WATER AND SANITATION AGENCY
F D A , F A I S A L A B A D
ISLAMIC REPUBLIC OF PAKISTAN

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR UPGRADING OF MECHANICAL SYSTEM OF WASA FAISALABAD
IN
ISLAMIC REPUBLIC OF PAKISTAN

MARCH 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
JAPAN TECHNO CO. , LTD.

SUMMARY

SUMMURY

1. General Description

The Islamic Republic of Pakistan (hereafter called "Pakistan") lies in southwestern Asia, bordering India to the east, Iran and Afghanistan to the west and facing the Arabian Sea to the south, occupying a total area of 796 thousand km^2. Its estimated population in 2008 was close to 166 million (World Bank), about 2/3 of which is the rural population as agriculture is still one of the main stays of the country's economy. Faisalabad, city targeted by this project, is located in the central area of Punjab province developing a national granary thanks to the dense canal network from the Indus River and its tributaries. According to the latest census in 1998, its population reached the third largest level in the country only behind Karachi and Lahore, and in 2009 is estimated at about 2.7 millions. At its birth in the 1960s, the place was intended to serve as a distributing center for agricultural products to its neighborhoods. It was not long before the city saw the textile industry becoming settled in the town, eventually developing as one of the country's largest industrial cities.

2. Background and Summary of the Project

Faisalabad city (population about 2.7 million persons, 2009 estimate) is the third urban center after Karachi and Lahore in Pakistan. Also, Faisalabad is one of the few industrial cities in the country centered on textiles and furnitures. Based on the ADB water supply and sewerage master plan of 1976 (and revised by the World Bank in 1993), through funding by ADB and provincial budget, new construction and replacement of mainly water supply facilities were carried out, but only Phase 1 was finally completed in 2000. However, as compared to water supply, improvements in sewerage and drainage were relatively delayed. Consequently, deterioration of pumps and cleaning equipment are obvious where about 30% of pumps are broken and most of the cleaning equipments were procured in the 1980's.

With this background, the Pakistani government requested the Japanese government to execute the "Project for Upgrading of Mechanical System of WASA Faisalabad" under grant aid assistance to replace deteriorated pumps and cleaning equipment to reduce damages from flooding which chronically occurs in Faisalabad city.

3. Summary of Results of the Study and Contents of the Project

During the study in Pakistan from November to December 2010, the request contents were confirmed on 11 November 2010 and these are shown in Table 1. Changes in the quantities of requested equipments were not made and the executing agency explained the priority ranking according to use purpose for each equipment. Then the study team carried out a technical review on the contents.

Table 1 Confirmation of Requested Equipment (11 November 2010)

No.	Equipment	Request		Confirmed (11 Nov. 2010)	
		Specifications	Q'ty	Purpose	Priority
1	Jet machine	Tank capacity: 4,000lit.	12	Sewer cleaning	High
2	Suction machine	Tank capacity: 4,000lit.	2	Sewer cleaning	High
3	Backhoe	Bucket size:0.35m^3	2	Channel desludging	High
4	Bucket crane (Clam shell)	Lifting capacity: 12 ton Boom length: 23.8m Jib length: 5.5m	4	Channel desludging	High
5	Dump truck	Payload: 4ton	6	Sludge transport	High
6	Dewatering set	1 cfs (Diesel)	24	Emergency dewatering	Medium
		4 cfs (Diesel)	12		
		4 cfs (Electric)	6		
7	Pumps for disposal stations	4 cfs	15	Pump replacement	High
		6 cfs	8		
		15 cfs	7		
		25 cfs	6		
8	Generator for disposal stations	100 kVA	1	Generator replacement	High
		200 kVA	1		
		300 kVA	1		
		500 kVA	1		
		635 kVA	1		
		730 kVA	1		
9	Tractor and Trolley	-	4	Transportation	Medium
10	Station wagon	-	12	Transportation	Medium
11	Pick-up truck	4x4, double cabin	6	Transportation	Medium
12	Safety equipment	Oxygen cylinder, mask, diving suit	12	Safety for sewer cleaning	High
13	Computer and software	-	1	Data management and monitoring	Low
14	Communication Equipment	-	49	Communication	High
15	Garage, Workshop	-	1	Maintenance	Medium
16	M & E system and equipment	-	1	Evaluation	Low

The technical review by the study team continued until 2 December 2010 and during the survey, the executing agency WASA requested changes in the quantities and specifications as shown in Table 2.

1) Concerning the quantities of requested equipment, in assuming that if procurement of all requested equipment becomes difficult due to limitations in the Japanese budget, WASA categorized priorities into high, medium and low. Then, quantities of higher priority equipment will be given higher priority for selection. Also, WASA proposed 2 options for selection in consideration of the budget and for equipment of low priority, procurement through WASA's own budget will be considered.
2) Concerning the equipments listed below, as a result of discussions on importance level

within the whole project, priorities of these equipments were lowered. Therefore, for equipments difficult to be procured in this project, WASA will consider a budget plan and self-efforts will be made as much as possible to procure these equipments, and thus, the following equipments will be deleted from the list.

① 4-wheel drive vehicle (Station Wagon): 12 vehicles

② Safety equipment (oxygen mask for sewer cleaning, oxygen cylinder, diving suit, others): 12 sets

③ Computer and software for monitoring: 1 set

④ Communication equipment: 49 sets

⑤ Garage and workshop: 1 set

⑥ Monitoring and evaluation (M&E) system and equipment: 1 set

Table 2 Reconfirmation on Contents of Request from Results of Field Survey (2 Dec 2010)

No.	Equipment	Request		Revised Proposal (2 December 2010)			
		Specifications	Q'ty	Specifications	Quantity*[1] Option 1	Quantity*[1] Option 2	Priority
1	Jet machine	Tank capacity: 4,000lit.	12	Similar to existing	12	8	High
2	Suction machine	Tank capacity: 4,000lit.	2	Similar to existing	2	2	High
3	Backhoe	Bucket size:0.35m^3	2	Medium size Small size	1 1	1 1	High
4	Bucket crane (Clam shell)	Lifting capacity: 12 ton Boom length: 23.8m Jib length: 5.5m	4	Medium size Small size	2 2	2 2	High
5	Dump truck	Payload: 4ton	6	Similar to existing	6	6	High
6	Dewatering set	1 cfs (Diesel)	24	1 cfs (Diesel)	25	13	Med.*[2]
		4 cfs (Diesel)	12	2 cfs (Diesel)	16	4	
		4 cfs (Electric)	6	2 cfs (Electric)	6	4	
7	Pumps for disposal stations	4 cfs	15	2 cfs	3	0	Low
		6 cfs	8	4 cfs	14	0	Low
		15 cfs	7	6 cfs	3	0	Low
		25 cfs	6	10 cfs	5	2	Med.
				15 cfs	4	2	High
				25 cfs	12	10	High
8	Generator for disposal stations	100 kVA	1	50 kVA	1	0	Low
		200 kVA	1	75 kVA	2	0	Low
		300 kVA	1	210 kVA	2	0	Low
		500 kVA	1	300 kVA	1	1	Med.
		635 kVA	1	500 kVA	4	2	Med.
		730 kVA	1				
9	Tractor and Trolley	-	4	Crane truck	6	2	Med.
10	Pick-up truck	-	6	Double cabin	6	4	Med.
11	Station wagon	-	12	-	0	0	Low
12	Safety equipment	Oxygen cylinder, mask, diving suit	12	-	0	0	Low
13	Computer and software	-	1	-	0	0	Low
14	Communication Equipment	-	49	-	0	0	Low
15	Garage, Workshop	-	1	-	0	0	Low
16	M & E system and equipment	-	1	-	0	0	Low

*[1] Options 1 and 2 were provided in consideration of budget constraints.

*[2] Pakistani side proposed "Low", but judged to be "Medium" according to the technical review

The Explanation on Draft Report has been carried out in February, 2012 after the considerations about specifications and quantity of equipment based on a result of field study and homework in Japan. Finally, the procurement plan for cleaning equipment has been concluded as follows.

Table -3 Plan for Cleaning Equipment

No.	Equipment	Main Specifications	Required Q'ty	Existing Q'ty		Procure Q'ty
				Total	To Use	
1	Jet Machine	Tank capacity: >3,500 lit Pump capacity: About200 lit/min	15	7	7	8
2	Suction Machine	Capacity: >3,500 lit	4	3	2	2
3	Wheel Backhoe	Struck capacity: 0.2 m^3 class Options: hydraulic clam shell, skeleton bucket	3	1	1	2
4	Mini-Backhoe	Struck capacity: 0.08 m^3 class Option: skeleton bucket	2	0	0	2
5	Bucket Crane (Clam Shell)	Crane lifting capacity: 25t	4	2	2	0
6	Dump Truck	Payload: >3,500 kg	7	2	0	7
7	Crane Cargo Truck	Payload: >2,500 kg Crane lifting capacity: 2.9t	2	0	0	2
8	Pick-up Truck	4x4 diesel, double cabin	6	7	6	0
9	Dewatering Set	1 cfs (Diesel)	70	70	53	17

The equipment for the disposal stations shall be procured as listed below.

Table-4 Allocation Plan for Pumps and Generators

Disposal Station	Pump		Generator			
	15 cfs	25 cfs	150 kVA	300 kVA	350kVA	650 kVA
PS-3 Chokera	-	2	-	-		1
PS-31 Satiana Road	-	4	-	1		-
PS-36 Ahmed Nagar	-	2	1	-		-
PS-30 Bawa Chak	-	1	-	-	1	-
Sub-total	-	9	1	1	1	1
Total	9		4			

4. Project period

After the exchange of notes (E/N) between the Japanese government and Pakistani government is concluded for this project, the grant aid assistance from the Japanese government will be executed. The project implementation schedule from conclusion of E/N is, 6 months for detailed design including tendering procedures, and 25 months for equipment manufacturing, procurement, installation and soft component activities. Installation of the equipment for disposal stations should not be scheduled during the rainy season when drainage systems are operated at their peak in order to avoid adverse influences from pumping operations.

5. Evaluation of the Project

Relevance and effectiveness due to Project implementation are expected as explained below.

1) Relevance of the Project

Damages caused by floods and inundations in Faisalabad are seriously affecting the economic and social activities as well as hygiene and sanitation aspects, and are issues required to be solved urgently. The Project will contribute directly to the above issues as an immediate effect on reduction of present damages. More than 1.6 millions population served by the sewage and drainage system will benefit directly or indirectly by the Project. Since the inundation damages are causing serious affects especially to the areas where roads and housings are less developed, the Project will contribute to the socially weak people who are living those areas. In addition, the Project links to the "Project for the Improvement of Water Supply System in Faisalabad" financed by the Japanese government currently being implemented and this link will contribute as the integral conception between water supply and sanitation.

2) Effectiveness of the Project

Quantitative Effects

The following table shows the expected outputs to be achieved through implementation of the Project.

Output Indicator	Current Value (2011)	Planned Value (2013)
Reduction in period needed to completely clean the sewer system using cleaning equipment (jet machine + suction machine)	21.6 years	10.8 years
Increase in possible number of emergency dispatches		
Jet Machine (Ave. Dispatch Requests: 40.3/day)	18.9 times/day	40.5 times/day
Suction Machine (Ave. Dispatch Requests: 10.1/day)	6.0 times/day	12.0 times/day
Dewatering Pump Set (Ave. Dispatch Requests: 69.9/day)	53 times/day	More than 70 times/day
Decrease in minimum time required to reach site	25 to 60min.	Less than 20 min.

(Dewatering Pump Set and Transport Vehicle)	(Livestock + Tractor)	(Crane Truck, Pick-up Truck)
Improvement in Emergency Drainage Capacity (Dewatering Pump Set)	26.5cfs	43.5cfs *64.2% capacity improvement
Increase in Amount of Sludge and Waste Removal Desludging Capacity (Excavator) Transport Capacity (Dump Truck)	 570 m^3/day 9.1 m^3/day	 936 m^3/day 63.7 m^3/day
Capacity Improvement of 4 Target Disposal Stations which discharge into final drains	246cfs	376cfs *52.8% capacity improvement

Qualitative Effects

The Project expects the following qualitative effects.

- Due to reduction in damages from flooding and inundations, risks of water-borne diseases caused by these phenomena will be reduced.
- Social and economic activities impeded by inundations and flooding will be reactivated.
- Due to improvements in conditions of uncollected waste and chronic inundations, sanitary environment in the city will be improved.

