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VOLUME THREE

Environmental Assessment for
Development of Clean Rural
Water Supply Program
Kingdom of Swaziland

ENVIRONMENTAL ASSESSMENT FOR DEVELOPMENT OF CLEAN RURAL WATER SUPPLY PROGRAM

KINGDOM OF SWAZILAND

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August 1977

REPORT OF AN ADVISORY TEAM VISIT TO SWAZILAND TO ASSIST IN THE DEVELOPMENT OF CLEAN RURAL WATER SUPPLIES PROGRAM INCLUDING AMONG OTHERS SCHISTOSOMIASIS CONTROL ACTIVITIES

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Recommendations

From available evidence, bilharzia appears to be widespread in Swaziland with about 30% or more of the population infected. Furthermore, the major water resource schemes all are currently serving as snail habitats and human exposures can be obtained at various times. There are several schemes such as fish ponds. newly established rice cultivation areas and others which have the potential for serving as snail habitats.

Although recommendations have been made, a much broader set which the advisory team considers will aid in the development of rational approaches to permit progress towards the development of a 'Safe Rural Water Supply' with major emphasis on the control of bilharzia and other water related diseases is presented.

1) Recommend the support of a program costing 2.3 million dollars over a five year period with implementation of a "Safe Rural Water Supply" to include among others control programs for bilharzia and other water-related diseases for the Kingdom of Swaziland.

2) Consistent with the implementation of a "Safe Rural Water Supply" Program, the Government of Swaziland should establish a national committee to plan, coordinate and direct the Rural Water Supply Program which includes control activities against Bilharzia and water-related diseases. The establishment of this committee would eliminate the costly duplication of efforts occurring among the ministries and which have led and will continue to contribute to the increased incidence of Bilharzia and other water-related diseases.

3) There should be closer cooperation between the Government of Swaziland and the business community, i.e., Sugar Estate owners and others, in implementing and carrying out control of programs against Bilharzia/Malaria and other water-related diseases. This cooperation should include exchange of information concerning plans for Snail Control, drugs used in treatment of infection and etc.

4) The existing National Health Program should be expanded to include a national program aimed at educating the entire population, especially those in rural areas who use infected bodies of water, of the danger of Bilharzia and the need to exchange current social/cultural practices for use of government-provided domestic water, laundry and toilet facilities.

5) Training of Swaziland citizens in such areas of expertise as medical and engineering technology, professional Engineer/Sanitarian, Biologist/Malacologists, Epidemiologists/Statistician, Health Education Specialists, Entomologists, Ecologists and other specialists as needed are strongly recommended.

6) The search for alternative control techniques, other than chemicals, such as Biological Control, Engineering (Syphon Spillways and Manual Control Gates), Removal of Vegetation, Solar Distillation, Water Conservation and Canal Relocation and others are strongly recommended.

7) All established fish ponds and rice cultivation fields should be carefully surveyed over a 1-2 year period to ascertain the extent of snail populations (if any) and to determine thier role in Bilharzia transmission. All newly established fish ponds and rice cultivation areas should include in the initial plans preventive measures against bilharzia as well as control programs if needed.

8) Immediate and relatively simple techniques such as fencing of water resources facilities or schemes such as springs, wells, fish ponds, dams-reservoirs, major canals (irrigation, distributary and others) should be carried out on a nation wide basis.

9) In return for the restriction of use of water bodies by Swazi population, piped-treated water, laundry facilities with safe water, toilet facilities. recreational facilities with swimming pools is mandatory.

10) Fencing of cattle and their restricted use of domestic water schemes is strongly recommended.

11) Crossing points at rivers and streams used by workers at various sugar estates in Swaziland should be bridged.

12) It is strongly suggested that in addition to the school children, surveys for incidence of bilharzia infection should be conducted among older age groups and that fecal, as well as urine, examinations, should be included in the National Survey.

13) New investments by both Swaziland and the donors should support:

a) the development of village-based health services delivery infrastructure with emphasis on environmental health;

b) investments within the context of the village-based health systems, in particular emphasizing:
   - safe water supply
   - nutrition
   - environmental sanitation
   - health education;

c) the policy, planning, management and training initiatives essential to create village-based systems;

d) the specific bilharzia disease control measures.

General Objectives

In February 1976, Dr. W. R. Jobin, Engineering Consultant (AID), and Dr. C. E. Jones, Epidemiologist (WHO), carried out a joint AID/WHO consultation on the status of bilharzia control in Swaziland. The Ministry of Health (MOH) of the government of Swaziland expressed satisfaction with the report and recommendations submitted by Drs. Jobin and Jones and now desires to undertake an intensified natural bilharzia control program. The MOH then submitted a draft project proposal incorporating the Jobin-Jones recommendations to the Ministry of Finance and Planning for consideration. The OSRAC in the meantime received requests for related assistance from the Ministry of Agriculture and the Water Resources Board. It was immediately recognized that a potential exists for a much broader and beneficial program for the country. The program envisioned would be for an inter-ministerial, multi-sectoral approach to the complex and broader health problem of providing clean rural water supplies for drinking/washing/bathing/cooking/ to avoid schistosomiasis as well as other water-related and prevalent health hazards. With this objective in mind, OSRAC requested the services of two short-termed technicians who could discuss with officials of the Government of Swaziland (GOS) a possible project (s) suitable for AID financing in the above mentioned areas.

The team was to review previous reports (Jobin/Jones, Gish, Syncrisis and others which they felt would aid them) as well as various current proposals now under discussion in Mbabane, Swaziland. After carrying out on-site visits and consultations with Swaziland government officials and OSRAC, the team was to recommend feasible activities for United States Government support, either under bilateral or regional funding. Within the constraints of time, the team was to assist in preparing the necessary documentation (PID) for the GOS to secure such funding.

The team from the continental United States (Bruce and Unrau) was joined at the start of the mission by Mr. Lewis E. Swanson (AID/Nairobi). Specific other duties for the three member team in addition to writing of the Primary Intermediate Document (PID), see Appendix 1, were as follows:

1) Advise on the present and/or new organization of the bilharzia/malaria unit of the Public Health Laboratory at Manzini.
2) Advise on the plans for renovation and/or addition of a new wing to the existing laboratory structure.
3) If possible, carry out surveys of selected areas for presence or absence of schistosomiasis and other water related diseases and their vectors.
4) Discuss and identify the biological life forms which may be used in studying as possible predator or competitors for biological control procedures.
5) Evaluate the methods currently used for control of schistosomiasis vectors.
6) Identify social, religious, political and cultural constraints which may interfere with the development of a safe rural water supply.
7) Evaluate parasitological techniques and procedures used by the bilharzia unit at the Public Health Laboratory at Manzini.
8) Define problems (present and future) of schistosomiasis in rice and fish cultivation areas.
9) Hold conferences with government officials and representatives from private industries to discuss the schistosomiasis problem and needs for a rural water supply.
10) Discuss the feasibility (of or of not installing syphon spillways in existing dams and its incorporation into the construction of all new dams.
11) Discuss with appropriate government officials the plans as put forth in the Jobin/Jones report for establishment of a National Bilharzia Control Organization.
12) Observe the National Health Education Program for Swaziland.
13) Identify other donors who are planning to or are willing to participate in a multi-sectoral, inter-ministerial approach to the establishment of a safe rural water supply with emphasis on control of schistosomiasis and other water related diseases.
14) Identify bodies of water as current or potential vector habitats.

Discussions were held with the Permanent Secretaries (and their senior staff) of the Ministry of Health and Agriculture and officials of the Water and Sewage Board. Visits were made to various sections of the above ministries, to irrigation schemes (canals, dams and/or reservoirs, water delivery systems and etc.) at private industrial estates, to a demonstration rice cultivation area, rural clinics, the Public Health Laboratory at Manzini and the Southern Rural Development Area (SRDA). A complete listing of all facilities visited and meetings held are as follows:

A) Office of the Permanent Secretary, Ministry of Health (MOH)
   1) Office of the Director of Medical Services (MOH)
   2) Office of the Health Planner (MOH)
   3) Office of the Health Education Section (MOH)

B) Office of the WHO Representative

C) Office of the Permanent Secretary, Ministry of Agriculture (MOA)
   1) Office of the Chief Project Coordinator, RDA (MOA)
   2) Office of the Land Planner (MOA)
   3) Office of the Fisheries Section
   4) Office of Deputy Project Coordinator, RDA (MOA)
   5) Office of Acting Financial Controller, RDA (MOA)
   6) Office of Vetrinary Services
   7) Office of Rural Development Area, (RDA- (MOA)
   8) Office of Home Economics and Nutrition Section (MOA)

D) Representative from the Ministry of Works and Planning

E) Office of Water and Sewage Board (WSB)

F) Public Health Laboratory, Manzini

G) Big Bend
   1) Umbombo Sugar Ranches
   2) Big Bend Clinic

H) Commonwealth Development (CDC) and Swaziland Irrigation Scheme (SIS)
   1) Mhlume

I) Demonstration Rice Cultivation Farm

J) Southern Rural Development Area (SRDA)

K) Mkwade Rural Health Clinic

L) School Health Team (Manzini District)

M) Conference to Discuss Primary Information Document (PID) developed by the Advisory Team.

To prepare this report, the advisory team has taken into consideration data from a number of documents such as the Jobin/Jones report, the Duncan/Fenwick Consultency report concerning bilharzia control at CDC/SIS, medical records and statistics of the Ministry of Health (MOH), results of surveys of human and of the presence of snails by the MOH, annual report by the Ministry of Agriculture (MOA), organization plans by the Water and Sewage Board (WSB), records from the Big Bend Clinic concerning snail surveys and molluscicides regimes used by the Bayer and Shell companies and information concerning treatment regimes for humans infected with schistosomiasis.

I) Geographical and National Characteristics

The Kingdom of Swaziland is a small landlocked country of approximately 6,700 sq. miles which is divided into four topographical regions running from north to south. These are the Highveld, Middleveld, Lowveld and Lubombo Plateau (maps 1 & 2). The mean annual rainfall for the Highveld area is 130 cm., for the Middleveld area it is 90 cm., for the Lowveld it is 70 cm. and 60 cm. for the Lubombo Plateau (map 3).

Swaziland is well watered, having four large rivers which run from the lowveld area in the east through the Lubombo Plateau to the Indian Ocean. The four rivers are the Komati, and Mbulzi in the north, the Great Usutu in the central part of the country and the Ngwavumci in the south. Other natural water resources which are substantial include springs and streams.

The population of Swaziland was estimated in 1975 to be approximately 510,212 of which 80-85% are rural dwellers. Map 4 shows population density as of 1966. Europeans comprise 3-4% of the total populations. The popu-

lation in the rural area is widely dispersed. There are very few organized settlements or villages.

The economy of Swaziland is somewhat diversified, being dualistic in nature and divided between a modern sector which is comprised of foreign owned enterprises and the traditional sector, or Swazi Nation land. Approximately 40% of the nation's arable land, ranges and forestry is held under individual tenure farms. These are held in freehold or concession leases by non-Africans. The government of Swaziland is making an effort to repurchase this land for use of its own people. The remaining 60% or more of land comprises Swazi Nation land which is held in trust by the King of Swaziland. This land is communally held and is distributed to local chiefs for the use of constituents in their respective homesteads. The chief has the power to take the land into receivership if it is not used within a specified interval after issue.

According to the most recent available data there were nearly 790 individual tenure farms (mostly foreign-owned) which account for approximately 60% of the total agriculture production of the country (map 5). The primary crop from these farms is sugar, with significant productions of cotton, citrus, pineapples and forestry products. Banana, rice and tobacco are also important crops from these farms (map 5). The small scale Swazi Nation farm(approximately 38,000) produces mainly subsistence crops such as maize, groundnuts, sorghum, beans, potatoes and assorted fruits. Nearly 70% of the population lives on the Swazi Nation lands which accounts for 40% of the agriculture production for the nation.

Another significant part of the economy is livestock. Its full potential as a contributing factor to the nation's economy is inhibited by a sociocultural constraint or belief. Traditionally, the number of heads of cattle possessed is evidence of wealth and prestige for the Swazi citizen. Cattle are used as prices for brides, as a readily available source for cash and are generally kept for long periods of time for these purposes. Only on rare occasions are they slaughtered for food. There is no limit to the number of heads of cattle any one individual may own. Overgrazing by these owners is a serious problem resulting in a reduction of ground cover,

causing erosion and pollution of water resources facilities. This tradition has interfered with the governments efforts to realize the full potential for the development of the livestock industry as an important source of national income as well as adversely affecting a more practical utilization of rangeland. The Government of Swaziland has attempted to diminish this traditional custom and the latest available data indicates some success. There was an increase of meat and meat products by about 25% since 1971. There are at present several cattle ranches in Swaziland where grazing areas are established and cattle are fenced to prevent them from polluting water resources used for human consumption.

Swaziland functions under a dualistic government system which is administered by a King. The King is advised by a cabinet presided over by a Prime Minister and a traditional Swazi National Council composed of Swazi chiefs which make all decisions concerning the nation's land use for local administration. The country consists of four districts with individual commissioners appointed by the central government. The cities of Manzini and Mbabane have municipal governments.

There is an illiteracy rate of approximately 70% in Swaziland, a maldistribution of income, a lack of skilled manpower and a very visible dependence on non Swazi citizens for carrying out key administrative functions.

There are critical shortages of available pools of trained manpower (teachers,technicians,etc.) which serve as a constraint to the overall development of the country. Government priorities for the development of the education system to provide trained manpower resources are reflected in budgetary allocations which have been increased from 14% of the total budget spent on education in 1970/71 to an estimated 16% of the national budget in 1974/75. Despite the government's priority towards education, additional help is required from other sources.

II) Rural Customs

Various practices, beliefs and/or taboos of the rural population were recognized as having the potential of being a cultural, social, religious, political or educational constraint to the establishment of a clean rural

water supply. These were identified as a result of indepth discussion with staff members of the various ministerial sections visited. In some instances the potential constraints listed are at best only indirectly related to the establishment of a clean rural water supply. The following is a list of those potential constraints:

A) Social and Cultural Constraints

1) Taboo concerning use of toilet facilities
2) Scattered nature of rural population
3) Because of generations of long standing practices there is a general reluctance (especially among older populations) to accept changes, i.e., boiling water before drinking, changing from routine use of rivers and streams for bathing, laundering, personal hygienne use and etc.,to use of constructed toilet, shower and laundry facilities.
4) Use of cattle for social status rather than for economical purposes; lack of restriction on the number of heads of cattle owned, overgrazing which leads to soil erosion.
5) Problem of convincing cattle owners to carry on good sanitary practices, i.e., tetanus in newborn children and etc..

B) Religious

1) Attitudes of certain religious groups which prohibit use of any substances containing chemicals, i.e., refering to treatment of water for human consumption with chlorine and other chemicals.

C) Political

1) Attitudes towards the use of fencing to restrict human and animal access to water resources facilities. This is considered by many to be a psychological factor related to past colonial practices.

D) Educational

1) A critical shortage of Swazi national skilled manpower in all areas of expertise due to a lack of manpower training in the past.

In most instances, the staff members of the ministerial sections were unanimous in their belief that the above listed potential constraints could be overcome and that the rural populations would accept new practices and procedures which would be conducive to improving their health and living standards. There are various examples of a rapid social-cultural adaptibility to new changes in the country in the important area of economics. Many traditional Swazi farmers adapting new techniques have changed from subsistence farming to that of cash croping. The growing industrial development in the country has created new socio-economic groups and these groups depend on earned incomes for their subsistence. There appears to be a greater expression of freedom by women as they clamor for entrance into the professional ranks. In addition the opinions of those with whom the subject of constraints were discussed indicated that there was a growing new defiance of traditional social forms and taboos.

In summary, it was unanimously stated that none of the social, cultural, religious or political practices which could be classified as constraints would interfere with the establishment of a clean rural water supply.

III) Rural Water Resources

Swaziland is a country with generally fertile land and more or less adequate rainfall. There is a readily available source of underground water and associated springs. There are four large primary rivers running from the east through the Lubombo plateau to the Indian Ocean. These are the Komati and Mbuluzi in the north, the Great Usutu in the center and Ngwavuma in the south. There are various man made bodies of water which are derived from the above sources and are used in an attempt to supply the agriculture and domestic needs of the nation. The classification of the natural and man made bodies of water are as follows:

A) Natural bodies

1) Rivers
2) Springs
3) Lakes
4) Natural Drains

B) Man Made Bodies

1) Canals (Main and Distributary)
2) Reservoirs and/or Dams
3) Gravel Pits
4) Fish Ponds
5) Constructed Drains
6) Oxidation Ponds
7) Field Channels
8) Wells

The development of a national water supply and sewage system has more or less bypassed the dwellers of the rural areas (Map 6). Rural dwellers suffer from illnesses caused by a lack of adequate sanitary facilities and contaminated water supplies. In addition, the distribution of health services is highly skewed with hospitals, doctors and nurses concentrated in the urban areas. In the urban areas water and sewage systems tend to be well up to international standards.

The settlement patterns of the Swazi rural population make delivery of protected water supply and provisions of sewage disposal systems most difficult. These services including both preventive and curative health care must be effected on a settlement by settlement basis. The fact that Swazis do not live in villages but in widely dispersed homesteads, forces such services such as health education, that could be provided in a community setting, to be given by outreach and extension programs. The establishment of the Rural Development Areas within the Ministry of Agriculture appears to offer excellent opportunities for the Swazi Covernment to provide sanitary services on an area wide basis for rural dwellers. The lack of establishment of a vigorous sanitation program by the agency which should be responsible (Ministry of Health) is due to poor coordination and interagency interaction between the Ministries of Agriculture, Health and others.

The Government of Swaziland is developing a widespread programme for the provision of potable safe water supplies (including toilet, laundry and shower facilities) throughout the nation. The plan includes requests for aid from various outside sources for implementation of certain phases

of the program and insuring that there will be Interministry cooperation and interaction. The plan also includes control and preventive measures against water-related diseases as well as a national Health Education Program. It is obvious that this plan is highly ambitious but absolutely necessary if Swaziland is ever to provide a healthy environment for its people to work and live. It is recognized here that the same factors responsible for creation of the dual political and economic system in Swaziland are also responsible for the same contradictions within the public health sector. However, despite these problems and contradictions the outlook for development is good. The indications are that the old static attitude toward change is rapidly wanning and the younger generation of Swazi citizens will readily accept these changes which will improve their general health and well being.

IV) The GOS Rural Water Supply Program

1) Spring Protection - This program is being carried on by a World Health Organization (WHO) Sanitary Engineer and a Senior Health Inspector of the Swaziland Ministry of Health (SMOH). Springs are located and protected by use of cinder block enclosures with a galvanized tin roof (Photograph 1). Water is piped from the springs to a collector tank (Photograph 2) and then by pipe from the collector tank to a storage tank or reservoir (Photograph 3). Both of the latter two structures are also completely enclosed and covered. The spring area is enclosed by a fence. Collector tanks holding 600 gallons and reservoirs holding 4500 gallons were observed. The durability of these units were estimated to be 20 years. Water is piped from the reservoir to homesteads, villages or settlements. The terminal source of water was usually a centrally located stand-pipe (Photograph 4). From this point on, villagers must pay for piping water to their homes. Maintenance of the enclosed springs, collector, reservoir and piping is carried on by the community. A complete system (includes two springs) described above will supply water for 2000 persons. The cost for protecting the spring is approximately R50, while the cost for the entire package including collector, reservoir, piping and stand-pipe is approximately R2000.

2) Pit Latrines - The cost for digging a pit latrine involves practically no cost for materials. No other information was obtained.

3) Wells - No information regarding digging of wells was obtained.

The major costs for the above facilities will be labor and transportation. Plans are intended initially to place one team in each district consisting of an artinian, two laborers and a health assistant. Each team would be expected to protect approximately 25 springs and dig 250 latrines and/or wells per annum.

A) The Rural Development (RDA) Program

The Government of Swaziland has decided to concentrate its rural development efforts into a better selected large Rural Development Areas (RDA's) which are located on Swazi Nation Land (Map 7). The program is administered by the Ministry of Agriculture and is a comprehensive plan which follows an integrated approach including dry land planning, arable land consolidation, separation of livestock by fencing, fish pond and water resources development, road building and improvement, soil and water conservation and provision of extension services for both animal husbandry and crops.

The RDA program at its inception was slow in starting due to planning and implementation problems, but at the time of the visit to Swaziland by this team, it was progressing quite well. In the Northern RDA, where most of the effort up to a few months ago has been concentrated, outputs and yields of a number of crops have improved significantly as well as farmer's incomes. Available results suggests that the RDA's have motivated farmers in other areas; for example, the increase in the number of farmers outside the RDA's seeking information and advice on growing cotton has been so great as to exceed the capacity of the extension service staff.

A number of international and bilateral agencies other than WHO are involved in supporting various activities of the RDA program. There is a conspicuous lack of provisions for environmental sanitation, such as water protection, sewage disposal (toilet facilities) and disease control. There is also a lack of interministry coordination which would be essential for implementation of disease control and environmental sanitary programs.

The Southern Rural Development Area (SRDA) located in the Highveld region was visited by this advisory team. This is a reasonably new RDA. There are approximately 35 persons who are currently staffed or living at this RDA. Houses provided for senior project members have piped water with toilet and laundry facilities. Junior members have no water facilities at this time but plans are being made for installation. There are the so called squatters huts located on the SRDA land. The junior staff members and these persons use the bush or river for toilet facilities. The piped water system used by senior project members is treated with chlorine. There was no idea of its efficiency. Covered or protected water sources such as springs are located nearby. A public health officer and assistants work near this area. Attempts are being made to integrate the public health program into the SRDA project. The nearest clinic is several miles away. Plans are for a clinic to be located at this RDA. The SRDA needs schools, recreation facilities and piped water facilities for toilet and laundry uses. The Canadian government will supply resources for the establishment of a SRDA water network. There are 4500 heads of cattle which are used mostly for personal use and as a prestige factor. There are 1800 heads of goat and sheep which are used for food and other purposes. There are vegetable gardens for subsistence and roadstand vendoring (potatoes, cabbage, tomato, maise and fruits). There is no central market area. Rice is not grown at the present time. Three fish ponds have been established and at the present time there are no plans for further establishment of fish ponds. The SRDA works very closely with the local authorities and populace in establishing development schemes. The procedure is as follows:

Rural Development Area (RDA)
↓
Chief
↓
Local Development Committee
↓
SRDA Development Scheme

There is complete people involvement. When asked if there were plans for control or prevention of major diseases along with development schemes, the answer was <u>no</u>. There was however a keen interest as to how information con-

cerning the various diseases which could be present or become established because of the presence of new water resources could be acquired.

It was believed that malaria was not present in the SRDA area. References were made to tick borne fever in cattle and tickbite fever in humans.

B) Water Resource Schemes at SRDA

a) Ram Pumping Facility
b) Main Canals (Lined and Unlined)
c) Cisterns
d) Fish Ponds
e) Dams

All of the above schemes are relatively new, having been established since 1975. A description of these schemes are as follows:

1) Ram Pumping Facility: The water supply for this system is drawn from the Indlomodolomo River. The water runs to the pumping facility along ditches and then into lined canals(photographs 5 & 6). Water pumped from this facility is used by persons at SRDA for all purposes. A search for snails in the main (unlined) canal carrying water to the Ram Pump was conducted. Several dips were made and no snails were found. There was vegetation along the margins of the unlined canal. The water flowed rather rapidly in these canals.

2) Main Canals: The main lined canals leading to the Ram Pumping Facility and those running from the dam were rapid flowing. The unlined canals (open ditches) contained slower flowing water. There were irrigation ditches near the dam area which contained vegetation along the margins. The water was slow moving. A search was made for snails. Several dips were made and none were found.

3) Cisterns: These structures were not examined. They are used to collect and store rain water.

4) Fish Ponds: There are 3 fish ponds at the SRDA. One of these ponds was visited. It is located approximately 1 to 2 miles from the Mpatemi Dam. The fish pond was 75 ft. (length) x 35 ft. (width) and approximately 15 ft. in depth (Photograph 7). There was vegetation along the margins of the pond. The pond was relatively clean. There was no evidence of animal or human pollution. Nearby there were numerous garden plots. The pond had been stocked with fish such as mirror carp. Other ponds had bass and *Tilapia sp.* Carp has been caught at this pond. A search was conducted for snails. A total of 15 dips were made covering the entire circumference of the pond. No snails were found.

5) Dams: There is one dam at the SRDA. The Mpatemi Dam supplies water to 20 hectares of small farming (46 plots). The dam area is fenced in to keep cattle out. There is a minor problem with goats. There is also a piped water supply for the dam area. The water is available through a stand-pipe system. This water comes from covered and protected springs.

The Mpatemi Dam has bass, *Tilapia*, yellow fish and *Barbel*. Ducks and ergots were observed in the dam water. There was sparse vegetation along the margin of the dam. The water in the dam was very clean. There was no evidence of pollution. A search was made for snails. A total of 12 dips were made for snails and none were found (Photographs 8 & 9).

The soil we were told by the SRDA staff is quite acidic in areas around the fish pond, Ram Pumping Facility and Dam site.

The SRDA is a relatively new development area. The advisory team found no snails there. It should be pointed out that the teams visit occured during the month of May which is the winter season in Swaziland. It may be that snail populations were at their lowest level, breeding was not occuring and that the temperature was too low for the schistosoma larva stages to develop in the snail. It is however highly probable that schistosomiasis does not exist in the SRDA area. The area should be thoroughly examined to determine the presence or absence of schistosomiasis.

Recommendations: a) As development proceeds plans for prevention of the establishment of schistosomiasis should be included.

b) A health education program should also be developed.

c) Fencing of all fish ponds to restrict human and cattle access.

d) Assimulate satelite villages and inhabitants into SRDA scheme, where piped and treated water is available for their usage.

e) Survey for snails and infected persons (urine and fecal specimens) should be conducted.

f) Examinations of persons for presence of malaria should also be conducted.

g) Establish toilet and laundry facilities for all inhabitants.

h) Provide fenced in areas for cattles to graze.

C) Rural Water Supply Branch

In 1974, the Rural Water Supply Branch was formed to become responsible for rural water schemes. The scheme includes providing water supplies for schools, clinics, police buildings and others. The RWSB is responsible for construction and maintenance of all existing systems. Money for maintenance is allocated by the Ministry of Finance. A sum of 1.3 million Emalangeni has been for use over a 3 year period. A total of 48 new schemes will be constructed, while 72 existing ones will be upgraded and expanded. RWSB board has district offices as well as a clerk of works. There are plans for use of mobile workshops for preventive maintenance of rural water systems. There is a training program for local citizens. Courses in water resource systems management and maintenance are offered at local colleges.

The establishment of a Rural Water Supply Board has been proposed which would include representatives from the Ministries of Agriculture, Education, Finance, Health, Geology, Public Works, Local Administrations and Town Councils, and a Prince. Representatives from the Ministries will be at both permanent secretary and field staff levels. For 1977, the Board would complete 20 schemes such as springs, wells and surface water facilities. Water will be tested and treated according to WHO standards. Aid is presently being requested from several sources for construction of toilet and laundry facil-

ities and water schemes. Canada is contributing $300,000 and England $1.3 million for the construction of water schemes. The ICCO is contributing funds for laundry facilities which must be matched by Swaziland Government funds.

The Rural Water Supply Board has proposed criteria for use in selections of water schemes and sites (Appendix 1). Criteria proposed for site selection are as follows:

1) Only settlements with 2500 inhabitants or less and located within a 2 km. radius should be included.
2) Cost effectiveness; maximum of E50/person should be imposed. Student (day) and clinic patients should count in addition as half a unit.
3) Current sources of water should be assessed for chemical, bacterial and parasitic comtamination. The adequacy of dry season water supply should be assessed.
4) Distance to nearest portable water supply (according to WHO standards) should be determined.
5) Location of schemes in relation to population growth centers should be considered.
6) Preference will be given to schemes where...
    a) A responsible member of the community has been or will be nominated from the community to take responsibility for operation of the scheme and to report faults,
    b) Community is willing to contribute unskilled labor for construction purposes.

V) The GOS Health Education Program

A major part of the Government's plan for the national health program is the development of Health Education. Educational activities at the present time are mainly carried out by public health nurses who present special sessions at health centers and touring of rural clinics. There is a Health Education specialist on assignment from WHO to the Ministry of Health for the purpose of aiding in the organization of the national Health Plan. The

Health Education section plans to expand Health Education programs employing all of the media at its disposal. In addition to the lecture sessions held at health centers and rural clinics, a health component will be included in the curricula of an increasing number of schools especially at the primary level. There is a curriculum development program being initiated by a contract awarded to Western Michigan University. Plans are for the conductance of seminars throughout the nation, to encourage industry and other private groups to accept the importance of Health Education, and to meet frequently with government agencies in regards to the inclusion of a Health Education Component in their National Programs.

The Health Education Section has a local basic training program for various level Health personnel such as Health Assistants, Rural Health Visitors and Domestic Science Demonstrators. Refresher Courses are given every two months for nurses. Senior personnel are sent abroad for specialized training to institutions in the United States, Nigeria and Kenya. Support for this comes from AID and WHO. The construction of a new training center for nurses will be started soon with AID funds.

Health Education has a major role to play in the Anti-bilharzia and Anti-tapeworm campaigns (Appendix 2). A major cause for the high incidence of such diseases is the lack of knowledge by persons in the rural areas of the important need to utilize safe methods of human waste disposal, the avoidance of bilharzia infested waters, the need to cook their meat completely done before consumption in order to avoid infection with tapeworms, and to use toilet facilities when provided by the government as well as dig their own pit latrines.

The introduction of an Health Education Program with provisions for training of Health Assistants in these techniques into the Rural Water Supplies and Sewage Programs described above will be a substantial educational element and thus should contribute in its own right to the eventual reduction in incidence of these diseases. The program will also serve to acquaint the rural populace of the dangers of other communicable diseases such as malaria, polio, tetnus, tuberculosis and others.

There are also plans for the incorporation of midwives into the community health workers (Rural Health Visitors or Motivators) who are given a two month training period. Training of these workers is consistent with the local situation. The Ministry of Health at the present time pays these workers a small token. The respective communities will eventually take over the responsibility for paying these workers. An additional major task of these workers is to carry out some phase of the protected water supply program, as well as aid in construction of and maintenance of pit latrines, promote use of and maintenance of new laundry and toilet facilities.

The Health Education Section of the Ministry of Health appears to be well organized and at the present time its operation and plans for the future are consistent with the opinions of experts in this area of expertise as to the importance of Health Education in Water Resources Development and disease control. The national objectives of the Health Education Program were presented as follows:

1) Promotion of Health and Prevention of Disease
2) Carry the Health Education Program to the individual group and mass population level.
3) Motivate the people to use available resources.
4) Early detection of diseases.
5) Rehabitation of those people affected by diseases.

A) School Health Teams

School Health Teams consist of two Peace Corp volunteers (having biology, health education or other health and medical related training) and one Swaziland National Nurse(R.N.) There are currently four national School Health Teams, one for each major province of Swaziland. Each team is assigned a vehicle for transportation. The teams are responsible for vaccinations, examination of urine and feces and dispensing medications. Examinations are performed only on children in grades one and two. Treatment for bilharzia is given only when a diagnosis is made by the team in an area which is low in percentages of cases. When diagnoses are made in areas known to have a large percentage of cases, treatment is not given. The cases are referred to a doctor for treatment. The drug currently used for

treatment of bilharzia by the School Health Teams is Bilharcil. This drug will be discussed in detail in a subsequent section. Followup of treatments is not done.

This advisory team met with the School Health Team assigned to the Manzini province. The team expressed deep concern over the lack of direct supervision by the chief medical officer. There is a lack of equipment especially that needed for fecal examinations. In many instances they were able to carry out their assignments as a result of improvision. It was evident that the Peace Corp members of the Health Team were very anxious to perform in a creditable manner for their country.

Recommendations:

a) Provide more direct sppervision especially in regards to dispensing of medication.
b) Provide equipment needed to conduct fecal examinations necessary to detect S. mansoni and other intestinal infections.
c) Increase the number of teams so that incidences of infections can be detected in older age groups.
d) Add a Health Education specialist to the School Health Team.

VI) A Review of the Public Health Problem in Swaziland as regards Water-Related Diseases and Diseases of Insanitation.

The present structure of the population of Swaziland is such that its greatest needs for Public Health services are those of the young and the dwellers of the rural area. This is not to ignore the future needs of urban dwellers which is likely to become significant in the near future. At the present time, approximately half the national population is below the age of 15. In addition, nearly 85% of the populace lives outside the defined urban areas. It is these persons who are affected and suffer from Swaziland's major health problems, that is water-related disease and diseases of insanitation such as bilharzia, gastro-enteritis and tapeworms. Indications are that with the present population growth (over 3% annually) the number of cases of the above diseases is constantly rising. The present disease pattern indicates the importance of providing environmental sanitation and health education to reduce the incidence of water borne diseases and diseases of insanitation. Facilities and services to meet these needs are very inadequate. This advisory team is convinced that the GOS now recognizes that there is an urgent need to reorientate their priorities for development in the health area away from conventional institutional facilities centered in urban areas to those in the rural areas. There is also a recognition that different kinds of programmes are needed which are cheaper, more simplified and closely geared to the preventive aspects of rural health in order that greater results may be obtained in attempts to solve the health problems of the rural population at large.

The GOS has outlined its major objectives for the national health services development scheme in that "They should contribute to the overall improvement in the level of living and quality of life of the mass of people in Swaziland." There are three policy statement objectives:

1) To improve the overall standards of public health and in particular to reduce the incidence of water borne diseases and diseases of insanitation amongst children and the other inhabitants of the rural areas.

2) To maintain present levels of curative services, improving their standard mode of distribution whenever possible.

3) To create a situation whereas a substantial moderation in the rate of population growth can be achieved within a reasonable period.

In order to achieve the above objectives, the GOS has identified four priority areas for development. They are:

a) Development of programs of rural sanitation and water-supplies in order to reduce the incidence of debilitating diseases and maintain and expand existing communicable disease control program against bilharzia, malaria and tuberculosis.
b) Improving the network of rural clinics.
c) Development of health education programs.
d) Expansion of training programs both at the local level (paramedic) and overseas (senior health staff). The GOS has requested aid from various foreign countries and private foundations to carry out certain phases of the national health program. This advisory team visited Swaziland to advise on the preparation of a safe and clean rural water program.

As has previously been stated, the major health problems in Swaziland is caused by diseases borne by water or associated with insanitary conditions. Bilharzia is one of the most urgent diseases affecting approximately 60 to 90 percent of the population in the Middleveld and Lowveld and significant numbers in the highveld as well. The incidence of bilharzia is spreading with the development of irrigation, in spite of the fact that 24,000 out of a total of more than 70,000 irrigated acres are under snail control. Plans are also being formed to increase the number of acres under control to at least 50,000 acres with the help of the private sector despite the lack of success with the program thus far. Typhoid is still endemic, tapeworm is prevalent throughout the country and gastro-enteritis is a very serious problem particularly among infants ranging in age from four weeks to two years. These diseases occur in all parts of the country where purified water or protected supplies are not available. It is thought that climatic conditions cause incidences to be lower in the Highveld than in the subtropical Lowveld.

Bilharzia is considered by the COS to be a major element sapping the energies of children and adults alike, thus reducing their effectiveness at school or at work. Gastro-enteritis, among other factors is an important cause of infant mortality. The tapeworm which infects cattle, affects the rural dweller directly by infecting the meat which he eats and indirectly by reducing the value of his cattle on the market. This has national consequences as it also restricts the ability of Swaziland to meet demands for its meat on world markets.

Tuberculosis is the most important among other diseases. There has been a recent increase in the number of reported cases. This, however, may be due to improved diagnostic techniques and a better awareness of its prevalence.

Malaria which has been reduced to negligible proportions with less than 200 cases reported last year, now appears to be on the increase. Deaths among Swazi citizens and expatriates have recently been reported. It is not known if drug resistance malaria is present or not. Evidence of mosquito vector resistance to DDT and Dieldrin has been obtained.

The incidence of syphillis and gonorrhea continues to be high despite free treatment at government hospitals and clinics. Diptheria, poliomyelitis and measles are reduced to a level where they appear only sporadically. Leprosy has shown a steady decline, while smallpox has completely disapapeared.

There are several diseases in cattle, sheep and horses which are more or less water-related. Schistosoma boris and S. matthei, Fasciola hepatica and F. gigantica are all found in cattle; hydatid disease is found in cattle and sheep; African horse sickness and blue tonque are found in horses.

The agency responsible for dealing with the above described health problems is the Public Health Section of the Ministry of Health. Its responsibility is very wide and its aims will be pursued in cooperation with other Ministries and Departments, i.e., the advisory team identified a general lack of interaction and cooperation between ministry sections in regards to an understanding of the need for disease prevention and control when new water resources are established.

Specific aims of the Public Health Section of the Ministry of Health are the provision of portable water supplies (an objective or mission of the RDA's which are under the Ministry of Agriculture), refuse disposal and sewage facilities, pest control, improved standards of nutrition and improved housing.

The Office of the Senior Medical Officer of Health is located in Mbabane from which the national public health program, environmental health and hygienne, health education, the enforcement of health legislation, supervision of two city health departments and the public health nursing unit are directed. There is another health office at Manzini under the direction of a second Medical Officer of Health, who has responsibility for the control of bilharzia and malaria. The Office of Health support staff consists of a Senior Health Inspector, four Health Inspectors (one per district) and five Health Assistants. It has the support services of the pathology laboratory in Manzini where routine biochemical, bacteriological and haematological examinations are performed.

A) Public Health Centers

At the present time there are two urban public health centers, one in Mbabane and Manzini with simular services being offered at Siteki, Hlatikulu and Mankayane hospitals. These centers concentrate on preventive aspects of health care and service. Activities include health education, medical examinations (includes establishing vital statistics data bank) prophylactic injections, medications, maternal and child health services and nutrition guidance. These centers are staffed by a Sister and a number of public health nurses. There are regular visits by doctors.

