2.2.2 Geological Description

In this Chapter, general features of each geological unit are presented (for more detailed description, see Chapter 4 of the Supporting Report).

1) Pre-Karoo Basement

Red sandstones and shales of the Fish River Subgroup of the upper Nama Group underlie the Karoo succession throughout most of the basin. They outcrop to the west and south. They have been intersected below the Karoo in boreholes in the study area such as the deep Vreda core borehole (Wilson, 1965) and JICA test borehole No. J-9A: Klein Swartmodder (in detail, see Chapter 3 of this report and Chapter 6 of the Supporting Report). Very few of the water boreholes have been drilled through the Karoo into this in the northern basement area.

2) Karoo Sequence

The Karoo Sequence in the Stampriet Artesian Basin, in terms of the SACS (1980) nomenclature, consists of a basal Dwyka Group, overlain successively by the Prince Albert Formation, the Rietmond Member and the Whitehill Member. The Rietmond Member is included as a formation at the top of the Prince Albert Formation. The Whitehill Member remains a formation on its own at the top of the succession in accordance with the 1:1 million geological map of Namibia since it overlies the Rietmond Member conformably (Heath, 1972).

(1) Dwyka Group

The Dwyka Group is uppermost Carboniferous to earliest Permian in age. The Dwyka Group thickens significantly to the south, being 100 m thick in the Mariental area and 210 m thick in the Asab area.

Although most of the shale units above the basal tillite are greenish to yellowish in outcrop, drilling has shown all to be dark grey to black in depth. However, the dark Dwyka shales can be distinguished from similar looking Mukorob shales by the presence in places in the former of paper-thin pyrite lamellae on bedding-plane. Dropstones are also a distinguishing feature of the Dwyka shales.

(2) Nossob Member

The base of the Nossob sandstone marks a regional unconformity and the lowest stratigraphic unit of the Prince Albert Formation (see table 2.2-1).

The change from Dwyka to Nossob depositional conditions was abrupt and the base of the Nossob Member is marked in places by a distinct scour surface on which a thin, pebbly sandstone up to 54cm thick with pebbles derived from the underlying Dwyka sediments was deposited in places.

The Nossob Member consists of two coasing shale-siltstone units. Locally, a third, thin unit occurs either at top or at the base.

In the Weissrand Escarpment several natural springs seep out in the escarpment face at the base of the Nossob Member or a few metres down in the shales below the sandstone.

(3) Mukorob Member

For the purposes of this study, the Mukorob Member is taken as the shale-siltstone-sandstone succession between the top sandstone of the Nossob Member and the scoured base of the medium- to coarse-grained Auob Member.

The base of the Mukorob Member is marked in several places by a gradual transition over about 20 m through an interbedded siltstone and shale succession above the Nossob sandstone from dark grey to black, plane bedded shales. An important marker at or near the top of the shale-dominated lower part of the Mukorob Member is a very thin but widespread, grey limestone or calcareous siltstone or shale layer between 2 and 36 cm thick.

The upper part of the Mukorob Member is marked by a gradual progradation and coarsening upward over as much as 40 m of section through thin, highly micaceous fining-upward siltstone-shale cycles into fine-grained sandstone-siltstone cycles with or without shaley tops.

For the purposes of this study, the medium- to coarse-grained upper part of the Mukorob Member is considered to be part of the Auob aquifer and possibly even the underlying fine-grained sandstones where they are essentially shale free and porous.

(4) Auob Member

The Auob Member is divided into five units as shown in Table 2.2-2, a lower sandstone (A1), a lower bituminous shale and coal (A2), a middle sandstone (A3), an upper bituminous shale and coal (A4), and an upper sandstone (A5). Neither the shale nor the coal horizons crop out and it is therefore uncertain which of the sandstone horizons the outcropping sandstone represents. Evaluation of the shale horizons is considered important as they may form significant barriers to flow between the three sandstone horizons.

Table 2.2-2 Description of Subdivided Auob Member

Formation			Lithology
Auob Member	Upper Sandstone	(A5)	White, massive sandstone weathering light yellow. Coarse-grained to locally gritty; high porosity and permeability; accessory biotite; cross beds and clay pellets up to 13 mm. . Common brownish black, calcareous concretions up to 3.6 m. , in places coalescing to form a continuous layer;
	Upper Auob Bituminous Shale and Coal	(A4)	
	Middle Sandstone	(A3)	Light grey to light brown, well bedded, fine to medium-grained sandstone; sand grains well rounded and well sorted; accessory biotite; isolated clay pellets. Petrified wood, often inside elongate, calcareous concretions in a layer of red, Fe-rich or yellowish white clayey sandstone; logs up to 50 cm. , 23 m long. Wood – *Dadoxylon porosum* and *Phyllocladopitys capensis* mainly, also *Abietopitys perforata*, Dadoxylon *rangei*, *Medullopitys sclerotica*; leaf impressions – *Glossopteris, Cordaites hislopi.*
	Lower Bituminous Shale and Coal	(A2)	
	Lower Sandstone	(A1)	Medium-to coarse-grained, white to cream-coloured, thick bedded, faintly cross bedded channel sandstones. Mainly multistory channel sands up to 30 m thick. Thickness 5 to 30 m.

