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VOLUME THREE

The Northern Zone, Lake Chad Basin Environmental Health Assessment

THE NORTHERN ZONE, LAKE CHAD BASIN ENVIRONMENTAL HEALTH ASSESSMENT

(BOL POLDER PROJECT AREA)

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1. INTRODUCTION

The Bol-Polder Project represents the principal focus of economic development in that vast region of central and northern Chad lying between the capital city (N'Djamena) and the Lybian border. The Project represents an extension of traditional attempts at agricultural exploitation of peripheral bottom-land of Lake Chad. Eventually, sufficient land may be developed near the town of Bol to constitute a significant contribution to the Chadian economy and to employ numerous local farmers. Many other Chadians will benefit from secondary employment generated by the Project.

"Polder" is adapted from a Dutch word coined to describe diked farm-land claimed from the sea. Land-form in the Bol region presents certain unique advantages for construction of polders in that numerous elongated islands project into a large shallow lake. Thus, a few short dikes serve to isolate large polder areas. Once isolated, the impounded region is pumped dry in order to expose the extraordinarily fertile soil that covers the bottom of Lake Chad. Although rainfall is minimal, water for irrigation is readily available from the Lake. These advantages are offset by the difficulty of maintaining the polder, once constructed. Problems of drainage and salinization have

made useless all but a small portion of land already empoldered. The objective of the Project is to apply modern techniques to prevent such loss of land, to permit reclamation of lost land and to facilitate construction of new polders. Particular care is taken to insure the well-being of local residents.

Millet, the basic crop of the region, is grown on the sand dunes typical of the Sahel. It is planted in May and harvested in October after the periodic rains have ended (Exhibit 1). Supplementary crops, as vegetables and corn, are grown at receding borders of the Lake and in the numerous small wadis of the regions. When the water-table is within 2 meters of the surface, small parcels of land may be irrigated manually using the counter-weighted bucket known as the "shadoof". Cattle are pastured in the narrow transition zone between the dunes and the Lake and in wadis. Goats are raised on the dunes and fish harvested from the Lake. Polders are a natural development of this system, representing conversion of receding lake line into large permanent wadis.

More than 50 polders have been constructed in the Bol region beginning before the present century. Originally, local authorities organized groups of prospective farmers

into teams for the building of dikes, and such participation was rewarded by assignment of parcels of land in the new polder. Dikes were constructed of parallel wicker walls filled with sand and polders were pumped dry by means of shadoof. Various technical and social factors eventually forced abandonment of most of these farms and the land reverted to rearing of cattle.

The modern era began in July 1950 when the new Postmaster of Bol recommended that the central colonial authorities supervise construction of dikes to empolder 3000 additional hectares. Tchingam Polder near N'guela was the first constructed. The general plan followed the traditional idea that those who constructed the dike would be repayed with shares in the farmland that resulted. Generally about 200 men would work for about a month using the simplest of hand tools. Because wicker supporting walls rapidly failed, the dikes soon dissolved. Steel reinforcement was, therefore, incorporated into some of the new structures. Guini, No, Baga-Sola, Djiboulboul and and Berim polders appeared during the next few years, and by 1954, there was great optimism for the 6 extant polders incorporating nearly 4000 hectares of productive land.

Unfortunately, the entire system of dikes was virtually

destroyed between 1954 and 1957 by flooding due to unusually high levels of the Lake. The system of rewards that sufficed for initial construction of polders failed to insure maintenance. Brief experiments with hired labor and tenant associations were no more successful due to lack of capital. At the time of independence, in 1960, the system remained in disarray.

During the post-colonial decade of the 1960's, central authorities provided capital for hired labor on the polders using the proceeds of a flour mill constructed in the capital city. Flour was sold on the open market and revenue was converted into foodstuff to pay the dike workers. In this manner, about 6000 hectares were reclaimed by 1970.

The entire polder system was reconsidered in 1972 and a comprehensive report made available recommending that the "California System" of irrigation should be instituted. The principal of this system requires that irrigation water enter the polder by gravity and be removed by pumping. Water is distributed in concrete lined channels and pipes and drained by a series of ditches and earth-lined canals. The traditional system of small peasant farms would be augmented by hired labor and directed by skilled agriculturalist. The system is intended to produce two cash-crops each year; wheat and cotton

will alternately be grown on the same land (Exhibit 1).

This basic system of peasant farming is labor-intensive and requires that large human populations reside close to their polder farms. People who provide secondary services, as mechanics, merchants and administrative personnel, will concentrate in communities nearby. Accordingly, many thousands of people will become vulnerable to any hazards to the public health that may be generated by the system. The objective of the present study is to begin to assess these dangers and to recommend measures for surveillance, prevention and control of such problems that appear.

2. PHYSICAL DESCRIPTION OF THE BOL POLDERS REGION

2.1 BIOTOPES

Progressive wet and dry periods throughout geologic time reduced the great Paleochadian Sea from its initial Pleistocene size (when it extended over an area of some 350,000 km2 in what is now southern and central Chad, eastern Niger, northeastern Nigeria and northern Cameroon) to the relatively shallow, weed-choked puddle of today. The recession of waters in Lake Chad has been particularly visible during the present century, and within the last 10 or 15 years fluctuations in the Chari River and the recent drought have combined to reduce the area of the lake by as much as a third.

2. The present configuration of terrain in the Bol area of the lake can be separated into 4 principal biotopes:

a. Dunes. Long, narrow sand dunes oriented northwest to southeast support a low steppe vegetation. The dunes continue into the lake as an archipelago of sand islands. Dunes near the lake and islands on the lake may have smaller ponds on them.

b. Lake. Lake Chad is relatively shallow, averaging in open water only 4 to 5 meters in depth although greater depths (11 meters) are reported in the Bol area.

c. Fringe vegetation and floating islands. The mainland and the islands are fringed by a community of reeds (*Phragmites*),

papyrus (Cyperus papyrus), cattail (Typha), leguminaceous trees, and sedges. Smaller plants include water lettuce (Pistia stratiotes), duckweed (Lemna), and water weed (Ceratophyllum demersum). This community, dominated by papyrus, also breaks off into floating masses of vegetation or floating islands which in many places effectively block water access from one island to the next. It is correct to call the fringe community an interface between lake and dunes.

d. Polders. These are man-made additions to the biotope types. A polder is land reclaimed from the lake and protected from inundation by dikes. The two main polders in the Bol area are Guini and Berim. They support many of the plants that occur in the fringe community on the lake, and also characteristic introduced trees dominated by Eucalyptus.

2.2 CLIMATE AND WATER-TABLE OF THE POLDER REGION

The climate of the Bol region (30° 20 N) is strongly desert-like. Total precipitation is less than 300 mm per year and is essentially restricted to the period July - September (Exhibit 2). Even during the wettest month (August), precipitation is measurable only 1 day out of 3. This rainy period just precedes the period of maximum relative humidity. September is most humid with 5 AM readings averaging nearly 90%. During the period November through April, 5 AM readings range around 50%. Winds are moderate, and of constant strength throughout 9 months of the

year. Some increase is noted during the rainy season. Northeast tradewinds which predominate during the winter (November to March), are reversed during the summer. These northeast winds, called "Harmattan", are dry and dust-laden due to the influence of the desert. The hottest days occur in April and May and the coldest nights during December, January, and February.

The level of the water-table is difficult to estimate and no systematic recordings are now available. Long-time residents of Bol estimate that the water-table in the Guini polder follows the level of the Lake, but with a delay of about 2 months. The flow of the Chari River is greatest in October (Bouquet, 1944) and this suggests that the level of the Lake must reach maximum levels soon after. Thus, the water-table is probably highest during December.

3. THE SURVEY STUDY AREA

The study area was comprised of Bol and eight outlying villages. Bol, the capital of Lac prefecture, is the administrative and commercial center of the region. The results of the household survey (Exhibit III) revealed it to be a melting pot of several tribes and dozens of sub-tribes derived from various regions of the country. The outlying villages were chosen as representative of the widest range of levels of development and degree of involvement with the existing polders (Guini and Berim). Matafo Ancien and Matafo I were selected as representative of traditional villages fully involved in polder farming and at the upper end of the limited development scale. Tala I and Tala II were chosen as representative of traditional villages at the lower end of the development scale and having no contact with the polders. Lafia Kafia and Moun-Dagami represent a mid-point on the development scale with some involvement in the polders. Yakoua and Mamdi are island villages whose economies are based more on fishing than on farming and which have no direct contact with the polders. Both will eventually be joined to the mainland by Mamdi polder, which is projected for the future. All of these villages lie within a radius of 10 kms. of Bol and are located on sand dunes. Virtually all closed structures in villages outside of Bol are traditional, hemispherical grass-thatched huts ranging from

3 to 6 meters in diameter with one opening - a doorway, usually about 80 cm wide x 120 cm high, facing west. No vent for exhausting smoke is provided. The sandy floor is at least paritally covered by woven-reed mats. As often as not, cooking is done in the main hut over an open charcoal or wood fire with 3 upturned earthen pots serving as support for an aluminum or earthen cooking pot used to boil "boule" - a gruel made from ground millet and baked in the sun. Usually tea is boiled in an enamelled teapot over charcoal placed in a wire hibachi. Cooking utensils are limited to grinding stones, a wooden mortar and pestel, a cooking pot or two and a stirring stick or ladle. Water is carried from the source (Peace Corps pumps in half of the villages studied and dug wells for Tala I, Tala II, and the lake for Yakoua and Mamdi) in fired clay jugs, the profile shaped like a narrow lyre. These jugs, which hold 10-15 liters, are stored on the sand inside the huts and covered.

Beds are framed with either wood or wicker and are raised about 0.5 meters above ground. Virtually every person interviewed claimed to habitually sleep under mosquito bars, some of which are made of thick flour-sack like material. These would seem also to be effective filters against dust but must cause discomfort due to reduced circulation of air. Certain persons sleep on

woven mats laid out on the sand floor of the house. The population of the villages studied ranged from about 100 in Tala I and Tala II to about 400 in Matafo I. The number of families ranged from around 30 to over 100 per village. No attempt at a direct count was made because of limited time. Except in Yakoua and Mamdi, the main occupation was farming and animal husbandry. Although there were no obvious signs of starvation, the quantity of stored grains appeared to be very limited. Doum palm nuts which are a much less desirable food than millet were stored in large quantities in Tala I and Tala II. This suggests that these inhabitants may anticipate famine.

Three natural factors - sand, sun and dryness - aided by the practice of defecating outside the village limits and effective sweeping of compounds and burning the limited trash, maintain an acceptable level of sanitation. The recent introduction of Peace Corps drilled wells and pumps appears to be the most practical additional public health measure which can be taken where such pumps do not yet exist. Continued maintenance of these pumps should be assigned maximum priority among whatever services are to be provided in the future.

4. THE WORK OF THE TEAM

Scope of work

The objectives, as stated in the APHA's instructions on March 3, 1977 were:

- To identify the major endemic disease problems in the Bol, Moussoro and N'Djamena areas of the Republic of Chad.
- To identify the relevant environmental factors responsible for disease transmission.
- To assess any existing programs or plans with environmental health significance.
- To make recommendations and develop alternative proposals for any further surveys, projects or control programs complimentary to those planned or in existence, including essential health infrastructural requirements for maintaining and improving the health status of the communities particularly those within the rural development project areas.

Upon ASID/Chad's request and with AID/Washington's agreement, the areas of Moussoro and N'Djamena were deleted from the scope of work.

Briefing

The team assembled for briefing and team planning at APHA and AID H.Q.s in Washington, D.C., from 15 to 18 March.

Further briefing took place at N'Djamena (Chad) AID office. 22 to 26 March. During this period of time contacts were made with local authorities and technical organizations and additional informations gathered.

The Survey

The survey was conducted in Bol and in its surrounding area including Matafo, where the polders agriculture development project station is located and in a number of nearby villages during the period March 28 to April 12. Contacts were made with the local authorities, the SODELAC project management and the "Lac" province health service.

Mission Report

The report was drafted at N'Djamena from the 13th to the 20th of April. During that period, meetings were held with the Ministry of Health and SODELAC.

Note: Two members of the Team, Curt Schneider, and Andrew Speilman, left the Chad on April 16th. Joe Haratani and R. Mark Malan remained in N'Djamena until April 20th in order to complete the final report.

5. **CONTACTS MADE AND PERSONS INTERVIEWED** (listed in chronological order)

N'Djamena

Mrs. Sudie McGahuey (AID)

Mr. Jack Nixon (AID)

Mr. Jack Morris (AID)

Mr. Raymond Fontaine (AID)

Dr. Tahirou Bana (WHO Repre.)

