as possible, and that stock piles of sand and soil etc are well screened from residential areas. It may be considered appropriate to use sprinklers at times when dust levels become unacceptable, using water pumped from the Zambezi.

2) Increased air pollution as traffic levels increase

As traffic levels increase air pollution, particularly from diesel trucks will become more of a problem. The improved border control facilities, with greatly reduced waiting times should help to reduce the length of time trucks sit with their engines running.

8.7.9. WATER RESOURCES

1) Risk of pollution to River Zambezi during construction period

During the construction period there will be a risk of pollution to the River Zambezi, from blasting or earth moving activities causing increased sediment, and also from concrete spills, oil and diesel. It is essential that strict controls are placed on operations in the concrete batching plant, with regard to washing down, and that all potentially contaminating liquids such as oils, be stored in secure containers in a bunded area. Emergency procedures should be developed in the event of an accidental spillage.

Results of the water sampling carried out are provided in Appendix 4. The findings indicate that water quality is generally good, and therefore pollution incidents could have a significant impact on the river. In particular increases in turbidity, from discharge of sediment; or increases in pH from discharge of untreated water from the concrete batching plant could adversely affect processes at the water treatment plant. An increase in turbidity will reduce the effectiveness of disaffection process.

2) Demolition of water treatment plant

Option A will result in the demolition of the water treatment plant. However, according to the Chirundu Layout Plan a new water treatment plant is proposed some distance upstream from the existing bridge. It is essential that the new water treatment plant is fully operational before construction begins, to ensure that there is a sufficient supply of water for the township.

3) Pollution of water supplies for the hospital and users downstream

Any pollution of the river during construction will impact on users further downstream. In particular the hospital has its water intake located downstream from the existing bridge, and is already sensitive to increases in sediment loads and changes in water levels. Members of the community who collect their water directly from the river would also be adversely affected. Regular water sampling should be carried out during the construction period, and emergency procedures should be developed in the event of a pollution incident, including measures to inform the public of the dangers and to supply treated water.

4) Lack of water resources for construction workforce

The existing water supply in Chirundu is already inadequate, with the water treatment plant only serving a small proportion of the population, with reputedly poor quality water. The addition of 100 workers and their families will only increase the problems which already exist. It is therefore essential that the new water treatment plant, which is planned for the township, be in place, and operational in time for the commencement of works.

8.7.10. VISUAL ISSUES

1) Conflict with existing bridge in size and design

The preferred route option provides the most suitable location, since there is sufficient space between the bridges to allow each to have its own "space" and not detract from each other's setting. The relative levels of the bridge decks will be approximately the same (existing bridge deck 396-398m and proposed bridge deck 395-400m) so that the proposed bridge will not dwarf the existing bridge.

2) Cutting of river cliffs

There will be some minor cutting of the river cliffs on both sides of the river. However since there will be a 10 metre rise from the Zimbabwe to the Zambian side of the river, cutting of the higher river cliffs on the Zambian side will be kept to a minimum.

3) Loss of visual continuity of river's edge

The bridge abutments will be set back approximately 25 metres from the rivers edge and the bridge deck will be approximately 30 metres above mean water level on the Zambian side and 25 metres above the water level on the Zimbabwe side. This will allow visual continuity along the river's edge from river level, although there will be some loss of visual continuity when the river is viewed from the top of the river cliffs.

8.8. EVALUATION OF ENVIRONMENTAL IMPACTS – ZIMBABWE

8.8.1. SOILS

Owing to the nature of the soils, which consist of fine grained sand overlaying sodic horizons which are usually almost impervious, the soils are liable to sheet erosion during periods of high rainfall intensity. During the construction period areas of vegetation will be cleared for the construction of housing for the workforce, and for the working site. It is therefore inevitable that during the wet season there will be an increased risk from soil erosion, which could result in loss of topsoil and gullyng. Mitigation measures include the reduction of ground clearance wherever possible, and shallow grading of slopes to reduce sheet erosion. Slopes should be planted with good ground covering vegetation to reduce rainfall impact. Excavation and earthworks should be carried out during the dry season as far as possible.

8.8.2. VEGETATION, ECOLOGY AND WILDLIFE

The impacts of the preferred route option (alignment of approach road and border facilities) on vegetation, ecology and wildlife are summarised in Table 8.2.

Table 8.2 Impact of the Preferred Route on Ecology – Zimbabwe

Route Option	Alignment of Approach Road	Border Facilities
Option A	Avoids sensitive downstream areas where game come to drink. Intrusion into frequently used valley game access under existing bridge. Loss and severance of continuous mopane local game corridor. Some destruction of river edge cliff vegetation.	Terminal building can be sited close to existing bridge and customs building. The existing developed land can be utilised, including the VID site and old road cuttings. There would be a minimum amount of vegetation loss. There is the opportunity to enhance the area and remove the present unsightly developments.