(i) Lower Sandstone (A1)

The Lower sandstone rests on the Mukorob Member with a scoured contact. The change from the medium- to fine-grained, light brown, thinly cross bedded deltaic sands of the upper Mukorob Member to the medium- to coarse-grained, immature, feldspathic, more massive to thickly cross bedded, cream-coloured channel sands of the lower Auob sandstone is marked. The unit is largely built up of multistory channel sands up to 30 m thick. Thickness of the unit varies from 5 to 30 m but there are places where the unit appears to be missing having pinched out or been removed by pre-Kalahari erosion.

(ii) Lower Bituminous Shale and Coal (A2)

Swamp and marsh deposits of bituminous shale and coaly material are interbedded in places with thin, distal crevasse splay deposits consisting of thin fining-upward cycles of fine-grained sandstone, siltstones and dark, often carbonaceous shales.

(iii) Middle Sandstone (A3)

This Sandstone gradually coarsens upwards. Carbonaceous shales and silts at the base gradually pass upwards into increasingly coarser and thicker upward-fining cycles of intertidal deposits and crevasse splays with wavy and ripple lamination of micaceous sandstone, siltstone and shale. Beach sands are common in places and channel sands are scattered through the sequence but become more abundant towards the top. Widespread bioturbation is indicative of shallow water conditions. Numerous thin coaly and micaceous laminae occur in these sediments indicating the proximity of swampy conditions.

Facies changes over relatively short distances appear to be a characteristic of this Middle Sandstone. Distal crevasse splays passed laterally in to swampy depressions in which coal and carbonaceous shale deposits accumulated. These are commonly overlain by both distal and proximal crevasse splays. Channel switching and erosion of lower lying units appears to have been common as many of the sandstones contain shale and coal fragments.

(iv) Upper Bituminous Shale and Coal (A4)

This marks a second event of widespread swamp, marsh and possibly lagoon deposition with associated coals. Thin, bioturbated, fine-grained, coarsening-upward crevasse splay sandstones and possible beach sandstones are interbedded with the black, bituminous swamp shales and coals. Wavy and ripple laminated sandstone-shale tidal deposits may also be present. The coal in this unit is approximately 50 m above the lower coals. As with the lower shale and coal unit, thickness varies significantly from just a metre or two to 36 m. The unit is not as laterally continuous as the lower shale and coal unit and correlation from well to well is not always straightforward. In places, scour and erosion by the overlying channel sandstones has removed the upper shale and coal unit completely and the Middle and Upper Sandstone merge into one thick unit.

(v) Upper Sandstone (A5)

This horizon consists of stacked, coarse-grained channels sandstones, often with lag deposits, and associated proximal splay deposits of fining-upward cycles of medium- and fine-grained sandstone. A thin black, bituminous shale layer up to 4 m thick occurs in this unit. Preserved thickness has been severely affected by thick Karoo dolerite sills that intrude the Upper Sandstone and by pre-Kalahari erosion which cuts deep into this and lower units in places.

Preserved thickness varies from 0 to 61 m.

(5) Rietmond Member

The Rietmond Member consists of two units, a Lower Rietmond Member consisting of shale and an Upper Rietmond Member consisting mainly of sandstone with some shale layers. The Upper Rietmond rests unconformably on the Lower Rietmond.

(i) Lower Rietmond Member

The Lower Rietmond Member shale appears to rest conformably on the Auob Member sandstones. It crops out east of Mariental on the farm Rietmond 118 and east of Asab on the farms Goamus 70 and Salami 239. It weathers to light and dark grey tones but below the Kalahari unconformity it has weathered to a yellow colour. In borehole cuttings where it is fresh, the colour varies from grey to blue grey, dark grey and almost black. In borehole logs it has often been described as "blue shale". In several places below the Upper Rietmond unconformity, the Lower Rietmond shale is deeply weathered to a yellow colour. However, the erosion that preceded deposition of the Upper Rietmond Member also removed this yellow weathered capping in places so that one also finds the Upper Rietmond sandstones resting directly on grey Lower Rietmond shales.

The Lower Rietmond shale was deposited over the whole basin but was partly or completely removed in many areas by two periods of erosion, one preceding deposition of the Upper Rietmond Member and the other preceding deposition of the Kalahari succession. Where best developed, it is over 100 m thick but because of the above erosion, thickness varies erratically in the areas where it is present.

The Lower Rietmond Member is the impervious cap and the main aquitard to the Auob artesian sandstone. However, it can happen, although very rarely, that a borehole drilled to near the base of the Lower Rietmond shale, but not right through it, becomes artesian due to fractures in the basal part if the shale providing connectivity to the underlying sandstone (e.g. borehole WW 39874).

(ii) Post-Lower Rietmond – Pre-Upper Rietmond Erosion

Prior to deposition of the Upper Rietmond Member, the Lower Rietmond sediments were uplifted, exposed and eroded. In the northern and southwestern parts of the basin, this erosion removed very little of the Lower Rietmond shales and thicknesses are generally in excess of 50 m (Fig. 3.6-3). In places in these areas, this period of weathering and erosion caused strong alteration of the top part of the shale to a yellow colour. Elsewhere in the basin, erosion removed most or all of the shale. This erosion left a highly dissected landscape so that the remaining Lower Rietmond shale, where present, is highly variable in thickness, even between closely spaced boreholes. Where the erosion removed the Lower Rietmond shale completely, the Upper Rietmond sandstones rest directly on the Auob Member sandstones.

