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Ministry of Water Resources and Irrigation

LIFE Integrated Water Resource Management
Task Order No. 802
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Task # 4: Environmental Services for Improving Water Quality Management

Wastewater Treatment Design Report

Report No. 8

July 2005

International Resources Group
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Technical Report No. 8

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Water and Environment Group (WEG)

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Abbreviations and Acronyms

BCWUA	Branch Canal Water Users Association
BOD	biochemical oxygen demand
CDA	Community Development Association
COD	chemical oxygen demand
DBAF	Dual Flow Aerated Bio-filters
GEF	Global Environmental Fund
hp	horsepower
IAS	Irrigation Advisory Service
IWMD	Integrated Water Management District
IWRM	Integrated Water Resources Management
MOE	Ministry of Education
MWRI	Ministry of Water Resources & Irrigation
PVC	polyvinyl chloride
RBC	Rotating biological contactors
TA	technical assistance
TKN	total nitrogen
TP	total phosphate
TSS	total soluble solids
USAID	United States Agency for International Development
WEG	Water and Environment Group

1. Introduction

This report presents the technical aspects of the design for a dual biological aerated filter sewage treatment plant with a capacity of 600 cubic meters (m^3) per day in Sinbo Village, Zifta, Gharbiya. The report meets the technical requirements of the governing laws for wastewater treatment and disposal, and presents the technical level of the work of the Water and Environment Group (WEG), the inventor of this plant. It includes the design, description, and technical specifications for the plant units and options for planning the layout are shown in the detailed drawings. The plant's design takes into consideration the following conditions:

- Minimize construction costs
- Maximize use of existing facilities
- Maximize use of locally manufactured parts
- Optimize capabilities to meet variable loads
- Ease of erection and installation
- Ease of operation and maintenance
- Minimize required land area
- Respect for environmental laws.

2. Technical Report

Background

The purpose of this short-term technical assistance assignment was to provide local technical support to the implementation of Task # 5, Environmental Services for Improving Water Quality Management. The consultant worked with the LIFE–IWRM technical assistance (TA) team, USAID, IWMU, and involved stakeholders to prepare plans and develop alternatives to implement a wastewater management pilot project. Specifically the consultant:

- Reviewed existing liquid waste treatment practices in Egypt and selected the most low cost and non-conventional three to five alternatives for presentation to the stakeholders
- Worked with LIFE/IWRM to select one practical and reasonable solution for the targeted Branch Canal Water Users Association (BCWUA) at Sinbo Vllage, Zifta Irrigation Directorate
- Prepared breakdown cost estimates and feasibility studies to implement the recommended solution
- Worked with LIFE/IWRM to prepare a proposal requesting grant fund from alternative sources such as the Japanese Embassy or GEF
- Worked with local field agencies to design the approved and selected solution
- Briefed and made presentations to the USAID technical officers, Ministry of Water Resources and Irrigation (MWRI) officials, donor organizations, and other stakeholders on behalf of LIFE/IWRM program.

Methods of Wastewater Treatment in Egyptian Rural Areas

Stabilization Ponds

Stabilization ponds are the most commonly used system for wastewater treatment in rural areas of Egypt. Figure 1 shows three stabilization ponds. This system offers many benefits, including simple operation and maintenance, and excellent removal of pathogenic organisms. The stabilization ponds are usually classified according to the nature of the biological activity taking place: anaerobic, aerobic, aerated aerobic, or facultative.

A pretreatment anaerobic waste stabilization pond is essentially to increase removal efficiency of the overall system, and decrease the detention period of the process. The anaerobic pond can be described as a digester that requires no dissolved oxygen, since anaerobic bacteria break down the complex organic waste. A facultative waste stabilization pond is one in which there is an upper aerobic zone (maintained by algae) and lower anaerobic zone. The stabilization of wastes is brought about by a combination of aerobic, anaerobic, and facultative bacteria.

A tertiary maturation pond is designed to provide for secondary effluent polishing and seasonal nitrification, and the number of disease-causing bacteria are reduced through extended detention time.

The waste stabilization pond system may comprise one pond only (facultative) or several ponds in series (anaerobic, facultative, maturation). In addition, it may be desirable to construct a number of series of the same type to permit parallel operation.

Figure 1 Stabilization Ponds

The stabilization pond can be modified by the addition of air by a mechanical aerator in the facultative stages. This has the beneficial effect of increasing the treatment quality, while reducing the land area required for the ponds. Operation cost, however, is much higher due to the mechanical aeration. This system is installed in several places in Egypt as El-Wadi el-Gadid villages (6), Adlyia, in Damieta, Sharm el-Shiekh, Dahab, Newibaa, El-Tor and Taba in South Sinai, and Waked, in Behira.

Aerated Lagoon

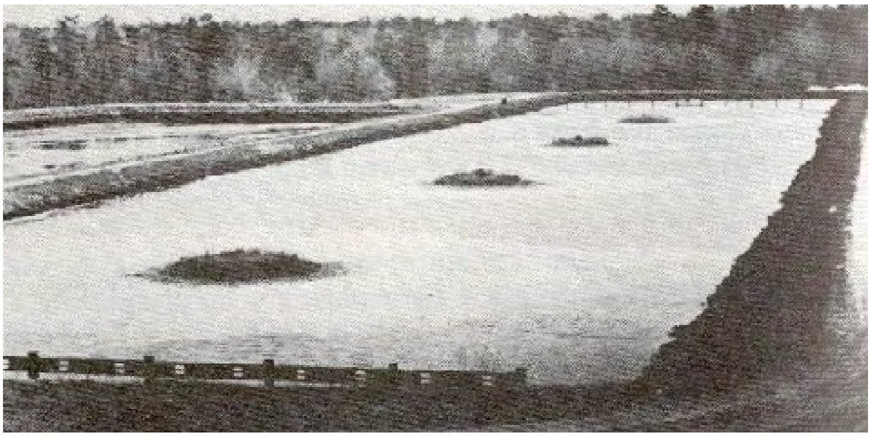
The aerated lagoon is a basin in which wastewater is treated either on a flow-through basis or with solids recycled. Oxygen is usually supplied by means of surface aerators or diffused-air aeration units. The aerated lagoon process is essentially the same as conventional-aeration activated sludge processes, except that an earthen basin is used for the reactor and the oxygen required by the process is supplied by surface or diffused aerators.

Seasonal and continuous nitrification may be achieved in aerated lagoon systems. The degree of nitrification depends on the design and operating conditions within the system and on the wastewater’s temperature. Generally, with high wastewater temperature and lower loadings, higher degrees of nitrification can be achieved.

The action of the aerators and that of the rising air bubbles from the diffuser keep the contents of the basin in suspension. The contents of an aerated lagoon are mixed completely and neither the incoming solids nor the biological solids produced from waste conversion settle out.

Depending on retention time, the effluent contains are about one-third to one-half the value of the incoming biochemical oxygen demand (BOD) in the form of cell tissue. Before the effluent can be discharged, the solids must be removed by settling in a setting tank. If the solids are returned to the aerated lagoon, there will be no difference between this process and a modified activated sludge process. This system is installed in several places in Egypt: Mit Mazah, in Daqahliya, El-Nazlah, in Fayoum, Nekla el-Enab, in Behira, Seif el-Din, in Damieta, Ismailiyia New Wastewater Treatment Plant, and Suez New Wastewater Treatment Plant. An aerated lagoon is shown in figure 2.

Figure 2 Aerated Lagoon



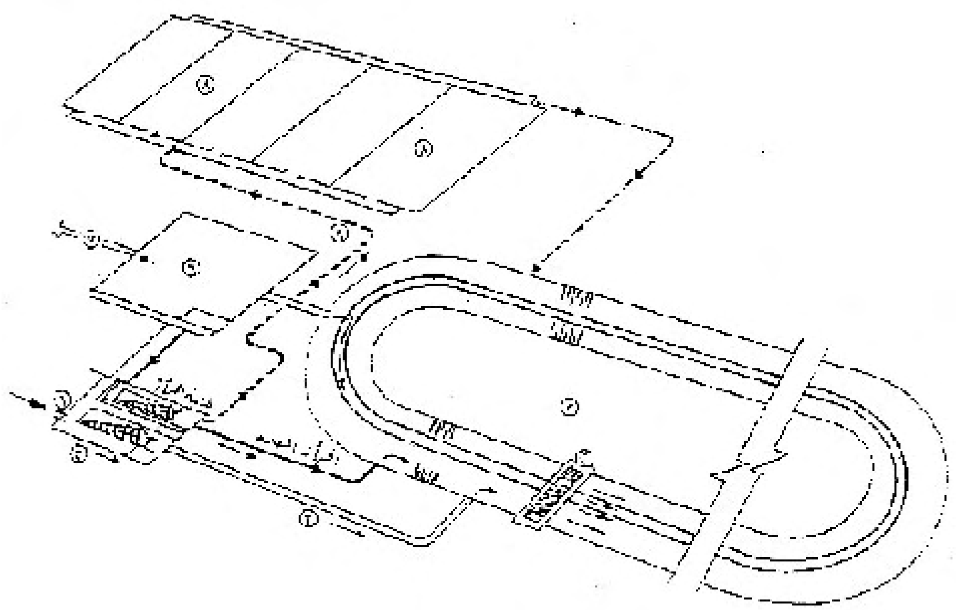
Oxidation Ditch

The oxidation ditch is increasing in numbers. In this system, the wastewater is pumped around a circular pathway, or racetrack, by a mechanical aerator/pumping device at one or more points along the flow circuit.

