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Section II Part A
VOLUME THREE

Environmental Assessment Report - Southern Zone, Republic of Chad

ENVIRONMENTAL ASSESSMENT REPORT

SOUTHERN ZONE

REPUBLIC OF CHAD

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July 26, 1977

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APPENDICES I through IX

1. INTRODUCTION

1.1 Work of the Team

1.1.1 Scope of Work

The objectives of the work as stated in instructions from the American Public Health Association dated April 28, 1977 were:

A. To identify the major endemic disease problems in the: -

1. Koumi area, north of Bongor (Logone Dike Project)
2. Sategui-Deressia, Lai area (IBRD Irrigation Project)
3. Guelengdeng area (Multi-Donor Irrigated Perimeters Project), all in the Republic of Chad;

B. To identify the relevant environmental factors responsible for disease transmission;

C. To assess any existing programs or plans with environmental health significance;

D. 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 the request of USAID/Chad, the Guelendeng area was deleted from the scope of work.

1.1.2 Description of Work Areas

1.1.2.1 Sategui-Deressia Project

The Sategui-Deressia Project consists of a plan to control floo waters and concurrently increase and improve traditional wet rice cultivation over a 5,700 hactare area (=14,079 acres or about the equivalent of 22 square miles). This is a project of the Republic of Chad, with funding secured by loans from the International Bank for Reconstruction and Development (IBRD) and the International Development Association (DA). The project is administered by the

Organization pour le Mise en Valeur de Sategui-Deressia (OMVSD), a Chadian office in N'Djamena. OMVSD has, in turn, contracted with the Italian firm of Carlo Lottie Associati for hydroagricultural development and construction, and with a firm of French agricultural consultants (SATEC) for improvement of culture techniques.

The flood-control project plans to prolong the local high-water periods in the Sategui-Deressia flood plain without permitting an increase in the inundated surface area. This will be mediated by a large canal (7,800 meters long, 20 meters wide) and a large reservoir. The canal will accept water directly from the Logone River by gravity flow and will feed to rice-growing sectors: (1) a 2,500 hactare area (6,175 acres) and: (2) a 3,200 ha area (7,904 acres). A set of dikes connecting with the main canal will enclose the reservoir. The main road from Sategui to Deressia will run along one of the dikes.

Lastly, about 12 kilometers north of Sategui, a snail irrigation canal drawing water from the Logone will irrigate some 200 ha (=494 acres) at the Experimental Station at Boumo, where activities will be devoted to the development of rice seeds.

The work began with local labor in December, 1975. In 1976, work on a contractural basis commenced during the dry season. Structural modifications are expected to be finished in another two years. There is a plan to seek a second World Bank Loan to permit an additional 7,000 ha development in a "second phase".

1.1.2.2 Logone Dike Project

The Logone Dike Project envisages the repair or new construction of a retaining wall or dike along a 60 km stretch of the Logone River in Mayo-Kebbi Prefecture between the towns of Ogal and Kotao, north of Bonfor. The purpose will be to prevent or control flooding of the natural "yaere" or flood plain, thus increasing cultivation time and freeing much needed farm land for productive use. A draft PRP exists. In the PRP the work to be pursued is divided into two parts, each with a different impact assessment.

1. The first stage of the work will repair the pre-existing, torn-down dike along a 35 km interval between the villages of Ogal and Mogodi. In the PRP certain conceptual impacts were discussed:

a) population growth would not be significantly accelerated;

b) it was thought that vector mosquitoes would not increase but, with controlled flooding, might decrease, (The problem of vector snails is not tackled in the PRP);

c) if indeed the use of pesticides and herbicides increase, this will learn (sic!) precautions;

d) if rat populations increase as the result of increased food supplies, the villagers know how or will learn to cope.

In the PRP, a negative threshold decision was recommended for this component of the project, since it represents essentially a repair job rather than a new departure.

2. The other component of the project proposes the construction of a new dike to run the 25 km between Mogodi and Kotoa. According to the PRP, the impacts will be magnified because this will be altered. The effect on the ecosystem behind the dike may be beneficial but this remains to be determined. In the PRP, a positive threshold decision

was recommended for this component of the project.

1.2 Briefing

The team met for briefing at APHA and the Department of State in Washington on May 5, and 6, and in the USAID office of the American Embassy in N'Djamena on May 10, to 13. In Washington, the team benefitted from comments presented by Mr. John Lundgren, Country Development Officer, N'Djamena. (At this time Mr. Lundgren suggested that the Field Team consider adding the region of Gounou-Gaya, in Mayo-Kebbi Prefecture, to the scope of work. This idea was abandoned after discussions with CDO staff in N'Djamena). In Chad, officials responsible for health planning were contacted in the Ministries of Health and of Planning and relevant technical information was gathered.

After several days of forced delays during which problems of vehicles, drivers and gasoline supplies were addressed and solved, the team drove south to Bongor on May 17. One member of the team remained in Bongor in order to take advantage of the availability and cooperation of the Services des Grandes Endemies representative in that town. The rest of the team continued south to Lai on May 18, returning through Bongor to N'Djamena on May 21. One other team member (FPC) remained in Bongor at this time in order to collect water quality data, and returned to N'Djamena on May 30.

1.3 Report

The report was drafted in N'Djamena from June 6, to 9 and was based on individual contributions from each team member.

2. EPIDEMIOLOGY

2.1 National Morbidity Statistics

Data on the occurrence of diseases in Chad are derived from the four urban hospitals (N'Djamena, Moundou, Sarh, and Abeche) 41 Medical Centers, approximately 112 government and 25 private mission Dispensaries reporting through S.G.E., and from S.G.E. itself. They are of vastly varying quality and are based largely on the clinical impressions of modestly trained and poorly supervised infirmiers unsupported by laboratory studies. The data collected must therefore be interpreted with great caution, and cannot be used to calculate incidence rates because of massive underreporting. Also these medical services are available to only a limited part of the population.

The reported information does, however, provide some clues to the diseases of importance in Chad, and to temporal changes. Table 1 is a record of the reports of certain selected diseases, nationwide, from 1969 through 1975.

To provide some comparative information for the areas of greatest interest to the Assessment Team (Mayo-Kebbi and Tandjilé Prefecture), Table 2 is presented. Data from Prospection Teams of the S.G.E. nationwide are shown separately because they may be as reliable as any available, and from the largest hospital (N'Djamena) to reflect the diseases encountered in an urban area.

A somewhat different impression is provided by Table 3, which is a compilation of the 10 leading causes of morbidity and mortality as reported from the large urban centers in Chad and the rural Dispensaries in 1974.

2.2 Medical Services in Mayo-Kebbi Prefecture

The five medical centers in Mayo-Kebbi are located in Bongor, Léré, Finanga, Pala and Gounou-Gaya (although the latter has no physician, it is headed by an Infirmier d'Etat, and is sometimes referred to as an Infermery).

Only the Medical Center at Bongor was visited. It has three physicians Dr. Ramadan, a Chadian educated in the Soviet Union, his Russian wife, and a Russian surgeon. There are 100 beds, although many additional patients sleep on palets outside the buildings, which are divided into Medical, Surgical, Obstertric and Pediatric Services. The iron beds are cemented into matresses, bedcovers, mosquito nets or screening; surgical patients were not adequately protected from filth and flies. There is no electricity, there is an adequate municipal water supply. Surgery is performed by the light pressure lanterns. The present X-ray machine and an electricity generator to operate it are expected soon from N'Djamena. Laboratory services are limited to microscopic examinations, including stains for blood parasites and tubercle bacilli in sputum smears, and simple chemical tests for sugar and albumin in urine. It is reported that the medical center is always very low on supplies of essential medications. The hospital provides one meal per day to its patients; other food is provided by relatives. The Bongor Medical Center reports directly to the Ministry of Public Health in N'Djamena, and is not considered to be within the Formation Sanitaire of the Prefecture for purpose of reporting in Sector 2 of Services des Grandes Endemies (S.G.E.) (See map, page 18)

There are 23 Dispensaries in the Prefecture, 12 government-supported and 11 private (operated by religious missions), distributed as follows:

Sub-Prefecture Bongor

Kiw

N'Gam

Guelengdeng

Biliam Oursi

Kogoni (Pvt.)

Moulkou (Pvt.)

Sub-Prefecture Pala

Torrock

Dari

Gagal (Pub. & Pvt.)

Keuni (Pvt.)

Moursala Bambiá (Pvt.)

Baje (Pvt.)

Sub-Prefecture Pianga

Lallé

Tickem

Koupor (Pvt.)

Sere Dawa (Pvt.)

Sub-Prefecture Léré

Binder

Bissi Mafou (Pvt.)

Sub-Prefecture Gounou-Gaya

Djodo Gassa

Berem

Gaya-Ganbi (Pvt.)

Tagal (Pvt.)

Each dispensary is headed by an Infirmier Brevetè, and is under the nominal supervision of the Medicine Chef of the S.G.E. The welding of the Dispensaries and the S.G.E. has worked out very badly, and is bitterly critized by everyone. The S.G.E, with a long and proud tradition, is run by a specialized service of French Military Surgeons. It has always been an independent, disciplined, well-trained, well-supplied corps, directed toward the detection and control of specific diseases with the ultimate aim of prevention. It provides general curative services principally as an operational technique permitting it to reach the maximum possible proportion of the population for surveillance (dépistage) of trypanosomiasis, leprosy, tuberculosis, onchocerciasis, the trepanematoses; for the detection of epidemic out-

breaks of meningitis and measles; and for mass immunizations against smallpox, yellow fever, measles, and tuberculosis. The humanitarian provision of curative services during the course of its tournees des depistage is secondary.

With this background and orientation, responsibility for fixed dispensary services seems alien, made worse by the fact that the S.G.E. appears not to be given additional medications for supply to the dispensaries, therefore it is unwilling to share its supplies with the latter. Presumable, the rationale for the welding of the two services was so that the dispensaries could serve to enlarge greatly the surveillance operations of S.G.E., and in turn, the S.G.E. being mobile could readily get to the dispensaries. Yet the weld is defective, with nutural complaints and recriminations.

In Mayo-Kebbi, Dr. Le Moal, or his adjoint, visits each dispensary one to three times per year (according to Dr. Le Moal's tour record). Drugs are provided for no more than about three months use, and the dispensaries then go without unless they receive supplementary supplies from the World Health Organization agency. The Infirmiers have limited training, and do not receive refresher training. The S.G.E. is interested principally in detecting diseases clinically rather than laboratory. Dr. Le Moal believes that they are competent to do laboratory diagnosis. However, the reports on diseases, which form a large part of the national morbidity statistics, are said to be inaccurate.

Sector two of the S.G.E. serves only Mayo-Kebbi Prefecture. At the present time its Equipes Mobiles are organized as follows. One

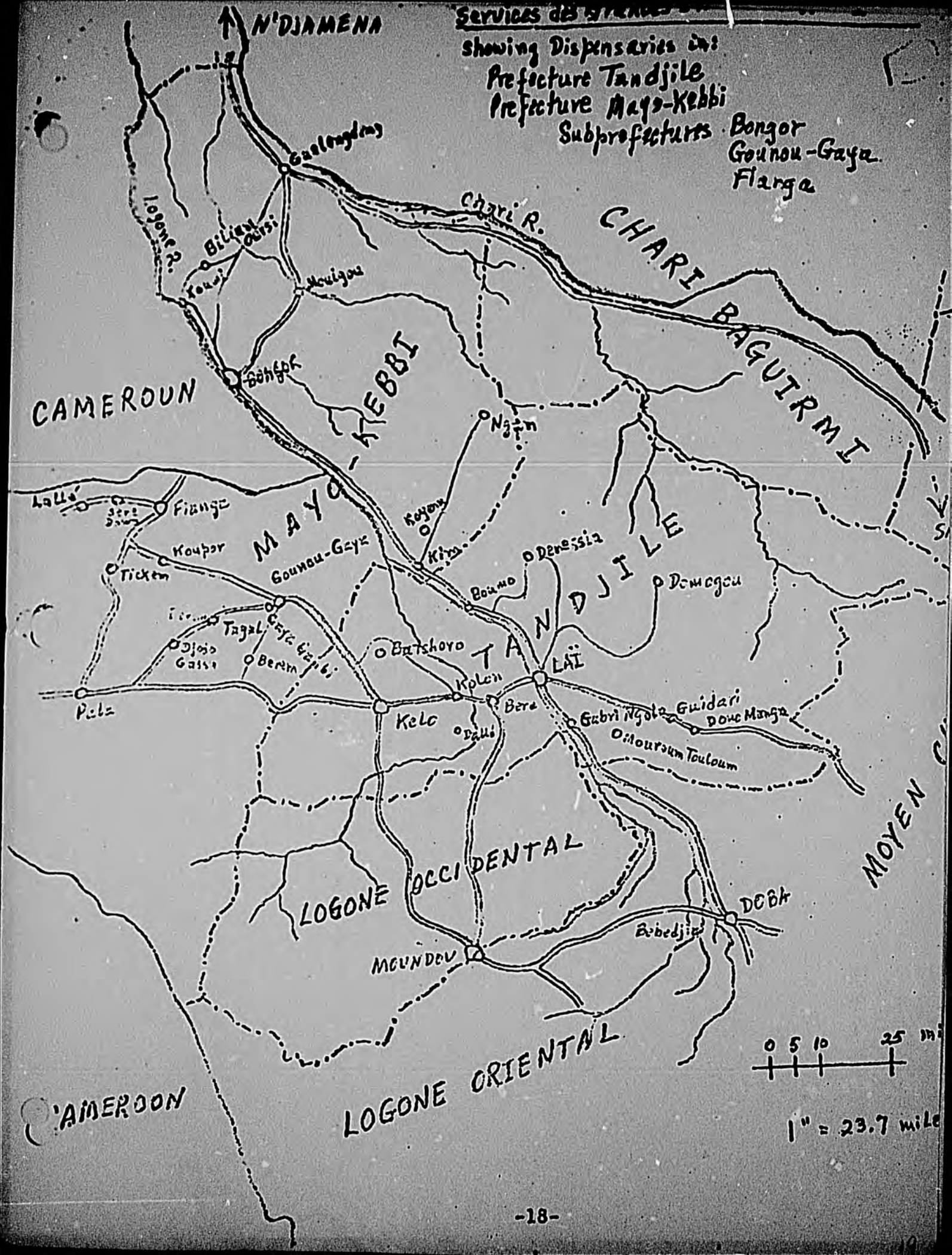
large, "polyvalent" team, staffed by twelve persons and carrying a mobile laboratory which includes a capacity for spinal fluid and skin biopsy examinations, is responsible for intensive surveillance by physical examination of all persons, rendering curative care as needed, and immunization against the four diseases for all age groups. It does not visit dispensaries. Mayo-Kebbi is divided into four zones, and the schedule for this team is so planned that it will cover the entire population in four years. However, during its last cycle, coverage was almost completed in three years.

The polyvalent team is supplemented by an Equipe Mobile Legère, composed of three persons, for childhood immunizations (ages 6 to 30 months only). It also covers one zone per year, therefore, the administration of vaccines to children is repeated on a cycle of two years.

Three light mobile teams are reserved exclusively for follow-up and only used for some detection of leprosy and tuberculosis cases for treatment. They check on the continued use of the prescribed médications and the clinical state of the patients. They are expected to visit and resupply each case every six months.

One light team is kept in reserve for emergency, epidemic control. It is prepared to move within 24 hours, the state of the roads (most difficult in July and August) and the supply of gasoline permitting. In the event of serious need, other teams could be diverted to epidemic control.

The schedule of routine mass immunization is as follows:
Children (6-30 months) - simultaneously administered smallpox vaccination by scarification on left lower arm, B.C.G. scarification


Services des Sanitaires
showing Dispensaries in:
Prefecture Tandjile
Prefecture Mayo-Kebbi
Subprefectures Bongor
Gounou-Gaya
Flanga
N'DJAMENA
Chari R.
CHARI BAGUIRMI
Logone R.
Bongor
MAYO KEBBI
CAMEROUN
Ngam
Flanga
Lalle
Koupar
Tickem
Gounou-Gaya
Kyom
Kim
Deressia
Bouno
Domogou
TANDJILE
Tagal
Djoja
Gassi
Berim
Batchoro
Kolon
LAÏ
Pala
Kelo
Bera
Gabri Ngola
Guidari
Doue Manga
Dalli
Mourum Touloum
MOYEN C
LOGONE OCCIDENTAL
DOBA
Bebedjia
MOUNDOU
LOGONE ORIENTAL
CAMEROON
0 5 10 25 mi
1" = 23.7 mile

on the inner aspect of left lower arm, and measles and yellow fever (17D strain) together, by Ped-O-Jet.

Smallpox - scarification repeated every four years throughout life.

BCG - repeated at about age 10, and once again at about age 20.

Yellow fever - Dakar strain, by scarification, repeated every four years beginning at age 15. No individual records are kept; smallpox vaccine and BCG scars are used as evidence of childhood vaccination, and children who are missed on one visit by this criterion are given the four-agent course on the next.

Prospection Team (including immunization) coverage averages 75-80% based on an S.G.E. census of 469,908. Note that the national census gives Mayo-Kebbi a population of 592,000, which, if correct, would reduce coverage to 59-64%. Reported coverage is poorest in Bongor Canton - as low as 63%.

The impressive extent of this program is indicated in Table 4, showing vaccinations performed.

Table 4. Vaccinations Performed by S.G.E., 1973-1976.

Year	Smallpox	Yellow fever	Measles	BCG
1973	123,743	102,281	16,094	63,952
1974	109,560	41,800	16,950	16,120
1975	113,738	39,190	25,614	25,554
1976	127,027	51,510	35,772	80,551

2.3 Current Status of the Major Diseases in Mayo-Kebbi Prefecture

2.3.1 Malaria

Twenty-eight thousand two hundred and sixteen (28,216) cases of malaria were reported in Mayo-Kebbi in 1975, but this figure is stated

to be meaningless. Most people with the diseases do not seek treatment, and the diagnosis in the vast majority of cases is based only on the occurrence of fever and headache not otherwise explained. The S.G.E. does not make microscopic examinations for this disease. It is believed to be heavily endemic everywhere, throughout the year. National figures show some seasonal increase at the end of the rainy season (with a modest peak in October), but this may underestimate the seasonality of the disease since travel to medical facilities is most difficult at this time of the year. There have apparently been no authenic studies of this disease in Chad in recent years.

2.3.2 Schistosomiasis

Five thousand four hundred seventy nine (5,479) cases of urinary bilharziasis were reported in Mayo-Kebbi in 1975, and 561 cases of the intestinal form. These figures give no true indication of the incidence or prevalence of this disease since diagnosis is based usually on the appearance of gross urinary or intestinal bleeding, sometimes "confirmed" by hepato-and spleno-megaly, and infrequently confirmed by microscopic examination. Limited microscopic surveys in various localities indicate the prevalence of S. hematobium to be between 20% and 70%. Dr. Le Moal believes that it is heavily endemic throughout Mayo-Kebbi, but least important along the banks of the Logone River which does not provide a good breeding area for snails. Everyone agrees that the urinary parasite is much more frequent than S. mansoni.

2.3.3 Leprosy

This disease persists at a prevalence rate of 1% or more in Mayo-Kebbi with 200-500 new cases discovered each year as indicated in the following table.

Table 5	Leprosy, Yearly New Cases	Prevalence rate
Year	Incidence rate (%)	(%)
1971	0.16	1.45
1972	0.089	1.37
1973	0.075	1.26
1974	0.023	1.14
1975	0.032	1.07
1976	0.045	0.98

These figures are minima, since there are probably false diagnosis, but the prospection teams reach at most 75-80% of the people. The cure rate is low (based on skin scrapings for Hansen's bacillus), most cases being removed from the registry by death, emigration or disappearance rather than cure. This low cure rate is attributed to dependence on self-treatment, the patient being given 6-12 months supply of medications to use at home under S.G.E. team supervision once, or at most twice, per year. Up until about 10 years ago there was a corps of 20 infirmiers who had weekly circuits of visits for surveillance and distribution of medication. These were terminated for lack of funds, and Dr. Le Moal has only recently been able to reintroduce four bicycle circuits in Bongor Sub-prefecture. The apparent upturn in incidence rates shown in the table above may reflect this deterioration of treatment effectiveness. Prevalence is fairly uniform throughout Mayo-Kebbi. It is highest in Bonfor Sub-prefecture, at 1.25%. The distribution of the 4,620 known cases at the end of 1976 in Mayo-Kebbi was: Lepromatous - 16.4%, indeterminate - 29.0%.