Mr. G. Baguidi (WHO sanitary engineer)

Dr. Andre Delas (WHO epidemiologist)

Dr. Cheneau (FARCHA veterinary service)

Dr. N'Dokadje Laoundole Doumtabe, Director of Health

Dr. F. M. M'Baitoubam, Studies and Professional Training

Mr. Guidingar Kamougue, Director of SODELAC

Mr. Mathieu, Geologist/ORSTOM

Peace Corps Staff

Medical General Roussillon (FAC)

Bol

Mr. M'Baipoutoum, Prefect of the "Prefecture du Lac"

Dr. Jean-Pierre Dompnier, Chief Medical Officer of the Lac Province

Mr. Jean Rabes, Manager SODELAC agriculture project

Sultan Adoum Gaspar, Chief of Bol "canton"

Dr. Favier, Grandes Endemies, N'Djamena

6. THE HEALTH SITUATION

6.1 THE POPULATION OF THE TOWN OF BOL

Bol, a typical urban development of some 4,000 inhabitants, made of adobes and straw huts, and located on Chad Lake 6 kms from the SODELAC agricultural project, is the main town near the polders.

The people of Bol, contrary to the statement one encounters in a number of reports that the lake population consists mainly of Kanembous and Boudoumas, present a mosaic of races and tribes from various parts of Chad and also from neighbouring countries.

In order to get a better knowledge of this melting pot of races which bring with them their culture and the pattern of diseases of their areas of origin, the team surveyed the inhabitants of 106 households, covering approximately 10% of the town's population. In the course of the survey members of the team interviewed either the head of the family or his wife, and carried out a cursory medical examination in a number of cases. 62.4% of the dwellers surveyed, due to the timing of the visits, happened to be females; 37.6% males.

The ethnic composition of the 106 persons visited was as follows:

Kanembou	
(from 13 different sub-groups)	49
People from South Chad	
(12 Sara Sub-groups)	24
Boudoumas	
(4 sub-groups)	17
Arabs	6
Gourane	
(from North Chad)	4
Baguirmi	
(Sara-Arab, cross breeding N-E of N'Djamena)	3
Nigerians	3
	106

The migratory nature of the population was further stressed by finding that some 70% of those interviewed (approximately 71% women and 69% men) were born in areas more than 20 kms from Bol. It was further shown that 18.8% of them had spent less than one year in that town, and 26.4% from 1 to 5 years. The break-down in age groups of those interviewed revealed that 84% of the men were between 15 and 45 years of age, only

13.2% were over 45.

Inquires about the occupations of those interviewed provide the following information:

farmers or farm laborers	21
housewives (some of whom also work in the fields)	54
merchants	4
masons (SODELAC workers)	4
prostitutes	5
marabouts	3
teachers	2
tailors	2
male nurse	2
watch repairmen	1
boatmen	1
ex-military	1
governmental administrator	1
cabaret owner	1
goat herder	1
servant	1
fisherman	1
no occupation	2
	106

Keeping in mind the limited size of mud and straw huts, although one family may own 2 such dwellings, houses may be considerably crowded with an average occupancy of 4.12 persons.

It proved impossible to assess the level of divorce. For one thing one can hardly draw a line between marriage separations and divorce cases, since divorces seem to be a very simple procedure and very few couples contact the Chef de Canton for that purpose. The impression was, however, that the number of divorces is high and increasing. It was equally difficult to assess the extent of polygamy although 5 cases of it were reported during the survey.

Hygienic conditions of the households are dealt with in another section of this report. Suffice to say here that the upkeep varied greatly and that some households were remarkably clean, had screened windows and no fly problem. The prophylactic value of the water pumps installed by the Peace Corps in the streets of the town is impressive.

6.2 THE MAJOR ENDEMIC DISEASES OF THE BOL PREFECTURE

In order to avoid repetition, with regard to the major diseases of Chad, reference is made to Dr. .. Barkhuus' "Report on Chad Health Services" (APHA, January 15 - March 20, 1976) and to WHO's "Epidemiological Surveillance" Report of the Regional Director for Africa (6 August 1976).

The statistical data on the following pages are reported by the chief medical officer of the "Prefecture Sanitaire" of Lac Chad (the province of Bol) in his annual report for 1976.

Note figures provided directly by the Prefect of Bol reported the population to be 100,000 and the size of the province to 25,000 km2.

Monthly number of persons seen by Bol Medical Center and its six rural sub-centers during the year 1976

T A B L E A U No. I

NOMBRE DE CONSULTANTS PAR DISPENSAIRES ET PAR MOIS

	Janv.	Fevr.	Mars	Avr.	Mai	Juin	Juil.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Bol	1355	729	911	1188	1007	1072	890	784	824	729	811	1161	11.421
Ilsseirom	312	464	218					467	303	466	442	273	2.945
Kouloudia	235	613	431	471	364	391	341	414	294	489	438	371	4.852
N'Gouri	674	889	661	767	638	554	595	746	463	900	744	576	8.207
Bagasola	419	1095	832	566	638	504	633	873	681	959	446	639	8.285
Liwa	465	650	818	639	670	569	480	529	452	682	654	579	7.187
Doum-Doum											845	736	1.581
Total	3460	4440	3871	3631	3317	3090	2899	3813	3017	4225	4380	4335	44.478

Monthly statistical figures of the main diseases reported by Bol Medical Center to the Ministry of Health for the year 1976. They cover equally the cases of disease reported to Bol by its 6 rural sub-centers.

TABLEAU NO. 2

	Jan.	Fev.	Mars	Avr.	Mai	Juin	Juil.	Aout.	Sept.	Oct.	Nov.	Dec.	TOTAL
Paludisme	158	261	138	278	118	163	184	273	231	406	330	253	2.792
Diarrhee	340	509	333	437	211	268	184	354	294	336	468	443	4.177
Aff. Broncho-Aigues Pulm.	174	348	414	214	124	101	108	189	164	288	286	286	2.698
Aff. Gono.	182	121	112	208	63	177	123	138	86	136	143	173	1.662
Bilharzoise Visicale	95	100	70	95	35	59	80	87	41	58	60	55	665
Tuberculose	4	4	2	5	4	3	3	12	1	8	3	1	50
Syphilis	162	115	100	114	60	58	122	144	62	106	129	108	1.280
Amibiase	23	30	26	32	7	35	25	20	6	13	19	27	263

Monthly Health Report of Bol Chief Medical Officer for the month of February 1977 (report addressed to "Direction de la Sante. Service des Grandes Endemies. N'Djamena").

Disease	Cases	Deaths
Tuberculosis	4	1
Syphilis (recent)	62	-
Gonorrhoea	117	-
Typhoid	-	-
Other Salmonelloses	-	-
Amoebiasis	27	-
Dysentery (bacillary)	-	-
Scarlet fever	-	-
Diptheria	-	-
Whooping Cough	1	-
Meningitis	1	-
Leprosy	1	-
Tetanus	-	-
Anthrax	-	-
Poliomyelitis	-	-
Smallpox	-	-
Measles	-	-
Mumps	4	-
Infectious Hepatitis	14	-

Rabies	-	-
Typhus and other Rickettsial Diseases	-	-
Malaria	218	-
Urinary schistomiasis	57	-
Intestinal schistomiasis	2	-
Onchocerciasis	-	-
Ancylostomiasis	1	-
Dracunculiasis	-	-
Recurrent Fever	-	-
Yaws	1	-
Chicken Pox	-	-
Dengue	-	-
Trachoma	5	-
Cutaneous Leischmaniasis	6	-
Trypanosomiasis	-	-
Influenza	-	-
Pneumonia	25	-

Information collected during the household survey suggests the following:

Infants and children seem commonly to be affected by gastroenteritis. Indiscriminate and above-ground defecation, faulty personal and food hygiene, crowding of dwellings and the large fly population apparently play an important role in this problem. To make things worse, multiple infections by different agents in the same person blur the picture of diseases making diagnostic assessment considerably more difficult. The figure of 20 children reported dead in the first year of life seems to be consistent with the high rate of infant mortality in Africa. Nutritional problems, a considerable proportion of which may be addressed by appropriate educational action, loom large in the picture. Children of two years were seen still breast feeding. Cases of Kwashiorkor are said not to be rare. Malaria was reported by a majority of the persons interviewed. Residents pointed out that people suffered from the disease mostly during the rainy season. This fact which seems to be supported by the negative results of blood examinations made by the team and concurs with the low prevalence of malaria during the time of the survey. However, the fact that the medical officer of Bol reported 218 cases of malaria for the month of February, 1977, points to the need of further investigations.

Three persons appeared to be affected by pulmonary tuberculosis. The team came across six cases of conjunctivitis, a clear case of leprosy, two frank cases of mental illness, three histories of otitis, two cases of blindness. A few cases of hepatitis, gonorrhoea and meningitis were

also reported. No case of goiter was observed. Most of the persons interviewed bore facial tribal scars. In this connection, the medical officer of Bol reported of a young girl who was cut too deeply and bled to death. Among the Sara ethnic group, the practice of extracting the two lower central incisor teeth at the age of 12-13 years is still practiced. Two such cases were seen. The dental health of the persons examined was on the whole good and no outward signs of starvation were detected.

6.3 THE INFRASTRUCTURE OF THE HEALTH SERVICE OF BOL PREFECTURE

The health services of the prefecture of Bol includes a medical center, located in Bol, and six dispensaries located in major villages in the prefecture. The medical center consists of the following:

a) concrete structures: a 27 bed hospital pavilion. A small surgery, a delivery room, a laboratory, an X-ray room, a treatment room, and an isolation department for tuberculosis patients.

b) mud brick structure: a doctor's office; a pharmacy store room.

c) straw hut: a kitchen for the patients.

The Center is presently staffed by a French doctor on a one-year contract as an alternative to French military service, one registered nurse, one technician, seven licensed male nurses, a traditional midwife, three orderlies, a male secretary and a cook.

The six dispensaries located in major villages of the prefecture are each staffed by one or two licensed nurses and an orderly.

As reported in the chief medical officer's annual report, 11,421 persons were seen at the Bol medical center in 1976, and 33,057 at the six dispensaries.

Four Protestant missions contribute to these services at Tatveron, Aikoulou, Magui and Kingeria.

In addition to regular curative services, the medical center has weekly neonatal clinics and a monthly well-baby clinic.

The shortcomings of the system

The medical system in Bol experiences the same problems that affect the entire national system: lack of proper drugs and medicines for treatment, lack of basic equipment; almost complete lack of preventive health education.

The use of a helicopter for the evacuation of emergency cases to N'Djamena hospital has been discontinued. The inadequacy of transport facilities hinders the doctor's visits out into the province.

There is only one microscope in the whole province. The work of the laboratory is limited by lack of adequate facilities and personnel to perform the following tests:

- sputum examination (detection of tuberculosis)
- stools examination (ascaris, amoeba)
- urine schistisomiasis
- blood (malaria)

The dispensaries, none of which has a microscope, send sputum from suspected tuberculosis cases to the Bol laboratory for analysis. Urinary schistosomiasis is diagnosed without microscopic examination and is based on evidence of blood in the urine.

No serological tests are used for the diagnosis of syphilis which is claimed to be a growing public health problem in Chad (12,348 cases reported for the year 1975). Diagnosis is symptomatic as is that for diagnosis of malaria.

The mobile team of "Grandes Endemies", the backbone of preventive medicine activities which was established by the French administration in 1925 for the control of trypanosomiasis, has not visited Bol for the last 11 months. Under the circumstances, despite the remarkable diagnostic ability of the health staff, a considerable number of diseases are missed and the magnitude of public health problems cannot be adequately assessed. It is not surprising that the Ministry of Health lists under the category "other diseases", 143,213 of its reported 324,546 patients ("Releve annuel des symptomes et maladies des hospitalises, cas constates et enregistres dans les centres medicaux et infirmeries au Tchad en 1975").

Since there is neither a surgeon nor a dentist in the province of Bol, patients requiring such service must procure a place on the six-seat plane which comes from N'Djamena twice a week, or must travel the 300 km. of bumpy dirt road which connect Bol with the capital of Chad.

6.4 CONSIDERATIONS OF THE IMPACT OF THE POLDERS ON THE HEALTH OF THE POPULATION

Population

Negative Aspect

There is reason to believe that immigration to the Lake area is going to increase with the development of the polders project. Statistical figures supplied by the local authorities indicate movement of some 600 temporary and 400 permanent immigrants into Bol each year. On the other hand emigration is limited to some 150 persons, most of whom eventually return to the Lake area.

Immigration of larger numbers of people, especially from southern areas of Chad threatens to introduce intestinal schistosomiasis. In addition, the overcrowding may cause a worsening of diseases such as tuberculosis, cerbro spinal meningitis, hepatitis and venereal diseases. Cholera is also an ever-present threat. There was a recent epidemic in Chad in 1971 with 8,000 cases and 2,300 deaths reported in the country. Again, in 1973 there were 75 cases and 21 deaths in Kingeria (Lake province) and 104 cases and eight deaths in N'Djamena.