The public health center at Mbabane appeared to be very well organized. There were many patients waiting to be seen during our visit. The staff (matron), nurses and health visitors were very well informed and concerned about the health needs of Swaziland. The concept that health education should be a component of all health programs was being perpetuated by this office. In evidence was part of the media, such as posters, and other material which are used in their efforts to encourage good nutritional personal hygiene and family planning by the citizens of Swaziland(Photograph 10).

Three health centers will be constructed within the near future at Siteki, Pigg's Peak and at a still to be determined site in southern Swaziland. UNFPA have agreed to finance the center at Siteki while equipment will be provided by UNICEF.

B) Rural Clinics

There are approximately 60 rural clinics in Swaziland, 31 of them are operated by the GOS, the remainder are run by industry and private organizations. In many instances there are gross inadequacies in these clinics such as lack of equipment, poor physical conditions (piped water), under staffing and lack of general supervision. In most instances the private clinics (those located on the sugar estates) are better equiped but some have a general lack of support staff.

Three rural clinics were visited, one operated by the government (Nkowade), and two operated by private concerns (Big Bend sugar estates and CDC/SIS-Mhlume).

The government operated clinic at Nkowade was recently constructed and was staffed by a registered nurse and a nurses assistant. The clinic was located at a school complex. There was water available from a standpipe in the courtyard, toilet facilities were also available for the clinic and school (photographs 11,12 & 13). There was also a water storage tank accross from which water was piped to the clinic and school. There was a general lack of basic equipment. Approximately 2 patients with blood in their urine are seen each week. The patients are usually referred to a doctor who then recommends the specific treatment. No fecal examinations are performed. There was no laboratory equipment available for conducting urine or fecal examinations for schistosome ova.

In contrast to the rural government operated clinic at Nkowade, the privately operated one at Big Bend was well equiped. The professional staff consisted of one expatriate physician and a Swaziland registered nurse or matron (Photograph14). who attend to approximately 15,000 patients per year. An average of 50 to 60 schistosomiasis patients are seen each year. There is no organized treatment scheme no specific diagnostic procedure for schistosomiasis. Patients suspected of having bilharzia (ir-

regardless of species) are treated with a specific drug. The attending physician stated that malaria, malnutrition, tribal medication practices, ameobic dysentery (caused by E. histolytica) viral hepatitis, tapeworms, hookworm and ascaris are medical problems in addition to schistosomiasis. Malaria cases appear to be increasing at Big Bend. One week prior to our visit, 8 out of 12 persons examined were positive for malaria by blood examinations. All blood examinations are performed at the Public Health Laboratory in Manzini for this clinic. One death due to malaria was reported one to two weeks prior to our visit. There was no indication of drug resistance malaria in the Big Bend area. No hydatid disease has been observed. There has been an increase in hepatitis cases recently.

The clinic operated by the CDC/SIS Mhlume sugar estates was also well equiped and housed in a very well kept building with air conditioning. The professional staff consists of all expatriates, two physicians (1 full and 1 part-time), nurses, receptionist and a biologist who had arrived for duty only three months prior to our visit and who will administer the bilharzia control program at CDC/SIS. The biologist was appointed as a result of one of the recommendations made in the Duncan/Fenwick report for CDC/SIS. The diagnostic procedure used to detect bilharzia is usually a urine examination technique, only in certain instances are fecal examinations carried out. When patients are initially examined, liver enlargement or its absence determines the drug of choice for treatment of bilharzia. This examination usually preceeds the specimen examinations. Recent cases of bilharzia were reported among expatriates who had been water skiing at the yacht club. Estimates of the number of Schistosomiasis cases each month vary from 4 - 30. Malaria cases were also reported at this clinic but the information given was not followed up.

The United Kingdom and the UNFPA will soom finance the construction of six clinics, while equipment for them will be provided by UNICEP. The Government of Swaziland has plans for upgrading the staff of all clinics including non-government operated ones as well. Each clinic is slated to be staffed by two nurses (one trained in clinical medicine and one in public health) and one health assistant.

Recommendations:

1) It is recognized that these clinics have a multitude of services to perform and thus under the constraint of inadequate staffing cannot devote the amount of time required for bilharzia problems alone. However, it should be pointed out that none of those facilities visited has an organized diagnostic and treatment scheme (including follow-up observations after treatment) which could be included in the GOS planned national bilharzia control program. It is therefore recommended that the clinics (both government and non-government) be urged to develop an organized diagnostic and treatment scheme (with appropriate post treatment follow-ups) which can be included in the GOS national control program.

C) GOS Program of Control for Communicable Diseases

There are two major disease control programs with central offices in Manzini. There is a national TB program which is supervised by a medical officer who is assisted by 10 health assistants. The program now is in its second round of case finding and treatment will, when completed, be turned over to the normal public health services of the nation.

The second national disease control program is malaria/bilharzia under the supervision of a second medical officer assisted by 40 health assistants and is centered at the public health office in Manzini. At the present time, however, the malaria/bilharzia unit is being directed by a health inspector in absence of the medical officer. The amount of spraying required against malaria varies from year to year according to the incidence of mosquitos. The WHO assists in this program. Presently, the majority of the staff of the malaria/bilharzia unit are utilized for constant control measures against malaria and therefore current activities against bilharzia, despite its prevalence, are limited to survey and control efforts encompassing a few small scale projects. The national efforts against bilharzia are limited because of the above constraints.

The bilharzia control unit's laboratory and organization was visited and reviewed. A field trip was taken with the bilharzia survey and control

team and the techniques used were reviewed. As a result of the advisory teams observations, the following discussions and recommendations are presented:

1) The present facilities, equipment, shortage of technical personnel and present procedures used for specimen collection and examination limits the identification to predominately S. haematobium. S. mansoni appears to be under-reported in spite of the widespread prevalence of Biomphalaria sp. In addition, the techniques used for bilharzia diagnosis in the bilharzia laboratory are not complete. The bilharzia field survey and control teams technique and/or procedures also could be improved. The dispencement of drugs for bilharzia treatment by the bilharzia unit is undersupervised.

To properly carry out an adequate bilharzia program the following facilities are recommended:

1) Central records section, treatment areas (for bilharzia and malaria) with physician examination room and office, pharmaceutical dispensary, storage section (to accomodate all items except medications), insectary (for malaria unit), snail laboratory, ecology and water analysis laboratory, expanded bilharzia diagnostic laboratory, glassware washing section with autoclaves, sinks, cabinets for storage of glassware and general dispensary forms, laboratory animal quarters (see PID) and a Health Education Laboratory.

2) Personnel shortage were recognized by the advisory team and the following recommendations are presented (see PID):

   a) One Biologist/Malacologist
   b) One Water/Sanitary Engineer
   c) Consultants (short term) in Epidemiology, Sanitary Engineering, Biology, Malacology, Parasitology and Laboratory supervision. These persons would be required to aid in establishment of correct and adequate laboratory and field survey procedures.
   d) Three clerks (records and typists)
   e) Pharmacy aids (perhaps a nurse's assistant or someone of simular background would be adequate after proper training) and a health educator.

f) One general administrative supervisor.

g) One statistician assistant and/or data clerk (this person should be trained in the computation of all data collected by field teams. Duties should also include mapping and organization of all data for presentation to a senior statistician for analysis).

h) Two laboratory assistants for Biologist/Malacologist

i) Four construction team workers to be under direct supervision of Water Sanitarian/Engineer.

j) One general maintenance supervisor (with knowledge of mechanical ability to be responsible for all equipment maintenance) for the entire Health Laboratory.

k) Four laboratory assistants who will be exclusively confined to the diagnosis of malaria and bilharzia. It is strongly suggested that these persons be given permanent assignments for this task and that they be adequately trained. This unit would be constantly staffed by four laboratory assistants at all times in order to handle the present and anticipated workload. It is also further suggested that this unit will examine only those specimens collected by field survey teams, school health teams and would assist laboratory staff of hospitals where necessary in this area of work.

3) Discrepancies in procedures used in dispensing of drugs for treatment by field survey team, school health teams and lack of followup of persons treated were observed. In addition teams and some clinics dispensing drugs were not aware of serious side reactions which could result in death of patients. The following recommendations is thus suggested:

a) In view of the existence of a strong infrastructure of rural clinics (as well as plans outlined for future developments) within the country (see PID) it is proposed that clinic nurses be involved in the decentralized treatment of malaria and bilharzia cases.

b) To assist these nurses a schedule for treatment should be drawn up which should be distributed and followed more closely by these nurses. Information concerning side-reactions and precautions should also be drawn up and disseminated. In addition

the nurses at the malaria and bilharzia unit should assist and advise these nurses.

4) It is the opinion of the advisory team that the laboratory diagnostic section of the bilharzia unit was undersupervised and that techniques and/or procedures were not being adequately carried out for proper diagnosis of bilharzia. This is due to an immense workload for the Health Inspector acting as Director of the malaria/bilharzia unit. To alleviate this situation and to prevent its occurance in the future in the absense of a medical officer the following recommendation is made:

It is strongly suggested that the diagnostic section of the malaria/bilharzia unit be transfered under the supervision of the pathologist and laboratory technicain of the central Public Health Laboratory. It is further recommended that the malaria/bilharzia diagnostic section be expanded to four laboratory assistants whose work will be confined to malaria and bilharzia diagnosis. They will receive specimens collected by field survey teams, school health teams and will assist laboratory staff of hospitals in this area of their work where necessary. The proposed organizational scheme under this recommendation is shown in Figure 1.

A further recommendation is that the malaria/bilharzia unit be reorganized to include the following new sections and/or personnel: A biologist/malacologist with support laboratory assistants, an engineer with support construction teams, an administration section with clerical and statistics staff, a Sister (SRN) to supervise health education activities and treatment or chemotherapy section, the present health inspector would be in charge of survey and control field teams for malaria and bilharzia, and expansion of the bilharzia field teams to four district teams each consisting of one supervisor and four laborers. The entire unit would be under a director. The organizational scheme for this unit is shown in Figure 2 (see PID).

5) The advisory team suggests a program for the interim period before the status of the proposed project is decided, and if affirmed, implemented. The program would consist of the training of local per-

sonnel locally and initiation of third country training. Local training and reorganization of the existing facilities and resources should be performed over a period of 6 months to a year by using short term consultants in biology/malacology, engineering, epidemiology and laboratory supervision.

6) As mentioned previously, the advisory team identified a serious lack of cooperation and coordination among the various ministries responsible for disease control, water resource development and financing. This lack of interaction is not as apparent at the level of Permanent Secretaries as it is at the so-called bench level, which is the level where the various programs are carried out. In many instances, the attitude of section chiefs or supervisors was very naive. In other instances, key personnel were not aware of the dangers of bilharzia, malaria and other water-related diseases. Construction of new water-related facilities were being planned without any intention of providing for prevention and/or control of the major water-related diseases which could become endemic or increased in intensity or prevalence because of the planned construction. The persons responsible for construction of fish ponds and planting of gardens for people with access to more nutritious food near infected rivers and dams were not aware of the dangers of coming into contact with bilharzia infected water.

The Rural Water Supply Board has drawn up a scheme for a National Comcittee to coordinate the development of the Rural Water Supply program. The Chairman of this committee would be the Permanent Secretary of Works with the Permanent Secretary of Health, the vice-chairman. The proposed organization chart is shown in Figure 3.

The following recommendation is made in regards to the above information: The establishment of a National Bilharzia Control Committee and a Rural Water Supply Board, as well as any other organization tending to foster cooperation and coordination of groups involved in the supply of clean water and/or control of water related diseases is strongly encouraged. The above organizations should include representatives from the Ministries of Health, Agriculture, Works, Power and Communication, Education, Finance, Economic Planners, district traditional government representatives, Prince,

WHO, UNEP, Governments and other organizations providing bilateral aid to Swaziland. It is strongly recommended that this committee be established as soon as possible by the GOS.

There are other important disease control activities which are being undertaken with the assistance of voluntary agencies. A nationwide measles and polio vaccination campaign has recently been completed by the Swaziland Red Cross, OXFAM and the Ministry of Health. The Ministry of Health has now taken on the continuing maintenance phase of the program by making measles vaccine available to all hospitals, health clinics and rural clinics. A program whereas mobile eye clinics visit all rural clinics, health centers and schools throughout the country, surveying blindness and eye diseases, treating minor eye ailments, referring patients to hospitals for major treatment and advising on the care and protection of eyes is sponsored by the Royal Commonwealth Society.

VII) A Description of Water Resource Schemes at the Commonwealth Development Corporation (CDC) and Swaziland Irrigation Scheme (SIS).

The advisory team visited most of the heavy agricultural production regions in Swaziland and met with the persons who are or could be, associated with rural water. The visit to CDC/SIS (Map 8) was particularly rewarding for it provided an opportunity to observe and discuss water resources schemes which is more or less a cross section of the schemes throughout Swaziland. The water resources at CDC/SIS can be classified as follows:

1) Main Canals
2) Storage Reservoirs
3) Distributary Canals
4) Duck Bills (term used by CDC/SIS engineers only)
5) Field Channels
6) Pump Stations
7) Overhead Irrigation
8) Domestic Water Supply
9) Cattle Watering Systems

10) Garden Water
11) Rice Paddy Fields
12) Dams or Reservoirs
13) Sand River Dam
14) Natural Rivers at CDC/SIS
15) Gravel Pits
16) Oxidation Ponds
17) Natural Drainage System
18) Constructed Drainage System
19) Fish Ponds

As many of the above water resource schemes were visited as possible within the constraints of time. Other schemes were discussed with the CDC/SIS Biologist. References are made as to whether snails are present or not and whether human contact with the water bodies are carried on or not. Many of the descriptions reported in this section can also be found in the Duncan/Fenwick consultancy report for CDC/SIS in 1975. A description of observations during visits to selected areas and descriptions of other areas not visited but described from literature and statements by the CDC/SIS Biologists are as follows:

1) Main Canals: No live snails can be found in main canals when the water is flowing at a rapid rate (Photograph 15). What happens when the decrease for water in the rainy season is diminished and the water is flowing at a slow rate is not well defined. It is speculated that snails could breed in the grassy verges during this time. At certain other times of the year these canals are dry and no snails are present. Some of these canals are used by children for swimming and at times for domestic purposes by adults. It is therfore possible that seasonal transmission could occur, but highly unlikely that these are a major source of infection.

   Recommendation:

   It is suggested that human contact with the canal water could be reduced by the provision of laundry facilities (such as swimming pools) in the villages. Fencing some of the larger canal areas is also suggested.

2) Storage Reservioro: (see Duncan report) All of these structures contain snails, but in low numbers. There is regular human contact, mainly for fishing. It was suggested that this is a potentially major transmission site. Control efforts should be carried on and studies designed to define the snail transmission potential as well as for current infection.

Recommendation:

Restricting human and animal access by physical barriers, i.e., fencing. Removal of vegetation, i.e., weeds and grass. Use of gravity flow, if possible. Use of molluscicides, only if necessary.

3) Distributary Canals: The water distribution system, which goes to the various field of crops, is included in this large category. Many canals are concrete lined with fast flowing water, others are not concrete lined. In the concrete lined ones, vegetation and silt are not present for the most part, and snail are not present, because of their inability to survive in fast flowing water (velocity of flow exceeds 65 cm/sec). As the land levels off the canals it is possible that snail habitats may become established (it does not matter whether or not canals are lined in this instance) since the water flow is reduced and vegetation is often found (photograph 16). Excellent snail habitats were observed in selected sections of all canals of the CDC/SIS from cane, citrus and through to Tamkankulu. (see Duncan report). Distribution canals form the sole water supply to the Vuvulane Irrigation Farming (VIF) area which consists of approximately 265 homesteads. It appears that these farmers and their families are at high risk because of their frequent contact with the water from this system. It appears that the snail populations (if present) will vary from farm to farm according to local conditions but various areas appears to be very good transmission sites.

Recommendation:

As Duncan and Fenwick have recommended in their report, it also is recommended strongly that an indepth survey be conducted for infected snails and that stool and urine examinations of the farmers and their families be conducted to determine presence or absence of infections. It is also recommended that a health education program be carried on continuously for the purpose of acquainting the farm-

ers and their families of the dangers of bilharzia and what preventative measures are necessary to guard against infection. The VIP farmers and their families should be probided with a safe and clean water supply, including showers and latrines. From all indication these farmers and their families appear to be at a greater risk than the average worker in other parts of the CDC/SIS area.

4) Duck Bills: The advisory team observed these structures from a distance. The duck bills are concrete control points which enable canal junctions to be managed (description from Duncan report). The water engineers at Mhlume devised the name "duck bills" for the concrete control points. At the canal junctions there are "concrete sumps" which quite often contain stagnant or slow flowing water. These offer excellent snail breeding habitat. It is reported that massive snail populations are found in these structures. These structures are used by children and workers who sit on the concrete to wash, paddle and carry on other activities.

Recommendation:

The advisory team recommeds, as in the Duncan/Fenwick report, that special attention be paid to the duck bills and associated "concrete sumps" especially those near villages. It is recognized that this is one area where use of molluscicides is warranted to reduce immediately the risk of human infection with bilharzia.

5) Field Channels: When sugar is irrigated (furrow irrigation) and citrus (basin irrigation) the water is channelled through a duck bill into a field channel (mostly unlined)and then in the field crops. The syphon irrigation workers have maximum contact with water in these channels. Snails from the concrete sumps at the duck bill could be washed into them from the distributary canals. Control of snails in the distributary canals (duck bills and associated concrete sumps) should eliminate this possibility.

Recommendation:

Constant surveillance of this structure is recommended and if snails are found the use of molluscicides is recommended immediately.

6) Pump Stations: Water (standing and stagnant) is often found near pump houses (Duncan report). The advisory team did not find any snails at the one pump house which we visited (not at Mhlume). It is not determined if these areas would form transmission sites. However, they should be included in any survey scheme.

Recommendation:

Constant surveillance to determine transmission site potential.

7) Overhead Irrigation: The possibility of snails invading the pump houses settling tanks or water storage areas supplying water to overhead irrigation sprays is slight. However, in view of the fact that cercariae could withstand pumping and emerge from the irrigation sprays and because of this possibility, the overhead irrigation and its water source should be checked routinely.

Recommendation:

The overhead irrigation sprays do not constitute a great risk at this time because of the probable absence of snails at its water source. Routine checks should be made of these facilities especially at the source of its water.

8) Domestic Water Supply: The advisory team visited housing development or village #5 at Mhlume. This village has approximately 1200 persons. The conditions for the most part were quite presentable. There were laundry facilities, shower facilities, toilet facilities and water storage tanks (photographs 17 & 18). There were provisions for heating this water for shower and laundry use. The water is treated and piped into these facilities. There were canals running on either side of a main road just adjacent to this village. Human contact is made with the canals in spite of piped water supply and laundry and toilet facilities. A description of the villages and farms on the CDC complex was provided.

a) The Vuvulume small agriculture farms, their families and labourer's villages deserve special mention. Their water supply is obtained from canals, there is no piped water system to homes. We were told that a piped water system is planned.

b) Major farms have a slightly lower standard of housing but still were provided piped water and showers.

c) There are satellite villages or "squatters areas" where people live in cattle grazing areas and on the opposite of the Komati River are using canal piped water for cattle consumption, river and pond water which may be contaminated with cercariae and other infectious agents.

d) The Tamkankulu area have some villages with good water supplies, toilet and laundry facilities but others have no water supplies. These must obtain their water from streams and drains which pass through the village.

e) The Sukasamte village is provided with piped water supply to all houses. However, a large canal (3L) runs through the middle of the village. Human contact is regularly made with this body of water.

Recommendations:

Provide piped (treated) water supply to all villages as well as toilet, laundry and shower facilities. Restrict human access to canals at villages by fencing or concrete covers in immediate village area. Include satellite villages in control programs.

9) Cattle Watering Stations: There are over 100 watering stations for the cattle herds at CDC/SIS. Duncan and Fenwick report the presence of snails in the watering troughs. They speculate that the snails managed to survive passage through the pumps sending water to the watering stations.

Recommendations:

Chemical treatment of pumped water to eliminate snails. Continue to restrict human access to cattle watering stations by use of fencing.

10) Garden Water: Water for domestic gardens of management houses at Mhlume is untreated. Even though the risk of transmission occuring is low, it is possible that cercariae could be piped onto lawns and infect labourers' and children. Water used by Vuvulume farmers is likewise untreated.

Recommendations:

The use of treated water for gardening is strongly recommended. The elimination of semi-permanent pools of water in gardening

areas is also recommended.

11) Rice Paddy Fields: The advisory team visited one rice cultivation area at CDC/SIS in the company of the CDC/SIS Biologist. The rice paddies were dry. The crop had been harvested previous to our visit. It should be mentioned that plans were being formulated for a crop rotation program. Rice had been grown in this area for over 20 years. Bilharzia has been a problem for many years. Infected snails can be found in the rice paddies where crops are grown. Efforts by the Shell and Bayer companies to eliminate snails in this area by use of molluscicides had failed and the two companies had given up their efforts to control the snail and schistosomiasis. Rice yields at the present time were not good. Crop rotation was also being considered as a means of controlling the snails.

Snails were found in this area in:

a) An irrigation canal which contained very small amounts of water (Photograph 19). The species of snails found were Bulinus sp. and Biomphalaria sp.

b) A drainage canal area adjacent to a slaughter house and its oxidation pond. This drainage canal contained very slowly flowing water, with vegetation. There was evidence of human contact (debris and footprints). The species of snails found were Bulinus sp., Biomphalaria sp. and Lamistes sp. Positive Biomphalaria sp. and Bulinus sp. have been previously found in this canal.

Recommendation:

The problem of schistosomiasis in rice paddies and irrigation canals supporting the cultivation efforts should be thoroughly assessed. In view of the fact that rice farming has been in progress for nearly 20 years in some sections of the country any data relevant to bilharzia during this period should be obtained. Plans for increasing the production of rice are being formulated. The potential of paddy fields as potential snail habitats and transmission sites for schistosomiasis should be thoroughly assessed. It may be necessary to use chemicals to treat irrigation water in order to reduce the infected snail population. This treatment of course would depend on the snail invasion rate

within irrigation canals, and the rice paddies.

12) Dams or Reservoirs at CDC/SIS: A description of the CDC/SIS dams in regard to their involvement or potential in Schistosomiasis transmission was presented by the CDC/SIS Biologist. A map of the water resources at CDC/SIS was also provided (Map 8). Visits to Dam #5 were also carried out.

13) Sand River Dam: There are two main human contact points at this dam. One is the Yacht Club and the other is the fishing area and fisheries station. Snails are reported to be present in the vegetation aroung the margin of the dams. Snails have also been found in the fisheries area. Fishing can be done only from the dam wall. Water skiing is done by Europeans. A suspected case of bilharzia in a European was reported. Cattle also feed at an isolated section of this dam.

Recommendation:

As in the Duncan/Fenwick report, we recommended clearance of vegetation from margins of the dam. Routine examination of persons having contact with this body of water should be conducted. If positive persons are found they should be treated. Tests should be conducted for *S. mansoni* and *S. haematobium*.

a) Kolindi Dam. No snails are reported from this dam.

Recommendation:

Continue surveillance.

b) Dam #2: Both *Bulinus sp.* and *Biomphalaria sp.* are found in this dam. Positive snails have been reported.

c) Dam #5: The AID/PID team visited this dam. There is a high human contact with this body of water. Both infected *Bulinus sp.* and *Biomphalaria sp.* and *Melanoides sp.* are found in this dam.

d) Dam #12: *Bulinus sp.* and *Biomphalaria sp.* were reported from this dam by Duncan/Fenwick (statement by Biologist).

Recommendations:

(for b, c, and d) Human access to these dams should be restricted. Vegetation should be removed from the margins of the dams. The use of molluscicides is recommended only if warranted.

14) Natural Rivers at CDC/SIS: There are 3 rivers which traverse the CDC/SIS complex. These are the Sand River, Komati River and the Unbuluzi River (Map 8).

a) The Sand River: Bulinus sp. and Biomphalaria sp. of snails have been reported from certain focal points in this river.

b) The Komati River: Snails (species unknown) have also been found at certain focal points in this river. Many labourers live on the opposite banks of the river and therefore many cross daily to and from work at SIS.

Recommendations (for a & b):

Surveys at crossing points in the Komati River and at points to the highway along the Sand River where human contact is possible should be conducted to determine extent of snail population and corresponding bilharzia infection. Health education programs are also recommended to aid in preventing human contact with possible infected water.

c) The Unbuluzi River: This river runs between sections of Tamkankulu Estates. No information is available as to its role in Schistosomiasis transmission.

Recommendation:

Conduct indepth survey to determine if there are snails present.

15) Gravel Pits: There are many gravel pits throughout the CDC/SIS estate. We drove past one pit during our visit. It is reported that some of the pits contain snails and that children visit and play at a few of these containing snails and which were used as rubbish dumps. These pits are considered a potential transmission site.

Recommendation:

Determine role of gravel pits in transmission scheme, fill by use of top soil and treat with molluscicide if necessary.

16) Oxidation Ponds: These ponds are probably too polluted to sustain snail population. The advisory team visited one oxidation pond at village #5. Human contact appeared to be minimal. There was an adjacent drainage pond which perhaps could sustain snails.

Recommendation:

These ponds should be completely fenced to prevent any possible

human contact. The drainage ponds should be examined to determine if snails can successfully live there.

17) Natural Drainage System: This system consists of swampy areas; drainage ponds, which eminate from oxidation ponds, dams or reservoirs. They may have dense vegetation growth in the marshy hollows to those with rocks and vegetation in the so called ponds. These areas all act as excellent habitat for snails and as reservoirs for snail repopulation (Duncan/Fenwick report). Many of these have a natural catchment, where excreta could flow in or be meshed in to infect snails. There are swampy and natural drainage areas on the CDC/SIS estate and they present an immense problem for the snail control effort.

Recommendation:

Fencing of these areas to restrict human contact is recommended. All areas should be found and evasive action taken.

18) Constructed Drainage Systems: There are many drain lines at the CDC/SIS estate. These are considered as potential problem areas in any snail control scheme. Water flows from the land into small channels and then into larger channels. Excreta dropped into the fields by workers and animals could be washed into the drains and cause infection to snails (if present) or that infection could arise from inefficient oxidation ponds.

Recommendation:

Map the entire drainage system, identify all human contact points, carry out spot treatment with molluscicides if necessary, fence in all human contact points.

19) Fish Ponds: The AID/PID team did not visit fish ponds at CDC/SIS. However, we were told that there are numerous ones at Mhlume. These ponds are considered an extreme potential future danger where snails and the corresponding schistosoma infection could become established in the Mhlume fish ponds.

Recommendations:

A survey should be conducted immediately to determine the snail population in the fish ponds.

A) General Recommendations Relevant to the Water Resources System at CDC/SIS

Indication are that prevalence of schistosomiasis is higher than that reported, intestinal schistosomiasis is under-reported. The data presented to us show cases of schistosomiasis which were discovered in the clinics at CDC/SIS. This data does not give a true picture of incidence and prevalence. The visit of the advisory team occured in May and that of the Duncan/Fenwick in August. It is possible that snail populations were at a low point during these two periods. Also it may be that during the cold season parasite development in the snail is not occuring at the level that it would be if during the hot season. In view of the above considerations, the following recommendations are made:

1) An indepth survey to determine incidence and prevalence of Schistosomiasis caused by S. mansoni and S. haematobium should be carried out. Both, expatriates and indigenous populations should be examined.
2) A comprehensive map showing the complete water resources network including such bodies of water as gravel pits, constructed drainage lines and etc. should be drawn up and kept up to date.
3) An indepth survey of the entire water resources network at CDC/SIS covering all of the previously listed schemes should be carried out to determine snail populations and their natural seasonal fluctuations over a one to two year period.
4) Fencing of all accessible water schemes to prevent human access and/or contact (including drainage canals, main canals, vleis contact points, duck bills and others).
5) Bridges over all water crossing points.
6) Provision of safe (treated) piped water supply to all villages (including so called satellite villages and labourers villages).
7) Provision of shower, toilet and laundry facilities for all villages and their inhabitants.
8) Provide recreational facilities for villages (especially for children) such as swimming pools and play areas.
9) Plan and implement health education programs for the purpose of relating to the population the dangers of bilharzia, its prevention and the use of toilet and laundry facilities.

VIII) A Description of Water Resource Schemes at Big Bend Sugar Estates

The advisory team visited the Big Bend Sugar Estates with the bilharzia field survey and control team from the Public Health Laboratory in Manzini. The area visited was the Ubombo Sugar Ranches which are a part of Big Bend. The field survey and control team carry on routine spraying and surveys at the Ubombo Sugar Ranches for both mosquitos and snails. The water resources facilities observed at the Ubombo Sugar Estates were as follows:

a) Dams and/or Reservoirs
b) Canals
c) Drainage Ponds

The field survey and control team use the molluscicide Frescon to spray against snails. The Dams at Ubombo are sprayed every six weeks. Just prior to spraying the dams are checked for presence of snails. Checks are not made for presence of eggs to determine if new snails will be found. Frescon is not effective against eggs.

1) Dam #1: This dam is routinely sprayed every six weeks with Frescon by use of hand sprayers (Photographs 20 & 21). This dam was relatively small (Photograph 22), and had sparse vegetation around its edges. Both *Biomphalaria sp.* (Photograph 23) and *Bulinus sp.* were found in this dam (Photograph 24). The majority of snails found appeared to be young.

2) Van Ebb Dam: This dam is sprayed routinely every six weeks with Frescon by use of the drip method. Human contact with water from this dam is through fishing and use of water for gardening.

3) Drainage Ponds: This water resource was located just below the Van Ebb Dam (Photograph 25). Human contact with water from this pond is through use of water for daily routines as well as for gardening. Positive snails are found in this pond. *Biomphalaria sp.*, *Bulinus sp.*, *Lymnea sp.* and *Melan-*

oides sp. were found during our visit.

4) Canals: One canal located on the other side of the highway which runs past dam #1 (Photograph 26) contained only Melanoides sp. of snails. There was no vegetation and the water flowed very slowly. Another canal with very slow moving water was located just adjacent to the drainage pond of the Van Ebb Dam and large amounts of vegetation. This canal contained Biomphalaria sp., Bulinus sp., Lymnea sp. and Melanoides sp. Positive snails are also found in this canal.

Recommendations:

The advisory team was afforded an opportunity to observe the bilharzia field survey and control team perform techniques in the field. Molluscicide spraying and searches for snails were conducted. It is the opinion of the advisory team that the field procedures and techniques need improvement. The following recommendations are presented:

a) Followup searches one to two weeks after spraying with Frescon to determine snail kills. Searches for snail eggs.
b) Use of a molluscicide which is active against snail eggs.
c) Examination of collected snails more frequently for presence of schistosome infections.
d) Program to present human access to infected water such as use of fencing.
e) The Big Bend Sugar Ranch owners should be encouraged to provide piped and treated water, toilet and laundry facilities and recreation facilities.
f) Provide health education programs to acquaint sugar estates population of the dangers of bilharzia and other water-related diseases.

A) Results of Surveys Conducted by the Advisory Team (Blood, Urine and Fecal Specimens examined at Schistosomiasis Research Center, University of Lowell).

1) Snail Surveys: Searches for snails were made at Big Bend Sugar Estates, CDC/SIS Sugar Ranches, the Taiwan Demonstration rice farm (Photographs 27 & 28) and Southern Rural Dev-

elopment Area (SRDA). The results of these searches are presented in Tables 1, 2, and 3. The species of snails found were as follows: Biomphalaria sp. (intermediate host for S. mansoni); Bulinus physopsis/ Bulinus globoscus, Bulinus bulinus, Bulinus tropicus, Lymnea sp. (intermediate host for parasites in this area of Africa not positively determined - maybe Fasciola sp.); Melonoides sp. (intermediate host for parasites in this part of Africa not positively determined); Lamistes sp. (intermediate host for parasite in this part of Africa not positively determined). In some instances the number of dips made for snails were counted, in other instances only the presense or absence of snails was recorded. Within the constraint of time, species identification were made whenever possible.

During the course of the snail searches, information was gathered concerning which water schemes are currently serving as snail habitats, as well as in which ones infected snails have been found. This information is based on statements made by various persons at the facilities visited.

Live Snail species (Bulinus globosus and Bulinus truncatus) were obtained from the Biologist at CDC/SIS and returned to the Snail Labotatory at the Schistosomiasis Research Center, University of Lowell.

2) Urine Surveys: The advisory team conducted a survey of school children (age 7-9) at Saint Florence's School in the Hhohho District of Swaziland. Urine samples were collected from fifty-two children. The specimens were returned to the Manzini Laboratory, subjected to centrifugation, the resultant sediment collected, placed in small vials with 10% formalin sealed and returned to the United States for examination. Twenty-two of the 52 specimens were positive for S. haematobium for a percentage of 42.3 (Table 4).

3) Fecal Surveys: The advisory team conducted a survey of school children (age 7-9) at Saint Florence School in the Hhohho district of Swaziland. Fecal samples were collected from fifty-two child-

ren. The specimens were returned to the Manzini Laboratory, mixed thoroughly with MIF solution, placed in vials, sealed and returned to the United States for examination. The results of the laboratory examination are presented in Table 5. Protozoa, Nematode and Trematode infection were found. The highest percentage of infection found were by Protozoa, while the lowest percentage were by the Trematodes.

4) Blood Survey: The advisory team conducted a survey of school children (age 7-9) at Saint Florence School in the Hhohho District of Swaziland. Blood specimen (thick and thin films) were collected from fifty-two children. The specimens were returned to the Manzini Laboratory, fixed, packed and returned to the United States for examination. Examination of the blood films revealed no malaria parasites (Table 6).

IX) Water Resource Schemes Currently Serving as Snail Habitat in Swaziland.

A number of water schemes have been identified either through observations by this advisory team, as a result of reviewing such consultancy reports as Duncan/Fenwick, Jobin/Jones and others or as a result of conversations held with various GOS and public sector personnel. These water schemes are as follows:

a) Canals (containing slow-flowing water and vegetation)
b) Storage Reservoirs
c) Dams
d) Distributary Canals
e) Duck Bills
f) Field Channels
g) Pumping Stations
h) Cattle watering systems
i) Rice Paddy Fields
j) Irrigation Canals
k) Rivers
l) Gravel Pits
m) Natural Drainage Ponds
n) Constructed Drainage Ponds

o) Garden Water (cercariae only)

p) Temporary Bodies of Water (rain puddles,etc.)

A complete description of this water scheme can be found under section 7.

X) Water Resource Schemes having Potential of Serving as Habitat for Snails

Several types of water resource schemes were identified as having the potential for serving as snail habitats (both infected and non-infected) in Swaziland. These schemes are as follows:

1) Fish Ponds
2) Rice Paddy Fields (newly established ones)
3) Springs
4) Ram Pumping Stations
5) Lakes
6) Overhead Irrigation Spraying Systems (dispensing cercariae infected water only)

1) Fish Ponds: The fish pond construction program in Swaziland includes as part of its program fish farming, commercial fishing, fish hatchery expansion and encouraging Swaziland inhabitants to utilize local fishes in thier diet. The program was started in early 1975 and up to the present time there are, according to various sources, 100 to 500 completed ponds. The fish ponds are mostly built by hand by women who usually operate them. Regular visits are made by the Domestic services staff to assist in any problems which may arise. Lectures and color slide shows are given at various sections of the country where farmers are trained in various aspects of fish cultivation. Subsistence and recreational fishing on the many lakes and streams of Swaziland has increased because of the result of lectures and demonstrations mentioned above. Commercial fish farming operations continue to expand. Three new farms began operations during 1975, and three 12-50 acre farm are expected to begin operation by mid-1977. A commercial fishery operation has been established on the SIS's Sand River Dam (snails are present in this dam). Fish production

is at the rate of 300 - 500 pounds per day with increases projected up to 1200 - 1500 pounds per day after new facilities are ready. The success of the Sand River Dam fisheries program has caused interest by groups in other areas of Swaziland for commercial fish production programs and training of local persons as fisherman farmers. The species of fish usually used to stock the ponds are Tilapia mossambica, Tilapia melamoplema and Cyprinus carpio. A small trout brood stock and bass are also being tried at the Nyetane hatchery for use in ponds. The fish pond program staff consists of a UNDP/FAO provided fisheries officer, 2 Peace Corps volunteers and several Swazi-counterparts.

The fisheries program currently in operation and those planned for the future will employ a large number of Swaziland citizens. From all indication, no programs which are currently in effect, nor those slated to be completed in the future have in their plans for prevention or surveillance of the snail intermediate hosts of bilharzia or other water-related diseases. It is felt that fish ponds constitute a very real potential for serving as snail habitats. Because of the large number of persons who are currently or will be involved in future fisheries programs the risk of acquiring infection will be great if fish ponds become endemic foci for bilharzia or other water related diseases. Only one fish pond was visited by the advisory team and no snails were found. However, as mentioned previously it is probable that snail populations in the month of May were probably at their lowest level. Indications from conversations held during visits to various facilities are that there are ponds in Swaziland with snail populations.

Recommendations:

a) Shoreline around fish ponds should be cleared of vegetation.

b) Fences should be installed to prevent unnecessary human contact and to prevent access by animals.

c) An assessment of the snail population in all fish ponds should be carried out as well as a study to determine natural fluctuations over a 1-2 year period for both the snail and para-

site if present.

d) The two molluscicides currently in use in Swaziland, Bayluscide and Frescon are toxic to fish. If it becomes necessary to use molluscicides in fish ponds then the use of one that is not toxic to fish should be considered.

2) Rice Paddy Fields (newly established ones): The rice cultivation scheme in Swaziland has made great progress since 1970 when the Chinese Agricultural Mission was established. In the Nkungwini Scheme, which is at the Hlatikulu area, there were 26 farmers (1975), while at Mvembili in Pigg's Peak area there were 45 farmers (1975) with plans for expanding to 50 farmers by 1977. Farmers in these two schemes are producing rice in the summer and vegetables in the winter.

