MINISTRY OF FOREIGN AFFAIRS DANIDA

FIVE DISTRICTS WATER SUPPLY AND SANITATION PROJECT

Consultancy Services for :

DPHE - DANIDA URBAN WATER AND SANITATION PROJECT

BANGLADESH

DRAFT

(in-complete)

TECHNICAL REPORT

SANITATION

(mission 2)

PUBLIC TOILETS AND COMMUNITY LATRINES

Review and Evaluation of Existing Designs
Proposals for New Design Concepts

November 1997

Danida reference no : J.nr.104 Bang 174
DHV file no : L4081.01.001
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prepared by :
DHV Consultants
Aqua Consultants & Associates Ltd
DEVCONsultants Ltd

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EXECUTIVE SUMMARY

This document reports on activities completed during two missions on sanitation for the Five Districts Water Supply and Sanitation Group (5DWSG), which contributes to the DPHE-DANIDA Urban Water and Sanitation Project Bangladesh.

The main objective of the Project is to contribute towards improved public health conditions through the provision of safe drinking water and environmental sanitation.

The primary task of the sanitation component of 5-DWSG is to analyze current designs of public and shared sanitary facilities and, within the framework of sanitation improvement, develop these to more sustainable units, that also serve, women in a proper way.

Work during the first mission focused on evaluation of general and existing design documentation and on the preparation of appropriate criteria and starting points for design. The second mission subsequently prepared detailed designs with tender documentation of four standard types of public toilets for the larger towns and four down-sized units for smaller towns.

Socio-religeous requirements that have to be adhered to and the need for a more private access for women to a public facility appear to have considerable influence on the lay-out of these units, to such an extent that four distinct layouts had to be developed.

Soil texture in the Project Area in general is not particularly suitable for infiltration of large amounts of wastewater. Overflow water from the septic tanks might have to be discharged to streams or ponds. Several options for additional treatment of the effluent before final discharge are discussed in this report. Two types of filters could be useful in this respect, a shallow field planted with reed and an additional compartment to the septic tank, in which effluent receives further an-aerobic treatment. It is suggested to set up a pilot test unit for this so-called an-aerobic upflow filter.

The options presented take into account that the amount of wastewater overflowing from the septic tank of a public toilet is small and does not justify a piped sewer system with wastewater treatment system. As long as no use can be made of a public sewer and when infiltration is not possible, alternative solutions might not be ultimate solutions but improvements with regard to current conditions.

However all alternatives considered here do realize the main objective of sanitation, which is to prevent people to come too easily into contact with fecal contaminated matter.
The report includes proposals for the improvement of the infiltration facilities at existing communal latrines; the suggestions could be applied also for new latrines.

Public Sanitary Facilities - Summary of Capital Investment Cost:

Public Toilet	Type A-1 [5+2 seats - 6 urinals]	Tk.	000
	Type A-2 [3+2 seats - 3 urinals]	Tk.	000
Public Toilet	Type B-1[5+2 seats - 6 urinals]	Tk.	000
	Type B-2[3+2 seats - 4 urinals]	Tk.	000
Public Toilet	Type C-1[5+2 seats - 6 urinals]	Tk.	000
	Type C-1[3+2 seats - 3 urinals]	Tk.	000
Public Toilet	Type D-1[5+2 seats - 6 urinals]	Tk.	000
	Type D-1[3+2 seats - 4 urinals]	Tk.	000

1 INTRODUCTION

1.1 General

This is the final report on Public Sanitary Facilities of the Five Districts Water Supply and Sanitation Group (5-DWSG). The 5-DWSG covers specific consultancy services for the DPHE-DANIDA Urban Water and Sanitation Project.

The DPHE-DANIDA Project is carried out under the Agreement between the Government of the Kingdom of Denmark and the Government of the People's Republic of Bangladesh signed on 22 December 1996. The project concerns urban water supply and sanitation in Patuakhali, Barguna, Noakhali, Laksmipur and Feni districts.

The development objective of the DPHE-DANIDA Project as formulated in the Agreement is to provide :

> *"a contribution towards improved health conditions of the target communities through the provision of safe drinking water and environmental sanitation services with particular emphasis on sustainability of the systems"*

1.2 Objective and Scope of the Sanitation component of the Project

Main objective of the Sanitation component of 5-DWSG is to evaluate design and operation of the public toilets and community latrines, constructed under Phase 1 of the DANIDA/DPHE project and recommend improvements to the final disposal of sludge and wastewater. Particular attention is to be paid to the lay-out of the public toilet, aimed at providing more privacy to female users of the facility.

The scope of the sanitation component is described in the Terms of Reference as follows:

- evaluation of public toilets designs
- preparation of standard tender and contract documents for Public Toilets
- review of community latrines
- proposal of new design concept for community latrines

This scope of work has been discussed and worked out in more detail in a meeting between DANIDA/DPHE and 5-DWSG on April 28, after which a work plan was prepared.

The activities and final output of the 5-DWSG Sanitation component consist of :

First Mission (May-June):
- evaluation of existing designs of public toilets
- proposals for modification complete with cost estimates
- proposals for disposal options for public toilets
- outline standard BOQ, specifications and contract

- **review of existing design of community latrines**
- **proposal for modification of community latrines**

Second Mission (October-November):
- Detailed design for public toilets
- BOQ for public toilets
- Technical Specifications (in English)
- Technical Specifications (in Bangla)
- Conditions of Contract (in English)
- Conditions of Contract (in Bangla)

1.3 Lay-out of the report

The Report is organised in six chapters and a number of Annexes. This section contains brief descriptions of the chapters for easy orientation of the reader.

Chapter 1 gives an introduction to the sanitation component of the Project, with objectives, scope of work, expected output and bar charts of activities and personnel.

Chapter 2 reports results of the initial review of existing design documentation and discusses findings of field inspections.

Chapter 3 explains the impact of some particular socio-religeous aspects on the design of sanitary facilities and analyses surveys of the Socio-Economic group, performed during Phase 1 of the Project.

Chapter 4 provides information on soil texture and permeability, prevalent in the Project Area and relevant for subsurface infiltration of wastewater.

Chapter 5 contains criteria and starting points for the design of the components of public toilet facilities, shows the calculations, gives final dimensions and recommendations for materials and construction. The chapter includes alternatives for the disposal of septic tank sludge and effluent.

Chapter 6 presents Capital Investment Cost for four large and four smaller public toilets with separate septic tank and soak-away, if technically feasible. The Outline Design drawings are included in the last Annex of the Report.

2 EVALUATION OF DOCUMENTATION, DESIGNS AND FACILITIES

2.1 Introduction

The first activity of the Mission has been the collection of existing documentation, designs, criteria and starting points, technical specifications currently in use and specific experience gained during the construction and operation of public and shared sanitary facilities. The Mission paid field inspection visits to public toilets and community latrines in Chaumohani and Laksmipur, constructed under Phase 1 of the DPHE-DANIDA project.

In the course of this data collection and review effort, discussions have been held with Technical and Socio-economic Staff of the DANIDA Advisory group in Dhaka and with field staff in Noakhali. Field coordinators from the Noakhali office accompanied the Mission on the field visits.

The Mission further collected information from AQUA, the consultant involved in Phase 1 of the Project and in charge of the design of public toilets and community latrines. Similar visits have been made to the 18 District Towns Water and Sanitation Project (18-DTP), to the Secondary Towns Infrastructure Development Project - II (STIDP-II) and to the 9 District Towns Water Supply and Sanitation Project. All projects have the design and construction of sanitary facilities included in their activities.

Dhaka City Corporation (DCC) is currently constructing 33 public toilets and some of the units have been visited.

Discussions with DPHE staff of the Planning and Design units, with WHO experts involved in sanitation and with engineers of the Meghna Estuary Study and the Land Reclamation Project LRP on soil characteristics in the Project Area completed data collection.

Additional information on alternative wastewater treatment and disposal methods was obtained from the Bangladesh Council of Scientific and Industrial Research, Institute of Fuel Research, on the possibility of applying biogas tank technology using human waste and from the Duckweed Research Project, on utilizing human wastewater to grow green fodder for fish breeding. Both options are being implemented already in Bangladesh, usually in clearly rural settings; it must be studied further whether these technologies might be useful alternatives for the smaller towns in the Project.

2.2 Field Visits to Chaumohani and Laksmipur

The DPHE-DANIDA Phase I project constructed in Chaumohani and Laksmipur 11 public toilets near markets and bus stations and 6 community latrines in areas where individual household latrines could not be constructed for lack of space.

The initial Phase 1 design of public toilets concerned aqua-privies, where toilets are constructed on top of a tank; the design was abandoned in favour of a toilet building with separate septic tank and soak-away and with one toilet for female users.

Designs for the community toilets differ not in selected technology but show a variety of construction materials and two different roof constructions to bring down costs.

All types of facilities have been visited and findings have been included in the Field Visit Report May 1997, which also gives a photographic impression of the units.

All sanitary facilities experience problems with de-sludging of pit/tank contents and with the infiltration of (overflow) wastewater. Causes, possible solutions or alternatives are discussed in separate sections of this report.

2.2.1 Toilet building with Aqua-privy and Soak-away

Although this type of facility is replaced by the off-set septic tank option, it still might be considered if the plot for a sanitary unit is too small for a toilet building with septic tank and soak-away. There are however points that need attention during construction and operation. If the facility is used less than intended or if the tank is not fully watertight, the water level in the tank may fall to below the water seal of the pans and methane gas could enter the toilet room; besides odour and flies may become a nuisance.

Some observations that are useful for the design of other types of facilities as well are:

- the size of the toilet room is too small for a comfortable use
- the orientation of the toilet pan has been changed, compared to the construction drawings, in order to meet the preferred North-South direction; the location of the pan now is not optimal
- the pan is a full-flush type that needs at least 4 liter of water; a pour-flush pan with a slope of 25^0 to 30^0 requires half that amount, hence considerably less water needs to be infiltrated; it is doubted that the design of the soak-away is made for this higher wastewater production
- the ceramique pan has no integrated foot rests; the separate steps cause more joints in the floor and make the set difficult to clean
- the toilet pan is above floor level, which makes cleaning of the floor more difficult; the type with a pan. level with the floor is preferred
- vent pipes and concrete columns in the toilet room create places hardly accessible for cleaning
- the connection to the electricity network is below standard and was found inside a toilet room; the connection and meter should be in a lockable room (for instance the store) and not accessible for users

-

- light and ventilation is by far not sufficient

- steel doors and frames are not suitable for this always wet environment

- the GS pipes to the roof tank stand free without any support; fixing to the wall is better and also looks more professional

- the outside washing basin stands on brickwork columns, the floor below is difficult to clean; a slab between the walls, incorporating the basin would leave the floor free

- the manhole cover on the soak-away is difficult to make to an acceptable quality as per current design; a cast iron frame with cover would solve that problem, but still require better supervision of construction

- the soak-away is high above ground level; the upper part is closed masonry, the below ground part consists of honey comb brickwork; this lower part - intended for infiltration of overflow water from the unit- is filled with sand and gravel; it is unlikely that water will reach the lower part of the pit as the top of the sand/ stone fill will easily clog and become impermeable, as problems experienced with infiltration with these pits have demonstrated.

- site selection needs all the attention of Project Staff and Client; a unit constructed in the wrong location will not attract sufficient users for a financially feasible operation, hence find no lease holder and will not create income and operational funds for the Municipality (Pourashava)

2.2.2 Toilet building with Septic Tank and Soak-away

Experience with the aqua privy led to a complete overhaul of the design concept and to the decision to include urinals and a separate toilet for women. The Mission visited two of these new facilities in Laksmipur. Many of the above observations apply also to the adjusted design;
the following general notes can be considered for design improvements:

- the caretaker partly blocks the access to the women's toilet

- entrance to male and female sections should be clearly separated

- a change in the orientation of toilet pans, probably during construction, resulted in some poor toilet room lay-outs and to a problematic connection to discharge sewer pipes

- doors need a handle on the outside and a heavy duty lock on the inside to withstand frequent use
- the wash basin in the ladies toilet is not very attractive; the connection of the water tap to the wall needs a wall plate and the water main must be in the brickwork; the same applies to the male section

- **outside urinals might conflict with the general urban environment, are impractical during the rainy season and deter women to approach the toilet building**

- the cast iron covers on the septic tank are not above but aside the T-pieces on inlet and outlet pipes; it will be difficult to inspect the T-'s and to remove blockages by scum from these pipes

- the septic tanks lack a vent pipe

2.2.3 Community Latrines

The community latrines consist of a block of four toilet rooms, with two or four soak pits.
Again some general observations that must be considered in future designs:

- All soak pits were found overflowing (often from a hole made in the back of the pit just above ground level) although they had been emptied in the last five months.

  As the groundwater table is low at the end of the dry season, which was confirmed by low levels in nearby streams and ponds, the most likely explanations include too shallow pits, too small volume pits, a low permeability of the soil, wastewater production larger than design flows and combinations of these factors.

- the pits are connected to two toilets, or in one case four pits serve three (or four ?) small pits; the lay-outs suggest offset twin leaching pit designs, but the switch boxes do not function;
  both (or all four) pits are filled simultaneously and there are no extra pits to be taken into operation when the first sets are full; the design concept is not clear, direct single pits or double leaching pits

- the switch boxes, where available, are covered by heavy concrete slabs and hardly accessible for operation or maintenance

- the PVC-U pipes between latrine and leaching pits are protected by a concrete layer; the heavy concrete might become a cause of damage in itself

- the design of the latrine building and the materials used are simple but cost effective, without sacrificing function or ease of use and cleaning;

  the galvanized iron sheet used as door cover could be painted to delay rusting and improve appearance

- one community latrine has a concrete roof and separation walls up to the ceiling, the other walls up to door level and a roof constructed with galvanized corrugated iron sheets; the latter solution is fully acceptable in a peri-urban setting, has better ventilation and light in the building and is more economical

- one of the latrine blocks had cement mortar floors and walls; it is suggested to use terrazzo (mosaic) for floors and at least plinths but preferably also the walls (lower 1.50 m) with mosaic finishing to ease cleaning

- the same latrine also had cement mortar footrests; a pan with integrated steps is preferred, again for ease of cleaning

- doors need a better lock on the inside

2.3 Review of Design Documentation

2.3.1 General observations

While reviewing the designs of public toilets, septic tanks, soak pits and community latrines. used in various sanitation projects over the last ten years, a striking similarity was found, possibly because the same local consultant was involved in all these projects. It was relatively simple to collect the concept and construction drawings, somewhat harder to find criteria and starting points on which the designs had been based. It appears that components of sanitary facilities have standard sizes based on total number of users only; actual wastewater production, soil permeability, -seasonal- groundwater table and flood levels, means of de-sludging and possibilities of discharge of effluent in an acceptable way seem not to be taken into account.

The designs probably do not consider toilet building, septic tank and soak-away as elements of one system that operates under gravity flow; the drawings show elements but not the complete system with interrelated levels.

As designs are so similar, it is of little use to discuss each of them separately: the following observations therefore follow mainly from the Phase 1 designs but occasionally include findings related to the 12 Towns Project, the 18-DTP or STIDP-I designs that are relevant for an improved design.

- standardization of the design of the aqua-privy led to a rigid use of just this one design in all locations; designs must be flexible to meet specific site conditions or more designs must be made

- not taking into account the preferred north-south orientation of toilet pans resulted in poor adjustments during construction. changes of which the designer most likely was (and will not be) informed; designs of sanitary facilities must take this requirement into account, simply adjusting the direction of toilets on a plan is not sufficient.

- the Lay-out Plan, must show the location of the access (road) for a de-sludging vehicle, the distances between the components and the lay-out of connecting piping

- one of the detailed design drawing must show a section over all components of the sanitary facility (toilet building, septic tank, soak-away, final disposal) and give levels of the components and their connecting piping, relative to Finished Ground Level (FGL), which is related to the average flood free level

- temporary flooding of parts of the Project Area must be expected; the design must indicate Original Ground Level (OGL), Finished Ground Level (FGL) and the Plinth Level (PL); the latter has a freeboard to OGL

- the drawings should give invert levels of all inflow and outflow pipes and of final discharge level

- the drawings should include information on level, frequency and duration of flooding of the area where the sanitary facility is planned

2.3.2 Public Toilet - Toilet Building

- a sink must be included in the floor; floors sloping towards it for easy cleaning

- wooden door frames start at floor level, hence are constantly wet; the frames should be on a plinth to prevent rot.

- internal plumbing is not complete

- sewer pipes to septic tank / soak-away often lack the indication of essential elevations

2.3.3 Public Toilet - Toilet Room

- all designs show inside opening doors; this saves space in the building but makes entering the small room and especially closing the door complicated

- the drawing must indicate whether a pour-flush pan or the more water (and larger soak-away) requiring full-flush pan is intended

2.3.4 Public Toilet - Septic Tank

- the septic tank has three compartments: this lay-out is normally selected when also sullage (wastewater from bathing, washing clothes and from the kitchen) is discharged to the septic tank: sullage is then discharged to the second compartment in order not to cause turbulence in the first room and disturb the settling process. The public toilets do not produce sullage, hence there is no reason for three compartments. The separating wall is neither essential nor beneficial, it can be left out.

