ISLAMIC REPUBLIC OF PAKISTAN
WATER AND SANITATION AGENCY, FAISALABAD

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR THE IMPROVEMENT OF WATER TREATMENT PLANT AND WATER DISTRIBUTION SYSTEM IN FAISALABAD
IN
ISLAMIC REPUBLIC OF PAKISTAN

DECEMBER 2020

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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SUMMARY

Summary

1. Overview of Pakistan

Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") has the boundary with India, China, Afghanistan, and Iran, and faces to Arabian Sea. Population in Pakistan was counted to about 208 million according to "6th Population and Housing Census 2017". As compared to 132 million in the previous census of 1998, the population has increased by about 1.6 times in 19 years.

The climate in Pakistan varies from tropical to temperate such as desert climate in south-central region, semiarid climate in northern region, and temperate climate with a rainy summer in northern mountain region. Therefore, the temperature and precipitation vary in the regions. Basically there are four seasons; i) cool and dry from December to February as winter, ii) high temperature and dry from March to May as spring, iii) monsoon from June to September as summer, and iv) transition period of summer to winter from October to November as autumn.

Pakistan's GDP (real) in 2018 is about 314.5 billion USD according to World Bank. GNI per capita in 2018/19 is about 1,500 USD according to Ministry of Finance. Regarding the ratio of GDP (2017/18) in sector according to Pakistan Bureau of Statistics, agriculture, industry (including mining, manufacturing, electricity generation & distribution and gas distribution, Construction), and services (including general government services) account for 19.0, 20.6, and 60.4 %, respectively. For the international trading, the export and the import in 2018 are 23.1 billion and 60.1 billion USD, respectively, according to JETRO. Main items for the export are textile, agriculture, and food products. On the other hand, main items for the import are petroleum product, crude oil, and machinery.

2. Background of the Project

Ministry of Environment formulated the National Drinking Water Policy in 2009. One of the goals in this policy is to improve access to safe drinking water to the country’s entire population by 2025. In addition, the National Water Policy prepared by Ministry of Water Resources states that all citizens of Pakistan have the right to access clean drinking water. However, according to the "Pakistan Social and Living Standards Measurement Survey 2014-2015", only 27% of households in Pakistan can access drinking water through piped water supplies.

The project site is located in Faisalabad, the third-largest city by population in Pakistan. The population in Faisalabad has increased from 2 million in 1998 to 3.2 million in 2017 according to the 6th Population and Housing Census 2017. The population growth rate of the city is 3.3 % per annum, which is higher than the average of 2.7% in urban areas of Pakistan. Under such rapid growth, it is expected that the water demand (maximum daily) for Faisalabad will exceed the current water supply capacity in the near future. Furthermore, the water distribution has not been managed properly. As a result, the water is suppled under the condition of the low pressure and the intermittent service limited

for about six hours per day in the area. These operational challenges of the water services in Faisalabad have resulted in the low collection rate of water bills. Therefore, it is an urgent issue for WASA-F to improve its water supply services through formulating the plan on facility development to satisfy the water demand, improve the distribution pressure, and strengthen the capacity of O&M.

Responding to a request from the Government of Pakistan for improving the challenge, Japan International Cooperation Agency (JICA) implemented a technical cooperation project, "the Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad" (hereinafter referred to as "M/P Project") from 2016 to 2019. Through the M/P Project, a master plan for water supply, sewerage and drainage development was formulated. In the water sector of the formulated M/P, four-phased facility development plan from 2018 to 2038 was included for i) water resource development, ii) facility investment based on the urban plan, and iii) the proper maintenance of existing facilities. In addition, the pilot activities of the M/P Project demonstrated that i) an income from the tariff was increased, and ii) the understanding about the tariff was improved, through an improvement of the services such as the supply volume, water pressure, and supply hours as a result of isolating the distribution area.

For the further improvement of water service and the realization of the master plan, the Government of Pakistan requested "the Project for the Improvement of Water Treatment Plant and Water Distribution System in Faisalabad (hereinafter referred to as "Project")" as the Japan's Grant Aid. The components of the Project are mainly to renew/expand the Old JK WTP and install transmission and distribution facilities (see Table 1), which is a part of the priority projects identified in the M/P Project. The Project is expected to contribute to the improvement in water services such as the supply volume and water pressure.

Table 1 Project scope requested by Pakistani side

Category	Facility	Detail requested by Pakistani Side
Construction	Intake (10 MGD*)	Intake mouth, branch valve chamber
		Raw water pump station
	Water Treatment Plant (5 MGD*) (Applicable to expand the capacity to 10 MGD)	Receiving and distribution tank
		Mixing tank Flocculation tank Settling tank
		Rapid sand filter
		Clear water reservoir
		Transmission pump station
		Waste water tank and sludge tank
		Sludge thickener
		Sludge extraction pump station
		Sludge drying bed
		Chlorination building
		Chemical building
		Administration building
		Power receiving and transforming, and generator house
		Electricity meter house
	Distribution Center	Ground reservoir (2 ponds)
		Overhead reservoir (2 ponds)

Category	Facility	Detail requested by Pakistani Side
	Transmission and Distribution Main (Applicable to transmit a capacity of 10 MGD partially)	Transmission main (approx. 4 km)
		Distribution primary main (approx. 11 km)
		Distribution secondary main (approx.. 20 km)

Note: 5 MGD=22,700m^3/day, 10 MGD=45,500m^3/day

Following the request, JICA implemented the preparatory survey to examine the applicability of the Japan's Grant Aid. Through the preparatory survey, the outline design was prepared for figuring out the project cost after examining the appropriateness of project size and components as the Japan's Grant Aid.

3. Results of the Preparatory Survey and Scope of the Project

3.1 Results of the Preparatory Survey

JICA dispatched the preparatory survey team to Pakistan in the following period.

First survey in Pakistan: 24th March to 9th May, 2019
Second survey in Pakistan: 14th July to 22nd July, 2019
Third survey in Pakistan: 12th December to 20th December, 2019

The mission for explaining the Inception Report was dispatched from 24th March to 2nd April, 2019. After that, the preparatory survey team conducted data collection required for the outline design, the survey on the existing water supply facilities, topographic survey, geotechnical survey, and excavation and underground infrastructure observation survey. Through these surveys followed by the work in Japan, the draft outline design was prepared. Based on this design, the Japanese and Pakistani sides discussed and agreed on the outline design including the obligations of the recipient country by on-line meeting from 14th to 16th September, 2020.

3.2 Scope of the Project

After reviewing the request from the Pakistani side as shown in Table 1, the project size was deemed to be too excessive for the Japan's Grant Aid. As a result of comparing alternatives for reducing the project cost, some changes were made to the following components.

1) Length of Distribution Mains

Table 2 summarizes the length of distribution mains for i) the request from Pakistani side and ii) the result of the outline design in the preparatory survey consisting of development by the Japan's Grant Aid and Pakistani side.

Table 2　Length of Distribution Mains

	Request by Pakistani side	Result of outline design		
		Development by Japan's Grant Aid	Development by Pakistani side	Total
Distribution Primary Main (km)	about 11	about 1.2	about 7.1	about 8.3
Distribution Secondary Main (km)	about 20	about 1.9	about 18.1	about 20.0
Total (km)	about 31	about 3.1	about 25.2	about 28.3

The following is conditions for examining the development area for distribution mains and the approach in the project.

- Distribution primary and secondary mains are installed partially by the Japanese side with consideration of applicable length under the Japan's Grant Aid. In detail, the distribution primary and secondary mains are installed near the distribution centers at a length of about 3.1 km whose route is able to contribute a positive impact directly to more number of residents than the other areas.
- The remaining part at a length of about 25.2 km will be installed by the Pakistani side. The Pakistani side will also connect new distribution mains to existing mains, and isolate DZs and DMAs in the target service areas. The installation of the distribution mains has been already planned by the Pakistani side, and is therefore not included in the obligations of recipient country in the Project.

2) Oxidation and Disinfecting Agents at WTP

The oxidation and the disinfecting agents at the WTP is changed from liquid chlorine (requested by Pakistani side) to sodium hypochlorite. Since the facility for sodium hypochlorite is smaller than one for liquid chlorine, the chemical building can accommodate the facility for sodium hypochlorite. As the result, the chlorination building was eliminated from the project components.

The following table shows the main components of the Project.

