THE STUDY
ON
URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM
IN
HANOI CITY

APPENDIX (L)

URGENT PROJECT

FEBRUARY 1995

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L1. INTRODUCTION

Hanoi, the capital city of Viet Nam, is the political and economic center of the country, developed on an alluvial plain between the middle reaches of the Red River and the Nhue River.

Most of the city area is located on low and flat lands below EL. 6 m, and in the rainy season is subject to frequent flood damages due to poor rain water drainage.

To protect the city from inundation caused by flooding of the Red and Nhue Rivers, levees were constructed along the rivers. Rivers and drainage canals in the city area have been provided to improve drainage conditions of the city area. These rivers and drainage canals, however, are poorly maintained due mainly to lack of equipment and materials, and do not work at their full capacity.

In view of the above situation, the Government of Viet Nam applied to the Government of Japan a grant aid for the provision of equipment and materials to improve the drainage facilities in Hanoi City and for technical guidance to operate, maintain and repair such equipment and materials, as an urgent project.

In response to the request of the Government of Viet Nam, the Government of Japan decided to conduct a basic design study as a part of the Study on Urban Drainage and Wastewater Disposal System in Hanoi City.

The Study Team confirmed the objective and the scope of the requested urgent project and made studies and investigations on the existing drainage conditions and the project executing method. In this report, are presented the results of the studies on the project justification, scale and scope of the project and institutional aspects for project execution.

L2. BACKGROUND OF THE PROJECT

2.1 Background of the Project

The proposed project area located in the heart of the capital, Hanoi City, has an extremely high population density and its population is increasing rapidly due to recent reurbanization. Moreover, the project area is subject to frequent flooding due to the low altitude of major parts of the project area where the highest altitude is six meters above sea level.

The project area is drained through a network of sewers (combined type, some 120 km in total length), then through drainage canals, then through four (4) rivers and finally into the Nhue River. As there is no waste water treatment, the water is heavily polluted.

In spite of the implementation of the river improvement and flood protection projects, Hanoi City still habitually faces serious flooding. Approximately 80 % of Hanoi area was inundated due to flooding in 1984, causing formidable damage. About 70 % of households are affected by frequent floods 2 - 5 times per year, of which the majority (50 %) are affected more than 5 times a year. This flooding was largely attributed to the poor maintenance of the existing drainage system, impeding it's normal functions. This means that the major parts of the drainage system are clogged due largely to soil and stone sedimentation, causing the reduction of the original drainage capacity.

Drainage and sewerage issues are directly related to sanitation and to the conservation of the city's natural environment. As has been defined in many previous studies (e.g. UNDP/IBRD's Sanitation Sector Study, 1990), the existing condition is already at an intolerable level, unable to sustain hygienic conditions.

With due consideration of the above, the Government of Viet Nam formulated a retrieval plan for the existing drainage system in Hanoi. In order to materialize this plan, the Government officially requested Grant Aid to the Government of Japan for the purpose of purchasing necessary equipment and materials for the project, and technology transfer for its operation and maintenance.

2.2 Outline of the Request

The contents of the request by the Government of Viet Nam are as follows:

(1) Objectives

a) Procurement of equipment and materials necessary for the retrieval of the existing drainage system (cleaning and dredging of sedimentation in sewers and canals).

b) Technical guidance services for operation, maintenance and repair of the equipment and civil work operation.

c) Consulting advisory services for procurement, on-site job training and field work supervision.

(2) Executing Agency

Hanoi Sewerage and Drainage Company under the supervision of Hanoi People's Committee.

(3) Project Area

4 districts in the center of Hanoi City; Ba Dinh, Hoan Kiem, Dong Da and Hai Ba Trung Districts.

(4) Equipment and Materials Requested

The equipment and materials requested are for the retrieval work of the sewers and canals existing in the project area. This will take 3 to 4 years, including the most urgent work which will completed in one year. The equipment and materials are listed in Table L2.1.

2.3 Project and/or Program of Other Donors

No request has been made to other donors to closely assist with this project.

L3. Outline of the Project

3.1 Objective of the Project

The short-term objectives of the Project are a) to alleviate habitual flooding in the city urban area and b) to improve the unhygienic environment along the drainage canals.

The medium and long-term objectives are to upgrade the City's sanitation environment through sustaining the efforts used in achieving the above short-terms objectives.

The proposed project comprises the following three components:

a) Supply of equipment and materials:

   (i) Equipment for cleaning the existing sewers

   (ii) Equipment for dredging the existing urban canals

   (iii) Spare parts, repair tools and some basic consumables

b) Technical guidance services (at technician level) for equipment operation, equipment maintenance/repair and civil works operation associated with the supplied equipment, for about one and half years duration on the site.

c) Consulting advisory services for procurement, on-site job planning and field work supervision, for about two years duration on the site.

3.2 Study and Examination of the Request

As the rapid urbanization progresses in and around Hanoi City, flood damage has tended to increase in recent years.

By means of the removal of sedimentation deposited in sewers and drainage canals, it is expected that the flood damage will be substantially reduced or dissolved. Moreover, without the removal of sedimentation, it is unlikely that the new construction of a drainage pumping plant at Yen So in the future, will not greatly improve the overall drainage capacity.

In view of the above situation, it is strongly urged to remove sedimentation deposited in sewer and canals.

Moreover, it is also indispensable to mobilize equipment and materials to remove a large amount of sediment totaling as much as 115,000 m^3.

So far, Hanoi Sewerage and Drainage Company (HSDC or SDC) has been implementing operation and maintenance works for sewers and drainage canals. However, due to the acute shortage of the necessary machinery and equipment, dredging works have long been implemented manually. With this situation, the works have been implemented with marginal progress due to an extremely low work efficiency. Table L3.1 demonstrates equipment owned by HSDC at present. However, most of them are almost out of use since they are already beyond their life expectancy. Taking the above

into account, it is extremely useful to procure equipment and material necessary for the retrieval of the sewers and drainage canals.

Although procurement should cover a variety of and a large number of equipment, and this is the first case of mechanized dredging works in Viet Nam, this scheme is widely applied in Japan and with the appropriate technology transfer by experts related to operation and maintenance, continuous operation will be secured. In addition, though the project is not budgeted, HSDC is ready to earmark the necessary budget for the works in case the official Request is approved by the Government of Japan.

3.3 Project Descriptions

3.3.1 Executing Agency and Operational Structure

(1) Organization

HSDC will be in charge of operation and maintenance for the supplied equipment. During the implementation, the Planning Section, and the Operation and Maintenance Section will be responsible for the formulation of an explicit O & M schedule, superintended by the executive director.

The project is to be implemented by HSDC under the supervision of Transportation and Urban Public Works Service (TUPWS) under the Hanoi People's Committee, and the Construction Equipment Division in the Ministry of Construction. The Structure of the Hanoi Transportation and Urban Public Works Service and the organization chart of HSDC are shown in Figure L3.3 and L3.4 respectively.

HSDC has been rendering operation and maintenance work on a small scale for the dredging equipment necessary for the improvement works in Hanoi. At present HSDC has the following personnel available for the works and has a plan to reinforce its staffing for the purpose of operation, maintenance and repair to be required for the newly supplied equipment. Given the condition that transfer for the said personnel concerning the operation and maintenance is to be undertaken in the course of the training, it is highly likely that HSDC will be able to effectively deal with proper operation and maintenance in a year.

Position	Staffing
• Management engineers	10 persons
• Senior Engineers in charge of OM planning and implementation	30 persons
• Outdoor workers	330 persons
• OM and repair workers	70 persons

(2) Budget

Hanoi People's Committee and HSDC budget the routine operation and maintenance cost, but not for this project. They are, however, committed to earmark the necessary budget in case the Official Request is approved by the Government of Japan.

The budget for HSDC during the past four years is as follows (million Dong).

	1990	1991	1992	1993
Total budget	1,570	3,613	9,433	12,000
Capital expenditures	400	900	2,300	2,900
Operation & maintenance	1,170	2,713	7,133	9,300

Latest foreign exchange rate: US$ 1 = Dong 10,810 (January 1994)

The Municipality of Hanoi intends to increase its budget for the improvement of sewerage and drainage facilities in order to mitigate flood damage. However, the present level of budget cannot afford to bear the cost necessary for the Project, estimated at around Dong 7,324 million, and it is urgently required to allocate the necessary budget to include the cost for O & M of equipment and securing a motorpool for the equipment.

3.3.2 Plan of Operation

The proposed Project is intended to remove the sedimentation deposited in the sewers and drainage canals in Hanoi by the use of equipment. Based on the life time of the equipment, as well as the contents of the Request from the Government of Viet Nam, a 3-year time period is planned for the entire implementation. Sewers are, subject to the work schedule, largely classified into 3 groups: 300 ~ 800 mm, 900 ~ 1,200 mm, and 1,300 mm and over. Respective improvement plans of the sewage system and the planned sewage capacity using the equipment, are presented below. On the other hand, the drainage system, also subject to the work schedule, is also grouped into 3 categories in terms of canal bottom width: less than 2 meters, 2 - 5 meters, and 5 meters and over. Respective improvement plans of the drainage system and the planned drainage capacity using the equipment are as below.

Removal of sediment in sewers

The project area proposed by Viet Nam side and the location of the sewers are presented in Figure L3.2.

The data for the existing sewer and sediment are listed in Table L3.2 and L3.3.

The total length of the sewer and the total sediment volume to be removed, are as follows:

1) Total length : 120,009 m
2) Total volume : 25,887 m^3

Removal of sediment in drainage canal

The data from the results of the site survey, are summarized in Table L3.4 and L3.5, and the total length of the drainage canal and its total sediment volume are as follows:

1) Total length : 31,300 m
2) Total volume : 89,544 m^3

3.3.3 Location and Condition of Project Site

Work Site of the Equipment to be procured

The Proposed Project site is located in the heart of Hanoi City, and covers Ba Dinh, Hoan Kiem, Dong Da and Hai Ba Trung. The habitually inundated area within the project site is shown in Figure L3.5, and explained as below.

