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WATER AND SANITATION FOR HEALTH PROJECT

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NIGHT SOIL DISPOSAL AND EFFLUENT REUSE IN MASERU, LESOTHO

WASH FIELD REPORT NO. 55

SEPTEMBER 1982

Prepared for:
USAID Mission to the Kingdom of Lesotho
Order of Technical Direction No. 88

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30 September 1982

Ms. Edna A. Boorady
Mission Director
USAID
Maseru, LESOTHO

Attn: Fred Zobrist

Dear Ms. Boorady:

On behalf of the WASH Project, I am pleased to provide you with 10 copies of a report on Night Soil Dispcsal and Effluent Reuse in Maseru, Lesotho.

This is the final report by Dr. Dan Okun and Dr. John Briscoe and is based on their trip to Lesotho from July 11, 1982 to July 25, 1982.

This assistance is the result of a request by the Mission on March 18, 1982. The work was undertaken by the WASH Project on April 26, 1982 by means of Order of Technical Direction No. 88, authorized by the USAID Office of Health in Washington.

If you have any questions or comments regarding the findings or recommendations contained in this report, we will be happy to discuss them.

Sincerely,

James E. Beverly
Acting Director
WASH Project

cc: Mr. Victor W.R. Wehman, Jr.
S&T/H/WS

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Prepared for for the USAID Mission to
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Prepared by:

Daniel A. Okun
and
John Briscoe

September 1982

Water and Sanitation for Health Project
Contract No. AID/DSP-C-0080, Project No. 931-1176
is sponsored by the Office of Health, Bureau for Science and Technology
U.S. Agency for International Development
Washington, DC 20523

TABLE OF CONTENTS

Chapter		Page

ABBREVIATIONS USED

cmd - cubic meters per day

lpd - liters per day

lps - liters per second

m - meters

gpd - gallons per day

EXECUTIVE SUMMARY

In response to a request from USAID/Lesotho, USAID/Washington issued Order of Technical Direction (OTD 88) authorizing the Water and Sanitation for Health (WASH) Project to provide technical assistance to the Government of Lesotho on the following problems: night soil disposal and effluent reuse through crop irrigation in Maseru.

A two-person WASH team was in Lesotho from July 11 to 25, 1982. Working in conjunction with the Water Branch of the Ministry of Water, Energy, and Mining and the Office of the Maseru Town Engineer of the Ministry of the Interior, the WASH team prepared this report.

Night soil from bucket latrines of 30 percent of the population of Maseru is deposited in open trenches above reservoirs which are an emergency water supply for Maseru.

The WASH team was instructed to assess the feasibility of alternative night soil disposal. Estimates of the capital and operating costs of the alternatives were to be developed and recommendations presented to the Ministry of the Interior.

In their investigation the consultants found that an equally if not more serious public health hazard to the night soil problem was the use by some 15 percent of the population of dongas (drainage ditches) which drain into the city water source. Regarding the night soil disposal problem, it was recommended that the only viable alternative was the construction of a night soil disposal facility at the new sewage treatment plant and that all night soil be transported and disposed of there.

Regarding the effluent reuse through crop irrigation, the design and performance of the new Maseru treatment plant was assessed and the suitability of the effluent for crop irrigation evaluated. A number of specific improvements for the operation of the treatment plant were recommended. The suitability and availability of agricultural land in the vicinity of the sewage treatment plant was assessed. A pilot wastewater reuse scheme for Maseru was deemed feasible with the condition that agricultural specialists be involved.

ACKNOWLEDGEMENTS

The team is grateful for the whole-hearted assistance of all at the Water Branch and the Office of the Town Engineer of Maseru, and especially to Jeff Hendrich, Director of the Water Branch.

Chapter 1

WASTE DISPOSAL IN MASERU: EXISTING PRACTICES AND LIKELY DEVELOPMENTS

1.1 Analysis of Current Conditions

The present population of Maseru is about 60,000. A recent survey of housing conditions in Maseru found that over 13 percent of all households had no sanitary facilities, 31 percent used bucket latrines, 42 percent used conventional pit latrines, and 14 percent had access to flush toilets (Cross, 1982). About 30 percent of the flush toilets use conservancy tanks and the other 70 percent are connected to the sewerage system (Ministry of the Interior, 1982).

1.1.1 Populations With No Facilities

The 8,000 people who do not have access to sanitation facilities defecate in dongas* and other open spaces. This practice constitutes the most serious excreta-related problem in Maseru, and effects both local residents and the city population.

For local residents the threat to health is greatest from insect vectors, such as flies and cockroaches, acting as fecal transmitters.

For the town as a whole, open defecation constitutes a serious threat to the quality of the water delivered through the public distribution system. Poorer areas of Maseru, where the majority of the families have no sanitation facilities, are located on the catchment area for the reservoirs, which serve as a reserve water supply for the town. Although these reservoirs are seldom used, upon completion of construction of the Maqalika reservoir, this catchment will become important as a supplemental source of water for Maseru.

1.1.2 Conventional Pit Latrines

The median household income in the peri-urban areas of Maseru is about M80 (U.S. $68) per month (Shanawany, 1980). The only truly low-cost sanitation option available is the conventional pit latrine, and it is the choice for about 50 percent of the households with some sanitation facility.

There are, however, a number of problems with the conventional latrines; they are malodorous, flies breed in them, the covers and sometimes the pits themselves collapse, and the pits have to be relocated every few years. Because of these characteristics, children, in particular, are discouraged from using them thereby increasing the proportion of the population defecating in dongas and other open spaces. In peri-urban areas where boreholes are used for the water supply some of the pit latrines themselves constitute a threat to water quality.

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*A donga is a natural gulley, usually a couple of meters deep, formed by erosion during the rainy season.

1.1.3 Ventilated Improved Pit Latrines

Over the past few years several hundred ventilated improved pit latrines (VIP) have been built in Maseru, mostly in conjunction with sites-and-services projects financed by the Canadian International Development Agency and the World Bank. Both single- and double-pit latrines have been built. The cost of the latrines remains high, with the cheapest version (an unlined, single-vault pit) costing about M340 (US$283).

At present the Government of Lesotho offers loans at 9 percent, with repayment over 20 years, for the construction of VIPs in new housing developments. At this interest rate the monthly charge for the cheapest VIP latrine is M3.10 (US$2.63). Since the market interest rate is substantially higher (about 18 percent), this low interest rate represents a cost subsidy of the VIP latrine. At an interest rate of 18 percent, the unsubsidized monthly cost of a VIP would be M5.30 (US$4.50).

A problem with such an expensive permanent structure is that tenancy rates of up to 75 percent are common in the peri-urban areas of Maseru (Cross, 1982). Landlords, particularly absentee landlords, are reluctant to make an investment in a VIP even at the subsidized rate, and tenants do not want to make an investment in property not their own.

In addition, it is not now known who will have responsibility for organizing a pit desludging service. In fact, no technology is yet available for desludging, and consequently the viability and costs remain uncertain.

In addition, the VIPs, like conventional pit latrines, are a threat to water quality where boreholes are used.

1.1.4 Bucket Latrines

Maseru has an old, well-established and remarkably efficient bucket latrine collection system. The system was first established in the 1930's when similar systems (still used) were established in the black areas of the towns of the Republic of South Africa. Until recently this system was also advocated for urban areas by the Government of Lesotho. Indeed, the Sanitary Services and Refuse Removal Regulations of 1972 describe in detail specifications of a "pail closet" and proscribe the location of latrines relative to water sources. In the 1972 Legal Notice construction of pit latrines was prohibited in any area served by the bucket collection system. While the 1972 Legal Notice has not been rescinded, since late 1980 the Ministry of the Interior has only issued bucket permits with great reluctance. It is now believed that the bucket latrine system poses a threat to public health and should be phased out.

It was the disposal of the night soil from the bucket latrine system serving 19,000 people in Maseru which was of particular concern to the WASH team. The bucket system is described in detail below.

About 2,200 households in Maseru pay the M0.75 (US$.64) fee to have their night soil collected twice weekly. The distribution of the latrines in town is indicated on the map (Figure 1).

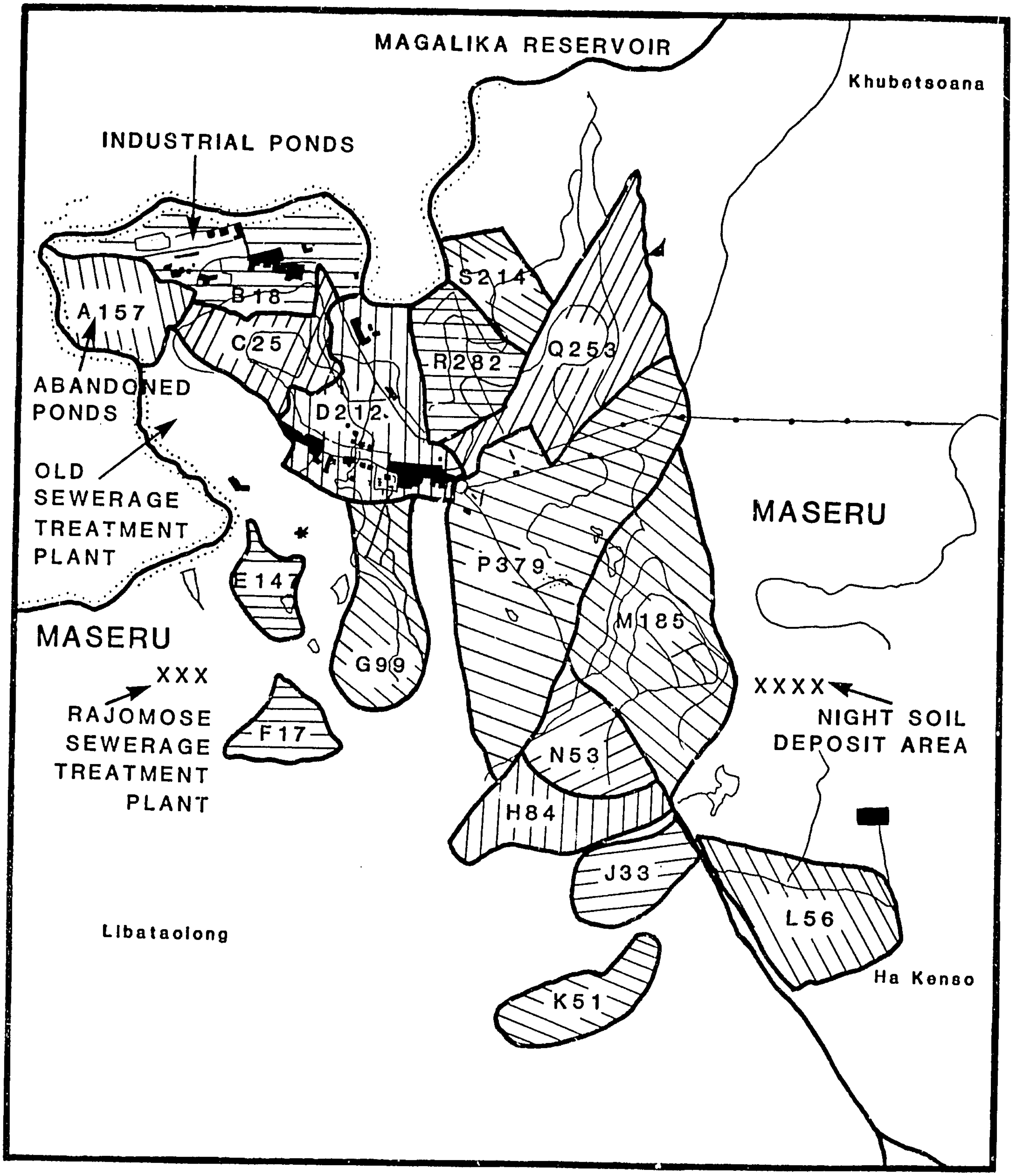


FIGURE 1. Location of Bucket Latrines

Key: P379 indicates that there are 379 bucket latrines in zone P.

The collection system is operated by the Ministry of the Interior, the administrative authority responsible for Maseru. The bucket collection system is well managed and operated, providing a fairly reliable and clean service with the unpleasant characteristics generally associated with such an operation reduced to a minimum.

The town has a fleet of five tankers, two with a capacity of five cubic meters each, similar to the vacuum trucks used for cleaning conservancy tanks, and three especially constructed for the bucket latrine collection system with a capacity of about three cubic meters each. All of the tanks are covered.

At the start of a shift, a driver who is also the crew leader, and 13 night soil collectors assemble at the depot next to their housing compound in the industrial area. Most of the collectors wear gum boots, rubber gloves, and coveralls which are provided every six months. First, they load a sufficient number of clean buckets on the back of the truck, and fill several 20-liter heavy plastic night soil buckets with water. In the winter the crews leave the depot at about 4 p.m., completing their work in two to six hours. In the summer they start their work at about 3 a.m.