(1) Vegetation

1) Loss of mature trees and bush vegetation

For preferred route option the alignment road will result in the loss of some mopane woodland, but an advantage is that the border facilities will be located close to the existing bridge and incorporate the existing customs buildings, thus reducing the overall amount of vegetation loss.

2) Loss of nationally rare species *Newtonia hildebrandtii*

The preferred route will not result in the loss of any *Newtonia hildebrandtii*.

3) Destruction of river edge cliff vegetation

The preferred route option will result in some loss of the river edge cliff vegetation.

4) Location of housing for workforce could encroach in to mopane scrub

At this stage in the assessment the location of the housing for the workforce is not known. This should be sensitively placed to avoid encroachment in to the mopane scrub.

(2) Animals

- 1) Intrusion into local game corridor caused by location of the border facilities and also siting of housing for workforce

The alignment of the approach roads and siting of the border facilities is critical to the conflict between humans and animals. At present the vehicle inspection depot (VID) is located across the game corridor, and as a result, elephants, in particular, have caused damage to fencing, and on occasion the death of truck drivers who have cornered the animals. The border facilities will be located as close to the existing bridge as possible, incorporating the existing facilities. Although this will encroach onto the local game corridor, the main game corridor will be unaffected. The main and local game corridors are illustrated in Figure 8.3.

- 2) Loss of waterside access for animals

The preferred route option will not encroach in to the mopane scrub area downstream from the existing bridge, which provides the main animal access to the waterside.

- 3) Loss of access under existing bridge

The narrow strip of land under the existing bridge provides access from the game corridors to the river's edge. The design of the new bridge will be important in allowing animals to pass. The bridge abutments will be set back approximately 25 metres from the river's edge, with overhead clearance of approximately 10 metres. Animal access will therefore still be possible.

(3) Birds

- 1) Disturbance to birds during construction

During construction, noise and dust will result from the movement of mechanical plant and any blasting or drilling activities. It is likely that any birds roosting or feeding in the area will move away to quieter areas. The return of birds will depend on the scale of the border facilities and increased noise from greater numbers of trucks, as well as the tolerance of the birds to repeated disturbance.

(4) Fisheries

- 1) Disturbance to fisheries during construction

During the construction period the disturbance caused by any piling, or activities which require mechanical plant to be in the water, will result in fish moving elsewhere in the river. This will only be significant to the game fishing operators or local people who will be required to fish further up- or downstream from the works.

- 2) Risk from pollution to aquatic fauna during construction period

More significant than the risk of disturbance to fish is the risk of pollution to aquatic species (from oils or diesel for example) during the construction period. This could have a more long-term impact on fish populations, in particular the tiger fish, which is an important game species. The findings indicate that water quality is generally good, and therefore pollution incidents could have a significant impact on aquatic fauna. In particular increases in turbidity, from discharges of sediment; or increases in pH from discharge of untreated water from the concrete batching plant could adversely affect flora and fauna.

(5) Game Corridor

- 1) Severance of game corridor

As discussed in Section (2) the siting of the border facilities is critical to the retention of the game corridors, and reducing potential conflict with human activities (Figure 8.3). The border facilities are being located as close to the river's edge as possible, to reduce the potential conflict.

(6) Poaching

1) Risk of increased poaching as a result of improved access

Poaching is already known to occur in the area, both from cross border activities and internal subsistence poaching. Since there has been a partial lifting of the ban in trading of ivory and other elephant products the demand for illegally poached ivory should be reduced. As there is easy access across the river by boat, it is considered that the new bridge facilities will have no effect on any illegal activities.

8.8.3. SOCIO-ECONOMIC PROFILE

1) Economic gains to businesses as trucks reach their destinations more quickly

At present truck drivers may be delayed at the border for between three and seven days waiting for customs clearance. This costs businesses valuable time and lost revenue. The improved border facilities, which should mean that 95% of vehicles clear customs within 15 minutes to 1 hour, will result in economic gains, since goods for export can reach their destination more quickly. For the remaining 5% of trucks which are required to undergo a full customs search it is estimated that the delay should be no more than five to eight hours.

2) Land take due to alignment roads and border facilities

The proposed alignment roads and border facilities, which are estimated to require approximately 5 ha of land, will result in land take. The preferred route will result in the demolition of 1 police house and the takeaway for the construction of the alignment roads, and the demolition of 4 commercial buildings (privately owned) and 4-6 houses for the police and other officials to construct the border facilities. Alternative housing must be provided prior to demolition, and compensation paid to private land/building owners.

3) Demolition of Police Housing

As noted above the alignment of the approach road will result in the demolition of one police house, and the border facilities will result in the demolition of 4-6 police houses (Figure 8.2). Although this is considered to be a popular option with the local staff, alternative housing will need to be constructed. It is estimated that the cost of demolishing one 50 m² two bedroomed house would be Z\$15 000, and the cost of reconstructing a similar house at a different location would be Z\$100 000.