Disposal Site for Sediments

Two disposal sites for the sediment are planned outside of the project site, but are not yet exactly identified. The proposed disposal sites are situated around 7 km from the drainage work sites in Hanoi. Since there is very little settlement in the vicinity of the proposed disposal sites, it will be unlikely to cause serious sanitary problems. Hauling time from the work sites to the disposal sites ranges between 40 and 60 minutes with an average time of 50 minutes. The proposed sites are shown in Figure L3.1.

Motorpool of the Equipment

Two motorpools for the equipment are planned, as illustrated in Figure L3.1.

(1) Motorpool A: Approximately 0.1 ha of land is already secured for the depot.

(2) Motorpool B: Approximately 0.4 ha of land is planned.

Out of the above two sites, motorpool A which is closer to the work site, is planned to be used as the stationery depot for special purpose equipment, while miscellaneous vehicles including dump trucks, will be stationed in motorpool B. It is also planned that regular inspections as well as necessary repair works for the procured equipment will be undertaken at a new repair shop set up in the quarters of motorpool B.

3.3.4 Outline of the Equipment and Materials

The equipment and materials to be procured under the Project involves the following and is summarized in Table L2.1.

(1) For cleaning and dredging of sewerage

(2) For cleaning and dredging of drainage canals

(3) For disposal sites

(4) For motorpools, including maintenance and repair shop

3.3.5 Maintenance and Management Plan

Maintenance and Management Organization

With the highest superintendent of HSDC, the executive director, the Operation and Maintenance Section of HSDC will be responsible for O & M of the equipment, using the staffing mentioned in Figure L3.4.

The O & M Division is directly in charge of the implementation of the Project by mobilizing the equipment and materials. In relation to this, the O & M Division is also responsible for the construction supervision (progress control, quality control etc.), safety control, personnel management and construction cost control for the entire project. In addition, the O & M Division is in charge of fuel and water supply for the equipment.

The Vehicle Management Division, on the other hand, controls the two planned motorpools and is responsible for the operation and maintenance of the equipment to be used for the drainage improvement works. For this, equipment management covers a wide range including planning, maintenance (site maintenance and overhaul) and repairs.

Maintenance and Management Scheme

Taking into account the suspension period due to rainfall, holidays, and maintenance as well as repairing the equipment, the possible workable days are estimated at around 220 days/ year. It is planned to mobilize units of construction equipment and vessels, in parallel with the labor works. Given the above conditions, work units for the Project are estimated as follows:

- Daily fuel consumption (light oil) : 2,700 l/day
- Daily field workers : 345 heads/day
  - Foreman : 15 heads/day
  - Operator (including assistant) : 130 heads/day
  - Civil workers (including traffic control) : 200 heads/day

In order to reduce the unit cost through the improvement of work efficiency and to avoid potential accidents in the course of the works, the Engineering Division is to be responsible for the following undertakings.

(1) Progress Control: To supervise the work progress based on the annual work plan.

(2) Construction Management: To formulate a work plan for the equipment and labor, and to supervise the works at site.

(3) Construction Cost Control: To control the construction cost based on the annual budget and expenditure plans.

(4) Equipment Control: To undertake spare parts management, maintenance control and repair and repair control for the equipment.

(5) Safety Control: To carry out prevention measures during the construction works and safety measures for the equipment.

(6) Personnel Control: To secure the required number of workers and to carry out workers' health control

Among the above duties, the Project calls for the Equipment Control in particular, as listed below.

(1) Daily Inspection	:	Damage check by appearance inspection
	:	Measurement of abrasion for abrasive parts
	:	Inspection and adjustment of clearance for adjustable parts
	:	Inspection of slackness for fastening parts
(2) Weekly Inspection	:	The above inspection and greasing supply
(3) Monthly Inspection	:	The above inspection and replacement of engine oil and oil filters or their cleaning
(4) Annual Inspection	:	Annual maintenance/overhaul

It is also intended that such parts as undercarriages, engine filter elements, wire ropes and other consumables, all of which are of high abrasion, are procured under the Project.

Operation and Maintenance Cost

The operation and maintenance cost, which is to be borne by the Viet Nam side for the operation and maintenance necessary for the equipment, is estimated at around Dong 3.7 billion annually. Therefore, the total cost amounts to Dong 25.5 billion for the entire period of 3.5 years up to the project completion. The annual cost requirement is broken down as follows:

Annual Operation, Maintenance and Management Cost for Equipment

(1) Labor						1,230.0 Million Dong
• Foreman	:	15 P x	400,000 Dong/month x	12 month	=	72.0 Million Dong
• Operator of equipment	:	50 P x	400,000 Dong/month x	12 month	=	240.0 Million Dong
• Assist. Oper. & driver	:	80 P x	300,000 Dong/month x	12 month	=	288.0 Million Dong
• Skilled labour	:	50 P x	300,000 Dong/month x	12 month	=	180.0 Million Dong
• Common labour	:	150 P x	250,000 Dong/month x	12 month	=	450.0 Million Dong
(2) Fuel (diesel) (Including lubricant)	:	2,700 lit/day x	220 day	x 3,100 Dong/lit	=	1,841.4 Million Dong
(3) Maintenance and Repair	:	5 % of the equipment cost				3,500.0 Million Dong
(4) Others						95.0 Million Dong
Measures for safety	:	12 x	5,000,000 Dong/year		=	60.0 Million Dong
Surveying	:	20 km x	1,500,000 Dong		=	30.0 Million Dong
Preparatory work	:	Lump Sum				5.0 Million Dong
(5) Administration	:	10 % of (1), (2) & (3)				657.1 Million Dong
		Total:				7,323.5 Million Dong

L4. BASIC DESIGN

4.1 Basic Design Concept

Basic design concept for the procurement of equipment is as follows.

(1) It is assumed that the increment of flood discharge during the wet season (from June to September) will hinder the progress of removing the sediment in the drainage canals, if the selection of equipment is incorrect. To achieve the annual work quantity, continuous operation even during the wet season should be considered when selecting the equipment.

(2) Regarding canal dredging in residential districts, relocation of a part of the houses along the canal is advantageous in accessing the work sites. However these methods should not be introduced considering the encountered problems, and this should be considered during the selection of the dredging equipment .

(3) Alternation should be paid to the prevention of sanitary problems such as odors, during the canal dredging and the transportation of the sludge when preparing specifications of the equipment.

(4) There is a possibility that accidents such as the occurrence of harmful gas during the removal of the sediments in the sewers may occur. Safety measures for the operation should be considered in addition to the efficiency of the equipment in the selection of the equipment.

(5) The clearance under the existing crossing structures over the canals such as bridges and water supply pipes, is less than 2 m, and grab bucket dredgers can not pass through these structures. Therefore dredging equipment should be assembled and dismantled with ease at these crossing points.

(6) Since Viet Nam has not had experience in applying these types of cleaning and dredging equipment for removing sediment in sewers and drainage canals, technical transfer is necessary for the management and maintenance of the equipment to be supplied. Spare parts for the required equipment are considered to be procured for this project.

4.2 Design Conditions

4.2.1 Conditions for Equipment Use

Required conditions for the equipment use are assumed as follows.

(1) Dredging works of the drainage canals that use equipment set up on the banks are difficult because almost all the canal banks do not have maintenance roads. Therefore, the dredging equipment will approach the site from the drainage canal to be dredged.

(2) The illegal dumping of garbage is observed in the drainage canal. A grab bucket dredger is recommended for this canal because a large quantity of solid wastes are

mixed in the deposit. However vacuum trucks with high vacuum and manpower are used for the narrow canals where the grab bucket dredger can not approach.

(3) A large quantity of plastic bags and solid waste are mixed in the sewers. Since the large of sewers are not very long, the dimensions of these sewers are 2 m in depth and 2 m in width and water depth is approximately 1 m at some sections, even in the dry season. Judging from these conditions, sediment removal by manpower method, which is applied by HSDC, should now be applied.

(4) The daily required water for the water jet cleaner is estimated at approximately 40 m^3/day. The water will be supplied from some of the large reservoirs of the existing seven distribution reservoirs in the City

(5) Judging from the existing road width and present traffic conditions from the project sites to the sludge disposal site, a 4-ton class truck is recommendable even though large class trucks are accessible to some project sites.

4.2.2 Working Hours

Working hours, which are the basic conditions for determining the required number of equipment, are estimated as follows:

(1) Average daily working hours

Judging from the field working conditions, a one shift system is recommended for this project. The average daily working hours are assumed at 8.5 hours which is average in Viet Nam. Included in this 8.5 hours, 2.5 hours are required for the preparation of the works, maintenance of equipment, rest and clearing of the daily work site. Therefore the net working hours, without loss time due to the weather conditions, are assumed to be 6 hours.

(2) Annual workable days

Workable days of the equipment are affected by rainfall amount and intensity because they will be used for the sewers and drainage canals. Judging from the experience of canal dredging works, and the cleaning the sewers in Japan, and the rainfall pattern in Hanoi City, the following loss (waiting) time with relation to the rainfall amount is assumed:

Daily Rainfall Amount and Loss (Waiting) Time

Range of Daily Rainfall	Loss(Waiting) Time
~ 3 mm	0 day
3 mm ~ 10 mm	0.2 day
5 mm ~ 10 mm	1.0 day
10 mm ~ 20 mm	1.0 day
20 mm ~ 50 mm	1.5 days
50 mm ~ 100 mm	2.5 days
100 mm	4.0 days

Reviewing the hydrometeorological data obtained at Lang station in the project area during the years 1885 and 1986, it is found the daily rainfall pattern is analyzed as shown in Table L4.1. Working hours of equipment are closely related to the daily rainfall depth, and the annual unworkable days is estimated to be 83 days. Moreover national holidays and Sundays will be about 60 days per year, then the annual workable days are estimated to be 220. [365-(52+8+83)=222≒220]

(3) Total Working Hours of Equipment

HSDC has prepared a plan that the retrieval work will be completed within 3.5 years, including one year for the most urgent area. In this case, the working hours of equipment for 3.5 years are estimated to be 4,620 hours in total. [3.5*220*6=4,620] On the other hand, the life of equipment (such as bulldozers, dump trucks, water jet cleaners, mobiles etc.) are 5 to 6 years (6,500 to 7,800 hours). Accordingly, the equipment will be further utilized for other places in the city and for re-dredging and re-cleaning after the completion of this project.