Positive Impact

The positive impact of the polders agricultural project should not be disregarded. The economic benefits of the operation is expected to improve the level of well-being of the people of this area and to have a favorable

influence on housing and nutrition. Ultimately it could positively affect the general level of education and personal hygiene. Equally, the economic development of the area should have a positive impact on public services, transport facilities and recreational opportunities, thus offsetting to some degree the negative impacts of urbanization.

7. ENVIRONMENTAL SANITATION, BOL

Despite the almost total absence of public services (i.e., piped water supply, sewerage and drainage systems, garbage collection, electric power, etc.) the level of environmental sanitation observed in the town of Bol during this visit (March 28-April 12, 1977) was surprisingly high, considering the local stage of development. Several key factors were seen to account for this fortunate state of affairs.

First, we must acknowledge the primary role of the climate. The torrid daytime temperatures and the extremely low humidity work together as an efficient, natural human-waste treatment system operating by rapid desiccation.

Secondly, due credit must be given to the cultural wisdom of the tribes who have traditionally inhabited this region. The practice of locating villages in the center of a sand dune rather than down along the lake and wadi banks represents by far the most important public health action any community in the area can take. The porous shifting sands act as an effective leaching system for receiving and disposing of liquid wastes.

Finally, one might deduce that the tribes in this region have survived the threat of certain diseases by reason of sound traditional sanitation practiced within the physical limits of the huts and compounds.

The non-working inhabitants spend most of the day out-of-doors under open-air shelters made of woven reed mats placed on raised wooden framework supported by poles. Most of the compounds visited during the house survey contained spacious open areas and nowhere does one experience the sensation of crowding within the living compound. Closed structures, both mud-brick and thatched, are used for only two purposes, to sleep in or to cook in. In a few instances a horse or a goat was found occupying a hut. Some of the compounds were grossly unkempt but these were offset by others where the yards presented a virtually sterile appearance. In numerous compounds, women were seen sweeping leaves, straw and other trash which were then placed in a pile or a dung pit and burned. Occasionally women were seen actually sifting the sand through loosely woven reed platters to remove foreign objects for disposal.

Human feces were apparent in none of the compounds visited. An occasional unformed stool was evident in the streets. However, standard practice of villagers was to walk to the edges of the village or down into the polder to the lake area to defecate. Evidence of defecation was present along this circumference of the village but due to the hot, dry climate it did not present an odor problem. The only exception to this practice was found along the west wall of the hospital compound where sick patients and

perhaps their attending family members relieved themselves. The walk to the lake through two long blocks of loose sand being impractical.

While no immediate dangers to the health of the inhabitants of Bol was observed during this study period, one must remember that the delicate balance of the traditional excreta disposal system can be lost overnight if the town were to be affected by an epidemic of diarrheal nature such as the cholera epidemic which was reported in the Bol area in 1971 and 1973. (Bol Site Report, Peace Corps, September, 1975). An epidemic of that type would quickly change one of the elements which makes the present excreta disposal system effective--the elimination of feces outside the physical limits of the town. During a diarrheal epidemic the streets and living compounds will of necessity become receptacles for feces, thus closing a gap in the transmission cycle and thereby presenting an imminent threat to the populace.

Although many people reported the presence of rats, only one rat trap was noted by us. The use of rodenticides was not reported nor was any evidence of its presence seen. Although no rats were observed in Bol, palm rats were occasionally seen scampering away in the outlying villages.

Bol can boast of very little in terms of the trappings of development making it an unlikely candidate as a watering spot. From a bare-bones health standpoint, it has several environmental and cultural factors in its favor

and it presents some interesting and positive possibilities for maintaining and improving public health as it continues to grow.

7.1 WATER SUPPLY

The traditional sources of drinking water have included the lake as well as open dug wells. Both are subject to continual pollution by people and animals. Either source could provide safe water if boiled or properly treated. However, neither of these alternatives are realistic within the limits of available resources and levels of technical competence now existing in the Bol area. Fortunately, a third and relatively safe source exists: the Peace Corps well.

The whole region in and around Lake Chad is underlain by an enormous reserve of sub-surface waters. Phreatic water is often encountered within a meter or two of the surface of the polders. An almost limitless supply of safe ground water is waiting to be tapped at greater depths.

Through some stroke of genius and luck, the Peace Corps has been supplying the manpower to operate a well drilling and hand-pump installation program in the Bol area. This program has been in operation since July, 1975 and has installed some 70 drilled wells equipped with hand pumps (Exhibit IV). The project employs two drilling rigs. Alternating five-man teams consisting of two Peace Corps Volunteers (PCVs), two Chadian counterparts and one Chadian cook travel from N'Djamena to the Bol area to man the drilling rigs.

A total of 180 medium depth (15 to 20 meters) wells are planned within this project. Each well and hand pump is installed at an approximate cost of CFAF 350,000 including all materials, equipment, salaries, transport, fuel and overhead.

The second phase of the project is the fielding of a well and pump maintenance team which services each installation once every 3-4 months. During the past year only one pump was found to be inoperative at the time of periodic maintenance. Ideally, at some point in the future, certain local residents should be trained to provide preventive maintenance and minor repairs to the pumps.

Bol cannot long remain with its present level of public services. Increase in the number of polder farmers will be accompanied by increase in the population of Bol, the local center of administration, commerce and public services. In the realm of water supply, the next step beyond hand pumps is necessarily a quantum jump to a piped water supply system. The fact that a pumped gravity system exists and operates at the Matafo research station places the construction of a similar if expanded system in Bol within the realm of immediate possibility.

Ponding of water was observed at most pump sites. This condition poses a continual threat of contamination of those aquifers not overlain by an impermeable layer of clay. In the case of the wells in the Bol area, inspection of soil samples from drilling operations confirmed the information

given by the Peace Corps and SODELAC drilling crews that only thin lenses of clay (up to 10 cm. thick) were encountered in the first 20 meters of drilling. Massive clay formations were usually not encountered until the 50 meter level. Under these conditions, the medium depth wells installed by the Peace Corps are subject to possible contamination by pathogens filtering down through the sandy soil.

Resultats analyses of well water sample in Bol and adjacent villages (region de BOL-TCHAD)

Stations	Conductivite umhos/cm a 25°C	Cl^-	SO_4^{2-} (1)	Na^+	K^+ (1)
ANCIEN MATAFO PC WELL	590	0,10	0,12	1,06	1,45
ORSTOM POMPE BOL	1615	0,77	2,30	9,30	1,85
BOL PC 1	2220	0,77	1,24	15,60	0,58
BOL PC 2	1964	1,19	1,60	13,20	1,30
BOL PC 3	1476	0,36	0,65	10,50	0,57
BOL POMPE HOPITAL	1076	0,32	0,36	7,00	0,23
MOUN PC WELL	260	0,35	0,25	0,32	0,16
LAFIA-KAFIA PC WELL	347	0,03	0,27	2,64	0,15
MATAFO II PC WELL	206	0,17	0,30	0,30	0,10
MATAFO STATION KITCHEN	631	0,05	0,53	2,72	0,55

(1): a titre indicatif

7.2 EXCRETA DISPOSAL

In Bol and in the outlying villages, the universal system for excreta disposal is simply disposition of feces out beyond the built-up limits of the town in those locations that afford enough screening for modesty. Young children, being less self-conscious than adults, do not bother to go into the bushes when nature calls. Although this system is lacking in aesthetics, apparently the hot, dry climate provides protection against sweeping epidemics of filth-borne diseases, at least during the dry season. How effective the system is during the rainy season should be studied and reported at a later date.

There are no models which can predict when, in the expansion and development of a town such as Bol, circumferential defecation becomes both offensive to the senses and dangerous to health. Certainly there are time and distance limits beyond which people will not walk to defecate. At present Bol contains just over 100 city blocks and it takes a maximum of five to six minutes to walk from the center of town to the closest defecation point.

Since Bol is bounded on one side by the Berim polder and another by the lake, any future expansion must take place mainly to the north along the road to Matafo and, to a limited extent, to the south-east along the road to the airport. Growth in the near future will cause Bol to grow in length but not much in width. Translating this in terms of present defecation habits, the pressures of time and distance may not be increased for some time.

What may happen, as the number and concentration of inhabitants grow, is that the fecal ring surrounding Bol will become offensive enough to motivate people toward another alternative. Hopefully, this would occur at or after the installation of a piped water system, making it possible for Bol to move directly from the bush to the flush toilet. If this does not happen, the only other alternative would almost be a step backward, proliferation of the offensive pit privy in the compounds.

7.3 PERSONAL HYGIENE AND FOOD SANITATION

With the immediate needs for a safe source of domestic water being resolved through the installation of Peace Corps pumps and the health threat from human excreta removed outside the village limits, the focus of attention in the transmission cycle of diseases shifts away from the physical environment and directs itself to the people.

As difficult as it is to implicate flies or dust in the transmission of specific diseases, it is doubly difficult to negate the role personal hygiene and food handling play in these cycles. The most direct method for transmitting excreta-borne diseases is the anal-oral route. The chances for anal-oral transmission where toilet paper is unknown and water is out of reach is maximized.

Observations made on personal hygiene and food handling habits during the house surveys revealed a wide range in levels of cleanliness. We watched in amazement as one of the interviewees bathed her baby in a basin of water as we queried her and dressed the child in a thin rag diaper covered by a pair of plastic pants. This was not the standard practice. It was the only incident of its kind. It may be of interest to note that her modest mud-brick house was also the cleanest and most orderly seen. Although we did not observe her food handling techniques, it would be quite safe to suppose that they would be exemplary within the limits of available resources.

From this peak, the level of cleanliness could only go downhill. Naked babies crusted with a mixture of sand, sweat and excrement were observed crawling in the dirt of some of the compounds. Many of the women merely went through the motions of rinsing out their food bowls and cooking utensils without the benefit of soap. "Boule de mille" was spread out in balls or chunks on woven trays to dry for hours in the sun, thereby attracting masses of flies. Often, foodstuff was seen stored on the floor of the huts or in gunny sacks and open containers making attractive targets for rats.

Two engine-drive grain mills were observed in Bol. The

charge for grinding a "kouru" of grain (equivalent to 2 kilograms) ranges from CFAF 15 for millet to CFAF 30 for corn. The shift from hand grinding of grains to machine grinding appears to be a matter of convenience for the housewives. It is not seen to have any direct impact on the sanitary aspects of food handling since the products of both processes are invariably cooked.

All in all, it appears that personal hygiene and food handling habits present a greater threat to health than do water supply or excreta and solid wastes. There is a definite need to provide information about alternatives to present practices.

8. MALARIA

8.1 POTENTIAL VECTORS OF MALARIA

Seven species of Anopheles have been reported from Central Chad (Cano + Marcos, 1971). Two of these, A. gambiae and A. funestus, are dangerous vectors of malaria. Another pair of species, A. pharoensis and A. coustani, are less efficient and the remaining, A. wellcomei, A. rufipes, and A. squanosus are generally considered to be of little public health importance.

A. gambiae populations may be extraordinarily efficient vectors. However, the problem of estimating vector potential is greatly complicated by certain peculiarities of the structure of populations. At least four biologically distinct, reproductively isolated, yet morphologically indistinguishable populations carry the name "A gambiae" (White, 1975). Each may be distinguished by such sophisticated means as cross-mating experiments, analysis of polytene chromosones or isoenzyme analysis. Only two members of the complex are potentially important in the transmission of malaria. Both are highly competent hosts for the malaria parasite, are highly anthropophilic, long-lived and feed frequently. Transmission may be sustained when the density of A. gambiae is such that the average person in an area is bitten less often than once a month (Macdonald, 1959). Higher densities will produce explosive outbreaks of

disease (Bancroftian filariasis and O'nyongng-nyong fever as well as malaria). More than 10% of adult A. gambiae may be carrying sporozoites (Gillies and Dr. Mellon, 1975).

A. funestus is nearly as effective a vector of malaria as is A. gambiae. It may be even more anthropophilic. However, sporozoite rates are generally somewhat lower rarely exceeding 5%.

Because A. pharoensis is predominantly zoophilic and short-lived it is relatively unimportant as a vector of human disease. However, it is a proven secondary vector in Egypt. A. coustani is even less anthropophilic. Although occasional malaria infections may be transmitted by this mosquito, vector efficiency is probably inadequate to sustain transmission. (Hamon and Mouchet, 1961).

No previously gathered information on the mosquito fauna of the Bol area is known to the environmental assessment team. Accordingly, a general survey for mosquitoes was performed by means of "dipping" for larvae, "spray-catches" and "man-biting catchers" for adults.

8.2 BIOLOGY OF POTENTIAL VECTORS

A. gambiae breeding is largely a function of human activity. Recently created, sun-lit pools, as borrow-pits, hoof-prints and tire tracks are rapidly exploited by this insect. Opportunity for breeding is provided wherever the water-table is close to the surface of the ground and vegetation is sparse or low. Flooding of once-irrigated farm-land for example, may create vast breeding sites during the period that plants are sprouting. Once emergent vegetation is high, breeding is restricted to the margins of the flooded area. In addition, the larvae are found breeding in more permanent pools, irrigation ditches and marsh situations. However, such stable situations generally support only sparse breeding due to the opportunity provided for slowly-developing predators.