8.8.4. HEALTH

1) Decreased spread of AIDS due to reduced waiting period for truck drivers

The current delay at the border facilities, while truck drivers wait to clear customs and immigration, is an important factor in the transmission of AIDS. At present drivers may have to wait up to one week before clearing customs. The improved border facilities should allow 95% of drivers to proceed within 15 minutes to 1 hour, with the remaining 5% being required to undertake a full customs search, taking on average five to eight hours. These improved

facilities should reduce the demand for prostitutes at the border post, which should in turn reduce the spread of AIDS amongst the population. However, although individual truck drivers will have reduced potential exposure periods, the predicted increase in traffic using the facilities will mean that increased number of drivers will be exposed to AIDS, for whatever period of time. Such effects are hard to quantify since at present no accurate statistics exist on the rate of infection in Chirundu. It should also be noted that improvements to the border facilities alone will not lead to a great decrease in the spread of AIDS, without a campaign of AIDS awareness and education leading to changes in lifestyle practices.

2) Risk of increased transmission of diseases particularly cholera due to increased numbers of people using the border post

Cholera is currently not a major health problem in Zimbabwe. However, discussions with the hospital in Chirundu, Zambia show that during the wet season there are outbreaks of the disease. There is therefore, a risk that with increased movement across the river cholera may spread to Zimbabwe. However, since standards of hygiene and refuse disposal are generally better in Zimbabwe, this is not considered to be significant.

3) Risk of malaria for the construction workforce, and resultant delays to construction

As already noted malaria is a significant problem during the wet season, with numerous pools of water providing ideal breeding habitats for mosquitoes. If the workforce is drawn from outside the low veld area, the medical clinic in Chirundu recommended that Malasone should be taken once a week, two weeks before moving to the area, during the stay and for four weeks after departing. However, they stated that local residents do not take anti-malarial drugs, since this would reduce the effects of treatment.

4) Increased pressure on medical clinic

Discussions with staff at the medical clinic show that there is an urgent need for increased resources at the clinic. These include the need for a doctor, an ambulance to transfer patients to hospital in Karoi, and even the most basic necessities such as blankets, sheets and stretchers. During the construction period there will be an estimated additional 700 people in the township, who will require medical facilities to be available, especially considering the increased risk of accidents on construction sites. It is therefore recommended that additional funds be made available to improve the services provided by the existing clinic, and also that the construction workforce should be given basic training in first aid and site safety before being allowed to start work on site.

(2) Education

At present there is no school in Chirundu, which means either that children are sent to boarding schools remote from their families, or that they never attend school at all. During the construction period there will be an estimated 100 additional workers and their families. There will, therefore, be an urgent need to provide a school in the area. Although a school is currently under construction it is not yet operational. It is therefore recommended that before construction begins consideration be given to establishing a school. In the long term this will be beneficial to the area, to increase literacy, and also to attract skilled workers who would otherwise be deterred from settling in Chirundu.

(3) Road Safety

A secondary impact from the improved border facilities will be the rise in road traffic, particularly trucks using the crossing. The steep road which descends the Zambezi escarpment is already prone to traffic accidents, with evidence of past crashes, such as at the Tsetse Control post, and several abandoned containers at the roadside. A rise in traffic will inevitably lead to increased accidents. The traffic volume for the year 2010 is predicted to rise to 500 vehicles per day, representing a ten fold increase in traffic levels.

(4) Crime

At present the main crimes recorded are theft and smuggling. Smuggling appears to be increasing, with trade in second hand clothing, tape cassettes and skin lightening cream. With an increase in population, thefts and petty crime are bound to increase.

(5) Other Services

It is envisaged that with the improvement of facilities at the border post new businesses will be attracted to the area, such as banks, new hotels, shops and other activities. This should provide an important base to the local economy, and also provide much needed employment. It is important that development of Chirundu is carried out as part of the Development Plan, in a structured way.

8.8.5. TOURISM

1) Potential loss of tourist revenue owing to severance of game corridors and access to river

At present there are several tourist operators based along the river's edge, who rely on the existence of game in the area to attract the tourists. In particular the chalets at Tiger Safaris are in an ideal location to watch animals coming down to the river's edge to drink. Option A which is located upstream from the existing bridge should not interfere with game access to the river. During the construction period, owing to additional noise and disturbance game may temporarily move away.

2) Potential loss of revenue to CAMPFIRE owing to severance of game corridors

CAMPFIRE currently operates in the neighbouring areas of Charara and Chewore/Mukwichi, with large revenues made every year from hunting and photographic safaris (Z\$ 1 244 700 in 1996). However, discussions with a safari operator suggest that the severance of the game corridors would not directly impact on safari activities, since hunting is carried out far enough away from Chirundu to ensure that animals can find alternative corridors in which to move. Although there is the possibility that animals may be driven up into the settled areas, thus posing a risk to crops, this is considered unlikely.