2.3.4 Tuberculosis

Known cases of this disease are far fewer in number than for leprosy, only 263 in Mayo-Kebbi at the end of 1976. Only the most

serious cases are detected. Diagnosis is by clinical signs and symtoms, usually confirmed on positive sputum examination. Sputum smears are made from suspect cases in the dispensaries and by the S.G.E. Prospection teams and are sent for examination at a medical center if this cannot be done locally. The S.G.E. does its own. If positive, the patient is hospitalized at a medical center for one month and treated on a domiciliary basis for six to eight months more. The patient may be declared cured after sputum examination at a dispensary or medical center and if missed would be sought by the S.G.E. Prospection team on its next visit. Five hundred sixty one (561) sputum examinations were made in 1976 in Mayo-Kebbi; 105 of 439 suspect new cases were positive as were 45 of 132 follow-ups. The incidence and prevalence rates in Mayo-Kebbi, as reported by this minimal system, are fairly constant but rising during the last few years:

Year	Incidence rate	Prevalence rate
1974	22	28
1975	28	40
1976	30	55

(* per 100,000 persons)

2.3.5 Trypanosomiasis

This disease had all but disappeared in Chad, only two new cases having been reported in the entire country in 1975, giving a total of 1,811 known living cases in that year. The last known case in Mayo-Kebbi died in 1976. However, focus of over 200 cases was discovered this year southeast of Lai on the Logone River in the Tandjile Prefecture. Dr. Le Moal fears its return in Mayo-Kebbi also, and it is a priority prospection activity of the S.G.E. Teams, principally by examination for and aspiration of lymph nodes for microscopic examination.

2.3.6 Meningitis

This occurs in sporadic outbreaks throughout Mayo-Kebbi principally in November-March. An outbreak of 212 cases in an area just northeast of Counou-Gaya in February of this year (1977) went unreported until it was mentioned to school teachers by students returning from their villages. Treatment by the Equipe d'Urgence is by sulfonamide, inoculation of the patients and tablets to their families. Diagnosis is believed to be accurate, but many cases are missed. Case fatality rate tend to be highest in years of low incidence because of delayed reporting. The recent record shows:

Year	No. cases	Fatalities	* CFR(%)
1973	881	50	5.7
1974	106	9	8.5
1975	146	8	5.5
1976	54	13	24.1

2.3.7 Measles

A very serious disease in poorly nourished children. The incidence of measles has been greatly reduced by the routine mass immunization program. The latter has largely limited outbreaks among children not yet old enough to have been served by the vaccination teams and those missed by the teams. It occurs throughout Mayo-Kebbi and the recent records show:

Year	No. cases	No. deaths	* CFR(%)
1973	1006	15	1.5
1974	337	23	6.8
1975	100	2	2.0
1976	555	38	6.8

*(Case fatality rate)

2.3.8 Onchocerciasis

Occurs in two very limited areas in Mayo-Kebbi, in a larger focus on the Mayo-Kebbi River, between Fianga and Lere in the western part of the prefecture and a smaller focus at the extreme southeastern border with Cameroon. Fourhundred twenty-two (422) cases were diagnosed by nodule detection in 1976. A special prospection undertaken in five villages near the Mayo-Kebbi River rapids in 1973 revealed a prevalence rate of 33.9%. Seven hundred thirty six (736) of 2,168, (34.9%), persons examined had nodules, 306 had ocular lesions, 14%, and 632 (49.7%) of 1,271 skin biopsies were positive. An insecticide campaign in the area during 1955-1963 had been effective in reducing Simulium flies by 90% but it was terminated because of lack of funds.

2.3.9 Venereal diseases

Both syphilis and gonorrhea are highly prevalent but only a small percentage of each is reported and treated. They are diagnosed almost exclusively by physical signs and symptoms, syphilis rarely being confirmed by serology and gonorrhea by microscopic examination of urethral exudates. Five hundred seventy six (576) new cases of syphilis were reported in Mayo-Kebbi in 1976, and 1810 cases of gonorrhea in 1975.

2.3.10 Yaws

Once common, this disease is now rare in Chad. No cases were found by S.G.E. teams in Mayo-Kebbi in 1976, and Dr. Moal questions the 31 cases reported by dispensaries last year. Only 16 cases (6 contagious) were reported by the S.G.E. throughout Chad in 1975.

2.3.11 Infectious Hepatitis

This is heavily endemic in Chad. It is one of the most serious problems among expatriates, and even among Africans, in whom the diag-

nosis is based entirely on signs and symptoms. Many cases are missed because of the diagnosis method used, yet 1647 cases were reported in Mayo-Kebbi in 1975.

2.3.12 Tetanus

One hundred sixty two (162) cases, with 88 deaths were reported in Mayo-Kebbi in 1976. Dr. Ie Moal believes that these figures are far too low and has officially suggested the advisibility of including this disease in the immunization schedule.

2.3.13 Anthrax

This disease may be far more common among humans in Chad than has previously been recognized. It is an important disease of cattle, and its control is a major activity of the veterinary service. An outbreak of about 30 cases occured early this year in several villages around Koyon in Bongor subprefecture.

2.3.14 Guinea Worm disease

Generally not important, this disease does occur focally. In one village 10-15 km from Bonfor over 30 cases were found several months before this report. Interestingly, the village is occupied by two different ethnic groups, one of which had access to a well and the other which uses water from a nearby pond. The disease occured only among the latter group.

2.3.15 Diarrhea and Dysentary

These are omnipresent, and the reported figures give no true indication of their prevalence. The bacterial etiologies are not diagnosed as such, amoebiasis is also usually a clinical guess, and intestinal worms are found everywhere. Despite Buck's failure to find evidence of Ascaris infection, this is also common as demonstrated by Dr. Ramadan

who showed this investigator a bottle of preserved mature round worms.

2.3.16 Cholera

The most recent pandemic hit Chad in 1972, but was confined to that part of the country north of Lake Chad. It did not remain in the country after that year, and evidentally has no major endemic potential here.

2.3.17 Smallpox

No case has been seen for many years. Although one cannot be certain about the north of Chad, the disease has probably been eradicated. Certainly the extensive immunization program will prevent this from ever gaining any importance in Mayo-Kebbi.

2.3.18 Plague

This has not been known in Chad in living memory.

2.3.19 Malnutrition

Although poor nutrition may be assumed generally, frank malnutrition is not common. Dr. Le Moal has seen only two cases of kwashiorkor in four years, and a very few cases of maraskius. No detailed nutritional surveys have been undertaken in Chad, and little is known about specific vitamin and mineral deficiencies.

2.4 Medical Services in Tandjile Prefecture

There are two Medical Centers in Tandjile located at Lai and Kelo, and 15 dispensaries distributed as follows:

Sub-Préfecture Lai	Sub-Prefecture Kelo
Buomo	Kolon
Doumongou	Batchoro
Dona Manga (1 Pub. 1 Pvt.)	Bologo

	Sub-Prefecture Bere
Marou Touloum	**Dalle**
Gabri N'Golo	**Bere (1 Pub., 2 Pvt.)**
Deressia (Pvt.)	
Guidari (Pvt.)	

2.5 Current Status of Major Diseases in Tandjile Prefecture

The annual report of the Medical Center in the city of Lai for 1976 was obtained by Mr. Grenier during a trip there in about May 18, 1977. Table A. contains a list of selected diseases taken from that report.

Table 6 (Reported New Cases of Selected Diseases Diagnosed at the Lai Medical Center, Tandjile Prefecture.)

Disease	Infants	Adults	Total	Deaths	CFR
Syphilis	1	48	49	——	——
Gonorrhea	——	151	151	——	——
Amebiasis	867	1,637	2,504	——	——
Meningitis	9	8	17	5	——
Tetanus	2	4	6	2	3.4
Measles	179	——	179	20	6.0
Hepatitis, Infect.	4	24	28	——	——
Malaria	8,741	9,467	17,708	30	590
Schistosomiasis, uri.	260	716	976	——	——
" " Intest.	10	44	54	——	——
Onchocerciasis	53	382	435	——	——
Yaws	115	49	164	——	——
Pneumonia	1,329	990	2,319	9	258
Bronchitis, choronic	15	42	57	5	11.4
Eye infections	484	304	788	——	——

Cont.

Ear infections	410	248	658	——	——
Tuberculosis	——	28	28	——	——
Dysentery	685	536	1,221	——	——
Total				71	

Table 7. (Ten Leading diseases (New Cases) during 1975, 1976 in Lai Medical Center)

Rank by Nos. of cases	Time Period	
	1975	1976
1	Malaria	Malaria
2	Amebiasis	Amebiasis
3	Hepatitis	Pneumonia
4	Schistosomiasis (urinary)	Desentery
5	Dysentery	Schistosomiasis (urinary)
6	Gonorrhea	Eye infections
7	Meningitis	Ear infections
8	Pertussia	Onchocerciasis
9	Varicella	Measles
10	Mumps	Yaws

Overall this Medical Center treated or cared for 36,440 patients, in 1976, and provided 67,587 consultations. There were 212 births and 88 deaths (the 71 listed in Table 1, plus 11 stillbirths and 6 deaths from animal bites).

When the selected diseases shown in Table 6 are compared with Dr. Gelfan's report, Table 2, and ranked by the number of new cases during 1976 and 1975, respectively, it is apparent that only certain diseases

prevail from year to year. It can be seen, Table 7, that Malaria, Amebiasis, Dysentary and Urinary Schistosomiasis are consistently seen in patients attending the Lai Medical Center year after year whereas the other diseases of the 10 most frequently seen in any one year are of wave, epidemic or outbreak occurrence.

Other possible explanations for difference in occurrence of diseases may be due to:

1) difference in peoples acceptance of the Medical Center activities;

2) difference in Staff's awareness and interest in different disease entities; and

3) differences in the funds available that permit the Medical Center personnel to completely work up patients for laboratory and clinical diagnosis.

Although it is not possible to know which one or more of these factors may play a role in reporting diseases, it should be possible for an established clinic to provide expected numbers of cases and to be able to explain changes from the expected. Such information serves a useful guideline for program evaluation and planning.

3. STATUS OF DOMESTICATED ANIMAL HEALTH WITH SPECIAL CONSIDERATION OF DISEASES TRANSMISSIBLE TO MAN

3.1 Introduction

Cattle, sheep and goats comprise the majority of the livestock enterprise in Chad. Swine and poultry raising are much less components of the industry today.

There are two major groups of cattle used and raised in Chad;

1. the commercial cattlemen who have heads numbering from 30 to 50000 head each and;

2. the villagers who have 1-10 head of cattle primarily for use as beast-of-burden for cultivating the land.

3.1.1 Commercial cattle

During the dry season herds of cattle are grazed in the savannah region of Chad ($9^{o}$to 12° latitude north). As the rainy season sets in, the herds are driven north into the upper savannah and southerly steppe region (12° - 15° latitude) and then moved to the Cameroon border into the market places in Cameroon and Nigeria. Most herds are tended by families and cattle movements are pre-planned to utilize new grazing grounds. These herds may only be moved 20-50 kilometers during any one season. The larger herds are sometimes driven the distance of 500 kilometers to adequate grazing areas before the cattle are moved into the market places.

3.1.2 Beast of burden cattle

The Arab livestock owners drive some of the commercially less valuable animals south into Chad to sell to farmers as beasts-of-burden. These are usually small, under-developed animals that have little other value. These cattle are used for cultivating fields and hauling farm products, but their stamina is limited; they can only work several hours in the mornings before they begin to stagger and become inadequate for continued work on any given day.

3.1.3 Cattle husbandry

Animal husbandry practices are very primitive yet in spite of that livestock is one of the major enterprises in Chad and Chadians are judged by their African neighbors as good livestock raisers. Probably due to a combination of undernutrition and diseases, calves do not attain sexual maturity until they are at least three years old which is twice the age physiologically expected in well-nourished and disease-free animals. Such conditions are obviously an economic

waste of the livestock potential in Chad.

3.1.4 Potential disease problems in cattle-raising families and/or villagers from cattle

The family members herd cattle and consume the sick or dying animals as food. Milk from lactating cows often is the prime source of food for many families. It appears to be a general practice for the calves to be separated from their dams and at the end of the day the cows are milked just enough for the families needs. Then the calves are brought in to nurse the dams dry. Obviously, calves are not getting adequate nutrition most of the time and are forced to forage before they develop the rumen flora to adequately utilize grass and hay. Even more important is that the calves are not getting enough milk from their dams, perhaps not even getting the colostrum needed immediately after birth, depriving them of material immunity which comes from the milks. Consequently most calves are probably diseased and malnourished for lack of good husbandry practices.

It follows then that the milk and the meat consumed by families is a potential source of disease to them. None of the references cited in the literature review of this report have acknowledge this as a major health threat. Maybe there is need for investigation to determine whether or not the milk and meat, consumed by the families, are potential sources of disease.

3.2 Project Assale-Serbewel Report

The report by S. Diffend, (1976) entitled "Personal Report Concerning the Development of the Animal Health, Extension, Marketing and Range Management Project known as Project Assale/Serbewel in the Sector Serbewel, " animal, but not human health, was considered by

the team.

It is pointed out in this report that the tsetse fly, Glossina tachinoides, has been stamped out in the Serbewel Sector, probably as far south as Dongor in the Lake Chad River basin. The tsetse fly eradication project in 1972-1974 set the stage to initiate Livestock Associations in the fly-free areas. The Cameroon Livestock Service was the main veterinary service providing vaccination programs supported by local livestockmen. Their main objectives were to annually vaccinate cattle (380,000 head) for pleuropneumonia and rinderpest and to irregularly vaccinate against anthrax and blackleg. The program has been effective in removing for former two diseases, but anthrax is an ongoing problem. Foot and mouth disease is under surveillance.

Diffendd states that in 1976 there were 484,383 head of cattle in Serbewel Sector that would be relatively well vaccinated, free of trypanosomiasis and recommended anthelminthic treatment to improve weight gains and general health of the animals. The tick problem is important for piroplasmosis heart water and streptotrichosis in cattle but dipping programs have not yet begun.

According to Diffendd the average herd size is 125 head. Calves are herded separately from adults until weaned. Herds are kept at home from July to January when the waterholes begin to dry up and they drive their herds 40-80 km. from home to new grazing areas. The cattle graze at night and during the day they are in compounds around which smug-pats are used to reduce the fly and mosquito problem. The most common cattle breeds are shorthorned zebu, N'Borora, and Kouri. According to Mr. B. Wood, Chadian livestockmen do not utilize castration

of young bulls for improved meat production. In general 59% of the cattle are cows, 15% bulls, 13% heifers (1-3 yrs. old) and 18% calves.

3.3 Meat Inspection

There are two government owned abattoirs in Chad, one in N'Djamena and the other near Sarh. The choicest meat is exported and good meat is sold to local European residents and the lower (cheaper) grades are sold to the Chadians.

Inspection is by sight; if organs or parts of the carcass are obviously diseased they are discarded and the carcass down-graded. No records are kept to know what percent of animals have obvious disease, i.e., infestation or infective tuberculosis Talnia, etc.

Probably the majority of meat consumed in Chad is slaughtered in the villages without any supervision or concern for animal diseases. It is not the usual practice to use lungs or GI tract for food. And, fortunately, it is not the usual practice to consume meat uncooked, although cooking practices are extremely variable.

3.4 Diseases of Animals Potentially Transmissible to Man in Chad

Since there are no records of animal diseases in Chad, other than the ones for rabies vaccination programs in selected areas, the actual threat of animal disease to people in Chad is unknown.

The list of zoonotic disease suspected of prevailing here is shown in Table 7. This is certainly not an exhaustive list and other zoonoses may be present but it would require special surveillance efforts to document their presence and importance.

Table 7

List of Animal Diseases Potentially Transmissible to Man in Chad

Tuberculosis
Brucellosis
Leptospirosis
Anthrax
Trichinosis
Q Fever
Rabies
Histoplasmosis

3.5 Discussion of Selected Diseases of Animals Transmissible to Man in Chad

3.5.1 Tuberculosis

Buck et al (1970) found with tuberculin testing of the population in five villages in Chad that positive cases varied from 13-12%. Interestingly, the areas with more positives were in the areas with livestock. But these authors made no mention of sources of infection and did no culturing of sputa to identify mycobacteria species that may have indicated source.

Since meat and milk are largely taken from cattle in which the occurence of tuberculosis is unknown it is conceivable that Mycobacteriumbovis is a cause of human cases.

3.5.2 Brucellosis

Buck et al (1970) are the only authors known to this writer who considered the occurrence of brucellosis in people in Chad. They found 11 of 1609 sera tested positive, or 0.7%. Buck states "the geographic arrangement of the cases by household in the five communities parallels the distribution of the number of domestic animals.....".

3.5.3 Leptospirosis

Buck et al (1970) reported 27 of 1511 sera tested with pools of leptospira antigen by the slide agglutination test were positive (1.8%). Positives were believed most common in areas where the practice of eating rat meat was most common. Although not an obviously important problem in Chad now it may be in the future if agricultural practices change to manioc rice growing and farming.

Leptospirosis occurs with various manifestations in dogs, cattle, pigs, sheep, goats and horses. Fatality in man is usually low, but can reach 20%.

3.5.4 Anthrax

It is now a sporadic disease in cattle and most domestic animals. Transmission to man is:

1) by contaminating skin wounds with anthrax spores (cutaneous anthrax);

2) by inhalation of spores from environment or animal hides (pulmonary anthrax); or

3) by ingestion of uncooked meat (not milk) from animals infected with anthrax (intestinal anthrax).

Fatality associated with the cutanous form is up to 20%, pulmonary and intestinal forms are over 80% fatal.

Control of anthrax in cattle and all domestic animals is possible by annual vaccination. The Sterne-spore vaccine (non-encapsulated, avirulent vaccine) is the preferred vaccine according to present standards.

3.5.5 Trichinosis

Trichina infection of people in Chad probably is not a major problem.

Buck et al (1970) tested 1592 sera and found 4.6% positive. They felt that the Chad test used for the sera survey was inaccurate and many more false-positives were present than was realistic. Trichina is transmittal to man primarily from pigs, both domestic and wild and a number of rodents when meat is improperly cooked. Thus in Chad the true occurence of trichina is unknown, but is possibly negligible due to the small amount of pork consumed.

3.5.6 Q-fever

This rickettsial disease is generally an inapparent infection of animals that is transmissible to man by the respiratory route, by ingestion of infected milk as well as by tick vectors (the latter is the only mode of transmission for other rickettsiasis). Buck et al (1970), did a serosurvey of 1,459 sera from 5 villages in Chad and found 32 positives for Q-fever by complement-fixation. They associated the positives with camel caravans traveling in the Sahara. The occurrence of Q-fever in cattle and sheep is unknown but its presence in Chad in over 2% (32/1459) of persons tested warrants further study. Q-fever causes less than 1% fatalities in man, but it does result in chronic hepatitis and endocarditis.

3.5.7 Rabies

Rabies is a viral infection that can be considered 100% fatal to man and animals. All warm blooded animals are susceptible. In Chad it undoubtedly exists in wild animals and attacks man and domestic animals including dogs. Consequently cattlemen and farmers are more at risk from rabies than the more urban dweller. Rabies has been considered by other authors writing about Chad to be increasing. The following information taken from Dr. Gelfand's report indicates that this may be correct:

Table 8

Year	No. Rabies Deaths	Reference
1966	1	Buck (from S.G.E.)
1967	1	Gelfan (" ")
1968	1	Gelfan (" ")
1969	23	" (" ")
1970	16	" (" ")
1971	13	" (" ")
1972	5	" (" ")
1973	25	" (" ")
1974	28	" (" ")
1975	33	" (" ")

Rabies vaccination for domestic animals is available and effective as is vaccination and treatment for man. There is no evidence that any of these are generally available now to Chadians or their animals.