4.2.3 Work Volume

Existing sewer pipes and drainage canals are categorized as follow in consideration of the work procedure and the scale of the sewers and canals. The volume of sediments to be removed from those sewers and canals are also shown in the following table.

(1) Sewer

Size (m)	Total Length (m)	Volume of Dredging(m^3)
0.3-0.8 (BW<0.8)	91,874	12,992
0.9-1.2 (BW 0.9-1.2)	18,094	5,266
BW>1.3	10,041	7,629
Total:	120,009	25,887

(2) Drainage Canal

Size (m)	Total Length (m)	Volume of Dredging(m^3)
BW<3.0	10,650	17,724
BW 3.1-4.9	8,350	24,495
BW 5.0-8.9	9,550	33,598
BW>9.0	2,750	14,727
Total:	31,300	89,544

4.3 Equipment Plan

4.3.1 Selection of Work Methods

(1) Removal Method of Sediment in Sewers (See Figure L4.1 and Table L4.2)

There are four (4) typical removal methods of sediment in sewers

1) Removal method with bucket machine

This method is to remove sediment in a block between manholes by dropping a bucket into the sewer and drawing it by a winch set near the manhole. In the case of maximum sediment deposited in the sewer, it is difficult to apply this method because of the time spent changing buckets from small to large size, and the low efficiency. This method is only applicable for blocks with suitably sized manholes.

2) Removal method with manpower

This method can be applied for sections of sewers which have a comparatively large size space of more than 0.9m in height and width, to enable workers to enter. At present the removal of some sections of sewers in Hanoi is carried out by this method. It needs a drainage pump for the working section and is extremely inefficient. However, it has some advantages such as low investment costs for equipment and encourages employment.

3) Removal methods with high vacuum truck

This method is most recommendable for sewers sized 0.8 to 1.2 m in diameter, although a number of workers are necessary to handle the suction hose.

4) Removal method with water jet cleaner

The sediment in sewers less than 0.8 m in diameter, but not limited to this, is removed by high pressure water jetting from nozzle through high pressure hose after muddling by its jet water. This method is applicable regardless of the size of the sewer and the kind of sediment, although a large amount of water, 20 m^3/unit/day, is required for the daily operation of this equipment.

Considering the present condition (average sediment rate of 32 %) in Hanoi, and the size and location of manholes, the bucket machine method is not recommendable. The cleaning of sewers with a diameter less than 0.8 m should be carried out using the water jet cleaner method which provides an efficient work rate. For the section with dimensions greater than 0.9 m, the combined method of high vacuum truck and manpower and the combined method of portable winch and manpower are applicable and recommendable, because of the decrement of efficiency against the increment of sewer size.

(2) Removal method of sediments in drainage canals (See Figure L4.1 and Table L4.2)

There are three (3) typical removal methods of sediments in drainage canals.

1) Removal method with pump (water pump or vacuum pump)

This method, using a submersible sand pump or vacuum pump, is one of the most efficient, it is unnecessary for water shuttering and is applicable even during the rainy season. On the other hand, some disadvantages of this method are floating trash and solid sediments can easily cause clogging of the suction head and it is unable to pump/suck up a large amount of water with dredged materials. However, the vacuum suction method is recommendable for dredging narrow and shallow canal sections with more mud than water.

2) Removal method with grab bucket excavator

A combined dredging method using a grab bucket excavator and hauling equipment such as a barge, a dump truck and a vacuum truck is a common method for canal dredging. It is efficient, but not as efficient as the pumping methods, and is applicable for all types and volume of sediment.

3) Removal method with manpower

This method is not applicable for wide and deep sections of canals, but is recommendable for narrow and shallow sections.

Cleaning and dredging is carried out using manpower and a small barge, a submersible pump, and a generator. The collected materials are hauled by dump trucks to the disposal site.

The combined method of manpower and high vacuum truck is also recommendable for narrow and shallow sections with high sedimentation.

Considering the present condition of drainage canals in Hanoi, three removal methods are recommendable.

4.3.2 Selection of Equipment

The equipment and materials required for the works stipulated in the previous clause, and their purpose of use are summarized as below:

(1) Equipment for cleaning and dredging the sewer

- Water jet cleaner

The water jet cleaner is equipped with a water tank, a high pressure water pump and necessary accessories on the truck chassis. The cleaner dredges the sediment by jetting high pressure water into the sewer using high pressure hose and nozzle, muddling the sediment and directing it to a suction point under the manhole.

- Lift type vacuum truck with dehydrator

  This vacuum truck is equipped with a vacuum tank, a vacuum pump, a dehydrator, lifting mechanism, and necessary accessories on the truck chassis. The vacuum truck sucks the muddled sediment collected by the water jet cleaner, dehydrates and discharges it to the dump truck and the extracted water into the sewer.

- Water tank truck

  The water tank truck supplies water to the water jet cleaner. The water will be supplied from the distribution reservoirs in the city by the Hanoi Water Supply Company.

- Dump truck

  This truck is for hauling the dredged and dehydrated sediments to the disposal site.

- Vacuum truck with high vacuum

  This vacuum truck is equipped with a vacuum tank, a vacuum pump with a high vacuum and a large air flow, and necessary accessories on the truck chassis. There are two methods for sucking; direct sucking and assisted sucking through a sludge tank. The former method suck the sediment through a suction hose and hauls it to the disposal site and the latter assists the sludge tank truck to suck the sediments through a suction hose and a connection hose between the sludge tank and vacuum truck.

- Sludge tank truck

  The sludge tank truck is equipped with vacuum tank for hauling the muddled sediment on the truck chassis. The loading (sucking) of the sediment will be made by the above vacuum truck and discharged by a self-dumping device.

- Portable winch for sewer cleaning

  This is a portable and light type winch for assisting sludge collecting work by manpower in sewers with a width of 1.3 m or more and set up near manholes or the sewer outlets.

- Blower

  The portable blower is powered by a diesel generator and used for ventilating air to protect workers from harmful gases in the sewer.

- Submersible pump for construction use

  This submersible pump is powered by a diesel generator and is used for diverting sewage during the cleaning by water jet cleaners or in draining the sewage from blocks during the dredging by manpower.

- Floodlight

  The floodlight is powered by a diesel generator and is used for lighting up the sewer during dredging by manpower.

- Diesel generator

  This generator supplies electric power for the submersible pump, the blower, lighting, etc..

- Handy gas detector

  This gas detector is used for detecting harmful gases in sewers and drainage canals during cleaning and dredging.

- Truck with crane

  This truck is necessary for handling and transporting a lot of equipment, tools, and materials required for each working group.

- Pick up truck

  This small truck is used for field work supervision and communication between work sites, and for transporting light weight equipment and materials if necessary.

(2) Equipment for dredging the drainage canals

- Crawler type hydraulic grab bucket excavator

  This is a common grab bucket excavator and is used for dredging in canals from the bank or on a working barge.
  When dredging from a working barge, the excavator must be removed from the barge when passing under low clearance bridges. A rough terrain crane will be used to load or unload the excavator, which will then be driven to the next site or moved by a trailer.

- Working barge

  This barge is a portable type working platform for a grab bucket excavator and is moved using towing ropes hauled by manpower on the bank. The launching and landing will be done using a rough terrain crane and the transportation will be by trailer.

- Sludge hauling barge

  This barge is used for hauling the sediments dredged by the grab bucket excavator to the vacuum truck on the bank. The launching and landing, and towing methods are the same as above.

- Vacuum truck

  This vacuum truck is used for sucking sludge from the above barge and transporting to the disposal site.

- Dump truck

  This truck is used for hauling the dredged sediments (solid or low water content) to the disposal site.

- Vacuum truck with high vacuum

  This is a same type vacuum truck mentioned in the item for sewer cleaning, but used for suck dredging in the narrow canal.

- Sludge tank truck

  This is the same as mentioned for sewer cleaning.

- Submersible pump for construction use

  The same as mentioned for sewer cleaning.

- Diesel generator

  The same as mentioned for sewer cleaning.

- Handy gas detector

  The same as mentioned for sewer cleaning.

- Rough terrain crane

  This crane is selected for work in narrow spaces due to it's good maneuverability and is used for handling the excavator, barge and other craning work in the field and motorpools.

- Tractor and trailer

  This set is used for transporting the equipment and heavy materials for the field works.

- Small sludge barge

  This is used for cleaning and dredging the small canals by manpower. The transfer of sediments from barge to dump truck is also made by manpower.

4.3.3 List of Equipment

The list of equipment with quantity selected in accordance with the requirements is shown in Table L4.3.