- **the septic tank has brickwork walls; in this case the drawing should indicate the distance a de-sludging truck should stay free from the tank, or better, indicate the location of the road related to the septic tank**

- the outlet pipe must be below the level of the inlet pipe to make good for hydraulic losses in the system

- the finishing of the floor in each compartment slopes to one side; there is no good reason for this, septic tanks need not to be washed nor cleaned out completely, in fact some of the sludge should be left to quick-start the biological decomposition process again after de-sludging; the finishing can be left out

- the lower two/third of the first compartment is intended to collect settlable sludge; the opening in the partition wall is at this maximum allowable sludge level in the tank

- the T-piece on inlet and outlet pipes can become clogged by scum (the floating material in a septic tank); regular inspection/ cleaning is required which needs small covers not aside but right above the T-pieces

- the 450 mm manholes near the T-pieces can be replaced by 200 mm covers

- the 450 mm manhole in the pit cover must be replaced by two 600 mm manholes, one for each compartment. to improve accessibility

- there is no vent pipe on the septic tank; a short pipe with two elbows and screened ends must be included in the design

2.3.5 Public Toilet - Soak-Away

- the pit is filled with sand and graded broken bricks up to the top of the honey comb masonry, for which no reason could be given nor found; the pit should be left empty; a fill, if any, should be around the pit

- there is a concrete ring with a sharp end at the bottom of the pit wall; the ring cuts through the soil while excavating the pit; the device is very useful when the groundwater table is high; masonry is added on top gradually and left to harden before excavating further

- the ring gives support to the masonry as well but unfortunately will also effectively smear soil along the pit wall and substantially limit the infiltration capacity of the unit; excavation must be done in dry soil, so when the groundwater table is low, the pit wall must be left rough (see also section .....)
  a concrete ring is still required as a foundation for the brickwork, but the knife-like shape is not necessary anymore

- the drawing indicates an extension of the inlet pipe (dotted lines); no explanation could be given, the pipe can be omitted

- there is an outlet pipe in the soak-away, well above the inlet pipe, with a T-piece outside the pit and at ground level; the T-piece is closed on both ends; the function of this closed outlet could not be clarified; the pipe could be an overflow, to be connected to a drain in case the soak-away would fail; the use of an emergency overflow is discussed in the section on soak-aways

- the 450 mm manhole in the pit cover must be replaced by a 600 mm manhole

2.3.6 Community Latrine - Toilet Building

- Comments on the community latrine have been included in section 2.2.3.

2.3.7 Community Latrine - Leaching Pit

- a seasonally high groundwater table does not hinder the breakdown of fecal matter in a leaching pit; the pit however must be given larger dimensions to have sufficient area for infiltration of liquid into the soil and to handle peak discharges of wastewater

- the contents of a leaching pit in the Project Area might not reach the normal density because of the high groundwater table or even flooding; digging out the contents might not be possible. the concrete top of the pit must have a 200 mm cover to ensure quick access to the pit for the hose of a vacuum tanker truck

3 SOCIO/ RELIGEOUS ASPECTS

3.1 Orientation of sanitary facilities

Daily life of a great part of the population in the Project Area is regulated or influenced by cultural/religeous rules, codes or habits, to such an extent that also the design of a public sanitary facility is affected.

The majority of the population in the southern part of Bangladesh does not accept a toilet in east-west direction, but insist on a north-south orientation; this applies to both toilets and urinals (Reference: Sahih Al-Bukhari, Hadith Book 1, translated by Mr. Moh. Muhsin Khan. The English translation mentions that (for Bangladesh) a person should be in north-south direction when defecating or urinating ". . . if in the open . . ." The addition could mean that the restriction does not apply to a closed area like a toilet room; nevertheless, people's perception is taken as the more relevant guideline for current designs.

This starting point for the design of a public toilet clearly influences the lay-out of a toilet building; conflicts occur with the location of the squatting plate and the position and proper functioning of the sewer pipe if not given attention during the initial design. The necessity to design in north-south direction obviously also influences the floor plan of the toilet building, the lay-out of discharge pipes and in some cases the location of the entrance.

If the size and shape of a plot of land selected for a toilet building allows for it, the building can be constructed in the proper direction without changes to the design; only one standard design would be sufficient to cover all possible sites. In most cases however, land is not abundant or available at choice and the design has to follow size, shape and orientation of the plot on offer.

Figures A/D-1/2 show that the designer can satisfy the orientation requirement for different plots mainly by changing the direction of the squatting plate. The toilet room has to be made slightly larger and the location of the sewer pipe related to the foundation must be adjusted to be able to use the standard lay-out of the room.
The plan of the toilet building itself however needs more changes for different orientations of the plot.

The conclusion is that it needs three distinct and one mirrored standard designs to comply with requirements on the orientation of persons during defecation. If only one design is provided, un-authorized changes will be made during construction of the facility, also when this leads to a problematic connection to the discharge sewer or to a poor location of the squatting plate, as was observed during field visits.

3.2 Toilet unit for women in a Public Toilet.

A large part of the female population in the Project Area is assumed not to leave the house if not accompanied by their husband or a male member of the family who then is intermediary when she has to deal with a man, for instance with a male shopkeeper.

Although the rules are relaxing a bit, dealing with the caretaker of a public toilet might be too much too fast.

The caretaker collects fees from the users, usually at the entrance of the building used by men. The Consultant suggests that women are not requested to pay for the use of a public toilet, which means that they can avoid the caretaker and the male entrance altogether. The loss of income will be negligible.

An other item that needs attention is the fact that women (feel that they) should not be seen by men when they enter a public toilet. This means that it is not sufficient to have a separate entrance for women, the entrance should also be away from the entrance used by men and not directly along the road. It is not so much a separate entrance but a separate access to the toilet building that is required to let women feel more comfortable.

Findings of a CARU survey (Lit. C- 02) illustrate the phenomenon. About 8% of the owners of a private sanitary latrine not even use their own (outside) facility for lack of privacy: they feel uncomfortable and embarrassed.

A separate access for women has a considerable impact on the floor plan of a toilet building.

3.3 CARU Surveys - Findings and Recommendations

Much information on the use of sanitary facilities has been collected in the course of Phase 1 of the Project in Chaumohani and Laksmipur by the Communication and Action Research Unit (CARU) of the project. Annex 2 - Literature gives an overview of the for public and community sanitary facilities most relevant publications of the unit. Items that must be taken into account when designing these facilities are summarized and briefly discussed hereafter.

Report C-04 gives an inventory of the number of females, possibly including employees, observed in a market area and compiles the opinion of shopkeepers and female employees/visitors on the need for a toilet for women. The survey found per day about 70 females' potential users in the area. Actual users will be much lower, which means that in a market area one toilet for females seems to cover current need.
A separate room and entrance are mentioned by all. One of the recommendations is to engage a full-time female caretaker/sweeper. If this suggestion is followed, a place for this female caretaker must be allocated as well as an extra store for cleaning equipment.

Report C-06 mentions that about 30 % of the water seals in latrines is broken and that this number increased compared to earlier surveys. Blockages of the seals apparently occur and are solved in a rather destructive way, probably using sticks. The high number of broken seals could indicate that families use as little water for flushing as possible (as they know that infiltrating water will not be easy).

Broken pans have been seen also during recent field visits by the Mission, both in public toilets and in community latrines. Caretakers and users should be made aware

of the rather brittle material pans are made of. A broken seal means fly and odour nuisance usually followed by a fall in use of the facility; a hand made stopper could solve that only partly.

Report C-07 gives the actual number of visitors to four public toilets in Laksmipur on market and non-market days. All facilities included one toilet for women; the surveys took from 5 a.m. to 10 p.m. in November 1995

A remarkable outcome of the surveys is that there is no difference in the number of visitors on market and non-market days, which could lead to the conclusion that the facilities are used mainly by shop owners and their personnel. On average 1,250 male users and 4 female users were observed; two units had no female users at all, the third only one. The units do not show peak hours.

The caretakers of the public toilets visited by the Mission in May 1997 indicated that women are still not using the facility.

The number of users varies between 20 to 160 visitors per day and per seat. The facility with 160 users/(day.seat) also showed the highest level of not satisfied users, who mentioned not clean and bad smell and little privacy -the unit is located along a road and facing the road- as main reasons. The large number of visitors might explain part of the problems: 35% of the male users is using the toilet for females, which indicates that the capacity is not sufficient, in other words that one seat cannot satisfactorily serve 160 users per day. Not surprisingly the caretaker cannot keep the toilets clean during the day with this high number of visitors.
Two other units had 80 to 90 users/(day.seat) with few complaints related to capacity, although the time available per user is rather limited.

The survey again made clear that siting of the entrance is important, not only for women. Future designs should locate the toilet rooms inside a building or behind a wall facing the road.

Report C-08 gives results on the use of community latrines. The survey shows that the overhang latrines in the area disappeared, which means that the new community latrines are used. The number of families using the facility varies between 10 and 40 (60 to 280 persons), the number of actual users between 30 to 60.
The number of users per family that can be calculated from these data shows that on average not more than 1.7 members out of each family make use of the community latrine.
It is recommended to allocate a four-seat community latrine to not more than 20 families (about 100 to 140 persons), leaving some capacity free for families that later might join.

Report C-02 recommends to focus in the promotion of latrines more on hygiene as a reason for buying a latrine. Hygiene and health no doubt are the important reasons why sanitation programmes are implemented, but convenience, privacy and status are the more likely and more effective motivators for families to buy and later start using a latrine, not so much health aspects.

4 SOIL CHARACTERISTICS - GROUNDWATER TABLE

The field surveys showed that all public toilets and community latrines have problems with the infiltration of sewage or overflow water. It was reported (Ref. C-06) that 96 % of household latrines, with one direct pit still did not require emptying after 2-3 years of operation, which shows that the small amounts of water from household latrines still can be infiltrated. The amount of water to be infiltrated from the larger facilities apparently exceeds what the type of soil allows to. It was reported that no infiltration tests have been carried out, hence the permeability or the long-time infiltration capacity of the soil is not known.

The Mission collected some soil samples in Chaumohani during the field visits; soil texture from feel and appearance tests indicate silty clay loam.

It is suggested to perform infiltration tests as a matter of routine as soon as a site for a public toilet or a community latrine has been allocated. The results should provide starting points for the design of soak-aways and leaching pits or, if not successful, indicate the need for alternative disposal options.

Soil characteristics:
Chapter 5 discusses various options for the handling of effluent from septic tanks; infiltration plays a role in most of these options. It was considered useful to have some idea of soil characteristics in the Project Area beforehand and then concentrate on the technically feasible solutions. The following sections summarize this preparatory work.

Experience gained in Laksmipur, Noakhali and Feni Districts during Phase 1 of the Project, points to a limited infiltration capacity of the soil. That information is confirmed by results of test borings and infiltration tests by the LRP project between 1980 and 1990 (Ref. G-10 and G-11). The project is situated about 20 km south of Noakhali and results are considered applicable in general also the Project Area, taking into account the geological history of the area.

Useful information on soil in Pathuakali and Barguna Districts can be obtained from a nationwide Reconnaissance Soil Survey, results of which have been re-printed by the Soil Research Development Institute, Ministry of Agriculture in 1990 (Ref. G-09).

The information from the two agriculture related sources is very useful as it provides more detailed information on the upper few meters of soil, where infiltration takes place, than bore logs generally do.

In general it can be said that the soils are relatively young alluvial soils. Although overall profiles have much in common, significant differences may occur. The predominant soils in the area are Fine Sands, Silty Clay Loam and Silty Clay, all with low to very low permeability. It is known that these types of soil are easily smeared during handling, for instance when digging a pit or trench in wet soil; tests by the LRP project confirmed this. The project found that infiltration capacity decreased by 50 % compared to virgin soil.

Ref. 12 and Ref 13 on respectively Maijdee and Barguna indicate clay for the first few meters, followed by silty clay and thin lenses of fine and very fine sand.

As mentioned before, actual design of a shallow or deep infiltration facility, should be preceded by percolation tests; until then, the infiltration rates listed in table 4.1 can be used for approximate calculations for soils in the Project Area. Annex 4 presents infiltration test methods.

Table 4.1 Long-term application rates of Septic Tank Effluent on Subsurface Infiltration Systems

Soil Texture	Percolation Rate (measured in test pit) [min/cm]	Infiltration Rate/ Long-term Application Rate for design [l/m^2.day]
- fine sand, loamy sand	2.4 - 6.0	32
- sandy loam and loam	6.3 - 11.8	24
- loam, silt loam	12.2 - 23.6	18
- silty clay loam	24.0 - 47.2	8 - 10
- clay loam	-	< 10; not suitable

Soils with infiltration rates below 12-10 l/m^2.day are usually considered unsuitable. Considerable part of the Project Area is expected to be near this range.

As topsoil in the Project Area is clayey or silty clay and the subsoil layered, a deep infiltration facility might reach more of the -in general thin- sandy layers and accept higher application rates. A deeper pit will for this reason have a higher chance of partly becoming dry, at least during the dry season. Aerobic bacteria will then be able to regenerate the infiltration capacity of pit walls by absorbing particles that entered the wall and there formed a clogging mat.

Groundwater Table

The groundwater table is another important element in the construction of leaching pits and soak-aways for infiltration of sewage or overflow water. Water table hydrographs over a ten year period show the for the Project Area familiar features:

- rapid rise in May-June, when the first rains recharge the groundwater reservoir
- a more or less stable groundwater table in the monsoon from June to October, when 80 % of total annual rainfall occurs
- groundwater table nearly at ground level during most of the main rainy season
- rapid fall in November-December when the rains have stopped
- groundwater tables go down as low as 3 meter, occasionally even 5 meter below surface level by mid February-March (pre-monsoon)

There is little room for water in the small pores between the soil particles, so not much water moves when the groundwater table falls. Vertical change in water table is mostly due to capillary forces and there is little horizontal groundwater flow. Air enters soils with these small silt and clay sized particles only with great difficulty. It was observed that a soil/air volume of 5-10 % is reached only after the groundwater table falls to 2 to 3 meter below ground level.

Patuakhali and Barguna Districts are located on the so-called Old Lower Meghna tidal flood plain. The deposits are predominantly clays with large areas of silty clay loams around Bakerganj, some twenty km north of Patuakhali. The deposits are almost uniform in texture for the upper 1.50 meter, overlaying more silty material below.

Monsoon tidal floods make the influence of the tide felt as far north as the town of Barisal. All rivers in the area are tidal in the dry season. The entire area is subject to flooding in the monsoon season, by fresh (rain) water. Daily tidal range varies between 2.40 m in the south to 0.9 m in the north. The land is almost level at about 1.50 m above mean sea level. The ridges on the flood plain are flooded for the greater part of the rainy season at depths between 0.60 to 1.50 meter.

Infiltration versus Groundwater Quality

Infiltration of effluent from a septic tank is the preferred on-site solution for the disposal of this overflow water, as there neither is, nor will there soon be a piped sewer system with wastewater treatment plant in the Project Towns. Effluent can be infiltrated without affecting groundwater quality if the seasonal high groundwater table is about one meter below the bottom of the pit.
It will not be possible to always meet this last condition in the Project Area; for half the year the water table will be near or at ground level in many places.

The situation can be accepted if the shallow aquifer is not used as a source for water supply; shallow in this context means the upper few meters. The Project plans the construction of 150 to 300 m deep production wells to replace the shallow tubewells currently in use and to be abandoned just because of their already unacceptable water quality. Safe piped water supply will thus be made available for the population, in the Project Towns.

There might still be objections against infiltration of effluent, but it should be considered, that infiltration of the relatively small amounts of effluent from a public toilet in the upper few meters of the subsoil will hardly influence the already poor quality of the shallow aquifer.
Keeping a safe distance to hand-dug wells, might these still be used, should be sufficient safeguard.

Biological contamination of ground or ground water by the infiltration of effluent has been studied extensively. Bacterial movement through soil systems depends on soil permeability and groundwater flow. Coliform (and other) bacteria tend to move mainly horizontally, away from the infiltration pit and in the direction of groundwater flow; vertical infiltration occurs at a much smaller rate. Soil in the Project Area has a very low infiltration rate because of the fine soil particles and the low porosity; groundwater flow is very slow and might in tidal areas even be close to zero.

It is unlikely that bacteria under these soil conditions, even in saturated soils will travel much faster than the infiltration rates for the soils of 1 to 2 cm/day. The soil will be an effective barrier to the movement of pathogenic organisms. A distance between an infiltration facility and a hand-dug well of about 10 m should be sufficient.

5 CRITERIA, STARTING POINTS AND DESIGN OF THE COMPONENTS OF A PUBLIC SANITARY FACILITY

5.1 General

The sanitary facility proposed for Project Towns consists of a toilet building, a septic tank and where possible some type of infiltration unit, with or without additional treatment of the septic tank effluent.

There have been two facilities designed; Type 1 one for larger groups of users an Type 2 for towns or public places with lower numbers of possible users.

In addition, attention has been given to the proper orientation of the toilet pans, resulting in four different floor plans (types A, B, C and D).

The total number of designs thus comes to eight, Types A/D-1 and Types A/D-2

5.2 Toilet building

Important design considerations for a public or shared sanitary facility are good ventilation, abundant access for daylight and construction materials that are hard and smooth to allow for easy cleaning.

Significant additional requirements in Bangladesh are private entrances to the section for women and strict adherence to the preferred north-south orientation of toilet pans and urinals.

Appearance of the building is a quality that is often overlooked but evenly important. A bright colour scheme for outside walls and interior is not more expensive than the usual dark brown/red for brickwork and dull dark gray for doors; some green plants between the building and the plot boundary along the street (a distance of 1.50 m is required anyhow) might make a difference in acceptance of the facility.

The following summary gives social and technical criteria and considerations that have been used for the design of the public toilet facility:

Design Capacity	:	60 persons/ (seat.day)
Number of seats	:	Type A/D-1 5 for men, two for women
		Type A/D-2 3 for men, max. 2 for women
Type of toilet pan	:	(tropical) squatting pan, level with the floor, suitable for pour-flush (bottom slope 25^0 - 30^0)
Urinals	:	squatting type, level with floor
		Type A/D-1 6 urinals
		Type A/D-2 3 or 4 urinals
Type of flushing	:	pour-flush; requires 2 liter per flushing
Water supply	:	connection to piped system, with water meter, tap inside the toilet rooms

Back-up water supply	:	roof tank of 1,000 liter for Type A/D-1 600 l for Type A/D-2)
Hand wash basin	:	2 units in male section 1 unit in female section
Store	:	1 locker for cleaning materials
Electricity	:	connection to network, with electr. meter

The standard size of the toilet room has been chosen at 1,200 x 1,400 mm, which allows adjustment of the direction of the toilet pan to the orientation of the plot/building without changing dimensions. The size is also convenient for pregnant women.