The system operates in a nitrification–de-nitrification mode. As the wastewater passes through the aerator, the dissolved oxygen content increases and then is depleted with time as the wastewater traverses the circuit. The economics of oxidation ditches appear most favorable when the sediment rate is long and particularly when nitrification or nitrification–de nitrification is required. For conventional nitrification, or carbonaceous treatment, the influent generally would enter a re-aeration compartment where the aerator is located and the effluent would be removed just prior to returning to the re-aeration compartment. For a nitrification–de-nitrification–nitrification system, the influent point is at the point of de-nitrification initiation. The oxidation ditch is assumed to be both primary and secondary treatment accomplished together.

Oxidation ditches provides full treatment of wastewater for small communities at the same cost per capita as treatment by a conventional activated sludge system for large communities. This system is installed in several places in Egypt: four villages in Damieta, and in 72 industrial project in six governorates in the Delta. Figure 3 shows a flow diagram that explains the oxidation ditch plant system.

Figure 3 Oxidation Ditch Plant Flow Diagram



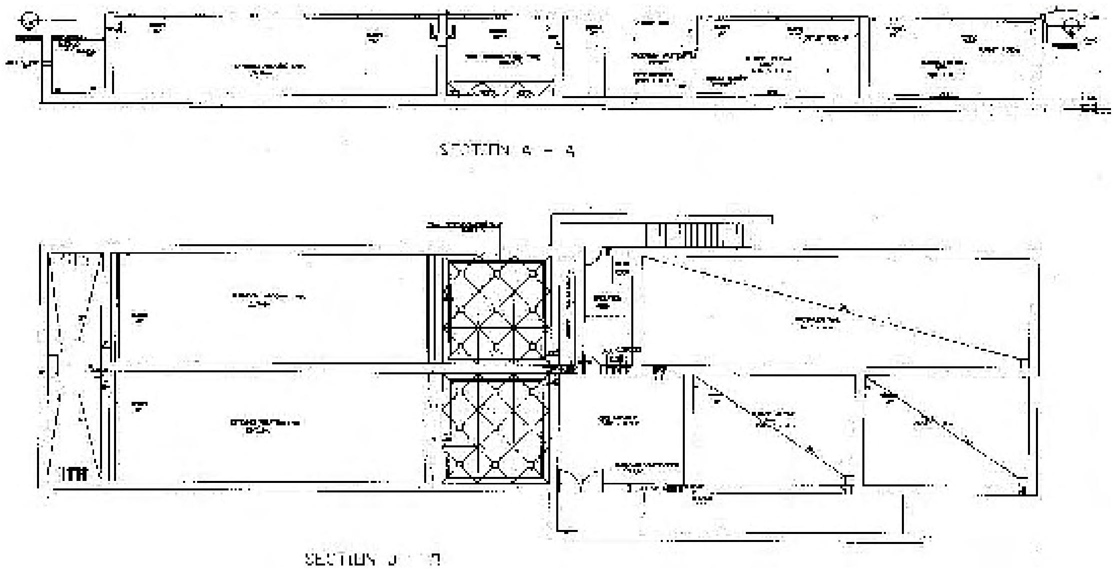
Extended Aeration

The extended-aeration process is a modification of the conventional activated-sludge process. It is commonly used to treat the wastewater generated from small rural communities.

The system consists of a single or of multiple basins designed for completely mixed flow, followed by a settling basin to separate the mixed liquor solids from the treatment wastewater. In extended aeration activated-sludge, detention time is increased by a factor of four or five compared to conventional activated-sludge. The main advantage of the extended-aeration process is that the amount of excess biological solids (sludge) produced is eliminated or minimized.

The extended-aeration process is further simplified since only preliminary influent wastewater treatment is required to remove coarse materials and the primary clarifier is eliminated. However, the size of the aeration basin is much larger than that of the conventional activated-sludge process, as can be seen in figure 4.

Figure 4 Extended Aeration Plant



Although the amount of excess sludge in the extended-aeration process is significantly reduced, secondary clarification is needed to remove the accumulated non-biodegradable portion of sludge and the influent solids that are not degraded or removed. The only disadvantage of this system is its sophisticated form of technology. It is too sophisticated in terms of operation and maintenance.

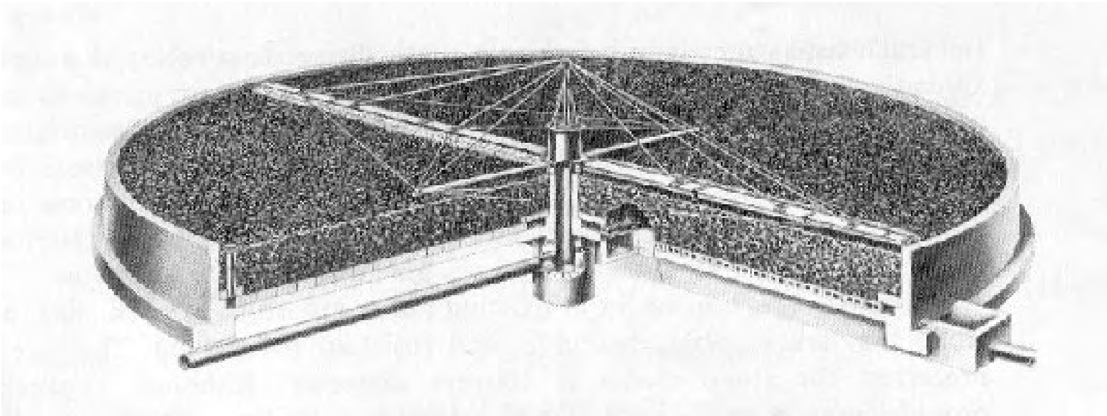
This system is installed in several places in Egypt including six villages in Damieta, most tourism villages on the west north coast , Ras Sedr, El-Sokhna, and Hurgadah.

Trickling Filter

The trickling filter system is an aerobic attached-growth biological treatment process. The system consists of primary settling tank, trickling filter, and final sedimentation tank.

The modern trickling filter consists of a bed of a highly permeable medium to which microorganisms are attached and through which wastewater is trickled. The filter media usually consists of filter rock or a variety of plastic packing materials. In rock filled trickling filters, the size of the rock typically varies from 25–100mm diameter, and the depth of the rock media ranges from 0.9–1.5m. Rock filter beds are usually circular, and a rotary distributor distributes the liquid wastewater over the top of the bed. Figure 5 shows a cross section of this system.

Figure 5 Conventional Trickling Filter Unit



Filters are constructed with an under drain system for collecting the treated wastewater and any biological solids that have become detached from the media. This under drain system is important both as a collection unit and as a porous structure through which air can circulate. The collected liquid is passed to a settling tank where the solids are separated from the treated wastewater. In practice, a portion of the liquid collected in the under drain system or the settled effluent is recycled, usually to dilute the strength of the incoming wastewater and to maintain the biological slime layer in a moist condition.

The advantage of trickling filters compared to other wastewater treatment systems is that no power is consumed in agitation or gas compression for the creation of a gas–liquid contact area. Power is consumed only in transferring liquid to and from the unit and in distributing it over the packed bed, so that operating costs are low. The differences between alternative versions of biological filters systems are principally in the material used as the packing to form the bed and provide the solid support for the film of microbial slime, and in the rate and manner in which the wastewater load is applied to the bed

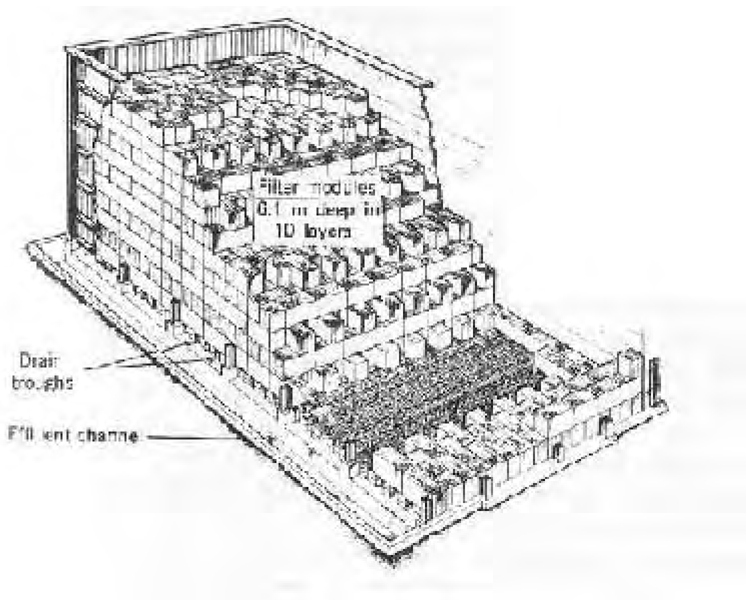
The graded stones are stacked to form a bed 2–3m deep, and the bed may have a base of larger stones and be topped with a layer of smaller stones as seen in figure 5. In some countries, smaller grades of stones are used. This gives a higher value of specific surface, but the interstices between adjacent stones are narrower and there is consequently a greater risk of blockage occurring.

This system is installed in several places in Egypt, including Shobrakhit in Behira, Samanod in Gharbiya, Beni Suef, Fayoum, and El-Minya.