4.3.4 Specifications of the Equipment

The specifications of the equipment and material selected are as follows:

Specification for Equipment and Materials

GROUP	EQUIPMENT/SPECIFICATION	PURPOSE OF USE	QUANTITY
A-01	Swampdozer, 7 t Ground pressure : <0.15 kg/cm^2 Total operating weight : >7 t Engine output : 70 PS W/Canopy & other accessories	Disposal sites	2 units
A-02	Excavator, grab bucket, 0.2 m^3 Crawler type hydraulic excavator Outreach of grab bucket : >6.0 m Engine output : >55 PS W/Extra backhoe attachment	Canal dredging	2 units
A-03	Working barge for bucket dredger Steel made portable type Size : 5 (B) x 8 (L) x 1.3 (H) x 0.8 (D) m Max. unit piece : 2.5 x 4 x 1.3 m Accessories : bollards, winches	Canal dredging	2 units
A-04	Sludge hauling barge, 6 m^3 Steel made, for bucket dredger Size : 2.5 (B) x 5 (L) x 1.1 m Towing by manpower on shore Accessories : bollards, rope (200 m)	Canal dredging	4 units
A-05	Sludge hauling barge, 2 m^3 Steel made, for manpower cleaning Size : 1.5 (B) x 3.5 (L) x 0.7 (H) x 0.5 (D) m Pushing/towing by manpower Accessories : bollards, rope (50 m)	Canal cleaning/dredging	8 units
A-06	Sludge settling vessel, 6 m^3 Steel made, for bucket dredger on ground Size : 2 (B) x 3 (L) x 1.5 (H) m W/slide gate for water draining and sling wires for relocation	Canal cleaning/dredging	2 units
A-07	Dump truck, 4 t Capacity : >2.6 m3 (standard) Vessel : w/extension & rear gate Engine output : >170 PS/2900 rpm	Canal and sewer cleaning/dredging	12 units
A-08	Water jet cleaner, 4 t truck Water pressure : >200 kg/cm^2 Discharge volume: .200 lit/mm High pressure hose : 3/8" x 90 m Prime mover : 170 PS, thru PTO Water tank capacity : >2.5 m^3	Sewer cleaning	2 units
A-09	Water tanker, 4 m^3 Water tank capacity : >4 m^3 Suction/delivery pump : 0.3 m^3/mm Suction/delivery hose : >80 mm dia.. Prime mover : 170 PS, thru PTO Accessories : suction hose (80 mm x 5 m) and delivery hoses (80 mm x 5 m x 2 pcs.)	Sewer cleaning	5 units

A-10	Vacuum truck, 8 t For excavating sludge in sewer and canal thru pipeline & sludge tank truck Vacuum pressure : >740 mm Hg Air flow : 38 m^3/min Tank : >4.5 m^3, w/dumping system Prime mover : >210 PS, thru PTO	Canal and sewer dredging	2 unit
A-11	Vacuum truck 4 t w/dehydrator For sucking sludge excavated by high pressure water jet cleaner Vacuum pressure : >740 mm Hg Air flow : 18 m^3/min Tank : >2.8 m^3, w/dehydrator, lift and dumping system Prime mover : 170 PS thru PTO Accessories : suction hose w/quick connector, etc.	Sewer cleaning	2 units
A-12	Vacuum truck, 4 t For sucking & hauling sludge excavated by bucket dredger Vacuum pressure : >700 mm Hg Air flow : 18 m^3/min Tank : >3.0 m^3 w/dumping system Prime mover : 170 PS, PTO Accessories : Suction hose w/quick connector, etc.	Canal dredging	14 units
A-13	Sludge tank truck 4 t For hauling sludge sucked by assisting of 8 t vacuum truck Tank : >2.8 m^3, w/dumping system Prime mover : 170 PS Accessories : suction hose w/quick connector, etc.	Canal and sewer dredging	6 units
A-14	Portable winch for sewer Engine (5 PS) driven winch for sewer cleaning Control : by levers for forward and reverse, and brakes Accessories : wire rope adjuster, anchor weight, wire rope (100 m), canopy, etc.	Sewer cleaning	2 units
A-15	Truck 4 t w/crane 3 t Steel flat bed truck, 4 t w/side & rear gates Crane : hydraulic, 3 t/2.5 m, PTO w/max. reach not less than 7 m Engine output : >170 PS Accessories : outriggers and other safety devices	Canal and sewer cleaning and dredging	7 units
A-16	Rough terrain crane, 30 t Capacity : 30 t/3.0 m w/30 m boom Engine output : 250 PS Accessories : outrigger and safety devices	Dredging/etc.	1 unit
A-17	Tractor & trailer, 20 t Tractor : 4 x 2, wheel base : 3.2 m Engine : Diesel, 210 PS Trailer : low bed (1.0 m) 2.9 x 5.2 m Accessories : parking jacks and safety devices	Equip. transport	1 unit
A-18	Pick-up truck, 1 t Capacity : >1 t Cargo vessel : 1.8 (B) x 2.3 (L) x 0.6 (H) Engine output : 110 PS	Supervision and field service	8 units

A-19	Submersible pump, 150 mm Bore : 150 mm dia. Motor : 3-phase, 220 V, 5.5 kW Accessories : delivery hose (50 m), w/quick connectors & cable (20 m)	Sewer and canal cleaning and dredging	6 units
A-20	Submersible pump, 100 mm Bore : 100 mm dia. Motor : 3-phase, 220 v, 3.7 kW Accessories : delivery hose (50 m), w/quick connectors & cable (20 m)	Sewer and canal cleaning and dredging	9 units
A-21	Diesel generator, 30 kVA Skid mounted w/entire awning, w/control panel, distribution switches and terminals Engine output : >40 PS Generator : 3-phase, 4-wire system, 380/220 V, 30 kVA or more	Sewer and canal cleaning and dredging	6 sets
A-22	Diesel generator, 20 kVA Skid mounted w/entire awning, w/control panel, distribution switches and terminals Engine output : >25 PS Generator : 3-phase, 4-wire system, 380/220 V, 20 kVA or more	Sewer and canal cleaning and dredging	4 sets
A-23	Spare parts for the above For 2-years operation	15%	1 lot
B-01	Portable gas detector, 3 gases Oxygen, hydrogen sulfate and combustible gases	Sewer and canal dredging	7 nos.
B-02	Floodlight, 300 W, w/tripod Water-proof type reflector lamp, single-phase, 220 V, 300 W W/adjustable tripod and cabtyre cable of 10 m	Sewer dredging	10 sets
B-03	Blower, 300 mm dia., 0.5 kW For scavenging gases in sewer Single-phase, 220V, 0.5 kW W/300 mm dia. x 5 m air duct	Sewer dredging	11 nos.
B-04	Transceiver	Sewer and canal dredging	7 sets
B-05	Hand tools for dredging/cleaning of small connection pipes, etc.	Sewer cleaning	1 lot
B-06	Equipment & tools for maintenance and repair shop	M & R shop	1 lot
C-01	Dredge suction pipe (steel) set Spiral steel pipe, 150 mm dia. 6 m x 35 pcs., w/flange joints, bolts, nuts and packings	Canal dredging	3 sets
C-02	Suction hose, 150 mm x 5 m	Canal dredging	6 pcs.
C-03	Delivery hose, 150 mm dia. x 50 m	Cleaning/dredging	30 sets

C-04	Delivery hose, 100 mm dia. x 50 m	Cleaning/dredging	45 sets
C-05	Cabtyre cable, 3 c x 8 mm^2 x 100 m with cable reel	Cleaning/dredging	30 sets
C-06	Fuel and lubricant (for 1 year) Diesel oil for equipment Engine oil, gear oil, hydraulic oil and grease	Cleaning/dredging	600 m^3

4.3.5 Technical Guidance on Equipment

(1) Transfer of Technology

Rehabilitation works of the existing drainage system, including sewers and drainage canals will consist of several kinds of work items, in which more than 60 nos. of construction equipment are to be operated in parallel works. This equipment require rather complicated operation and maintenance, such as adjustment in pressure of the water jet cleaner, the overhaul and assembling of the dredging equipment, and so forth.

To date, HSDC has not had any experience in the operation and maintenance of such equipment. From this particular viewpoint, it is strongly recommended the technical guidance on equipment will be well programmed in the frame of this project. Through out this program, it is expected that work efficiency of the equipment will increase and accidents during the operation and maintenance of the equipment will be avoided.

By implementing this project, it is anticipated flood damage in the area where retrieval work is urgently required, will largely be mitigated. It is also important to show the effects of flood mitigation by implementing this retrieval work together with the technical guidance on the equipment mentioned above.

(2) Conditions of Transfer of Technology

Transfer of technology will be programmed by the Japanese Consultant. Guidance engineers will be despatched from the manufactures and/or specialized contractors who have had a lot of similar experiences in this field. Vietnamese engineers and technicians in charge will be selected from the staff of HSDC.

(3) Transfer of Technology

Working conditions in the drainage area greatly vary between the rainy season and the dry season. During the rainy season (June to September), working conditions at the drainage canals will worsen due to the increased discharge, and the efficiency of the equipment will decrease remarkably. Moreover, it is rather difficult to carry out retrieval work of the sewer on a large scale, with which workers must access the site after the shuttering of the sewage flow. On the other hand, working conditions during the dry season (October to May) are much better than that of the rainy season. In consideration of the working conditions during the seasons, the equipment schedule should be well programmed to maximize the efficiency of the equipment introduced. Transfer of technology is programmed to be made during both dry and rainy seasons as some special equipment such as the water jet cleaner requires different operation modes for all seasons.

As is described hereafter, it is estimated that it will require about ten (10) months until the major construction equipment and vehicles arrive at the site after the signing of the Exchange of Note (E/N). In case the retrieval work is carried throughout the year, even in the rainy season, the transfer of technology will total eighteen (18) months (2 dry

seasons and 1 rainy season). However, retrieval work by manual operation for large sewers is recommended to be done only in the dry season.

4.4 Implementation plan

4.4.1 Special Consideration in Implementation Plan

The work mainly consist of 1) procurement of equipment and materials, and 2) technical guidance of equipment at the site. Broadly speaking, it will require about six (6) months until the equipment arrives at the site after the issuance of the purchasing order, as most of the equipment is specialized. Technical guidance of the equipment and vehicles using a demonstration operation is very important, especially in the wet season. The schedule of the technical guidance and the procurement of this equipment should be well programmed.

Safety measures should be considered during technical guidance and the succeeding retrieval works, as various kind of equipment are introduced and operated in parallel works. Superintendents at the site are requested to consider safety precautions and also to take appropriate measures to prevent dispersing bad odors from the excavated sediments and excessive noise from the construction.

Through the said technical guidance, the Vietnamese counterpart personnel will be able to understand the operation and maintenance of the equipment. Close contact among the parties concerned is essential to attain this purpose.

4.4.2 Supervision of the Project

The Consultant, acting as an executing agency of HSDC, will announce the tender of this retrieval work. The Consultant will despatch well experienced engineers and experts in the field of sewerage and drainage retrieval works, and also mechanical engineers who are well acquainted with the equipment to be introduced. The Consultant will be responsible for the construction supervision, operation and maintenance schedule of the equipment, quality control, transfer of technology, safety control, and so forth.