Early results of sociological field surveys suggest a possible need for more than one toilet for women for a public toilet at a bus station. The layout of the facility now includes two seats in the women section. For locations other than bus stations one of the toilets must be locked until demand justifies the opening of the second toilet. But also in bus stations it is suggested to start with only one toilet for women and monitor actual use. If use is clearly below design expectations, the sewer pipe might get blocked easily as not much water will be flushed through the pipe.

5.3 Septic Tank

5.3.1 Brief description

A septic tank is the first element in an on-site sanitary system, which partly treats fecal contaminated human wastewater. The system needs at regular intervals removal and final disposal of sludge that settles in the tank after decomposition of fecal matter; the liquid component that passes the tank is infiltrated in the subsoil, or more often, is discharged to nearby surface water, a road-side drain or where available to a piped wastewater collection system that further transports the water to a wastewater treatment plant or a large surface water body.

The septic tank operates without the need for daily attention, but requires regular checks on the accumulation of sludge in the tank and on functioning of the infiltration system or discharge component. Settled sludge in the tank has to be removed about once a year to prevent spill-over and subsequent clogging of the infiltration system.

Options for de-sludging and for disposal of overflow water are discussed in sections 5.4 and 5.5.

The pre-treatment process in the tank finds place for the greater part under an-aerobic conditions and is in tropical climates able to remove 70-80 % of the settleable and suspended solids, reduce BOD (Biological Oxygen demand) with about 30 % and removes 35-70 % of Nitrogen. The process removes only a small part of the pathogens in the raw sewage; 90% of bacteria, viruses, protozoa and worm eggs are still present in the sludge, in the scum (floating layer) and in the overflowing liquid, also called effluent.

Digestion of organic matter in the wastewater is done mostly by anaerobic bacteria, first the simple hydrocarbons, later also the ammonia and nitrogen containing components. The end product is water, carbon dioxide and methane gas; the process takes less time in hot climates. Suspended solids, together with micro-organisms either settle at the bottom of the tank or float to the surface of the liquid.

As the pre-treatment process in the tank requires a retention time of at least 24 hrs, the tank should be big enough to contain the wastewater produced in a day.

An other main function of the tank is withholding the small solid particles that are the end product of mineralizing of fecal matter, as to be able to infiltrate the still harm full effluent in the subsoil filters. The hydraulic characteristics of the tank should therefore be optimal for settlement and limit as much as possible the effect of surges (discharge of wastewater) and temperature gradients. These two requirements form the starting points for design and basically decide size and shape of the tank.

5.3.2 Public Toilets - Design parameters and Considerations

Seat capacity
CARU surveys show a higher number of visits per seat than the 60 persons used as parameter for Phase-1 and current designs. The results indicate a still manageable situation at somewhere near 80 to 90 persons per seat and by far unacceptable conditions when the number of visitors is 160 (but probably already at lower figures). The Project takes a design capacity of 60 persons per seat, assuming that the facility is used for about 12 hours per day and providing for some peak use during the day.

Amount of water for flushing
The public sanitary facility is assumed to have pour-flush toilet pans, that require only 2 liter for flushing the pan; for that the slope of the bottom of the pans is $25\text{-}30^0$.
There are two reasons to adopt a slightly higher figure for design purposes:
- if the wrong type of pan would be installed, about 4-6 liter would be required to have satisfactory results; the situation should be avoided, to limit the amount of effluent
- there is a tap available inside the toilet room, which means that the amount of water used for flushing cannot be controlled effectively; people will be inclined to use more water for flushing/ cleaning the pan to avoid embarrassing situations.

The 5-DWSG adopts for the above reasons a wastewater production of 3 liter per flushing (pour-flush pan). The flat-bed pan is strictly discouraged as it would worsen already considerable problems with the infiltration of effluent. The amount of urine plus flushing is small and not considered for sizing the tank.

It is not expected that the owner/operator of the public toilet facility might install a cistern type flush (10-13 l reservoir to the wall), considering the poor reliability of these units and the additional much larger amount of effluent to be discharged.

Interval between de-sludging
The interval between two de-sludgings of the septic tank is selected at one year, to limit the size and so the cost of the tank; the more common design period is once

every two year. It could however be considered to even further reduce the interval to, for instance, twice a year. The tank would then be about half the size and the cost roughly 60% of the tank as designed. The total cost of the unit would be about 10% lower.

The buffer capacity would then also be halved and there would be two periods a year when the process in the tank is not operating optimally, that is after de-sludging when the biological process is developing again. These disadvantages are considered not worth the slight cost advantage.

Design Capacity

Actual use of the facility might and most possible will be lower than the 60 persons per seat every day, the second toilet for women might not be needed immediately and the other toilet for women might not instantly have the 60 users as per design.

It appeared not economical to take a lower initial capacity into account and construct the facility in phases; the unit is already too small for that. The effect will be that wastewater flows will be lower at first, with the risk of blocked sewer pipes. The operator should close toilets if total demand is considerably lower than design capacity.

The process of sedimentation and BOD removal improves when the tank is under-loaded. Due to the longer retention time; the effluent quality will be better.

01 Design Capacity	:	- 60 persons/(seat.day) (for 12 hr period)
02 Number of seats	:	- Type A/D-1 5 for men - max. 2 for women - Type A/D-2 3 for men - max. 2 for women
03 Design Population	:	- Type A/D-1 7 x 60 = 420 users
	:	- Type A/D-2 5 x 60 = 300 users
04 Flushing requirements	:	- 2 l/ (user.day), theoretically needed for pour-flush type of pan - 3 l/ (user.day), design flush - 4 to 6 l / (user.day), for less economic types - 10 to13 l/ (user.day) for cistern flush - 50 l/ day in total for general cleaning purposes
05 Design wastewater flow	:	- Type A/D 1 420x3 = 1,260+50 = 1,310 l/day
	:	- Type A/D 2 300x3 = 900+50 = 950 l/ day
06 Retention time	:	- minimum 24 hours
07 Sludge accumulation rate	:	- 25 l/ (person.year), assuming: - pour-flush toilets - water used for anal cleansing - no discharge of sullage
08 Liquid depth	:	- minimum 300 mm at tank-full conditions

09 Sludge removal	:	**- when sludge and scum together occupy 67 % of net tank volume**
10 De-sludging interval	:	- about one year
11 Shape of septic tank	:	- rectangular, length over width is 2 over 1 - minimum depth 1.00 m (sludge and liquid)
12 No./size of compartments	:	- minimum 2 with one common wall - compartment 1 - 67 % of total volume - compartment 2 - 33 % of total volume
13 Connection between compartments	:	- two 300x300 mm openings in separating wall - top of opening at 300 mm below water level
14 In and Outlet pipe	:	- 150 mm PVC-U with 150 mm T-piece - outflow inlet below water level
	:	- difference in elevation in/outlet 150 mm
15 Free board	:	- 300 mm above bottom inlet pipe
16 Ventilation	:	- two 100x100 mm openings at the top of the separator wall - double elbow on tank (screened)
17 Sewer pipe	:	- PVC-U, sewer class, diam. 150 mm - slope 1 cm /100 cm between toilet/ septic tank - slope 1 cm / 300 cm for discharge of effluent

5.3.3 Dimensions of the Septic Tank

The capacity and shape of a septic tank is calculated in three steps; first the volume for sludge and scum is calculated, then the volume required for liquid after which the total volume and tank shape is found, as follows:

Sludge and scum storage capacity (S)
$S = P \times N_D \times F_T \times Ss$. in which:

S	is total volume for sludge and scum	- -
P	is total number of users per day	- 420 or 300 persons
N_D	interval between tank de-sludging	- one year
F_T	correction factor for climate	- 1.3 for Bangladesh
Ss	sludge/scum accumulation rate	- 25 l/(person.year)

Type A-1 $S = 420 \times 1 \times 1.3 \times 25 / 1{,}000 =$ 13.65 m^3

Type A-2 $S = 300 \times 1 \times 1.3 \times 25 / 1{,}000 =$ 9.75 m^3

Liquid storage capacity **(L)**
L = P x q x F_R plus wash water, in which:

L	is total volume for liquid at chosen retention time	
P	is total number of users per day	- 420 or 300 persons
q	is wastewater production per person	- 3 l/(person.day) + 50 l
F_R	factor for selected retention time	- 1 if retention time is 24 hrs

Type A-1 L = (420 x 3 x 1)/ 1,000 = 1.26+ 0.05 = 1.27 m^3

Type A-2 L = (300 x 3 x 1)/ 1,000 = 0.9 + 0.05 = 1.00 m^3

Septic Tank Volume and Dimensions (V)

V = S + L, or
V = 1.5 x S if L is smaller than 0.5 x S, which is the case,
hence:
Septic tank volume Type A/D-1: V = 1.5 x 13.65 = 20.48 m^3

Septic tank volume Type A/D-2 : V = 1.5 x 9.75 = 14.63 m^3

Septic Tank Type A-1
Dimensions of the septic tank for the larger Type A-1 public toilet have been chosen at:

- width	:	2.30 m for both compartments
- length	:	4.00 m for the first compartment
		2.00 m for the second compartment
- depth	:	1.50 m net depth of tank contents
- volume	:	first compartment : 13.8 m^3
		second compartment : 6.9 m^3
		total for tank : 20.7 m^3 (> 20.48 m^3)

Septic Tank Type A-2
Dimensions of the septic tank for the small Type A-2 public toilet have been chosen at:

- width	:	1.80 m for both compartments
- length	:	3.60 m for the first compartment
		1.80 m for the second compartment
- depth	:	1.50 m net depth of tank contents
- volume	:	first compartment : 9.7 m^3
		second compartment : 4.9 m^3
		total for tank : 14.6 m^3 (>14.4 m^3)

5.4 Septic Tank - Sludge and Effluent Disposal

The primary function of a septic tank is to take out settleable material from the raw sewage to make it suitable for on-site sub-surface infiltration and to reduce the Biological Oxygen Demand (BOD) of the effluent. The effluent (the water that overflows from a septic tank) has indeed considerably lower levels of suspended solids and BOD than the influent, depending on ambient temperature, retention time of the liquid in the tank and on its hydraulic design. The effluent however is not clear, smells, has a gray to yellow colour and still contains 90% of the pathogenic bacteria.

The overflow water preferably is to be infiltrated on-site, where it finds further treatment while percolating through the soil. If that is not possible because of lack of space, high groundwater table or unsuitable soil, further treatment is needed before it can be discharged to a natural stream. Discharge directly to a road-side drain might be accepted as a financially feasible, albeit temporary measure.

The next sections discuss a number of options available for septic tank sludge removal and for further treatment and final disposal of effluent. The options for handling of effluent are part of four main groups of alternative disposal methods:

5.5 Septic Tank - Sludge Removal and Disposal

5.5.1 General

Sludge settles mainly in the first compartment of the septic tank; some of this sludge comes to the surface again and forms a rather solid floating layer, called scum. This scum is often mistakenly understood to be a sign of a full tank.

The caretaker/ operator of the public toilet must check the sludge level at the bottom of the tank at regular intervals in the presence of an inspector of the Conservancy section of the Municipality. A stick with a piece of white cloth can be used to check the level of the sludge. The stick must be gently pushed down in the tank through the scum until the bottom is reached, then withdrawn. The sludge level is shown on the cloth. The tank needs de-sludging when about two/third 's full.

Current practice of manual de-sludging of the septic tank and almost indiscriminate disposal needs to be improved. Some mechanical way of tank emptying, using a pump will minimize health risks for those involved. On-site disposal of the sludge will not be possible for the selected locations under the Project, which means that sludge must also be transported.

There are several types of de-sludging or vacuum trucks that would serve the purpose. The selection of a vehicle must take into account accessibility of the septic tank. Shared use by a number of Municipalities in the Project Area will make operation and maintenance of the car more feasible.

Final disposal of the sludge can take place on the solid waste dump sites, that are constructed in the framework of the Project. Disposal in Duckweed/ Fish farms, if these are within reasonable distance, or controlled land-spreading if that would be acceptable, are further options.

5.5.2 Mechanical De-sludging

Emptying the large volume septic tanks of public toilets needs some type of machine to remove the sludge from the tank and transport it to a final disposal. When the sludge is removed yearly, the density and of the sludge allows pumping out, using a vacuum pump.

There are vacuum tanker trucks in the market specially designed to empty septic tanks. They combine a sludge tank, a vacuum pump and 3" or 4" hoses. Depending on the make, the tank volume is between 2 to 17 m^3.

With improving levels of water supply in the Project Towns it must expected that more families will opt for the convenience of a septic tank, as long as there is no piped sewer system in the town to collect and discharge wastewater. Hence there will develop a larger need for septic tank emptying services. The vacuum truck procured for the de-sludging of public toilet septic tanks could be used also for servicing private tanks at a certain tariff.

The tanker truck could be operated by the Conservancy departments of a number of municipalities and stationed in the district capital. The institutional aspects of a septic tank emptying service are part of a separate study by 5-DWSG, hence will not be discussed here.

The main specifications for a small vacuum tanker suitable for operation in the Project Area are:

- Car	: 4x4 (also to be able to maneuver at the dump site)
- Tank capacity	: 6 m^3 steel tank
- Tank design pressure	: 2 bar test pressure; working pressure 1 bar
- Vacuum pump	: air-cooled, rated for continuous duty service of 500-600 m^3/h air displacement
- Pump drive	: vacuum pump driven from P.T.O. of chassis
- Sight glass	: sight windows on rear door
- Suction hoses	: 10 No. 3" - 4 m^1 hose (total length 40 m)
	: or flexible 3" hose on a reel
- Tank unloading	: by opening valve at rear door, then opening the door or by a hydraulic tipping ram

5.5.3 Septic tank Sludge Disposal

The sludge from a septic tank contains on average one year old material but also relatively fresh waste with pathogenic organisms, worm eggs etc. The material should not come into contact with human beings, hence methods of collection and disposal should meet this condition.

Land Spreading

Disposal of sludge on farmland is common in many countries, but the option might run into cultural objections. The sludge however has its value as fertilizer and soil conditioner and if acceptable, disposal on land should be considered; there are restrictions on the use of the land. Farmers must take necessary precautions and it might need up to one year before (green leaf) vegetables can be grown on the land, fit for consumption; other produce require less long periods. Also allowing cows to graze on the land has time limitations.

Land spreading is a very economic way of sludge disposal but causes odour nuisance. This can be overcome by injecting the sludge into the soil. The method needs special, rather costly equipment.

The main disadvantage of land spreading in Bangladesh is that most of the land is flooded part of the year, which can cause the contamination of large areas and affect public health. The option for this reason might not be feasible for most of the Project Area.

The recently adopted "Environmental Policy" of the Government of Bangladesh urges the restriction of the use of chemical fertilizers as far as possible and encourages the use of organic manure.

Composting

Compost does not replace fertilizers but it is a good, humus-like soil conditioner that limits the adverse impact of longtime chemical fertilizer use; it is highly valued by vegetable and fruit farmers.

Septic tank sludge, mixed with solid waste can be composted fully. Composting takes from three to six months and the temperature in the compost pile reaches 50^0 C, conditions that are lethal to all excreted pathogens. Already at 45^0C, one week would achieve almost complete pathogen death.

The option of composting the sludge should be considered if there is a plant nearby that recycles organic waste.

Wastewater Treatment Plant

Sludge from the septic tanks can be handled in a sludge treatment plant or brought to a general wastewater treatment plant.

There is for some time to come not sufficient sludge to justify the construction of a treatment plant specifically for septic tank sludge. At the medium term however there will be room for such a plant when income levels grow and individual septic tanks become affordable and attractive for a larger part of the population in the Project Towns, but not in such numbers that would make some type of piped sewer system financially feasible.

There are no wastewater treatment plants operating in the Project Area. If one would be considered for construction, the design should make extra capacity available for septic tank sludge handling.

Disposal in Ponds
Recent surveys by a project on fish production in ponds showed that human waste is an important source of nutrients for the production of fish fodder. Latrines are connected to a pond where duckweed is grown; the duckweed is harvested and fed to fish in an adjacent fish pond.

Most of the duckweed ponds become dry in the winter months which means that de-sludging must be planned for the summer period and an alternative disposal must be found for the winter season.

Towns located not too far from a duckweed based fish production pond can find here a good. even beneficial solution for their sludge disposal problem.

Controlled tipping on a Solid Waste Dump site
It might turn out that none of the options discussed so far provide a viable solution for final disposal of the sludge. In that case dumping the sludge on a properly operated solid waste dump site is a good solution.

The vacuum truck brings the sludge to the dump site, where it is unloaded. The sludge will get mixed with earlier and later dumped solid waste. As the dump face is covered with soil at the end of each day as a mater of routine operation, odour nuisance is limited.

5.6 Septic Tank - Effluent Treatment and Disposal

5.6.1 General

The options considered for handling the water that overflows from a septic tank, also called effluent, can be divided into four main groups of alternative disposal methods:

A Sub-surface infiltration of Effluent
- A-1 - horizontal drain bed
- A-2 - soak-away

B Filtration of Effluent - discharge to stream/ pond/ roadside drain
- B-1 - (elevated) filtration bed
- B-2 - (elevated) double (intermittent) sand filter
- B-3 - helofyt filter
- B-4 - an-aerobic upflow filter (pilot unit)

C Discharge of Effluent to an off-site facility for further treatment

D Disposal of Effluent without further treatment

These options are discussed in the next paragraphs.

5.6.2 Sub-surface Infiltration of Effluent

A-1 - horizontal drain bed

A-2 - soak-away

A-1 Horizontal drain bed

Horizontal shallow infiltration options like trenches and drain beds occupy large areas of land which are usually not available near bus stations and markets. The reason for horizontal drains is usually to stay clear from ground water; as that will not be possible in the rainy season, there is no particular reason to opt for this type of facility.