(iii) Upper Rietmond Member

This rests unconformably on the underlying rocks. It crops out on the farms Neu Lore 97, Helpmekaar 588 and Doornboompan 542 west of Leonardville, in the Nossob River valley at Leonardville and north and south of the town and in road cuttings at Stampriet. It is not know to crop out anywhere else. Although reaching 180 m in thickness, the thickness of the Upper Rietmond Member is highly variable due to pre-Kalahari erosion which cut deeply into the Karoo succession, and at its deepest, cut right through both Rietmond and Auob Members into the underlying Mukorob shales.

The Upper Reitmond Member is highly variable in character. Athough consisting mainly of sandstones, it contains layers of interbedded shale in places which vary in number from one to six (e.g. six in WW 10869, Elbow 392, 2318CB). It is rare for shale to exceed sandstone in amount but in a few places shale makes up 70% of the Upper Rietmond succession (e.g. WW 820, Schurfpenz 120, 2418 AB; WW 696, Helgoland 117, 2418 CB).

Characteristically, the Upper Rietmond sandstones have a reddish brown colour which is relatively light at higher stratigraphic levels but usually deepens in intensity with increasing depth. However, white, brown, orange, purple, red, pink, green, grey and yellow sandstone layers are also commonly recorded in the borehole logs. Where exposed, bedding tends to be thin to very thin. Grain size varies continuously, often on a small scale, and coarse- to medium-grained sandstones often have a thin cover of very fine-grained, highly micaceous sandstone or siltstone. Many of the sandstone layers are highly micaceous whereas others are less micaceous. Porosity of the sandstones is highly variable and often porous layers are bounded by highly micaceous layers with low porosity.

The interbedded shales are also highly variable in colour and although often grey when fresh, red, brown, reddish brown, purple, pink, yellow, white and black coloured shales have been recorded in borehole logs. Locally thin coal lenses are interbedded with the dark grey to black shale layers.

Rather than consisting of continuous layers, the succession appears to consist of stacked lenses of shale and sandstone of differing grain size and mica content.

In the absence of the Lower Rietmond Member shale, it can be difficult distinguishing the sandstones and grey shales of the Upper Rietmond Member from the grey shales and sandstones of the Auob Member. However, characteristic for the Upper Rietmond sandstones are their reddish brown colour and the high mica content of many of the layers.

The water table in borholes drilled only into the Upper Rietmond Member is highly variable and deeper than the Auob water table in nearby boreholes that go all the way down into the Auob Member.

There appears to be minimal lateral and vertical permeability within the Upper Rietmond Member due to the lithological variability, the lensoid nature of individual layers, the high mica content and the highly variable water table levels. The Upper Rietmond Member, therefore, despite it consisting mainly of sandstone, appears to be an effective aquitard where it lies directly on the Auob sandstones. Any large-scale connectivity between the Rietmond and Auob sandstones would be reflected in the Rietmond and Auob having the same water table elevation over large areas and this is not the case. In a few boreholes that were drilled to near the base of the Upper Rietmond Member where it rests directly on the Auob Member, the Rietmond water table is the same as that in nearby boreholes than went into the Auob Member. This indicates a fracture connectivity between the basal Rietmond sandstones and Auob Member in a few isolated cases.

(6) Whitehill Member

The White Hill Member is know to occur with certainty in only one place in the area of investigation on the farms Dorndaberas 16 and Gross Daberas 17 east of Asab. The 1:1 million scale Geological Map of Namibia shows the White Hill Member here to occur in a succession of shale overlying the Auob sandstones. Part of the Lower Rietmond Member must therefore be the lateral equivalent of the White Hill Member but nothing in the rock chips or the geophysical logs of the JICA boreholes indicates exactly which part of the Lower Rietmond Member would be equivalent to the White Hill Member.

(7) Kalkrand Basalt

The distribution of the Kalkrand Basalt is shown in Fig. 2.2-1. Dated at 180 million years, the basalts are Triassic in age. There is thus a large time gap between the Rietmond Member and Kalkrand Basalts. The basalts rest unconformably on the

Rietmond Member on the farm Rietmond 116 east of Mariental and then transgress westwards across each of the underlying formations

The Kalkrand succession consists of stacked basalt flows with or without fragmented bases and tops. Scattered over much of the exposed part of the basalt succession are several thin interbeds of limited lateral extent of well bedded pan deposits consisting of basalt-derived sandstones and gritstones and white fresh-water limestones. The sandstones also contain well rounded quartz grains of aeolian origin. Casts of gypsum roseates are common.

The basalt succession is up to 370 m thick. Since many of the water boreholes struck water within the basalt succession, some of them were clearly in the interbedded pan deposits based on the descriptions of the cuttings and very few were drilled through to the underlying rocks.

(8) Karoo Dolerite Sills

Karoo Dolerite Sills intrude the top of the Karoo Sequence and in places cut out the whole of the Rietmond Member and most of the Auob Member. The dolerite may consist of more than one intrusion since Karoo sediments are often interbedded with dolerite. South of 26° S, many of the faults in the Karoo Sequence have been intruded by dolerite dykes. Many of these dykes must be feeders to the dolerite sills. Faults and feeder dykes must be expected below the Kalahari cover in the main Stampriet Basin. Only the aero magnetic data is likely to show the location of such faults and dykes.

