SUSTAINABLE ANIMAL AND RANGE DEVELOPMENT PROGRAMME (SARDEP)

The Productivity of Rainfall in the Southern, Eastern and Northern SARDEP Pilot Areas

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1.0 INTRODUCTION

The three contrasting regions which are being investigated are typical subsistence farming areas. The first is a small-stock farming area while the second and third areas are devoted to large-stock farming. The problem of reliable rainfall is common to all these areas. The effectiveness of the rainfall is the over-riding consideration and there is a risk of prolonged spells between these falls of productive rain. These risks are experienced on an almost regular basis. This is the current risk of drought. Although these three areas form parts of separate magisterial districts and are now in local government regions which are designed to get away from the former names. The former names are used to ensure that the communal nature of the rangeland is not lost sight of. Further, these communal farming areas do not have the economic resilience which one anticipates will be the stronger platform from which the commercial farmers can be expected to withstand the ravages of drought, more especially recurrent droughts.

2.0 GEOGRAPHICAL LOCATION OF AREA OF ANALYSIS.

Rainfall analysis is required by SARDEP in three Pilot Areas in southern Hardap and northern Karas Regions, in three Pilot Areas in the Otjosondjupa Region, and in three Pilot Areas in the Omusati, Oshana and Ohangwena Regions. The areas are part of the great interior plateau which comprises much of the southern African hinterland. The areas are largely flatland with no orographic features, except the Okakarara Pilot Area which is well within sight of the Waterberg Plateau.

The pilot areas in the south will be described under 2.1, those in the east under 2.2, those in the north under 2.3.

2.1

Pilot Area 1	Gibeon
Pilot Area 2	Blouwes
Pilot Area 3	Gainachas

2.2

Pilot Area 1	Epukiro (Omawewozonyanda)
Pilot Area 2	Okakarara
Pilot Area 3	Okamatapati

2.3

Pilot Area 1	Tsandi
Pilot Area 2	Oshana South (Uukwambi)
Pilot Area 3	Okongo

2.1 The pilot areas in the south lay on the gently declining, seemingly level, plateau which forms the bulk of the southern Namibian hinterland. Drainage is southwards towards the Orange River. This is an area of some Summer but largely an Autumn rainfall. The highest percentage of the rainfall comes from thundershowers which can be about

2.3 The pilot area in the north extends from the western area of the Etosha drainage area to the extreme eastern end of this drainage area. This eastern part is almost on the western end of the Kavango catchment area. The rainfall pattern declines from east to west, but with the consideration that, in the wetter years, the decrease is more north to south as the wetter ranges tend to extend more to the west than is usual. The rainfall pattern is typically a January to March range, but December will be the fourth wettest month, especially in the east. The term "wettest month" does not mean wettest in the reliability of the rainfall, rather that, of the full range of months, this particular month has the fourth wettest aggregate. Rainfall variability is as serious a problem in this general area as it is over any other part of the country. Generally, the rainfall regime is similar to that of the pilot area in the east. Winter night frost can occur from May to August, also.

Any rainfall study in the sub-tropical areas of the world must take into account the localized nature of each thundery shower. Broad areas of general rain, precipitating similar amounts, are few in numbers of occurrence in these areas. The reliable representative range of the individual rain-gauge is considered to be of the order of some 500 metres radius. The detail provided by any one particular rain-gauge is not automatically deemed as being an accurate characterization of the rainfall of the district. Only satellite images can attempt to create a picture of the accurate spread of rainfall across any such area.

Locality descriptions are included in the text for the individual Pilot Area.

Maps 1, 2 and 3 indicate these areas on a Scale of 1:1 000 000. Section maps are of the scale 1:50 000.

3.0 Rainfall Stations used in the Analysis and their Relationship to the Pilot Areas

3.1: Namaland, now part of the Magisterial Districts of Mariental and Keetmanshoop

Pilot Area 1 — GIBEON:
Gibeon Police Station, Kranzplatz Welfare Office, Voigtsgründ 24, Kabiais Suid.

Pilot Area 2 — BLOU WES:
Berseba and Tses Police Stations, Gelwater, Faalgras, Achterfontein I 59, Kabiais Suid, Gellap Ost 3

Pilot Area 3 — GAINACHAS:
Berseba Police Station, Tses Police Station, Keetmanshoop. Gellap Ost 3

3.2: Hereroland, now the Magisterial Districts of Okakarara and Otjinene

Pilot Area 1 — Epukiro (OMAWEWOZONYANDA):
Omawewozonyanda (Epukiro Welfare), Epukiro Mission, Hennep 424.

Pilot Area 2 — OKAKARARA:
Okakarara W, Okosongomingo 149, Waterberg, Okawitumbika 237.

4.0 The Analysis Criteria

Certain factors have been established as providing the most appropriate base from which this form of analysis can function. There is a shift from the basis of cumulative rainfall and the resultant figure of the monthly total which is then compared to the monthly average. This detail lacks value when used in the Namibian context because of the range of variability of amounts and because the impact of rainfall on the rangeland is overlooked. This impact of the rainfall is identified by certain values which are proposed and evaluated in this chapter. The following proposed values of rainfall are designed for rangeland use with regard to rainfall productivity, so avoiding the regularly applied figure of cumulative rainfall.

4.1 The foundation parameters

4.1.1 Rainfall Year

This is from September to August, thus keeping the summer months under the one group[1].

4.1.2 Rainfall Season

Record books will indicate that good, effective, rains have occurred during the months from September to May. As far as the analysis for Namibia has gone, though, this has never happened within one season. The good years of rainfall have focused on prolonged and regular effective value rainfalls occurring from December or January to March or April. The contribution of other months, in such years, varies from the non-existent to negligible. We are really looking at a season which has a peak in a brief set of months and those months which fringe this peak period.

4.1.3 Rain-days

A day on which rainfall occurs is considered as a day of rainfall; this means all precipitation: from drops to the deluge. The term precipitation also covers hail and snow. These occurrences are normally totalled up and the mean calculated. This figure is then used as a pillar upon which all further data must rely. In the Namibian context, this conclusion to the "rain-days" is frequently mis-leading. However, the rain-day description remains in place, but is adapted to reveal other values, as is noted below. The actual period of the "day" is from 08h00 on the one day to 24 hours later, 08h00 on the next day.

4.1.4 Substantial Rainfall

This is the type of fall which will have a very deep penetration and will refresh the aquifer levels. Such falls supplement the productive levels of penetration and the growth which is maintained by an increased moisture content of those levels. The value of this is 25 millimetres in one day.

4.1.5 Productive Rainfall

rangeland. This term will be applied as being both relative to the individual season and to certain values which occur during any rainfall season and these refer to all values below 10 millimetres in one day. A year of rainfall of non-productive values only, no matter on how many days, will be a year of rangeland drought.

4.1.7 Definition of Effective Rainfall

This gives the benchmark values for Productive and Substantial Rainfalls: 10 and 25 millimetre falls.

The basis upon which these key values of Effective rainfall relies needs to be set out. While many shallow rooted plants will perform a cycle on scant amounts of rainfall, the various members of the grass family, which are indigenous to the country-side, provide the value of the veld; these grasses and their reaction to the rainfall are the proof of the values of Effective rainfall in top-soil which is usually hotter than 50 Celcius at 14 hours.

These various grasses have similar rooting systems, the common characteristic of which is their depth. This depth is sufficiently below the surface, the vicinity of 50 centimetres, to ensure a certain longevity, not more than 30 days, which enables the grass to complete its growth cycle following a effective fall of rain. This fall of rain is required over a brief time-scale to ensure that the necessary penetration occurs.

The rainfall values which these grasses require for such penetration to occur has been given as being of the order of 7.7 to 8.0 millimetres. Similar values pertain to the scrub-type vegetation which borders the grasslands, especially on the plateau lands in the south of the country. The 50 centimetre root depth applies throughout.

The probability of convective, thundery, showers occurring is usually limited to later in the day following considerable heating by the sun, usually after the maximum temperature has been attained.

The surface is at least hot, if not very hot, and this extreme of temperature is consistent throughout the top-most layers of the surface: between 50 and 60 Celcius. The probability of an 8.0 millimetre fall soaking through this hot layer, without loss, is unlikely. The loss will be by a process in which evaporation will play a major role.

Further, the individual raindrops are often large. Their impact on the surface does not automatically break them down. They arrive and compact the hot soil cover immediately beneath them, leading to another loss by the process of evaporation. The first millimetre or two, at the very least, will be lost before a cooling occurs.

However, should there be a fair amount vegetation cover, dried grass stalks, twigs or even leaf cover, the individual raindrop shatters and myriad droplets spatter over the immediate area. Once again, these minute droplets reach the hot surface and a quick evaporation-loss takes its toll. Another millimetre or so is sacrificed.

Clearly, to provide an exact assessment of these evaporation losses is impossible. To attempt such a process and to arrive at a definitive, or at least a distinctive, answer would require a very lengthy process with risks of uncertainty still prevalent. Further, such a study would be bedevilled by such factors as the wind on the day or days of study, cloud cover, both before and after the precipitation of the rain, the humidity of the air (one can assume that it will be dry, but for such a study a measure of numerical precision is surely necessary), other factors can be brought in, all of which will vary from day-to-day.

A similar approach concerns the definition of a Substantial fall. Such falls will require a level of penetration which is observed by indirect methods; in this case, the cooling brought about by the moisture penetration to the deepest level of the Soil Thermometer range: 120 centimetres. This cooling factor, usually about 0.1 of degree Celsius over a six-hour period, indicates that a supply of moisture, from a downpour some days earlier, has reached that level, or deeper.

4.2 Absence of Rainfall

The definition of drought implies a deficiency which will become more dire as this period of deficiency continues. This deficiency will be translated, in its effect upon the rangeland or the crop-planted area, as providing a decreasing level of value in the rangeland or in the amount of the crop to be finally harvested. Drought may lead to ultimate disasters like the death of the animals which were to have fed off that rangeland or the utter devastation of the planted area. The effects of drought are felt long before such benchmarks of disaster are attained. The effects, which are the benchmarks of the onset of drought, are those where the sustainable value of the grassland, rangeland, bush or cultivated crop will decline below the least acceptable level. The animal world will start losing condition and the cultivated crop yield will be below the initial harvesting estimate. The major users of these various grasslands, rangelands, and bush are the large and small-stock of the Namibian farming scene and the cultivated crops focus around Maize and Mahango (Pearl Millet).

Definitions, as found in a dictionary, of drought amount to overall generalizations. In relation to the agricultural and rangeland requirements, however, the need is for a definitive value to be brought out: the absence of productive and substantial falls on any day will identify a drought spell or a drought-ridden year. The opposite of effective rainfall are those periods when there is a lack of such effective values: drought.

But drought, as noted above, will have several levels of its own method of effectiveness.

4.2.1 Threshold Drought

The long winter drought which begins from the first day after the last effective fall of the previous season and is only relieved by the next effective fall, presumably, in the forthcoming season needs a practical name: this is described as Threshold Drought. This is the period which is centred around the dry winter months, linking them with the autumn months of the past season with the summer, pehaps spring, months which form the threshold of the forthcoming season when rain may fall. This is the lengthy period between the last effective fall of the previous season and the first effective fall of the next season. This represents a Winter drought, but there can be days of winter rain. These falls are seldom above 10 millimetres and are not discussed any further.

4.2.2 Total Drought

Should the Threshold Drought carry on throughout the forthcoming season, with no relief provided by an effective fall of rain, then the term Total Drought is deemed the most descriptive: the anticipation is that annual grasses will remain dormant and not commence their growth-cycle. The perennial grasses and plants will remain dormant: palatable growth cannot be anticipated. There will be no growth for a complete season. Such occasions in an arid climate, this is deemed a valuable figure. Such occasions appear to be on the increase. There is no certainty that such an occurrence will automatically show up as being part of a drought-spell, hence the decision to give such a month a specific identity.

4.2.5 Large Stock Drought

The Large Stock, mainly cattle, prospects in much of Namibia are limited. Part 1, and its three Pilot Areas, is not a realistic area for Large Stock. Part 2, and its three Pilot Areas, historically, the Large Stock heartland of Namibia; actual data indicates how marginal this heartland is. Part 3, and the two western Pilot Areas, appears to be very marginal for a serious cattle industry; prospects should improve in the east: Pilot Area 3. Nevertheless, it deserves fuller attention. In these marginal areas, Large Stock drought is an all-too-frequent occurrence. The drought causes the values of grassland palatability to be lost completely and the annual grasses will be dormant for the rest of the season. Such occurrences can happen twice, or even thrice, in the course of one season. 40 days, without a further effective fall of rain, hallmarks Large Stock drought.

4.2.6 Small-stock Drought

The sheep and goat populations are less demanding, the spread of vegetation in their area ia more sparse. This vegetation is generally much hardier: the period of survival is longer between occurrences of effective rainfalls. The period is about double that of the large stock requirement. The die-back which accompanies such drought reduces the palatability of the various plants. Such occurrences are limited across much of Namibia. The main incidences are the south and west. 80 days, after the last effective rainfall day, hallmarks Small Stock drought.