A. funestus exploits larger breeding sites that are more or less permanent. Swamps, margins of lakes and ditches are characteristic sites provided that emergent vegetation is abundant, that there is moderate (but not dense) shade and that

the water is free of salt (less than the equivalent of 0.2% NaCl). Stability is an important requirement, because, once eliminated from a region, the species is slow to reinvade. Around the edge of Lake Victoria, Haddow (1942) reported that breeding depended upon seasonal flooding of the coastal swamps outside of the papyrus belt.

A. pharoensis is primarily a species of large vegetated swamps. Papyrus seems to be a indicator plant, but breeding occurs outside of the papyrus itself. Larvae are commonly abundant in the dense floating vegetation that surround these mats. The species may tolerate brackish water salinity levels as high as 0.5%.

A. coustani exploits relatively permanent natural bodies of clear water where emergent vegetation is abundant. Neither shade nor salinity appear to be limiting factors.

A. wellcomei breeds in well-vegetated swamps. Larvae tend to ascend emergent vegetation when disturbed, rendering then difficult to collect.

A. rufipes is found in all kinds of water provided that the surface is not totally obscured by shade.

A. squamosus exploits a variety of aquatic sites provided that vegetation is abundant. This species, characteristically, becomes abundant toward the end of the rainy season.

8.3 VECTORS DISCOVERED DURING THE SURVEY

Abundant larval A. gambiae were discovered breeding in the shallow, sun-lit pools near Bol formed during the manufacture of adobe bricks. This area appears to be the most prolific source of A. gambiae anywhere in the region. At least a dozen of these pools were sampled and several hundred larval and pupal A. gambiae were collected. Although immature Culex pipiens-quinquefasciatus, were abundant, no other mosquitoes were present.

Larval A. gambiae were occasionally abundant in the disused drainage ditches in Guini Polder. Due to the present temporary absence of irrigation water, these ditches had dried except where the water table had intersected. At least seven pools thus formed, contained immature A. gambiae and C. pipiens. Larger, weed-choked pools contained larval Culex sp., Ficalbia sp. and Vranotaenia sp. but no apparent Anopheles.

Ground water had accumulated at numerous points in Guini, Berim and Djiboulboul Polders. Areas close to the dikes were most notable for these seepage pools. For example, several hectares of permanent water had

accumulated behind Noun Dike in Berim polder and behind the Djiboulboul dike. The double dikes between Guini and Berim Polders were accompanied by several small pools and the water inlet in Guini Polder permitted accumulation of about a hectare of permanent water. A small adobe brick site near this pool contained a large, shallow pit about two meters deep and with a square meter or so of water surface. Larval A. gambiae were present in the smaller pools and primarily where vegetation was absent. Most notable were the pools near the double dikes. A few larval A. gambiae were found in sparse grass in the pool near the Matafo water inlet. Culex sp., Ficalbia sp. and Vranotaenia sp. were also present. Larval A. gambiae were found in the ponded water around the Peace Corps pump in the Bol hospital compound.

No larval mosquitoes were discovered in the lake. Hundreds of standard dip samples were taken from every conceivable kind of site. Access was by pirogue, horseback and on foot and repeated samples were taken with due care to prevent loss of larvae. Potential predators were everywhere abundant.

Four adult Anopheles were collected during the course of the study. One A. gambiae was discovered resting on the wall of a native house near Matafo and another was collected while biting a man out-of-doors in Matafo. Both were parous females but neither exhibited oocyst or sporozoite infection. Two A. coustani were collected indoors in a European-style house in Matafo. One was taken while feeding on a man. Numerous C.p. quinquefasciatus

were taken in midnight biting collections on man and while resting in houses. However, the undisputed pest mosquito of the region was Mansonia sp. These large insects were most annoying and fed on man throughout the night. One 30-minute collection taken on man just after dusk in the town of Bol contained 83 of these insects and a comparable collection taken at midnight contained seven. Presumably, these Mansonia were derived from the lake where larvae would have attached to the roots of floating plants. Breeding may be year-round.

8.3.1 OTHER INSECTS NOTED

The Bazaar-fly, Musca sorbens, was abundant throughout every inhabited portion of the Bol region. Because they are strongly photoactic, they are rarely found inside houses. They are active during the hottest parts of the day and are powerfully attracted to sores and moist regions of the face of man. Small children are particularly affected. The team found difficulty in sampling blood from the earlobes of children due to the tenacity of these flies. Flies frequently had to be lifted from the welling drop of blood. Human feces apparently provide the principal breeding source. Although their role as vectors of disease has not conclusively been demonstrated, bazaar-flies constitute a hindrance to effective work on the polder. A crust M. sorbens eggs coasts the basic millet dish ("Boule") of the region.

8.4 PROTECTIVE MEASURES PRESENTLY PRACTICED AGAINST MOSQUITOES

One question routinely asked by the team in each community was "Are

you bothered by mosquitoes?", and the answer was invariably affirmative. Mosquito-bars covered almost every bed. However, these were generally constructed of cotton sheeting rather than netting and this must have been uncomfortable during warm nights. Furthermore, the bars were frequently torn and blood-fed mosquitoes (C.p. quinquefasciatus) were occasionally found trapped inside.

Fires were frequently built on the floor of native housing and these ventless dwellings would become filled with smoke. The inside of the roof was generally stained black with soot. Residents claimed to be ignorant of the use of insecticide. However, in one island dwelling a can of agricultural insecticide concentrate was found. This material was intended for spraying cacao and the container was labelled in English.

Thus inhabitants of the region universally take elaborate and effective means to protect themselves against mosquitoes. Although these efforts are probably directed against Mansonia sp., reduced transmission of malaria must result. In this manner, certain mosquitoes seem, locally to prevent the spread of disease.

8.4.1 MEASURES POTENTIALLY APPLICABLE TO CONTROL OF VECTOR MOSQUITOES

The stick and reed walls lining the insides of native straw houses provide little surface suitable for the retention of residual insecticides. Furthermore, the numerous wall-hangings in these and in traditional mud-brick houses further obstruct application of effective spray. The people, however, generally sleep indoors. Only rarely was evidence of outdoor sleeping noted and answers to the questionnaire confirmed this impression. In any case, malaria control through conventional residual spraying seems impractical.

Source reduction aimed at larval A. gambiae may be practical. since breeding sites seem to be well-defined, periodic spraying of the brick-works pools and of other appropriate sites would probably reduce the abundance of these vectors.

Efforts to protect human population against non-vector Mansonia mosquitoes may be counter-productive.

8.5 INTENSITY OF TRANSMISSION OF MALARIA

Blood samples were taken from 239 children aged 3 to 15 in 9 towns in the Bol area. Both thick and thin smears were prepared from each sample and all slides have been appropriately fixed and stained with Giemsa. A sample of 6 slides from each of the 9 areas has already been examined microscopically and the remaining reserved for later study. All slides should be restudied using better illumination than was available in the field. None of the 54 slides already examined appeared to contain malaria parasites or any other recognizeable blood-parasite.

The clinical records of the hospital at Bol list numerous cases of malaria diagnosed through the year. However, these include diagnoses made by nurses working without laboratory facilities in outlying areas. No proven malaria case was called to the team's attention during its 2 week stay in Bol. The hospital physician, Dr. J. P. Dompnier, reports that malaria is frequently diagnosed during and after the July and August

rainy season. Questions relating to malaria were posed in each of the nine locations studied. Local residents claim to know about malaria ("Kange" in Kanembou) and report that the period September through November is the season during which such disease most commonly occurs. The question of the prevalence of malaria remains unanswered.

Malaria has frequently been reported from Chad. Most recently, Cano and Marcos (1971) reported rainy season parasite rate of 15.7% in children (2-9 years) and 11.6% overall in residents of N'Djamena. Plasmodium falciparum predominates. Sporozoites were present in one out of 50 A. gambiae collected in the Chagoua region of that city.

An account containing more definitive conclusions of the malaria parasite-rate in the Bol area will be submitted in an addendum following the completion of necessary laboratory analysis of blood-films collected during the field study.

8.6 USE OF INSECTICIDE

8.6.1 Agricultural Insecticides

Recently, the relationship between agricultural and public health use of insecticide has come to be appreciated (Georghiou, 1975). For example, in El Salvador, application of chemicals to protect cotton has produced catastrophic effects on the transmission of malaria. A. albimanus, the local vector, has become resistant to all standard insecticides and conventional insecticidal control of malaria is no longer

possible. Similar effects on other mosquitoes have been documented in California, the Middle East and India. Thus, non-essential agricultural use of insecticides should be minimized. Shallow, et al (1975) advocate just such a policy for the Sahel. They discuss the "dirty field concept" in which the presence of pest-insects is tolerated. Pest control is initiated only when the density of these insects is such that economic loss is imminent. A surveillance system must be maintained to warn of this "economic threshold" system that implements action as soon as the presence of a pest is recognized. Similarly, periodic applications of insecticides on some fixed schedule would be counter-indicated. Shallow, et al base their recommendations on economic arguments and these suggestions are consistent with requirements of public health.

Malathion and propoxur are the agricultural insecticides used in the area at present and are the adulticides most likely to be used in malaria control in the Bol region. In so far as possible, and to avoid over-dosage in the area, these chemicals should be reserved for malaria control and not for control of agricultural insects.

8.6.2 USE OF INSECTICIDES - PUBLIC HEALTH

Abate is generally regarded as the insecticide of choice for control of larval mosquitoes. This chemical was specifically recommended for control of A. gambiae in N'Djamena by a recent WHO malarialogy team (Cano + Marcos, 1971) and fenthion was suggested as an alternative. In the event that malaria control measures are indicated, larvicidal

application of abate appears to be appropriate.

Adulticidal measures might employ malathion propoxur delivered by airplane (ULV) in an ultra low volume formulation. Krogstadt, et al (1973) tested this procedure in Haiti in an area where residual spraying of houses was impractical and reported satisfactory control of malaria. Because inhabited areas of the polders are compact, aerial ULV treatment appears to be useful. The structure of local straw housing renders residual applications of the insecticides futile.

At the time of the present preliminary study, both the lake and the inland wadi areas (excluding the polders) seemed remarkably free of disease. The level of sanitation was acceptable, schistosomiasis was rarely found and no evidence of the transmission of malaria was noted. However, reported infant mortality appeared to approach unacceptable levels and personal medical services were inadequate. Those dangers to the public health that were noted were associated with the polders and with the town of Bol.

The system of open, earth-lined ditches used to drain the Guini Polder appears to be a main source of snail hosts of schistosomiasis and an important source of anopheline vectors of malaria. The most prolific source of anophelines was the brick works near the town of Bol. Thus. at least during March and April, the polder itself and the urban center associated with the polder appeared to constitute the main environmental hazard to health.

8.7 INFLUENCE OF CLIMATE UPON LOCAL TRANSMISSION OF MALARIA

The climate during March and April appears to be relatively unfavorable to the transmission of malaria. Rainfall is nil and the water-table is at low levels. This indicates minimum opportunity for anopheline breeding. August would be the month for maximum accumulation of rainwater, October must be the month when the borders of Lake Chad would flood and December would be the period when ground-water might rise to the surface. Breeding of A. gambiae might be most intense during August and December and, if present, A. funestus might be most abundant during October.

High wind, low humidity and high temperatures adversely affect the longevity of adult mosquitoes. Since vectors of malaria become infectious for man at about ten days after they themselves become infected, survival of the adult is crucial to transmission. July, August and September appear to be most favorable for adult survival. March, April and May are most unfavorable due to heat and low humidity. December and January, on the other hand, may be too cold to permit development of the malaria parasite within the insect.

Thus, the optimum season for transmission by A. gambiae may be during August and September. If A. funestus is an important local vector, the optimum season may be during November.

8.8 OTHER ARTHROPOD-BORNE DISEASE

Few potential arthropod vectors of disease were noted during the present, dry-season survey. Many vectors ordinarily associated with the region clearly can not thrive near Bol.

Tsetse flies (Glossina spp.) have retreated south along the Chari River from their ancestral range along the margin of Lake Chad. This was a result of tsetse control campaign conducted some years ago (personal communication, Dr. Cheneau, Director of the Tropical Veterinary Center, Farcha). Often tsetse were eliminated from local areas, herders established cattle there and the ground was grazed clear of undergrowth. This rendered such areas unsuitable for tsetse and the entire region will remain free as long as cattle remain. Thus, neither nagana, nor human sleeping sickness need to be considered as a threat to the Polder project.

The Bol region is unsuitable for the black flies (Similium) vectors of onchocerciasis. These insects require flowing water and no streams are present near the polders.