3.5.8 Histoplasmosis

The mycotic agent of histoplasmosis has been known to occur in Africa since 1954 (Buck et al) (1970). There are two antigenically related species in soils of Chad, H. capsulatem and H. dubosir. The latter is now considered as variant of H. capsulatem and the cause of African histoplasmosis. Clinically it causes subacute granulomata of the skin and bone and is most common in males 10-20 years of age. Its prevalence, reservois, mode of transmission and incubation period are unknown.

Buck found that in Southern Chad, (Boum Khebir), 38% of 352 people were skin-test positive. Approximately one-half of the positives had pulmonary lesions detected and chest roentgengrams.

It appears that more epidemiological investigation of histoplasmosis is needed in Chad.

3.6 Other Animal Diseases Transmissible to Man Occurring Sporadically or In Cyclic Outbreaks

3.6.1 Louping-ill

Is a tick-borne encephalomyelitis of sheep, deer and man. This is a virus infection of the central nervous system causing fever, malaise and impaired locomotion. Man acquires it from ticks or by consuming milk from infected animals and can develop a nofatal meningoencephalitis. Vaccine is available and apparently confers good immunity.

3.6.2 Rift Valley Fever

Is an influenza like disease in man, not fatal. Primarily it is an acute viral disease of sheep, cattle and goats. Mortality it is high in lambs (30%) and cows (20%). It is mosquito-transmitted in most cases, but transmission to farmers by contact with infected tissue is possible. It is widely distributed in Africa but its actual occurrence in Chad is unknown.

3.6.3 Toxoplamosis

A protozoan infection caused by Toxoplasma gondii, of cattle, sheep, swine and many other animals. In man it causes mainly inapparent infections except when primary infection occurs during pregnancy which may lead to abortion or to congenital anomalies of the newborn (mainly CNS disturbances). Since toxoplasmosis has a world-wide distribution and its occurrence in Chad is unreported, it needs epidemiologic investigation.

3.6.4 Tetanus

This is an increasingly important disease in Chad. Between 1969 and 1975 there were 3,642 cases reported nationwide and the fatality rate is from 30-50%. Tetanus spores occur in all soils contaminated with feces, of horses, cattle and sheep and perhaps some wild animals. It is now a particular problem of the newborn infant due to improper cleaning of the unbilical cord at delivery. Immunization of people is a more effective means of control than are immunization programs for animals. Use of toxoid and antitoxoids in animals is reserved for post-traumatic and post-surgical prophylatics.

Table 9

3.7 List of Other Animal Diseases Possibly Transmissible to Man as Occupational Hazards in Chad

Disease	Reservoir	Transmission (Vector)	Nature of human infection
3.7.1 Anboviruses			
Chikungunya	monkeys	Aedes	fever & rash
Sindbis	birds	Culex	fever & rash
O'Nyong Nyong	unknown	Ano pheles	Fever & rash
Dengue	monkey?	Aedes	fever, rash, hemorrhagic fever complications
Nesselstron	monkey	Ades	fever
West Nile	birds	Ades	fever, myocarditis
Yellow fever	monkey	Haemogogus; Ades	hemorrhagic fever
Bungamwere	monkey, birds rodents	Ades	fever & rash
Germiston	cattle	mosquito	fever & headache
Congo fever	cattle	tick	fever
Nairobi sheep disease	sheep, rodents	tick	fever

3.7.2 **Other Viruses**

Cowpox	cattle	direct contact	skin lesion
Newcastle	chickens	direct contact	conjunctivitis
Orf	sheep, goat	direct contact	cutaneous lesion
Psittacosis	parrots, pigeons	respiratory	pneumonia

3.7.3 Rickettsiae

African tick fever	rodents, dog	tick	fever & rash

3.7.4 Bacteria

Esysipeloid	swine, fowl, fish	direct contact	cutaneous lesion
Glanders	horses, mules	direct contact fomites, man-man	TB-like, fatal (rare today)
Plague	wild rodents	fleas (pneumonic, mon-man	bubonic, septacemic pneumonic

3.7.5 Fung

Actinomycosis	most domestic animals, esp. cattle	contact	granulomas of jaw thorax, abdomen
Trichophytosis	dogs, cats, cattle, rodents	direct contact	ringworm

3.7.6 Parasites

Hydatidosis	cattle, sheep swine, rodents	direct contact infestion	variable

4. MALARIA

4.1 Findings

What is known about the malaria situation in Chad has already been reported elsewhere. Burkhuus (1976) has made a very good review and presentation of facts that he obtained from authors

such as Buck (1970), Watson (1969), Cano and Marcos (1971) and Noamesia and Marcos (1973). The numerous problems of the medical centers, hospitals, dispensaries and the Service des Grandes Endemies in Tandjile and Mayo-Kebbi Prefectures are thoroughly presented by Masumbuko (1974 and 1976).

The four irrigated rice projects under assessment are located in Tandjile and Mayo-Kebbi prefectures. Both of these prefectures lie within a zone extending from the 500 mm. isohyet south to the 1200 mm. isohyet within which Watson (1969) considers malaria to be hyper-endemic, except in the Logone River flood plains where he considers malaria to be meso-endemic. All four of the projects are situated in the Logone River flood plains and would therefore be considered to be meso-endemic by Watson's standards. Unless the periodical floodings that occur annually have currents strong enough to flush the anopheline breeding sites in the villages and sorrounding areas, this should not be the case as the villages visited during this hot period have the signs of being highly malarious areas.

The fact that malaria is the most important disease of public health significance in Chad is evident even when one analyses the incomplete and unreliable annual health statistics reports for 1974 and 1975 prepared by the Bureau of Health Statistics. Malaria data is presented in Tables 10, 11, and 12.

Table 10 - TOTAL NUMBER OF NOTIFIED MALARIA CASES AND DEATHS IN CHAD FOR 1969-1967
(Bureau de Statistiques Sanitaires)

Year	Notified Cases	Deaths	Year	Notified Cases	Deaths
1969	125,498	163	1973	121,776	433
1970	127,487	110	1974	132,815	247
1971	148,740	288	1975	153,646	354
1972	142,506	81	1976	Not available May 1977	

Table 11- TOTAL NUMBER OF MALARIA CASES REPORTED FOR CHAD IN 1974 - 1975 (Est. Pop. 4,4000,000)
(Bureau de Statistiques Sanitaires)

Year	Jan.	Feb.	March	April	May	June	July
1974	10,292	9,505	11,746	7,925	8,672	10,881	9,054
1975	12,476	9,359	11,224	10,700	12,225	11,938	9,327

	Aug.	Sept.	Oct.	Nov.	Dec.
1974	13,753	13,566	13,838	12,036	11,547
1975	14,078	13,490	18,219	17,092	13,457

Total:

1974: 132,815

1975: 153,646

Table 12 - Incidence of Malaria for Tandjile and Mayo-Kebbi

PREFECTURES

(Est. Pop. Tandjile : 287,000, Mayo-Kebbi : 592,000)
(Bureau de Statistiques Sanitaires)

Tandjile

Year.	Jan.		Feb.		Mar.		April		May		June		July	
1974	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1974	753	-	315	-	1149	-	717	8	796	-	1137	8	357	-
1975	870	2	239	2	863	6	768	2	1182	5	1434	6	1212	8
*1976	867	-	1358	-	1565	-	1342	-	1120	-	841	-	839	-

Year.	Aug.		Sept.		Oct.		Nov.		Dec.		Totals	
	C	D	C	D	C	D	C	D	C	D	C	D
1974	1678	-	1320	6	854	3	1365	5	417	4	10,858	45
1975	1423	11	1493	-	1395	8	1377	13	659	-	12,921	63
*1976	1364	-	1392	-	1941	-	2056	-	3030	-	17,715	?

* Data for 1976 obtained from Lài Medical Center

Mayo-Kebbi

Year	Jan.		Feb.		Mar.		April		May		June		July	
	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1974	1266	2	723	-	2195	-	1306	-	684	-	1828	3	1505	-
1975	2580	3	2580	1	1212	-	1381	4	2621	6	2497	4	1343	2

Year	Aug.		Sept.		Oct.		Nov.		Dec.		Totals	
	C	D	C	D	C	D	C	D	C	D	C	D
1974	2268	2	3628	6	3213	6	1864	1	3369	5	23,849	20
1975	3522	3	1980	4	2636	9	3467	11	3188	5	28,618	52

C : Clinical Cases

D : Reports Deaths

Only a small portion of the sick population lives close enough to walk to the existing health institution. Most reported cases of malaria are clinical diagnosed as many health units do not have microscopes or they have microscopes that are damaged. Some health authorities such as S.G.E. doctors, realize that malaria is their main health problem in the rural areas but there is not enough time or funds to adequately care for all the other serious disease problems in the country.

Barkhnus (1976) also points out that the reporting from a health institutions is so poor and irregular that it in no way can indicate the present disease situation in Chad. A typical indication of this problem surfaced while working with data obtained from the Lai Medical Center.

The Lai Annual Report for 1976 (Rapport Techniaque de la Sous-Prefecture Sanitaire et du Centre Medical de Lai) gives the following distribution of notified malaria cases for that year.

	Cases			Deaths		
o to 1 yr.	M	F	Totals	M	F	Totals
o to 1 yr.	890	403	1273	7	5	12
1 to 5 yrs.	704	690	1394	5	6	11
5 to 15 yrs.	3000	2554	5554	2	1	3
Adults	4116	535	4651	1	3	4
Totals	8710	4182	12892	15	15	30

There was no statement incorporated into the report to indicate that these cases were clinically diagnosed and/or laboratory confirmed.

There is an annual report for 1976 prepared by the same medical center with the following break-down for reporting malaria cases which differs from that given above.

Infants 8,241 cases

Adults 9,467 cases

Total 17,708 cases with 30 deaths

The discrepancies in these two reports deemed it necessary to cross-check the monthly reports.

The following monthly and annual total were obtained for 1976.

Month	Infants	Children	Adults	Totals
January	224	404	339	867
February	292	448	618	1358
March		834	731	1565
April		686	656	1342
May		597	523	1120
June		362	479	841
July		361	478	839
August		654	710	1364
September		606	786	1392
October		1026	915	1941
November		571	1151	2056
December		2029	1001	3030
TOTALS	850	8478	8387	17715

The figures obtained from the monthly reports should provide the correct data for the annual report but that was not the case. ONe wonders why the figures above were not submitted in the annual reports rather than in two different sets of figures.

The laboratory technicians at the Medical Center examined a total of 18,309 blood slides during 1976. A total of 13,660 plasmodium and 435 filaria cases were laboratory diagnosed. P. falsiporum predominated. There were no trypanosome cases reported.

Monthly Malaria parasite rates for the Lai Medical Center 1976

January	-	63.8%	July	-	75%
February	-	65.2	August	-	82.6
March	-	78.3	September	-	76.7
April	-	77.7	October	-	76.9
May	-	73.8	November	-	79.8
June	-	63.3	December	-	73.8

4.2 Observation-Sategui - Deressia Project.

This irrigated rice project is located in the flood plains of Sategui-Deressia, on the right bank (east) of the Logone River, about 20 kilometers north of the city of Lai. The plan is to irrigate and grow rice over a surface area of 5,700 hectares (14,079 acres). Funds are made available through two loans, World Bank and the African Development Bank. The project is under the control of O.M.V.S.D. with its headquarters in N"Djamena and is advised by two firms. - 1. Carlo Lotti for water irrigation and SATEC for rice cutlure. Mr. Rob-Mba is the Director of O.M.V.S.D. and Mr. Lorain is the Chief Technical Advisor. We did not have the opportunity to meet with these two gentlemen. We conferred with Mr. Savandy, SAOEC representative, and four Italian technicians at the Carlo Lotti firm.

The object of this project is to prolong the period of flowing without increasing the flooded surface area. They are now constructing a canal 7,800 meters (4.8 miles) long and 20 meters (65 feet) wide. The canal will obtain water directly by gravitation from the Logone River which will permit them to irrigate two sections for rice growing, one of 2,500 hectares (6,175 acres) and the other 3,200 hectares (7,904 acres). Towards the end of the canal and the two rice growing sections, a series of dikes will create a large reservoir of water which will permit the accumulation of water reserves for part of the dry season and regulate the water distribution during the period of maximum flooding.

According to Mr. Savandy, the period of maximum flooding will be from August 15 to October 20 with the peak being reached in mid-September and that only one crop of rice will be grown each year. The flood water of the Logone River overflows the banks of the river every season and floods the entire area surrounding the project area. The villages in the area are virtually islands during the rainy season and there is no means of communications between the villages except by canal or walking in hip-deep water. There will be some means

of communications by vehicles in the project area as a road is being built along the right bank (south) of the canal.

At the end of the rainy season, the water surrounding the project area and villages will be drained off by one of the tributaries of the Ba-Illi River about 15 kilometers north of Deressia and the area dries up fast. The impounded water in the project reservoir will be used to extend the rice growing period for another month or so into November-December when the rice will be harvested. There will be no water in the canals or reservoir during the dry season as there are no pumps to force water from the river into the main canal. Fertilizers will be applied to the rice fields twice during the growing season. A derivative of HCH will be the insecticide used against rice plant pests periodically and this will be applied by the field workers who will be given pumps and materials in addition to some training. Tons of fish were caught in the flooded area last year so the local people do not like to use insecticides as they realize that these can kill the fish. Aerial spraying of residual chemicals should not be considered as a means of controlling snails and anopheline larval in this area.

Eventually, a small canal at Boumo, 12 kilometers north of the main project, will bring water from the Logone River to a 200 hectares (444 acres) experimental rice station farm where the rice seed plants will be grown. At present, there is a small rice field bordered by the river and the main road just north of the town of Sategui where we were unable to find anopheline larval or snails. There is a verbal agreement between the Ministry of Public Health and O.M.V.S.D. to improve the health services for the workers at dispensarils in Boumo and Sategui.

In addition to this irrigation project, the O.M.V.S.D. is building residential homes for the technical and administrative staffs, warehouse for the

storage of rice and making future plans to extend the rice fields southward towards Lai. 1980 is the target date to complete the project which will cost approximately US $25 million.

The population for the project area for 1977 is approximately 9,550 with an annual growth of 2%. The people live in round or rectangular huts made of dry mud bricks with thatched roofs. The villages are situated on elevated areas because of the flooding conditions. There are 7 principal villages ranging in population from 100 to 1,000.

The most important of those villages is Deressia, which we had the opportunity to visit during this extremely hot and dry period of the year. There were no anopheline breeding sites in this village except the practically dry wells located throughout the village. The one good, cement constructed well had sufficient water and a drainage gutter that led to a pig wallow. The only pools of water in the area were located at Djogdo village, 15 kilometers north of Deressia and at the village of Mande, 5 kilometers north of Sategui.

The villages visited had many dry borrow pits of different sizes which are ideal breeding sites for A. gambiac and A. funestus when they are filled with water. The huts are rather small with many openings between the mud bricks and larger openings where the thatch roof sets on the mud brickwall. These huts would be extremely difficult to spray with residual insecticides. Filling the numerous borrow pits in the villages would require a good health education program.

The village chiefs in Deressia and Djogdo with whom we talked, through an interpreter, both realized that malaria is a serious disease problem in the area. When asked to name their major illness in their villages the Deressia chief named diarrhea, chicken pox and malaria, whereas the Djogdo chief named meningitis,

diarrhea and fevers in all age groups. Mr. Savandy later reported that there was a severe epidemic of meningitis in the village during the month of March 1977 and that there were many cases of malaria during the rainy season of 1976 and for a few months after March.

The "Service des Grandes Endemies" last visited Deressia to conduct case destestion and treatment of diseases in January 1976. It does not visit the village of Djogdo.

It is very doubtful that the impoundment of water in the project reservoir to irrigate rice fields in a surrounding flooded area during the rainy season and for a few weeks into the new dry season will have any adverse effects on the health of the people in the project area. The Medical Research Council (MCR) of Great Britain had recently had a team of three entomologists conducting studies of the impact of irrigation projects on A. gambiae populations. The MCR group feel that the contribution of the rice project was negligible compared with the general A. gambiae population of the surrounding area. This would generally hold true for the several rice projects being developed in the Logone River flood plains.

4.3 Technical Considerations for Various Self-Help Methods

4.3.1 Source Reduction

This method of using ditching, drainage and filling to control anopheline larvae is too sophisticated to be useful in villages but it could be helpful in and around urban areas where the work could be properly planned, implemented and supervised.

4.3.2 Larviciding

This method would not be economical during the rainy season. In the dry season larvicides for A. gambiae control may be useful.

4.3.3 Adulticides, Residual Spray

In spite of the effectiveness of residual insecticides against A. gambiae, this method is not suitable as a self-help anti-malaria measure for villagers in Chad. The yearly per capita cost, using an insecticide such as Fenotrothion, would be approximately U.S. $4.00. Additional research on Anophelis gambiae is needed, including the perplexing question of where the species passes the dry season, particularly in the more arid portion of its range.

In the southern part of Chad, malaria is described as being "stable". That is, it is characterized by high infant and child mortality, high levels of immunity beginning in late childhood, and with little obvious adult disease. This is not particularly the case in the Sategui-Deressia area as the adults appear to suffer from fever and chills. It is extremely difficult to truly assess the impact of the disease in adults. Further research is needed.

4.3.4 Personal Protection

4.3.4.1 Screening

This would restrict the movement of air in the huts of rural people who are used to having free space between the roof and walls, particularly where cooking is done in the huts.

4.3.4.2 Repellents

These are too expensive for consideration in Chadian villages.

4.3.4.3 Bed-nets

This is one of the best possibilities of self-help, particularly on the basis of free distribution to the villagers.

4.3.4.4 Adulticiding

Space grazing, using inexpensive "flit guns" and pyrenthrum solutions might be effective, if practiced every night and morning. According to 1975 estimates, it would cost approximately U.S. $7.67 per hut per year which is also too expensive for Chad. Pyrethrum is produced in Kenya.

4.3.4.5 Distribution of Drugs

This method has the attraction of simplicity and could be conducted at the village level with little or no medical supervision. Mass drug distribution schemes have been attempted with very mixed success. These have involved distribution of Choroquine to school children and pregnant women. In Cameroon, Senegal and Madagascar difficulties were encountered in the distribution of the drugs and in supervision. Also the coverage was not satisfactory. The cost is approximately U.S. $80 per person per year. There is some concern that the routine use of prophylatic drugs in the population may interfere with the development of immunity.

Recent programs in the research for developing a vaccine against the malaria parasite is encouraging but the prospects of producing an effective vaccine soon are dim and it may be fifteen to twenty years before one is perfected.

5. Schistosomiasis

5.1 Schistosomiasis in Southern Chad

Schistosomiasis is well established in Chad although the disease is not evenly distributed throughout the geographic south. Prevalence figures released by the Ministry of Health (which must be approached with considerable caution considering the non-uniform, and often inadequate, methods of collection) indicate that urinary schistosomiasis due to Schistosoma maematobium may represent the fourth or fifth most prevalent infectious disease in Chad.

Prevalence was unequal in six southern prefectures of the republic, with Tandjile and Chari-Baguirmi contributing approximately 7% each of the total number of cases reported during the five-year period 1970-74 (Table 11). Such low figures probably reflect the relatively underpopulated status of these two prefectures but may also reflect the effect of dry environmental conditions on transmission patterns. More than half of all cases in the southern prefectures were reported from the most heavily populated prefectures of Mayo-Kebbi (25%) and Moyen-Chari (27.2%).

Schistosomiasis haemotabia was formerly assigned an unimportant role as a cause of significant morbidity, and did not figure in any tables of mortality. In recent years, the role of schistosome eggs in causing severe bladder lesions, pulmonary arteritis and corpulmonale, and even

Table 11. Distribution of urinary schistosomiasis in Southern Chad 1970-1974 (data adapted from Masumbuko, 1976).