Biological Towers (Bio-tower)

In recent years, several forms of manufactured media have been marketed for filters. The main advantage, relative to crushed rock, is the high specific surface (m^2/m^3) with a corresponding high percentage of void volume that permits substantial biological slime growth without inhibiting passage of air supply oxygen. Other advantages include a uniform media for better liquid distribution, light facility construction of deeper beds, and the ability to handle high strength and unsettled wastewater. With this development, the term *biological tower* was introduced. Better results are achieved and greater organic loading can be applied when the beds are 6.0m or more in depth, as illustrated in figure 6, which shows the construction of a rectangular biological tower. Wastewater is piped to the top of the tower, spread over the packing, and trickles down through the bed. The under flow is conveyed by drains to an effluent channel. These towers allow a greater contact time and the liquid can be applied continuously by fixed distributors instead of by rotating arms.

Figure 6 Rectangular Biological Tower



In special cases, existing treatment plants may install a biological tower preceding primary settling. This type of unit, referred to as a roughing filter, improves overall plant efficiency by reducing influent BOD, enhancing settle-ability by pre-aeration and leveling out (absorbing) shock loads of high-strength industrial wastes discharged to the municipal system. Direct recirculation in biological towers is preferred for increased BOD removal. For strong municipal wastewater, two towers may be set in series with or without an intermediate clarifier.

The exact design loading for a biological tower is based on placement of the unit within the treatment scheme; wastewater recirculation pattern and ratio; type of synthetic media employed; and strength, biodegradability, and temperature of the wastewater.

In high-strength, soluble food-processing wastes can be handled by multiple-stage biological towers. Normal high rate filtration plants use flow patterns similar to conventional packed filter systems. Allowable organic loading on deep beds range from 400–2,400gm/m^3/d with hydraulic loading up to 10m^3/m^2/d. BOD removal efficiencies rely on volumetric organic loading, and are generally independent of depth if it is greater than about 3m. Normally, towers are constructed with 6m depth of media. Biological towers using synthetic media do not appear to be as susceptible to operational difficulties of quality control and odors as are rocked-filled filter.

This system is installed in several places in Egypt, including Abu el-Matameer in Behira, Basuion in Gharbiya, and several industrial plants in 10th of Ramadan City.

Dual Flow Aerated Bio-filters (DBAF)

To further increase performance and simplify operation of an aerated filter, a new up-flow bio-filter system has recently been developed. For total soluble solids (TSS), BOD, and chemical oxygen demand (COD), the average removal ratio was 90-89 percent and 90 percent, respectively, for the total system. The up-flow filter gave an average removal efficiency of 28 percent TSS at an average influent concentration of 83 mg/l and an average effluent concentration of 59 mg/l. This value was considered high, in spite of the absence of clarifier after the up-flow filter and could be attributed to the fact that most of the suspended solids accumulated with the biomass were entrapped in the voids in the packed media of the up-flow filter

The up-flow filter gave an overall removal efficiency of 25 percent BOD with an average influent concentration 115 mg/l and an average effluent concentration of 86mg/l (r=1.5). The up-flow filter gave an overall removal efficiency of 27 percent COD with an average influent concentration of 260mg/l and an average effluent concentration of 189mg/l.

The down-flow filter gave an average removal efficiency 38 percent TSS at an average influent concentration of 59mg/l with average effluent concentrations of 36mg/l TSS. This was considered a good result compared with many study, which achieved an average effluent of 88 mg/l. This was due to the per-filtration stage, using the up-flow filter.

The down-flow filter gave a 56 percent BOD removal efficiency, with an average influent concentration of 38 mg/l. This result is lower than the previous study, which gave a 67.8 percent removal ratio. The results showed that the fractions of BOD removed by the down-flow filter were decreased with increasing the up-flow filter’s performance. This caused most of the organic substrate to be removed and the remaining portion of organic substrates applied to the down-flow filter were less treatable.

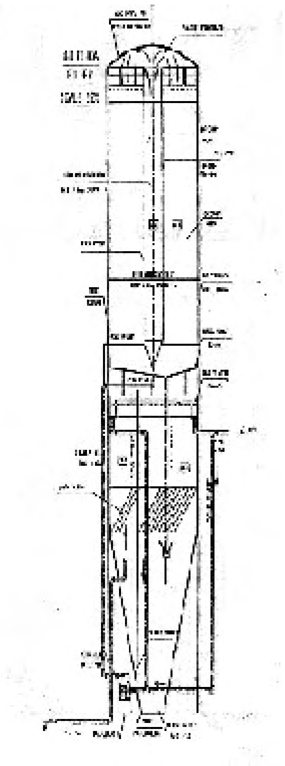
The plant performance was improved using the DBAF over a previous study, the results of which did not comply with Law 48/Year 1982’s effluent standards with an average removal ratio of 70 percent for TSS, 67 percent for BOD, and 66 percent for

COD. The pilot result compared with the same pilot treatment procedure using gravel as a packing material, was also consider better. The removal ratios achieved were 90.38 percent for TSS, 81.40 percent for BOD, and 81.73 percent for COD.

The up-flow filter achieved high BOD removal efficiency in spite of its small volume compared with the down-flow filter volume; its efficiency is approximately half the efficiency of the down-flow filter. This result matches other studies, which state that the second stage filter is less efficient than the first stage due to the decreased treatability of the waste fraction applied to the second reactor, which affects the reaction rate and type.

This system is installed in several places in Egypt, including four villages in Nobaraiah, El-sayed el-badawy in Kafr el-Shiekh, Kalabsho in Dakahlyia, El-Gehad in Beni Suef, El-Tonab in Aswan, and three tourist villages on the west north coast. Figure 7 illustrates the DBAF system.

Figure 7 DBAF System



Rotating Biological Contactors (RBC)

Rotating biological contactors (RBCs) were first installed in West Germany in 1960 and were later introduced in the United States. In the United States and Canada, 70 percent of the r RBC systems installed are used for carbonaceous BOD removal only, 25 percent for combined carbonaceous BOD removal and nitrification, and 5 percent for nitrification of secondary effluent.

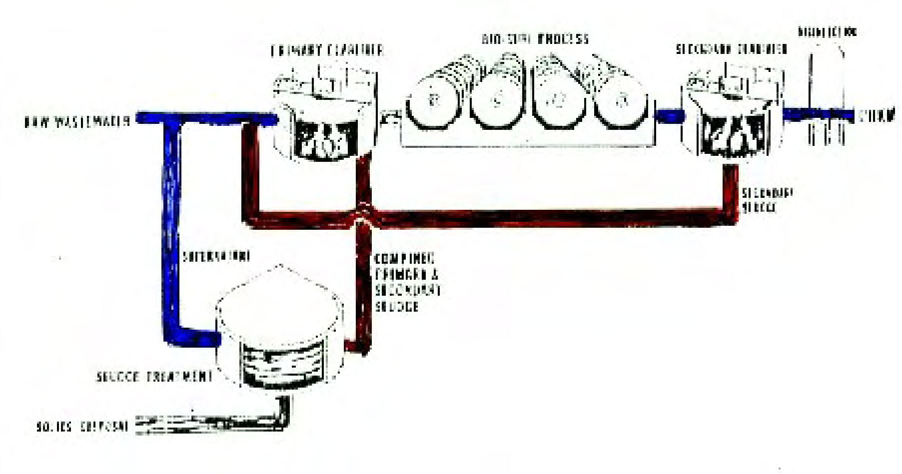
A rotating biological contactor consists of a series of closely spaced circular disks of polystyrene or polyvinyl chloride. The disks are submerged in wastewater and rotated slowly through it.

In operation, biological growths become attached to the surfaces of the disks and eventually form a slime layer over the entire wetted surface area of the disks. The rotation of the disks alternately contacts the biomass with the organic material in the wastewater and then with the atmosphere for adsorption of oxygen. The disk rotation affects transfer and maintain the biomass in an aerobic condition. The rotation is also the mechanism for removing excess solids from the disks by shearing forces it creates and maintaining the sloughed solids in suspension so they can be carried from the unit to a clarifier. Rotating biological contactors can be used for secondary treatment, and they can also be operated in the seasonal and continuous nitrification and de-nitrification modes.

RBCs are usually designed on the basis of loading factors derived from pilot plant and full-scale installations, although their performance can be analyzed using an approach similar to that for trickling filters. Both hydraulic and organic loading-rate criteria are used in sizing units for secondary treatment. The loading rates for warm weather and year-round nitrification will be considerably lower than the corresponding rates for secondary treatment. Properly designed, RBCs generally are quite reliable because of the large amount of biological mass present. This large biomass also permits them to withstand hydraulic and organic surges more effectively. The effect of staging in this plug-flow system eliminates short-circuiting and dampens shock loading. The flow process is illustrated in figure 8.

This system was installed in one place in Egypt for testing, but was unsuccessful.

Figure 8 Flow Line in an RBC Plant



Comparison Among Treatment Methods

Technical Comparison

Table 1 gives a technical comparison among the various treatment methods.

From the comparisons in the table, it seems that the stabilization pond is the optimum technical solution for the low requirements for operation and maintenance and minimum control. The main problem is the required land, which raises construction costs to the higher value compared with other technologies. There is also concern about the environmental impacts, especially insect generation and the large wet area that could breed water-borne diseases.