A-2 Soak-away

A Soak-away or infiltration pit is selected when shallow types of infiltration facilities have no clear advantage or for lack of space; for both reasons the soak-away is suggested in the Project Area.

A soak-away is a deep absorption system used for subsurface infiltration of household wastewater, also called sullage, and partially treated overflow water from septic tanks, also called effluent.

In both cases the wastewater goes through a pre-sedimentation stage; the water that enters the pit should then be free from grease and solid particles (suspended solids).

The lower part of the pit where infiltration takes place is usually constructed of honey comb brickwork with open vertical joints; the upper part is a closed wall, to prevent water leaking to surface level when the water level inside is high during peak discharges. This occurs under high groundwater table conditions and would make the area around the pit muddy. The pit itself is left empty with some gravel on the bottom to prevent damage by falling water during the dry season, when the groundwater table might be below pit bottom. A backfill of a sand/gravel mix around the honeycomb masonry enlarges the effective diameter of the infiltration unit and thus its capacity.

The size of a soak-away is based on the amount of wastewater discharged per day and on soil characteristics, especially permeability and porosity. Infiltration takes place mainly through the side wall as the bottom of the pit clogs up after some time. Also the wall gradually becomes less pervious, mainly due to an-aerobic micro-biological processes that form a so-called clogging mat just behind the surface. The pit wall regains most of its infiltration capacity when it is exposed to aerobic conditions during the dry season. Some regeneration of the pit bottom is possible if the pit is taken out of operation: this would require two pits and a dry season groundwater table well below pit bottom.

The size of the pit depends on the infiltration capacity of the soil; it is strongly advised to conduct an infiltration test to assess the long-term infiltration rate (l/m^2.day) for the selected site. The capacity of the system can be increased by enlarging the surface available for infiltration. To this end an area between excavation and the masonry wall is filled with a gravel/sand mix. It might be necessary to construct two pits in poorly draining soils at sufficient distance from each other; 2 to 4 times the diameter of the pit would be sufficient.

Soils in the Project Area are clayey/silty, the type of soils that easily smear during excavation of a pit in wet conditions. Effective percolation through soil can decrease by half (Ref. G-10) if construction of the pit is not done with great care. Excavation

should for that reason take place only during the dry season and the side wall must be left irregular and open or even made rough instead of finished smoothly.

Dimension of Soak-Away

The main criteria for the design of a soak-away are wastewater flow and long-term infiltration rate of the soil.

The soak-away is a circular structure with honey comb brickwork with open joints for the lower part of its wall and a closed concrete ring for the upper part. The diameter of the excavation is larger than the diameter of the pit; the space is filled with a gravel/sand mix; the thickness of the backfill depends on the infiltration capacity of the soil.

It is assumed that the bottom of the pit gets clogged soon and that this area does not contribute to the leaching capacity of the pit.

Soil infiltration capacity	: 10 - 15 - 20 l/(m^2.day) (silt clay loam mix)
Wastewater flow	: Type A/D-1 - 1,310 l/day
	: Type A/D-2 - 950 l/day
Effective pit depth	: 3.00 m (height honey comb brickwork)
Honeycomb brickwork	: open joints of 1.5 cm width

Table 5.1 Dimensions of Soak-Away for three different Long Term Infiltration Rates

Long-term Infiltration Rate [l/(m^2.day)]	Brickwork pit diameter [mm]	Backfill [mm]	Total diameter Soak-away [mm]	Infiltration area [m^2]	Total Infiltr. Capacity [l/day]
10	1400	200	1800	17.0	170
		400	2200	20.7	210
		600	2600	24.5	250
15	1400	200	1800	17.0	260
		400	2200	20.7	310
		600	2600	24.5	370
20	1400	200	1800	17.0	340
		400	2200	20.7	410
		600	2600	24.5	490

Even assuming an optimistic soil infiltration rate of [illegible] l/(m^2.day), just one soak-away cannot cope with the expected design flow of even the smaller Type A/D-2 units. More soak-away units are required to cover the wastewater flow, but also then an emergency overflow to a nearby pond, stream or roadside is necessary. The number of pits is decided on the actual soil infiltration rates; assuming rates of of 10, 15 or 20 l/(m^2.day), the number of pits to be constructed per public toilet becomes:

Soak-away

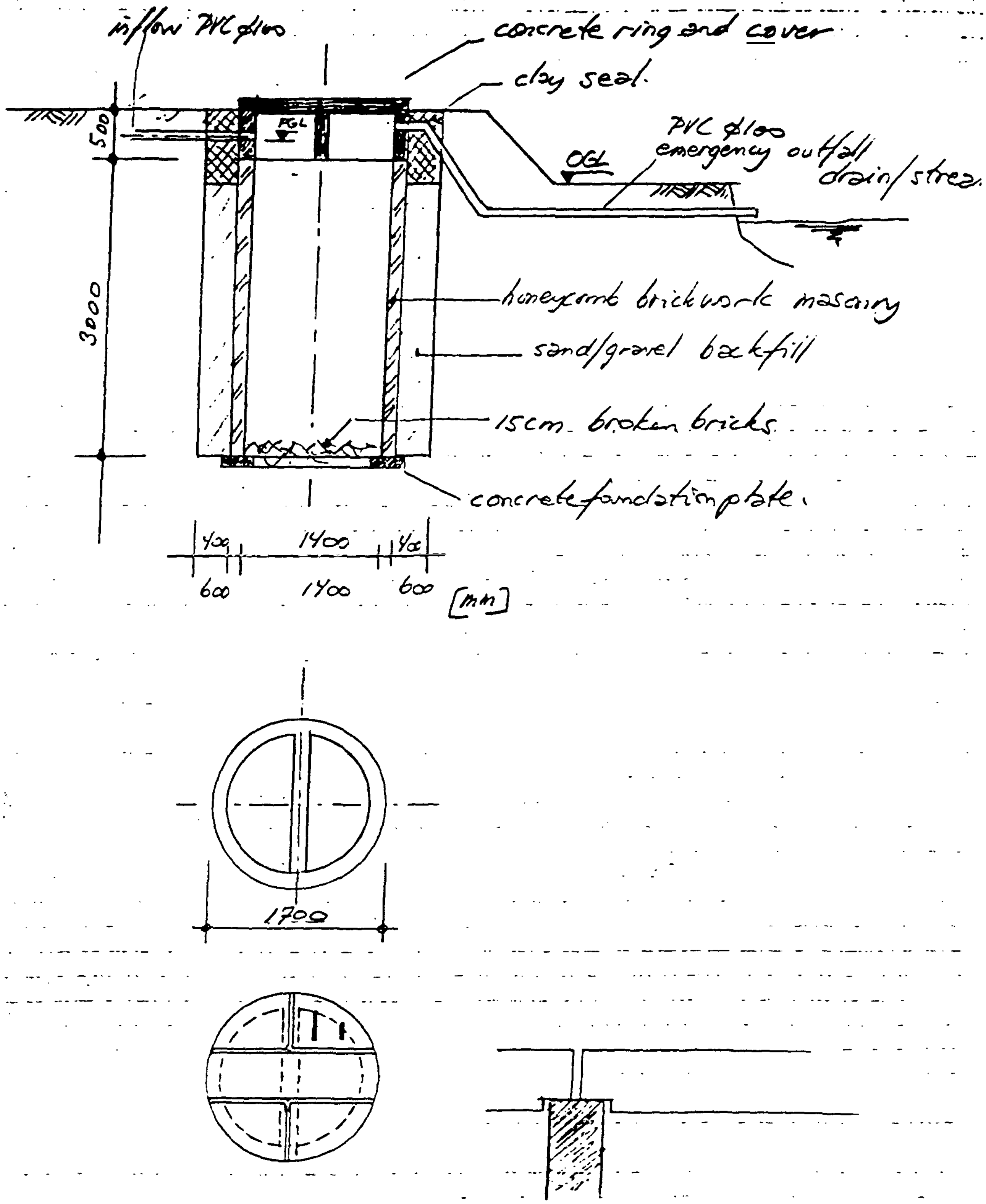


Figure 5.1 Soak-away

- Type A/D-1 : **5, 4 or 3 soak-aways with maximum backfill**
- Type A/D-2 : **4, 3 or 2 soak-aways with maximum backfill**

The above calculations assume a rather homogenous soil profile but it is known that the profile in the Project Area often shows small layers of fine sand, which improves the infiltration capacity. A soil infiltration test will always be necessary to indicate whether a soak-away is possible or not in a certain location and what infiltration capacity should be used for the dimensioning of the pits.

The soak-aways not necessarily have to be constructed near the septic tank. The effluent can be discharged to a location where space is available for the pits. As the effluent does not contain solid matter, the pipe can be 100 mm at a slope of 1:300, if proper attention is paid to the sand bedding of the pipe.

All soak-aways must be provided with an emergency overflow pipe to a pond, stream or road-side drain. The towns under the Project will be provided with a storm water drainage system, that could be used also to bring the overflow water to an acceptable discharge point.

5.6.3 Filtration of Effluent followed by Discharge

B-1 - Filtration Bed / Elevated Filtration Bed
B-2 - Double Sand Filter / Elevated Sand Filter
B-3 - Helofyt filter
B-4 - An-aerobic Upflow Filter

B-1 Filtration Bed - Elevated Filtration Bed

Description
The filter consists of a body of filter sand. Drain pipes bring effluent from the septic tank to a layer of gravel on top of the filter. Drain pipes in a layer of graded gravel at the bottom of the sand filter discharge the percolate to a stream or drain. Aerobic micro-organisms, that develop on the sand particles, break down the components in the effluent. Apart from this biological process some physical/ chemical treatment takes place. The bacteriological quality of the final effluent is such that discharge to open water is allowed. The filtration bed is covered by soil; the bottom is above flood level (above the so-called plinth level).

Effluent percolates under gravity through the filter, hence some difference in height between the septic tank outflow pipe and the final discharge point is required. This head is in general not available in the Project Area, which is rather flat. The effluent from the septic tank has for that reason to be pumped to the top of the filter. The pump will ad to the operational cost and complexity of the public toilet facility.

The filtration facility is constructed in two phases of two plus one bed.

Application

The elevated filtration bed is used:

- always in combination with a septic tank
- when sub-surface infiltration of the effluent is not possible
- when sufficiently large, perennial stream is available to dilute the effluent 1:1000
- when the receiving water body or drain is at such a level that discharge under gravity from the septic tank, via a filter at ground level to the drain is not possible.

Capacity

Effluent flow Type A-1	:	1,310	l/day
Max. hydraulic load	:	30	$l/(m^2.day)$
BOD load (*)	:	4.64	kg/day
Max. BOD load	:	5.4	$g/(m^2.day)$
Surface required	:	860	m^2
No. of beds	:	3	(2 in first phase)
Dimensions	:	12x24	m for each bed

(*) Septic tank effluent of black wastewater only (24 hour retention time), taking into account ambient temperature in Bangladesh

Effluent flow Type A-1	:	950	l/day
Max. hydraulic load	:	30	$l/(m^2.day)$
BOD load (*)	:	3.32	kg/day
Max. BOD load	:	5.4	$g/(m^2.day)$
Surface required	:	615	m^2
No. of beds	:	3	(2 in first phase)
Dimensions	:	10x20	m for each bed

B-2 Elevated Double (intermittent) Sand Filter

Description

This sand filter consists of two units that are operated in turns. Water is sprinkled on top of the filter, after which it percolates through the sand and is collected by drains at the bottom of the filter. There is some oxygenation taking place at the top of the filter, reason why the BOD load on this type of filter can be much higher than for a filtration bed, so the filter itself can be much smaller. The filter however can become clogged and then has to be taken out of operation for regeneration, for a period of 3 months. A second filter must be available to take over during this period.

Application

The intermittent elevated sand filter has the same applications as the B-1 filtration bed, which means that it is used:

- always in combination with a septic tank
- when sub-surface infiltration of the effluent is not possible
- no large stream with perennial flow is available (dilution 1:1000)
- discharge under gravity to the receiving water body or drain is not possible

Also in this option a pump is required, that adds to the running cost of the sanitary facility.

.2 Filters

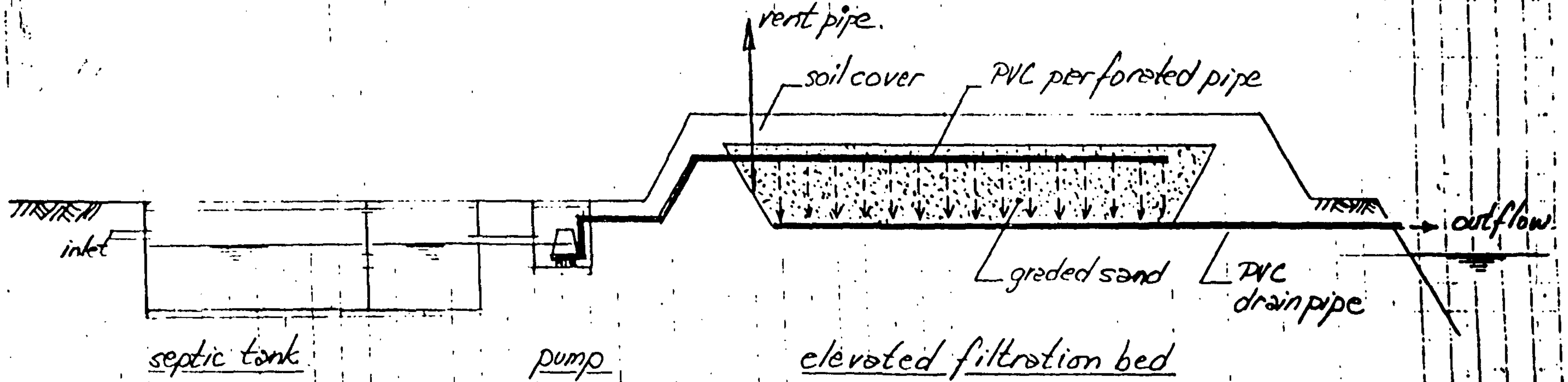


Figure Elevated Filtration Bed

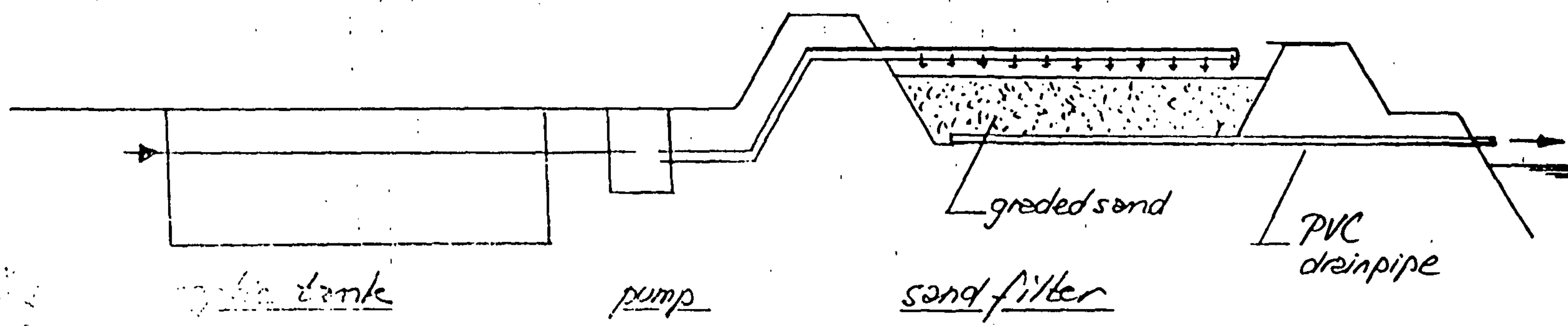


Figure Intermittant Sand Filter

Capacity

Effluent flow Type A-1	:	1,310	l/day
Max. hydraulic load	:	200	$l/(m^2.day)$
BOD load (*)	:	4.64	kg/day
Max. BOD load on filter	:	36	$g/(m^2.day)$
Surface required	:	129	m^2
No. of beds	:	3	(one bed for intermittent use)
Dimensions	:	5x13	m for each bed

(*) Septic tank effluent of black wastewater only (24 hour retention time), taking into account ambient temperature in Bangladesh

Effluent flow Type A-2	:	950	l/day
Max. hydraulic load	:	200	$l/(m^2.day)$
BOD load (*)	:	3.32	kg/day
Max. BOD load on filter	:	36	$g/(m^2.day)$
Surface required	:	92	m^2
No. of beds	:	3	(one bed for intermittent use)
Dimensions	:	5x10	m for each bed

B-3 Helofyt filter

Description

A helofyt filter basically is a shallow, marsh-like area in which reed or similar plants that grow in shallow water. Wastewater flows through the field, at or below surface. Aerobic bacteria that develop around the roots of the plants break down the organic material in the water. Oxygen required by the bacteria is transported from the air to the roots through the reed shafts. At some distance from roots, the soil has little oxygen and other types of bacteria continue further mineralisation under an-aerobic conditions. The final effluent can be discharged to streams. The field has a technical lifetime of about 25 years, when the soil is saturated with phosphates. The reed must be mowed and removed once a year.
The plants break down or absorb suspended solids, oxygen consuming matter, nitrate, phosphate, heavy metals, organic micro-contaminants and pathogenic organisms.

Typical efficiencies are:

- BOD	:	95 %
- N_{total}	:	30 %
- P	:	25 %
- Pathogens	:	100 %

There are three types of helophyt filters:
- the flow-through filter (flow is horizontal above/below ground level)
- the infiltration filter (vertical flow)
- the root-zone filter (flow is horizontal, below ground level)

Application

The Helophyt filter is used:
-always in combination with a septic tank, as the water that enters the filter must have passed a sedimentation phase

- when sub-surface infiltration of the effluent is not possible
- no suitable roadside drain is available for further transport of the effluent to an acceptable discharge point
- no large stream with perennial flow is available (dilution 1:1000)
- discharge under gravity to the receiving water body or drain is not possible

B-3.1 Flow-Through Helophyt Filter

Description

The Flow-Through filter is a 30 cm deep sand filter in which reed grows. The effluent flows slowly over and through the filter; water depth is about 20 cm. The system hardly needs any maintenance but may be a breeding ground for mosquitoes.