A visit was made to a rice paddy field at CDC/SIS Mhlume. The rice paddy field was dry, but irrigation canals supplying water to the rice fields as well as drainage areas in the same vicinity contained snails. Positive Bulinus and Biomphalaria snails have been found in the above canal drainage area. The potential of the rice paddy fields as snail habitats has not been fully ascertained. By way of speculation it is felt that rice paddy fields may play an important role in Bilharzia transmission and that all newly established ones should be included on any list containing water-schemes as potential snail habitats. The advisory team visited the Chinese Rice Demonstration Farm near Mbabane and found no snails. It is again pointed out that the visit was during a winter month and therefore snail population could be very low. Because of the constraint of time a planned visit to Pigg's Peak Rice Cultivation Area was not carried out.

The CDC/SIS Biologist stated that bilharzia was a problem in the rice paddy fields at the CDC/SIS area. Previously the Shell and Bayer Companies had conducted mollusciciding programs in the rice paddy fields in an effort to control the snails and bilharzia. The program was not successful and was discontinued. More information is needed concerning the total aspect of this program.

Recommendations:

a) Indepth surveys should be conducted at all rice cultivation areas over a 1 - 2 year period to determine natural fluctuations in snail populations and infection rates (if present).

b) Preventive and surveillance schemes for snails and bilharzia should be included in all newly established rice cultivation schemes.

c) Crop rotation should be tried as a control method where snail and bilharzia are found.

d) If molluscicides are used initial flooding of fields should be with water treated with Bayluscide. Frescon does not kill snail eggs.

3) Springs: Under the spring protection and well digging program in Swaziland springs are covered and protected by stone casements. No snails have ever been found in springs. There are no problems with seepage to wells or springs from pit latrines because wells or springs are located considerable distances from villages or homesteads and are also on higher elevations. All springs are also fenced to prevent access by cattle and humans. Mosquito larva have been found in these wells (culex sp.). It should be pointed out that Bulinus sp. snails are found in springs and wells in Saudi Arabia and Oncomelania sp. in wells and springs in the People's Republic of China. Water was observed in a thickly vegetative area around the covered spring visited by this advisory team at Ludze, Ludze Village.

Recommendations:

a) It is felt that the liklihood of snails becoming established in the covered wells or springs is very slight. However, in the absence of a water treatment scheme, surveillance program should be carried out.

b) Continued fencing of all springs or wells should be encouraged.

4) Ram Pumping Stations: (Photograph 5) Standing water surrounding the pumping area even through fenced could contain snails or the

water entering the station from its source could contain infective larva. Even though it is doubtful if these are transmission sites they should be investigated.

5) Lakes: No information was obtained concerning snail populations or bilharzia in lakes. In view of the situation concerning bilharzia in lakes in other regions of Africa immediate attention should be given to determining the extent of the problem in lakes in Swaziland.

6) Overhead Irrigation Spraying Systems: Duncan and Fenwick (1975) in their consultancy report for CDC/SIS point out the possibility of cercariae which could withstand pumping and in theory be contained in irrigation sprays. Despite the possibility of this occurance being very slight, the risk of infection would be greater if infected snails managed to invade pumping stations supplying water for the overhead irrigation.

The possibility of overhead irrigation water containing infective larva should be noted and surveillance procedures initiated.

XI) Review of Health Data Collected From Various Sources in Swaziland

A) GOS Health Data and Statistics

Excellent cooperation and support was provided by the GOS in support of this advisory team's mission. Various sections of the Ministry of Health provided the advisory team with copies of the most recent health data concerning human bilharzia and other water related diseases. In addition the advisory team was given recent data concerning a major health survey conducted by the MOH of GOS. In most instances the data obtained from surveys is more or less complete, in others, however, figures reflecting number of cases for example are missing. This lack of data in some instances may be due to the constraint of time under which the advisory team operated and thus did not examine in depth many of the data so kindly supplied by the various MOH facilities immediately at the time of our visit. Much of the data obtained during our visit represents the results of new surveys conducted since the last AID advisory's or consultant team visit in 1975. The data is presented as collected

from each MOH section and discussed accordingly.

B) Results of School Health Survey (March, 1976 to October 1976) for School Children of Grades I and II.

The data presented to the advisory team was prepared and organized into tables under the guidence of Dr. E.L. Huppert and with the assistance of Mr. Raphael Mambo (Health Statistics Unit, Central Statistical Office). The data is based on survey results obtained from a total of 9,797 (Table 7) school children (Grades I and II) for abnormalities in height, weight, nutritional standards, eyes and ears, posture, ringworm, skin defects and others, and urine. The fecal specimen of 792 children were also examined. Records of immunization vaccinations given during the survey are also presented. Not all of the 9,797 school children examined received the complete series of examinations (Table 7c). The reasons for this were that 8162 school children were classified "normal", "over" or "under" with regard to height and weight only after the measurements were taken of the first group of school children. It was also sometimes necessary to spread the complete series of examinations over more than one day and some of the school children were absent on the following day.

Percentages in some groups may not add up to 100% as a child may have been included in more than one sub-group. Symbols used "-" means "no case"; "0" means less than 0.5%. It should also be pointed out that "1%" for example means any values between 0.5% and 1.49%.

The results of the school health survey are shown in Tables 7 to 13. The number of schools examined by district, type of area (urban and rural), ages and sex and numbers of examinations performed for abnormalities of height and weight, nutritional standards, eyes and ears and urine are shown in Table 7. The total number of persons examined were thus 9,797. A total of 126 urban and rural schools were surveyed and which included community, mission, private and GOS schools. The four major districts of Swaziland were covered (Table 8) in the survey. The results of examinations for abnormalities according to districts is shown in Table 9 & 9a. The results obtained according to type of school area (urban or rural) are shown in

Table 10. Thirty (30) percent of the children examined in the urban schools were without defects or abnormalities while thirty-seven (37) percent of those in the rural schools were classified as "normal". The results of examinations by sex for abnormalities are shown in Tables 11 and 11a. There was not a great difference in percentage of abnormalities between the sexes.

Parasitism by S. haematobium was determined by examining the children's urine microscopically for eggs. Urines were collected from approximately 96% of all students examined. Samples were collected between ten A.M. and 12:30 P.M. since eggs released by the body appear to peak between 11:00 A.M. and 2:30 P.M.. All urines were centrifuged in order to sediment the schistosome eggs and red blood cells. The sediment was then examined microscopically. The presence of eggs was considered evidence of infection.

Examination of the statistical information obtained on bilharzia shows that it constituted the major disease problem when considered both in terms of the great numbers of children infected and the known severity of the disease (Tables 10, 11 and 11a). A total of 9434 urines were examined and 11.37% or 1073 children contained S. haematobium eggs in their urine while 7938 or 84.1% were free of bilharzia. These figures represent approximately one-third (1/3) of the total grade I and II students and do not include all the schools in the country. The geographical distribution of the schools visited during 1976 are shown on Map 9. The percentages of students found infected by districts are categorized into three groupings, 0-5% = (blue color on map); 5-20% = (green color on map) ; and over 20% = (red color on map). In general it is apparent that schools examined in the Hhohho district, primarily a Highveld area, exhibit the lowest percentage (4%) of infection than the other districts (Table 12). One explanation may be that the water supply which must support the snail host to allow for bilharzia is not entirely appropriate to support good snail populations or bilharzia. There is little or no transmission above an altitude of 1800 meters where water temperature are too low. Also, snails are not usually found in swiftly flowing or heavily shaded streams. This may also account for the low percentage of infection in the Highveld areas.

The Manzini district showed the highest overall percentage of infection at 19% (Table 12 and Map 9). Preliminarily, it appears that there is a significantly higher number of infections in the northeast section of the dis-

trict, Lowveld, and the section west of Manzini which is a Middleveld area (Map 9). This focus which is in the Lobamba area corresponds to the only significant incidence of infections in the Hhohho schools, which increase as one proceeds southeast of Mbabane towards Lubombo (Map 9). Shiselweni, has a district percentages of infection of 13% (Table 12) and shows a relatively high incidence in the area south of Nhlangano, however, there is little or no bilharzia in the highveld schools in and around Gege (Map 9).

The Lubombo district has a 14% incidence rate (Table 12). Its greatest incidence is in the southwestern area and also around the irrigation complex at Big Bend (Map 9). The major factors which may contribute to a high incidence of bilharzia in the Lowveld and Middleveld areas include slow heavily vegetated streams that provide an ideal habitat for growth and reproduction of bilharzia carrying snails, large irrigation canals that are also easily populated and a large human population that contaminates the water supply through promiscuous urination and defecation. In the dense areas of the Southwestern Lubombo district small watersheds provide the entire water supply for large communities. Once these water holes are contaminated with infected snails, entire commodities are exposed.

Certain cultural aspects may cause an increase of bilharzia in some areas. At the Dumisa School in the Lowveld area near the Usutu River (Map 9) a large percentage of Grade II girls were infected but very few boys. One explanation may be that the girls wash clothes in the shallow area of the river where the snails that carry bilharzia are very numerous, while, the boys swim in the middle of the Usutu which does not support snails very well and therefore have limited contact with the snail infected water.

There was no significant difference found when incidences of infection were compared between sexes. There does appear to be a very real trend from the perspective of age however in the incidence of bilharzia in children ranging in age from 0-5 years, to 12 years (Tables 11 and 11a). Starting with 93% of normal urines against 4% bilharzia at age 0-5 years, a decline in normal values is noted at age 6 to 87% normal versus 6% bilharzia; 86% normal versus 7% bilharzia at age 7; 84% normal versus 11% bilharzia at age 8; 79% normal versus 14% bilharzia at age 9; 77% normal versus 18% bilharzia at age 10; 75% normal versus 21% bilharzia at age 11 and 75% normal

versus 22% bilharzia at age 12. From this data, a probable interpretation may be that the older the age of the children the greater the opportunity for them to become infected. It is also reasonable to assume that in older age groups an even higher incidence of urinary bilharzia might be encountered.

The school health survey for intestinal parasites was conducted on 792 school children in the Manzini district. Fecals were collected and examined microscopically for evidence of parasitic infections and the results are shown in Table 13. The parasite showing the highest rate of infection was Ascaris lumbricoides (roundworm) with 13% of the children infected. Intestinal bilharzia constituted less than 1% of the total parasites found in stools. This number is surprisingly low in view of the large numbers of Biomphalaria sp. (the intermediate host of S. mansoni) found in various areas of Swaziland. It is felt that the figure obtained is not representative of the true incidence of S. mansoni for reasons which may be due to to the number of samples examined, low level of S. mansoni infections and others.

Other parasite eggs found averaged approximately 4% of the total school population examined and included amoebas, tapeworms, penworms and threadworms among others (Table 13).

A survey was conducted by MOH to obtain some information concerning the incidence of bilharzia in areas where irrigation, surveillance and water-treatment was occuring or not (Table 14). Specimens (fecal and urine) were taken from 13,677 children ranging in age from 0-15 years. The total number of fecal specimens examined was 3,675 while 10,002 urine specimens were examined. The results of the urine and fecal examinations are shown in Table 14. Of the 3,675 fecal specimens examined 9% were positive for S. mansoni while 34% of the 10,002 urine specimen were positive for S. haematobium. Of the six areas surveyed, only three were done for fecal samples. Fecal samples were apparently more difficult to obtain than urines. The results however do point out that S. mansoni infections are nevertheless quite prevalent.

The results of a survey for S. mansoni and S. haematobium conducted by a school health team in each of the four geographical districts of Swaziland during the months of Nov. 1976 and March 1977 are shown in Table 15. The Mhohho, Manzini and Lubombo districts showed the highest infection rates for S. haematobium respectively. S. mansoni infections were detected only in the Manzini district.

The results of a school health team survey for urinary bilharzia in the Manzini District as recent as March 1977 is shown in Table 16. A total of 650 children were examined and 105 positive cases were found for a 16% infection rate.

At the Central Public Health Laboratory in Manzini, the urines of 685 pregnant females (Table 17) were examined for presence of S. haematobium eggs during Jan 1977 to May 1977. A total of 83 cases were detected for a 12% infection rate. At the same laboratory the urines of 198 military personnel were examined and 46 cases of S. haematobium were detected for an infection rate of Twenty- three (23%) percent (Table 18).

B) Private Sector Health Data and Statistics

Data was obtained from the CDC/SIS clinic files concerning the number of cases seen during the years of 1973 to 1977. The data as shown in Table 19 gives percentages of employees infected at CDC/SIS. This data should not be taken as a true indication of the incidence of bilharzia at the CDC/SIS since only patients with complaints are seen and specific diagnosis of the disease is not based on presence of schistosome ova but on symptomatic evidence. The data, however, serves to underscore a major problem and that is the need for the private business sector to work with the GOS in identifying the extent of the Bilharzia problem on the various sugar, citrus, rice and fisheries enterprises and then to collaborate in attempts to control the disease.

To summarize, the results of various surveys conducted since 1976 to 1977 for both urinary and intestinal bilharzia by the MOH of Swaziland reveals that the disease is widespread especially among school children of grades I and II and up to ages of 15 years. Smaller surveys conducted on pregnant females and military personnel show that the disease is present at relatively high incidences among adults. The data from the sur-

veys presented also show that examinations are more frequently than not, conducted on urines rather than on fecal specimen. This apparently suggests that S. mansoni is under-reported. However, in surveys where examinations for S. haematobium and S. mansoni were conducted simultaneously, S. haematobium was clearly the predominate species. The presence of other parasitic infection was also clearly shown and there is no doubt that parasites such as Ascaris lumbricoides (roundworms) is a problem among small children where poor sanitation with great numbers of Ascaris worms are found may lead to nutritional deficiencies and intestinal obstruction.

It has been argued that bilharzia does not affect the life of its human host, that they can live just as easily and well as those unaffected. Outwardly, this may appear to be so but the effects of the parasite upon the organs of the body can only lesson the ability of the body to perform its function. Bilharzia has four stages of development:

a) Invasion by the parasite
b) Maturation to the parasite
c) Acute stage of the disease
d) Chronic stage of the disease

Recommendations:

The following recommendations are presented by the various sections of the MOH of Swaziland for inclusion in this report:

1) Education of people to limit contact with streams or rivers infested with bilharzia - i.e., no bathing, swimming, or wading. In areas where people must ford streams, inform them of the necessity of wiping themselves dry after leaving the water. Government and community paricipation in the construction of footbridges and overpasses near bilharzia infested waters would be helpful.
2) Provision and use of safe water for washing and drinking - if contaminated water must be used for these purposes, encourage people to boil their water or allow the water to sit for 48 hours before use so that the infective organisms die.
3) Adequate toilet facilities - how successful this measure is will depend to a large degree on an individual's financial resources to create such facilities for his family and then, of course, an ind-

ividual's willingness to use toilet facilities. A possible solution could be governmental encouragement of communities to subsidize the construction of inexpensive facilities at individual homesteads.

4) Education of the populace to use toilet facilities so as not to contaminate water supplies with infected urine or stool. This measure can only be effective when there are sufficient toilet facilities.

5) Treatment of rivers, pools and other water reservoirs with molluscicides to control the intermediate snail hosts of bilharzia.

6) Mass treatment of heavilty infected segments of the population.

Malaria: During the course of the advisory team's travels throughout Swaziland to accomplish its mission frequent statements were made by various persons in regard to the increase in malaria cases during the past several years. Definite evidence of this increase was provided by the malaria unit of the Public Health Laboratory in Manzini. This data is shown in Tables 20, 21, and 22. During the period from July 1, 1973 to June 30, 1974 a total of 70 cases were detected; during July 1, 1974 to June 30, 1975, 165 cases were detected and during July 1, 1975 to June 30, 1976, 210 cases were detected. This data reflects a significant increase during the period of 1973 - 1977.

Resistance of mosquitos to DDT and Dieldrin were observed by the malaria unit. The data which suggests this resistance is shown in Table 23. Statements were made by various Public Health and Private Clinic staff that deaths had occurred recently from malaria. No statistical data concerning these deaths were obtained.

XII) The Treatment of Human Bilharzia in Swaziland

During the course of our visits to various public health facilities operated by either the GOS or private industry, an opportunity to discuss the various regimes used in treatment of bilharzia was afforded. The treatment rationale varied according to facilities visited and by School Health Teams.

Ethenol (Hycanthone) is used by the medical staff at CDC/SIS clinics to treat patients who are examined and show no liver enlargement but have other symptoms of bilharzia. If liver enlargement is present the drug Ambilhar is used. Serious side effects are reported at CDC/SIS especially from Europeans who are treated with Ambilhar.

The medical staff at the Big Bend Clinic have suspended the use of Ethenol due to side effects experienced by patients. The most common side effect experienced was vomiting. At the present time, Ambilhar is the drug of choice. The cost of the treatment regime for Ethenol was R9.60 and currently the cost for the treatment regime for Ambilhar is R3.66.

The School Health teams are currently using the drug Bilarcil (Metrifonate) and Ambilhar in a treatment program under the direction of the medical officer. For schools located in remote regions, urinary bilharzia is treated by the School Health Teams using drugs dispenced by the medical officer at the Central Health Office in Manzini. For those schools with a high percentage of cases children are referred for treatment to the Government hospital or the bilharzia Control Unit of the Central Health Office in Manzini. For schools with very low numbers of cases,children are treated immediately upon diagnosis for S. haematobium with Bilarcil. For those cases identified as S. mansoni the drug Ambilhar is used. The advisory team observed that among those members of the School Health Team with whom discussions were held, no one was aware of the precautions which should be taken when treatment with Bilarcil is given. This was in spite of the fact that each tin of tablets contained literature with printed precautions. The precautions to be taken to prevent serious side effects would be to identify patients who have had previous exposure to substances inhibiting cholinesterase and possibilty not treat them. Such side effects occur in patients who have had previous exposure through handling or coming into contact with organophosphate compounds used for plant protection, eradicating insects or for antihelminthic treatment of animals (see Appendix 4). The medical staff at the CDC/SIS clinic espressed great concern over the dispensement of this drug by the School Health Team at the CDC/SIS. The organophosphate compounds are used in spraying citrus fruits, cotton, and sugar as well as being used for antihelminthic purposes.

The rural clinic at Nkwade visited refers all bilharzia patients to a doctor who prescribes Ambilhar in that region. A summary of the doses used for each of the above drugs is as follows:

Ethenol:

a) Single Im dose at 2ml/kg or less

Ambilhar:

a) 14 tablets of 100 mg. each for 7 days

b) 28 tablets of 400 mg/day for 7 days

Bilarcil:

a) A single dose of 7.5 - 10 mg/kg is taken once every two to four weeks to a maximum of three doses.

Recommendations:

1) More direct supervision of persons dispensing antischistosome drugs is urged.
2) Coordination of treatment programs between MOH and Clinics in private sectors is encouraged.
3) More clinic nurses should be involved in the decentralized treatment of bilharzia.

XIII) Suggested Life Forms which should be Investigated as Possible Biological Control Agents.

Although biocontrol appears to be an attractive alternative to use of molluscicides and possibly to engineering approaches, the subject is still in its infancy and can only be suggested as a possibility at the present time. Nevertheless, basic research into biocontrol methods and field testing of likely methods should be encouraged.

In Swaziland, the CDC/SIS Biologist and the Peace Corp Volunteer-Biologist at the Central Public Health Laboratory both have plans to conduct investigations to identify possible indigenous life forms which could be used to develop a biological control technique for the purpose of controlling the snail intermediate hosts of schistosomes. Discussions with the two biologists have led to the following list of possible antagonists, predators and competitors.

1) Non-human trematodes against schistosomes and their snail intermediate hosts.
   a) Echinostones as antagonists.
2) Non-human schistosomes against human schistosomes.
   a) Bird schistosomes as antagonists.
3) Microsporida sp.
4) Indigenous snail species
   a) Indigenous snail species which might serve as competitors against snail intermediate hosts of schistosomes.
5) Predators
   a) Turtles
   b) Ducks
   c) Ergots
   d) Rodents
   e) Snakes
   f) Fish
      i) Talipia sp., catfish and other species
   g) Insects
      i) Sciomyzid flies
      ii) Water beetles
6) Poison plants

Recommendations:

1) There is a reasonable risk to the introduction of new species in the existing biotype. It is strongly suggested that all investigations concerning the use of life forms for developing biological control methods be carried out with those forms which are indigenous only to Swaziland.
2) There is considerable literature available concerning what has been done in the area of biological control. This literature should be thoroughly consulted before any effort is put forth in this regard. Appendix 5 is a recent publication by the World Health Organization on this subject. The publications of Ferguson should also be reviewed.

XIV) Chemical Control of Snails in Swaziland

A review of the snail control methods in Swaziland can be found in the Jobin/Jones consultation report of February 1976. This report also contains cost analysis for the use of chemicals in the snail control program. Simular information as presented in the Jobin/Jones report was obtained by this advisory team concerning the mollusciciding campaign from 1970 to the present time. To briefly sumarize, the snail control program employing chemicals has been in operation since 1970 Various programs have been carried out either by private concerns and/or the Swaziland Government. At Big Bend, the Shell Company of South Africa carried on unsuccessful mollusciciding campaigns which were discontinued after several years. The Shell and Bayer Companies have also carried out mollusciciding campaigns at CDC/SIS in rice cultivation as well as other areas and the program was discontinued after several years. At the present time the antisnail campaign at Big Bend is carried out by the Bilharzia Unit of the Central Public Health Laboratory in Manzini. Frescon and Bayluscide are used according to the local conditions. A description of the spraying techniques and recommendations are presented under section VIII of this report. At CDC/SIS the management has agreed to take on complete responsibility for control of bilharzia within their domain. A biologist has been hired (as previously mentioned in this report) for directing the program.

The effectiveness of the two molluscicides in use are as follows: Frescon is very active against Biomphalaria sp. Its drawbacks are that it is ineffective against snail eggs and is hydrolysed rapidly is acid ph water (at ph 8 its half life is 100 hrs., at ph 7, 10 hrs). Frescon can be drip-fed for long periods without altering the irrigation practice in use in the particular area. Bayluscide is active against snail eggs. When using Bayluscide it is quite often necessary to alter the irrigation pattern in use by emptying the dams before treatment.

Recommendations:

1) A shorter interval for sampling of snail populations to determine initial kills and re-population rates.
2) Placing of caged snails in the water body to determine the effectiveness of the molluscicide in killing of snails.

3) Analysis of water after spraying to determine success of spreading of chemicals.

4) Search for snail eggs.

XV) Use of Syphon Spillways in Current and Newly Constructed Dams (Recommendations from Jobin/Jones report).

The meetings to discuss the Jobin/Jones recommendations for use of syphon spillways in currently used dams and those to be constructed in the future were held in conjunction with general discussions on irrigation as carried out in Swaziland. It was pointed out that in Swaziland the general aim was to put all irrigation water in a pipe. Swaziland has a problem with poor land preparation and water control. Many farmers do not believe that they need to use a land plane. The Ministry of Works, Power and Communication and Agriculture receives requests to do jobs for other agencies, i.e., provide a water source at the base of a dam for a school water system. Local persons do become involved with some of these projects. The water engineer and land planner with whom discussions were held concerning the syphon-spillways expressed some reservation about the practical aspect of the syphon-spillway when used on large dams or reservoirs due to the cost of installation, large water losses and size of syphon required to obtain the draw down rate required. Some areas only receive water during one period a year so losses could not be replaced and fluctuations would not be frequent enough to be effective for snail control.

It appears that there may be a problem of misinterpretation of the Jobin/Jones report in regard to their recommendations. Jobin's report does recognize that syphons are restricted to set conditions and not applicable to large reservoirs. It was suggested by the GOS engineers and land planners that an alternate method might be to control the drawn down by a manual control gate which might waste less water and cost less to construct. It should be pointed out that none of the above suggestions and/or comments were made in the tone of a lack of cooperation. It was generally agreed that syphons should be tried initially but on a few selected dams.

In general, for water supplies, collector systems are used, i.e., infilteration galleries, as the ideal is to try for sub-surface systems, that

is putting all water in a pipe. Water harvesting was discussed and it was generally agreed that this should be encouraged. Spring development which has been overlooked in the past was being encouraged. For water which is supplied by the Agriculture Ministry, a minimum of 25 gal/house with a maximum of 40 to 50 gal/house if possible.

Recommendations:

1) In addition to the excellent results obtained by Jobin in Puerto Rico by manipulation of water levels, simular results have been obtained in lakes of the Tennessee Valley Authority where growth of rooted aquatic plants has been prevented completely leaving an environment that is unsuitable for larvae of Anophele sp. to survive. This method should be tried initially on a small scale to determine its feasibility.
2) Other methods such as relocation of canals and irrigation ditches, filling of gravel pits and etc. should be tried as is done in the People's Republic of China.
3) The control of irrigation water should also be tried more extensively than is practiced. Using rapidly flowing water at all times should be extensively tried.
4) The complete removal of all aquatic vegetation and its continued prevention as practiced in Israel is also stressed.

XVI) Conference for Discussion of PID and Review of AID/PID Team Activities in Swaziland.

A final meeting was held with representatives of Minsitries concerned with the establishment of a "Safe Rural Water Supply" in Swaziland for the purpose of discussing and approving the PID and to review the activities of the advisory team. The following persons were in attendence:

Ministry of Health

Mr. M. Dlamini - Permanent Secretary
Dr. F. Friedman - Director of Medical Services
Mr. A. T. Green - Health Planner
Mr. K. Vanayagan - WHO i/c Health Assistant Training Unit

Matron Dlamini - Public Health Unit

Mr. L. Menouta - WHO Health Educator

Dr. M. Felze - WHO (MCH/FP) Physician (Team Leader)

Mr. P. Mathews - Health Inspector, Acting i/c Malaria/Bilharzia Unit

Mr. J. Bailey - School Health Team

Mr. A. Guyre - Laboratory Technician

Ministry of Works, Power and Communication

Mr. Nathan - Senior Water Reservoir Engineer (FAO)

Mr. S. Day - Water Engineer

Ministry of Agriculture

Mr. F. Ferentchek - Water Engineer

U.S. Embassy (AID Office)

Mr. J. Kean - AID

Mr. B. Bahl - Assistant Program Office - AID

Mr. R. L. Wrin - Swaziland Desk, AID/Washington

AID/PID Team

Dr. John I. Bruce - Dean, College of Pure and Applied Science, University of Lowell

Mr. Gladwin O. Unrau - Sanitary Engineer, Rockefeller Foundation (USA)

Mr. Lewis E. Swanson - Dept. of State, Nairobi (ID), Kenya

The excellent attendance, with representation from all sectors of government services, and AID, involved with water resources development and Public Health indicated the interest and awareness of the water-health relationship. Dr. Bruce summarized the team's activities. Then followed a presentation of the AID/PID teams recommendation (PID) for rural safe water supply with emphasis on control of schistosomiasis. A general discussion of recommenda-

tions followed. During this discussion there were inputs by everyone, demonstrating a general interest in the subject by the various Ministry representatives. There was a great deal of discussion on the reorganization of the Public Health Laboratory under the Central Laboratory Services at Manzini. There was considerable discussion on the merits of centralization versus decentralization of Laboratory services. No firm conclusion was reached and further consideration will be necessary based on a final review of the advisory team's recommendation. Also strongly stressed was the need for cooperation between the private sector and government in the future development of water resources and control of water related diseases especially Schistosomiasis. The Permanent Secretary of Ministry of Health asked for advice and assistance to aid in the organization of a national schistosomiasis control program and a safe rural water system. He pointed out that Swaziland needed help. Mr. Kean, AID Director, responded by stating that AID was interested in assisting Swaziland in the development of projects for safe water supplies and the control of water borne diseases.

Dr. Friedman noted that Swaziland was a small developing country with good resources such as water which needed to be developed and that control of bilharzia and other water related diseases was an important aspect of the water resource development. At the same time there are constraints, such as the lack of trained personnel, identifying trainable personnel and the scattered nature of the poulation which must be overcome. She stressed that some central organization which controls and directs the national rural water supply program and malaria and schistosomiasis program is needed and would be sought.

The need of good rapport and interaction between the various ministries as well as elimination of duplication among various agencies was also discussed.

XVII) Meeting with Dr. Michael Dlamini (Geneva, Switzerland) to Brief and Discuss the PID (Mr. Unrau's report).

Mr. Unrau visited Geneva to brief Dr. Michael Dlamini, Medical Officer, Ministry of Health, concerning the PID and other recommendation put forth by the advisory team. He thinks the PID reflects much of what government of

Swaziland would like done.

He expressed concern about the interim period between now and possible project implementaition. He believes the AID/PID team discussions on laboratory organization and re-organization could be useful. The problem of the private sector with regard to lack of interest in improving sanitation and health was mentioned by him; he thinks government may be partially at fault for not providing a mandate to private sectors to comply with good health practices.

Also discussed was the problem of finding suitable local personnel for training. There is a shortage of persons suitable for training to fill the position of the Technical assistant on AID projects as proposed.

He spoke highly of the activities of Village Health Visitors in the Piggs Peak area and feels the Home Economic/Nutrition sections' evaluation is not quite current as to the demand and rate of Latrine installation. He regretted that the advisory team did not visit the Piggs Peak area.

XVIII) Suggested Equipment and Supplies for Laboratory, Offices and Storage Facilities.

During the conference held to discuss the PID and the advisory teams activities a request was made by the Senoir Medical Officer to prepare a list of equipment and supplies for the recommended laboratories and storage facilities. The following list is submitted:

Laboratory: Chairs, tables, air outlets (need control compressor for this), gas outlets (a control gas service), hot and cold water services, sinks (at two for each laboratory), air conditioners (for all laboratories). Laboratory working tables should have a minimum of 125 sq. ft. working area. These tables should be covered with laminate. Vacumn.pumps or a vacuum line in each laboratory (especially the snail laboratory and insectary). Examination tables, desks, folding beds or cots in treatment rooms (4), typewriters, Typewriter tables, animal cages and racks (for mice and hamsters), water bottles and feeders for animal cages and racks, card holders which attach to

animal cages for identification of experimental animals, table centrifuges, floor centrifuges (non-refrigerated), book cases, microscopes (at least 5 binocular and 5 dissecting), water flowing devices, continuous recorder for water temperatures, balances (3), air pumps (6) glass aquaria, air stones, rubber hose (assortment of sizes), ph meters (2), refridgerators (4), stop watches, protective clothing for persons working in snail laboratory and on snail field survey teams, Autoclaves (2), glassware washing apparatus, apparatus for use in analysis of molluscicide in water after spraying, cages to be used in exposure of animals in infected water-bodies to check for presence of cercariae, polaroid land camera and film for taking on the spot photographs of unusual situations, storage cabinets, telephones, file cabinets, recork files (for record of persons treated with drugs), snail survey equipment (scoops and hand sprayers), map cabinets, shelving (for snail laboratory and other types of laboratories), equipment for health education (movie projectors, slide projectors, film, cameras, microphones, tape recorders, record players, screens, and overhead projectors).

Expendable supplies: Chemicals (formalin, alcohol, sulfuric acid), filter paper (assorted sizes), methiolate, biological stains, microscope slides, urine vials, fecal collection cups, glass vials with screw caps (assorted sizes), rubber surgical gloves, leather gloves, adhesive tape, masking tape, labels (assorted sizes), maps, graph paper, drawing instruments for map making, animal feed (for mice and hamsters), sodium chloride, other chemicals as needed by staff, rubber hose (assorted sizes), glassware (beakers, volumetric flasks, petri dishes, desicators, and etc.).

Storage room: Shelving (assorted sizes), brooms, mops, buckets, tool kits (for use by maintenance personnel).

Pharmacy issue room: Desk, chairs, storage cabinets, refridgerator (for storage of perishable drugs), file cabinets, balance and shaker.

Acknowledgements

During the ten days the advisory team visited Swaziland a considerable number of persons representing the GOS and private sector (sugar estates) were met and meetings took place for the purpose of discussing the possibility of establishing a "Safe Rural Water Supply" with emphasis on controlling bilharzia and other water related diseases in Swaziland.

There was exhibited at all levels of the Government and private sector facilities a ready willingness to co-operate in supplying information for the successful completion of our mission. In all instances the use of facilities when desired by the advisory team was willingly provided. Without the unselfish cooperation of the various government officials and scientists, medical staff, scientists and employees in general from the sugar ranches and estates, the task would have been extremely difficult to accomplish. The gratitude and thanks, therefore are extended to all who were involved.

The personnel in Swaziland with whom the advisors met and held discussions are as follows:

Ministry of Health

Dr. M. Dlamini - Permanent Secretary
Mr. Andrew Green - Health Planning Officer
Dr. F. Friedman - Director of Medical Services
Matron Dlamini - Public Health Unit
Mrs. Edith P. Ntimane - Health Education Unit
Mrs. Maggie P. Makhuba - Health Education Unit
Mr. Leslie Mtetwa - Senior Health Inspector
Mr. Ken Vanarzagan - WHO - Sanitarian
Mr. Peter M. Matthews - Health Inspector, Acting i/c Malaria/ Bilharzia Unit
Mr. Wilfred J. Gininoza - Health Assistant, Manzini Health Office
Mr. Lemma Menorita - Health Education Specialist, Mbabane Office
Mr. Bailey - Peace Corp,Bilharzia Unit, Manzini

Ministry of Agriculture

Dr. A.R.V. Khoza - Permanent Secretary

Mr. Andy Tainsh - Chief Project Coordinater (RDA)

Mr. Frank Ferentchak - Land Planner.

Mr. Caleb M. Bhembe -

Mr. John Stickel - Peace Corp, Fisheries Section

Mr. Allen Low - Acting Financial Controller (RDA)

Mr. Nick Gumede - Deputy Project Coordinator (RDA)

Mr. Chris Lomas - Project Manager, SRDA

Mr. Ingo Thomassen - Staff Member, Nutrition Section

Water and Sewage Board

Mr. Cliff Williams - Rural Water Supply Engineer

Private Industry

Dr. Smith - M.D. in charge, Big Bend Clinic

Mr. J. Logan - Biologist (CDC/SIS)

Dr. M.C.A. Holmes - Medical Officer, CDC/SIS

Dr. Jane Doran - Part Time Physician, CDC/SIS

U.S. Embassy (AID Office)

Mr. Baron Bahl - Assistant Program Officer

Mr. W.H. Johnson - AID Agriculture Development Officer

Mr. R.L. Wrin - U.S. AID - Swaziland Desk - Washington,D.C.

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Table 1

Results of Snail Survey at Big Bend Sugar Estates (May 10, 1977)

Type of Water Scheme	Species of Snails Found	Number of Dips	Number of Snails Found
Dam #1	*Bulinus tropicus*	53	48
	Biomphalaria sp.	53	146
Van Ebb Dam	ND	ND	ND
Canal #1 (near Dam #1)	*Melanoides sp.*	6	15
	Bulinus tropicus	2	5
Canal near Van Ebb Dam	*Bulinus physopsis*	2	1
	Lymnea sp.	2	6
	Melanoides sp.	2	34
	Biomphalaria sp.	6	5
Drainage Pond	*Bulinus tropicus*	6	50
	Bulinus physopsis	6	96
	Lymnea sp.	6	26
	Melanoides sp.	6	5

Table 2

Result of Snail Survey Conducted at Southern Rural Development Areas (SRDA) and the Taiwan Demonstration Rice Farm (May 13, 1977)

Type of Water Scheme	Species of Snails Found	Number of Dips
Dam	none	12
Canals (unlined)*	none	10
Irrigation Canals to Rice Field	none	8
Fish Pond	none	15
Rice Paddy Field	none	dry field
Ram Pumping Station	none	12

* Canals at Taiwan Rice Demonstration Farm and at SRDA contained vegetation and appeared suitable as snail habitats.

Table 3

Species of Snails Observed at Various Water Schemes at CDC/SIS Mhlume; Swaziland. (May 12, 1977)

Type of Water Schemes	Species of Snails Observed
Dams	*Bulinus bulinus* ?
	Bulinus sp.
	Biomphalaria sp.
	Melanoides sp.
Drainage Ponds	*Biomphalaria sp.*
	Lamistes sp.
Rice Paddy Field Irrigation Canals	*Biomphalaria sp.*
	Bulinus sp.
	Bulinus globoscus
	Lamistes sp.

Table 4

Results of Urine Examinations Detecting Urinary Schistosomiasis in School Children (ages 7-9) in the Mhohho District of Swaziland (St. Florence School; May 17, 1977)

Number Examined	Number of Positives	Percent Positive
52	22	42.3

Table 5

Results of Fecal Examinations of School Children (ages 7-9) in the Hhohho District of Swaziland (St. Florence School; May 17,1977)

No. of Persons Examined	Types of Parasitic Infection Detected	No. of Persons Infected	Percent of Total
52	*Entamoeba histolytica*	8	15.38
52	*Entamoeba coli*	27	51.92
52	*Endolimax nana*	16	30.77
52	*Iodamoeba buetchlii*	10	19.23
52	*Ascaris lumbricoides*	7	13.46
52	*Ascaris lumbricoides* (UF)*	2	3.85
52	*Giardia lamblia*	4	7.68
52	*S. haematobium*	2	3.85
52	*S. mansoni*	1	1.92
52	*Chilomastix mesnili*	1	1.92
52	*Hymenolepis nana*	1	1.92
52	No speciman	2	3.85
52	Parasite-free	8	15.38

*(UF) - Unfertilized eggs; MIF-Direct smear method was employed in this examination.