The second best option was the DBAF plant. That would meet environmental needs and solve the equation of area needed. Operation and maintenance costs are low and the small structure is not expensive. It is easily built and could be constructed quickly.

Table 1 Technical Comparison of Methods of Wastewater Treatment in Rural Areas in Egypt

Area of Comparison	Stabilization Pond	Aerated Lagoon	Oxidation Ditch	Extended Aeration	Trickling Filter	Biological Tower	DBAF	RBC
Required area	Very large	Large	Medium	Medium	Large	Small	Very small	Medium
Construction materials	Earth and lining mat	Earth and lining mat with mechanical equipment	Earth and lining mat with mechanical equipment	Reinforced concrete tanks with mechanical equipment	PVC and bricks with mechanical equipment and gravel	PVC and bricks with mechanical equipment and plastic	Reinforced concrete or steel with mechanical equipment and plastic	Reinforced concrete or steel with mechanical equipment
Required power	Nil	Medium	High	Very high	Medium	Medium	Low	Low
Required operators	A small number of ordinary laborers needed periodically	A number of employees with medium skills	A few staff with high skill levels	A few staff with high skill levels	A number of employees with medium skills	A number of employees with medium skills	A few employees with medium skills	A medium number of employees with medium skills
Removal efficiency	98–99%	90–96%	95%	95%	80–85%	85%	92–97%	70–80%
Ease of operation and maintenance	Easy	Medium	Difficult in control	Difficult in control	Easy	Medium	Easy	Difficult in control
Operation and maintenance problems	Not many problems but difficult to solve	Medium	Continual problems with control	Continual problems with control	Medium	Medium	Few problems and easy to repair	Medium
Effect of climate	High	Medium	Medium	Small	Medium	Medium	Small	Medium
Required chemicals	Few or none	Few	Essential	Essential	Essential	Essential	Essential	Essential
Need for lab control	Per month	Per week	Per day	Per hour	Per week	Per day	Per week	Per day
Facing shock loads	No problems	Some problem	Affected highly	Affected highly	Some problem	Some problem	Some problem	Affected highly

Economic Comparison

Table 2 gives an economic comparison of the various treatment methods. The comparison was made according to the cost of plants built in Egypt during the last 2 years, taking into consideration inflation.

Power costs were calculated as L.E.1/kWh and labor cost as L.E.100/month for ordinary labor, L.E.300/month for technicians, and L.E.500/month for engineers. Lab costs were calculated as the price of analysis in outside labs taking into account both the type of analysis and frequency such tests are required.

From the comparison in the table, it seems that the stabilization pond is the optimum solution due to low requirements for operation and maintenance and minimum control. The problem is the need for land and the construction costs because of the liner that prevents the system having an impact on the ground aquifer. Those factors raise construction costs compared with other technologies.

The second best option was the DBAF plant, which meets environmental requirements and solves the equation of area needed and low costs for operation and maintenance. Initial cost are low as well, due to the small structure and ease of erection, which minimize time needed for construction.

Table 2 Economic Comparison of Methods of Wastewater Treatment in Rural Areas in Egypt

Area of Comparison	Stabilization Pond	Aerated Lagoon	Oxidation Ditch	Extended Aeration	Trickling Filter	Biological Tower	DBAF	RBC
Area share $m^2/m^3/d$	40–45	8–0	2.5–4	2–3.5	3–6	1.2–1.8	0.1–0.2	1.5–3
Construction cost (L.E./m^3/d)	1300–1500	1200–1300	1200–1350	1100–1200	1000–1200	1100–1200	700–900	1000–1300
Power cost (L.E./m^3/d)	Nil	0.2–0.8	1–2.5	1.4–2.8	0.5–1.5	0.6–1.6	0.1–0.6	0.15–0.75
Labors cost (L.E./m^3/d)	0.25–1.0	0.5–2.0	2.5–4.5	3.0–6.0	2.0–3.0	2.0–3.0	0.35–0.50	0.50–0.80
O & m cost (L.E./m^3/d)	0.25–1.0	1.0–2.0	3.5–5.5	4.0–6.0	1.0–3.0	1.0–3.0	0.30–0.70	0.80–1.80
Spare parts cost (L.E./m^3/d)	Nil	1.0–2.0	3.5–5.5	4.0–6.0	1.0–3.0	1.0–3.0	0.30–0.70	0.80–1.80
Chemicals cost (L.E./m^3/d)	Nil	0.05–0.30	0.05–0.70	0.05–0.70	0.05–0.70	0.05–0.70	0.05–0.20	0.05–0.70
Lab cost (L.E./m^3/d)	2.50	1.00	1.50	2.50–4.00	1.50	1.50	1.50	2.00

Remarks:

1. Cost estimate of O & M and other running items are on monthly basis for a unit of m3/day of the capacity of the system (means multiply this cost by the number of cubic meters of the capacity of the system)
2. O&M cost is for temporary workers, oil, grease and other small repairs such as replacing broken pipes
3. Lab cost depends on number of samples and measured parameters (1 to 4 samples for the 1st month and then 1 sample every 3 month)

3. Project Data and Considerations

Treatment Technology

The technology used is biological filtration, with a dual biological aerated filter (DBAF).

Flow Rates

Design flows are:	maximum daily flow	$600m^3$/day
	hourly flow	$25m^3$/hr
	peak flow	$40m^3$/hr

Influent Sewage Characteristics

Influent properties are:	BOD	300mg/l
	suspended solids (SS)	350mg/l

Effluent Sewage Characteristics

Effluent properties for design should comply with Law 48/1982 for reuse of treated wastewater in irrigation. Limits are:

BOD	5.30mg/l
SS	20mg/l

Required Area

The site for the DBAF sewage treatment plant needs to be 8m × 20m, with total area for the plant about $160m^2$.

Process Description

The tender includes the following works:

Treatment Line

Water Line

Raw sewage pump station

Primary settling tank

Recirculation pumps

Dual biological aerated filter tower

Final clarifier

Contact tank and chlorination equipment

Filter pumps and pressure sand filter

Sludge Line

Sludge storage tank

Sludge dewatering unit

Service Parts and Units

Power and control electric switch board

Laboratory kit

Administration room

Units Description

The continuous flow pilot plant consists of:

Primary sedimentation tank

Pumping unit

Dual biological aerated tower filter (DBAF)

Final sedimentation tank

Contact chlorine tank.

Air pump

Sludge tank

Pressure sand filter

The plant's components are made of steel or reinforced concrete and plastic. The major parts of the unit and their mode of function are:

Sedimentation Tanks—The tanks are square or circular, divided into two compartments. One works as a primary sedimentation tank and the other as a final sedimentation tank. The tanks can be erected above or below ground, depending on site conditions. The unit can be made of steel or reinforced concrete to a total depth between 2m and 3m, with 1m vertical sides. The balance of the side slopes between 45–60 degrees to the horizontal to lessen sludge accumulation, eliminating the need to scrape it. The effluent will go through a perimeter weir fixed on the walls with a vertical baffle to prevent the escape of any floating material. The sludge will be guided to a sludge tank or to the nearest sludge disposal site, which hosts sludge digestion units and drying beds. The sludge will be dried and recycled as fertilizer.

DBAF—The tower is erected above the sedimentation unit with possible heights ranging between 3m–6m, according to design requirements. It is composed of vertical steel columns on the perimeter covered by plastic sheets or plates to form a circular shaft. The shaft holds an inner central fixed shaft filled with packed special polyvinyl chloride (PVC) media and surrounded by the packed media inside the external shaft. The influent enters the inner shaft from the bottom and is sprayed onto the top inside the outer shaft via rotary spray nozzle. The outlet pipe runs from the top of the outer shaft to the final sedimentation tank.

Chlorine Contact Tank—This tank is erected above or beside the sludge tank to receive the final sedimentation tank effluent. There it is disinfected by adding the chlorine solution (sodium hypo-chlorite). The solution is injected from a special tank erected above the chlorine contact tank through a special monitoring valve.

Sludge Tank—The sludge from the primary and final sedimentation tanks is collected in an aerobic sludge digestion unit where the biological degradation is completed by aeration. The sludge is retained for 5 days and then taken by sewage truck to the nearest sludge disposal site.

Pressure Filter—The pressure filter ensures that standard limits are met. It consists of a cylindrical closed tank containing a layer of sand 90cm thick on top of a 30cm gravel layer. The PVC drainage pipe is buried in the gravel. The unit has two horizontal pumps for filter operation and washing.

Laboratory Kit—The kit allows for needed analyses to control plant operation. The inlet, intermediate, and effluent wastewater can all be analyzed. The lab kit is equipped with equipment to measure COD, SS, residual C_{l2}, and the sludge index. These parameters are enough for field needs for the standard relation between COD and BOD.

DBAF Unit Advantages

The DBAF unit has several advantages:

- Reduces required land area to about 20 percent that required by any other type of biological plant with the same biological load
- Reduces required power supply to about 10 percent that required by any other type of biological plant with the same biological load
- Minimizes operating requirements to optimal value
- Minimizes control requirements to minimal value
- Achieves high removal efficiency for BOD, SS, total nitrogen (TKN), and total phosphate (TP)—up to 95 percent
- Minimizes the need for effluent disinfection
- Improves the sludge capability for dewatering and improve its suitability as fertilizer
- Requires only one operator with minimum operation and maintenance
- Reduces initial cost to about 25 percent of any other type of biological plant with the same biological load
- Minimizes the force main length because it is completely covered and sealed
- Achieves all environmental requirements to deal with gases, odors, and air pollution.