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ISLAMIC REPUBLIC OF PAKISTAN
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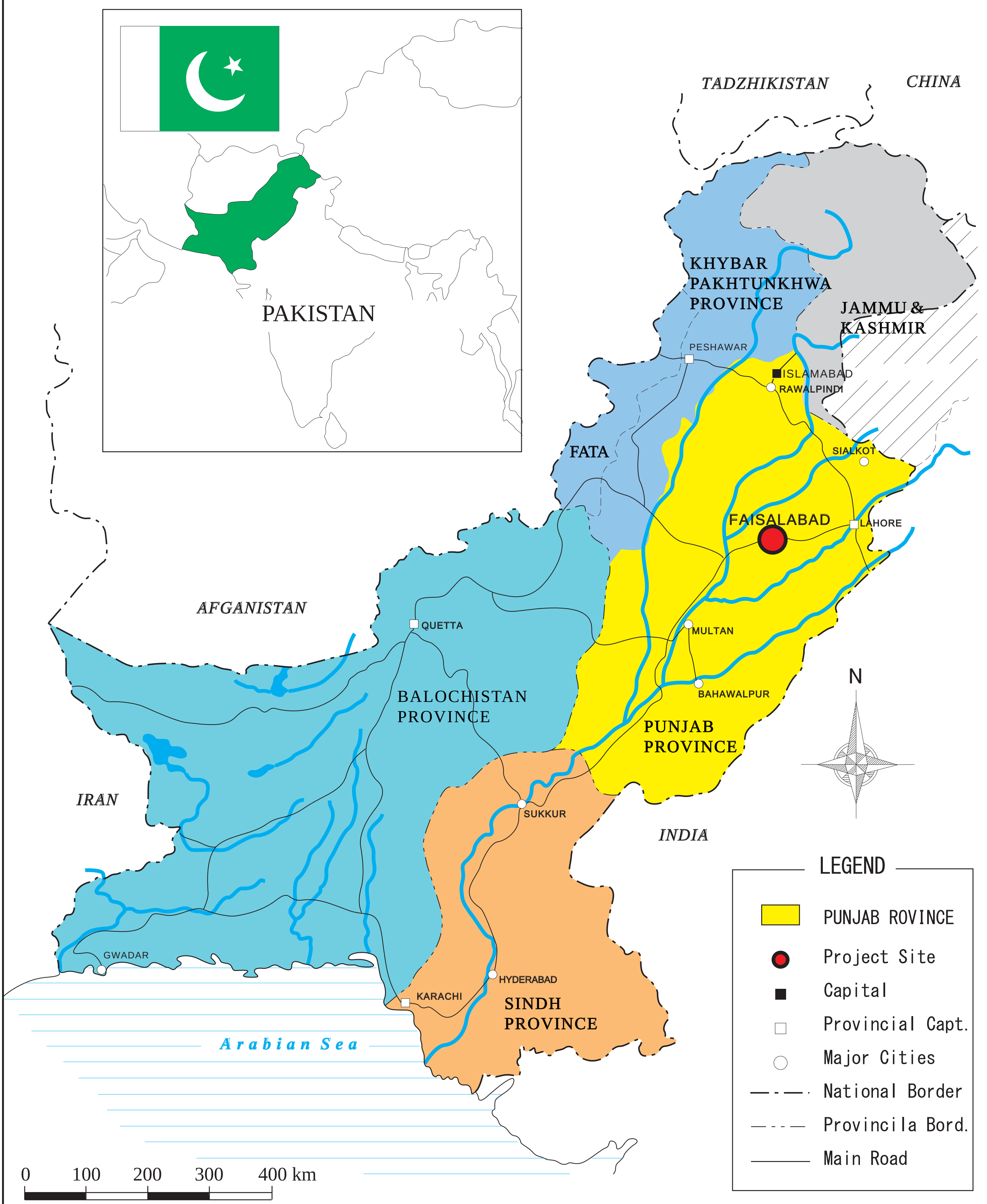
LOCATION MAP OF PROJECT SITE



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ABBREVIATION

ADB	Asian Development Bank
ADP	Annual Development Program
cusec	cfs (ft^3/sec)
EAD	Economic Affairs Division
EIA	Environmental impact assessment
FDA	Faisalabad Development Authority
HUD&PHED	Housing, Urban Development and Public Health Engineering Department
IEE	Initial environmental examination
JICA	Japan International Cooperation Agency
O&M	Operation and maintenance
PC	Project Concept
P&D	Planning and Development
P&E	Planning and evaluation
TMA	Tehsil Municipal Administration
WASA	Water and Sanitation Agency
VAT	Value added tax

CHAPTER 1
BACKGROUND OF THE PROJECT

Chapter 1　Background of the Project

1-1　Background and Outline of the Project

Faisalabad city (population about 2.7 million persons, 2007 estimate) is the third urban center after Karachi and Lahore in Pakistan. Also, Faisalabad is one of the few industrial cities in the country centered on textiles and furniture. Based on the ADB water supply and sewerage master plan of 1976 (and revised by the World Bank in 1993), through funding by ADB and provincial budget, new construction and replacement of mainly water supply facilities were carried out, but only Phase 1 was finally completed in 2000. However, as compared to water supply, improvements in sewerage and drainage were relatively delayed. Consequently, deteriorations of pumps and cleaning equipment are obvious where about 30% of pumps are broken and most of the cleaning equipments were procured in the 1980's.

With this background, the Pakistani government requested the Japanese government to execute the "Project for Upgrading of Mechanical System of WASA Faisalabad" under grant aid assistance to replace deteriorated pumps and cleaning equipment to reduce damages from flooding which chronically occurs in Faisalabad city.

Improvement of the sewerage system plays an important role in development of urban centers. The cholera epidemic during the 19^{th} century in Europe and Asian countries caused by stagnant sewage and unsanitary environment from rain flooding gave recognition that this can have a significant impact on socio-economic infrastructures. As a result, history reveals that, thereafter, improvements in sewer systems were promoted at a rapid pace.

In the suburbs of Faisalabad, a large urban center developing around the textile industry, the sprawling phenomenon is expanding due to the population growth rate of about 3.8%. Although WASA, having responsibilities for sewerage management, is promoting improvements in sewer services such as sewer line extensions and new construction of disposal stations using limited funds. However, the weaknesses of sewer systems such as deterioration of existing facilities, accumulation of wastes inside channels and blockage of sewers are being left alone. The primary causes of water disasters are natural factors including topography and geology; inefficient social infrastructures such as delays in sewer improvements; expansion of non-infiltration areas and reduction of rainwater storage capacity; degradation of sewer and channel functions due to solid waste accumulation; and other negative impacts due to urbanization by population growth and economic development.

Equipments necessary for maintenance such as periodic cleaning, upon becoming deteriorated, are not replaced. Therefore, daily cleaning works are neglected, aged equipments are not maintained, and sewers and channels are not cleaned to cause flooding due to blockages which applies extensive negative impacts on urban functions. Though there are budget problems, cleaning and inspections related to routine maintenance cannot be conducted due to the necessity to respond to frequent emergencies.

Therefore, unless sewer and drainage capacity strengthening is carried out starting from familiar tasks such as renewal of deteriorated equipment of existing disposal stations and improvement and reinforcement of equipment capacity, as well as procurement of necessary equipment to desludge channels and clean sewers, risks of water disasters will arise every year. By strengthening the sewer and drainage capacity, the hidden water disaster vulnerability of Faisalabad city under the socio-economic foundation can be relieved, and complaint management as daily emergency countermeasures can be efficiently and systematically solved.

The results of survey on sewer and channel cleaning situation using existing equipment and sewerage system of Faisalabad city showed that the problem of the sewerage system is garbage, domestic solid waste, industrial waste, animal carcasses and other wastes, which should normally be collected, transported and disposed in a proper manner, are thrown into the sewers and channels. Since drainage channels are the responsibility of WASA, wastes inside channels should be removed and transported to landfill sites (final disposal sites) by WASA. However, due to shortage of transport equipment of WASA, solid waste is raked out from channels and placed along the sides of channels. Then, WASA has arranged for Tehsil Municipal Administration (TMA) to remove the wastes from the channel sides and transport them to the landfill sites, but TMA cannot always carry out this task. As a result, solid wastes overflow along the streets and are again thrown into channels or naturally fall down to create new blockages and flooding.

Furthermore, in areas where sewer systems are not yet developed, inundations during the rainy season are chronic and unsanitary conditions are continuing. Therefore in these areas, WASA is promoting the construction of new sewer lines and rehabilitation of deteriorated existing networks, as well as installation of trunk sewers to the principal disposal stations. Improvements in pumping capacities of the principal disposal stations are required as measures against these inundations.

1-2 Environmental/Social Consideration

Upon confirmation of Pakistan’s Environmental Law, and from Pakistan Environment Protection Agency (Review of IEE and EIA) Regulations 2000, projects requiring IEE are those within the following sectors.

① Agriculture, livestock and fisheries
② Energy
③ Manufacturing and processing
④ Mining and mineral processing
⑤ Transport
⑥ Water management, dams, irrigation and flood protection
⑦ Water supply and treatment (Water supply schemes and treatment plants with total cost less than Rs25 million)
⑧ Waste disposal (Waste disposal facility for domestic or industrial wastes, with annual capacity less than 10,000 cubic meters)
⑨ Urban development and tourism
⑩ Other projects: Any other projects requiring IEE

On the other hand, projects in the following sectors require EIA.

① Energy
② Manufacturing and processing
③ Mining and mineral processing
④ transport
⑤ Water management, dams, irrigation and flood protection
⑥ Water supply and treatment (Water supply schemes and treatment plants with total cost of Rs25 million and above)
⑦ Waste disposal (Waste disposal facility for domestic or industrial wastes, with annual capacity more than 10,000 cubic meters)
⑧ Urban development and tourism
⑨ Environmentally sensitive areas
⑩ Other projects: Any other projects requiring EIA

Since this project involves procurement of equipment related to sewage and wastewater, the above sectors do not apply, and therefore, execution of IEE and EIA are not required. However, as part of environmental and social considerations, WASA hired a consultant in January 2011 to carry out the “Environmental and Social Impact Assessment of Upgradation of the Mechanical System of Water and Sanitation Agency (WASA) Faisalabad”, which becomes the environmental impact assessment for this project. The following is a summary of this report.

Basically, the environmental and social impacts from this project are assessed to be not very high. Although negative impacts such as noise, vibration, solid waste generation and accidents at work sites during project implementation can be presumed, the impacts are localized. Also, operational impacts can be assumed as exhaust emissions from running machinery on fossil fuel, noise generation from working during the night, sewer blockage/overflow from using damaged machinery, and infrastructure damages from using heavy machinery for cleaning sewers in narrow roads and congested areas. On the other hand, the negative impacts on users resulting from insufficient managerial performance of WASA Faisalabad include throwing solid wastes into channels, improper maintenance of sewer connections inside individual households, and illegal sewer connections.

Measures for mitigating negative impacts to the environment and society are proposed in the environmental and social management plan (ESMP) for each stage of design, implementation and operation as explained below.

Design stage:

- Proper project designing indicating timeframe for each activity
- Advance preparation of all necessary drawings and layout plans
- Handling of concerns and suggestions from stakeholders and beneficiaries

Implementation stage:

- Preparation of checklists for conducting each activity
- Timely issuance of public notices before conducting activities
- Identification of alternate routes in case of temporal road blockade
- Isolation of work site with fences or sheets
- Proper stockpiling of construction materials, preferential work during daytime
- Assurance of site safety during installation works

Operation stage:

- Proper operation and periodic maintenance of equipment,
- Establishment of an effective system for handling public complaints
- Ensuring sufficient stock of necessary spare parts and consumables,
- Operational training of concerned personnel
- Public awareness and sensitization to prevent residents from throwing wastes into channels.

CHAPTER 2
CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

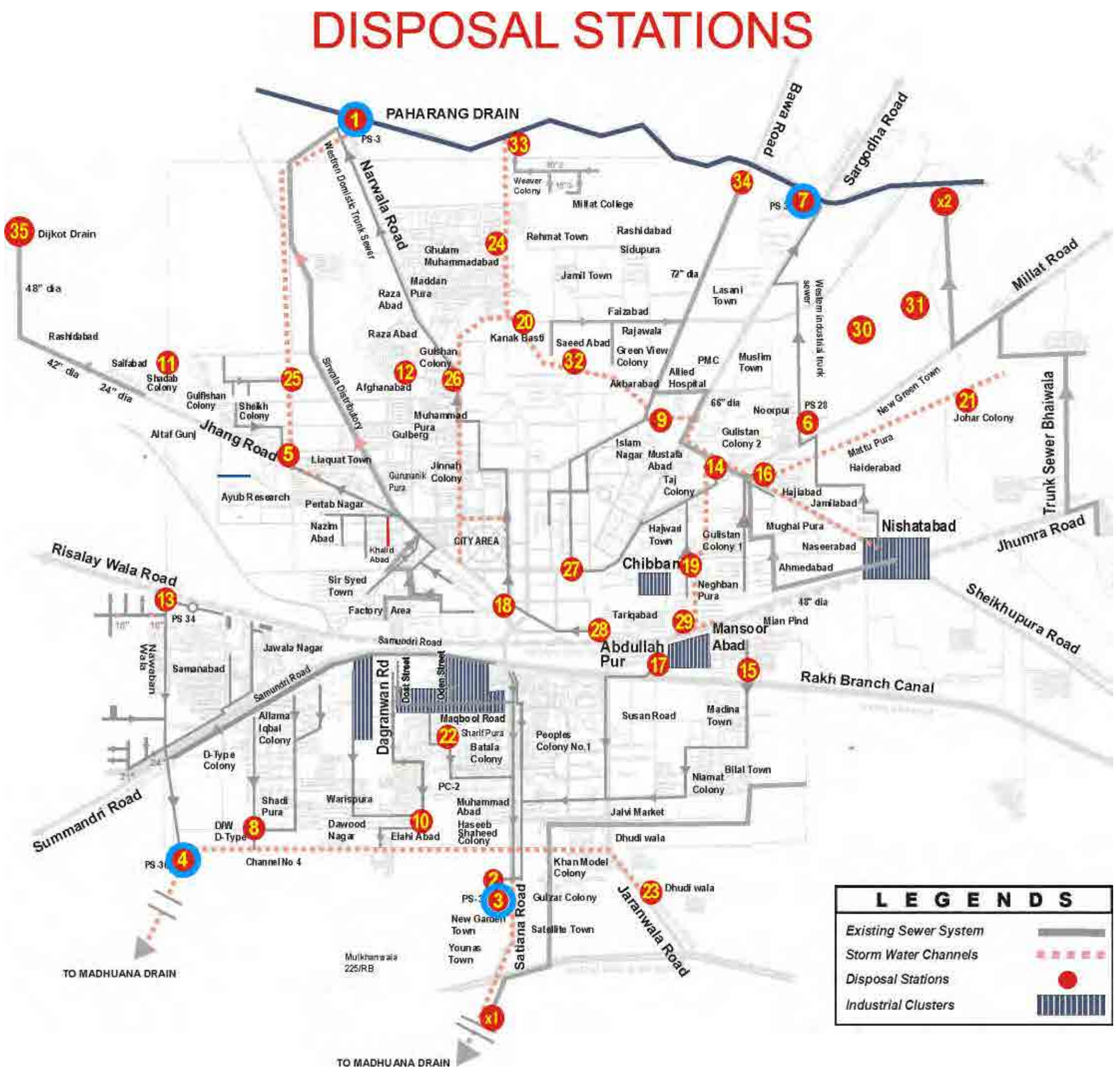
2-1-1 Present State and Issues of Disposal Stations and Sewer/Drainage System

The record-breaking torrential rains from July to August 2010 in Pakistan caused the historically worst flood disaster in the entire basin from northwest to south of the country (inundated area about 160,000 km^2). According to the Pakistani government (in January 2011), 20% of the country including Punjab Province received damages resulting in an estimated 20 million victims (of which, 9 million were children), over 15 million deaths, 190 collapsed houses, damages to roads and irrigation facilities, and 200 thousand livestock deaths. For about 1 month, the flooding could not be cleared, sheltered life became inevitable, worsening of living and sanitary conditions continued and the importance of urgent measures against flooding was recognized.