Prefecture	1970		1971		1972		1973		1974		5-year Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Logone Occidental	1,883	26.8	2,740	19.7	2,009	14.3	2,415	16.2	1,487	11.0	10,534	16.6
Logone Oriental	2,313	32.9	2,053	14.7	2,360	16.8	1,729	11.6	1,229	9.1	9,684	15.3
Tandjile	586	8.4	856	6.1	1,074	7.7	692	4.6	1,586	11.7	4,794	7.6
Chari-Bajuirmi	813	11.6	871	6.2	1,074	7.7	939	6.3	1,024	7.6	4,721	7.4
Moyen-Chari	1,311	18.7	3,874	27.8	3,699	26.4	4,891	32.7	3,507	25.9	17,282	27.2
Mayo-Kebbi	115	1.6	3,557	25.5	3,084	27.1	4,283	28.6	4,688	34.7	*16,447	25.9
TOTAL	7,021	100.0	13,951	100.0	14,020	100.0	13,521	100.0	13,521	100.0	63,462	100.0

* The total figure for Mayo-Kebbi would be 16,332 for the 4-year period 1971-1974, excluding the apparently inadequate reporting for 1970 from this prefecture; relative percentages in the six southern prefectures would remain largely unchanged.

cancer of the bladder, has been emphasized. If victims are unconcerned about a little blood in the urine and do not often seek medical help for this condition, it remains nevertheless, a matter of grave concern for the epidemiologist and the public health officer. In Lai, a survey conducted by Dr. Savin at the primary school showed that 349 of 1,595 students (21.9%) were infected with S. haematibium, and that the school authorities were concerned about the elevated rate of school absenteeism due to this parasite. (Table 12)

Intestinal schistosomiasis due to Schistosoma mansoni poses less of a threat for southern Chad. Except for the prefecture of Moyen-Chari, where extremely high prevalence rates are reported (19.7% of the total cases from six southern prefectures), the picture is one of low prevalence and incidence. (Table 13)

Table 12. Urinary schistosomiasis in 1,595 individuals of the Primary School of Lai, in 1974 (data adapted from Dr. Savin, reported by Masumbako, 1976).

Age	Number examined	Number positive	Percentage
6 - 8	511	97	19.0
9 - 11	437	88	20.1
12 - 14	478	116	24.3
15 - 59	169	48	28.4
TOTAL	1,595	349	21.9

Table 13. Intestional schistosomiasis in Southern Chad, 1970-1974 (data adapted from Masumbuko, 1976)

Prefecture	1970		1971		1972		1973		1974		5-year Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Logone Occidental	582	35.1	1,312	35.2	961	28.8	1,677	46.1	1,559	45.6	6,091	38.6
Logone Oriental	496	29.9	1,039	27.9	796	23.9	571	15.7	559	16.4	3,461	21.9
Tandjile	146	8.8	350	9.4	278	8.3	302	8.3	247	7.2	1,323	8.4
Chari-Baguirmi	34	2.1	72	1.9	85	2.6	38	1.0	56	1.6	285	1.8
Moyen-Chari	389	23.5	850	22.8	509	15.3	659	18.1	694	20.3	3,101	19.7
Mayo-Kebbi	10	0.6	105	2.8	702	21.1	395	10.8	304	8.9	*1,516	9.6
TOTAL	1,657	100.0	3,728	100.0	3,331	100.0	3,642	100.0	3,419	100.0	15,777	100.0

* The precentage of 9.6 for Mayo-Kebbi remains unchanged if the undependable figures for 1970 are omitted from the calculations.

5.2 Site Visit - Sategui-Deressia Project

Sategui is 12 km north of PCV John Eck's house, on the main road. We visited the experimental rice plots just north of the town on the morning of May 19. Most of the rice varieties were fully grown and some appeared to be mature. Water is fed into the plot by pump from the Logone River. The fields are to be kept full of water all year long. The water contained many toad tadpoles, some toadlets, some small larvivorous fish (deliberately introduced to control mosquito larvae?), but no snails of any kind! In many places the surface of the water bore an oily slick, suggestive of the chemical carrier for some pesticide. In one paddy the water was literally covered with dead mosquito adults and larvae plus pupal and larval skins. The water surface in this paddy was a mass of insect debris.

The only explanation we could adduce for the absence of snails, apart from the obvious one that they had been discouraged somehow by whatever pesticides had been applied to control rice pests, was that the ponds were only recently established (about 3 months old) with water taken directly from the Logone River; thus, no snails had yet had a chance to be introduced because it is the dry season and there are no pulmonate snails around. It is true that pulmonates are not found in the Logone River, but other snails, particularly the large operculates such as Bellamya and Pila, might have appeared in the paddy fields but were not found. It would be interesting and informative to explore these experimental fields at the end of the next rainy season, say, in October or November of 1977, to check again on the presence of snails of any kind and pulmonate snails in particular.

From Sategui we drove to Deressia, passing the smaller villages of Mande, Dila and Maskena, as well as isolated groups of huts. At this time of year, May-June, just in advance of the annual rains, the area is totally dry. No water was evident in the fields. A large pond at Mande, used to water livestock and also to support the manufacture of mud bricks (poto-poto), was devoid of any vegetation. This was the only sizeable body of water seen on the road between Sategui and Deressia. It was evidently not a conducive location for snails.

At Deressia we spoke with the Chief de Canton who informed us of the presence of two large "marigots" or ponds to the north near the village of Djogdo. We visited these two ponds which proved to be extensions of the Ba-Illi River, isolated from the mainstream by drying. They were much visited by people and cattle, were heavily contaminated with cattle manure, supported flourishing colonies of muck-loving water lilies (Nymphea), and yielded only operculate snails. No pulmonate snails were found.

Returning to Deressia, we had another chat with the Chief de Canton who told us that snails appear in the surrounding waters only after the first rains which soften up the soil. He thought that some of the snails spend the dry season aestivating deep in the mud. If it is true that aestivation is an intrinsic life cycle requirement, the absence of any pulmonates in the Djogdo marigots in May might be more easily explained.

5.3 Snails of Southern Chad

During May, 1977, no pulmonate snails were found, dead or alive, in the areas of Southern Chad visited by the Assessment Team (Lai and

Bongor). Appropriate water collections were visited although there were very few of these. Likely snail sites were almost absent, as was most of the surface water except that in the main rivers. These findings agreed with those of degremont in February, 1976.

However, schistosomiasis is being transmitted in Southern Chad, as proved by prevalence figures (see above chart). The snails, then are seasonal absent during dry season and repopulating the region where and when they can after the advent of the rains.

At present, there can only be speculation about the species involved. Vesical Schistosomiasis is transmitted by species of Bulinus. Species reported from Chad are listed in Table 14. Buck et al, 1970, found B. rohlfsi and B. jousseaumei in the Petit Mandoul at Ouarai, in the dry season of 1967 (February through May). This is a sluggish river draining a swampy area that, according to these authors, is never quite dry even during the height of the dry season. WHO (1966) and Leveque (1967) also reported B. rohlfsi as a probable vector in Chad, in the vicinity of Lake Chad. In the flood plain at Lai, Degremont speculated that B. rohlfsi or B. globosus would prove, upon further study during wetter times of the year, to be the transmitting agent. Since B. globosus has not been reported by others from Chad, it is indicated that the species B. jousseaumei, which closely resembles globosus and is in the same subgenus Physopsis, may be involved.

Strong emphasis must be placed on adequate field studies of these snails before any decision can be made about their vector roles. This means getting a trained snail biologist into the area when water is abundant and there is a possibility of finding snails.

TABLE 14. Bulinine pulmonates (vectors of Schistosoma haematobium) reported for Chad

	WHO (1966)	Leveque (1967) (1)	Buck et al. (1970) (2)	Degremont (1976) (3)
Bulinus (Bulinus) Truncatus	+	0	0	0
B. (B.) t. rohlfsi	+	+	+	+ (4)
B. (Physopsis) globosus	0	0	0	+ (4)
B. (Ph.) jousseaumei	+	+	+	0
B. (Pyrgophysa) forskalii	+	+	0	+
B. (Pyr.) Senegalensis	+ (5)	0	0	0

(1) Only in Lake Chad and immediate vicinity.

(2) Only in the Petit Mandoul River at Ouarai (Prefecture of Moyen Chari)

(3) At Lai, the Sategui-Deressia flood plain.

(4) Presence inferred, specimens not found.

(5) Report based on a single specimen collected in the lake at Moussoro.

Studies are needed on (1) species present, (2) their preferred habitats and whether these remain the same from year to year, (3) their population dynamics, i.e., numbers achieved and generation times in connection with annual water cycles, (4) the rate of natural infection if any and whether this can be observed in the field, (5) experimental infections to demonstrate intrinsic suitability as vectors. Such studies will require observations during the wettest parts of at least two successive years in Lai. Degremont (1976) was of the opinion that the snails appeared in sufficient numbers either at the end of the rainy season when water begins to recede or at the beginning of the rainy season with numbers gradually building up to a level capable of supporting transmission by the beginning of the dry season. The latter picture seems more likely. Evidently the snail populations are largely destroyed by annual drought in the flood plain, possibly with a few individuals which happen to be protected by drying mud surviving to provide breeding stock for the following year. An analogous situation is reported for Bulinus truncatus in the Nile Delta of Egypt, during periods of irrigation canal closure. If this proves to be the case, studies will be needed on the generation time of these snails under natural conditions. Large populations of snails are needed to provide effective transmission of schistosomiasis, and such populations do not build up to numbers to develop their infections overnight.

Bulinus forskalli seems to offer a special case. In the opinion of WHO, it is not a transmitter in nature, and Degremont (1976) dismisses it as unworthy of consideration although it was the only species of mollusk that he actually found in any water collections during his visit. B. forskalli seems to be capable of surviving under more rigorous conditions than some of the other bulinines. In the area of N'Djamena and Bol, it has been found in surprisingly

large numbers at times when other species of Bulinus are rare or absent. B. forskali has been infected experimentally with S. haematobium in Liberia and has been found naturally infected in Ghana. Its possible role as a vector should certainly be explored both experimentally and in the field in Chad, using Chadian strains of schistosome. It should not be dismissed as a snail of no medical importance.

Intestinal schistosomiasis due to Schistosoma mansoni occurs in Chad but achieves importance only in the southernmost part of the country bordering the Central African Empire (Buck et al., 1970). The prevalence rate in the Lai region would appear to be low and is less than 2% of the total cases reported from Southern Chad in the period 1970-1974 (see Table 13). This fact raises the question of why the disease is so limited. The answer undoubtedly has something to do with the number and/or distribution of the transmitting Biomphalaria snails. The Chadian vector of S. mansoni is reported to be either B. pfeifferi or B. alexandrian wonsoni or both. (Buck et al., 1970). Leveque (1967) reported B. pfeifferi and B. sudanica from eastern Lake Chad. Little is known of the requirements of these pond snails in southern, dry Chad. This fate during the dry season is unknown and they are thought to be less resistant to annual dessication, (in Egypt for example), than Bulinus. Thus there is still something to learn about these vector snails although their relative importance may be less than that of Bulinus.

5.4 Control of Schistosomiasis at Sategui-Deressia.

Degremont, (1976), points out that recommendations regarding control of any form of schistosomiasis in the Sategui-Deressia flood control perimeter must await completion of studies on the aquatic ecology of the snails. He also notes that the present advanced status of the project is unlikely to

permit modifications of any sort in the name of disease control.

He mentions the possibility of aerial spraying of molluscicide (Frescon) but adds that the ecological consequences of such an activity would be disastrous.

Traditionally, schistosomiasis control has been approached at four points, each representing an effort to break the life cycle of the parasite at one point. In summary, (1) drugs can be employed to kill or sterilize worms to prevent eggs from entering the environment, (2) waste disposal prevents hatching of miracidia and or their reaching suitable snail hosts, (3) molluscicides kill the vector snails and prevent development of cercariae, and (4) health education teaches people to avoid waters containing cercariae.

Each of these points can be considered in the light of what has been seen or predicted on the Sategui-Deressia flood plain.

5.4.1 Drugs. It is the job of clinical medicine to isolate infected individuals and treat them. The drug now used for treating haematobium infection is niridazole (Ambilhar, of CIBA) and good cures can be effected in infections of relatively short duration where the liver retains its functional capacity to detoxify. Ambilhar should be stocked by the medical center at Lai and by the dispensaries that are now planned for Sategui and Boumo. (Ambilhar is also sometimes used for mansoni infections but it is not recommended in chronic cases in adults because of bad side effects).

Waste disposal. This problem has no obvious solution at Sategui-Deressia. Latrines become open wells during the height of the flooding. It is hard to imagine the circumstance that would impel a local resident to go out of his way to find a latrine for purposes of urination. During the dry season, the problem takes care of itself, parasite eggs succumb when deposited on dry,

hot soil. In the case of mansoni infection quantitatively less important than haematobium in this part of Chad, sanitary feces disposal must be achieved if the cycle is to be broken at this point. During the dry season, feces deposited on dry ground quickly develop an internal temperature that kills schistosome eggs (mature eggs survive less than 24 hours at 22° C and are said to last about 1-2 days under the usual warm tropical temperatures with the diurnal variation taken into account).

5.4.3 Mollusciciding

Available molluscicides are applied in amount which kill most large life forms indiscriminately, including fish. This is clearly and unacceptable price to pay in most regions of Chad where fish provide such a large proportion of ingested animal protein.

5.4.4 Health Education

Teaching people about the dangers of cercaria infested waters should not be omitted, however, the benefits of education in an area so devoid of practical response may escape the locals. During the height of the year, when water covers the entire flood plain up to a depth of 10 or 20 cm, only the villagers on the highest rises escape having to get their feet wet as they move about their daily business. Yet, the pirogue often cannot be used as the draft is apt to be too great. It would be helpful, in health education, to be able to identify areas of local transmission, thus permitting the option of avoidance, other things being equal.

6. ENVIRONMENTAL ENGINEERING AND SANITATION

6.1 Introduction

The environmental engineering field component of the APHA Chad

Health Team study was conducted from May 18 to May 23, 1977 in Bai-Sategui-Deressia (Tandjile Prefecture) and from May 23 to May 28, 1977 in Bongor and Loumi (Mayo-Kebbi Prefecture). The field investigations consisted of:

1) inspection of present and planned rice production projects;

2) interviews with local project officials and village leaders (Appendix 9)

3) inspection of sanitation conditions in various villages in the project areas;

4) physical, chemical and microbiological analysis of natural surface waters (Logone River), irrigation diversions and drainage, and public water supplies (village wells).

The objective of this study was to:

1) assess the existing water supply quantity and quality and the sanitation conditions in potential AID project areas;

2) identify specific aspects of those issues requiring particular consideration in the design of development projects, and

3) make recommendations for health sector development activities.

Supplementary data was provided through interviews with Government and USAID officials in N'Djamena (Appendix 9). Specific findings are discussed in detail below. Conclusions and recommendations based upon these investigations are subsequently presented.

6.2 Background

Although quantitative data relative to the subject under investigation is meager, prior initiatives provide relatively thorough background information valuable in the design of future activities. These especially include Cabot (1965), Buck et al (1970), and N'Baihigui (1975) 34 11. Cabot provides a predominately qualitative description of climate hydrology, topography, soils, vegetation, demography, culture, sociology, and economy of the Logone Basin, which

* References on pp. 107, 108.

circumscribes both study areas. Kawata's discussion of environmental health factors in four Chadian villages (Buck et al, 1970) quantitatively describes a situation not uncommon to the experience of the present team. N'Daihigui reports basic water supply and excreta disposal data and rural sanitation activities in the Lai area considered essential for any health extension program.

6.3 Relevant Institutions

Institutionally, the Bureau de l'Eau (Ministee de Travaus Public) has in conjunction with the Paris Bureau de Recherches Geologiques et Minieres (Brgm) produced two hydrogeological studies in the project area, which included partial chemical and physical analyses of selected groundwater 12,13. These do not provide comprehensive information, however. The United Nations has provided the Bureau de 'Eau with a Hach DR-EL/2 Portable Laboratory for chemical and physical analysis. Mnapower constraints appear to be the limiting factor in its cost-effective use, although interest is high for the conduct of a systematic well monitoring program. The Societe Tchadienne de l'Eau et de l'Electricite (STEE) is charged with maintianing the six urban water supply systems now in operation in Chad. Data for the town of Bongor (the only one of the six within the area under investiation) is presented in Appendix 1.

No surface water monitoring program is known to exist currently. The function of the Ministry of Health have been discussed in detail elsewhere. It may simply be added that the tabulated health statistics underscore the primary importance of rural sanitation and water supply programs in the amelioration of endemic disease problems in Chad.

*References on pp. 107, 108.

In the agricultural sphere, the issues of pesticide and fertilizer usage appear to be the concern of several Government organizations. The Plant Protection Service (Ministere d'Agriculture) has administrative jurisdiction in the application of insecticides for agricultural pest control. Organization National Development Rural (ONDR) acts as the executing extension service which instructs farmers in the use of agricultural chemicals (including fertilizers) and provides credit through revolving funds for the purchase of same (a system which has not yet functioned satisfactorily). Cotonchad, a semi-private Government corporation, works with ONDR in application of chemicals for the production of cotton. Office du Centre de la Lutte Anti-Acridienne et Anti-Aviaire (OCLALAV) employs pesticides for the control of locusts and bird pests on food crops, primarily by means of aerial spraying. Their activities are not controlled by the Plant Protection Service.

Currently, there appears to be no utilization of pesticides for health purposes, nor do agricultural spraying programs incorporate a health component in the form of first aid for acute exposures.

6.4 Related Projects

Several planned or on-going projects which might interface with or have implications for possible USAID actions in the Sategui-Deressia and Koumi areas have been identified. The following compilation is not intended to be necessarily exhaustive.

1) Peace Corps Well Program (Appendix 8). The proposed 5 year/$2,700,00 extension to the current project under the management of Fonds de Development et d'Action Rurale (FDAR) is of primary interest to health sector development. One hundred fifty (150) protected, small-bore wells would be constructed in Tandjile out of a six-province total to 500. Mayo-Kebbi presently is not included in the planning.

2) USAID Accelerated Impact Program Project. In response to the Sahel drought effects, this project is comprised of a singular input of $4,000 to bolster millet and sorghum production. In addition to transport elements, $260,900 is budgeted for 350 tons of BHC, 20,000 liters of ULV BHC, and 7,500 liters of malathion. Aerial spraying may be employed in certain cases.

3) USAID Sahel Food Crop Protection Project/Chad 15. This is an ongoing project focusing on the cultivation of millet, sorghum, rice and maize throughout Chad. The FY 76 budget of $268,000, involves commodities, training and $30,000 for research in the use of carbaryl (85%), Lindane (5%, 50%, and 99%), and coper carbonate (50%). The FY 77 request amounts to $100,000, of which $43,000 is intended for pesticide research.

4) Club des Amis du Sahel Plant Protection in CILSS Member Countries Project 5,6. This is a comprehensive 15 year, 3-phase project aimed at bolstering national institutions, training, research, and agricultural extension in the areas of integtated pest management (IPM) for food crops migratory pest control, rodent control, and post-harvest crop production. The first 5-year phase is estimated to have multi-donor cost of $68.6 million for eight countries. The IPM program, the U.S. contribution, is budgeted at $29.7 million, of which $3.7 million is earmarked for Chad. Additionally $0.2-0.3 million is expected to be recommended for the construction of a research laboratory. Other costs involve technical assistance, training, local manpower, field and laboratory equipment, transport, and a minor component ($25,000) for malathion and BHC use in research. The IEE stresses the comprehensive

* References on pp. 107, 108.

nature of the IPM program and recognized the limited use of pesticides for research purposes.

5) IBRD Chad Rural Projects Fund 9. This is a three-year umbrella mechanism to finance seven, relatively unrelated, small-scale rural projects. Of interest are the cotton/food crop irrigated perimeter (Chari-Basin) and village water supply (including Tandjile Prefecture) components. The irrigated perimeter package would finance forty-two perimeters (23 ha. each) in terms of technical assistance, irrigation distribution systems, farm supplies, transport, and service centers at a total cost of $2.48 million. Of this, approximately $57,000 is budgeted for NPKSB fertilizer and $76,000 for peprothion insecticide (a 2:1:1 mixture of DDT endosulfan, and methyl parathion) for use on cotton. The village water supply project foresees a $1.96 million investment for the rehabilitation of 145 existing wells and the drilling of 110 small-bore tubewells. It is not known what portion of this level of effort is planned for Tandjile -- the project is slated for a total of three prefectures -- but the available data suggest that only repairs to existing wells are contemplated in this region.