8.8.6. FISHERIES

1) Disruption to fishing during construction period

During the construction period works will be carried out in the river bed to construct the temporary access bridge and the two piers for the proposed bridge. This will result in disturbance in the flow of the river, and may also cause increased sediment loading and increased risk of pollution incidents. The access road required will be made from steel piles and decking, and should therefore cause minimal impact on river flows, although during installation disturbance will be caused.

Although fishing operators are based close to the existing bridge, the actual fishing activities take place elsewhere along this stretch of river. It is therefore considered unlikely that a significant impact will be caused, unless the jetty and landing facilities are affected. The preferred route should not cause disturbance to these activities.

2) Disruption of water level and water quality at the fish farm during construction

The fish farm, which employs 140 people is already sensitive to changes in water levels in the River Zambezi. During construction any alterations to the flow of the river, through the use of coffer dams etc may cause additional pressure on this important source of local employment. Any deterioration in water quality, such as increased sediment loads or pH may also adversely affect the fish stock.

8.8.7. HISTORIC/CULTURAL ARCHAEOLOGICAL

1) Conflict with the setting of the existing bridge

The existing bridge is an elegant riveted steel suspension bridge, and is an attractive sight in the early morning or late day sun. The simplicity of the design and flowing lines complement the river landscape. Option A is considered to be far enough away from the existing bridge not to detract from each other's setting. Although the chosen PC box girder bridge construction is not in itself very symbolic or attractive, this will mean that, when viewed from downstream, the setting of the existing bridge will be disturbed to the minimum extent.

2) Risk of damage to ancient sites or workings

Investigation of ancient sites or workings has been undertaken as a separate part of the EIA. It is an offence under Zimbabwean law to excavate or damage an ancient site without the permission of the Director of the National Museums and Monuments Board. However, the archaeological assessment did not identify any sites of significance along the route alignments. Several pottery scatters were seen in the study area, none of which was of sufficient significance to warrant further investigation.

8.8.8. MINERALS

1) Increase in traffic levels during construction for the importation of aggregates

There are no gravel pits close to Chirundu, which could provide an easy source of aggregates. Therefore, aggregates (15,000m³) will be brought from existing quarries, from already developed sites at Kafue of Zambia or vicinity of Harare. This will increase traffic levels along the entire stretch of road between Harare and Chirundu. However, since heavy vehicles already use this road, and the estimated number of vehicle movements is 1,500 spread out during the project, it is not considered a significant issue, although there will be a slight increased risk of accidents on the Zambezi escarpment.

2) Borrow pits potential source of disease vectors

If local sources of sand are used for construction the borrow pits could pond water and provide ideal habitats for disease vectors, in particular mosquitoes carrying malaria. However, malaria is already a significant problem during the wet season and was recorded as the most common disease for all age groups at the health clinic during 1996. It is not considered that the

increase in standing water will have a significant effect on the spread of the disease, although the creation of additional mosquito habitats is obviously not desirable.

8.8.9. FUEL/WOOD/ENERGY

Fuel wood is already in very short supply in the area, and since wood is not allowed to be collected from the area immediately surrounding Chirundu, local residents are forced to go further afield to supply their needs. During the three year construction period this situation will become critical as an additional 100 workers and their families will require facilities for cooking their food. Unless a reliable supply of electricity can be provided fuel wood will be the main source of energy for cooking. This will place a serious strain on existing resources and may lead to unnecessary depletion of forest resources.

8.8.10. NOISE AND AIR POLLUTION

1) Noise dust and vibration during construction

It is inevitable that noise and dust will be considerable during the construction period. Noise measurements show that ambient noise levels are generally low, except when trucks are passing. Since construction activities will result in almost continuous noise from mobile mechanical plant, blasting and piling activities, noise levels will be significantly increased during this period. It is therefore recommended that working hours be restricted to daylight hours, and that the World Bank Suggested Standards for Construction Sites be adhered to.

Dust is already a cause of air pollution in the area, in particular during the long dry season. It is recommended that blasting activities should be restricted as far as possible, and that stock piles of sand and soil etc are well screened from residential areas. It may be considered appropriate to use sprinklers at times when dust levels become unacceptable, using water pumped from the Zambezi. Multi directional fall out buckets should be used to monitor dust levels.

2) Increased air pollution as traffic levels increase

As traffic levels increase, air pollution particularly from diesel trucks will become more of a problem. The predicted traffic volume for 2010 is estimated at 500 vehicles per day, representing a ten fold increase in traffic volume, however, the air pollution effects from such traffic figures is still expected to be low.