In Faisalabad, abnormally high rate of precipitation in the rainy season from July to September was also recorded, but escaped from catastrophic disaster which occurred in other areas. However, many areas in the city became inundated and the situation continued. The sewer system of Faisalabad is supposed to be a system separating sewer and storm water, but in actuality, wastewater from households and factories flows through sewer lines laid underground which flow into disposal stations, and then is pumped out into channels and sewers. Furthermore, the present sewers and channels act as courses for storm water during the rainy season, and therefore, wastewater and storm water are not completely separated to create a combined system. When sludge and solid waste accumulate inside the course to restrict the flow capacity, storm water flowing into the course increases the sewage flow rate to cause overflow in sewers and channels with eventual flooding and inundations to disrupt the urban mechanism, and create concern to the sanitary environment.

Faisalabad is divided into East and West by a railroad crossing through the center from southwest to northeast. Sewage pumped from disposal stations scattered around the city flows into sewers and channels, and flows out either into Madhuana Drain located in the eastern edge of the city or Paharang Drain located in the western edge of the city. From these drains, sewage finally flows to Ravi River from the east and Chenab River from the west.

The location map of disposal stations under the responsibility of WASA is shown in Figure 2-1, and the list of existing pumps is shown in Table 2-1.



N.B.: Disposal stations shown by blue ringed numbers are principal stations targeted for this project, and pink colored broken lines are principal drainage channels
Source: Faisalabad WASA (2010)

Figure 2-1 Location Map of Existing WASA Disposal Stations

Presently, WASA is independently conducting a pumping capacity strengthening program where 3 disposal stations (No. 14, 21 and 32) out of the total 35 stations under the responsibility of WASA were abandoned and bypassed to new sewer lines. Further, 4 more disposal stations (No. 22, 23, 24 and 33) are scheduled to be abandoned. By strengthening the remaining 28 stations along with new construction and extensions of sewer lines, efficiency of the whole sewerage system is being promoted.

However, since some of the equipments in the existing disposal stations were installed in the 1970's and are already operating for over 30 to 40 years, some pumps are extremely deteriorated and can break down anytime. Also, as a result of increase in sewage rates due to the population increase in Faisalabad, some disposal stations have deficits in pump capacities for pumping up sewage to weaken management of the sewerage system.

Depending on their characteristics, disposal stations in Faisalabad city can be divided into 2 types.

1) Booster disposal stations inside the city: These are mainly small scale disposal stations scattered inside the city which act as boosters.
2) Drain disposal stations in the city outskirts: These are located near the perimeter of the city and since their functions are to drain out sewage pumped from the booster stations into the main drains, these are relatively large scale stations.

These disposal stations are explained below.

Booster Disposal Stations inside the City

These are disposal stations located along roads, in corners of residential areas and next to factories. At these stations, uncovered circular wet wells to receive sewage and wastewater are installed, and although diesel engine generators and control panels have roofs, pumps and motors are placed outdoors (however, motors are completely contained with external fans of water-proof type and unless they are inundated, no problems will arise). Wet wells have diameters of 4m to 10m, above ground concrete walls are about 1m high with thicknesses of 0.3m to 0.6m, and inside pit depths are about 10m. Pumps are connected to pipes which are laid over the well wall or penetrated through the wall. At a point a few meters below the highest level of riser pipes, check valves are installed to assure priming water for pump startups. Pumps are installed outside the wet wells and powered by belt-driven motors.

Drainage Disposal Stations in the City Outskirts

These stations are located at the terminals of channels and have functions to pump up wastewater flowing from the city interior into final drains. The stations have housing structures with large size pumps orderly lined below the ground. After the sewage inflow gate, a manual influent gate, solid waste removal screen and settling basin are installed. Then, the sewage flows into the wet well and pumped up into sewers or drains.

Table 2-1 List of Existing Pumps at WASA Disposal Stations (as of November 2010)

No.	Disposal Station	Type	Zone	Pump Capacity (cfs)	Procured/ Manufacturer	Year Installed	Condition
1	PS-3 Chokera	Drain	West	15	KSB	2000	Broken
				25	KSB	2010	Working
				25	KSB	2010	Working
				15	KSB	2000	Working
				15	KSB	2010	Working
				15	KSB	2000	Broken
2	Satiana Road	Drain	East	15	Poland	1981	Deteriorated
				15	KSB	1976	Deteriorated
				15	KSB	1976	Deteriorated
				10	KSB	1981	Deteriorated
				6	KSB	1987	Deteriorated
				6	KSB	1987	Deteriorated
				6	KSB	1987	Deteriorated
				4	KSB	2000	Working
				4	KSB	2000	Working
3	Satiana Road PS-31	Drain	East	15	KSB	1998	Broken
				15	KSB	1998	Working
				25	Torishima	1988	Deteriorated
				25	Torishima	1988	Deteriorated
4	PS-36 Ahmed Nagar	Drain	East	15	Local	1998	Working
				15	Local	1998	Working
				15	Local	1998	Working
				15	Local	1998	Working
5	Jhang Road	Drain	West	12	Poland	1975	Deteriorated
				12	Poland	1975	Broken
				12	Poland	1975	Broken
				4	KSB	1998	Working
				4	KSB	1998	Working
				6	KSB	1998	Broken
				6	Local	1998	Working
				6	Local	2000	Broken
				4	KSB	2000	Working
				4	KSB	2000	Working
6	PS-28 Noor Pur	Booster	West	8	Itay	2000	Working
				8	KSB	2000	Working
				8	KSB	2000	Working
				6	Local	2000	Working
				4	Local	2001	Useable
				6	Local	2001	Useable
				8	KSB	2001	Useable
7	PS-30 Bawa Chak	Drain	West	13	Weir	2000	Working
				13	Weir	2000	Working
				13	Weir	2000	Working
8	D-Type	Booster	East	4	Local	1976	Deteriorated
				6	KSB	1987	Deteriorated
				4	Local	1976	Deteriorated
				4	Local	1976	Broken
				4	Local	1976	Broken
				4	KSB	1987	Deteriorated
				6	Local	1987	Broken

No.	Disposal Station	Type	Zone	Pump Capacity (cfs)	Procured/ Manufacturer	Year Installed	Condition
9	Akbarabad	Booster	West	4	KSB	1985	Deteriorated
				4	Local	1985	Deteriorated
				4	Local	1985	Broken
				4	KSB	1985	Broken
				4	KSB	1995	Working
				4	KSB	1995	Working
				4	KSB	1995	Working
10	Elahiabad	Booster	East	6	KSB	1987	Deteriorated
				4	KSB	1987	Broken
				4	KSB	1987	Deteriorated
				4	KSB	1987	Deteriorated
				4	KSB	1987	Deteriorated
				6	KSB	1987	Deteriorated
11	Shadab Colony	Booster	West	4	KSB	1995	Broken
				4	KSB	1995	Working
				4	KSB	1996	Working
				4	KSB	1996	Working
				4	KSB	1996	Working
12	Metropole	Booster	West	4	KSB	1995	Working
				4	KSB	1995	Working
				4	KSB	1995	Working
				4	KSB	1995	Working
				4	KSB	1995	Working
13	PS-34 Samanabad	Booster	East	6	KSB	1987	Deteriorated
				6	KSB	1987	Deteriorated
				4	KSB	1987	Deteriorated
				4	KSB	2000	Working
14	No. 2 Gulistan Colony	Booster	West	Abandoned			
15	Mansoorabad	Booster	East	6	KSB	1981	Deteriorated
				6	KSB	1987	Deteriorated
				4	KSB	1987	Deteriorated
16	No. 1 Gulistan Colony	Booster	West	10	KSB	2010	Working
				10	KSB	2010	Working
				10	KSB	2010	Working
				15	KSB	2010	Working
17	Abdullahpur	Booster	East	4	KSB	1987	Deteriorated
				4	KSB	1981	Deteriorated
18	Girja Ghar	Booster	West	4	KSB	1995	Working
				4	KSB	1995	Working
				4	KSB	1995	Working
19	Shadman	Booster	West	4	Local	1985	Deteriorated
				4	Local	1985	Deteriorated
				6	Local	1998	Working
				4	Local	2010	Working
20	Kanak Basti	Booster	West	4	KSB	1985	Deteriorated
				4	KSB	1985	Broken
21	Nishatabad	Booster	West	Abandoned			
22	Sharif Pura	Booster	East	To be abandoned			
23	Last Stop Dhudi Wala	Booster	East	To be abandoned			
24	Shahi Chowk	Booster	West	To be abandoned			
25	Liaqat Town	Booster	West	1	KSB	1995	Working
				1	KSB	1995	Working
				2	KSB	1995	Working
26	Gulshan Colony	Booster	West	2	Local	1988	Deteriorated
				2	Local	1988	Broken

No.	Disposal Station	Type	Zone	Pump Capacity (cfs)	Procured/ Manufacturer	Year Installed	Condition
27	G.B.S. (General Bus Stand)	Booster	West	2	Local	2000	Useable
				2	Local	2000	Useable
28	Tariqabad	Booster	West	2	Local	1988	Deteriorated
				2	Local	1988	Deteriorated
29	Mehmood Abad Tower	Booster	West	2	Local	2000	Useable
30	Millat Town B-Block	Booster	West	2	Local	1988	Deteriorated
31	Millat Town D-Block	Booster	West	2	Local	1988	Deteriorated
32	Raje Wala	Booster	West	Abandoned			
33	Weaver Colony	Booster	West	To be abandoned			
34	Bawa Road	Drain	West	15	KSB	2010	Working
				15	KSB	2010	Working
				15	KSB	2010	Working
				15	KSB	2010	Working
				15	KSB	2010	Working
				10	KSB	2010	Working
35	Dijkot Drain	Drain (not target)	West	4	KSB	2010	Working
				4	KSB	2010	Working
				4	KSB	2010	Working
				4	KSB	2010	Working

Source: Prepared by the study team using WASA data (2010)

The above disposal stations are summarized below for east and west directorates.

Table 2-2 Number of Disposal Stations by WASA Directorate

Directorate	Booster Disposal Station			Drainage Disposal Station			Total		
	Working	Abandoned (or scheduled)	Sub-Total	Working	Abandoned (or scheduled)	Sub-Total	Working	Abandoned (or scheduled)	Sub-Total
East	7	2	9	2	0	2	9	2	11
West	14	5	19	5	0	5	19	5	24
Total	21	7	28	7	0	7	28	7	35

Sewage includes nightsoil and wastewater from households through daily living; wastewater from industrial, commercial and other activtities; and storm water which all flow into sewer lines and channels, and during the rainy season, the sewage rate increases. Since the field survey for this project was conducted in the dry season (November 2010), influence from rainwater was very low; and water levels of wet wells in disposal stations which could be confirmed visibly were low. During the dry season, disposal station operation in the city center is sufficient for pumping sewage into sewers and channels, but sewage flow rates of disposal stations located near the city borders are high due to concentration of sewage from disposal stations inside the city. Therefore in the rainy season, due to increase in sewage flow rate, WASA reported that pumps are being operated at peak capacities. When sewage, which increased through reinforcement of the sewer system in the city, cannot be effluented, sewage overflows in the outer areas of the city.

In the sewer system of Faisalabad which is located inland, wastewater is directed towards main drains flowing outside of the city. Although Faisalabad has 35 disposal stations as shown in Table 2-1, these are connected through a network of sewer pipes and channels, and the amounts of wastewater and storm waters from the area increase as these are cumulatively collected going from the city center to the city outskitrts. This means that when the principal disposal stations located near main drains stop functioning, the extent of influence will widely affect residents to explain the high importance of these disposal stations. On the other hand, the disposal stations inside the city also need measures against break downs and capacity upgrading, but since these are smaller facilities, WASA is capable of carrying out their replacements and improvements. However, for replacement of the large capacity principal disposal stations surrounding the city, the difficulties both financially and technically are considered very high.

As the opinion of WASA in consideration of population growth and future vision of the sewer system, out of the drainage disposal stations located in the city outskirts, which are included in the 35 disposal stations within Faisalabad city listed in Table 2-1, the following 6 are designated as the principal disposal stations.

- No. 1 PS-3 Chokera
- No. 3 PS-31 Satiana Road
- No. 4 PS-36 Ahmad Nagar
- No. 5 Jhang Road
- No. 7 PS-30 Bawa Chak
- No. 34 Bawa Road

Another disposal station, namely No. 2 Satiana Road, is located next to disposal station No. 3 PS-31 Satiana Road. Although this station No. 2 is also located near the final drain and functions as a drainage station, WASA does not considered this as a principal disposal station. Therefore, this station is not targeted in this Project.

Within the above, since Bawa Road is a new disposal station just completed in 2010, rehabilitation is presently not required. Also, although Jhang Road is presently considered as a principal disposal station, when the large diameter sewer trunk main connecting directly to PS-3 Chokera is completed, load on Jhang Road is expected to decrease and capacity expansion of PS-3 Chokera will be needed, which means rehabilitation of Jhang Road will not be necessary. Under these circumstances, discussions were made with WASA on which disposal stations would be most effective for capacity strengthening of the sewer and drainage system in Faisalabad. Consequently, under a limited budget, to attain the most efficient use of investments, the following 4 disposal stations were finally decided as the targets for rehabilitation in this project.

- No. 1 PS-3 Chokera
- No. 3 PS-31 Satiana Road
- No. 4 PS-36 Ahmad Nagar
- No. 7 PS-30 Bawa Chak

Presently in Faisalabad, to cope with the increase in amount of sewage due to population growth as well as future increase in wastewater from commercial and industrial areas due to economic and social activities, extension works on sewer mains and branch lines are rapidly being promoted. Actions to tackle this situation are the urgent issues for the 4 disposal stations targeted in this project as explained below.

1) PS-3 Chokera

This disposal station, located adjacent to Paharang Drain along the western edge of the city, receives sewage from the city's western side through the existing Western Domestic Trunk Sewer. When the 1,800mm diameter Sir Wala Distributary line, which commenced works in 2009 and presently under construction, is completed, since inflow into the disposal station will increase, expansion of the pumping capacity accordingly is required. Out of the 6 existing pumps, 2 are broken.

