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WATER AND SANITATION
FOR HEALTH PROJECT

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1611 N. Kent Street, Room 1002
Arlington, Virginia 22209 USA

Telephone: (703) 243-8200
Telex No. WUI 64552
Cable Address WASHAID

ECONOMIC AND AFFORDABILITY ANALYSIS OF SANITATION ALTERNATIVES FOR SELF-HELP HOUSING AREAS IN BOTSWANA

WASH FIELD REPORT No. 148

JANUARY 1986

Prepared for
the USAID Mission in Botswana
under WASH Activity No. 144

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LIST OF ACRONYMS

BHC	Botswana Housing Corporation
GOB	Government of Botswana
lcd	Liters per capita per day
MLGL	Ministry of Local Government and Lands
NPV	Net present value
O&M	Operations and maintenance
REC II	Revised Earth Closet Type II
ROEC	Reeds Odorless Earth Closet
SHHA	Self-Help Housing Areas
VIDP	Ventilated Improved Double Pit
WASH	Water and Sanitation for Health Project

EXECUTIVE SUMMARY

At the request of the U.S. Agency for International Development (USAID) Mission in Botswana and the Government of Botswana (GOB) through the Ministry of Local Government and Lands (MLGL), the Water and Sanitation for Health (WASH) Project sent a consultant to Gaborone in April-May 1985 to develop an economic and affordability analysis of sanitation alternatives for low-income and self-help housing areas in four urban towns. This consultancy is the second WASH project in Botswana, the first being the "Sanitation Feasibility Study for Kanye Village, Botswana" completed in July 1983.

The following is a summary of the consultant's findings.

Findings:

1. Field investigations show that in Botswana:

   a. Water, except in Francistown, is becoming a scarce and costly commodity.
   b. Existing sewerage facilities have little or no extra capacity.
   c. Geotechnical conditions are difficult (rocky).
   d. Housing and infrastructure needs are high and significant upgrading of sanitation facilities is needed in many areas.
   e. The GOB has a policy of minimizing subsidies to urban infrastructure development.
   f. Income levels in the Self-Help Housing Agency (SHHA) are generally low and vary significantly from town to town.

2. On the basis of economic analysis, the provision of a Revised Earth Closet (REC II) latrine to SHHA and low-income areas is the least-cost solution by a significant economic margin over the septic tank/soakaway alternative and/or the conventional fully waterborne public sewerage alternative.

3. A septic tank with soakaway is the second least-cost alternative and is likewise applicable to SHHA and low-income areas. However, in view of the high initial capital and recurrent costs and the generally difficult field conditions, this alternative appears to have limited application.

4. Taking into account related but unquantifiable aspects, such as the impact on public health, water resources, energy, and applicability to self-help schemes, the REC II and septic tank options have advantages, except for public health. In that regard, conventional sewerage has the advantage in being able to remove wastes totally and rapidly from their source.

5. Housing areas with REC II or septic tank/soakaway facilities have the potential to upgrade their sanitation systems in the future, using small-bore sewerage or conventional waterborne sewer systems for example. Neither on-site sanitation measure would preclude possible staging (phasing) to the waterborne option as future needs and finances permit.

6. The total annualized cost per household of each option are shown below.

Option	Cost per household (in pula) Net present value average annual cost: Cost Less Salvage Value	Relative Cost
REC II	535	1.0
Septic tank and soakaway	2,150	4.0
Conventional public sewerage	3,452	6.5

These costs are indicative of conditions in all towns except Francistown based on an opportunity cost of money of 8%, no subsidy (full cost recovery), and no shadow pricing. Due to the excess water capacity in Francistown, the relative costs for septic tank and sewerage for that town decline to 3.3 and 5.4 respectively.

7. In 1985, household (and plotholder) incomes are estimated to range from P161 to P272 per month at the lower-income level in SHHA and low-cost housing areas.

8. On the assumption of full cost recovery, a plotholder would have to allocate the following percentages of his income for the alternatives:

Option	Percent of income allocable to sanitation
REC II	2.0 - 3.4
Septic tank and soakaway	9.9 - 16.6

Sanitation costs are generally more affordable in Gaborone and Lobatse due to higher income levels. As a basis for comparison, cost indicators commonly used to measure sanitation affordability are generally in the range of 2-3% of household income. (See Chapter 5 for coverage of affordability issues.)

9. It is clear that the conventional sewerage option would prove even more costly and thus less affordable and that neither the septic tank nor the conventional sewerage options could be implemented without substantial levels of direct government subsidy.

*One pula is equal to U.S. $.59.

Chapter 1

BACKGROUND

1.1 Scope of Work

The USAID mission in Botswana requested WASH to provide a sanitary engineer with experience in financial analysis to perform an economic and financial comparison of on-site sanitation facilities vs. waterborne sewerage disposal. The following tasks made up the scope of work for the WASH consultant:

1. Review previous documentation relating to such comparisons during a one-day briefing at the WASH office prior to departure to Gaborone.

2. Meet with AID and MLGL officials to clarify task requirements and gather information on current and proposed housing projects in Botswana.

3. Coordinate task activities with the Senior Public Health Engineer attached to the MLGL. The work efforts of the consultant will be coordinated by this Health Engineer.

4. Document the total per capita costs (capital investment plus operations and maintenance) of on-site sanitation systems and waterborne sewerage collection systems. Several towns in Botswana will be used as case studies.

5. The costs of these systems that are to be identified include, but are not limited to:

   A. On-site systems
      - Construction
      - Labor for construction and disposal
      - Disposal
      - Maintenance, including vehicles
      - Community participation training
      - Types of units, e.g., public vs. individual family latrines

   B. Waterborne sewerage systems
      - Construction
      - Labor for construction
      - Operations and maintenance (O&M), including personnel needed, buildings and materials
      - Equipment needed, e.g., sewer-cleaning vehicles, backhoes, trucks
      - Training of O&M personnel

6. Prepare a draft report of findings for review by the appropriate mission and government officials; finalize the report.

The initial draft of this report was prepared by consultant Leonardo V. Gutierrez based on his field visit to Botswana in May 1985. Certain portions of the draft report, particularly those dealing with financial and economic issues, were subsequently reviewed and the method of presentation modified by financial consultant James S. Baker.

1.2 Community Profiles

1.2.1 Introduction

The four principal towns -- Gaborone, Francistown, Lobatse, and Selebi-Phikwe -- lie in the east of the country, three of them along the line of the road and rail links between Zimbabwe and South Africa (see Map 1, Appendix 1). Selebi-Phikwe was founded away from this main arterial link to service an important mine. Two of the four main towns -- Selebi-Phikwe and the capital, Gaborone -- were established in the mid 1960s. Francistown and Lobatse have longer histories going back to the earliest colonial days. All of the towns have experienced rapid growth and transformation during the last 15 years.

1.2.2 Gaborone

The formal plan for Gaborone, the new capital of independent Botswana, was prepared in the early 1960s. The plan's projected population of 20,000 in 1980 was reached by 1971 and by 1981 it had grown to nearly 60,000.

This rapid and unanticipated growth caused many problems, with some areas planned for industrial or commercial uses becoming squatter areas which government at first designated for resettlement. This effort was unsuccessful and the squatter areas are being upgraded as permanent residential zones. Gradually, the government has developed its ability to anticipate growth and to provide basic infrastructure and services for lower-income/self-help housing areas. The Broadhurst and Tsholofelo developments were the first to anticipate site and service needs on a large scale and the current Gaborone West Development will essentially provide for the doubling of the size of the town.

Most of the town is presently serviced by a system of gravity sewers, although the lower-income housing areas make use of on-site nonwaterborne sanitation systems. Treatment is through waste stabilization ponds which have been built sequentially in several locations around the town to accommodate growth areas. Much of the original reticulation system is deemed to be badly constructed and virtually all trunk sewers and stabilization ponds are at full capacity or are overloaded. Pond effluent quality is poor, creating odor problems in some areas and environmental concerns in general.

Gaborone's water supply is provided from a combination of surface and groundwater sources. Recent drought conditions have resulted in a shift toward greater reliance on the wellfields. Lower-income housing areas are generally served by standpipes, with as much as 65% of the housing in the Gaborone West Development estimated to be served in this manner.

1.2.3 Lobatse

Lobatse is one of the slower growing towns, with an annual growth rate between 1971 and 1981 of 4.8% per year. By 1981 its population had reached 19,000.

The provision of on-site sanitation facilities as a site and service policy has been lacking in Lobatse, with most low income area residents having to dig their own latrines. Currently construction is ongoing in the Woodhall 2 and Peleng overspill site and service SHHA areas with some 950 plots to be allocated, all have on-site sanitation as part of the development. Construction work on the town's sewerage system was initiated in 1982 and the first stage is now complete; work continues on several projects.

The town's water supply system is served by a combination of groundwater sources and surface water from a local dam and the Gaborone dam. All sources are deemed somewhat unreliable; goundwater options are being reappraised.

1.2.4 Francistown

This town is one of the older developments, with many of its housing areas having developed originally as squatter areas surrounding a major gold mining operation. The mining company has generally controlled development and continues to be a major influence on the town's development.

With much of the town's population being in the squatter category, the low income housing areas suffer from a general lack of services and are in need of major upgrading. As of 1983 however, latrine substructures have generally been installed on all new plots.

The present sewerage system generally serves the central commercial, industrial, residential and institutional areas. The stabilization ponds are considered overloaded and unsuitable for meeting the needs of future development.

The town's water supply is provided through a combination of ground and surface water sources which have an ultimate capacity far in excess of current demand.

1.2.5 Selebi-Phikwe

This town was established in the late 1960s to serve a newly opened copper-nickel mine. Its early growth rates of 14% per year have slowed to annual rates of 7%; its 1981 population was in excess of 29,000. The town's lower income housing areas evolved from initial settlements on tribal lands into currently approved municipal site and service areas.

The sewerage system and treatment capacity have only minimal excess capacity. Water is provided from surface sources, with current capacity estimated to be adequate until 1992. An extension of the production works is being planned which will further extend capacity and alleviate potential problems during peak consumption periods.

Additional information on each town is presented in Appendix 1.

1.3 Housing and Future Needs Projection

Table 1 shows the status of housing in the four principal towns as of 1982-83. It shows that nearly half of all the housing in the four towns comes under the SHHA program. SHHA housing ranges from 36% in Gaborone, where there has always been a large element of Government/BHC housing, to 64% in Francistown. It is clear from these figures that the SHHA has had a major impact on the housing stock in the four towns, and, if the program continues as it has in recent years, it is likely that the SHHA will be providing over 60% of all new housing in the future.

Table 2 shows that an additional 32,500 dwellings will be needed for the period 1981-1991 (item 12). These projections are based on the population growth rates during the period 1971-1981, with the exception of Selebi-Phikwe, where a lower growth rate (3%) would seem to be appropriate in view of the economic situation surrounding the mine. The table also includes projections to 1986 made by the MLGL in its submission to the World Bank for Urban III, 1982, (item 13).

1.3.1 Gaborone

The estimates in Table 2 (item 12) suggest that some 25,000 additional dwellings will be required by 1991, a 250% increase over the 1981 level. This is based on the very high population growth rate during the 1970s which may well not continue. The MLGL's projections to 1987 give a range of much lower figures -- 7,000-9,350 new dwellings -- but this is based on the assumption that population growth will slow to 9% or 10.5%. Assuming that 60% of this increase is met by the SHHA, between 840 and 1,500 plots/year will be provided annually over the next five to ten years. This compares with a rate of provision in the last five years of about 800 plots per year (including upgrading).

1.3.2 Lobatse

Projecting the growth of population on the basis of the 1971-81 rate (just under 5% per annum) would imply the need for some 180 new dwellings per year over the next ten years. This figure is comparable to the range forecast by the MLGL (170-250 per year). Assuming 75% site-and-service, this means 130-180 plots per year for SHHA. There is also the need to upgrade around 500 squatter plots (in addition to the 950 of Peleng).

Table 1

Status of Housing in Four Principal Towns (1983)

	Item	Gaborone	Lobatse	Francis-town	Selebi-Phikwe	Total
1.	SHHA: site-and-service	3,602	750	1,185	2,569	8,106
	upgrading	1,620	953	3,540	918	7,031
	Total	5,222	1,703	4,725	3,487	15,137
2.	BHC: Low cost	2,785	256	369	293	3,703
	med./high cost (incl. flats)	2,063	125	176	49	2,413
	Total	4,848	381	545	342	6,116
3.	Town council	442	50	--	70	562
4.	Institutional	930	140	365	2,010	3,445
5.	Private	2,515	620	460	200	3,795
6.	Subtotal	14,394	2,894	6,095	6,109	29,492
7.	Squatters (approx.)	--	500	1,300	--	1,800
8.	Total	14,394	3,394	7,395	6,109	31,292
9.	SHHA as a percent of total	36%	50%	64%	57%	48%
10.	1981 census no. of dwellings	10,660	3,020	6,009	5,377	25,066

Sources: 1. SHHA returns for April 1982 (For Lobatse, Peleng only partially upgraded).

2. BHC Annual Report 1982/83.

3. Data obtained from town councils.

4 and 5. MLGL Report to World Bank for Urban III, 1982, Table 1 (including figures for both developed and undeveloped as of 1982).

7. Data from town councils and fieldwork.

10. 1981 census.

Table 2

Housing Needs Projection (1983)

	Item	Gaborone	Lobatse	Francis-town	Selebi-Phikwe	Total
1.	1971 population	17,713	11,936	18,613	10,940	
2.	1981 population	59,656	19,033	31,065	29,467	
3.	Pop. growth rate per annum	12.9%	4.8%	5.3%	10.4%	
4.	Projected 1991 population	200,900	30,400	51,9000	39,000 *	
5.	No. of households (1981)	15,204	4,389	6,664	5,878	
6.	Average household size (1981)	3.92	4.34	4.68	5.01	
7.	No. of dwellings (1981)	10,660	3,020	6,009	5,377	25,066
8.	Average no. of persons per dwelling (1981)	5.60	6.30	5.17	5.48	
9.	Approx. increase in no. of dwellings 1971-1981	7,500	1,100	2,400	3,400	
10.	Total no. of SHHA plots	5,222	750 (excl. Peleng)	4,725	3,487	
11.	Total SHHA site-and-service plots	3,602	750	1,185	2,569	
12.	Projected additional no. of dwellings required by 1991	25,000	1,800	4,000	1,700 *	32,500
13.	MLGL projection of additional plots required by 1986	7,000-9,350 (1987)	915-1,285	2,100 3,340	-- —	

Sources: 1, 2, 5, 7. Census.
3, 6, 8. Derived directly from census.
4. Projection based on 1971-81 population growth rate (not strictly equal to Central Statistics Office projections).
9. Item 7 minus item 1/item 8.
12. Item 4/item 8 minus item 7.
10, 11. From SHHA data April 1983.
13. Projections prepared by MLGL for World Bank Urban III submission, 1982; lowest figures based on five persons per plot and 9% population growth (Gaborone), 6% (Francistown), 4% Lobatse); high figures based on 4.5 persons per plots, 10.5% population growth (Gaborone), 8% (Francistown), 6% (Lobatse).

Note: Items 12 and 13 exclude any upgrading or additional units required for squatters or displacees.

*Projections for Selebi-Phikwe are based on a 3% population growth 1981-91.

1.3.3 Francistown

Table 2 shows that, based on the rate of growth of population during the 1970s, some 400 new plots would be required each year over the next ten years. The figure calculated by the MLGL for the next five-year period is 420-670 per year; the higher figure is based on the assumption that Francistown may expand faster in the near future than it has in the past, due to shifts of investment away from Gaborone (as a result of the drought) and out of Zimbabwe. Of these total figures, around 75% will need to be met by SHHA, i.e., 300-500 plots/year. This compares with a SHHA program that has averaged around 500 plots per year.

1.3.4 Selebi-Phikwe

Its rapid growth in the past is clearly not going to continue. The world recession has created serious problems for the mine, and it looks as if the growth of the town will be minimal over the next few years, although a change in the economic situation could well lead to faster growth in the late 1980s. Assuming a population growth rate of 3% (little more than the natural increase), this will imply a demand for new sites at the rate of around 170 per year. This is obviously considerably less than the rate at which the SHHA has been developing plots in the last few years (around 400 per year, excluding upgrading). At present there are a considerable number of unallocated plots and no waiting list, except for those with incomes of over P2,500 per year, for whom there is a maximum quota of 10% of allocations. The present capacity should serve for the next two to three years. Beyond that a new program will be needed, the scale of which will depend on what happens to the mine.

1.4 Botswana's Urban Development Policy

Faced with increased and rapid urban expansion, the Government of Botswana in its National Development Plan (1975-1981) set forth an urban development policy based on:

- economic self-sufficiency,
- labor intensive techniques,
- restriction of subsidies, and
- provision of self-help housing areas to low income groups.

1.4.1 Infrastructure Standards

Associated with the self-help concept and following extensive review, including the construction of several prototypes for critique and review by residents, the MLGL has since 1980 provided as part of the SHHA infrastructure a Revised Earth Closet Type II (REC II), also commonly known as a "ventilated improved double pit" (VIDP) latrine. At the time of this consultancy it was estimated that over 4,300 REC II latrines had been constructed in the various projects in Gaborone alone.

In Botswana major housing programs in newly developing areas are provided through the BHC or the SHHA. The BHC was established in 1971 with the mandate

to provide housing for all income groups (generally classified as high-cost (HC), middle-cost (MC), and low-cost (LC) housing). In the mid-1970s, the self-help housing concept was developed through town councils to service lower-income groups (basically those that could not afford BHC low-cost housing) and for upgrading squatter areas. Within the general context of water supply and sanitation, BHC homes are provided with water connections and waterborne public sewerage, whereas SHHA areas have public water standpipes and low-cost sanitation (mostly REC II latrines). The current standard provision for infrastructure in most SHHA schemes is as follows:

- Water: one standpipe per 20 plots and no plot more than a 200-meter walk from a standpipe; residents may pay to install private plot connections, but relatively few have done so.

- Sanitation: a two-compartment, lined, ventilated pit latrine (REC II) on each plot (substructure provided by SHHA, superstructure provided by plotholders); in upgrading areas, REC IIs are installed on any plot which does not already have adequate facilities.

- Roads: distributor roads (secondary): graded earth; access roads (tertiary): destumped.

- Street-lighting: main roads and shopping areas only.

- Electricity connections: none (unless privately paid for).

- Refuse collection: one bin per two to five plots, emptied once or twice per week.

Infrastructure standards for all types of housing are shown in Table 3.

1.4.2 Service Levy for SHHA Projects

The GOB policy of self-financing has been applied to the self-help housing schemes. Since 1982 the SHHAs have been required to charge plot-holders, through an "economic" service levy, the full costs (capital amortization and recurrent costs), including the operating costs of the SHHA and town council services provided to them. SHHA plot-holders do not pay owners' rates, although like other urban residents who are employed or who are self-employed, they are liable for a local government tax. The operating costs of educational, health, and social services are not recovered though the service levies but fall on the general funds of the town councils and are thus met from rates, local government tax, other local revenues, and any central government deficit grants.

The government's policy on urban areas permits the financing of urban development through loan capital which is then repaid via some cost-recovery mechanism. In the case of the SHHA program, most of the development has been financed through loans and grants from foreign donors. The cost recovery arrangement is decided by the Ministry of Finance for projects affected by soft loans and grants.

TABLE 3

Infrastructure Standards

Area	Approx. annual household income served	Plot size (sqaure meters)	Road standards Primary-double seal secondary-double seal	Stormwater drainage standard	Sanitation	Water supply	Power supply	Street lighting
High cost		1000-1200	Tertiary-double seal	Drainage for sealed surface roads to be full standard; all other areas to be most economically and technically acceptable standard	Full water-borne system	Domestic connection	Domestic connection	Fully reticulated along main routes, primary roads and business district
Medium cost		600-1000	Tertiary-double seal					
Low cost		400 +	Tertiary-engineered earth					
Site and service Type III	P1,500-4,000	400 +	Tertiary-engineered earth		Approved low cost system	No stand-pipe in excess of 200 m from plot (one-way walking distance)	none	
Site and Service Type II	P1000-1800	400 +	Tertiary-destumped					
Site and Service Type I	P0-P1200	400	Tertiary-unformed		Self-help assisted by SHHA	No stand-pipe in excess of 400 m from plot (one-way walking distance)		

SOURCE: Urban Development Standards, Ministry of Local Government and Lands, Dec. 1981

For SHHA plots, the central government pays the town councils an initial "Development Grant" of P140 per plot on the issuance of Certificates of Rights. This is intended to compensate town councils for the staff costs involved in plot development and allocation.

Funds for the building materials loans of up to P1,200 per plot, which are normally included in a donor's program, are re-lent to town councils at standard terms (8% over a 15year period). The costs are recovered from plot-holders who take out individual loans, using an interest rate (9%) that permits the town council/SHHA a small operating margin.

The SHHA housing program is a local responsibility, and thus the town council is responsible for determining the level of the service levy.

The 1983-1984 service levies for the four principal towns are as follows:

Gaborone	P9.00/month
Lobatse	8.85
Francistown	8.50
Selebi-Phikwe	8.60

The formula for calculating the service levy is set out in the Manual of Administrative and Operational Procedures for SHHA supplied by the MLGL's Principal Housing Officer to each SHHA (see Appendix 2). The main components of this calculation are as follows:

- the full costs of running the SHHA offices at headquarters and ward level, including all staff and all costs associated with the running of the building-materials stores, except the cost of the stored items themselves;

- a proportion of central town council department (Town clerk's and Treasury) staff and administrative costs, calculated on the basis of the ratio of SHHA staff salary costs to total town council salary costs;

- a proportion of the estimated annual costs of refuse collection, street lighting, and road maintenance services provided by the Town Engineer's Department, plus the estimated costs of water supply consumption;

- a sanitation component, representing the cost of equipment for emptying toilets (where this service is provided), and cost recovery for providing special "REC II" toilets to those plots that have them; and

- loan charges payable for the cost of on-site (tertiary) infrastructure.

These sums are calculated using the budget estimates for the levy year. From their sum is deducted the total development grant of P90 per plot estimated to be receivable in respect of plot allocations expected during the levy year. (An assumed allowance for levy arrears is added as 5% of total costs included in the levy calculation). The resultant figure is then divided by the

estimated number of "collection units" (in effect, plot-months) for the year to give the monthly levy.