Table 6

Analysis of Blood Films (Examined on May 17, 1977) for Malaria Parasites at Mafutseni Nazarene School (ages 5-46)
Manzini District

	No. of Films Examined	% Positive	% Negative
No. of Males Examined	26	0	100
No. of Females Examined	61	0	100
Total	87 *	0	100

* 87 thin and 87 thick films

Table 7

School Children of Grades I and II Examined

A)

By District	No.	%
Hhohho	2993	31
Manzini	2260	23
Shiselweni	2081	21
Lubombo	2463	25
Whole Country	9797	100

B)

Type of Area	No.	%
Urban	2972	30
Rural	6825	70
Total	9797	100

C)

Type of Examination	No.	%
Height, Weight	8162	83
Nutritional Standard	9507	97
Eyes	9721	99
Ears	9747	99
Urine Specimens	9434	96
Total Examined	9797	100

D)

Age		Male	Female	Total
Under 6	No.	134	144	278
	%	3	3	3
6	No.	718	739	1457
	%	15	15	15
7	No.	1102	1228	2330
	%	22	25	23
8	No.	1074	1055	2129
	%	22	22	21
9	No.	644	604	1248
	%	13	13	12
10	No.	362	309	671
	%	7	6	6
11	No.	169	131	300
	%	4	3	3
12	No.	268	225	493
	%	5	5	5
Unknown	No.	442	408	850
	%	9	8	9
Total	No.	4944	4853	9797
	%	100	100	100

Table 8

Schools Visited by District and Type of School

Type of School → / District ↓		Urban	Rural	Community Rural	Mission Urban	Mission Rural	Private Company Urban	Private Company Rural	Whole Country Urban	Whole Country Rural	Total No.	Total %	School Children Examined No.	School Children Examined %
		Society Segments												
Hhohho		2	2	4	9	15	-	-	11	21	32	25	2993	31
Manzini		5	1	6	9	9	-	-	14	16	30	24	2260	23
Shiselweni		2	6	8	8	7	-	-	10	21	31	25	2081	21
Lubombo		1	2	7	6	15	1	1	8	25	33	26	2463	25
Whole Country		10	11	25	32	46	1	1	43	83	126	100	9797	100
Total	No.	21		25	78		2		126					
	%	16		20	62		2		100					

Table 9

Examination Results by Districts (Percentages)

Districts	Hhohho %	Manzini %	Shiselweni %	Lubombo %	Totals %
Total Children Examined (#)	2994	2260	2081	2463	9797
Immunization Vaccination:					
B.C.G.	74	75	58	52	66
Small Pox	76	82	61	53	69
Height:					
normal	98	98	100	89	96
over	1	1	-	8	3
under	1	1	-	3	1
Weight:					
normal	98	98	100	89	96
over	1	2	-	7	3
under	1	-	-	1	1
Posture:					
normal	99	98	100	99	99
not normal	1	2	0	1	1
Nutrition:					
good	95	85	98	83	90
fair	5	13	2	15	9
poor	0	2	0	2	1
referrees	0	1	1	0	1
Ringworm	3	17	0	2	5
Skin defects	1	12	3	5	5
Other defects	2	3	1	2	2

Table 9a

Districts	Hhohho %	Manzini %	Shiselweni %	Lubombo %	Totals %
Eyes:					
sight normal	98	98	99	99	98
sight defective	2	2	1	1	2
Defects:					
cornea	0	0	-	0	0
conjunctivitis	1	1	1	0	1
strabismus	0	1	-	0	0
other defects	0	2	0	0	1
injury	0	0	-	0	0
referrals	2	3	1	1	2
Ears:					
Hearing normal	100	99	100	100	99
Hard of Hearing	0	1	0	0	1
Defects:					
inflamation	0	0	-	0	1
perforation	0	1	-	1	1
blockage	5	13	0	0	4
anomalies	0	0	-	-	0
Otitis Media	1	2	0	1	1
Otitis Externa	0	0	-	0	0
Referals	3	3	1	1	2
Dental Examinations:					
teeth normal	67	57	39	49	66
teeth missing	0	-	0	0	5
dental caries	32	40	52	29	37
Abnormalities:					
gums	0	2	0	19	5
over retained teeth	0	3	0	1	1
crowding	1	1	7	3	3
other defects	1	2	1	23	7
referals	26	0	40	-	17

Table 10

Examination Results by Type of School Area (Percentages)

Type	Urban %	Rural %
No. Children exam.	2972	6825
Immunization Vaccination:		
B.C.G.	65	66
small pox	74	67
Height:		
normal	97	96
over	2	3
under	1	1
Weight:		
normal	97	96
over	2	3
under	1	1
Posture:		
normal	99	99
not normal	1	1
Nutrition:		
good	91	90
fair	8	9
poor	1	1
referrals	1	0
ringworm	5	6
skin defects	5	4
other defects	2	3
Eyes:		
sight normal	98	99
sight defective	2	1
Defects:		
cornea	1	0
conjunctivitis	1	1
strabismus	1	0
other defects	1	1
injury	0	0
referalls	4	1

Type	Urban %	Rural %
No. Children exam.	2972	6825
Ears:		
hearing normal	99	100
hard of hearing	1	0
Defects:		
inflamation	1	0
perforation	1	0
blockage	7	3
anomalies	0	0
otitis media	1	1
otitis externa	0	0
referrals	3	2
Dental Examinations:		
teeth normal	52	56
teeth missing	0	0
dental caries	44	35
Abnormalities:		
gums	5	6
over-retained teeth	1	2
crowding	2	3
other defects	4	8
referrals	22	18
Urine Specimen Examinations:		
normal	96	85
red blood cells	10	12
white cells	7	7
bilharzia	11	12
other parasities	0	1
sugar	-	-
other abnormalities	1	2
Children without defects or abnormalities:	30	37

Table 11

Examination Results by Sex and Age

Age	0-6		6		7		8		9		10		11		12		unknown		Total	
Examination	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %
No. children examined	134	144	818	739	1102	1228	1074	1055	644	604	362	309	169	131	268	225	442	408	4944	4853
Immunization Vaccination:																				
B.C.G.	52	49	62	65	66	67	72	64	68	67	77	66	56	66	61	63	56	54	66	64
small pox	64	57	66	73	72	66	74	68	69	67	74	68	65	69	64	64	58	53	70	67
Height:																				
normal	97	94	97	97	95	98	97	96	95	95	92	94	99	94	99	98	-	-	96	96
over	2	3	2	2	4	1	2	3	3	4	7	3	-	4	1	1	-	-	3	3
under	1	3	1	1	1	1	1	1	2	1	1	3	1	2	-	1	-	-	1	1
Weight:																				
normal	99	98	96	97	96	97	97	97	96	96	93	94	99	95	97	96	-	-	96	97
over	1	1	3	2	3	2	2	2	3	3	5	4	-	1	1	1	-	-	3	2
under	-	1	1	1	1	1	1	1	1	1	2	2	1	4	2	3	-	-	1	1
Posture:																				
normal	98	98	99	98	98	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
not normal	2	2	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nutrition:																				
good	97	95	92	92	91	92	88	90	89	91	90	90	89	90	91	91	84	88	89	91
fair	2	5	7	7	8	8	10	9	10	8	9	10	10	9	8	9	15	10	9	8
poor	1	-	1	1	1	-	1	1	2	1	1	0	1	1	1	-	1	2	1	1
referrals	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
ringworm	3	2	6	6	6	6	6	5	5	5	4	3	4	3	2	1	4	5	5	5
skin defect	6	4	4	8	5	4	3	5	4	3	4	3	2	1	2	1	6	4	4	3
other def.	0	1	1	3	1	1	1	1	1	1	2	2	2	3	2	0	2	2	1	2
Eyes:																				
normal	96	97	97	98	98	99	98	99	97	99	99	99	98	99	98	97	97	97	98	98
defective	4	3	3	2	2	1	2	1	3	1	1	1	2	1	2	3	3	3	2	2
Defects:																				
cornea	-	1	0	-	0	-	-	0	0	-	-	0	-	-	-	-	0	-	0	-
conjunctis	1	-	0	0	1	0	0	0	0	0	1	1	1	-	2	2	1	-	0	-
strabismus	1	1	0	0	0	-	0	0	-	-	-	1	-	-	-	0	0	0	0	0
other def-	1	-	1	0	0	0	1	0	0	0	0	-	1	2	1	-	3	1	0	0
injury	-	-	0	-	0	0	0	-	-	-	-	-	-	-	1	-	-	-	0	0
referrals	5	4	2	2	2	1	1	1	2	1	1	1	2	1	3	2	1	0	2	-

Table 11a

Examination Results by Sex and Age

	0-6		6		7		8		9		10		11		12		unknown		Total	
	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %	B %	G %
Ears:																				
normal	100	99	99	98	99	99	99	98	100	99	99	100	99	100	99	98	99	98	99	-
hard hearing	-	1	1	1	1	0	1	2	-	0	1	-	0	-	0	2	1	2	0	-
Defects:																				
inflamation	1	-	0	-	0	0	0	0	0	0	0	-	-	-	-	-	1	-	0	-
perforation	-	1	0	0	0	0	0	0	-	0	-	0	0	-	0	-	2	1	0	-
blockage	4	2	5	5	6	5	3	4	4	4	3	3	3	3	2	-	3	3	4	-
anomalies	-	-	-	0	0	0	0	-	-	-	-	0	-	-	-	-	0	-	0	-
otitis media	-	-	0	0	2	0	2	2	0	0	1	1	1	1	1	-	2	1	1	-
otitis extre	-	1	0	-	0	0	-	0	-	0	0	0	-	-	-	0	0	0	0	-
referrals	1	1	2	2	2	1	2	1	1	0	1	1	2	1	1	-	3	3	2	-
Dental Examinations:																				
normal	52	55	55	50	53	56	60	56	49	52	56	55	52	49	48	30	58	52	54	-
teeth missing	-	-	-	-	0	0	0	0	0	0	1	0	-	-	1	-	-	0	0	-
dental caries	43	36	41	43	41	38	33	37	40	37	33	38	32	35	33	43	30	28	36	-
Defects:																				
gums	1	-	3	1	3	2	4	4	8	4	7	6	11	12	17	16	9	7	6	-
over-retained	2	1	0	1	1	0	11	0	0	0	0	0	0	0	0	0	0	0	1	-
crowding	4	6	1	2	1	2	2	2	3	2	2	3	1	0	3	1	1	1	2	-
other def.	1	1	2	2	4	4	5	5	7	9	10	11	10	12	14	24	9	5	6	-
referrals	32	22	23	24	23	21	26	20	20	18	12	15	13	9	9	7	3	4	13	-
Urine Examinations:																				
normal	94	91	90	84	88	84	85	83	82	76	78	77	72	78	74	76	82	86	84	83
red blood cells	1	4	5	6	7	7	10	11	13	11	19	16	22	10	21	18	13	9	11	10
white blood cells	1	5	4	8	4	5	5	5	7	6	10	8	10	5	6	5	2	3	5	6
bilharzia	3	5	5	7	8	7	11	11	17	10	19	17	26	15	24	20	12	6	12	10
other parasities	-	-	0	0	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	0
sugar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
other abnormalities	1	2	2	4	1	2	1	2	0	1	2	1	1	2	2	2	2	4	1	3
Children without defects	40	40	35	27	33	34	35	35	34	38	34	42	40	33	32	27	37	33	35	34

Table 12

Results of Urine Examinations (By Districts)

Abnormalities	DISTRICTS				
	Hhohho %	Manzini %	Shiselweni %	Lubombo %	Totals %
Urine Normal	94	74	81	83	84
Red Blood Cells	5	16	8	16	11
White Blood Cells	1	22	3	1	6
Bilharzia (S. haematobium)	4	19	13	14	11
Other Parasities	0	1	0	0	0
Other Abnormalities	1	7	2	1	3

Table 13

Results of Fecal Speciman Examinations in the Manzini District

Results	No. Specimen Examined	Percent of Positives
	792	100.00
Blood/Mucous	10	1.26
Bilharzia (S. mansoni)[1]	2	0.30
Ascaris Lumbricoides	106	13.40
Other Parasites:		
Taenia species	5	0.63
Entorobius-Vermiculoris[2]	13	1.64
Hymenolepis nana	6	0.76
Bacterial infections	2	0.25
Giardia lamblia	1	0.13
Amoebic cyst	1	0.13
Stongyloides stercolaris/ Stercolaris	1	0.13

1) Stool speciman examinations were only carried out by the School Health Team working in the Manzini district; out of the 792 stool specimen examined, 122 were from Black Mbuluzi Nazarene Mission School in the Hhohho district.

2) Found by indirect examination of urine specimen (Possible Contamination).

Table 14

Result of Surveys for Incidence of Bilharzia Under Various Irrigated Surveillance and Water-Treated Conditions (0-15 yrs. of age)

Age Group	IUS			INUS			INUSWT			NIUS			NINUS			NINUSWT		
	No. of Fecal Sampled	% Pos.	% Neg.	No. of Fecal Sampled	% Pos.	% Neg.	No. of Fecal Sampled	% Pos.	% Neg.	No. of Fecal Sampled	% Pos.	% Neg.	No. of Fecal Sampled	% Pos.	% Neg.	No. of Fecal Sampled	% Pos.	% Neg.
Stool Speciman 0-9	418	7	93	--	-	-	553	13	87	938	6	94	--	-	-	--	-	-
9-14	257	5	95	--	-	-	532	9	91	706	6	94	--	-	-	--	-	-
15+	25	4	96	--	-	-	71	22	78	175	6	94	--	-	-	--	-	-
All ages	700	7	93	--	-	-	1156	12	88	1819	7	93	--	-	-	--	-	-
Urine Speciman 0-9	578	15	85	157	60	40	575	19	81	2426	23	77	463	47	53	167	35	65
9-14	466	18	82	103	67	23	561	16	84	2264	40	60	776	62	38	267	63	37
15+	209	24	76	8	63	37	66	33	67	617	35	65	331	47	53	30	64	36
All ages	1253	18	82	268	62	38	1202	19	81	5305	32	68	1510	54	46	464	53	47
Total of all Stool Speciman	3675	9	91															
Total of all Urine Speciman	10,002	34	66															

IUS = Irrigated under surveillance
INUS = Irrigated not under surveillance
INUSWT = Irrigated not under surveillance, water treated
NIUS = Not irrigated under surveillance
NINUS = Not irrigated not under surveillance
NINUSWT = Not irrigated not under surveillance, water treated

Table 15

Results of Surveys Conducted by School Health Teams for Bilharzia (By Geographical District; Grade I&II; Standard I to V)

Grade Levels	March 77 Highveld & Middleveld (Shiselweni District) Nkungwini School			March 77 Highveld & Middleveld (Shiselweni District) Franson School			March 77 Highveld & Middleveld (Hhohho District) Bulandzeni School			November 77 Highveld & Middleveld (Manzini District) Ekutssimleni School			November 77 Lowveld & Lubombo (Lubombo District) Sistsatsauen School			November 77 Lowveld & Lubombo (Lubombo District) St. Charles School		
	No. of Cases	% Pos.	% Neg.	No. of Cases	% Pos.	% Neg.	No. of Cases	% Pos.	% Neg.	No. of Cases	% Pos.	% Neg.	No. of Cases	% Pos.	% Neg.	No. of Cases	% Pos.	% Neg.
Grade I	--			--			30			52			23			20		
S. haematobium		12.0	88.0		4.8	95.2		66.7	33.3		40.4	59.6		8.7	91.3		15.0	85.0
S. mansoni											2.0	98.0		0.0	100.0			
Grade II	--			--			12			54			24			32		
S. haematobium		5.6	94.4		1.7	98.3		75.0	25.0		46.3	53.7		12.5	87.5		12.5	87.5
S. mansoni											0.0	100		0.0	100.0		0.0	100
Standard I	--			--			19			56			11			25		
S. haematobium		7.0	93.0		1.6	98.4		79.0	21.0		64.3	35.7		18.1	81.9		24.0	76.0
S. mansoni											0.0	100		0.0	100		0.0	100
Standard II	--			--			14			49			10			27		
S. haematobium		16.6	83.4		11.4	88.6		100	0.0		63.2	36.8		0.0	100		22.2	77.8
S. mansoni											0.0	100		0.0	100		0.0	100
Standard III	--			--			--			42			7			14		
S. haematobium		25.0	75.0		11.5	88.5					59.5	40.5		0.0	100		14.3	85.7
S. mansoni											0.0	100		0.0	100		0.0	100
Standard IV	--			--			--			36			--			8		
S. haematobium		21.7	78.3		22.2	77.8					72.2	27.8					12.5	87.5
S. mansoni											0.0	100						
Standard V	--			--			--			23								
S. haematobium		22.7	77.3		12.8	76.2					65.2	34.8						
S. mansoni											4.3	95.7						

NOTE:
"--" = Data Not Supplied

Table 16

Result of School Health Team

Survey for Urinary Bilharzia in the Manzini District (March 1977)

School	Total Urines Examined	Number of Cases	Percent Positive
New Mbuluzi	36	1	2.7
Mafutseni, R.C.	54	2	3.7
Mafutseni, Nazarene	32	1	3.1
Emtfonjeni	45	2	4.4
Dameseko	19	0	0.0
Esigombeni	31	1	3.2
Mpembekati	47	1	2.1
Ekukhanyeni	97	10	10.3
Nyakeni	49	12	24.5
Engwazini	50	11	22.0
Bhekinkhosi	99	34	34.3
Luthosha	38	16	42.2
Ekutsimleni	53	14	26.4
Totals	650	105	16.1

Table 17

Number of Urinary Schistosomiasis Cases Detected in Pregant Females at the Central Public Health Laboratory, Manzini (January 1977 to May 1977)

Number Examined	Number of Positives	Percent Positive
685	83	12

Table 18

Number of Urinary Schistosomiasis Cases detected in Military Personnel at the Central Public Health Laboratory, Manzini (March 17 to May 17, 1977)

Number Examined	Number of Positives	Percent Positive
198	46	23.2

Table 19

Number of Schistosomiasis Cases at the Commonwealth Development Corporation's Swaziland Irrigation Scheme (CDC/SIS), (1973 to 1977)

Years	January		February		March		April		May		June	
	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected
1973	4	0.24	2	0.12	8	0.46	5	0.41	8	0.38	7	0.44
1974	8	0.45	11	0.60	5	0.27	6	0.31	6	0.27	5	0.22
1975	9	0.48	4	0.23	5	0.28	8	0.71	13	0.50	9	0.50
1976	6	0.32	8	0.43	5	0.26	11	0.68	15	0.22	5	0.22
1977	7	0.36	7	0.39								

Years	July		August		September		October		November		December	
	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected	Number of Cases	Percent Employees Infected
1973	8	0.21	4	0.44	8	0.34	6	0.65	11	0.32	6	--
1974	4	0.26	5	0.50	10	0.36	7	0.32	6	0.46	9	--
1975	9	0.54	10	0.54*	10	0.75	10	0.59	14	0.59	11	--
1976	5	0.88	20*	0.44	9	0,63	13	0.31	6	0.29	6	--

*Clinic staff checked along with patients complaining of symptoms (Clinic staff not complaining). Other cases are patients with complaints.

Table 20

Analysis of Blood Films Examined for Malaria Parasites

(July 1, 1973 to June 30, 1974)

		July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	Totals
Total Films Examined		4001	7003	6870	7520	25394
Age Grouping of Films	Infant	239	493	325	503	1560
	Child	1020	2380	1955	2776	8131
	Adult	2742	4130	4590	4241	15703
Total Immigrant Films		70	138	122	140	470
Age Grouping of Films	Infant	6	16	9	7	38
	Child	12	27	31	32	102
	Adult	52	95	82	101	330
Territorial Division of Immigrant Films	P.E.A.	27	43	13	36	119
	Z.L.D.	2	27	6	10	45
	T.V.L.	41	18	102	94	305
	Others	--	--	1	--	1
Total Indigenous Films		3931	6865	6748	7381	24924
Total Positives		-	4	31	35	70
Age Grouping of Positives	Infant	-	-	-	1	1
	Child	-	1	14	12	27
	Adult	-	3	17	22	42
Total Immigrant Positives		-	2	18	10	30
Territorial Division of Immigrant Positives	P.E.A.	-	1	16	10	27
	Z.L.D.	-	-	1	1	1
	T.V.L.	-	-	1	1	1
	Others	-	1	-	-	1
Total Indigenous Positives		-	1	8	15	25
Pos. (source not yet known)		-	1	5	9	15

Ratio of Indigenous Immigrant Positives in Age Groups		In	Im	In	Im	In	Im	In	Im	In	Im
	Infant	-	-	-	-	-	-	1	-	1	-
	Child	-	-	1	-	2	8	4	3	7	11
	Adult	-	-	1	2	6	10	10	7	17	19
TOTAL		-	-	2	2	8	18	15	10	25	30

Table 21

Analysis of Blood Films Examined for Malaria Parasites

(July 1, 1974 to June 30, 1975)

		July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	Totals
Total Films Examined		3892	7612	8740	16837	37081
Age Grouping of Films	Infant	220	534	567	1035	2346
	Child	1062	2960	3388	6722	14132
	Adult	2610	4128	4785	9080	20603
Total Immigrant Films		22	59	100	77	258
Age Grouping of Films	Infant	1	3	5	4	13
	Child	7	15	17	15	54
	Adult	14	51	78	58	191
Territorial Division of Immigrant Films	P.E.A.	2	13	41	35	91
	Z.L.D.	2	-	6	1	9
	T.V.L.	18	46	53	41	158
	Others	-	-	-	-	-
Total Indigenous Films		3870	7553	8640	16760	36823
Total Positives		3	27	34	105	169
Age Grouping of Positives	Infant	-	-	-	3	3
	Child	-	5	13	30	48
	Adult	3	22	21	72	118
Total Immigrant Positives		3	6	8	28	45
Territorial Division of Immigrant Positives	P.E.A.	2	6	7	27	42
	Z.L.D.	-	-	-	-	-
	T.V.L.	-	-	-	1	1
	Others	1	-	1	-	2
Total Indigenous Positives		-	11	14	51	76
Pos. (source not yet known)		1	10	12	29	52

		In -	Im	In	Im	In	Im	In	Im	In	Im
Ratio of Indigenous Immigrant Positives in Age Groups	Infant	-	-	-	-	-	-	4	-	4	-
	Child	-	-	2	1	5	3	18	12	25	16
	Adult	-	3	9	5	9	5	20	16	47	29
Totals			3	11	6	14	8	44	28	76	45

Table 22

Analysis of Blood Films Examined for Malaria Parasites

(July 1, 1975 to June 30, 1976)

		July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	Totals
Total Films Examined		8427	7626	9433	10717	36203
Age Grouping of Films	Infant	445	451	574	569	2039
	Child	3229	2912	3763	4090	13994
	Adult	4753	4263	5096	6058	20170
Total Immigrant Films		111	110	69	151	441
Age Grouping of Films	Infant	14	12	2	9	37
	Child	17	21	21	23	82
	Adult	80	77	46	119	322
Territorial Division of Immigrant Films	P.E.A.	58	35	26	78	197
	Z.L.D.	7	3	5	-	15
	T.V.L.	-	72	38	70	180
	Others	46	-	-	3	49
Total Indigenous Films		8316	7516	9364	10566	35762
Total Positives		22	2	69	117	210
Age Grouping of Positives	Infant	-	-	-	4	4
	Child	7	-	9	36	52
	Adult	15	2	60	77	154
Total Immigrant Positives		3	-	1	3	7
Territorial Division of Immigrant Positives	P.E.A.	2	-	1	1	4
	Z.L.D.	-	-	-	-	-
	T.V.L.	1	-	-	-	1
	Others	-	-	-	2	2
Total Indigenous Positives		17	2	31	65	115
Pos. (source not yet known)		2	-	37	49	88

		In	Im	In	Im	In	Im	In	Im	In	Im
Ratio of Indigenous Immigrant Positives in Age Groups	Infant	-	-	-	-	-	-	1	-	1	-
	Child	-	7	-	-	9	-	30	-	39	-
	Adult	-	15	2	-	60	1	34	3	94	-
TOTALS		-	22	2	-	69	1	65	3	134	-

Swaziland Entomology Results EX. United Kingdom Egg. Batches vs Cytogenetic Identification

Date sent	Dr. Davidsons results from egg. batches
1/25/75	Mhlangatane eggs not many arrived 1/30/75 no hatch (c.k.)
2/27/75	Sipofaneni-eggs arrived 3/4/75 no hatch (c.k.)
3/6/75	Shortys compound (Big Bend) arrived 3/11/75 few hatched but larvae died (h.r.)
3/10/75	Mhlangatane (c.k.) Speci[illegible]n letter dated 4/7/75 definitely identified as species C. In letter 5/8/75. Hope to cross with species D. from Uganda.
3/24/75	Mpaka - U.K.A.E. Station (Ka Ndambuza) arrived 2/2/75. No hatch (c.k.)
4/14/75	Compound at Mbuluzi Bridge south of Mhlume arrived 4/18/75. No hatch (H.R.)
5/1/75	Logo pools Big Bend arrived 5/6/75 two good hatches out of 4 batches (H.R.) one batch from Logo pools has been identified as species B.
7/3/75	Two families from Logo pools identified as species B. Pooled population tested on DDT and Dielorin indicate resistance to both with mortalities as shown viz. 0.4% DLD for 1 hr. 29% of 27 tested 4.0% DLD for 2 hrs. 69% of 23 tested 4.0% DDT for 1 hr. 64% of 25 tested
5/30/75	From Dr. Davidson Mhlangatane species C. died

Date sent	Dr. Service's results from half-gravid females in carnots
1/27/75	Mhlangatane eggs received 2/25/75 species determination not possible as ovaries too far advanced for cytogenetic identification
3/24/75	Species A-3 (H.R.) Species A-8 (C.K.) Species B-1 (C.K.) Species A-9 (C.K.) Species C?-1(C.K.)
4/14/75	Species A-3 (H.R.)
5/5/75	18 Agambiae sent. of these 14 were unfed with immature ovaries 3 were gravis with fully developed eggs and only 1 was half gravid andr this was species B. (H.R.)
7/17/75	Vector mosquitos including 4 branded palps sent to Dr. Service for cytogenetic identification (H.R.)

Other Observations made in the Past.

1) 5/3/74 egg batches from hut catches from sivunga show 5 species B.

2) Letter dated 7/8/74 from Ross Institute intimates that that D.M. Eckard in 1969 sent 2 cattle kraal families one each from (1) Mliba (2) Nkambeni. This last according to Coluzzi was a hybrid of species C. and amerus.

3) Letter dated 3/28/74 those caught biting man sivunga did not hatch.

Mhlangatane laid 5/3/74 1 species C. Sivunga Hut catches 5 species B. Some sivunga material was tested on DDT and Dieldrin and shown to be resistant to Dieldrin and shown to be resistant to Dieldrin but not DDT.

* (c.k.) = Cattle Kraal Collection

(h.r.) = House Resting Collection

Figure 1.

PROPOSED REORGANIZATION CHART OF CENTRAL PUBLIC HEALTH LABORATORY

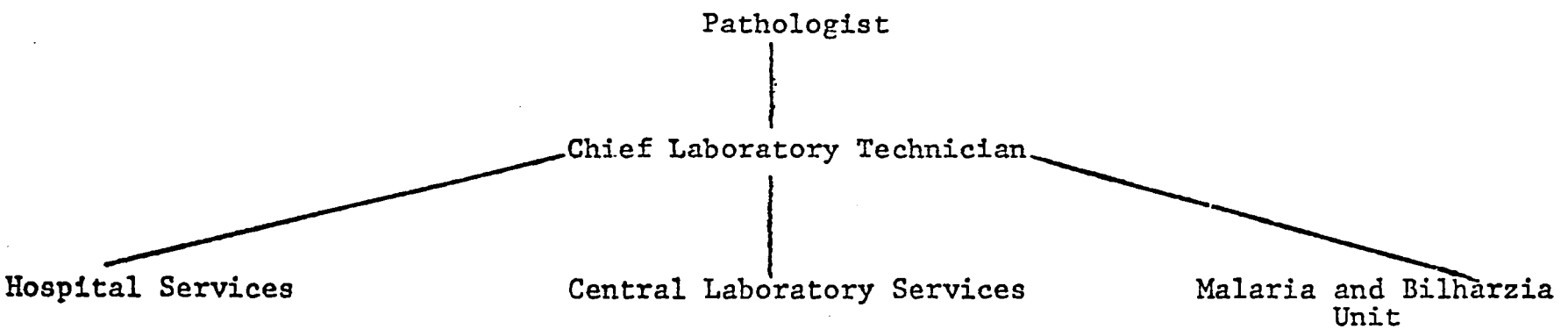


Figure 2.

PROPOSED REORGANIZATIONAL CHART OF THE BILHARZIA AND MALARIA UNIT

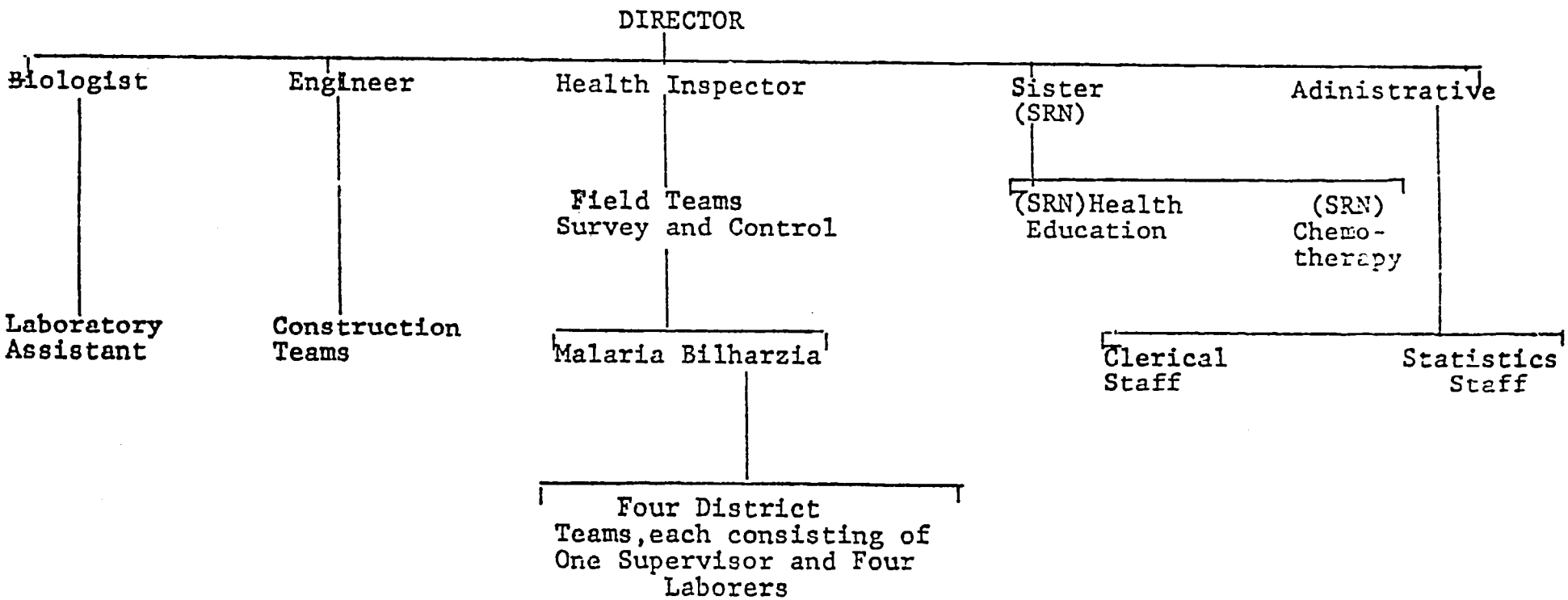
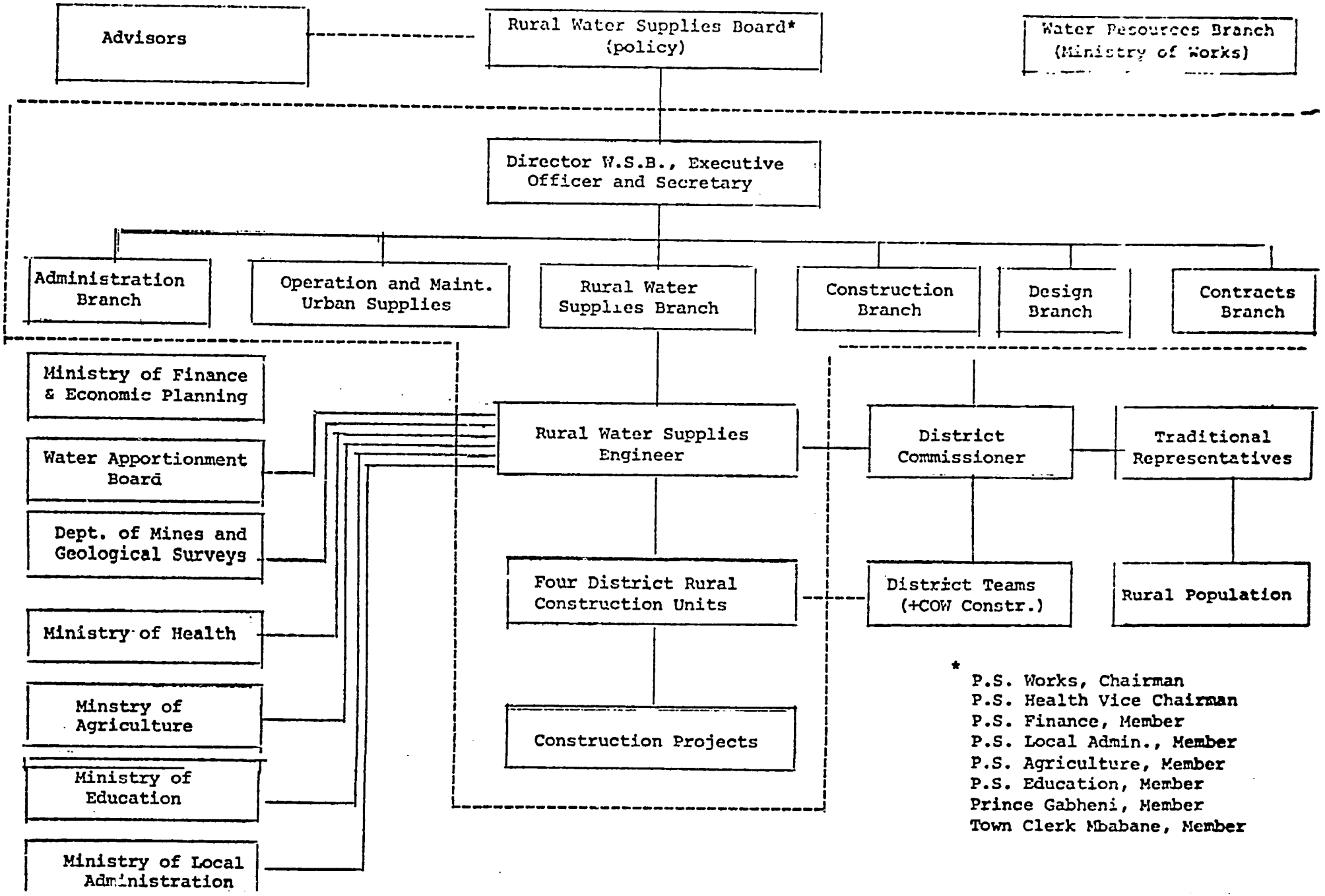


FIGURE 3

RURAL WATER SUPPLIES ORGANISATION CHART



APPENDIX 1

(1)

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IDENTIFICATION DOCUMENT FACESHEET

TO BE COMPLETED BY ORIGINATING OFFICE

1. TRANSACTION CODE: A = ADD, C = CHANGE, D = DELETE

PID

2. DOCUMENT CODE: 1

3. COUNTRY/ENTITY

4. DOCUMENT REVISION NUMBER

5. PROJECT NUMBER (7 DIGITS)

6. BUREAU/OFFICE: A. SYMBOL B. CODE

7. PROJECT TITLE (MAXIMUM 40 CHARACTERS): CLEAN RURAL WATER SYSTEMS AND SUPPLIES

8. PROPOSED NEXT DOCUMENT: A. 2 = PRP, 3 = PP B. DATE MM YY

9. ESTIMATED FY OF AUTHORIZATION/OBLIGATION: a. INITIAL FY b. FINAL FY

10. ESTIMATED COSTS ($000 OR EQUIVALENT, $1 =)

FUNDING SOURCE		LIFE OF PROJECT
A. AID APPROPRIATED		
B. OTHER U.S.	1.	
	2.	
C. HOST COUNTRY		
D. OTHER DONOR(S)		
TOTAL		

11. PROPOSED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. FIRST FY ____ F. GRANT	E. FIRST FY ____ G. LOAN	LIFE OF PROJECT H. GRANT	LIFE OF PROJECT I. LOAN
(1)							
(2)							
(3)							
(4)							
			TOTAL				

12. SECONDARY TECHNICAL CODES (maximum six codes of three positions each)

13. SPECIAL CONCERNS CODES (MAXIMUM SIX CODES OF FOUR POSITIONS EACH)

14. SECONDARY PURPOSE CODE

15. PROJECT GOAL (MAXIMUM 240 CHARACTERS)

To support the Government of Swaziland's efforts to improve the level of living and quality of life of the rural population by providing a clean safe supply of domestic water.

16. PROJECT PURPOSE (MAXIMUM 480 CHARACTERS)

To provide clean safe water to rural areas utilizing methods that control bilharzia and other water-related diseases. Clean safe water is a critical factor in the improvement of health standards which, in addition to being an important element of the individuals health and well-being will also enable him to assure his active role in the economic development of the country.

17. PLANNING RESOURCE REQUIREMENTS (staff/funds)

18. ORIGINATING OFFICE CLEARANCE

Signature

Title

Date Signed MM DD YY

19. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION MM DD YY

AID 1330-2 (3-76)

Project Identification Document (PID)

CLEAN RURAL WATER SYSTEMS AND SUPPLIES

Background

The Kingdom of Swaziland is a small landlocked country of 6,700 square miles which is divided into four topographical regions running from north to south. These are the highveld, the middleveld, the lowveld and the Lubombo plateau, with the lowveld occupying about 40 percent of the country. The country is predominantly rural with about 90 percent of its total population living in rural areas.

Water resources are represented mainly by streams, to a lesser extent by springs and marginally by ground water. Of the four major rivers, only one rises in Swaziland, while the others originate in other countries.

Recent studies (Jobin-Jones, Duncan-Fenwick and others), as well as observations by the AID/PID Team, reveals that Swaziland's major health problem centers upon diseases related to water and unsanitary conditions.

Of these diseases, bilharzia appears to require the most urgent attention, to wit, 80 percent of the school children of the irrigated areas are infected, in non-irrigated areas, 40 to 60 percent are infected. Older age groups are reported to have an even higher incidence of infection. Topographically, the middleveld and lowveld have the highest incidence of infection. Government publications indicate that bilharzia is debilitating to both children and adults, restricting productivity both at school and at daily work.