Items 2) through 5) above will help set the tone for pest management practices in Chad for the future. A unique opportunity exists in project areas, therefore, for the timely consideration of the integration of this issue with the question of environmental health.

Furthermore, the scope of items 1) and 5) presents an obvious need for coordination of health sector activities in the provision of rural water supplies. This is especially important in light of the fact that two different Government entities exercise administrative responsibility for the two projects: FDAR for the former, and Service des Amenagements Ruraux d'Hydraulique (SERARHY) for the latter.

6.5 WATER RESOURCES

6.5.1 Climate

The Sategui-Deressia region (S-D) is situated on the east bank of the upper Logone River flood plain at approximately 16.3°E longitude and 9.5°N latitude. The proposed Koumi project site is located about 150 km downstream from S-D on the east bank of the lower Logone flood plain at 15.3°E longitude and 10.5°N latitude. The climate is classified as Sahelo-Sudan, the region lying between the 110 mm and 800 mm annual precipitation isohyets in the south and north, respectively. Rainfall figures for Lai and Bongor from the last eleven years are presented in Appendix 2. These data indicate a rainy season of four-five months (May-June to September) and a dry season of seven-eight months (October to April).

Although specific figures for the study areas were not available to the Team, temperature records from Brusso (approximately 125 km NE of S-D and 150 km E of Koumi on the 900 mm isohyet) show two average maxima of 32.4°C (April) and 27.9°C (October), and two average minima of 24.6C (January) and 26.0°C (August). Diurnal variations can reach 12°C. Relative humidity approaches a maximum of 85% at the end of the rainy season (August-September) and a minimum of 25% in February.

The alternating wet and dry seasons are predominantly caused by the peripatetic effects of the southwesterly "pseudo-monsoon" originating in the Gulf of Guinea and the northeasterly desert harmattan, respectively, and

vary primarily according to latitude.

6.5.2 Surface and Groundwater Hydrology

The hydrology of the Logone basin has been studied both by ORSTOM and BRGM in recent years 4, 12, 13. The watershed can be demarcated into upper and lower hydrodynamic units at an approximate latitude of 9.5° (in the vicinity of Lai). The upper basin, therefore, is characterized essentially by accretion from runoff in the Adamaoua Mountains in Cameroon (headwaters) and from several tributaries at or South of 9.5°N - the M'Bere, the Pende, and the Tandjile. The lower course of the Logone is subject to depletion by flooding over the vast plain north of Lai, drainage to the Ba-Illi River basin, and groundwater replenishment. Although some of these floodwaters eventually result as return flow, a significnat portion is diverted out of the basin, estimated at 400,000,000 m^3/yr to the left bank alone. Another estimate places the annual loss between Lai and the Chari River confluence (approximately 400 km) at 20-30% of the total flow. At Lai (drainage area = 60, 320 km^2), the average annual volume has been reported as 15,230,000,000m^3 (Qavg = 483 m^3/sec; Qmax = 1400 m^3/sec in October; Qmin = 45 m^3/sec in April). The daily maximum observed flood for the period of record is 2610 m^3/sec, and the estimated 100-year flood is 4000 m^3/sec. In the lower basin, an average maximum of 750 - 850 m^3/sec and an average minimum of 70 - 80 m^3/sec are reported.

* Reference numbers referred to, found on pages 110 and 111.

As the Logone flows north, the discharge coefficient steadily decreases as the result of decreases in slope and precipitation, and increases in evaporation and temperature. Initial rains contribute little to river flow, the local soils being highly dessicated after the long dry season. Only in July does the river begin to rise significantly, with flooding common from mid-August to end-October. Residual lakes remain in depression and marigots for several months afterwards.

Large variations in maxima recorded at Lai do not appear at Katoa (200 km downstream), where the flood peak is clipped constant maximum from August to November, indicating a regulating effect on river flow by flood plain diversions. Data collected from 1955 - 1960 also suggest a change in the Logone flow regime as a result of the 1954 - 1956 construction of the Bongor-Mogodi dike for agricultural purposes. Higher flows (16% and 11%, respectively) were thus experienced at Koumi in 1959 and 1960 than in 1955, a year of a much greater flood (by 19% and 30%, respectively), as recorded at Lai.

The characteristics of the groundwater regime in the Logone River basin have been studied less than the surface hydrology, but general descriptive information does exist. 7, 12, 13 In the upper sector, the surface watercourses in general serve to drain the phreatic layer in a northerly direction. The hydraulic gradient of this shallow groundwater (depth predominantly in the range of 5 m) varies between 0.001 and 0.004. The amplitude of the waterlevel fluctuation varies between two and three meters, with the low point being reached between mid-June and mid-July. The annual rise of the groundwater occurs more rapidly than its descent, and follows the precipitation regime

* References on pp. 107, 108.

with a minimum time lag of three months. Recharge primarily results from rainfall, which begins to have effect above a total of 350 -450 mm. The level quickly begins to drop as the rains diminish.

Downstream in the lower Logone basin, the recharge pattern reverses, with surface waters playing an important part in supply to the aquifer. The northerly hydraulic gradient is weak in this region as well (0.001) and the phreatic depth shallow (approximately 5 meters). The annual water table fluctuation varies from one to two meters. Diversions from the Logone tend to be directed permanently away from the river and toward the Ba-Illi and Chari basins to the east.

The quantitative dynamic behavior of the aquifer remains to be established before its full potential can be realized. The status of deep groundwater is also presently unknown.

6.5.3 Water Supply and Demand

Villages in the study area exploit shallow groundwater for most domestic requirements through the use of open, hand-dug wells. Such a well of five meters depth in sandy clay soil, partially reinforced with adobe brick, may cost from $40 - $60. A completely unimproved excavation would cost approximately $30. The 1975 GNP per capita in Chad was $88.

With an absorbable population growth (2.25% to 2.63% from 1975 to 1985 for southern Chad) and population densities ranging from 1 - 5 inhabitants/km^2 in the S-D region, to 50-75/km^2 at Koumi and Bongor, shallow wells can continue to provide an adequate domestic supply for the foreseeable future. This can be done without risking profound detrimental effects on the aquifer, provided that normal minimal pre-

cautions are followed in the location of wells.

The primary water resource demands in the project areas are agriculture (including livestock) and domestic supply. Population centers such as Lai, Deressia, and Bongor, exhibit commercial requirements as well, and some shallow wells (e.g. Deressia) are singularly reserved for the market place. No industrial demands were identified, the only establishments noted being a cotton ginning operation in Lai and rice mills in Lai and in Biliam-Ours (Koumi area).

No precise annual consumption can be presently determined for the study sites, except in the case of the town of Bongor water supply system (Appendix 1). The reported per capita use is low for a piped delivery system and one would expect that the light density deployment of public standpiped (one per 1,200 residents) favors the convenience of traditional private wells. Custom also plays a role, as it was observed that much bathing is conducted in the river.

In rural areas located far from surface supplies (e.g., Deressia, Dila, Ninga) the local well must serve all domestic needs. A reasonable estimate of per capita consumption under such conditions is 25-40 l/day. Water utilization for cleansing drops in the absence of bathing holes, although the total demand is more quantifiable. A town the size of Deressia (population about 7,000), therefore, would exhibit a maximum annual domestic demand in the range of 100,000 m^3.

Food crops (rice and millet) are grown in the Sategui-Deressia area by the predomenantly farming and stock raising population in conjunction with the seasonal floods. (Straw for construction purposes grown during the dry season). It is impossible to estimate, therefore, the traditional

irrigation requirement. Planning for the IBRD/IDS-FAD Sategui-Deressia rice project assumes a diversion requirement of 15,000 m^3/ha, or 75 million m^3/year under the first phase (5,000 ha), and 165 million m^3/year under the second phase (11,000 ha total). It has been projected that the Sategui-Deressia region can potentially support 50,000-50,000 ha of rice cultivation (750 to 900 million m^3/year demand under current irrigation practices). This can be compared with the previously noted average annual volume of the Logone River at Lai of 15,230 million m^3. Since the project anticipates harvesting only one crop in phase with the floods, water supply for such an endeavor is not deemed to present a major problem.

No data were available for the diversion requriements of the Casier B rice project in Bongor, which might be considered a model for possible future AID activities in the Koumi area. Due to the generally higher clay content of the local soils than in the Sategui-Deressia area, however, one could estimate that the demand would certainly be no higher than 15,000 m^3/ha. crop. Since this project is a double-cropping scheme, a maximum of 30,000 m^3 ha is projected. At the current cultivation of 420-500 ha, the annual demand would not exceed 12.6 to 15 million m^3. With an additional 250 ha as per current plans, the requirement would rise to 22.5 million m^3/year. This is in contrast to a 1976 consumption of 116,000 m^3 from the central distribution system of Bongor, the largest town in the area. (This figure is believed to be low for the town as a whole.) A loss in river flow of as much as 30% downstream from Lai, an above-noted estimate, would still make available approximately 10,000 million m^3/year at Bongor-Koumi even when one considers the needs of the Sategui-Deressia project.

The total demand of Casier B at a 750 ha level of dry season cultivation still represents only one week's total diversion of the Logone River under minimum flow conditions. Clearly, the current surface hydrologic regime will permit expansion of water-consuming development activities without causing critical shortages in the domestic sector. Reliable quantitative data are lacking, however, and are required to establish just what level and type of hydraulic manipulation can be entertained in an environmentally sound approach to development, sensitive to local economy and culture (e.g., possible alteration of fish habitants).

6.6 Water Quality Sampling Methodology

Physical, chemical, and microbiological analyses were conducted on various surface and groundwaters in the Logone basin (Tandjile and Mayo-Kebbi prefectures) during the period of 18 May to 27 May, 1977. At this time of year, the hydrologic regime is at its minimum, just prior to the onset of seasonal rains. The timing of the field study, therefore, provided an optimum opportunity to investigate surface waters at their lowest assimilative capacity, while on the other hand it prevented observation of increased village sanitation problems associated with the floods of late summer and early fall.

A rough estimate of the flow of the Logone River 3 km south of Lai was made on 18 May using floats and cross-sections. This calculation indicated a minimum discharge of approximately 45 m^3 sec. This compares with figures compiled for six years (1948-1953(showing an annual average of 483 m^3/sec, an average maximum of 1400 m^3/sec (October), and an average minimum of 45 m^3/sec (April).[4]

Physical and chemical analysis was performed with the aid of a Hach DR-EL Portable Laboratory. The parameters measured are listed in Appendix 4. Microbiological tests (i.e. total coliform counts) were conducted using a Millipore Portable Water Analysis Kit (membrane filter technique).

Water samples were collected from the Logone River, a marigot near the Sategui-deressia project site, selected wells used by villagers and nomads for drinking purposes, the protected water supply system of Bongor, and various points in the irrigation systems of the Sategui-Deressia and Bongor rice projects. Surface samples within a maximum of three meters of the bank were taken in the case of river and irrigation waters, except for the first Logone sample (18 May, Appendix 4), which was collected from midstream (river width = 150 m). Well samples were extracted by means of rope and bucket.

Physical and chemical analyses were conducted on fourteen samples, one within 12 hours of collection, four within 24 hours, eight within 48 hours, and one within 72 hours. Inadequate refrigeration facilities, however, prevented optimal storage of samples in several cases. This situation, combined with a suspicion of the ionic quality of demineralized water employed and the action of some reagents, place some results notably silica and sulfate, in doubt. Turbidity was measured on settled samples, and pH was determined only after storage. All microbiological samples were stored at ambient temperatures and incubated within six hours of collection (35 $\pm$ 1°C for 24 hours).

A short study of the diurnal variation of dissolved oxygen in the Logone River at Lai was conducted on May 20 and 21, using a modified Azide-Winkler technique. Although time coverage was mininal and the DO peak could only be extrapolated, the data are somewhat informative.

Results of all analyses are tabulated in Appendices 3, & 4 and 5. As with any single point-in-time investigation, the data cannot precisely describe annual water quality conditions. A small degree of intensive coverage, however, does permit one to develop a general idea of dynamic water quality processes operating at the time of sampling and to highlight important considerations for future studies. Such information also adds to the knowledge collected over time which is necessary for rational rational long-term evaluations of the environmental effects of development projects.

6.7 Water Quality

It is one thing to recognize the availability of water resources for rural development, yet quite another to assure a quality thereof not only to promote merely the absence of disease but also to provide for the wholesome well-being of the populace. The long-term economic returns from such investments have too frequently in the past been overlooked in the rush to forecast an immediate rate-of-return on investment sufficiently high to enliven the attraction of projects, which themselves are sometimes conceived in the absence of endogenous initiative. In many rural areas of the world, of course, even lowering the endemicity of water-borne diseases through improved quality control would mark a substantial step forward.

The APHA Chad Health Team's field study region would be included

in this group. Although very few reliable health statistics exist for the country, it is evident that intestinal and parasitic diseases caused by poor drinking water quality and poor sanitation rank near the top (along with malaria) of Chad's health problems. The chief of Deressia and Djogdo specified "diarrheas" as being the number one malady in their villages. Considering the endemic nature and the commonality of such afflictions, rendering them a fact of life, such statements are indicative not only of the magnitude of the problem but also more importantly of local insight.

6.7.1 Existing Data

As previously noted, few data exist regarding the quality of waters in southern Chad. No such prior studies could be identified during the Team's visit. Groundwaters have been investigated in conjunction with hydrogeologic mapping and control of public water supplies (six cities only). The sole microbiological testing is performed once a month on the delivery water in five cities, and more frequently for N'Djamena.

The town of Bongor is included among these five, although no results of microbiological analysis could be procured. Nevertheless, a sample of tap water tested during the field investigation, although small by APHA standards, indicated a potable supply (appendix 3). Subsequently, the writer was informed that semiautomatic hypochlorite disinfection is effected immediately after pumping to a dosage of 0.3-0.5 mg/l of free residual cholrine at the main distribution point. This treatment is primarily necessary because of the proximity of the well to the Logone River, which supplies the groundwater at Bongor. Physical and chemical analysis indicates a sweet, clear, slightly mineralized

water of low alkalinity and little ionic sign of organic contamination.[7] This does not differ markedly from samples collected at various points along the Logone during the current study (Appendix 4).

Numerous, unidentified shallow wells have been sampled in Tandjile and Mayo-Kebbi prefectures for physical and chemical quality of their waters in the course of BRGM mapping activities,[12,13] The composite report furnishes a picture of relative homogeneity, with an increasing gradient of mineralization indicated from south to north in the Logone and Chari basins. Still, along the Logone, electroconductivities rarely rise above 100 μmhos/cm, a quite tolerable level. Calcium and bicarbonate are the primary ions. Magnesium was found to be the least abundant cation, with chloride and sulfate of low importance on the anion spectrum. The groundwater temperatures were found to vary little, from 28° to 31° C.

6.7.2 Field Study

Water quality sampling was conducted in the course of the Team's field investigation as described in the previous methodology section. Results of analyses are presented in Appendices 3, 4, and 5.

The waters of the Logone River along the stretch studies (approximately 175 km) are relatively homogeneous. They are of acceptable physical and chemical quality for agricultural purposes and, with treatment, for domestic use as well. Turbidity is currently at a marginally acceptable level but would be expected to increase during the rainy season. Color is also somewhat high. The river water is quite soft, exhibiting no noncarbonate hardness. Alkalinity is low and exists totally in the bicarbonate form. The PH ranges from 7.7 to 8.6 and under low buffering capacity and high algal productivity conditions

* References on pp. 107, 108.

might experience shifts of importance to fish life, a staple of the local diet. The river is low in mineral content, with electroconductivity varying between 56 and 64 μmhos/cm. Dissolved silica appears to be the predominant metal. Iron values are at a level sufficiently high to cause staining (0.15-0.3 mg/l). Manganese is less important but could also cause staining at some of the concentrations reported. Sulfate and chloride are of minor anionic importance. The low levels of nutrients (NO_3 and PO_4) combined with observations of floating algae at minimum flows levels and midday D.O. values 152% of saturation (appendix 5), suggests a fairly efficient turnover in production. Most probably, organic nitrogen is recombined into algal mass soon after it becomes available and thus acts as the limiting factor in river productivity. The nutrient balance might be expected to change as the rains progress, with river flow, turbidity and reduced sunlight attenuating productivity, and an increased nutrient load from the flushing of manures and rightsoil stimulating the process.

Microbiologically, the one sample analysed from the Logone at Koumi (appendix 3) implies a water normally considered impermissible even for secondary contact activities. On the contrary, the focus of the river for all possible uses - from drinking to waste disposal - is a most common aspect of life in West and Central Africa.

Results of analysis of one sample of standing flood waters (N'Dang marigot, Appendix 4) indicate rather degraded quality resulting primarily from high algal productivity. Still, villagers were noted hiking eight kilometers round-trip to bathe, wash clothes, and fetch water from this lonely surface source. Under such conditions, microbiological quality is expected to be quite poor as well.

Several analysis were conducted on irrigation waters in the Sategui-Deressia and Bongor rice fields. Within the limits of the sensitivity of the instrumentation employed, no build-up of nitrates or other anionic constituents measured could be detected in drainage waters, except for a doubling of bicarbonate alkalinity (noncritical) in the Bongor samples. Increased mineralization was apparent only in the case of Bongor. This is not illogical considering the more intensive cultivation at the Bongor site. In all cases, however, iron, and to a lesser extent, manganese, exhibited annoying rises (five- to tenfold for iron). Increases in all samples might be attributed to iron or algal growth in the relatively stagnant waters. Indeed, the lowered pH of drainage waters stored 24-48 hours is further suggestive of significant algal activity. In such a case, nutrients, even if undetected in the oxidized form, would appear to be readily available. Whether the greater productivity of drainage waters over that of the Logone River is due more to increased detention times than to nutrient fertilizers remains to be determined, however. It is the writer's opinion that the former is the more important variable.

Drinking water for the field workers at Sategui-Deressia is supplied without disinfection from tank trucks filled with river water and transferred to open 200-liter drums, from which portions are scooped. The system is wholly unsatisfactory, as the initial source, already unacceptable microbiologically, is considerably further degraded before final delivery (Appendix 3).

The rice field workers at Bongor Casier B obtain their

drinking water from the main irrigation canal, delivery ditches, or small excavations dug in the banks of delivery ditches. The data indicate these methods to be more satisfactory than that employed at Sategui-Deressia, but still no better than direct extraction from the Logone, and most probably worse.

Several types of rural wells supplying drinking water were sampled in the two field study areas. These ranged from completely unimproved and unprotected nomadic watering holes used by both man and livestock (Namri); to limited-use, open, unimproved pits (Mogodi, Koumi No. 1); to limited and public use open, cement-lined and -rimmed wells (Koumi No. 2, Deressia, Ninga). The traditional method of raising water from all types of excavations is by means of hand-held rope and calabash or metal bucket.

Microbiologically, all three categories were found to be more contaminated than river water (Appendix 3), ranging from one and one-half times the coliform count (semi-protected) to forty times that of the Logone River (completely unimproved nomadic). A previous health extension program in the Sategui-Deressia area to provide periodic disinfection of public wells is currently inoperative solely due to the lack of supplies.

Physical and chemical analyses were performed on two well samples in the Sategui-Deressia region. Ironically, except for higher color, turbidity, and iron levels in nomadic Namri well, the semi-protected Deressia well provides water of less desirable quality. Nitrate as nitrogen was measured at a concentration three times that determined to be critical for development of methaemoglobinemia in babies (Appendix 4). Phosphate and

chloride values are suggestive of considerable organic contamination. Electroconductivity is double that of river water. The highest hardness and alkalinity values of any sample were found for this well also. One might expect the cause of this condition to be related to overuse and lack of maintenance; indeed, it is the only such public well in Deressia, serving a population of approximately 7,000.

One somewhat effective approach to the problem of contamination of traditional water supplies in the study area is exemplified by the town of Bongor's central distribution system. A comparison shows that potable water can be provided but at a dear price considering the minimal treatment applied (Appendix 3). It is laudable that the municipality covers the expense of the use from public taps, assisting those least able to pay. The coverage of the system is questionable, however, serving on a strict per capita basis 1,200 people per standpipe vs. 7,000 people per well at Deressia. It has been stated previously that a significant number of residents of Bongor nevertheless fulfill many of their water needs at the edge of the Logone River and perhaps from private wells. The cost-effectiveness of such an expensive central distribution system must therefore be called into question. A more appropriate approach, certainly one meriting pilot investigation, might revolve around a rehabilitation and reliable disinfection program for existing rural wells, and construction and maintenance of inexpensive protected wells. Such strategies are already being implemented but require more input of resources.