2) PS-31 Satiana Road

This disposal station handles a portion of the sewage from the southern part of the city which includes large industrial areas and densely populated areas such as People's Colony. Sewage from this disposal station flows through Satiana Road Sullage Drain and drains out into Madhuana Drain, the main terminal drain in the eastern side of the city. Upon completion of the sewer trunk main from People's Colony which is under construction and branch lines being expanded in the covered area, inflow into this disposal station is expected to increase by 2011, and therefore, the pump capacity needs to be increased. Out of the 4 existing pumps, 1 which has lapsed 12 years since time of installation is broken and the other 3 are functioning, but 2 of them which have operated 22 years are deteriorated and require replacement.

3) PS-36 Ahmad Nagar

Similar to PS-31 above, this station covers the southern part of the city. From this disposal station, sewage flows through Channel No. 4 and drains into Madhuana Drain. In addition to the inflow from the existing sewer trunk main, Sammanabad, the presently under construction sewer main of 1,350mm diameter from D-Type disposal station, which is scheduled to be completed in 2011, will increase the flow rate. Out of the 5 existing pumps, 1 has elapsed 29 years from the time of installation and is heavily deteriorated.

4) PS-30 Bawa Chak

This disposal station is located in the city's northern part and covers the north-western areas. Sewage from Nishatabad industrial area flowing through Western Industrial sewer main is directly drained out into Paharang Drain, the western terminal drain. Although new sewer trunk mains to flow into this disposal station are not being planned, since sewer branch lines will be expanded by 2011 to cope with the population growth and increase in industrial wastewater in the covered area, increasing the pump capacity becomes necessary.

2-1-2 Present State and Issues on Sewer/Channel Cleaning Equipment

To improve and maintain flow capacities of sewers and channels, pump capacities need to be strengthened, and to cope with torrential rains during the rainy season, the number of permanently installed standby pumps needs to be increased. However, if sewers and channels do not have capacity to receive increased amounts of sewage, then overflow will increase. Therefore, strengthening the capacities of sewers and channels is also important along with strengthening of disposal station capacities.

The geography of Faisalabad city is generally flat. Since ground level differences in the city are limited, gradients of sewers and channels for natural flow are mild. Therefore, gravity flow capacity is greatly influenced by permissible capacity of sewers/channels as well as internal gradient and frictional resistance. Solid wastes and deposits thrown into channels are causing blockages to severely lower the functioning of disposal stations. On the other hand, deposits and solid wastes accumulated inside sewers and channels can block the passage to prevent gravity flow and allow overflow to cause flooding and inundations. Consequently, improvements and strengthening of cleaning works to recover the natural flow along with desludging of channels and cleaning of sewers are urgently needed. Also, strengthening of the organization to effectively manage the sewerage system is required. Furthermore, since deterioration and shortage of existing cleaning equipment as shown in Table 2-3 are the issues, procurement of new equipment is essential.

Review of cleaning equipment owned by WASA is shown in Table 2-2. Since most of the equipment have past their service life and are deteriorated, they need to be replaced.

One method of measuring deterioration is life of the equipment. In a sewerage system, deterioration can be caused by mechanical aspects such as rotation, vibration and repetitive loads; electrical aspects such as insulation deteriorations and contact failures; and environmental aspects such as corrosive gases, sand/dust adhesion, moisture and ultraviolet rays. Also, service life can greatly influence the maintenance conditions of equipment. Generally, if the equipment is kept indoors, spare parts and consumables are sufficiently stocked, and replacements with specialized tools are repeatedly practiced, unless core parts such as engines or motors are not broken, the equipment can last more than the service life. Also, preparing standby equipment is a countermeasure against deterioration. Deterioration of individual equipment will progress, but consideration in terms of the system as a whole, by operating standby equipment, the system function can be maintained. Keeping a spare is important from the viewpoint of continuity. Some deteriorated equipment can still be used, but since the length of use cannot be objectively calculated, as an evaluation standard, the “Sewerage Design and Cost Estimate Guideline” of the Japan Sewerage Association will be referred to determined the possibilities for continued use upon consideration of the actual operation conditions.

Table 2-3 List of WASA Owned Cleaning Equipment and Service Life (as of November 2010)

No.	Equipment	Managed by	Zone	Q’ty	Specification	Procured	Year	Life*	Condition
1)	Jet Machine	People's Colony	East	1	6,500 lit	Sweden	1991	9.5	Deteriorated
		People's Colony	East	1	7,000 lit	Pakistan	2003	9.5	Operating
		Allama Iqbal Colony	East	1	6,800 lit	Hino	1994	9.5	Deteriorated
		Madina Town	East	1	5,682 lit	Perkins	1984	9.5	Deteriorated
		Ghulam Muhammad Abad	West	1	4,500 lit	Isuzu	1996	9.5	Deteriorated
		Gulberg	West	1	6,500 lit	Samsung	1986	9.5	Deteriorated
		Civil Line	West	1	5,400 lit	IVECO	1995	9.5	Deteriorated
2)	Suction Machine	People's Colony	East	1		Nissan	2005	11.0	Operating
		Civil Line	West	1	7,000 CC 6 cylinder	PMC	2000	11.0	Broken
		Civil Line	West	1	6,000 lit	Hino	2007	11.0	Operating
3)	Backhoe	Ghulam Muhammad Abad	West	1	10 ton (148 HP)	Daewoo	2003	9.0	Operating
4)	Bucket Crane	Civil Line	West	1	25 ton	Sumitomo	1987	14.5	Deteriorated
		Civil Line	West	1	25 ton	Sumitomo	1987	14.5	Deteriorated
5)	Dump Truck	Civil Line	West	2	7,000 CC 6 cylinder	DAF	2000	11.0	1 Useable 1 Broken

6)	Dewatering Set	O&M East Directorate	East	37	1/2 cfs	27 Pakistan 10 China	1981: 7 2000: 20 2009: 10	13.0	30 Operating 7 Broken
		O&M West Directorate	West	33	1/2 cfs	China	1995: 6 2000: 12 2009: 15	13.0	23 Operating 10 Broken
7)	Tractor/Trolley	O&M Water	West	1	75 HP	Millat 375	1998	－	Deteriorated
8)	Station Wagon	WASA HQ	West	6	800 cc	Suzuki Pak.	1987-90	8.5	Deteriorated
9)	Pick-up Truck	WASA HQ	West	4	800 cc	Suzuki Pak.	1990-92	8.5	Deteriorated
				2	800 cc	Suzuki Pak.	2004	8.5	Useable
		O&M Directorate	West	1	3500 cc	Mazda	1990	9.5	Deteriorated
10)	Safety Equipment	O&M Sewerage	W/E	17	Gas mask	France	2008-10	－	Useable
11)	Computer/ Software	WASA HQ	West	10	P-III	HP	1998-2002	－	Not used
				25	P-IV Laptop	HP	2003-10	－	Useable
12)	Communication	O&M Water	West	40		Japan	2009	－	Using
13)	Garage/Workshop	Gulistan Colony (Civil Line)	West	1	Vehicle workshop		Constructed 1980	－	Deteriorated

*Service life from Construction Machinery Rental Fee Table and Japanese Sewerage Association document (Design and Cost Estimate Guide for Sewer Wroks)

Source: Prepared by the study team using WASA data (2010)

2-1-3 Position of this Project

The request is composed of cleaning equipment for sewers/channels and pumping equipment for disposal stations. Since appropriate donor support for the master plan cannot be received, budget is deficit and progress according to plan cannot be seen. However, the aim for the sewerage and drainage goal of WASA Faisalabad is being followed along the 1993 master plan. Although projects are delayed, budgets of Punjab Province and WASA are being funded to lay sewer lines from inside the city to outer drains and construct disposal stations.

On the other hand, phase 1 of the original master plan started in 1985 and was completed in 2000, but over 10 years have lapsed. Therefore, deterioration of the existing disposal stations is progressing and many facilities are broken or have high possibilities to break down. This is the reason that the present mechanism cannot be maintained.

Furthermore, during the long years, sludge and solid wastes have accumulated inside sewers and channels installed in master plan phase 1 and equipment necessary for desludging and cleaning are also deteriorated to degrade the operation and maintenance mechanism. Consequently, backflow due to sewer blockage and flooding due to channel overflowing frequently occur. During the rainy season, storm water enters sewers and channels to increase damages due to flooding and inundations. Based on the current situation, results of the field survey are summarized below.

1) The basic concept of the master plan for transferring sewage and wastewater from the central part of Faisalabad to drains located at the outskirts of the city hass not changed.

Also, WASA has started laying works on replacing original channels with large diameter (54 to 72 inch pipes) sewer lines.

2) Some disposal stations located in the city center will be abandoned after the above mentioned new sewer lines start to function. On the other hand, plans for new disposal stations in growing population areas are being made to match improvements in the sewerage system, which follows the master plan concept, along with the urban development.
3) In order to transfer all sewage and wastewater to the drains following the basic concept of WASA, roles of disposal stations located at the outer perimeter of the city are becoming more important.
4) Disposal stations at city outskirts are essential for the sewerage system of Faisalabad. However, pumps are breaking down and capacities are becoming insufficient to necessitate improvements, but this is not included in the master plan concept. Even if new sewer line installation works are completed, as long as disposals stations of city outskirts do not function properly, the plan will be ineffective to cause chaos in the entire sewerage system.
5) In the existing open and covered (covered with concrete slabs) channels, solid waste is thrown in, sand is sedimented and sludge is accumulated in many parts of the city to prevent flow inside the channels. Improvement of this situation is also urgently needed and is an important issue to assure the original functioning of sewers, but the master plan is centered on hard aspects of new construction works with neglection of soft aspects on improvement of present conditions and management.
6) Also for sewers, accumulation of waste, sand and sludge is alarming and sewer blockages are frequent. If sewage and wastewater cannot flow inside sewers, the sewerage system does not function and improvement of the sewer blockage problem is presently the most important issue of WASA. This issue is not considered in the updated 1993 master plan and present plans are centered on new installation of sewers with no plans for solving this problem.
7) Mechanical cleaning and desludging activities are effective to resolve issues of 5) and 6) above. Work organization, work personnel, working area allocation, equipment allocation and other organizational framework are prepared, but many of the existing equipment are broken and do not operate. Also, they are old and cannot function sufficiently; and many equipment are not suitable for narrow roads or areas where electric wires are hanging low. This situation cannot cope with emergency situations.
8) Reinforcement of pumps of principal disposal stations where pumping capacities will become insufficient and strengthening of cleaning equipment to assure proper flow in existing sewers and channels are important to supplement the concepts and functions of

the updated master plan. However, presently, remedial measures are not taken and so, support is required.

9) To relieve damages from recent year flooding and inundations in Faisalabad, renewal of the above mentioned equipment for cleaning and desludging of sewers and channels and reinforcement of disposal stations in the city outskirts can upgrade the sewerage system mechanism of Faisalabad city. To solve these problems, support is urgently needed.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

This project does not involve planning on construction or rehabilitation of the sewerage system. Such basic plan was formulated through the master plan for WASA Faisalabad. This project aims to clear flooding or reduce flooding areas as an urgent measure through equipment plan and facilities design in consideration of the following.

1) **Necessity for reinforcement of disposal stations:** From results of survey on present conditions including deterioration state of existing facilities, pump capacity deficiency and handling of power failures, effective measures and necessary equipment will be proposed.

2) **Necessity for improvement and assurance of flow capacity in sewers and channels:** Even if capacity of pumps is increased and standby pumps for emergency during torrential rains are added, if sewers and channels do not have enough capacity to receive the increased flow, then channels will overflow to increase the risk of flooding. Although the annual precipitation rate of Faisalabad is low, storm water concentrates during the rainy season. Also, since original flow capacities of sewers and channels are not maintained, surrounding areas become inundated. Complete removal of inundations caused by sewage and wastewater generated throughout the year is the important issue.

Concerning the inundation problem due to storm water, since low lying agricultural lands function as storm water balancing tanks, this can delay drainage flow into disposal stations as an effective measure for storm water management. Also, when low lying areas become inundated, by using dewatering sets and other equipment, inundations can be recovered after a few hours to about 1 day, except for some areas. Therefore, to solve problems of inundations, securing the original capacities and prioritized strengthening of sewers, channels and disposal stations are considered to be effective, although symptomatic.

(2) Policy on Natural Environment Conditions

Faisalabad city is formed on flat geography of alluvial and diluvial sandstones. Drainage channels constructed on this flat geography are gradually sloped to create slow sewage flow. Therefore, sands inside channels easily subside and solid waste thrown in are not swept away but accumulate.

Also, Faisalabad is rapidly urbanizing as to follow Lahore, capital of Punjab Province, where main roads are paved and houses of concrete or bricks can be found widely throughout the city. Farmlands having good water retension and livestock grazing areas are decreasing to increase the outflow of storm water along the ground surface.

The annual precipitation rate of Faisalabad between 1995 and 2009 is on average about 376mm. Annual number of rainy days is about 40 days, of which the number of days with daily precipitation rates over 10mm is about 10 days. From past data, Faisalabad city shows a dry climate with 350 days out of the year being fine days. Upon analyzing data from the agricultural university for 6 years (2005 to 2020) of precipitation rates in the city obtained from WASA, the maximum daily precipitation rate is calculated as 92mm/day[1] using the once in 5 years probability calculation method which is generally used in Japan. Assuming WASA's area of responsibility is about 15km in 4 directions for an area of about 225km^2, the total precipitation rate during this period is about 240m^3/sec. However, since this area has a dry climate, hydrologically and from a water balance point of view, 3/4 of this amount evaporates and infiltrates into the ground, and therefore, the remaining 1/4 of about 60m^3/sec is the flow rate of storm water flowing into channels and low lying areas.

Upon inquiries in the field on inundation situation of low lying areas by storm water, time for clearing of water is normally about 3 to 4 hours, but on 13th of July 2010 when heavy rain occurred, it took about 5 to 6 hours and at low lying areas where water concentrates from surrounding areas, the time for clearing was 12 to 24 hours. Therefore, as measures for reducing inundation in Faisalabad, since the geography is flat with a mild gradient, assurance of flow routes for sewage along with improvement of flow capacity are essential.