4. Treatment Unit Sizing

Raw Sewage Pump Station

Wet Well

volume = $9m^3 = 2 \times 3 \times 1.5m$

max. W.l. = invert level of inlet sewer - 10cm.

min. W.l. = max. W.l. – depth of actual volume

bottom level = min. W.l. – 35cm.

Pumps

No. of units = 2 working + 1standby

pump flow rate = 5.0l/s.

pump total head = 10.0m.

max. horsepower (hp) = 1.0hp.

Primary Sedimentation Tank

No. of units = 2

surface area = $1.0472m^2$ = 1/3 of circle of diameter = 2.0m

water depth = 3.00m

tank depth = 3.30m with side slope after 1.50m from surface 60 degrees on horizontal

Dual Biological Aerated Filter (up-flow bio-filter)

No. of units = 2

diameter of tank ∅ =0.5m

depth of media =3.00m

Air Blowers

No. of units = 1working + 1 standby

head of air blower = $0.45kg/cm^2$

q of air blower = $75\ m^3/h$

Down Flow Filter

No. of units = 2

diameter of tank ∅ =2.0m

depth of media =3.00m

Final Sedimentation Tank

No. of units = 2

surface area = 2.945m2 = 2/3 of circle of diameter = 2.0m

water depth = 3.50m

tank depth = 3.80m with side slope after 1.50m from surface 60 degree on horizontal

Contact Tank

No. of units = 2

depth = 3.50m

water depth = 2.35m

breadth =0.5m

length =2.0m

Chlorine Dosing Pumps

pump dosing rate = 0.55l/h

dosing pump head = 2–4m

Recirculation Pump

Pump type = horizontal centrifugal

No. of units = 1 working + 1 reserve

pump flow rate = 6.0l/s

pump total head = 12m

maximum hp =1.90hp

Pressure Filters

Filters

No. of units = 1 working + 1 standby

diameter = 1.0m

media depth = 0.3m gravel + 0.70m sand

Filter Pumps

No. of units = 1 working + 1standby

pump flow rate = 2.5l/s

pump total head = 15.0m

maximum hp = 1.0hp

Sludge Storage Tank

No. of units = 2 tank

length = 2.50m.

breadth = 2.00m.

sludge depth = 3.20m

tank depth = 3.50m

5. Equipment Schedule

Pumping Units

Raw Sewage Pumps

model	com 500/15	
manufacturer	Ibara, Italy	
No. of units	3	
pump type, description	centrifugal, submersible	
pump capacity	5.0	l/s
static head	8	m
friction head	2	m
total head	10	m
pump speed	2,850 rpm	
power input to motor at design duty	2.20 kW	
maximum power absorbed by pump	1.80 kW	
installed motor rating	2.00 kW	
motor enclosure type	65	ip
guaranteed motor power factor at design load cos. Phi		0.80
type of motor insulation	Class F	
type of motor coupling	direct	
full load current	4.90 amp	
single phase	220 v /50 hz. Delta	
delivery branch diameter	50mm	
maximum diameter of passage sphere	50mm	
pump weight	48 kg	

Material of Construction

casing	stainless steel
impeller	stainless steel
shaft	stainless steel 304
type of sealing	mechanical seal

Recirculated Water Pumps

model	com 500/15	
manufacturer	Ibara, Italy	
No. of units	6	
pump type, description	centrifugal, horizontal	
pump capacity	6.0	l/s
static head	10	m
friction head	2	m
total head	12	m
pump speed	2,850 rpm	
power input to motor at design duty	2.20 kW	
maximum power absorbed by pump	1.80 kW	
installed motor rating	2.00 kW	
motor enclosure type	65	ip
guaranteed motor power factor at design	load cos. Phi	0.80
type of motor insulation	Class F	
type of motor coupling	direct	
full load current	4.90 amp	
single phase	220 v /50 hz. Delta	
delivery branch diameter	50mm	
maximum diameter of passage sphere	50mm	
pump weight	48 kg	

Material of Construction

casing	stainless steel
impeller	stainless steel
shaft	stainless steel 304
type of sealing	mechanical seal

Filter Pumps

model	com 350/07	
manufacturer	Ibara, Italy	
No. of units	6	
pump type, description	centrifugal, horizontal	
pump capacity	3	l/s
static head	7	m
friction head	8	m
total head	15	m

pump speed	2,800 rpm	
power input to motor at design duty	0.75 kW	
maximum power absorbed by pump	0.60 kW	
installed motor rating	0.70 kW	
motor enclosure type	44	ip
guaranteed motor power factor at design load cos.phi		0.8
type of motor insulation	Class F	
type of motor coupling	direct	
full load current	5.20 amp	
single phase	220 v ,50 hz.delta	
pump weight	33 kg	

Material of Construction

casing	stainless steel
impeller	stainless steel
shaft	stainless steel 304
type of sealing	mechanical seal

Chlorine Dosing Pumps

model	GMB	
manufacturer	GMB	
No. of units	2	
pump type	electric cont. solenoid diaphragm	
pump capacity	0.55	l/h
total head	2–4	m

Air Blowers

model	Dan Mar	
manufacturer	Japan	
No. of units	6	
blower capacity	75	m^3/hr
outlet pressure	0.45	bar
power input to motor at design duty	1.20	kW
maximum power absorbed by air blower	1.20	kW
installed motor rating	1.20	kW
motor enclosure type	ip 44	
guaranteed motor power factor at design load cos. Phi		0.80
type of motor insulation	Class F	

full load current	5.20 amp.
three phases	380 v, 50 hz.

Valves

Gate Valves

Material of Construction

Part material

Body cast iron

Wedge cast iron

Seat in body and wedge bronze

Stem brass alloy

No. of units	6	9
Nominal diameter	75mm	50mm
Nominal pressure	6 bar	6 bar
Test pressure	9 bar	9 bar

Butterfly Valves

Material of Construction

Part material

Body cast iron

Wedge cast iron

Seat in body rubber seal

Stem brass alloy

No. of units	6
Nominal diameter	50mm
Nominal pressure	6 bar
Test pressure	9 bar

Non-return Valves

Material of Construction

Part material

Body cast iron

Wedge cast iron

No. Of units	6	9
Nominal diameter	75mm	50mm
Nominal pressure	6 bar	6 bar
Test pressure	9 bar	9 bar

Non-return Valves for Air Blowers

Material of Construction

Part material

Body brass alloy

Wedge brass alloy

No. Of units	6
Nominal diameter	50mm
Nominal pressure	2 bar
Test pressure	3 bar

6. Technical Specifications and Table of Quantities

Tables 3 and 4 show the specifications and the tables of quantities are for a sewage pump station and treatment plant for Sinbo Village in Zifta Markaz, Gharbiya Governorate. They were prepared by Prof. Dr. Eng. Mohammed el Hosseiny el Nadi, of the Water and Environment Group (WEG).

Table 3 Pump Station Works

Item	Information and Specifications	Unit	Quantity	Unit Price (L.E.)	Total Price (L.E.)
1	Supply all the materials and construction of complete reinforced concrete pump station sump with thickness 25 cm for walls and floor and with reinforcement 6 ø10mm in the two directions and isolated with sika mortar from the inside and with bitumen from the outside with dimensions2.5m × 1.5m × 4.70m. The price is included the excavation works, water drainage, plain concrete for footing, the ladder from painted steel bars, the cover from shaker plate 3mm thickness, the frame for heavy duty painted with bitumen, the roof is from reinforced concrete12cm thickness with reinforcement 6 ø10mm in the two directions, the filling and compaction, disposal of excess excavation products, the internal and external protection, fixing the inflow and effluent plastic pipes in sump wall and all other requirements according to drawings and technical specifications.	Lump Sum	1		
2	Supply, erect and test the group of good condition raw wastewater pumps that consists of 3 submersible pumps, the discharge of one pump is 3l/s with head 10m, efficiency not less than 40 percent and power not exceeding1 hp and the item includes the motor, the base bent, the energy cable, the plastic force main pipes to the treatment unit, fittings, the	Lump Sum	1		

Item	Information and Specifications	Unit	Quantity	Unit Price (L.E.)	Total Price (L.E.)
	ball check valve, cast iron or brass non-return valve, electricity and control cables, and all the erection and operation needs according to technical specifications and drawings.				
3	Supply all the materials and construction of operation room of generator and switchboard from brick with wall thickness 12cm and the roof is reinforced concrete with thickness 10cm and reinforcement 5 ø10mm with length 3m and width 4m according to drawings and technical specifications.	Lump Sum	1		
Total value of table 3					

The total (written) value: Only ____L.E.