(9) Kalahari Beds

The Kalahari Beds form a continental deposit made up of unsorted fluviatile deposits, aeolian sands and local pan accumulations all variously cemented by calcrete and minor silcrete. The base of the Kalahari Beds is made up of poorly sorted, small-pebble, partly imbricated conglomeratic fan-deposits thoroughly cemented by calcrete. Where the top of these calcretes is exposed over considerable areas (e.g. on top of the Weissrand escarpment south of Mariental), a karst topography has developed. The age of this karsting is uncertain but since water strikes are often made in the calcretes at the base of the Kalahari it is likely that this karsting is extensive underneath the younger Kalahari sediments. The overlying Kalahari deposits are largely poorly sorted sands of fluvial origin and better sorted aeolian sands. Gritty zones can be either aeolian lag deposits or fluvial in origin. Calcrete cement varies in abundance in these sands. Silcretes are reported from some of the water boreholes but tend to be relatively rare in the southern Kalahari.

2.2.3 Geological Structure

Geological structures (faults) are shown in the Geological Map (Fig. 2.2-1). Dykes are also included into these categories.

A number of large-scale faults are recognized in the western part of the study area, showing mainly N-S in direction. NW-SE and N-S trending lineaments are developed in the southwestern part of the study area, where the Kalahari calcrete crops out. In other area, geological structures are recognized scarcely.

Some lineaments are almost parallel to main drainages such as the Auob, Olifants and Nossob Rivers and seem to control flow direction.

Many NE-SW faults in the northeastern part of the study area (Aminuis area) are covered the Kalahari Beds.

The identified faults are post-Karoo in age and have been identified through the borehole analysis. Some but not all, can be identified on the aeromagnetic maps of the basin. Most do not have a post-Kalahari expression. However, some of the NS faults in the western part of the basin do cut the basal Kalahari calcrete and are visible on aerial photographs.

2.3 Meteorology and Hydrology

2.3.1 Meteorology

Due to the geographical location, the climate of Namibia is classified as subtropical and, most of the Namibian territory falls under semi-arid to arid zone. The annual rainfall varies from 50mm to 700mm. The evaporation is much higher than the rainfall. There are two distinct seasons; the rainy season starts in October and continue until end of April. Most of the rainfall occurs between end of December and middle of April. The average temperature is 25 °C, the highest may rise up to 40 °C in the dry season and the lowest could be below freezing point over most of the country during the winter.

°C In the study area, the highest annual rainfall was 774 mm (1977-78) in Owingi located in the upstream of the Black Nossob River. Rainfall is high in the north and gradually decreases towards the south. The isohyetals of annual average rainfall are presented in Fig.2.3-1. The study area approximately falls within the area of annual average rainfall 150 – 300 mm.

Most of the study area has a maximum average temperature of 30 °C and minimum average temperature of 2 °C.

Annual potential evaporation is between 3,200 mm and 3,800 mm (Refer to Fig.2.3-2). Using the data measured at Hardap dam site (70% of actual value), daily evaporation rate for the study area is between 9.7 mm/day (December) and 4.2 mm/day (July).

The longest and shortest sunshine hours measured at Mariental are the longest, 11.4 hours/day in December and 9.3 hours/day in March respectively.