Yellow fever poses little threat around Bol. The main

vector, Aedes aegypti, breeds in small collections of water accumulating in trash and discarded automobile tires. The Bol region is now free of the kind of trash that would provide suitable breeding sites and it will be many years before tires accumulate. Furthermore the area is so dry for most of the year that eggs of A. aegypti would probably not successfully aestivate.

Leishmaniasis is a possible problem in the area but the team knows of no evidence of transmission. The local clinic reports no Kala-azar and few cases of tropical ulcer. No phlebotomine sand flies were encountered during the survey.

9. SCHISTOSOMIASIS

9.1 SCHISTOSOMIASIS HAEMATOBIA IN THE BOL AREA

Barkhuus (1976) stated that urinary schistosomiasis, due to Schistosoma haematobium, occurs in 100% of people in the Bol area and 85-90% of people in the coastal areas of Lake Chad. He referred to this area as a focus of hyper-endemicity and noted that "nowhere are less than 10% of children found infected and prevalence in this age-group is usually higher -- between 20 and 50%". He noted that "transmission occurs all the year round in Lake Chad but that elsewhere infection takes place mainly in the dry season from November to May, reaching a maximum in February and March. During this period there is snail-man contact wherever infected water occur -- marshes, springs, lake shores, residual pools, etc. Lake and river fishermen and their families, living in constant contact with the water, are more or less permanenly exposed to infection risk. It is practically impossible, even for parents knowing the risk to their children, to prevent them from bathing and playing in the water."

In the present study, efforts were made to detect cases of urinary schistosomiasis in children of the Bol area between the ages of 4 and 15. Single urine specimens were obtained at the same time that anthropometric measurements were made and

blood samples taken. The fact that the urines were taken usually late in the morning and that only single specimens were obtained means that the results must be viewed conservatively and the figures might be augmented by improved collection methods. Specimens were taken only from boys. Most were of normal appearance, straw or yellow in color. Only one of the 118 was grossly bloody. All specimens contained sand (the boys normally squat to urinate, the prepuce touching the ground). Specimens were not centrifuged but were allowed to settle for 3 or more hours. Cooperation was almost 100% (only one boy became frightened, three away his specimen tube and ran off).

Results of this study in 9 different villages are given in Tables 1 and 2 (pages 64 and 65). The villages are grouped according to location, i.e., Bol itself, polder villages, two small towns inland from the polders, and two towns on islands in the lake. It will be immediately seen that the polder villages had a high prevalence of schistosomiasis. With regard to the lake villages, the expectation of 100% infection was not sustained by the results, in fact, the only infection detected, in a 12-year old boy, was rather light.

It was concluded that transmission of schistosomiasis in the Bol Polders area was taking place <u>on the polders</u>. All of the people questioned in these villages admitted to visiting the water

of the drainage ditches on the polder, with one exception (Moun, where the barrage is leaky and where a good-sized swamp has appeared on the polder side of the barrage). Although no Bulinus truncatus were found, as the ditches were mostly dry during our visit, it is believed that the indirect evidence appears to suggest that the ditches may be an important source of infection when irrigation is underway and standing water is present.

The data from the island villages (Yakoua and Mamdi) were adequate only for purposes of inference. Of the 15 children who presented themselves to us, only four were above the age of ten; the ages of the others ranged from four to seven, not good ages for detecting schistosomiasis. Thus, the lake village examinations would have to be much more extensive before a definitive statement could be made about the status of schistosomiasis in them. Nevertheless, we were impressed by the contrast between the actual figures and those that published reports led us to expect ("100% infection on the islands").

The failure to find evidence of urinary infection in the two Tala villages was not surprising, but again the samples were too small to use for anything more than inference.

Age distribution of cases of schistosomiasis haematobia among boys in the Bol Polders area. (Number positives/number examined).

Table 2

Location	Age												
	4	5	6	7	8	9	10	11	12	13	14	15	
Bol					0/3	1/6	2/13	1/2	0/1				4/25
Lafia Kafia		0/1	0/1		0/1		2/2		2/3		1/1	2/3	7/12
Old Matafo	0/1	0/3	0/2	0/2	1/3	0/1	0/1	1/1					2/14
Matafo (I)		0/1	0/2	0/6	3/6	0/4	2/3	2/2	1/2				8/26
Moun			1/6	2/3	0/1	0/1	2/3		1/2		1/1		7/17
Tala 1		0/1		0/3	0/1		0/1		0/1				0/7
Tala 2	0/1											0/1	0/2
Yakoua	0/2	0/1	0/2	0/2				0/1	0/1				0/9
Mamdi		0/1	0/2	0/1				1/2					1/6
TOTAL	0/4	0/8	1/15	2/17	4/15	1/12	8/23	4/6	5/12		2/2	2/4	29/118

Distribution and prevalence of schistosomiasis haematobia in boys, Bol Polders area, Lake Chad, Republic of Chad.

Table 1 Urine Samples

Date	Location	Ethnic Group	N° Examined	N° Positive	%
4/4	Bol (school)	Mixed	25	4	16
	Polder Region				
5/4	Lafia Kafia	Kanembou	12	7	58
9/4	Old Matafo	"	14	2	14
9/4	Matafo (I)	"	26	8	31
10/4	Moun	"	17	7	41
	(subtotal)		(69)	(24)	(35)
	Inland Region				
6/4	Tala 1	"	7	0	0
6/4	Tala 2	"	2	0	0
	Lake Islands				
7/4	Yakoua	K. & B.	9	0	0
7/4	Mamdi	Boudouma	6	1	17
	(subtotal)		(15)	(1)	(7)
	TOTAL		118	29	25

9.2 SNAIL COLLECTIONS

The following pulmonate snails have been reported from Lake Chad (Leveque, 1967):

Lymanaea natalensis

Biomphalaria pfeifferi

B. sudanica

Segmentorbis angustus

Gyraulus costulatus

Anisus natalensis

A. coretus

Bulinus jousseaumei

B. truncatus rohlfsi

B. forskali

Ferrissia sp.

These are in general surface dwellers, living in and on emergent vegetation and requiring water rich in oxygen or even atmospheric oxygen for respiration. Table 3 (page 67) lists collection sites and species collected during the present field activity.

Table 3

Site	Date	Bulinus forskali	Bulinus truncatus rohlfsi	Biomphalaria pfeifferi	Segmentorbis angustus	Anisus coretus	Lymnaea natalensis
Yakoua, site 1	3/30	+	0	+	+	+	+
Yakoua, site 2	3/30	+	0	+	+	+	+
Mafou Island	3/31	0	0	0	0	0	+
Dessoulom Island (1)	3/31	0	0	+	+	+	+
Bol (2)	4/1	0	0	0	+	0	0
Bol (3)	4/1	+	0	0	0	0	0
Matafo (4)	4/8	0	0	0	+	0	0
Matafo (5)	4/8	0	0	0	0	0	0
Moun	4/10	+	0	+	+	0	+

(1) Ceratophyllum mats edging lake

(2) pond at south end of Berim polder

(3) Phragmites pond between Matafo and the lake

(4) Drainage ditch just east of Experiment Station

(5) On the lake side of the Moun barrage, Berim polder

9.3 VECTORS OF SCHISTOSOMIASIS IN THE BOL AREA

According to published reports there are three species of snail capable of transmitting urinary schistosomiasis and two species capable of transmitting intestinal schistosomiasis in the Bol area.

1. Buinus truncatus rohlfsi (Clessin). Leveque (1975) reported that this snail inhabits the Certophyllum mats fringing the shore of Lake Chad in large numbers. It is thought that the snail benefits from the daily reversal of pH and O_2 values mediated by the plants (descending out of the heat of the day when the plant is actively photosynthesizing and producing oxygen and consuming CO_2, and rising to the surface to breath during the cool hours of the night when the plant reverses its cycle, consumes oxygen and releases CO_2). Populations of B. T. rohlfsi exhibited considerable variation in 3 of 4 collecting sites throughout one year (Leveque, 1975). The discovery of a large population of people inhabiting dunes near the polders but not convenient to the lake led to the thought that B.T. rohlfsi must also occur on the polders. Since the only location of open water capable of supporting this species occurs in the drainage ditches, these were searched, but no snails were found. It is believed, nevertheless, that the snails will be found in the ditches during the rainy season or during periods of intense

irrigation, when the drains are full.

2. Bulinus forskali (Ehrenberg). This species is the regular intermediate host of the cow shistosome, Schistosoma intercalatum. It can also serve as an intermediate host of S. haematobium of humans. Small numbers of B. forskali were collected in the fringe vegetation on the lake, and very large numbers were found in a pond at the south end of Berim polder. where it touches the town of Bol. More than half of the specimens collected near Bol were examimed microscopically after crushing between two slides: of a total of 156 snails so examined, 11 (= 7%) were infected with a xiphidiocercaria (which may be the immature stage of a trematode of frogs). No snail was found harboring schistosome cercariae. The large numbers of snails found in the Bol pond may have represented a peak in the life cycle which was estimated by Leveque (1968) to be about 5 weeks from egg to egg. B. forskali should be considered a prime suspect as a polder transmitter.

3. Bulinus joursseaumei (Dautzenberg). This species, although capable of transmitting human schistosomiasis, was unknown to Lake Chad until 1967, when it was reported in collections taken by Leveque. It was not collected during the present work. Its role in transmission in the Bol area has yet to be determined.

4. Biomphalaria pfeifferi (Kraus). This is a common species in the fringe vegetation around islands in the lake. It was not found in ditches or ponds on the dunes or polders. This is the main transmitter of schistosomiasis mansoni (= intestinal schistosomiasis) of humans in the south of Chad. This disease occurs only sporadically in the lake area where its public health significance is judged to be minimal. However, it must be noted that the established presence of the proper vectors constitutes a threat. In the event of significant migrations of southerners, carrying the mansoni parasite with them, to the lake region, holoendemic transmission might become a fact.

5. Biomphalaria sudanica (Martens). This species is reported by Leveque (1967) to be sympatric with B. pfeifferi in fringe vegetation on the lake. Its role as a potential host for Schistosome mansoni would appear to depend upon the chance introduction of parasites, as above, but its efficiency as a host has yet to be determined.

10. ANTHROPOMETRY

Malnutrition and disease are interrelated and either may adversely affect the rate of growth of children or result in wasting. Thus, comparison of appropriate dimension of children residing in different locations, may suggest some pathology peculiar to certain of these locations. If genetically homogeneous populations of children of a given age differ in height or in weight, chronic insult may be suggested. Acute pathology would be suggested by wasting of such muscle tissue as the biceps. This parameter can readily be estimated by comparing the length of the left upper arm to the mid-point circumference. Accordingly, 229 children in 9 villages were appropriately measured and weighed.

A "left-arm index" was calculated for each child by dividing mid-point circumference of the upper arm by length and these results are displayed in Table 4. (page 72). Mean indices for various towns ranged from 62 to 71, but the children with the most slender arms appear to reside in Bol, the town that seems to contain relatively well-cared for children. These results suggest that no acute wasting process characterizes any of the village populations. Girls were characteristically somewhat thicker-armed than were the boys.

Town	No. of children	left arm index*			% larger than Bol standard		
		male	female	total	No. of boys	weight	height
Bol	47	62	67	64	-	-	-
Matafo	48	65	69	67	29	51	14
Old Matafo	27	68	66	67	9	44	44
Lafia Kafia	27	63	67	65	5	60	20
Moun	33	65	69	67	15	40	33
Tala	17	64	69	67	5	60	20
Mandi	13	68	69	69	5	60	20
Jakoua	17	71	70	70	6	80	0
total	229				74	51	34

*length divided by mid-point circumference

Table 4. Height, weight and thickness of the left upper arm of children residing around the Polders near Bol.

In studying height, boys from Bol were used as a standard (Figure 1., page 74). Results were graphed against age on an arithmetic scale and a regression line estimated by eye. Percent of each local population falling above this median is displayed in Table 4 (page 72). Weight was treated similarly (Figure 2., page 75). Thus, it is apparent that the Bol median for weight does not differ radically from that of other populations. However, Bol children tend to be taller than those from outlying towns.

It is interesting that boys excreting eggs of S. haematobium tend to be similar in weight and height as compared to those of the general population (Figures 1. and 2., page 74 and 75). Thus, chronic infection may have little effect on the general life budget of local children.

In summary, children in outlying towns appear to have some subtle chronic disadvantage as compared to residents of Bol. This may be nutritional or may result from a greater incidence of infectious disease. No focus of sharp pathology was discovered. These measurements will provide base line data in the event that famine develops (as now threatens) and for future reference.