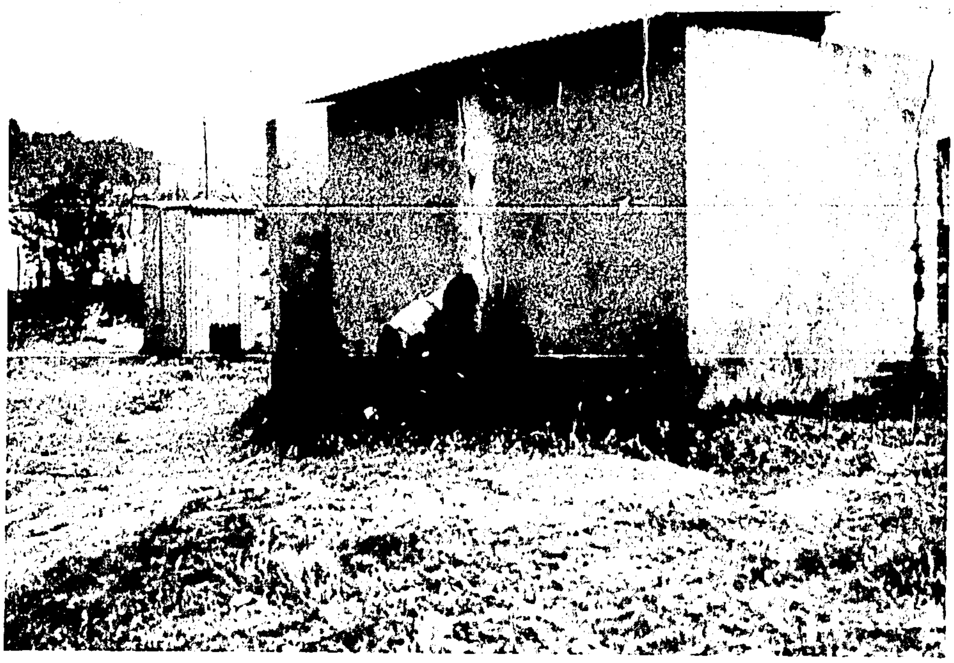
The trucks follow well-defined routes, with every household served every third day (providing there are sufficient tankers in repair). Upon reaching a group of houses to be served, the collectors jump off the truck, each with a clean bucket in hand. They remove a used bucket from the back of the latrine and replace it with a clean bucket. Then, they return to a particular place where they wait for the trucks. Sometimes the truck is waiting for them.

Generally, the buckets are more-or-less full, but it is common to see buckets barely half-full. Besides fecal material, the buckets also contain the materials used for anal cleansing, particularly newspaper.

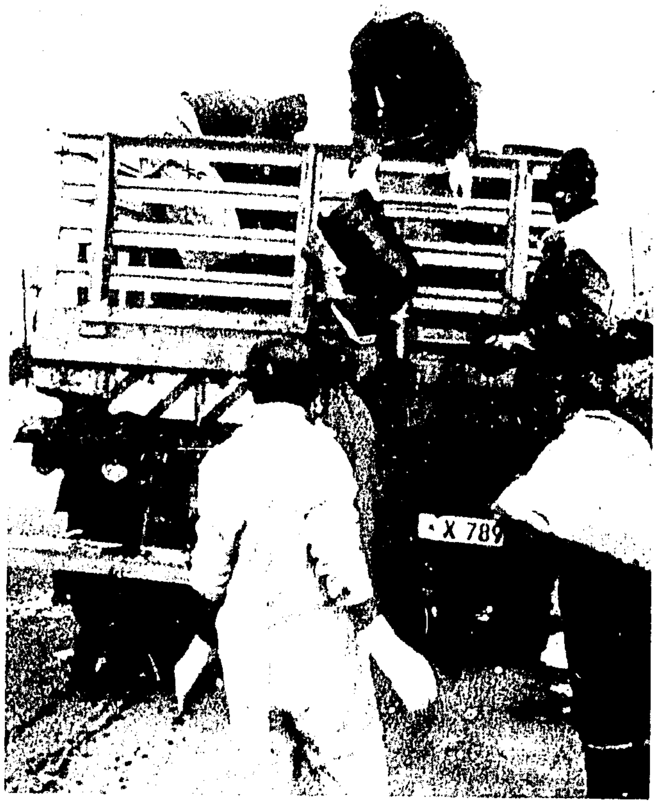
Typically, five or six buckets await the truck when it arrives at a collection point. The collectors pass the bucket up to a co-worker who passes it to the man responsible for pouring its contents into the tanker. After pouring the night soil into the tank, the worker passes the bucket to another. He in turn pours water into the soiled bucket and rapidly rinses and scours it with a brush. The rinsed bucket is then stored on the side of the tanker reserved for soiled ones. The man responsible for rinsing buckets reuses the water about six or seven times. Eventually he pours the water into the tank. He then uses another bucket of water brought from the depot to clean the next bucket, and so on.

The tanker will generally be full by the end of the day. Every third day a longer route is covered, and the tanker makes two trips. Since two crews and tankers are in operation each day a total of about 16 or 17 loads of night soil is collected each week.

When all the night soil is collected, the driver goes to the disposal ground near the Leprosy Hospital. The hospital is on the east side of the watershed and virtually all the areas served are on the west. The driver must go onto the main thoroughfare Roma Road, and then return to Leprosy Hospital. Although the disposal ground might appear close to the areas served by bucket latrines, in fact, a trip of several miles is required to reach the disposal ground.



A night soil worker collects a bucket from a latrine in a densely populated area of Maseru.



Night soil buckets being passed up for emptying into the night soil truck.

Two workers at the disposal ground open trenches to receive the night soil. These trenches are sometimes as deep as 2 meters, but are sometimes as shallow as 1/2 a meter. The tanker truck filled with night soil backs up to a trench, the drain at the bottom of the tank is opened, and most of the night soil is discharged into the trench.

In principle, the night soil should be covered by a layer of soil. In practice, this never happens. The night soil lies in the open ditches. Heavy rainstorms wash much of the night soil out of the trenches and down into the reservoir.

After the night soil is discharged, the tanker truck returns to the depot where most of the workers are left off. The truck then continues on to the stabilization ponds located in the industrial area. There, the remaining workers thoroughly wash the collected buckets and fill about half of the tank with water. Long wire brushes are used to scrub the inside of the tank, and most of the solid material goes into suspension. Since the Water Branch forbids the night soil crews from discharging anything other than bucket washings into the manhole used by the conservancy tankers, the truck returns to the disposal grounds near Leprosy Hospital. This time the truck discharges a mixture of water and residual night soil. (An agreement to allow discharge of wash water into the individual ponds was reached during the consultants' final presentation, which was attended by the Director of the Water Branch and the Town Engineer.) Finally the crews return home for the day.

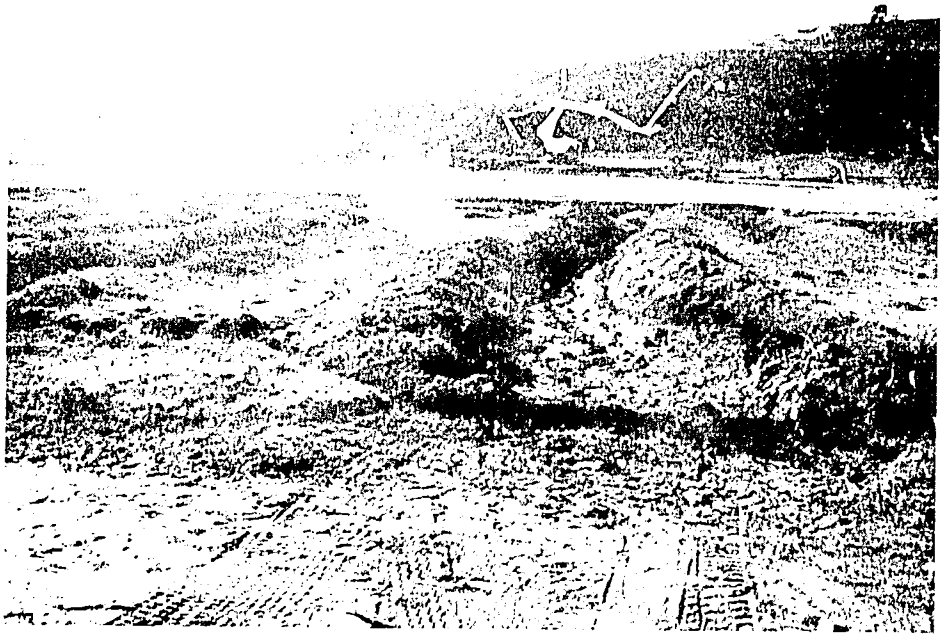
In a recent study for the Ministry of the Interior (Jackson and Stern, 1982) the annual costs of the night soil collection system were estimated as follows:

Night soil truck labor	M29,400	(US$24,990)
Night soil farm labor	6,600	($ 5,610)
Safety equipment	2,000	($ 1,700)
Buckets	7,400	($ 6,290)
Transport costs (average)	32,000	($27,200)
Staff accommodations	10,000	($ 8 500)
TOTAL ANNUAL CHARGE	M87,400	($74,290)

The average cost per latrine for the 2,200 bucket latrines served is about M3.30 (US$2.88) per month. The monthly charge levied by the Ministry of the Interior is only M0.75 (US$.64).

1.1.5 The Conservancy Tank System

A conservancy tank is a reinforced concrete vault into which both household sewage and grey water are discharged. These tanks are used by households with indoor plumbing in areas of Maseru not served by the sewer network. The tanks are emptied by vacuum tankers operated by the Water Branch. The vacuum tankers discharge into a manhole next to the stabilization ponds in the industrial area.



The open trenches in which the night soil from the bucket latrines is dumped. In the background one of the back-up reservoirs for the Maseru water supply can be seen.

In principle a conservancy tank is supposed to store seven days of wastewater, but in fact many tanks have only a one day capacity. While some tanks are emptied more often than weekly, it is common for conservancy tanks to overflow before they are emptied.

There are an estimated 775 conservancy tanks in Maseru, serving about 3,000 people. The number of tanks has doubled over the last two years.

Conservancy tank owners pay a flat rate of M4.50 (US$3.83) per month, the same as those who have a sewer connection. The cost of servicing these tanks, however, is much higher, about M16 (US$13.60) per month (Jackson and Stern, 1982), excluding the cost of sewer lines, pumping, and treatment attributable to the contribution from the conservancy tanks. As suggested by Jackson and Stern, the system could operate better if charges were a function of load and frequency of emptying.

1.1.6 The Waterborne Sewerage System

About 10 percent of Maseru households discharge their wastewater into sewers. These sewers also cover the main business, hotel, and industrial areas. As mentioned earlier, wastewater from households served by conservancy tanks are also discharged into the sewers. The newly-constructed Ratjamose Sewage Treatment Plant is discussed in detail in Section 3 of this report.

1.2 Likely Sanitation Developments in Maseru

This section is concerned with the vast majority of households which cannot afford in-house or connection costs of the universally-preferred sanitation system, a flush toilet. For these households, the options are to have no sanitation facilities, to construct conventional pit latrines, to make use of the bucket latrine system, or to construct VIP latrines.

If a householder were to bear the full cost of sanitation, he would be faced with the following choices:

- Build a latrine super-structure with available materials and pay M3.30 per month (US$2.80) for night soil collection;
- Pay M340 (US$289) to construct a VIP latrine;
- Construct a conventional pit latrine using available material;
- Have no sanitation facility.

If householders were faced with this choice the proportion of the population using no sanitation facilities at all would increase substantially, thus exacerbating the most serious aspect of the sanitation problem in Maseru. A variety of measures can be taken to avoid having to make this decision. These measures are discussed below.

1.2.1 Reducing Costs of the Bucket System

There are several ways to reduce the cost of the night soil collection system. The cost of vehicle maintenance could be reduced if it were entrusted to a private contractor (Jackson and Stern, 1982). When the current night soil disposal ground is abandoned for a new site, water will be made available for washing the buckets and the truck at the discharge point. Furthermore, the washwater will be discharged at the point of disposal. This will eliminate up to 30 percent of the mileage covered by the tanker trucks. This measure alone will reduce the cost per bucket from about M3.30 (US$2.80) per month to about M2.90 (US$2.47) per bucket. The cost per bucket might further be lowered by reducing the stock of buckets and by accepting contracts for additional bucket latrines in areas already covered. A reduction of the cost of the collection system to about M2.50 (US$2.13) per bucket per month is a reasonable goal.

1.2.2 Improving Conventional Pit Latrines

The only truly low-cost sanitation technology available to residents of Maseru is the conventional pit latrine. The VIP latrine was developed to find a low-cost substitute to the conventional latrine, which would not have its major disadvantages: odor, fly-breeding, and structural instability, but ended up relatively expensive. Therefore, there remains a clear need for a simple and cheap technology which can be used in upgrading conventional latrines. In particular, there is a need to fabricate and market a simple, cheap, and strong latrine slab. Experience in Mozambique has shown that such a slab can be locally-produced for about M10 (US$8.50) and can markedly improve the safety of a conventional latrine.

1.2.3 The Ventilated Improved Pit Latrine

With respect to the VIPs, the cost of units being installed in the World Bank-funded project in Khubetsoana is considerably more than M340 (US$289) because of more expensive double-vault latrines and the necessity of lining the pits. It thus does not appear to be feasible to reduce the cost of the VIP latrine below M340 (US$289) which will make it difficult for many Maseru residents to have them.