Application

The treatment efficiency of this basic filter is limited as some of the effluent will simply pass and, being not in contact with bacteria in the soil, benefit mainly of the longer retention time. The filter however is easy to construct and hardly needs supervision or maintenance.

B-3.2 Infiltration Helophyt Filter

Description

The Infiltration Helophyt Filter is a 1.10 m deep sand filter with reed or similar plants. Effluent flows sub-surface through the filter and on its way percolates through the sand to drain pipes at the bottom of the filter.

This type of vertical-flow filter is relatively young. Literature mentions problems with the vertical filter after some years, for which solutions might have been found and are currently being tested. Pending results of this research, the filter is not recommended for use in the Project.

The 1.10 m deep filter, as it is operated under gravity flow, would need to be build above ground to be able to discharge to a stream/ drain. Under prevailing conditions in the flat Project Area, this would require a small pump to bring effluent from the septic tank to the top of the filter.

B-3.3 Root-zone Helophyt Filter

Description

The root-zone filter is the facility that combines many of the advantages of the two other types of filters without the problems of the vertical filter. Much experience has been gained over the last 20 years with filters installed in Germany, Denmark, Sweden, England and later in the USA and for the last ten years in Nigeria, Namibia, India, Columbia and Venezuela.

The filter is highly efficient in polishing effluent from septic tanks, or otherwise pre-settled wastewater.

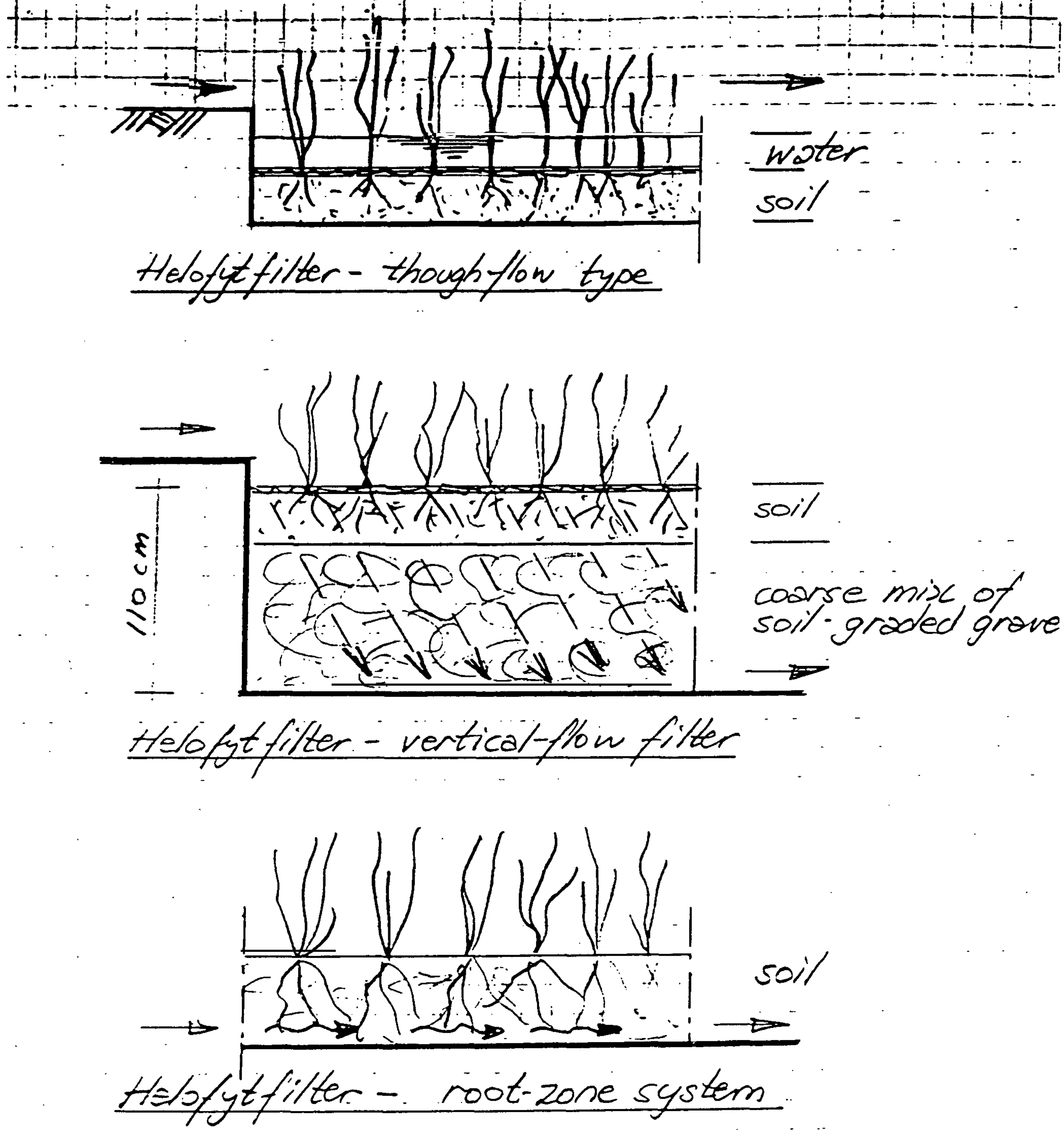


Figure 5.3 Helofyt Filter

The effluent enters the filter through a drain pipe in a gravel pack; the pipe divides the water equally over the width of the filter. The effluent then flows sub-surface through the filter; there is no water on the surface. The 0.50 m thick filter consists of a layer of fine sand, clay and organic material to allow bacterial growth and assure a porous medium that is not clogged easily. Drain pipes at the end of the field bring water to a collection box with adjustable overflow; the pipes and overflow allow control of the water table in the filter and drainage of rainwater

It depends on the local situation whether a septic tank with root-zone filter can operate under gravity or needs a pump. A careful selection of site and final discharge point might avoid the need for a pump.

Capacity

The BOD-load on a root-zone system, under climatic conditions in Bangladesh can be taken as 7.0 g BOD/ m^2 ; dimensions for a root-zone filter can then be calculated as follows:

Capacity

Effluent flow Type A-1	:	1,310	l/day
BOD load (*)	:	4.64	kg/day
BOD load on filter	:	7	g/(m^2.day)
Surface required	:	663	m^2
No. of beds	:	3	(2 in first phase)
Dimensions	:	10x22	m for each bed

(*) Septic tank effluent of black wastewater only (24 hour retention time). taking into account ambient temperature in Bangladesh

Effluent flow Type A-2	:	950	l/day
BOD load (*)	:	3.32	kg/day
BOD load on filter	:	7	g/(m^2.day)
Surface required	:	474	m^2
No. of beds	:	3	(2 in first phase)
Dimensions	:	8x20	m for each bed

B-4 An-aerobic Upflow Filter (Pilot unit)

Description

This type of filter is one of the technical options available to polish the effluent of a septic tank before it is discharged to a drain, pond or stream. The filter consists of graded gravel or crushed stone or some other medium in a third compartment, added to the septic tank. Water enters the compartment at the bottom through a pipe with perforations and flows upwards through the filter to the outlet.

A properly functioning an-aerobic upflow filter can produce clear, odourless, light yellowish water, reduce pathogens further to 80 % of the value in the original wastewater and bring BOD down to 35% of the raw sewage. The level of pathogenic bacteria is still high and disposal of this effluent still needs due attention.

Experience with this type of filter in Thailand and India, constructed for individual households and for slightly larger groups of users, shows that more research is required before this option can be recommended; families who own a septic tank with a filter appear to by-pass this part of the unit. The filter material is not functioning well and the lower section of the filter gets clogged easily. The filter has then to be emptied and cleaned manually; back-washing would be a more elegant solution but is difficult to do for a small filter without a pump.

The 5-DWSG designed a double compartment unit with a different operation of the filter and with mechanical back-washing, avoiding the need to manually replace the filter medium. The unit could be constructed as a pilot facility at one of the future septic tanks, to gain experience with its operation under field conditions.

Changes to previous designs are utilization of a plastic filter medium with substantially more specific surface area and a much better porosity, and the installation of a hand pump to backwash the filter unit mechanically.

The filter medium preferably be of the type of plastic hollow cylinders used in trickling filters at wastewater treatment plants. The advantage of this material is that it combines a very high porosity with a large specific area for micro-organisms to grow on, and unlike broken bricks, does not crumble and clog the drain pipe.

The filter consists of two chambers that are operated simultaneously. When the performance of the filter decreases, one chamber is taken out of operation and emptied by a hand pump installed on top of the tank. Water and sludge is pumped to the first compartment of the septic tank; the filter can be cleaned by flushing (hose connected to a tap at the public toilet building). If the filter medium needs some cleaning, it can be back-washed in the same way, after which it is operational again. Washing the filter medium should be done with care as the medium should keep most of the slime-layer with active micro-organisms; without this slime-layer it will take considerable time before the filter operates again.

The facility needs a tank with two compartments for intermittent back-washing, adjacent to the septic tank, a hand pump, two valves and a short pipe to the septic tank.

Application

The an-aerobic upflow filter reduces BOD considerably and produces an only slightly coloured, odourless effluent, with still a high content of pathogenic material. The filter could be considered for use in locations where infiltration is not possible and where a natural drain is not available or too far away for discharge of effluent by gravity.

Discharge of the filtered effluent to the roadside drainage system, which is also constructed as part of the Project, is under these conditions a practical, although not optimal option to be considered. The effluent is odourless but contains pathogens. It should however be taken into account that the water in a roadside drain is always fecal contaminated already from other sources; the effluent from an upflow filter will not make that any worse.

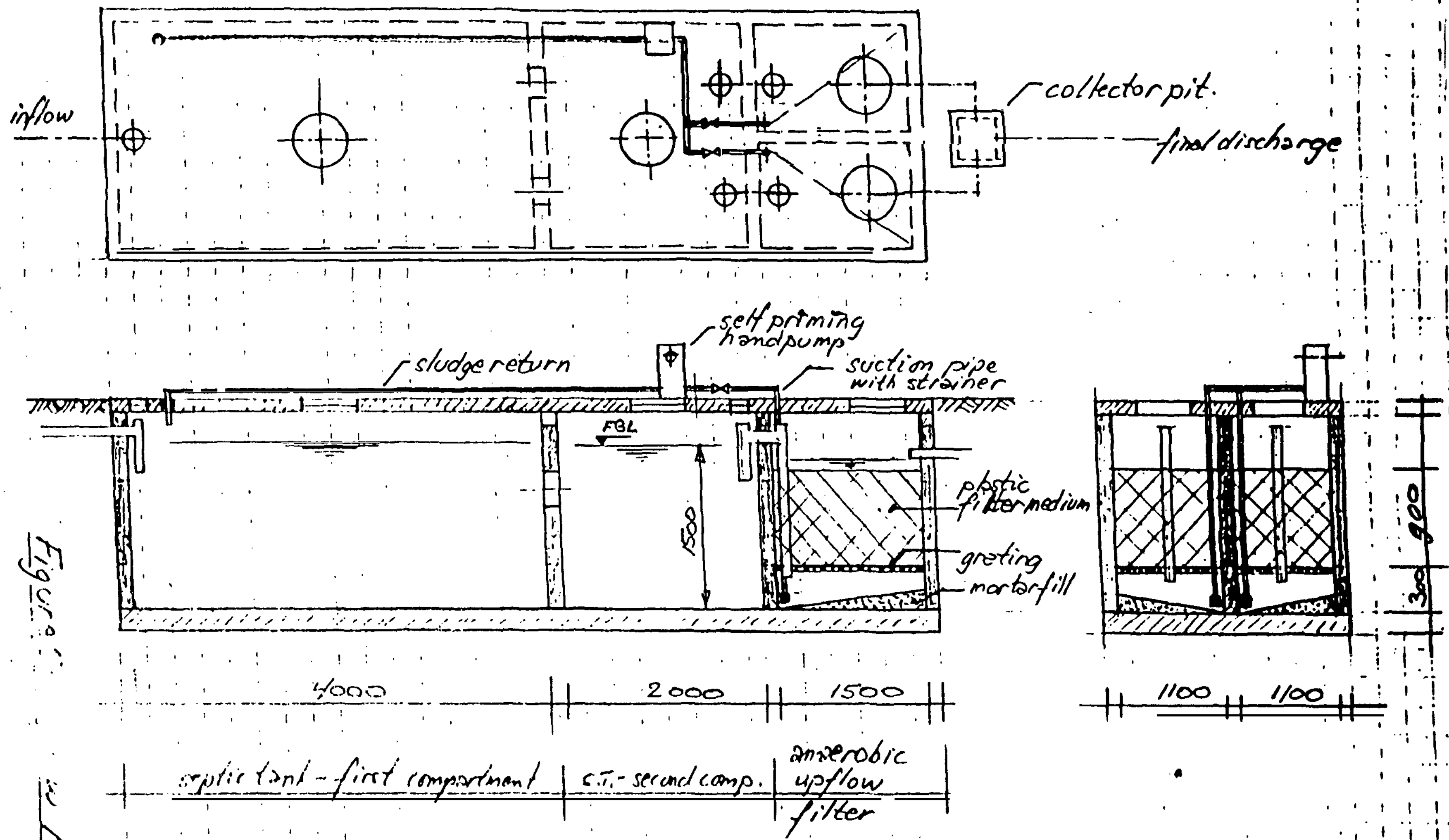


Figure ... Filter

Capacity

The unit needs an other 6 hours, on top of the retention time of the septic tank to achieve the BOD reduction mentioned before. This means that the filter should have a volume of about a quarter of the volume of the septic tank, which comes to 6 m^3 for the A/D-1 types; the same unit size is also suggested for the A/D-2 units.

5.6.4 Discharge of Effluent to Off-site Facility for further Treatment

The effluent of a septic tank could be discharged to a fish pond or to a duckweed producing pond as has been discussed earlier for septic tank sludge.

If such ponds are not operated within reasonable distance, that is within a distance that can be bridged by gravity flow, other ponds, if not utilized as a source of drinking water, could be used for final disposal.

The amount of effluent from a septic tank is too small to justify the construction of a simple waste stabilization pond. A lagoon type of treatment could be an option if some type of sewer system is considered for the town; this should be studied in the framework of a master plan for sewerage and drainage.

5.6.5 Disposal of septic tank effluent without further treatment

If none of the options discussed so far are technically feasible or financially acceptable, land disposal can be considered. The use of effluent for irrigation has the same sort of limitations regarding access to the land and use of its produce as mentioned for sludge disposal

Finally, effluent could be discharged to a large stream, a pond or a roadside drain until other alternatives become available or affordable.

5.7 Hydraulic Profile Sanitary Public Facility

The sanitary facility operates under gravity; human waste is flushed (transported) by water from the toilet pan to the septic tank and water from the septic tank flows into the soak-away. In order to work properly and in reverse order, the inlet pipe to the soak-away should be above flood level. the outlet pipe of the septic tank should be above the inlet pipe to the septic tank to make good hydraulic losses in the tank and the toilet pan should be above the inlet pipe of the septic tank to cover losses due to flow through pan, inspection pit and connecting piping.

The relevant reference level for the unit is flood level and the elevation of the inlet to the soak-away; all other levels follow from here.

The following sketch gives the hydraulic profile for the whole facility; the profile shows that plinth level, or the level of the floor in the toilet building needs to be higher, than the usually selected level.

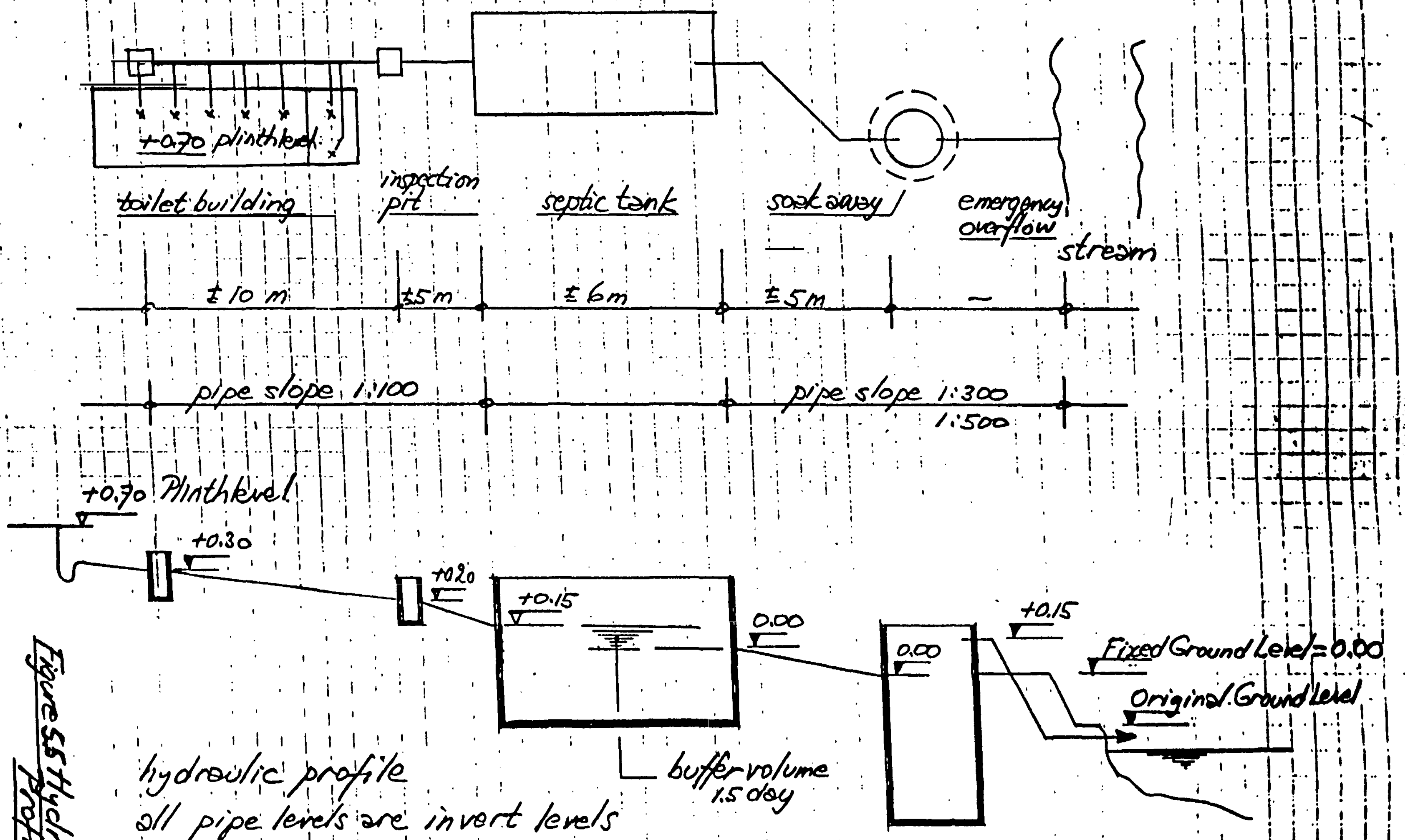


Figure 5.5 Hydraulic profile

5.8 Biogas Digester

Discussions have been held with authorities and institutions involved in biogas digesters in Bangladesh. The results so far do not suggest an already viable solution for the handling of public toilet waste, including the disposal of sludge and effluent, rather a transfer of problems from the Municipality to the Lease holder/ operator of the public toilet, who might be in an even worse position to solve these.