4.4.3 Procurement Plan of the Equipment

It is observed that the majority of existing construction equipment in Viet Nam is of Russian, German, and Chinese origin. The amount of construction equipment recently imported from Japan, Russia, Germany, and Korea is limited.

It is planned that the major equipment, except a few dump trucks (6-ton class), will be procured from outside of the country. This include special equipment such as water jet cleaners, mobile cranes, vacuum trucks, dredging equipment, dump trucks, and pumps. The total quantities of this equipment will be more than one hundred.

Most of the equipment and materials will be imported from Japan in consideration of various conditions. After receiving an inspection by the Consultant at the factory, the manufactured equipment and materials will be shipped to Hanoi and transported to HSDC's motorpool.

4.4.4 Implementation Schedule

Detailed design work will be commenced by the Japanese Consultant immediately after the signing of E/N, and will take about three (3) months. Procurement of equipment and materials and also technical guidance will follow. As was described herein above, most of the equipment to be procured is specialized, and will take about six (6) months to arrive at the site after contracting. Prior to the arrival of the equipment, the Consultant and Supplier of the equipment will despatch the guidance engineers to the site to prepare to receive the cargo and also to transfer technology. How to operate and maintain the equipment introduced will be demonstrated to the local staff concerned, intensively during the first month. After training the actual operation at the site will commence.

The transfer of technology by the guidance engineer will be intermittently extended over a period of eighteen (18) months.

The Tentative implementation schedule for whole project is presented in Figure L4.2.

4.4.5 Scope of Works

The scope of works to be executed by the Japanese side and by the Viet Nam side are summarized below, together with the required undertakings by the Government of Viet Nam.

(1) Scope of the works to be executed by the Japanese side

- Procurement and supply of the equipment and materials
  - Equipment and materials for cleaning the sewers

    Water jet cleaner and others as listed in Table L4.4
  - Equipment and materials for dredging the canals

    Grab bucket excavator and others as listed in Table L4.4
  - Equipment and materials for the disposal site

    Swampdozer and others as listed in Table L4.4
  - Equipment, tools, and materials for the motorpool

    Maintenance equipment and others as listed in Table L4.4
  - Stand-by equipment

    Water tank truck and others as listed in Table L4.4
  - Spare parts for the above equipment

- Technical guidance service for the operation and maintenance of the equipment to be supplied

(2) Scope of works to be executed by the Vietnamese side

- Advising commission of Authorization to Pay
- Tax exemption and custom clearance of the equipment and materials at the port of Haiphong
- Provision of necessary land for and construction of motorpool facilities (See Figure L4.3)
- Provision of necessary land for disposal site(s)
- Recruitment of operation and maintenance staff for the special equipment
- Expenditures in connection with the implementation of the project

4.5 Project Benefit and Conclusion

4.5.1 Project Benefit

When the existing drainage and sewerage facilities are cleaned and dredged and restored to their full drainage capacity by the use of the equipment and materials to be provided to HSDC under the project, the following project benefits are expected.

(1) Economic Benefit

According to the Study on Urban Drainage and Wastewater Disposal System in Hanoi City currently underway by the Japan International Cooperation Agency, the drainage capacity of the existing facilities in the central part of Hanoi City is assessed to be only sufficient to cope with rainfall intensity of a return period of a little less than one year for the sewerage system, and to manage flood flows with a return period of 1 to 1.2 years for the rivers and drainage canals. Actually, due to the accumulation of solid waste, the drainage capacity of the existing system is remarkably reduced and the rain water inundates the city area several times a year. This causes considerable flood damages to houses, offices and public facilities such as the communication network, and transportation network.

The above-mentioned study has estimated the damages due to rain water inundation as follows.

Return Period in years	Estimated Damages in 1,000 US$
0.8	630
2	5,080
5	21,840
10	41,600
Annual Average	12,800

The Study on Urban Drainage and Wastewater Disposal System in Hanoi City aims to improve the drainage condition in the central part of the city to cope with a rainfall intensity with a return period of 5 years, and to contribute to a considerable reduction in the inundation damages. The urgent project, as the first step of the entire project, is formulated to retrieve the existing drainage facilities. Upon completion of the urgent project, the existing system will be able to cope with a rainfall intensity with a return period of about 0.8 years and will contribute to the reduction of inundation damages of about US$ 400,000 annually.

(2) Social Benefit

1) The habitual rain water inundation in Hanoi City causes such epidemics as diarrhea, and dysentery and Hanoi City faces a serious health and sanitary problem. The proposed urgent project, when implemented, will improve the health and sanitary conditions of Hanoi City and, as a result, will contribute to the upgrading of people's living standards and social stability.

2) Every year in the rainy season, Hanoi City is inundated with rain water for a duration of several days, which seriously affects the urban transportation network. The project execution will ease the traffic congestion due to frequent inundation and will enhance the economic activities of Hanoi City.

3) Garbage accumulated in the drainage facilities causes deterioration of the water environment and generates foul odors. Cleaning of the drainage facilities, including the removal of garbage, under the project will improve the living environment of the Hanoi people.

4.5.2 Conclusion

The project execution through the Japanese Grant Aid will be justifiable in regard to the great contribution to better living conditions and environment of the Hanoi people. The Hanoi People's Committee and HSDC will assure a special budget to operate and maintain the equipment and materials to be provided by the project.

HSDC also assures a sufficient staffing for the operation and maintenance of the project. The executing agency of the project is, well prepared to operate and maintain the project from the viewpoints of budgeting and staffing.

However, proper measures are recommended to be taken to control the illegal disposal of garbage into the drainage and sewerage system through education of the local people and improvement of the solid waste management system, to ease future maintenance of the drainage and sewerage system. It is, therefore, of vital importance to establish and execute such measures, as a parallel activity to the project, through coordination among the Governmental and public institutions concerned.

The transfer of appropriate technology to the Government of Viet Nam staff for drainage and sewerage improvements, should be realized throughout the project execution. This will enable the Vietnamese authorities to extend drainage and sewerage improvements to the surrounding areas of the central 4 districts in Hanoi City to be improved by the project, and to other important cities in Viet Nam.

Table L 2.1 LIST OF EQUIPMENT AND MATERIALS REQUESTED

GROUP	EQUIPMENT/SPECIFICATION	PURPOSE OF USE	QUANTITY
A-01	Swampdozer, 7t	Disposal sites	2 units
A-02	Excavator, grab bucket, 0.2 m3	Dredging	2 units
A-03	Working barge for the above	Dredging	2 units
A-04	Sludge hauling barge, 6 m3	Sludge hauling	4 units
A-05	Sludge hauling barge, 2m3	Sludge hauling	8 units
A-06	Sludge settling vessel, 6 m3	Sludge hauling	3 nos.
A-07	Dump truck, 4 t w/extension	Clean/dredging	12 units
A-08	Water jet cleaner, 4 t truck	Cleaning	2 units
A-09	Water tanker, 4 m3	Cleaning	4 units
A-10	Vacuum truck, 8 t w/high vacuum	Dredging	1 unit
A-11	Vacuum truck, 4 t w/dehydrator	Cleaning	4 units
A-12	Vacuum truck, 4 t	Dredging	22 units
A-13	Sludge tank truck 4 t	Dredging	5 units
A-14	Sewer cleaning winch set w/motor	Dredging	2 sets
A-15	Truck, 4 t w/crane 3 t	Clean/dredging	7 units
A-16	Rough terrain crane, 30 t	Dredging/etc.	1 unit
A-17	Tractor & Trailer, 20 t	Dredging/etc.	1 unit
A-18	Pick-up truck, 1 t	SV/F-service	8 units
A-19	Submersible pump, 150 mm dia.	Clean/dredging	8 units
A-20	Submersible pump, 100 mm dia.	Clean/dredging	8 units
A-21	Diesel generator, 30 kVA	Clean/dredging	3 sets
A-22	Diesel generator, 20 kVA	Clean/dredging	6 sets
A-23	Spare parts for the above	15 % of CIF	1 lot
B-01	Portable gas detector, 3 gases	Cleaning	5 nos.
B-02	Floodlight, 300 W, W/tripod	Cleaning	10 sets
B-03	Blower, 300 mm dia..	Cleaning	7 nos.
B-04	Transceiver	Clean/dredging	6 sets
B-05	Hand tools for Dredging/Cleaning small canal, collector basin, small connection pipes, etc.	Clean/dredging	1 lot
B-06	Equipment & tools for maintenance and repair shop	M & R shop	1 lot
C-01	Dredge suction pipe (steel) set, 150 mm dia. x 200 m	Dredging	3 sets
C-02	Suction hose, 150 mm x 5 m	Dredging	6 pcs
C-03	Delivery hose, 150 mm dia. x 50 m	Clean/dredging	30 sets
C-04	Delivery hose, 100 mm dia. x 50 m	Clean/dredging	30 sets
C-05	Cabtyre cable, 100 m w/cable reel	Clean/dredging	30 sets
C-06	Fuel and lubricant (for 1 year)	Clean/dredging	600 m3

Remarks: SV/F service: Supervision & field service for equipment

Table L 3.1 LIST OF MACHINERIES & EQUIPMENTS OWNED BY HSDC

(Date: Dec, 1993)

No.	Item	Quantity	Notes
1	IFA - 50 truck 4.5 ton	8	2 brokendown
2	MAZ truck 7 ton	1	
3	Sludge transportation vehicle (China) 4 ton	3	
4	Crane vehicle	1	
5	HITACHI excavator vehicle (Japan) 0.45 m3	1	
6	TY 45 Excavator vehicle 0.15 m3	1	Brokendown
7	Sludge sucker vehicle (Japan) 2.6 m3	1	
8	Sludge sucker vehicle (Russia)	1	Brokendown
9	TOYOTA CAMRY car 4 seats	1	
10	TOYOTA 12 - seats car	1	
11	LADA car 4 seats	1	Brokendown
Total		20	
12	Kim Lien Wastewater Pumping Station Capacity: 28 - 30 kw/h, 160 m3/h	3 pumps	
13	Kim Lien Stormwater Pumping Station Capacity: 33 kw/h, 960 m3/h	2 pumps	
14	Tan Mai Stormwater Pumping Station Capacity: 28 kw/h	3 pumps	Not operating yet
Total		8	