Table 3　Main Components of the Project

Facility	Detail	Major Specification / Contents
Intake	Intake mouth, branch valve chamber	Reinforced concrete structure Width 0.6m x water depth 1.0m x 2 nos. Raw water transmission pipe: DCIP DN800
	Raw water pump station	Reinforced concrete structure Pump well: width 3.6m x length 19.6m x water depth 5.3m x 1 unit Pump room: width 7.4m x length 20.0m Electric room: width 4.2m x length 20.0m Raw water transmission pump: 3 unit (stand-by 1 unit)
Water Treatment Plant	Receiving and distribution tank	Reinforced concrete structure Width 3.0m x length 3.7m x water depth 5.5m x 2 units
	Mixing tank Flocculation tank Settling tank	Mixing tank Reinforced concrete structure Water flow energy type (freefall from weir) Receiving: width 3.0m x length 3.0m x water depth 4.5m x 1 unit Mixing: width 3.0m x length 0.8m x water depth 2.8m x 1 unit Flocculation tank

Facility	Detail	Major Specification / Contents
		Reinforced concrete structure Up-and-down type, Width 1.85m x length 9.7m x 4 stages x water depth 3.5~3.8m x 2units Settling tank Reinforced concrete structure Inclined pipe type Width 8.4m x length 13.75m x water depth 3.5m x 2 units
	Rapid sand filter	Reinforced concrete structure Single filter medium, constant rate filtration Filtration rate: 140m/day Width 4.5m x length 9.4m x 4 units Filtration area: 42.3 m^2 x 4 units Air-wash and backwash
	Clear water reservoir	Reinforced concrete structure Width 15.8m x length 17.2m x water depth 4.5m x 2 units Effective volume: 2,440m^3 Retention time: 1.2 hours for 10 MGD
	Transmission pump station	Reinforced concrete structure Pump room: width 9.4m x length 32.4m Electric room: width 4.2m x length 32.4m Transmission pump: 3 units (stand-by 1 unit)
	Waste water tank and sludge tank	Waste water tank Reinforced concrete structure Width 4.2m x length 20.0m x water depth 2.5m x 2 units Transfer pump: 2 units (stand-by 1 unit) Recycle pump: 4 units (stand-by 2 units) Sludge tank Reinforced concrete structure Width 4.2m x length 20.0m x water depth 3.0m x 2 units Transfer pump: 4 units (stand-by 2 units)
	Sludge thickener	Reinforced concrete structure Dia. 12.8m x water depth 4.0m x 1 unit
	Sludge extraction pump station	Reinforced concrete structure Pump room: width 5.0m x length 12.0m Electric room: width 5.0m x length 12.0m Transfer pump: 2 units (stand-by 1 unit)
	Sludge drying bed	Masonry retaining wall and reinforced concrete structure Width 20.0m x length 30.0m x 4 units
	Chemical building	Reinforced concrete structure Single story, width 8.2m x length 29.4m Dosing equipment for aluminum sulfate Dosing equipment for polymer Dosing equipment for sodium hypochlorite
	Administration building	Reinforced concrete structure Single story, width 18.0m x length 20.0m SCADA Equipment for water quality analysis
	Power receiving and transforming, and generator house	Reinforced concrete structure Single story, width 13.0m x length 11.0m Generator: 1,000kVA
	Electricity meter house	Reinforced concrete structure Single story, width 3.5m x length 5.0m
Distribution Center	Ground reservoir	Abudulah Pur Distribution Center Reinforced concrete structure Width 7.5m x length 15.4m x water depth 6.0m x 2 units Effective volume: 1,390m^3 Retention time: 4.0 hours Lift pump: 4 units (stand-by 1 unit) Generator: 300 kVA Madina Town No. 2 Distribution Center Reinforced concrete structure Width 13.1m x length 21.1m x water depth 4.8m x 2 units Effective volume: 2,650m^3 Retention time: 4.0 hours Lift pump: 4 units (stand-by 1 unit)

Facility	Detail	Major Specification / Contents
		Generator: 300 kVA
	Overhead reservoir	Abudulah Pur Distribution Center Reinforced concrete structure Dia. 10.8m x water depth 5.5m x 1 unit Effective volume: 500m^3 Retention time: 1.5 hours Low-water-level: 25m from formation ground level Madina Town No. 2 Distribution Center Reinforced concrete structure Dia. 14.7m x water depth 5.5m x 1 unit Effective volume: 933m^3 Retention time: 1.5 hours Low-water-level: 25m from formation ground level
Transmission and Distribution Main (Applicable to transmit a capacity of 10MGD partially)	Transmission main	DCIP DN600, L=990m HDPE DN450, L=1,730m HDPE DN400, L=1,270m HDPE DN300, L=60m Pipe bridge DN500, L=40m 1 no. Total length: L=4,090m
	Distribution primary main	HDPE DN450, L=590m HDPE DN350, L=630m Total length: L=1,220m
	Distribution secondary main	Part of DMA I-1, DMA II-2 HDPE DN200, L=800m HDPE DN150, L=1,100m Total length: L=1,900m District meter: 2 nos. (DMA I-1, II-2)
Soft Component	O&M of water treatment plant	Water production in accordance with the water demand plan Operation method of Old JK WTP under unusual circumstances Maintenance of water treatment facilities
	O&M of transmission and distribution facilities	Efficient pump operation with adjustment of flow rate according to changes in demand Continuous water transmission/distribution during the RBC closure

4. Implementation Schedule and Cost Estimate

Project implementation will start with detailed design and proceed to tendering followed by construction. The planned period for each stage is 7 months for the detailed design (from concluding the consultant's contract to approval of bidding documents), 4 months for the tendering process (from prequalification until commencement of construction), and 29 months for the construction. The project cost borne by the Pakistani side is estimated at 209 million PKR.

5. Project Evaluation

5.1 Relevance

5.1.1 Beneficiaries

The beneficiaries of the project are the residents that receive WASA-F's water service. The service population of the Project area (Abudulah Pur and Madina Town No. 2) is expected to be increased due to the Project from around 30,000 in 2018 to around 79,000 in 2038.

After the implementation of the Project, water from the existing source will no more be required for the supply to the Project area. As a result, a certain amount of water currently supplied to the Project area will be available for utilization by WASA-F's customers of 130 million (Year 2018) residing in the other district. Therefore, the population of 130 million is also benefited by the surplus.

5.1.2 Urgency

It is expected that the amount of water demand will exceed the supply in 2021 due to rapid population increase in the supply area. In order to address this issue, the development of safe and stable water supply facilities such as water treatment plants and pipe network under an appropriate plan is an urgent priority.

5.1.3 Relevance to Overall Goal

The National Water Policy 2018 states that the provision of safe drinking water to the urban and rural population in the country is a key issue. The project site is located in the service area of WASA-F, where the water is supplied on a daily basis. However, the service is not satisfactory due to the intermittent supply and the low distribution pressure as well as an increase in water demand day by day. Thus, water shortages are expected to occur as the water demand exceeds the supplying capacity of WASA-F in 2021. The facilities such as WTP, transmission and distribution mains, and distribution center (GR, OHR) to be constructed under the Project enables the continuous provision of safe water in the area. Therefore, the Project is consistent with Pakistan's water policy.

5.1.4 Relevance to Japan's Assistance Policy

One of the priority issues identified in Japan's Country Development Cooperation Policy for Pakistan (February 2018) is the realization of human security and the improvement of social infrastructure. The policy focuses on developing the infrastructure and O&M models including collection fees for water supply and sewerage sector of the urban area.

In addition, JICA Country Analysis Paper for Pakistan (October 2014) maintains that development of water supply and sewerage facility is important in major cities. Therefore, the Project is consistent with the Japan's assistance policy and analysis.

5.2 Effectiveness

5.2.1 Quantitative Effects

Table 3 presents the expected quantitative effects through renewing and expanding the Old JK WTP and installation of transmission and distribution facilities.

Table 3　Quantitative Effects

Indicator	Baseline data (Year 2020)	Target (Year 2027) (3 years after project completion)
Production volume by WTP[*1]	6,800 m^3/day	14,800 m^3/day
Distribution pressure	approximately 0 - 8 m (average: 1.7 m) [*2]	25 m or higher[*3]

Note:
*1: Average of production volume by WTP excluding closing period of RBC approximately for 3 weeks per year
*2: Average of maximum pressure at tap surveyed in 2019-20
*3: Measurement at flowmeter room of OHR

5.2.2 Qualitative Effects

The following is the expected qualitative effects in the Project.