FIGURE 1. HEIGHT OF MALE CHILDREN ATTENDING SCHOOL IN BOL

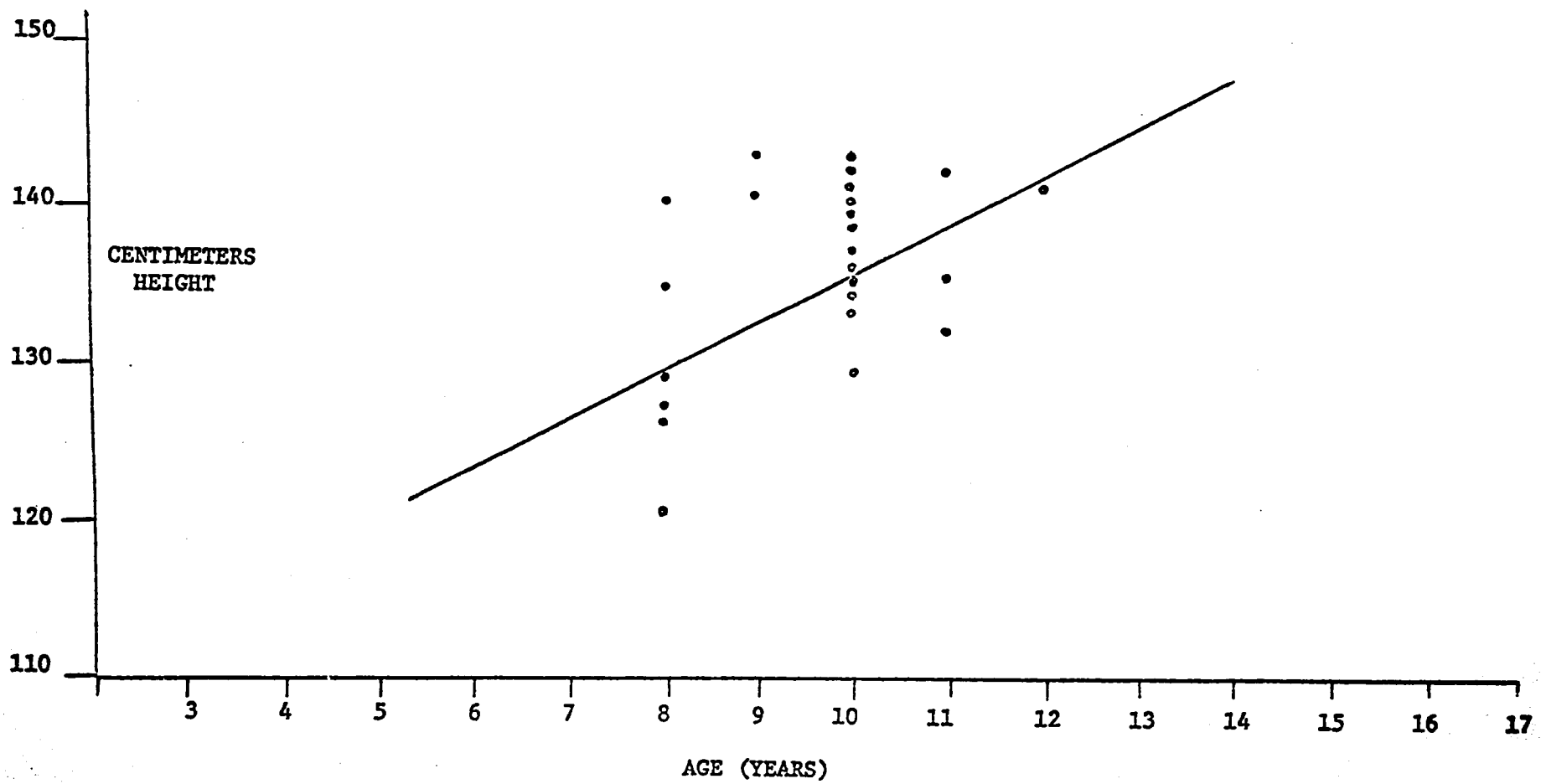
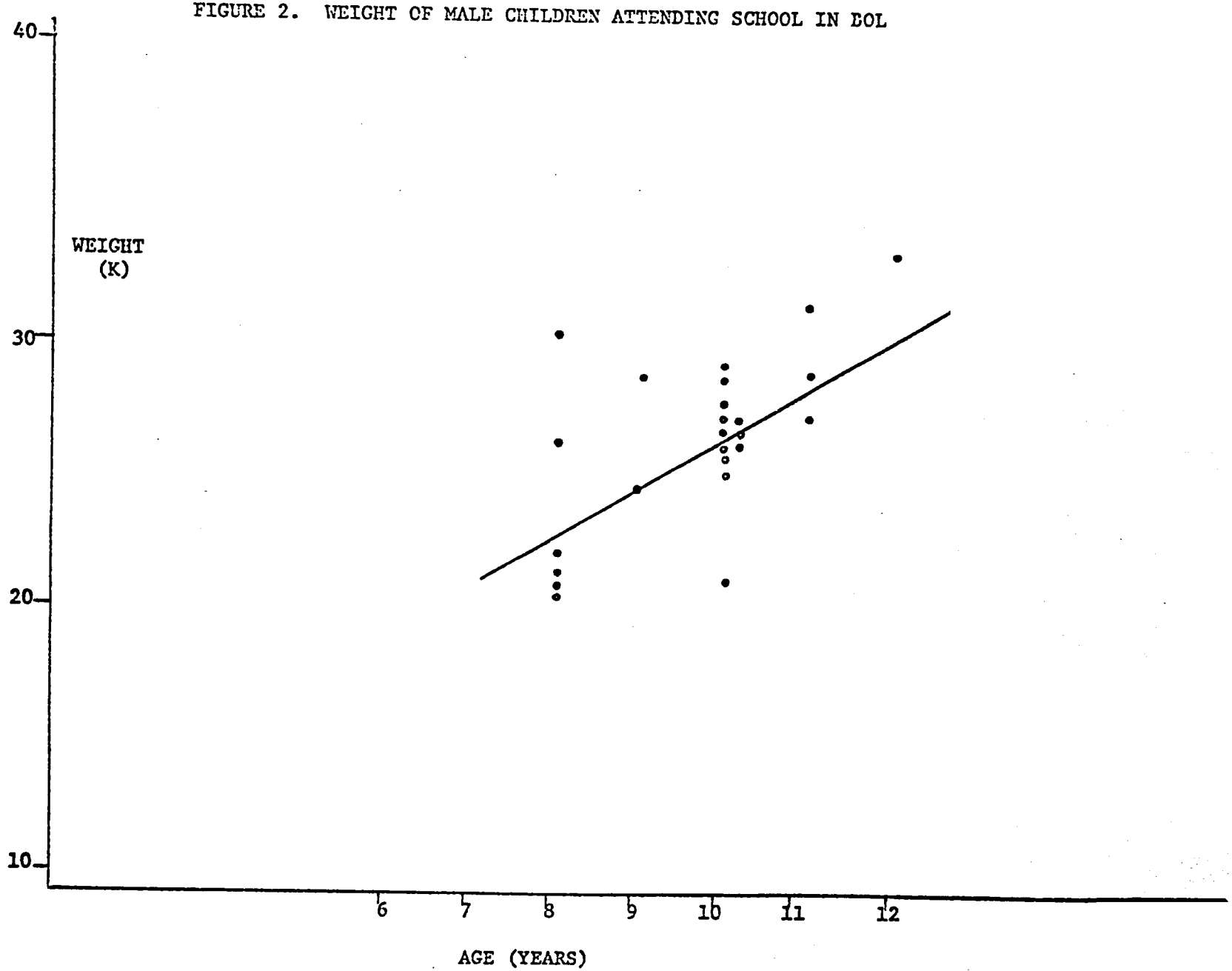


FIGURE 2. WEIGHT OF MALE CHILDREN ATTENDING SCHOOL IN BOL



11. DESCRIPTION OF MUD-BRICK HUTS

Building material called "mud-brick" in Chad is known in the Americas as "adobe". Each mud-brick is about 3 inches thick, 8 inches wide and 16 inches long. They are made in the same way as adobe by mixing straw, clay and mud. The resulting slurry is formed into the standard brick shape by placing it into a wood frame laid on flat dry ground. Once formed, the frame is removed and the wet mud-bricks are left to dry in the sun.

The mud-brick huts which outnumber the traditional thatch hut in Bol are built in the form of a cube approximately 3 to 4 meters wide, 4 to 6 meters long and about 3 meters in height. The walls are plastered with mud mortar and are about 35-40 cm. thick. The typical hut has but one wood frame door (90 cm. x 1.90 cm.) covered with corrugated metal sheeting and one window (40 cm. x 50 cm.) of the same construction. Many of the windows are screened but separate screen doors were less common. Most doorways were screened by means of a cloth drape

The roof structure is of an interesting design. Palm trunks are laid across the top of the walls at approximately 30 cm. center-to-center. Woven reed mats are then laid over these pole beams. The mats are then overlaid with mud plaster which is sloped to allow for drainage of rain through tin lined spouts which pierce the parapet walls at roof level. It was reported that these roofs had to be rehabilitated every year or two. The floors are just the natural sandy ground and, in most cases are covered with woven mats.

Because of the thickness of the walls and roofs, these mud-brick huts remain much cooler than the thatched huts and can be made virtually mosquito and fly proof. For these reasons they are much preferred by the people in Bol and a continued trend away from the thatched hut seems to be assured.

12. RECOMMENDATIONS

12.1 MEDICAL RECOMMENDATIONS

The following action aimed at the prevention and control of prevalent diseases and the promotion of the health of the population of the Lake region is recommended.

1. The opening of a rural dispensary in a locality close to the polders.

2. The assignment of a second laboratory man at the medical center of Bol.

3. The supply of microscopes to the 6 dispensaries of Bol province after trained personnel are provided to make adequate use of them.

4. The building of a wing or separate pavilion at Bol hospital to be used for preventive medicine. This new section, which would complement the activities of the "Grandes Endemies" service, would expand the maternal and child health work already carried on by the center and develop an extramural program of health education. The personnel to staff the section, possible to be recruited locally and trained in N'Djamena, should be given the opportunity to spend some time at a demonstration center abroad. Under the direction of the chief medical officer, he should be instrumental in the setting up of a local committee to help in the identification of needs and methods to raise the level of hygiene of the community. The showing of education health

films, easily available from embassies, international organizations, etc. located in N'Djamena, would be of value.

5. The routine flights of the helicopters to evacuate emergency cases to N'Djamena should be resumed.

6. Adequate means of transport should be made available to the chief medical officer of Bol so that he can inspect his area of responsibility.

7. A pharmacist's aid should be assigned to the Bol hospital.

8. The medical center should be rehabilitated and supplied with much needed additional equipment.

9. The possibility of monthly visits to the medical center by a surgeon, a dentist, and other specialists should be considered.

10. Clinical services available in the polder region should be improved. These measures might include efforts to upgrade local diagnostic facilities through training of personnel and provision of appropriate equipment and supplies. The physical plant of the Bol clinic should be improved and construction of satellite clinics should be considered. Measures to improve nursing care as well as surgical and dental services are indicated. These improvements should be implemented as part of an integrated plan and require further study by specialized personnel.

12. 2 ENVIRONMENTAL SANITATION RECOMMENDATIONS

It is recommended that the Peace Corps pump maintenance program be expanded to include two additional activities.

The first would be to find some method to solve the problem of ponding around the hand pumps. It is realized that there is no easy solution to this problem and it may be that future wells should be located only where the ground slopes enough to provide for natural run-off away from the well. Several of the existing wells in Bol are located on sloping ground and existing ponds could be drained quite readily. An ideal approach toward providing continual maintenance to the pumps and their immediate surroundings would be to hire and train local residents to perform preventive maintenance, minor pump repairs, and upkeep of the drainage system.

The second additional activity would be a water sampling and analysis program coordinated with the maintenance visit. Samples from each well should be analyzed for E. coli and salinity using compact field kits available from suppliers such as Hach Chemical Company of Ames, Iowa. These field kits are self-contained and can be used by anyone who is able to carefully follow the

instructions accompanying each kit. No laboratory equipment is required. It is understood that the long-range objective of the well installation and maintenance program is to transfer total responsibility for operation to FDAR at the national level.

As suggested above, serious consideration should be given toward delegating some maintenance responsibilities to local authorities and their constituents. Perhaps the Peace Corps drilling and/or maintenance training at the FDAR warehouse compound in N'Djamena could be a source for upgrading local staff.

It is further recommended that planning be initiated now to study the feasibility of installing and operating a piped water system in Bol.

A practical activity sponsored under the Bol medical center should be initiated to make the people more aware of health problems related to poor personal hygiene and food handling and to demonstrate acceptable techniques.

12.3 MALARIA RECOMMENDATIONS

1. The present preliminary study should be broadened by additional surveys performed during different seasons. Each additional visit would require about two weeks of field work and can be performed by a physician-epidemiologist and an entomologist - malariologist preferably cooperating with a malacologist-helminthologist. In particular, one such visit should take place early in September at the end of the rainy season, and another in

December after the water table has risen to maximum levels. Ideally, both visits would be repeated the following year.