1.2.4 Subsidies and Financing

Both the bucket collection system and the VIP latrines are heavily subsidized. With the bucket collection system the household pays M0.75 (US$.64) and the Government subsidizes M2.55 (US$2.19) per month for servicing. The VIP householder pays M3.10 (US$2.64) per month in finance charges, and the government M2.20 (US$1.87) per month.

Both systems are extremely important for residents of Maseru. The VIP latrine is excellent for householders who already own or are building their own houses. The bucket latrine system is currently the only system for tenants in the dense peri-urban areas. It is recommended that the prices for both of these options should remain more or less the same as at present.

A newly constructed and already well used VIP latrine.

1.2.5 A Likely Future Scenario

On the basis of considerations presented in the previous section, it seems likely that in the next ten years or so:

- There will be a substantial increase in the number of VIP latrines, mostly in areas of new housing development;
- There will be a general improvement in the structural features of conventional pit latrines through the introduction of a cheap and sturdy latrine slab;
- There will continue to be a bucket collection system, with the number of bucket latrines in the service area increasing; and
- Few households will be left without some form of adequate excreta disposal.

There will continue to be a problem with night soil disposal and a growing problem of sludge disposal from the VIP latrines.

Chapter 2

POTENTIAL NIGHT SOIL DISPOSAL OPTIONS

2.1 General Considerations

Night soil disposal on the watershed must cease because of the health hazard. Consideration of general principles governing the disposal of night soil and of particular economic, cultural, and organizational factors pertinent in Maseru suggest that an analysis of night soil disposal options be based on the following considerations:

- Night soil should not be diluted with water and added to the sewerage system since substantial costs would be incurred separating the solids.
- The distance travelled by the tanker trucks should be minimized. Transportation is the most expensive item in the system.
- The buckets and the tanker truck should be washed at the disposal site.
- Improved housing and, particularly, improved washing facilities should be built for the night soil workers and their families. The present facilities constitute a health threat to the workers, their families, and the community at large.
- Attention should be given to the administration of the new disposal site so that it does not degenerate into a health hazard, as has happened at the present site.
- Attention should be given to reclaiming organic material in the night soil and applying it to park and cropland.
- Demand for digested sludge from the sewage treatment plant exceeds supply, and digested night soil could supplement the primary sludge.

2.2 Available Options

The Ministry of Interior has determined that a new disposal ground must be found for night soil collection. The possible options for a new disposal method might include:

- burial of night soil in a new disposal ground;
- discharging night soil into the stabilization ponds in the industrial area;
- discharging night soil into sewers at convenient manholes;
- using the clarigester and drying beds at the abandoned sewage treatment plant at Hoohlos;

- o digesting night soil anaerobically in a facility capable of recovering and using the methane generated;
- o composting the night soil aerobically with organic material from refuse and other sources;
- o discharging night soil into abandoned stabilization ponds at Hoohlos;
- o adding night soil to the primary sludge in the new Ratjamose Sewage Treatment Plant.

The remainder of this section discusses the feasibility and advisability of the options suggested above.

2.2.1 Burial in New Disposal Ground

Maseru is rapidly growing. The peri-urban population is increasing by 11 percent annually. Officials responsible for zoning do not forsee any suitably-isolated area within the greater Maseru area. Therefore, any new disposal ground would have to be beyond the present peri-urban area, meaning greatly increased transportation costs. In addition, since providing an appropriate water supply for washing the buckets and trucks far from the town would also be difficult, a new disposal ground is not viable.

2.2.2 Discharging into Sewers or Industrial Stabilization Ponds

If night soil were discharged directly into the sewers it would lead to periodic cloggings, since the sewers are designed to handle only liquid wastewaters. This problem could be overcome, however, by discharging the night soil into the stabilization ponds in the industrial area (as done by the conservancy tankers). But, the practice of mixing night soil with sewage is highly undesireable since it increases the strength of the sewage and it subsequently is necessary to separate the solids at the treatment plant--a costly process.

2.2.3 Using Abandoned Stabilization Ponds at Hoohlos

Night soil might be discharged into existing ponds at nearby Hoohlos and covered with sewage easily diverted from the trunk sewer. There would be no discharge from the ponds and, although no longer in use, the ponds are in good condition.

A problem, however, is that to the north and east of the ponds is a high income housing area. The politically powerful residents complained about the stabilization ponds when they were in use. The nearest of the houses is about 150 meters from the ponds, but the prevailing wind is southerly and the residents would occasionally smell the digesting night soil.

An additional concern is the possibility of overloading the ponds. The permissible loading on ponds for an average monthly temperature of 8 degrees C (the Maseru average for June and July) is only about 100 kg of BOD* per hectare per day (Mara, 1976).

As mentioned earlier, approximately 19,000 people are served by the bucket collection system. However, from the quantity of night soil collected, about 6.5 cubic meters per day (cmd), and from descriptions of local practice ("men usually urinate in a small hole beside the latrine, or in a metal curved sheet outside the latrine, or in a separate bucket, so that the one in which they defecate does not fill up quickly") (Shanawamy, 1980), it is clear that a substantial amount of urine goes uncollected. Assuming that the per capita BOD contribution is 11 grams (gms) feces, 10 gms urine and 1 gm paper used for anal cleaning (Mara, 1976), and that only 50 percent of the urine is collected in the buckets, the per capita BOD contribution is 17 gms per day. The total BOD in the night soil per day is thus 323 kilograms (kg).

Therefore, there would be an additional biological load on the ponds due to the addition of sewage. Assuming an evaporation of 5 millemeters (mm) per day in the winter months, as the area of the ponds is 2.0 hectares, 100 cmd of sewage and night soil could be added daily without requiring additional pond volume. With a daily input of night soil of 6.5. cubic meters, about 93 cmd of sewage would be added to the ponds. Assuming a BOD of 400 mg/liter, this would mean an additional organic load of 37 kg BOD per day. The total organic load thus would be about 323 + 37 = 360 kg BOD per day. At a permissible loading of 100 kg BOD/ha/day, the required area of the ponds would be 3.6 hectares, which is almost twice the 2.0 hectares available.

Because the area available for pond extension is much less than necessary, and as the amount of night soil to be disposed of is unlikely to decrease in the near future, this option is not feasible.

2.2.4 Using Abandoned Hoohlos Sewage Treatment Plant

The clarigester at the Hoohlos plant could be transformed into an open anaerobic digester by removing the partition between the clarifier and digester. The capacity of the unit would be about 100 cubic meters. Assuming that 0.10 cubic meters of digester capacity is required per capita (Okun and Ponghis, 1975) the requirement for the 19,000 people served by the bucket collection system is about 2,000 cubic meters of digester capacity. Consequently, the capacity of the clarigester at the old treatment works is inadequate.

2.2.5 Aerobic Composting

Before night soil can be composted thermophilically its moisture content must be reduced to below 60 percent (Kalbermatten, et al, 1980). Mechanical dewatering is a complex process which is inappropriate in Maseru. Thus, for sufficient moisture, absorbent biodegradable waste material such as refuse, saw-

*BOD refers in this report to five-day biochemical oxygen demand.

dust, wood chips, or rice husks must be added to the night soil. The same materials would raise the carbon to nitrogen ratio from about 10:1 (in night soil) to the 20 or 30 needed for preventing ammonia loss and for achieving rapid stabilization of the organic material.

No source of suitable industrial waste material was identified in Maseru. Maseru refuse consists largely of discarded beer cans with little organic material. No other suitable material for adding to the night soil was identified.

Even if a good additive were to be found, an adequate administrative structure would be necessary to ensure control of the composting process. It would also be necessary to determine whether compost produced directly from night soil is acceptable to consumers in the Maseru area.

Although aerobic composting may become an option in the future, for the present it is not workable.

2.2.6 Biogas Generation

When sewage sludge and night soil undergo anaerobic digestion, methane is generated. The methane can be captured and used for a variety of purposes (such as heating the digester itself, driving specially-adapted diesel motors, and fueling natural gas cookers). Although capturing and using methane is simple in principle, problems of safety (in certain proportions, methane and air are explosive), operation, and maintenance are considerable.

If, after several years, all operation and maintenance problems at the Ratjamose Sewage Treatment Plant have been resolved, consideration should then be given to covering the digesters and using the methane.

2.2.7 Adding Night Soil to Primary Sludge at Ratjamose Sewage Treatment Plant

Another option for dealing with night soil disposal would be to set up a deposition facility at the Ratjamose Sewage Treatment Plant.

A sketch of a night soil deposition facility is presented in Figure 2. The actual structure could be designed by an engineer of the Ministry of the Interior in collaboration with an engineer from the Water Branch. The estimated capital cost of the facility is M5,000 (US$4,250). At the deposition facility, the night soil from the tanker trucks would first pass through a bar screen and then flow by gravity through a pipe into a primary sludge wet well. A hose bibb carrying plant effluent would be installed for plant cleaning as part of a small pipe network which the Water Branch plans to install at the Sewage Treatment Plant. The effluent in this plant water system could be used for washing the buckets and the tanker and would discharge, not into the primary sludge wet well, but into the influent sewage stream above the bar screen.

As shown in Figure 3, the total distance covered by the tanker trucks in collecting and discharging would be similar to the distance now covered.

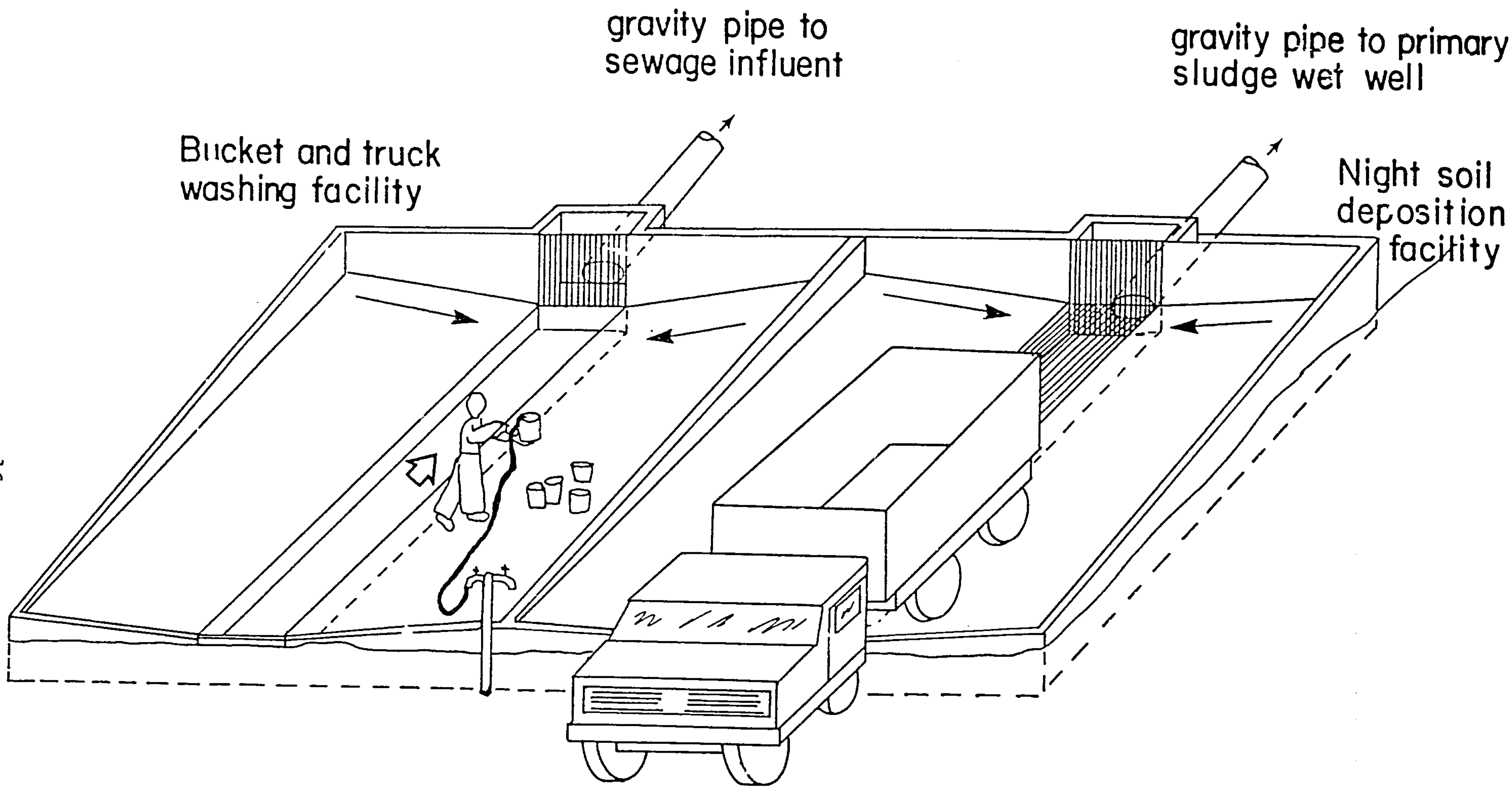
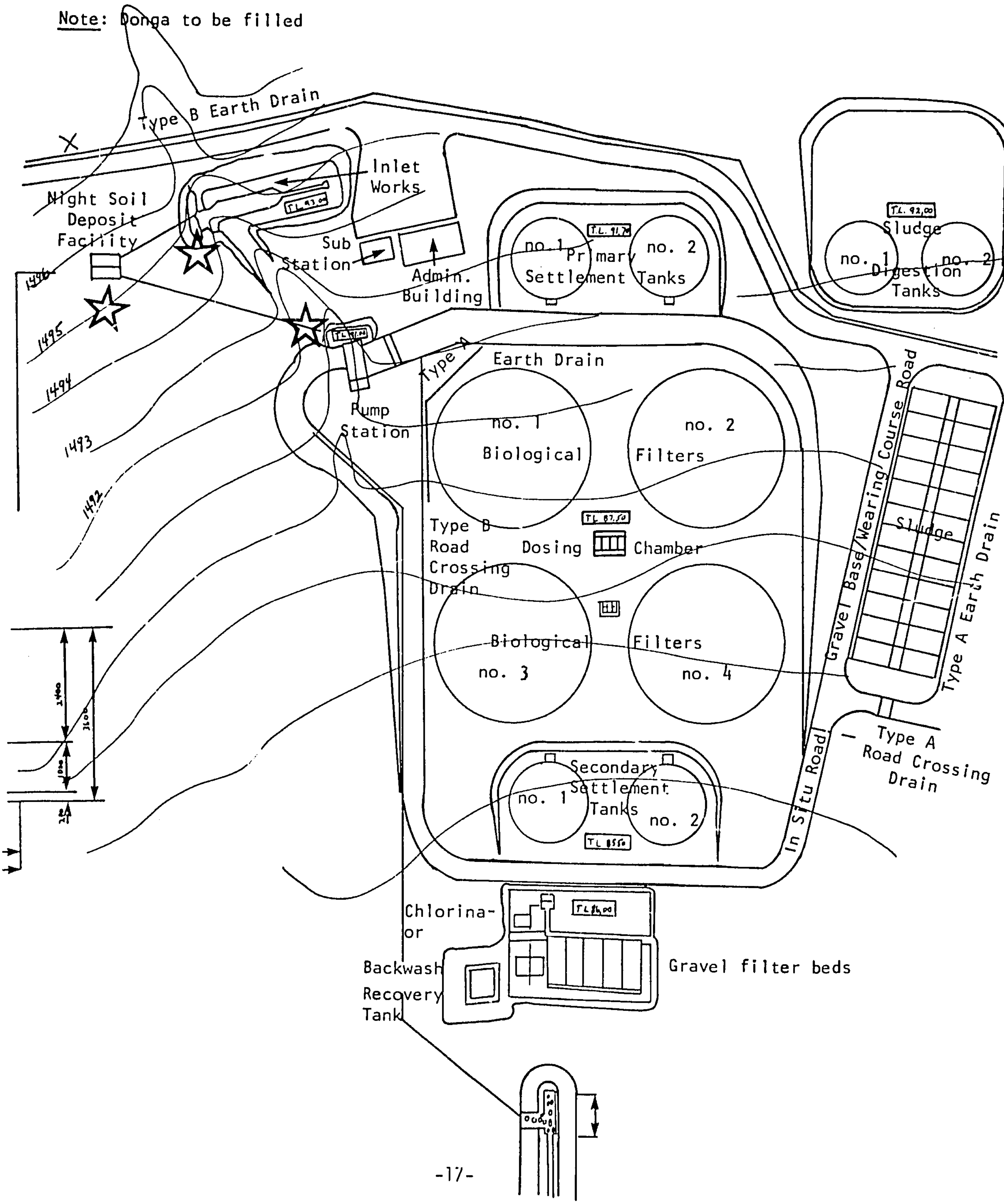