Table L 3.2 SEDIMENTS IN SEWER (SURVEYED)

Size / District		φ 300～φ 800 W>800	φ 801～φ 1,200 W>1,200	φ 1,201～ W>1,201	TOTAL
1. Ba Dinh District	L	15,498 m	3,295 m	5,400 m	24,193 m
	V	1,318 m3	771 m3	2,283 m3	4,372 m3
2. Hoan Kiem District	L	30,572 m	5,698 m	3,133 m	39,403 m
	V	4,447 m3	2,439 m3	2,810 m3	9,696 m3
3. Hai Ba Trung District	L	24,694 m	5,978 m	4,166 m	34,838 m
	V	1,885 m3	1,257 m3	3,035 m3	6,177 m3
4. Dong Da District	L	16,471 m	3,475 m	1,629 m	21,575 m
	V	2,194 m3	1,284 m3	2,164 m3	5,642 m3
Total	L	87,235 m	18,446 m	14,328 m	120,009 m
	V	9,844 m3	5,751 m3	10,292 m3	25,887 m3

Remarks: L: Length
V: Volume

Table L 3.3 PRESENT STATUS OF SEWER

DESCRIPTIONS	SIZE OF SEWER (m)																Total
	SIZE OF SEWER (Small)						SIZE OF SEWER (Medium)				SIZE OF SEWER (Large)						
	0.3 ϕ	0.4 ϕ	0.5 ϕ	0.6 ϕ	0.8 ϕ	S-total	0.9 ϕ	1.0 ϕ	1.2 ϕ □	S-total	<1.49□	<1.69□	<1.89□	<2.09□	>2.1□	S-total	
Ba Dinh Dist.																	
Length (m)	0	4,330	0	7,020	4,148	15,498	0	3,295	0	3,295	3,890	1,510	0	0	0	5,400	24,193
Total Volume (m3)	0	596	0	1,831	2,102	4,529	0	2,946	0	2,946	5,343	3,207	0	0	0	8,550	16,025
Sediment Volume (m3)	0	286	0	609	423	1,318	0	771	0	771	1,636	647	0	0	0	2,283	4,372
% of Sedimentation	0	48	0	33	20	29	0	26	0	26	31	20	0	0	0	27	27
Hoan Kiem Dist.																	
Length (m)	452	6,584	713	16,511	6,312	30,572	1,775	2,092	1,831	5,698	312	447	98	905	1,371	3,133	39,403
Total Volume (m3)	32	582	249	4,835	6,053	11,751	2,212	2,476	3,320	8,008	612	805	141	2,891	4,708	9,157	28,916
Sediment Volume (m3)	15	297	110	1,995	2,030	4,447	548	1,014	877	2,439	175	318	106	843	1,368	2,810	9,696
% of Sedimentation	47	51	44	41	34	38	25	41	26	30	29	40	75	29	29	31	34
Haiba Trung Dist.																	
Length (m)	1,942	7,391	619	10,858	3,884	24,694	0	5,554	424	5,978	0	2,668	112	1,386	0	4,166	34,838
Total Volume (m3)	208	939	272	2,976	2,154	6,549	0	4,505	712	5,217	0	7,952	200	3,840	0	11,992	23,758
Sediment Volume (m3)	90	360	68	895	472	1,885	0	1,155	102	1,257	0	1,818	38	1,179	0	3,035	6,177
% of Sedimentation	43	38	25	30	22	29	0	26	14	24	0	23	19	31	0	25	26
Dong Da Dist.																	
Length (m)	0	570	978	7,864	7,059	16,471	0	3,475	0	3,475	0	1,191	134	0	304	1,629	21,575
Total Volume (m3)	0	64	361	2,008	3,546	5,979	0	2,728	0	2,728	0	2,222	289	0	1,459	3,970	12,677
Sediment Volume (m3)	0	26	97	749	1,322	2,194	0	1,284	0	1,284	0	1,059	193	0	912	2,164	5,642
% of Sedimentation	0	41	27	37	37	37	0	47	0	47	0	48	67	0	63	55	45
Total																	
Length (m)	2,394	18,875	2,310	42,253	21,403	87,235	1,775	14,416	2,255	18,446	4,202	5,816	344	2,291	1,675	14,328	120,009
Total Volume (m3)	240	2,181	882	11,650	13,855	28,808	2,212	12,655	4,032	18,899	5,955	14,186	630	6,731	6,167	33,669	81,376
Sediment Volume (m3)	105	969	275	4,248	4,247	9,844	548	4,224	979	5,751	1,811	3,842	337	2,022	2,280	10,292	25,887
% of Sedimentation	44	44	31	36	31	34	25	33	24	30	30	27	53	30	37	31	32

Table L 3.4 SEDIMENT IN DRAINAGE CANAL (SURVEYED)

	B. Width ≦ 3.0 m			B. Width ≦ 3.1−4.9m			B. Width ≦ 5.0−8.9m			B. Width ≦ 9.0m			Total		
	D (m)	T.V (m3)	S.V (m3)	D (m)	T.V (m3)	S.V (m3)	D (m)	T.V (m3)	S.V (m3)	D (m)	T.V (m3)	S.V (m3)	D (m)	T.V (m3)	S.V (m3)
1. To Lich River Basin	4,000	21,265	4,712 (22%)	4,200	41,566	7,270 (17%)	6,550	106,368	21,063 (20%)	2,350	63,507	12,064 (19%)	17,100	232,706	45,109 (19%)
2. Lu River Basin	1,250	11,034	2,418 (22%)	2,800	29,709	12,805 (43%)	400	3,523	550 (16%)	300	8,442	2,180 (26%)	4,750	52,708	17,953 (34%)
3. Set River Basin	2,650	18,300	5,070 (28%)	300	714	399 (56%)	0	0	0 (0%)	100	3,039	483 (16%)	3,050	22,053	5,952 (27%)
4. Kim Ngun River Basin	2,750	24,337	5,524 (23%)	1,050	7,945	3,021 (38%)	2,600	34,854	11,985 (34%)	0	0	0 (0%)	6,400	67,136	20,530 (31%)
Total	10,650	74,936	17,724 (24%)	8,350	79,934	23,495 (29%)	9,550	144,745	33,598 (23%)	2,750	74,988	14,727 (20%)	31,300	374,603	89,544 (24%)

Remarks: D: Distance

T.V: Total volume

S.V: Volume of sediment

Table L 3.5 PRESENT STATUS OF DRAINAGE CANAL

No.	Name of Drainage	B. Width ≤ 3.0 m				B. Width = 3.1 ~ 4.9 m				B. Width = 5.0 ~ 8.9 m				B. Width ≥ 9.0 m				S - Total			
		Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%
T1	Hao Nam - Yen Lang	0	0	0	0	500	4,464	371	8	1,500	36,474	1,688	5	1,200	21,186	6,293	30	3,200	62,124	8,352	13
T1-1	Tayson	550	1,251	654	52	0	0	0	0	250	6,789	430	6	0	0	0	0	800	8,040	1,084	13
T1-2	Thanh Cong	0	0	0	0	0	0	0	0	1,000	5,546	5,405	97	500	19,957	3,210	16	1,500	25,503	8,615	34
T1-3	Ngoc Khanh I	0	0	0	0	0	0	0	0	900	10,413	2,507	24	0	0	0	0	900	10,413	2,507	24
T1-4	Nha Mat Cheo	500	2,093	869	42	0	0	0	0	0	0	0	0	0	0	0	0	500	2,093	869	42
T1-5	Ngoc Khanh II	300	1,776	367	21	0	0	0	0	0	0	0	0	0	0	0	0	300	1,776	367	21
T1-6	Giang Vo	0	0	0	0	400	3,444	840	24	0	0	0	0	0	0	0	0	400	3,444	840	24
T1-7	F.C.G.V.	100	460	106	23	0	0	0	0	0	0	0	0	0	0	0	0	100	460	106	23
T1-8	Cuc Thue - Hoang Cau	1,000	3,152	650	21	0	0	0	0	0	0	0	0	0	0	0	0	1,000	3,152	650	21
T1-9	Trai Toc	300	672	35	5	0	0	0	0	0	0	0	0	0	0	0	0	300	672	35	5
T1-10	Muong 164	0	0	0	0	600	2,610	684	26	0	0	0	0	0	0	0	0	600	2,610	684	26
T1-11	D.T.D.	200	536	32	6	0	0	0	0	0	0	0	0	0	0	0	0	200	536	32	6
	Sub-total :	2,950	9,940	2,713	27	1,500	10,518	1,895	18	3,650	59,222	10,030	17	1,700	41,143	9,503	23	9,800	120,823	24,141	20
T2	Trung Kinh	50	4,006	40	1	750	13,592	1,176	9	300	3,446	860	25	0	0	0	0	1,100	21,044	2,076	10
T2-1	M.T.M.	0	0	0	0	400	2,688	412	15	0	0	0	0	0	0	0	0	400	2,688	412	15
	Sub-total :	50	4,006	40	1	1,150	16,280	1,588	10	300	3,446	860	25	0	0	0	0	1,500	23,732	2,488	10
T3	Nghia Do	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-total :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	Lieu Giai - Cong Vi	0	0	0	0	0	0	0	0	1,050	18,089	5,563	31	650	22,364	2,561	11	1,700	40,453	8,124	20
T4-1	Ngoc Ha	0	0	0	0	950	7,586	1,856	24	50	3,887	131	3	0	0	0	0	1,000	11,473	1,987	17
T4-2	Dai Yen	1,000	7,319	1,959	27	0	0	0	0	200	10,888	885	8	0	0	0	0	1,200	18,207	2,844	16
	Sub-total :	1,000	7,319	1,959	27	950	7,586	1,856	24	1,300	32,864	6,579	20	650	22,364	2,561	11	3,900	70,133	12,955	18
T5	Thuy Khue	0	0	0	0	600	7,182	1,931	27	1,300	10,836	3,594	33	0	0	0	0	1,900	18,018	5,525	31
	Sub-total :	0	0	0	0	600	7,182	1,931	27	1,300	10,836	3,594	33	0	0	0	0	1,900	18,018	5,525	31
	Total of T :	4,000	21,265	4,712	22	4,200	41,566	7,270	17	6,550	106,368	21,063	20	2,350	63,507	12,064	19	17,100	232,706	45,109	19
L1	Fuong Mai	0	0	0	0	300	2,307	365	16	0	0	0	0	0	0	0	0	300	2,307	365	16
	Sub-total :	0	0	0	0	300	2,307	365	16	0	0	0	0	0	0	0	0	300	2,307	365	16
L2	Y.Khoa	450	6,090	570	9	550	3,124	1,197	38	0	0	0	0	0	0	0	0	1,000	9,214	1,767	19
	Sub-total :	450	6,090	570	9	550	3,124	1,197	38	0	0	0	0	0	0	0	0	1,000	9,214	1,767	19
L3	Nam Dong	300	1,458	189	13	100	351	139	40	400	3,523	550	16	0	0	0	0	800	5,332	878	16
	Sub-total :	300	1,458	189	13	100	351	139	40	400	3,523	550	16	0	0	0	0	800	5,332	878	16
L4	Cong Trang - Trung Tu	0	0	0	0	900	15,852	7,886	50	0	0	0	0	300	8,442	2,180	26	1,200	24,294	10,066	41
L4-1	Lang Fuong Lien	0	0	0	0	700	5,655	2,228	39	0	0	0	0	0	0	0	0	700	5,655	2,228	39
L4-2	Thong Phong	500	3,486	1,659	48	0	0	0	0	0	0	0	0	0	0	0	0	500	3,486	1,659	48
L4-3	Luong Su	0	0	0	0	250	2,420	990	41	0	0	0	0	0	0	0	0	250	2,420	990	41
	Sub-total :	500	3,486	1,659	48	1,850	23,927	11,104	46	0	0	0	0	300	8,442	2,180	26	2,650	35,855	14,943	42
	Total of L :	1,250	11,034	2,418	22	2,800	29,709	12,805	43	400	3,523	550	16	300	8,442	2,180	26	4,750	52,708	17,953	34