Itemizations for the 1983/84 service levy rate calculations are shown in Table 4.

Table 4

1983/84 Service Levy Calculations
(pula/month/plot)

	Gaborone	Lobatse	Francistown	Selebi-Phikwe
SHHA overhead	3.72	4.02	4.50	5.30
Town council overhead	1.31	2.46	1.77	1.27
Refuse collection	0.64	0.64	0.52	0.26
Road maintenance	0.70	0.78	0.89	0.22
Water	1.25	0.97	0.80	1.33
Street lights	-	-	-	-
Secondary infrastructure	2.15	0.24	1.43	1.00
Sanitation	0.19	-	-	0.40
Subtotal	9.96	9.11	9.91	9.78
Less development grant (-)	1.15	0.68	2.55	1.87
Default factor (+)	0.44	0.46	0.40	0.39
Roundings (-)	0.25	0.04	-	0.07
Service levy	9.00	8.85	7.76	8.23

Chapter 2

OPTIONAL APPROACHES FOR MEETING SANITATION NEEDS

A number of sanitation options have been considered for the urban communities of Botswana over the years. This chapter provides a summary of the studies made to date, the fundamental features of the options being considered in this paper and some of the factors associated with each option which lead to problems of comparability.

2.1 Previous Studies

Between 1976-1978, studies were undertaken in Botswana by the Ministry of Local Government and Lands (MLGL) and the Canadian International Development Research Center to determine which alternatives would be pursued as a low cost sanitation solution. The resulting report published in July 1978 recommended the use of the following systems:

- Reeds Odorless Earth Closet (ROEC) in impermeable but nonrocky conditions, and
- Type B Toilet (pour/flush) with soakaways (drain field) where good ground soakage (percolation) is available, *
- Double Vault Latrine where the ground is both impermeable and rocky.

Subsequently, the above recommended alternative systems were tried on both an experimental and full scale basis in Gaborone and elsewhere in Botswana. Results of these field studies indicate that certain system inadequacies or causes of failures are associated with one or more of the following factors:

- poor siting with regard to topography and soils,
- substandard construction, and
- misuse by householder.

Concurrently in the late 1970s, desk-top investigations were carried out to design waterborne sewerage systems within allowable overall costs for low-cost development. Costs were reduced basically by lowering plot sizes and also by taking credit for lower road costs per plot from such reductions.

*In the early 1970s various other low cost systems were tried in Gaborone. The principal one of these was the Aqua-Privy, a forerunner of the Type B. The Aqua-Privy, after testing with local residents, was rejected for social and practical reasons (see Appendix 4).

The Broadhurst Stage II Study Report suggested that at 1975 cost levels some variation of a waterborne sanitation system may be provided at a cost comparable to a pit latrine, ROEC, or Aqua-Privy, for plot sizes of 310 m^2 and less.

In 1977, it was calculated that the cost of waterborne sewerage in Botswana was twice the cost of aqua-privy systems (S.E. Daher, Personal Communication, 1977). It was therefore concluded that an on-site system be considered as the most appropriate sanitation measure to cope with the high rate of urban development.

In the 1979 Gaborone Sewerage Study, provision of alternative waterborne systems for the Sekgwa and Bongleng areas were investigated. These two areas have plot sizes of around 450 m^2 and overall densities of 9.6 and 14.8 plots per hectare. The resultant costs at mid-1979 prices (in pulas) were as follows:

Type of system	Cost per plot	Capital recovery cost per plot annually	Capital recovery cost per plot monthly	Cost per month inclusive of min. water charge	Economic ranking
Type B Toilet with soakaway	596	55.8	4.65	6.90	1.00
Waterborne sewer system	730	68.4	5.70	7.95	1.15
Type B Toilet with sewers	753	70.6	5.88	8.13	1.18

It can be seen from this data that the three systems analyzed were cost comparable. With further reduction in plot sizes costs could possibly be reduced even more.

Considering the 1979 findings above, it was suggested that future layouts incorporate an area for low-cost development with 200 to 300 m^2 plots to enable further comparisons. If it is then found that some form of low-cost waterborne sanitation system is cost effective, then these plot sizes would be incorporated in the final development and the market or social acceptability of small plots with waterborne sewerage would be tested. This proposal was considered as the next step toward finding an economic solution to the current problems of providing a hygienic and socially acceptable sanitation system, having regard to the prevailing ground conditions in Gaborone and Botswana generally. However, because of significant opposition from planning and political entities, proposals to develop smaller plots were never pursued.

A cursory review of the economic studies tabulated above reveals certain deficiencies, such as lack of hard and tested information and unvalidated assumptions. In addition, the economic comparison ignored certain factors that

are critical to the analysis and results, and the analytical methodology was not clearly presented.

As noted, all four of the towns included in this report have existing sewerage and treatment facilities. Each has had more or less continuing analyses of needs for system expansion and/or upgrading through a series of master plans, development/feasibility studies and updates thereof. The design community in Botswana is also active on a continuing basis in the development of system extension designs and construction supervision.

In 1983, the Development Administration Group, Institute of Local Government Studies, University of Birmingham (England), conducted a social survey for the MLGL. Although the survey clearly shows the major concerns to be in the areas of income, employment and food prices, it provides some insights into attitudes toward sanitation services. In most SHHA areas with a REC II latrine installed, between 20-35% of plot holders were found to be "dissatisfied" (see Appendix 3). With reference to SHHA project areas, questions are being raised as to whether the REC II latrine is the only acceptable and low-cost sanitation solution. Septic tanks with soakaways or waterborne public sewerage would likely be considered as preferable alternatives to REC II latrines.

2.2 Options to be Considered

The options to be considered are basically (i) a low-cost on-site option amenable to the self-help approach and (ii) two waterborne options, one being self contained on-site when soil and lot size conditions permit (e.g., conventional septic tank with drain pit or "soakaway") and the other being conventional sewerage system with stabilization ponds, discharging effluent to irrigation fields. Thus three options will be compared as follows:

- REC II latrine
- Septic tank and soakaway
- Conventional sewerage and treatment

As noted in previous sections, the REC II system has been included as a standard provision in a number of site and service areas with the basic plot development package including the substructure only. The owner is responsible for providing the superstructure at the time of house construction. The two waterborne options involve construction of an indoor bathroom facility as part of the home.

Conceptually, it is possible to provide initially to the SHHA low-cost sanitation facilities with future upgrading through the use of small-bore sewerage. Small-bore sewerage[1] is an applicable technique for systems where solids are essentially excluded from the wastewater flow. In the case of REC II users, sullage water from baths, kitchen sinks and laundry may be pumped and diverted into a small-bore sewerage. In septic tank applications, overflow from the septic tank which is solids-free may be connected to the small-bore sewerage. The small-bore system generally would be less costly than a

conventional sewer system since the pipe system can be flatter and therefore may be laid at shallower depths. In addition, it may be possible to reduce the number of manholes since pipe access is primarily to remove blockage in systems that carry solids. This approach might be most appropriate for upgrading areas where construction of conventional sewerage in cramped street and lot conditions would not be feasible. It would thus carry sullage and septic tank effluent away from congested areas to a conventional sewerage system, which would be required in view of the need to provide full scale sewerage service to industrial and commercial customers.

Appendix 4 provides desciptions of low cost on-site sanitation options including the REC II option along with photographs of representative housing and sanitation facilities.

2.3 Disparities in Benefits

The three options to be considered do not provide the same levels of service or benefits. Economists have difficulty in quantifying these variations in benefits and it is therefore necessary to simply keep in mind that disparities exist. Some of the more important service disparities are:

- Public Health: Public health benefits are, at least theoretically, optimized through the conventional sewerage and treatment systems, with the septic system and on-site improved latrine systems following in descending order of benefits derived. This conclusion is based on the assumption that the wastewater collection systems are designed and operated properly and create no surface water contamination problems and that septic tank soakaways are properly sited to avoid potential groundwater contamination and associated health problems. One must acknowledge, however, that in the real world, these ideal situations do not always occur.

- Convenience: The two waterborne options clearly offer benefits in terms of convenience that cannot be matched by any of the latrine approaches. The ability to dispose of sullage water and to use the facilities without going out of the home are conveniences not subject to quantification, but nonetheless factors that impact beneficially on the lifestyles of the beneficiaries.

- Suitability in the Urban Setting: The two on-site options are generally better suited to rural or suburban situations, where the distances between neighboring homes is greater and lot sizes can be larger. The development of hundreds or thousands of plots that are essentially 50 by 80 feet in size with septic pits or outbuildings for latrines does not enhance urban life and creates the potential for future health or nuisance problems.

(1) Chapter 16, "Small-Bore Sewers, Appropriate Sanitation Alternatives". A Planning and Design Manual, World Bank Studies in Water Supply and Sanitation.

Chapter 3

COST ESTIMATES

The estimated costs of each of the optional sanitation approaches are developed in this chapter. Capital costs consist of direct costs incurred in developing the sanitation facilities, associated costs of developing additional water supply facilities (for the two options that require water for flushing) and the costs of operations and maintenance. A discussion of shadow prices and how they may affect the economic comparisons will also be provided.

3.1 Direct Capital Costs

Data representing current (1985) prices for various construction components have been provided by an engineering consultant located in Gaborone, and are presented in Appendix 5. Table 5 presents a summary of cost data developed on a "per plot" basis which provides some indication of relative capital costs. However, such broad comparisons have little validity due to factors that limit their comparibility such as differing service lives and "lumpiness" in the scheduling of capital investments.

Price differentials between the four towns are deemed to be negligible. The direct costs of developing a waterborne system have been assumed to include stabilization ponds, outfall sewers, trunk mains, pump stations, force mains, tertiary sewers, house connections and toilet areas with required plumbing. The septic tank option was priced based on the cost of a two chamber tank, 5 meters of 100 mm diameter drain pipe, drain field and toilet area with required plumbing. The REC II option is priced to include the cost of the substructure and the contract price of superstructure, thus providing for the value of the labor component even though the labor would typically be provided by the owner in the self-help housing areas.

3.2 Associated Costs

For the fully waterborne sewerage option and the septic tank option, additional investments will be required (with the exception of Francistown) to provide the water needed for flushing. The water requirements in liters per capita per day (lcd) for these options are shown below in comparison with the estimated average water consumption associated with the nonwaterborne sanitation option.

REC II latrine	40 lcd
Septic tanks	100 lcd
Sewerage	125 lcd

The water utilities in all of the towns except Francistown appear to be operating at full capacity and will require expanded supply facilities to accommodate anticipated growth. The incorporation of one of the two waterborne options into the development plan would introduce the need for an incremental expansion of water production facilities which should be included in the capital costs of the two waterborne options for the purpose of the economic

Table 5

Summary of Sewerage and On-Site Sanitation Cost Estimates for Self-Help/Low-Cost Housing Areas

		1985 Prices (in pula)
A. Sewerage		
House connection (15 m length), avg. cost per plot		975
Toilet area and plumbing costs/plot		549
Tertiary sewers, avg. cost/plot		2,300
Stabilization ponds and irrigation, avg. cost/plot		142
Trunk mains, outfall sewers, pump stations and force mains, avg. cost/plot		336
	Total	4,302
B. Septic tank and soakaway		
Average cost/plot assuming two chambers and 5 m of 100mm diameter drain pipe		2,028
Toilet area and plumbing costs		549
	Total	2,577
C. REC II latrine		
Average cost, substructure		480
Average cost, superstructure		200
	Total	680

Source: NZA Associates (Pty) Ltd., Consulting Engineers, Gaborone (see Appendix 5 for additional detail)

comparisons. In the case of Gaborone, introduction of the sewerage option into the low-cost/self-help housing developments would increase average daily consumption in the year 2000 by about 7,000 cubic meters per day and by more than 5,000 cubic meters per day if septic tanks are used. The capital costs of providing the expanded water production capability is estimated to be P1.5 million per 1,000 cubic meters per day of capacity.*

In Francistown, where only about 30% of the existing water supply capacity is being used, the use of excess water capacity can be considered as a net benefit to the extent that the prices charged for water exceed the costs of production. For the purposes of this comparison however, it has been assumed that the prices charged are equal to the costs of production, resulting in no net benefits or costs.

For the nonwaterborne sanitation option, disposal of sullage water is potentially associated cost. There appears to be no developmental provision made specifically for sullage water, however, with lot and street drainage facilities in the self-help housing areas being designed without specific reference to the type of sanitation service. No provision has been made therefore, for this item in the economic cost comparisons.

3.3 Operating Costs

Operating costs for the sewerage option are estimated at 1.5% of the costs of capital facilities in place (not including the costs of toilet areas, water facilities and plumbing), a figure used by the MLGL in projecting O&M costs.

Operating costs for septic tanks and REC II latrines are deemed to be basically comparable, and consist of the costs of desludging. The design of both facilities provides for a nominal three-year capacity. As a practical matter however, a two-year cleaning cycle has been incorporated to take into account variations in the rate of filling and to avoid overflow situations. Annual workload requirements are based on the assumption that households would switch chambers after the first two years, the first chamber would remain sealed during the third year and would be emptied during the fourth year, following which the household use would return to the first chamber. Following this cycle, the annual desludging requirement would gradually increase to some 6,600 plots per year by the year 2000.

The calculation of operating and maintenance costs for the two on-site options is presented in Table 6 along with the principal assumptions. Crew productivity is based on their ability to empty six chambers per day, six days per week with 15% downtime for holidays and vehicle repairs and servicing, which results in an estimated annual production of 1,580 plots per year per crew. Desludging equipment would be acquired and crews added as required by the annual workload requirements. Equipment purchases and crew formation can be deferred for several years (when the workload will be limited to emergency calls and other unscheduled requirements), through the use of rental equipment and contractors.

*This is based (conservatively) on an assumed cost of P0.70 per cubic meter for developing and operating additional groundwater sources, with P0.50 for capital recovery and P0.20 for O&M.

Table 6

Estimated Costs of Operations and Maintenance,
REC II and Septic Tank Options

I. Productivity

4-man crew
6-day week
1.5 m^3/chamber
3 chambers/load
6 chambers/day
44 weeks/year on the job

Per crew

6x6x44 = 1,584 plots/year

II. Crew Costs

- Capital cost of desludging vehicle — P86,520
- Vehicle maintenance, 10% of capital cost — 8,652/year
- Vehicle operation (fuel) assuming 2 round trips of 40 km ea.
  - 80 x 6 x 44 = 21,120 km/yr.
  - 1.8 km/1 fuel onsumption
  - 11,700 liters @ P0.77/liter — 9,009/year
- Labor costs
  - wage rate = P5.5/day
  - labor overhead = 30% = P1.65
  - 4 x (5.5 + 1.65) x 6 x 52 — 8,923/year

III. Workload

Sample calculations:

Year	New plots served	Plots desludged/cycle 1	2	3	4	Total annual
1986	900	50				50
1987	900	100				100
1988	900	200	50			250
1989	1,000	900	100			1,000
1990	1,000	900	200	50		1,150
1991	1,000	900	900	100		1,900
1992	1,100	1,000	900	200	50	2,150

Note: Unscheduled and emergency service calls will occur in addition to the routine workload. These are represented by the workload shown for 1986, 1987 and 1988.

The O&M costs of the incremental water consumption for the two waterborne options must also be calculated and included in the economic cost comparisons. Estimated O&M costs for this incremental water consumption are P0.20 per cubic meter in all towns.

3.4 Accounting Prices

Shadow pricing factors in Botswana suggested by the Ministry of Finance are as follows:

Unskilled labor	0.5
Skilled labor	1.1
Foreign exchange	1.1
Local materials	1.0
Fuel oil/gasoline	1.1

These reflect the relative values to the economy of the various cost elements. The extent to which the use of these pricing factors would affect the cost comparisons would depend upon the relative mix of the various cost components. There would also be an indirect element to be determined, for example, in the local materials category. In some cases, local materials have been processed in a manner that employs imported equipment, uses skilled labor and consumes fuel oil or electricity. Thus a portion of the local materials should be priced at something above the 1.0 factor. Application of these factors to representative cost breakdowns for the REC II and sewerage options indicates that plus and minus tradeoffs result in marginal impact on relative costs, in the vicinity of four percent. Given the "order of magnitude" level of accuracy in the basic cost estimates, the economic comparisons are deemed to be insensitive to shadow prices and they have therefore been omitted in the analyses that follow.

Chapter 4

COST COMPARISONS

4.1 Problems of Comparability

As previously noted, there are serious conceptual problems to be dealt with in attempting to compare the costs of alternatives that have such differing features in terms of benefits, nonquantifiable costs, timing of required investments, and differences in useful service lives. Briefly, the most important of these issues are as follows:

- Nonquantifiable Costs

  Examples of costs that are difficult to quantify include remedial measures to correct pollution problems created by groundwater contamination from septage and/or surface water contamination from improperly designed or operated sewage treatment plants. It is also difficult to measure costs to the economy from the incidence of diseases that may be more prevalent under the latrine approach. In addition, it is difficult to measure the cost to Botswana's economy of the larger energy requirements associated with the sewerage option.

- Timing of Investments

  The sewerage option involves making significant capital expenditures for treatment, trunkage and pumping facilities before the first beneficiary can be connected to the system. Capital investments for the two on-site options, however, involve only a negligible lag between outlays and the provision of service at full capacity. For the costs of operations and maintenance, it is necessary to acquire desludging equipment and to form work crews which initially will not be fully utilized and likewise to add crews and equipment in the future which will be underutilized during the first several ensuing years.

- Differences in Service Lives (The sewerage system service life cited herein is a composite of the system's various components, which have service lives ranging from 10 to 50 years.)

  Each of the options has a different basic service life: 33, 20 and 15 years respectively for the sewerage, septic tank and REC II options.[1] The desludging equipment is assumed to have a six-year life. This introduces a life cycle element; a valid comparison must take into account for example, that it will be necessary to replace the latrines more frequently than the sewerage system components. At the end of any given period, the residual or salvage values for each option will be significantly different.

4.2 Basis of Comparisons

The cost comparison methodology has been constructed to minimize the various problems of comparability. This is accomplished by establishing streams of capital and operating costs over the time and discounting them to determine a net present value, taking into account the residual values of capital items. The stream of plots served is also discounted so that one may then determine the average cost per plot. Some of the main assumptions incorporated into the cost comparisons are as follows:

- Towns Analyzed

  Gaborone is taken as being representative of all four towns with the exception that the incremental costs of water for the two waterborne options are not considered for Francistown, where the water system has a significant surplus of production capacity.

- Time Span

  A 15-year period (1986-2000) is analyzed. This provides coverage of the full life of the REC II facilities installed during the first year and provides a reasonable time span for illustrating differences among the three options.

- Service Levels

  The rate of connection to the sewerage system or of constructing on-site systems is basically as projected in Table 2, assuming that 60% of future development will be in the self-help/low-cost housing categories. It has been assumed that no connections can be provided during the first year of development of the sewerage system, but that the full year's worth of services would be provided during the first year of construction of the two on-site options. Thus during the 15-year time span, a total of 15,000 plots would be served under the sewerage option and 15,900 under the two on-site options.

- Discount Rates

  The World Bank recommends use of 8% as the opportunity cost of capital for Botswana. Rates of 10% and 12% are also shown for comparison.

- Salvage/Residual Values

  These have been calculated for the year-end 2000, based on assumed service lives.

- Cost Streams

  For the sewerage option, it has been assumed that construction of the treatment, transmission and pumping facilities would be undertaken in stages, generally providing enough capaciy to serve approximately 25,000 people. Associated investments in expanded water production facilities are projected to occur at intervals, providing increases

of about 1,000 cubic meters daily each. Sewerage, connections and toilet area costs would occur in the same year in which services are provided. For the two on-site options, capital costs parallel service provision. The capital costs associated with O&M, however, are "lumpy" and also involve replacements during the time span covered.

4.3 Cost Comparisons

The present value comparisons are presented in Tables 7, 8, and 9. Although based on the development of facilities in Gaborone, these are deemed to be representative of the other three towns. As expected, these indicate the least cost option to be the REC II approach. The septic tank and sewerage options are 4.3 and 7.8 times more costly respectively, as shown in Table 10. When salvage values are considered, these factors decline to 4.0 and 6.5. The relative costs for Francistown are further reduced due to the absence of water costs as a net cost factor.