According to the above surveys and substantiated by government reports, the incidence of bilharzia is increasing with the expansion of irrigation, despite the fact that a considerable amount of the irrigated area is under government and/or private sector control programs.

Other diseases such as malaria, dengue, typhoid, cattle tapeworm, hydatid, amoebiasis, hepatitis, gastro-enteritis and fascioliasis remain serious health risks. Information given to the AID/PID Team revealed that malaria appears to be on the increase in certain areas and in addition, there is suggested evidence that the mosquito vector is developing resistance to DDT and dieldrin.

Transmission of the above mentioned diseases are a direct result of the lack of an adequate, convenient and safe water supply and the availability and the education to use sanitary

human waste disposal and laundry/shower facilities in rural areas. This is in contrast with most of the urban areas where these facilities are provided under controlled conditions and standards. There are, at present, numerous plans and programs proposed by various agencies that would, at least, alleviate some of the above risks. However, their effectiveness has been limited due to the lack of funds, trained personnel, and coordinated effort.

The Government of Swaziland (GOS) is, and has been aware of the need to control water-related diseases as evidence by programs presently in effect. They actually have prepared plans for a national program to provide sanitary waste disposal, laundries/shower facilities, protected springs and wells, and a safe, convenient water supply to the rural homestead.

In 1974, the Water and Sewerage Board was established within the Ministry of Works, Power and Communciation and subsequently, a Rural Water Branch was established "to coordinate the development and establishment of a rural water system." However, the Ministry of Agriculture (MOA) and the Ministry of Health (MOH) are also presently engaged in similar activities. At present, the Bilharzia Control Unit is directed from the Health Office in Manzini in conjunction with a program for malaria control, resulting in a lesser emphasis on bilharzia. The efforts required for malaria control varies yearly according to the incidence of mosquitoes. At the present time, the majority of the staff of the Malaria/Bilharzia Unit is engaged in constant control measures against malaria, therefore, current activities against bilharzia, despite its high prevalence, are limited to a small number of projects.

Present facilities, equipment, shortage of technical personnel and present procedures used for specimen collection and examination limits the identification to predominately Schistosoma haematobium. Schistosoma mansoni is under-reported in spite of the widespread prevalence of Biomphalaria sp.

A social custom that may be a constraint in the establishment of rural water supplies, observed by the AID/PID Team and recognized by the GOS is the wide disbursal of the population over the rural areas and the lack of established villages. Schools, hospitals, clinics, municipal offices and marketing facilities necessary for rural centers are also widely disbursed. However, the GOS has developed plans and presently is engaged in a program for the resettlement and the concentration of these homes and facilities into rural centers.

There is every indication that with present plans for future agriculture development, the expansion of irrigation and increased utilization of water resources, the incidence of bilharzia and other water-related diseases will continue to increase.

This is recognized by the GOS and has resulted in their request to USAID for assistance in planning appropriate measures for inclusion in development/expansion plans that will facilitate control of these diseases.

The AID/PID Team visited most of the heavy agriculture production regions and met with the people who are, or could be, associated with rural water and there is positive evidence that the vector host is present in most areas. It therefore follows that the potential for expansion of this disease is present and there are indications that its incidence is already expanding. It is evident that no single method will suffice to control bilharzia and other water-related diseases, however, one key element in any control is the protection of man and animals from contaminated water and vice versa.

It is therefore proposed that USAID provide technical assistance to the GOS in developing a coordinated, concentrated control program based on the provision of safe water to the rural areas of Swaziland. In addition, USAID will provide commodities and facilities to expand the identification and curative services of bilharzia and other water-related diseases.

The emphasis of AID assistance shall be concentrated on the following objectives:

1. To improve the overall standards of public health and particularly to reduce the incidence of water-related diseases among rural population with emphasis on children.

2. To support and maintain efforts and organizations presently engaged in the control of water-related diseases and improve and expand their capacity to discharge their responsibilities.

3. To design organizational structures that will ensure cooperation and coordination between those government identities involved in the supply and delivery of rural water as well as those involved in water-related diseases.

4. To amplify present health education programs to include basic knowledge of modern preventive measures and control procedures for water-related diseases with emphasis on bilharzia.

5. To supply an opportunity for Swazi nationals to receive training either in-country or overseas to improve their capacity to implement and carry out control and curative programs for bilharzia and other related diseases.

6. To furnish commodities and physical facilities necessary to carry out diagnostic and vector surveys and surveillance procedures including water quality control.

With relation to objective 1, it is proposed that AID furnish the services of Water/Sanitary Engineer for a period of not less than 60 months. His duties will include, in addition to daily training of local personnel, the design and installation of source protection (such as syphon spillways, manually controlled water level fluctuation, physical barriers, i.e., fencing) and control, delivery systems and equipment that will assure a safe water supply. Initial priority will be directed toward those areas where bilharzia has the highest endemicity, particularly where rural primary schools and high risk groups such as estate workers, are involved.

Objective 2 related to the lack of personnel, space and facilities of the present Bilharzia Control Organization. To alleviate this shortage and the resulting inability to discharge the units mandate, it is proposed that AID furnish the services of a biologist for a period of not less than 60 months. This biologist will initiate and implement a national prevalence and intensity survey for snail host and the schistosome parasite. This survey will also identify other water-related disease problems such as malaria, fascioliasis, and constructive efforts can be initiated for proper control. The biologist will also address the possible problems of increased bilharzia due to expanded rice farming and fish culture. In addition, he will investigate the possibility of biological control of bilharzia.

Objective 3: The water/sanitary engineer and the biologist will support and encourage the establishment of a National Bilharzia Control Committee, and a Rural Water Supply Board, as well as any other organization tending to foster cooperation and coordination of groups involved in the supply of clean water and/or control of water-related diseases. The above organizations should include representatives from the Ministry of Agriculture, Ministry of Health, Ministry of Works, Power and Communication, Ministry of Education, and Ministry of Finance, economic planning, district traditional government representatives and other specialized organizations such as WHO, UNEP, etc.

Objective 4: The biologist and water/sanitary engineer will also analyze information gathered in the above activities and will assist in the preparation of data, information, and plans for inclusion in the National Health Education Porgram. This also will include acquisition of audio-visual material and equipment. This will be in support of the present on-going Health Education Program.

Objective 5 consists of three types of training; overseas, third-country and on-the-job. It is proposed that project funds be included to cover participant training in the U.S. for one water/sanitary engineer, one biologist/malacologist, to at least an M.S. degree and, if possible, to Ph.D. In addition, funds should be included to train, in the U.S., four technicians

to a B.S. degree in biology with emphasis on parasitology, ecology, and diagnostic techniques. Provision should be included for training health education personnel at a local facility and provision for on-the-job and local training for a clerk/statistician for collection and analysis of bilharzia and other related health data.

To support the efforts of the technical assistance it is proposed that funds be provided for the expansion of present facilities to include a diagnostic laboratory, insectary, snail laboratory, central records, glassware washing facilities, water analysis and ecology laboratory, pharmacy unit and required storage. Present facilities will be utilized to the extent possible and with revision and more efficient space utilization it is anticipated that new construction will be no more than enclosing and finishing an area presently under roof.

Commodities required to support this activity will be identified after careful examination of existing supplies, equipment and need.

INPUTS

(1) Technical Assistance $1,200,000

One (1) Biologist/Malacologist
5 years

One (1) Water/Sanitary Engineer
5 years

Consultant (Epidemiology, Sanitary Engineer, Biology, Laboratory Supervision)
2 years

Total Technician Years - 12
Average Cost $100,000/year .

(2) Commodities $ 135,000

Vehicles, 2 each, pickup with covered box tools and spares @ $14,000 each-$28,000

Laboratory Equipment 72,000

Office and Field Equipment 25,000

Visual Aids and Equipment 10,000

(3) Training $ 310,000

Two Participants to M.S. or Ph.D.
3 years each @ $15,000 $ 90,000

Four Participants to Diploma or B.S.
4 years each @ $12,000 192,000

In-country Training Support 28,000

(4) Other Costs		$ 665,000
Construction:		
Two houses for technicians @ $35,000	$ 70,000	
Construction and Revision of Bilharzia Laboratory, etc.	90,000	
Vehicle and Equipment maintenance	200,000	
Support Cost for development and installation of prototype safe water systems and sanitary facilities	100,000	
Other items not yet identified	200,000	

ENVIRONMENTAL EFFECTS

Swaziland is currently engaged in implementing a national program to improve agriculture, health and natural resources, including water, forest, land, etc. The proposed Clean Rural Water Systems and Supplies Project will have a major effect and be a directing factor upon the water and health components of this national program. The activities included in this project will be designed to protect and improve the environment, health and well being of the rural population.

Activities included in this project will include investigation of the prevalence of bilharzia and initiate control measures. Careful examination will be given to the utilization of biological control and physical designs that will reduce or eliminate present use of molluscicides. Water systems and sanitary installations will be designed to insure maximum protection against all water related disease hazards. In the event that the use of medical drugs or chemicals will be required, only those approved as safe by the FDA will be utilized.

It therefore, appears that the effects or results of this project and the activities contained therein will be generally beneficial to the overall environment and well being of the rural poor. It is hoped that this project will serve as a model to influence other governments in Africa to initiate similar bilharzia control activities in their country.

OTHER DONORS

Other identities and international organizations presently engaged in assistance activities include, but are not limited to the following:

Rural water supplies - CIDA/UK

Assistants training	-	WHO
Rural Health Centers and Clinic Construction, etc.	-	UK
Foot bridges	-	EDF
R.D.A.	-	IBRD, UK, USAID
MCH/FP	-	WHO/UNICEF/UNFPA/IPPA
Institute of Health Sciences	-	USAID
Health Education T.A.	-	WHO

The activities of the above organizations have been briefly reviewed and there does not appear to be any conflict or duplication of the activities proposed in clean rural water systems and supplies with any of the above. Rahter, the proposed project will augment and support several of the activities of these organizations.

The following attachments are the result of a final meeting to discuss recommendation with representatives of government departments concerned. With the inclusion of these three statements, it is felt that there was a general consensus of opinion at the desirability and viability of the recommendation.

ATTACHMENT NUMBER 1

It is strongly suggested that the diagnostic section of the malaria/bilharzia unit be transferred under the supervision of the pathologist and laboratory technician of the Central Public Health Laboratory, and that any requirements for renovations or reorganization of the laboratory space be funded within the proposed project.

We recommend that this malaria/bilharzia diagnostic unit be expanded to four laboratory assistants, whose work will be confined to malaria and bilharzia diagnosis. They will receive specimens collected by field survey teams, school health teams and will assist laboratory staff of hospitals in this area of their work where necessary.

We further recommend, given that there is a relatively strong infrastructure of rural clinics within the country (31 government clinics at present and proposed construction at the rate of three per year), that clinic nurses be involved in the decentralized treatment of malaria and bilharzia cases. To assist these nurses a schedule for treatment should be drawn up which should be distributed and followed closely by these nurses. In addition the nurses at the malaria and bilharzia unit should assist and advise these nurses.

APPENDIX 2

Rural Water Supplies: Proposed criteria for Selection of Schemes

Introduction

Responsibility for approval of projects to be submitted to O.D.M. will rest with the Rural Water Supplies Board. The recommended programme of construction of water supplies will be drawn up by the Rural Water Supplies Branch after analysis of the proposed achemes, taking into account the priorities indicated by the District Teams for each region.

It is suggested that items one and two are used for general screening of projects for suitability, in order to exclude quasi-urban schemes and to ensure that limited resources are used with reasonable cost-effectiveness.

Within these quidelines, priority should be given to those communities with the greatest. However, it is diffecult to quantify 'need' according to a precise ranking system. It is therefore suggested that each scheme is assessed individually taking into account all items mentioned below.

A) Maximum Settlement Size

To avoid the inclusion of quasi-urban schemes, it is proposed that only schemes with a fewer than 2500 resident population within a radius of 2 km. should be included. Figures should be taken from the 1976 population census and should include resident staff and boarders at schools and other institutions.

B) Cost Effectiveness

It is proposed that a maximum cost limit of E50 per person should be imposed. Persons served should be defined as above, except that day pupils and clinic patients should count in addition as half a unit. This figure may be raised during the implementation of the project to allow for inflation. Other things being equal, preference should be given to schemes with a lower cost per head, but this should not necessarily be the deciding factor.

C) Existing Water Supply

Sources of water currently in use should be assessed for chemical, bacterial and parasitic contamination. In addition, the adequancy of the dry season water supply should be determined.

D) Distance to Nearest Potable Water

The distance to be travelled by the majority of the population to the nearest existing source of potable water (according to WHO admissible standards) should be determined. The quantity of this water should also be con-considered.

E) Growth Centers

Where schemes are sited in areas identified as Growth Centres this may be considered as a further matter for preference.

F) Community Involvement

Preference will be given to schemes where:

a) A responsible member of the community has been, or will be, nominated from the community to take responsibility for operation of the scheme and to report faults.

b) The community is willing to contribute unskilled labour for construction purposes.

RURAL WATER SUPPLIES

(to accompany technical details)

NAME OF SCHEME:
DISTRICT:
NUMBER: e.g. IU/3/77 - 8

1) Estimate of Population to be served

a) Resident Population.....

b) Schools	(i)	Resident staff and teachers	.....
	(ii)	Day pupils	.....
c) Clinics	(i)	Resident staff	.....
	(ii)	Daily patients	.....
d) Other	(i)	Resident	.....
	(ii)	Non-resident	.....

Total _____

Total Excluding b(ii) c(ii) d(ii) _____

2) Construction Cost

a) Materials	_____
b) Equipment	_____
c) Skilled Labour	_____
d) Unskilled Labour	_____
e) Contracted Services	_____
f) Transport	_____
Total	_____

3) Existing Water Supplies

This section should comment on the quality and adequacy of the water now being used, and on the distance being travelled. Where existing water supply is considered unsafe, the location of the nearest acceptance water supply should be mentioned.

4) Operation and Maintenance Requirements

5) Person Responsible for Operation

6) Other Relevant Factors

(e.g., RDA. Community Contribution. Social reasons for priority)

SOLAR DISTILLATION FOR SWAZILAND

Solar Distillation represents a water resource which is most available in many areas where population density may be low and where conventional energy resources may be expensive. Its use for production of fresh pure water is technologically feasible.

In nature, fresh water is produced by a very large-scale process of solar distillation. Solar radiation impinging on the surface of rivers, lakes, marshes and oceans is absorbed as heat and causes evaporation of water from these surfaces. The resulting vapour rises as humidity of the air above the surface and is moved along by winds. If and when the air-vapour mixture is cooled to the dew-point temperature, condensation may occur; and the pure process are the production of vapour above the surface of the liquid, the transport of this vapour by air, the cooling of the air-vapour mixture, and condensation and precipitation.

The natural process is copied on a small scale in basin-type solar stills. A water surface of limited size is covered with a cover transparent to solar radiation. This cover serves two major purposes: it prevents escape of the humid air above the water surface; and it furnishes a cool surface upon which part of the humidity can condense. The cover also serves as a radiation shield and reduces the energy loss by emitted long-wave radiation from the water surface. While neither glass nor the sheet materials used for the cover are completely transparent to solar radiation, they absorb and reflect only a small portion of it and interfere little with the evaporation process.

A schematic scross-section of this type of solar still is shown in figure One. There are several existing solar-still designs, which differ from one another in materials used and in geometry, but all include elements serving the same functions. The saline-water container or basin must be water-tight; it is blackened to absorb solar radiation effectively. The transparent cover must be vapour-tight and sloped at an angle sufficiently great to permit water condensing on its inside surface to flow by gravity into the condensate troughs.

Condensate troughs must be arranged to collect all of the water dripping from the lower edges of the cover and to drain this product water to the outside of the enclosure. The basin liner may be laid directly on the ground or insulated therefrom to reduce heat loss through the bottom. Metal, concrete or other long-lived materials may be used for the structural elements and condensate troughs. Further differences are introduced by the use of various configerations and sizes.

The following steps and consideration are suggested for assessing solar distillation as a method of meeting a particular water need, to provide information with which to compare it with alternatives:

1) Climate - If the solar radiation climate is good, i.e., skies are generally clear, a solar distillation plant may be feasible. Productivity of stills is a direct function of solar radiation received on a horizontal surface.

2) Scale of need - Solar distillation now appears suited to water requirements on a relatively small scale,i.e., less than about 50,000 gallons per day. For larger demands, or demands that are anticipated to increase in the near future, other desalination methods are now more economical.

3) Site - Land that can serve as a site, with unobscured solar radiation, for the still installation, should be near the water users. Saline water must be available for feed water to the process. Competing uses for sites should also be considered.

4) Estimate of preliminary still size - A well-designed, well-constructed still in a good climate should produce about twenty-five gallons per square foot of still per annum. This yield, compared with annual water needs, will give a first approximation of the required solar-still area.

5) Design - One or more designs can be selected or developed in the light of local conditions, available materials and skills of local work force, and evaluated for the particular location.

6) Estimate of monthly yield - Based on a particular design, monthly yields of distilled water can be estimated from experimental data on similar stills in other locations, or through the use of estimation methods. These monthly yields should be based on monthly mean radiation levels and temperatures.

7) Rainfall contribution - If the local conditions and regulations permit, rainfall run-off from the still can be recovered. This can be estimated from average monthly rainfall data or minimum monthly rainfall, applying a reasonable recovery factor. Usefull monthly rainfall collected can then be added to still yield to provide an estimate of month-to-month production of useful water from the still.

8) Monthly needs versus production - A comparison of month-month distributions of water production and water needs will indicate water storage requirements, modifications in still size or possible uses of supplementary sources.

9) Estimate of cost - With the foregoing information, the appropriate data on still designs, first costs, service life, maintenance and operating requirements, and local information on interest rates and other economic factors, the cost of delivering water from the solar stills can be estimated and compared with alternatives.

10) Other considerations - Considerations not directly quantifiable in terms of cost may also be important. These could include, for example, sociological and personal factors, resistance to change, distance of users from the potable water-supply, protection of the still from vandalism, methods of water cost distribution or sales methods, subsidies and/or fuel savings.

Solar distillation is a capital-intensive process, requiring relatively large capital investment per unit of capacity and, in properly designed and constructed systems, a minimum of operating and maintenance costs. Product-water costs thus depend primarily upon still productivity, capital cost of the installation, its service life, and amortization and interest rates.

Solar-still productivity is conveniently referred to, in round numbers, as being typically, 0.1 gal per sq. ft. for a good day. It is, however, highly dependent upon solar radiation and less dependent upon air temperature and other factors. On clear winter days a well-designed still will yield perhaps 0.03 and on clear, hot summer days, perhaps 0.12 gal per sq. ft. per day.

Summing up these yields over a year, experience shows that annual still yields of about 25 gal/sq. ft. are obtained, with some variations due to climate and still design.

The unit capital of solar stills built in recent years has been $2.00-0.60 ($) per sq. ft. Most of the estimates based on current designs of durable stills show costs of materials and labour for still construction to be in the neighbourhood of $1/sq. ft.

The projected lifetime for stills construc ed of concrete, glass and other long lived materials is twenty years or more. Other still designs have been developed using some materials with shorter service lives which must be periodically renewed.

Assuming favourable interest rates, such as those granted to a public utility type of venture, and service lives as noted, one obtains water costs of $3-$6 per 1,000 gallons. Variations within and from this range are experienced because of rainfall collection, storage costs and unpredicted factors affecting still productivity.

In review, the total fixed costs an an annual percentage of capital investment, the total cost of supplying salt water to the distiller over a year's time and the tutal operating labour and supervision expense, when added together equal

the total annual cost of providing solar-distilled water for use. This amount divided by the toal gallons of distilled water produced (plus assured collection and storage of rain-water) per annum equals the cost of each gallon of potable water produced. If all of this water can be used, this figure is also the cost of each gallon of water used. The following equation, in which $\overline{IA}$, $\overline{MR}$ and $\overline{TI}$ represent the average value over the estimated life of the installation, summarizes this relationship:

$$C = \frac{10\ I\ (\overline{IA} + \overline{MR} + \overline{TI}) + 1000\ (Oc + S)}{A(Y_D + Y_R)}$$

C = cost of water (dollars per 1000 gallons

I = total capital investment ($)

$\overline{IA}$ = annual interest and amortization rate (% of investment)

$\overline{MR}$ = annual maintenance and repair labour and materials (% of investment)

$\overline{TI}$ = annual taxes and insurance charges (% of investment)

O = annual operating labour (man-hrs.)

c = operating labour wage ($ per man-hr.)

Y_D = annual unit yield of distilled water (gallons per sq. ft.)

Y_R = annual unit yield of collected rain-water (gallons per sq.ft.)

A = area of distiller on which yields are based (sq. ft.)

S = total cost (fixed and operating) of salt-water supply

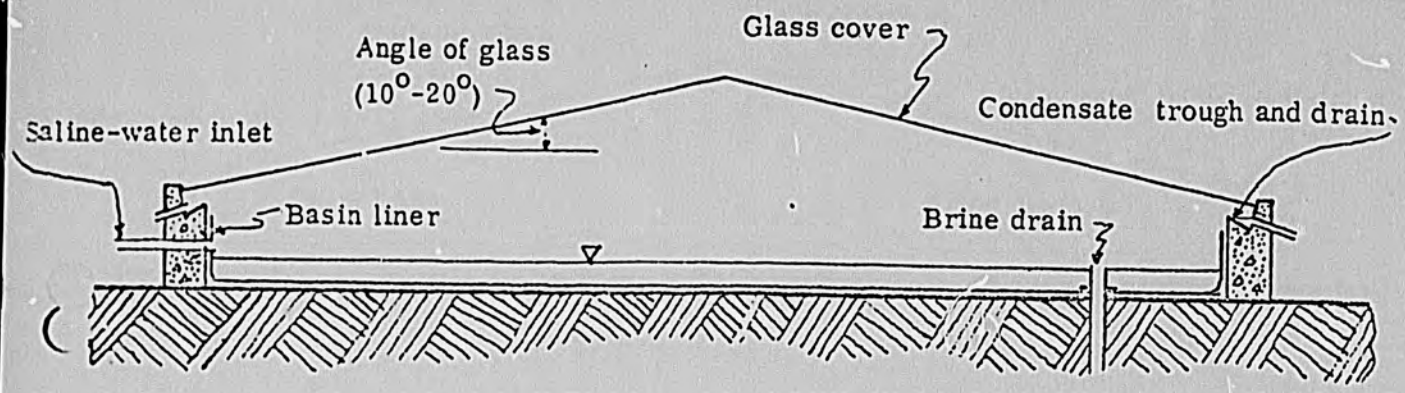
These cost estimated would be affect by rain-water collection, i.e., if an additional 12 inches of precipitation were to be collected, stored and used, the total fixed costs quoted above could be reduced per 1000 gallons of usable water.

In the entire field of desalination, solar distillation can have economic advantages in capacity ranges up to possibly 50,000 gpd and most certainly up to 25,000 gpd. For small communities in climates of good radiation, in areas where power supplies or sources of waste heat are not readily available and where skilled labour is at a premium (features common to essentially "remote" or "isolated" communities or water demand centres), solar stills have a distinct economic advantage over the other processes for desalting sea water. The

where skilled labour is at a premium (features common to essentially "remote" or "isolated" communities or water demand centres), solar stills have a distinct economic advantage over other processes for desalting sea water. The total water production cost, although much higher than usual large-scale fresh water supplies, can be substantially cheaper than alternative sources in many locations where potable fresh water is unusually scarce and expensive. In addition, the rather low foreign exchange element of solar-still costs (where locally available materials of construction are used) may be of special economic importance.

Figure 1

Figure [illegible] Schematic cross-section of the [illegible]-type solar still



APPENDIX 3

MINISTRY OF HEALTH - HEALTH EDUCATION UNIT
LUKHUBA (BILHARZIA)

Luyini?

Lukhuba sifo lesibangwa kunggena kwesibunga emtimbeni ligama laso kutshiwa yi Schistosoma. Siveta tibonakaliso letibalwa,futshi kwenteka etindzaweni letitshite temhlaba. Lesibungwana sihlala emantini.

Tinhlobo Telukhuba.

1. Lukhuba loluchamisa inggati sesinyeni (bladder)
2. Lukhuba lolusematfunjini (rectal)
3. Lukhuba loluvame eJapane

Uma umuntfu sesimngenile lesibungwana uyaye ahlale emaviki langaba lushumi noma abe lishumi namabili lungakatibonakalisi lolukhuba, ngaleso sikhatshike lesibungwana sitalela emaqandza lapha emtimbeni walowo muntfu.

Sentanjani?

Uma umuntfu ageza noma awasha emantini lanaletilwanyana noma awanatsa uykutfola lokugula kokuchamisa inggati. Letibungwana tingena esikhunkeni uma ugeza tihambe ngemitsambo wengeti,tingene enhlitiyweni, tendlulele emaphashini kutsi emva kwemalanga lamatsatfu bese tiyafohla emaphashini kuhumba ngengati kuze kufike esibindzini lapho kondleka khona kubekukhulu kulungele kutalela. Kuyesuka lapho kuyehla ngayophela ingati kuya emitsanjeni yematfumbu noma yesinye. Laphoke kufike kutalele emaqandza. Emaqandza aloku lokuhla ematfunjini acijile emaceleni,kantsi aloku lokuhlala esinyeni acije ekugcineni.

Lamaqandza ngoba acijile ayahlaba aphume emitsanjeni,uma asematfunjini ayaye aphume nemangcoliso,uma asesinyeni aphume kanye nemchamo,emva kwalowo muchamo besekuphuma inggati,phelaloko kwentiwa kutsi adzabula imitsambo uma aphuma.

Umake umuntfu lonalolukhuba achamela emufuleni emantini, lamaqandza atshi ngokuba semantini bese ayabhamuka sekuphuma tibungwana tonake setifuna umnenkhe,tingawitfola tiyaye tingene kuwo tihlale kuwo tize tikhule besetiyaphuma futshi setifuna umuntfu.Umake kwenteka kutshi kungene umunftu lapha emantini kuyayebese kuya mmamatshela lokwetibungwana.

Kubonakala Njani?

1. Uma ugeza emantini lanako utshi uma sewephumile uve ulunywa emtimbeni lapho kungene khona.

2. Uye ashise umuntfu emtimbeni achuche,ahlante,umtimba ubebuhlungu,akhwehlele,kulesinye sikhatsi sibindzi sivuvuke. Loku ungeke ukunake kakhulu kulesinye sikhatshi.

3. Kutfolaka emaqandza emchameni walo naso lesifo.

4. Uchama inggati umuntfu lonaso.

5. Kuyaye kubebuhlungu esinyeni.

6. Uyaye achamele futshi umuntfu.

7. Kungenteka kutshi kwenteke ematje esinyeni abangwe ngulamaqandza,lamanye langaphumi bese aguqukq ematje.

Lesifo Asivikeleki Ngemijovo Kodvwa:

1. Kufanele kutshi kungagezwa emifuleni lenako nekuwasha kungawasha futshi anganatfwa emanti aleyomifula. Uma ufuna kuwasha uqale ngokuwabilisa.

2. Makungachanyelwa emifuleni ikakhula labo labanalokufa, ngoba lamaqandza lasemchameni atakukhandza iminenke bese kwandza kufa.

3. Akwahive tindlu tangasese kute emaqandza laphuma emangcolisweni noma emchameni angangeni emifuleni. Qaphela ungagezi,angawashi,unganasi umfula lonalokufa. Uma unako sita ungachameli emfuleni bilisa emanti ekunatsa.

Against schistosoma haematobium

Composition

1 tablet contains 100 mg of 0,0 dimethyl-2,2,2-trichloro hydroxyethyl-phosphonate (INN: Metrifonate).

Administration and Dosage

The tablets are swallowed whole with some water. It is recommended not to exceed the number of tablets stated per kg bodyweight.
A single dose of 7,5—10 mg per kg bodyweight is taken once every two to four weeks to a maximum of three doses.

Bodyweight		Tablets per single dose
10 kg	22 lbs	1
15 kg	33 lbs	1–1½
20 kg	44 lbs	2
25 kg	55 lbs	2–2½
30 kg	66 lbs	3
35 kg	77 lbs	3–3½
40 kg	88 lbs	4
45 kg	99 lbs	4–4½
50 kg	110 lbs	5
55 kg	121 lbs	5–5½
60 kg	132 lbs	6
65 kg	143 lbs	6–6½
70 kg	154 lbs	7
75 kg	165 lbs	7–7½
80 kg	176 lbs	8
85 kg	187 lbs	8–8½
90 kg	198 lbs	9
95 kg	209 lbs	9–9½
100 kg	220 lbs	10

Contra-indication

None have so far been established.

Precautions

The simultaneous exposure of patients under Bilarcil treatment to substances inhibiting cholinesterase may cause side effects. Such exposure occurs in patients handling or coming in contact with some compounds which are used e. g. for plant protection, eradicating insects or for anthelminthic treatment of animals. The simultaneous use of DDT does not impair Bilarcil therapy.
Should serious side effects occur following uncontrolled intake, the immediate administration of atropine sulphate is recommended, e. g. s. c. injection of 1 mg once or several times.

Presentation

Tins with 1,000 tablets of 100 mg

Keep in a cool place.
The contents of opened tins should be used as soon as possible.

Made by

Bayer Leverkusen, Germany

311454 e-fr.

® = Regd. Trade Mark

WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTÉ

WHO/VBC/75.573
WHO/SCHISTO/75.40

ENGLISH ONLY

NON-CHEMICAL METHODS OF SNAIL CONTROL

Appendix 5

by

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"It has been everyone's dream that he might set some mechanism in motion which through the enlistment of natural causes, would eventually lift the burden . . ."

Lewis W. Hackett, 1937
p. 23

1. INTRODUCTION

The reduction in numbers of undesirable organisms is essential to man's continued use of the earth to sustain his own numbers, but many of our methods are proving to be unacceptable from the standpoint of long-term goals. Whether disease-causing organisms, vectors, or crop destroyers, the popular methods of reducing their abundance have been called into question in recent years. Chemical methods which once seemed miraculous and which brought their inventors the highest scientific accolades have been attacked on several important grounds. It has been demonstrated that many target species have developed resistance to the chemicals. It has been shown that desirable predators and parasites of target species have suffered greater and more prolonged destruction than the target, with the result that the target species returns to an undesirable abundance ever more rapidly; it has been shown that species which formerly had been inconsequential have become important pests through the inadvertent destruction of their predators and parasites by the general application of broad-spectrum poisons; and it has been shown that persistent poisons are carried by ecological processes to many desirable species, and accumulated in them to destructive levels. The extent of many of these unforeseen effects is documented by DeBach (1974).

Thus, the pesticides, once viewed as panaceas, are increasingly regarded as mixed blessings at best used with caution in conjunction with other methods. It is true that the criticisms have rarely been made of the use of molluscicides specifically, but this is probably because they have never been used over large areas for long periods. There is no reason to suppose that the same or similar unfavourable results would not be obtained from intensive and prolonged use of molluscicides. None is specific to snails, much less to the intermediate hosts of schistosomes, and the general biocidal property is certainly undesirable, as is the potential for killing competitors of target snails.

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[1] Professor of Zoology, Director, Museum of Zoology.

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It is therefore of great importance that we seek alternative methods of reducing snail populations, as snail control has been an integral part of all successful programmes for the reduction of transmission of schistosomes.

The present report begins with a consideration of the factors to be considered in searching for non-chemical means of reducing snail populations.

Similarities and differences between snail control and the numerous instances of successful population reduction of insects and weeds must be considered.

These theoretical considerations will be followed by descriptions of the actual attempts that have been made. In each case, assessments will be attempted of the degree of success achieved, of the possibility of expanding the method, and where possible the cost of the operation.

2. THEORETICAL CONSIDERATIONS

2.1 Biological properties of snails relevant to control

The success or failure of a programme to reduce the abundance of any species depends upon certain fundamental ecological properties of that species, and upon the quantitative nature of its interactions with the other species in its environment, both the ones naturally there and the ones that are proposed to be added.

In conjunction with the non-living part of the habitat, these intrinsic properties and interspecific interactions determine the number of individuals of the target species present. All vary from species to species and from one situation to another. Thus, exact general predictions are not possible. However, certain principles can be claimed from a consideration of the various factors.

There is a very large ecological literature dealing with the relative importance of different factors in determining the abundance of species in nature. It is quite impossible to do more than to give the interested reader references which will permit an entry into the literature on limiting factors. Among numerous recent texts Collier et al. (1973) and Krebs (1972) give well-balanced accounts; monographs by May (1973) and Maynard Smith (1974) are noteworthy: and the symposium edited by den Boer & Gradwell (1971) records some illuminating discussions.

2.1.1 The carrying capacity of the environment

It is axiomatic that for each species in each habitat there exists a theoretical maximum number of individuals that can be supported by the resources available. The degree to which this carrying capacity is approached in nature has been the subject of intense debate in the ecological literature. A reasonably balanced account is given in two papers by Huffaker & Messenger (1964a,b). Some ecologists maintain that the carrying capacity of a habitat is approached closely enough in many instances to provide a strong negative effect on population growth rates. Others are of the opinion that unfavourable events, such as severe weather, occur sufficiently often to keep numbers at such low levels that population growth is unaffected by the hypothetical carrying capacity.

Resolution of the controversy has not been as easy as it might appear, for several reasons. The first of these is that unlike the mathematical models that are ordinarily used, nature provides no assurance that the carrying capacity remains constant. Thus, severe weather might reduce this parameter as well as directly reducing the numbers of the species involved. A second problem concerns the proportion of saturation that a species must achieve for negative effects to be apparent. The most commonly applied model of population growth, the logistic equation, requires negative feedback of population growth rate at all levels of density, and this has been demonstrated in the closed microcosms of laboratory experiments. Field data are less easily interpreted.

A third problem connected with carrying capacity concerns the influence of predators and parasites. Some workers have held that the influence of these enemies, being part of the environment, should be included in an assessment of the carrying capacity, because they do control the abundance of their prey and thus set an effective limit (capacity) to the prey's environment. We believe, however, that predator-prey relationships are best considered independently of the carrying capacity, in spite of the fact that food supply and predation can work jointly to determine population size (Slobodkin, 1960; Slobodkin, Smith & Hairston, 1967).

Regardless of the difficulties of measuring the carrying capacity of the environment, it is necessary to deal with it conceptually, because the introduction of a competitor species to reduce a population would have no chance of success unless it had the effect of reducing the capacity of the environment for the target species. Moreover, at least two studies on snails have given strong indications that the population was near the limit that the habitat could support. Pesigan et al. (1958b) showed that Oncomelania hupensis quadrasi, the intermediate host of Schistosoma japonicum in the Philippines, had remarkably constant population densities in each of 10 habitats that were sampled bimonthly for two years. The differences between habitats were highly significant and consistent over time. Thus, the authors concluded that weather had little or no direct effect on population density, as it would have affected all populations alike. These observations, in conjunction with a strong negative relationship between reproductive rate and survival, and the absence of significant predation or parasitism, indicated populations at or close to the carrying capacities of the respective habitats.

The second example was an experimental field study of the pond snail, Lymnaea elodes by Eisenberg (1966). After placing pens in a habitat and manipulating densities of adult snails in the spring to 5 times and 1/5 control densities, he showed that the number of young snails produced per pen was not significantly different among treatments. A separate experiment involving the addition of food showed that production of young could be increased dramatically. Thus Lymnaea elodes was normally at densities close to the limit set by its food supply. Unlike the Oncomelania example, the population showed marked seasonal changes in abundance, suggesting strongly that the carrying capacity itself varied in a regular way. The population, therefore, was apparently "tracking" this limit set by the food supply.

Seasonal variations in population density, which have often been correlated with weather conditions (Shiff, 1964; Webbe, 1962; Dazo et al., 1966; and many others) are shown by this example not to rule out a relationship to the carrying capacity of the environment.

The significance of the carrying capacity for any attempted reduction in the population, including biological control, is clear. In principle, a population close to the capacity of the environment to support it will be more affected by the successful introduction of a competitor than will a population held by other factors well below the carrying capacity. There are further implications from the relationship between density and population growth rate. These will be discussed below.

2.1.2 Reproductive capacity of the population

The ability of a population to increase following either a major natural decimation or a deliberate one is an important attribute. Its magnitude should be known for both theoretical and practical reasons in considering means of reducing populations of undesirable species.

It is universally agreed by ecologists that the most useful measure of this ability is the intrinsic rate of natural increase - an instantaneous rate at which the population would grow provided it were at the hypothetical stable age distribution, and provided it were not influenced by changes in its own numbers - or in other words, under density-independent conditions.

This parameter can be calculated from a knowledge of the survival of individuals to each age, and of the production of young (eggs or live-born) at each age, provided that the observations are made under conditions free of the influence of the density of individuals. The method of calculation and its assumptions were devised by Sharpe & Lotka (1911). A good description of its rationale is to be found in Slobodkin (1961). It has been applied to many kinds of organisms and values for several species of snails are given by Hairston (1973).

The intrinsic rate of natural increase is the most accurate measure of the relative favourableness of different physico-chemical environments for a species, and it thus provides an exact assessment of the conditions under which a population can or cannot maintain itself (Birch, 1953).

The magnitude of the maximum value of this parameter for any species has been determined by the evolutionary history of that species (Hairston, 1973). Species which have been subjected to conditions close to the carrying capacity of the environment tend to have lower values than do those whose populations have been subject to frequent decimations through drastic changes, as by disastrous weather conditions occurring at unpredictable times. The ability to rebound quickly from such conditions would be of obvious advantage whereas a population under closer dependence on the carrying capacity of the environment would tend to be selected for ability to retain the resources (MacArthur & Wilson, 1967; Hairston, Tinkle & Wilbur, 1970).

The example of Eisenberg's study of Lymnaea elodes shows that the dichotomy may not be as straightforward as has just been suggested. That population would have a high value for the intrinsic rate of increase through being selected to follow closely a rapid change in the carrying capacity. A high rate of increase therefore does not necessarily mean that the population is kept below the carrying capacity for a large fraction of the time. A low value, however, is likely to characterize a population that remains close to a largely stable carrying capacity.