- Improvement of living environment and public health for citizens, and contribution in promoting infection control measures by improving water supply service quality such as water supply hours
- Improvement of WASA-F's financial status by increasing customers and the income through water tariff

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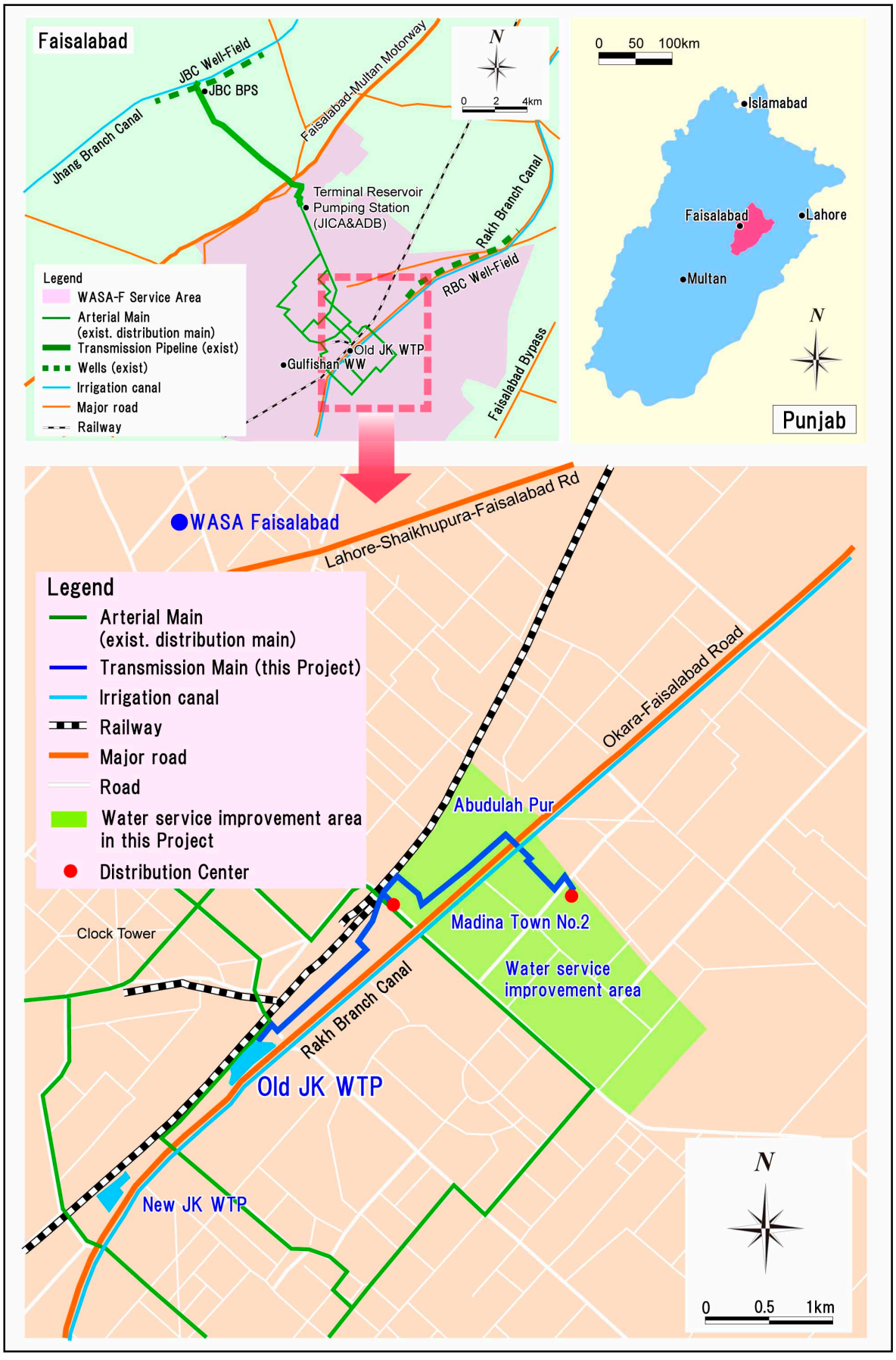
【APPENDICES】



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Abbreviations

AB	Acquiring Body
ADB	Asian Development Bank
AFD	Agence Française de Développement
AP	Affected People
BHU	Basic Health Unit
BOD	Biochemical Oxygen Demand
CCTV	Closed Circuit Television
CEO	Chief Operating Officer
COD	Chemical Oxygen Demand
cusec	Cubic Feet per Second
dBA	Decibel A
DC	Distribution Center
DCIP	Ductile Cast Iron Pipe
DD	Data Deficient
DD	Deputy Director
DEO	District Environmental Officer
DMA	District Metered Area
DMD	Deputy Managing Director
DN	Nominal Diameter
DZ	Distribution Zone
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
EPA	Environment Protection Agency
EPA-F	Environment Protection Agency-Faisalabad
EPD	Environmental Protection Department
FDA	Faisalabad Development Authority
FESCO	Faisalabad Electric Supply Company
FFP	French Fund Project
FWMC	Faisalabad Waste Management Company
G/A	Grant Agreement
GBC	Gugera Branch Canal
GDP	Growth Domestic Product
GNI	Gross National Income
GR	Ground Reservoir
GSM	Global System for Mobile Communications
GTS	Government Transport Service
HDPE	High Density Polyethylene
HIV/AIDS	Human immunodeficiency virus infection and acquired immune deficiency syndrome
HUD&PHED	The Housing, Urban Development and Public Health Engineering Department
HWL	High Water Level
I&C	Implementation and Coordination
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature and Natural Resources
JBC	Jan Branch Canal
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
JPY	Japanese Yen

kW	Kilo Watt
kWh	Kilo Watt Hour
LAA	Land Acquisition Act
LC	Least Concern
LCC	Lower Chenab Canal
LWL	Low Water Level
m^3/day	Cubic Meter per Day
m^3/hr	Cubic Meter per Hour
m^3/min	Cubic Meter per Minute
m^3/sec	Cubic Meter per Second
MC	Municipal Corporation
MD	Managing Director
M/D	Minutes of Discussion
MGD	Million Gallon per Day
M/M	Man Month
M/P	Master Plan
NEQS	National Environmental Quality Standards:
NEQSAA	National Environmental Quality Standards for Ambient Air
NGO	Non-Governmental Organization
NJK	New Jhal Khanuana
NOC	No Objection Certificate
NRP	Pakistan National Resettlement Policy
NT	Near Threatened
NTU	Nephelometric Turbidity Unit
OHR	Overhead Reservoir
OJK	Old Jhal Khanuana
O&M	Operation and Maintenance
OP	Operational Policies
PAC	Poly Aluminum Chloride
PC-1	Planning Commission Form -1
PCGIP	Punjab Cities Governance Improvement Project
P&D	Planning and Design
PE	Polyethylene Pipe
PEPA	Pakistan Environmental Protection Act
PEPC	Pakistan Environmental Protection Council
PEQS	Punjab Environmental Quality Standards
PHA	Parks & Horticulture Authority
PIU	Project Implementation Unit
PKR	Pakistan Rupee
PLC	Programmable Logic Controller
PN	Pressure Nominal
PQ	Pre-qualification
PTZ	Pan–tilt–zoom
PVC	Polyvinyl Chloride
RAP	Re-allocation Program
RB	Requiring Body
RBC	Rakh Branch Canal
RHC	Rural Health Center
RI/O	Remote Input/ Output
R&R	Revenue and Recovery

SCADA	Supervisory Control And Data Acquisition
SS	Suspend Solid
TDS	Total Dissolved Solid
TEPA	Transport Engineering Planning Agency
TOR	Terms of Reference
TR	Terminal Reservoir
UC	Union Council
UPS	Uninterruptible Power Supply
US	United States
V	Volt
WASA	Water and Sanitation Agency
WASA-F	Water and Sanitation Agency, Faisalabad
WDM	Water Distribution and Maintenance
WHO	World Health Organization
WSZ	Water Supply Zone
WWF	World Wildlife Fund

CHAPTER 1
BACKGROUND OF THE PROJECT

Chapter 1 Background of the Project

1-1 Background and Basic Concept of the Project

Ministry of Environment of Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") formulated the National Drinking Water Policy in 2009. One of the goals in this policy is to improve access to safe drinking water to the country's entire population by 2025. In addition, the National Water Policy prepared by Ministry of Water Resources states that all citizens of Pakistan have the right to access clean drinking water. However, according to the "Pakistan Social and Living Standards Measurement Survey 2014-2015", only 27% of households in Pakistan can access drinking water through piped water supplies.

The project site is located in Faisalabad, the third-largest city by population in Pakistan. The population in Faisalabad has increased from 2 million in 1998 to 3.2 million in 2017 according to the 6th Population and Housing Census 2017. Consequently, it is expected that the water demand (maximum daily) for Faisalabad will exceed the current water supply capacity in the near future. In addition, as a result of aged or malfunctioned equipment, the production volume has been reduced to 6,800 m^3/d, 43% of the capacity of the Old Jhal Khanuana (hereinafter referred to as "JK") Water Treatment Plant (hereinafter referred to as "WTP"). Furthermore, the water distribution has not been managed properly. As a result, the water is supplied under the condition of the low pressure and the intermittent service limited for about six hours per day in the area. These operational challenges of the water services in Faisalabad have resulted in the low collection rate of water bills. Therefore, the challenge is the lack of autonomous management and the lack of planned operation and maintenance, too.

In such a situation, responding to a request from the Government of Pakistan for improving the challenge, Japan International Cooperation Agency (JICA) implemented a technical cooperation project, "the Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad" (hereinafter referred to as "M/P Project") from 2016 to 2019. Through the M/P Project, a master plan for water supply, sewerage and drainage development was formulated.[1] In addition, the pilot activities of the M/P Project demonstrated that an income from the tariff was increased through an improvement of the services such as the supply volume, water pressure, and supply hours.

For the further improvement of water service and the realization of the master plan, the Government of Pakistan requested "the Project for the Improvement of Water Treatment Plant and Water Distribution System in Faisalabad (hereinafter referred to as "Project")" as the Japan's Grant Aid. Table 1-1 presents the request, mainly to renew/expand the Old JK WTP and install transmission and distribution

[1] As background information of this preparatory survey, the outline of the M/P Project is described in Appendix 6 (1).

facilities. The component of the request is a part of the priority projects identified in the M/P Project. The Project is expected to contribute to the improvement in water services such as the supply volume and water pressure.