Each visit should include a general survey of Anopheles mosquitoes. This would include collection of mosquitoes biting man at specified times of day; collection of mosquitoes resting in houses, both individually and with the aid of insecticidal spray; standard sampling by means of portable light-trap; and manual collection of immature Anopheles from aquatic breeding sites. This survey should cover the entire geographical area covered by the present survey. Salivary glands should be dissected from a sample of each anopheline species collected and tissues examined microscopically for the presence of sporozoites.

The precise identity of the A. gambiae fauna of the Bol region should be established. Living material might be transported to the WHO Anopheles Reference Center in London. Alternatively, preserved ovaries might be retained for later cytological study.

Blood samples should be obtained from persons residing in villages throughout the study area. Children are readily available for such study and both thick and thin films should be prepared. A spleen-survey would be an essential supplement to this parasite-survey.

If an interested local person can be identified, he should be encouraged to conduct weekly light-trap samples of mosquitoes in one location throughout the year. These samples could be stored and transported and mosquitoes identified by qualified taxonomists elsewhere. Such local personnel might also collect

and store blood-films from fever patients seen at the Bol clinic.

2. Any shallow holes in the ground made during the manufacture of adobe bricks should be treated with insecticide once each week. Only the brick-works near Bol need be treated. A standard formulation of abate is recommended.

3. All drainage ditches should be designed to provide minimum opportunity for puddle-formation. Vegetation should periodically be removed from these ditches.

12.4 SCHISTOSOMIASIS RECOMMENDATIONS

1. Schistosomiasis control should be approached through snail control. Because of the failure to identify susceptible snails in April in Bol and surrounding regions, certain further studies are indicated:

a. Baseline data should be collected regarding the population dynamics of Bulinus truncatus rohlfsi in the region of the Bol Polders, including adjacent lake waters. The field work should be pursued at favorable times of the year, emphasizing the period between the onset of rains (July) to the beginnings of the ensuing dry season (November). During periods of snail abundance, some attempt should be made to determine the rate of infection, if any, in snails in different localities on the polders and in the lake. Localities on the polders where man/snail contact is optimal should be identified and such places should be subject to snail control measures.

b. In view of the abundance of Bulinus forskali in ponds, ditches and the lake in April, coupled with the failure to find B. forskali to miracidia S. haematobium.

c. Snail control can be done by application of molluscicides but these chemicals have the disadvantage of being dangerous to handle, or expensive, or both. It is unlikely that, as a first measure, the use of molluscicides will be considered environmentally acceptable by the agencies concerned. A more practical approach and more suitable to the Bol Polders region would be the employment of naturalistic methods. One of these could involve clearing vegetation from the drainage ditches. Snails are found on plant stems but they are either eating dead plant material or are grazing on microscopic organisms using the plant stems as a substrate. In any case, snails cannot exist where there is no food. The drainage ditches of the Guini and Berim polders were found to be uniformly choked with dense growths of reeds (Phragmites) and cattails (Typha). It can be guessed that these plants provide considerable protection and substrate for Bulinus snails when the ditches are full of water. A regular program to clear out these plants from the ditches would do much to discourage snails on the polders. Likewise, in the lake, Bulinus has been reported to live in close contact with the mats of submerged water weeds (Ceratophyllum) which fringe the borders of the lake particularly near the boat landing at Bol. Removal en masse of these mats would deprive the snails of a necessary niche in this local area.

d. It may also be speculated that a biological control measure involving the use of predators might have a positive effect on snail control in the polders. One such measure might employ herds of ducks, which eat snails with avidity. Such measures have been observed to be effective in clearing ponds in Northeast Thailand of the snail Indoplanorbis exustus (a transmitter of paddy field itch).

In all snail control work, some provision must be made to assay the situation in the field before, during and after the completion of the work. There is no other yardstick by which success can be measured. Considering the apparent seasonality of Bulinus on the polders, follow-up studies on snail abundance should be pursued at several times during the year, preferably during and after the rains, and should not be abandoned because of apparent success in control. Snails have a way of sneaking back.

2. Apart from snail control, human schistosomiasis can be controlled by: (a) specific treatment, (b) waste disposal, and (c) health education.

Treatment of cases. Children suffering from schistosomiasis haematobia can be treated with niridazole. Such cases should be

actively sought and treated in villages ringing the polders. Bad side effects such as psychiatric changes which have often been attributed to niridazole (= Ambilhar) are not often seen in young patients who have just contracted the disease and whose livers are still healthy and able to detoxify the drug. In the present study, boys began to be seriously affected from about the age of 8 to 10 years. This observation agrees in general with others with regard to the age of onset.

Waste disposal. There is not much chance that this approach will be useful. Eggs of S. haematobium are passed in the urine and the micturitional habits of little boys are not easily controlled.

Health education. Some sort of program to acquaint the villagers of the polders with the nature and seriousness of the disease schistosomiasis is owed them. In other countries this has often taken the form of popular talks in an informal atmosphere, in local dialect, and using educational demonstrations and aids such as photographs, blackboards, flannelographs, and even cinematography.

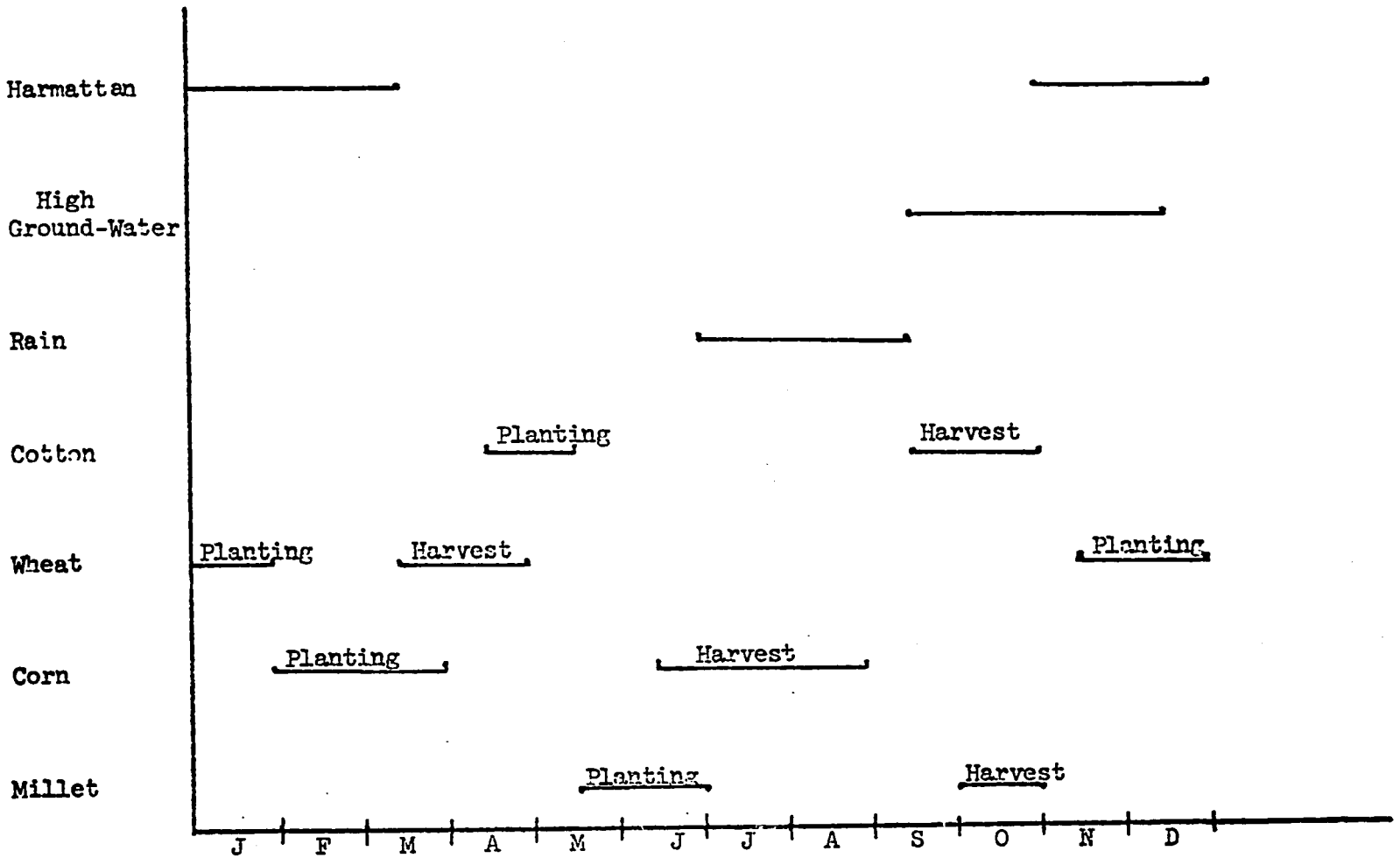
3. In order to measure a reduction in transmission of urinary schistosomiasis, a diminution in incidence (i.e., the rate

of new cases) must be recorded. In practice this will require semi-annual or annual surveys of urine samples from the same population, keeping careful records of names of individuals, in order to prove that new cases are not occurring in non-transient people.

4. These recommendations have thus far all dealt with urinary schistomomiasis, caused by Schistosoma haematobium and transmitted by snails of the genus Bulinus. The other form of the disease, intestinal schistosomiasis, caused by Schistosoma mansoni and transmitted by snails of the genus Biomphalaria, is also reported from Chad. However, it is concentrated in the south. The number of cases reported from the region of the lake is negligible. However, it should be recognized that potential vector snails exist in Lake Chad. We had no difficulty in collecting Biomphalaria in the lake and in ponds on the polders in April at a time when Bulinus unaccountably absent. Thus the Bol Polders area would seem to be ready for an environment accident of major proportions in the event that significant numbers of southern Chadians moved northwards and settled in the lake area or the region of the Bol Polders. Intestinal schistosomiasis is much more pathogenic than is the urinary form, and is more difficult to treat. It would be preferable to avoid the problem by preventing introduction of the infestion.

E X H I B I T S

EXHIBIT I



Calendar of events affecting human populations around the Polders near Bol.

EXHIBIT II

Mean Monthly Climatological Data Collected at Matafo during 1965 - 1970. Abstracted from ORSTOM records.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	tr	-0-	tr	0.8	14.0	34.4	68.8	126.8	49.5	1.4	-0-	-0-
Relative Humidity at 0500 (%)	52.4	46.0	42.5	45.6	62.2	72.8	81.7	86.2	88.3	67.0	44.0	48.3
Wind Velocity (M/S)	1.8	1.9	1.9	1.9	1.8	2.1	2.3	2.5	1.7	1.5	1.9	1.8
Maximum Air Temperature (°C)	30.6	33.5	37.0	39.3	38.3	35.9	33.9	32.9	33.7	37.3	34.8	32.8
Minimum Air Temperature (°C)	9.2	10.4	13.4	19.3	20.7	22.5	23.7	23.2	23.3	17.7	14.2	10.4