Table 7

Net Present Value Analysis
Gaborone, REC II Sanitation Option

Costs (in pula)

Year	Total annual capital costs	Recurrent costs: Equipment new/repl.	Recurrent costs: Operations and maintenance	Total annual costs of REC II option
	-Pula-			
1986	612,000	-	2,500	614,500
1987	612,000	-	5,000	617,000
1988	612,000	-	12,500	624,500
1989	680,000	86,520	23,000	789,520
1990	680,000	-	24,000	704,000
1991	680,000	85,520	46,580	813,100
1992	748,000	-	49,500	797,500
1993	748,000	-	53,160	801,160
1994	748,000	-	53,160	801,160
1995	816,000	173,040	73,160	1,062,200
1996	816,000	-	78,000	894,000
1997	816,000	173,040	100,000	1,089,040
1998	748,000	-	103,000	851,000
1999	748,000	-	106,330	854,330
2000	748,000	86,520	126,000	960,520
Salvage Value at year-end 2000	6,011,200	194,670		6,205,870

Costs - NPV - 8% - 6,680,180
10% - 5,868,300
12% - 5,196,390

Salvage - NPV - 8% - 1,956,390
10% - 1,485,670
12% - 1,133,810

Adjusted NPV - 8% - 4,723,790
10% - 4,382,630
12% - 4,062,580

Beneficiaries/Workload

Plots served per year	Cumulative plots served	Plots to be desludged	Year
900	900	50	1986
900	1,800	100	1987
900	2,700	250	1988
1,000	3,700	1,000	1989
1,000	4,700	1,150	1990
1,000	5,700	1,900	1991
1,100	6,800	2,150	1992
1,100	7,900	2,900	1993
1,100	9,000	3,150	1994
1,200	10,200	3,900	1995
1,200	11,400	4,250	1996
1,200	12,600	5,100	1997
1,100	13,700	5,450	1998
1,100	14,800	6,300	1999
1,100	15,900	6,650	2000

Plots - NPV	Total avg. annual cost/plot	Adjusted total avg. annual cost/plot
8% - 8,824	757	535
10% - 7,788	754	563
12% - 6,928	750	586

Table 3

Net Present Value Analysis
Gaborone, Septic Tank with Soakaway Option

	Direct costs of septic tank option				Associated costs of water			Beneficiaries/Workload			
		Recurrent costs									
Year	Total annual Capital costs	Equipment new/repl.	Operations and maintenance	Total direct cost of septic tank option	Capital costs of incremental water prod.	Recurrent costs of incremental water prod.	Total associated costs of water	Plots served per year	Cumulative plots served	Plots to be desludged	Year
1986	2,310,300	-	2,500	2,312,800	-	22,000	22,000	900	900	50	1986
1987	2,310,300	-	5,000	2,315,300	-	44,000	44,000	900	1,800	100	1987
1988	2,310,300	-	12,500	2,322,800	1,500,000	66,000	1,566,000	900	2,700	250	1988
1989	2,567,000	86,520	23,000	2,676,520	-	91,000	91,000	1,000	3,700	1,000	1989
1990	2,567,000	-	24,000	2,591,000	-	115,000	115,000	1,000	4,700	1,150	1990
1991	2,567,000	86,520	46,580	2,700,100	1,500,000	140,000	1,640,000	1,000	5,700	1,900	1991
1992	2,823,700	-	49,500	2,873,200	-	167,000	167,000	1,100	6,800	2,150	1992
1993	2,823,700	-	53,160	2,876,860	-	194,000	194,000	1,100	7,900	2,900	1993
1994	2,823,700	-	53,160	2,876,860	1,500,000	221,000	1,721,000	1,100	9,000	3,150	1994
1995	3,080,400	173,040	73,160	3,326,600	-	250,000	250,000	1,200	10,200	3,900	1995
1996	3,080,400	-	78,000	3,158,400	1,500,000	280,000	1,780,000	1,200	11,400	4,250	1996
1997	3,080,400	173,040	100,000	3,353,440	-	309,000	309,000	1,200	12,600	5,100	1997
1998	2,823,700	-	103,000	2,926,700	-	336,000	336,000	1,100	13,700	5,450	1998
1999	2,823,700	-	106,330	2,930,030	1,500,000	363,000	1,863,000	1,100	14,800	6,300	1999
2000	2,823,700	86,520	126,000	3,036,220	-	390,000	390,000	1,100	15,900	6,650	2000

						NPVs	Avg. annual direct costs/plot	Avg. annual associated costs	Total average costs/plot
			Costs NPV-8% -	23,454,080	5,425,740	8,824	2,658	615	3,273
			10% -	20,562,890	4,698,290	7,788	2,640	603	3,243
			12% -	18,266,940	4,098,810	6,928	2,637	592	3,229
Salvage Value at year-end 2000	25,182,270	194,670		25,376,940	6,045,000	6,045,000			
			Salvage NPV - 8% -	7,999,890	1,905,640				
			10% -	6,075,050	1,447,120				
			12% -	4,636,280	1,104,400				
							Adjusted avg. annual direct costs/plot	Adjusted avg. annual associated costs	Adjusted total average costs/plot
			Adjusted NPV - 8% -	15,454,190	3,520,100	8,824	1,751	399	2,150
			10% -	14,487,840	3,251,170	7,788	1,860	417	2,277
			12% -	13,630,660	2,994,410	6,928	1,967	432	2,399

Table 9

Net Present Value Analysis
Gaborone, Full Waterborne Sewerage Option

	Direct costs of sewerage								Associated costs of water			Beneficiaries			
						Recurrent costs									
Year	Treatment and disposal	Trunk mains, outfall sewers, pump stations & force mains	Sewerage and connections	Toilet areas, plumbing and fixtures	Total annual capital costs	Incremental	Cumulative (total annual)	Total annual sewerage costs	Capital costs of incremental water production	Incremental recurrent water costs	Total annual incremental water costs	Plots served	Persons served	Population served cumulative	Year
1986	640,000	1,535,000	1,473,750	247,050	3,895,800	54,750	54,750	3,950,550	-	-	-	-	-	-	1986
1987	-	-	2,947,500	494,100	3,441,600	44,250	99,000	3,540,600	-	31,000	31,000	900	5,040	5,040	1987
1988	-	-	2,947,500	494,100	3,441,600	44,250	143,250	3,584,850	1,500,000	63,000	1,563,000	900	5,040	10,080	1988
1989	-	-	3,275,000	549,000	3,824,000	49,125	192,375	4,016,375	-	97,000	97,000	1,000	5,600	15,680	1989
1990	-	-	3,275,000	549,000	3,824,000	49,125	241,500	4,065,500	-	132,000	132,000	1,000	5,600	21,280	1990
1991	640,000	1,535,000	3,275,000	549,000	5,999,000	81,750	323,250	6,322,250	1,500,000	167,000	1,667,000	1,000	5,600	26,880	1991
1992	-	-	3,602,500	603,900	4,206,400	54,000	377,250	4,583,650	-	205,000	205,000	1,100	6,160	33,040	1992
1993	-	-	3,602,500	603,900	4,206,400	54,000	431,250	4,637,650	1,500,000	243,000	1,743,000	1,100	6,160	39,200	1993
1994	-	-	3,602,500	603,900	4,206,400	54,000	485,250	4,691,650	-	281,000	281,000	1,100	6,160	45,360	1994
1995	640,000	1,535,000	3,930,000	658,800	6,763,800	91,500	576,750	7,340,550	3,000,000	323,000	3,323,000	1,200	6,720	52,080	1995
1996	-	-	3,930,000	658,800	4,588,800	59,000	635,750	5,224,550	-	365,000	365,000	1,200	6,720	58,800	1996
1997	-	-	3,930,000	658,800	4,588,800	59,000	694,750	5,283,550	-	407,000	407,000	1,200	6,720	65,520	1997
1998	-	-	3,602,500	603,900	4,206,400	54,000	748,750	4,955,150	1,500,000	445,000	1,945,000	1,100	6,160	71,680	1998
1999	640,000	1,535,000	3,602,500	603,900	6,381,400	86,600	835,350	7,216,750	-	483,000	483,000	1,100	6,160	77,840	1999
2000	-	-	3,602,500	603,900	4,206,400	54,000	889,350	5,095,750	1,500,000	521,000	2,021,000	1,100	6,160	84,000	2000

					Avg. direct cost/plot	Avg. assoc. cost/plot	Tot. avg. cost/plot
Costs NPV - 8% - 40,395,890		7,054,920	7,991		5,055	883	5,938
10% - 35,454,760		6,039,780	6,970		5,086	867	5,953
12% - 31,368,210		5,209,470	6,124		5,122	851	5,973
Salvage value at year-end 2000	54,327,900	NPV salvage values 8% - 17,126,450	8,632,000	2,737,930		Adjusted avg. direct cost/plot	Adjusted avg. associated cost/plot	Adjusted total average cost/plot
10% - 13,005,690				2,078,400		2,912	540	3,452
12% - 9,925,520				1,586,170		3,221	568	3,789
Total adjusted NPVs 8% - 23,269,440				4,316,990	7,991	3,501	592	4,093
10% - 22,449,070				3,961,380	6,970			
12% - 21,442,690				3,623,300	6,124			

Table 10

Relative Costs of Sanitation Options

Option	Net Present Value average annual cost (in pula)		Relative cost	
	(i = 8%)			
	Costs only	Costs less salvage values	Costs only	Costs less salvage values
REC II	757	535	1.0	1.0
Septic tank	3,273	2,150	4.3	4.0
Sewerage	5,938	3,452	7.8	6.5

Notes:

1. For Francistown, wherein the water costs are assumed to be neutralized, the relative costs are 3.5 and 3.3 for the septic tank option and 6.7 and 5.4 for the sewerage option.

2. The effect of higher discount rates is to accentuate the disparities between the REC II and sewerage systems. Relative costs between REC II and the septic tank options are not sensitive to the discount rates applied.

Chapter 5

AFFORDABILITY ANALYSIS

An analysis of the plotholder's ability to pay for sanitation costs is provided in this chapter. Financial, rather than economic, cost information is developed and compared with household incomes typically found in the self-help and low-income housing areas of the four communities.

5.1 Household Incomes

Data on household incomes in Botswana are taken from a 1983 survey and evaluation which was prepared by the Institute of Local Government Studies, University of Birmingham, England. A summary of those findings most pertinent to this study is presented in Table 11. Some factors to be noted are:

- Even among the SHHA/low-income housing areas in the same town, there is a wide range of average incomes from employment.
- Fifty percent or more of the low-income households in Gaborone and from 15-34% of the households in the other three towns receive rental income. A smaller, but still significant percentage of households receive transfer payments from other areas.
- Some households have no income and appear basically indigent.

To avoid underestimating the ability to pay of a reasonable proportion of the households in the SHHA/low-income housing areas, several adjustments should be made to the foregoing data: (1) an adjustment to the employment income data to reflect other incomes including nonmonetary receipts, (2) an adjustment to reflect the increases in incomes that have occurred between 1983 and 1985, and (3) a recognition of the fact disclosed in the survey, that more than one household occupies a plot and that a proportional amount of supplemental income would be available to meet expenses. "Plotholder" incomes as shown in Table 12, are therefore developed for use in evaluating the affordability of sanitation facilities. Income levels fall into two groups, with Gaborone and Lobatse in the high range and Francistown and Selebi-Phikwe in the low range.

5.2 Plotholder Expenses for Sanitation

Plotholder expenses for the least- and second least-cost options have been calculated and are presented in Tables 13 and 14. For the REC II option, it has been assumed that the operating costs of desludging, including cost recovery for the equipment and capital costs of the latrine substructure, would be financed through the economic service levy. Calculations have been based on the examples provided in Appendix 2, including a surcharge for defaults and deduction for a pro-rata share of the development grant. Representative interest rates and repayment periods which in practice are based on the terms of specific donor assistance programs are also employed.

TABLE 11

Analysis of Household Income Data (1983)

Settlement	Income from employment		Rent		Transfers	
	Households with employment (percent)	Average earnings (pula)	Households receiving rent (percent)	Average rent received[1] (pula)	Households receiving rent from rural areas[2] percent)	Households receiving income from other countries (percent)
Gaborone						
Bontleng/Ext. 14	94	220	65	38	4	3
Broadhurst/Tshol.	95	180	51	30	1	3
Old Naledi	73	146	58	20	6	0
Lobatse						
Maipaafela	85	142	29	17	13	21
Woodhall	80	174	34	23	4	17
Peleng	68	202	18	35	5	14
Francistown						
Monarch	75	112	16	13	10	21
LWS/Aerodrome	97	219	33	23	8	8
Tatitown	81	167	23	17	4	23
Somerset	90	144	18	20	2	2
Selebi-Phikwe						
Botshabelo	89	128	17	20	4	3
Western Areas	100	171	32	23	5	5
South East Extension	95	114	15	30	7	5

Source: SHHA Evaluation Survey, Institute of Local Government Studies, University of Birmingham, 1983.

[1] An adjusted figure for rent received in the case of LWS/ Aerodrome and Peleng was derived by averaging reported rents received and rents paid.

[2] This column represents the proportion of households that receive more from rural areas than they send to them (i.e., they are net recipients)

Table 12

Monthly Incomes Per Plot (1985)
(in pula)

	Item	Gabarone	Lobatse	Francis-town	Selebi-Phikwe
1.	Household income from employment 1983, lowest average of settlements	146	142	112	114
2.	Ten percent adjustment for rentals, remittances, non-monetary and other income	14	14	11	11
3.	Income growth since 1983.[1]	30	29	23	23
	Total adjusted household incomes	190	185	146	148
4.	Survey findings, number of households per plot	1.43	1.45	1.10	1.10
	Total adjusted incomes per plot	272	268	161	163

[1]Assumed to match inflation at 11% from 1983 to 1984 and 7% from 1984 to 1985.

Table 13

Plotholder Costs, Rec II Option
(in pula per month)

A. Service levy costs			
1. Desludging crew and equipment -		86,520	
• Capital recovery (6% - 6 years)		1,434 annually	
• Labor		8,923	
• Operations (fuel)		9,009	
• Maintenance		8,650	
Total annual cost		28,016	
Annual plotholder cost (28,016 ÷ 1,580)	17.73		
Monthly plotholder cost			1.48
2. REC II substructure			
• Cost of P480 financed at 6% for 20 years			3.44
3. Adjustments			
• Subtotal			4.92
• 5% default surcharge			0.25
• Pro-rata share, development grant			-0.30
			4.87
Rounding			-0.02
			4.85
B. Superstructure cost			
• Building materials loan of P100 at 6% for 20 years.			-0.72
Total monthly cost			5.57

Table 14

Plotholder Costs, Septic Tank Option
(in pula per month)

A. Capital investment	
o Full cost of P2,567 financed at 6% for 25 years	16.54
B. Operating costs	
o Desludging crew and equipment[1]	1.48
o Default surcharge	.08
o Incremental water consumption[2] (nominally 60 lcd, five-person household)	8.70
Total monthly cost (except Selebi-Phikwe)	26.80[3]
Total monthly cost (Selebi-Phikwe)	23.80

[1]See Table 13

[2]Representative of all towns except Selebi-Phikwe, where the difference in tariff schedule would result in a monthly cost of 5.70.

[3]Plotholder costs for the conventional waterborne option would be approximately P 44 per month.

Table 15
Affordability Comparisons
(in pula)

Town	Adjusted monthly incomes/ plot	Costs of sanitation			
		REC II		Septic tank	
		Cost per month	Percent of income	Cost per month	Percent of income
Gaborone	272	5.57	2.0	26.8	9.9
Lobatse	268	5.57	2.1	26.8	10.0
Francistown	161	5.57	3.5	26.8	16.6
Selebi-Phikwe	163	5.57	3.4	23.8	14.6

It has been assumed that the superstructure would be constructed by the plot-holder, who would finance the cost of the materials through a building materials loan. Monthly costs, as shown in Table 13, would amount to P5.57, which should be reasonably indicative of the cost in each of the four towns. It is noted that this amount would increase the typical service levy by about 60%.

For the septic tank option, it is assumed that the full cost of the tank and appurtenances and the toilet area and plumbing can be financed at 6% interest over a 25-year period. Desludging costs are the same as for the REC II option and would be billed as part of the service levy. Incremental water consumption has been shown at a composite tariff for all towns except Selebi-Phikwe, which is the only town to have a significant difference in its tariff structure.

Total monthly costs developed in Table 14 then become P26.80 for all towns except Selebi-Phikwe where it is estimated at P23.80. These costs are nearly five times greater than those of the REC II option.

5.3 Affordability Parameters

There are no clear indicators of affordability that can be used to evaluate any given situation. Experience in many different parts of the world over numerous projects, however, has provided some parameters that may be broadly indicative. For the lower-income groups, the allocation of 15% of household income for housing can be used as a guideline, with about one-half of that proportion for the shelter itself and the remainder for infrastructure. The infrastructure component covers water, sanitation, streets, drainage, electric power and refuse collection. With only 7-8% of income available for all such costs, it would not seem likely that sanitation costs could feasibly exceed 2 or 3% at the maximum, since sanitation is typically several steps down from being the top priority service.

Comparisons between estimated costs for the least- and second least-cost options and adjusted plotholder incomes are shown in Table 15. The REC II option appears reasonably affordable in Gaborone and Lobatse and significantly less so in Francistown and Selebi-Phikwe without subsidy, due to the significantly lower incomes in those communities. The septic tank option would require some 10-16% of incomes, which seems well beyond the range of affordability.

It is clear that the conventional sewerage option would prove even more costly and thus less affordable and that neither the septic tank nor the conventional sewerage options could be implemented without substantial levels of direct government subsidy.

APPENDIX 1

Data on the Four Principal Towns

DATA ON THE FOUR PRINCIPAL TOWNS

Introduction

The four principal towns -- Gaborone, Francistown, Lobatse, and Selebi-Phikwe -- lie in the east of the country, three of them along the line of the road and rail links between Zimbabwe and South Africa. Selebi-Phikwe was founded away from this main arterial link to service an important mine. Two of the four main towns -- Selebi-Phikwe and the capital, Gaborone -- were established in the mid 1960s. Francistown and Lobatse have longer histories going back to the earliest colonial days. All of the towns have experienced rapid growth and transformation during the last 15 years. (See Map 1.)

Gaborone

General Description

The town lies at a relatively high point in a mainly featureless area. The principal physiographic point is the Notwane River which flows from the Notwane Dam at the southern end of the town in a north-easterly direction. Flows only occur in the watercourses after heavy prolonged rainfall. The Notwane River is controlled by Gaborone Dam and flows take place only when excess water is discharged over the dam spillway.

The natural vegetation is highveld bush and small trees. General ground slopes are between 1 in 75 and 1 in 150. The gradient of the Notwane River immediately adjacent to the town is about 1 in 400.

The long-term annual average rainfall is 537 mm with a seasonal variability of 30%. The period May to September is almost completely dry and most of the rainfall is concentrated in a small number of intense storms, generally of short duration, occurring in the months from October to April.

Mean monthly maximum temperatures vary from 35°C in January to 22°C in July. Mean monthly minimum temperatures vary from 4°C in July to 18°C in January. In June and July, the temperature not infrequently falls to below freezing. Average yearly evaporation is around 2,500 mm per annum.

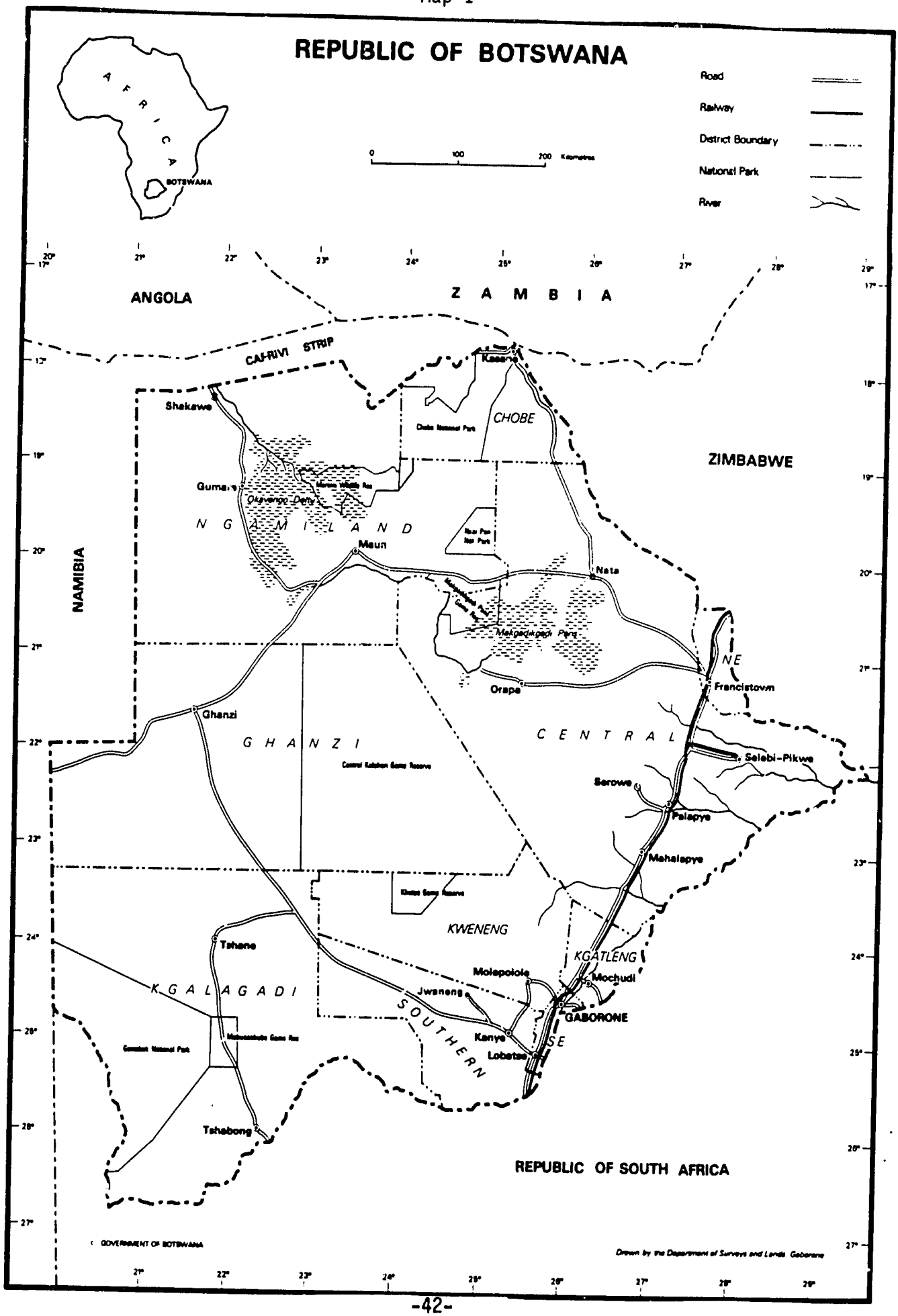
The prevailing winds blow from the northeast and are generally of low velocity.

The formal plan for Gaborone, the new capital of independent Botswana, was drawn up in the early 1960s. This plan provided for an anticipated population of about 20,000 by 1980. However, the population had already reached that level by 1971. By 1981 it had more than tripled to reach nearly 60,000.