Biogas digesters are reservoirs in which organic material is broken down under an-aerobic conditions with the intention to produce gas for useful purposes. Biogas plants are usually operated in rural areas where proper feed material such as cow dung (in general animal manure), and straw, rice husks, or other crop waste is available in sufficient quantities. The digestion process produces ammonia, carbon dioxide and methane. The methane gas is used for cooking and lighting.

The feed material needs to consist of a good mix of carbon and nitrogen rich matter, preferably in ratios of 20:1 to 30:1 for good gas production. Human excreta has a C/N ratio of about 1:8 and is without the addition of other material not very suitable, but digestion is possible. The waste of 7 persons is needed to cover the daily energy demand of one person.

The components are mixed in a small tank and the slurry is fed to the digester. The slurry must have a certain density for optimal digestion.
Human excreta, as it is usually flushed down with water, has a high liquid content, resulting in a less efficient gas production process and in a larger volume digester.

The biogas digester consists of an inlet/mixing chamber, the actual digester, usually with a fixed gas dome, the compensating/removal tank in which effluent and sludge overflow and a number of infiltration pits for the infiltration of the effluent. The sludge is to be removed about once a year.

A biogas plant with fixed dome needs careful attention of an experienced operator.

LGED is planning the construction of fixed dome biogas digesters for public toilets near bus stations and markets and lease the facility to persons who can make use of the methane gas for cooking (small restaurants, tea shops). Valuable experience will become available from these plants, operated exclusively on human excreta and in an urban environment. LGED intends to involve NGO's, that will invite bids, do supervision of construction, take care of community participation, train the operator and supervise operation and maintenance for about one year. LGED prepared special contract documents and will give training to NGO staff on biogas technology and construction management.

A biogas plant is certainly an option to be considered in combination with a public toilet. It is suggested that the Project awaits the results of the LGED plants before adopting the concept.

5.9 Outline Designs of Standard Types of Public Toilets

The outline designs prepared as part of the Mission's tasks cover the larger towns in the Project with sanitary units consisting of 5 toilet seats and 6 urinals for men and two toilets seats for women. Down sized versions with [3+2] seats and 3 or 4 urinals have been made for the smaller towns. The outline designs are included in Annexes 3 to 10.

Figure A.1	Public Toilet Type A-1 Plan and Front Elevation [5+2 seats - 6 urinals]
Figure A.2	Public Toilet Type A-2 Plan and Front Elevation [3+2 seats - 3 urinals]
Figure B.1	Public Toilet Type B-1 Plan and Front Elevation [5+2 seats - 6 urinals]
Figure B.2	Public Toilet Type B-2 Plan and Front Elevation [3+2 seats - 4 urinals]
Figure C.1	Public Toilet Type C-1 Plan and Front Elevation [5+2 seats - 6 urinals]
Figure C.2	Public Toilet Type C-1 Plan and Front Elevation [3+2 seats - 3 urinals]
Figure D.1	Public Toilet Type D-1 Plan and Front Elevation [5+2 seats - 6 urinals]
Figure D.2	Public Toilet Type D-1 Plan and Front Elevation [3+2 seats - 4 urinals]

5.10 Communal Latrine - Sludge and Effluent Disposal

The existing infiltration pits of the Communal Latrines are overflowing, even when they have been de-sludged recently. Some of the units give the impression that they have been designed as pour-flush double pit latrines, which means that pits are used intermittently. One pit is connected to the toilets, while the other (full) pit is left for digestion of the contents. Actual connecting piping however shows that the concept is not fully implemented, with all pits now full-time in operation.

Although all pits were used, the capacity seems still not sufficient, as all pits observed were overflowing. There are several possible reasons for this, which may occur simultaneously as well:

- the pits are small or there are not sufficient pits, hence the infiltration area is too small; the size of the pits observed are usually designed for 10 to 15 persons, not for the 120 to 150 that mow use the facility
- the volume of the pits is too small, hence they fill-up before the decomposition process is able to reduce the volume of the first loads of solid matter
- the pits are small and so fill up quickly with solid matter, which at the same time reduces the area available for infiltration of the liquid component
- the long term infiltration rate of the soil is lower than the figure used for the

dimensioning of the pits

- **the pit is constructed with concrete rings with only a few holes, limiting the effective infiltration area considerably and so the infiltration capacity of the pit**
- the pits cannot handle peak discharges (during busy morning hours) as there is not sufficient buffer
- the pipe at the entrance to the pit is not above flood level, hence there is little hydraulic head available at high ground water levels and discharge to the pit is hampered
- the pits were excavated during the rainy season, and walls got smeared, halving the infiltration rate of the soil

The current situation can be improved in two ways:

- Check the hydraulic profile of the unit and see whether there is sufficient buffer capacity in the pits to provide for the early morning peak flow (about half of the daily 350 liter)

Repair the holes at ground level in the pits, add an (emergency) overflow to each pit and de-sludge regularly, probably twice a year. In this way the pits are left to function as mere septic tanks, with some infiltration capacity, possibly sufficient during the dry season but not all summer.

As most units functioned properly at first, until they got full and were not emptied, more frequent emptying might restore some of the infiltration capacity and limit overflow.

Because of the high de-sludging frequency and the number of latrines concerned, it is suggested to empty the pits mechanically. The machine must be able to remove the more dense sludge of a latrine. The same machine could be used also for newly to be built community latrines and for household sanitary latrines, of which many are reported to be abandoned when full.

- the second solution for existing community latrines is to replace the current pits with properly sized soak-aways. One or two large pits will be required, depending on soil conditions and attention must be paid to the proper elevation of inflows to the pits, with regard to flood level (also known as Finished Ground Level or FGL) and as far as possible with the floor level of the existing latrine. Similarly important is the level of emergency disposal of overflow water.

The infiltration unit described next is also suggested for newly to be built community latrines.

01 Design population	:	- 20 families, or
		- 100 to 140 persons, max. 150 persons
02 Flushing requirements	:	- 2 l/(person.day)
03 Cleaning	:	- total 50 l/day
03 Toilet pan	:	- squatting type, slope 25-30^0

04 Design wastewater flow : - 150 x 2 + 50 = 350 l/day

05 Sludge accumulation rate : - 25 l/(person.year)

06 Effective pit depth : - 3.00 m

07 Pit type : - brickwork honeycomb masonry with open vertical joints

After conducting soil percolation tests, a suitable selection of the number of infiltration pits can be made from the next table, taking into account actual infiltration rates at that particular site.

The second pit in the table can handle the design flow of 350 l/day, assuming that the test showed an average infiltration rate of 15 $l/(m^2.day)$.

Table 5.3 Dimensions Soak-away for Communal Latrines

Long-term Infiltration rate [$l/(m^2.day)$]	Brick work pit diam. [mm]	Backfill [mm]	Total diameter Soak-away [mm]	Infiltration area [m^2]	Total Infiltr. Capacity [l/day]
10	1400	600	2600	24.5	250
15	1400	600	2600	24.5	370
20	1400	600	2600	24.5	490

It can be estimated that even this large diameter pit fills up with solid matter within about one year (at a sludge accumulation rate of 25 l/day and maintaining some freeboard to the inlet pipe). This means that gradually the area remaining available for infiltration decreases and the pit will start to overflow. It explains why the current small pits are overflowing; even with a pit as large as shown in Table 5.3, a second pit is required.

As a second pit will be needed, there is the possibility to split the functions of the pits to some extent. The first pit operates as interceptor, receiving the solid matter and the liquid from the latrine; settleable material stays in this pit and liquid infiltrates, until the infiltration capacity becomes too small and liquid starts overflowing to the second pit. This second pit, without solid matter, is fully available for infiltration and is on its own capable of handling the daily wastewater flow.

The first pit needs to be emptied after one year (but probably longer). The pit cover should have a manhole to allow for mechanical de-sludging.
The two pits together can much better handle the early morning hydraulic peak load, which reduces the chance of emergency overflow. Still, the second pit should have a connection to a nearby stream or drain.

Mechanical De-sludging
The sludge in the interceptor has at the end of the de-sludging cycle a higher density than septic tank sludge, as some of the liquid component infiltrated into the soil surrounding the pit.
Although de-sludging equipment is an established and not too complicated

technology, the higher density sludge and the large distance over which sludge has to be pumped from the pit to the vacuum car pose specific problems to the emptying of the pit of usually not easily accessible community latrines. The road might be of poor quality or be just a dirt road and the car might even not be able to come near the pit. These conditions require the following main specifications and requirements of a latrine de-sludging facility:

- the car should be light, have a small wheel base and be able to travel on unpaved roads, also during the rainy season
- the vacuum pump must be able to pump dense sludge over a distance of 60 to 80 m, from pit to vacuum tank
- the vacuum tanker truck must have these 80 m of flexible hose "on-board"
- the volume of the reservoir should be sufficient to empty the pit in one or two visits
- the vacuum truck must have a fresh water reservoir with pump to fluidise exceptionally dense sludge when needed
- the vacuum truck must be able to unload itself (for instance at a solid waste dump site)

A car with these specifications could also be employed to empty sanitary household pit latrines.

6 CAPITAL INVESTMENT COSTS

6.1 Summary of cost

The cost estimates in the following sections have been prepared on the basis of specifications and unit costs given in the "Schedule of Rates", published by the Public Works Department in July 1997.

In the total cost for the Types A/ D, mentioned under item I concern a toilet building with mosaic floor finish, a mosaic plinth of 20 cm high and glazed wall tiles unto 1.60 meter high.

Cost Basis November 1997; one U$ = Taka 44

Summary of Cost:

Public Toilet	Type A-1 [5+2 seats - 6 urinals]	Tk.	000
	Type A-2 [3+2 seats - 3 urinals]	Tk.	000
Public Toilet	Type B-1[5+2 seats - 6 urinals]	Tk.	000
	Type B-2[3+2 seats - 4 urinals]	Tk.	000
Public Toilet	Type C-1[5+2 seats - 6 urinals]	Tk.	000
	Type C-1[3+2 seats - 3 urinals]	Tk.	000
Public Toilet	Type D-1[5+2 seats - 6 urinals]	Tk.	000
	Type D-1[3+2 seats - 4 urinals]	Tk.	000

6.2.1 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE A-1
[5+2 seats]

I	1	Civil Work	Tk.	342 000
	2	Plumbing	-	88 000
	3	Septic Tank	-	77 000
	4	Soak-away	-	-
	5	Electrical Works	-	10 000
		Total capital investment	Tk.	517 000
II	-	Soak-away (one)	Tk.	25 000
III	-	Septic tank with an-aerobic upflow filter	Tk.	102 000

6.2.2 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE A-2
[3+2 seats]

I	1	Civil Work	Tk.	265 000
	2	Plumbing	-	68 000
	3	Septic Tank	-	62 000
	4	Soak-away	-	-
	5	Electrical Works	-	10 000
		Total capital investment	Tk.	405 000
II	-	Soak-away (one)	Tk.	25 000
III	-	Septic tank with an-aerobic upflow filter	Tk.	89 000

6.3.1 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE B-1
[5+2 seats]

I	1	Civil Work	Tk.	000
	2	Plumbing	-	000
	3	Septic Tank	-	000
	4	Soak-away	-	-
	5	Electrical Works	-	000
		Total capital investment	Tk.	000

II -

III -

6.3.2 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE B-2
[3+2 seats]

I	1	Civil Work	Tk.	000
	2	Plumbing	-	000
	3	Septic Tank	-	000
	4	Soak-away	-	000
	5	Electrical Works	-	000
		Total capital investment	Tk.	000

II -

III -

6.4.1 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE C-1
[5+2 seats]

I	1	Civil Work	Tk.	000
	2	Plumbing	-	000
	3	Septic Tank	-	000
	4	Soak-away	-	-
	5	Electrical Works	-	000
		Total capital investment	Tk.	000
II	-		Tk.	000
III	-		Tk.	000

6.4.1 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE C-2
[3+2 seats]

I	1	Civil Work	Tk.	000
	2	Plumbing	-	000
	3	Septic Tank	-	000
	4	Soak-away	-	000
	5	Electrical Works	-	000
		Total capital investment	Tk.	000
II	-			
III	-			

6.5.1 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE D-1 [5+2 seats]

I	1	Civil Work	Tk.	000
	2	Plumbing	-	000
	3	Septic Tank	-	000
	4	Soak-away	-	-
	5	Electrical Works	-	000
		Total capital investment	Tk.	000

II -

III -

6.5.2 SUMMARY COST ESTIMATE PUBLIC TOILET TYPE D-2 [3+2 seats]

I	1	Civil Work	Tk.	000
	2	Plumbing	-	000
	3	Septic Tank	-	000
	4	Soak-away	-	000
	5	Electrical Works	-	000
		Total capital investment	Tk.	000

II -

III -

6.6 Plan and Elevations of Standard Types of Public Toilets

The Outline designs of the eight types of public toilets are included in Annex 03 of this Report.

ANNEXES

ANNEX 01 **REFERENCES**

G - General Reports and Design Documentation

C - DANIDA - CARU Reports

D - Detailed Engineering Designs

LITERATURE - GENERAL REPORTS AND DESIGN DOCUMENTATION

G-01 Five Districts Water Supply and Sanitation Project
Contract for Consultancy Services - Nov. 1996
April 1997

G-02 Water Supply, Sanitation and Drainage System in District and Upazila Centres - Phase I
Detailed Engineering - Project Report
- Volume I - Description
- Volume II - Appendices
N&R / R&H and AQUA Consultant - June 1991

G-03 Urban Water Supply & Sanitation Project in Noakhali, Laksmipur and Feni Districts,
Project Preparation Study - Final Report
- Volume I
- Volume II
- Volume III - Growth Centres
AQUA Consultant & Associates Ltd. - September 1993

G-04 Urban Water Supply $ Sanitation Project in Patuakhali & Barguna Districts, Bangladesh
Project Preparation Study - Final Report
- Volume I
- Volume II - Annexures
Community Development Council - May 1994

G-05 Urban Water Supply $ Sanitation Project in Patuakhali & Barguna Districts, Bangladesh
Final Appraisal Report
DANIDA - June 1995

G-06 Five Districts Water Supply and Sanitation Project
1st Progress Report - Jan/March 1997
DHV / AQUA / DEVCON - April 1997

G-07 Five Districts Water Supply and Sanitation Project
Solid Waste Management Plan
- Mission I - Tecnical Report
DHV / AQUA / DEVCON - April 14. 1997

G-08 Five Districts Water Supply and Sanitation Project
Inception Report
DHV / AQUA / DEVCON - April 1997

G-09 Soil Survey Project
Reconnaissance Soil Survey of Barisal District 1967
Reprinted in the series SRDI publications,
Soil Resource Development Institute,
Min. of Agriculture, Dhaka 1990

G-10 Land Reclamation Project
Land Reclamation on Char Baggar Dona
Drainage and Salinity Investigation 1984-1985
LRP Technical Report No. 26, September 1985

G-11 Land Reclamation Project
Report on Soil, Agriculture, Land use and Salinity Investigation of South Hatia
LRP Technical Report No - , November 1990

G-12 **Groundwater Investigation Report Maijdee**
S. Hvam, November 1989

G-13 **Barguna Drinking Water Supply**
A. van Weel, August 1994

G-14 Duckweed Research Project
- Inception Report -
Annex 1 Literature Review
Annex 2 Scientific and Technical Validation of Prism Duckweed Activities

- Socio-economic and Technical Validation of Duckweed based Fish Production (Draft)

- An-aerobic Wastewater Treatment, An important step in Rational Re-use Strategies of Nutrients and Energy

- Economic Feasibility of Duckweed based Fish Production (Draft)

Ministry of Fisheries and Livestock, DHV Consultants, IHE Delft, BPMC

DPHE-DANIDA Water Supply and Sanitation Project in Chaumohani and Laksmipur Pourashavas - (Phase 1 of current Project)

Reports prepared by the Project and its Communication and Action Research Unit (CARU), Noakhali.