Table 4 Treatment Plant Works

Item	Information and Specifications	Unit	Quantity	Unit Price (L.E.)	Total Price (L.E.)
Civil Works					
1	Excavation till reaching the footing level with the complete area of the plain concrete footing area (10.40m × 6.40m) according to the rules of manufacturing, site condition, and instructions of soil consultant.	m^3	66		
2	Supply and fill with good backfill soil imported from outside the site composed of sand completely free of chloride and magnesium salts according to specifications, with thickness 0.60m, including all the necessary works such as supply, transport, empty, put the layer in its place, and compact it to get the maximum possible density using all the necessary and suitable equipment and the compaction tests listed in the standard specifications for roads and bridges. All in cubic meters.	m^3	40		
3	Supply and cast plain concrete for footing with dimensions (6.4m × 10.40m × 0.2m) without pump station place, using concrete grade 2 according to the Egyptian code for concrete and industry rules.	m^3	12		
4	Supply and cast reinforced concrete for footing with dimensions (6m × 8m × 0.30m) without pump station place, using concrete grade 2 according to the Egyptian code for concrete, industry rules, and drawings with steel 5ø12/m in the two directions for the two layers the top and the bottom.	m^3	13		
Steel Works					
1	Supply and erect the treatment unit (DBAF) with capacity 200m^3/day from 5mm thickness steel treated with epoxy that consists of bio-filter tower with outer diameter of 2.00m, inner diameter of 0.60m, height 4.00m, that rests on a sedimentation unit with diameter of 2.00m, that contains both primary and final sedimentation tanks with included weirs, connections, settler plates, and all the erection requirements divided with the ratio one-third to two-thirds by a	Lump Sum	3		

Item	Information and Specifications	Unit	Quantity	Unit Price (L.E.)	Total Price (L.E.)
	vertical baffle, according to drawings, technical specifications, and industry rules				
2	Supply and erect the sludge and contact tank from 5mm thickness steel treated with epoxy with a diameter of 2.00m and depth of 3.85m, according to drawings and manufacturing rules	Lump Sum	3		
3	Supply and erect the pressure sand filter, which consists of steel treated with epoxy cylinder with diameter 1.00m and height 1.25m, equipped with all the necessary connections including pipes, valves, inspection openings, a gravel layer of 30cm thickness, and the sand layer of 50cm thickness, and the under-drainage pipes with diameter ½ inch according to drawings and manufacturing rules	Lump Sum	3		
4	Supply and erect a chlorine solution tank made of plastic or polyethylene, equipped with a mechanical paddle and with control valve with variable power to control the added chlorine dosage	Lump Sum	3		
	Mechanical Works				
1	Supply and erect the recirculation pumps, which consists of two centrifugal horizontal pumps for every unit with discharge 6l/s for the one pump and head 12m and power not exceeding 1.9hp and efficiency not less than 50 percent and the item includes all requirements for erection and operation, including the pipes, valves, electricity, and control cables	Lump Sum	3		
2	Supply and erect the filters pumps, which consists of two centrifugal horizontal pumps for every unit, with discharge 3l/s for the one pump and head 15m, power not exceeding 1hp, efficiency not less than 50 percent, and the item includes all the requirements of erection and operation, including the pipes, valves, electricity, and control cables	Lump Sum	3		
3	Supply and erect the air blowers, which consists of two air blowers for every unit, with discharge 75m^3/hr for one	Lump Sum	3		

Item	Information and Specifications	Unit	Quantity	Unit Price (L.E.)	Total Price (L.E.)
	blower, head 0.45 bar and operational efficiency not less than 40 percent, and the item includes all the requirements of erection and operation, including the pipes, valves, electricity, and control cables				
Electrical Works					
1	Supply, erect, and test the switchboard and item includes all the electrical connections, such as operation switches, indicator lamps, main switches, the necessary circuit breakers, and connection cables between the unit and the board according to drawings, technical specifications, and manufacturing rules	Lump Sum	3		
2	Supply and erect a small generator unit—a Japanese Honda model or equivalent—with power 20kW, with diesel or benzene engine (mobile type) to ensure the continuous plant operation	No.	1		
Total value of table 4					

The total (written) value: Only ____L.E.

Figure 9 Pump Station Section

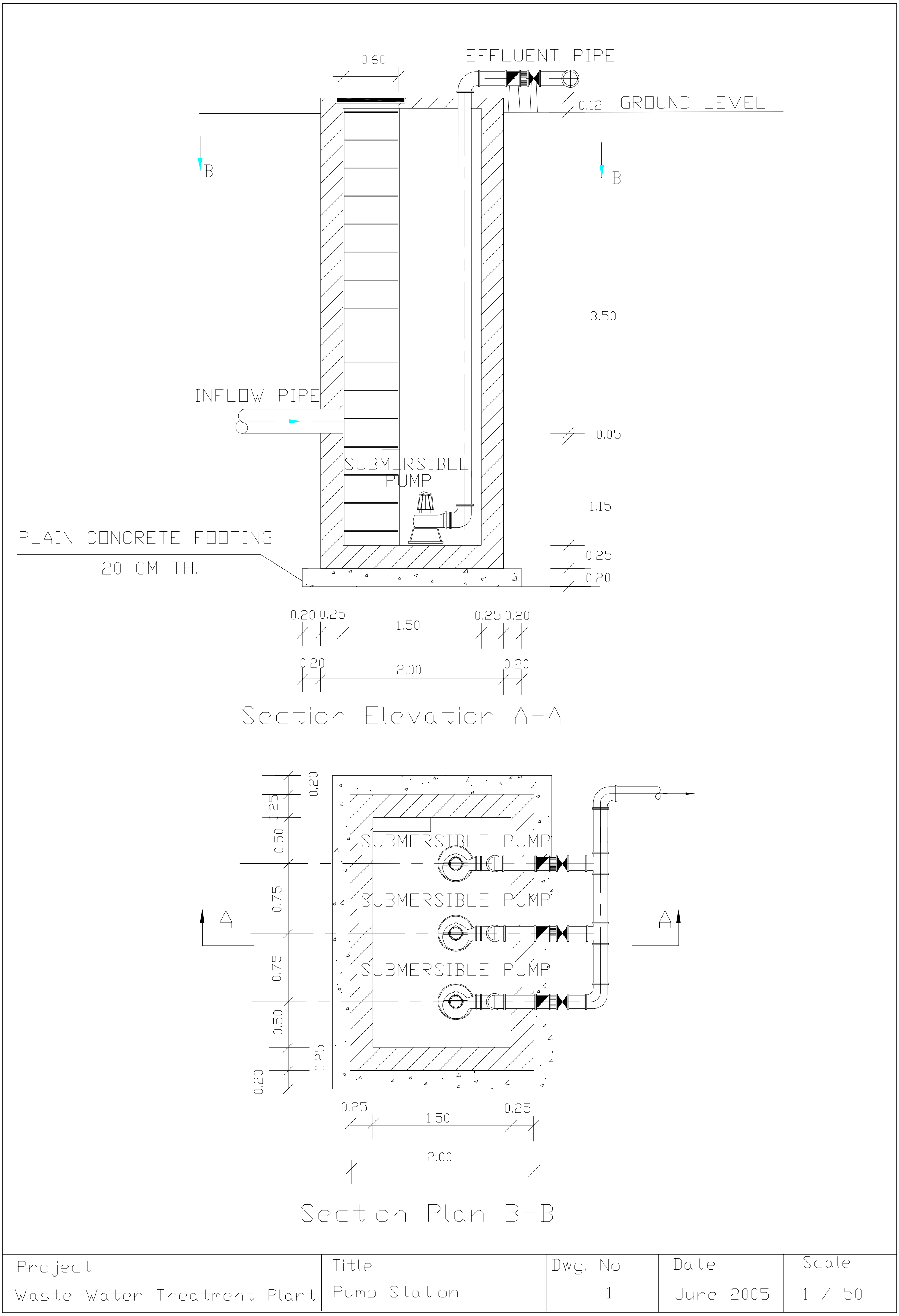
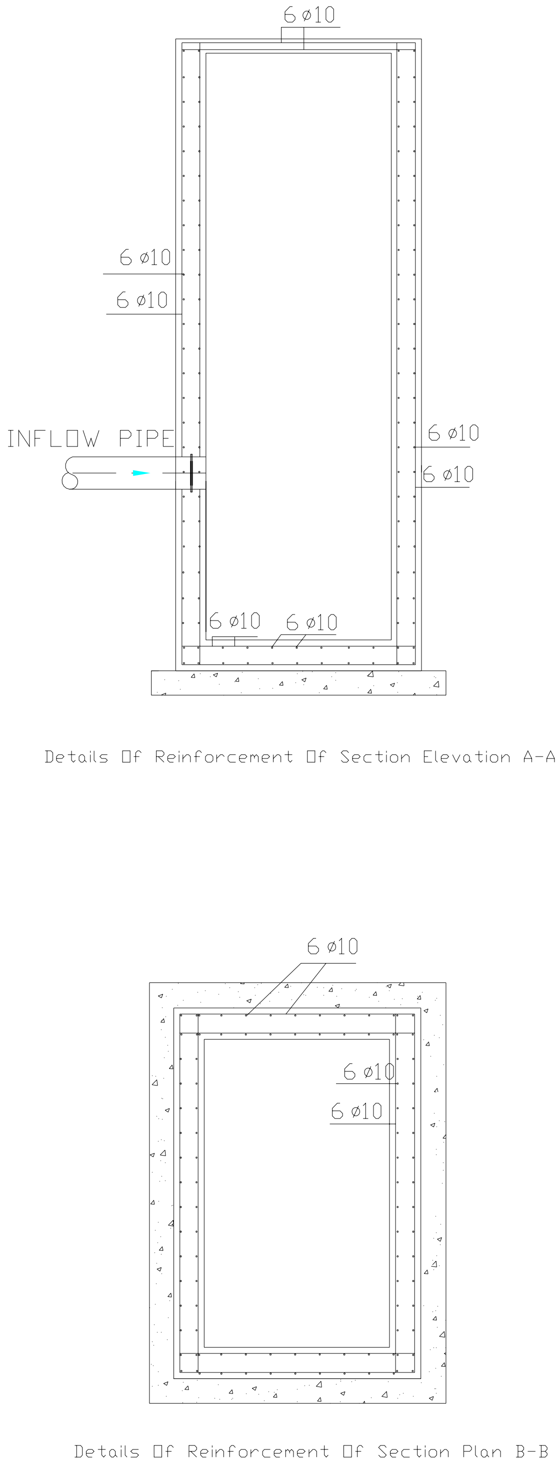
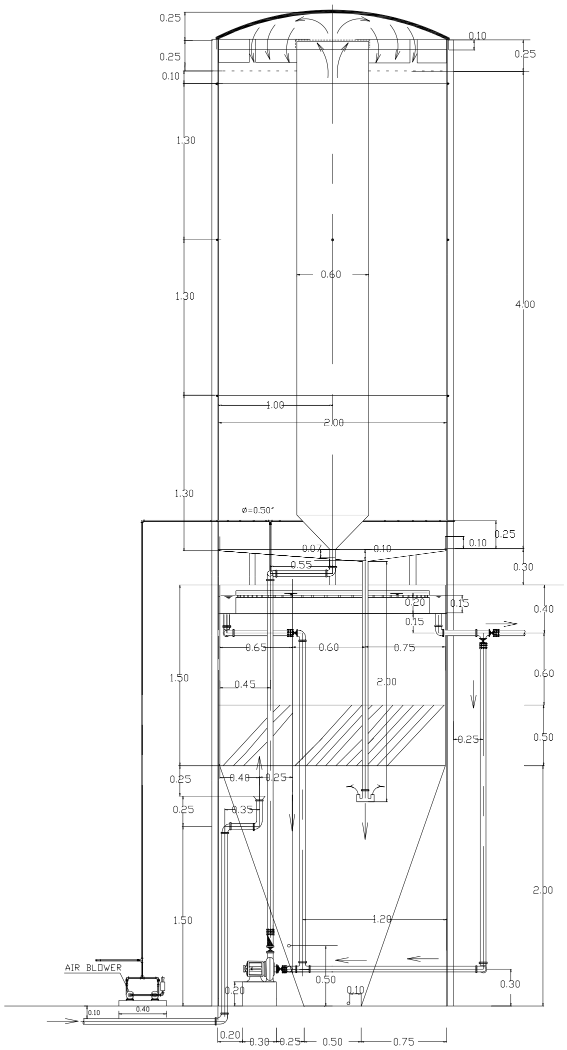