In terms of attempted reductions in a population, the intrinsic rate of natural increase is a nearly perfect predictor of the events subsequent to the application of a short-term measure, or to the ability of the target population to recover quickly from a failure of a biological control agent to continue its effectiveness.

2.1.3 Interactions with external factors

2.1.3.1. Competition

From the preceding sections, it is easy to visualize the size of the population at any time as having been determined by the interaction of its capacity to increase and factors external to the population. For many species, the most important feature is the carrying capacity of the environment, and recent ecological literature has stressed it almost to the exclusion of other factors. In fact a whole theory of biological community structure has grown up on the assumption that carrying capacity, through its enforcement of intraspecific and interspecific competition, is solely responsible for the abundance of the different species involved (Levins, 1968; MacArthur, 1972; MacArthur & Wilson, 1967; Vandermeer, 1969; and many other authors).

Competition, thus, is of major importance in determining the abundance of many species. It follows that the successful introduction of a competing species would reduce the population of the target species.

Indeed, if the requirements of the two species are sufficiently alike, and if the introduced species is really superior to the target species in obtaining the requirements, ecological theory predicts the complete elimination of the target species. This theory is now called the principle of competitive exclusion, but was known by several other names in the past.

A particularly well-documented example of competitive displacement following an introduction is that of three species of Aphytis into California (DeBach and Sundby, 1963; DeBach, Rosen, & Kennett, 1971). Aphytis is a genus of hymenopteran parasites of scale insects. A. lingnanensis was introduced in 1948 as a means of controlling red scale of citrus. It proved to be effective, especially in coastal areas, and incidental to its spread over the citrus-growing parts of the state, it virtually eradicated the pre-existing population of A. chrysomphali - also a parasite on red scale, but one which was ineffective in controlling the population of the pest. In 1957, a third species, A. melinus, was introduced. It proved to be highly effective in reducing populations of red scale, especially in inland areas, where it rapidly displaced A. lingnanensis. This is a convincing example of competitive displacement, but the principle has been applied intentionally in only a few instances, and with either equivocal success or none at all. The examples of attempted competitive exclusion having to do with snails will be treated in a later section. The most carefully prepared attempt to use competitive exclusion is the introduction of Aedes albopictus on one of the Marquesas Islands in order to displace Aedes polynesiensis, the vector of filariasis (see DeBach, 1974). This introduction was preceded by studies of the two species in competition in the laboratory (Gubler, 1970a, b, & c; Rozeboom, 1971; Lowrie, 1973a & b; Ali & Rozeboom, 1973). Factors contributing to the competitive superiority of A. albopictus were determined, and many tests were performed to ensure that A. albopictus, if successful, would not interbreed with the indigenous species nor inadvertently transmit any other local disease agent.

The results of this important experiment are awaited with much interest, not only because of the practical potential, but because the conditions and purposes differ so greatly from the well-known successes in controlling agricultural pests by the introduction of biological agents. The first important difference has already been mentioned. It is the use of competition, rather than predation, to eliminate an undesirable species. It is unlikely that competitive displacement of an agricultural pest is ever desirable, as the winner in competition is almost certain to be at least as serious a pest as the species it displaced. In theory, such is not necessarily the case with carriers of disease organisms, because effective competitors need not be satisfactory hosts of the disease organisms that are the ultimate object of attack.

The second important difference between the present example and the typical success story in agriculture is the attempt to displace an indigenous species from its essentially undisturbed habitat. In the agricultural context, native species have become pests, and some of them have been controlled by introduced biological agents, but they were attacking agricultural plantings, and were not in essentially undisturbed habitats.

The principles of evolution would seem to work against success in the introduction of a competitor against an undesirable native species that has evolved to be adapted not only to the climate and other physico-chemical parts of its environment, but also to the innumerable species of plants and animals that constitute its biological environment. Under such conditions, the introduced competitor would have to be pre-adapted to maintain itself under the prevailing conditions, as well as being superior in direct competition with the undesirable species.

Despite the theoretical difficulties and the paucity of examples of intentional introductions of competitors, the number of successful introductions for other reasons is impressive, particularly on oceanic islands. The fact that many of these have had undesirable consequences may have contributed to a hesitancy in attempting introductions of competitors. Given careful preliminary research of the kind carried out by Rozeboom and his colleagues, however, such introductions are to be encouraged.

There appears to be a valid reason for the ease of introductions onto oceanic islands as contrasted with continents, where nearly all introduced species are confined to habitats disturbed by man. Continental species must be adapted to a much larger array of coexisting species than are those native to oceanic islands (MacArthur & Wilson, 1967), and hence it is much more unlikely that a foreign species will be strong enough competitively to maintain itself in the natural communities of continents than it is in the case of island communities.

2.1.3.1.1 Warnings on introductions of competitors

The attempted introduction of any species into a foreign environment is most likely to end in failure, for the reasons given above. Once such an introduction succeeds, it is difficult to predict all of the effects, and the frequency with which these effects have been undesirable serves as a warning that the properties of the introduced species should be thoroughly studied before any introduction. In snail work, the classic example of inadvertent damage is that of the Giant African Snail, Acatina fulica. Its rarity in Africa is not at all indicative of its potential in other areas, most notably the Pacific Islands, where it is a pest of major proportions (Mead, 1961). Moreover, few if any people are able to use it for food - one of the original purposes of its introduction.

A second potential danger from the introduction of snails derives from the fact that parasites of much veterinary importance are also transmitted by snails, and careful preliminary work on this possibility should precede any introduction.

A final, and largely hypothetical source of concern comes from the following consideration. When a group of species is competing, the successful introduction of an additional competitor can only decrease the populations of those species already present, and hence cannot be beneficial to the target species. This result is theoretical, however, and occurs provided that no higher-order interactions take place among the members of the community. Thus, if the target species and the introduced species had a combined detrimental effect on one of the original competitors of the target species, the result of the successful introduction of a new competitor might not be the one intended. Such results are not purely hypothetical, as is shown in the experimental communities of ciliate protozoa described by Hairston et al. (1968). Harm to the target species can thus not be guaranteed, even by the successful introduction of a competitor.

2.1.3.2 Predation, including parasitism

The second kind of interaction with the environment which serves to lower the size of populations is predation. Given a predator or a parasite population which responds either numerically or behaviourally to an increase in the abundance of prey, the population of the prey will be held to a lower level than it would be in the absence of the predator.

The key part of the foregoing statement is the implication of a denisty-dependent relationship between prey and predatator populations. A great deal of theoretical-mathematical effort has been spent on this subject (Lotka, 1925; Volterra, 1926; May, 1973). Laboratory experiments seem to support various aspects of the theory (Gause, 1934; Huffaker, 1958; Luckinbill, 1973, 1974), in that stable or unstable oscillations of prey and predator populations are produced. In the field, events are less predictably oscillatory, and the successful introduction of a predator or parasite has frequently led to straightforward reduction in prey populations (DeBach, 1974).

Based on a very large amount of experience, DeBach (1974) has developed a series of characteristics that are typical of effective natural enemies of undesirable organisms. As it is rare to have such a compact synthesis, his conclusions and recommendations are given verbatim:

(1) Exotic pests are obviously suitable subject for biological control by importation of natural enemies, but native pests also have been controlled by imported enemies and should receive serious consideration. Effective natural enemies may be obtained abroad from either the target pest or from species related to it or from the same type of mirohabitat.

(2) The ultimate success of a given natural enemy candidate for importation cannot be accurately predicted in advance, but we can find and select good probabilities. The effectiveness of natural enemies can be evaluated - experimentally or otherwise - in the country where they occur and their potential estimated. An effective natural enemy can be

deduced to have the following characteristics: (a) high searching ability, (b) high degree of host specificity or preference, (c) good reproductive capacity relative to the host, and (d) good adaptation to a wide range of environmental conditions. The most essential characteristic is high searching ability. It should be borne in mind that a really effective enemy may be scarce in its native home because it regulates the host population at low levels.

(3) A really effective natural enemy becomes established easily and rapidly if correctly handled; usually the first year. Intensive and continued research effort should not be wasted on ones that do not. Rather, additional species or strains of species should be sought. Complicated and expensive programmes are not necessarily required to achieve successful results.

(4) Multiple importation, either simultaneously or chronologically, of diverse natural enemy species is the only practical manner of obtaining the best natural enemy for a given habitat, or the best combination for the entire host range.

(5) Multiple importation of similar species of enemies is not ecologically unsound because competition between natural enemies normally is not detrimental to host population regulation; in fact, the displacement of a fairly effective established enemy species by another imported species means that the second one is even more effective and will produce even better host population regulation. Although competing natural enemy species may affect the individual efficiency of each other, their combined effect in host population regulation is greater.

(6) There usually is one best enemy for each pest species in a given habitat, and one frequently is sufficient for complete biological control. Often, however, a second or third enemy species may add to host population control. The best enemy species may differ for different host habitats; hence there is generally no single best natural enemy extending throughout the range of a pest species. Therefore, all natural enemy species of any promise should be imported and each one colonized in all of the different habitats within the range of the pest species.

(7) The best natural enemy may not be found until all natural enemies a[illegible] hence basic studies in biosystematics are of utmost importance and need in[illegible] and support. Current knowledge is woefully inadequate.

(8) The genetics of natural enemy populations needs to be taken more into [illegible]ration. Collections should be made over the range of a species with the view of obtaining [illegible]er distinct races or ecotypes which would best fit the host and the new environment, o[illegible] of obtaining sufficient genetic variability among the imported stocks so that natural selection would result in the best fit becoming established.

(9) From a practical standpoint, long-term basic ecological research on a "real" pest species need not precede importation of new natural enemies. Such studies are not likely to help a really effective enemy and obviously the enemy cannot effect control unless it is imported. Any delay in discovery, importation and colonization of a really effective natural enemy merely lengthens the period that the pest species remains a problem.

(10) No geographical area or crop or pest insect should be prejudged as being unsatisfactory for biological control attempts. The wide variety of successful results now obtained from importation of natural enemies suggests that nearly anything is possible.

(11) Direct pests (i.e. one that at low population densities directly damage the marketable item, such as fruit) are suitable objects for biological control but the probabilities for success may be somewhat lower than with indirect pests which can exist at higher population densities without causing economic damage.

Appendix 5

Habitat alteration has certain advantages over all other methods of reducing populations of undesirable species. These advantages can be enumerated as follows:

(a) Habitat alteration has as much an effect on native species of undesirable organisms as it does on introduced species, in contrast to the effect of introduced parasites or especially competitors, for which the chances of success are low.

(b) In many instances of habitat alteration, there are beneficial side effects, the most outstanding examples being the increased usefulness of the land.

(c) The effect of habitat alteration is limited to the immediate area involved, and should it prove undesirable, there is no danger that the effect will spread, such as is the case with introduced competitors or predators.

There are also disadvantages of habitat alteration relative to the introduction of enemy organisms:

(a) The expense of many kinds of alterations is great, and there is a continuing expense of maintaining such features as drainage ditches and flushing siphons. This disadvantage is somewhat negated by agricultural benefits.

(b) There are some situations where it is impractical to alter the favoured habitat of an undesirable organism. An example would be large irrigation canals, which cannot be piped, although that is feasible for some smaller canals.

(c) In contrast to the introduction of parasites, predators or competitors, alteration of habitats is not self-generating.

2.1.4 Genetic manipulation

In a few instances, spectacular success has been obtained in eliminating populations of undesirable species by genetic means. All examples known to date involve insects. The method involves the liberation of very large numbers of sterile males relative to the number in the wild population. In most examples, the introduced males have been previously sterilized by radiation. In one instance, use was made of a naturally occurring stock in which the males were cytoplasmically incompatible with the local females.

The universal practical requirement of overwhelming a population genetically with sterile males appears to eliminate the possibility of using this approach in the case of any schistosome except *S. japonicum*, as the intermediate hosts of the other human parasites are all hermaphroditic.

Oncomelania, the intermediate host of *S. japonicum* does have separate sexes, but the populations that have been studied carefully (McMullen et al., 1951, Pesigan et al., 1958) did not exhibit numerical fluctuations of a sufficient magnitude to make the "sterile male" technique attractive as a potential control measure.

2.1.5 Non-susceptible strains

Infection with schistosomes is damaging to snails, as it increases the death rate by a factor ranging from 1.3 to 3.5 (Hairston, 1973), and decreases egg-laying to around 20% of that achieved by uninfected snails (Pesigan et al., 1958).

From these figures, it is easy to conclude that a genetic strain resistant to the parasite, but alike in other respects, would have a strong selective advantage over the susceptible strain. Inasmuch as local strains of snails vary widely in their susceptibility to schistosome infection (DeWitt (1954), Hsü & Hsü (1960, 1967, 1968), Files & Cram (1949), Barbosa & Barreto (1960)), it might appear anomalous that receptive strains should continue

to exist. The obvious explanation is that the parasite is not without evolutionary capability, and is doubtless constantly adapting to changes in host susceptibility. Also, resistance to the parasite may have other effects on the biology of the snail, and these may cause selective disadvantages.

The existence of non-susceptibility is interesting, but at present there appears to be little practical use that can be made of the phenomenon. Genetic analyses of susceptibility have been carried out on Biomphalaria glabrata (Richards, 1970, 1973; Richards & Merritt, 1972) and Oncomelania hupensis (Davis & Ruff, 1973). The results indicate that a number of loci are involved.

Inasmuch as non-susceptible strains interbreed freely with susceptible ones, the result of their introduction into natural populations would most likely be that they would be swamped genetically by the local strain. It is conceivable, of course, that the non-susceptible strain would spread through the selective advantage discussed above and might thus be of value in disease control. Unlike competitor or predator species, non-susceptible strains would not have the potential for making matters worse than before their introduction. The overall prospects for effective control of schistosomiasis by this means appear to be poor.

3. SNAIL POPULATION REDUCTION BY HABITAT ALTERATION

3.1 The Philippines - drainage, ponding, filling, and improved agriculture

The only non-chemical method of snail control that has been assessed in a scientifically acceptable manner with regard to its effect on the transmission of schistosomiasis is habitat alteration. The most thoroughly documented example is that of the joint WHO-Philippines project on the island of Leyte.

Over the period of 1954-56, the Project personnel devised a series of naturalistic measures for the control of Oncomelania hupensis quadrasi, the snail that serves as intermediate host for schistosomiasis in the Philippines. The measures devised involved radical alterations of the habitat, making it unsuitable for the survival and reproduction of the snail (Pesigan et al., 1958c). The kinds of alterations that were attempted were based on thorough ecological studies of the snail over a two-year period (Pesigan et al., 1958b). O. h. quadrasi is an amphibious snail laying its eggs singly at or very near the water line. The newly hatched snails require a period of up to 10 days of purely aquatic life, and thereafter spend over half of their existence out of water, but close to it. Most habitats contained dense emergent vegetation; some were only shaded by large shrubs and trees. Whether small seepage areas, extensive rice fields, grass-choked streams or swamps, all habitats were characterized by gently flowing, or oozing water. Standing water did not support the snails.

Drainage of habitats was an obvious measure, and was most successful when the drains intercepted the water where it appeared aboveground. Instead of being distributed over a whole field or swamp, the few snails remaining after drainage were confined to the sides of the drainage ditch.

A less obvious method of dealing with habitats that could not be drained was to convert them into stagnant ponds. From the practical standpoint, these were converted into fish ponds. Snails were unable to reproduce satisfactorily under this condition.

The third approach was to change the rice planting pattern from the haphazard one employed to a regular spacing as recommended by the U.S. Department of Agriculture. This further permitted removal of the weeds that provided protection for snails.

Properly implemented, all of these measures gave marked reductions in the number of snails (Pesigan et al., 1958c, Hairston & Santos, 1961). In most instances, the reduction

was eventually to 1% or less of the initial density. Care was taken to follow untreated control areas in all of the early experiments, and these showed remarkably constant populations, fluctuations rarely exceeding 15% of the initial population.

In 1956, after preliminary experiments were completed, an attempt was made to interrupt transmission of schistosomiasis in the whole municipality of Palo, Leyte, by the methods that had been devised. Not all habitats could be attacked simultaneously, but by the end of 1957 an important impact had been made on the total snail population of the area, and by July 1959, there were only 14.3% as many snails as had been in the area originally (Hairston & Santos, 1961). Omitting four large habitats where no control was attempted, the reduction was to 5% of the initial density.

The effect of this reduction on the transmission of schistosomiasis was measured by comparing age-prevalence data from 1954 (before any control was started) with data taken in the same way in 1959. Children under 10 years old (the group most sensitive to changes in transmission) showed a significant reduction in prevalence (Pesigan & Hairston, 1961). Moreover, it was shown that the overall change in the age-prevalence curve was close to what would have been expected had the snail control measures been completely effective in stopping transmission. The adjacent untreated municipality of Tanauan was also surveyed in 1954 and 1959, and there, the prevalence of schistosomiasis in children under 10 showed a slight increase in prevalence, which was statistically non-significant.

Thus, the appropriate requirements of experimental design had been met, and it is safe to conclude that the snail control measures had been effective in interrupting transmission of schistosomiasis.

3.1.1 Costs and benefits

The cost-benefit analysis of this project is complicated by the experimental nature of the work, and the sometimes poorly quantifiable benefits of improved land use.

There can be no question that the cost of habitat alteration is high. In 1956, for example, drainage cost around US$ 70 per hectare, while fish-pond construction was around US$ 1250 per hectare (Pesigan et al., 1958c). The areas treated, of course, were only those actually containing snails, and amounted to a relatively small fraction of the total. The consensus was that agricultural benefits had to be taken into account in order to help justify the cost. Some of these benefits were substantial. The rice yield approximately doubled that obtained by the previous routine, when the two methods were compared in a carefully controlled experiment. The added monetary value of drained land was less easily calculated, but there was no doubt about an increase in productivity. The cost of not controlling the disease has been calculated in a number of different ways. These are discussed by Macdonald & Farooq (1973), who conclude that the Philippines national plan for schistosomiasis control would be a profitable investment, since it was projected to cost less than 10% of the annual cost of the disease.

3.2 Israel - Control of water and of aquatic vegetation

Israel is a special case among countries dealing with aquatic hosts of schistosomes, because it represents a highly technical culture introduced into an endemic area. Little transmission of schistosomiasis has taken place since the mass immigrations of the early 1950s (Saliternik & Witenberg, 1959; N. Gil, personal communication). The success in preventing transmission cannot be attributed solely to non-chemical methods, as molluscicides were used in various places, and extensive public health education was also important. Nevertheless, water control has played an important part.

3.2.1 Irrigation water

The importance of conservation of water in Israel has been a significant if inadvertent factor in restricting the breeding of Bulinus truncatus, the intermediate host of Schistosoma haematobium. Most irrigation water is distributed in pipes, and in those cases where open ditches are used, they are concrete-lined, and the water flows rapidly (more than 20 cm per second) and intermittently as other parts of the system are irrigated (Wittenberg & Saliternik, 1957). These arrangements have restricted the habitats to natural stream courses, drains, ponds and other reservoirs, plus a few very local places where the irrigation system has leaked. Continuous surveillance, combined with a vigorous health education programme, has prevented these places from becoming sites of transmission.

3.2.2 Removal of aquatic vegetation

Most authors on the subject have given evidence that several species of aquatic plants improve the habitat for both Bulinus truncatus and Biomphalaria alexandrina, the intermediate host of Schistosoma mansoni in the Eastern Mediterranean Region (see Dazo et al., 1966 for example). In Israel, removal of aquatic plants is stressed, and in one instance, the introduced water hyacinth, Eichornia crassipes, was eradicated by mechanical means. This operation also, in combination with increasing pollution, resulted in the the total elimination of Biomphalaria from its only known habitat in the country.

3.3 Puerto Rico. Manipulation of water levels.

The habitats of some mosquitos have been made unsuitable through rapid changes in water levels in impoundments. The method was spectacularly successful in the lakes of the Tennessee Valley Authority, where growth of rooted aquatic plants has been prevented completely, leaving wave-swept shorelines that are unsuitable for the larvae of Anopheles quadramaculatus.

It is natural that attempts should have been made to eliminate snail populations in the same way. In the Philippines the impoundments on which the method was tried were too small for effective fluctuations (Pesigan et al., 1958c).

The only documented example of the control of snail populations by this method is that reported by Jobin (1970) in Puerto Rico. Following laboratory experiments on appropriate rates and timing of drawdown (Jobin and Michelson, 1969), control of Biomphalaria glabrata was achieved in a small reservoir.

The ultimate effectiveness of this method will probably depend upon the duration for which water must be stored. Thus, in an area with dependable rainfall or brief dry seasons, the loss of water involved in stranding snails would not be important, but where water lost cannot be recovered for months, it can probably not be spared, nor could the necessary return of the water to a higher level be achieved.

3.4 China - relocation of canals

The assessment of achievements in the People's Republic of China is made difficult by the absence of common standards in reporting, and the following comments might have to be revised upon the receipt of more detailed information.

The elimination of schistosomiasis has been stated to be one of the country's goals, and among the methods used is extensive habitat alteration. The most impressive measure taken has been the relocation of irrigation canals in endemic areas, and the filling of the old, snail-infested waterways.

Given the degree to which the population is mobilized, the achievement appears to be distinctly possible, and from the knowledge of the ecology of Oncomelania hupensis in the

Philippines and Japan, it is very likely that the measures would be effective, at least temporarily. The situation is such, however, that infestation of the new canals would appear highly probable. If it were possible, it would be highly desirable to obtain an independent assessment of the current state of affairs in this important endemic area.

4. SNAIL POPULATION REDUCTION BY THE INTRODUCTION OF COMPETITORS

Among attempts to use biological control methods against the intermediate hosts of schistosomes, by far the greatest effort has been made in the introduction of competing species of snails. In the present report all snail species used against schistosome vectors will be called competitors, acknowledging that at least part of the effect may be through predation.

4.1 Marisa cornuaretis

This large ampullarid snail was introduced into Puerto Rico from South America around 1950. As far as is known, the introduction was unintentional.

4.1.1 Puerto Rico

By 1955 the influence of Marisa on Biomphalaria glabrata had been observed and had been evaluated in the laboratory (Oliver-Gonzalez et al., 1956; Chernin et al., 1956). The effect of Marisa on the intermediate host is two-fold: as a competitive feeder, and as an incidental predator on the eggs and newly-hatched young.

Field trials followed, and despite flawed experimental design and other difficulties, a sufficient mass of evidence was accumulated to demonstrate the effectiveness of Marisa in certain ecological situations, specifically ponds (Radke et al., 1961, e.g.). Marisa does not eliminate Biomphalaria from swamps, streams or irrigation canals (see Ruiz-Tiben et al., 1969, and Palmer et al., 1969), but it has been an effective and important part of the overall campaign against Biomphalaria in Puerto Rico (Jobin et al., 1970). Among the habitats where this form of biological control has been successful are irrigation night-storage ponds, which in Puerto Rico and in Africa are important in maintaining populations of intermediate hosts (McMullen, 1973). Fluctuating water levels in these reservoirs, following daily demand, has made them less attractive to Marisa than are more stable ponds, but the difficulty was overcome by regular inspection and reintroduction (Ruiz-Tiben et al., 1969).

It is important to comment that persistence of effort is necessary in the use of Marisa, as it is with other forms of control of intermediate hosts. Of the 111 night storage ponds of Puerto Rico, discussed above, 10 still contained B. glabrata after five years of effort, and inspection showed that reintroduction of Marisa was necessary in 22-41 ponds in different years after 2/3 of them were judged under control by this means (Ruiz-Tiben et al., 1969).

4.1.1.1 Cost analysis

The harvesting of Marisa from natural habitats and their distribution into Biomphalaria-infested waters has been the subject of two independent analyses (Ruiz-Tiben et al., 1969; Jobin et al., 1970). In each case, the cost of labour and automotive transport was calculated to be around US$ 0.03 per adult snail transplanted. At the densities of Marisa which were found to be effective, this effort was estimated to cost about 30% of the cost of treating the same ponds with the best molluscicide.

It should be noted that in the well-documented study of Jobin et al. (1970), the supply populations of Marisa were able to sustain a weekly removal of large adults amounting to one per 43 m^2 of water surface, or one per 4.55 m of shore line. No detectable diminution of the number available was observed during the 22 weeks of the study.

Benefits obtained can only be assessed through the destruction of Biomphalaria, as molluscicides were used in habitats of the kinds not suitable for the use of Marisa. Moreover, the prevalence of schistosomiasis declined throughout Puerto Rico during the period of control effort (1954-1966), regardless of whether specific efforts were made at control (Jobin et al., 1970). Thus the amount of benefit achieved, in terms of effort expended, is not specifiable.

It should be stated that in Puerto Rico there have been no reported injurious effects of introducing Marisa, although various warnings have been given on the possibility that it might damage young aquatic crop plants, as has been reported for other ampullarids in Africa.

4.1.2 Egypt

The success reported from Puerto Rico has prompted several proposals to use Marisa elsewhere. The only such project which has been adequately prepared for or properly reported is the work done in Egypt. Laboratory studies demonstrated that Marisa is a voracious predator on each of the three local snail species of medical or veterinary importance (Bulinus truncatus, Biomphalaria alexandrina and Lymnaea cailliaudi). The predator attacks not only eggs and young, but fully adult specimens of each (Demian & Lufty, 1965a, b, & c).

In addition to these studies, another most important piece of laboratory research was performed. This was the test of the extent to which Marisa would feed on a large number of species of plants, including aquatic pests and a large number of terrestrial species, both beneficial and harmful (Demian & Ibrahim, 1969). The plants found acceptable to the snails included eight species of floating and rooted submerged aquatics, plus 30 species of soft-leaved terrestrial dicotyledons. The snails did not feed satisfactorily on any terrestrial or semiaquatic monocotyledons (18 species) and they also rejected 21 species of terrestrial dicots, many of which produce noxious chemicals. Of special interest in this study was the failure of Marisa to accept rice plants, and although Demian and Ibrahim are cautious about full acceptance of the result, rice had been a specific source of concern in evaluating the potential effects of introducing such a voracious feeder.

The next step was to test the effect of Marisa on populations of undesirable snails under conditions approaching those in the field, but in situations designed to prevent its escape, should its introduction prove to be unwanted.

In a series of small experimental canals, well designed to prevent the escape of Marisa, the results were the same as they had been in the laboratory (Kamel, 1973). Bulinus truncatus was completely eliminated, regardless of the relative initial densities or of the season in which the experiment was begun. Control populations of B. truncatus continued to flourish.

These experiments seem to have removed any objections to full field trials in Egypt, but Marisa should be tested equally carefully in Africa south of the Sahara before its practical use is attempted.

4.2 Helisoma duryi

Ram's Horn snails of the genus Helisoma are popular for use in fresh-water aquaria. These planorbids are well-adapted to aquarium life, and anecdotal reports have been made from time to time of their displacing other species (Rasmussen, 1974). Helisoma duryi is the species that has drawn the most attention, due to the vigorous efforts of Dr G. Mandahl-Barth of the Denmarks Aquarium.

The species was brought to Egypt, and introduced into an outdoor concrete-lined pool which had been used to maintain a supply of Bulinus truncatus and Biomphalaria alexandrina.

One year later, H. duryi was abundant in the pond, had spread to three others, and had eliminated the two species of intermediate hosts from all of them (Abdallah & Nasr, 1973; Rasmussen, 1974). No controls are reported, and no experiments were carried out in canals or other flowing water, which characterize the normal habitats of B. truncatus and B. alexandrina in Egypt. The more or less casual observations must be regarded as inconclusive for control of vectors.

The proponents of the use of H. duryi, however, felt sufficiently encouraged to carry out further experiments in Tanzania. The first experiment, an introduction into a pond near Mwanza, ended inconclusively as far as Biomphalaria pfeifferi was concerned, both species disappearing during a drought.

The second introduction of Helisoma was into a series of experimental canals near Moshi. The data presented do not indicate that any reasonable experimental design was used, as there is no indication of what either Helisoma duryi or Biomphalaria pfeifferi would have done in the absence of the other species. Both species persisted throughout the study, and there was a general trend towards an increase in abundance of both species in all canals. No convincing evidence is available to show that either species had any effect on the other.

The foregoing interpretation is at variance with that of the original author (Rasmussen, 1974), whose discussion indicates encouraging results.

4.3 Pomacea haustrum

A second species of ampullarid snails has been investigated in Brazil by Andrade (1969) and by Paulinyi & Paulini (1970). Pomacea haustrum appears to act in much the same way as Marisa against Biomphalaria glabrata. As far as we know, field experiments have not been attempted. The natural distribution of P. haustrum is over much of South America. It thus appears probable that increasing its natural abundance will be difficult, except for introducing it into newly created habitats which it has not reached.

4.4 Potamopyrgus jenkinsi

This minute hydrobriid snail has been proposed as an agent for the control of Bulinus truncatus (Doby et al., 1965). The proposal was based on the observation of its having apparently displaced B. truncatus from a number of habitats on the island of Corsica, and on its rapid spread over the continent of Europe. No follow-up is known to us.

4.5 Bulinus tropicus

Like Helisoma, Bulinus tropicus has been observed to displace Bulinus truncatus in laboratory aquaria; and its use as an agent of biological control has been suggested (Mandahl-Barth, 1965). There are some features of its ecological distribution which suggest a complementarity with other members of the B. truncatus group of species. It is known to be a host of Schistosoma bovis, however, and thus caution is indicated where cattle are important. Alves (1956) has provided a description of an accidental field experiment in Rhodesia in which B. tropicus displaced B. (Physopsis) globosus. The result was only temporary, however, and B. tropicus was eventually displaced itself, with B. globosus returning to its former abundance.

4.6 Tarebia granifera

This thiarid snail is in the same category as Pomatopyrgus. It has been observed to spread in Puerto Rico, and in some areas there has been a decrease in abundance of Biomphalaria glabrata. Tarebia, however, is a satisfactory host for Paragonimus westermani, and its use as a biological control agent is not recommended (McMullen, 1973).

5. SNAIL POPULATION REDUCTION THROUGH THE INTRODUCTION OF PREDATORS

There exist in the literature a great many casual observations of predation on snails by many different species of animals. Ferguson (1972), for example, lists some 32 examples of predation, documented by more than 40 references. Some of them are obviously pathological results of confinement in aquaria; others are of no possible practical importance. Aside from Marisa, which Ferguson lists as a predator, only two examples have been the subject of sufficient study to warrant description in this report, and the reader is referred to Ferguson's paper for the remaining references. For analogues comments, see Levine (1970) and Berg (1973).

Similar remarks apply to the list of parasites, one group of which have been studied extensively, and is discussed below.

5.1 Snail-eating fishes

Snails are eaten by a number of species of fishes, and various authors have supported the use of fish in snail control. Inasmuch as fish ponds in many parts of the world constitute potential sites for transmission of schistosomiasis, the use of specific kinds of fish to keep down populations of intermediate hosts would be a major advantage.

Actual examples, however, are few, and are confined to Africa. De Bont (personal communication) reports that schistosome bearing snails were kept out of fish ponds in Zaire (then Belgian Congo) by the introduction of Serranochromis sp. (presumably S. macrocephala). The fish are palatable, and after consuming the snails are able to thrive on other aquatic life, so that a continuous population can be maintained (De Bont & De Bont Hers, 1952). Serranochromis is only one of a number of snail-eating fishes in Africa, and further work indicates that Astatoreochromis alluaudi may also be a potential agent for control of snails (Mvogo & Bvard, 1964), but data from East Africa are inconclusive (N. Ansari, personal communication). Doubtless the nature and management regime of the ponds in question would have an important bearing on the usefulness of these or other species of fish. The East African work, for example, was carried out in small impoundments, not intended to be managed as fish ponds.

The method could well be explored further, as there appear to be no potential ill effects, so long as the method is used within the natural distribution of the fish species in question. There are many examples of the unanticipated bad effects of the introduction of various species of fishes. The recent escape of the "walking catfish" in Florida is an example much to the point as members of its genus (Clarias) are stated by Mozeley (1951) to be predators of snails.

5.2 Snail-eating insects

The great majority of successful examples of biological control of undesirable species have involved the use of insects. This fact probably reflects both the effort of entomologists and the preponderance of insect species in part, but it also reflects the fact that insects have properties that increase the likelihood of their conforming to DeBach's (1974) list of qualities of good biological control agents. The power of flight and the tendency to specific foods combine to increase searching ability and specificity for a host, and they normally also have high rates of reproduction.

In theory, then, special attention should be given to insects that prey on snails.

5.2.1 Sciomyzid flies

These insects are highly specialized to feed on mollusks as larvae, and nearly all of the hundreds of species which have been investigated feed on gastropods. Interest in their use as agents of biological control was initiated by C. O. Berg (1953), and has been

sustained by him (Berg, 1959, 1961, 1964a & b, 1966a & b, 1973) and his students (Berg et al., 1959; Berg & Neff, 1959; Bratt et al., 1969; Fontana, 1972; Foote, 1959; Foote et al., 1960; Kaczynski et al., 1969; Knutson & Berg, 1963, 1964; Knutson et al., 1967; Neff, 1964; Neff & Bay, 1961, 1962, 1966).

Sciomyzids have properties that do not entirely coincide with DeBach's criteria. The adults of species that attack the aquatic snails that transmit schistosomes do not seek out the prey of the larva for egg-laying, as would be desirable for a predator with a high searching efficiency. The eggs are ordinarily laid on emergent vegetation, and the larvae must find snails on their own. Conversely, the species in which adults seek out larval prey and lay eggs on their shells are parasitoids of terrestrial snails. These species are also the most host-specific of the known sciomyzids.

Counterbalancing these disadvantages is the fact that the species feeding on aquatic snails kill many more prey during larval development than do the parasitoids, which kill a single specimen only.

An additional disadvantage of sciomyzids is the fact that they are most effective in shallow water or on mud. Eckblad (1973), for example, found significantly higher predation rates when the same number of prey were kept in water 0.5 cm deep than when the water was 10 cm deep.

Despite the difficulties, research on sciomyzidae should be encouraged, as many species remain unstudied, and it is likely that desirable properties may be found among them. Moreover, the demographic properties of the individual predator-prey systems are only beginning to be investigated (Geckler, 1971; Eckblad & Berg, 1972; Eckblad, 1973), and these studies provide an extra basis for rational choice of control agents.

One introduction of a sciomyzid species has been made in an attempt to control a trematode parasite. Sepedon macropus from Nicaragua was introduced into Hawaii in 1958 for the control of Fasciola gigantica. The flies are known to have become established, and to kill the intermediate host, Lymnaea ollula (Chock et al., 1961). The attempt was not accompanied by any quantitative studies, and a practical effect cannot be reported, either for the parasite or the snail host (Berg 1964b, 1973).

5.2.2 Other predaceous insects

Among the many species of insects that have been observed to feed on snails (Michelson, 1957; and Ferguson, 1972, give extensive lists), the only non-sciomyzid that has received more than cursory attention is the aquatic hemipteran Limnogeton fieberi, which was studied in Egypt by Voelker (1966, 1968).

The species is an obligatory feeder on snails, and in quantitative studies, required an average of 126 snails to grow from first instar to the adult stage. There appeared to be no specificity of choice by the bugs, and virtually all local species of freshwater snails were eaten. Biomphalaria alexandrina constituted about half of the total, most of which were consumed during the second half of the 6-7 week developmental period.

Inasmuch as Limnogeton is abundant in the Nile Delta, it is obviously not preventing the transmission of schistosomiasis, but such a voracious feeder on snails might possibly have a serious impact on populations of intermediate hosts, particularly outside its natural range in North and Central Africa.

It is necessary to call attention to the cautions given above (2.1.3.2.1) concerning the potential dangers of introducing predators. The cautions also apply to the Sciomyzidae.

6. THE USE OF NON-HUMAN TREMATODES AGAINST SCHISTOSOMES AND THEIR SNAIL HOSTS

The last 10 years have witnessed a large amount of careful and interesting research on the interactions of different species of trematodes infecting the same snails (see Lie, 1973, and Lim & Heyneman, 1972 for recent reviews).

The stimulus for this work was the demonstration that certain combinations of species of trematodes show marked antagonism between the larval stages in the same snail (Lie et al., 1965). The antagonism may take the form of direct predation by one species on the other, or may be indirect, operating by chemically-induced degeneration of the other species.

Happily for the experimenters, schistosome sporocysts are inferior to most redia-producing species, especially the echinostomes (Kuris, 1972). The idea was thus conceived that schistosome infection in snails could be eliminated in nature by massive infections with echinostome miracidia, which would be harmless to man or to animals important to man.

The work has progressed to the point where a number of small-scale trials have been carried out in the field in Malaysia and Thailand. Some of these field experiments have been successful; some have not (Lie et al., 1970, 1971, 1974a & b). In the experiments in which the schistosome (S. spindale, a parasite of the water buffalo) was eliminated, it was possible to achieve the very high infection rate of 70% of Echinostoma malayanum in the snail population. Where for one reason or another, this could not be achieved, negative results were obtained. One of the difficulties was caused by epidemics of a microsporidian hyperparasite in both trematodes. The microsporidia affects Echinostosoma more than Schistosoma, thus hampering the former. In successful experiments, the snail population was severely reduced, in addition to the direct affect on the schistosome. This is due to increased death rates and decreased fecundity caused by the parasites.

In an unsuccessful experiment in Thailand, the snail infection rate could only be raised to 51.5% (Lie et al., 1974b), despite the introduction over seven months of 596 million echinostome eggs into two ponds estimated to contain 13 000 snails. Failure to obtain a higher infection rate was attributed to the high turbidity and the loss of eggs in the silty bottom. The snail population was not measurably affected.

As intriguing as this approach to schistosome control may be, there are practical problems to its extension, and they may prove to be insurmountable. The results emphasize the necessity of achieving a very abnormal infection rate of the antagonistic species in snails (70% or more); and this is easily seen to be necessary on theoretical grounds. In order to achieve such rates, hundreds of millions of eggs were introduced into small ponds covering 77 m^2 to less than 1000 m^2. The calculated success rate of these eggs is unexpectedly poor, based on estimated population sizes and the assumption that the snail host, Indoplanorbis exustus, has an average survival comparable to that of Biomphalaria alexandrina in the field (Hairston, 1973). If the assumption is correct, the best experiments involved success rates of eggs of around 1-2% - slightly worse than natural success of eggs of Schistosoma japonicum (Hairston, 1962) or S. mansoni (Hairston, 1965).