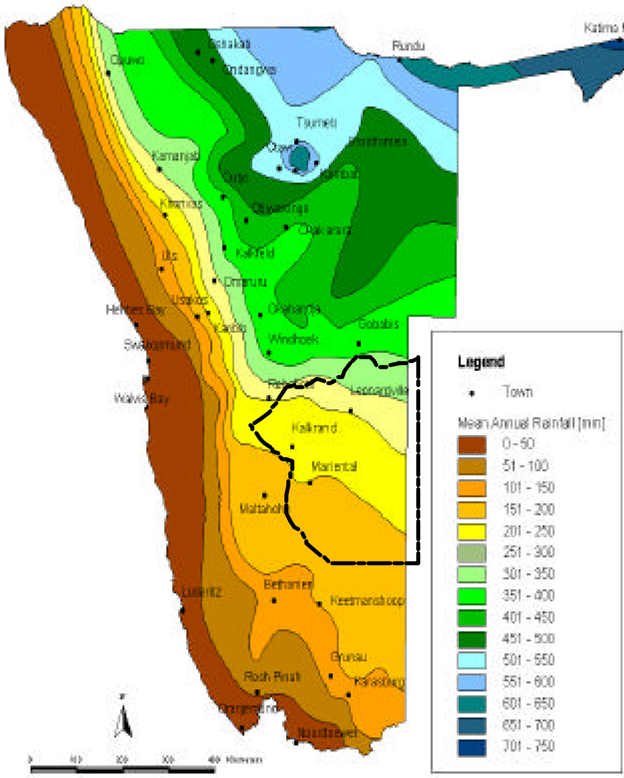

Fig.2.3-1 Mean Annual Rainfall in Namibia

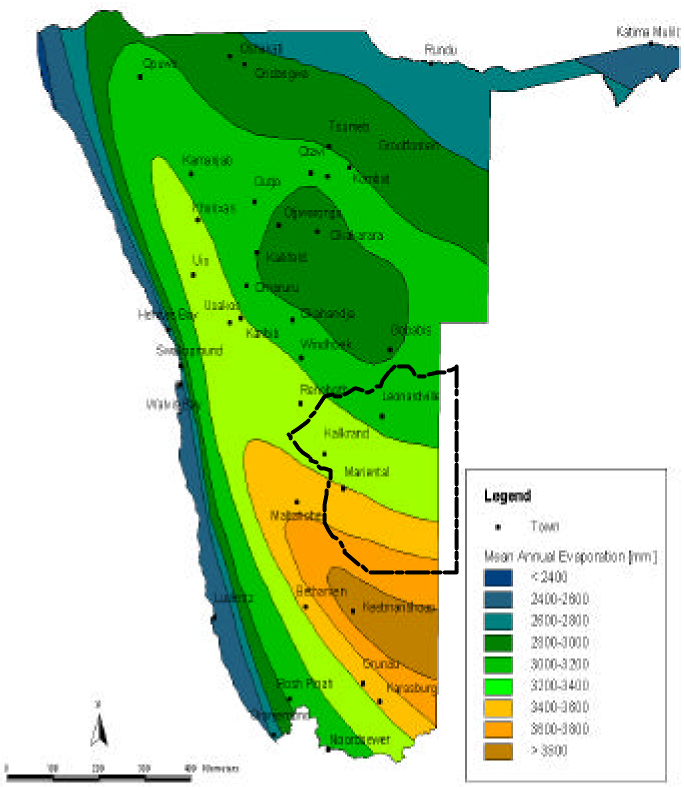

Fig.2.3- 2 Mean Annual Evaporation in Namibia

2.3.2 Hydrology

Except the international rivers such as the Kunene, the Okavango and the Zambezi in the northern border, and the Orange in the southern border, Namibia does not have any perennial river within its territory. The rivers within the Namibian territory are intermittent, however, during the rainy season all become active according to the amount of rainfall in the catchments.

The study area is situated within the catchments of the Nossob-Auob Rivers. The rivers are ephemeral and only flow for short periods during the rainy season. Both of the rivers originate near Windhoek.

The upper part of the Nossob River has two tributaries namely, the Black Nossob and the White Nossob. They merge at a point approximately 20 km north of Leonardville in Gobabis District of the Omaheke Region. Another tributary, the Klein Nossob, joins the Nossob at a point about 20 to 30 km before the Nossob crosses the Namibian border with Botswana. The catchment area of the Nossob within Namibia is 50,050 km^2.

The Auob River originates from northwest of Stampriet at an elevation of about 1,200 mASL. The Olifants River originates in the northeast of Windhoek and meets the Auob at Tweerivier in the southeastern corner of the Mariental District. The Auob Catchment Area including the Olifants River within Namibia is 74,081 km^2.

Five runoff stations are available in the study area. The observed runoff data was reviewed and an annual average was calculated. The results are tabulated in Table 2.3-1.

Table 2.3-1 Annual Runoff Calculated in the Study Area

Name of Station	Name of River	Catchment Area (km^2)	Annual Average Runoff (m^3)	Runoff Depth/ Unit Runoff (mm)
Henopsrus (10 years data)	Black Nossob	4,530	2,459,000	0.54
Mentz (15 years data)	Black Nossob	8,160	1,689,000	0.21
Amasib (11 years data)	White Nossob	9,250	2,165,000	0.23
Stampriet (11 years data)	Auob	19,200	4,646,000	0.24
Gochas (15 years data)	Auob	19,600	9,249,000	0.47

According to the "Unit Runoff Map of Namibia" by DWA, the value of the unit runoff is very small. This is due to the fact that the observed runoff value is very small.

Using the proper data set of rainfall and runoff, runoff coefficient was calculated on the Nossob and the Auob Rivers. Characteristics and calculated runoff coefficient are shown in Table 2.3-2, 2.3-3, respectively.

Table 2.3-2 Characteristics of Gauging Stations

	Black Nossob	Auob
Runoff gauging station	Henopsrus	Stampriet
Catchment area	4,530 km^2	19,200 km^2
Type of section	weir	open section
Rainfall stations used for calculation	Owingi and Otjisororindi	Hofmeyr, Kous, Krumhuk and Stampriet

For the calculation of runoff coefficient, only two hydrological years with a sufficient rainfall and runoff sets have been selected: the 1985-86 and 1988-89 years.

Table 2.3-3 Runoff Coefficients Calculated in the Study Area

River	Year	Month/ Date	Total Observed Runoff (x $10^3 m^3$)	Average Rainfall (mm)	Runoff Coefficient
Black Nossob	1985-86	3 - 9 Feb	122.6	36.8	0.00073
Black Nossob	1988-89	28 Jan - 14 Feb	178.4	177.2	0.00022
Auob	1983-84	2 - 12 Dec	141.8	20.0	0.0004
Auob	1983-84	25 Dec - 4 Jan	43,950.0	47.0	0.0487
Auob	1983-84	20 Mar - 21 Apr	4,021.0	65.0	0.0032
Auob	1990-91	1 - 11 Dec	553.7	36.0	0.0008
Auob	1990-91	15 Mar **	944.8	49.0	0.0010

Runoff coefficient is given by following formula:

Runoff Coefficient = (Total observe runoff)/(Runoff without loss)

= (Total observe runoff)/(Average rainfall x Catchment area)

In the hydrological year, 1999-2000, the study area received an intensive rainfall. This rainfall caused huge amount of runoff to the Auob and the Nossob Rivers, and they reached the border with South Africa. The monthly rainfall data of some selected stations in and around the study area are presented below.