4.2.7 Crop Drought

Because, in the more northerly parts (Pilot Areas 2 & 3), there can be the attempt made to pursue dry-land cropping, the criteria for crop drought need to be introduced. The crop requirements for productive rain are very delicate. The ideal requirements, for rain-fed cropping to commence, need some 75 millimetres of rain over five consecutive days: two days of light falls, say 6 millimetres each day, to dampen and soften the surface, followed by three consecutive days which will have two falls of more than 10 millimetres and one fall exceeding 25 millimetres, the accumulation totalling 75 millimetres. This ideal soaking enables the soil moisture content to attain that level at which preparation, planting and initial growth can be done in optimum conditions, thereby setting that one field, at least, off to a sound start and providing ample rain-fed sustenance for the initial growth to survive for a number of days without the need of further rain. These optimum conditions are rarely met. Very often, the cropping process sets off with the optimism, rather than the optimum, leading the field.

These very delicate requirements then focus on the return of productive falls of rain recurring within a ten-day period. With 90-day and 88-day crop-strains available, the period for such repetitive falls to continue is some 50 days. The barest minimum to obtain full value from a planted area would be a Productive fall every ten days over 50 days: not an impossible attainment. After that period, when the creative stages of the plant growth have been completed, the rainfall requirement is less demanding: 15 to 20 days appears to be adequate. The plants require cooling rather than watering. Although these requirements are within the realms of possibility, the variability factor stalks this scene with unceasing attention. These requirements would seem to be met some 7

To determine the detail for this period of Alert, use would be made of applied satellite imagery. First, there is the daily Cold-Cloud-Duration as read off from the sequence of images which indicate the likelihood of further productive falls. Second, the Vegetation Index shows the increasing greenery of the rain-affected area; a yellowing image shows the increasing deterioration of the rangeland. If no further effective falls are registered in the following 39 days, the 40th day means the onset of large-stock drought. A similar technique will perform this function for the small-stock areas with the 80-day parameter providing the bench-mark. The Small-stock alert lasts for 79 days: the 80th day sees the commencement of Small-stock drought.

The advice of an impending return of a drought condition should be used to ensure that measures to secure either fodder supplies or links to fodder supplies are available, so that the fodder-supply process can be set in motion to forestall a serious loss of condition of the live-stock involved.

It is a reasonable anticipation that, say around the 35th day, the possibility of either the return or continued absence of widely-spread thundershowers will be evident. Early enough for reaction to be made either way. It must be stressed that, even with a very promising rain-bearing pattern appearing, due to the limited size of most thundershowers, such a pattern could imply relief for a majority of, but not all, the rangeland users in the alert-area. The small-stock approach will become critical around the 75th day; a similar approach applies. The relevance of this approach is to provide a form of protection for those who are at the mercy of both drought and the absence of productive rain. This approach covers the entire country and the Pilot Areas in particular

4.3 Other relevant factors concerning Rainfall

4.3.1 Rainfall Probability across the season

In 1990, the South African Weather Bureau Technical Paper 24 devoted a section to the progress of the rainfall season across Southern Africa. The denomination of Rainfall Provinces was given and divisions were created. The term "core months" was used to denote the peak of the season. In an unpublished work, Olszewski has adapted the principle of the "core months" to the Namibian scene. These core months should provide some 70 per cent of the total rainfall and thus depict the probable heart of the agricultural season. The rainfall season focuses around these core months. So, while it can rain during any one month or any set of months, from September to May, this range needs identifying against the background of a rainfall season framework.

Olszewski has delved into the seasonal framework also. If we take the Core months and then investigate what happens prior to or after these months, we find months which contribute satisfactorily to the events of a season and which are clearly more rain-prone than those months more removed from the core of the season. These months are named the Associated months which contribute, according to records, almost 25 per cent of the nnual rainfall. The outer periphery, when effective rains can and have fallen, are named the Possible months which contribute barely 5 per cent of the mean annual rainfall. The variation between NENAM and FEMAR will focus on the briefer core and the fact that the variable rainfall range does spread itself across the 6 months when the heavier showers can occur.

For Pilot Areas in the south the season is demarcated thus:

millennia. The task, these days, is to extract the best from these basic conditions and even develop an improved infrastructure. This type of rainfall analysis is designed to point the way towards what is probable and what is improbable, perhaps just impossible, against this background of excessive variability.

The point is this: having set out the rainfall season into perspective, it should be clearly understood that, in the worst of seasons, the Core months can be virtually rainless, with one effective fall in one of the Possible months or even with no productive fall registered over the entire calendar year, let alone the actual rainfall season. The permutations are very numerous indeed. The variability factor is particularly ever-present in the Namibian rainfall picture.

What these descriptions do imply is that the best rainfalls can be looked for across the Core months and that reasonable support values can be expected across the Associated months. This is fully supported by the Productive and Substantial rainfall occurrence analyses.

4.3.3 Reliability of Rainfall during "favourable looking" days

There is a wealth of detail, background information, which is accessory to the events which culminate in a day where any rain is reported from one or several points[2]. There is no ground to believe that because such an event occurred on one day, the next similar day will do the very same thing. This sequence of thought may hold water in the temperate zones of the world. The sub-tropics differ in the wide range of variability which can occur across small distances, from day to day, from one weather pattern to another similar system.

4.3.4 Prognosis of the Probability of Rainfall at a given place

No matter how advanced the technology, no matter how powerful the computer, no matter how thorough the programming, there exists no tool which can be used to predict to any acceptable level of accuracy the occurrence of rain at a given point in the sub-tropics. It boils down to the difference between "It will rain, today" and "It will rain here, today". The likelihood of there being rain "within sight" of a given place is forecast with high percentages of accuracy. The precision of "it will rain here", at that given place, is far less accurately achieved. The idea of forecasting amounts of rainfall across 6-hour periods has received practical attention in the output of the Bracknell Forecast Centre and the products of the ECMWF[3]. These prognoses cover the period 48 hours ahead from the time of issue. Their accuracy, really no more than an areal indicator, is sound, but it is only 48 hours ahead at this period of time. Good, but there is much further to go.

While we are unable to predict the future, we are able to monitor the present and note the ebb and flow of the various events as they occur across the day, the week, the dekad and the month. The meaningfulness of analyses which flow from such monitoring will improve with practice and perseverance. For those who seek the rapid results which the "push-button" world suggests would be readily available, this is bad news. For those who understand the value of research and its attendant labours, this will underscore the value of diligence.

4.3.5 The Rainfall Stations and their duration.

4.3.6 THE VERTICAL APPROACH

By taking one or two stations of long-duration in an area and calling them core stations, from which the general rainfall aspect of that area becomes apparent, and then taking the various brief-duration stations which have come and gone within that area, satellite stations perhaps, and matching these stations to the time-scale and see what variation, if any, occurs to the initial aspect. This can be called the Vertical Scale; it may be applied to years, or months, across the period of the core stations. This provides depth to the analysis across the period under review, a depth which does not appear to form part-and-parcel of any current method of analysis. The Vertical Scale would put another perspective to the reliability range of each rainfall report.

This methodology will give a detailed approach to any one particular area which is considered extremely marginal for the proposed activity. Whether or not to proceed with the plans for that particular area will thus depend on the exhaustive analysis which this amount of data will provide as the basis. At this stage, this Vertical Scale is not deemed essential across any one of the Pilot Areas or at the individual places pin-pointed for the SARDEP plan for rangeland management is being considered; where the basis of rainfall expectation, ie: the frequency and amounts, associated with Productive values of Rainfall are concerned.

4.3.7 RAINFALL STATION DATA, RAINFALL VARIABILITY AND THE PILOT AREA ANALYSIS.

It has been noted that thunderstorms, thundery showers, the regular precipitation of the tropical regions, are very small in areal extent, perhaps a kilometre across. The range of accountability of an individual rainfall station is perhaps as little as 500 metres across. These dimensions are as small as pin-pricks on the normal 1: 1 000 000 scale wall-map. The factor of variability serves only to highlight the limited range of reliability that can be attached to a rainfall reading from any one station on any one particular day. The regular description of the precipitation pattern on that particular day will vary from "isolated" to "scattered" which means not more than a 30 per cent to not more than a 60 per cent chance of precipitation occurring, irrespective of the amounts of rain which are recorded.

This litany of problems serves to keep in the forefront of the mind that Namibia, let alone any one particular part of the country, is situated in an arid zone. That rain falls to any effective extent at any one location across a span of years is remarkable. That such rain supports an ecology and an environment in which livestock farming has any viability is equally remarkable. To determine the values which apply to this rainfall means that a level of adaptation, of whatever detail is available, needs to be made. This process will mean that levels of precision in this adaptation process will not mean the same as those levels more usually associated with the understanding of the word "precision".

This analysis, in particular, and any other analysis made on the rainfall in an arid region will need to search for an applicable methodology. This methodology will be the base of this actual analysis of similarities and probabilities across any particular region and, in this case, the designated Pilot Areas. These similarities and probabilities are based on the analysis of the rainfall station record from the point of view of the productivity of the rainfall and the absence of such productive occasions together with the numbers of days elapsing between such occasions of productive rainfall.

4.4 Climatic Variability and Climate Change

Climatic variability should not be confused with climate change. Climatic variability refers to and covers the range of the ambient climate in its registered extremes, its norms and those departures from the norms. Wetter, warmer, drier, colder years are part and parcel of the subject of climatic variability. Climatic variability should not be confused with comparisons of climate regimes which are geographically distant. These will be separate climate zones. There will be, frequently, along the areas where these zones border or are inclined to overlap, those places which, from their data, could fall into either group. Lines of demarcation, isohyets for instance, are most wisely drawn on small scale maps covering large areas. Such maps and their lines are designed to show the core areas of particular topic being outlined. They will depict generalizations and not pin-pointed facts.

The chance of climate change is very real. Climates are only static in mankind's calender. The clock of climate changes matches geological calenders. The fact that very gradual climate changes are currently and always with us must be accepted. It is their measure, their pace and their direction which are the acute matters

What is the uncertain factor is the affect which mankind, in search of an improved civilization, has made on an otherwise able climate.

The existing global climate, with its ranges of variability, are estimated to have held sway for some quarter of one hundred-thousand years at least. The ecology has adapted to the ranges and thrived during the periods of normalcy. What are cyclic periods and what are slowly improving or degenerating tendencies becoming more and more apparent are matters which will only come into focus across a millennium or so.

4.5 Rainfall reporting and recording.

The early records show a very commendable level of daily rainfall recording. This level has clearly fallen away during later years. The divide would appear to come after the era of the 1940's. Most notable are the absences of the 0.0 falls and the tendency to either round off to the millimetre or to the nearest half millimetre in falls above the one millimetre value. This casts a suspicion over each and every value recorded, of course.[4]

4.6 Hailfall

Hailstorms are extreme results of rather unusual sets of circumstances within the water droplet section of a massive cumulus cloud.

These droplets fall just like any other raindrop. In unusual circumstances, other influences become dominant, so the normal pattern is interrupted. Raindrops are thrust upward by a powerful convection current, freeze, and gather more droplets to become a larger ball of ice, fall again, may endure the same up and down thrusting process some more times until they are so large, so heavy, that nothing can stop their fall. On their descent, they may lose some of their mass, will eventually start a melting process as they pass through the freezing level and, virtually a matter of seconds later, crash into whatever is beneath them on the top of the Earth's surface.

Hail and livestock are a poor mix. Rarely can livestock reach any form of shelter during a hailstorm and are prone

But hailstorms are usually very localized. Widespread hail-fall is very rare. A hailstorm is usually associated with a thunderstorm. Thundery hail is overwhelmingly damaging in its occurrence: few are the days of hail where the hail was so slight that the damage was negligible.

The longer term benefit is that a hailstone is 79% Nitrogen, a basic fertilizer; however, explaining that benefit to someone surveying a shattered scene of hailstone damage will require considerable persistence, if not courage.

These are the parameters which form the base, outline and the form of the analysis.

5.0 RAIN-FALL ANALYSIS OF THE PILOT AREAS

There are three parts of the country with three Pilot Areas each which are under consideration:

In the south	GIBEON	BLOU-WES	GAINACHAS
In the east	Epukiro (OMAWEWOZONYANDA)	OKAKARARA	OKAMATAPATI.
In the north	TSANDI	OSHANA SOUTH	OKONGO

5.1 THE PILOT AREAS AND RAINFALL DATA AVAILABILITY.

Major evaluation of rainfall data will be made for the south from the following stations:
.1 Gibeon Police, Kranzplatz Welfare, Voigtsgründ 24, Kabiais Suid 54
.2 Berseba Police, Tses Welfare, Geiwater, Kabiais Suid, Faalgras 61, Achterfontein I 59, Gellap Ost 3
.3 Berseba Police, Tses Welfare, Keetmanshoop, Gellap Ost 3.