6.8 Agricultural Chemicals

The application of agricultural chemicals is an important environmental health issue from the perspective of the development of resistance in disease vectors, acute poisonings and the long-term accumulation of nondegradable pesticides and nitrates in water supplies. Fortunately in Chad, the usage of such chemicals has not yet become so widespread as in some other areas of the world.

6.8.1 Pesticides

Although little pertinent information exists and much research remains to be conducted on pest management in the Sahel--the objective of several projects previously noted--it may be safely stated that resistance of disease vectors, notably *Anopheles gambiae*, as a result of the agricultural use of pesticides, does not now appear to be a problem. In 1975, only 24,000 ha. of food crops were treated (Sahel areas) out of a total of 500,000 ha. in all of Chad. Also, 32,000 ha. of cotton, of an approximate total of 250,000 ha. under cultivation, received treatment.

Hexachlorocyclohexane (HCH or BHC) at 25% has been the primary insecticide. In 1975, 295 metric tons (MT) of HCH was applied. In response to this, only 100 MT was dispatched in 1976. The 1977-1978 total rate of HCH application has been calculated to be 379 MT. Recent usage, therefore, has remained essentially constant. In the Lai region, 33.2 MT of HCH were used in 1975. The Casier B.project employed 10 MT, and Casier A, a single-crop rice area east of Koumi lying fallow at the time of the Team's investigation, used 25 MT. Hence, the 1975 appli-

cation of HCH in the study areas amounted to 68.2 MT, or 34% of the total used throughout the country.

Experimentation with malathion has begun this year, and several other products are additionally being considered (Appendix 6). Regulations of the Plant Protection Service governing the use of various insecticides and rodenticides are presented in Appendix 7. It is worth noting that the IBRD agricultural development projects in Chad (Sategui-Deressia and Rural Projects Fund) anticipate the use of pe prothion (a 2:1:1 mixture of DDT, endosulfan, and methyl parathion), an extremely toxic concoction and one which does not appear on the Government's approved list.

As far as could be determined, there currently is no utilization of insecticides for control of disease vectors in Chad. Neither do any agricultural development projects contain a health extension component incorporating first aid for acute exposure to pesticides. With the gradual changeover from the vertical French system of intervention to the encouragement of self-reliance programs in the whole of the agricultural production process, such a health action may not be ill-advised. Should occasional aerial application of insecticides continue to be practiced, it would be further justified.

The thoughtful and logical approach which has been taken to date by the Plant Protection Service towards the use of pesticides in Chad is to be commended. The promotion by this nascent agency of integrated pest management research and practices presents an encouraging sign for the future.

6.8.2 Fertilizers.

The application of fertilizers has likewise not reached major proportions in Chad. In the Sategui-Deressia area, an application rate of 100 kg/ha of urea (46% N) in two doses 20 days apart is envisioned by project officials. It was noted that this usage may double in several years. At Casier B in Bongor, the writer was told that only 15 kg/ha of urea is presently applied, followed by two doses of NPKSB at 15 kg/ha each. The former figure is considered to be questionable, expecially in light of the double-cropping scheme.

None of the samples of drainage water from the two projects which were analyzed during the current investigation indicated elevated nitrate concentrations. The study was not adequately comprehensive, however, to make a definitive statement of this issue. It is believed that the present low utilization of fertilizers will not introduce a significant water quality problem in the near future. Should agriculture in the Logone Basin become both much more intensive and extensive, however, the potential health impact of nitrate buildup in groundwaters cannot be overlooked, especially since this might already be an important variable in the Deressia water supply (appendix 4).

6.9 Rural Sanitation

N'Baihigui (1975) highlights some of the primary sanitation problems in the Lai-Sategui-Deressia region and some his efforts at instituting rural health education programs. Principally, he cites the disposal of garbage and wastewaters, malaria vector

breeding sites (especially borrow pits), the high expense of treatment at the private medical center in Deressia, and the flood damage rendered to traditional wells as requiring increased attention. Major constraints noted are inadequate supplies, lack of transport, and a shortage of personnel assistance. He nevertheless commends the local populace on their response to health education activities and their comprehension of the modes disease transmission. In support of this judgement, he reports a nascent latrine construction program.

During the course of the Team's field investigation numerous villages were visited, including Deressia, Ninga, Namri, Boumou, Goular, Dila, Djogdo, and Sategui in Tandjile prefecture; and Mogodi, Koumi, and Biliam-Oursi in Mayo-Kebbi prefecture. Around houses and public areas, disease inviting sanitation problems common to many parts of West and Central Africa were noted. While family compounds are kept tidy and swept often, open food containers and inadequate construction of granaries encourage the propagation of rats. Flies congregate around and inside buildings, and most children go barefoot even in stock holding areas blanketed with manure. Houses are round or oblong, constructed of adobe or straw, and most commonly roofed with several layers of thatched and bound straw. While adobe affords insulation superior to fire brick, most living quarters contained no windows, and condition preventing daytime use for anything but sleeping. Of the houses visited, sleeping space ranged from 8.5 - 12.5 m^2 per capita. The straw roofs invite termites and must be replaced every 2-3 years. Refuse is often thrown over the fence encircling the family compound and builds up in streets

and other common areas. No latrines were viewed, defecation being reserved for village fringes and urination approached somewhat less modestly.

One livestock slaughter area was visited at Deressia. The open-air show, although not contiguous to housing, was a combined operation involving slaughtering, hanging or laying out to dry, and boiling and smoking of selected parts for export. Uncooked meat lying in the tropical sun provided a breeding ground for flies and other less visible organisms.

For a more complete discussion of rural sanitation conditions quite similar to those experienced by the present Team, the reader is referred to Buck et al. (1970), Chapter 2 - "Environmental Factors".

6.10 Health Impacts of Agricultural Development

In the absence of specific plans for USAID development activities in the study regions, it is difficult to forecast particular adverse impacts on public health resulting from degraded water quality and sanitation conditions. A secondary impact to consider in any development plan, however, is the potential environmental health problem caused by crowding from population migration into the area. Already at Sategui-Deressia, for example, approximately 50% of the workers are imported from distances greater than 10-15 km, with many coming from 70-80 km away. It is hard to believe that they would be drinking water of much poorer quality elsewhere than that supplied at the work site. Furthermore, although building density is not great in

the Sategui-Deressia region, the available high ground above maximum flood stage would appear to be limited.

Given the basic status of the water quality and sanitation variables as described above, it is equally difficult to suggest that agricultural initiatives whose goals are oriented towards increasing local food crop supply at nonmaximum production levels would measurably exacerbate already significant environmental health problems which drain the productivity of the Chadian people. On the contrary, improved nutritional status would aid the populace in combatting the debilitating effects of endemic disease. This statement does not imply, however, that agricultural development projects without built-in health components can be properly justified on a nutritional basis alone. Cost-effective health engineering programs of an appropriate technological level and mindful of existing infrastructure are a requirement for the success of rural development schemes, which can only be approached on an integrated basis. Recommendations for various component activities follow.

6.11 Human Resources

Regarding the environmental health infrastructure in terms of human resources, Mr. N. Tatala, chief of the Red Cross in Lai, epitomizes the concern for rural health extension activities expressed by numerous Chadians encountered both in and out of government. His proposals for training, village visitation schedules, medical evacuation procedures, community self-reliance, and financing of a public dispensary in

Deressia are meritorious. Likewise, villagers express an interest in operating their own health programs. The problem does not seem to be primarily one of manpower constraints. Rather, adequate supplies and transport (not only vehicles but gasoline as well) have been nonexistent in rural areas. That one such as Mr. Tatala can maintain his enthusiasm in the face of such chronic problems is a small wonder.

On another front, Ministry of Health officials in N'Djamena have undertaken initiatives in the past unfavorably reacted to by USAID. The recently rejected three-year/$500,000 MOH proposal to provide for construction of rural wells and latrines, water supply pipe, disinfection and microbiological analysis equipment, transport, and training is a case in point. Given the endogenous initiative of such a request, it is recommended that any similar overtures in the future be further scrutinized within AID program constraints.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Epidemiology in Chad

7.1.1 Health Impact of Economic Development

If the primary purpose of this mission was to assess the potential for increased disease incidence consequent upon major land and water management schemes, the principal finding must be that there is little danger that any substantial change in the disease picture might occur. Specific comment on malaria and schistosomiasis is left to the other members of the team expert on those topics. Unless they disagree in the instance of those two diseases, this investigator is convinced that no concern for adverse health effects should be permitted to interfere with

economic development and with whatever improvement in the physical and social poverty of this area those projects might bring. On the other hand, there is every reason to urge that real medical and sanitary services be brought to a people that lacks them now. If populations are moved, and if the population in the project areas increases, the people will transfer their old diseases to the new places. Development projects must assume an obligation for the provision of at least minimum local health facilities and maximum health services.

7.1.2 Health Services in Chad

The problem of the organization of medical services in a country such as Chad has been studies and commented upon by many advisors. Apparently, the need is not so much for an improved organizational structure, but for more good will, more efficiency, more training, more money and more implementation.

7.1.3 Services des Grandes Endemies

It is useful to comment specifically on one aspect of health care in Chad. It is now fashionable to criticize the Service des Grandes Endemies, perhaps becasue it is an anachronistic remnant of French of colonialism although the reason given is that it has not served well in the support and improvement of dispensary services. Probably no organization could do this under the present circumstances of staffing, supplies, and other support. For the foreseeable future, however, in Chad emphasis must be placed on prevention of disease rather than on curative medicine. That means:

1. immunization wherever possible (with the addition of tetanus toxoid to present armamentarium, trials of meningococal vaccine

and those against malaria, gonorrhea, syphilis, and hepatitis when they become available, and a watchful attitude toward polio-myelitis);

2. case and outbreak detection and control where those are feasible approaches;

3. the provision of sanitary water and fecal disposal facilities; and

4. a beginning of elementary health and nutrition education.

The S.G.E. is doing many of these things, and those that it is not doing could logically be an extension of its present and past orientation and role. Rather than permit the continued deterioration of this service, it should be strengthened and expanded. Preventive activities require centralized and disciplined direction, and should not be allowed to pass into the hands of the presently fragmented, improverished, and demoralized basic curative services.

As stated above, suggestions for the optimal organization of curative services must come from others. It is sufficient to say that massive improvement in this area is also necessary. This is so not only for humanitarian purposes, but also becuase an effective network of dispensaries would provide the broadest base for a disease surveillance system in support of preventive medicine.

7.2 Diseases Transmissible from Animals in Chad

Programs to promote animal health in Chad have apparently not been seriously addressed previously. Improving animal health has a two-fold effect:

1. it would improve the economy of Chad by increasing productivity of the livestock enterprises and;

2. it would most likely result in an improvement of the overall health of Chadians.

In a limited area just south of Lakd Chad livestock immunization programs have apparently been successful in controlling pleuropneumonia, rinderpest, blackleg and anthrax. Such efforts are of direct benefit to stockmen and to the local economy and should be extended to include no less than tuberculosis, brucellosis, leptospirosis, Q-fever and tetanus to list but a few of nearly 30 animal diseases transmissible to man.

It is also foreseeable in the future that as flood control projects and irrigation capabilities develop resulting in increased feed products, grain and forage production, there will be increased potential for dairy, poultry and livestock industries to develop in the Lake Chad River Basin areas. In order for these new developments to occur in a logical manner education programs for veterinary assistance, for farmers and for the consumer, to say nothing of the medical technologists, are needed for surveillance and control of as many of the animal health and zoonotic problems as is feasible.

Perhaps a reasonable beginning to improving health in man through his animals is to improve inspection of meat, dairy and other animal products by veterinary-trained inspectors. Following that veterianry pathology and microbiology diagnostic services should be developed. In this way the types and numbers of animal diseases can be documented to set priorities for field testing and immunization programs for livestock.

7.3 Malaria

A malaria control program should not be initiated in Chad unless there is prospect for protection of non-immunes who may be stricken

later in epidemic form should the control program fail. A detailed planning must be completed before any effort, even a demonstration project is undertaken. Classical malaria surveys during the wet season need to be conducted in the Logone River flood plains area and in the other different ecological areas of the country before a control program can be planned.

In malaria control programs much attention must be devoted to such matters as larval and to the ecology and to the vector mosquitoes. It may also involve other sections (such as drainage) which may be conducted on a community or self-help basis rather than with the rigid central direction required for a malaria eradication program. The Chad rural health infrastructure is not in the position to support a malaria control or eradication program. Serious attempts should be made by the Health Services to develop within the project areas (and all of Chad) a strong health education program initiating preventive medicine (including malaria) in order to institute a type of self-help malaria control program. It should be emphasized that any progress in malaria control must be coupled to the improvement in rural health services.

The characteristics of malaria in Chad depned on the characteristics of the main vectors A. gambiae and A. funestus, particularly the former Anopheles gambiae is perhaps the most efficient vector in the world; highly anthropophilic, long-lived and capable of reaching high population levels in a wide variety of temporary water collections. It is easier to list the habitats where the larvae of A. gambiae will not be found rather than list the positive sites. Much additional research on Anopheles gambiae is needed, including the perplexing question of where

the species passes the dry season, particularly in the more arid portion of its range.

In the southern part of Chad, malaria is described as being "stable". That is, it is characterized by high infant and child mortality, high levels of immunity beginning on late childhood, and with little obvious adult disease. This is not particularly the case in the Sategui-Daressia area as the adults appear to suffer from fever and chills. It is extremely difficult to truly assess the impact of the disease in adults. Further research is needed.

7.4 Schistosomiasis

7.4.1 Snail Studies at Lai

Nothing has been written about the population dynamics of pulmonate snails on the flood plain at Lai and the following is entirely inferential.

Because of road conditions, visitors to the flood plain region have come during the dry season. This permits easy circulation, but the fields are dry, there is little surface water in evidence apart form permanent rivers, and no snails are to be found. This was the experience of Dr. Degremont (1976) and also that of the present team. Nobody visits Lai during flood periods because the road is under water. However, Lai is accessible at all times of the year, either by air or by road from Kelo. Until a year-round study of local pulmonate snails is done with field work carried out during flood times, only guess work is possible and snail control cannot be planned intelligen

The local villagers say that snails survive the dry season buried in the mud. This is a good guess and the idea conforms

with what is known of the biology of Bulinus and Biomphalaria in the Nile Delta of Egypt during periods of winter closure.

It would seem only logical to expect some changes in transmission patterns to accompany the construction of a major system of canals and permanent reservoirs on the Sategui-Deressia plain. However, it is not clear, in the absence of knowledge of the snails, what form the changes will assume. It can be guessed that the presence of perennial water would permit the presence of snails on a year-round basis. But this idea is not supported by the finding that some of the largest collections of water, (the marigots at Djogdo) when examined in May, appeared to contain no pulmonates. These ponds looked as if they were ideal for Bulinus jousseaumei, B. forskalii, and Biomphalaris ssp.; their absence was unaccountable.

It seems likely that something intrinsic in the life-cycles of the snails in nature remains unknown. Perhaps the requirement for aestivation is intrinsic. Perhaps the requirement for aestivation is intrinsic. Perhaps the natural life span of these snails is shorter than it appears under laboratory conditions. If so, construction of canals will not change it. It is not clear that the incidence of schistosomiasis would be affected, although conventional wisdom acceeds to the possibility if not the probability. The effect of canal construction on the prevalence and incidence of other waterborne diseases would have to be judged on an individual basis.

The present principal need is for ecological studies of snails during and immediately after the rainy season at Lai.

7.4.2 Health Education at Lai

Although health education is one of the four approaches to schistosomiasis control, it can be one of the most elusive to implement and also one of the most unsure of success. It requires special training of personnel. As noted by Nasumbuko (1976), the Republic of Chad is fortunate in possessing in the Zootechnical Center at Farcha an excellent, strong, useful tool for the training of such sanitation agents. Because the Farcha sanitarians receive an orientation that includes a perspective of zoonoses as well as strictly human disease problems, they are more willing to leave the urban market places and devote themselves to work in the remoter villages. Their participation in any program to limit the spread of schistosomiasis in Chad would seem to be essential.

We encountered one such agent in Lai. He is Mr. Ndo-Toi Ngar Tatala. He recently completed a program of "recyclage" at Farcha and had been assigned by the Ministry to the region of Lai with responsibilities in particular for the rice-cultivating area of Sategui-Deressia. If his present duties consist of little more than passing out Nivaquin tablets and disinfecting wells, he is curiously well placed for participating in, even developing, a program of health education to combat schistosomiasis in this area. He is intesely motivated to get his job done but was frustrated in the performance of even routine duties by the lack of any useful means of transportation. The Sategui-Deressia project covers an area of about 22 square miles and the Ministry expects Mr. Tatala to cover it with some regularity on bicycle! He gratefully seized on the chance to accompany our team in the Land-Rover on a "tournee" of some of the villages for which he is responsible. It required all morning

to drive to a third of them.

Since any serious project to control schistosomiasis in the Sategui-Deressia area will have to recruit the cooperation of all villagers at risk, Mr. Tatala would seem to be already well-placed and trained to make a contribution. At the minimum, he or his equivalent should be provided with a vehicle, something better than a mobylette, and be assured the means of using and maintaining it.

7.5 Environmental Engineering and Sanitation

7.5.1 Summary of Conclusions

1. Existing drinking water supply and sanitation conditions remain the primary public health problem in the rural areas investigated.

2. Agricultural development schemes based on increasing local food supplies at reasonable production levels will not by themselves exacerbate already severe environmental health problems.

3. Pesticide and fertilizer usage at current rates does not pose a significant public health problem, except for possible acute exposures to pesticides.

4. The Plant Protection Service, as a nascent infrastructure, is approaching the question of pesticide use in a rational and logical manner.

5. The Logone River provides an adequate quantity of water year-round for increased agricultural development initiatives in the basin.

6. The Logone River and selected groundwaters are acceptable irrigation quality. They are undesirable for domestic use without disinfection as a minimum treatment. A high nitrate level found in

one well is cause for some concern. The low buffering capacity of river water might allow pH swings hazardous to fish life should algal production be further stimulated at low flow.

7. The current status of all traditional wells in the areas investigated is unacceptable.

8. Although central water supply systems provide high quality water, other intermediate options remain to be investigated and compared for cost-effectiveness in rural areas.

9. Although rural health infrastructures are not stron, it is possible to identify key individuals with motivation and initiative to design programs and implement them at the community level. Villagers themselves are cognizant of their environmental health problems and actively supportive of relief activities. The primary constraints of rural health programs are adequate supplies, and transport and direction.

7.5.2 Peace Corps Proposal

The pending Peace Corps well proposal (Appendix 8) should be approved in a timely manner. Consideration should be given to expansion of the program, as it is one of the few successful US technical support activities in Chad to date. The town of Deressia should be a primary site for well construction under this plan. Regular monitoring of the quality of well water and disinfectant control should be included in the package. This might be initiated as a pilot project in a town such as Deressia.

7.5.3 Plant Protection Service

Continued support should be given to the Plant Protection Service in its control of pesticide usage in particular and in the development of integrated pest management programs in general.

7.5.4 Health of Field Workers

Agricultural development projects should include as health sector components, among other things, provision for an adequate supply of drinking water for field workers and first aid services for injuries and acute exposures to insecticides.

7.5.5 Fish Breeding

Proposed hydraulic manipulations of river flow for irrigation purposes must not interfere with the breeding of fish, a most important aspect of local economies.

7.5.6 Nitrogen

Any additional water quality studies in the project areas should investigate in more detail various forms of nitrogen in drainage and groundwaters. Algal production should also be studies in the Logone River at minimum flow from the point of view of pH effect on fish life.

7.5.7 Health Extension Activities

Support should be given to the Ministry of Health for the propagation of comprehensive rural health extension activities such as those proposed by Mr. Tatala above. By the encouragement of community self-sufficiency, environmental health education, and the provision of essential goods and services, investment programs will approach maximum cost-effectiveness. At the very least, basic supplies and adequate transport for reaching a wide service area and conducting evacuations should be assured.