8.8.11. WATER RESOURCES

1) Risk of pollution to River Zambezi during construction period

During the construction period there will be a risk of pollution to the River Zambezi, from blasting or earth moving activities causing increased sediment, and also from concrete spills, oil and diesel. It is essential that strict controls are placed on operations in the concrete batching plant, with regard to washing down, and that all potentially contaminating liquids, such as oils, be stored in secure containers in a bunded area. Emergency procedures should be developed in the event of an accidental spillage.

The results of the water sampling indicate that water quality is generally good, and therefore pollution incidents could have a significant impact on the river. In particular increases in turbidity, from discharges of sediment; or increases in pH from discharge of untreated water

from the concrete batching plant could adversely affect processes at the water treatment plant. An increase in turbidity will reduce the effectiveness of disinfection processes.

2) Demolition of water treatment plant

The existing water treatment plant located adjacent to the Otto Beit Bridge supplies water to the police and customs housing, the medical clinic, hotel and other residential houses located on the hill and in Baghdad. The re-routed alignments would not result in the demolition of the water treatment plant.

3) Pollution of existing water supplies

The intake for the existing water treatment plant is located directly underneath the existing bridge. Any work undertaken in the river will have an impact on water quality. Regular monitoring should be made of the water quality during construction and, if necessary, a temporary intake established some distance upstream of the works.

4) Lack of water resources for construction workforce

It is essential that adequate water supplies are provided for the workforce. Additional water resources should also be provided for the workforce during construction, either from the existing water treatment plant, or from an additional treated supply pumped from the Zambezi.

8.8.12. VISUAL ISSUES

1) Visual conflict with existing bridge in size and design

Table 8.3 summarises the impact of the route option on the existing bridge and Table 8.4 summarises the impact of the bridge design and size on the existing bridge and its setting.

2) Cutting of river cliffs

There will be minor cutting of the river cliffs on both sides of the river, with more significant cuttings to make space for the alignment roads.

3) Loss of visual continuity of river's edge

The bridge abutments will be set back approximately 25 metres from the rivers edge and the bridge deck will be approximately 30 metres above mean water level on the Zambian side and 25 metres above the water level on the Zimbabwe side. This will allow visual continuity along the river's edge from river level, although there will be some loss of visual continuity when the river is viewed from the top of the river cliffs.

Table 8.3 Impact of Route Option on Landscape

Route Option	Impact on Landscape
Alt. A	The bridge would be located on river cliffs and would therefore not conflict with the river landscape or existing bridge. There is sufficient space between the bridges to allow both to have their own 'space' and not detract from each other's setting. Bridge decks at approximately the same level (396-398m for the existing bridge and 395-400m for the new bridge) to avoid dwarfing.

Table 8.4 Impact of Bridge Design on Ecology and Landscape

Bridge Design Option	Impact on Ecology	Impact on Landscape
3 span continuous PC girder bridge	Increased disturbance to river bed ecology and water quality during construction.	In-water structure detracts from the river landscape Overly simple design does not relate to the setting of the existing bridge Does not form any kind of gateway monument feature

8.9. MITIGATION PLAN

8.9.1. INTRODUCTION

The Mitigation Plan for the pre-construction and construction phases of the project is presented in this chapter.

The objectives of the mitigation plan are to review the impacts identified during the environmental impact assessment (EIA), and incorporate probable working practices into the mitigation plan at the pre-construction and construction phases of the project, in order to anticipate those issues which are likely to require close environmental management.

The Mitigation Plan addresses the negative impacts generated by the construction works. The impacts are mostly of a temporary nature lasting only for the duration of the construction period, about 3 years. They are outlined in detail in Table 8.5 and cost effective mitigation measures have been recommended. The principal mitigatory measures are:

- maintenance of clean and safe water supplies throughout the project;
- provision of a reliable source of energy (ie electricity) for construction workers to alleviate pressure on collection of fire wood;
- provision of appropriate training and equipment for the work force especially when undertaking potentially hazardous activities such as blasting;
- locating of contractors' compounds and the routing of access traffic as far as possible away from sensitive downstream areas;
- provision of adequate medical facilities.

Mitigation measures should be incorporated in to the tender documents prepared under the engineering component of this project to ensure that the contractor is obliged to comply with the measures proposed in the EMP.

8.9.2. IMPLEMENTATION

The requirements of the Mitigation Plan should be incorporated in the following :

- project design; the invitation to tender to contractors; conditions of contract; and
- terms of reference for consultants.

The following tables provide a summary of the measures necessary to mitigate the negative environmental and social impacts identified. The organisations responsible for implementing and monitoring are identified, plus the implementation schedule which indicates when during the project the mitigation measure should be set in place.