The south has one Pilot Area, Gibeon, which has data right from the area itself with Gibeon and Kranzplatz. The other two Pilot Areas rely on three long-running stations to provide an outline of conditions which are deemed to prevail in the Gainachas and Blou-Wes Pilot Areas.

Major evaluation of rainfall data will be made for the east from the following stations:
.1 Omawewozonyanda Welfare, Epukiro Mission, Hennep 424
.2 Okakarara Welfare, Okosongomingo 149, Okawitumbika 237, Höhensee on 304
.3 Okamatapati Commissioner, Gabasis 172, Annenhof 158.

The east can provide data from all three Pilot Areas. Two of the stations, Okakarara and Okamatapati are defunct, the other, at the Epukiro Welfare Office, does not appear to have the latest figures available. This last station is in the village of Omawewozonyanda; not the easiest name to handle, but it distinguishes the Epukiro Welfare from Epukiro station of farm 268, Gobabis, which was run first by the Police and today by the Catholic Mission. Because Mission stations are frequently found as part of a former "Native Reserve", the opportunity should be taken to ensure the difference is clarified between the Mission and the Welfare Office. The name then any offering may cause a shaking of heads. However, the general scheme of the rainfall pattern, in these remote areas will be brought to a near, if not the exact, truth. So that decisions will be based on reasonable, perhaps very reasonable, reliable grounds. The absence of major topographical features favours this assumption. The south and all the Pilot Areas falls within the FEMAR rainfall regime or rainfall province:

Core	February	March			50% of total aggregate
ASSOCIATED	NOVEMBER	DECEMBER	JANUARY	APRIL	45%
Possible	September	October	May		<5%

The east and north and all their Pilot Areas fall within the NENAM rainfall province:

Core	January	February	March	70% of total aggregate
ASSOCIATED	NOVEMBER	DECEMBER	APRIL	25%
Possible	September	October	May	<5%

The stations used are given below with the station name and farm or the urban erf number.

Station	Latitude	Longtitude	Duration in years (All years, whether daily data is available or not)
Pilot Areas 1,2 and 3 in the south			
Gibeon	25.08	17.46	98
Kranzplatz	28.08	17.46	75
Voigtsgrūnd 24	24.50	17.26	73
Berseba	26.00	17.47	67
Kabiais Suid 54	25.22	17.36	10
Tses	25.53	18.07	64
Gellap Ost 3	26.28	18.05	77
Pilot Areas 1,2 and 3 in the east			
Okakarara	20.35	17.27	52
Okamatapati	20.24	18.13	06
Omawewozonyanda	21.35	19.25	66
Okawatumbika 237	20.55	17.29	17
Okosongomingo 149	20.39	17.06	81
Hōhensee on 304	20.21	17.29	42
Annenhof 158	20.02	17.51	58
Gabasis 172	19.57	18.04	63
Okanakasewa 216	19.41	18.24	24
Epukiro 268	21.42	19.06	84
Hennep 424	21.55	19.05	21

5.2 THE ANALYSIS OF THE PILOT AREAS IN THE SOUTH

5.2.1 Pilot Area 1: Gibeon District

Gibeon is the former magisterial centre of the Mariental district. It is a population centre of some magnitude in the local context. The population pressures on the immediate vicinity have been at a premium for many years, any deleterious results will be clearly manifest and trends should be readily observable in the area. Popular knowledge will be able to advise of decreased vegetation coverage and of the increased area which man and livestock must range to gain adequate nutrition. Gibeon is situated on the course of the Fish River.

The geographical location is on the Fish River. This is an area of gently meandering rivers which, in turn, indicates a gentle southward slope at the Northwestern end of the Karoo-type plains which form much of the south-eastern quadrant of Namibia. The value of the river to the ambient vegetation is not known.

There are two long-running rainfall stations in the town area. Surrounding stations are of either brief duration or of a distance-range which cannot match the immediate value of the stations Gibeon Police Station and the Gibeon Reservaat: the Commissioner and, recently, the Welfare Officer. This station also has the name of Kranzplatz. This name is used here to avoid any confusion with the Gibeon Police station. The historic station of Voigtsgründ 24, which provided temperature data for a many years, is used as a monitor for the Gibeon area. Voigtsgründ is rather remote to the north-west of Gibeon. Having been a climate station, the quality of the data recorded should be above that which can be encountered from certain "official" stations.

The recently established Kabiais Suid station has been included to provide another current station to the analysis. The cumulative rainfall means for these stations are quoted, if only to underscore the weakness of such a level of data when undertaking an analysis for a practical purpose.

Months:	S	O	N	D	J	F	M	A	M	Annual Total	Period
Gibeon	1	5	10	13	34	45	40	12	1	171	1897-1982
Kranzplatz	1	4	11	15	31	49	41	17	3	184	1911-1996
Voigtsgrund	1	5	11	16	34	61	52	17	3	204	1906-1979
Kabiais Suid	2	3	9	11	10	41	27	19	2	126	1986-1996

Apart from highlighting the alignment of the season for the determination of the Core and Associated months, there is nothing more of practical value which can be derived from this level of data. The reduced values of the newly-founded Kabiais Suid station are of note. Although this period has been one of limited rainfall, the realization that there is a 30 percent deficiency and that this reduced level is sacrificed by the Core and the Associated months of the season can be considered with a measure of alarm. Is this just the manifestation of a dry period or is this the fulfilment of years of vegetation depredation, especially trees, a pattern which appears to be revealing itself in the Damara and western Owambo communal areas?

This area can be likened to being the northward extension of the Karoo. The Karoo is best known for the Small-Stock type of farming which has achieved world-wide recognition. The southern parts of Namibia have achieved

5.2.2 Pilot Area 2: Gainachas District

Gainachas is in area which has a series of rainfall stations, past and present, among the enclosed farms of the south-western end of the Mariental Magisterial District to the north. The two large "farms" of Berseba and Tses comprise the former Berseba and Tses Native Reserves. This is communal farming land. Places of settlement are virtually non-existent, so the ability to gain rainfall data from such an area has been limited to the two settlements of Berseba and Tses. The commercial farms, away to the west, are not felt to be representative of the Pilot Area. Hence the reliance on places to the north-west and south-east to try and gain a balanced view of this area. The generally flat countryside may give that extra quality of assurance when the analysis is made.

Mount Brukaros maybe just too far removed to have an effect upon the local rainfall pattern in this Pilot Area

The risk of nil or limited growth seasons persists. The pattern of perennial Large Stock Drought persists and is overriding. The somewhat higher rainfall, on average, may just mean that the depredation of the drier years is less malign than in the Blou-Wes vicinity, which lies to the east-south-east.

Small Stock will survive in this Pilot Area; the nomadic practices of the past are surely the key to the ability to cope during the drier years which do recur with a reliability which cannot be pinned down to "every so many years". This nomadic quality needs to be stressed at every turn when considering reaction to the climatic factor in the south of Namibia.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS IN THE GAINACHAS PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Berseba	Tses	Gelwater	Faalgras	Achterfontein I	Kabiais Suid	GellapOst
No. of Years on record	61	63	26	19	38	9	62
Mean Duration in Days	277	290	238	280	265	268	263
Maximum Duration in Days for the Years on record	380	463	440	400	428	387	433

Total Drought:

Berseba	Nil				
Tses	4	771 (1933)	752 (1946)	747 (1984)	566 (1951)
Gellap Ost	2	699 (1945)	630 (1964)		

Table 2

TOTAL DROUGHT OCCURRENCES IN THE GAINACHAS PILOT AREA:

Table 3

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE GAINACHAS PILOT AREA:

Station & Detail	Berseba	Tses	Gelwater	Faalgras	Achterfontein	Kabiais Suid	Gellap Ost
Years	61	63	26	19	38	9	72
40+ days	40	37	19	11	30	6	50
80+ days	16	13	5	1	7	1	15
Mean Duration	80	68	70	64	69	60	75
Max. Duration/Year	179/1930	124/1975	121/1961	112/1943	203/1955*	99/1987	153/19814

Notes: *Achterfontein I had two Small Stock Drought occurrences 113 and 114 days in 1939 when productive rain fell early and late season with a July rain which punctuated the Threshold Drought period.

5.2.3 Pilot Area 3: Blouwes District

Blouwes lies in an area where the annual rainfall expectancy ranges between 175 and 125 millimetres. The rain is most predictably expected during the months of February and March, January is a moderate contributor in amount while April has some value in that such showers fall in cooler conditions rather than those of the heat of midsummer.

These four months provide 80 per cent of the normal anticipation of rain. The two core months provide some 50 per cent of the regular expectation. The number of days which should rain approximates to one twenty-fourth of the year (15 days) of which between 2 and 4 days will be productive. The upward limit of the chance for productive rain has not attained 20 days; these years will be found amongst the 1934, 1974 and 1976 group of years. Such years were able to match the normal annual Productive rainfall expectancy in any one month of the four months in question.

The drought-factor is increased by the regularity in which years of decreased values of rainfall occur. This factor of variability can range from Absolute Drought (zero annual rainfall: Tses in 1946) to values which approach the 500 millimetre bench-mark Some 20 per cent of the years will have either 1 or 2 productive days.

Although spring/early summer rains are of scant expectation, these occurrences are of considerable value to the veld; most years will see a productive day in either November or December. The normal return of greenery is strengthened by such falls. The recurrence can maintain the vegetation until the next productive fall during the Core months of the season, hopefully. This is not an impracticable requirement: it is met most years. If it were not attained, bio-degradation would be well in evidence. The interruption caused by an 80-day drought spell occurs also. These Small-Stock droughts are the risk which any undertaking in these Pilot Areas must be prepared to accept. However, it should be clearly noted that the normal method of Small-Stock farming in this area has a strong nomadic arm. Because the rainfall data indicates a drought spell at one point, the next point may have avoided this, or some other points, too. An interruption in rainfall data can be due to "trekking": Faalgras 1960.

Table 2

TOTAL DROUGHT OCCURRENCES IN THE BLOUWES PILOT AREA:

The " /Year " indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Berseba	Tses	Gellap Ost
Occurrences	0	4	3
First/Year		771/1933	380/1982
Second/Year		752/1946	675/1930
Third/Year		747/1984	636/1945
Fourth/Year		566/1951	

Table 3

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE BLOUWES PILOT AREA:

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Berseba	61	40	16	80	179/1930
Tses	63	37	13	68	124/1975
Gellap Ost	72	50	15	75	153/1981

Table 4

ALL THE STATIONS AND THEIR PARAMETERS AS GIVEN IN THE TABLES FOR THE THREE PILOT AREAS

Stn & Det	Yrs	Thr D	M Dur	Tot D	Mx TD	40+ D	80+ D	M Dur	Mx Dur
Gibeon	50	259	435	2	709	43	14	73	141
Kranzplaats	49	266	498	Nil		50	11	65	126
Voigtsgründ	63	263	432	2	689	50	16	74	129
Gelwater	26	238	440	3	771	19	5	70	121
Achterfontein	38	265	428	2	587	30	7	69	203
Kabiais Suid	9	268	387	Nil		6	1	60	99
Faalgras	19	280	400	1	607	11	1	64	121
Berseba	62	277	. . 380	Nil	-	40	16	80	179
Tses	63	290	463	4	771	37	13	68	124

Table 5

COMPARISON OF TOTAL DROUGHT YEARS WITH THE MEAN THRESHOLD DROUGHT PERIOD FOR EACH LONG TERM STATION AND THEIR COMPARISON WITH THE STATIONS CLOSE TO THE 3 PILOT AREAS IN THE SOUTH

Station & Years	1919	1933	1945	1959	1964	1982	Mean
Gibeon	326	192	326	340	200	637+	259
Kranzplaats	No data	No data	405	307	498	No data	260
Voigtsgründ	190	314	689	281	630	No data	263
Gelwater	212	240	No data	771	239	No data	239
Achterfontein I	No data	380	346	439	676	No data	265
Faalgras	No data	No data	335	368+	328	No data	256
Kabiais Suid	No data	No data	No data	No data	No data	No data	242
Berseba	No data	318	No data	324	371	380	277
Tses	No data	771	370	393	431	747	290
Gellap Ost	187	307	214+	316	420	680	263

Note The/Year indicates the Rainfall Year which saw the commencement of the occurrence.

Table 6

EFFECTIVE RAIN & CONTINUOUS GROWTH PERIODS COMBINING TO INDICATE YEARS OF ABUNDANT GROWTH

Key 11 Effective number of rain-days
116 days of presumed consistent growth

T, in the end column, indicates the total number of years of Abundant growth.