FIGURE 2 : NIGHT SOIL DEPOSITION FACILITY
RATJAMOSE SEWAGE TREATMENT PLANT

FIGURE 3. LOCATION OF NIGHT SOIL DEPOSITION FACILITY



A primary consideration in evaluating this option is whether the capacity of the sludge pumps, sludge digesters and drying beds could handle the additional organic load. Assuming a primary sludge production of 1,680 gms of wet solids/capita/day (Okun and Ponghis, 1975), with a population of 27,000, a daily production of 45 cubic meters of sludge is to be expected. The additional influent into the primary sludge wet well from the night soil would be about 6.5 cubic meters or about 15 percent of the existing primary sludge production. In the analysis of the Ratjamose Treatment plant, presented in Section 4, it is shown that capacity in the digesters and sludge drying beds is adequate to handle this additional load.

The digested sludge would be indistinguishable from the present sludge. Therefore, since the demand for sludge exceeds supply, there will be no difficulty in passing on 15 percent more dried sludge.

A serious problem with the present night soil collection and disposal system is the very poor sanitary facilities available to the night soil workers. An appropriate place for the installation of bathing facilities and a workclothes storage place would be at a night soil disposal facility at Ratjamose. If the workers continued to live in the compound in the industrial area, transportation from Ratjamose to their homes would be a problem. Since it is necessary, in any case, to improve housing for these workers, serious consideration should be given to constructing a new compound next to the Ratjamose Sewage Treatment Plant.

If the night soil deposition facility was located at the sewage treatment plant supervision of the operation would be much more likely than at a separate, isolated facility. An appropriate arrangement would be to have the workers responsible for the deposition facility subordinate to the Chief Operator of the Sewage Treatment Plant. The administrative and financial details would have to be worked out between the Ministry of the Interior (which has responsibility for the night soil collection system) and the Water Branch (which has responsibility for operating the sewage treatment plants). The Ratjamose Sewage Treatment Plant is described in more detail in the next section.

Chapter 3

THE RATJAMOSE SEWAGE TREATMENT PLANT

3.1 Overall Description

This sewage treatment plant originally proposed in a "Report on Maseru Sewerage Scheme" by Brian Colguhoum and Partners (February 1974), was placed in operation in 1980 with only slight modification of the original recommendation in the report. It was designed for an average flow of 5,000 cmd, with a capacity for handling peak hydraulic flows of 10,000 cmd. Piping connections, have since been provided to permit the plant to be doubled in size. The biological loading is based on a contribution from a population equivalent to 27,000 persons. Based on these parameters the per capita flow is calculated at 185 liters per day (lpd).

The plant includes the following units:

- One hand-raked bar screen, with 25 mm bar openings, designed for 10,000 cmd.

- Two constant-velocity grit channels, designed for 10,000 cmd.

- Two circular mechanically-cleaned primary sedimentation tanks, 15 m in diameter, 2.5 m deep, which provide a detention period of four hours and an overflow rate of 14 cmd at a flow of 5,000 cmd.

- Four circular trickling filters 35 m diameter and 2 m deep, with dosing siphons, which provide for a hydraulic loading of 1.3 cmd at a flow of 5,000 cmd, and a biological loading of about 0.15 kg BOD cmd at a population equivalent of 27,000. (This assumes a per-capita contribution of 60 gallons per day (gpd) of BOD and 30 percent removal in primary sedimentation).

- Two circular, mechanically-cleaned, final sedimentation tanks, 15 m in diameter and 2.5 m deep, which provide a detention period and an overflow rate of 4 hours and 14 cmd respectively, at a flow of 5,000 cmd.

- Chlorination facilities.

- Six upflow gravel filters, with a total area of 10 m by 25 m or 250 cubic meters, which provide a loading of 20 cmd at 5,000 cmd flow.

- Two circular open sludge digesters, 13 meters in diameter and 12 meters deep (average), for a total capacity of 3,186 cubic meters or 0.135 cubic meters per capita based on an equivalent population of 27,000.

- Forty-eight open sludge drying beds, with a total area of about 1,800 square meters for a loading of about 0.07 square meters per capita, based on a population of 27,000.

- Two 25 liters per second (lps), 3-in by 4-in, centrifugal primary sludge pumps, designed to operate alternately to lift sludge from the wet well to the sludge digestion tanks. The pumps start automatically when the wet well fills.

- Two 60 lps, 6-in by 8-in, centrifugal sludge pumps to provide mixing at the sludge digesters by removing sludge from the bottom and discharging it through nozzles at the top.

- Two 20 lps, 3-in by 4-in, centrifugal sludge pumps for automatically and alternately pumping secondary sludge and wash water from the gravel filters to the head of the plant upstream from the primary sedimentation tanks.

3.2 Plant Capacity

In general, the plant is conservatively designed, with loadings well within, and even below, those generally used in developing countries. (See WHO publication "Community Wastewater Collection and Disposal" by Okun and Ponghis, 1975). Of particular interest is the loading of the trickling filters (which have the greatest influence on the treatment efficiency of the plant) and the loading on the digesters (which affect their ability to handle an additional load of night soil).

3.3 Plant Treatment Efficiency

Actual loadings and performance are more significant than design loadings and assumed performance. One factor which mitigates against complete analysis of the plant is the absence of flow data: influent flows, sludge flows, etc. This plant has both influent and effluent flow-measuring devices, but neither operate. Actually, only one is needed. The V-notch weir at the effluent can easily be read manually, and this could be done continuously, at least once per hour around the clock, until the mechanical unit is made operative. Such readings were made hourly from 6 a.m. to 6 p.m. from 18 Februrary 1982 to 12 April 1982. The average for this higher-flow 12-hour period was about 3,800 cmd. An estimate made by the design consultants at the principal pumping station in early 1982 revealed a flow of about 2,500 cmd, or about one-half the design average flow.

3.4 Detailed Descriptions of Wastewater Treatment at the Plant

3.4.1 The Trickling Filters

While most trickling filters are so-called "high-rate" filters, which require recirculation, these units are designed as "low-rate" units, without requiring recirculation. Hydraulic loadings for low-rate units generally range from 1 to 4 cmd, while these are loaded at 1.3 cmd. Furthermore, provision has been made to add recirculation pumps in the future, allowing a loading range from 8 to 40 cmd.

Similarly, the organic loadings for low-rate filters generally range from 0.08 to 0.40 kg BOD per cmd, which may then increase to 0.4 to 50 kg per cmd with recirculation. The design loading for this plant is only about 0.15 kg per cmd.

While comprehensive analytical data are not available, it is clear that the plant is not operating at its full efficiency. Only two of the filters are being used, and the biological growth on the stones is poor, possibly because of inadequate seeding. Based on winter data for 1981 the BOD removals averaged about 85 percent, which is satisfactory. However, because of the strong waste, the effluent BOD averaged 66 mg/l, which is high for this type of plant, particularly with its current low loading.

One reason for the widespread adoption of high-rate filters is their much higher efficiency due to recirculation which continuously reseeds the filters, helps maintain a more uniform flow and mitigates the deleterious effects of any sudden changes in flow or strength of the influent. Although adding pumps and piping to permit large-scale recirculation is not now warranted, and may not be for many years, some significant recirculation can be obtained with the present facilities by operating secondary sludge pumps continuously (one at a time, alternating their use daily or weekly). This would continuously remove the humus from the secondary tank so that it would remain in better condition and would draw underflow for recirculation, thus instituting the most common of the single-stage high-rate trickling filter flow patterns. Also, this would permit the activation of at least one of the two now-dormant trickling filters, and perhaps both. Higher treatment efficiency should result, as indicated by the formula.

$$E = \frac{1}{1 + 0.44(W/VF)^{1/2}}$$

where E = efficiency of second stage in %
W = loading of filters in kg per cmd
V = volume of filters in cubic meters
F = recirculation factor in the following formula

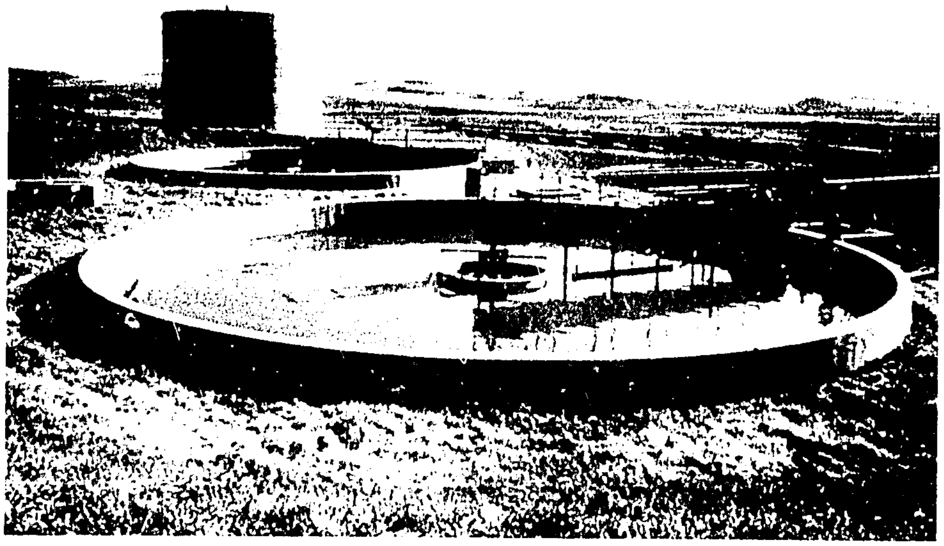
$$F = \frac{1 + R/I}{\left(1 + \frac{0.1R}{I}\right)^2}$$

where R = rate of recirculation, cubic meters per day (cmd)
I = influent rate, cmd