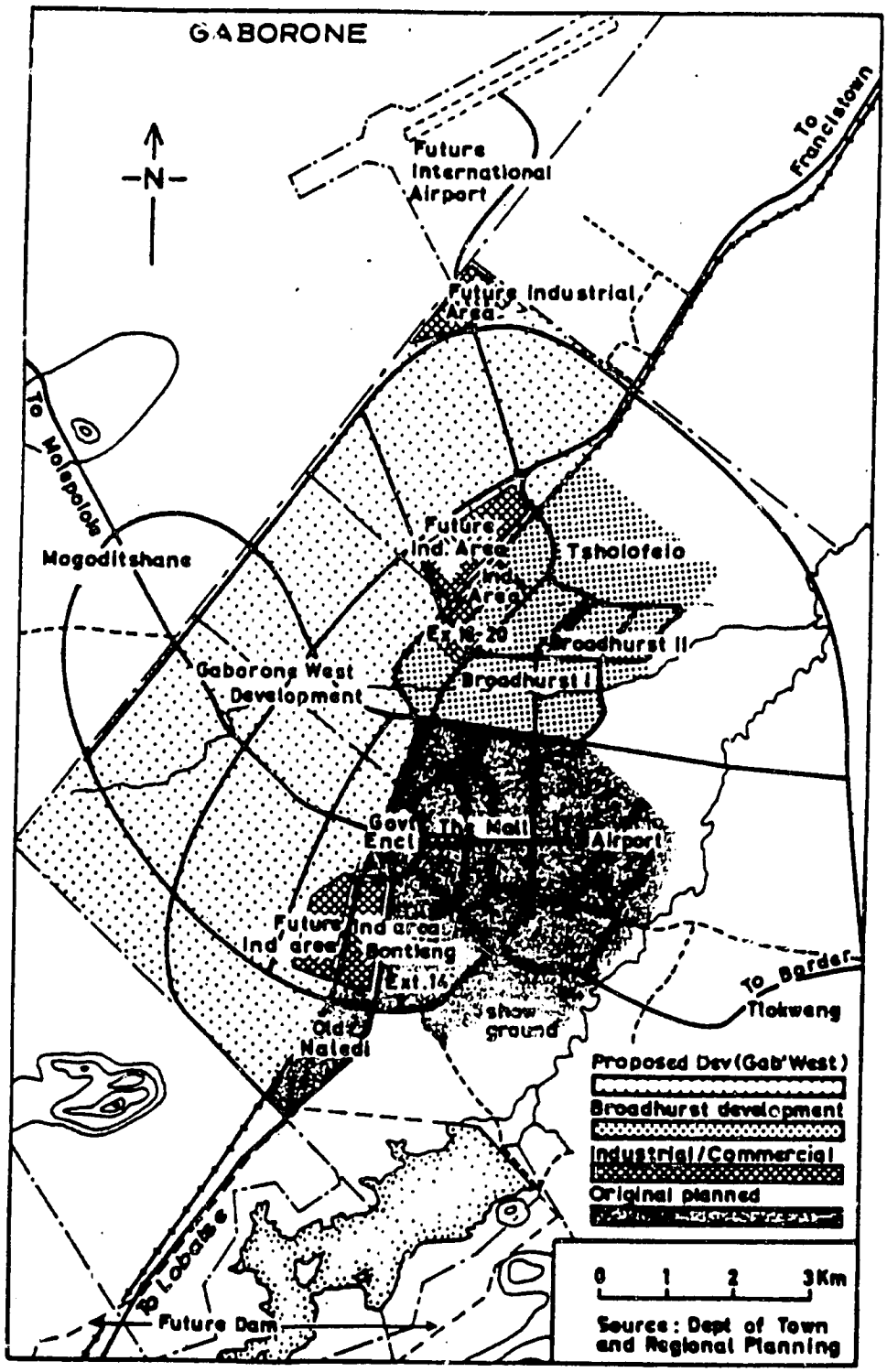
Low-Income Areas

Construction began in 1964. A temporary labor camp was established in plots within the proposed future industrial zone. The expansion of building activity and of employment opportunities made the labor camp the basis for future settlements. By 1971 a quarter of Gaborone's population lived in the area called Naledi. (See Map 2.)

Map 1


REPUBLIC OF BOTSWANA
AFRICA
BOTSWANA
Road
Railway
District Boundary
National Park
River
0
100
200 Kilometres
ANGOLA
ZAMBIA
CAPRIVI STRIP
Kasane
Shakawe
CHOBE
ZIMBABWE
Gumare
Okavango Delta
NGAMILAND
Maun
Nata
NAMIBIA
Makgadikgadi Pans
NE
Francistown
Orapa
Ghanzi
GHANZI
CENTRAL
Selebi-Pikwe
Serowe
Palapye
Mahalapye
KWENENG
Tshane
KGATLENG
Molepolole
Mochudi
KGALAGADI
Jwaneng
GABORONE
SOUTHERN
Kanye
SE
Lobatse
Tshabong
REPUBLIC OF SOUTH AFRICA
© GOVERNMENT OF BOTSWANA
Drawn by the Department of Surveys and Lands, Gaborone

Map 2. Gaborone



The government's response was initially to remove the population from the industrial zone by creating low-income settlements. In 1972, a new residential area called Extension 14 was laid out with basic infrastructural services for the building of site and service and traditional houses. In 1973, the BHC built a new low-cost housing area called New Naledi specifically for the resettlement of the squatters. The long-term strategy is to accommodate future expansion by extending the city northwards into Broadhurst with mixed low-, middle-, and high-income housing. The policy of creating serviced plots for anticipated expansion, rather than of reacting to growth, has been maintained with the current development of Gaborone West, which will essentially double the size of the town.

In 1975, the government changed its policy, revoking Old Naledi's industrial designation and recognizing it as a residential area. Plans were drawn up in 1976 for the upgrading of the area. The objectives of the upgrading were to supply basic affordable infrastructure, to give security of tenure through the Certificate of Rights, to give credit for the purchase of building materials, and to improve the area in consultation with the residents. In 1978, funding was found for upgrading and for the development of two new resettlement areas for displacees. The step-by-step process of upgrading has become a classic case of participatory planning. The existing pattern of streets and plots was taken as the basis for development; residents were consulted on road and boundary realignments and the location of new services; compensation was paid to those whose plots were affected and displacees were offered a choice of plots in Broadhurst or in the Old Naledi resettlement area.

Old Naledi is an example of a squatter area being successfully upgraded. The eventual acceptance of Old Naledi's right to exist, after initial attempts to shift the population, brought forth a new approach to all squatter areas.

Bontleng represents the first experiment to provide lower-income housing through self-help. During 1966, 380 surveyed plots were allocated; however, there was little control over the selection of beneficiaries or the building process. The result is an area containing a wide range of income groups and housing quality. Moreover, the area attracted non-owners (tenants), living often in rooms added on to the back of the main house. The proximity of Bontleng to the center of the town made it particularly attractive.

Started in 1972, Extension 14 was developed to cope with the rapid expansion of the low income population, especially in Naledi. Initially about 300 plots were designated as a "traditional" area with permission given for the use of mud-bricks and thatch. In fact, residents of Extension 14, as of Bontleng, have chosen mainly to use concrete blocks and metal roofs. Roads in the area are relatively low standard, narrow, and often without drainage ditches. Unlike neighboring Bontleng, Extension 14 was provided with aqua-privy latrine sub-structures as part of the project.

Developed between 1971-78, Broadhurst and Tsholofelo represent the first of major site-and-service schemes on the scale demanded by the town's population growth. It constituted practically a doubling of the physical size of the town extending northwards. Mixed within the SHHA site-and-service areas are houses built privately and by the BHC. The project has been undertaken in three phases adding up to 3,500 plots -- Broadhurst I and II and Tsholofelo.

In Broadhurst II aqua-privy latrine substructures were provided on each plot; in Tsholofelo, the REC II substructure was used.

The Sewerage System

The original sewer system was installed as part of the Gaborone Capital Project in 1965-66 to drain sewage to a series of waste stabilization ponds lying to the south of the Tlokweng Road, adjacent to the Notwane River. These are referred to as the Southern Sewage Disposal Works.

Expansion of the town necessitated the construction of additional sewage treatment facilities. These were built to the north of the airport in 1970 and are referred to as the Northern Sewage Disposal Works. With the more recent development of the Broadhurst areas to the north of the town, a third set of stabilization ponds was constructed in 1976 to treat the sewage flows from Broadhurst Stage I and Stage II. These ponds were extended in 1981 to provide added capacity.

Practically the whole of the town is sewered by a system of gravity sewers, although waterborne sewerage is not provided to the site-and-service (self-help) housing areas.

According to the Gaborone West Engineering Study Report (1979) the original reticulation system was badly constructed. Many sewer lengths were laid with little or no gradient, thus allowing deposits of silt and gravel to settle out in the pipe inverts. This reduces the capacity of the sewers and eventually leads to blockages. The town council is trying to improve this situation by carrying out preventive maintenance. Also in 1978, the main outfall sewer lines were investigated for spare capacity. It was concluded then that there is no spare capacity in these main sewers and that if any major new development were to drain to either the Northern or Southern Disposal Works, it would be necessary to provide new trunk sewer capacity.

Limited inspection of the Broadhurst sewers indicated that they were properly designed and constructed. The trunk sewer serving Broadhurst I and II was not at capacity. With Tsholofelo (Broadhurst II) completed, there is still a nominal amount of spare capacity in the Broadhurst trunk sewer.

According to the 1983 Gaborone Sewerage Study Master Plan, the Southern Sewage Disposal Works are overloaded and produce poor quality effluent. The quality of the effluent from these works has given rise to considerable concern for many years as it is discharged directly into the Notwane River. Sewage effluent constitutes the total flow in the river practically all the time. It is diluted only after periods of heavy and prolonged rainfall. The bacteriological quality of the effluent is extremely poor and reflects the low retention times that are provided in the tertiary ponds. The ponds are grossly overloaded and urgently require modifications to increase their capacity and to improve the effluent quality. These sewage works have been a continuing source of odor nuisance to adjacent residential areas. In 1983 the flow to the Southern Disposal Works was estimated at 2,500 m^3/day.

There has been a continuous gradual deterioration in the physical condition of the Northern Sewage Disposal Works, according to the Gaborone Sewerage Study

Preliminary Report of 1983. At present, improvements to the disposal works are underway and should resolve most of the problems.

The Northern Works are slightly loaded beyond their theoretical capacity, but effluent results are poorer than would be expected. This is caused by a reduction in capacity of the primary pond due to the accumulated sludge and flow short circuiting. Odors from these ponds cause complaints from residents of the Jinja housing area at certain times of the year. Improvements for these works were suggested in the 1982 Report on Upgrading of Gaborone Sewerage and Sewage Treatment Works to increase the capacity of the ponds and improve the quality of the effluent. The effluent is currently utilized for lawn and golf course irrigation. It rarely reaches the river, as it is lost by evapotranspiration or by direct percolation and evaporation. The estimated 1983 average flow to this plant is about 1,900 m^3/day.

The Broadhurst Sewage Works are of recent construction. The original ponds were built in 1976 and the extensions in 1981. They were well constructed and are currently being expanded. The existing pond layout includes two separate pond systems each designed to treat 3,000 m^3/day of raw sewage with a BOD5 strength of 270 mg/l. The effluent from Phase I of the Broadhurst Works is discharged onto the Notwane flood plain in the same manner as that of the Northern Sewage Treatment Works. The effluent from Phase II of the Broadhurst Works discharges directly into the river. The estimated 1983 average flow to the Broadhurst Sewage Works is about 3,000 m^3/day.

The Water Supply System

The Gaborone raw water system has a capacity of 35,760 m^3/day at full supply level in the dam (water level 990 m) and a capacity of 24,700 m^3/day at minimum water level in the dam (water level at 984 m). The water treatment works have the following capacities:

- average capacity: 28,500 m^3/day;
- peak capacity: 34,125 m^3/day.

There are two elevated treated water tanks in Gaborone with a total capacity of 1,790 m^3.

Estimated water demand for the Gaborone systems (excluding Lobatse) in 1983/84 was 21,165 m^3/day (annual average).

Approximately 45% of Gaborone's existing housing is self-help plots which rely on water standpipe servicing. In Gaborone West the figure may be as high as 65%. If self-help areas are upgraded and get individual water connections, water demand will inevitably rise.

The 1984 VIAK study of water resources in Eastern Botswana assumed household consumption of a maximum of 300 l/pd in the future (including 120 l/pd for garden watering). Within standpipe areas, consumption of 50 l/pd has been assumed for Gaborone households. Future water demand projections are shown in Table A-1-1.

Table A-1-1

GABORONE:
WATER-DEMAND PROJECTIONS

Year	Population	Water demand (m^3/day) High	Low
1985	87,342	24,000	22,000
1990	122,501	35,000	29,000
1995	156,345	47,000	37,000
2000	199,541	60,000	45,000
2005	242,772	77,000	54,000
2010	295,369	100,000	63,000

Two sources have been developed to supply water to Gaborone, the Gaborone Dam and Ramotswa Wellfield. Other sources which have been identified are the Kolobeng Dam, the Metsemotlhaba Dam, the Leflhakeng Wellfield, and the Mmamabula Wellfield. In the future, resources from further north may have to be exploited to provide for the continued growth of Gaborone.

According to the 1979 Gaborone West Water Supply Project Report, the planned development program was to include the following:

- Raise Gaborone Dam by 8 m to full supply level of 998 m. (This is now complete.)
- Construct Kolobeng Dam with a full supply level of 1,074 m.
- Construct Metsemotlhaba Dam with a full level of 1,066 m.
- Develop the Ramotswa Wellfield. (This is now complete.)

The water crisis which Gaborone has been facing since 1982/83 speeded up the development of the Ramotswa Wellfield. Currently, because of the effects of the drought, the Ramotswa Wellfield is supplying over half of Gaborone's water. A re-evaluation of other priorities may be made as a result of the VIAK Study Report.

The 8 m raising of the Gaborone Dam to a full supply level of 998 m will increase the safe yield at a one in twenty years risk of failure to 31,500 m^3/day, which will decline over 50 years to 28,600 m^3/day. However, the reservoir has to fill up before increased yields may be fully realized.

The current drought and water crisis shows the importance of finding alternative reliable water sources for Gaborone if continued development in the town is to be possible. Studies are currently being conducted on alternative water sources for Gaborone, and further underground water sources may be developed either before or in conjunction with the building of the Kolobeng and Metsemotlhaba Dams.

Geology and Soils

The town lies on the ancient rocks of the Gaborone granite complex. The major part of the town is on the Central Assemblage. These granites are found as coarse to fine grained rocks and, in an unweathered state, are hard and durable. The granite is found as rock outcrops at all locations in and around the town and elsewhere at depths up to two meters.

Overlying this shallow bedrock are soils formed by the decomposition of the granite. For the most part these are fine sandy alluvial topsoils. Below the top soils and elsewhere may be found decomposed granite and some extensive outcrops of hard lateritic gravel. Small pockets of calcrete are also found, and in the valley of the Notwane River there are black expansive clays.

For the Gaborone West area, where future town development will occur, a soils survey consisting of 149 pits on a 500 meter grid was carried out. The holes were dug to a maximum depth of three meters or down to "refusal," which was either hard bedrock or the ferricrete layer. The ferricrete in certain pits was further excavated by hand, so as to expose the underlying material for testing. The pits were logged, and samples were taken and tested from each pedological layer, including the ferricrete and weathered granite, where encountered.

In general the soils map shows that the poor clayey soils are found in the stream valleys. The good granular soils are separated from the clays by a "butter" zone of the medium category material. It is expected that any pits excavated would have to be lined to prevent collapse, and soakaway systems would flood during the rainy season. Therefore, for this area, septic tanks with soakaway disposal systems would be likely to fail. For site-and-service housing, low cost sanitation would need to be based on non-waterborne systems such as the REC II.

Lobatse

General Description

The town is located on the flat bottomed valleys of the Peleng River and its tributaries. Generally, the elevation of the town is at 1,200 m with the hills rising to 1,400 m. The Peleng valley stretches from northeast to southwest narrowing down to 500 m as it approaches the town center. It is then interrupted by several small hills before widening to a broad valley of about 2 km at the border with South Africa. The Peleng River forms the major part of the town's drainage system.

The average rainfall is 556 mm per year with the rainy season extending from November to March. Fifty percent of the year's total rainfall occurs from December to February. Some occasional showers occur during the months of September and October. Because of its altitude, Lobatse experiences marginally lower temperatures than Gaborone. The prevailing all-year-round winds are from the northeast. Winds from the south are mainly due to the passage of thunderstorms.

Natural vegetation is characterized by bushveld with scattered thorn and acacia trees, scrub, and grass. Outside the town itself, the land has been extensively grazed.

In 1981 Lobatse had a population of 19,033. Between the years 1971 and 1981 it grew at the rate of 4.8% per annum. Thus, Lobatse shows the slowest growth rate of all primary and secondary centers in the region, but its growth rate is still higher than the average growth rate, which is estimated to be 3.3%.

The relatively slow rate of growth is possibly the result of a mature population profile, lack of rapidly growing employment opportunities, and the presence of other centers which act as a focus for migration (principally Gaborone). (See Map 3.)

Low-Income Areas

Peleng was the first settlement within the township of Lobatse. Initially owned by the British South Africa Company and then administered by the district administration, it was eventually handed over to the Lobatse Town Council in 1974. Peleng has a large area of lower- and middle-income housing.

There are currently 956 SHHA plots in Peleng. Close to three quarters of them are estimated to have pit latrines which have been dug by the plot holders, except for a few toilets connected to septic tanks. Following the installation of standpipes by the Water Utilities Corporation in the late 1970s access to water is as good as in site-and-service areas.

Woodhall I is one of the earlier site-and-service schemes in Botswana following Extension 14 in Gaborone and Area W in Francistown. Certificates of Rights for the first phase were issued in 1975. The Woodhall I scheme includes 589 plots. Unlike later site and service schemes, Woodhall I did not provide plotholders with a latrine substructure, and progress towards the full development of the area has been slow.

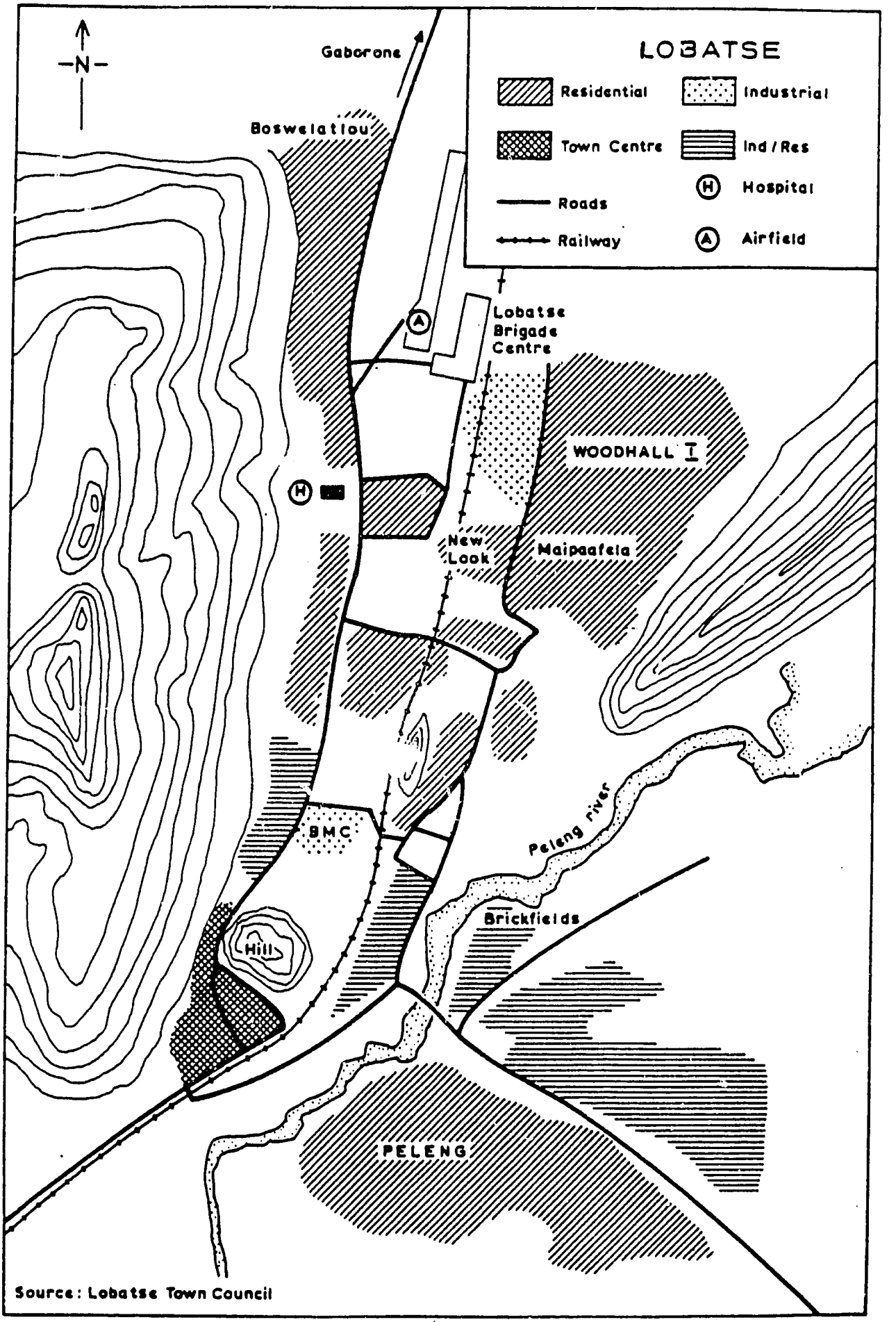
The Maipaafela site-and-service project benefited from its proximity to the adjacent Woodhall I scheme. In the process of implementation some plots at the center of the project area were not properly pegged and new squatters took the opportunity of settling in the area. Plot plans, based on aerial photographs, were finally sent to the Department of Surveys and Lands for gazetting in July 1983. Until then residents remained with Temporary Occupancy Permits.

There are 215 plots in the area, about two thirds to three quarters of which are considered by the SHHA to be developed to the point of having at least a toilet and one habitable room. Latrine substructures in Maipaafela, like Woodhall, were not provided by the SHHA and had to be dug by residents.

The Sewerage System

In 1979 the Lobatse Sewerage Study recommended reticulation of certain areas as a first stage, and the construction of stabilization ponds at a point 1.7 km upstream of the Lobatse Estate Office. Treated effluent from the ponds was to be used for irrigation. Work started in 1982, and the first stage of the

Map 3. Lobatse



system is complete. Additional funds were required to provide domestic connections, the irrigation scheme, and the reticulation of the heavy industrial area in the south.

The study proposed a strategy for the future based on limited expansions to the southeast in the mid-1980s to cater for needs in the late 1980s and early 1990s.