Stn & Year	1917	1925	1934	1950	1954	1963	1971	1974	1976	T
Gibeon	Nil	Nil	Nil	Nil	Nil		11/116			1
Kranzplaats	Nil	Nil	Nil	Nil	Nil	Nil				0
Voigtsgründ	Nil	Nil	Nil	Nil	Nil	19/136	Nil	Nil	Nil	3
Gelwater	Nil	Nil	Nil	Nil	Nil		12/105	Nil	Nil	2
Achterfontein	Nil	Nil	26/147	20/127		16/131	Nil	Nil	Nil	6
Faalgras	21/209		27/157	20/126						5
Kabiais Suid	Nil	Nil	Nil	Nil	Nil	17/154	12/128	13/124	12/110	5
Berseba	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		1

5.3 THE ANALYSIS OF THE PILOT AREAS IN THE EAST

5.3.1 Pilot Area 1: Epukiro (Omawewozonyanda) District

The Epukiro area lies in the NENAM rainfall province: January, February and March are the core months of the season. The expectancy for early showers to occur on an occasional basis is sound enough, as is the probability that either April or May will provide productive showers to improve the winter grass.

This area, like those of the other districts in the former Hereroland, is considered to have very good ranching, Large Stock, potential. This potential is exploited very fully by the local population.

An interesting anomaly appears in the data for the two major stations under consideration here. Although some 30 kilometres apart, there is a 25% difference in the overall means between these two stations. Although only 30 kilometres apart, it would appear from the monthly and daily detail that the rainfall regimes vary. That the more westerly station is wetter is another matter of interest. The concern that there was an irregularity in the data from Omawewozonyanda for about one year is real, but this does not show up as being an underlying problem across any other period of the stations' record. The fact that two varying regimes affect this micro-area would seem to be the truthful response. But this matter and its cause could be investigated further.

The cumulative data distinguishes the Core and Associated months with clarity:

Months:	S	O	N	D	J	F	M	A	M	Annual Total	Years
Omawewozonyanda	2	12	34	40	70	73	56	41	5	317	1926-1990
Epukiro Mission	4	14	42	58	87	87	59	36	6	400	1903-1992
Hennep	4	20	51	49	81	86	66	38	8	408	1950-1975

Although the station at Omawewozonyanda no longer records (since 1990), the Epukiro Mission data has been taken for the last three years, the detail looks promising for the period from 1926 onwards. Two years are left out because of missing detail. The last decade shows a tendency to drier conditions at Omawewozonyanda, a fact which is not fully supported by the Epukiro Mission data. There is also a tendency for the occasions of the Core and Associated months with zero rainfall to have increased in number, which is common cause among most reporting stations

As the tables will show, there is a marked decrease in the severity of the arid conditions across the three Pilot Areas of the east. While this amelioration is to be expected, this does not automatically mean a grassland paradise will ensue. The regular toll of drought stalks this portion of Namibia relentlessly.

Small-Stock should thrive here, but the grasses found in this more north-easterly portion are very suitable for Large Stock. But the record reveals a seemingly surprising high number of Large Stock Drought periods across the years. Once again, the nomadic methodology should be considered. Because one locality is short of rain and the growth has died back, this does not necessarily mean that the entire district is so stricken.The news about those parts with better fortune for the particular period will have spread, so the trek will begin in search of those greener pastures. Further, because the onset of Large Stock Drought on the 40th day does not mean a benchmarks could consolidate such a classification[6]. The result of which would define the levels of agricultural activity such classified zones of Aridity could truly support most years out of plenty.

With the compilation of the tables showing the monthly totals of Effective Rainfall occurrence and the concurrent tables showing the date of these occurrences and the intervening days of occurrence of Small/Large Stock Drought periods, there is a pattern discernable towards the dating of the first effective rain of the season. This event will occur between mid-October and mid-November some 60 to 70 percent of the period on record. This is still rather vague, but the tendency for there to be a date-period for the start of the Productive Rainfall season is note-worthy. The opposite, for the close of the season, has the sketch of an outline also. This covers the mid-March to mid-April period for similar percentage of the record. It is untrue to assume that early starts automatically lead to early cessations of the Productive rainfall season. The variability factor is the one constant factor of the rainfall scene. This outline holds good for the area covered by the analysis for Part Two.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT EPUKIRO (OMAWEWOZONYANDA) PILOT AREA
The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Omawewozonyanda	Epukiro Mission	Hennep
No. of Years on record	63	73	24
Mean Duration in Days	215	215	209
Maximum Duration in Days for the Years on record	322	300	269

TOTAL DROUGHT OCCURRENCES IN THE EPUKIRO (OMAWEWOZONYANDA) PILOT AREA

There were no Total Drought Occurrences recorded in this Pilot Area.

Table 2

THE OCCURRENCE AND DURATION OF GRAZING (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE EPUKIRO (OMAWEWOZONYANDA) PILOT AREA

Station & Detail	Omawewozonyanda	Epukiro Mission	Hennep
Years	65	73	24
40+ days	45	48	21
80+ days	3	3	1
Mean Duration	56	54	55
Maximum Duration/Years	105/1927	98/1921	87/1967

The station at Okakarara has a 50 years history, surely adequate in the local context. Nearby, to the west and to the south-west of the Waterberg, lies Okosongomingo with a recording history dating back to 1902 and still going strong. Further downwind lies a much newer station, Okawitumbika, with just 18 years under its belt. Hohensee lies north of Okakarara and to the east of the Waterberg with 43 years history to 1962. The correlation between these stations' values is not immediately clear, as the cumulative means show, but the clear outline of the Core and the Associated months is evident:

Months	S	O	N	D	J	F	M	A	M	Annual Total	Period
Okakarara	2	8	31	43	91	98	62	30	5	375	1930-1981
Okawitumbika	4	9	31	47	88	118	93	29	1	369	1976-1996
Okosongomingo	3	15	41	61	106	118	86	40	7	476	1902-1996
Hohensee	1	19	45	70	99	118	93	34	6	466	1913-1962

Realising that Okawitumbika has not yet experienced a wet group of years, its below-400 figure is accepted as being a reflection of the drier spell of years which have dominated since the late 1970's. Hohensee is on the east side of the mountain, so the wetter influences appear to hold sway here. Also, the dry 1960's are only partially represented. Okosongomingo has the longest record, with the pre-1940 data now written-up a true station analysis has now been achieved. Okakarara evidences the anticipated rain-shadowing of the Waterberg.

With an absence of the excesses of drought, there being no Total Drought and Year long Drought, so that there are only two occasions when the 300-day Threshold Drought benchmark was passed. This is a haven for Small-Stock, but this is Large Stock orientated country. Okosongomingo has 79 years of daily data for analysis, there are 60 Large Stock Drought periods. There are 10 years with two or three periods of Large Stock Drought and there are 24 occasions when the Large Stock Drought was 40 to 49 days long. Still an uphill struggle for the dedicated Large Stock developer, but the prospects of good returns for the outlay made are reasonable. Once again, the ability to trek in times of impending need becomes the loophole for this Pilot Area.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE OKAKARARA PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Okakarara	Okosongomingo	Okawitumbika	Höhensee
No. of Years on record	59	79	18	20
Mean Duration in Days	272	211	215	234
Maximum Duration in Days for the Years on	416	330	297	311

TOTAL DROUGHT OCCURRENCES IN THE OKAKARARA PILOT AREA

There are no occurrences of Total Drought in this Pilot Area.

5.3.3 Pilot Area 3: Okamatapati District

This Pilot Area centres around Okamatapati. The settlement had a Commissioner who maintained rainfall reports and records for 6 years during the 1970's. Also in the NENAM Rainfall Province, this is the most northerly of the Herero cattle districts in the Pilot Area discussion. The rainfall prospects should be an improvement on Pilot Areas 1 and 2. Indeed, the means are somewhat higher than Epukiro Mission which lies some 200 kilometres to the south-east. This area lies in the featureless landscape that typifies the extremities of the Kalahari merging with the northern bushveld.

Okamatapati has run for only 6 years; the six years of the mid- and late 1970's. These include some of the wettest years on record in Namibia. The run of years from 1974 to 1978, across much of Namibia is usually wetter than the 1921 to 1925 spell, where three years can have wet records, or than the 1954 to 1958 spell which can provide 2 or more years of wet records. The individual annual mean for this station is 450 millimetres.

In a north-westerly direction lies the former station Annenhof. This station reported from 1923 until 1985, giving, therefore, simultaneous readings with Okamatapati. This lengthy record is viewed as giving a good control and a good indication of the overall rainfall regime of Okamatapati. The correlation through the three wet years and the two dry years is very positive. The initial impact is that Okamatapati is rather wetter than is Annenhof there is no real reason though to assume a better condition at Okamatapati until more is eventually known. There is less reason to assume that this wetter spell was simply fortuitous and that the area is less promising than is Annenhof. As a support, another long-life station Gabasis, is included in the analysis also.

With Gabasis as a current station, this data is assumed to provide an adequate working range for this Pilot Area for the purpose of this analysis. The tendency for rain-less months has increased at Annenhof over the last 30 or so years. The month of April, a key month for winter and early spring grassland values, has had no less than 5 rain-less Aprils' since 1968; in the previous 43 years there were only two such occurrences. There was also one rain-less November and one rain-less March during the same period; there was also one of each during the previous 43 years. The latter-day trend of not recording the 0.0 falls, perhaps the less obvious 0.1 or so falls as well, may be the prime factor in this increase of occurrence. The tendency to heavier downpours is less clearly understood.

Although apparently one half of the years on record indicate the occurrence of Large Stock Drought, some of the years have endured two occasions of such drought in the one year. Other years fall into the 40 to 49 day category. Annenhof had two double years and 12 occasions below 50 days. Gabasis had 5 double years and 10 occasions below the 50-day mark.

Overall, this Pilot Area should flourish as a Large Stock raising area, given mobility and constructive management.

Table 1

spells of Large Stock drought in each of the other years since 1980. The 15 years since the onset of this dry period provide records which are more at home in the Grootberg environment. The last year which provided a good range of productive and substantial falls was 1976.

The other station which covered much of this same spell of years is Ongandjera. This station ceased recording in 1989 and provides a reasonable match to the occurrence record of productive and substantial falls as found at Ombalantu. The excesses of Threshold Drought and the incidence of Total Drought are not to be found at Ongandjera. The very driest year for this measure of drought is 1959, with 357 days of Threshold Drought. The 1980 detail matches Ombalantu precisely in a 291 day period of Threshold Drought

The cause of this excess and the drier period may be found in the man-made desecration of the woodland of the western Owambo. Those people who left their home in the course of the 1960's and returned in the 1990's were faced with a clearly visible deterioration in the environment as they had remembered it: the disappearance of the trees. The precise link between the presence or absence of trees and the occurrence of rainfall is not well established. But the imprecise link, or series of linkages, has several positive positions from which the confirmation of a linkage can be provided. Assuming this linkage to be factual as far as the western Owambo areas are concerned, then there are many more years of great departures from the normal expectations on rainfall and drought in the offing.

It is for this reason that the remote station of Okaukuejo has been, reluctantly, ignored. This station lies well away to the south-east of the Pilot Area, in the Etosha Park. Man-made depredation of the vegetation has not occurred in this protected area. So, although the data from Okaukuejo will give a worthy measure of reality of the balance between rainfall and drought, the practical environmental considerations mitigate against the use of this valuable station in the context of this Pilot Area.

Given the mobility of the Large Stock and their herders, it is a fair assumption to note that Large Stock will survive, if not actually thrive, in most years. Perhaps one year in ten would have proved taxing for the Large Stock farmer. But with the record of the period since 1979, the future for Large Stock must be problematical. Small Stock will have survived, mobility could have provided solutions for even the worst of years. The final decision may lie in the nature of the vegetation and whether or not this is suitable for widespread Small Stock farming. This consideration is beyond the scope of the rainfall aspect.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE TSANDI PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Tsandi	Ombalantu	Ongandjera
No. of Years on record	54	64	54
Duration in Days	229	236	208
Maximum Duration in Days for the Years on record	316	422	291

Table 3

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Tsandi	Ombalantu	Ongandjera
Years	54	64	54
40+ days	21	32	33
80+ days	2	1	3
Mean Duration	56	54	56
Maximum Duration/Year	90/1928	96/1958	134/1920

5.4.2 PILOT AREA 2 OSHANA SOUTH

This area spans the southern end of the Oshana delta region, to the south of the major towns and villages of the central Owambo, where the Efundja can have positive value on the vegetation of the stream-beds and the neighbouring banks. The area is well within the NENAM rainfall province with December the fourth most hopeful month and, as is common to most of the stations in the Owambo Regions, April will have the highest total of Nil rainfall occurrences.

With a focus on a possible deterioration within the last few years of the range of the various stations' data, the dire conditions of the western Owambo are not reflected this far to the east. Immediately, though, it should be noted that the Pilot Area does not have a recording station, past or present. The stations available lie to the north and will be, presumably, just that much wetter with higher expectations of productive and substantial falls and with a lesser extent to the Threshold Drought duration. The prospects for this Pilot Area, as revealed by the data available, should be down scaled by a moderate proportion, therefore. To provide a balance in this regard the Ongandjera station is again used. This station lies to the west of the Pilot Area and represents a drier factor. There are various stations to the north. Each one has been looked at and the records as noted in their data are given due consideration in the assessment for this Pilot Area. Okatana is currently open, but Ondangwa has not been reopened since the closure of the Air Force base whose data superseded the long-running Post Office station. The other stations which are over viewed are Oshakati, still open but of short duration, and Oniipa which supports the Ondangwa data. Olukonda has a good history but ceased reporting in 1964, perhaps too distant in time for current use.