Precipitation in Faisalabad is normally low even in the rainy season, but in recent years, from effects of climate change, the trend shows increase in precipitation. Also, from annual maximum precipitation, 5 year probability precipitation rate of 92mm/day and precipitation frequency, the precipitation rate is very low. However, from reports on past inundation

1 Since precipitation data to calculate 5 years probability from 6 years' data is too few, and other appropriate data for precipitation are not available, this value is used.

damages, even for flat topography of sand layer such as Faisalabad, if rain concentrates within a short time, inundation can occur in certain areas. Therefore, if measures are to be considered, using topographic maps and precipitation contours of Faisalabad, low lying areas where rain concentrates to cause inundations need to be located and considerations are needed to strengthen the pumping capacities of disposal stations near those areas (hardware measures). At the same time, software measures such as timely inundation warnings and announcements to residents using precipitation data and past inundation damage information; allocation of dewatering pump sets and other inundation measures; and prioritizing of routine sewer and channel cleaning to urgent areas will be considered for Output 2 of the soft component program..

As a measure for strengthening of disposal stations, actual identification of rainfall patterns, flow of storm water along the surface, and extent of storm water puddling is difficult. Also, in consideration of changes in natural environment and future climate changes, determination of required scale and capacity of disposal stations as measures for flooding is difficult. Since disposal stations along the city outskirts, which are responsible for pumping out storm water combined with sewer into drains, have capacities for removing storm water, from the viewpoints of effective use of limited resources and strengthening of the total sewerage system of Faisalabad, investment to the 6 principal disposal stations is considered to be most effective.

(3) Policy on Disposal Stations

From results of survey on present conditions of the 35 disposal stations of WASA, necessary improvement measures for effective facilities operation were considered as follows.

1) Since deteriorated equipment can hinder actions to be taken in emergency situations, replacement with new equipment is essential. Upon reviewing the existing types of equipment, electrical machineries, operating conditions, use objectives, equipment characteristics and difficulties in operation and maintenance, considerations were made on which equipment need to be replaced and what alternatives are available.
2) Upon determining geographical conditions, operation frequencies, population density distributions and WASA's sewerage system vision, disposal stations to be strengthened were specified. These disposal stations have important functions to remove storm waters which concentrate during a short period in the rainy season although the target area is a dry area with low precipitation rate.
3) WASA is improving and strengthening their sewerage system. Upon sufficiently

comprehending this action, while confirming the effectiveness of disposal station improvements, directions for strengthening were planned.

4) The characteristics of presently functioning disposal stations are different in terms of their features and locations. Although types of existing equipment are varied, combinations with existing equipment were considered and while making best use of effective parts of existing facilities, optimum replacement equipment were selected.
5) When considering the power source for pumps, the power supply situation of Faisalabad city was considered. As a countermeasure against power failures, since black outs are occurring throughout the year, operators have emphasized the importance on the high necessity of diesel engine generators for emergency operations.

(4) Policy on Procurement Conditions

This project is for procurement of equipment. The procurement will be made through a general open tendering process involving Japanese trading firms or manufacturers. A condition of companies participating in the tender is to assure an after-sales service network. The procurement is composed of (1) equipment which are relatively easy to handover such as vehicles and heavy machinery, and (2) equipment requiring installation works and test run/initial operation guidance such as pumps and generators. Therefore, considerations will be made to divide the tender into lots for rational implementation.

Procurement of equipment from Japan, Pakistan and third countries will be considered. However, availabilities of local after-sales services of the manufacturers will need to be confirmed. Third country procurement can be considered from European countries, the United States of America or Asian countries. However, not only cost and quality, but also appropriateness from the viewpoint of the user will be evaluated for an overall decision. This means that the conditions will be operational methods and operation and maintenance aspects which do not differ greatly from existing WASA owned equipment, and easily acceptable by local concerns.

(5) Policy on Operation and Maintenance

Since WASA is already using equipment similar to those being requested, their operation after implementation of this project would not present any problems. In relation to long-term, periodic cleaning operations of sewer facilities, formulation of appropriate work plans will be supported through the soft component program. Since servicing of equipment is being contracted out by WASA, the project will not elaborate the servicing system of

WASA, but procurement will be considered with emphasis on local, after-sales servicing.

(6) Policy on Equipment Quality Level

As for the sewerage system under WASA plan, sewer line underground laying works are being executed in several areas of the city, new disposal stations are now operational, and some construction works are planned to be commenced in 2012. As such, WASA is independently strengthening its system to promote sewerage improvements. However, pumps, appurtenant facilities and valves of existing disposal stations are becoming deteriorated. Large capacity pumps (25cfs) are relatively new, but medium capacity pumps (10cfs and 15cfs) are being operated for over 30 years. From survey of disposal stations, to improve efficiency of disposal stations, replacing deteriorated medium capacity pumps with those of 1 or 2 rank higher capacities were considered. The following 3 points are important matters for consideration.

1) To effectively continue sewage flow without interruption, pumps including accessories of principal disposal stations within the existing sewerage system which are broken down or deteriorated will be replaced to improve their capabilities. Also, generators in preparation for power failures will be reinforced.
2) Equipment appropriate to resolve blockages of sewers which are receiving complaints from residents will be procured.
3) Vehicles to transport procured equipment for rapid mobilization to the site requiring problem resolution will be procured.

Although improvement of equipment for effective functioning of WASA will be considered, the ability of WASA to effectively use the procured equipment through strengthening of their capacity, labor force and managerial structure is important. Therefore, an appropriate operation and maintenance plan will be proposed.

To determine the specifications of equipment, conformity with their use environment was considered. Since pumps must be able to handle sewage and factory wastewaters containing textiles and other wastes, considerations are needed in selecting the pump structure, and the impeller material must consider the water quality of inflowing sewage. For heavy vehicles, considering transport inside the city, a wheel type rather than the crawler type is preferred. Also, since working in inundated roads and off-road areas needs to be considered, vehicles of rigid structure with all-wheel drive and other working conditions were considered in deciding on the specifications.

(7) Policy on Related Regulations and Permit System

Laws and regulations related to demolition of existing structures of disposal stations and removal of pumps and generators, as well as new construction of sewage facilities are not set in Pakistan. Also, permits for these works are not needed. However, the removed materials and facilities must be deposited in the central storehouse of WASA Faisalabad.

(8) Policy on Procurement Schedule

Transportation of procured equipments includes internal transportation from Karachi port. In consideration of havoc in inland transportation due to last year's floods in Punjab Province and this year's floods in Sindh Province centered at Karachi, the schedule will avoid internal transportation during the rainy season. Also, even if transportation is completed before the rainy season, since flow rates into sewers, channels and wet wells during the rainy season will increase, stopping of existing disposal stations to carry out installation works under responsibility of the Pakistani side needs to be avoided. Therefore, sufficient coordination with the Pakistani side will be made to complete all installation works before the rainy season.

Since the timings for transportation and installation works depend on the period for contracting with the contractor on the Japanese side, the procurement schedule will be made flexible for consideration as to whether to complete the works before the rainy season or transport equipment internally after the rainy season.

2-2-2 Basic Plan（Equipment Plan）

(1) Overall Plan

The requested equipment can be divided into 2 categories as follows.

Table 2-4 Categorization of Requested Equipment

Category	Equipment	Use Purpose
Cleaning Equipment	Jet Machine Suction Machine Backhoe, Bucket Crane Dump Truck Crane Cargo Truck Pick-up Truck Dewatering Set	Sewer cleaning Sewer cleaning, inundation clearing, wet well cleaning Channel cleaning Deposits transportation Equipment and staff transportation Equipment and staff transportation Inundation clearing
Disposal Station Equipment	Pump Generator	Sewage pumping Emergency power

In the request list of WASA, station wagons, safety equipment, computer/software, communication equipment, garage/workshop, and monitoring/evaluation system were also included. However, since these are low priority for WASA, agreement was made that the Pakistani side will procure these under their own responsibility whenever the need arises.

(2) Equipment Plan

The contents of the request as confirmed through the field survey are as shown in the table below. Option 1 is the priority of WASA and in case difficulties arise, option 2 was proposed upon discussions with the study team. Furthermore, priority rankings were given for each equipment.

Table 2-5 List of Requested Equipment

No.	Equipment	Specifications	Quantity*[1]		Priority
			Option 1	Option 2	
1	Jet machine	Similar to existing	12	8	High
2	Suction machine	Similar to existing	2	2	High
3	Backhoe	Medium size Small size	1 1	1 1	High
4	Bucket crane (Clam shell)	Medium size Small size	2 2	2 2	High
5	Dump truck	Similar to existing	6	6	High
6	Crane truck	Transport dewatering sets and other equip	6	2	Medium
7	Pick-up truck	Double cabin	6	4	Medium
8	Dewatering set	1 cfs (Diesel)	25	13	Medium*[2]
		2 cfs (Diesel)	16	4	
		2 cfs (Electric)	6	4	
9	Pumps for disposal stations	2 cfs	3	0	Low
		4 cfs	14	0	Low
		6 cfs	3	0	Low
		10 cfs	5	2	Medium
		15 cfs	4	2	High
		25 cfs	12	10	High
10	Generator for disposal stations	50 kVA	1	0	Low
		75 kVA	2	0	Low
		210 kVA	2	0	Low
		300 kVA	1	1	Medium
		500 kVA	4	2	Medium

*[1] Options 1 and 2 were provided in consideration of budget constraints.
*[2] Pakistani side proposed "Low", but judged to be "Medium" according to the technical review
Source: Prepared by the study team according to Technical Note (2010)

The sewerage facilities targeted for cleaning equipment are sewers and channels with objectives to prevent and restore damages from inundations. When sewers are blocked, sewage overflows to inundate the surrounding area. Residents of the inundated areas submit complaints to WASA and in response; WASA dispatches personnel and equipment to the sites to restore the situation. Other than handling these complaints, equipments are used for operation and maintenance works such as periodic cleaning of sewerage facilities, but since the number of complaints is so huge, handling of complaints is given priority. Concerning procurement of disposal station equipment, since many are deteriorated, they cannot handle the inflowing sewage which is a reason for overflows, and therefore, improvement of this situation is an objective. In combination with the procurement of cleaning equipment, procurement of disposal station equipment is an effective measure to reduce damages from inundations.

In view of this predicament, from results of confirmation on the contents of the request, results of examination on their feasibilities are shown below.

Table 2-6 Feasibility of Requested Equipment

No.	Equipment	Requested Main Specifications	Feasibility
1	Jet Machine	Tank capacity: 4m3 class	This equipment is being used to resolve inundations caused by sewer blockages. Replacement of outlived existing equipment and addition of deficit number are needed.
2	Suction Machine	Tank capacity: 4m3 class	This is being used for emergency handling of inundations due to overflow and backflow of sewage, but will also be used for cleaning of sewers and wet wells. However, since the present number is in shortage, additional procurement is required.
3	Backhoe Medium capacity	Wheel type	This equipment is being used to resolve problems of sludge and solid wastes accumulating inside channels in the city which prevent flow of sewage and wastewater. Also, since some portions of channels are located along narrow roads, small sized equipment is necessary. Therefore, medium and small capacity equipments are appropriate.
4	Backhoe Small capacity	Weight 2.5t or less	
5	Bucket Crane (Clam Shell)	Medium and small capacities	This equipment is necessary for desilting wet wells of disposal stations and for cleaning channels in response to complaints. Since these need to be used in areas where access is narrow, medium size as well as small size machines are necessary.
6	Dump Truck	Payload: 4t class	This is needed to transport sludge and wastes cleaned out from channels to landfill sites, but the number of trucks is in shortage. Therefore, additional equipments are necessary and in consideration of the use environment, similar specifications are needed.
7	Crane Cargo Truck	Payload: 2.5t class Lifting capacity: over 2.2t	This is needed to transport small capacity backhoes and dewatering sets to the work sites. In consideration of maneuverability, this was changed from the originally requested tractor and trolley.
8	Pick-up Truck	4×4, double cabin	This is needed to transport equipment and personnel to the sites in cases of inundations and other emergencies.
9	Dewatering Set	1 and 2 cfs	This is being used to handle inundations caused by storm waters and sewage overflow. In consideration of present conditions and portability, specifications similar to existing sets need to be considered.
10	Pump for Disposal Station	2 - 25 cfs	Pumping capacities of existing disposal stations are degrading due to deterioration of equipment as well as increase in sewage flow rates resulting from increase in population. As countermeasure to this situation, replacement of broken and outlived pumps, and reinforcement to cope with increased rate of sewage are needed. Specifications and quantities are determined for each disposal station.
11	Generator for Disposal Station	50 - 500 kVA	Diesel generators are needed as emergency power sources to operate disposal stations during power failures. Replacements of outlived existing generators, as well as reinforcements of capacity shortages and stations without standby power are needed. Specifications and quantities are determined for each disposal station.

Source: Prepared by the study team according to Technical Note (2010)

Based on the above, the equipment procurement plan was formulated along the following basic policies.

- To clear out blockage of sewers, jet machines will be used. The spray nozzle of the jet machine is inserted from a manhole just before the blocked portion of the sewer and the blocked material is jetted out to assure flow inside the sewer.
- To clean out wastes accumulated in channels, excavators such as backhoes or suction machine will be used for desludging and dump trucks will be used for transporting the removed waste. Since excavators are available in various sizes, the required sizes were determined from the conditions of the working areas of channels to be cleaned. For suction machines, their basic function is to suck out sludge generated from the cleaning operation of jet machines, but will also be used for cleaning wet wells and emergency clearing of inundations.
- For clearing away inundated areas, portable dewatering sets or suction machines will be used. For power, in consideration of instability of commercial power, diesel engine drive is proposed.
- Although existing equipments are deteriorated, those which can be used are included in the necessary quantity. This can suppress the quantity of newly procured equipment to avoid overlapping with existing equipment.
- Including excavators and transport vehicles, quantities of vehicles and machinery are determined from units of 2 directorate offices in West and East as well as 6 sub-divisions.
- Concerning quantities of equipment, the minimum required number will be assured to solve problems of daily damages and complaint treatment to reduce inundation damages in the city which is the project objective.
- Concerning basic cleaning operations, the present WASA activities are not systematically managed and the responsibilities of the 2 directorates and 6 sub-divisions are centered on residents' complaint treatments. Therefore, for assurance of stabilized living of residents and stable socio-economic activities in Faisalabad, importance of daily cleaning operations will be guided and formation of a new organization will be supported.