Table 1-1 Project scope requested by the Pakistani side

Category	Facility	Detail requested by Pakistani Side
Construction	Intake (10 MGD*)	Intake mouth, branch valve chamber
		Raw water pump station
	Water Treatment Plant (5 MGD*) (Applicable to expand the capacity to 10 MGD)	Receiving and distribution tank
		Mixing tank Flocculation tank Settling tank
		Rapid sand filter
		Clear water reservoir
		Transmission pump station
		Waste water tank and sludge tank
		Sludge thickener
		Sludge extraction pump station
		Sludge drying bed
		Chlorination building
		Chemical building
		Administration building
		Power receiving and transforming, and generator house
		Electricity meter house
	Distribution Center	Ground reservoir (2 ponds)
		Overhead reservoir (2 ponds)
	Transmission and Distribution Main (Applicable to transmit a capacity of 10 MGD partially)	Transmission main (approx. 4 km)
		Distribution primary main (approx. 11 km)
		Distribution secondary main (approx.. 20 km)

Note: 5 MGD=22,700m^3/day, 10 MGD=45,500m^3/day

Following the request, JICA implemented the preparatory survey to examine the applicability of the Japan's Grant Aid. Through the preparatory survey, the outline design was prepared for figuring out the project cost after examining the appropriateness of project size and components as the Japan's Grant Aid.

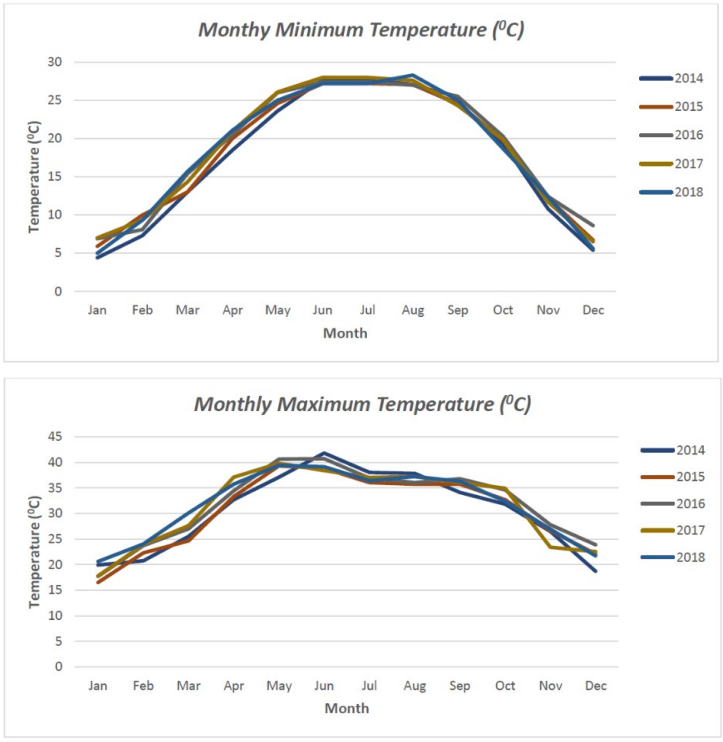
As a result of the preparatory survey, the project scope presented in Table 2-1 was selected. The basic approach is described in "2-2-1-1, (1), 4) Scope of the Project". The selected scope different from the request is described in "2-2-2-4, (5) Chemical Application" for the chlorine dosage, and "2-2-2-6 Transmission and Distribution Mains" for the distribution mains.

1-2 Natural Environmental Conditions

(1) Temperature and Rainfall

Faisalabad is located in an arid weather regions with seasonal changes in climate. In summer, the temperature becomes 40 ˚C or higher with high humidity in the daytime, while in winter, the minimum

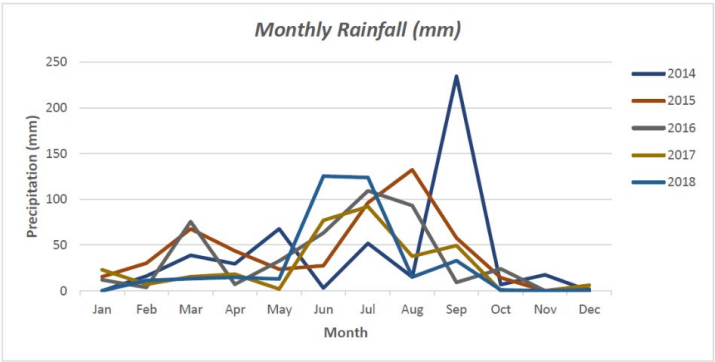
temperature becomes 5 ˚C or lower. Figure 1-1 shows the mean of monthly minimum and maximum temperatures from 2014 to 2018.



Source: Pakistan Meteorological Department

Figure 1-1 Mean of Monthly Minimum and Maximum Temperatures from 2014 to 2018

Figure 1-2 shows the monthly rainfall from 2014 to 2018. The amount of monthly rainfall is relatively small at about 100mm even in the rainy season from July to September.



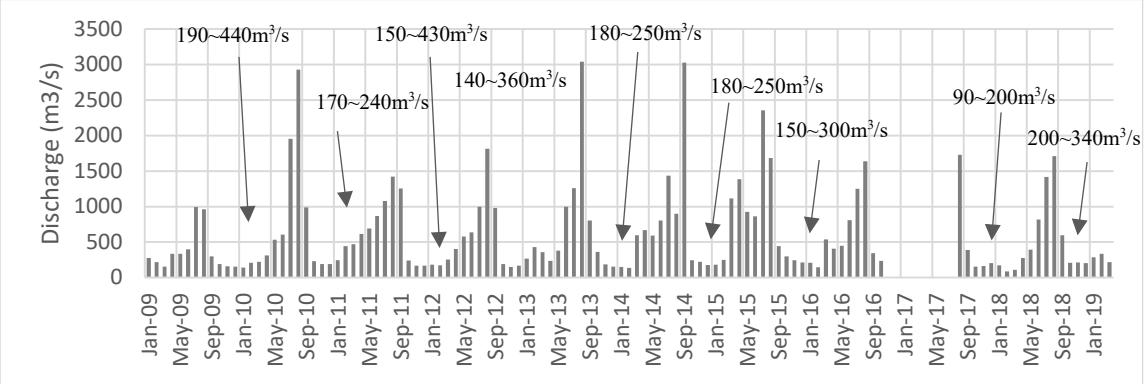
Source: Pakistan Meteorological Department

Figure 1-2 Monthly Rainfall from 2014 to 2018

(2) Discharge of the Chenab River

The RBC, the water source of the Old JK WTP, is branched from the Khanki head works of the Chenab River. Figure 1-3 shows discharge records from 2009 to 2019 at the Khanki head works. The

discharge from October to February has the lowest volume in a year. However, any tendency to increase or decrease the discharge is not observed in the period of October to February from 2009 to 2019.

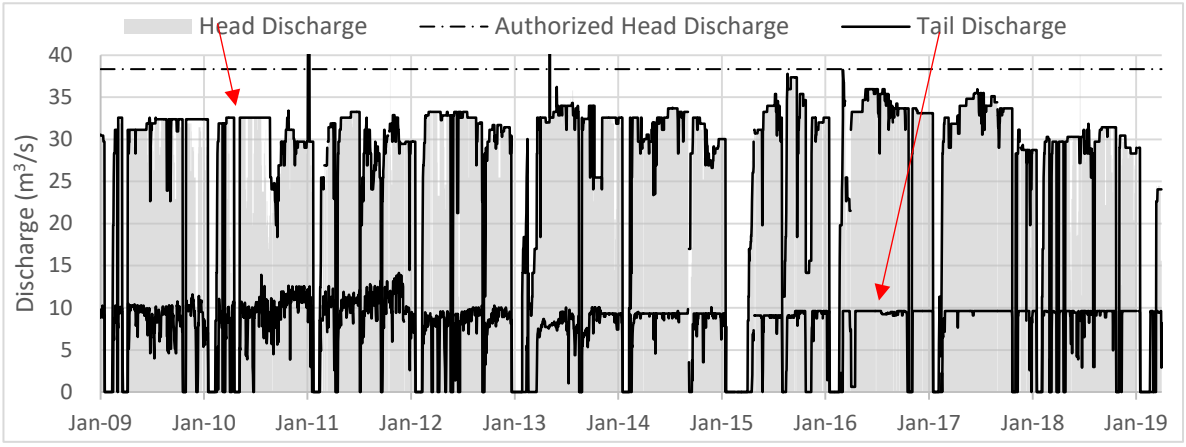


Source: Irrigation Department, note: no record from November 2016 to January 2017

Figure 1-3 Monthly Mean Discharge at the Khanki Head Works from 2009 to 2019

(3) Discharge of the RBC

Figure 1-4 shows discharge records of the RBC from 2009 to 2018. The discharge of the RBC is measured at two points, the upstream end (Head Discharge) and downstream end (Tail Discharge). The intake of the Old JK WTP is located at the downstream of the RBC. The flow rate for the last 10 years is about 30 m^3/sec or more in the upstream end, and about 10 m^3/sec in the downstream end. The period of "without any discharge" is mainly the closing period of the RBC in January every year (see "2-2-1-2 Environmental Factors, (3) Closing Period of the RBC"). The rest of "without any discharge" is data "not available".