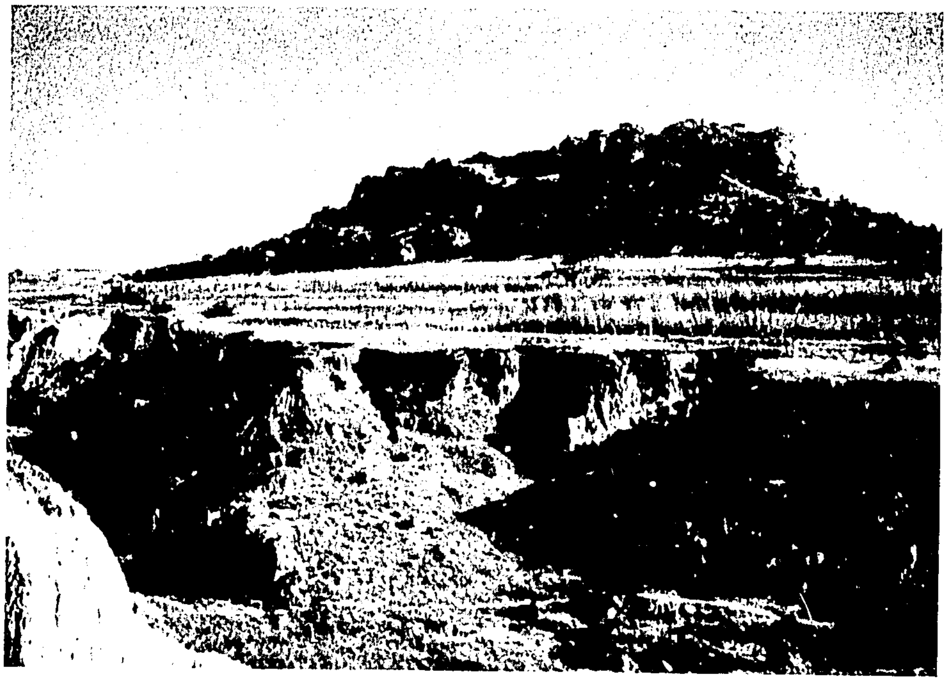
Recirculation of 20 lps at an average flow of 3,500 cmd (R/I = 0.5) would increase the plant efficiency by several percent. More importantly, it would improve reliability of operation.

3.4.2 Tertiary Gravity Filters

While secondary effluent can sometimes be used for irrigation, operations are improved when a "polished" effluent is used.



The primary clarifiers with the open, aerobic digesters in the background.



A "donga", a typical drainage canal in the lowlands of Lesotho. The "duplex" soil in which an impervious clay layer underlies the top soil, is evident. Where duplex soils are prevalent the capacity of the soil to absorb water is limited and the suitability for irrigation, with wastewater or other water, is limited.

The purpose of upflow gravity filters is to polish effluent but, unfortunately, these filters have not operated well. The units are unconventional, particularly in the gravel support structure of 100 mm concrete beams with an open space between them of 3 mm which is intended to distribute the inflow.

Experience with use and particularly cleaning is limited. Accordingly, improved performance will require an experimental approach to determine the best mode of operation and washing.

3.4.3 Chlorination

While facilities for effluent chlorination are available, there would be no reason to initiate chlorination until the effluent is used for irrigating crops to be eaten raw, such as vegetables. Chlorination is contraindicated for effluent discharged to the Caledon River or for effluent used for most land application.

Chlorine is expensive. Should it be required, it should be applied following the gravel filters to reduce the chlorine demand, and then only to that portion of the effluent to be used for vegetable irrigation.

3.4.4 Monitoring

Continuous monitoring is essential to check performance and to permit operating improvements. During start-up especially, special analyses help determine the best procedure. A particularly appropriate monitoring measure is turbidity, which is a rough measure of both suspended solids and BOD. In fact, for secondary effluent and for plant effluent, a correlation may be developed between suspended solids and turbidity, and between BOD and turbidity. Turbidity measurements can also help identify sudden changes in the influent sewage and in the performance of the unit processes. Running such tests at the plant would be particularly useful if the samples could be collected each hour, or every few hours, so that diurnal changes could be established. The Water Branch Laboratory should install a simple immersion turbidimeter at Ratjamose and train the wastewater plant staff in its operation.

Turbidity analyses would be extremely valuable in assessing performance of the tertiary upflow gravity filters. For example, the best depth for the gravel can be determined by using different depths on the beds and measuring the effluent turbidity.

The most important tests and those that should be run most frequently, and preferably on composite samples, are pH, suspended solids, BOD and turbidity. Other tests such as COD, need only be done occasionally.

3.5 Details of Sludge Handling Features

Sludge pumping, treatment, and disposal can be the most troublesome of the plant processes. The loading of sludge handling processes and their ease of operation has a bearing on the ability of the plant to handle night soil collected in buckets. Four elements are important: sludge pumping and piping, sludge digestion tanks, sludge drying beds, and sludge disposal.

3.5.1 Sludge Pumping and Piping

Primary sewage flows by gravity from the primary tanks to a wet well from which one of two centrifugal pumps discharges the sludge to the digesters through about 150 m of 150 mm pipe. A serious problem is the use of centrifugal pumps for pumping primary sludge. Even with screening of the raw sewage, a considerable amount of rags and other debris collects in the hoppers of the primary tanks. Centrifugal pumps are not designed to handle such material, and are subject to frequent clogging and to fouling of the check valves on the discharge side of the pumps. Okun and Ponghis (1975) state (p227): "Reciprocating pumps are commonly used to transport primary sludge because of the high solids concentration and the ease with which clogging can be remedied." Furthermore, such pumps require no check valves and are more easily started. This factor is important, since these sludge pumps operate only intermittently, several times per day, and almost never at night. Also, the manufacturer's pump curves for the raw sludge pumps are very flat, so that any small increase in head resulting from clogging virtually ends sludge delivery. When thick sludge remains in the 150 m of 150 mm discharge pipe overnight, particularly in winter, centrifugal pumps have difficulty pumping in the morning. The time required to empty the wet well indicates that the pump moves only a very small fraction of its capacity. Positive-displacement, reciprocating, plunger-type pumps are ideal for such service. The same pump manufacturer (Lee, Howl & Co. Ltd) has a range of reciprocating pumps available for use on sewage sludge when the solids content is too high to be dealt with by centrifugal pumps (which is clearly the case with primary sludge). Steep head-capacity curves are characteristic of positive displacement pumps, so they can continue pumping even when clogging occurs.

Because the discharge is not metered and there are no sampling taps, the operator has difficulty knowing the discharge of the centrifugal pumps. Also, when the check valve hangs up, the sludge returns through the centrifugal pump, when it is not in operation, to the wet well. Often the centrifugal pumps turn without moving much sludge. By contrast, the discharge of a reciprocating pump is simple to measure and requires no instrumentation other than a watch reading seconds in seconds.

As discussed in the preceding section, one option for the disposal of night soil from bucket latrines would be to add the night soil to the primary sludge. The addition of night soil, estimated at 6.5 cmd, represents an increase of about 15 percent in the primary sludge flow under full design conditions. Since the sludge pumps should only operate for short periods of time, there would be no problem. However, the night soil would add to the difficulties with the centrifugal pumps. A high priority, whether or not the night soil is added, is the replacement of the primary sludge centrifugal pumps by positive displacement pumps.

In the interim, the problem may be reduced by temporarily replacing the existing bar screen with one that has 10-15 mm openings or by placing a new screen just upstream of the existing one. The screen can be fabricated locally.

A screen with smaller-openings will, of course, require more frequent cleaning.

3.5.2 Sludge Digestion Tanks

The capacity of the two sludge digestion tanks provides about 0.14 cubic meters per capita, about 20 percent more than the South African standard for open, unmixed digesters. Periodic mixing, and operating in a 2-stage mode, which is permitted by the existing piping, should improve the performance of the digesters. In any event, the additional load of night soil would not exceed the capacity of the digesters. A study of the primary sludge now generated would verify this. A measure of the sludge pumped to the digester each day, possibly by measuring the changing depth in the wet well at appropriate times, together with a sample of the sludge to determine its solids content, would establish the current loading on the digesters.

3.5.3 Sludge Drying Beds

These beds, allowing about 0.07 square meters per capita, are within the capacity range of 0.07 to 0.09 square meters per capita called for by the South African National Institute for Water Research. However, their design is unconventional and it is already giving excessive trouble. As stated in Okun and Ponghis (1975, p234): "Sludge drying beds are commonly made of 300-600 mm of coarse sand underlain by about 300 mm of coarse gravel, laid, in turn, on tile underdrains." The drying beds at the Ratjamose plant have sand laid on several sizes of rough stone, without underdrains. The beds are in sets of four, with the bottoms sloped to a common collecting channel at the lower end of the fourth (lowest) bed. The expectation, apparently, was that the interstices in the large stones at the bottom would permit the water drained from the sludge to flow along the bottom to the collecting channel.

Whereas rounded gravel can keep a sand layer separated, sharp-edged stone cannot. The sand and fine stone has already worked its way into the bottom of the beds, virtually stopping drainage. Whatever drying that does occur can only be attributed to air drying in the very dry atmosphere of Maseru.

If the beds are to perform adequately, the stone will have to be replaced with rounded gravel and drain tiles be installed. Local staff and labor could gradually make the change. In the interim, some improvement may be effected by applying the digested sludge in thinner layers, thus depending more on evaporation, due to dry air and high winds, than on drainage. Also, the burden on the beds can be reduced by applying the sludge on only one bed in a second set and so on, rather than by filling all four beds in a set.

If the beds are improved, they should be able to handle the additional night soil load. Should the beds be overloaded, however, two options are possible: additional beds can be built, as these are not costly or, preferably, arrangements can be made for partial disposal of the wet sludge on land, which is common practice throughout the world and particularly appropriate in the vicinity of Maseru. In an emergency the digested sludge could be hauled in tanker trucks, similar to those used for night soil, to the abandoned lagoons at Ratjamose, where it could be air dried for ultimate disposal. The approximately 500 square meters of area is more than twice that of the drying beds.

3.5.4 Sludge Disposal

All of the dried sludge produced thus far has been used for soil enrichment by public agencies and private persons. The soil in Maseru and vicinity is dry and low in humus. Tilling dried sludge into the soil improves its quality and moisture-holding capacity. There is no question that demand for dried sludge, even without publicity, will exceed supply. The addition of night soil to the sludge will increase the supply and represents a reclamation of a valuable resource opposed to a waste and a pollutant.

3.6 General Plant Operations

Operations, within existing constraints, are satisfactory, but additional monitoring is indicated. A major difficulty with the present plant is its location 5 kms from the city center. Transportation for personnel is inconvenient. On-site housing would do much to improve the worker morale and consequently operations. Also, if night soil were to be discharged at the plant, supervisory personnel would need to be present. Since this supervision would be for brief periods during the night, residence at the site would be helpful. If on-site housing is considered, housing for night soil collectors and sewage treatment plant operators should also be constructed.

Chapter 4

LAND APPLICATION OF WASTEWATERS

Application of wastewaters to the land can serve two dissimilar purposes;

1. replacing, in part, conventional treatment systems; or
2. irrigating land where wastewater is considered a water resource.

The two purposes are often confused and must be distinguished.

4.1 Land for the Treatment of Wastewaters

The first modern application of wastewaters to land was in Britain and continental Europe in the early 19th Century. The facilities were called "sewage farms." However, because of the vast areas of land required for treating sewage from cities and because land in the vicinity of cities increases in value, it became more economic, aesthetic, and healthful to build treatment plants to permit discharges of wastewater into rivers and other waters. In time, however, with an increased interest in the abatement of water pollution, and because of the high cost of conventional treatment, land treatment reemerged as an option. Land treatment has the potential for eliminating point sources of pollution and returning nutrients to the ecosystem through the production of agricultural products.

Land treatment, however, is not a panacea: it has constraints and disadvantages:

- The area required for land treatment is site-specific, being a function of soil properties and climate. The area required may be determined by hydraulic loading, salt loading, or organic loading. Heavy metals and toxic substances may further limit land use, if they do not eliminate the option entirely.
- Where infiltration rates are low, large areas of land are required, often limiting the practice to small communities in rural areas where ample low-cost land is available.
- Where precipitation is concentrated in a rainy season, much of the infiltration capacity of the land will be consumed during the rains, and wastewater will need to be discharged to receiving waters, requiring conventional treatment facilities.
- If groundwater is abstracted from aquifers below the land treatment site or if the ground water issues at a lower elevation into a water course the quality of the water may be adversely affected.
- Because of the large area required, cost of the application system may be high. In addition, pumping to a suitable site may be more costly than transporting sewage to a treatment plant, which can be located closer to the population served.

- Land treatment does not eliminate conventional treatment entirely. Preliminary treatment (screening and grit removal) is always required, and often primary treatment and/or lagoons may be necessary.