Considerations on necessary quantities and procurement plan for cleaning and disposal station equipment are as follows.

1) Plan for Cleaning Equipment

① Jet Machine and ② Suction Machine

Within the total length of 1,785km of WASA sewer lines, about 3.8% are large diameter pipes having diameters larger than 27inch which are indicated on the sewer network map. The total length of sewers of smaller than 21inch diameter which are not shown on the map is considered to be 96.2%. Pipe diameters larger than 27inch can be entered by personnel for cleaning, and therefore jet machines and suction machines are not necessary for these pipes. In consideration that, as the pipe diameter becomes smaller, the chances for blockages become higher, and so, the amount of sludge and wastes inside the pipes was estimated. However, in actuality, since sewage is flowing inside the pipes, the upper limit for becoming blocked will be set at 50%. The required number of sets of jet machines and suction machines if sewers are to be cleaned in 5 year cycles is shown below.

Table 2-7 Quantity of Equipment Necessary for Sewer Cleaning

Total sewer length (km)	A	1,785
Total length of pipes less than 27 in (km)	B	1,716.8
Daily amount of deposits possible to be cleaned by 1 equipment set (m^3/day) (from Japan Sewerage Facilities Operation and Maintenance Cost Estimate Handbook, 2009)	C	1.2 to 4.5, depending on pipe diameter
Annual operation days (days)	D	250
Total amount of deposits inside pipes (m^3) Refer to Annex-4, Table 3	E	44,582
Required cleaning days for 1 equipment set (days) Refer to Annex-4, Table 3	F	10,803
Quantity of equipment required for cleaning in 5 year cycles (sets)	G=F/(Dx5)	8.6→9

Source: Analyzed and prepared by study team using WASA data (2011)

For the method of calculating the operation days of cleaning, refer to the annex.
Since WASA is presently not adopting the original method of using the jet machine and suction machine in pairs, these will be considered separately.

Jet Machine

For jet machines, if the existing 7 machines are to be continuously used, from the above calculation, 63 new machines need to be procured. However, since operation of this number of machines with the present WASA organization is considered to be difficult, the present WASA usage of handling emergencies of sewer blockages, rather than routine cleaning operations, will be the main presumption. Therefore, from WASA records of sewer blockages, the quantity required for mobilization when blockages occur was determined.

Emergency handling of sewer blockages is necessary to treat reports from residents complaining about flooding and inundations. Complaints are frequently reported on a daily basis and not limited to the rainy season, and therefore, the number of equipment to solve this problem needs to be determined. On the other hand, the existing equipment will be evaluated, and the number of continuously usable equipment will be deducted from the total required number. As to the decision on whether the existing 7 jet machines can be used or not, although deterioration is progressing, they are well maintained, and therefore, all 7 can be used.

From records of WASA staffs, the average working period of jet machines is 2 hours, and if preparation, mobilization and demobilization are included, the full operation requirement time is considered to be 4.5 hours for one machine. On the other hand, within the workers' 24 hours shift system, although emergency dispatches are necessary even during midnight, the daily equipment working hours is about 12 hours. Therefore, as shown in the table below, since the total required quantity of jet machines is 15, this minus 7 existing machines results in 8 jet machines which need to be procured.

Table 2-8 Required Quantity of Jet Machines

Parameter	July 2008 to June 2009	July 2009 to June 2010
Sewer blockages/year	14,175	14,726
Sewer blockages/day	38.8	40.3
Operation time/jet machine* (hr)	4.5	4.5
Operation frequency/day/machine (working hours: 12 hours)	2.7	2.7
Total required No. of jet machines	14.4→15	14.9→15

*Average operation time = Mobilization + jetting operation + demobilization + loss time
= 1.0 + 2.0 + 1.0 + 0.5 = 4.5hr

Source: Analyzed by study team using WASA and World Bank data (2011)

The requested tank capacity of the jet machine is $4m^3$. The jetting capacity of the pump for jet machines of this class is 200 to 250 lit/min and for operation at maximum capacity, operation time is 16 to 20 hours. Assuming that jetting operation is continued for 2 hours with a pump capacity of 200 lit/min, then a tank capacity of about 3 times or $12m^3$ is needed. However, from past records, maximum capacity is $10m^3$ and in this case, the chassis would be of 25t class which is unsuitable from the viewpoint of maneuverability to clean sewers inside the city. Consequently, water tankers of 4 m^3 to $6m^3$ are usually used. In actuality, during the 2 hours operation time, the pump is normally not operated continuously at full capacity. At the work site, activities such as preparation, confirmation and removal of wastes are needed and so, according to WASA, the actual pump operation time is less than 30 minutes for each work. Therefore, the tank capacity of $4m^3$ class and a pump capacity of 200 lit/min is proposed.

Suction Machine

Presently, WASA is using the suction machine to suck up unsanitary sewage overflown due to sewer blockages, and then draining the collected sewage into sewers and channels. Therefore, since using the jet machine and suction machine to mutually support each other, as an example of usage in Japan, is not the main purpose, a large number is not needed for this project. WASA possesses 3 suction machines, of which 1 is broken and 2 are functioning. To handle such situation, 2 machines are not sufficient and if 1 of these requires maintenance work, then operation will be affected. Also, in consideration that these will become deteriorated and eventually break down, procurement of at least 2 more suction machines are needed as substitute equipment. With procurement of new equipment, operational machines will increase for possibilities of handling blockage of sewers, clearing damages caused by inundations and cleaning wet wells of disposal stations.

Therefore, originally, the quantity of suction machines equivalent to jet machines is necessary, but the number needed to handle the present situation will be determined. From inquiries to WASA, about once in 4 times the jet machines are dispatched, the support of suction machines is required because sludge and wastes cannot be completely washed away. From this situation, we can assume that suction machines need to be dispatched for about 25% of complaints. Therefore, with 2 new procurements, a total of 4 machines are necessary.

Table 2-9 Required Quantity of Suction Machines

Parameter	July 2009 to June 2010
Sewer blockages/day	40.3
Required no. of dispatches by suction machines（about 25%）	10.1
Operation time/suction machine* (hr)	4.0
Operation frequency/day/machine (working hours: 12 hours)	3.0
Total required No. of suction machines	3.4→4

* Average operation time = Mobilization + jetting operation + demobilization + loss time
= 1.0 + 1.5 + 1.0 + 0.5 =4.0hr

Source: Analyzed by study team using WASA and World Bank data (2011)

Sewer Cleaning by Jet Machines and Suction Machines

In Table 2-10, one each of jet machine and suction machine were considered as one set, and the required quantity to clean the sewers in 1 year cycles was calculated. Here, with the planned equipment, the number of years required to completely clean the sewers under responsibility of WASA is calculated. From previous results, the quantities of jet machines and suction machines under this project are shown below. If these are to be used in pairs, then 4 crews are possible for sewer cleaning. Using the conditions shown in Table 2-10, one crew requires a total of 10,803 cleaning days, and for 4 crews, the sewers can be cleaned in cycles of 2,701 days or 10.8 years.

Table 2-10 Number of Sewer Cleaning Crews and Required Cleaning Years

Equipment	Required Q'ty	Existing	Newly Procured	Possible No. of Sewer Cleaning Crews
Jet Machine	15	7	8	4
Suction Machine	4	2	2	
Required cleaning days for 1 set (days)				10,803
Possible cleaning days with 4 sets (days)				2,701
Annual operation days (days)				250
Required cleaning years with 4 crews (years)				10.8

③ Backhoe and ④ Bucket Crane (Clam Shell)

WASA's 7 main drainage channels and 28 disposal station wet wells (out of 35 disposal stations, 7 are abandoned or scheduled to be abandoned) which are targets for cleaning are explained below. Within WASA's jurisdiction, a total 62.2km of channels are existent and within those, the main channels span 46.5km. Since deposits of sand and wastes inside these 7 channels are given as reasons for inundation damages, all 7 channels will be targets for cleaning. Also, various sizes of wet wells are installed at 35 disposal stations, but of these, 28 are functioning, and therefore, wet wells of these 28 stations will be targeted for cleaning. Although diameters and depths of circular wet wells of disposal stations are various, a deposit thickness of about 1m at the wet well bottom will be considered as target for removal.

Table 2-11 Target Facilities for Cleaning

Main Channel		Length (m)	Width (m)	Depth (m)	Max. Deposit Thickness (m)	Deposit Volume (m^3)
1	Channel #1F	8,747	1.8	1.7	0.8	12,596
2	Channel #1G	2,550	3.0	1.9	1.4	10,710
3	Channel #1	9,813	4.8	1.8	1.2	56,523
4	Channel #2	4,173	1.8	0.9	0.6	4,507
5	Channel #3	5,273	3.3	2.0	1.1	19,141
6	Channel #4	12,599	3.6	2.1	1.1	49,892
7	Sullage Drain	3,360	3.9	2.4	1.1	14,414
	Total	46,515				167,783
	Maximum		4.8	2.4		
	Minimum		1.8	0.9		
			Diameter (m)	Depth (m)	Deposit Thickness (m)	Deposit Volume (m^3)
8	Wet Well		Max: 10 Ave: about 5	Max: less than 12	about 1	$20m^3 \times 1m \times 28$ =560

From the above information which was provided by WASA, since the deposit thicknesses are more than 50% of the channel depths, if volumes are calculated by assuming that all of the deposits are sludge, silt and wastes, then the amount will be enormous. Therefore, since the deposit thicknesses shown in the table were probably measured at locations where wastes are likely to deposit such as at places having siphon effects, the values are not averages along all channels, and most of the deposits are presumed to be solid wastes. Using examples of sewers in Japan, the moisture content of sludge is 99% and that for sludge before drying is 97%. Consequently, to assume that the calculated deposit volume is the amount to be cleaned out is unrealistic.

On the other hand, no sludge deposit is unthinkable, but since most of it is moisture, due to the mixing effect during the desludging process, sludge is thought to flow downstream. Actually, upon observing the work operations for clearing sewer blockages, jet machines remove solid wastes, but sludge is washed down. Therefore, sludge flowing down from channels and sewers accumulate into wet wells at disposal stations, and the main deposits in wet wells are sludges.

From this situation, deposits to be removed are considered separately between a) channels and b) wet wells as follows.

a) Channel

Channels flowing in the city have many siphon points at locations crossing roads and also, some portions are narrow. Therefore, deposit depths shown in Table 2-11 are assumed to be those for areas where deposits are accumulated, and from aerial photos, these areas are 20% of the total length. Also, solids removable within the deposits are assumed as 50% (including the volume lost when removed in consideration that these are submerged in water).

Volume to be Removed = $167{,}783\text{m}^3 \times 0.2 \times 0.5 = 16{,}778\text{m}^3$

b) Wet Well

The volume of 560m^3 shown in Table 2-11 and volume of sludge flowing down from channels will be added together. Assuming that the sludge flowing down into wet wells is the remaining half of the deposits volume removed from channels which is mostly moisture, with reference to the moisture content of Japan's sewer previously mentioned, moisture content is considered to be 97% after the 99% moisture content sludge is desludged from wet wells. Under this assumption, the amount to be removed is calculated.

Volume to be Removed = $\{(167{,}783\text{m}^3 \times 0.2 \times ½)+560\} \times (100-99) \div (100-97) = 5{,}779\text{m}^3$

Presently Owned Backhoe

Presently Owned Bucket Crane
(Mechanical Rope Type Clam Shell)

For desilting and clearing of sludge, sand and wastes accumulated in channels, WASA is presently using a 10t class wheel type backhoe (above left photo) and a 25t class wheel type jib crane with rope type bucket crane (above right photo). The backhoe, procured in 2003, is relatively new, but since it is also being used for excavation and maintenance works of underground pipelines for sewerage as well as water supply (WASA is also in charge of water supply), the one machine owned by WASA is not enough to handle the workload. On the other hand, the 2 bucket cranes (clam shell), procured in 1987, are very old, but since these are effective for removing wastes from channels due to their structure suitable for dredging, these are being used in high frequencies. Therefore, the request from WASA for the bucket crane is given high priority, but presently, the wheel type lattice jib crane (mechanical rope type clam shell) is not being manufactured by any manufacturer and alternative equipment or measures need to be considered. Faisalabad city is a metropolis with about 2.7 million persons and most roads in urban areas are paved while behind the main streets, residential roads are narrow. As a result, maneuverability of excavators is demanded and using large scale vehicles is difficult. From this point of view, excavators of small and medium scale wheel type equipment to be used in accordance with the size of the working area around channels and wet wells were considered.

Figure 2-2 Channel Cleaning of Narrow Road

From the above Table 2-11, a medium size backhoe (bucket capacity of $0.2m^3$ class, maximum horizontal excavation depth of 4.5m, working radius of 4m) can handle the work for main channels. However, in the city, some channels are located along narrow roads where cleaning work is presently being carried out manually (as shown in the photo to the left) which is dangerous and unsanitary. Therefore, since mechanical work is desirable, a small capacity backhoe (bucket capacity of $0.08m^3$ class, maximum horizontal excavation depth of 2.4m, working radius of 1m) is appropriate for this situation.

On the other hand, at the disposal stations scattered around the city, the depths of wet wells are from 10 to 12m below the ground surface. Therefore, backhoes are not suitable and bucket cranes are necessary. The bucket cranes presently used by WASA are wheel type 12t lattice cranes and they have no problems in transport, but have difficulties in making small turns and they are deteriorated. Consequently, replacements are requested, but wheeled bucket cranes of both lattice jib type and telescopic type are presently not manufactured. Crawler type equipments meeting the requested specifications are available, but for transportation within Faisalabad city, large trailers are needed. From this situation, if a crane having high maneuverability and meeting the specifications are to be selected, a rough terrain crane would inevitably be selected. However, when manufacturers were questioned on the possibilities for using the clam shell bucket, they answered that technically it is possible, but since it is not commercialized as a standard product and there are problems with after-care services, even if it is adopted at the design stage, the possibilities for tenderers to not offer any bids are very high. Therefore, during the rainy season when flow rates are high (and urgency is high), the backhoe with options of clam shell and skeleton bucket can be used, while during the dry season when flow rates are low (and urgency is low), the suction machine and manpower can be used. As a result, procuring the clam shell and skeleton bucket as options for the backhoe is effective for cleaning channels.

Following the above concept, the number of equipment necessary to clean channels and wet wells under the responsibility of WASA in one-year (annually 250 working days) cycles will be calculated.