Current sewerage projects in progress include the town center, the areas around the BMC plant and village, Maokaneng, and other areas west of the railway. In addition, provision has already been made for the laying of a trunk sewer along the western edge of Peleng Village and through Woodhall I and part of Woodhall II. Although it is unlikely that waterborne sanitation will be introduced in most of Peleng, under the current upgrading proposals the other areas of the town indicated on the map may be reticulated through later projects after 1986.

The Water Supply System

The town relied on ground water as its source of supply until 1964 when Nuane (Nnywane) Dam was constructed 13 kilometers north of the town. The town today is supplied from three main sources:

- Groundwater: Estimated at about 900 m^3/day available from the boreholes; however, recent aquifer failures have cast doubt on the reliability of this service. Groundwater resources are currently being studied and reappraised.

- Surface Water: The Nnywane Dam was the main source for more than a decade. The firm yield has been assessed at 2,250 m^3/day with a risk of failure of once in twenty years. The relatively small catchment area and patchy nature of precipitation makes this source also somewhat unreliable.

- Distance Surface Source: After a drought in 1969 a pipeline was constructed connecting the Lobatse system to the Gaborone Dam. The present capacity of the pipeline of 3,500 m^3/day can be increased to 6,000 m^3/day only by the introduction of further booster pumps. The current demand on Gaborone Dam, combined with the recent drought, has resulted in the introduction of water-use restrictions.

The 1984 VIAK Water Resources Study projected water demands from 1985-2010 as shown in Table A-1-2.

Table A-1-2

LOBATSE:
WATER-DEMAND PROJECTIONS

Year	Population	Water demand (m^3/day)	
		High	Low
1985	23,135	3,900	3,700
1990	29,526	5,100	4,600
1995	34,620	6,800	5,700
2000	40,283	9,200	6,700
2005	46,530	11,900	7,700
2010	53,372	16,000	8,800

Soil Conditions

Although a complete investigation of soil conditions throughout the Lobatse planning area has not been carried out, some information is available in recent geotechnical reports on the Woodhall II development area and on the sites associated with the Peleng upgrading scheme.*

The following characteristics were identified in the Woodhall II areas:

- Bedrock is relatively close to the surface in the extreme east but is still overlain by about one meter of sandy soil.

- The thickness of the soil and underlying highly weathered bedrock (gravel) increases towards the north-northeast of the area.

- Soil thickness is greatest on the lower slopes of the eastern quartizite hills where it may also be associated with buried scree deposits.

- A north-south trending low-angle reverse fault traverses the central part of the area. It is reflected by an abrupt change in the soils to the east and west. The Woodhall Phase I investigation recognized the same soil change but failed to relate it to the fault. The soils are essentially residual, and the differences in soils on each side of the fault is a reflection of different underlying bedrock separated by the fault.

- As soil depth generally exceeds two meters within the study area, there should be no problem in digging latrines. Fresh bedrock lies at between four and ten meters in depth throughout the area.

*Woodhall Phase II Township Preliminary Geotechnical Evaluation of Soils and Substrata Conditions 1980 by Brian Colquhoun, Hugh O'Donnell & Partners for the Ministry of Local Government and Lands and Lobatse Physical Development Peleng Upgrading Subsoil Site Investigation Technical Report 1984 by Scott Wilson Kirkpatrick & Partners for the Ministry of Local Government and Lands.

- The very low clay content of the soils indicates that they have high porosities and are thus ideal for siting latrines.

Francistown

Historical Background

Francistown was formally established in 1897, thirty years after the discovery by Europeans of the Tati gold mines started the first gold rush in southern Africa. Throughout the protectorate the town was effectively administered by the Tati Company, which acquired the mining rights at the end of the nineteenth century. The company also controlled land settlement in the surrounding Tati District.

During the 1950s squatters began to occupy company land along the banks of the Tati and Ntshe Rivers. In 1957 the company created Tatitown to control the squatters and to move from the east bank. Settlements subsequently started near the gold mines at Somerset and Monarch and along the west bank of the Tati River in Tatitown and Riverside. These remain the areas where the population is concentrated. In 1982, with the development of Somerset East Extension and Donga, site and service areas began to be implemented. The Tati Company remains an important influence on the town's future development through its continued ownership of large tracts of urban as well as rural land.

Low-Income Areas

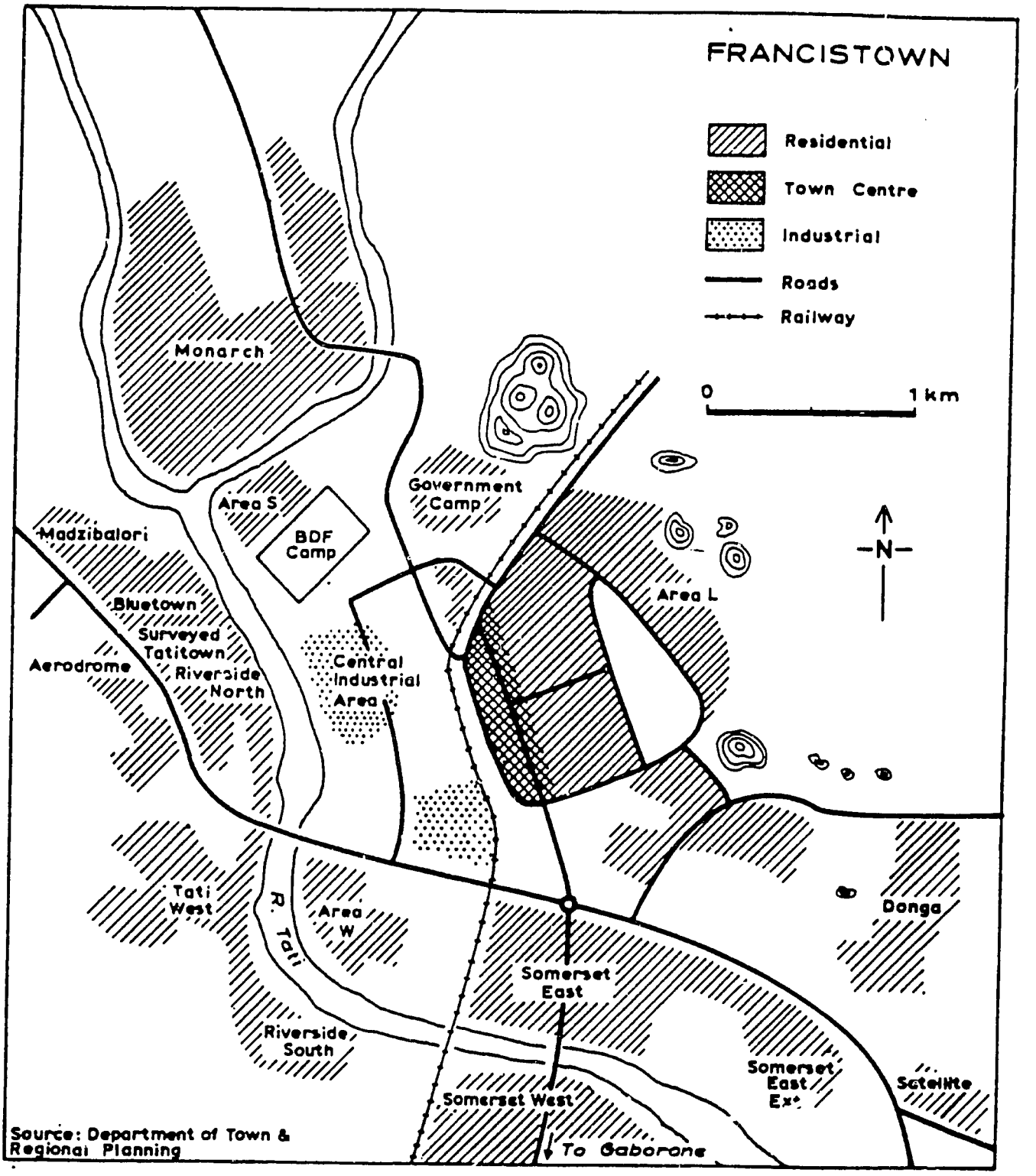
The long history of Francistown and the concentration of the population in a semi-legal but unserviced peripheral settlement has left Francistown with a severe upgrading problem. The World Bank estimated the "squatter" population at 60% of the town total in 1975. (See Map 4.)

Areas L, W, S, and Aerodrome are all highly developed site-and-service areas with a relatively high standard of both building and service provision, although Area W and Aerodrome are only now being provided with REC II toilet substructures.

Monarch was part of a 1978 project which provided basic infrastructural services and a primary school to the area and allocated further plots for "traditional" housing without building material loans. Most houses are built with mud-brick walls and thatch roofs. A second urban project in 1979 upgraded the area with improved roads, a new primary school, a health clinic and a shopping area, and extended building-materials loans to plotholders. Certificates of Rights were introduced progressively throughout the area between 1978 and 1983. REC II substructures began to be installed by the SHHA throughout the area in 1983.

Tatitown covers surveyed Tatitown, Tati West, Madzibalori, Bluetown, and Riverside North and South. Together these account for about 1,350 plots reduced from approximately 2,000 before upgrading began. Certificates of Rights for the area were issued in 1983. Until recently there has been no security of tenure and no access to building-materials loans. Apart from surveyed Tatitown (the Tati Company's original laid-out squatter location),

Map 4. Francistown



there has been only a little durable building in the area. As in Monarch, latrine substructures (REC II) started to be installed on all plots in 1983.

Somerset East and West areas are located on either side of the River Tati but share a health clinic and primary school which are both located in Somerset East. The area was upgraded as part of an urban project, prior to which there were few public services in the area -- only two standpipes in Somerset East and none in the West. Plot rationalization and security of tenure were put in effec in the early 1980s. The majority of houses are of mud and thatch. Like the other "periurban" areas of Francistown, both parts of Somerset suffer a poor refuse collection service, and latrine substructures are only now being provided. Together Somerset East and West upgrading areas exceed 600 plots. Somerset West is now being occupied by further squatter settlements which depend on the upgraded area for their access to water.

The Sewerage System

At present sewerage reticulation in Francistown is found in the Central Business district, the Central Residential Area, the prison, the Botswana Defense Forces (BDF) Camp, the Central Industrial Area, Mater Spei College, part of Government Camp, the Teachers Training College, and other areas.

Francistown is served by one trunk main and two subsidiary sewers, two pumping stations, and a set of oxidation ponds located south of the Tati River between the new Gaborone road and the rail line.

The Francistown Feasibility Study (1983) indicated that the existing stabilization ponds were overloaded and a health risk. These ponds are located unsatisfactorily with regard to the town's future development. Two alternative sites for new sewage ponds have been suggested. The new sewage ponds have been designed to deal with future contributory sewage flows.

The study's recommendations which are currently being implemented include the following works:

- waste stabilization ponds,
- a pumping station in the south-east corner of development and the gravity trunk sewer to the railway line, and
- tertiary sewage reticulation.

The Water Supply System

Francistown is provided with a potable water supply from two main sources:

- the Shashe Dam, approximately 25 km south of Francistown and
- a number of boreholes at Masimenyenga, in the satellite area, and on the eastern bank of the Tati River.

The combined supply potential is estimated to be 12,000 m^3/day from Shashe Dam plus approximately 3,500 m^3/day drawn from the boreholes, making a total of about 15,500 m^3/day. The present (1983) water demand in Francistown is 4,500

m^3/day. Water supply is adequate in town. At present only 29% of the apparent ultimate capacity of 15,500 m^3/day is used by Francistown. Water demand projections from the 1984 VIAK report are shown in Table A-1-3.

Table A-1-3

FRANCISTOWN:
WATER-DEMAND PROJECTIONS

Year	Population	Water demand (m^3/day) High	Low
1985	37,759	5,600	4,200
1990	48,192	9,000	6,000
1995	60,655	13,000	8,000
2000	74,708	18,000	11,000
2005	90,225	24,000	17,000
2010	107,040	32,000	17,000

The site-and-service and upgraded areas are served mainly by communal water standpipes. Generally there are private connections to low-, medium-, and high-cost housing plots. The site-and-service and upgraded areas are designed in such a way that in future the communal water standpipe system could be replaced in part with individual plot connections.

Geology and Soils

The bedrock of the area consists of rocks of the Basement complex, being predominantly granites with some intrusives and metamorphics. Much of the bedrock is fractured and, near the surface, weathered in varying degrees. There are rock outcrops in the river beds. The Penhalonga Mixed Formation consists of a variety of schists with some minor metasediments. The formation is cut by numerous wide basic dykes and quartz reefs which have been dislocated and fractured by geological movements.

No detailed geological survey has been made covering the whole planning area (township area) and its immediate environs. However, three reports were produced between 1973 and 1983 -- all for the purpose of specific development projects.* The first report relates to the Urban I project covering the Aerodrome, Madzibalori, Tati West, Surveyed Tatitown, and Bluetown areas, and Areas L, S and W. The survey, however, covered a larger area from beyond

*Geotechnical Report on the Francistown Area by Brian Colquhoun, Hugh O'Donnell & Partners, May 1977; Final Engineering Report, Volume 2, Francistown Growth Study, September 1977, by John Burrow and Partners, Consulting Engineers, Lincoln and Gaborone; and Geotechnical Report for Areas 1, 2 and 3 of Francistown Phase IV Development, 1982 by Geotechnical Services (Botswana) (Pty.) Ltd. DTRP Plan 4.40.114 'Francistown Phase 4, Area South of Tati River, Preliminary Block Layout' (this plan is available, by request at scale 1:100000 from DTRP, Francistown).

Monarch in the northeast to a line running northwest-southwest crossing the southwest boundary of the Golf Course, including 60% of Somerset East Extension. The second report relates to the Urban II project, covering Dumela Industrial Estate, South Monarch, Central, Golf Course, Donga, Satellite Central Industrial Area Extension, Central Business District Extension, Somerset East and Somerset East Extension, Bluetown, Surveyed Tatitown, Tati West, Somerset West, and an area south of the Tati River (roughly to an east-west line along the north edge of the sewage ponds). The third report concentrated on Areas 1, 3, and 4 of the proposed Francistown Phase IV Development Project. These areas are situated south of the Tati River roughly on an east-west line along the north edge of the sewage ponds).

A geotechnical study of the Francistown Phase IV area was carried out in mid-1982 and has been supplemented by 28 trial pits excavated in the area south of the sewage ponds and to the west of Gaborone Road.

Apart from areas of black clays which are located adjacent to watercourses, soil profiles are typified by a thin layer of aeolin sands and silts with colluvial quartz gravel overlying weathered bedrock. The mean depth to bedrock is approximately 0.6 m, the upper horizons of which are extensively weathered. In general the rock is shattered to such an extent that only 30% of the trial pits indicated "unpickable" conditions. Where these conditions were encountered the mean depth of the rock was approximately 0.9 m.

The shallow bedrock throughout the Phase IV area will present some difficulties in the excavation of pit latrines. The weathering of the bedrock is extremely variable, and it is difficult to identify areas which may present particular problems. Although the soakage rates were generally fair to good, it is considered that such rates may decrease with time because of the clogging of fissures. Furthermore, because of the close proximity of the underlying bedrock, it is possible that localized perched water tables may arise during periods of heavy rainfall.

Trial pits which were excavated in the area southwest of the aerodrome show significant depths of black clay which the test results prove to be moderately expansive. These soils would exhibit low allowable bearing pressures which would not be suitable as satisfactory foundations for low-cost buildings, and soakage conditions would be very poor.

The trial pits which were excavated in the Somerset East area show that it is underlain by alluvial deposits which are predominantly sandy in nature. Conditions for upgrading of the area are considered to be good with respect to both foundations and soakage for sanitation units, outside the limits of the stream.

The area known as Satellite has been fully covered by investigations which were carried out under the 1977 Francistown Growth Study. Soil cover is generally thin and depths to bedrock of 1.5 meters or less are common. Conditions for house foundations appear good, but problems are likely to be encountered in the excavation of pit latrines. Excavation to the required depth may not be possible in all cases with the use of pneumatic tools. The soakage tests which were carried out in this area show fair percolation rates which reflect the shattered nature of the bedrock.

The area south of the Tati River was studied by the previous investigations of 1977 and 1982. Soil conditions within the area are generally good with the exception of an area of approximately 2 hectares in the northwest which is coincident with the upper reaches of a watercourse. The soils are considered to be suitable with respect to house foundations, although soakage test results have been found to be variable, ranging from marginal to good.

Selebi-Phikwe

Historical Background

Selebi-Phikwe was established to service the copper-nickel mine which was opened in the late 1960s. The first plan for the town was prepared in 1968. It projected an eventual population of 13,000 but by 1976 it had already reached 21,000 with annual growth rates close to 14%. Since 1976 the annual rate of growth has slowed down to about 7%, bringing the town's population in 1981 to over 29,000. (See Map 5.)

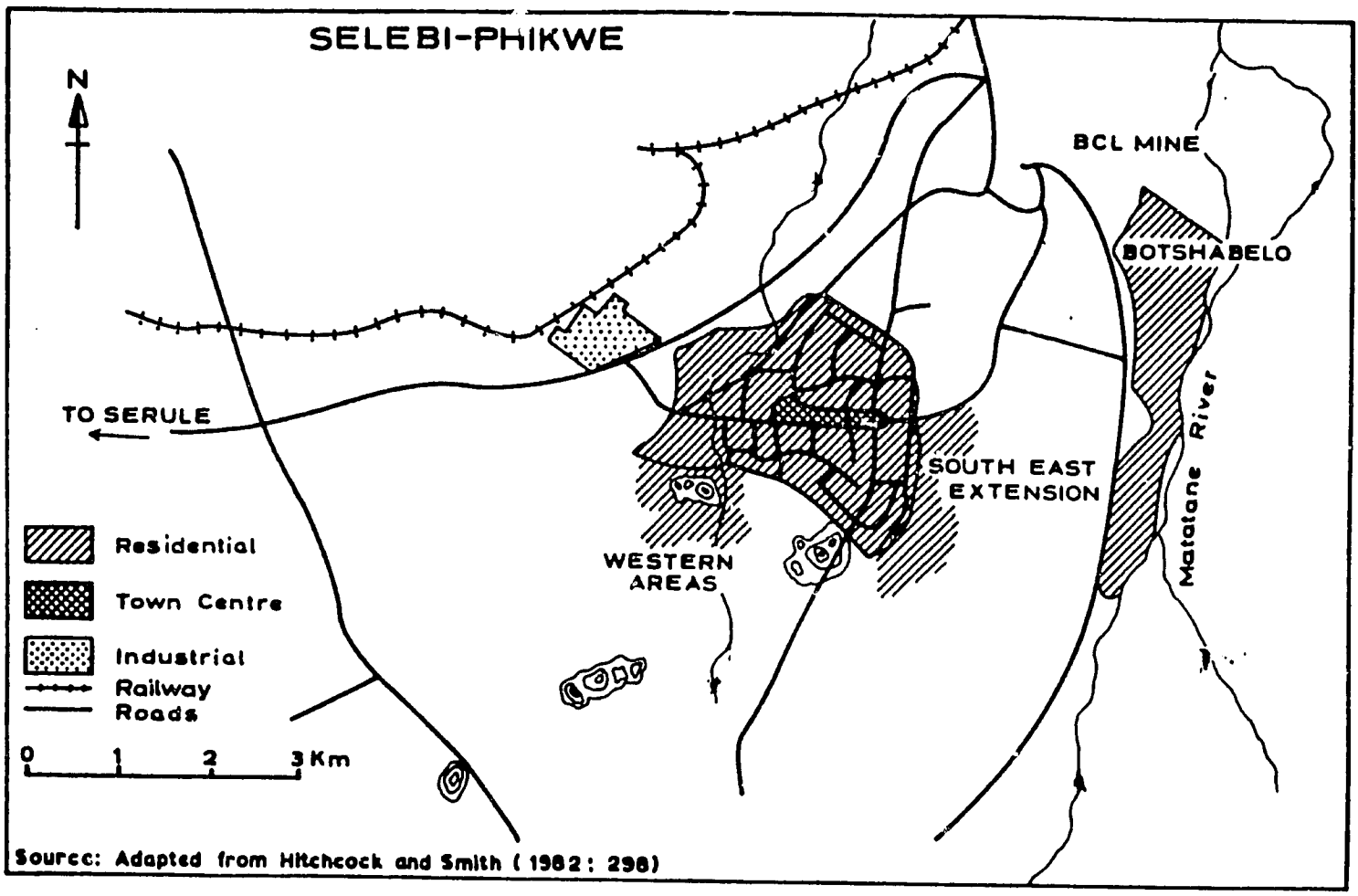
Low-Income Areas

The largest part of the town's early growth was focused on the unplanned settlement of Botshabelo. The first plots occupied in 1969 were in an area then classified as tribal land. The 1981 MLGL Botshabelo Baseline Study showed that more than half the residents of the area had been allocated their plots by traditional authority. They were attracted by the availability of free land with security of tenure within the traditional system, and by the proximity of the area to the mine shaft. The settlement was legally incorporated into the town in 1975 and was then provided with a few standpipes, a primary school, and debushed roads. By that time it accounted for about half of the town's population. Beginning in 1979 Botshabelo was provided with improved roads, more standpipes, REC II latrine substructures, streetlights, and a health clinic.

The Western Extension Areas contained three grades of provision -- "traditional areas" where low income groups could build using traditional methods but without building-materials loans; a site-and-service area for higher income groups who had access to loans and were expected to build using modern materials; and an adjacent area of units built by the Botswana Housing Corporation. A second urban project increased the number of serviced areas and provided REC II toilet substructures and access to building-materials loans to all plotholders. The number of occupied plots in Western Areas now exceeds 1,200.

The Southeast Extension is a new site-and-service area between the center of town and Botshabelo. In 1983 about 547 plots were allocated and 95 were occupied. In this project residents are expected to build their toilet superstructure and at least one officially approved room before occupying the plot.

Map 5. Selebi-Phikwe



The Sewerage System

The existing sewerage system was designed in 1968 for a town expected to grow to 20,000. The reticulation system allowed for gravity feed to a collection point to the north of the town. From there a 450 mm outfall pipe conveyed the sewage to a treatment works 4.5 km away. The treatment works consist of three parallel sets of oxidation ponds each comprising primary, secondary, and three tertiary ponds in series.