Only Ongandjera and Oshakati note Nil rainfall months, apart from April month, in the course of the last few years: 1985 in the case of Ongandjera and 1990 in the case of Oshakati. The other stations only have April

The ability for rain-fed crops to survive in any but the wettest of years ensures that attempts to secure any value from such effort are reliably doomed to failure. The scarcity of wet spells coupled with the regularity of dry spells and their lead into 40-day droughts provide sufficient evidence for this anticipation to be met year after year. This applies to rain-fed crops, chiefly Mahango, what prospects there are for better crops in the Oshana beds, for instance, is not known, but any attempt to expect regular support from rainfall is too risky.

With good management, the Uukwambi, or the southern Oshana, has fair prospects for Large Stock enterprise.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE OSHANA SOUTH PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Ongandjera	OndangwaMs/PO	Okatana
No. of Years on record	54	64	357
Duration in Days	208	221	294
Maximum Duration in Days for the Years on record	357	294	352

TOTAL DROUGHT OCCURRENCES IN THE OSHANA SOUTH PILOT AREA

From the records of all the stations pertaining to the four regions covering the former Owambo district, with the exception of Ombalantu (as noted in Pilot Area 1), there have been no occurrences of Total Drought. This fact holds good for the remote stations, on the south side of Etosha Pan, of Halali, Namutoni, Okaukuejo and Ombika. Even Otjovazandu, far to the south-west of the Pilot Area, has no record of a Total Drought.

Table 2

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE OSHANA SOUTH PILOT AREA

Station & Detail	Ongandjera	Ondangwa Ms/PO	Okatana
Years	54	62	59
40+ days	33	29	29
80+ days	3	2	1
Mean Duration	56	55	49
Maximum Duration/Years	134/1920	86/1922	102/1981

Ondangwa Air Force Base notes 1983: 45+55 days.

PART THREE PILOT AREA 3 OKONGO DISTRICT

The further north that one goes, and the further east, so will not only the amount of the rainfall increase but also the variability factor will tend to diminish. This is, of course, a generalization which will have positive and negative sections when applied to any one particular area. Pilot Area 3 is remote from the main centres of population in the northern parts of Namibia. It is far removed from natural surface water supplies. Hence this is not an area of burgeoning growth. But it is still in an area where rainfall expectations will be as optimistic as anywhere else in the country and on a par with those of the Kavango valley and the Caprivi.

The remoteness of the area presents a problem, though. No major Mission stations, no major areas of settlement exist where some government Official or Post Office or Police station may need to be established. So, unfortunately, there is no rainfall data from this site. It is understood that Mr Joseph Hailwa has a Forestry project operating in this area, but dating from only 1990, there will be only little value in whatever data may have accrued thus far. Away to the west, Enana Finnish Mission has provided a smattering of detail across a dozen years, to the east Mpungu Mission provides another small window on to the rainfall world. Far away to the south-east, the 40 years of data from the farm Choantsas 202 provides much more detail; supported by other farms nearby. By being to the south-east, there is the probability that the rainfall regime will be fairly similar and that the amounts will provide a feasible pattern also. The matter of precision is far from guaranteed. But, as has been revealed with the variation between stations fairly close by in the Ondangwa and Oshakati districts, precision is an imprecise word to use when analysing rainfall in Namibia.

The Pilot Area is in the KAVCZ Rainfall Province. To recap: the initial expectation is that this Pilot Area is sufficiently far west to place it within the NENAM regime. But by being so far north, the possibility of an earlier start to the core of the season cannot be ignored. With only 12 years of data to go on, from Enana to the west, there can be doubts, but Enana is to the west, so the positioning of this Pilot Area in the rather wetter Rainfall Province is not unreasonable. The precise definition to the Core of the season appears to be mid-December to mid-March. The Associated months would span from mid- to late October and extend to mid-April. Nevertheless, at this stage, there is no immediate desire to switch the alignment of the months. Further investigations in to this sphere show, initially, that there is substance to the existing alignment. This is based on the commencement of the Productive rainfall season (by December) and the conclusion (during March). April sees the late closure to the Productive rainfall season and October, at least late October, can see the early start to this season. A third configuration is thus provided below:-

The NENAM configuration is:

Core	January	February	March
ASSOCIATED	NOVEMBER	DECEMBER	APRIL
Possible	September	October	May

The KAVCZ configuration is:

This is a quality which the Choantsas area could not be expected to match, but which does merge with the Mpungu data. Although there is an anomaly that from the sequence of the monthly data for both Enana and Mpungu (Enana is to the west, Mpungu to the east) the reverse would be the conclusion that Enana would be to the east and Mpungu to the west. The cause for this is not readily explained. Mpungu recorded during the entire period of the wet 1970's, which would explain its higher, overall, total. Enana recorded during the wet 1950's and the dry early 1960's, which provides some explanation for its lower (12%) overall total when compared to the more easterly, presumably wetter Mpungu. Mpungu has a fair comparison with Kuren Kuru, even further to the east and on the Kavango itself.

Months	S	O	N	D	J	F	M	A	M	Annual Total	Period
Enana	1	16	46	101	101	134	90	30	4	541	1951-1962
Mpungu	1	20	69	85	159	132	124	32	2	617	1963-1981
Kuren Kuru	2	18	62	102	147	132	96	37	2	594	1910-1996
Choantsas	3	13	47	73	115	107	75	35	4	473	1951-1996
Fairview	3	14	48	72	105	113	88	39	4	486	1924-1980

The cumulative values for the station duration will substantiate the comments made above.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE OKONGO PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Enana	Mpungu	Choantsas	Fairview
No. of Years on record	12	17	48	55
Duration in Days	215	214	218	220
Maximum Duration in Days for the Years on record	258	247	295	322

TOTAL DROUGHT OCCURRENCES IN THE OKONGO PILOT AREA

From the records of all the stations pertaining to the four regions covering the former Owambo district, with the exception of Ombalantu (as noted in Pilot Area 1), there have been no occurrences of Total Drought. This fact holds good for the remote stations in the Tsumeb Magisterial district.

Table 2

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE OKONGO PILOT AREA

Table 3

LARGE STOCK DROUGHT: NUMBER OF YEARS WITH 40 TO 50 DAY OCCURRENCE AND MULTIPLE OCCURRENCES IN THE OKONGO PILOT AREA

Station & Detail	Enana	Mpungu	Choantsas	Fairview
Years	2	17	48	55
40 to 50 day	4	3	13	20
Year 1	Nil	1972/60+47	1965/46+40+45+47	1939/40+48
Year 2			1980/44+46	1965/97+43
Year 3			1982/85+60	1973/67+60

Table 4

COMPARISON OF TOTAL DROUGHT YEARS WITH THE MEAN THRESHOLD DROUGHT PERIOD FOR EACH LONG TERM STATION AND THEIR COMPARISON WITH THE STATIONS CLOSER TO PILOT AREA 3.

Number of Days duration of Total or Threshold Drought, comparing Mean Threshold Drought in days

Station & Years	1929	1932	1946	1959	1981	1992	Mean
Tshandi	219	272	No data	298	316	No data	229
Ombalantu	No data	251	32	297	314	429	236
Ongandjera	No data	No data	No data	357	253	No data	208
Ondangwa	212	251	246	218	219+	No data	221
Okatana	No data	No data	247	231	272	265	228
Enana	No data	No data	No data	218	No data	No data	215
Mpungu	No data	No data	No data	No data	No data	No data	214
Choantsas	No data	No data	No data	231	243	279	218
Fairview	201	266	322	220	No data	No data	220

6.0 ANNEXURE A

6.1 THE TABLES

There is the consideration that, for certain purposes, the tables may suffice and thereby avoid the text. For such an eventuality, the tables are re-presented in their sequence for a consolidated review of the data.

The tables are constructed as follows:

Table 1	Threshold Drought Analysis
Table 2	Total Drought Occurrences
Table 3	Occurrence of Grazing & Small-Stock Droughts, Mean Drought duration, Maximum days of occurrence and the year of this occurrence

The Pilot Area analysis is based on rainfall data from that area or from those places which are deemed to have a practical similarity to the Pilot Area. The rainfall data presented should not be taken as being precisely applicable to the Pilot Area, but it can be taken as presenting a good level of similarity to the conditions anticipated in the Pilot Area.

Table 1
THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS IN THE GIBEON PILOT AREA
The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Gibeon	Kranzplatz	Voigtsgründ	Kabiais Suid
No. of Years on record: Daily data available	69	66	63	9
Mean Duration in Days	259	266	263	268
Maximum Duration in Days for the Years on record	399	498	432	387

Table 2
TOTAL DROUGHT OCCURRENCES IN THE GIBEON PILOT AREA:
The " /Year " indicates the Rainfall Season (Jan. Feb Mar) with no Effective Rainfall

Station & Detail	Gibeon	Kranzplatz	Voigtsgründ	Kabiais Suid
Occurrences	2	0	2	0
First or Longest/Year	709/1929		689/1945	
Second Longest/Year	667/1981*		636/1964	

* Gibeon ceased records in December 1982, the Total drought which commenced on 05 March 1981 was still unbroken until December 1982. Kranzplaats, some 500 metres away, had no Total Drought occurrences.

* Gibeon had 2 occurrences of Small-stock Drought within the same year: 1918 to 1919 and 1940. Both of these were caused by a downpour of winter rain which means that the Threshold Drought spell has been punctuated and two Small-stock Drought periods identified.

* Kranzplatz has endured several years with two or even three occurrences of Large-stock Drought. This occurrence is also applicable to Gibeon Police station and Voigtsgrūnd.

* Voigtsgrūnd had a spell of 143 days in 1939 which was punctuated by a Productive fall of rain in July; thereby shortening the Threshold Drought and introducing an extra figure for Small-Stock drought calculation.

The winter rain occurrences are of a thundery nature. Their overall value is problematical, it is with some reservation that such outbreaks are noted when they interrupt the Threshold Drought period.

5.2.2 Pilot Area 2: Gainachas District

Table 1
THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS IN THE GAINACHAS PILOT AREA
The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Berseba	Tses	Gelwater	Faalgras	Achterfontein I	Kabiais Suid	Gellap Ost
No. of Years on record	61	63	26	19	38	9	62
Mean Duration in Days	277	290	238	280	265	268	263
Maximum Duration in Days for the Years on record	380	463	440	400	428	387	433

Total Drought:

Berseba	Nil				
Tses	4	771 (1933)	752 (1946)	747 (1984)	566 (1951)
Gellap Ost	2	699 (1945)	630 (1964)		

Table 2
TOTAL DROUGHT OCCURRENCES IN THE GAINACHAS PILOT AREA:
The " /Year " indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Berseba	Tses	Gelwater	Faalgras	Achterfontein 1	Kabiais Suid	Gellap Ost
Occurrences	0	4	3	1	2	0	3
First/Year		771/1933	771/1959	607/1949	587/1930		680/1952
Second/Year		752/1946	590/1930		5731932		675/1930
Third/Year		747/1983	509/1924				630/1948

Stn & Detail	Y	Thr	M	Tot	Mx	40+ D	80+ D	M G Dr	Mx
Gibeon	50	259	435	2	709	43	14	73	141
Kranzplaats	49	266	498	Nil		50	11	65	126
Voigtsgründ	63	263	432	2	689	50	16	74	129
Gelwater	26	238	440	3	771	19	5	70	121
Achterfontein	38	265	428	2	587	0	7	69	203
Kabiais Suid	9	268	387	Nil		6	1	60	99
Faalgras	19	280	400	1	607	11	1	64	121
Berseba	62	277	380	Nil	-	40	16	80	179
Tses	63	290	463	4	771	37	13	68	124
Gellap Ost	72	266	420	3	680	50	15	75	153

Abbreviations

The above table, Table 4, has abbreviated headings; these are:

Stn & Det: Station & Detail
Thr D: Threshold Drought
Tot D: Total Drought
M Dur: Mean Duration
Max TD: Maximum (longest)

40+ D: Grazing Drought of 40 Days and longer
80+ D: Small-Stock Drought of 80 Days and longer
M G Dr Mean Grazing/Small Stock Drought (days)
Max Dur: Maximum Grazing/Small-Stock Drought Duration (days)
Total Drought (days)

Table 5

COMPARISON OF TOTAL DROUGHT YEARS WITH THE MEAN THRESHOLD DROUGHT PERIOD FOR EACH LONG TERM STATION AND THEIR COMPARISON WITH T
STATIONS CLOSE TO THE 3 PILOT AREAS IN THE SOUTH

Station & Years	1919	1933	1945	1959	1964	1982	Mear
Gibeon	326	192	326	340	200	637+	259
Kranzplaats	No data	No data	405	307	498	No data	260
Voigtsgründ	190	314	689	281	630	No data	263
Gelwater	212	240	No data	771	239	No data	239

5.3.3 Pilot Area 3: Okamatapati District

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHT AT THE OKAMATAPATI PILOT AREA

Station & Detail	Okamatapati	Annenhof	Gabasis
No. of Years on record	6	60	65
Mean Duration in Days	200	224	225
Maximum Duration in Days for the Years on record	230	329	330

Total Drought Occurrences in the Okamatapati Pilot Area
There were no Total Drought Occurrences recorded in this Pilot Area.