C-01 **Spot Surveys on Water, Sanitation and Hygiene Behaviour**
Oct.-Nov. 1993

C-02 **Spot Survey on Promotion, Installation and Utilization of Pit Sanitary Latrine**
May 1994

C-03 **Guidelines for the Implementation of the Sanitation Activities**
(Revised Aug. 1994)

C-04 **Assessment of Potential Female Users for the Public Toilet at the Fish Market, Laksmipur**
January 1995

C-05 **Guidelines for the Orientation of the Beneficiaries of Community Latrines**
June 1995

C-06 **Second Spot Survey on Functionality, Utilisation and Maintenance of Pit Sanitary Latrines**
July 1995

C-07 **Spot Check on use of Public Toilets in Laksmipur**
November 1995

C-08 **Monitoring Report on Functionality, Use and Maintenance of Community Latrines**
November 1995

C-09 Software Activities (CARU components)
- Volume VI
June 1996

C-10 O&M Planning for Sanitation Components - Volume V
June 1996

DETAILED ENGINEERING DESIGNS REVIEWED BY THE MISSION

D-01 Secondary Towns Infrastructure Development Project - STIDP - Phase 1
LOUIS BERGER INT. / AQUA Consultants

Drawing No. TYP/SN/92, 09.09.1992
Typical Public Toilet

D-02 12 District Towns Water Supply Scheme
AQUA Consultants

Public Toilet - Brahmanbaria

Drawing PT/01 of 02, November 1992
Details of Site Plan, Septic Tank and Soak Pit

Drawing PT/02 of 02, November 1992
Details of Toilet, Foundation, Reinforcement and Electric Connection

D-03 DPHE-DANIDA Water Supply and Sanitation Project in
Chaumohani and Laksmipur Pourashavas
Phase 1, Det. Engineering Design
N R / R&H / AQUA Consultants

Drawing No. CL-01, LAKS-SAN, June 1995
Civil/Electrical works
Plan, Elevation, Lay-out & Overhead Tank Details
(of public toilet) No. 04

Drawing No. CL-02, LAKS-SAN, June 1995
Plan, Elevations, Section & Structural Details of
Public Toilet No. 03

Drawing No. CL-03, LAKS-SAN, June 1995
Civil/Electrical works
Standard Detailed Design Drawing for Public Toilet
with Septic Tank Below the Latrine Seat

Drawing No. PT/02 of 02, June 1993
Structural Details, Septic Tank and Soak Pit

Drawing No. PT/02 of 02, October 1993
Structural Details, Septic Tank and Soak Pit

D-04 18 District Towns Project
Water Supply, Sanitation, Hygiene Education
DHV / BKH / IWACO / AQUA Consultants

Drawing No. 1, August 1996
Detailed Design drawing of Public Toilet (Revised)

A4 sketch, 20.01.1996 - Revision 1, 28.07.1996
Typical drawing for construction of Pour-flush Latrine with Off-set Pits in the Primary Schools, under 18-DTP
(four seats, double pit school latrine)

A4 sketch, 20.01.1996 - Revision 1, 28.07.1996
Typical drawing for construction of Pour-flush Latrine with Off-set Pits in the Primary Schools, under 18-DTP
(two seats, school latrine)

A4 sketch, 20.01.1996 - Revision 1, 28.07.1996
Typical drawing for construction of Pour-flush Latrine with Off-set Pits in the Primary Schools under 18-DTP
- Details of Junction Chamber

May 27 '97 The Independent 13

Kidney diseases among our women

by Golam Mostakim

IN June, 1994 I was working at Patuakhali. Around 50 students of the Department of Anthropology, University of Dhaka, were heading for Kuakata. It was a study tour. The leader was a Professor. But due to bad weather they were stranded at Patuakhali town and district administration had to arrange for their accommodation. We selected the nearby Polytechnic Institute for their temporary abode. After an hour news reached me that a female student vomited as soon as she entered into the toilet.

I just narrated the incident as a brief introduction to point out the general condition of the toilet in a governmental institute. Situation is the same and even worse at other places.

The non availability of toilets for the womenfolk in public places like schools, colleges, universities, bus stands, railway stations, launch terminals and ferries and other working places is a major factor for developing kidney diseases among women in the country.

And where available, the conditions make these latrines unusable as narrated. There is no study on this aspect but it is high time that the concerned authority should look into the matter with utmost care and attention. Let us begin with the schools.

It is an admitted fact that thousands of young children both male and female are coming to the primary schools for various reasons primary education is compulsory and some NGOs are running several thousand primary schools. In the government-run primary schools and also in the non-governmental primary schools, latrine facilities for the girls are not sufficient. In the girl's high schools the situation is the same. And it is natural that after attaining puberty the use of the latrines becomes essential for obvious reasons. In the higher educational institutions too, where the number of female students decreases, toilet facilities cannot cope with the demand.

> The nonavailability of toilets for the womenfolk in public places like schools, colleges, universities, bus stands, railway stations, launch terminals and ferries and other working places is a major cause for developing kidney diseases among women in the country.

It is reported in the newspapers that women in the developing countries are suffering more and more form kidney ailments. This is because most of the female students leave the educational institutions with kidney diseases in one or another form after getting the highest degrees. This is very unfortunate.

If we can make a survey among the educated and working women in our country, I am sure that this assumption will be proved correct. The kidney diseases like many other diseases are slow killers.

Our female workers comprise more than 95 per cent of the total labour force in the garment sector. Not to speak of other environmental and working conditions, the toilet facilities for the female workers, it is alleged, are far from adequate and the situation is really pitiable. Recently in a TV interview, one garments factory owner opined that if 1 (one) per cent of the profit was spent for the welfare measures for the female workers, the situation would dramatically improve and in the long run the profit would surely increase. It is only the mentality of the owners and manufacturers of the garments that is needed.

Inside the jails in our country, there is a female ward. Female inmates of all types are accommodated within the same earmarked quarters and they have the common toilet facilities. Sometimes, some female inmates of good family background and social status have to share the same toilets with the other female inmates who might be suffering from various veneral diseases. And we can well imagine the effect.

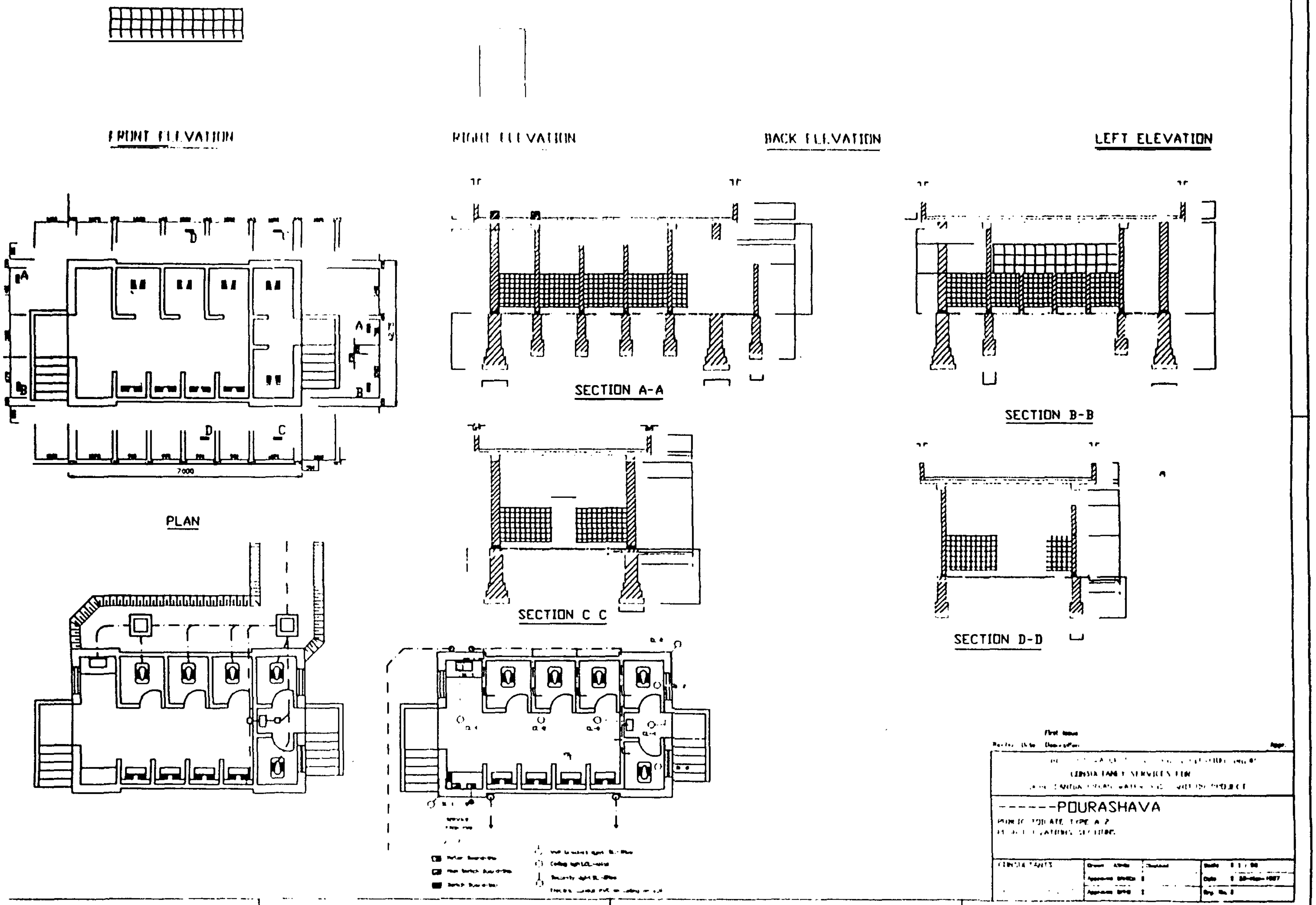
The female bus passengers abstain from drinking water because they do not want to use the toilets because of social taboo and at the same time the lack of the facilities makes the situation ever worse. In many parts of the country, especially in the rural areas there are no proper toilet facilities. Moreover, the females are apparently too shy to respond to natural calls. And in the long run they suffer.

In the government offices throughout the country, the conditions of the toilets as a whole are really deplorable for many reasons. Because of our selfishness we fail to remember that if we do not clean the toilets after use, the persons coming later might suffer. This is one of the major lack of civic sense which we must learn and cultivate nationally.

The other day, one of my female colleagues was virtually complaining regarding the insufficient toilet facilities as a whole and for her female colleagues in particular inside the Bangladesh Secretariat in our country it is not expected that both men and women should use the same toilet.

In conclusion, it may be said that proper and sufficient facilities for the female users will certainly have a positive impact on the health conditions of country. ☐

ANNEX 03 OUTLINE DESIGNS


FRONT ELEVATION
RIGHT ELEVATION
BACK ELEVATION
LEFT ELEVATION
SECTION A-A
SECTION B-B
SECTION C C
SECTION D-D
PLAN
7000
First Issue
------POURASHAVA

ANNEX 04 INFILTRATION TESTS

The first section of this Annex presents a standard method for infiltration tests.

Source:

Environmental Sanitation Information Center, Asian Institute of Technology, **Septic Tanks and Septic Systems**, Environmental Sanitation Reviews, No 7/8, Bangkok, April 1982.

The second section of this section presents a more simple infiltration test, as developed and applied in Egypt where soil and groundwater conditions are similar to those in Bangladesh.. It also gives some considerations on the influence of groundwater levels on infiltration.

Source:

Fayoum Drinking Water and Sanitation Project, **On-site Sanitation, Testing of Family Latrines, Volume I** - Technical Design Report, Egypt-Netherlands Development Co-operation, DHV, IWACO, ECG, May 1996.

6.1.1.7 Soil Permeability Measurements

The most widely used indicator of soil permeability is the percolation test, which measures the ability of soils to absorb water. A well established method for determining the percolative capacity of soils has been notified (259, 137). One of the methods of making percolation tests is shown in Figure 26, and detailed test procedure is presented in Table 11.

The length of time required for percolation tests depends on the types of soil. Fine textured soils require longer presoaking than coarse textured soils to obtain steady infiltration rates (16). MOKMA (371) reported that percolation tests should be made in soils which have been presoaked for a minimum period of eight to twenty four hours. Numerous investigators have emphasized the importance of continuing percolation tests for sewage absorption systems until the water seeps away at a constant rate, or until a degree of consistency is obtained in the results (118, 367, 328, 7).

Most engineers agree that the leaching area required for a sewage absorption system can be determined by percolation tests (185, 215, 216). MACHMEIR (146) presented a method to run a percolation test for the determination of a required trench bottom area to absorb septic tank effluent. He also described the methods of measurement and calculation for percolation rates. KIKER (287, 367) presented empirical formulaea to calculate the area required for the sewage absorption field.

The percolation test is based on the assumption that the ability of a soil to absorb sewage effluents over a prolonged period of time may be predicted from its initial ability to absorb clear water (73). The rate of water flow from a hole depends on the hydraulic conductivity of the soil, the shape of the hole, and the depth to the water content of the soil surrounding the hole (6, 7). ALLISON (298) has stated that the migration of fines, as well as the ion exchange phenomena, will lead to a reduction of the rate at which even clear water enters a soil after the initial wetting period. CHRISTIANSON (299) has shown that the period of increased permeability results from the removal of entrapped air by liquid in the percolating waters. The subsequent long period of decreasing permeability due to microbial activity is reported by ALLISON (300). Occasional changes in both the test procedure and in the sewage loading rates have occured from time to time (91, 158). FREDERICK (301) proposed a modification of Ryon's test involving a formula instead of a curve for relating percolation rate to soil loading.

Table 11. Falling Head Percolation Test Procedure (264)

1. Number and Location of Tests

Commonly a minimum of three percolation tests are performed within the area proposed for an absorption system. They are spaced uniformly throughout the area. If soil conditions are highly variable, more tests may be required.

2. Preparation of Test Hole

The diameter of each test hole is 15.24 cm (6 in.), dug or bored to the proposed depths at the absorption systems or to the most limiting soil horizon. To expose a natural soil surface, the sides of the hole are scratched with a sharp pointed instrument and the loose material is removed from the bottom of the test hole. Two inches of 1.27 to 1.91 cm (1/2 to 3/4 in.) gravel are placed in the hole to protect the bottom from scouring action when the water is added.

3 Soaking Period

The hole is carefully filled with at least 30.48 cm (12 in.) of clear water. This depth of water should be maintained for at least 4 hr and preferably overnight if clay soils are present. A funnel with an attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons or float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

In sandy soils with little or no clay, soaking is not necessary. If after filling the hole twice with 30.48 cm (12 in.) of water, the water seeps completely away in less than ten minutes, the test can proceed immediately.

4. Measurement of the Percolation Rate

Except for sandy soils, percolation rate measurements are made 15 hr but no more than 30 hr after the soaking period began. Any soil that sloughed into the hole during the soaking period is removed and the water level is adjusted to 15.24 cm (6 in.) above the gravel or 20.32 cm (8 in.) above the bottom of the hole. At no time during the test is the water level allowed to rise more than 15.24 cm (6 in.) above the gravel.

Immediately after adjustment, the water level is measured from a fixed reference point to the nearest 0.16 cm (1/6 in.) at 30 min intervals. The test is continued until two successive water level drops do not vary by more than 0.16 cm (1/6 in.) At least three measurements are made.

In sandy soils or soils in which the first 15.24 cm (6 in.) of water added after the soaking period seeps away in less than 30 min, water level measurements are made at 10 min intervals for a 1-hour period. The last water level drop is used to calculate the percolation rate.

5 The percolation rate is calculated for each test hole by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in terms of min/cm. To determine the percolation rate for the area, the rates obtained from each hole are averaged. (If tests in the area vary by more than 7.87 min/cm (20 min/in.), variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.

Example: If the last measured drop in water level after 30 min is 1.59 cm (5/8 in.), the percolation rate = (30 min)/(1.59 cm) = 18.87 min/cm, or
= (30min)/(5/8 in.) = 48 min/in.

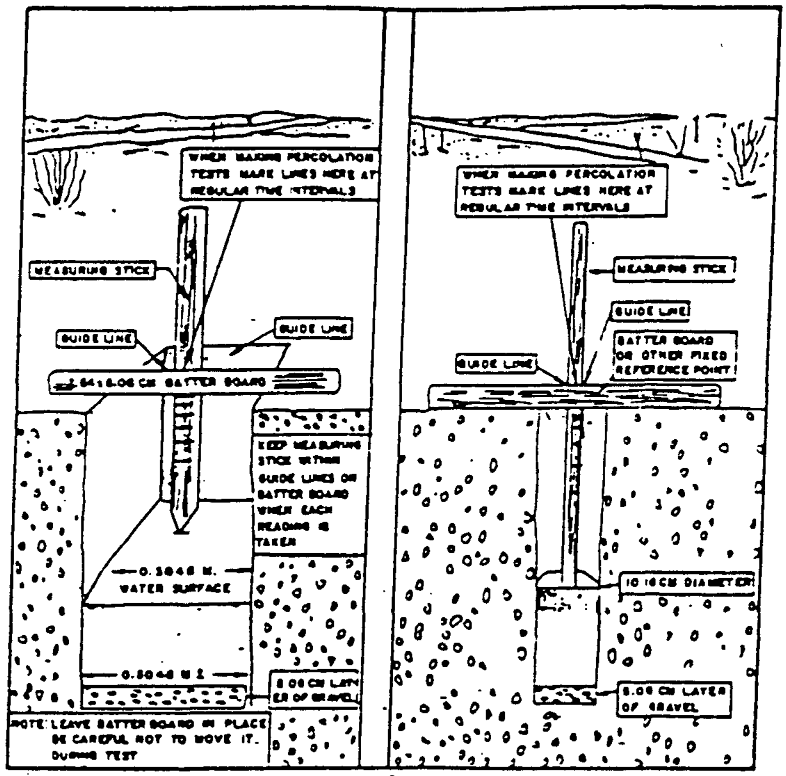


Figure 26 Methods of Making Percolation Test (368)

Table 14. Recommended Rates of Wastewater Application for Trench and Bed Bottom Areas (377, 79, 378).