The 1979 Growth Study indicated that the central system would be overloaded only if the central area were to be fully developed and demand for sewage disposal occurred in the east. The general conclusion reached in the Growth Study was that the outfall main was the main constraint on the ability of the existing system to absorb increased flows.

A re-assessment of the capacity of the system made in 1980 concluded that the present outfall sewer was still adequate.

More recently, the 1983 Continuation Study estimated that the sewage treatment works capacity of 2,700 m^3/day has minimal spare capacity. The study indicated this may be insufficient to attract new water-consuming industries to the town and recommends an extension to the works and improvements to the treatment process.

The Water Supply System

Water is supplied to Selebi-Phikwe from Shashe Dam, 90 km northwest of the town. The water is delivered to bulk service reservoirs from which BCL (Bamangwato Concessions Limited), the Power Station, and treatment works draw their requirements. The existing capacity of the treatment works is 13,900 m^3/day, an increase of 4,800 m^3/day over the figure given in the Growth Study. This has been achieved by improved chemical treatment. BCL (nickel/copper operations) currently uses 19,000 m^3/day of untreated water.

The present average consumption of potable water is 9,200 m^3/day and the margin between this and the maximum existing capacity of the treatment works is 4,000 m^3/day. This margin reduces to 500 m^3/day during peak periods. On the basis of current trends (about 4% growth per annum) consumption is estimated to reach the 13,900 m^3/day capacity figure by 1992.

An extension to the treatment works is now being planned and the 1983 Continuation Study has recommended that the provision of this (and improvements to storage capacity) be accelerated. The new treatment works will have a capacity of 20,000 m^3/day and will be able to cope with a peak week consumption 35% above average.

The distribution system was substantially expanded under the Urban II project. It is considered that the existing distribution network with minor extensions, will be able to meet the needs of the town over the national development plan period (1985 to 1991).

Water demand projections from the 1984 VIAK report for Selebi-Phikwe are shown in Table A-1-4.

Table A-1-4

SELEBI-PHIKWE:
WATER-DEMAND PROJECTIONS

Year	Population	Water demand (m^3/day) High	Low
1985	33,553	12,200	11,600
1990	39,467	14,000	13,000
1995	46,204	15,500	13,500
2000	53,681	17,400	14,200
2005	61,918	20,000	15,000
2010	70,928	23,400	15,700

Soil Conditions

A soils investigation undertaken as part of the Growth Study indicated that topsoil coverage is scant. Rarely was a depth recorded in excess of 1.75 m and the average varies between 1.0 and 1.5 m. Subterranean rocks preclude development contiguous to the base of the kopjes. Bearing conditions are suitable for founding single story structures.

Percolation (soakage) tests carried out in 1977 were discouraging. On the average, permeability was poor and in some locations nonexistent. Because of the scant topsoil cover and the underlying impervious bedrock, soakaways or drainfields have to be used on a very limited and selective basis. It appears that totally dry disposal systems or waterborne sewerage would be feasible solutions to sanitation needs.

APPENDIX 2

Procedures for Calculating an Economic Service Levy

(Source: Manual of Administrative and Operational Procedures for Self-Help Housing Areas)

Procedures for Calculating an Economic Service Levy

1. The Service Levy must be recalculated once every year after preparation of the estimates for the new Fiscal Year (FY).

2. Refer to MLGL's Levy Manual for detailed assistance. However, adhere to the following procedures, which were created to guarantee that all Councils use the same assumptions and formulae.

3. SHHA Costs:

   i) Overhead and staff costs to be taken from new FY estimates. (Overhead includes only those items not recovered elsewhere in the Service Levy or in the BML programme.) (Do not include revenue from the Development Grant.)

   ii) Calculate the administrative costs of Council attributable to SHHA as follows: Town Clerk and Town Treasurer votes for the new FY less any item that generates its own revenue (e.g, agricultural show, pound fees, licenses, etc.) or that is totally unrelated to SHHA (e.g., loan repayments, maintenance of grounds and buildings, etc.). For example, only 30% of the following votes were deemed attributable to SHHA because the remaining 70% related to Council as a whole: Staff travelling, gratuities, medical treatment, transfer allowance, printing stationery and advert, post and telephone charges, library books and periodicals, insurance (excl. vehicles), end of tour passages. In addition, none of the following were included because they generate their own revenue or are entirely unrelated to SHHA: Market Masters salary, Commercial Affairs Officer, Assistant Rate Officer, loan charges, valuation fees, water and electricity recurrent costs. Multiply the result of the preceding by the result from the division of Council ULGS salaries into SHHA ULGS salaries. The answer equals the amount of administrative costs attributable to SHHA.

$$\text{Town Clerk and Town Treasurer's Adjusted Votes} \times \frac{\text{SHHA ULGS Salaries}}{\text{Council ULGS Salaries}} = \text{Admin Costs Attributable to SHHA}$$

   iii) The result of (ii) must be added to the result of (i).

   iv) The total costs from (iii) must be divided by the total number of plots allocated or available for allocation. The answer equals SHHA costs per annum (divide by 12 months for the monthly per plot SHHA cost).

   v) SHHA costs comprise the largest portion of the Service Levy. Strict budgetary controls, wise planning, and economic use of overhead items can help keep the Service Levy to a minimum.

4. Shortfall calculation (must be recalculated each year and not carried forward from the previous year):

i) Determine how many plots will be allocated as of the new FY.

ii) Estimate how many plots will be allocated each month during the new FY.

iii) Add the running total for each month of the FY to find the total number of collection units for the FY. A collection unit equals 1 plot for one month, so in an entire FY 1 plot would generate 12 collection units (i.e., Council would collect the Service Levy from that plot 12 times.) For example, in April 1983 the Council has 4000 plots but expects to allocate 200 plots every month for 10 months, therefore,the Council would calculate its collection units like this:

April	4 000	October	5 200
May	4 200	November	5 400
June	4 400	December	5 600
July	4 600	January	5 800
August	4 800	February	6 000
September	5 000	March	6 000

The number of allocated plots for each month are added together resulting in the FY's collection units. The collection units total for the above example equals 61,000. (Therefore, a Service Levy of P8,00 should net Council P488,000.)

iv) Multiply the total number of plots allocated or available for allocation (6,000 plots as in the above example) times 12 months. This equals the collection units of all plots for one year.

Total no. Plots x 12 months = FY Collection Units if all Plots were Allocated

v) Subtract the result in (iii) (e.g., 61,000) from the result in (iv) (e.g., 72,000). The answer equals the number of collection units subject to the shortfall factor.

Collection Units If all Plots Allocated
Actual Collection Units
No. Collection Units Subject to Shortfall

vi) Multiply the answer from (v) times the figure for SHHA Costs. Then divide this answer by the actual number of collection units in (iii). The result equals the shortfall factor.

$$\frac{\text{(No. Collection Units Subject to Shortfall X SHHA Costs)}}{\text{Actual Collection Units}} = \text{Shortfall Factor}$$

5. Refuse Collection

i) Ministry of Local Government and Lands recommends one dustbin per five plots to be picked up twice a week. Any deviation from this recommendation will result in increased costs caused by a larger dustbin to plot ratio and/or more frequent pick-ups -- this should be avoided.

ii) Calculate plant costs based on actual costs. If Council has added a new unit since the previous FY, average its costs with the old units still in service.

$$\frac{\text{Cost of old units} + \text{cost of new units}}{\text{Number of Units}} = \frac{\text{Average Cost}}{\text{7 years}} = \text{Cost for one FY}$$

iii) Request the Town Engineer to provide the running costs and the labour costs to operate one unit for the FY.

iv) Add the results of (ii) and (iii) which will equal the total costs of refuse collection.

FY Plant Cost + FY Running Cost FY Labour Cost
= Total Cost of Refuse Collection

v) Divide 264 working days into the Total Cost to find the cost per day.

vi) Determine how many dustbins are emptied in one week and divide by 5 days to find the number of dustbins collected in a day.

vii) Divide the cost per day by the number of dustbins collected in a day to find the cost per bin per day.

viii) Multiply the costs per bin per day times the number of collections per month, then divide the answer by the number of plots sharing one bin.

ix) The result equals the refuse collection component (i.e., cost per plot per month for refuse collection.)

x) Request the Town Engineer to produce a refuse collection schedule. Monitor the schedule to make sure the assumptions for dustbins picked-up in a week and the number of collections in a week are accurate.

6. Road Maintenance

i) The Levy Manual has a detailed formula for this component, however, the Town Engineers have recommended another method.

ii) The Town Engineers should produce a maintenance schedule for all "SHHA" roads.

iii) During implementation of the schedule, the Roads Foreman must keep an accurate record of all materials, labour, plant, and vehicles used on the job (i.e., total hours of use.)

iv) The Town Engineer can then multiply the actual hours of use times the hourly rate of the various plant (etc.), and add the cost of materials.

v) The answer from (iv) would equal the total cost of road maintenance.

vi) The total cost of road maintenance is divided by the FY's collection units to obtain the cost per plot per month for roads maintenance.

$$\frac{\text{Total Cost of Road Maintenance}}{\text{FY's Collection Units}} = \text{Cost per plot per month for road maintenance}$$

vii) When using the Levy Manual method, if full maintenance is not possible, each Town Engineer must estimate the percentage of roads that can be maintained. The cost of full maintenance would then be reduced accordingly.

7. Water

i) This component must be calculated from the <u>actual</u> costs of water from the public standpipes.

ii) Check with the Treasury Department (Accounts Section) to find the actual costs from the previous year (or any 12 month period).

iii) Next, divide the actual costs by the collection units for the same 12 month period used in (ii). The answer equals the cost per plot per month.

iv) If Water Utilities Corporation (WUC) plans a price increase, the cost per plot per month (from iii) must be increased by an equal percentage. For example, WUC announces an increase from P0,20 per kl to P0,25 per kl, which equals $\frac{25 - 20}{20} = .25$. Therefore, the result from (iii) must be increased by 25% to allow for the new water rate.

v) If standpipe maintenance costs are not included in the SHHA Costs component, the maintenance cost must be included in this component (include the maintenance costs in only <u>one</u> component).

vi) If the maintenance costs are included in this component, divide them by the collection units and add the result to (iv).

$$\frac{\text{Actual Costs}}{\text{New FY Collection Units}} + \text{Any WUC Rate Increase} + \text{Maintenance Costs if not included elsewhere}$$

= Water cost per plot per month.

vii) Some plotholders will obtain a private water connection and request a reduction in their Service Levy. MLGL recommends the following for such cases:

a) require all COR plotholders to pay the full Levy amount,

b) Offer an annual 10% refund of the Service Levy to any plot holder with a private water connection (the 10% refund must not exceed the amount of the Water Component),

c) At the end of the FY require all plotholders with private water connections to present their Service Levy and WUC receipts to Council,

d) If the plotholder is paid up-to-date for Service Levy and BML (if any), he or she may receive the refund (see "b"). For example, Mr. Mpe is paid up-to-date for BML and Service Levy and has WUC receipts to prove he has his own water connection. At the end of the FY, Mr. Mpe takes his Service Levy and WUC receipts to Council. He then receives a 10% refund; 12 mos X P8,00 = P96.00 X .10 = P9.60 refund (divide the answer by 12, then check the water component amount to make sure the refund does not exceed the water component amount), e.g., 9.60 - 12 = P0.80. Is the P0.80 greater than the water component amount? If so, adjust the refund to equal the water component amount.

8. Street Lights:

i) Determine the exact number of street lights serving residential COR plots, and the number of hours per day that they are on.

ii) Botswana Power Corporation (BPC) uses two formulae to calculate the cost:

a) Maintenance: Per Annum Rate Per Lamp x No. Lamps = Maintenance Cost p.a.

b) Consumption: 365 days x .125kw x Rate per kw x No. hours lamps are used in one day x no. lamps = consumption cost p.a.

c) The maintenance cost p.a. is added to the consumption cost p.a. to find the total cost to Council.

d) Note: The p.a. rate per lamp for maintenance and the rate per kilowatt for consumption may change from year to year-- consult BPC to obtain the current rates.

iii) Divide the result from (ii, c) by the collection units for the new FY. The answer equals the cost per plot per month for the street light component.

$$\frac{\text{Total Cost of "SHHA" Street Lights}}{\text{New FY Collection Units}} = \text{Street Light Cost Per Plot Per Month}$$

9. Development Grant:

i) Determine how many plots will be allocated for the first time during the new FY.

ii) Multiply the number of plots from (i) times the amount of the Development Grant for one plot (currently P90.00 per plot). The answer equals total FY revenue from the Development Grant.

No. Plots to be Alloc'd 1st Time x Development Grant =

Total Development Grant Revenue

iii) Divide the answer from (ii) by the new FY collection units. The answer equals the amount of Development Grant to be credited to each plot every month.

$$\frac{\text{Total Development Grant Revenue}}{\text{New FY Collection Units}} = \text{Amount per plot per month Development Grant Credit}$$

10. Secondary Infrastructure:

i) Obtain the costs of secondary infrastructure from the Urban Development Coordinator (UDC). If your Council has had more than one project, be sure to obtain the outstanding balance of all the projects. (note: If a Council has more than one project with different interest factors, each project must be calculated separately from step (i) through step (iii), then the answers for each project would be added together before proceeding to step iv.)

ii) Multiply the costs from (i) times the interest factor for the loan (e.g., interest factor for 8.25% interest over 25 years equals 0.09367878). The UDC can help identify the correct interest factor.

iii) Divide the answer from (ii) by the number of plots allocated/available for allocation to find the cost per plot per annum.

iv) Divide the cost per plot per annum by 12 months to find the cost per plot per month for the Secondary Infrastructure component.

v) Note: When the UDC determines the Secondary Infrastructure costs of any project, cost proportions must be assigned to Commercial plots, COR plots, Civic/Community plots, Medium or High-Cost plots, etc. Council should assist the UDC in this task by forming an ad hoc committee consisting of the UDC, the Town Treasurer, the Deputy Town Treasurer, the PHO, the SHHA Senior Administration Officer, and the Deputy Town Clerk.

11. Sanitation Pumper:

i) Calculate the cost of one unit including Plant, Labour, and Running Costs (as per the Refuse Collection component).

ii) Divide the total cost for one unit as found in (i) by the new FY's collection units. The answer equals the cost per plot per month for the Sanitation Pumper Component.

$$\frac{\text{Total Cost one Unit}}{\text{New FY Collection Units}} = \text{Sanitation Pumper cost per plot per month}$$

iii) Some Councils do not fully utilize one unit in the "SHHA" areas, such Councils must determine the percentage of use in other areas. Then, the cost per plot per month must be reduced accordingly.

12. Sanitation (substructures):

i) Obtain the cost per substructure from the Town Architect (or other appropriate officer who is charged with supervision of the substructure installation).

ii) Ascertain the loan terms (interest and repayment period).

iii) Consult the Basic Payment Tables to determine the monthly payment. For example, a loan of P1000 at 6% interest over 25 years requires a monthly payment of P6.45 (according to the Basic Payment Tables). If the substructure costs P350 each, the monthly payment would be:

$$\frac{350}{1000} \times 6.45 - P2.26$$ which would equal the per plot per month cost for the Sanitation Component

13. 5% Default Loss Factor

i) Add the per plot per month cost of each component (SHHA Costs + Shortfall + Refuse Collection + Road Maintenance + Water + Street Lights + Secondary Infrastructure + Sanitation Pumper + Sanitation, less Development Grant).

ii) Multiply the total of (i) times .05 to find the amount of the 5% Default Loss Factor.

14. Summary

i) List each component with its corresponding Pula amount

ii) Be sure to subtract the Development Grant component

iii) Add the 5% Default Loss Factor

iv) Add all components

v) The result equals the Economic Levy for the new FY.

vi) For example:

SHHA Costs	5.92
Refuse Collection	0.76
Roads Maintenance	0.80
Water	1.29
Street Lights	0.41
Sec. Infrastructure (to be included F/Y 83/84)	0.00
Sanitation (REC II) *	.20
(See note) **	9.38
Less Development Grant	3.03
	6.35
Add Shortfall	1.59
Subtotal	7.94
Add 5% default loss factor	.39
Total	8.33
Economic Levy with REC II	8.33
Economic Levy without REC II	8.13

15. The figures in all components must be double-checked to ensure no errors were made.

16. The Town Treasurer, Principal Housing Officer and SHHA Senior Administration Officer should work together on this exercise.

17. When the calculations are complete, they should be stenciled and distributed to the Town Clerk, all Town Councillors, MLGL (Attention: LCHO, Finance Officer, and POI), and all SHHAs.

    After the economic Levy is approved by Council, the calculations may be distributed to other Council staff especially to SHHA and Treasury staff.

18. When presenting the study to the Councillors, make sure they have had at least one week to review the calculations. In addition, use visual aids such as flip charts, slides, and a blackboard to help explain the calculations.

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* The sanitation component is actually in a 5-year grace period, but is included in order to soften the expected jump in the Service Levy of about P2.00 (assuming 6% over 25 years), which is in compliance with MLGL recommendations. Note that this component will only be charged to plotholders receiving the REC II substructure.

** NOTE: Some loans go to Council with a grace period (2-5 years) during which time Council is not required to make any repayments. However, Council should "phase-in" such loans (for secondary infrastructure, sanitation, etc.) as in the above example for sanitation. This will minimize large increases to the Levy and provide Council with a better cash flow.

19. After Council approves the new Levy, follow the procedures in the State Land Act and the Certificate of Rights for raising the Levy. Then advertise the change through the Daily News, Gazette, Radio Botswana, posters, newsletters, public meetings, role plays, school children, etc.

20. The only means of reducing the Service Levy is by a reduction in the SHHA costs or in the services. If the Councillors feel that the proposed Levy is too high, the Administration must be prepared to explain the implications of lowering the Levy.

21. A sub-economic Service Levy or a high default rate can drain Council's resources to the point of financial ruin. This would increase Council's dependency on Deficit Grants and hinder Council's overall development programmes. Therefore, it is essential that the Service Levy calculations be produced every year, that Council endeavor to collect the Service Levy, and that the Council be aware of the consequences should either effort fail.

APPENDIX 3

Social Survey

SOCIAL SURVEY

As part of the Evaluation Study of Self-Help Housing Agencies, a Social survey was conducted in thirteen SHHA areas (of the 4 major towns) involving 769 plots with 856 households. The sample characteristics are shown in Table A3-1.

Respondents were asked to indicate the main problem facing their household. Overwhelmingly they mentioned problems connected with income, employment and food prices rather than with housing and public services. Their concern in brief was with the general problem of poverty rather than specifically with housing.

The following list shows the proportion of households indicating each problem.

Income - mentioned as main problem by 27% of the sample

Employment - 27%

Food prices - 20%

Cost of housing and services - 8%

Poor housing - 6%

Poor plot services - 3%

Health -3%

Personal problems - 2%

Crime and insecurity - 1%

The survey then asked respondents more directly about their housing and plot, questioning first whether they needed improvement and secondly what improvements were most important.

As would be expected the vast majority of plotholders (more than 76% in all settlements) felt that improvements were needed. Easily the most common aspiration was to extend or rebuild the house in all areas except Somerset (where the related point of improved house design was given more importance). Other points which stand out are the importance given in Monarch to improved plot space and ownership rights (implying some dissatisfaction with the Certificate of Rights), in Bontleng, Somerset and Monarch to improved sanitation, and to clearer plot boundaries in Peleng.

Table A3-1

1980 SOCIAL SURVEY
SAMPLE CHARACTERISTICS

Town/Settlement	Allocated Plots	Surveyed Plots	
		No.	%
GABORONE			
Extension 14 and Bontleng	702	46	6.5
Broadhurst and Tsholofelo	2900	110	3.8
Old Naledi	1620	67	4.1
LOBATSE			
Maipaafela	215	41	19.1
Woodhall	589	42	7.1
Peleng	956	40	4.2
FRANCISTOWN			
Monarch	1425	71	5.0
L W S Aerodrome	863	52	6.0
Tatitown	953	54	5.7
Somerset	596	50	8.4
SELEBI-PHIKWE			
Botshabelo	1212	80	6.6
Western Areas	1192	75	6.3
SE Extension	547	40	7.3
TOTAL	13770	769	5.6

Source: Report of an Evaluation of the Self-Help Housing Agencies (Sept. 1983) Government of Botswana, Ministry of Local Government and Lands. By: Development Administration Group, Institute of Local Government Studies, University of Birmingham, England.

The proportion of households wanting different improvements are shown in Tables A3-2 and A3-3.

The greatest importance in most areas was given to the improvement of roads and streetlighting followed in third place by refuse collection.

Table A3-2

IMPROVEMENTS MOST DESIRED TO HOUSE OR PLOT, BY SETTLEMENT

Improvement Desired	Percent of Whole Sample Desiring Improvement	Settlements in Which Owner Households Most Frequently Mentioned the Improvement
Extend/rebuild house	69	Maipaafela, Old Naledi Woodhall, S E Extension
Clearer plot boundaries	24	Peleng, Maipaafela, Bontleng/ Ext. 14, Botshabelo, Tatitown
Sanitation/toilet	23	Botshabelo, Somerset, Monarch, Broadhurst, Bontleng, Ext. 14
House design	20	Somerset, LWS/Aerodrome, Monarch
Access to water	19	Peleng, Bontleng, Ext. 14, Maipaafela, W. Areas, Somerset
Plot space or shape	17	Monarch, S E Extension, Tatitown
Electricity to plot	11	LWS/Aerodrome
Construction materials	10	Maipaafela
Improved ownership rights	8	Monarch

Table A3-3

IMPROVEMENTS MOST DESIRED TO AREA, BY SETTLEMENT

Improvement Desired	Percent of Whole Sample Desiring Improvement	Settlements in Which Owner Households Most Frequently Mentioned the Improvement
Roads	52	Monarch, Woodhall, Bontleng/ Ext. 14, Botshabelo, Maipaafela
Street lights	51	Somerset, Broadhurst, Botshabelo, Woodhall, Peleng
Refuse collection	29	Somerset, Botshabelo, Monarch
Area space	17	Tatitown, Monarch
Safety/Security	11	Old Naledi, Monarch, Maipaafela
Drainage	8	Monarch, Boardhurst

House owners were asked how much it had so far cost to build their house. The answers showed a clear distinction between types of housing- modern and traditional -- with the older areas of modern housing (where owners have had most time to build) showing especially high levels of investment (Table A3-4).