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APPENDIX 1

PUBLIC WATER SUPPLY DATA, BONGOR

ITEM \ YEAR	1974 (10 mo.)	1975	1976
Production (m^3)	68,490	84,930	107,150
Total Consumption (m^3)	72,795	88,726	116,336
Public (m^3)	68,582	79,842	105,993
Private (m^3)	4,213	8,884	10,343
Public Fountain in Service	17	16	16
Installed Meters	36	46	49
Population of Bongor	17,240	18,360	19,554
Per Capita Use (l/day)	14	13	16

NOTES: 1. Cost/m^3 = \$0.50 (\$1.90 per 1000 gal)

2. Data courtesy of STEE and Gil (1971) 8.

APPENDIX 2 A

RECENT RAINFALL DATA, CITIES OF LAI AND BONGOR: BONGOR

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
6	0	0	0	73.5	130.0	89.4	101.8	255.3	188.4	30.5	Tr	0	868.2
7	0	0	0	55.5	13.2	127.1	251.1	231.8	123.6	31.4	0	0	833.7
8	0	0	0	19.8	121.1	194.3	127.7	202.2	116.2	24.3	Tr	0	805.6
9	0	0	Tr	26.9	96.3	149.3	193.6	302.0	152.6	122.4	0	0	1043.1
0	0	0	0	4.2	66.4	120.9	193.7	385.9	171.4	16.7	0	0	959.2
1	0	0	Tr	4.8	17.7	144.7	120.9	399.3	203.7	4.9	0	0	896.0
2	0	0	0	11.4	42.0	88.6	185.0	341.3	75.3	31.4	0	0	775.0
3	0	0	0	30.4	94.7	231.3	203.0	240.1	96.1	24.9	0	0	920.5
4	0	0	0	Tr	33.2	43.2	213.9	277.5	252.6	4.3	0	0	824.7
5	0	Tr	0	6.2	117.5	77.0	183.1	203.3	99.2	154.3	0	0	840.6
N	0	0	0	23.3	73.2	126.6	177.4	283.9	147.9	44.5	0	0	876.8

NOTES: 1. Data courtesy of N'Djamena Office of Climatology
2. 1972 data not provided

APPENDIX 3 WATER SUPPLY AND MICROBIOLOGICAL DATA IN PROJECT AREAS

LOCATION	DATE (MAY 1977)	TYPE OF WELL	APPROX. POP. SERVED	APPROX. DEPTH TO WATER (m)	AIR TEMP. (°C)	WATER TEMP. (°C)	ELECTROCON-DUCTIVITY (mhos/cm)	SAMPLE SIZE (ml)	TOTAL COLI-FORMS PER 100 ml
Deressia	19	open. semi-protected cement reinforced with drainage	7000	4-4.5	37	31	110	1.0	too numerous to count (45 000)
Ninga	20	D.O.	2700	5.5	28	29.5	620	0.1	31.000 38.000
Nanri	22	open unimproved nomadic well. human and livestock use	unk.	3.5	33	30	47	0.01	1 030 000
Goular	22	one of two open un improved wells. 300 m from village; human/ livestock	450	4.5	31	30	755	-	-
Dila	22	same as Ninga and Deressia	100	8	31	30	340	-	-
Sategui	22	reinforced. w/wood base. open, unprotect. private family well	6	8.5	33	29	49	-	-
Sategui-Deressia Project Workers Drinking Water	20	drums filled with Logone R. water from tank trucks	unk.	-	-	-	-	0.01	200 000
Nogodi (16 km N of Koumi)	26	open, unimproved private family well	10	2.5	24	27	140	0.01	830.000
Koumi No. 1	26	D.O.	6	-	26	28	410	0.1	92.000
Koumi No. 2	26	open semi-protect. cement reinforced pri. well w/drainage	12	-	25	28	150	0.1	40.000

APPENDIX 3 (continued)

LOCATION	DATE	TYPE OF WELL	POP. SERVED	WATER DEPTH (m)	AIR. TEMP. (°C)	TH_2O	E. COND. (mhos/cm)	SAMPLE SIZE (ml)	COLIFORMS PER 100 ml
Logone R. at Koumi	26 26	- -	unk. unk.	- -	26 26	28 28	56 56	0.1 0.1	24.000 24 000
Casier B Rice Proj. at Bongor (29 km s of Koumi Main Irrig. Ditch)	26	-	unk.	-	25.5	27.5	72	0.1	28 000
Town of Bongor Tap Water	26	closed. well-protect. bore well 12-20"	20 000	-	-	-	-	10	0

APPENDIX 4 PHYSICAL AND CHEMICAL ANALYSES OF SELECTED SURFACE AND GROUNDWATERS, TANDJILE AND MAYO-KEBBI PREFECTURES

Location	Date of Sample/ Analysis May 77	Temp. Air (°C)	TH_2O Field/ Lab (°C)	pH	Color (APHA units)	Turbidity (FTU)	Total Hardness (mg/l $CaCO_3$)	Total Alkalinity (mg/l $CaCO_3$)	Electro-conductivity (mhos/ cm)	Fe (mg/l)	Mn (mg/l)	Si (mg/l)	NO_3 (mg/l N)	PO_4 (mg/l P)	SO_4 (mg/l)	Cl (mg/l)
Logone R. 3 km S of Lai Cath. Mission	18/21	40	32/21	8.6	10	0	30	40	56	0.15	0.3	28	nil	0.02	4	2.5
Logone R. 3 km N of Lai Cath. Mission	23/23	31	28/15	7.7	70	35	27	40	64	0.3	0	25	0.1	0.02	4	10
Logone R. 15km N of Lai at Sategui Irr.	22/23	33	31/12	8.0	50	17	27	35	59	0.2	0.2	55	nil	nil	1	2.5
Sategui Drainage Ditch (Rice flds)	19/21	37	36/23	6.2	90	15	20	45	65	1.15	0.8	-	nil	0.03	0	2.5
"	22/23	33	34/13	6.8	80	20	20	45	59	1.2	0.4	65	nil	0.01	3	2.5
N'Dang Meri. 4km W of Diogdo	19/21	38	31/24	6.4	500	230	15	55	110	1.8	/	-	nil	/	-	7.5
Deressia Well (semi-protected)	19/21	37	31/23	7.4	10	0	280	220	110	0.05	0.1	-	30	0.05	14	50
Nsari Well (unprotect.)	20/21	33	30/26	6.2	350	120	25	25	47	1.2	0.2	30	0.4	0.02	-	2.5

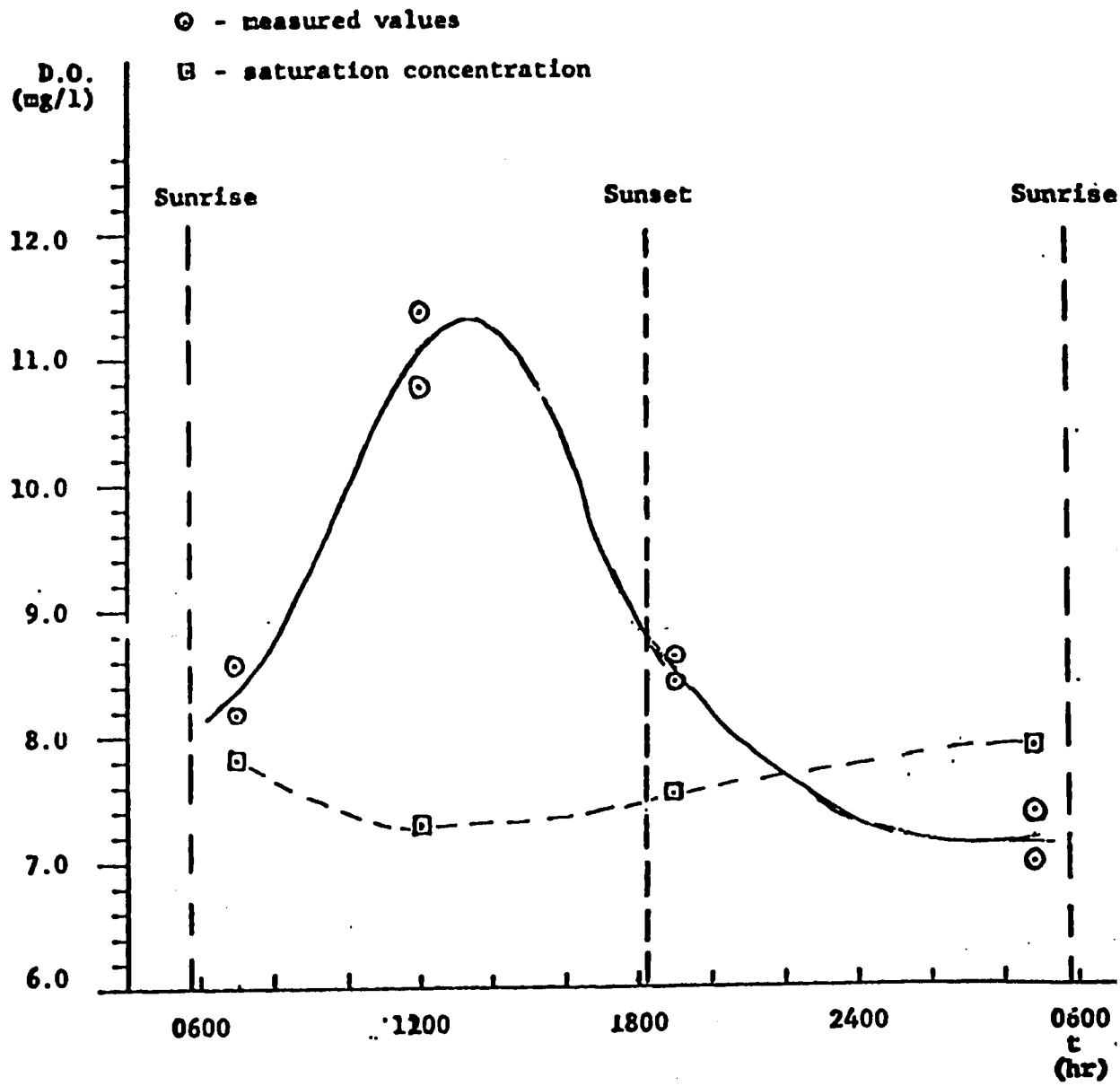
/ = Flotation of suspended floc prevented colorimetric analysis

APPENDIX 4 (continued)

Location	Date of Sample/ Analysis	Temp. Air (°C)	TH_2O Field/ Lab (°C)	pH	Color (APHA units)	Turbidity (FTU)	Total Hardness (mg/l $CaCO_3$)	Total Alkalinity (mg/l $CaCO_3$)	Electroconductivity (mhos/cm)	Fe (mg/l)	Mn (mg/l)	Si (mg/l)	NO_3 (mg/l N)	PO_4 (mg/l P)	SO_4 (mg/l)	Cl (mg/l)
Logone R. at Bongor Cas. B Irr. pump	25/27	33.5	29/18	7.8	25	15	27	40	60	0.2	0	-	nil	nil	7	2.5
Casier B main Irr. Canal (Bongor)	25/27	33.5	29/16	8.3	15	5	27	35	61	0.15	0	-	nil	nil	8	2.5
Casier B Rice Paddy Delivery (Bongor)	25/27	32	31/15.5	8.4	35	25	27	35	55	0.27	0	-	nil	0.01	9	2.5
Casier B Drainage Pond (Bongor)	25/27	28	30/15	7.1	65	30	55	90	160	1.3	0	-	nil	nil	11	5
Casier B Drainage Ditch (Bongor)	25/27	30	32/16	7.3	90	55	60	105	180	2.5	1.0	-	nil	0.02	12.5	2.5
Logone R. at Koumi (29 km N Casier B)	26/27	26	28/14	8.5	35	20	27	40	56	0.28	0	-	nil	nil	11	2.5

APPENDIX 5 : DIURNAL VARIATION OF DISSOLVED OXYGEN IN LOCHNE RIVER*

TIME	AIR TEMP. (oC)	WATER TEMP. (oC)	D.O.$_1$ (mg/l)	D.O.$_2$ (mg/l)	D.O. avg. (mg/l)	D.O. saturation (mg/l)	D.O.avg. / D.O.sat. %
0700	28	29	8.6	8.2	8.4	7.8	108
1200	37.5	33	10.8	11.4	11.1	7.3	152
1900	31	31	8.6	8.4	8.5	7.5	113
0500/1	24	28	7.4	7.0	7.2	7.9	91



* At a point 3 km N of Catholic Mission in Lai on 20/21 - 5 - 77

APPENDIX 6

DOSE RATES OF PESTICIDES APPROVED FOR USE IN CHAD BY THE PLANT PROTECTION SERVICE

Pesticide	Recommended Dosage
HCH 25%	5 to 10 kg/ha
Malathion 50	75-100 g/hl
Lindane ULV (120 g/l)	2 to 3 l/ha
Organil 66	250 g/hl
Pelt 44	100 g/?
Actidrine	150 cc/hl
Proservor	150 g/hl
Systoate 40	125 cc/hl
Typholine D	500 cc/hl
Thioral	200 g/100 kg
Malagrain P 2%	50 g/100 kg
Malagrain EM 50%	1 in 50 l water

HEXACHOROCYCLOHEXANE (HCH)

INSECTICIDE

- Poudre seche
- MATIERE ACTIVE : HCH ou Hexa
- UTILISATION :

L' Hexachlorochclohexane est connu sous le nom de HCH. C'est un produit de synthèse très actif. Son action toxique est equivalente à celle de DDT. Il agit par contact, ingestion et par inhalation. De courte remanence, il est utilisé par poudrage pulvérisation ou par atomisation (bouillie).

Le HCH est utilisé contre tous les insectes voisins des acridiens.

Le HCH est utilisé en appât, en poudre et en pulvérisation.

1°) En appât insecticides : coutre les criquets

Adultes : Gros son de blé (ou de sorgho), 100 kg

HCH à 25% 4 à 5 Kg

Eau (en quantité suffisante pour friser) 50 a 80 litres.

Quautité épendue à l'hectare " 50 a 60 kg d'appât humide

Larve " 1 kg à 2,5 kg suivant l'âge

2°) poudrage à la main (plus pratique chez le paysan). Il se fait à l'aide d'un petit sac de jute à mailles laches que le paysan secoue sur les tâches des jeunes criquets :

5 à 10 kg/ha.

Le poudrage peut se faire en outre avec des poudrages on par avion.

3°) Pulvérisation :

Le HCH étant insoluble dans l'eau, on le rend mouillable par l'adjonction se certains produit (par exemple Ligniosulfite de

soude) afin d'obtenir une suspension stable pour une bonne repartition de l'insecticide. Tout insecte touché par quelques fines gouttelettes meurt. Cette méthode est beaucoup utilisé pour la lutte antiparasitaire : 5 à 10 litres/Ha.

Contre les adultes des charancon, traitement du sol. Un ou deux traitement par an suivant les régions.

- PRECAUTIONS D'EMPLOI :

• Eviter de toucher les légumes ainsi que les sols destinés à porter les légumes-racines lors des traitements,

• Isoler les denrées alimentaires dans le cas de traitement des cases.

• Ne pas traiter pendant la floraison car le produit est toxique pour les abeilles.

Interdit de traiter 15 jours avant la récolte.

NB : le HCH pout provoquer une légère initiation des muqueuses au moment des traitements, mais celle-ci disparait rapidement.

MALATHION

INSECTICIDE

- Poudre mouillable
- Matière active : 20 g/l de Malathion
- Toxicité : Faible. DL 50 pour le rat par ingestion : 2 800 mg/kg. Non phytotoxique sauf pour les plantes enserre.

UTILISATION

Insecticide organophosphere, le malathion agit par ingestion et par vapeurs sur les insectes. La lumiere n'a auc-n effet sur lui cependant il est instable sous l'action de la lumière. As remanence est de courte durée. Il est peusoluble dans l'eau

Contre : Les pucerons et les accariens : 75 g/hl

Insectes des légumineuses : 100 g/hl

Altises : 500 a 700 g/ha en pulverisateur et 800 k/ha poudrage.

On peut utiliser le malathion pour le traitement des graines en stoc-. L'emploi du Malathion est autorisé sur les graines des céréales destinés à la consommation 1 g/hl.

Contre les accariens des farines et de grains de céréales, les bruches des légumineuses, les charancons de blé et de riz en utilise du Malathion en pulvérisation à raison de 200 CC/hl.

L'utilisation du Malathion sur les cultures et interdite 7 jours avant la récolte.

SYSTOATE

INSECTICIDE

Produit en emulsion concentree, le systoate est systemique

Matiere active : 400 G/L de Dimethoate

Toxicite : Legerement inferieure a celle du D.D.T. DL 50 pour let rat par ingestion 130 mg/Kg.

UTILISATION

Insecticide organo-phosphere, le systoate agit par contact et par ingestion usr les insectes et a un champ d'action tres important et sa rapidite d'action et liee a la forte obsorption et au cheminement rapide de la matiere active dans la plante.

Le systoa se repartit dans tous les organes de la plate et peut, de ce fait attenidre des insectes caches dans la plante. Il permet ainsi de controler sans danger un grand nombre d'insectes. A doses normales, il n'est pas dangereux pour les poissons et les oiseaux. Sa remanence est forte : 2 a 3 semaines.

Thrips, Psylle, Pucerons, Phytoptes, Araignes, cicadelle, Cecidomyie Mineuses des feuilles, carpocapse : 75 a 100 cc/hl

- Cochenilles : 100 a 125 cc/hl

Precautions a prendre

- Eviter le contact avec les yeux. Si cela arrivait, il faut les laver immediatement avec de l'eau propre.

- Eviter l'inhalation prolongee dans le brouillard de pulverisation ainsi qu'un contact cutane prolonge on repete.

- Pendant le traitement, il ne faut ni manger, ni fumer.

- Apres le traitement, se laver avec de l'eau et du savon. Changer, les habits souilles et les laver avec de l'eau chaude.

- Ne pas pulvériser les cultures en floraison

- Ne pas laisser le produit a la portee des enfants. Il ne faut en aucun cas le stocker pres de boissons ou des denrees alimentaires.

- Le traiteur doit porter des masques et des habits de approries aux traitements.

En cas d'ingestion, donner un vomitif au traiteur sous forme d'une cuilleree de sel dans un verre d'eau chaude. Avertir immediatement un medecin.

Le contre-poison est le sulfate d'Atropine. Interdit de traiter 7 jours avant la recolte; 10 jours avant la recolte; 15 jours pour les cultures légumiéres.

GAMACTIF

INSECTICIDES

- Produit pour poudrage
- Matiere active : Lindan 0.6%
- Toxicite : negligeable avec une grande marge de securite

UTILISATION

Insecticide au cout relativement bas, les risques de brulures et d'odorisation sur les recoltes sont nuls. D'une efficacite absolue de destruction, le Gamactif agit d'une facon rapide et brutale sur de nombreux insectes par par contact ingestion.

- Contre : les altises, le thrips, le negril : 20 Kg/ha
- Charancon, jeunes chenilles de pieride, punaises, fourmis, chrysomeles du cresson : 30 Kg/Ha
- Doryphore de pomme de terre : 15 Kg/Ha
- Charancons, Hannetons : 25 Kg/Ha
- Les vers des rizieres (chironomides) : 2,5 Kg/Ha de bouillie.

Le Gamactif poudrage, etant donne sa grande finesse, doit etre utilise dans des poudreuses a debit reglable, pour eviter du gaspillage.

La dos moyenne d'emploi est de 30 Kg/Ha, mais elle peut varier de 15 a 40 Kg, suivant le volume de la vegetation a proteger.

Le Gamactif est, comme la plupart des insecticides, toxique pour les abeilles. Ne pas traiter en pleine floraison, sauf derogation accordee par le service de Protection des Végétaux, uniquement contre le charancon.

Interdit quinze jours avant la récolte sur toute culture.

ORGANIL 66

FONGICIDE

- Produit mouillagle
- Matière active : 64% Manébe et 16% carbatene
- Toxicité : Tres faible DL 50,4 500 mg/kg pour unrat par ingestion.