Table 2.3-4 Monthly Rainfall observed in the year 2000

Station	Monthly Rainfall (mm)		Total (mm)	Annual Average (mm)
	February	March		
Stampriet	156.0	58.0	214.0	205
Leonardville	173.4	61.0	234.4	255
Gobabis	130.6	31.0	161.6	365
Aranos	224.5	41.0	265.5	230
Gochas	198.6	67.1	265.7	195
Mariental	349.6	106.3	445.9	198
Kalkrand	105.0	90.8	195.8	210
Otjisorindi	203.0	150.0	353.0	410
Windhoek	202.7	154.2	356.9	355

Note: Annual average has been estimated with Fig.2.3-1.

The intensity of rainfall (consecutive 3 days rainfall) during this rainy season at eight selected stations surrounding the study area is presented below.

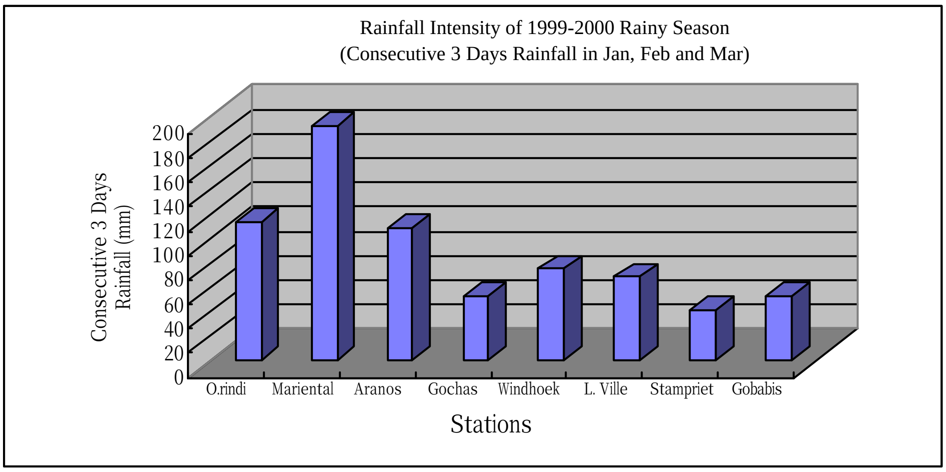

Fig. 2.3-3 Rainfall Intensity in 1999/2000 Rainy Season

At Gochas, there was no any runoff during October-November. In December, Gochas had about 18,880 m^3 of runoff, whereas Stampriet had 430,300 m^3.

The probable maximum annual rainfall was evaluated for few selected stations as shown in Table 2.3-5

Total rainfall at Stampriet in 1999/2000 is recorded 358mm, which is near to 1/50 in Table 2.3-5. A probability of annual rainfall in the study area could not be calculated accurately because of luck of rainfall data. In this study, the probability is regarded as 1/50 considering monthly rainfall at other locations in Feb. and Mar. 2000, news and so on.

Table 2.3-5 Probable Maximum Annual Rainfall (unit: mm)

Return Period (Year)	**Station Name**				
	Mariental	**Stampriet**	**Leonardville**	**Aranos**	**Gochas**
2	172	142	224	192	166
5	249	218	315	302	238
10	295	272	379	371	283
20	337	325	443	435	326
50	389	396	430	517	381
100	426	452	598	577	421