Source: Irrigation Department

Figure 1-4 Discharge of the RBC from 2009 to 2019

(4) Raw Water Quality

The water quality test for RBC was conducted in both wet and dry seasons during the M/P Project.

The result is presented in Table 1-2 together with the standard value of the guideline in Pakistan and the WHO guidelines.

Table 1-2 Water Quality Test Results in the M/P Project

No.	Parameter	Unit	PEQS (2016)	WHO Guideline (2011)	SW 3 (RBC)	SW 3 (RBC)
Sampling Date					Sep. 23, 2016	Nov. 16, 2016
1	Temperature	˚C	-	-	27	18.8
2	Turbidity	NTU	5	5	57	36
3	Colour	TCU	15	15	5.5	0.8
4	pH		6.5-8.5	(6.5-8.5)[1)]	8.2	8.83
5	EC	µS/cm	-	-	193	197
6	Hardness	mg/L	500	-	88	104
7	Total alkalinity	mg/L	-	-	70	120
8	Chloride (Cl^-)	mg/L	250	(250) [2)]	70	30
9	Total dissolved solids (TDS)	mg/L	1,000	(1,000) [3)]	140	141
10	DO	mg/L	-	-	5.64	5.04
11	Nitrite-N (NO_2^-)	mg/L	NO_2^--N:0.9 NO_2^-:3	NO_2^--N:0.9 NO_2^-:3	0.19	0.05
12	Nitrate-N (NO_3^-)	mg/L	NO_3^--N:19 NO_3^-:50	NO_3^--N:11 NO_3^-:50	5.5	4.9
13	Ammonia	mg/L	-	-	<0.01	<0.01
14	COD_{Cr}	mg/L	-	-	32	22
15	Sulphate ($SO4^{2-}$)	mg/L	-	(500)[4)]	22	32
16	Fluoride (F^-)	mg/L	1.5	1.5	4.8 (0.95)[8)]	0.11
17	Manganese (Mn)	mg/L	0.5	(0.4)[5)]	< 0.01	< 0.010
18	Iron (Fe)	mg/L	0.3	-	1.83	0.36
19	Calcium (Ca)	mg/L	-	-	21	30
20	Sodium (Na)	mg/L	-	(200)[2)]	55	13.8
21	Magnesium (Mg)	mg/L	-	-	<0.01	7
22	Aluminium (Al)	mg/L	0.2	0.2	<0.020	<0.020
23	Antimony (Sb)	mg/L	0.005	0.02	0.139	0.298
24	Barium (Ba)	mg/L	0.7	0.7	< 0.70	< 0.70
25	Cadmium (Cd)	mg/L	0.01	0.003	< 0.002	< 0.002
26	Chromium (Cr)	mg/L	0.05	0.05	0.30	<0.01
27	Copper (Cu)	mg/L	2	2	< 0.002	< 0.002
28	Lead (Pb)	mg/L	0.05	0.01	< 0.01	< 0.01
29	Mercury (Hg)	mg/L	0.001	0.006	< 0.001	< 0.001
30	Nickel (Ni)	mg/L	0.02	0.07	< 0.02	< 0.02
31	Selenium (Se)	µg/L	10	10	0.35	<0.04
32	Zinc (Zn)	mg/L	5	(3) [6)]	< 0.05	< 0.05
33	Cyanide (CN^-)	mg/L	0.05	(0.07) [5)]	< 0.002	< 0.002
34	Total Arsenic (As) [7)]	mg/L	0.05	0.01	0.002	0.002
	Soluble Arsenic (As) [7)]	mg/L	-	-	0.002	0.002
35	Standard plate count bacteria	MPN/ 100mL	-	-	120	4.1×10^2
36	E. coli	MPN/ 100mL	0	0	5.1×10^2	2.5×10^2
Remarks					3-point composite sample	3-point composite sample

1) Value for corrosion control in pipeline, 2) Value for taste, 3) Guideline value in the year 1984, 4) Recommended value from the viewpoint of gastrointestinal effects, 5) Guideline value in the year 2004, 6) Recommended value from the viewpoint of acceptability to consumers, 7) Analyzed in Japan, 8) Values from a supplementary survey conducted on Sep. 24, 2017.
PEQS: Punjab Environmental Quality Standards, 2016
Source: M/P Project

The further reference data is available for the water quality of: i) the RBC (the data obtained from the

New JK WTP (see Table 1-3)), ii) the RBC and Chenab River (the test conducted during the M/P Project, etc. (see Table 1-4)), and iii) the RBC and the JBC (see Table 1-4).

The characteristics of the raw water quality are i) large seasonal variations in water temperature (11 ~ 30 ˚C) and turbidity (20 ~ 1400 NTU), ii) high values of pH (7.6 ~ 8.7), iii) high values of alkalinity (70 ~ 120) in dry seasons, and iv) low values of ammonium, iron and manganese.

Table 1-3 Water Temperature, pH and Turbidity as Raw Water Quality at New JK WTP

	Season	Rainy season						Average
	Month	4	5	6	7	8	9	
Water temperature (°C)	Maximum	28.3	28.2	30.2	28.5	30.4	28.0	30.2
	Average	26.1	26.3	27.9	27.4	28.5	27.6	27.3
	Minimum	24.6	24.4	25.8	26.0	27.1	26.8	24.4
pH	Maximum	8.1	8.1	8.2	8.6	8.7	8.7	8.7
	Average	8.0	8.1	8.1	8.6	8.6	8.1	8.2
	Minimum	8.0	7.8	8.0	8.5	8.6	7.6	7.6
Turbidity (NTU)	Maximum	231	240	655	1436	1365	431	1436
	Average	153	142	276	603	571	187	322
	Minimum	101	32	92	298	221	102	32
	Season	Dry season						Average
	Month	10	11	12	1	2	3	
Water temperature (°C)	Maximum	26.9	22.3	17.5	15.1	20.4	22.9	26.9
	Average	26.1	18.9	15.1	13.3	16.4	21.4	18.5
	Minimum	24.8	17.2	12.7	11.2	13.4	18.9	11.2
pH	Maximum	7.9	8.7	8.3	8.5	8.4	8.6	8.6
	Average	7.8	8.1	8.1	8.2	8.3	8.1	8.1
	Minimum	7.7	8.0	8.0	8.0	8.2	8.1	7.7
Turbidity (NTU)	Maximum	109	77	140	91	125	130	140
	Average	76	48	44	52	39	88	58
	Minimum	45	31	22	28	20	26	20

Table 1-4 Water Quality Data Tested from the M/P Project (unit: mg/L)

Season	Date of Sampling	Alkalinity	Ammonium	Iron	Manganese
Source: RBC[*1]					
Wet Season	2016/9/23	70	< 0.01	1.83	< 0.01
Dry Season	2016/11/16	120	< 0.01	0.36	< 0.01
Source: Chenab River[*1]					
Wet Season	2016/9/23	110	< 0.01	0.32	< 0.01
Dry Season	2016/11/16	133	< 0.01	0.18	0.01
Source: Chenab River[*2]					
	2009	-	-	0.81 ~ 0.88	0.02
Source: JBC[*3]					
	2016	-	-	-	0.11
Source: RBC[*4]					
	2013 ~ 2016	-	0.1 ~ 0.5	-	-

Note [*1] Data Source: Report for Water Supply, Sewerage and Drainage Master Plan of Faisalabad, JICA 2016 - 2019

[*2] Chenab River is the source of JBC and RBC, Data Source: Environmental Monitoring of River Chenab, EPA Laboratory, Punjab 2009

[*3] Jang Branch Canal, Data Source: Feasibility Study for Extension of Water Resources for Faisalabad City Phase II, 2016

[*4] Rakh Branch Canal, Data Source: WASA-F Central Laboratory, 2013 - 2016

(5) Topography

In this preparatory survey, topographic survey was carried out at the Project sites. The survey results from the M/P Project are also utilized for the designing of the facilities.

More precisely, the topographic survey was carried out at the planning site of the intake mouth, the Old JK WTP, and the transmission and distribution mains. For the distribution centers, the data obtained during the M/P Project is used. These survey data are applied to the outline design of the facilities in the Project (see Appendix 7 (5)).

(6) Geology

In this preparatory survey, a geotechnical survey was carried out at the Project sites. The survey results from the M/P Project are also utilized for the designing of the facilities.