Figure 10 Structure of Pump Station



Project	Title	Dwg. No.	Date	Scale
Waste Water Treatment Plant	Structural of Pump Station	2	June 2005	1 / 50

Figure 11 Section of DBAF Unit



Project	Title	Dwg. No.	Date	Scale
Waste Water Treatment Plant	Section In DBAF Unit	3	June 2005	1 / 50

Figure 12 Section Plan in DBAF Unit

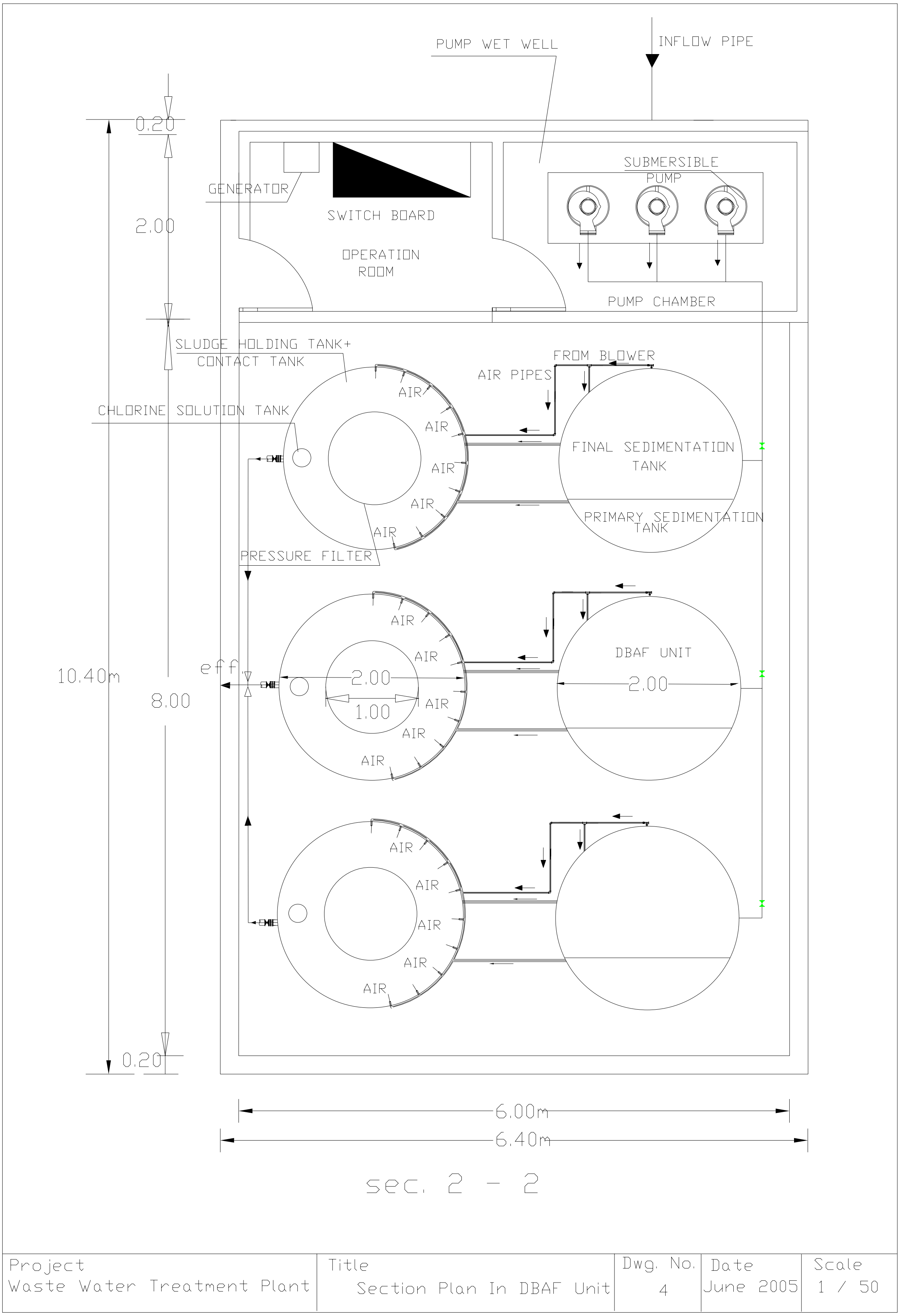