Deep wet wells will be handled by existing bucket cranes and sludges will be sucked up by suction machines (possible down to about 10m depths). Since the maximum dredging depth of backhoes is about 5m, these will be used for small wet wells.
For work capacities of excavators, since sludge softened under water of channels will be handled, the Japanese civil works cost estimation standards (Ministry of Land, Infrastructure, Transport and Tourism) for loose loading (work capacity of excavators) will be used.

Under these conditions, if daily work requirement (dredging) amount of channels and wet wells is divided by daily work capacity of excavators, the required number of excavators can be calculated.

$$\text{Required Number} = \frac{\text{Daily Work Requirement } (m^3/\text{day})}{\text{Daily Excavator Work Capacity } (m^3/\text{day/machine})}$$

Table 2-12　Required Quantity of Excavators according to Work Capacities

Cleaning Target	Volume to be Removed (m^3/250days)	Daily Workload (m^3)	
Channel	16,778	67	
Wet Well	5,779		23

Equipment		Work Capacity (m^3/day)	Required Quantity*
Existing	Backhoe: Struck cap. $0.6m^3 \times 1$	310	1
	Clam Shell: Struck cap. $0.8m^3 \times 2$	260	1
Planned	Medium Backhoe: Struck cap. $0.2m^3$	44	2
	Small Backhoe: Struck cap. $0.08m^3$	23	2

*For the case where each equipment is operated alone

According to the above table, without procuring new equipment, the existing excavators can remove the deposits within one year.　However, as mentioned previously, the existing equipment cannot work in narrow roads in the city.　Also, since the bucket cranes (clam shells) are deteriorated and presently no manufacturer is making similar type of equipment, these cannot be used for long periods.　Furthermore, WASA possesses only one existing backhoe and this is being used in full operation including work for the water supply department.

Therefore, for effective work in narrow roads and assure maneuverability within the city, one each of a small and medium capacity backhoes will be procured for each directorate in the East and West to equally divde the workload.

Table 2-13　Size and Quantity of Excavators to be procured

Use Target	Equipment	Bucket Capacity (m3)	Allocation	Quantity
Channels in City	Small Backhoe*1	$0.08m^3$ class	Directorate Drainage	2
Main Channels	Medium Backhoe*2	$0.2m^3$ class	Same as above	2
Wet Wells	Medium Backhoe＋Options*3		Use above backhoe	

*1:　In consideration of convenience in operation of both East and West directorates, a minimum of one for each is to be procured.　As option, skeleton bucket is to be procured to remove wastes from channels.
Since wheel type for the small capacity backhoe is not available, the 4t crane cargo truck to be procured separately can be used as a means for transportation (in consideration of the weight limit due to the payload, the standard bucket capacity is to be less than $0.1m^3$).

*2:　In consideration of convenience in operation of both East and West directorates, one for each is to be procured.
For maneuverability, the wheel type is proposed.
To remove wastes from channels, the skeleton bucket is equipped as option, and to remove sludges and silt under water, the clam shell is equipped as option (refer to *3).

*3:　The request is for 4 quantities of equipment, but in consideration of cost saving, one each of small and medium backhoes according to their use purposes will be allocated to both directorates, and medium backhoes will be equipped with clam shell and skeleton buckets and small backhoes will be equipped with only skeleton buckets as options.

⑤ Dump Truck

For transporting wastes removed by the existing clam shells and backhoe, WASA presently possesses 2 dump trucks of 4t load capacity procured in 2000, but both of them are now broken. Normally, one transport vehicle should be allotted for each cleaning equipment, but since the absolute quantity is lacking, sludge and wastes removed from channels are left beside the channels. Therefore, since transport of dredged deposits to the final disposal sites (landfill sites) is the responsibility of WASA, the number to be procured should basically match the number of existing equipment as well as excavators to be newly procured.

The required number of transport vehicles will be calculated from a) rated payload, b) transport distance from waste generation point to waste disposal site (landfill) and waste generation rate.

a) Rated Payload of Transport Vehicle

Load capacities vary from 0.35t to extremely large sizes, and in consideration of roundtrips to the landfill site, larger capacities are favorable, but from circumstances of use in combination with excavators, the size needs to consider use at the working areas of excavators inside the city. On the other hand, if specific sizes of transport vehicles are allocated for each type of excavator, then difficulties in maneuverability will arise. Therefore, a uniform size is desirable and the general medium class size (payload 2t to 4t class) was selected.

Table 2-14 Vehicle Size and Turning Radius of Medium Class Dump Trucks

Parameter	Payload 2t	Payload 4t
Total Length (mm)	About 4,700	About 5,400
Total Width (mm)	About 1,700	About 2,200
Turning Radius (mm)	About 5,100	About 4,800
Turning Angle (°)	90	
Minimum Road Width (mm)	About 3,300	About 3,800

As can be seen from the above table, the minimum road width required when making a 90° turn for the 4t capacity is about 50cm wider corresponding to the difference in vehicle width. However, this is the minimum required width of the entrance or exit when making left or right turns. That is, this is smaller than the 4m minimum width required for ordinary passenger vehicles to traverse each other. Therefore, even for areas such as those in the photo of Figure 2-2 showing a narrow area surrounding the channel inside the city (distance between the walls is about 3m as measured visually), if the entrance to this road is over 4m, then the 4t class dump truck can enter the area.

Consequently, although the 2t capacity dump truck has a disadvantage from the point of payload, vehicle dimensions in terms of workability of the 2 capacities do not have such differences. Also, from the viewpoint of operation and maintenance, if the chassis is standardized to a 4t capacity which is the size of the crane truck explained later, parts can be exchangeable. To be in compliance with the 4 new backhoes (2 each of small and medium sizes) to be procured, 4 dump trucks are needed. In addition, since the one existing backhoe and 2 existing clam shells are to be used, 3 new trucks are necessary. Therefore, a total of 7 new trucks need to be procured.

b) Transport Distance from Waste Generation Point to Waste Disposal Site (Landfill)

The final disposal sites for solid wastes carried in by TMA are located in the outskirts of the city, one in the north and another in the east. Using the railroad as the border, the western area transports wastes to the north disposal site and the eastern area uses the east landfill. Also, wastes removed from channels and wet wells are supposed to be transported to these sites according to their area of work in either the west or east sides.

Since transporting of wastes from channels is a process of working from a line to a point, transport distances are not uniform. Therefore, in consideration of the locations of channels, distances from mid-points and end points to the disposal sites were measured. For wet wells, since their transport can be considered as point to point, and wet wells are almost evenly scattered around the city, the distances from channels to landfills can be used as reference, and therefore, their distances were not measured.

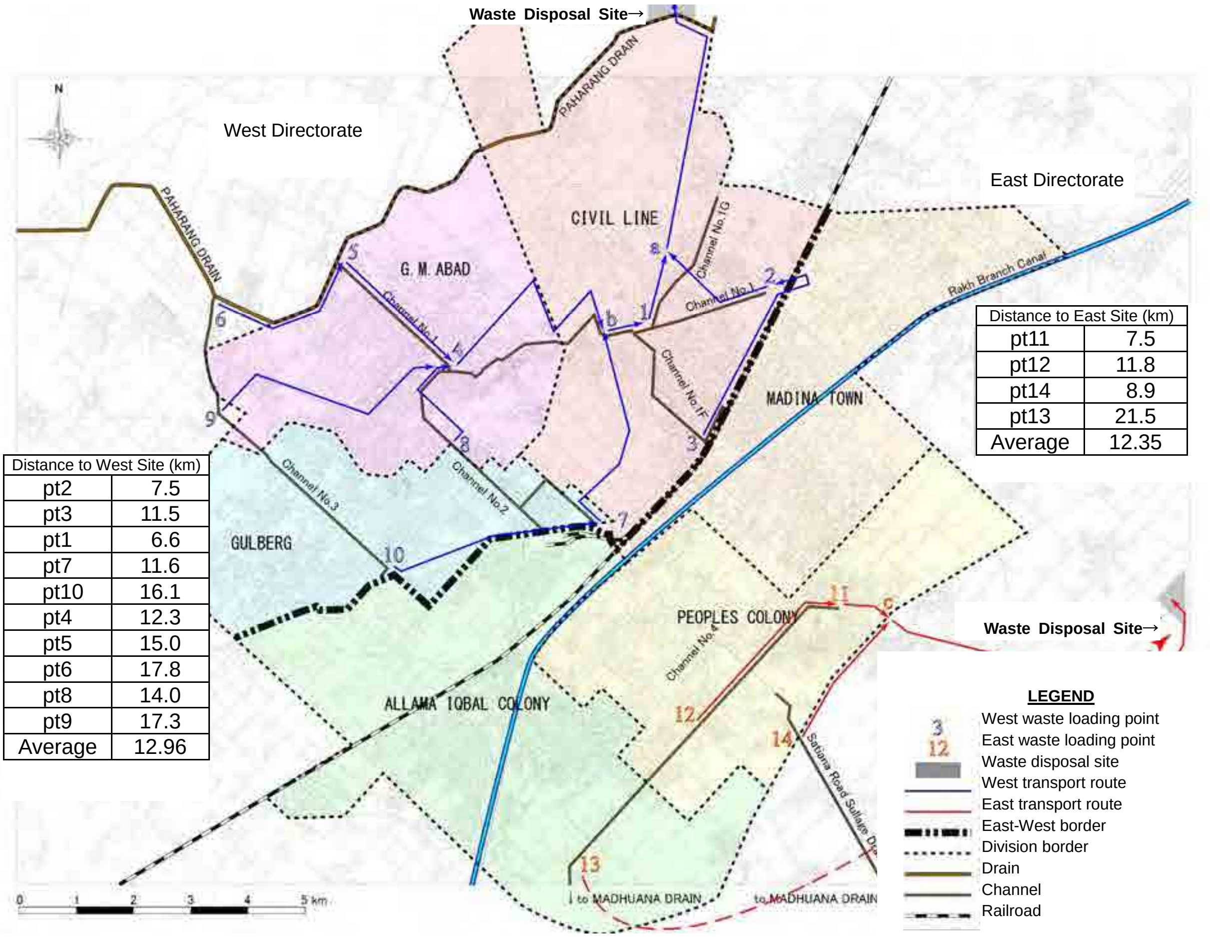


Figure 2-3 Waste Transport Distance from Main Channels to Disposal Sites

Since a local standard for transport days per unit transport volume for 4t capacity dump trucks is not available, the following Japanese standards from the Ministry of Land , Infrastructure, Transport and Tourism, Civil Works Cost Estimation Standards (2011 Edition), "Dump Truck Transport Days (per 10m^3) for densely populated areas" will be used.

Table 2-15 Transport Days for Dump Trucks

Dump Truck Transport Days (per 10m^3)					
Transport Distance (km)	Less than 7.0	Less than 9.0	Less than 12.0	Less than 17.0	Less than 27.0
Transport Days (Days)	0.6	0.8	0.9	1.1	1.5

Source: Japanese Ministry of Land , Infrastructure, Transport and Tourism, Civil Works Cost Estimation Standards (2011 Edition)

As shown in figure 2-3, the average transport distance is over 12km and less than 17 km.

Therefore, the the transportable amount per day can be calculated from Table 2-15 as,

$10m^3 \div 1.1$ days/vehicle = $9.1m^3$/day/vehicle.

The daily volume of waste to be removed is $67m^3$/day from Table 2-12 of the previous section ③/④. The number of dump trucks required to transport this amount is,

$67m^3$/day ÷ $9.1m^3$/day/vehicle = 7.4 trucks.

Since only one existing dump truck is usable, this is not enough to transport the daily volume of waste to be removed. Also, since the number of existing and newly procured excavators to handle the removal of wastes is 7, a minimum of one dump truck is required for each excavator. Therefore, 7 dump trucks of 4t capacity are to be newly procured.

Table 2-16 Required Number of Transport Vehicles corresponding to Excavators

Excavator			Transport Vehicle	
Existing	Backhoe	1	4t capacity Dump Truck	0
	Clam Shell	2		
Newly Procured	Medium Backhoe	2	4t capacity Dump Truck (Excavator total – Existing transport vehicles)	7
	Small Backhoe	2		
Total		7		7

⑥ Crane Cargo Truck

The original request was small tractors with trolleys to transport dewatering sets, but since mobilization of dewatering sets into sites requires urgency and the above explained ③ small backhoe requires transport for routine cleaning, the request was changed to crane cargo trucks during the survey. In the original request, the requested quantity was 6 sets presuming allocation of dewatering sets to 6 sub-divisions. However, since the crane cargo truck has maneuverability and 2 small backhoes are to be procured, allocation of one each for directorates in the East and West for a total of 2 new trucks will be procured (Option 2). Since existing vehicles and donkeys pulled trolleys are used for transporting the existing dewatering sets, this system will also be continued in accordance with distances to sites and degree of urgency. Therefore, crane cargo trucks will be used for transporting backhoes to the sites and returning to base divisions as well as for transporting dewatering sets.

In consideration of the size, from the weight of the small capacity backhoe (standard bucket capacity of $0.08m^3$ class) and since a crane is to be installed, a 4t class was selected. Since the 4t class chassis is the same as that of the dump truck, efficiency in terms of operation and maintenance can be expected. However, attention must be paid to not use the crane cargo truck for transporting wastes and sludge which is the use objective of the dump truck.

⑦ Pick-up Truck

Presently, the vehicle to transport WASA staffs in charge of operation and maintenance is one 3500cc pick-up truck. This pick-up truck, procured in 1990, is the only vehicle for operation and maintenance activities and is placed at the West directorate. Since only one vehicle is available, personnel transportation to work sites is carried out by riding together in work vehicles or using personal motorbikes or public transportations which are lacking in maneuverability. Also, since the existing pick-up, being used for over 20 years, is deteriorated and requires frequent repairs, further use becomes difficult.

Therefore, for prompt transporting of staffs to the sites, with possibilities for transporting tools and small cleaning tools, pick-up trucks were to be newly procured. However, from April 2011, since a decision was made that procurement of any vehicle using the provincial budget is not allowed, procurement of pick-up trucks was cancelled.