Two borings at the planning site for the pipe bridge of the transmission main, and two borings at the raw water reservoir A of the Old JK WTP were conducted. The survey included field investigations and laboratory tests. In addition, the data of four borings at the Old JK WTP and one boring in each distribution center obtained from the geotechnical survey in the M/P project are also utilized. Appendix 7 (2) includes the result of the surveys applied to the outline design of the facilities in the Project.

1-3 Environmental and Social Considerations

1-3-1 Environmental Impact Assessment

1-3-1-1 Project Components having Environmental and Social Impacts

The description of the facilities to be constructed in this project is summarized in Table 1-5.

Table 1-5 Components of this Project

Facility	Detail
Intake (10 MGD*)	Intake mouth, raw water distribution valve chamber
	Raw water pump station
WTP (5 MGD*)	Receiving and distribution tank
	Mixing tank, Flocculation tank, Settling tank
	Rapid sand filter
	Clear water reservoir
	Transmission pump station
	Waste water tank and sludge tank
	Sludge thickener
	Sludge extraction pump station
	Sludge drying bed
	Chemical building
	Administration building
	Power receiving and transforming, and generator house
	Electricity meter house
Distribution Center	Ground reservoir (2 ponds)
	Overhead reservoir (2 ponds)
Transmission and Distribution Main	Transmission main (4.1 km)
	Distribution primary main (1.2 km)
	Distribution secondary main (1.9 km)

Note: 5 MGD=22,700m^3/day, 10 MGD=45,500m^3/day

(1) Intake Facility

The water source for the project is the Rakh Branch Canal (hereinafter referred to as "RBC") which flows from the northeast to the southwest in the city. Since this is an irrigation canal, seasonal variations in water volume and water quality are small compared to rivers, but changes in water quality due to rainfall and changes in water volume due to irrigation canal management are present. The intake facility for an existing slow sand filter plant is installed on the RBC. A new intake will be constructed just next to the existing intake facility.

Regarding the water right to intake water from the irrigation canal, an agreement was renewed in July 2018 based on the agreement between the Irrigation Department and WASA-F in 1982. Therefore, the Irrigation Department has responded that any other application procedure related to water rights is unnecessary.

The irrigation canal is closed once a year for about three weeks in the winter for a maintenance purpose by the Irrigation Department. The separate operational plan shall be applied for supplying

water during this period.

(2) Treatment Facility

The new water treatment plant (hereinafter referred to as "WTP") of this project will be constructed within the premise of the existing slow sand filter plant where the raw water reservoir and rapid sand filter facility are to be demolished. Regarding the water treatment process at the new treatment plant, a rapid sand filter method is applied. The sludge generated during the operation will be transferred to the sludge drying beds treated by the sun and the natural air. The backwash wastewater will be recycled and retreated in the treatment process. To minimize the impact on the water supply service, the existing slow sand filter facility will continue to operate during the construction period. After the commencement of operating the new water treatment facilities constructed through this Project, the existing slow sand filter facility will not be operated.

(3) Water Distribution Facility

Ground reservoirs (hereinafter referred to as "GRs"), overhead reservoirs (hereinafter referred to as "OHRs") and pump stations will be constructed at 2 locations of the distribution centers. At these proposed distribution centers, there are existing OHRs and existing facilities which will be demolished and backfilled by the Pakistani side before constructing the new facilities. Although the land acquisition is not required as it is a public land, WASA-F is responsible to relocate 8 households of WASA-F and FDA staff from the premise to the other area and provide new housing.

(4) Transmission and Distribution Mains

The transmission main from the WTP to the distribution centers as well as the primary and secondary distribution mains from the OHRs of the distribution centers will be laid in this project.

1-3-1-2 Basic Environmental and Social Conditions

A survey of environmental and social considerations in the project area was conducted from April to May 2019. Based on the results, the basic environmental and social conditions are summarized in Table 1-6.

Table 1-6 Overview of Environment and Society

Overview		
Natural Environment	Area Overview	The target area of this project is the central area of Faisalabad City. Faisalabad District is located in the northeastern part of Punjab Province at an altitude of 184m. Faisalabad is known for being endowed with the most fertile land in Punjab Province.
	Climate	The climate of Faisalabad City belongs to a high temperature dry zone. In the rainy season (monsoon season) from July to August, the rainfall is more than half of the annual precipitation of 375mm. The average annual temperature is 17 to 32 ℃ and June is the hottest period of the year, often recording the highest temperature above 4℃. (Source: Faisalabad climate data, 2011)
	Topographic and Geologic Features	The target area is located in the low Rachana plains between the Chenab River and the Ravi River, and is on slightly higher elevation than the surrounding area. The topography is flat and gently sloped from northeast to southwest.
	Nature Reserve	No nature reserves exist in or near the target area.
	Ecosystem	Since Faisalabad is a fertile land, a wide variety of fauna and flora can be found, but there

Overview		
		are no rare or endangered fauna or flora. Fauna and flora commonly found in the target area are: (a) Plants: Kikar (Accasia nilotica), Eucalyptus (Eucalyptus camaidulensis), Shisham (Dalbergia sisso); (b) Animals: cat (Felissilvestris), cattle (Bos Taurus), domestic goat (Capra hicus); (c) Birds: crow (Corvus spp.), pigeon (Columba livia), sparrow hawk (Accipter nisus); (d) Insects: butterfly (Phopalocera), cricket (Grylloralpabrachyptera).
Environmental Pollution	Air Pollution	Air pollution is significant due to exhaust discharged from factories and vehicles. Concentrations of SO_2, NOx and $PM_{2.5}$ exceed standards of the Punjab Environmental Quality Standards (PEQS).
	Water Contamination	Due to infiltration from the wastewater canals of Paharang Drain and Madhuana Drain inside of Faisalabad City, groundwater around the wastewater canals are contaminated. Groundwater in some areas has high salinity and the TDS of Madina Town was 1,790 mg/L, exceeding the WHO water quality guideline value (1,000 mg/L). (Source: WASA-F laboratory, 2017)
	Noise and Vibration	Faisalabad City has noise and vibration problems due to traffic and construction works. The noise level at the west side of the city is 48 dBA, which is below the regional environmental standard PEQS value of 75 dBA. (Source: EIA report of 500 kV Faisalabad Grid Station and Transmission Line Project,2016)
Social Environment	Population	Faisalabad City is the third largest city of Pakistan, and according to the 2017 Census, the population of Faisalabad District is about 7.9 million and that of Faisalabad City is about 3.2 million. (Source: Provincial Wise Provisional Results of Census, 2017)
	Ethnic Groups and Religion	The main ethnic groups in Faisalabad District are Arain, Baluch, Bodla, Chishti, Hans, Johiya, Kathia, Khagga, Kharal, Khichi, Langrial, Syal, Waince, Tarohly and Wattu. The main languages are Punjabi and Urdu, and 97% of the population is Muslim with the rest being Hindu and Christian.
	Administration	Faisalabad District consists of 8 towns (Lyallpur, Jinnah, Iqbal, Madina, Chak Jhumra, Sammundri, Jaranwala and Tandlianwala). Under the towns are the smallest administrative unit called the Union Council (UC), where there are 123 urban units and 166 rural units for a total of 289 UCs. (Source: FPUSP, 2015)
	Economic Activities	The main industry of Faisalabad is the textile industry which contributes about 15% of domestic GDP as the third largest industrial city after Karachi and Lahore.
	Health and Hygiene	In the city, there are 10 public hospitals and about 20 clinics. According to the social survey conducted during the M/P, about 30% of the respondents had experience with waterborne diseases. (Source: JICA Preparatory Survey Team, 2017)
	Water Supply	The water supply service of WASA-F is limited to about 6 hours a day due to lack of water sources. Since the water supply has low pressure and shortage in water amount, many households use groundwater pumped up to a high water tank.
	Sewerage and Night Soil Treatment	The existing sewage drainage facility has been in service for many years and its capacity is small and can overflow due to rainfall. Sewage overflows into the rainwater drainage channel and the only sewage treatment plant in the city does not have sufficient capacity, and untreated sewage is used as irrigation water.
	Solid Waste	According to Faisalabad City Government, which is in charge of solid waste management, the amount of solid waste generated is about 1,250 ton/day. Since an appropriate solid waste management system is not yet established, the generated waste is dumped at waste sites around the city. (Source: City District Government of Faisalabad, 2017)
	Power	According to Faisalabad Electric Supply Company (FESCO), 1.8 million households are receiving power. Of the power supplied by FESCO, 55% are for domestic households, 30% for industries and 8-10% for well pumping. (Source: Punjab Development Statistics, 2015)
	Traffic and Roads	Due to increase in traffic in Faisalabad City, air pollution and noise pollution have been significant.
	Educational Institutions	Faisalabad is one of the leading educational cities in Pakistan with many universities and colleges specializing in science, technology, IT, engineering, medicine, nuclear power and agriculture.
	Cultural and Heritage Sites	Cultural, historic and heritage sites are not registered in the target area.

(1) Natural Environment

1) Overview of the Project Area

The proposed project area lies in Faisalabad City where the proponent (Water and Sanitation Agency Faisalabad: WASA-F) aims to carry out project activities. The proposed geographical locations for the

project are Jhal Khanuwana, Abudulah Pur and Madina Town in Faisalabad City.