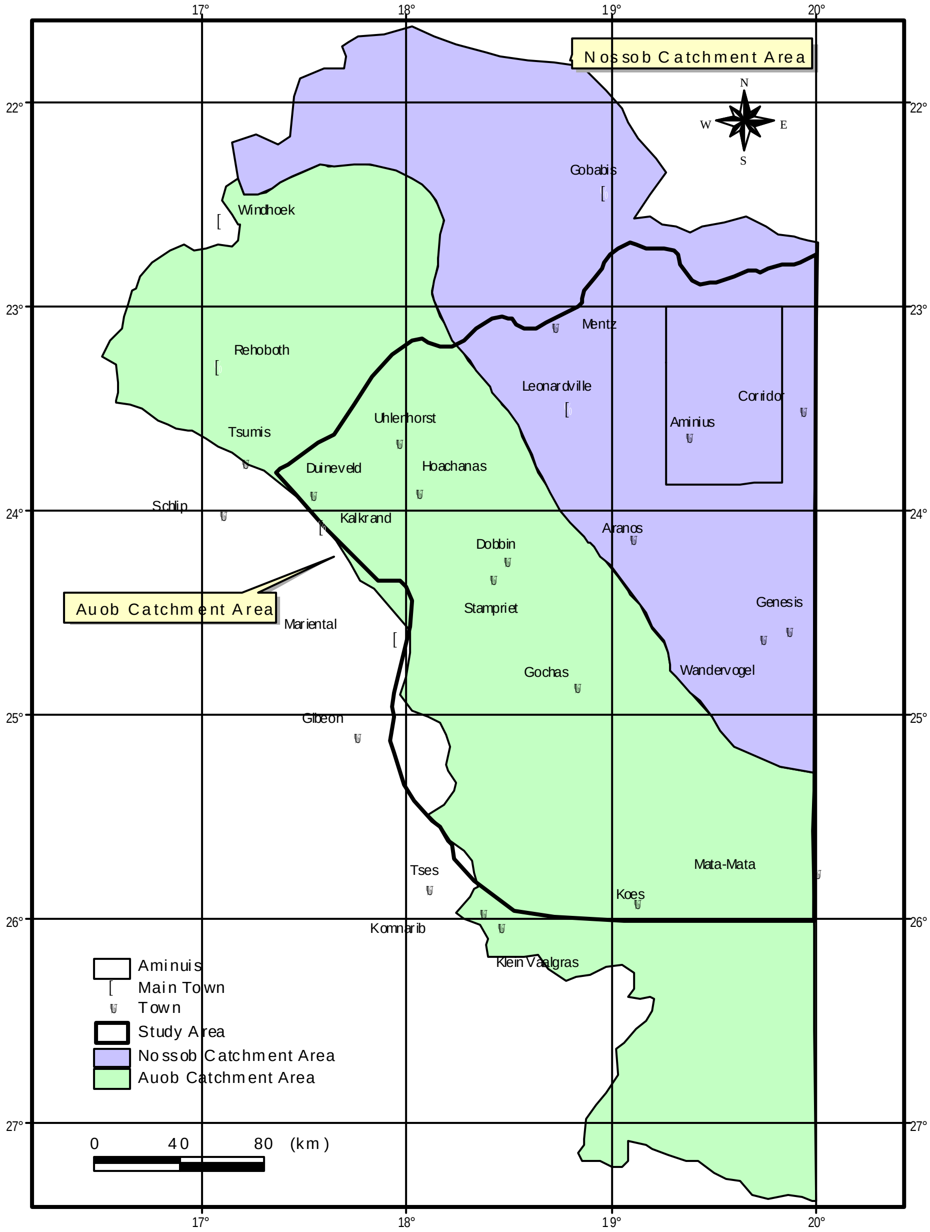

Fig.2.3-4 Catchment Area

2.4 Socio-economic Aspects

2.4.1 Socio-economy

1) Administration

The study Area is administratively composed of four regions, five districts and five villages and it includes communal lands in the three districts:

Regions	Districts	Villages	Communal Land
Khomas	Windhoek	-	-
Hardap	Mariental, Rehoboth	Aranos, Gochas, Stampriet, Kalkrand	Namaland & Hoachanas
Omaheke	Gobabis	Leonardville	Aminuis & Corridor
Karas	Keetmanshoop	-	Namaland

Each village has a village council to work for various social services. Mariental district office is located at Mariental municipality.

2) Population

The population in the Study Area is divided into three groups; village center, commercial farms and communal land. It will be estimated based on the result of the Hydro-census commenced in November 1999 by sub-contract basis. On the 1991 census basis, population in the Study Area was estimated at 28,815 and that of present taking into account annual growth rates since1991 would be 35,096.

Districts	Village Centers	Commercial Farms	Communal Land	Total
Mariental	3,865	7,944	1,906	13,715
Gobabis	797	3,451	7,830	12,078
Rehoboth	-	600	-	600
Windhoek	-	880	-	880
Keetmanshoop	-	474	438	912
Total	4,662	13,349	10,174	28,815

Note. Figures on 1991 census basis.

3) Ethnic Groups

Ethnic groups in the Study Area are composed of Tsuwana, Herero, Nama, San and Whites. In the communal land of Aminuis and Corridor, Tswana, Herero San groups depend mainly on raising livestock. Nama groups in the Hoachanas and Namaland live also on raising livestock. Most of "Whites" who own commercial farms are predominantly Afrikaaner and Germans.

4) Culture and Custom

Ethnic groups living in the Study Area have their own customs and way of life styles. "Whites" maintain their European lifestyle living on commercialised livestock raising or agricultural production with irrigation systems. Contrary native people like Herero, Nama, and San etc. live on subsistence livestock raising. The husband is the decision maker in their families as shown below;

	Money to Spend	Animals to be Sold	Food to be Bought	Children To be Sent To School	Cloths To be Bought
Head	72%	63%	50%	54%	49%
Spouse	3%	4%	15%	6%	9%
Both	17%	21%	26%	28%	33%
Others	8%	12%	9%	12%	9%

Source. Socio-economic survey eastern communal areas 1994

5) Livelihood of the People

"Whites" who manage commercial farms enjoy their lives with higher living standards in the Study Area compared to farm workers and people in the communal areas. On an average six workers are employed in a commercial farm. Farm workers live on the salary of N$200 to N$400 per month per capita and with some supplementary commodities and housing spaces. Owners of commercial farms live by selling livestock or agricultural crops on commercial basis. Most of agricultural products are marketed through cooperatives. Commercial farming is mechanized with tractors, irrigation systems, cold storage etc. While people in the communal land are living on subsistence livestock raising, pensions and wages. They sometimes sell livestock at auctions being held regularly. Catholic settlement areas also exist in the Study Area in which clinic, school, workshop, processing plant etc. are provided. They live on raising livestock and growing crops with irrigation systems. There are several farms which are distributed to landless families under the resettlement program of the government.

6) Income and Expenditures

Socio-Economic Survey in the Eastern Communal Areas 1994, SSD reports that 42% of households have access to between N$ 109 and N$ 250 per month and 38% of survey households spend more than N$250 whereas 20% of all households spend less than N$ 109 per month.

"The Value of Water-A Study of the Stampriet Aquifer in Namibia" written by Ms. Anna Lindgren, has tried to analyse the household income of the commercial farms in the Study Area, which is the only data available for the commercial farms at this moment. In this report, monthly income is estimated at about N$ 48,000 per commercial farm. This implies that there exists considerable disparity between commercial farms and communal farms in the Study Area.

7) Trend of Livestock and Agriculture

Livestock in the Study Area are composed of sheep, goats and cattle, of which sheep accounts for 65% while 15% for cattle and 14% for goats. Dependency on sheep farming is considered due to low rainfall and grazing capacity of the Study Area. Annual rainfall from 1949/50 to 1996/97 is averaged at 185 mm and since 1980s there were droughts continuously excluding 1990/91(385mm/year).