- The management of land disposal systems requires the close cooperation of a wide variety of specialists in both design and operation of the system. The institutional support for such a system must be strong.

4.2 Wastewater As a Resource for Irrigation

In areas where rainfall does not always suffice for optimum agriculture, irrigation may be introduced. Generally, water for irrigation is taken from surface or groundwaters. Where such waters are in short supply, or where quality requirements call for potable use, wastewaters have been utilized. Depending upon soil type and the crops to be grown, wastewater may be used after primary sedimentation, after secondary treatment, or after tertiary treatment, which generally calls for polishing by filtration. The following table indicates standards for various agricultural uses that might be found in Lesotho:

Table 1

Use	California	South Africa
Orchards	Primary effluent; no spray irrigation	Tertiary effluent; chlorinated; no spray irrigation.
Fodder	Primary effluent; surface or spray irrigation	Tertiary effluent
Crops processed for human consumption	Primary effluent for surface irrigation. Disinfected sec. effluent for spray irrigation (<23 coliform/100ml)	Tertiary effluent
Crops for human consumption in raw state	<2.2 coliform/100ml for surface irrigation. Disinfected, coagulated, filtered effluent for spray irrigation.	

The current treatment at Ratjamose would permit irrigation of all crops other than those used for human consumption in the raw state, but the treatment is excessive for other irrigation uses. On the other hand, chlorination would possibly be justified for all spray irrigation applications because of prevalent high winds in Maseru.

Adapting the present plant for reclamation for irrigation would require a storage basin or earth lagoon for regulation and use as a wet well for pumping the effluent to the fields. Depending upon demand, irrigation might use all (in the dry season) or a portion of the wastewater effluent. Only the reclaimed water would need chlorination.

Chapter 5

IRRIGATION USES OF WATER

5.1 Status of Irrigated Agriculture in Lesotho

The annual rainfall for the Maseru area averages 682 mm, with 540 mm or about 80 percent falling during the October through March summer rainy season, which is the principal growing season. Frank Berding, of the FAO team on Land Use Planning for the Ministry of Agriculture, estimates that there is approximately a 150 mm deficit for the growing of maize during the six-month growing season, based on his own calculations and studies by the FAO in a report on the Senqu River Agricultural Extension Project. (Douranbus, 1974).

Dr. Alvin Law of Farming Systems Research, Agriculture Research Centre of the Agriculture College, believes that the best agricultural land in Lesotho is along the rivers, including the Caledon, and that irrigation is highly desirable. He believes, for example, that the assurance of adequate water for supplemental irrigation during the growing season would permit the introduction of hybrid maize with the potential for a five-fold increase in production. He also asserts that irrigation of about 100 mm during the winter dry season would easily pay for itself in increased production of winter wheat.

5.2 Rates of Irrigation

Maize is a high-value crop suitable for irrigation. Since Lesotho has a rainy season deficit of about 150 mm for maize, some 400-500 mm should be made available for supplemental irrigation during the October through March period when there are losses due to evaporation with spray irrigation. While this requirement averages 2.5 mm/day, the application rates must actually be higher because of the variability of rainfall during the rainy season. Estimates for irrigation schemes in Lesotho indicate the need for facilities capable of applying water at rates of about 230 mm/month. (SWECO, 1977).

Irrigation during the April-through-September winter season for winter wheat calls for substantially less water. Facilities adequate in summer would be sufficient for winter with an estimated need of about 100 mm for the season; a capacity of about 300 mm would need to be made available.

5.3 Soils in the Vicinity of the Sewage Treatment Plant

At the request of the Water Branch, the WASH team arranged for a soil survey by the Soil Conservation Division of the Ministry of Agriculture near Ratjamose, the area which would be most conveniently irrigated with wastewater. The results of the survey appear as Appendix C.

In summary, the survey found the following in the approximately 2 km by 3 km, 600 ha area southwest of the plant and east of the Caledon River. A report "Farm Management and Research Appraisal in Lesotho" (Russel, 1979) contains the following comment about duplex soils, which predominate in much of lowland Lesotho, including the area around Maseru: "Yields are low and crop failures frequent due to the low moisture-holding capacity of the soil...Yields also may be low even in high rainfall seasons due to water logging during wet periods. Soil moisture cannot be stored to any extent in these soils, therefore a maize plant will usually exhibit moisture stress within a week after a rain."

Despite its obvious value, irrigation in Lesotho is in its infancy. Only modest irrigation is being done in the Maseru area, and there are a few projects in Phuthiatsana and Senqu River areas.

5.4 Soils in Ratjamose Area

Table 2

Soil Type	Depth m	Area ha	Permeability mm/hr	Water Capacity m^3/ha	Suitability for Irrigation
Deep loam	1.5	55	25	2500	Well-suited
Deep fine-textured	1.0-1.5	45	16	1500	Well-suited
Claypan or duplex	0.4-0.7	400	1.5-20	600-1000	Somewhat suitable
Shallow rocks		85			Poor
wet		2			Poor

According to the map accompanying the survey, the best soils are downstream from the plant and comprise a 5 km-long narrow band about 250 m wide along the Caledon River. Very good soils are also located on 20 ha about 1 km from the plant and 25 ha about 3 km from the plant. The duplex soils, which are more questionable, cover most of the rest of the area.

5.5 Wastewater Resources for Irrigation

Given the present discharge of the plant, about 2,500 cmd, and 400-500 mm necessary for supplemental irrigation in the growing season some 100 ha could be irrigated in summer, with substantially greater acreage, about 150 ha in winter. However, in order to make full use of the effluent, substantial regulating storage would be needed to hold wastewater during periods of rain for later use during dry spells. At design capacity, with regulatory storage, twice the proposed area could be put under irrigation.

However, with present discharges of about 2,500 cmd, and without investing in storage for regulation, and assuming irrigation would be done during the approximately 12 daylight hours, only about 30 ha could be served in summer and 45 ha in winter.

Given that more than 45 ha of Class A soil, highly suitable for irrigation, are located within 1 km of the treatment plant, it may be concluded that a sizable effluent irrigation study could be mounted with only minor facilities required. Only a small wet well and pump at the plant and irrigation piping for the fields would be needed.

Were the study to indicate that the supplemental water, and its nutrients of nitrogen and phosphorus, resulted in substantial increased yields, then facilities capable of using all the effluent would be justified. The facility would include regulatory storage to permit the full 100 ha to be irrigated in summer at present plant discharge rates.

5.6 Costs of Irrigation

The highest costs for irrigation are for piping and spraying equipment, energy for pumping, and maintenance and labor. Costs are site specific, but a rough estimate made for Lesotho (Bevan, 1974) indicated that the cost was then about M2.0/acre-inch (M0.20/ha-mm) including depreciation of equipment, fuel, and labor. Allowing for inflation of about 15 percent since 1974, the cost would now be about M0.50 ($US0.42)/ha-mm.

Based on providing facilities for 30 ha and irrigation with an average of 450 mm over the summer season and 300 mm over the winter, the annual cost would be about M10,000 ($US8,500). A less ambitious initial pilot study of 3 ha, would be proportionally less.

5.7 Implementation

Because irrigation is site- and crop-specific, agricultural specialists need to be involved in the conception, design, and operation of any pilot scheme. Personnel competent to deal with all phases of such a study are available in the Ministry of Agriculture, and in the Agricultural Research Center at the Agriculture College. These institutions should be involved in the planning from the outset.

While irrigation with wastewater is feasible and would be useful, irrigation of the same areas with Caledon River water would be only slightly less productive.

Chapter 6

CONCLUSIONS

6.1 Night Soil Disposal

The most serious sanitation problem facing Maseru is the use by some 15 percent of the population of dongas which drain into a city water source.

For the 86 percent of the unsewered population of Maseru, many options for sanitation are available and in use: bucket latrines, conventional pit latrines, ventilated improved pit (VIP) latrines, and conservancy tanks. But effort is necessary to improve the quality of the conventional pit latrines and to reduce the costs of bucket latrines, VIP latrines, and conservancy tanks.

The current practice of disposing night soil from bucket latrines in open trenches directly on the watershed of the Maseru water supply is entirely unsatisfactory. Immediate steps need to be taken to cover these trenches, and a potential disposal site located.

Of all of the disposal possibilities, the only acceptable option is discharge to the primary sludge handling facilities at the new Ratjamose Sewage Treatment Plant.

Night soil would constitute approximately 15 percent of the design load of the plant. Capacities of the relevant units at the plant are adequate for one additional load.

Irrespective of whether or not the night soil is discharged at the plant in the future, the primary sludge pumping and sludge drying bed facilities need to be improved.

6.2 Wastewater Treatment for Effluent Reuse

If effluent reuse for irrigation is adopted, the plant must consistently produce high quality effluent.

If operated properly, the sewage treatment plant should produce a high quality effluent.

Performance of the trickling filters can be improved by using the secondary sludge pumps as recirculation pumps and operating all four filters.

Tertiary gravel filters do not function as designed. However, studies can be mounted which may improve operation.

Consistent with effluent reuse, is a requirement for on-site monitoring which must involve responsive plant operators.

6.3 Irrigation

In an agricultural economy, with limited water resources in the lowland areas, treated wastewater effluent with high nutrient content is a significant resource. Agricultural productivity in Lesotho can be increased through supplemental irrigation. As evidenced by the initiation of pilot projects in the country, interest in irrigation is increasing.

Sufficient land, with potential high productivity, under supplemental irrigation, is available to the Ratjamose treatment plant.

A pilot wastewater reuse scheme for Maseru is feasible. Agricultural specialists should be involved in the specific design and operation of the pilot scheme.

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SWECO "Reconnaissance Study to Plan for Internal Uses of Lesotho's Water Resources", Final Report, Vol. 4, Irrigation Study, App 4.1, Ministry of Agriculture, 1977.

APPENDIX A

WATER AND SANITATION FOR HEALTH (WASH) PROJECT
ORDER OF TECHNICAL DIRECTION (OTD) NUMBER 88
April 26, 1982

TO: Dennis Warner, Ph.D., P.E.
WASH Contract Project Director

FROM: Victor W.R. Wehman, Jr., P.E., R.S.
A.I.D. WASH Project Manager
A.I.D./S&T/H/WS

SUBJECT: Provision of Technical Assistance Under WASH Project Scope of Work for U.S. A.I.D./Lesotho

REF:
A) Maseru 00825, dated 18 Mar 82
B) State 044006
C) Maseru 0394
D) Letter and Exhibits (maps and designs), Hendrich/Hafner, dated 16 Mar 82
E) WASH Telex to Henrich, dated 16 Mar 82
F) Henrich Telex to WASH (Hafner), dated 17 Mar 82

1. WASH contractor requested to provide technical assistance to U.S. A.I.D./Lesotho as per Reference A, paragraph(s) 4.A.1-4 and paragraph(s) 4.B.1-3. Paragraph(s) 4.A.5 and 4.B.4-5 will be authorized as an extension or amendment to this OTD subject to satisfactory development of analysis, assessment, feasibility reports and agreement by GOL to course of action. S&T/H will send a cable to U.S. A.I.D./Lesotho soon indicating to them that the Mission should not be planning on WASH doing an extensive design (second phase), but could consider a modest design involvment due to limitations on WASH funds.

2. WASH contractor/subcontractor/consultants authorized to expend up to 55 (fifty-five) person days of effort over a 4 (four) month period to accomplish this technical assistance effort.

3. Contractor authorized up to 45 (forty-five) person days of international/domestic per diem to accomplish this effort.

4. Contractor to coordinate with AFR/DR/HNP (J. Shepperd), AFR/DR/ENGR, (J. Snead), and Lesotho Desk Officer and should provide copies of this OTD along with periodic progress reports, invitations to briefing/debriefings and ETAs as requested by S&T/H or AFR Bureau personnel.

5. Contractor authorized to provide up to 1 (one) international round trip from consultants' home base through Washington, D.C. to Lesotho and return to home base through Washington, D.C. during life of OTD.

6. Contractor authorized local travel within Lesotho as necessary to accomplish mission.

7. Contractor authorized to obtain secretarial, graphics or reproduction services in Lesotho as necessary to accomplish tasks. These services are

in addition to the level of effort specified in paragraph(s) 2 and 3 above. For these items contractor authorized NTE $800 without written approval of A.I.D. WASH Project Manager.

8. Contractor authorized to provide for car(s) rental if necessary to facilitate effort. Mission is encouraged to provide Mission vehicles, if available and appropriate.

9. WASH contractor will adhere to normal established administrative and financial controls as established for WASH mechanism in WASH contract.

10. WASH contractor should definitely be prepared to administratively or technically backstop field consultants and subcontractors.

11. Contractor/consultant will leave draft coordinated reports with Mission before leaving Mission. Pending formal comments by Mission and GOL, WASH contractor will either (a) develop final report and close OTD or (b) initiate second phase design services at authorization of A.I.D. WASH Project Manager and formalize final report for Phase I. This section of OTD will have to be amended substantially if 11.(b) is initiated.

12. Mission should be contacted immediately and technical assistance initiated as soon as convenient to Mission/GOL.

13. Appreciate your prompt attention to this matter. Good luck!

ACTION COPY

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Department of Sta...