Table 2

THE OCCURRENCE AND DURATION OF GRAZING (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE OKAMATAPATI PILOT AREA

Station & Detail	Okamatapati	Annenhof	Gabasis
Years	6	60	65
40+ days	3	38	35
80+ days	3	4	3
Mean Duration	75	57	52
Maximum Duration/Year	85/1979	107/1926	96/1981

Table 4

COMPARISON OF DROUGHT YEARS AND THE MEAN THRESHOLD DROUGHT FOR THE STATIONS IN THE THREE PILOT AREAS

Number of Days duration of Total or Threshold Drought, compaing Mean Threshold Drought in days

Station & Years	1929	1932	1946	1959	1981	1992	Mean
Omawewozonyanda	268	244	277	255	169	No data	215
Epukiro Mission	266	235	259	236	213	183	215

5.4 THE ANALYSIS OF THE PILOT AREAS IN THE NORTH

5.4.1 Pilot Area 1: Tsandi District

Table 1
THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE TSANDI PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	Tsandi	Ombalantu	Ongandjera
No. of Years on record	54	64	54
Duration in Days	229	236	208
Maximum Duration in Days for the Years on record	316	422	291

Table 2
TOTAL DROUGHT OCCURRENCES IN THE TSANDI PILOT AREA

The /Year indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Tsandi	Ombalantu	Ongandjera
Occurrences	Nil	2	Nil
First/Year		582/1987	
Second/Year		727/1994	

Table 3
THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Tsandi	Ombalantu	Ongandjera
Years	54	64	54
40+ days	21	32	33
80+ days	2	1	3
Mean Duration	56	54	56
Maximum Duration/Year	90/1928	96/1958	134/1920

Total Drought Occurrences in the Oshana South Pilot Area

From the records of all the stations pertaining to the four regions covering the former Owambo district, with the exception of Ombalantu (as noted in Pilot Area 1), there have been no occurrences of Total Drought. This fact holds good for the remote stations, on the south side of Etosha Pan, of Halali, Namutoni, Okaukuejo and Ombika. Even Otjovazandu, far to the south-west of the Pilot Area, has no record of a Total Drought.

Table 2
The Occurrence and Duration of Large-stock (40+ days) and Small-stock (80+ days) Droughts in the Oshana South Pilot Area

Station & Detail	Ongandjera	Ondangwa Ms/PO	Okatana
Years	54	62	59
40+ days	33	29	29
80+ days	3	2	1
Mean Duration	56	55	49
Maximum Duration/Years	134/1920	86/1922	102/1981

Table 3
Large Stock Drought: Number of years with 40 to 50 day occurrence and multiple occurrences in the Oshana South Pilot Area

Station & Detail	Ongandjera	Ondangwa Ms/PO	Okatana
Years on Record	54	62	59
40 to 50 day Duration	15	12	15
Year 1	1918/55+45	1927/60+56	1953/42+51
Year 2	1963/88+57	1939/41+48	
Tear 3	1988/58+41+41	1953/50+48+42	
Year 4		1962/56+43	

Ondangwa Air Force Base notes 1983: 45+55 days.

Part Three Pilot Area 3 Okongo District

Table 1
The occurrence and duration of Threshold Droughts at the Okongo Pilot Area

Table 2

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS IN THE OKONGO PILOT AREA

Station & Detail	Enana	Mpungu	Choantsas	Fairview
Years	12	17	48	55
40+ days	6	4	23	30
80+ days	Nil	Nil	2	2
Mean Duration	49	49	54	51
Maximum Duration/Year	56/1961	60/1972	113/1964	103/1964

Table 3

LARGE STOCK DROUGHT: NUMBER OF YEARS WITH 40 TO 50 DAY OCCURRENCE AND MULTIPLE OCCURRENCES IN THE OKONGO PILOT AREA

Station & Detail	Enana	Mpungu	Choantsas	Fairview
Years	12	17	48	55
40 to 50 day	4	3	13	20
Year 1	Nil	1972/60+47	1965/46+40+45+47	1939/40+48
Year 2			1980/44+46	1965/97+43
Year 3			1982/85+60	1973/67+60

Table 4

Comparison of Total Drought Years with the Mean Threshold Drought period for each long term station and their comparison with the stations closer to Pilot Area 3.

Number of Days duration of Total or Threshold Drought, comparing Mean Threshold Drought in days

Station & Years	1929	1932	1946	1959	1981	1992	Mean
Tshandi	219	272	No data	298	316	No data	229
Ombalantu	No data	251	232	297	314	429	236
Ongandjera	No data	No data	No data	357	253	No data	208

Annexure B

6.2 THE CRITERIA FOR SUCCESSFUL YEARS

The consideration is that there is a range of differences between those various seasons not afflicted by a drought spell. These are seasons which will have provided rainfall enough to have stimulated growth and maintained that growth.

Obviously, a range of criteria should be identified which will indicate the years when this level of satisfaction can be achieved and to what degree.

An indicator of the years of sustained, probably abundant, growth and the number of days during which this growth will have been active and kept active. Finally, growth is anticipated to have ceased some 30 days (probably an extreme figure) after the last effective fall of rain, 10 millimetres or more.

The criteria are:

1 No drought spells
2 Consecutive months with effective rain-days which are 30 per cent or more above the normal expectation
3 Periods of growth in excess of 60 days

The same criteria would apply to the similar tables where Blank spaces indicate that the data does not meet the criteria and that Nil indicates that the station did not report during that year.

Annexure C

6.3 THE LONG-TERM STATIONS USED IN THE AREA ONE ANALYSIS FOR ALL THREE PILOT AREAS SHOWING ALL THE OCCURRENCES OF THRESHOLD DROUGHT WHERE THE 300 DAY DURATION IS ATTAINED OR EXCEEDED AND WHERE THE 100 DAY (SMALL STOCK DROUGHT + 20 DAYS) DROUGHT IS ATTAINED OR EXCEEDED

6.3.1 Threshold Drought periods of 300 day Duration

Place/Years	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
Gibeon	326		697	-	363						?399	308	312
							-	-	-	-	-	-	-

Place/Years	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943
Gibeon	-						338				391		
Kranzplatz	-	-	-	-	-					332			
Voigtsgründ			115		365				143	126			107
Gelwater	317				-	-	-	-	-	-	-	-	-
Achterfontein	573		380				332				403		
Faalgras	-	-	-	-	-	-	-	-	-	-	-	-	
Berseba	315	320	318		314		-		305			-	-
Tses		771					355	300	300		463		
Gellap Ost	331	372	307	366						-	-		

Place/Years	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Gibeon	326	362		357		315							
Kranzplatz	405	356	327	404		306					376	-	
Voigtsgründ		689				124							
Gelwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Achterfontein	387	346	381										
Faalgras		335	385	607		311		644					319
Berseba	-	-	-	-	-	-	-	352					
Tses	370	752		354		301	566				344		310
Gellap Ost	-	-	333	635		315							376

Place/Years	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Gibeon		340	345	353		331						349	333
Kranzplatz		319	307			337		499	315	324		324	

6.3.2 100 day Drought period attained or exceeded

Place/Years	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
Gibeon				-									
Kranzplatz	-	-	-	-	-	-	-	-	-	-	-	-	-
Voigtsgründ		129			111		110						
Gelwater		110	-	-	-	-				-	-	-	
Achterfontein	-	-	104	-	-	-		-	-	-			
Faalgras	-	-	-	-	-	-	-	-	-	-	-	-	-
Berseba	-	-	-	-	-	-	-	-	-	-			173
Tses	-	-	-	-	-	-	-	-	-	-			
Gellap Ost		135	125						127				

Place/Years	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943
Gibeon	-		132							113			
Kranzplatz	-	-	-	-	-					112		110	
Voigtsgründ	107		115		365				143	126			107
Gelwater					-	-	-	-	-	-	-	-	-
Achterfontein									113				
Faalgras	-	-	-	-	-	-	-	-	-	-	-	-	
Berseba							-		142		115	-	-
Tses													
Gellap Ost										-	-		

Place/Years	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Gibeon													
Kranzplatz						109			105			-	
Voigtsgründ		689				124							
Gelwater	-	-	-	-	-	-	-	-	-	-	-	-	-

Place/Years	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Gibeon								141		126		120	
Kranzplatz												119	
Voigtsgründ	432												
Gelwater					121				100		-	-	-
Achterfontein									-	-	-	-	-
Faalgras									-	-	-	-	-
Berseba				112					139	116	120		104
Tses										109			
Gellap Ost			103							130			

Place/Years	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Gibeon													-
Kranzplatz													
Voigtsgründ		689				124			-	-	-	-	-
Gelwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Achterfontein	-	-	-	-	-	-	-	-	-	-	-	-	-
Faalgras	-	-	-	-	-	-	-	-	-	-	-	-	-
Berseba									124				
Tses						124							
Gellap Ost						126		109		116	144	158	

Place/Years	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Gibeon	-	-	-	-	-	-	-	-	-	-	-	-	-
Kranzplatz	126				104								
Voigtsgründ	-	-	-	-	-	-	-	-	-	-	-	-	-
Gelwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Achterfontein	-	-	-	-	-	-	-	-	-	-	-	-	-

Annexure D

6.4 The Maps

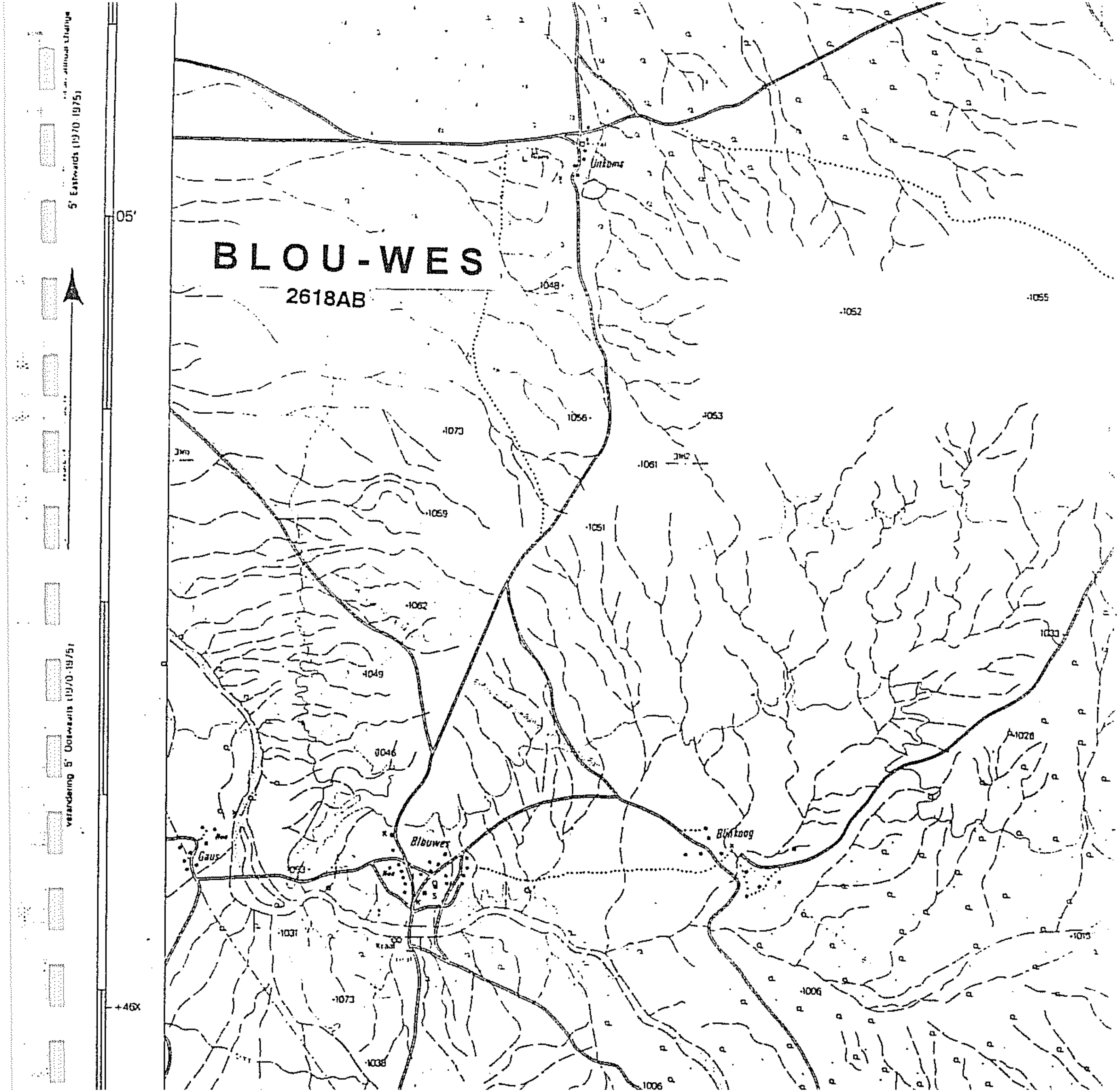
A series of maps are attached.