Table 8.5 Mitigation Summary Tables. (Bold – denotes most important impacts)

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Soils	NATURAL ENVIRONMENT Potential for soil erosion during the construction period	All earth works should be undertaken as far as possible prior to the start of the wet season, and bare slopes should be re-vegetated with fast growing, good ground covering plants, which are also resistant to drought conditions. Earthwork slopes must be suitably graded, to ensure that runoff speeds cannot cause erosion.	Soil erosion minimised, but not eradicated	Contractor	Engineer to monitor grading of slopes and re-vegetation.	On-going during construction.
Vegetation	Loss of mature trees and bush vegetation	The Contractor must identify individual mature trees to be felled with the agreement of the Engineer, to ensure that unnecessary felling of trees is avoided. Areas of bush scrub to be cleared must also be agreed in advance. As with the loss of mature trees and bush vegetation, all cliff vegetation to be cleared must be agreed with the Engineer prior to felling. The area to be cleared should be well marked to ensure that the area cleared is kept to the minimum possible.	Reduction in the number of trees to be felled.	Contractor	Engineer	Site preparation stage.
	Destruction of river edge cliff vegetation		Destruction of river edge cliff vegetation reduced to minimum	Contractor	Engineer	Site preparation stage

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/Institutional Arrangements	Monitoring Requirements	Implementation Schedule
	Location of housing for workforce could encroach onto mopane scrub	The location of housing compounds is not known at this stage in the project. However, before the housing is constructed the Town Council in Zambia and the Town Board in Zimbabwe must agree the locations for the respective compounds. The most sensitive area is the land immediately downstream from the existing bridge on the Zimbabwe side, which should not be used as a location for the housing.	Mopane scrub undisturbed	Contractor to liaise with relevant government bodies.	Engineer	Site preparation stage
Animals	Intrusion into local game corridor caused by location of the border facilities and also siting of housing for workforce	On the Zambian side the border facilities will not intrude into a game corridor. On the Zimbabwe side the border facilities will sever a local game corridor. A palisade type fencing will be used around the site, which will be fitted with low voltage electrical wiring at various heights. This type of electrical fencing is commonly used at game reserves in Southern Africa and has proven to be quite effective in controlling the movement of elephants. The location of housing compounds is not known at this stage in the project. However, before the housing is constructed the Town Council in Zambia and the Town Board in Zimbabwe must agree the locations for the respective compounds.	Animals diverted around site as much as possible.	Contractor	Engineer	On-going during construction and operation

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
	Loss of waterside access for animals	Not applicable to Zambia On the Zimbabwe side the minor game corridor along the top of the river cliffs will be affected during construction which will in turn impact on animals using this route for access to the waterside. However, providing access is maintained downstream from the existing bridge animals will be able to use an alternative route. The bridge abutments will be set back 25 metres from the river's edge so that animals can continue to pass along the river bank.	Animals to use alternative route to water side.	Contractor	Engineer	On-going during construction.
	Loss of access under existing bridge	Not applicable to Zambia The abutments for the new bridge will be set back approximately 25 metres from the river's edge, allowing animal access to be maintained. An unfenced route should be left open along the edge of the river bank to allow passage under both bridges.	Access maintained	Contractor	Engineer	Implementation through design of bridge and at end of project.
Birds	Disturbance to birds during construction	Although birds may be disturbed by the construction activities, the effect is likely to be very minor and birds will relocate to areas further away from the construction site. After construction birds will return, depending on the scale of activities at the border post.	Birds will move away	N/A	N/A	N/A

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Fish	Disturbance to fisheries during construction	As with birds, fish disturbed during construction are likely to move to quieter reaches of the river, although any local fish spawning grounds may be affected (no information is available).	Fish will move away	N/A	N/A	N/A
	Risk from pollution to aquatic fauna during construction period	Great care must be taken to ensure that potential contaminants do not enter the River Zambezi or any other water courses. All chemicals (oil, petrol etc) must be kept in secure banded areas with a capacity greater than the volume of chemicals stored. The concrete batching plant must be located away from the river bank, and effluent neutralised prior to disposal. Oil interceptors should be used, and oily wastes must be tankered to suitable disposal sites. The Contractor must submit written emergency procedures to be followed in the event of an accidental spillage.	Risk from pollution reduced but not eliminated.	Contractor	Engineer	On-going during construction

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Game Corridors	Severance of game corridor	Not applicable to Zambia. The border post facilities have been located as close to the river's edge, as possible, and incorporate the existing facilities. The main game corridor in the area will therefore not be affected, although a local route will be severed. The border post facilities should be fenced with high security fencing, which will encourage animals to use alternative routes across the main road.	Animals to use alternative route	Contractor	Engineer	On-going during construction and operation
Poaching	Risk of increased poaching due to improved access	The impact of the new bridge on poaching is unknown, and extremely hard to predict. Improved police facilities on both sides of the border may result in better policing of the river.	Unknown	N/A	N/A	N/A
Land Take	SOCIO-ECONOMIC Land take due to alignment roads and border facilities	Approximately 5 hectares of land take on either side of the river. Alternative houses, and most importantly water treatment works in Zambia, must be provided prior to land take. Compensation must be paid to private land/building owners. Alternative housing must be built in Zambia and Zimbabwe prior to demolition taking place.	Housing rebuilt in alternative location	Government of Zambia and Government of Zimbabwe	JICA	Before demolition begins
	Demolition of Police Housing		As above	As above	As above	As above