Figure 13 Section in DBAF Unit Showing Sand Filter and Holding Tank

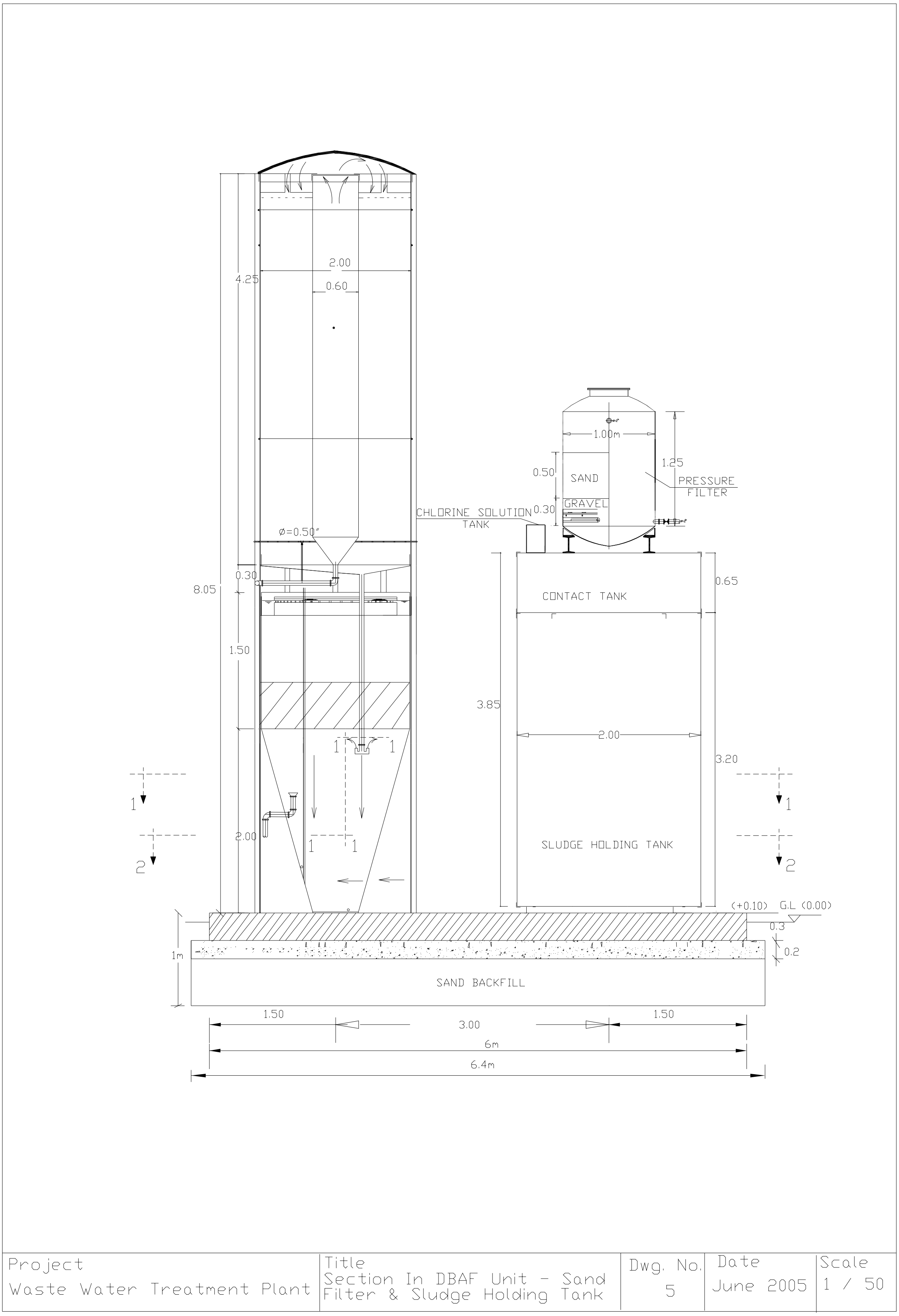
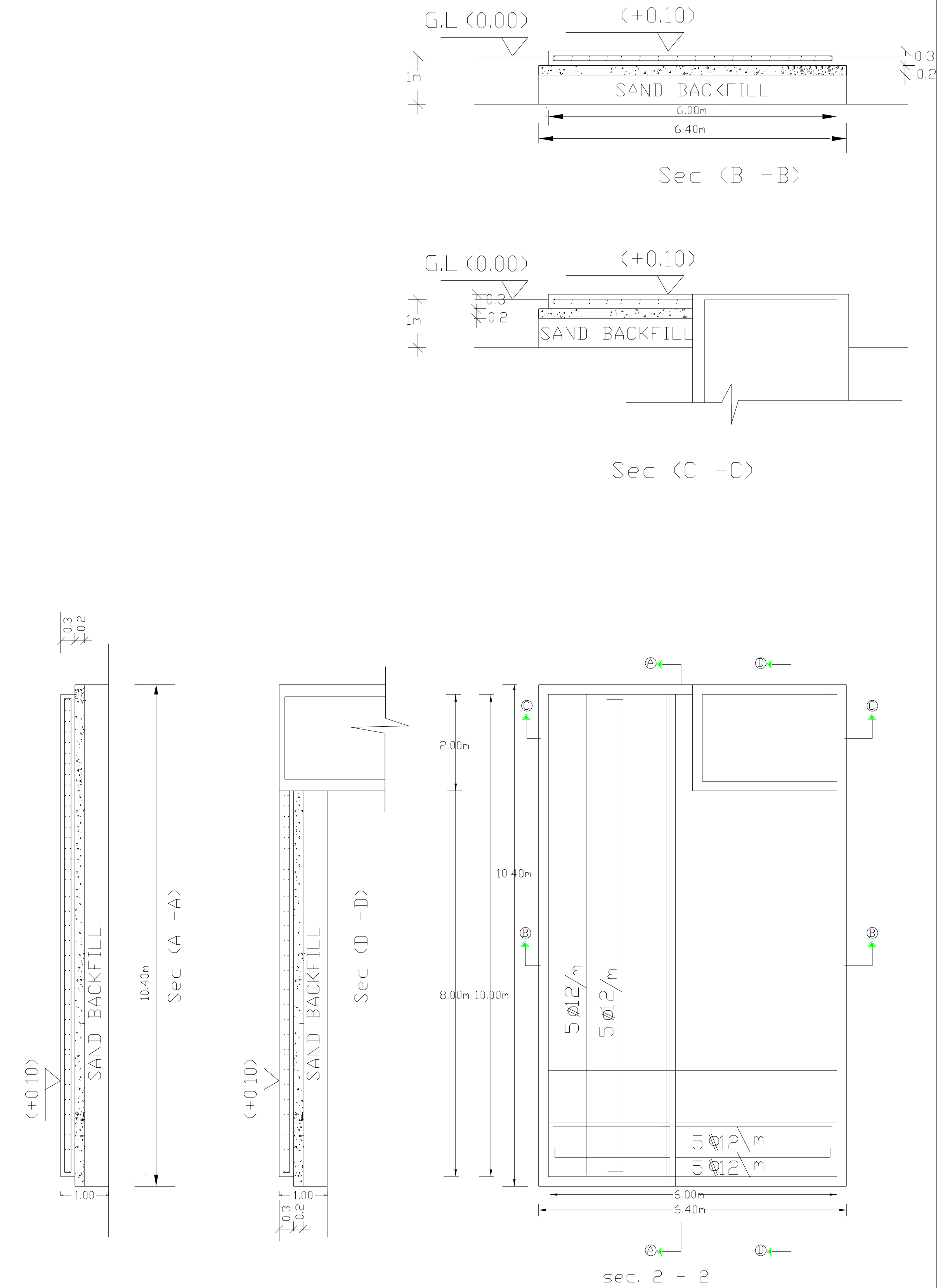


Figure 14 Reinforced Concrete Footing



Project	Title	Dwg. No.	Date	Scale
Waste Water Treatment Plant	Reinforced Concrete Footing	6	June 2005	1 / 100

Figure 15 Sludge and Chlorine Tanks

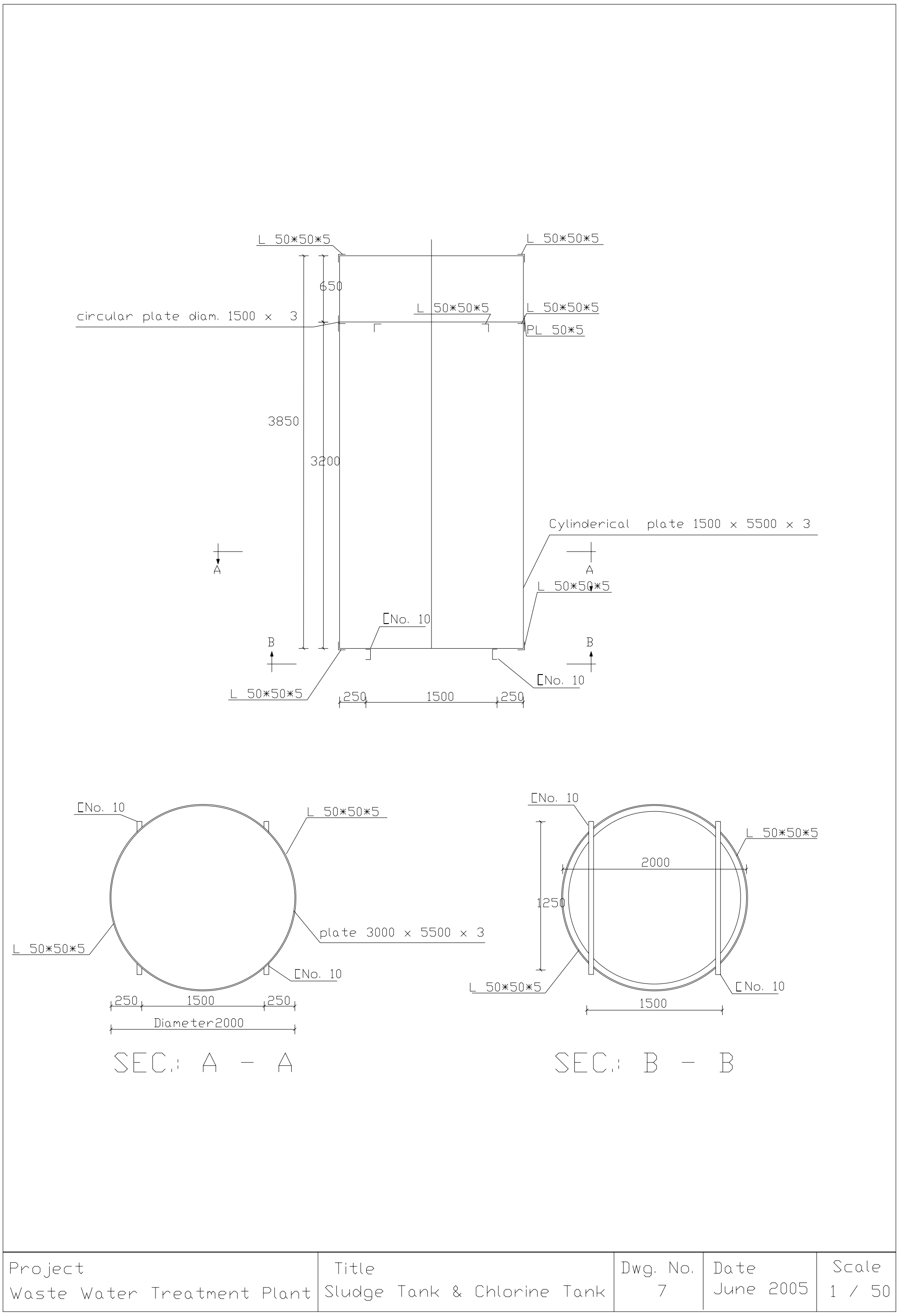


Figure 16 Sand Filter