Ce fongicide a une forte action sur un grand nombre de champignons. Tres voisins du zinebe, cependant son efficaeité est bien plus grande.

UTILISATION

- Mildiou : 250 g/hl
- Tavelure des arbres fruitiere : 160 g/hl
- Antrachose de la tomate, carcosporiose, septoriose : 250 g/hl

Produit d'une très grande efficacité, L'Organil est incompatible grace à ses composés. Dans certains symptomes de phytotoxicite sur les arbres fruitiers à pépin et sur les jeunes semis en cultures maraicheres.

L'Organil 66 peut egalement etre utilise entraitement de semence.

PROSEVOR-85 (SEVIN)

INSECTICIDE

- Poudre mouillage
- Matiere active : 85% de carbaryl
- Specialite commerciale : Prosevor 85 Sevin
- Toxicite : Assez faible. DL 50 pour le rat par ingestion : 540 mg/Kg
- Utilisation:

Insecticide du groupe des carbamates, le Prosevor est anciennement appele Sevin. Il agit par contact et par ingestion.

Pour le preparer, on commence par faire une pate epaisse avec la quantite du produit dans tres peu d'eau. Une fois la pate homogene, on ajoute lentement, en ajoutant, la quantite d'eau prevue. On utilise en general 60 a 70 litres d'eau/ha. Filtrer le produit prepare avec une toile d'americani au moment de sont introduction dans l'appareil de pulverisation.

- EN ARBORICULTURE

* Tous les 8 jours, contre : le carpocapse a 80 g/hl

* Tous les 15 jours, contre : carpocapse, cicadelle, Psylles, Charancon du prumier, Puctons verts et mauves, Bombyx, Tordeuse des bourgeons : 120 g/hl.

* Tous les 20 jours, contre : tous les insectes ci - dessus, plus cochenille d'ete chuilly mineuses des feuilles, Mouches : 150 g/hl

Autorisé jusqu'à 10 jours de cueillette.

- CULTURES MARAICHERES ET FLORALES

* Doryphor, Altises, Thrips, Cicadelles, Pucerons, Charancons, Mouches : 100 g/hl.

* Chenille de noctuelle (le PROSEVOR agit notamment de facon remarquable contre la chenille verte de la noctuelle de la tomate, meme à l'interieur du fruit : 150 g/hl).

Utilisation contre les les Borers des céréales.

- SUR LE COTON

Contre le Ver Rose (Platyedra Sp) : trois traitements tous les 20 jours a raison de 1,250 Kg/Ha.

Les traitements d'arriere-saison agissent effectivement sur la generation de de fin de campagne de la chenille epineuse Iearias insulana).

Le PROSEVOR peut etre associe aux fongicides (Organil, Ziram, Zinebe . . .), aux insecticides (Vinyphos, Typhon, Typholine . . .).

- CONDITIONS D'EMPLOI :

- Ne pas utiliser le PROSEVOR pendant la floraison.

- Son utilisation est interdite entre 7 à 10 jours avant la récolte.

LES RATICIDES

Les rats et les souris sont de véritables depredateurs des plantes. Il causent chaque annee des pertes considerables aux réclotes. Ils sont nocifs non seulement dans les champs, mais aussi dans les habitations, sur les denrecs stockces atc. Aussi faut - il les eliminer par differents procédés dont l' utilisation des raticides.

I°/ - R A T K

C'est un raticide dont la matiere active est Difecanum. Il est efficace contre les rats et les souris (en general contre tous les rongeurs). Son action se declanche surtout quand il est absorbe au moins deux fois par l'animal.

L'UTILISATIONS

Quand une infestation de rats se fait sentir, reperer les repaires, les endroits regulierement frequentes. Etant donne que le Ratak s'utilise en appat, on place 80 grammes de cet appat en plusieurs endroits infestes. Dans les champs on utilise 5 kg de Ratak a l'hectare.

Les appats sont toujors places dans des endroits secs. Eviter les coins humides.

Tous les jours, on inspecte les endroits ou l'on a place les appats pour voir si ces derniers ont ete consommes. Il faut approvisionner regulierement ces endroits en appats.

Quand les activites des rats auront cesse, on prendra soin de detruire les app appats.

PRECAUTIONS A PRENDRE

1/ Eviter tout contact avec la bouche. Le Ratak ne doit pas etre garde dans les endroits ou sont stockees les denrees alimentaires.

2/ Se laver les mains et les parties du corps ayant ete en contact

avec le ratak avant les repas.

3/ Le Ratak etre garde hors de portee des enfants et des animaux domestiques.

4/ Detruire les recipients ayant servi a preparer les appats.

ANTIDOT

En cas d' intoxication, la victime peut prendre en injection la vitamine L 1: Phytomenadione B.P. Dose : 5 a 20 mg. Le medicament est de preference administre en presence d'un medcin qui garde le malade a vue pendant au moins 24 heures.

2°/ - TONORIN

Le Tomorin est un raticide dont la matiore active est le coumachlore. Un anticoagulant de combinaison tres stable: tue les rats et les souris.

PRESENTATION:

* Tomorin I: poudre pour epandage renfermant I de coumachlore Technique. Il adhere bien et resiste aux moisissure, De co fait, il est insensible a l'humidite.

* Tomorin 5 appat pour epandage pret a l'emploi contenant 0,025% de coumachlore.

UTILISATION ET APPLICATION:

Dans la lutte contre les rats et les souris:

-Utiliser au mieux la connaissance que l' on a des moeurs de ces rongeurs.

-Detecter leurs voies de deplacement (pistes)

- Decouvrir les lieux ou ils se nourrissent, lieux d'abreuvement et de reunion.

UTILISATION:

*Tomorin I:

au moyen d'une poudreuse appropriee, saupoudrer

-les lieux detected et le long des pistes.

- traiter egalement les depots d'orduros et mes canalisation hors des periodes de pluie.

-Effectuer les controles quotidients

-Renouveler sia necessaire la couche de poudre ainsi appliquee.

*Tomorin 5

-Il est applique de maniere a former de petits tas a de nombreux emplacements a l'abri des pluies.

-Utiliser de preference une louche pendant l'operation.

-Avec la main, l'efficacite baisse a cause de l'odeur humaine.

-Controler chaque jour les emplacement d'appats

-Completer ceux-ci au besoin.

-Interrompre le traitement des qu'on ne decele plus de traces

*Securite:

Pour l'homme et les animaux domestiques, une absorption unique de Tomorin est pratiquement sans danger, En revanche, les absorptions repetees de Tomorin sont dangereuses.

Il est necessaire de prendre des precautions lors de l'application et eloigner si possible les animaux domestiques des lieux traitees.

3°/ - RATILAM BLOC APPAT: (Raticide a usage agricole)

Le Ratilan bloc appat est un raticide a base d'anticoagulant dont l'action lente et efficace agit de facon chronique par accumulation, entrainant une mort d'apparence naturelle qui n'eveille pas la mefiamce des autres rongeurs.

-S'emploi dans toutes les cultures

-Agit sur les rats noirs et souris

-agrit egalement sur beaucoup d'especes (Surmulot, avicantis, dasymys argentiventer etc...)

-les blocs Ratilan sont insensibles a l'action des agents atmospheriques.

TRAITMENT AVEC RATILAN DANS LES PLANTATIONS DE CULTURES ARBUSTIVES:

*En cas d'attaque ou en debut de traitement

-Placer un bloc au pied de chaque arbre

-Remplacer les blocs consommes sous les 6-8 jours

-Pour prevenir toute nouvelle attaque

-Renouveler chaque mois les bloss qui auront ete consommes.

DANS LES PLANTATIONS DE CANNE A SUCRE

*Reperer les parties du cham ps attaquees. Disposer en bordure du champ I bloc tous les 5 pas A l'interieur du champ la ou il y a des morsur fraiches 2 blocs pour 10 m2.

Remplacer les blocs manquant tous les 6-8 jours jusqu'a l'arret de la consommation.

*Pour eviter la reinvasion; disposer:

-en bordure du champ un bloc pour 100 m2

-Renouveler chaque mois les blocs qui auront ete consommes.

EN CULTURES VIVRIERES (RIZ.. MAIS - SORGHO ETC...)

- Repartir sur le sol I ou 2 blocs tous les 100 m2
- Dans le cas du riz irrigue, disposer les blocs le long des diguttes a raison de I bloc tous les 3 metres
- Remplacer les blocs consommes tous les 6-8 jours

PRECAUTIONS A PRENDRE

-Eviter que des personnes ou des anim aux ne consomment les blocs appats Ratilan

-Ne laisser pas les enfants jouer avec les appats ratilan

-Empecher les animaux de marger les appats ou les rats tues.

Appendix 8

Project Background

The Problem

The public health sector has been identified as a major area of concern for A.I.D. in Chad. Interventions in this sector will, for the forseeable future, concentrate on planning and manpower development for efficient health strategies.

GOC curative and preventive functions in rural areas may be expected to continue to be extremely limited and major improvement in the extremely low level of health conditions of the rural populations can only be expected to be apparent in the long-term. A major contributory factor to the low health standards of the rural population is a general lack of potable drinking water. Water for direct consumption, cooking and washing is procured from rivers, standing open water and from easily contaminated open wells. Serving as probably the major transmission point for intestinal and infectious diseases, these water sources are largely responsible for the unacceptably high incidence of amoebic and bacillary dysentary, schistosoniasis, and onchocercosis, along with an ever present danger of cholera and typhoid. While locally available health statistics are far from satisfactory, the magnitude of the problem is indicated by a 1967 Johns Hopkins Sample Survey which found that in routine examinations in the South of Chad, the prevalence of onchocercoses was 42% and that throughout the country, on any one day, of children ages 0 - 9, 25% had diarrhea. It is apparent then, that the single most effective

(and probably cost-beneficial) preventive health measure would be the provision of a permanent potable water supply to rural populations: potable water constitutes the most rapidly effective intervention in the arsenal of preventive health measures.

Proposed Response

This project will provide a permanent supply of potable water at the viklage level in selected rural areas through the installation of closed small-bore tube wells. These wells will be installed deep enough into the aquifer, or water bearing strata, so as to be largely unaffected by seasonal water variations or drought, thus assuring a high degree of permanency to the water supply.

Description of Project

The project would involve the installation and maintenance of approximately 500 wells in two different project areas affecting over 400,000 people. The first project area in the north would consist of the areas around and between Mao, Moussoro, N'Djamena rurals and Guelengdeng. One hundred and fifty wells would be installed in the larger northern section, while an extra 50 wells would be installed in the heavily populated area surrounding and following the road south from N'Djamena to Guelengdeng, which makes a total of 200 wells for the northern project area.

The second project area would be in the southern Prefectures of Tandjile, Logone Oriental and Logone Occidental. 150 wells would be installed by one team working in Tandjile, while the other team would install the remaining 150 weels in Logone Oriental and Occidental.

Thus, the two projects would operate simultaneously over a period of five years to install a total of 500 wells in six prefectures.

The sites of project operation, as described above, have been chosen by FDAR on the basis of two criteria. Hydrological-geological suitability for the technology involved, and the need for potable water supplies as an input into planned rural development efforts in these areas. The Northern two teams would work out of the existing FDAR warehouse and facilities in N'Djamena. It would be necessary, however, to construct a new base of operations around Moundou for the southern two teams. Each drilling team would be composed of two Peace Corps Volunteers and two Chadian counterparts (4 teams or a total of 8 PCVs) and would be equipped as follows:

a. one drilling rig and truck
b. one transport truck
c. two support vehicles
d. complete tool/equipment supply
e. fuel and lubricants/vehicle maintenance materials
f. necessary well installation materials
g. wells maintenance parts for five years after the installation phase ends.

In addition, the services of a direct-hire program coordinator are recommended to supervise the operations of the four teams, administer the two projects and act as a liaison between U.S.A.I.D., Peace Corps and the Chadian implementing agency (PDAR).

Contributions from the Chadian implementing agency would be in the form of salaries for the counterparts, administrative support and use of existing capital equipment and facilities.

The type of wells to be installed would be a closed, small-bore (2-3") well, operated by a manually controlled pump mechanism. The term "closed" refers to the fact that water is encased in piping from the source, and that the well is covered at the top, which prevents contamination by contact with surface water, waste products or other foreign substances. The type well proposed was designed in 1967 by Mr. Henry Tysen, an AID engineer, specifically for use in the rural Sahelian environment. The design has since seen a slight modification based upon actual successful experience with the well in Chad. The pump is designed to be easily operable, inexpensively fabricated of locally-obtainable materials and easily maintained. The well itself, especially with regard to the screen and cylinder, were designed to suit the specific sub-soil conditions of Chad, namely the widespread occurance of a sand aquifer. Prior experience in two different well installation programs in the North and South of Chad have verified the adaptability of the Tysen design to existing geo-hydrological conditions.

EXPERIENCE

This project is based upon the experience gained in two R & R funded projects which were implemented in 1975 as a response to the Sahelian drought: 677-125-IV-H, Well Construction and Maintenance, which was located in Lac and Kanem prefectures and 677-125-IV-L, Well Construction in Moyen-Chari and Logone Oriental, located in the southern part of the country. These projects

tested the utility of the Tysen pump and the viability of Peace Corps directed teams operating through FDAR. The successful operation of these projects has not only established a basic capability on the part of FDAR to manage the program, but have resulted in FDAR devoting an increasing amount of its funds to well development. A note of interest is that tests conducted on the water produced by the wells indicated a standard of water purity superior to that of the N'Djamena water system which is, itself, potable. Experience gained from the R & R well programs has determined that the magnitude of well installations proposed would require an implementation schedule of five years. The actual implementation of the project, would have the advantage of financial, organizational and practical experience gained in the R & R programs and would not be subject to delays in implementation.

HOST GOVERNMENT ACTIVITIES

Well development in Chad has been sporadically carried out by three different organizations. The Ministry of Public Health has, in the past, undertaken a limited well installation program for the provision of potable water at infirmary sites. This program is now defunct because of financial restrictions. SERARHY is the Chadian organization officially designed for well development in rural areas. However this organization is devoting its efforts to the provision and maintenance of expensive, deep, open-bore wells for human and livestock consumption. SERARHY

has its resources totally committed to a large, open-bore well project financed by UNDP and would be unlikely to be able to devote adequate attention to this project. FDAR has successfully managed and supported two closed, small-bore well projects since the inception of the R & R program. To these projects, FDAR provides a budget of $26,000 a year, which is used largely for maintenance purposes.

In addition, FDAR will have the continuing source of funds which are generated from the purchase and sale of grains within Chad to support the maintenance of the wells after the completion of the project. FDAR has exhibited a willingness to accept responsibility, though in the past they have had to do so only on a small scale. Where they have taken over funding, such as in the South, they have supplied everything necessary in a most efficient manner. In the North, where the role of FDAR has been one primarily of supervision, coordination and supplementary funding, they have fulfilled those functions well. FDAR is extremely interested in expanding the wells program and views the program as an important part of its organization and overall operations. There seems to be every indication that, given continued expatriate involvement at the daily administrative level, FDAR will be capable and willing to fulfill the necessary maintenance functions.

At this point it is strongly recommended that any practical wells program continue to work with the Fonds de Developpement et d'Action Rurale (F.D.A.R.) as the implementing agency. FDAR

has considerable experience administering current and previous USAID, Peace Corps sponsored wells programs, and has proven that, it is both capable of administrating the execution of the program and of continuing the necessary maintenance functions after the completion of the project. FDAR also possesses a pool of skilled and experienced technicians who would be used to form the nucleus of manpower necessary for the new program, as well as a good stock of modern capital equipment ($500,000) which would be put to immediate use as soon as funding for the project was approved.

ALTERNATIVE SOLUTION

While rural public health infrastructure is an unlimited area of need in Chad, no alternative use of resources offers the profound and immediate improvements to health and sanitation of a village level potable water supply.

The alternative choices which exist are between utilization of closed, small-bore, and open, large-bore wells. The most frequently noted draw-back of closed, small-bore wells is the requirement for regular maintenance by trained personnel. Experience has shown that routine visits are required at 4-6 month intervals for changing leather cups, lubrication, and making any necessary replacements or repairs of mechanical parts. Adequate maintenance would require comparatively limited resources in the form of manpower, vehicles, and spare parts.

On the other hand, the benefits of the closed, small-bore well over the open large-bore wells are numerous:

<u>Cost</u>: depending upon calculations of the cost of support

equipment and spare parts for installation; large-bore wells will run anywhere from three to seven times the cost, per well; of small-bore wells. This means that the funding proposed for this project might generate as few as 110 well sites, as opposed to 500 sites.

The cost of maintaining the Tysen design is approximately $50 per year--including fuel and vehicle expenses--and we have yet to find a better design of well that is as cost effective. The present life span of the Tysen well, with regular maintenance is from six to twenty years. The limiting factor is the galvanized pipe and Peace Corps has been conducting research into plastic pipe and other alternatives which would extend the life even longer. But even with the present life span the low cost of installation and maintenance of the well makes it a valid investment.

Sanitation: Because of their open design, large bore wells are extremely prone to pollution, and once polluted, virtually impossible to sanitize. As noted above, closed wells generate a continuous supply of uncontaminated water.

Because of the ease of pollution, the open well is not really a viable alternative for the goal of this project.

Environmental impact: In that open wells frequently supply a greater volume of water, they are useful for watering livestock (unlike closed wells). Where range management practices are not in force, resulting high concentrations of livestock during the dry season run the danger of reducing ground cover in the area of the well.

Maintenance: Although requiring less frequent maintenance when they must be repaired, open-bore wells are very expensive and require high levels of expenditure of foreign exchange.

From a technological point of view, the Chadian technicians of FDAR who now work with the wells program are capable of performing all functions relevant to the installation and maintenance of wells.

Major Assumptions:

The following assumptions are pertinent to project success:

- Peace Corps personnel and commodities arrive in a timely manner to assure adherence to the implementation schedule, resulting in the installation of approximately 500 wells in a five year period.

- FDAR will maintain its management initiative, undertake to assume during the life of the project total salaries of Chadian personnel recruited for the well teams, and have financial resources available for continuation of the maintenance program.

- Provision of permanent potable water in the project areas will have a significantly noticeable effect on the incidence of water borne diseases which are associated with drinking contaminated water.

- Provision of permanent potable water in the project areas will have a mutually salutary effect on the effectiveness of other AID inputs in these areas, thus reinforcing the trend toward area development.

APPENDIX 9

CHRONOLOGICAL ORDER OF PERSONAL CONTACTS,

F. CARROLL, CHAD, 9-5-77 to 6-6-77

1. Ms. S. McGahuey, Health Officer, USAID
2. Mr. J. Nixon, Deputy CDO, USAID
3. Mr. L. Prosser, Program Officer, USAID
4. Mr. T. Danner, IDI, USAID
5. Mr. Belty Rari-Kangar, IBRD Liaison, Chad Ministry of Plan
6. Mr. Hervieux, Director, O.R.S.T.O.M.
7. Mr. Allah Rabai, Director, Dureau de l'Eau
8. Mr. Berre, Advisor, Bureau de l'Eau
9. Mr. Y. Cheneau, Director, FARCHA Veterinary Laboratory
10. Mr. Baguidi, WHO Sanitary Engineer
11. Mr. John Hannum, PCV, N'Djamena
12. Mr. Stefan Krashevski, Agricultural Officer, USAID
13. Adjoint Prefect of Bongor
14. Adjoint Prefect of Lai
15. C. Lotti Engineers, Sategui-Deressia Project
16. Village Chief, Deressia
17. Village Chief, Djogdo
18. Mr. John Henley, IBRD Civil Engr. S-D Project
19. Mr. Ndo - Toingar Tatala, Chef, Red Cross, Lai
20. Village Chief, Ninga
21. Mr. Savandy, SATEC Representative, Sategui-Deressia Project
22. Chef de Canton, Doumi
23. Chinese Agricultural advisors, Bongor Rice Production Project
24. Mr. Ngorgas, Chef, Casier B, bongor Rice Project
25. Mr. N'Duosugar, Chef, Plant Protection Service
26. Mr. D. Shallow, USAID Consultant, Food Crop Protection and Production
27. Mr. A. Vendee, Societe Tchadienne de l'Eau et de l'Electricite