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Health	spread of AIDS	<p>The Contractor must liaise with the relevant government bodies with regard to an AIDS package, such as the National AIDS/STD/TB/Leprosy Programme and Family Life Movement in Zambia and the National AIDS Co-ordination Programme (NACP) in Zimbabwe. Prevention of AIDS is only achieved through raising awareness.</p> <p>Suggestions include training workers through peer educators. Peer lorry drivers, prostitutes and construction workers should be selected and trained by the NACP (Mr Genesis Chizodza based in Chinhoyi). Key managers should be trained since they will have the respect of their workers.</p> <p>The National Employers Council for Transport Operatives and Industry (NECTOI) issue condoms.</p> <p>Employment conditions should provide for the movement of whole families rather than individual construction workers.</p> <p>See also Section 11.6.4</p>	AIDS infection rate reduced	Contractor and government bodies.	Engineer	On-going during construction period and in the long term.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
	Risk of increased transmission of diseases particularly cholera due to increased numbers of people using the border post	All construction workers must be given basic health and safety education prior to starting work on the site, and adequate medical facilities should be provided, to help reduce the risk of spreading infectious diseases. In the long term health education should be implemented by the relevant government bodies.	Risk of transmission reduced.	Contractor to educate workers prior to construction. Government to implement health programme.	Engineer NGOs	On-going during construction.
	Risk of Malaria for the construction workforce and resultant delays to construction	As above. The medical clinic in Chirundu Zambia recommended that Malasone should be taken once a week, two weeks before moving to the areas, during the stay and for four weeks after departing. Spraying of workers huts should also take place during the wet season.	Risk of malaria reduced.	Contractor	Engineer	On-going during construction.
	Increased pressure on hospital/medical clinic	Assistance must be given to the hospital in Zambia and the medical clinic in Zimbabwe, either in the form of direct financial support, or through the provision of additional drugs/medication suitable for medical conditions typically associated with construction sites and also the local conditions (ie malaria and cholera), in order to make provision for the additional workforce and their families.	Pressure on medical facilities reduced.	Government of Zambia and Government of Zimbabwe	JICA	On-going during construction.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Education	Increased pressure on/requirement for school due to population growth, especially during construction period	The governments in both Zambia and Zimbabwe must make provision for educating the children of construction workers. In Zambia the existing school is already over subscribed, provision must be made for additional teachers and classrooms. In Zimbabwe a school building has been built, but as yet there are no teachers. The school should be up and running before the project begins.	Pressure on schools reduced, and children educated.	Government of Zambia and Government of Zimbabwe	JICA	Prior to construction
Road Safety	Increased risk of accidents due to increased road traffic	During the construction period trucks delivering materials to site should be thoroughly checked to ensure that they are road worthy and that the brakes are in full working order. Where feasible the trucks should avoid driving through, and especially night driving, in residential areas.	Risk of accidents reduced but not eliminated.	Contractor	Engineer	On-going during construction
Crime	Increased risk of crime due to increase in population	Simple measures such as the provision of street lighting around workers compounds, and security fencing around sites should ensure that crime does not escalate.	Opportunities for crime reduced.	Contractor	Engineer	On-going during construction.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Tourism	Potential loss of tourist revenue due to severance of local game corridors and access to river	Not applicable to Zambia In Zimbabwe the proposed bridge will be located upstream from the main tourist activities in the area. During construction there may be visual and noise impacts, although this will not cause a significant effect, since although tourists use the pier on the river bank the main fishing and canoeing activities take place much further downstream.	No loss of revenue anticipated	N/A	N/A	N/A
Fisheries	Disruption to fishing during construction period	As noted under tourism fishing activities take place remote from the construction site, and construction activities will therefore not have a major impact.	No/limited disruption.	N/A	N/A	N/A
	Disruption of water level and water quality at the fish farm	The Contractor will ensure that all measures are taken to prevent polluted materials from entering the Zambezi River. Water levels in the river are controlled more by the Zambezi River Authority who operate the hydro-electric dam at Kariba.	Reduced risk of effect on fish farm.	Contractor	Engineer	On-going during construction period.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Archaeology	Conflict with the setting of the existing bridge	The most upstream route option for the bridge has been chosen to ensure that the impact on the setting of the existing bridge, which is viewed mainly from the downstream side, is minimised as much as possible. In addition, although the box-girder concrete bridge design which has been selected is not in itself visually interesting, it will not conflict with the style/flowing lines of the existing bridge.	Limited conflict with setting of existing bridge.	Design Engineer	N/A	N/A
	Risk of damage to ancient sites or workings	Archaeological studies carried out for the Zambian and Zimbabwe sides of the river indicated that there are no known sites of archaeological importance on either side. Potsherds and other items of little significance were found on both sides of the river. If significant archaeological remains are encountered during excavations work should stop until the Engineer has given the all clear to continue.	Risk of damaging archaeological remains is minimal.	Contractor	Engineer	On-going during construction
Minerals	Increase in traffic levels during construction for the importation of aggregates	As noted above trucks used for transportation of material should be routed, where feasible, to avoid residential areas, and driving at night through residential areas should be limited.	Increased traffic, but limited night driving	Contractor	Engineer	On-going during construction.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
	Borrow pits potential source of disease vectors	Borrow pits should be filled or graded so that water cannot accumulate and be a potential source of disease vectors.	Risk of disease vectors controlled	Contractor	Engineer	On-going during construction and site restoration.
Energy	Increased demand for fuel wood during construction period	The Contractor must supply the construction workforce with an alternative source of energy during construction – such as the provision of electricity and simple electric stoves.	Demand on fuel wood controlled/reduced	Contractor	Engineer	On-going during construction period.
Noise	Noise and vibration during construction	The Contractor must limit the working hours to daylight hours and it is recommended that World Bank Standards for Construction Sites be adhered to.	Noise nuisance reduced and controlled	Contractor	Engineer	On-going during construction period.
Air Pollution	Dust during construction	Dust should be controlled with the use of water sprays where levels become unacceptable. Advanced warning must be given for any blasting activities.	Dust levels controlled	Contractor	Engineer	On-going during construction period
	Increased air pollution as traffic levels increase	In overall terms the air pollution effects from increased traffic levels are likely to be negligible. However the improved facilities at the border post should mean that trucks spend as short a time as possible with their engines running while waiting to clear customs and immigration.	Gradual increase in air pollution	N/A	N/A	N/A