Table L 3.5 PRESENT STATUS OF DRAINAGE CANAL

No.	Name of Drainage	B. Width ≤ 3.0 m				B. Width = 3.1 – 4.9 m				B. Width = 5.0 – 8.9 m				B. Width ≥ 9.0 m				S - Total			
		Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%	Distance (m)	G. Volume (m3)	Sediment (m3)	%
S1	Tran Mai I	0	0	0	0	0	0	0	0				0	0	0	0	0	0	0	0	0
S1-1	Tran Mai II	0	0	0	0	0	0	0	0				0	0	0	0	0	0	0	0	0
	Sub-total :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S2	Voi Ba Nhat	400	2,012	390	19	0	0	0	0				0	0	0	0	0	400	2,012	390	19
	Sub-total :	400	2,012	390	19	0	0	0	0	0	0	0	0	0	0	0	0	400	2,012	390	19
S3	D.T.	150	291	70	24	0	0	0	0	0	0	0	0	0	0	0	0	150	291	70	24
	Sub-total :	150	291	70	24	0	0	0	0	0	0	0	0	0	0	0	0	150	291	70	24
S4	Tran Khat Tran	1,100	8,769	3,634	41	300	714	399	56	0	0	0	0	100	3,039	483	16	1,500	12,522	4,516	36
S4-1	B.T.	100	716	131	18	0	0	0	0	0	0	0	0	0	0	0	0	100	716	131	18
S4-2	To Hoan - Lien Phai	500	3,112	678	22	0	0	0	0	0	0	0	0	0	0	0	0	500	3,112	678	22
	Sub-total :	1,700	12,597	4,443	35	300	714	399	56	0	0	0	0	100	3,039	483	16	2,100	16,350	5,325	33
S5	Dai Co Viet	400	3,400	167	5	0	0	0	0	0	0	0	0	0	0	0	0	400	3,400	167	5
	Sub-total :	400	3,400	167	5	0	0	0	0	0	0	0	0	0	0	0	0	400	3,400	167	5
	Total of S :	2,650	18,300	5,070	28	300	714	399	56	0	0	0	0	100	3,039	483	16	3,050	22,053	5,952	27
K1	Kim Nguu Tan	700	9,858	1,820	18	0	0	0	0	2,100	28,460	10,550	37	0	0	0	0	2,800	38,318	12,370	32
	Sub-total :	700	9,858	1,820	18	0	0	0	0	2,100	28,460	10,550	37	0	0	0	0	2,800	38,318	12,370	32
K2	Mai Dong	650	7,413	1,517	20	550	2,915	1,439	49	0	0	0	0	0	0	0	0	1,200	10,328	2,956	29
	Sub-total :	650	7,413	1,517	20	550	2,915	1,439	49	0	0	0	0	0	0	0	0	1,200	10,328	2,956	29
K3	Thang Nhan	150	692	266	38	150	1,763	520	29	0	0	0	0	0	0	0	0	300	2,455	786	32
K3-1	Mai Huong	450	1,243	363	29	350	3,267	1,062	33	500	6,394	1,435	22	0	0	0	0	1,300	10,904	2,860	26
	Sub-total :	600	1,935	629	33	500	5,030	1,582	31	500	6,394	1,435	22	0	0	0	0	1,600	13,359	3,646	27
K4	Lac Trung	800	5,131	1,558	30	0	0	0	0	0	0	0	0	0	0	0	0	800	5,131	1,558	30
	Sub-total :	800	5,131	1,558	30	0	0	0	0	0	0	0	0	0	0	0	0	800	5,131	1,558	30
	Total of K :	2,750	24,337	5,524	23	1,050	7,945	3,021	38	2,600	34,854	11,985	34	0	0	0	0	6,400	67,136	20,530	31
	G. Total : (T + L + S + K)	10,650	74,936	17,724	24	8,350	79,934	23,495	29	9,550	144,745	33,598	23	2,750	74,988	14,727	20	31,300	374,603	89,544	24

Table L4.1 AVERAGE ANNUAL WORKABLE DAYS

Data period: 1886 - 1985

Rainfall Depth (mm)	Number of Rainy Days according to Rainfall Depth													Waiting Day due to Rainfall	Actual Waiting Days
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
r<=3	29.1	25.2	28.2	24.6	24.7	21.2	20.7	22.0	22.0	23.2	27.7	30.3	298.9	0.0	0.0
3<r	0.8	1.4	1.5	0.9	1.4	1.1	1.5	0.8	1.0	1.5	0.8	0.3	13.0	0.5	6.5
5<r	0.5	0.9	0.9	1.1	0.9	2.0	1.7	1.4	0.9	1.6	0.5	0.2	12.6	1.0	12.6
10<r	0.5	0.5	0.4	1.6	1.9	2.4	3.1	2.1	0.9	1.6	0.6	0.2	15.8	1.0	15.8
20<r	0.1	0.2	0.0	1.6	1.5	2.2	2.6	2.8	3.7	2.2	0.2	0.0	17.1	1.5	25.7
50<r	0.0	0.1	0.0	0.2	0.2	0.9	0.9	1.8	1.2	0.9	0.2	0.0	6.4	2.5	16.0
100<r	0.0	0.0	0.0	0.0	0.4	0.2	0.5	0.1	0.2	0.0	0.0	0.0	1.4	4.0	5.6
150<r	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	5.0	0.5
Total	31.0	28.3	31.0	30.0	31.0	30.0	31.0	31.0	30.0	31.0	30.0	31.0	365.3	–	82.7

(at Lang Station)

1) Sunday : 52 days
2) National Holiday : 8 days
3) Non-workable days due to rainfall : 83 days
4) Off-working days : 143 days

Average Annual Workable days : 365 - 143 = 222
≒ 220 days

Table L4.2 CLEANING AND DREDGING METHODS AND EQUIPMENT REQUIRED (1/2)

	Methods of Works	Objective Sections	Descriptions of Works	Equipment Required
CLEANING AND DREDGING OF SEWER	S-1 Cleaning and dredging of sewer by using water jet cleaner	Sewer with size of 0.3 to 0.8 m in dia. and bottom width of 0.8 m or less	After preparation for traffic control and sewage diversion if necessary, the sediments in sewer will be muddled, dredged and collected by using high pressure water jetting through nozzle and rubber hose from water jet cleaner, then sucked dehydrated and dumped into dump truck by vacuum truck with dehydrator and transported to disposal site(s).	1) Water jet cleaner 2) Vacuum truck with dehydrator and lift 3) Water tanker 4) Dump truck 5) Truck with crane 6) Submersible pump for construction use 7) Diesel generator 8) Gas detector 9) Flood light 10) Blower 11) Transceiver 12) Pickup
	S-2 Cleaning and dredging of sewer by using vacuum truck with high vacuum	Sewer with bottom width of 0.9 to 1.2 m, where enable workers to enter	After preparation of the same as mentioned above, the temporary weirs at both ends of the work section will be built for sewer diversion and dewatering of the section. The sewer diversion and dewatering will be made by using submersible pump. The sediments in sewer will be sucked into sludge tank truck through rubber suction hose connected to vacuum truck and transported to disposal sites. The handling of hose will be made by manpower.	1) Vacuum truck with high vacuum 2) Sludge tank truck 3) Truck with crane 4) Submersible pump for construction use 5) Diesel generator 6) Gas detector 7) Floodlight 8) Blower 9) Transceiver 10) Pickup truck
	S-3 Cleaning and dredging of sewer by using winch and manpower	Sewer with bottom width of 1.3 m or more, where enable workers to enter and wok freely	After preparation of the same as mentioned above S-2, the sediments will be excavated by manpower, collected by using portable winch with engine, sucked by vacuum truck or loaded to dump truck by manpower, and transported to disposal site(s).	1) Portable winch with engine 2) Hand tools 3) Vacuum truck 4) Dump truck 5) Truck with crane 6) Submersible pump for construction use 7) Diesel generator 8) Gas detector 9) Floodlight 10) Blower 11) Transceiver 12) Pickup truck