The first is on the 1:1 000 000 scale to indicate the general area and the rainfall stations used in the analysis.

The second batch of maps for each part indicates the individual Pilot Areas on the 1:50 000 scale.

The maps are copies of those which are available at the Office of the Surveyor-General.


GIBEON
2517BA+BB
FISH RIVER
FISH RIVER



5' Eastwards (1970-1975)
verandering 5' Ooswaarts (1970-1975)
05'
+46X
BLOU-WES
2618AB
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1038
1006
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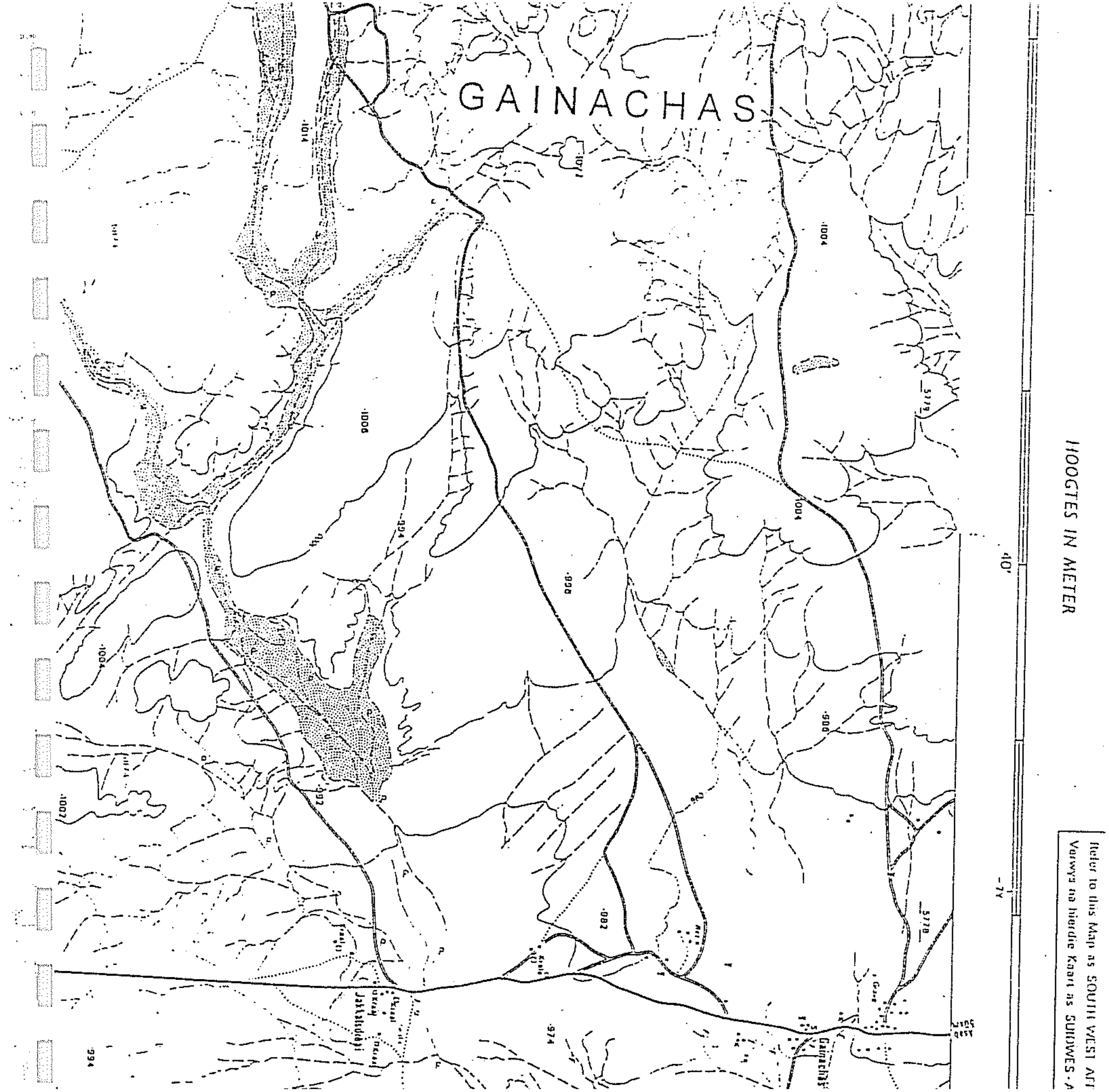
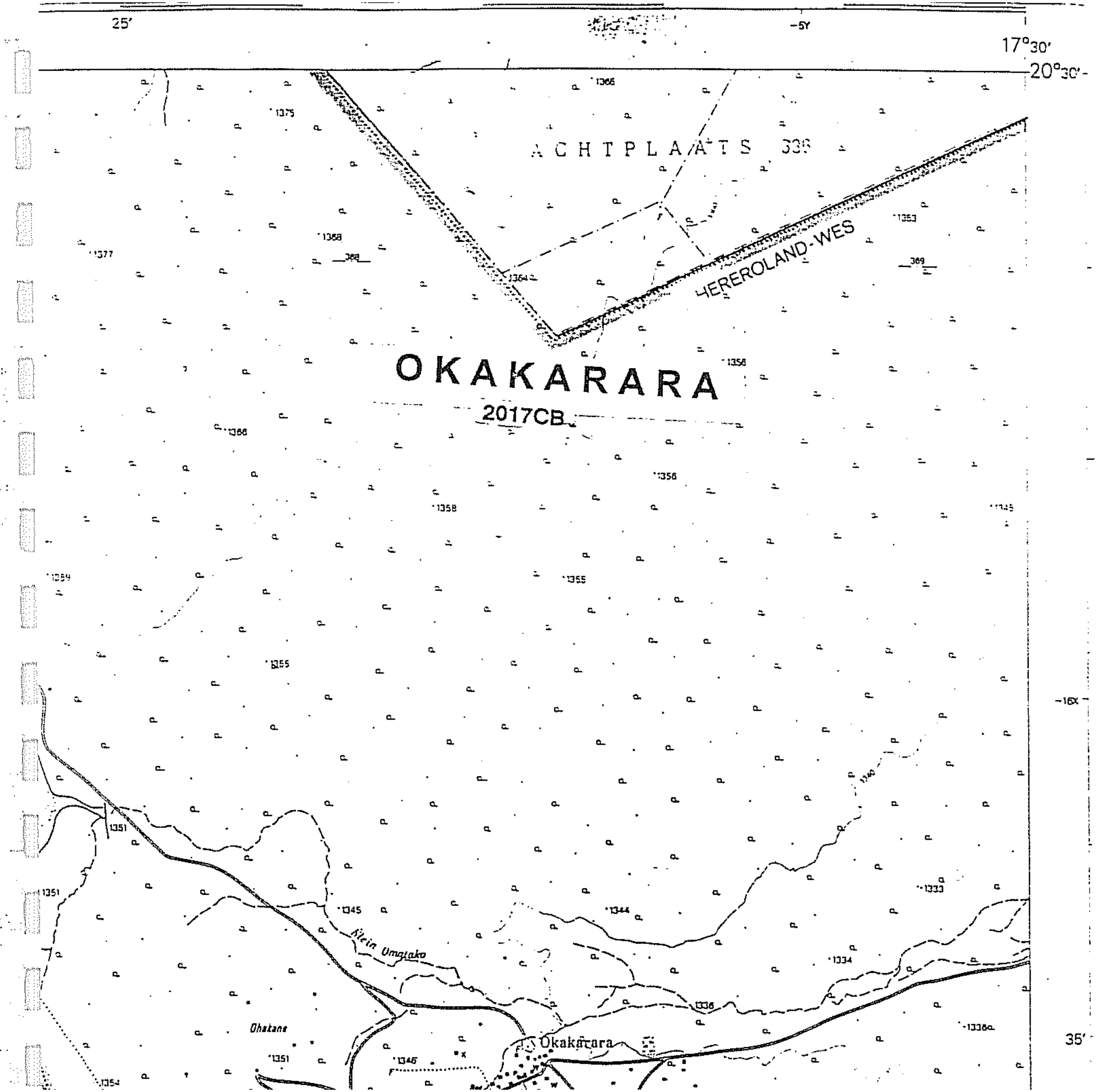


GAINACHAS
HOOGTES IN METER
Refer to this Map as SOUTH WEST AF
Verwys na hierdie Kaart as SUIDWES-A
Gainachas