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Water resources	Risk of pollution to River Zambezi during construction period	As noted under "Natural Environment" the Contractor must take adequate steps to prevent pollution, including the use of interceptors; bunding around areas where hazardous liquids (such as oil or petrol) are stored, (with a capacity greater than the volume of the liquid stored); neutralisation of water from the concrete batching plant; and careful disposal of waste water used to wash down sites. The Contractor must submit written details of the procedures he would propose to use in the event of a pollution incident.	Risk of pollution minimised but not eliminated.	Contractor	Engineer	On-going during construction period.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
	Demolition of water treatment plant	<p>On the Zambian side the Contractor must ensure that the proposed new water treatment plant is fully operational before construction of the bridge begins. This is essential to ensure that users downstream from the works are provided with a safe and clean supply of water.</p> <p>On the Zimbabwe side although the water treatment works will not be demolished as a result of the works the water intake is directly underneath the existing bridge, (ie downstream from the works). Therefore the contractor must ensure that suitable provisions are made to extract water from further upstream during the construction period, and that downstream users who extract water directly from the river have an alternative clean source.</p>	Clean water supplies maintained	Contractor	Engineer	On-going during construction period.
	Pollution of existing water supplies	As above	As above	As above	As above	As above
	Lack of water resources for construction workforce	As above	As above	As above	As above	As above
Other	Materials used for construction of workers housing	The Contractor will be responsible for the construction of houses for the construction workforce. If possible these should be constructed from clay and straw which is much cooler than tin houses.	Houses acceptable	Contractor	Engineer	Pre-construction phase.

Element	Negative Impact	Mitigatory Measure	Residual Impact	Responsibility/ Institutional Arrangements	Monitoring Requirements	Implementation Schedule
Landscape	Visual conflict with existing bridge in size and design	The route option chosen for the proposed bridge will ensure that the views of the existing bridge, which are mainly from downstream, will be largely undisturbed, with the exception of the bridge piers visible in the water. In Addition to this the simple form of the proposed box-girder concrete bridge, will not conflict with the flowing lines of the existing bridge	Visual conflict reduced to a minimum.	Design Engineer	N/A	N/A
	Cutting of river cliffs /use of embankments	Several minor cuttings will be made for the bridge abutments on both sides of the river, with more significant cutting on the Zimbabwe side for the access road construction. The Contractor must agree the earthworkings with the Engineer before commencing work.	Cutting of cliffs reduced to minimum necessary.	Contractor	Engineer	On-going during construction period.
	Loss of visual continuity of rivers edge	The bridge abutments will be set back approximately 25 metres from the rivers edge and the bridge deck will be approximately 20 metres above mean water level on the Zambian side and 10 metres above the water level on the Zimbabwe side. This will allow some visual continuity along the river's edge from river level, although the relatively low level of the bridge deck will result in some loss of visual continuity when the river is viewed from the top of the river cliffs.	Some loss of visual continuity.	Design Engineer	N/A	N/A