Table L4.2 CLEANING AND DREDGING METHODS AND EQUIPMENT REQUIRED (2/2)

	Methods of Works	Objective Sections	Descriptions of Works	Equipment Required
CLEANING AND DREDGING OF DRAINAGE CANAL	C-1 Cleaning and dredging of drainage canal by using grab bucket excavator on canal bank	Drainage canal where enable excavator to access canal bank and dredge from land side	Grab bucket set on bank will clear and dredge the canal and dumped into dump truck or sludge settling vessel. The sludge in vessel will be sucked by vacuum truck after unwatering and transported to disposal sites. But, the excavator will be used for C-2 work in accordance with work schedule. The total sediment volume to be excavated with this method is estimated at	1) Grab bucket excavator 2) Settling vessel 3) Dump truck 4) Vacuum truck 5) Truck with crane 6) Trailer 7) Pickup truck The equipment other than settling vessel and dump truck will also be used for C-2 wok below.
	C-2 Cleaning and dredging of drainage canal by using grab bucket excavator on working barge	Drainage canal with bottom width of 5 m or more, where unenable excavator to access canal bank and excavate from barge	The grab bucket excavator set on working barge will dredge the sediments and load to sludge handling barge. The dredged material will be transported to bank by manpower, then transported to disposal site by dump truck with solid material and by vacuum truck with sludge respectively. The handling volume by this method is estimated at 80 % of whole volume in canal with width less than 5 m and 100 % of canal more than 9 m.	1) Grab bucket excavator 2) Working barge 3) Sludge handling barge (large) 4) Material hauling barge (small) 5) Vacuum truck 6) Truck with crane 7) Rough terrain crane 8) Tractor and trailer 9) Pickup truck
	C-3 Cleaning and dredging of drainage canal by using vacuum truck with high vacuum and manpower	Drainage canal with narrow width less than 5 m and with considerably heavy sediment, where unable the equipment to access canal bank	The vacuum truck set at the crossing point of canal and road will suck the sediment in canal unwatered (by submersible pump, if necessary) through steel pipes and suction hose and load to sludge tank truck which will transport to disposal site(s). The solid and large size sediment will be transported by dump truck of other working group.	1) Vacuum truck with high vacuum 2) Sludge tank truck 3) Hand tools 4) Truck with crane 5) Submersible pump for construction use 6) Diesel generator 7) Gas detector 8) Transceiver 9) Pickup truck Rough terrain crane and trailer may be used for handling the piping materials.
	C-4 Cleaning and dredging of drainage canal by using small barge and manpower	Drainage canal where is narrow and shallow, and with light sediment	The sediment dredged and collected by using small barge and manpower will be loaded into dump truck by manpower and transported to disposal site(s). The work section may be unwatered by using submersible pump.	1) Sludge hauling barge (small) 2) Hand tools 3) Dump truck 4) Submersible pump for construction use 5) Diesel generator 6) Pickup truck

Table L4.3 LIST OF EQUIPMENT REQUIRED

No.	EQUIPMENT & MATERIALS	PURPOSE OF USE	QUANTITY	SEWERAGE CLEANING & DREDGING			DRAINAGE CANAL CLEANING & DREDGING				DISPOSAL SITES		MOTOR POOL	SPARES
				W. JET CLEANER	HIGH VAC. TRUCK	MANPOWER	GRAB FROM BANK	GRAB ON BARGE	HIGH VAC. TRUCK	MANPOWER	WEST SITE	SOUTH SITE	MAINT. & REPAIR	
A-01	Swampdozer, 7t	Disposal sites	2 units								1	1		
A-02	Excavator, grab bucket, 0.2 m3	Dredging	2 units				(2)	2						
A-03	Working barge for the above	Dredging	2 units					2						
A-04	Sludge hauling barge, 6 m3	Sludge hauling	4 units					4						
A-05	Sludge hauling barge, 2m3	Sludge hauling	8 units					2		6				
A-06	Sludge settling vessel, 6 m3	Sludge hauling	2 nos.				2							1
A-07	Dump truck, 4 t w/extension	Clean/dredging	12 units	4		2	2			3				
A-08	Water jet cleaner, 4 t truck	Cleaning	2 units	2										1
A-09	Water tanker, 4 m3	Cleaning	5 units	4										
A-10	Vacuum truck, 8 t w/high vacuum	Dredging	2 unit		1				1					
A-11	Vacuum truck, 4 t w/dehydrator	Cleaning	2 units	2										
A-12	Vacuum truck, 4 t	Dredging	14 units			4	(10)	10						
A-13	Sludge tank truck 4 t	Dredging	6 units		3				3					
A-14	Portable winch for sewer	Dredging	2 sets			2								
A-15	Truck, 4 t w/crane 3 t	Clean/dredging	7 units	2	1	2			1				1	
A-16	Rough terrain crane, 30 t	Dredging/etc.	1 unit				(1)	1	(1)		(1)	(1)	(1)	
A-17	Tractor & Trailer, 20 t	Dredging/etc.	1 unit				(1)	1	(1)		(1)	(1)	(1)	
A-18	Pick-up truck, 1 t	SV/F-service	8 units	2	1	1	(1)	1	1	1			1	
A-19	Submersible pump, 150 mm dia.	Clean/dredging	6 units		1	2			1		(1)	1		1
A-20	Submersible pump, 100 mm dia.	Clean/dredging	9 units	2	1	2			1	1	(1)	1		1
A-21	Diesel generator, 30 kVA	Clean/dredging	6 sets		1	2			1			1		1
A-22	Diesel generator, 20 kVA	Clean/dredging	4 sets	2						1				1
A-23	Spare parts for the above	15 % of CIF	1 lot											
B-01	Portable gas detector, 3 gases	Cleaning	7 nos.	2	1	2			1					1
B-02	Floodlight, 300 W, W/tripod	Cleaning	10 sets	2	2	6								
B-03	Blower, 300 mm dia..	Cleaning	11 nos.	2	2	6								1
B-04	Transceiver	Clean/dredging	7 sets	2	1	2			1					1
B-05	Hand tools for Dredging/Cleaning small canal, collector basin, small connection pipes, etc.	Clean/dredging	1 lot		(1)	1			(1)	1				
B-06	Equipment & tools for maintenance and repair shop	M & R shop	1 lot										1	
C-01	Dredge suction pipe (steel) set, 150 mm dia. x 200 m	Dredging	3 sets						3					
C-02	Suction hose, 150 mm x 5 m	Dredging	6 pcs						6					
C-03	Delivery hose, 150 mm dia. x 50 m	Clean/dredging	30 sets	30										
C-04	Delivery hose, 100 mm dia. x 50 m	Clean/dredging	45 sets	45										
C-05	Cabtyre cable, 100 m w/cable reel	Clean/dredging	30 sets	30										
C-06	Fuel and lubricant (for 1 year)	Clean/dredging	600 m3										2.7 x 220	

Remarks: The figures in bracket show number of equipment to be used alternately or in common.

Table L4.4 LIST OF EQUIPMENT AND MATERIALS REQUIRED

GROUP	EQUIPMENT/SPECIFICATION	PURPOSE OF USE	QUANTITY
A-01	Swampdozer, 7t	Disposal sites	2 units
A-02	Excavator, grab bucket, 0.2 m3	Dredging	2 units
A-03	Working barge for the above	Dredging	2 units
A-04	Sludge hauling barge, 6 m3	Sludge hauling	4 units
A-05	Sludge hauling barge, 2m3	Sludge hauling	8 units
A-06	Sludge settling vessel, 6 m3	Sludge hauling	2 nos.
A-07	Dump truck, 4 t w/extension	Clean/dredging	12 units
A-08	Water jet cleaner, 4 t truck	Cleaning	2 units
A-09	Water tanker, 4 m3	Cleaning	5 units
A-10	Vacuum truck, 8 t w/high vacuum	Dredging	2 unit
A-11	Vacuum truck, 4 t w/dehydrator	Cleaning	2 units
A-12	Vacuum truck, 4 t	Dredging	14 units
A-13	Sludge tank truck 4 t	Dredging	6 units
A-14	Portable winch for sewer	Dredging	2 sets
A-15	Truck, 4 t w/crane 3 t	Clean/dredging	7 units
A-16	Rough terrain crane, 30 t	Dredging/etc.	1 unit
A-17	Tractor & Trailer, 20 t	Dredging/etc.	1 unit
A-18	Pick-up truck, 1 t	SV/F-service	8 units
A-19	Submersible pump, 150 mm dia.	Clean/dredging	6 units
A-20	Submersible pump, 100 mm dia.	Clean/dredging	9 units
A-21	Diesel generator, 30 kVA	Clean/dredging	6 sets
A-22	Diesel generator, 20 kVA	Clean/dredging	4 sets
A-23	Spare parts for the above	15 % of CIF	1 lot
B-01	Portable gas detector, 3 gases	Cleaning	7 nos.
B-02	Floodlight, 300 W, W/tripod	Cleaning	10 sets
B-03	Blower, 300 mm dia..	Cleaning	11 nos.
B-04	Transceiver	Clean/dredging	7 sets
B-05	Hand tools for Dredging/Cleaning small canal, collector basin, small connection pipes, etc.	Clean/dredging	1 lot
B-06	Equipment & tools for maintenance and repair shop	M & R shop	1 lot
C-01	Dredge suction pipe (steel) set, 150 mm dia. x 200 m	Dredging	3 sets
C-02	Suction hose, 150 mm x 5 m	Dredging	6 pcs
C-03	Delivery hose, 150 mm dia. x 50 m	Clean/dredging	30 sets
C-04	Delivery hose, 100 mm dia. x 50 m	Clean/dredging	45 sets
C-05	Cabtyre cable, 100 m w/cable reel	Clean/dredging	30 sets
C-06	Fuel and lubricant (for 1 year)	Clean/dredging	600 m3