In the traditional and mixed housing areas of Tatitown, Somerset, Botshabelo, Maipaafela, Western Areas and Monarch, half of the owners had spent less than about P350 in building their house -- indeed in Somerset and Botshabelo half had spent less than P90. Peleng and the established site-and-services areas -- LWS Aerodrome and Bontleng/Extension 14 -- contained the most expensive housing averaging P2245 in cost. The newer site-and-services areas -- including South East Extension, Broadhurst/Tsholofelo and Woodhall -- are still in the process of development with an average costs of construction so far of P839.

The great majority of households depend on street standpipes for their water supply, with the normal level of provision being about one tap per 20 plots. Small proportions in some areas reported having water supplied to their plot - mainly Bontleng/Extension 14 (21% of households) but also at levels around 13% of households in Western areas, LWS/Aerodrome at Woodhall.

Table A3-4

COST TO DATE OF BUILDING HOUSE

Settlement	Predominant Housing Type	Median Cost (Pulas)
Gaborone		
Bontleng/Ext. 14	Modern	1500
Broadhurst/Tshol.	Modern	794
Old Naledi	Modern	858
Lobatse		
Maipaafela	Mixed	480
Woodhall	Modern	814
Peleng	Modern	2639
Francistown		
Monarch	Traditional	280
LWS/Aerodrome	Modern	2416
Tatitown	Traditional	440
Somerset	Traditional	89
Selebi-Phikwe		
Botshabelo	Traditional	83
Western Areas	Mixed	750
South East Ext	Modern	1107

In six of the thirteen areas surveyed, around 80% or more of owner households reported that they were wholly satisfied with the water supply. Of these highly satisfied settlements all but two (Woodhall and Maipaafela) were upgrading areas. The greater satisfaction is perhaps to be explained by the fact that their supply is an improvement on previous arrangements. (Table A3-5). In the other seven -- including four site-and-service areas where perhaps expectations are higher - between 46% (Somerset) and 64% (LWS/ Aerodrome) were satisfied (Table A3-6). In the other towns it was in each case an upgrading area which showed the highest level of satisfaction (Old Naledi, Botshabelo and Tatitown). On the other hand one upgrading area, Somerset, showed particularly high levels of dissatisfaction.

Among the approximately one third of the sample who made some complaint about water supplies, the major reason (in 84% of all cases) was that the water tap was too far away. Alternative complaints were very few -- four households in Boardhurst complained that too many people used the tap and three in Tatitown complained that the supply was irregular.

Table A3-5

SATISFACTION WITH WATER SUPPLY, BY SETTLEMENT TYPE

	Satisfied %	Fairly Satisfied %	Dissatisfied %	Total %
Site-and-services areas	60	6	34	100
Traditional and upgrading areas	75	4	21	100
All areas	68	5	27	100

Table A3-6

SATISFACTION WITH WATER SUPPLY, BY SETTLEMENT

Settlement	Satisfied %	Fairly Satisfied %	Dissatisfied %	Total % (No)
Gaborone				
Bontleng/Ext. 14	56	12	32	100 (34)
Broadhurst/Tshol.	55	5	40	100 (94)
Old Naledi	86	4	10	100 (49)
Lobatse				
Maipaafela	87	3	10	100 (39)
Woodhall	94	0	6	100 (36)
Peleng	91	6	3	100 (34)
Francistown				
Monarch	58	1	41	100 (66)
LWS/Aerodrome	64	8	28	100 (39)
Tatitown	79	7	14	100 (43)
Somerset	46	4	50	100 (44)
Selebi-Phikwe				
Botshabelo	79	3	18	100 (72)
Western Areas	53	6	41	100 (64)
South East Ext.	57	11	32	100 (37)

Table A3-7 shows that the majority of households in most areas use some form of pit latrine. This may be a simple pit dug by the plotholder or a latrine with a sub-structure of the Aqua privy type B, ROEC or REC II types which are usually installed by SHHA. The exceptional areas, which in the table are shown as having in the majority of cases no latrine, are Botshabelo in Selebi-Phikwe and Monarch and Somerset in Francistown. Tatitown, also in Francistown, is also shown as having a high proportion without a latrine. In the case of Botshabelo, REC II latrine sub-structures have in fact been generally provided by SHHA but a large proportion of plotholders have not completed them by building the superstructure. In the case of the Francistown settlements, the SHHA is, at the time of writing, installing REC II latrines wherever a proper sub-structure is currently lacking.

Table A3-8 shows the degree of satisfaction of those who have some form of toilet. What is most striking is that it is those areas, above all in Lobatse but also in Tatitown, with a simple pit dug by the plotholder that show the highest degrees of satisfaction. The least satisfied are those with the Aqua and ROEC types in Broadhurst, Extension 14 and Monarch. The areas with REC II toilets, come in between these two group in their level of satisfaction.

In Table A3-9 we show the proportion of those households with the use of a toilet who are critical of their facility, and the numbers in each settlement who offered some particular criticisms. The survey did not explore this question in sufficient detail to allow us to specify the reasons for complaint with much confidence. The reasons given in the table in many cases overlapped -- for example, latrines were considered not deep enough and therefore were seen as unclean and requiring emptying. The recurring complaint was that the pits were too shallow. It is not clear from this survey whether this is merely by comparison with the simple pit latrine with which respondents may have been more familiar, or whether the depth of more recent models really had given rise to problems.

Table A3-7

TOILET TYPE ACCORDING TO THE SURVEY, BY SETTLEMENT

Settlement	None %	Flush %	Pit Latrine %	Total %	Predominant Type of Pit Latrine
GABORONE					
Bontleng/Ext. 14	3	15	82	100 (34)	Simple pit in Bontleng Aqua Ext. 14
Broadhurst/	0	3	97	100 (94)	Aqua/Rec II
Old Naledi	2	2	96	100 (50)	Rec. II
LOBATSE					
Maipaafela	10	0	90	100 (39)	Simple Pit
Woodhall	0	5	95	100 (37)	Simple Pit
Peleng	6	0	94	100 (34)	Simple Pit
FRANCISTOWN					
Monarch	68	0	32	100 (66)	ROEC. Type B
LWS/Aerodrome	5	8	87	100 (39)	Rec. II in S & L Simple pit in W & Aer.
Tatitown	37	7	56	100 (43)	Simple Pit
Somerset	68	0	32	100 (44)	Simple Pit
SELEBI-PHIKWE					
Botshabelo	86	0	14	100 (72)	Rec. II
Western Areas	25	13	63	100 (64)	Rec. II
South East Ext.	0	3	97	100 (37)	Rec. II

Table A3-8

SATISFACTION WITH LATRINE BY SETTLEMENT

Settlement	Satisfied %	Fairly Satisfied %	Dissatisfied %	Total %	(No)
GABORONE					
Bontleng/Ext.14	42	6	52	100	(32)
Broadhurst/Tshol.	34	9	57	100	(94)
Old Naledi	55	16	29	100	(49)
LOBATSE					
Maipaafela	83	3	14	100	(35)
Woodhall	92	3	5	100	(36)
Peleng	84	0	16	100	(32)
FRANCISTOWN					
Monarch	24	0	76	100	(21)
LWS/Aerodrome	51	3	46	100	(37)
Tatitown	67	11	22	100	(27)
Somerset	43	7	50	100	(14)
SELEBI-PHIKWE					
Botshabelo	60	20	20	100	(10)
Western Areas	65	0	35	100	(48)
South East Ext.	57	13	30	100	(37)

Table A3-9

REASONS FOR CRITICISM OF TOILETS BY SETTLEMENT [1]
OF THOSE WITH USE OF A TOILET

Settlement	Propn.[2] With Use of Toilet %	Percent who are Critical %	Numbers Offering the Following Reasons for Criticism: Not Clean Smells	Not Deep Enough	Not Emptied Enough	Collapses
GABORONE						
Bontleng/Ext. 14	97.1	57.6	11	1	2	5
Broadhurst/Tshol.	100	66.0	45	6	5	4
Old Naledi	98.0	44.9	6	7	1	4
LOBATSE						
Maipaafela	89.7	17.1	0	1	1	3
Woodhall	100	8.3	2	1	0	0
Peleng	94.1	15.6	2	0	0	2
FRANCISTOWN						
Monarch	31.8	76.2	14	0	1	1
LWS/Aerodrome	94.9	48.6	9	3	2	3
Tatitown	62.8	33.3	3	1	4	0
Somerset	31.8	57.1	7	2	0	0
SELEBI-PHIKWE						
Botshabelo	13.9	40.0	2	2	0	0
Western Areas	75.0	35.4	9	3	7	1
South East Ext.	100	43.2	7	4	2	1

NOTES (1) The numbers offering criticisms are often small and are therefore not expressed as percentages.
(2) Having the use of a toilet does not imply that the building of the superstructure is completed.

In almost all the settlements surveyed, the majority of the people were satisfied with their water supply; in five out of thirteen settlements though, one third or more of residents were dissatisfied. The main cause of complaint in those areas was that the standpipes were two far away.

The social survey showed that, in most schemes, the vast majority of plots had pit latrines of some form, although in some areas (e.g., Botshabelo) few people had yet built the superstructure. Only in Bontleng/Extension 14 and Western Areas did a significant number of plots have flush latrines. In most areas, the majority of people were satisfied with their latrines, but in three areas, more than half the respondents were dissatisfied. The areas with greatest dissatisfaction were those with the old style Aqua or ROEC systems (Monarch, Broadhurst, and Extension 14), while the areas with greatest satisfaction were those in Lobatse, where people were required to build their own latrines (simple pits) themselves. In most of the areas with the current REC II systems, around 20-35% of plot-holders were dissatisfied.

The main complaints about the Aqua/ROEC system were that the latrines smelled and that they were not emptied often enough (particular problem in Bontleng/Extension 14, which has a very high plot occupancy rate). It is clear that these early systems are unsuitable in the Botswana context and were often not satisfactorily installed. These systems have now been abandoned, and the government has standardized on the REC II system. However, the REC II system also came in for criticism in the social survey for the shallowness of the pit, for infrequency of emptying and for collapsing. The complaint about infrequency of emptying would appear to reflect a misunderstanding about the nature of the system: with a two pit system, the intention is to close one pit once it is full and to leave it for 1-4 years to stabilize before emptying; however, it would appear that some people would prefer to have them emptied as soon as they are full. This suggests the need for greater effort in educating users of the system. Likewise, the complaint that pits are two shallow is based on a comparison with conventional pit latrines, which are very deep, whereas the volume of the REC II is sufficient without requiring a great depth.

APPENDIX 4

Sanitation Options

The Botswana Aqua Privy

J.G. Wilson[1]

Low-cost sanitation developments in Botswana date back to the early 1970s, when the government undertook initial work on fiberglass aqua privies. The prototype, called the Apec privy, had various technical problems, including flexing of the floor under load, an ill-designed sitting pedestal, and a superstructure that was uncomfortably confining while not offering sufficient privacy because of the large ventilation gaps at the top and bottom of the door. This resulted, in 1975, in the government officially banning any further installation of the Apec privy (Blackmore et al. 1978).

The Botswana "Type B" Aqua Privy

As part of the investigation into alternative forms of low-cost sanitation, the government, together with the International Development Research Centre (IDRC), Canada, developed the "type B" aqua privy (Fig. 1). Conceived around the necessity for a household to bring onto the plot, regardless of the distance to the source, a minimum volume of water for domestic purposes, the "type B" aqua privy simultaneously overcame the problem of sullage disposal and the need for aqua chamber topping up through a reuse facility. Based on the Vaal Potteries Spiraflow Aqua Pan, the "type B" aqua privy incorporated one of two alternative washing fitments, an internal handbasin/external wash through, plumbed into the flushing rim of the pan, whose hydraulic design

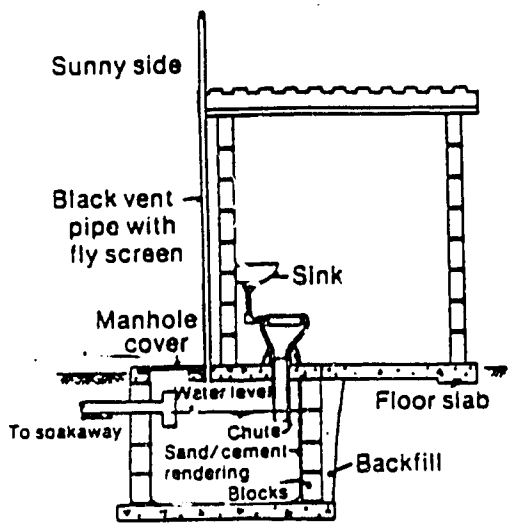

Fig. 1. Botswana type B aqua privy. (After R.A. Boydell, formerly with the Ministry of Local Government and Lands, Botswana.)

characteristics encourage a spiral scouring movement of the water when flushed from the fitment, around the ceramic wall and chute, before discharging into the chamber (Blackmore 1978).

A great advantage of the unit is its suitability for being upgraded at a later date. If the householder can afford a water connection, a conventional flushing cistern may be plumbed into the pan. In addition, the overflow from the tank can be connected to a piped drainage system if such a system subsequently becomes available.

However, since its general acceptance, certain user and technical problems have occasionally occurred. The most common problem is the rejection of the unit by some people on the grounds that the tank is too

[1]Senior Public Health Engineer, Ministry of Local Government and Lands, Gaborone, Botswana.

small; an assumption, based on the belief that the aqua privy operates in a similar manner as the pit latrine, that is incorrect. The inability to add at least 5 litres of water per day to the tank to maintain the water level is another problem. This lack of user maintenance is partially blamed on the lack of suitably close standpipes in some areas and also partially on the belief in secrecy when using the toilet (being seen carrying water to a toilet divulges the secret and causes acute embarrassment to the individual). A further problem has been the belief by some that any water placed in the wash-basin attached to the aqua privy immediately becomes contaminated and, therefore, people are very reluctant to use this facility, preferring to use a completely separate container instead.

Technical problems encountered include ensuring that the tank is and remains water-tight, together with preventing the rubber connection between the sullage drainpipe and the Spiraflow Aqua Pan from perishing; maintaining a fly screen; and ensuring that the soakaway does not become clogged.

The government appreciates the applicability of such systems, particularly in development areas that will eventually become upgraded and is, therefore, actively seeking methods to overcome these problems. In 1977, it was found that the cost of water-borne sewerage in Botswana was almost twice the cost of aqua-privy systems (S.E. Daher, personal communication, 1977) and, therefore, an on-site system should be considered as being the most appropriate, at present, to cope with the high rate of urban development.

It has not been the intention of this paper to create the impression that the aqua privy, as used in Botswana, is a failure. In fact, the opposite is prevalent wherever the aqua privy is in use. Botswana has learned from its past mistakes of introducing a sanitation unit before fully evaluating whether or not it was technically and culturally acceptable. As the government increases its manpower in the various disciplines of the sanitation sector, such mistakes are not repeated and sound economical, technical, and culturally acceptable sanitation programs are being implemented.

Blackmore, M.D. 1978. Alternative sanitation in Botswana. Progress in Water Technology, 11 (1/2), 219-224.

Blackmore, M.D. et al. 1978. In Pacey, A., ed., Sanitation in Developing Countries. New York, New York, John Wiley & Sons Inc.

The PIP and REC II Latrines

J.G. Wilson[1]

The rate of urbanization in Botswana is one of the highest in the world and is, at present, approximately 15% per annum. The government is actively engaged in a process of upgrading existing squatter settlements and undertaking site and service developments to the extent that this now constitutes approximately 70% of all housing production. Being actively aware of the need for appropriate sanitation, the government, in conjunction with the Building Research Establishment, England, has developed a twin-pit ventilated improved pit (VIP) latrine that could be the most appropriate form of sanitation for use in upgraded and site and service areas.

In urban areas, it is not always possible to abandon a full pit and dig a new one. The conventional single-pit latrine (modified or unmodified) can cause serious health hazards when being emptied. In order to overcome this, a new approach to pit latrine technology has been tried.

The permanent improved pit (PIP) latrine (Figs. 1, 2) and the revised earth closet II (REC II) (Fig. 3) have both been conceived for the purpose of providing a permanent unit that can be emptied as required. This can be achieved by providing double pits that are used alternately. The contents are retained within the sealed pit long enough for pathogens to die and when the contents are removed they are harmless and inoffensive.

Botswana, along with many other African countries, does not have a history of reusing excreta. Therefore, the resulting friable humus, though useful as a fertilizer, will initially be removed from the site by the council.

At present, the PIP latrine remains as a prototype at the Building Research Establishment to verify construction details and to investigate the effectiveness of alternative pit ventilation arrangements. The REC II, however, has already been constructed in quantity in Botswana. To date, approximately 2000 have been constructed by con-

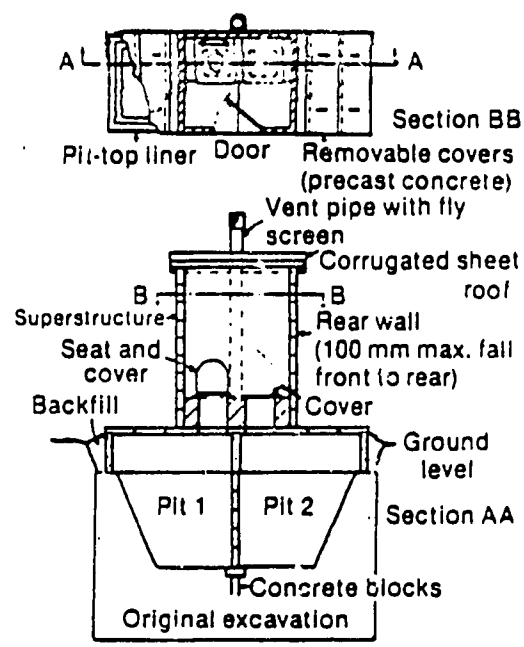

Fig. 1. Permanent improved pit (PIP) latrine type A. (After R.F. Carroll, Building Research Establishment, England. Note: Pit top supported by cast in situ concrete liner 100 mm thick, forming two compartments, each having an effective volume of 1.5 m³.)

[1]Senior Public Health Engineer, Ministry of Local Government and Lands, Gaborone, Botswana.

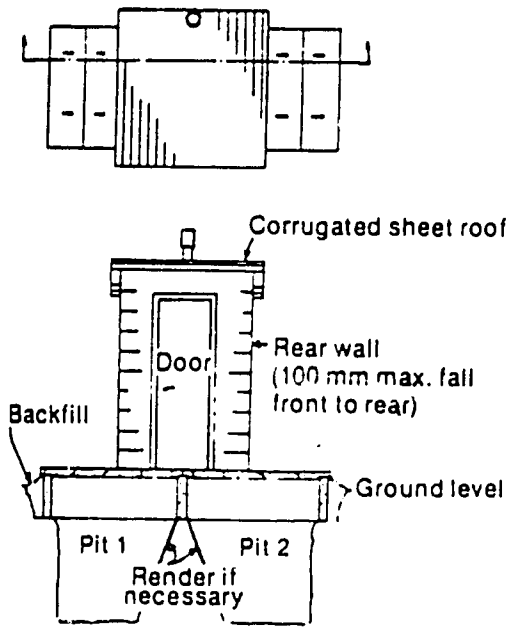

Fig. 2. Permanent improved pit (PIP) latrine type B. (After R.F. Carroll, Building Research Establishment, England. Note: Unspecified details are similar to those given in Fig. 1.)

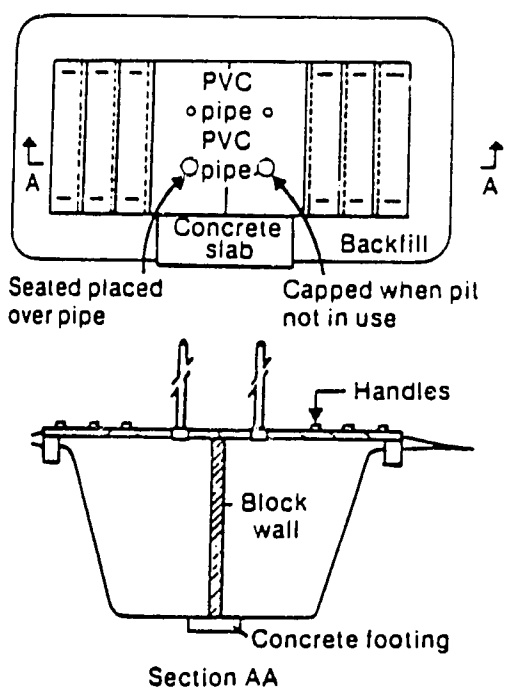

Fig. 3. Plan and cross-sectional views of twin-pit VIP latrine (REC II).

tractors in site and service and upgraded areas in Gaborone. Demonstration models have now been constructed in Francistown and Selebi Pikwe and it is proposed that between 3000 and 4000 will eventually be constructed in these towns.

The main features of the PIP and REC II latrines (Carroll 1980) are: (1) small double pits, each with an effective volume of 1.5 m^3; (2) supported pit tops and superstructure; (3) ventilated pits to reduce odour and attraction of insects; (4) mechanized or manual emptying; (5) 2 year retention period; (6) 3–4 year emptying cycle; and (7) pit contents once decomposed, harmless and inoffensive, to be used as fertilizer.

Because of the intensive housing construction program, the government has committed itself to invest heavily in this sanitation solution in urban areas. It is aware, however, that there are other important factors associated with the program that must be considered in order for it to succeed. The most important of these are affordability, emptying procedures, and health education.

The first of these is dealt with in greater detail in another paper (see Bellard). It can be said, however, that it is the government's policy to provide a latrine substructure to each plot at a cost that can be afforded by each plotholder. It is the plotholder's responsibility, however, to construct an approved superstructure and to purchase the locally made fiberglass seat unit.

Having introduced REC II latrines, the government now has 3 years (the time of the first emptying cycle) to complete its proposals with regard to emptying procedures. At present, it is proposed that emptying trials be conducted in conjunction with the Building Research Establishment using a machine that works on a high volume airflow principle and draws all types of material, ranging from light dry material to wet sludge, according to the groundwater conditions in the pit at the time of emptying.