Faisalabad was previously known as Lyallpur and established as a Mandi Town in 1895 as part of the program for colonization of West Punjab. It was formerly a part of Tehsil Jhang of Multan Division. Because of the fact that most of the area was un-cultivated and there were no regular crops, it served the purpose of only a meadow for the cattle of the indigence. The opening of Lower Chenab Canal in 1892 and its extension to the area in the form of Rakh Branch, Jhang Branch and Gugera Branch coupled with the introduction of a canal irrigation system, brought the whole area under regular cultivation. It was laid down on a parcel of land measuring 110 acres in a square form with eight bazaars radiating from the central Clock Tower.

The city of Faisalabad is situated in the center of the lower Rachana Doab, the area between Chenab and Ravi rivers, which has a mild slope from Northeast to Southwest with an average of about 0.2 to 0.3 meter drop per kilometer or about 1 to 1.5 feet per mile. The city is situated at an elevation of more or less 180 meters above sea level. The topography is flat or gently slopped.

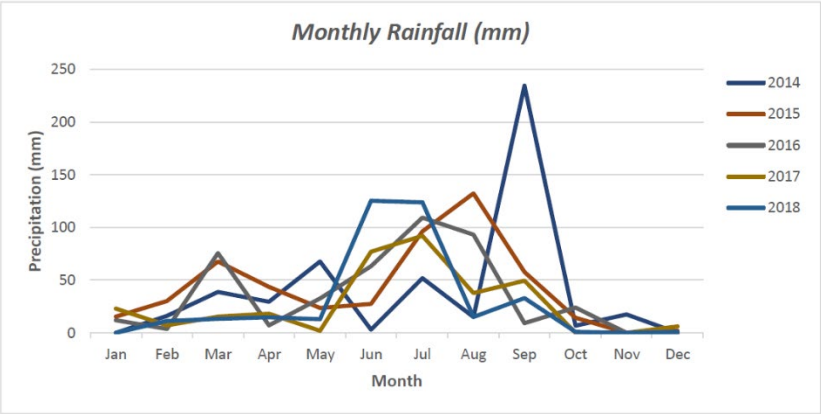
2) Climate

a) Climatic Conditions

The proposed project area lies in the arid climate region. It is located in the region that encounters four seasons; the hot summer starts from May and continues till July, monsoon starts from July and continues to September while the winter season ends in February starting from November and spring season lasts for two months from March to April. In summer, the temperature exceeds 40 °C.

b) Rainfall

The monthly rainfall data from 2014 to 2018 shows a variation between 0 mm and 234.5 mm.



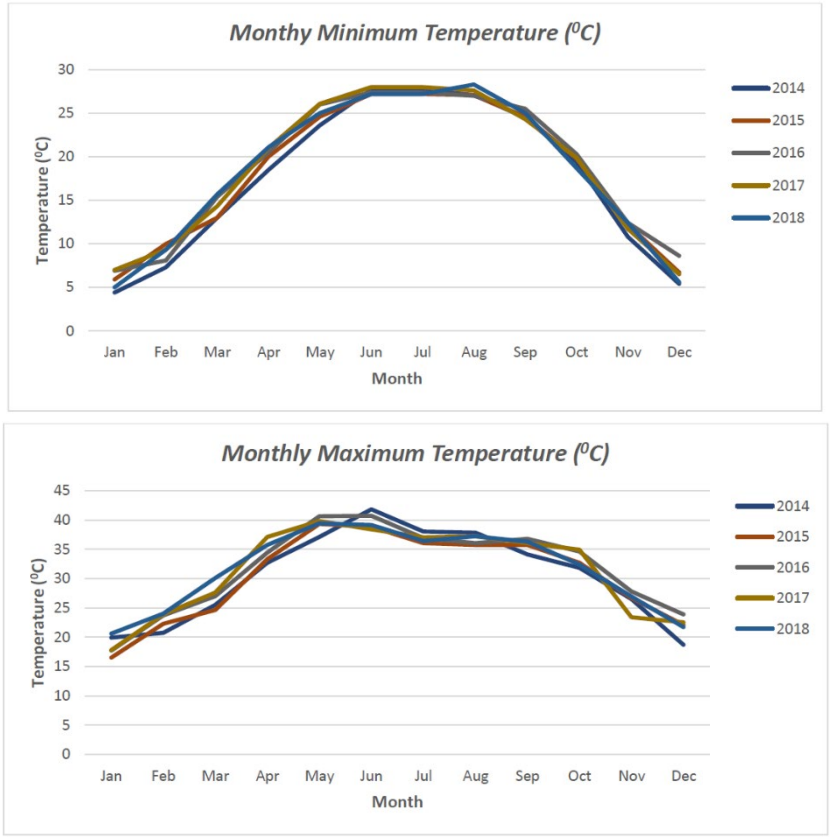
Source: Pakistan Meteorological Department

Figure 1-5 Monthly Rainfall from 2014 to 2018

c) Temperature

The ambient temperature of the proposed project area varies from summer to winter. The change in temperature has a direct influence on the environment of the project area. Hot and dry conditions during the summer season changes the air quality by an increase in particulate matters due to drying of

road pavements and open soil. According to the five years data (2014-2018), the mean monthly minimum temperature in the area varies from 3.5 to 28.6 C° and mean monthly maximum temperatures range between 16.6 °C and 41.9 °C.



Source: Pakistan Meteorological Department

Figure 1-6 Mean of Monthly Minimum and Maximum Temperatures

3) Topography and Geology

The city is located on the "Bar Upland" which is a relatively older alluvium deposit as found in the central part of the Doab. Because of its elevation above the bordering flood plains, the upland is generally beyond the reach of flood spills, which is the significant physiographic feature of the alluvial plain. Like other Punjab plains, the alluvium is quaternary and has been deposited on semi-consolidated tertiary rocks or on a basement of metamorphic and igneous rocks of the Precambrian age. It emanates from the mountain ranges of the north and has been deposited by the present and ancestral streams. The deposition is predominantly fluviatile sediments.

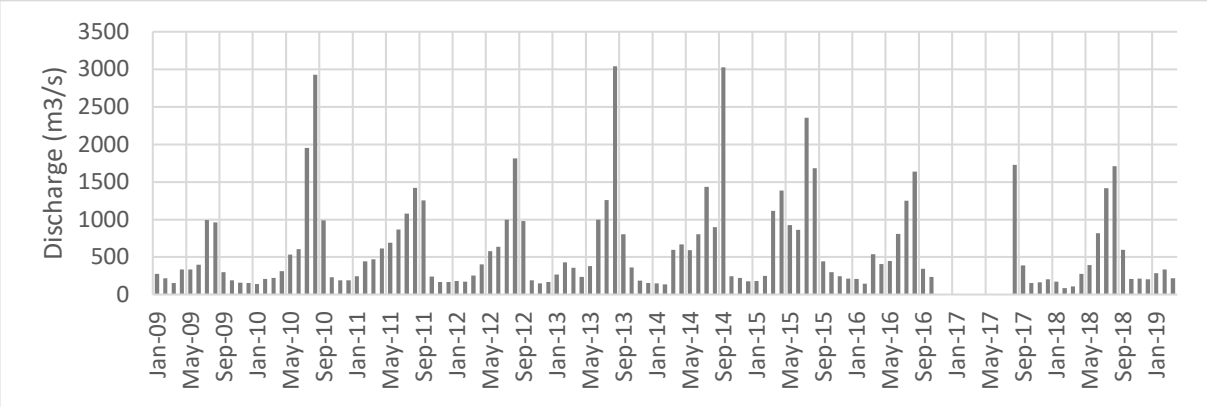
4) Water Source

a) Surface Water

Surface water sources are usually exposed to the surface of the earth in mobile and immobile situations which include snow-clad mountains, rivers, non-river streams, rain, sleet, wetlands and oceans. Surface waters are highly susceptible to natural and anthropogenic derived contamination in terms of

chemical and biological contamination and thus are not used for sensitive applications such as drinking directly, unless it is pre-treated.