⑧ Dewatering Set

For handling complaints on inundation damages from blockages of sewers and channels, dewatering sets and suction machines are being used. Presently, WASA possesses 70 sets of 1/2cfs dewatering sets (of which, 17 sets are broken), but the request is for larger size 1cfs and 2cfs dewatering sets. The most important usage of dewatering sets is resolving problems of inundation damages along roads and at low lying areas during the rainy season. Therefore, most of the operators and assistants for dewatering sets are hired only during the rainy season to effectuate the management costs.

Based on inquiries of operation hours of dewatering sets during recovery of inundations which occurred in July 2010, although sizes of inundated areas vary, most of the respondents said that, if dewatering sets and workers are dispatched, water from inundated points begin to clear after about 12 hours. Therefore, the average operation hours will be set at 12 hours, and including preparation time, the time needed to operate 1 set for 1 mobilization is 14.5 hours.

Upon calculating the total number of sets needed to handle the present complaints, by subtracting the number of useable existing equipment, the number of new sets to be procured can be calculated. The usability of existing dewatering sets was judged by considering that although some are deteriorated, those that are well maintained can be continued to be used based on WASA survey results on present conditions.

Table 2-17 Required Quantity of Dewatering Sets

Parameter	July 2009 to June 2010
Complaints/year	25,500
Complaints/day	69.9
Working hours (hr)	14.5
Dewatering set operation hours* (hr)	14.5
Operation/day/set	1.0
Total required No. of dewatering sets	69.9→70

*Average operation time = Mobilization + site operation + demobilization + loss time
= 1.0 + 12.0 + 1.0 + 0.5 = 14.5hr

Source: Analyzed by study team using WASA and World Bank data (2011)

Quantity to be procured is the required number of 70 minus the useable number of existing 53 sets which becomes 17 sets.

The quantity to be procured resulted in only replacing broken sets, and if this is the case, then pump capacities of the same as existing 1.2cfs is required. However, in order to increase complaint handling capacities (decrease handling time), larger capacity pumps as requested are required. Also, for maneuverability in small areas as the case for dump trucks, the capacity will be unified into 1cfs. Concerning power source, in consideration of the local power supply situation of frequent blackouts, the requested electric motor type will not be adopted and only engine driven types will be procured.

2) Summary of Cleaning Equipment Plan

The Explanation of the Draft Report has been carried out in February 2012 after the considerations on specifications and quantities of equipments based on results of field study and work in Japan. During the discussions, Pakistani authorities informed that in line with the policy of the Federal/Provincial government, the procurement of pick-up trucks need to be deleted. The Pakistani side requested to utilize the cost difference for procurement of additional dump trucks. The final plan for procurement of cleaning equipment is as shown below.

Table 2-18 Plan for Cleaning Equipment

	Equipment	Main Specifications	Required Q'ty	Existing Q'ty		Procure Q'ty
				Total	To Use	
1	Jet Machine	Tank capacity: >3,500 lit Pump capacity: About200 lit/min	15	7	7	8
2	Suction Machine	Capacity: >3,500 lit	4	3	2	2
3	Wheel Backhoe	Struck capacity: 0.2 m^3 class Options: hydraulic clam shell, skeleton bucket	3	1	1	2
4	Mini-Backhoe	Struck capacity: 0.08 m^3 class Option: skeleton bucket	2	0	0	2
5	Bucket Crane (Clam Shell)	Crane lifting capacity: 25t	4	2	2	0
6	Dump Truck	Payload: >3,500 kg	7	2	0	7
7	Crane Cargo Truck	Payload: >2,500 kg Crane lifting capacity: 2.9t	2	0	0	2
8	Pick-up Truck	4x4 diesel, double cabin	6	7	6	0
9	Dewatering Set	1 cfs (Diesel)	70	70	53	17

3) Plan for Disposal Station Equipment

⑨ Pump

As a result of discussions with WASA, the following 4 disposal stations have been selected as the project sites among the principal disposal stations which are located near the final drains.

- No. 1 PS-3 Chokera
- No. 3 PS-31 Satiana Road
- No. 4 PS-36 Ahmad Nagar
- No. 7 PS-30 Bawa Chak

At all of these disposal stations, deficiencies in pump capacities caused by the reinforcement plan of the sewer system promoted by WASA are expected in the near future.

A population growth rate of 3.8% is forecasted for Faisalabad city. The year 2015, 5 years after the study, will be considered as the design year used for facilities construction projects. The sewage rate will be determined from the 2015 population and unit sewage rate (maximum sewage rate of 180 liters per person per day) of the coverage areas of disposal stations. The amounts of domestic wastewater (sewage) flowing into the principal disposal stations are shown below.

Table 2-19 Flow Rates of Domestic Sewage flowing into Target Principal Disposal Stations

Target Principal Disposal Station	Present Population (2010, persons)	2015 Population (persons)	Unit Sewage Rate (lit/cap/day)	Daily Max. Sewage Rate (m^3/day)
PS-3	600,000	720,000	180	129,600
PS-31	250,000	300,000	〃	54,000
PS-36	250,000	300,000	〃	54,000
PS-30	150,000	180,000	〃	32,400
Total	1,250,000	1,500,000		270,000

Source: WASA data
N.B.: 1000 lit = $1m^3$

Other than domestic wastewater, wastewater flow rates of industrial wastewater and other wastewater were determined upon discussions with WASA. Total sewage flow rates (domestic+industrial+others) for each disposal station and pumps to be replaced are shown below. Other wastewater is wastewater other than those from domestic and industrial areas, which is wastewater from places of business such as commercial areas, administrative offices, schools, medical facilities, companies and offices.

Table 2-20 Total Sewage and Wastewater Flowing into Target Principal Disposal Stations

Target Principal Disposal Station	Daily Maximum Sewage Rate[2] (2015)				
	Domestic Wastewater Rate	Industrial Wastewater Rate	Other Wastewater Rate	Total Sewage Flow Rate	
	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	(cfs)*
PS-3	129,600	60,390	93,118	283,108	115.7
PS-31	54,000	120,780	55,871	230,651	94.3
PS-36	54,000	108,702	27,935	190,637	77.9
PS-30	32,400	72,468	37,247	142,115	58.1
Total	270,000	362,340	214,171	846,511	346.0

Source: WASA data
* 1 cusec = 0.02832 m^3/sec

Hourly maximum sewage flow rates are calculated from daily maximum flow rates using Babbit coefficients as shown below.

[2] If calculation of hourly maximum sewage rate from daily maximum sewage rate is difficult, the generally used formula is assumption of hourly maximum using the Babbit coefficient. The assumed amount is calculated by multiplying M (Babbit coefficient) in accordance with the piped sewage population. $M = 5/ (pop/1000)^{1/5}$

Table 2-21 Calculation of Hourly Maximum Sewage Flow Rate

Target Principal Disposal Station	Daily Max Sewage Rate cfs	Babbit Coefficient	Hourly Max Sewage Rate cfs
PS-3	115.7	1.34	155.2
PS-31	94.2	1.60	150.5
PS-36	77.9	1.60	124.5
PS-30	58.1	1.77	102.8

If wet weather sewage rates for combined sewers are to be calculated, the following presumptions are applied.

- Rainfall area: The total city area of 15km x 15km is divided into 9 large disposal stations, including the principal disposal stations, is $25km^2$ which is the rainfall area for each disposal station.
- Precipitation rate: Precipitation rate of 92mm/day of 5 years probability will be used (refer to Annex 3)
- Outflow coefficient: In consideration of sandy areas, 0.25 will be used (refer to footnote p. 22)
- Influent time: After a rainfall, the time for precipitation to reach a disposal station is 0.5 hours considering a flow rate of 10km/hr (3m/sec) and average distance of 5000m. Therefore, the hourly precipitation rate is presumed to flow into the disposal station in 1.5 hours.

Equation for precipitation rate:

$25km^2 \times 0.092m/day \times 0.25 / (24hrs \times 60min/hr \times 60sec/min \times 1.5\ hrs) / 0.02832m^3/sec$

Wet weather sewage rates of combined sewers and required quantity of pumps are calculated below.

Table 2-22 Wet Weather Sewage Rate and Required Quantity of Pumps

Target Principal Disposal Station	Hourly Max Sewage Influent Rate cfs	Precipitation Rate cfs	Wet Weather Sewage Rate cfs	Required Pump Q'ty	Existing Pump Capacity (incl broken) cfs
PS-3	155.2	155	310.3	25cfs×12, 15cfs×1	80
PS-31	150.5	155	305.6	25cfs×12, 10cfs×1	65
PS-36	124.5	155	279.6	25cfs×11, 5cfs×1	62
PS-30	102.8	155	257.9	25cfs×10, 10cfs×1	39

As shown above, required quantities of pumps were calculated from hourly maximum sewage flow rate and wet weather sewage rate. If calculations are made using daily maximum rate, hourly maximum rate, and combined sewer wet weather rate, the required capacity becomes remotely larger than the present pump capacity. However, in consideration of practicability of precipitation rates, adaptability of Babbit coefficient (hourly maximum calculations) in this area, and allowance of 2015 predictions, pump capacities for capacity strengthening from WASA data only are calculated as follows. The confirmation on appropriateness of designed pump capacities has been carried out in light of maximum inflows and outflows based on characteristics of each disposal station. (refer to Appendix 8)

Table 2-23 Requirements for Pump Renewal and Replacement of Principal Disposal Stations

Principal Disposal Station	Flow Rate (cfs)	Present Capacity (cfs)	Installed Year	Condition	Required Replacement	Comments
PS-3 Chokera		*15*	2000	Broken	Replace→25	Capacity shortage Replace 2 broken pumps with 25cfs
		15	2000	Broken	Replace→25	
		15	2000	Function	Continue	
		15	2010	Function	Continue	
		25	2010	Function	Continue	
		25	2010	Function	Continue	
Total	115.7	80			130	
PS-31 Satiana Road		*15*	1998	Broken	Replace→25	Capacity shortage Replace all 4 pumps with new 25cfs pumps
		15	1998	Function	Replace→25	
		25	1988	Deteriorated	Replace→25	
		25	1988	Deteriorated	Replace→25	
Total	94.3	65			100	
PS-36 Ahmed Nagar		15	1998	Function	Replace→25	Capacity shortage Replace 2 pumps of 15cfs with 25cfs
		15	1998	Function	Replace→25	
		15	1998	Function	Continue	
		15	1998	Function	Continue	
Total	77.9	62			80	
PS-30 Bawa Chak		13	2000	Function	Continue	Capacity shortage Add i pumps of 25cfs
		13	2000	Function	Continue	
		13	2000	Function	Continue	
					Add→25	
Total	58.1	39			64	

As a result, 9 pumps of 25cfs will be newly procured.

⑩ Generator

The required quantity of new generators needed to be procured for principal disposal stations were determined from the power requirements using total hydraulic head of 15m and efficiency rate of 0.9 based on pump capacities for 2015 calculated above. Power to drive the pump is calculated from the discharge rate, total hydraulic head and pump efficiency using the following formula (from Japanese Sewerage Society, Sewerage Facilities Plan and Design).

$$L = \frac{1}{60 \times 10^3 \times \eta} \rho g Q H$$

$$\left(L = \frac{0.163 \gamma Q H}{\eta} \right)$$

Where,

L: Power (kW)

ρ : Density of fluid (1000kg/m^3)

g: Gravity, 9.80 m/s^2

Q: Pump discharge (m^3/min)

H: Total hydraulic head (m)

η : Pump efficiency

γ : Specific weight per unit volume of fluid (kgf/lit)

Table 2-24 Power Requirements for Pumps of Target Principal Disposal Stations

Target Principal Disposal Station	Influent Rate (=Required Discharge Rate) (cfs)	Required Power*		Stand-by Power (kVA)		Required Generator Capacity (kVA)			
		kW	kVA	Existing	Deficit	150	300	350	650
PS-3 Chokera	115.7	534	628	0	628				1
PS-31 Satiana Road	94.3	435	512	300	212		1		
PS-36 Ahmed Nagar	77.9	360	423	300	123	1			
PS-30 Bawa Chak	58.1	268	315	0	315			1	
Motor Power Factor Cosθ=0.85		Total:				1	1	1	1

* If the above formula is used to calculate the required power, the unit is in kW, but since most generators are rated by kVA, kW is converted to kVA.

4) Plan for Spare Parts and Consumables

Since spare parts for this plan are all general purpose parts, spare parts and consumables for equipment to be newly procured will be manufacturer's standard parts only.

(3) Equipment Allocation Plan

Based on the results of the equipment plan explained above, existing equipment will also be utilized. Therefore, allocation of existing and newly procured cleaning equipment is planned as follows. Also, in the premises of the directorates and divisions, parking spaces and storage yards are available to store these equipments,

Table 2-25 Allocation Plan for Cleaning Equipment

No.	Equipment	Allocation	Newly Procured	Existing to be Used
1	Jet Machine	West Div. & 3 Sub-Divisions	4	3
		East Div. & 3 Sub-Divisions	4	4
2	Suction machine	West Division	1	1
		East Division	1	1
3	Wheel Backhoe	Directorate Drainage	2	1
4	Mini-Backhoe	Directorate Drainage	2	0
5	Bucket Crane (Clam Shell)	Directorate Drainage	0	2
6	Dump truck	Directorate Drainage	7	0
7	Crane cargo truck	Directorate Drainage	2	0
8	Pick-up truck	West Division3 Sub-Divisions	0	3
		East Division 3 Sub-Divisions	0	3
9	Dewatering set	West Div. & 3 Sub-Divisions	12	23
		East Div. & 3 Sub-Divisions	5	30
Total			40	71

*Offices of WASA Faisalabad HQ and West Division are located in the same premise.

According to the equipment plan explained above, the allocation plan for pumps and generators of the 4 target principal disposal stations in Faisalabad is as follows.

Table 2-26 Allocation Plan for Pumps and Generators

Disposal Station	Pump	Generator			
	25 cfs	150 kVA	300 kVA	350kVA	650 kVA
PS-3 Chokera	2	-	-		1
PS-31 Satiana Road	4	-	1		-
PS-36 Ahmed Nagar	2	1	-		-
PS-30 Bawa Chak	1	-	-	1	-
Sub-total	9	1	1	1	1
Total	9	4			

2-2-3 Outline Design Drawings

The following design drawings are attached.

- Cleaning Equipment and Disposal Station Equipment Allocation Map
- Drawing of Disposal Pumping Station
- Drawing of Drain Channels