INCOMING TELEGRAM

PAGE 01 MASERU 00825 160942Z 2276 044317 AID5626
ACTION AID-35

ACTION OFFICE STHE-01
INFO AAAF-01 AFSA-03 AFDR-06 PPCE-01 PDPR-01 PPPB-03 AAST-01 ENGR-02 HHS-09 AFDA-01 RELO-01 DAEN-01 MAST-01 WAB-01 /033 A4 818

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AIDAC

FOR VICTOR WEHMAN, ST/HEA

E.O. 12065 NA
SUBJECT WASH PROJECT TECHNICAL ASSISTANCE, LESOTHO

REF: A) MASERU 0394; B) STATE 044006

1. REQUESTED MAPS, PLAN AND PLANT DESCRIPTION HAVE BEEN FORWARDED TO HEFNER BY HENDRICH, MANAGING DIRECTOR OF THE WATER AND SEWERAGE BRANCH. HOPEFULLY THESE WILL BE ADEQUATE.

2. TIMING OF THE CONSULTANTS VISIT IS SUGGESTED FOR JUNE AND JULY, 1982. NO PROBLEMS ARE ANTICIPATED REGARDING COUNTRY CLEARANCE. TIMING AS SUGGESTED APPEARS A BIT SHORT. USAID AND GOL SUGGEST AN ALLOWANCE OF FIVE WEEKS FOR THE FEASIBILITY WORK.

3. THE POPULATION ON THE SANITARY SYSTEM IS CURRENTLY ABOUT 50 PERCENT OF THE DESIGN FLOW OF THE PLANT. THE POPULATION PRESENTLY SERVED IS APPROXIMATELY 15,000 PLUS SOME LIGHT INDUSTRY. THE BUCKET LATRINE SYSTEM SERVES APPROXIMATELY 30,000 PEOPLE THROUGH 2,145 BUCKETS LOCATED THROUGHOUT MASERU. EVERY BUCKET IS EMPTIED THREE TIMES PER WEEK AND ROUGHLY 10,000 GALLONS OF NIGHT SOIL IS COLLECTED EVERY WEEK. THE NIGHT SOIL IS BURIED IN 2M DEEP TRENCHES WHICH ARE LOCATED IN THE WATER SHED OF THE PRINCIPLE RESERVOIRS OF MASERU AND PRESENT A SERIOUS HEALTH HAZARD AT PRESENT.

4. THE SCOPE OF SERVICES ENVISIONED ARE AS FOLLOWS:
A) EFFLUENT REUSE THROUGH IRRIGATION OF CROPS.

- 1. INVESTIGATE THE FEASIBILITY OF AN EFFLUENT REUSE SYSTEM FOR THE MASERU TREATMENT PLANT.

- 2. DETERMINE ROUGH DESIGN PARAMETERS, COST, BOTH CAPITAL AND OPERATIONAL, BENEFITS DERIVED, SUITABLE CROPS ETC. AND/OR DESIGN A PILOT SCHEME TO DETERMINE THE ABOVE.

- 3. EVALUATE HEALTH HAZARDS AND DETERMINE CONTROLS REQUIRED.

- 4. PREPARE A REPORT CONCERNING THE IMPLEMENTATION OF AN EFFLUENT REUSE FOR MASERU.

- 5. IF THE PROJECT APPEARS FEASIBLE, UNDERTAKE DETAILED DESIGNS TO IMPLEMENT AN EFFLUENT REUSE SCHEME IN LESOTHO. THIS WOULD BE ACCOMPLISHED AS A FOLLOW UP OR SECOND PHASE.

B) NIGHT SOIL DISPOSAL.

MASERU 00825 160942Z 2276 044317 AID5626

- 1. TO INVESTIGATE ALTERNATIVES AVAILABLE FOR THE DISPOSAL OF NIGHT SOIL IN LESOTHO ESPECIALLY LOOKING AT AEROBIC DIGESTION OF THE NIGHT SOIL OR LAGOONING WITH LAND DISPOSAL AFTER STABILIZATION.

- 2. TO PREPARE A FEASIBILITY REPORT OUTLINING CAPITAL AND OPERATIONAL COSTS OF VARIOUS DISPOSAL SCHEMES.

- 3. TO RECOMMEND TO GOVERNMENT A PROPOSED METHOD OF NIGHT SOIL DISPOSAL.

- 4. UPON APPROVAL OF THE GOVERNMENT OF LESOTHO, PREPARE DETAILED DESIGN DRAWINGS OF THE PREFERRED ALTERNATIVE AS A FOLLOW UP OR SECOND PHASE PROJECT.

- 5. FOLLOW UP OR SECOND PHASE SERVICES, IF FEASIBILITY STUDIES SHOW SUCH A NEED, COULD PROBABLY BE ACCOMPLISHED AT THE WASH HOME OFFICES. TIME REQUIREMENTS OF SUCH SERVICES SHOULD BE DEVELOPED DURING THE FEASIBILITY STUDIES. MICHAL

Received ST/HEA (Wehman) 3-22-82
Passed to WASH 3-22-82

D. Warner

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APPENDIX B

PERSONS CONTACTED BY TEAM

AGENCY FOR INTERNATIONAL DEVELOPMENT - 23954

Fred Zobrist - Engineer
Dr. Joseph P. Carney - Human Resources & Development Officer

MINISTRY OF WATER, ENERGY & MINES - Water Branch - 22491

Jeffrey E. Hendrich, Director, Home - 24393
Wayne West, Training, Home - 22964
David kane, Water
Kometsi Khotle, Assistant Engineer
Felix Marsoha, Assistant Engineer
Nkhata Nkhahle, Water Treatment Plant Operator
Vicki Qheku, Water Treatment Plant Operator & chemist
Joseph Lehopo, Sewage Treatment Plant Operator

MINISTRY OF INTERIOR

MASERU TOWN ENGINEER

Eva Havelca, 23711 x 41

CHIEF HEALTH OFFICER, MASERU

Dan McGee, 23711 x 27

SUPERVISOR, NIGHT SOIL COLLECTION

Kori Paanya, 23711

MINISTRY OF AGRICULTURE

SOIL CONSERVATION SERVICE, 23600

SOIL SURVEY SECTION

P. Matt Cawley x11, Home 23104
Michael Gill, PCV x11

LAND USE PLANNING, FAO TEAM

Frank Berding x 23

FAO TEAM LEADER

Omar Mukhtar 23141

FARMING SYSTEMS RESEARCH

AGRICULTURE RESEARCH CENTER, AGRICULTURAL COLLEGE

Alvin Law 22372

APPENDIX C

SOIL SURVEY OF RATJAMOSE AREA

19th July 1982

by MICHAEL GILL
U.S. Peace Corps
Soil Conservation Division
Ministry of Agriculture

At the request of Water Branch, an area of about 600 hectares near the sewage treatment plant at Ratjamose and along the Caledon River was surveyed to determine the suitability of the soils for application/disposal of waste-water. Only about 100 hectares in this area are deemed well suited for this purpose. About 85 hectares are poorly suited because of shallow soils and steep slopes. The remainder of the area is considered at best only somewhat suited for wastewater application because of a very slowly permeable clay pan beneath the surface layer.

In general, all the soils in the area which are not poorly suited for waste-water application could be beneficially used for this purpose during the dry winter months. As a result of wastewater irrigation, spring planting could begin without having to wait for rains to replenish the moisture in the soil and winter crops, such as wheat, could be grown on most soils in the area.

During the summer months, when rainfall is plentiful but unpredictable, only those areas which are well suited should be used for waste water application, and then only during extended dry periods. The somewhat suited claypan (duplex) soils do not have a large capacity for wastewater disposal, and a rainy period following irrigation would result in waterclogged conditions detrimental to crops. An exception to this rule would be if rice were planted on these soils. For rice, wastewater application would be beneficial if it could be used to keep the fields flooded.

In the following description of the map units used in this survey, estimates for permeability and available water capacity are given for each suitable unit. These estimates were made in the best judgement of the soil surveyor ~~often~~ after observing core samples of the soils in the field and consulting guidelines for estimating these properties in the National Soils Handbook of the U.S. Department of Agriculture. Permeability is expressed as the rate at which the soil transmits water while saturated, in cm per hour. Available water capacity (is the amount of water that a soil can hold between 33kPa and

1500kPa) is expressed in cubic metres per hectare.

DESCRIPTION OF MAP UNITS

A - Deep loamy soils

These dark brown, well drained soils are in narrow bands adjacent to the Caledon River. They are loam in texture from the surface to a depth of 150cm or more and have moderately well developed structure. Some areas have a surface layer of sandy loam. Permeability is estimated at 2.5cm/hr and the available water capacity is greater than 2 500 cubic metres per hectare. Approximately 55 hectares of these soils were mapped in the area. This unit is well suited to waste water application.

B - Deep fine-textured soils

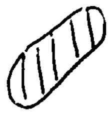
These reddish brown, well drained soils are on shallow knolls. They generally have surface layers of loam or fine sandy loam and clay or clay loam subsoils with well developed structure. These soils are generally 100 cm to greater than 150 cm to bedrock. Permeability is estimated at 1.0 cm/hr and the available water capacity is 1 500 cubic metres per hectare. About 45 hectares of these soils were mapped. This unit is well suited to waste water application.

C - Claypan soils

These brownish gray, poorly drained soils are on gently sloping to sloping colluvial slopes. They generally have a loam or fine sandy loam surface layer that is 40cm to 70 cm thick. Underneath the surface layer is a dense clay or clay loam pan which is very slowly permeable. These soils have a perched water table above the pan following heavy rains. Permeability is estimated at 2.0cm/hr for the surface layer and less than 0.15 cm/hr for the pan. Available water capacity is between 600 and 1 000 cubic metres per hectare. Roughly 400 hectares of these soils were mapped. They are somewhat suited to waste water application.

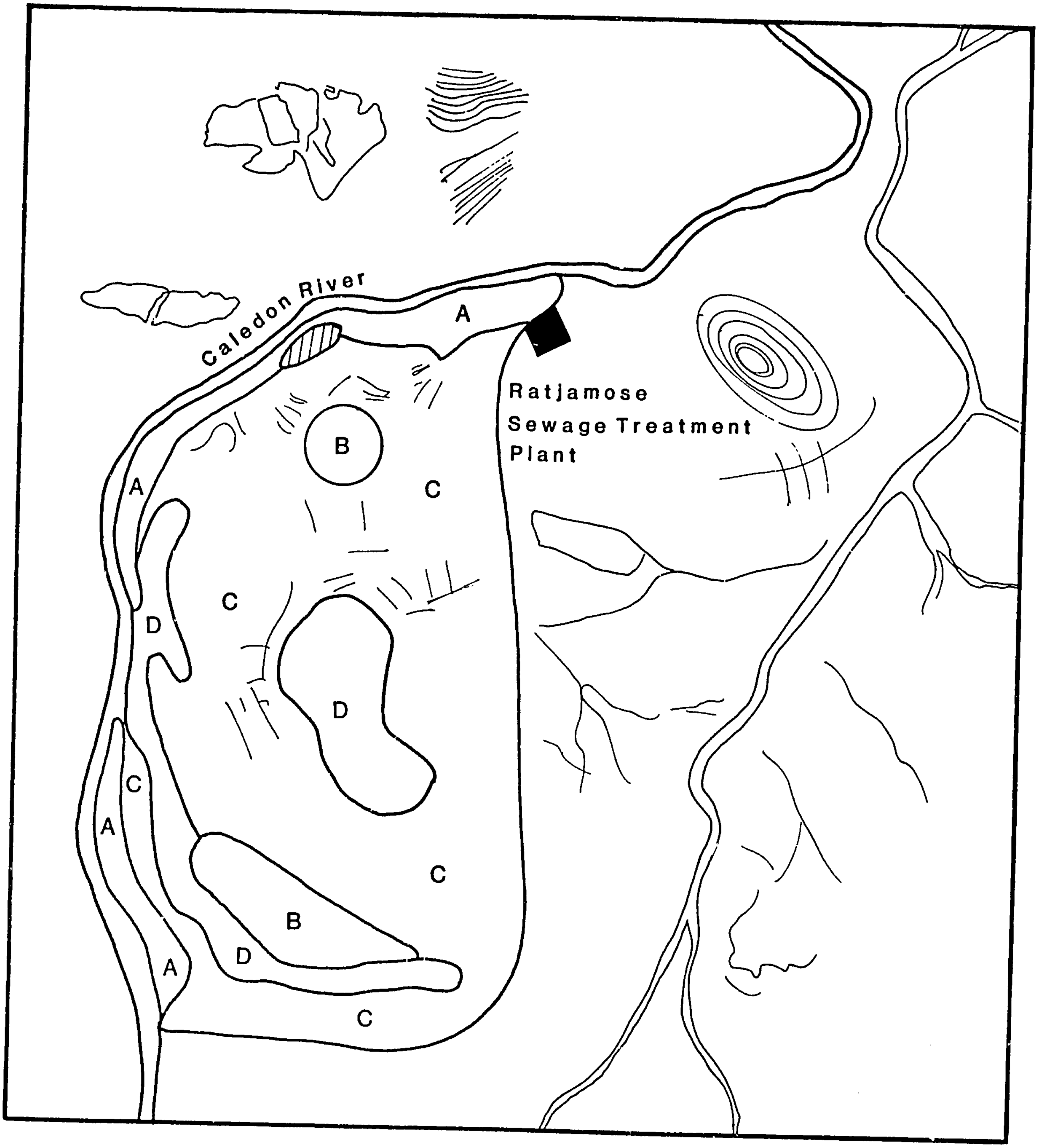
D - Shallow, rocky soils

These soils are on steeper sloped areas parallel to the river and on a hill in the center of the surveyed area. About 85 hectares of these soils were mapped. They are poorly suited to waste water disposal because of shallow depth to bedrock and steep slopes.