Number of Livestock

Cattle	120,941 head
Sheep	525,979 head
Goats	110,245 head
Horses	5,123 head
Pigs	713 head
Donkey	2,823 head
Ostriches	18,842 birds
Poultry	19,668 birds

Note. Estimated on 1998 livestock census

As a whole, the number of livestock in the Study Area shows a declining tendency over the past 10 years, particularly with regards to sheep and goats.

Natural grazing is prevailingly done on both commercial farms and communal lands for cattle and sheep/goats. Carrying capacity in the Study Area is considerably varied from 3 ha/SSU to 25 ha/SSU depending on wild grass production which is affected by rainfall. Grazing conditions from January to March is very good with rainfall and grass, but grass starts yellowing even in March and drying in May. From June to July livestock loses weight due to low temperature. In commercial farms supplementary feeding is usually done by feeding wheat, hay, Lucerne, etc.

Lucerne, Grapes, Water Melons, Sweet Melon and other vegetables are planted in the Study Area. However, those crops cannot be grown without irrigation because of the arid climate. Since irrigation needs higher investment only commercial farmers, therefore, can invest in irrigation systems although small-scale irrigation is done even in the Catholic settlements and other settlements under the Ministry of Lands, Resettlement and Rehabilitation. Irrigable and irrigated areas in the commercial farms are averaged at 10.7 ha and 7.2 ha per farm, respectively.

8) Industries and Its Products

Since economic activities in the Study Area are concentrated on livestock and agricultural production industrial products are also related to those. Sheep, goats and cattle are the major products in the Area. Sheep is processed into carcasses at the slaughterhouse in Mariental. Mariental district is known for Karakul and Dorper sheep as well as Ostriches. Karakul pelts are processed on small scale at the commercial farms. The first commercial Ostrich farm originated in Mariental.

Vegetables, sweet melons/watermelons, Lucerne and grapes are also main agricultural products, which are mainly grown along the Auob River with irrigation systems. Most crops are marketed to Windhoek as well as for export purposes. Lucerne (alfalfa) hay is processed into pellets by the plant of Hardap cooperative. Mariental is famous for producing good quality raisins for exporting.

9) Tourism

Tourism is also another industry in the Study Area. There are eight hotels and 11 lodges which have 10 to 15 rooms on average.

2.4.2 Infrastructure and Public Services

1) Water Supply

Local authorities are responsible for village water supply on contract basis with Nam Water. While DRWS is responsible for rural water supply for small communities. In the commercial farming areas it is the responsibility of the individual farmers themselves. In communal areas, a water-point is created for domestic consumption by DWA. However, currently there are no formal agreements on water supply between rural communities and DWA. Some farms in communal areas have windmills constructed by the government and beneficiaries pay a water fee of N$ 5 per household per month.

2) Electricity

Electricity network links most village centers in the Study Area but the unpopulated areas such as communal land are not reasonably developed for electrification.

3) Roads and Railway

The Study Area is traversed by the main trunk road traversed at the western part which provides direct link between Windhoek and South Africa. Well–maintained gravel roads as well as paved roads also link between the major village centers.

Main railway along main trunk also traverses in the Study Area and links between

Windhoek and South Africa.

4) Telecommunication

Telecommunication in the village centers is well developed in the Study Area, however poor in the communal lands.

5) Education

Primary and secondary schools are distributed in the Study Area. Currently Teacher/Pupil ratio is 1:21 to 1:24. One agricultural college is in Hardap region.

6) Solid Waste Treatment

Village councils manage dumping sites on the outskirts of the villages in which solid wastes are burned or buried into the ground.

7) Waste Water Treatment

Village councils are responsible for wastewater treatment in village centers by collecting wastewater regularly by tank lorries from household's conservancy tanks and dumping it into oxidation ponds which is placed at the outskirts of the villages.

8) Health

There are five hospitals in Hardap region, four in Karas, one in Omaheke, respectively. Ratio of bed/1,000 population is 5.5 in Hardap, 5 in Karas, 3.5 in Omaheke.

2.4.3 Employment Condition of Farm Workers

Farm workers on commercial farms usually live on the farm. They work caring for livestock, crops and repairing agricultural machinery and cars etc. Their salary ranges from N$ 200 to N$400 per month and in addition to the salary they are offered meal, tobacco, sugar and sometime meats etc. In the harvesting season, commercial farms planting vegetables and grapes hire many labourers from outside. The Labour Act (Namibian Labour Code) came into operation in 1992, which regulates the basic condition of employment.

2.4.4 Disposition of Waste Water and Solid Waste

Conservancy tanks or septic tanks combined with French drains are usually used in households in the village centers. Oxidation ponds are managed by the Local

Authorities to dump sewerage water collected from households. On the individual commercial farms, septic tanks combined with French drains are usually used, by which sewerage water is disposed by seepage into the ground. In the communal land there are considerable households and populations that use the bush as toilets. Solid wastes are treated at dumping sites outside the villages and burned or buried into the soil. Livestock manure is not treated because livestock usually grazes in broad areas.

2.4.5 Commodity Prices

Statistics on consumer price index is not available for the Study Area. However it can be said through survey in the Area that there is not a big difference in commodity prices between Windhoek and the Area.