At the same time, it is becoming very apparent that health education with regard to pit-latrine usage is of prime importance. For the REC II program to succeed and be acceptable to the plotholder, a health educa-

tion program must commence immediately. The following are examples of problems that are already occurring:

(1) Latrines are not being completed by the plotholders and, therefore, the government investment is not being utilized because the plotholders do not appreciate the advantages of having a latrine. As far as the plotholder is concerned, the bush is nearby and convenient and does not cost anything, whereas a superstructure does.

(2) Plotholders claim that the pits are too small and will fill too quickly. They do not fully understand the operating principles of the latrine.

(3) Some plotholders have removed the cap from the second pit so children may defecate into the second pit, thereby using two pits at the same time. The plotholder has also been known to use the latrine to wash in and then drain the water into the second pit, thereby flooding it.

Some of these problems will be overcome by slightly modifying the design of the substructure. Acceptance and correct usage and maintenance by the plotholder, however, are of prime importance if this sanitation program is to succeed. If it does not succeed, then apart from the loss of investment, it is the future health of the plotholders that is at stake and, therefore, emphasis must be placed upon increased health education, together with adequate manpower to supervise the implementation of the project.

Carroll, R.F. 1980. Improving the pit latrine. Presented at the 6th Water and Engineering in Developing Countries Conference, March 1980, Loughborough, England.

LOW COST SANITATION PLUS SMALL BORE SEWERAGE

Conceptually, it is possible to provide initially to the SHHA area low-cost sanitation facilities with future upgrading through the use of small-bore sewerage. Small-bore sewerage [1] is an applicable technique for systems where solids are essentially excluded from the wastewater flow. In the case of RECV II users, sullage water from baths, kitchen sinks and laundry may be pumped and diverted into a small-bore sewerage. In septic tank applications, overflow from the septic tank which is solids-free may be connected to the small bore sewerage. The small-bore system generally would be less costly than a conventional sewer system since the pipe system can be flatter and therefore may be laid at shallower depths. In addition, it may be possible to reduce the number of manholes since pipe access is primarily to remove blockage in systems that carry solids. The costs of a small-bore system is estimated to be:

House Connection (15m)	P 975
Small bore sewers	1955
Off-site Sewerage	460
Treatment	142
Total	P3532

Alternative D1 is essentially Alternative A with the small-bore sewer scheme added to it at some future date. The annual operating and maintenance cost of the small-bore system is approximately P70.6. The incremental cost of water should be basically equal to that calculated by Alternative B. Table A5-1 presents the matrix used to estimate the TACH, for REC II plus small-bore sewerage. It shows that the TACH for Gaborone, if the discount rate were 8% would be:

	Annual Cost	
Annualized Cost -- Small-Bore System	P 330.9	
O&M Cost -- Small-Bore System	70.6	
Incremental Cost of Water	83.3	
REC II -- ALT A -- Basic Cost	87.7	
Total Annual Cost	P 572.5	
Monthly Cost		P47.71

The total annual cost is P572.5 which is 8% less expensive than the conventional sewer system.

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(1) Chapter 16, "Small-Bore Sewers, Appropriate Sanitation Alternatives". A Planning and Design Manual, World Bank Studies in Water Supply and Sanitation.

Table A4-1

ALTERNATIVE D1
REC II PLUS FUTURE SMALL BORE-SEWERAGE
(in Pula)

	(1)	(2)	(3)
Capital Cost -- Small Bore Sewerage			3532
Annualized Cost	330.9	389.1	450.3
O & M Cost -- Small Bore Sewerage		[70.6]	
Incremental Cost of Water	45.4	to	83.3
TACH-ALT-A-REC II	87.7	97.8	108.5
TOTAL ANNUAL COST PER HOUSEHOLD (ALT D)	572.5	640.8	712.7
		to	
	534.6	602.9	674.8

Note: Columns 1, 2, and 3 represent the discount rates of 8, 10, and 12% respectively.

Alternative D2 is Alternative B with the small-bore sewer scheme added to it at some future date. Table A4-2 shows the calculation leading to the TACH estimates. The TACH for Gaborone, if the discount rate were 8% would be:

	Annual Cost	
Annualized Cost -- Small Bore Sewerage	P 330.9	
O & M Cost -- Small Bore Sewerage	70.6	
Septic Tank -- Alt B -- Basic Cost	379.0	
Total Annual Cost	P 780.5	
Monthly Cost		P65.04

Table A4-2

SEPTIC TANK PLUS FUTURE SMALL BORE SEWERS

	(1)	(2)	(3)
Capital Cost - Small Bore Sewers			P 3532
Annualized Cost CRF @ 8.10 and 12%	330.9	389.1	450.3
O & M Cost - Small Bore Sewers		[70.6]	
TACH - ALT B - Septic Tank	379.0 to 341.1	417.8 to 379.9	458.6 to 420.7
TOTAL ANNUAL COST PER HOUSEHOLD (ALT D2)	780.5 to 742.6	877.5 to 839.6	979.5 to 941.6

Note: Columns 1, 2, and 3 represent discount rates of 8, 10 and 12% respectively.

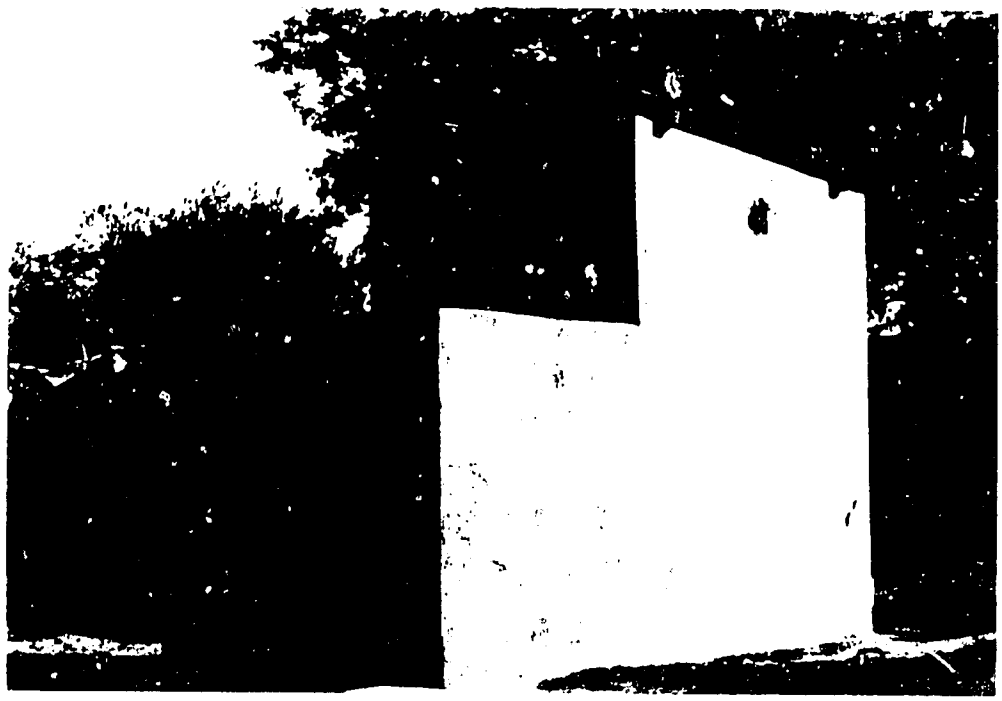

Photo 1. A nicely built and maintained VIP latrine.

Photo 2. Medium-cost housing -- Botswana Housing Corporation.

Photo 3. Low-cost housing in Gaborone.

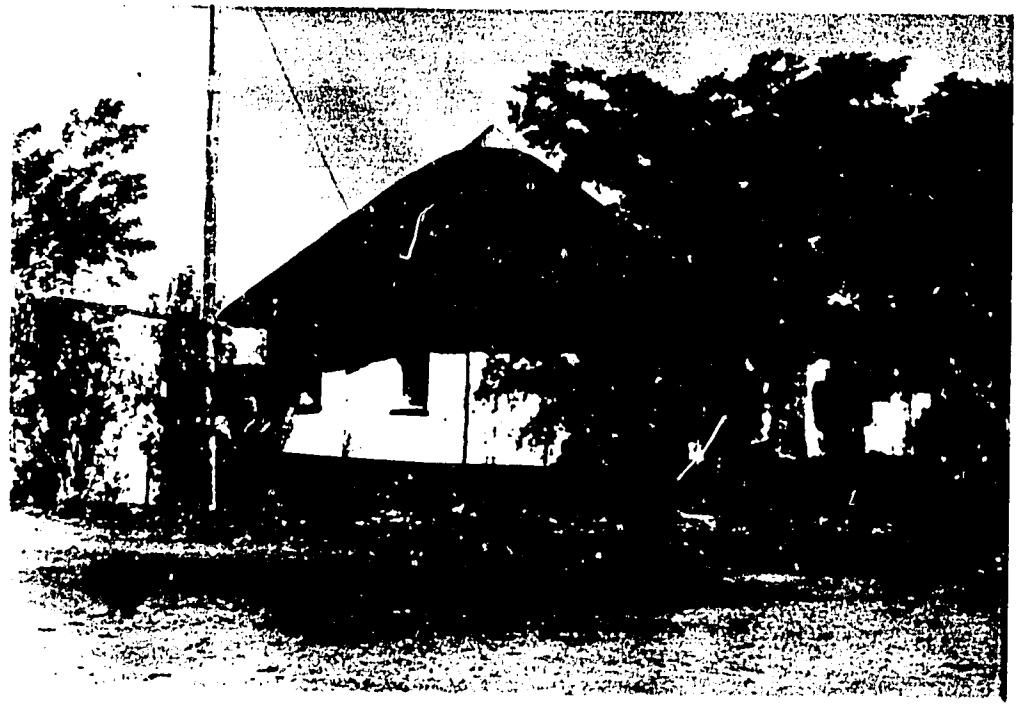

Photo 4. A modernized thatch and block home.

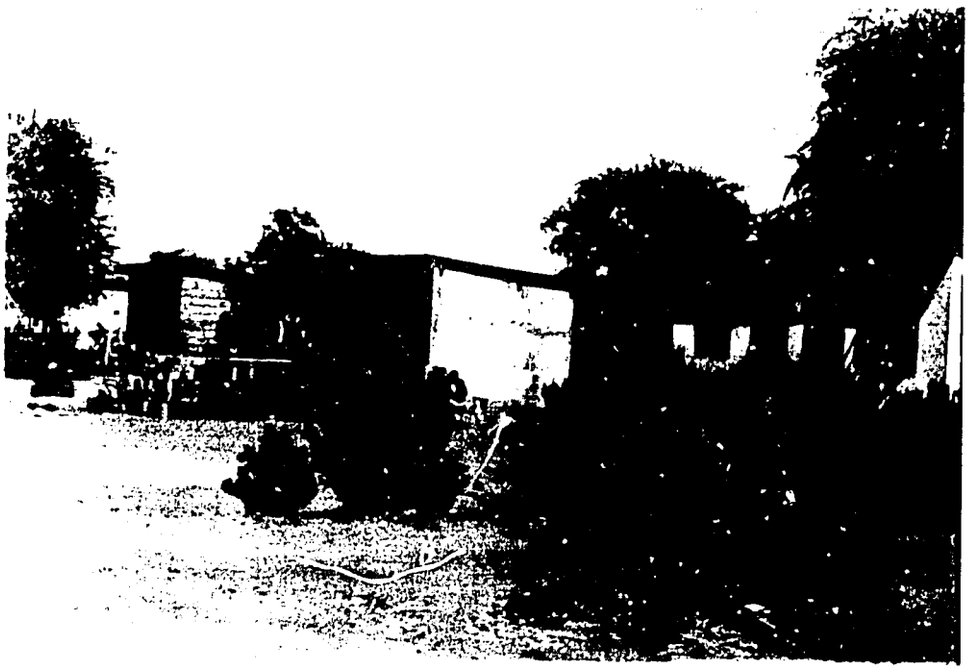

Photo 5. Example of SHHA housing units.

Photo 6. Traditional mud and thatch homes in an SHHA project.

Photo 7. A VIP latrine almost completed, emerging from a cluster of four.

Photo 8. Building-materials loan center.

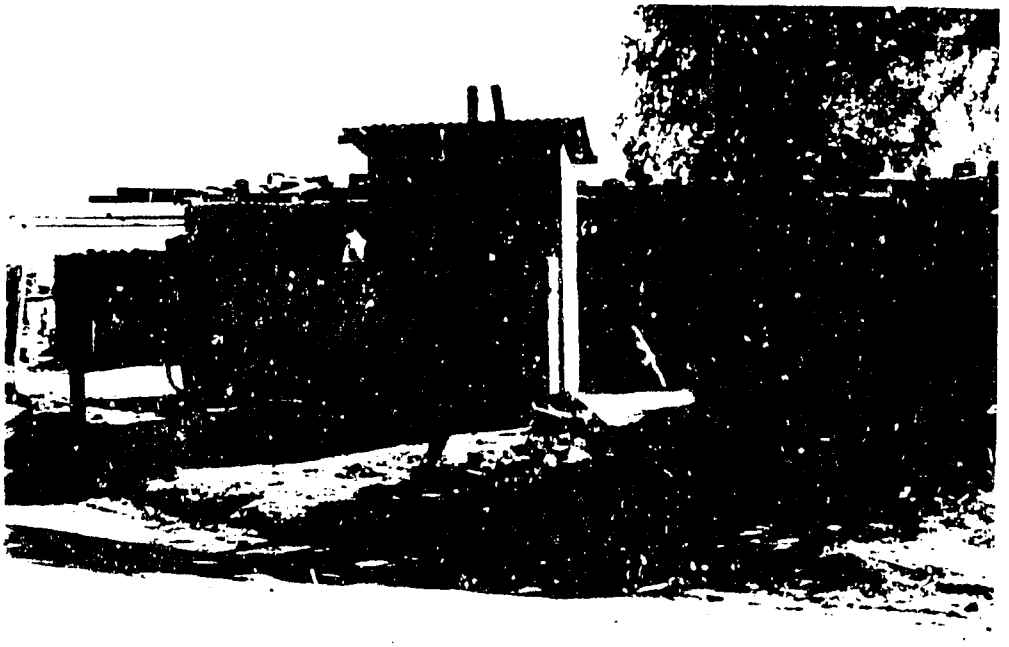

Photo 9. One of the SHHA plots with a VIP latrine in the back of the plot residence.

Representative Cost Data

I. SEWERAGE/SANITATION COSTS

This information was provided by NZA Associates (Pty) Ltd., Consulting Engineers of Gaborone.

A. Typical Unit Costs	Dimensions	Unit	1985 Prices (Pula)
Excavate sewer trench	0-1m deep	/m	6.00
	1-2m deep	/m	8.00
	2-3m deep	/m	12.00
Excavation - soft		$/m^3$	15.00
(small quants) - medium		$/m^3$	40.00
- hard		$/m^3$	70.00
Excavation (bulk - soft		$/m^3$	5.00
and either to - medium		$/m^3$	20.00
tip or to banks) - hard		$/m^3$	35.00
Binding concrete		$/m^3$	120.00
Shuttering - rough vertical		$/m^2$	25.00
- wrot vertical		$/m^2$	32.00
- soffit		$/m^2$	32.00
25 mpa concrete		$/m^3$	160.00
Benching		$/m^3$	170.00
Reinforcement - mild		/kg	1.50
- high yield		/kg	1.70
Brickwork	230 mm thick	$/m^2$	32.50
Rendering		$/m^2$	3.50
Chamber covers - 9C		No	80.00
Chamber covers - 9E		No	215.00
Chamber covers - 9B		No	230.00
Manhole covers - 4		No	170.00
Manhole covers - 2A		No	400.00
A/C Channel sections	100 mm dia	/m	14.00
	150 mm dia	/m	21.00
	225 mm dia	/m	28.00
	300 mm dia	/m	42.00
Pipe material - provide and lay	100 mm dia	/m	22.00
	150 mm dia	/m	28.00
	225 mm dia	/m	40.00
	300 mm dia	/m	70.00

Typical Unit Costs	Dimensions	Unit	1985 Prices (Pula)
Typar membrane		/m^2	3.50
Fencing		/m	12.00
Granular fill in soakage trench		/m^3	60.00
Provide and lay perforated PVC pipe	100 mm dia	/m	10.00
Electricity		/kw hr	0.13
Labor unskilled		/hr	.60
Labor skilled		/hr	1.20

B. Built up Costs

Septic tank for SHHA Plot		/No	900.00
Septic tank for LC Plot		/No	900.00
Septic tank for MC Plot		/No	1,100.00
Septic tank for HC Plot		/No	1,400.00
(Assumed range of soakage = 30 - 120 1/m^2/d)			
Drain field		/m	65.00
Drain field for SHHA Plot-H*		/No	275.00
or LC Plot -L*		/No	130.00
Drain field for MC Plot-H*		/No	530.00
-L*		/No	130.00
Drain field for HC Plot-H*		/No	975.00
-L*		/No	260.00
Chambers		/No	300.00
Manholes		/No	750.00
Sewers complete	100 mm dia	/m	65.00
(incl. chambers and manholes)	150 mm dia	/m	75.00
	225 mm dia	/m	85.00
	300 mm dia	/m	100.00
Pond interconnections		/No	1,200.00
Pond lining		/m^2	5.00
Pond wave protection		/m^2	10.00
Pond cost for	20,000 pop		500,000.00
Pond cost for	100,000 pop		2,500,000.00
Pond cost per capita			25.00
Irrigation cost for	20,000 pop		70,000.00
Irrigation cost for	100,000 pop		350,000.00
Irrigation cost per capita			3.50

*H = high range
*L = low range

C. Aerial Costs

(Capital costs excluding off site sewers. Per hectare costs assuming no unusual ground conditions.)

i. Sewerage
(SHHA costs assume all plots in hectare under consideration are sewered, not just 50% of them.)

	1985 Prices (Pula)
Low cost housing (per plot = P2,300)	37,000.00
Medium cost housing (per plot = P2,750)	27,500.00
High cost housing (per plot = P2,780)	22,250.00
Upgraded SHHA plots (per plot = P2,300)	37,000.00
ii. House Connections (15m length)	975.00
iii. Sewage Treatment (Per hectare costs @ 5 people/house and including irrigation.)	
Low cost housing (per plot = P 142)	2,280.00
Medium cost housing (per plot = P 142)	1,425.00
High cost housing (per plot = P 142)	1,140.00
Upgraded SHHA plots (per plot = P 142)	2,280.00

Summary of per plot costs for sewerage and sewage treatment:

	P
Upgraded SHHA	2,442
Low cost	2,442
Medium cost	2,892
High cost	2,922

D. Water Usage

	Liters per Plot per Day	
	Water Usage	Sewage Generated
Upgraded SHHA	300	250
Low cost	300	250
Medium cost	650	487.5
High cost	1,800	900

E. Allowance for 'Off Site' Trunk Mains, Outfall Sewers, Pumping Stations, Pumping Mains

		Total Cost per Hectare
Upgraded SHHA areas and Low cost plots	- Additional 5500/Ha.ie.14%	= 44,780.00
Medium cost areas	- Additional 5400/Ha.ie.19%	= 34,325.00
High cost areas	- Additional 5300/Ha.ie.23%	= 28,690.00

F. On-Site Costs

Septic tanks and drain fields only, excluding all superstructure costs and all work within buildings. Assuming 2 chambers and 5 m of 100 mm dia drain per plot.

	Pula - High Range	Pula - Low Range
Upgraded SHHA	2,100	1,955
Low cost	2,100	1,995
Medium cost	2,555	2,155
High cost	3,300	2,585

REC II units

Substructure	480
Superstructure	200

II. WATER SUPPLY COSTS

This information is taken from the 1983 VIAK Report.

Activity	Typical 1983 Prices (Pula)
Hydrogeological survey (studies already going on are not costed)	50,000
Borehole siting	3,000/borehole
Borehole drilling - rock	15,000/borehole
Borehole drilling - sand rivers	7,500/borehole
Test pumping	5,000/borehole
General design	15,000/village
Wellfield design	5% of
Pipeline design	construction
Reservoir design	cost
Wellfield construction:	
- borehole equipping	12,000/borehole
- service roads	12/m
- electrical grid system	12/m
- transformers etc.	12,000/borehole
- pipelines	see pipeline construction
Pipeline construction, including cost for administration, supervision, and contingencies (approx 20%)	200 mm - 35/m 250 mm - 55/m 300 mm - 120/m
Reservoir construction (main reservoirs on ground), icnincluding costs for administration, supervision, and contingencies (approx 20%)	180/m^3
Monitoring system incl. installation	5,000/borehole
incl. observation hole	8,000/borehole

APPENDIX 5

Persons Interviewed

Persons Interviewed

S. Baker	General Engineering Officer, USAID*
K. Basaako	Counterpart, Senior Public Health Engineer, Urban and Housing Division (U&H), Ministry of Local Government and Lands (MLGL)*
B. Bellard	Senior Engineer, Urban and Housing, U&H, MLGL*
R. W. Bowyer	Principal Finance Officer, Finance Unit, MLGL
E. Dipate	District Sanitation Coordinator, Kgatleng District
J. Gadek	Senior Public Health Engineer, U&H, MLGL*
D. Green	Planning Officer, Planning Unit, MLGL*
T. Gregory	Director, Department of Town and Regional Planning (DTRP)
R. Hackman	Housing Officer, U&H, MLGL
M. Horner	Housing Officer, U&H, MLGL
D. Knepper	SHHA Technical Officer, Gabarone Town Council
J. Letsholo	Planner, Department of Town and Regional Planning (DTRP)
N. Mbere	Senior Sociologist, Applied Research Unit, MLGL
S.T. Muzila	Housing Officer/C, Urban and Housing, MLGL*
C.T. Orapeling	Senior Administration Officer, U&H, MLGL*
S. Pathmanathan	Town Engineer, Gaborone Town Council
C. Sayles	Director/Manager, Water Utilities Corporation
A.A. Stanley	Urban Development Coordinator, U&H, MLGL*
B. Tlale	Administration Officer, U&H, MLGL*
J. Wareus	Planner, DTRP
J. Wilson	Economist, Ministry of Finance

* Member, Consultancy Reference Group

APPENDIX 6

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