25'
17°30'
20°30'
ACHTPLAATS 338
HEREROLAND-WES
OKAKARARA
2017CB
1375
1366
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1368
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1364
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1344
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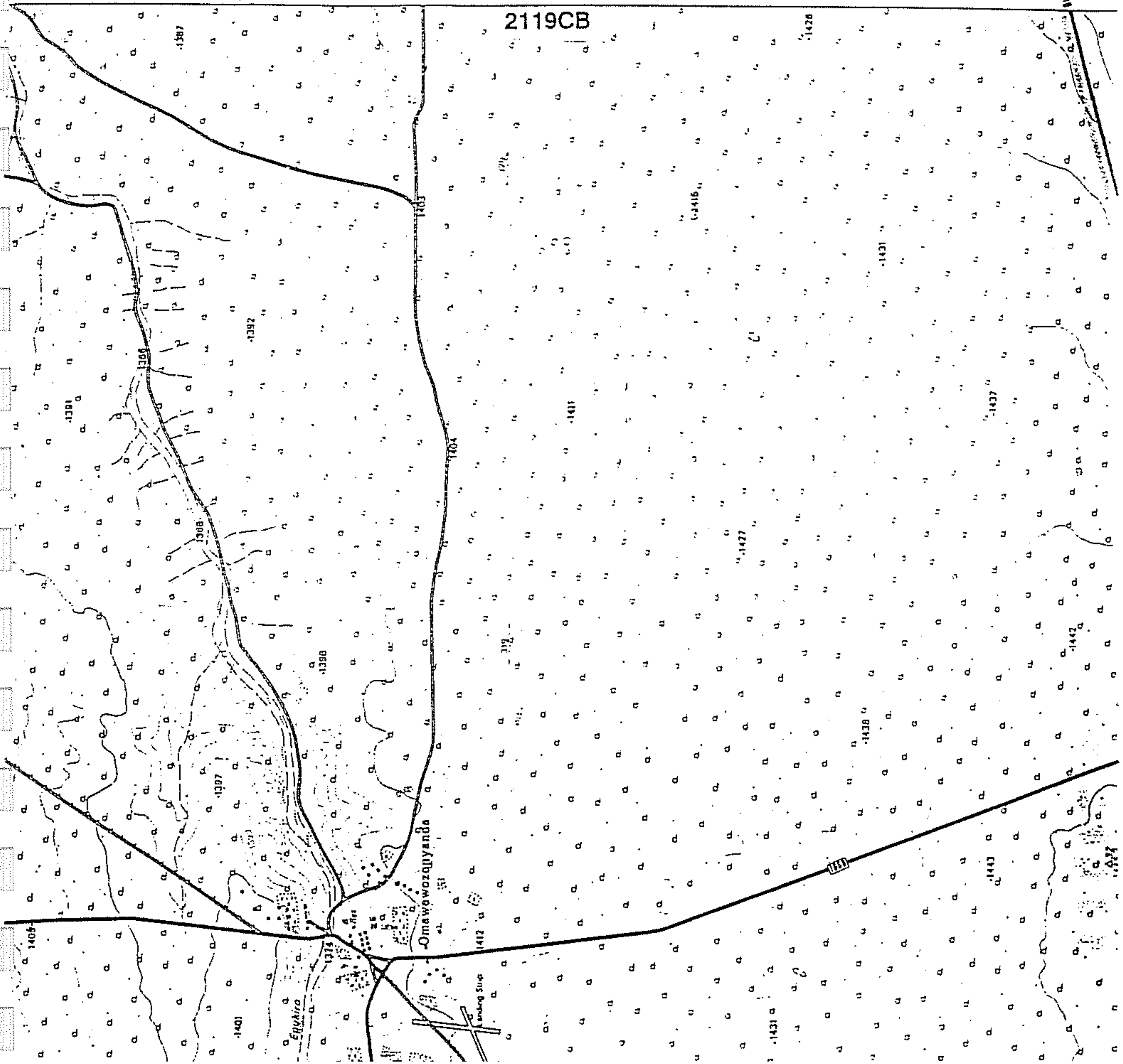
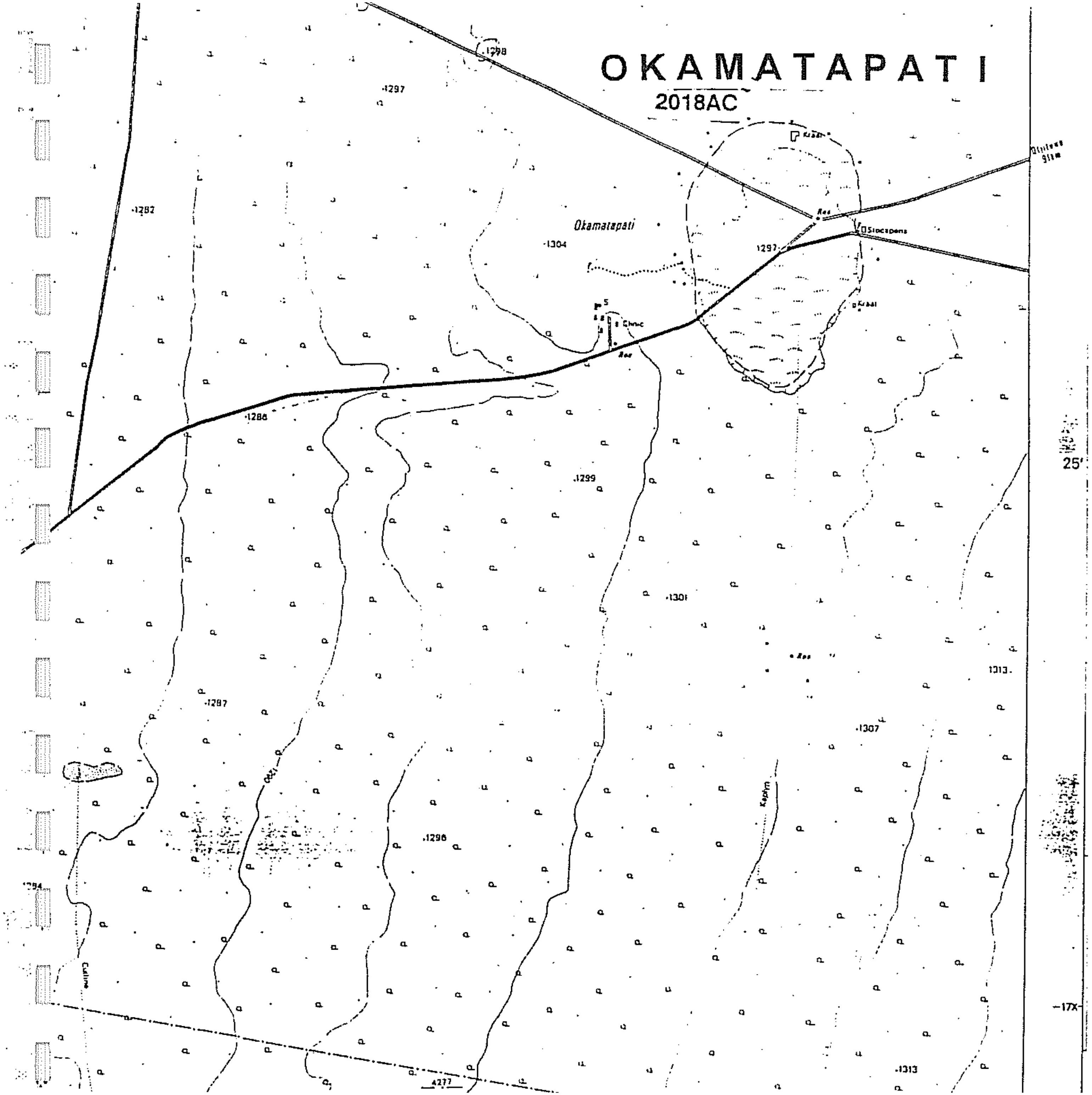
1336
1338
Klein Omatako
Ohakane
Okakarara
1346
1354
35'

OMAWEWOZONYANDA

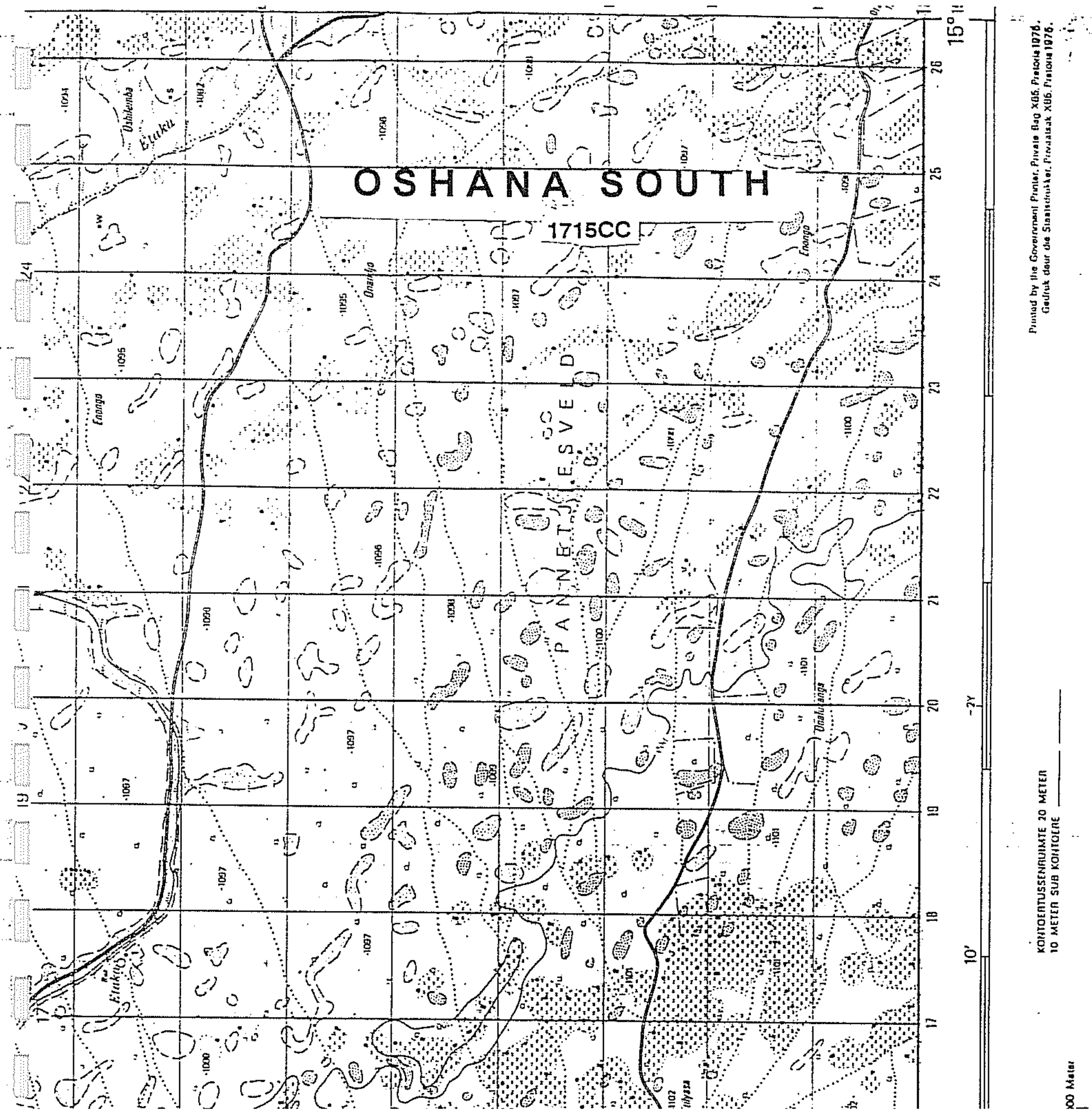
35'

2119CB

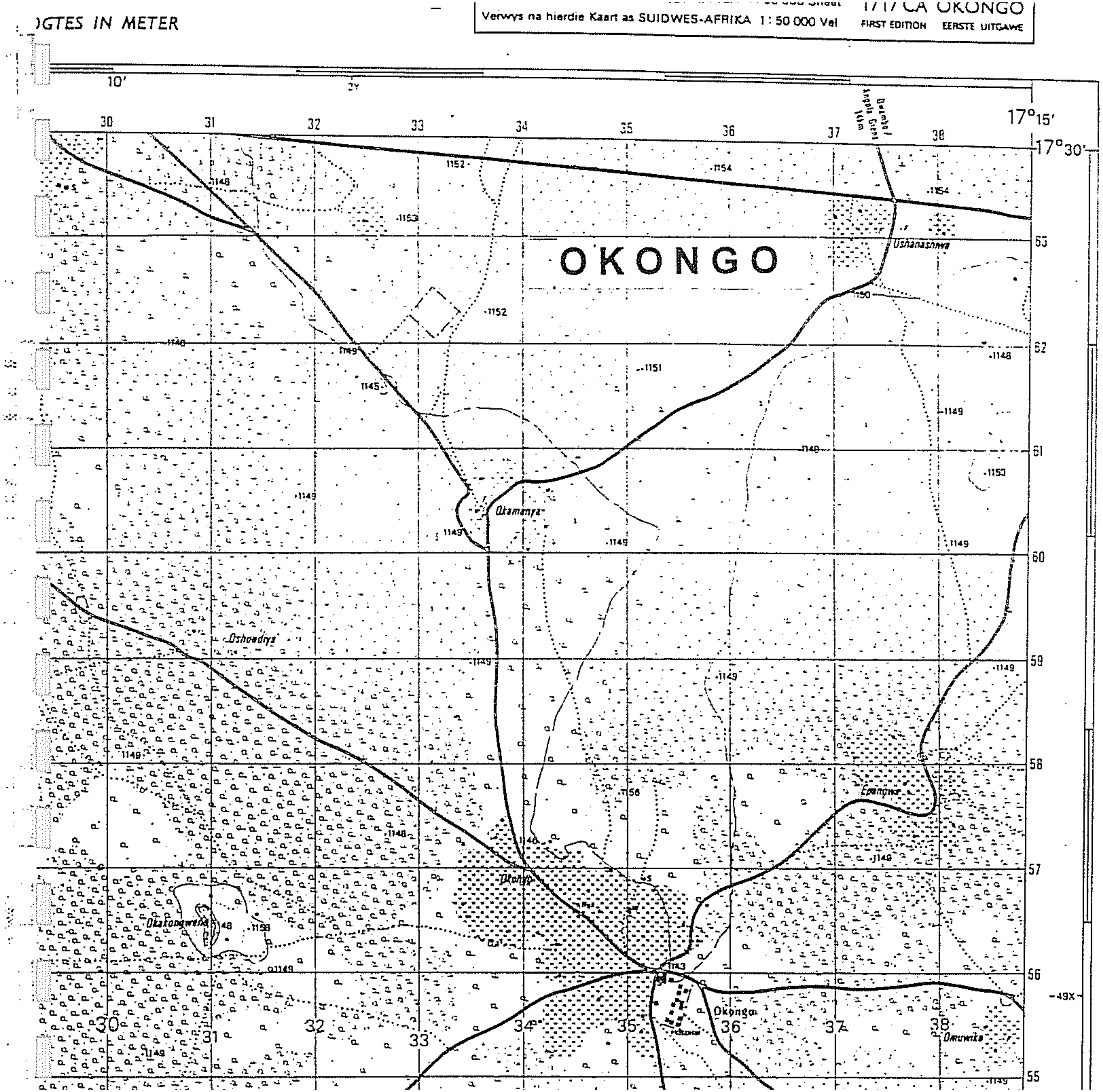




OKAMATAPATI
2018AC
Okamatapati
Kraal
Res
Stockpens
Clinic
1298
1297
1282
1304
1288
1299
1301
1313
1307
1287
1296
1294
25'
17X



OSHANA SOUTH
1715CC
PANNETJIESVELD
Etaku
Enanga
Onalulanga
15°
10'
Printed by the Government Printer, Private Bag X85, Pretoria 1976.
Gedruk deur die Staatsdrukker, Privaatsak X85, Pretoria 1976.
KONTOERTUSSENRUIMTE 20 METER
10 METER SUB KONTOERE


OGTES IN METER
Verwys na hierdie Kaart as SUIDWES-AFRIKA 1: 50 000 Vel
1717 CA OKONGO
FIRST EDITION EERSTE UITGAWE
10'
17°15'
17°30'
OKONGO
Ushanashiwa
Okamenya
Oshoediya
Epangwe
Okahyo
Okakongwena
Okongo
Omuwika
30
31
32
33
34
35
36
37
38
63
62
61
60
59
58
57
56
55


Hoachanas
Gibeon
Guchas