 Wet Spot

A small area, less than 2 hectares in size, was mapped at the northern end of the surveyed area and south of the Caledon River. It is a very poorly drained depressional area which becomes ponded following rains. This area is poorly suited for waste water application.

SOIL SURVEY MAP



A: Deep loamy soils

B: Deep fine-textured soils

C: Claypan soils

D: Shallow, rocky, soils

Wet spot

APPENDIX D

M E M O 23 July 1982

TO: Jeffrey E. Hendrich, Director, Water Branch
Ministry of Water, Energy and Mines, Lesotho

FROM: Daniel A. Okun, WASH Team

SUBJECT: Terms of reference and scope of work for consultant(s) to advise the Water Branch on water supplies for five towns in Lesotho.

While on assignment in Lesotho on WASH OTD 88, the writer was asked to advise on terms of reference and scope of work for consultants who would examine proposed additional facilities for water supply for five towns in Lesotho.

In December 1977, under sponsorship of KfW of West Germany, Binnie Shand Lesotho prepared a " Twelve Towns Water Supply Study". Funds for all but four of these have been made available. Funds for construction of additional water supplies for these four towns, Mafeteng, Mohale's Hoek, Quthing and Mokhotlong, plus Roma, which was not included in the original study, are now being sought.

Current population estimates for each of these five towns range from about 800 to about 5000, with a total of about 18 000. The consultants' construction cost estimates reported to Water Branch for implementing their proposals for additional facilities for the original four towns in first stage construction total some M23 million. Not only are the costs high, about M2000 per capita, but the financial burden on the Water Branch from such a program would result realistically in the work being done in only one or two of these towns. Accordingly, the Water Branch is seeking an approach that would meet the needs of these communities but at substantially lower first cost investment.

TASKS

The consultant(s) would be requested to review the proposed plans for additional water supply for each of the towns, focussing on the following points:

1. POPULATION AND CONSUMPTION ESTIMATES

Where funds are limited and borrowing is expensive, providing facilities for populations expected far into the future is excessively costly. Realistic demand estimates with a small allowance for growth, unless there is reason to expect more rapid development, would result in more realistic projects.

2. SIMPLE, BUT DEPENDABLE, INTAKE STRUCTURES

Such structures can often be designed by local staff to suit local field conditions and built by Water Branch personnel or local contractors using local materials. More attention needs to be given to various types of infiltration structures on surface streams.

3. PUMPING STATIONS

Assuring continuous operation of pumps is more important than water quality, and the utilization of dependable engines or motors and pumps, with easy availability of spare parts, is the most important criterion for their selection.

4. STORAGE

Given the topography of Lesotho, adequate raw water storage at sufficient elevation above the towns to assure gravity flow, through treatment facilities, if necessary, will permit 24-hour service with raw water pumping restricted to a few hours per day. As demand increases, the time of pumping can be increased.

5. TREATMENT FACILITIES

The relative inaccessibility of some of these towns would dictate a choice of treatment using little equipment and few chemicals. Slow sand filtration, preceded by roughing rapid sand filters where turbidity is a problem, followed by chlorination should be adequate for surface waters. Coagulation should not be necessary. Such treatment facilities can be built simply, with local materials.

6. RETICULATION SYSTEMS

A substantial portion of the water supply is lost through leakage, some caused by freezing. Proper materials selection and installation can mitigate this problem.

7. RELIABILITY

The effect of water shortages in the towns need to be examined to determine the relative importance of reliability of source. Heavy investment to avoid failure under extreme conditions of drought may not be warranted.

METHOD OF WORK

The consultant(s) are expected to be competent in the design, construction and operation of small community water supply systems in order to work in both office and field with engineering and technical staff of the Water Branch and local construction workers, be they employees of the Water Branch or local contractors.

The intention is not a formal complete redesign of facilities proposed by the original consultants but rather to help the Water Branch engineers in the preparation of design sketches detailed enough that, with adequate supervision in the field, the facilities can be built with local labor and materials. Such minimum equipment as needs to be imported can be ordered by Water Branch directly.

This approach should have several advantages: the costs would be substantially lower; the time for implementation would be sharply reduced; and perhaps most important of all, Water Branch engineers and technical personnel would gain useful experience in design and construction. Accordingly, the consultant(s) should be both engineer(s) and teacher(s).

For this approach to be effective, Water Branch would need to add to its permanent staff of engineers and technicians. If donor support could be obtained for employing staff engineers for the Water Branch, the funds would be better spent at this stage of these projects than on engineering design consultants who would, at high cost, leave behind only more paper plans, with the Water Branch engineers obliged to implement projects with which they are not familiar and solutions with which they may not be in accord.

IMPLEMENTATION

If one short-term consultant with all the necessary skills can be employed, perhaps one would be sufficient. However, given the relative inaccessibility of the towns, two consultants might be more expeditious. The Water Branch might decide on one or two or leave the issue open, to be determined by the availability of a competent team leader.

Estimated costs for the consultancy are based upon two consultants, four person-weeks preparation time, 16 person-weeks in the field and office advising Branch engineers on design, and on ordering of materials, to be followed up by 8 person-weeks at a later date on review of construction:

	US $
28 person-weeks for consultancy @ $220/day	37 000
Per diem, 16 person-weeks @ $60/day	7 000
Transportation:	
4 round trips, US to Lesotho	10 000
travel inside Lesotho, car-rental, etc. @ $30/day for each of consultants	5 000
Miscellaneous expenses	5 000
US $	64 000

Of course, the key to this approach is the employment of additional engineering and technical staff by the Water Branch so that staff can do the design and supervise construction.

In conclusion, this approach recognizes that the facilities required need to be simple and that experience in the design and in responsibility for supervision of construction of such facilities can provide valuable experience to the staff.

APPENDIX E

DRAFT TERMS OF REFERENCE FOR PREPARING: A MANPOWER DEVELOPMENT STRATEGY IN THE WATER AND SANITATION SECTOR IN LESOTHO

John Briscoe
WASH Consultant
July 1982

PREAMBLE

The Government of Lesotho, with external financial assistance, is involved in an ambitious national effort for improving water supply and sanitation.

This effort involves several ministries, the most important of these being the Ministry of Water, Energy and Mining (which is responsible for urban water supplies and waterborne sewerage), the Ministry of the Interior (which is responsible for urban non-water-borne sanitation), the Ministry of Rural Development (which is responsible for rural water supply programs) and the Ministry of Health (which is responsible for rural sanitation programs). The private sector, too, is heavily involved in the provision of supplies and consulting and contracting services.

A major constraint in fulfilling the ambitious goals of the International Water Supply and Sanitation Decade in Lesotho, namely the provision of adequate water supplies and sanitation for all by 1991, concerns the availability and utilization of manpower at the professional, technician and craftsman level.

With the objective of developing a strategy for manpower development in the water and sanitation sector, the Government of Lesotho wishes to identify consultants who will work with a Committee comprising members of these and other concerned Ministries and who will carry out the following tasks:

TASK 1. ASSESSMENT OF EXISTING MANPOWER AVAILABILITY

The Consultants are to determine the present availability of manpower in the sector. The manpower will be classified four ways:

(i) as expatriate or local,

(ii) as technical, administrative or accounting,

(iii) as professional, technician or craftsman, and

(iv) as established or non-established posts

This assessment will be made in the concerned Ministries, in projects run in conjunction with these Ministries, and in the private sector.

TASK 2. ASSESSMENT OF THE UTILIZATION OF THE EXISTING MANPOWER

The present utilization of available manpower will be assessed by intensive on-the-spot examinations of the tasks performed by workers at all levels. A comparison would be made between the job and the qualifications of the job-holder. While all constraints on the efficiency of the utilization of such manpower will be identified, particular attention will be directed to those problems which may be addressed by training programs.

TASK 3. MANPOWER DEMAND IN THE SECTOR

The likely development in the public and private sector over the next ten years will be assessed on the basis of information which will be collected from the Government of Lesotho and other financing agencies. On the basis of existing staffing patterns in Lesotho and figures developed from similar studies in other countries, detailed projections will be made of the manpower requirements in the sector at all levels for the next ten years.

TASK 4. MANPOWER SUPPLY IN THE SECTOR

The supply of manpower at all levels in the sector over the next ten years will be determined by:

(a) Determining present attrition rates and estimating future attrition rates of workers at all levels in the sector;

(b) Estimating the output of trained Basotho manpower from all existing and planned training programs both in Lesotho and other countries.

TASK 5. AN ASSESSMENT OF THE QUALITY OF TRAINING

A detailed assessment will be undertaken of the form and content of all the relevant training undertaken both in Lesotho and in institutions in other countries which are frequently used to train Basotho (such as the Swaziland College of Technology). This assessment will include a detailed evaluation of the procedure for selecting candidates, the curricula followed, the method of classroom and practical instruction, the availability of facilities and materials, and the length of training. The assessment will be done through observation of the training undertaken in the institution and through interviews with teachers, students, graduates and employers of the graduates.

TASK 6. IDENTIFICATION OF TRAINING NEEDS AND RECOMMENDATION OF TRAINING PROGRAMS

On the basis of the information collected in Tasks 1 through 5, an assessment will be undertaken on the training programs necessary to develop an adequate cadre of trained manpower for the water and sanitation sector in Lesotho for the next ten years.

Particular attention should be given to the following:

a) Every effort should be made to identify ways in which existing institutions may be upgraded or modified (where needed) to serve the training needs of the sector more effectively. Only where such a solution is not feasible should the establishment or use of an alternative institution be recommended.

b) Particular attention should be directed towards the continuing education needs of the cadres who have been, or will be, trained.

c) Where in-country training is not feasible, a list of alternative institutions and their programs in other countries should be developed and recommendations should be made on suitable training programs. Priority should be given to Regional, African and, other developing country programs in that order.

TASK 7. DETAILED SPECIFICATIONS AND COSTS OF WATER BRANCH TRAINING

For new or revised in-country training programs in which Water Branch personnel will be trained, the consultants should specify in detail the content of such programs. This would include specification of the entrance requirements, the duration of courses, the appropriate pedagogical methods, and the curricula. Detailed estimates should be made of the capital and operating costs of the recommended programs. This would be done for formal, non-formal and continuing education programs.

TASK 8. IDENTIFICATION OF SHORTAGES TO BE FILLED BY EX-PATRIATE RECRUITMENT

It is anticipated that expatriate manpower will be required in the water and sanitation sector for several more years. The numbers of expatriates required, their qualifications and the length of time they will be required are to be determined.

TASK 9. THE PRESENT ROLE OF EXTERNAL FINANCING AGENCIES IN THE SECTOR

The consultants are to assess in detail the available programs for manpower training in the sector available through external financing agencies.

****

QUALIFICATIONS OF THE CONSULTANTS

The team will comprise three people who, between them, will have expertize in the areas of sanitary engineering, training, manpower planning and health education.

TARGET IMPLEMENTATION SCHEDULE

It is anticipated that the consultants will spend two months each in Lesotho. After two weeks a concept paper is to be presented, and after six weeks a draft final report is to be presented to the Government and the financing agency. Prior to departure a second draft of the final report, incorporating the response to the first draft, will be presented. The final report is to be presented one week after the consultants return to their home base.

THE COST OF THE STUDY

The approximate cost of the study would be:

	US $
30 person weeks consultant's time @ $200 per day	36 000
Per diem: 24 person weeks @ $60 per day	10 000
Transportation:	
3 round trip tickets and excess luggage - US ~~Europe~~ - Lesotho	7 000
Airtravel to other African Countries	2 000
Travel within Lesotho @ $30 per day	5 000
Miscellaneous Expenses	5 000
TOTAL US $	65 000

PERSONS CONTACTED IN CONNECTION WITH THIS TERMS OF REFERENCE

Agency for International Development

Mr. F. Zobrist, Engineer

Dr. J. Carney, Manpower Development and Training Officer

Ministry of Water, Energy and Mines

Mr. S.Mokhubung, Training Officer

Mr. J. Hendrich, Managing Director, Water Branch.

Mr. D. Kane, Director, Water Branch

Mr. K. Khotle, Assistant Engineer, Water Branch.

Mr. W. West, Training Officer, Water Branch.

Ministry of Rural Development

Mr. Allen Tudor, Training Officer, Rural Water Program.

Ministry of the Interior

Mr. T. Khaketla, Director, Urban Sanitation Unit

Mr. T. Rameama, Principal Health Officer

Delegation of the European Economic Community

Mr. T. Rohrsted, Delegate

Mr. J. de Ryckman de Betz, Economic Adviser