EXHIBIT III

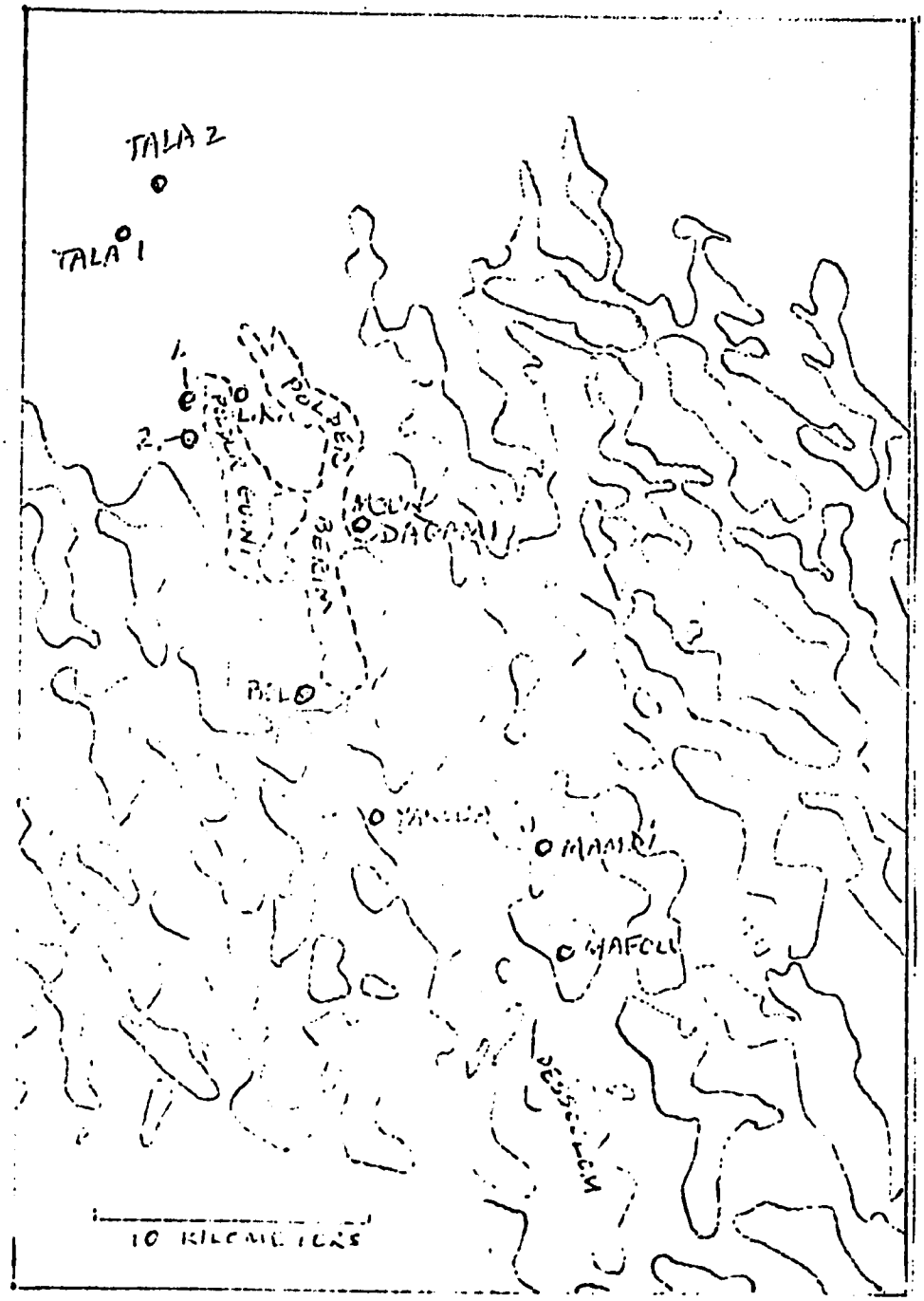
Results of Household Survey in Bol and Outlying Villages

	Bol	Lafia Kafia	Tala I	Tala II	Yakoua	Mamdi	Matafo Ancien	Matafo I	Moun-Dagami
Housing									
Thatch	80%	100%	100%	100%	100%	100%	100%	100%	100%
Mud-brick	20%	--	--	--	--	--	--	--	--
Water Source									
P.C. Pump	X	X	--	--	--	--	X	X	X
Dug well	--	--	X	X	--	--	--	--	--
Lake	--	--	--	--	X	X	--	--	--
Lake Contact	30%	--	--	--	X	X	--	--	X
Polder Contact	L*	X	--	--	--	--	X	X	X
Excreta Disposal									
Out of village	88%	100%	100%	100%	100%	100%	100%	100%	100%
Pit Privy	12%	--	--	--	--	--	--	--	--
Waste Disposal									
In compound	X	X	--	--	X	X	X	X	X
Out of compound	--	X	X	X	X	X	X	X	X
Water Storage									
Earthen jug with cover	X	X	X	X	X	X	X	X	X
Food Storage									
Open containers, sacks, etc.	X	X	X	X	X	X	X	X	X
Metal à cover	L*	--	--	--	--	--	--	--	--
Screen cooler	X	--	--	--	--	--	--	--	--

(*L - Limited)

MAP 1.

Bol Area Sites



1. Old Matafo

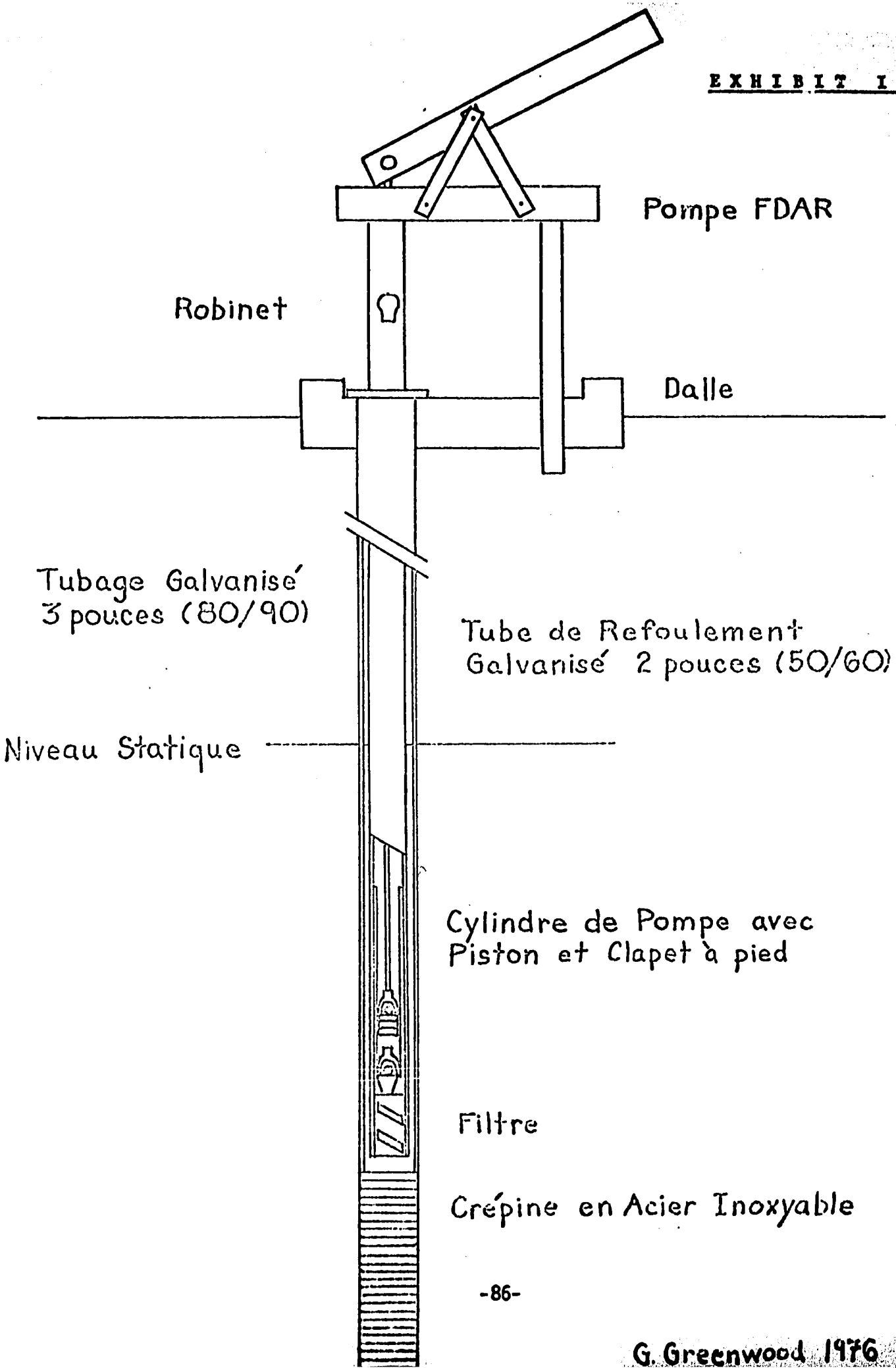
2. Matafo

OUTLYING VILLAGES

VISITED NEAR BOL

MAP 2.

EXHIBIT I



G. Greenwood 1976

MAP OF BOL

MAP 3.

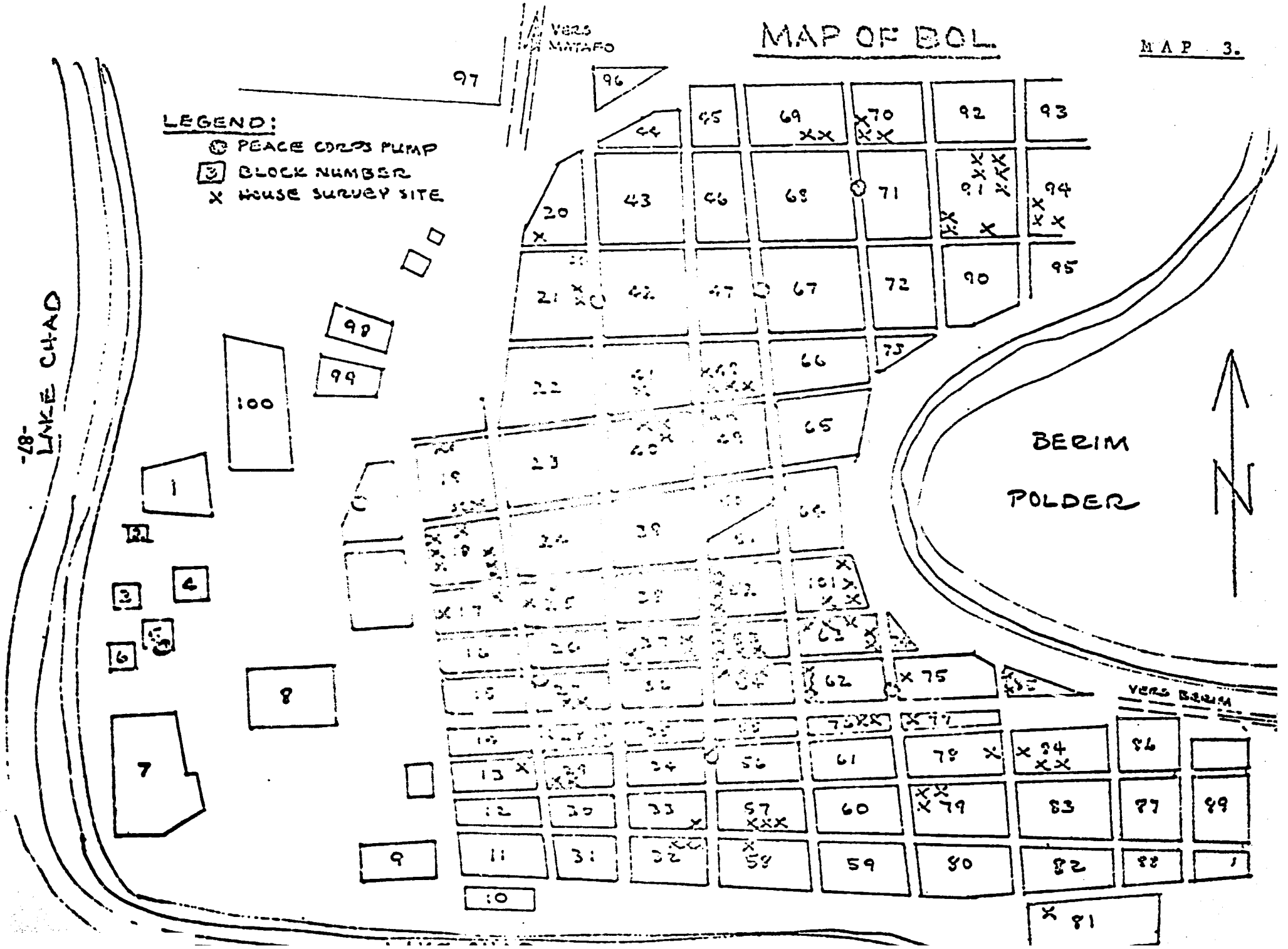


Exhibit IV Samples of Survey Forms used in carrying out the assessment.

HOUSEHOLD SURVEY

ID No _____ Date _____

No People in household : Adults (m) _____ (f) _____ Children (m) _____ (f) _____

(d) _____

Tribe _____ Length of residence _____

Place of origin _____

Occupation _____

Bothered by mosquitoes _____

Measures against mosquitoes _____

Where people sleep _____

Exhibit V: Sample survey form used in carrying out assessment.

ID No _____ HOUSEHOLD SURVEY DATE _____

ADDRESS OR
LOCATION _____

TYPE OF CONSTRUCTION

WALLS: STRAW _____ MUD _____ OTHER _____
ROOFS: STRAW _____ THATCH _____ OTHER _____
FLOORS: TAMPED EARTH _____ SAND _____ OTHER _____
DOORS: No _____ SIZES _____
CLOSURE: YES _____ NO _____ IF YES, MAT'L _____
WINDOW: No _____ SIZES _____
CLOSURE: YES _____ NO _____ IF YES, MAT'L _____

PLAN: (SKETCH ON OTHER SIDE)

CIRCULAR: DIAMETER _____
RECTANGULAR: L _____ x W _____

COOKING FACILITY:

HEATING: OPEN FIRE _____ MUD STOVE _____ OTHER _____
COOKING UTENSILS: _____
EATING UTENSILS: _____

CLEANSING FACILITIES: (DESCRIBE) _____

FOODS AND WATER STORAGE:

FOOD	HOW STORED
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____

WATER SOURCE (DESCRIBE) _____

EXCRETA DISPOSAL (DESCRIBE) _____

SOLIDWASTE DISPOSAL (DESCRIBE) _____

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