Lim & Heyneman (1972) make the point that only about 30 rats were needed to keep the experiments going. Extrapolation is dangerous, but these involved snail populations of up to 8000 per pond. In Palo, Leyte, the standing crop of snails (Oncomelania hupensis quadrasi) was calculated to be around 107 000 000 (Hairston & Santos, 1961). Other factors being equal, using larval antagonism as a control measure in Palo would have involved a colony of rats numbering in the tens of thousands. It is clear that before the method can be considered to have practical value, the efficiency of the system must be improved many fold, and that will require a major research effort to find suitably efficient parasites and to develop mass culture methods.

7. RECOMMENDATIONS

Our comments in conjunction with the description of the methods that have been tried show the reservations that we have regarding the various methods of non-chemical control. We are unable to endorse any method in a completely unqualified manner. In addition to the evaluations, we have been asked to make recommendations for future research in this area. Accordingly, we recommend that:

7.1 The Organization promote research on means of making the effective habitat alterations and the improvements in land use more attractive to the affected branches of governments other than health departments. These include especially public works, land development and agriculture.

7.2 The Organization encourage research on costs and benefits of having irrigation water and irrigation drains placed in underground conduits, especially in areas of very intensive land use such as the Nile Delta.

7.3 The Organization sponsor research to resolve the question of potential damage by the snail Marisa cornaretis to either:

7.3.1 rice plants at any stage of growth or

7.3.2 to the native aquatic fauna and flora of other parts of Africa. The latter studies should be carried out with the same degree of precautions against escape that have been used in Egypt.

7.4 If rice plants are unharmed under Egyptian conditions, the Organization should sponsor field trials of the use of Marisa under natural conditions in canals and drains.

7.5 The Organization encourage search in the tropics of both hemispheres for sciomyzid flies or other obligatory snail predators having the following attributes:

7.5.1 High search efficiency for the intermediate hosts of schistosomes and

7.5.2 Greater effectiveness as predators in water more than a few centimeters deep.

7.6 The Organization encourage field trials of appropriate sciomyzids and of Limnogeton fieberi. The trials should take place on small islands where the effect of the introduction can be evaluated, and where the introduction can be terminated in case of bad effects.

7.7 The Organization encourage research on the use of snail-eating fishes in any permanent impoundments, especially those not intended for use as fish ponds.

7.8 The Organization encourage search for agents or methods of biological control that can be used in flowing water. All agents now regarded as valuable are effective only in still water.

7.9 The Organization encourage interaction between workers interested in non-chemical means of snail control and those experts in biological control in the field of agriculture. The experience of those experts is contradictory to the untested opinions of some schistosome biologists (see, for example, DeBach, 1974 and Wright, 1968).

7.10 The Organization make efforts to obtain as much scientifically reported information as possible about snail control efforts in the People's Republic of China, including an assessment of the effectiveness of different methods, and of the result of the efforts on transmission of schistosomiasis.

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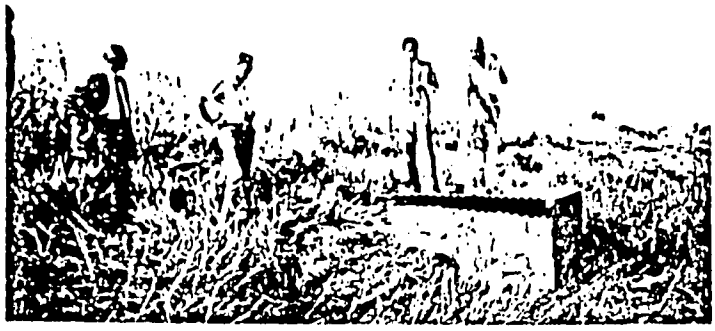
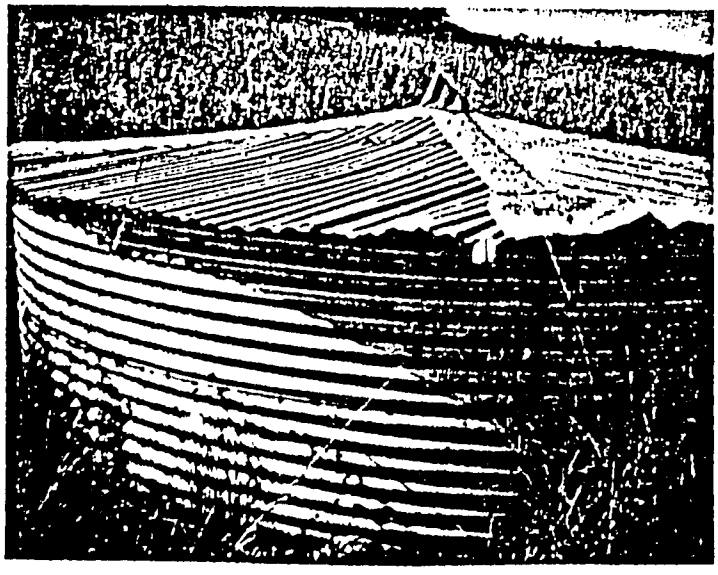


Photograph 1:

Covered Spring

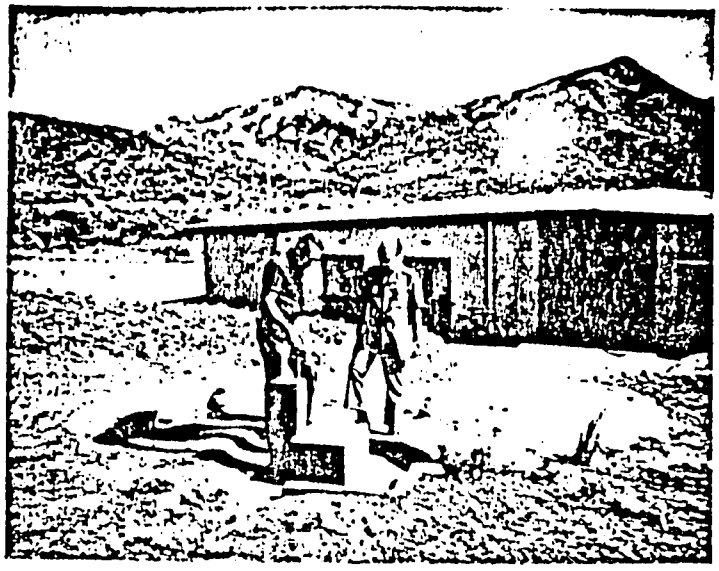
Photograph 2:

Collector Tank



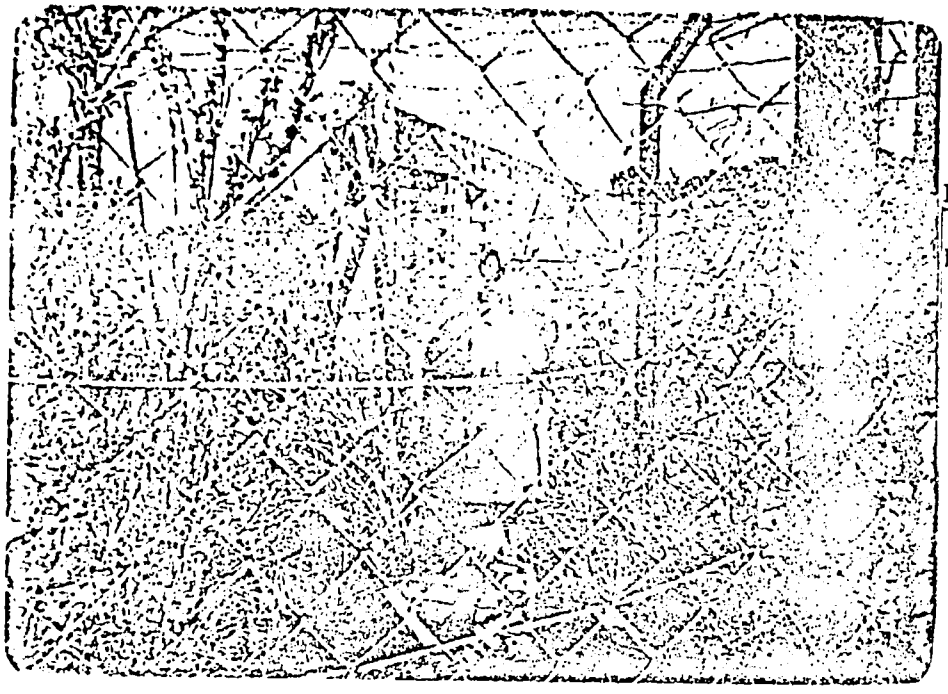
Photograph 3:

Reservoir



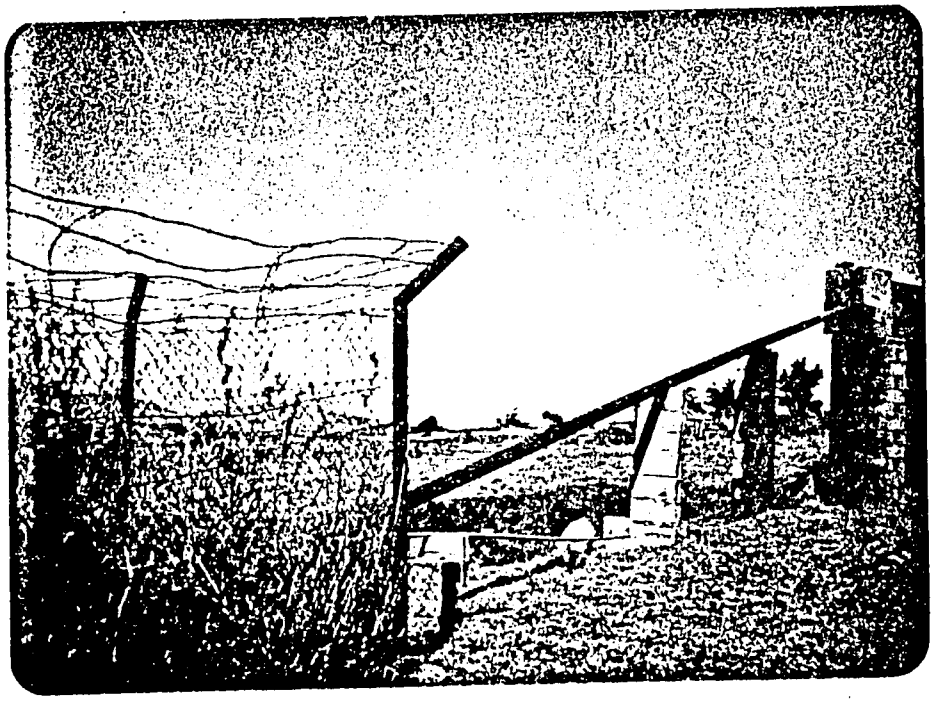
Photograph 4:

Stand-pipe



Photograph 5:

Ram Pumping Station

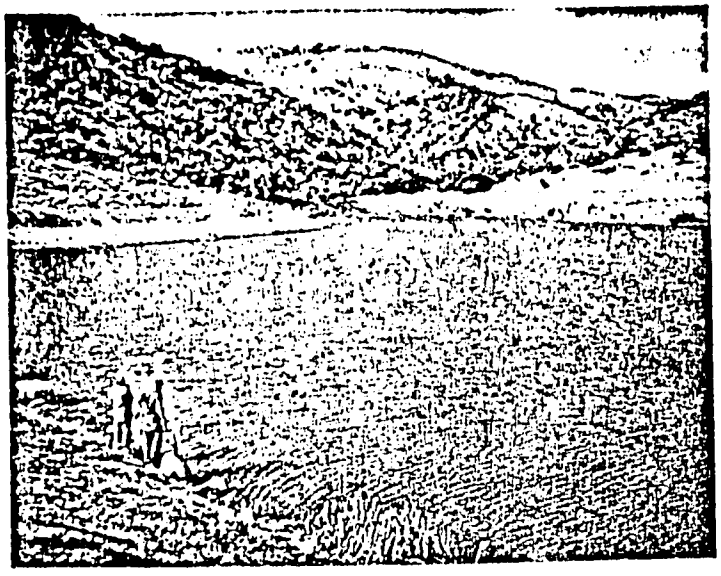


Photograph 6:

Ram Pumping Station

Photograph 7:

Fish Pond at SRDA

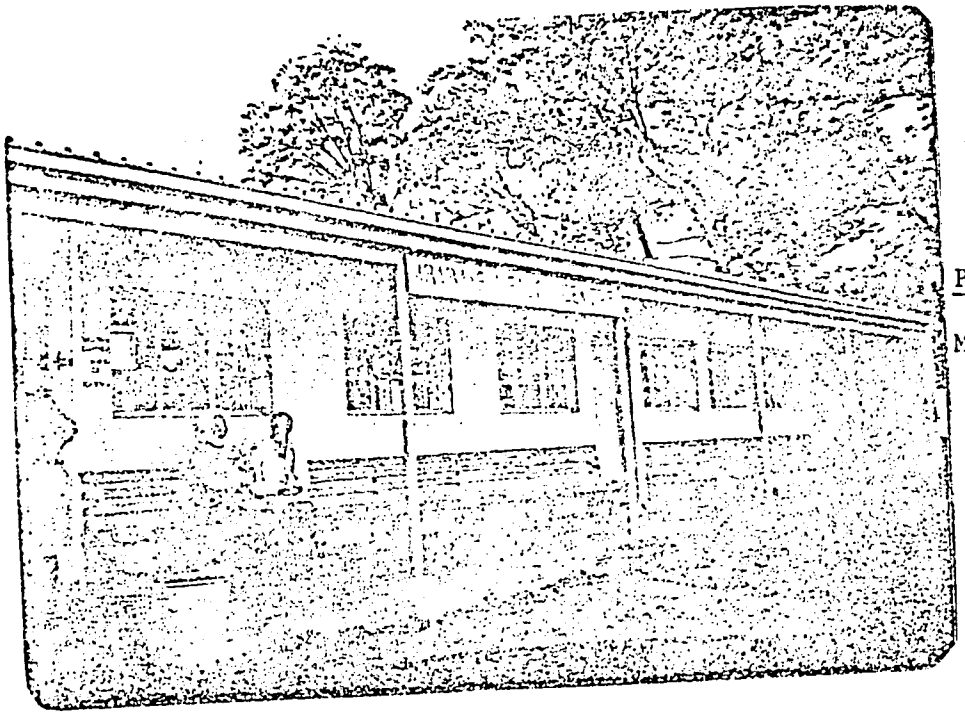


Photograph 8:

Mpatemi Dam,
Southern RDA

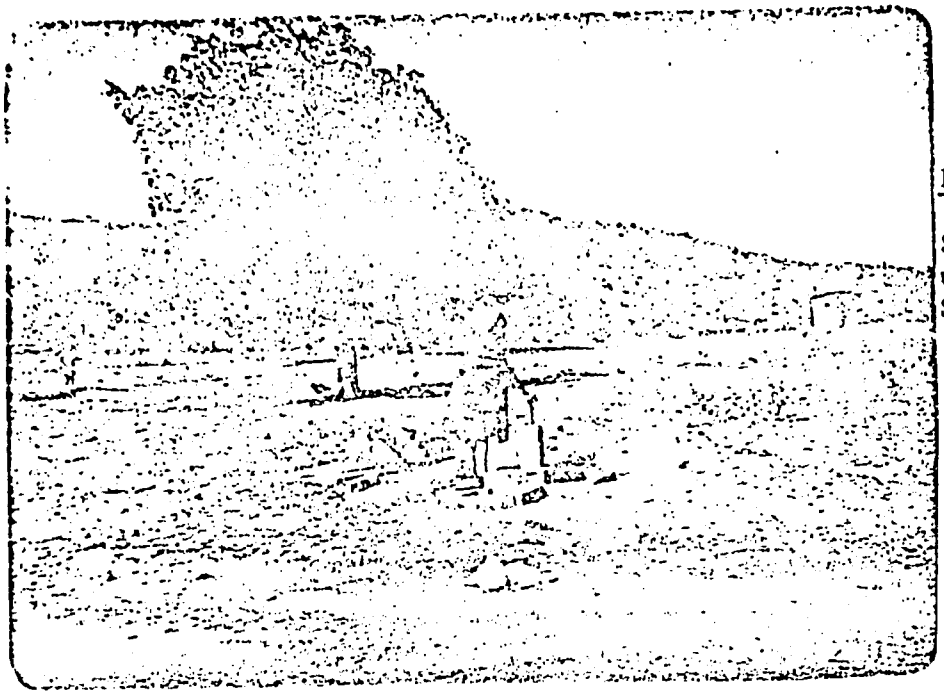
Photograph 9:

Mpatemi Dam,
Southern RDA



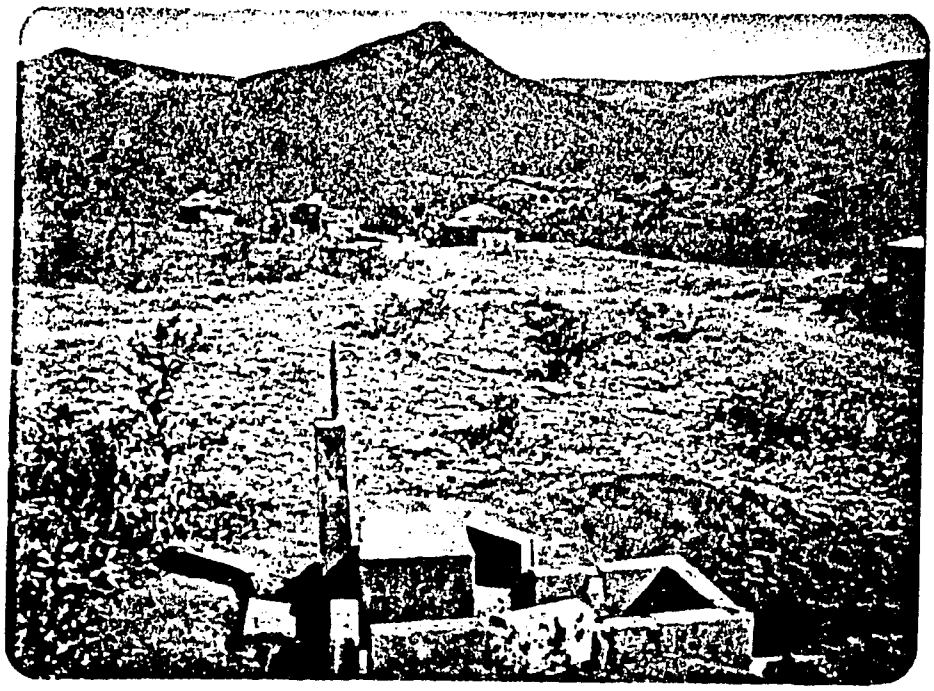
Photograph 10:

Mbabane Health Center



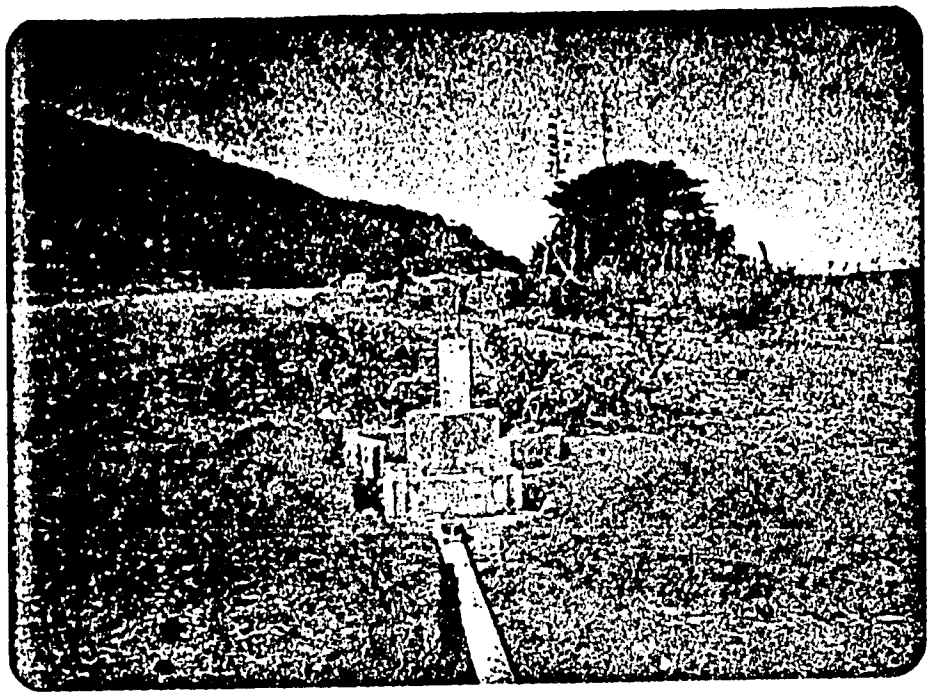
Photograph 11:

Stand-pipe; Local person using stand-pipe near Southern RDA



Photograph 12:

Stand-pipe near Southern RDA



Photograph 13:

Stand-pipe near Southern RDA

Photograph 14:

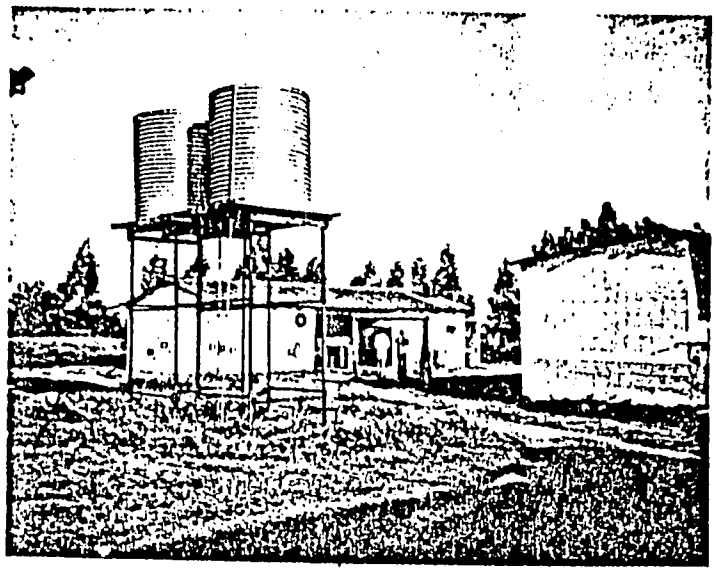
Medical Officer and Matron; Big-Bend Private Sector Clinic

Photograph 15:

Main Canal with rapidly flowing water at CDC/SIS Mhlume. Not suitable as snail habitat.

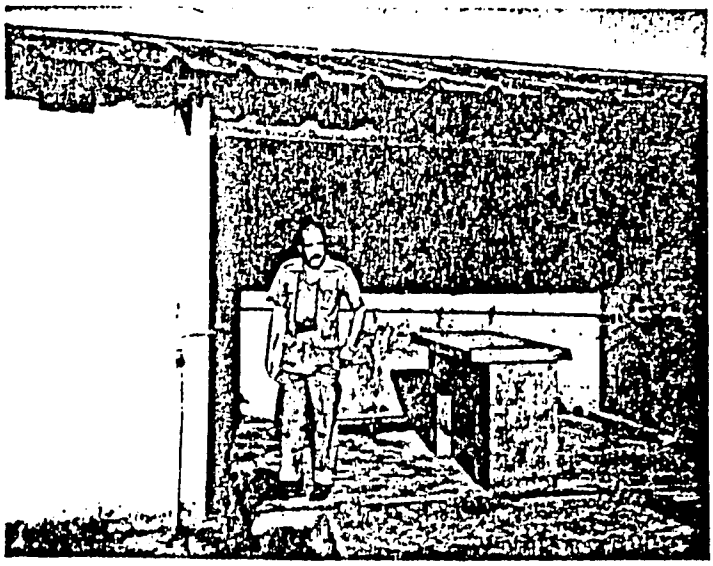
Photograph 16:

Distributary Canal Rice cultivation area CDC/SIS Mhlume. (*Bulinus sp.*, *Melanoides sp.* and *Biomphalaria sp.* in scoop)



Photograph 17:

Domestic Water Supply at Village #5,CDC/SIS Mhlume

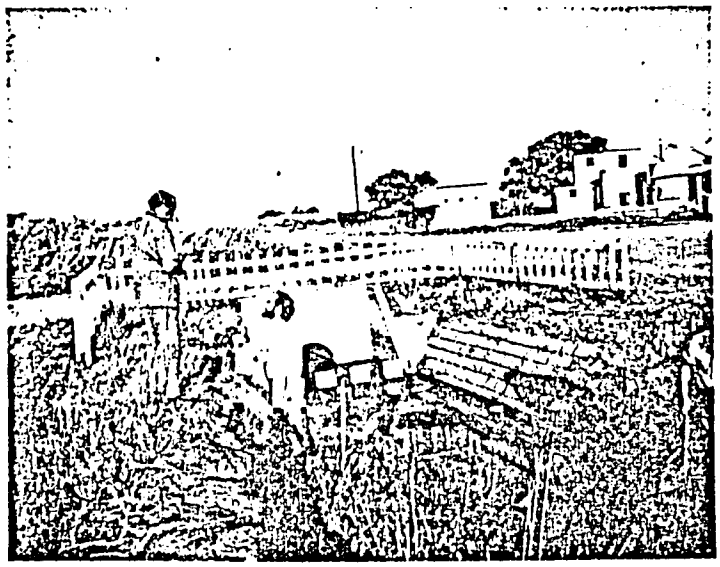


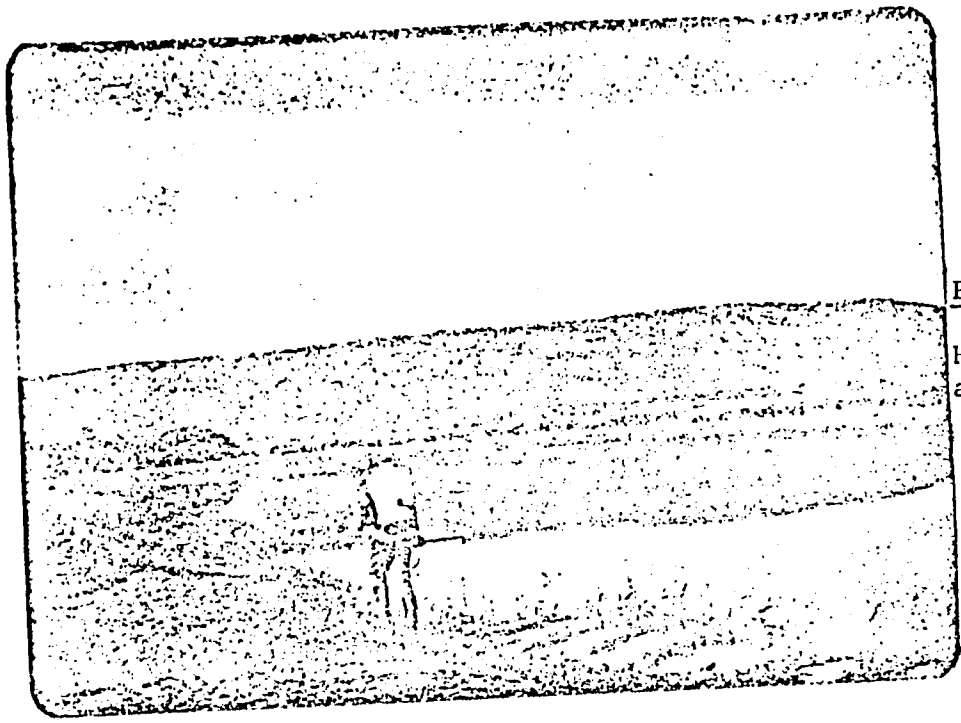
Photograph 18:

Laundry Facility at Village #5, CDC/SIS Mhlume

Photograph 19:

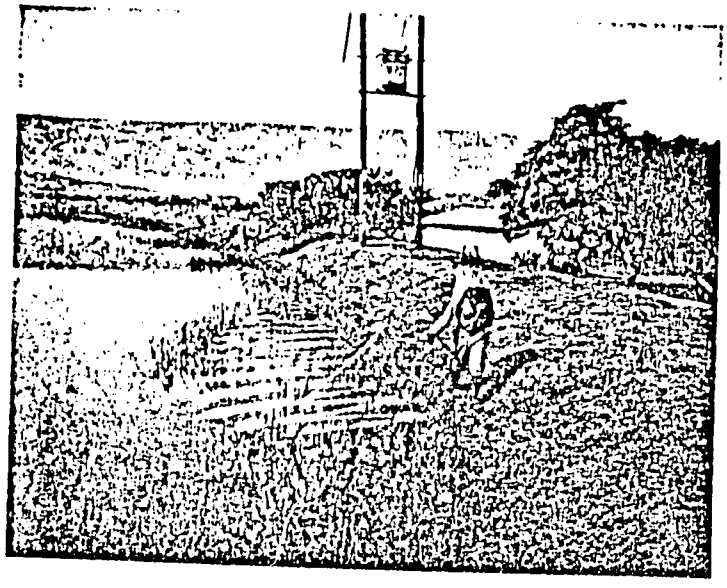
Irrigation Canal;
Rice cultivation area
CDC/SIS Mhlume





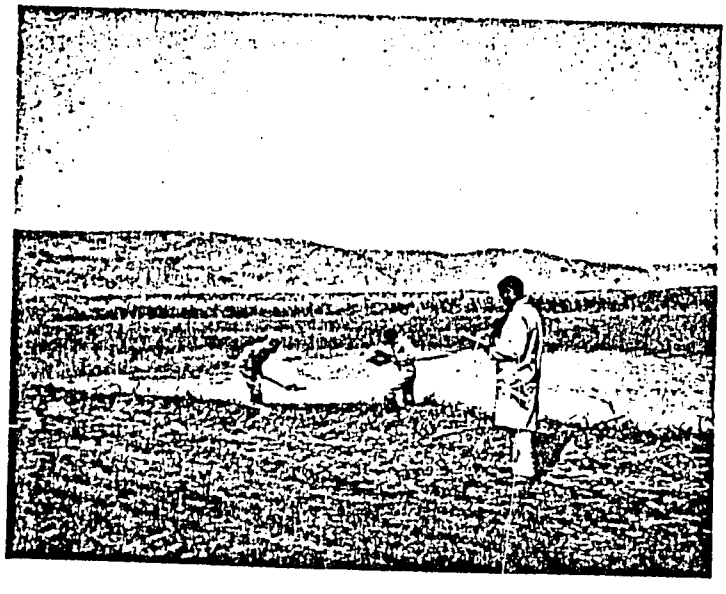
Photograph 20:

Hand Spraying of Molluscicide at Dam #I, Big Bend



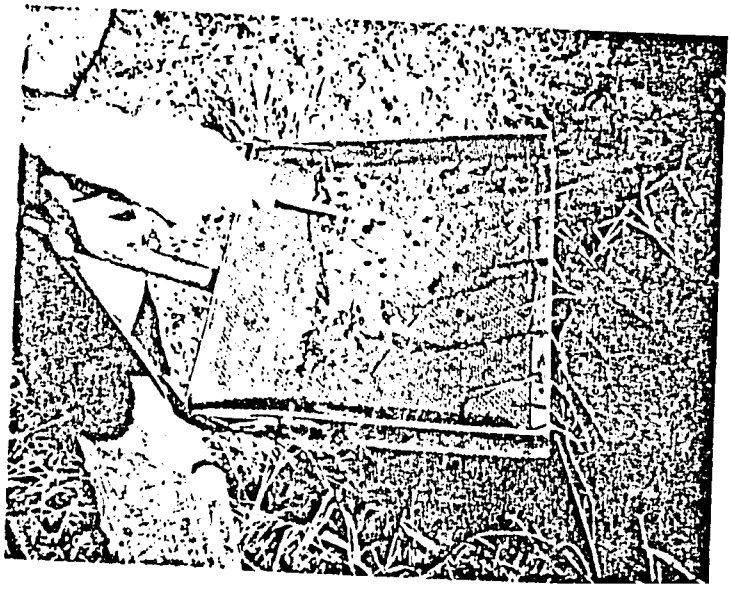
Photograph 21:

Hand Spraying of Molluscicide at Dam #1, Big Bend



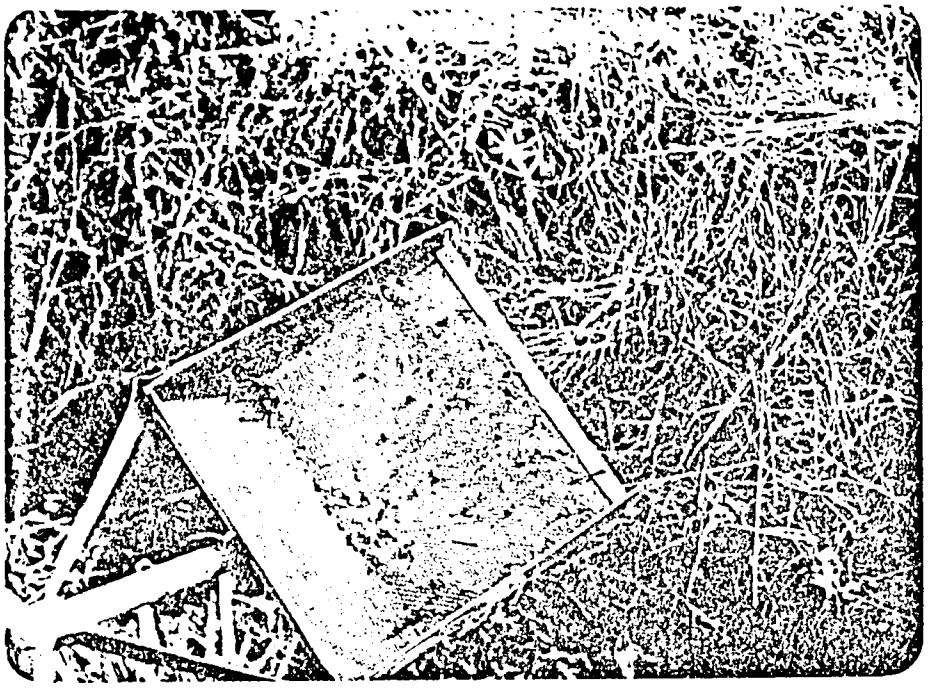
Photograph 22:

Dam #1,
Dipping for snails,
Big Bend



Photograph 23:

Biomphalaria sp.,
Big Bend

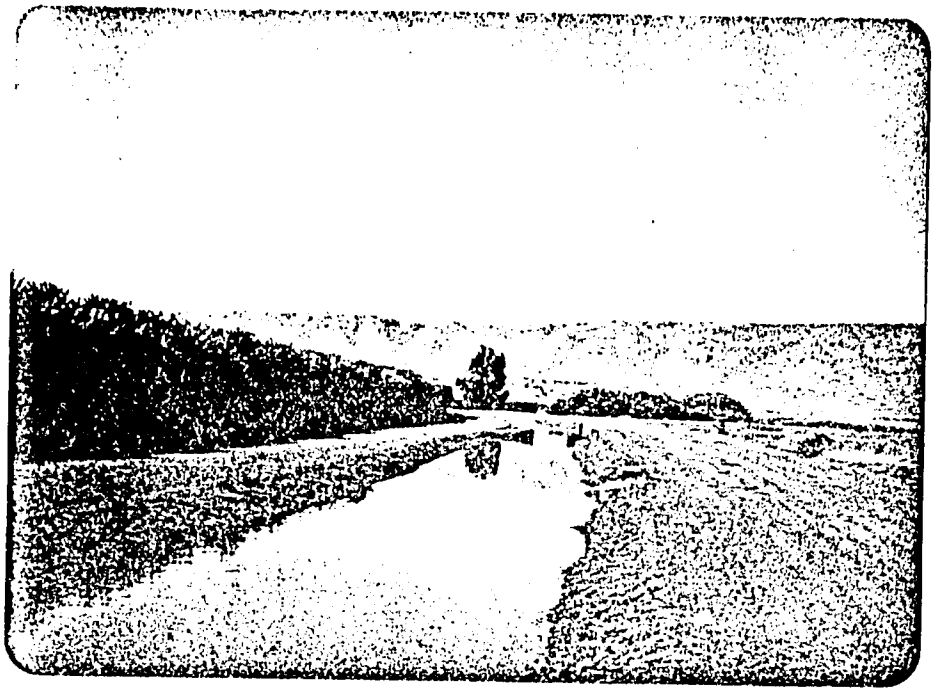


Photograph 24:

Bulinus sp., Rice Cultivation area CDC/SIS Mhlume

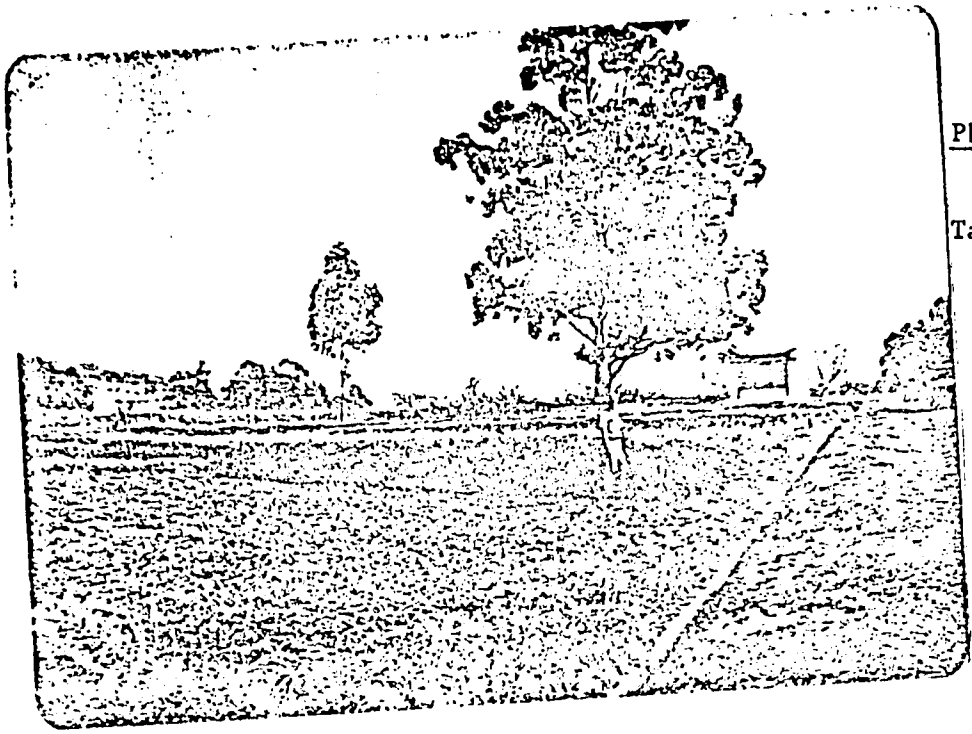
Photograph 25:

Drainage Pond



Photograph 26:

Canal without vegetation, Big Bend

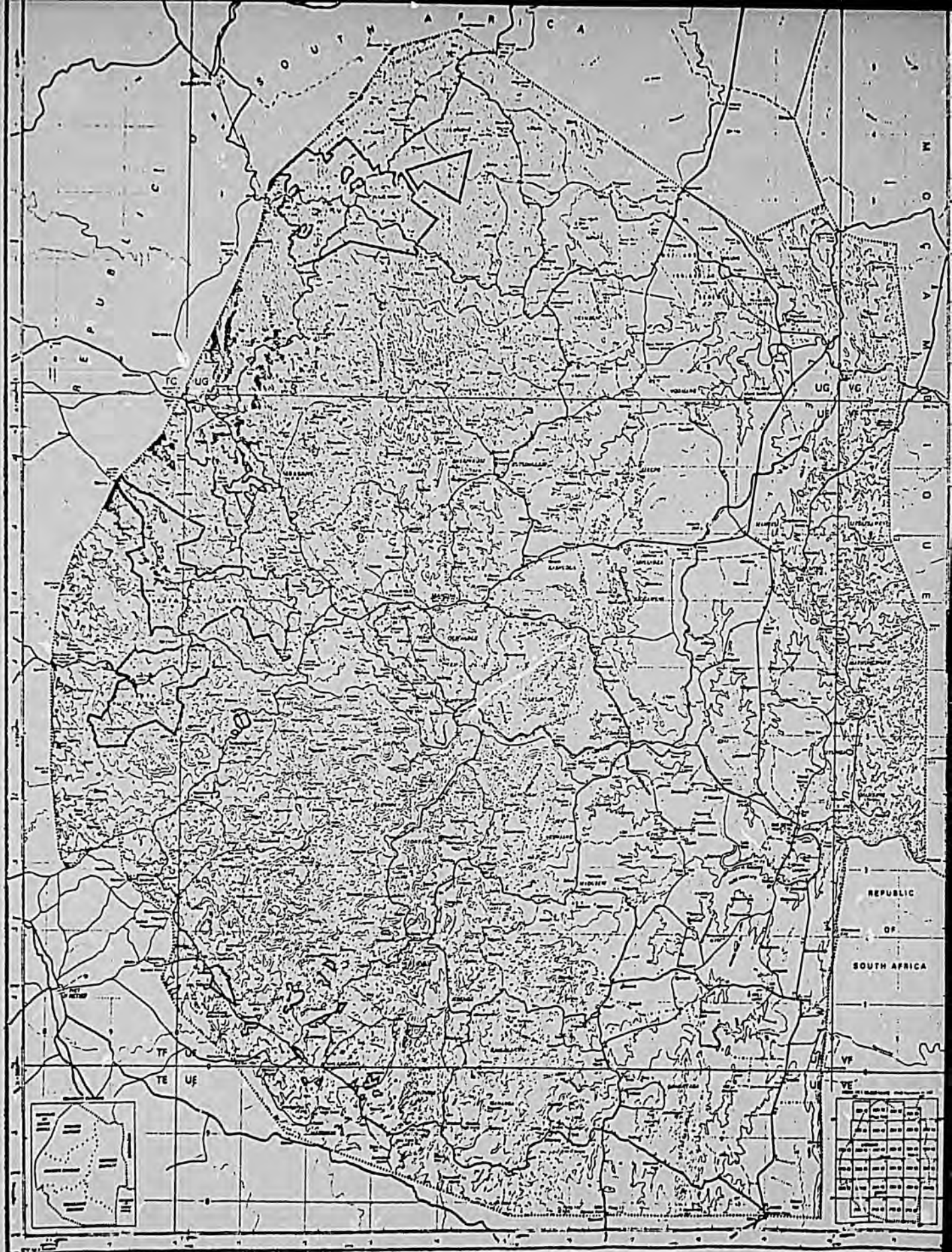


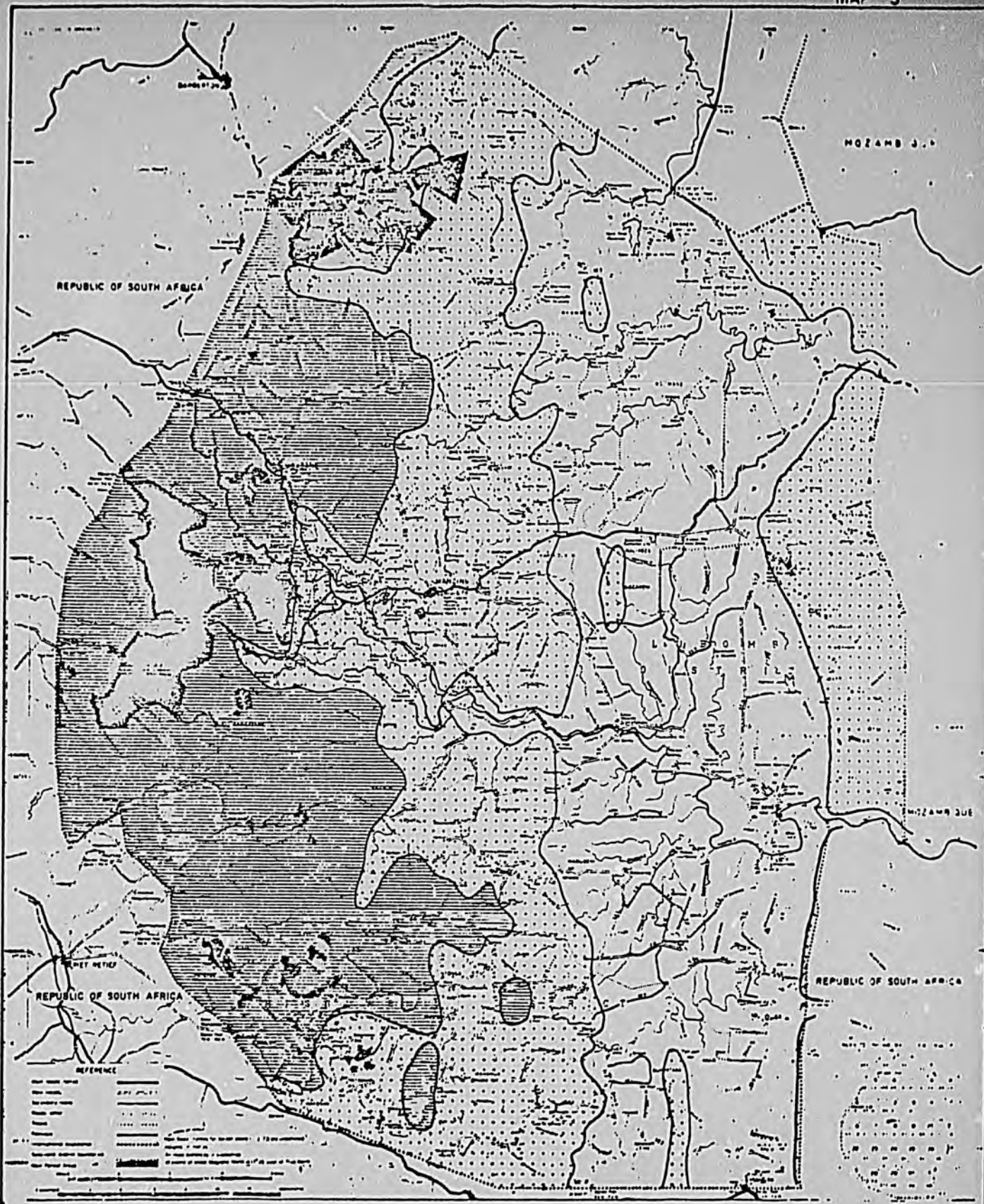
Photograph 27:

Taiwan Demonstration
Rice Farm

Photograph 28:

Taiwan Demonstration
Rice Farm

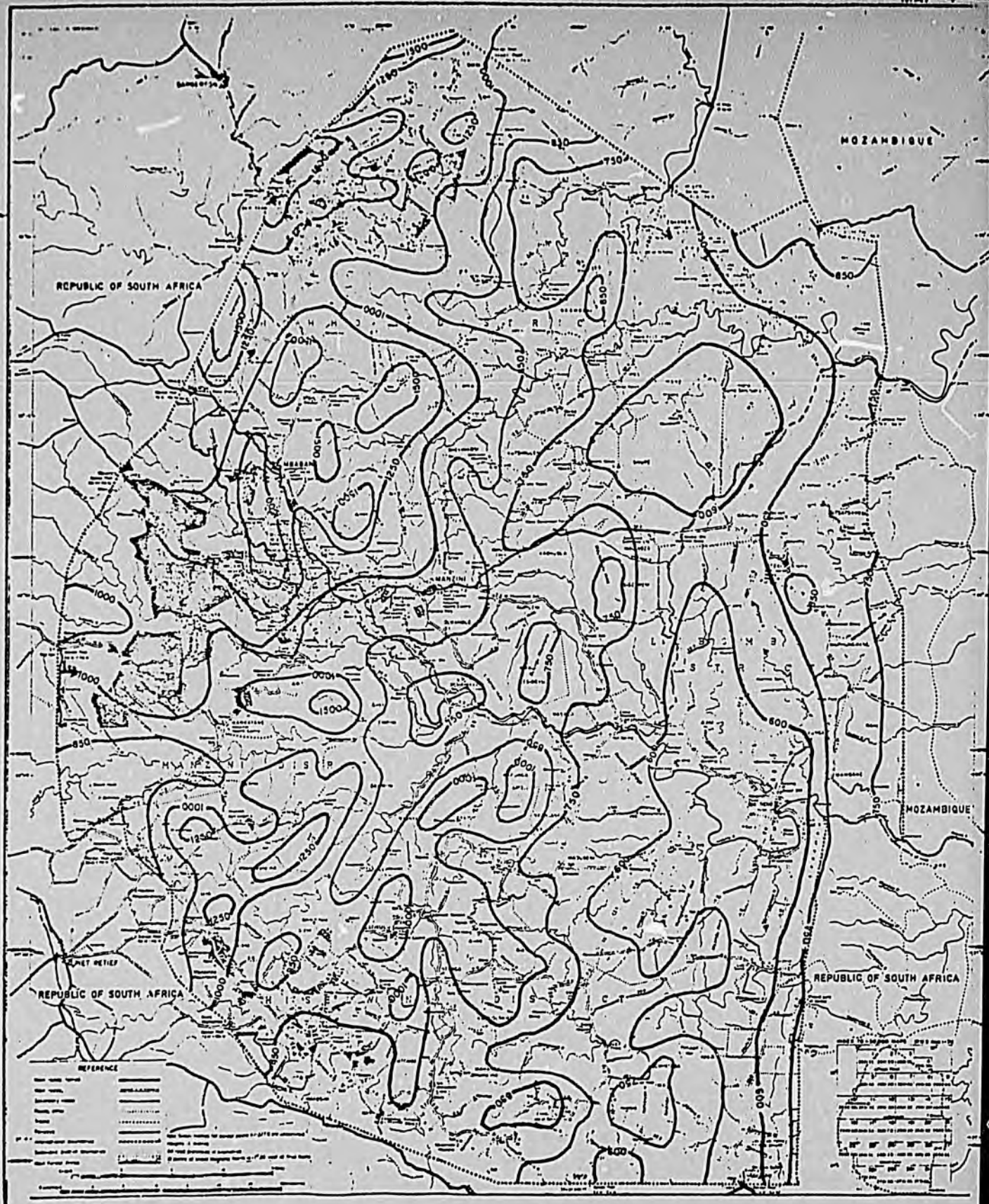

SOUTH AFRICA
REPUBLIC
OF
SOUTH AFRICA
TC
UG
UF
TF
UE
TE
VG
VF
VE



SWAZILAND - MAJOR ECOLOGICAL REGIONS

SCALE 1 : 500,000

	HIGHVELD	MIDDLEVELD	LOWVELD	LUBOMBO
Average height	1000m	600m.	240m.	600m
Terrain	Rugged Mountains Deep river valleys	Rolling hills Wide valleys	Gently undulating Lowlands	Eastward dipping plateau Cut by ravines.



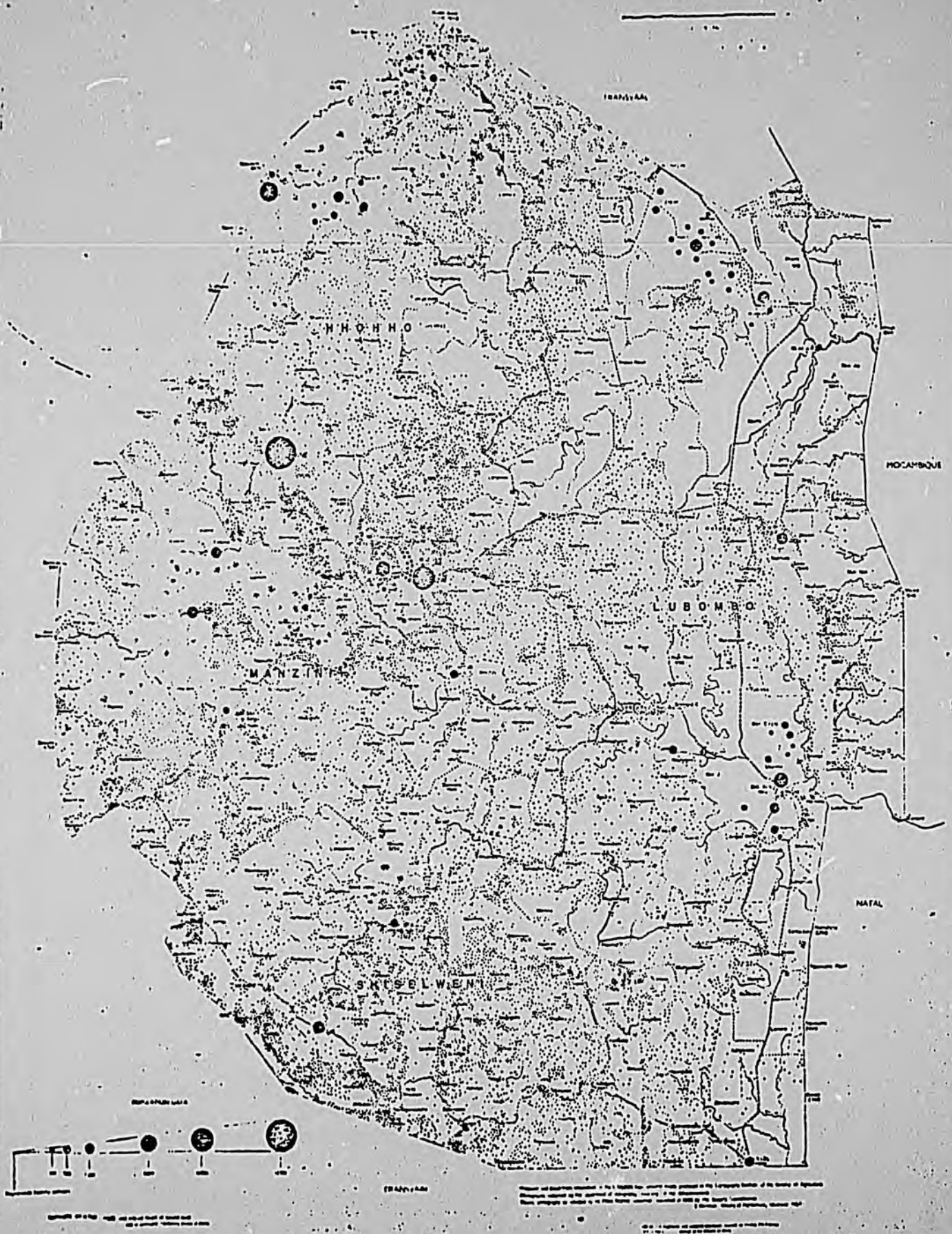
SWAZILAND – MEAN ANNUAL RAINFALL

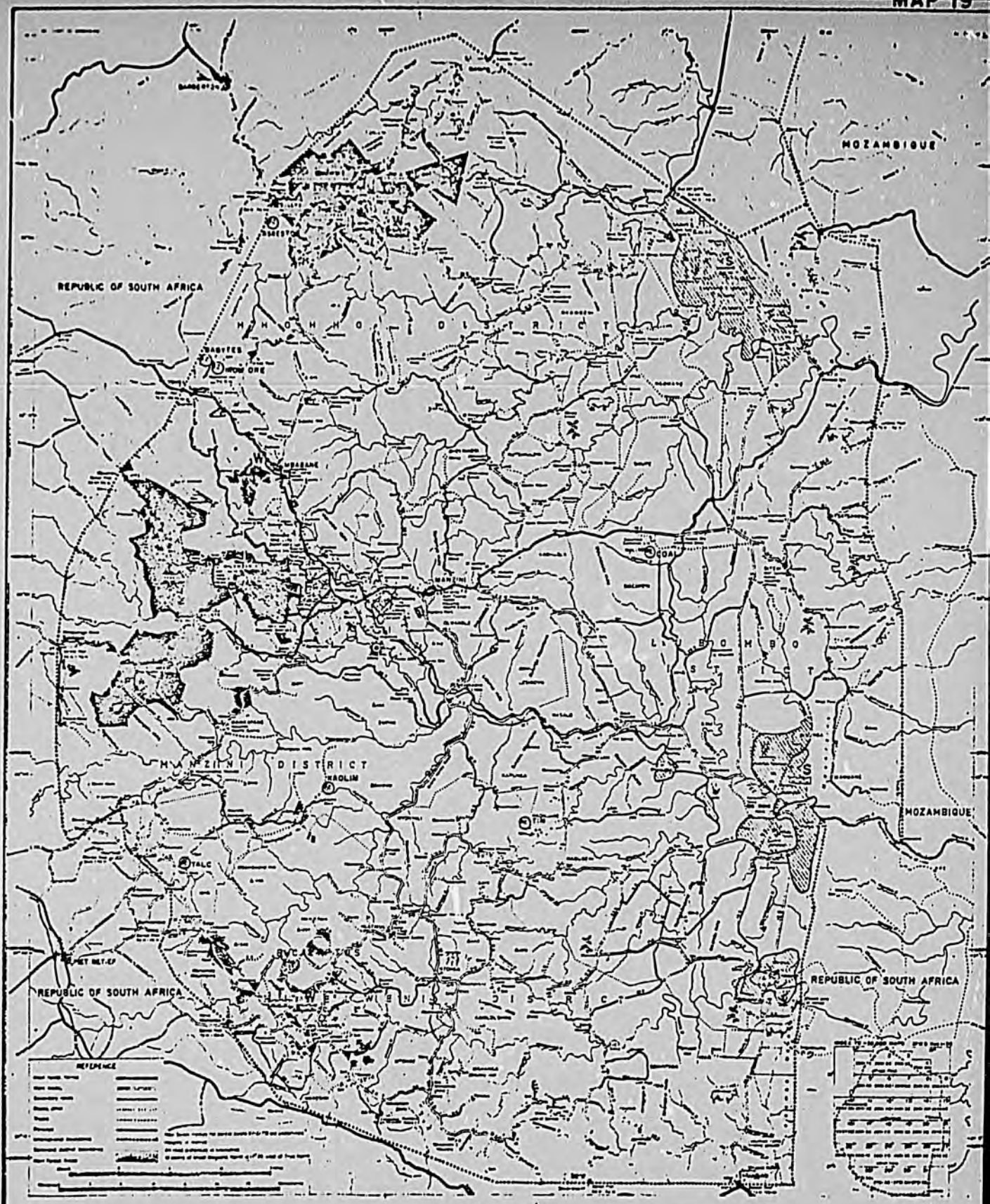
(In m.m.s)

SCALE 1:500,000

MAP #4

SWAZILAND
POPULATION DISTRIBUTION
1966





SWAZILAND – ECONOMIC ACTIVITY

MAIN CROP AREAS

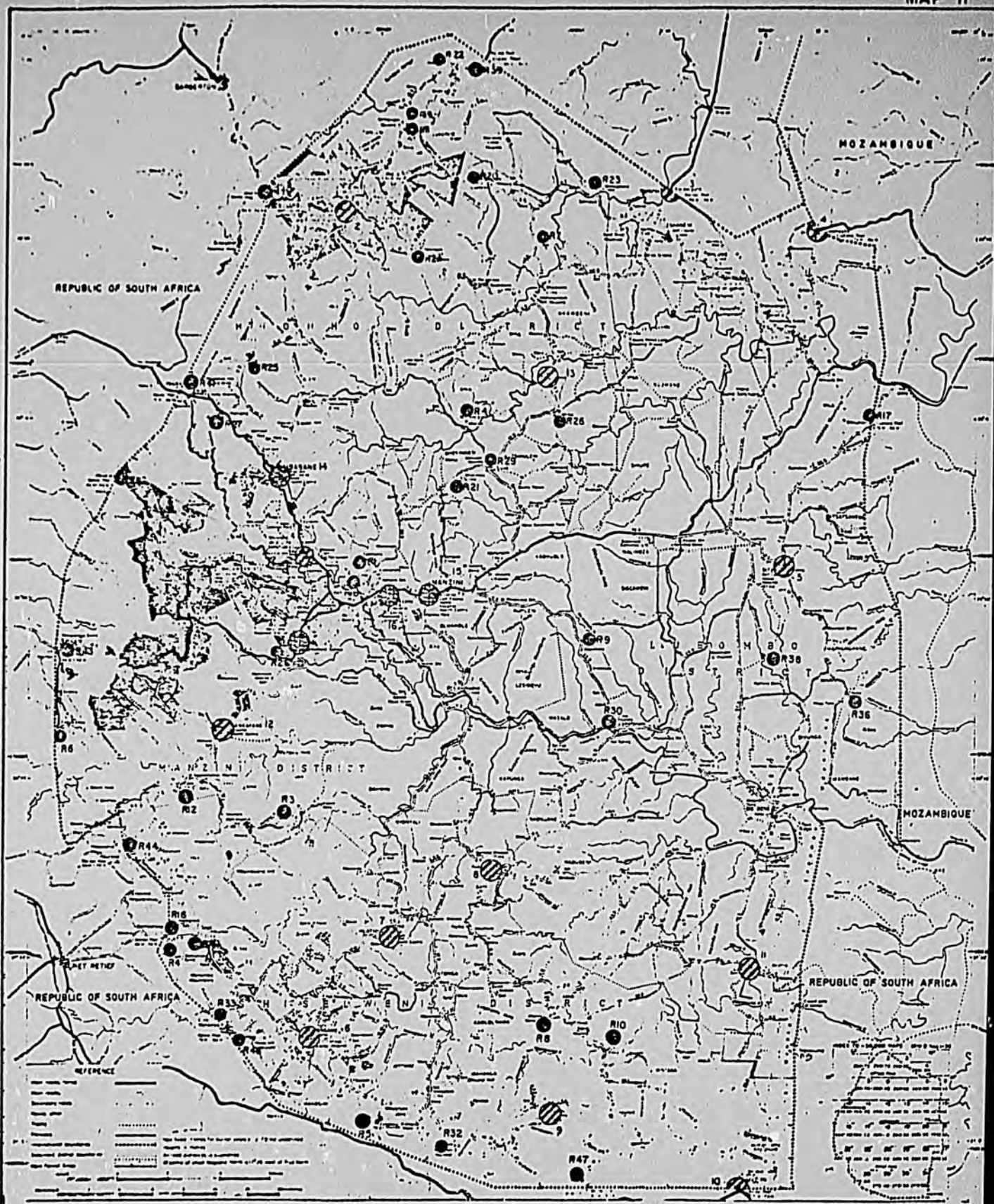
- Banana
- Citrus
- Cotton
- Pineapple
- Rice
- Sugar
- Tobacco

MAIN INDUSTRIES

- Industrial Estate
- Cannery
- Rice Mill
- Fertilizer Factory
- Saw Mill
- Pulp Mill
- Sugar Mill

MISCELLANEOUS

- Irrigation
- Pine and Gum Forest
- Hydro-Electric Station
- Mine
- Beef

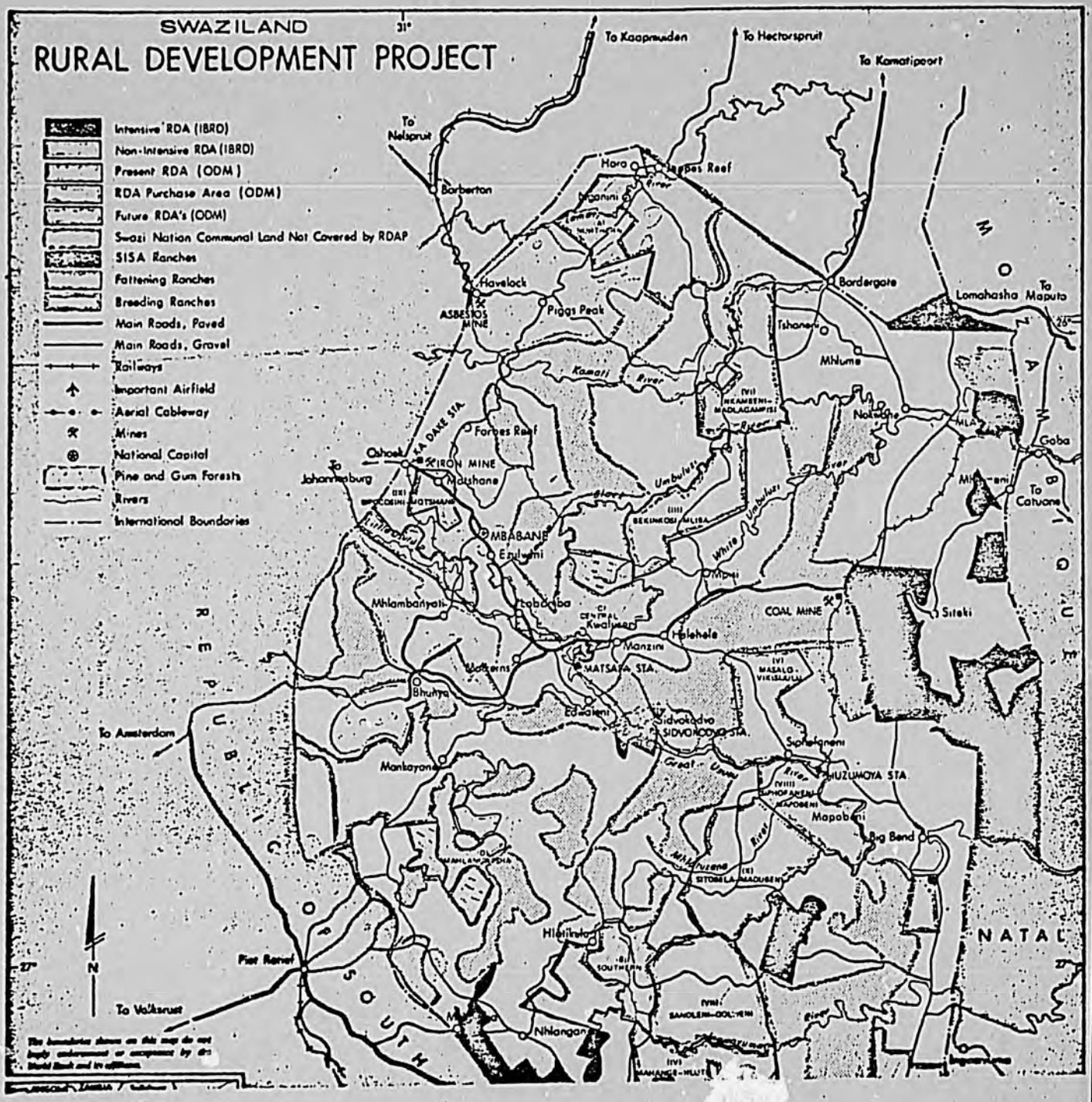


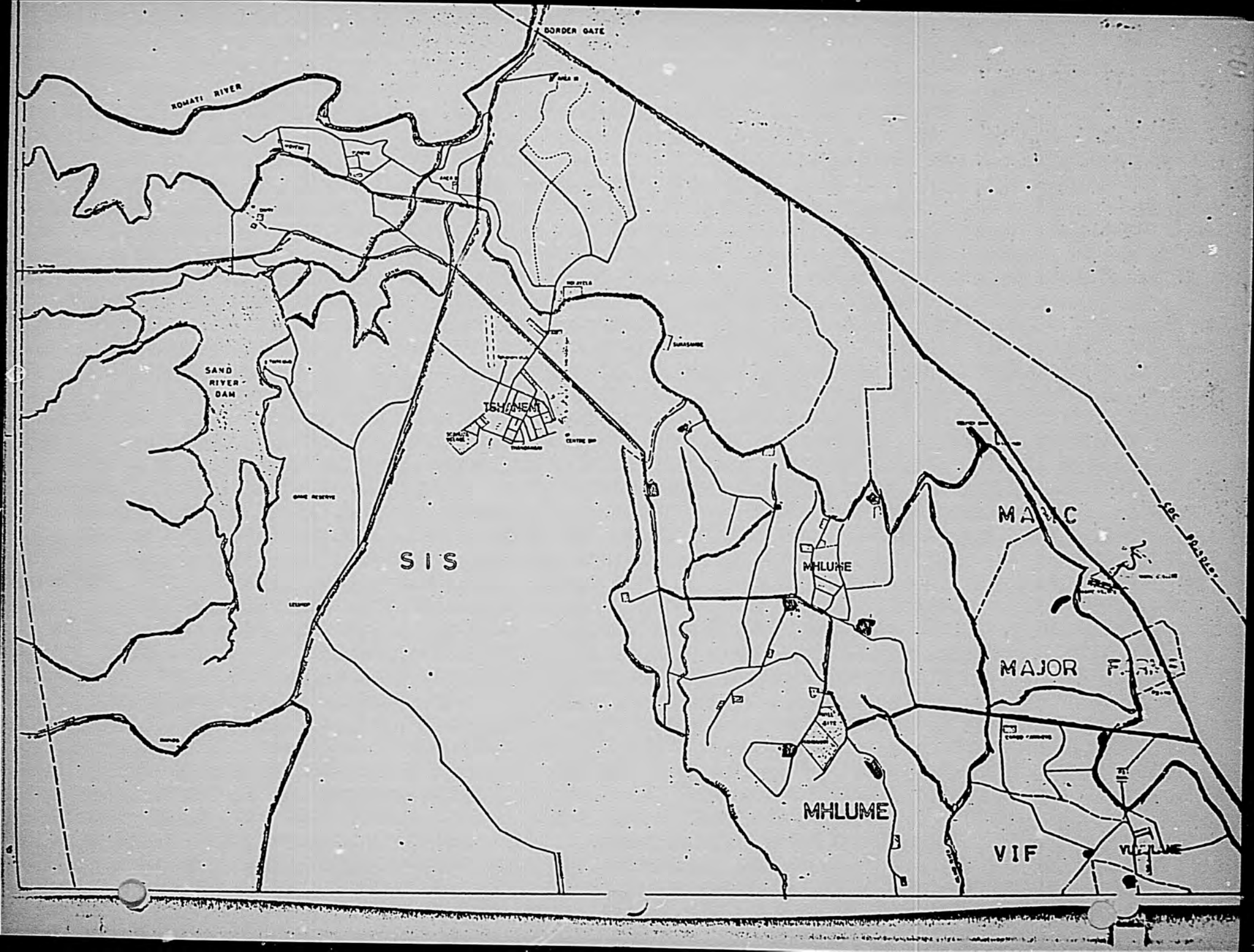
SWAZILAND URBAN AND RURAL WATER SUPPLIES

(MAINTAINED BY WATER AND SEWERAGE DEPT.

URBAN – WATER ONLY

MAP 87


SWAZILAND
RURAL DEVELOPMENT PROJECT
Intensive RDA (IBRD)
Non-Intensive RDA (IBRD)
Present RDA (ODM)
RDA Purchase Area (ODM)
Future RDA's (ODM)
Swazi Nation Communal Land Not Covered by RDAP
SISA Ranches
Fattening Ranches
Breeding Ranches
Main Roads, Paved
Main Roads, Gravel
Railways
Important Airfield
Aerial Cableway
Mines
National Capital
Pine and Gum Forests
Rivers
International Boundaries
To Kaapmuiden
To Hectorspruit
To Komatipoort
To Nelspruit
Barberton
Hora
Jeppes Reef
Havelock
ASBESTOS MINE
Piggs Peak
Bordergate
Lomahasha
To Maputo
Tshaneni
Mhlume
Kamati River
Nokwane
Goba
To Catuane
Forbes Reef
Ohsek
IRON MINE
Mdzhane
To Johannesburg
MBABANE
Ezulwini
Mhlambanyatsi
Lobamba
COAL MINE
Siteki
Hlatikhulu
Manzini
MATSAPA STA.
Bhunya
Edwaleni
Sidvokodvo
SIDVOKODVO STA.
To Amsterdam
Mankayane
HUZUMOYA STA.
Mapobeni
Big Bend
NATAL
Piet Retief
To Volksrust
Nhlangano
N
27°
31°
26°


BORDER GATE
KOMATI RIVER
SAND RIVER DAM
TSHANENI
SIS
MHLUME
MAJOR
MHLUME
VIF

SWAZILAND 1963

PRIMARY EDUCATION

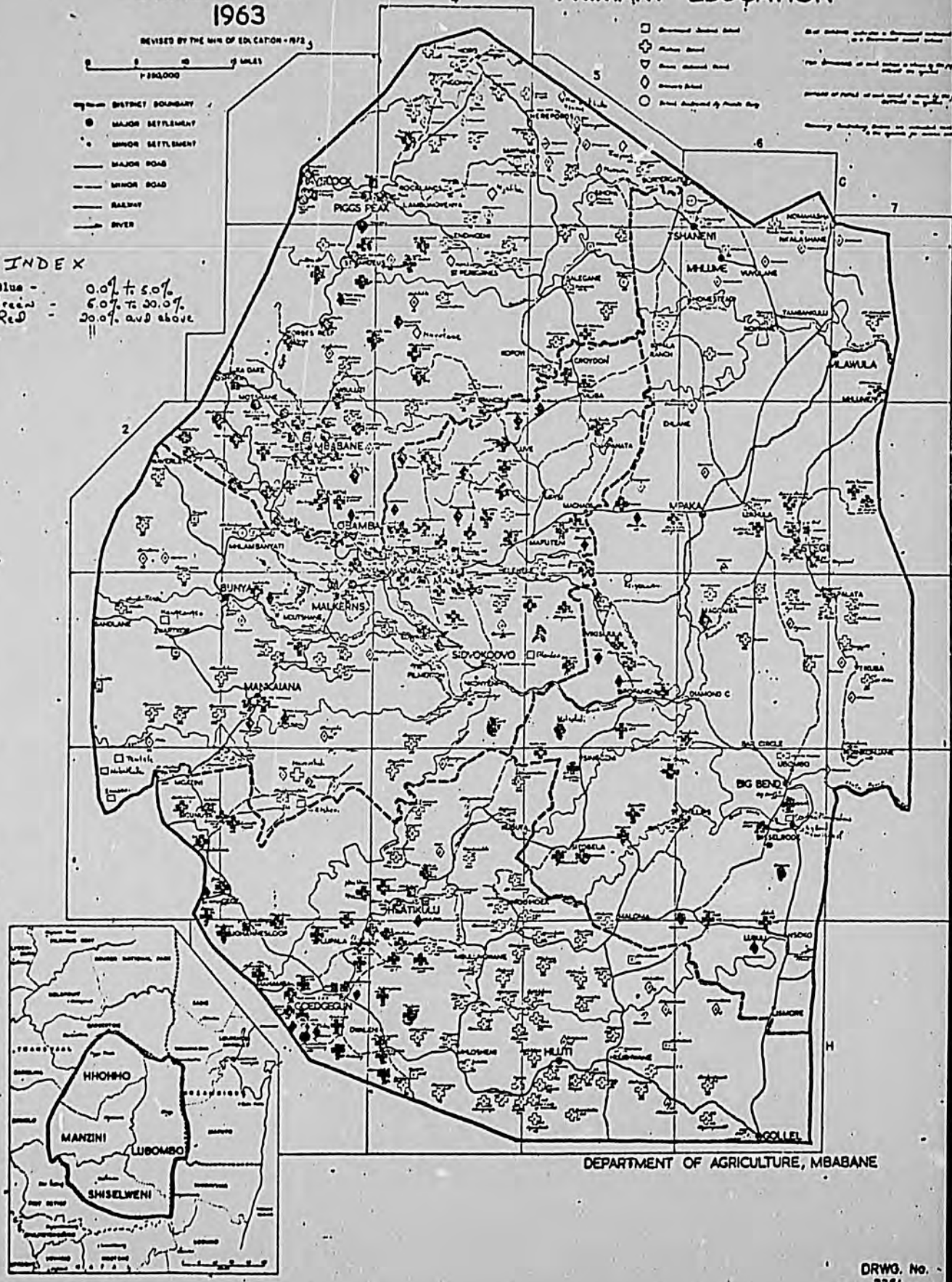
REVISED BY THE MIN OF EDUCATION - 1972

1 : 250,000

DISTRICT BOUNDARY
MAJOR SETTLEMENT
MINOR SETTLEMENT
MAJOR ROAD
MINOR ROAD
RAILWAY
RIVER

INDEX

Blue - 0.0% to 5.0%
Green - 6.0% to 20.0%
Red - 20.0% and above



DEPARTMENT OF AGRICULTURE, MBABANE

DRWG. No. 3364