Soil Texture	Percolation Rate, min/cm	Application Rate[1] m^3/m^2-day
Gravel, coarse sand	<0.39	Not suitable[2]
Coarse to medium sand	0.39 - 1.96	0.049
Fine sand, loamy sand	2.36 - 5.90	0.032
Sandy loam, loam	6.30 - 11.81	0.024
Loam, porous, silt loam	12.20 - 23.62	0.018
Silty clay loam, clay loam[3]	24.31 - 47.24	0.001

[1] Rates based on septic tank effluent from a domestic waste source. A factor of safety may be desirable for wastes of significantly different character.

[2] Soils with percolation rates <0.39 min/cm can be used if the soil is replaced with a suitably thick (<0.61 m layer of loamy sand or sand).

[3] Soils without expendable clays.

4. DESIGN OF THE CESS PIT

4.1 INTRODUCTION

The infiltration capacity of a cess pit depends on a number of factors such as:

- the permeability of the soil;
- the level of the ground water table;
- the quality of the water in the cess pit (i.e. clear water, liquid portion of the wastewater only or all wastewater);
- the dimensions or geometry of the cess pit.

4.2 SOIL PERMEABILITY

Typical values of the soil permeability for different types of soil are listed in table 4.1. In Fayoum soil permeability is often in the range of 0.05 to 0.2 m/day.

Table 4.1. Typical values of soil permeability K (ref.4)

Type of Soil (texture)	Permeability (m/day)
gravelly coarse sand	10 - 50
medium sand	1 - 5
sandy loam, fine sand	1 - 3
loam, clay loam, clay (well structured)	0.5 - 2
very fine sandy loam	0.2 - 0.5
clay loam, clay (poorly structured)	0.002 - 0.2
dense clay (no cracks, pores)	< 0.002

4.3 MEASUREMENT OF SOIL PERMEABILITY

A practical way to measure the soil permeability is the 'inversed auger hole method' (ref.5). The procedure is as follows:

1. Drill a hole with an auger to the required depth.
2. Fill the hole with water and leave it to drain away freely. Refill the hole several times until the soil around the hole is saturated over a considerable distance and the infiltration rate has attained a more or less constant value.(*)

(*) note: in our tests in Fayoum we have adopted a 'wetting' period of 4 hours, a period also mentioned in literature. We have not checked whether this period is long enough to saturate the soil around the hole. A period of 4 hours was mainly selected to be able to carry out infiltration tests within one day.

3. After the last refilling of the hole, the rate of drop of the water level in the hole is measured.
4. The infiltration rate I can now be calculated from the formula (see fig.4.1):

$$I = 0.57 * d * \{\log(h_o + d/4) - \log(h_t + d/4)\} / t \qquad (3)$$

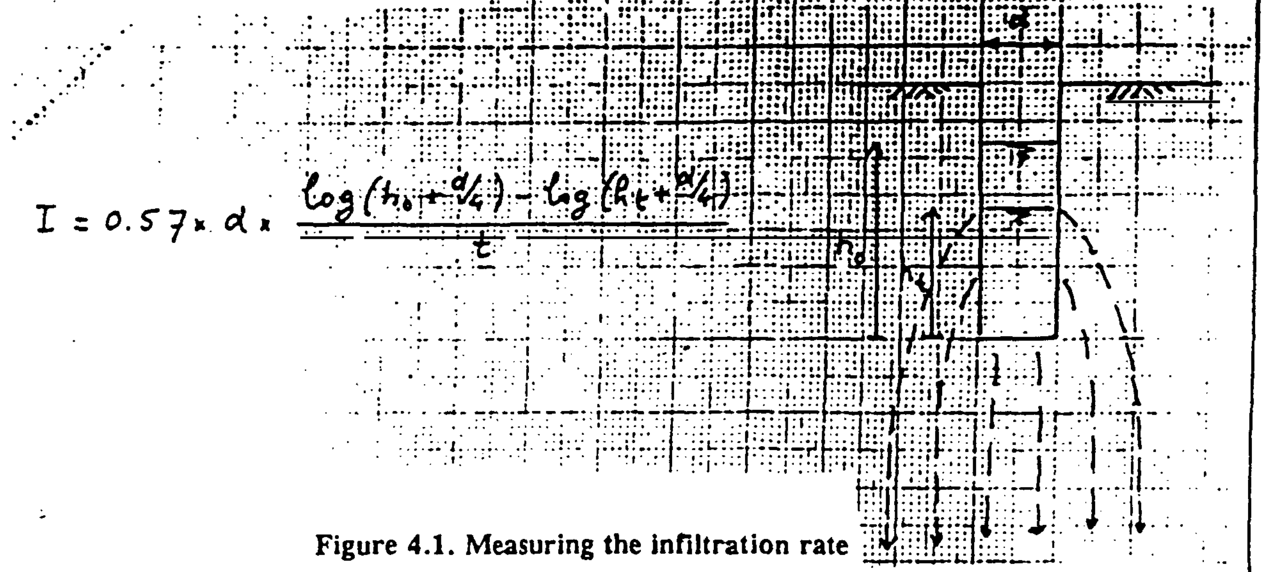


Figure 4.1. Measuring the infiltration rate

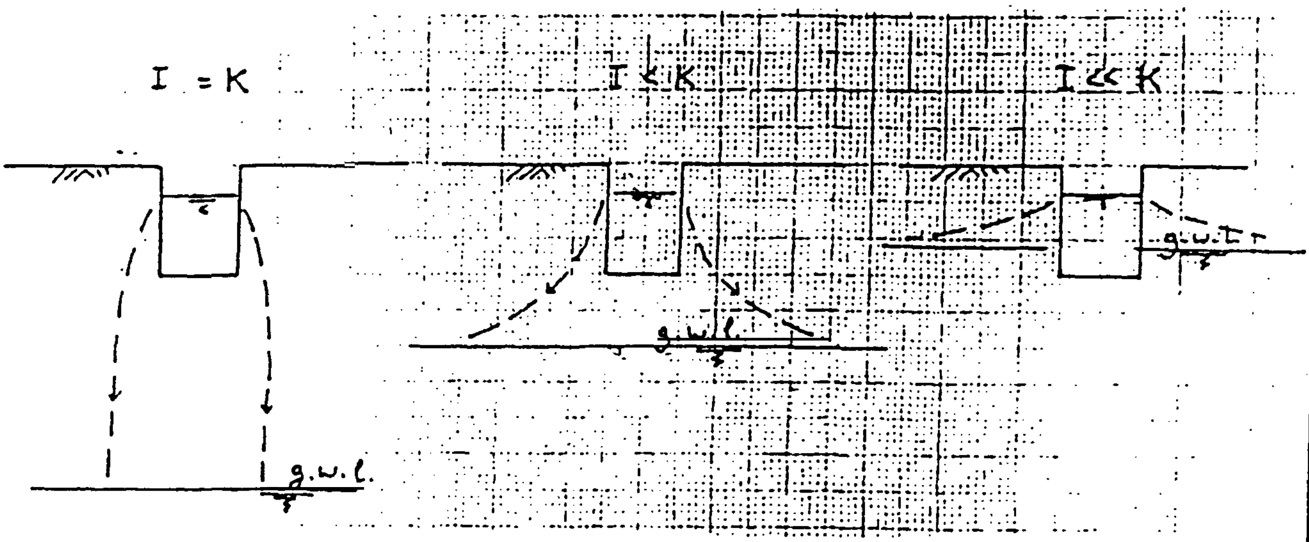


Figure 4.2. Reduced infiltration with high groundwater level

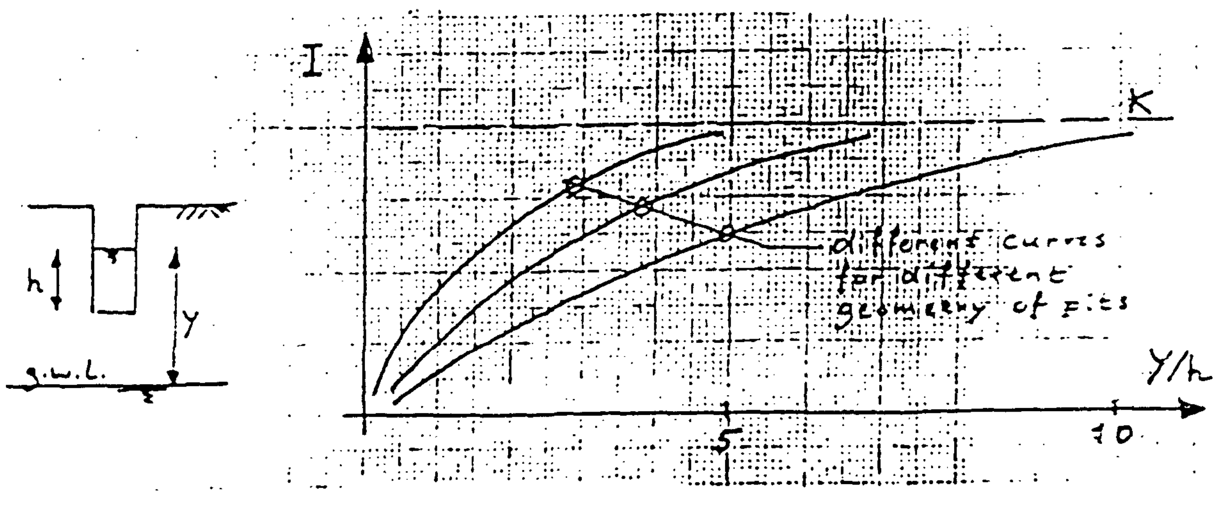


Figure 4.3. Infiltration as function of groundwater level

where: I = infiltration rate (cm/min)
d = diameter of the hole (cm)
h_0 = initial height of the water column in the hole (cm)
h_t = the height of the water column at time t (cm)
t = time since the start of the measurement (min)

5. Now the assumption is that the soil permeability K is equal to the infiltration rate I. This is true when the soil is well saturated prior to the test, and when the groundwater level is at sufficient depth below the bottom of the hole. Under these conditions (this is called a free-draining hole) the infiltrated water front will move vertically downwards. The area of the wetted water front is - under these conditions - assumed to be equal to the wetted surface area in the hole.

So, for a free-draining hole the soil permeability K is equal to the infiltration rate I: $K = I$

To convert the calculated value of K (or I, which was calculated in cm/min) to m/day, multiply it with 14.4.

Table 4.2 gives examples of recent infiltration tests in Fayoum.

Table 4.2 Measured infiltration rates in Fayoum (March 1995)

Location	Infiltration Rate I
El Azab Water Works	0.18 m/day
Senoures Maintenance Centre	0.10 m/day
Ibshway Maintenance Centre	0.13 m/day
Etsa Maintenance Centre	0.08 m/day

4.4 INFLUENCE OF THE GROUND WATER TABLE

Formula (3) is valid for the situation where the ground water table is at a sufficient depth from the bottom of the hole (i.e free-draining). If the ground water is close to the bottom, the rate of flow through the soil will be reduced because of the smaller gradient. Figure 4.2 illustrates this phenomenon.

The measured infiltration rate I will be lower than the actual soil permeability K. The value of I will approach K when the distance of the bottom to the ground water level is some 5 to 10 times the water depth inside the hole (ref.6). The exact relation is not known, and depends amongst others on the geometry of the hole. Figure 4.3 serves as illustration while table 4.3 presents results of recent infiltration tests in Fayoum, carried out in test holes of varying depth.

Table 4.3 Variations of infiltration rates with ground water level, Fayoum

Location	hole geometry (diam./depth)	g.w.l. factor y/h	infiltration rate I (m/day)
El Azab	10 cm/ 50 cm	2.49	0.18
	30 cm/100 cm	1.73	0.18
	10 cm/100 cm	1.12	0.12
gwl = 110 cm	10 cm/200 cm	0.50	0.09
Senoures	30 cm/ 50 cm	3.21	0.08
	10 cm/ 50 cm	1.71	0.10
gwl = 82 cm	10 cm/200 cm	0.38	0.04
Ibshway	30 cm/ 50 cm	1.22	1.03 *
	10 cm/ 50 cm	1.07	0.13
gwl = 53 cm	10 cm/200 cm	0.02	0.08
Etsa	30 cm/ 50 cm	1.93	0.67
	10 cm/ 50 cm	1.29	0.08 *
gwl = 63 cm	10 cm/200 cm	0.19	0.14

Although not all variations in the measured infiltration rates can be explained by the differences in distances between ground water levels and the bottom of the holes (see the I-values marked '*'), the general pattern may be illustrated.

The soil permeability K will be larger than the measured I-values shown in table 4.3. But it is not so relevant to know the actual soil permeability. More important is it to realize that the infiltration rate will change with the depth of the hole and the diameter. For example, when the test is carried out in a shallow hole but the cess pit will be constructed deeper, one should be aware that the actual infiltration rate will be less than originally measured. The cess pit will also have a larger diameter than the test hole which will again change the infiltration rate.

It is recommended to carry out infiltration tests at various depths, at least also upto the depth of the planned cess pit. Practically, the tests may be carried out at three depths: 200 cm (which will always be lower than the ground water table), 100 cm and 50 cm. This should give sufficient information as basis of the design.

4.5 QUALITY OF WATER IN CESS PIT

Permeability or infiltration tests in auger holes are carried out with clear water. But the cess pit will contain either all the wastewater (as in double leaching pit latrines) or only the liquid portion of the wastewater (as in cess pits for septic tanks). Over time the walls of the cess or leaching pit will clog, especially when there are solids in the wastewater. For that reason the safe application rate or design infiltration capacity I_d of cess pits is lower than the measured infiltration capacity. The 'safety factor' is generally higher for dry pits than for cess pits of septic tanks. Table 4.4 gives some examples.

Table 4.4 Design infiltration capacities

Measured infiltration rate (m/day)	Design infiltration capacities I_d (l/m²/day)		
	cess pit (a)	cess pit (b)	dry pit (c)
0.10	30	25	13
0.20	45	35	14
0.30	55	45	15
0.40	60	50	16

notes
(a) USA Health Department, for cess pits of septic tanks; settled water only (ref.7)
(b) Lesotho practice, for cess pits of septic tanks, settled water only (ref 8)
(c) Indonesia practice, double leaching pits receiving all wastewater (ref.9)
- The measured and the design infiltration capacities are expressed in different units (m/day and l/m².day respectively) to clearly differentiate between the meaning of the two parameters
- In handbooks, the measured infiltration rates (first column in table 4.4) are expressed differently, often as the time it takes for the water in the test hole to lower over a certain distance. We have converted these handbook-values into the infiltration rates using formula (3).

Most handbooks state that, for measured infiltration rates of less than 0.10 m/day, the use of leaching pits is not recommended. In Fayoum we are mostly faced with these low values. Considering that most of the measured infiltration rates are in the order of 0.10 m/day, we may - optimistically - set the design value I_d at 25 l/m².day. If we are more conservative, a design value of 15 l/m².day may be considered.

The validity of this design parameter is subject of the testing programme.

4.6 REQUIRED INFILTRATION AREA A

Using the design infiltration rates established above, and considering the various wastewater generation rates of table 3.1, we can calculate the required infiltration area A for the various classes of water users.

Table 4.5 Required infiltration areas A (m²) for households of 10 people

Case	q (l/c.d)	Area A (m²) I_d = 25 l/m².day	Area A (m²) I_d = 15 l/m².day
house connection, good drainage	100	40	67
house connection, bad drainage	30	12	20
public tap, good drainage	20	8	13.3
public tap, bad drainage	10	4	6.7

Table 4.5 shows that, when the wastewater generation rate is high, very large infiltration areas would be required. These can not be realized in cess pits. For example, to create an infiltration surface of 40 m², a pit of 3 meter deep and of 4.7 meter diameter would be required. The cost of such a pit would amount to around LE 3200.

Where such large infiltration areas are needed, infiltration beds could be considered. These are layers of gravel/sand in which the wastewater is made to infiltrate through perforated pipes. But given the restrictions on land availability, it seems hardly an option for the villages in Fayoum.

note Infiltration beds are being tested in Beni Suef under the FINNIDA assisted Water and Sanitation Project, especially for sullage (i.e. wastewater from bathrooms and kitchen)

Here we are examining the applicability of cess pits, and at this stage we can already conclude that our cess pits can only accommodate small quantities of wastewater

4.7 DIMENSIONS OF THE CESS PIT

In the design of the cess pit, it is normally assumed that infiltration occurs through the walls of the pit only. Solids will accumulate on the bottom and will clog it, even when the cess pit receives settled water: there will always be some solid matter that enters the pit.

Deep pits of small diameter have relatively more effective infiltration area than wider and shallower pits, and are also cheaper. Table 4.6 compares the costs of pits of various dimensions, all having the same infiltration area (i.e. wall surface area).

Table 4.6 Cost of cess pit as function of the depth

Depth of Pit (m)	Infiltr. Area A = 4 m^2		Infiltr. Area A = 6.7 m^2	
	Diam. (m)	Cost (LE)	Diam. (m)	Cost (LE)
1.00	1.80	400	3.00	900
1.25	1.35	290	2.25	620
1.50	1.10	230	1.75	465
2.00	0.75	180	1.25	350
2.50	0.60	160	0.95	285

notes: - 0.30 meter freeboard is included in the depth
- the cost estimated is based on the same parameters that where used for the septic tank, i.e. brickwork walls and a reinforced concrete cover slab. There is no bottom structure

However, the depth will be limited by the level of the ground water table. Not only will it restrict the possibility to construct the pit, the infiltration rate will also decrease when the pit is partially inserted into the groundwater (see paragraph 4.4). Therefore, a practical depth shall be chosen. We may stipulate that the bottom level of the pit shall not be lower than 0.50 meter below the groundwater level, which means that in most situations the depth of the pit will range between 1.00 and 1.50 meter.