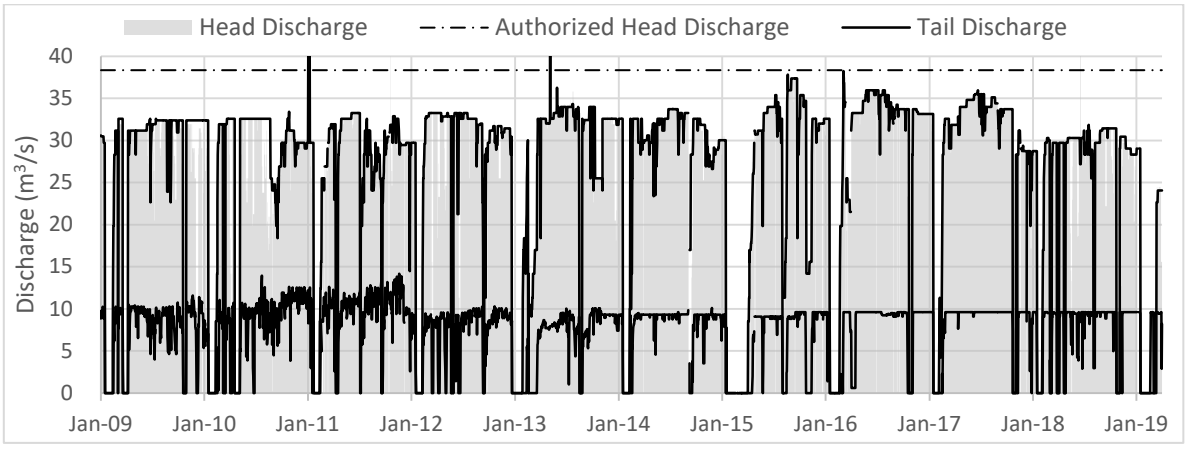
Among surface waters, near the project extremities there is a distributary canal (Rakh Branch) which is used for irrigation purposes and the same will be used in this project for water intake and treatment for drinking purpose. Past water volume fluctuations in the Kanki Head Works in the Chenab River, upstream of the RBC, and RBC are shown below.



Note: No records from November 2016 to January 2017
Source: Department of Irrigation

Figure 1-7 Average Discharge at Kanki Head Works in the Chenab (2009–2019)

The Chenab River has an average discharge of at least 100 m^3/s even in the dry season, although there is significant seasonal variation. On the other hand, the RBC has discharges of around 30 m^3/s upstream and 10 m^3/s downstream throughout the year. The flow rate of the water source is adequate for the design intake flow of approximately 0.55 m^3/s as described in "2-2-2-3 Intake and Raw Water Transmission Facilities".



Source: Department of Irrigation

Figure 1-8 Head and Tail Discharges of the RBC (2009—2019)

b) Groundwater

Groundwater resources are found hidden and camouflaged under the surface of the earth in mobile

and immobile states, and exist as shallow and deep wells, confined and un-confined aquifers, and springs. Ground resourced waters are not easily susceptible to natural and anthropogenic derived contaminations caused by chemical/biological pollution and thus is directly used for sensitive applications such as drinking even if it is untreated. Main visible pollutants such as turbidity, color and odor usually remain absent in ground extracted waters. Invisible biological contaminants such as bacteria, protozoa and viruses are also not expected in sub-surface water regimes unless it is contaminated by unexpected upheaval. The water table normally exists 40 to 90 ft below the ground level and contains high level of salinity in the project area.

5) Natural Protected Areas

Natural protected areas do not exist in the target area or its surroundings.

6) Ecosystems

Faisalabad consists of fertile land with a wide variety of fauna and flora, but rare or endangered fauna and flora are not found.

a) Flora

Based upon observations during the field visit, many species of plants were observed in the project area. The floral species in the project area are given in the following table.

Table 1-7 Flora Species found in the Project Area

Sr. No.	Common Name	Scientific Name	IUCN* Category
1	Kikar	*Acacia nilotica*	LC
2	Eucalyptus	*Eucalyptus camaldulensis*	NT
3	Jaman	*Syzygium cumini*	LC
4	Shisham	*Dakbergua sissoo*	—
5	Neem	*Azadiraccta indica*	LC
6	Sirris	*Akbuzzua lebbek*	—
7	Popular	*Salicaceae*	LC
8	Toot (Mulberry)	*Morus alba*	LC
9	Palm	*Arecaceae*	—
10	Willow	*Salix babylonica*	—
11	Simbal	*Bombax cieba*	—
12	Papeeta	*Carica papaya*	DD

Note: IUCN Category; DD: Data Deficient, LC: Least Concern, NT: Near Threatened, —: Not on the List

Natural Shrubs and Herbs

Natural shrubs and herbs found in the project area include Banafsha (Viola odorata Linn), Karir (Capparis apnylla), Aak (Calotrupis procera) and Kana (Saccharum bengalensis). Besides these, natural vegetation present in the area include: Babool (Vachellia nilotica, LC), Khabbal (Cynodon dactylon), Sooraj Mukhi (Helianthus, LC), Lamb (Aristida depressa), Gorkha (Lasiurus sindicus), Batthu, Mallah and Thohar.

b) Fauna

The main fauna of the project area comprises of mammals, amphibians and birds.

(i) Mammals

Although most of the project area comprises of urban area with high population density, presence of grass shrubs and some vegetation is observed due to which common mammalian species such as Stripped Palm Squirrel, House Cat (Felis catus), common bat (Eptesicus serotinus, LC), House Mouse (Mus musculus, LC) and House Rat (Rattus, LC) are found. Other animals such as dogs, donkeys, mule etc. can easily be observed. All of these species are commonly found in the project area as well as in the country and significant threats cannot be expected from any of their activities.

(ii) Amphibians

Amphibians such as Bullfrog (Hoplobatrachus tigernius, LC), Pahari tidda maindak (Fejervarya limnocharis, LC) and Indus valley toad (Buffo stomaticus) are present in the nearby canals during the rainy season.

(iii) Birds

House sparrow (Passer domesticus, LC), House crow (Corvus splendens, LC) and Mynah (Acridotheres tristis, LC) are the most commonly sighted birds in the project area. In addition, the following birds have also been observed in the area.

Table 1-8 Fauna Species found in the Project Area

Sr. No.	Common Name	Scientific Name	IUCN* Category
1	Black Drongo	*Dicrurus macrocercus*	LC
2	House Sparrow	*Passer domesticus*	LC
3	Dove	*Columbidae*	—
4	House Crow	*Corvus splendens*	LC
5	Titeeri	*Vanellus indicus*	LC
6	Bateer (Quail)	*Coturnix coturnix*	LC
7	Pigeon	*Columba livia*	LC
8	Parrot	*Psittacula krameria*	LC
9	Domestic Cock	*Gallus Gallus*	LC
10	Black Eagle	*Ictinaetus malaiensis*	LC
11	Little Egret	*Egretta garzetta*	LC
12	Black Kite	*Milvus migrans*	LC
13	Common Myna	*Acridotheres tristis*	LC

Note: IUCN Category; DD: Data Deficient, LC: Least Concern, NT: Near Threatened, —: Not on the List

(2) Environmental Contamination and Pollution

1) Air Pollution

The site for the water treatment plant lies along the RBC at Samundari Road. To the East of the site is Jhal Flyover that connects the outskirts area to the inner city where traffic is very heavy. Also, there is a market at Fateh Abad which is near the project area. In the North, the Government Transport Service (GTS) is operating with every kind of vehicles such as buses, wagons, rickshaws, motor bikes, motor cars and motor cycle rickshaws. Furthermore, near the Abudulah Pur OHR, the Abudulah Pur flyover is jammed with various kinds of vehicles. As such, no viable air contaminants are expected in

the air-shed of the proposed project site, but most common airborne contaminants that are likely to be emanated from the aforementioned sources giving rise to very low magnitude of these contaminants include smoke, CO, NO, NO_2, SO_2 and particulate matter.

The study team conducted an ambient air quality monitoring during the field survey, and the monitoring values of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10}) were compared with standards set by Punjab Environmental Quality Standards (PEQS). It should be noted that the PEQS was approved by the Punjab Government in August 2016 and adopts the same standards as the National Environmental Quality Standards for Air Pollution (NEQSAA), which were introduced in 2010. The ambient air quality monitoring was conducted for 24 hours at the Old JK WTP site during June 22-23, 2019 while the same was carried out at Madina Town No. 2 OHR during June 23-24, 2019. In the 24 hours air monitoring, CO was found to be 0.98mg/m^3 at the Old JK WTP while it was 0.52 mg/m^3 at Madina Town No. 2 OHR. The results show that these well comply with the PEQS guideline limit of 5.00 mg/m^3, while the results of the 24 hours air monitoring pattern on NO_2 and SO_2 indicate that they are within the safe limit as per PEQS guidelines. Moreover, particulate matter (PM_{10}) was recorded as 136.67 µg/m^3 at the Old JK WTP and 122.38 µg/m^3 at Madina Town No. 2 OHR which comply with PEQS defined limit of 150 µg/m^3 during 24 hours of measurement.

2) Water Quality Contamination

In order to assess the quality of ground and surface waters in the project area, the physical, chemical and microbiological parameters were analyzed to determine the concentrations of components. Water samples from the Old JK WTP were collected on June 23, 2019 while at Madina Town No. 2 OHR, on June 24, 2019. The test results show that all the chemical parameters are within limits defined by PEQS in all the tested samples of ground and surface waters. However microbiological parameters show presence of total coliforms and E. coli in surface water samples collected at RBC which is not surprising because as mentioned earlier, surface water is more susceptible to pollutant from anthropogenic sources. There are numerous factors that may be responsible for the presence of coliforms including disposing domestic/animal waste and storm water runoff into surface water channels.

3) Noise and Vibration

In the absence of reliable noise data, noise monitoring was conducted at five locations during June 22-24, 2019. The noise levels were found within the range of 55.3-85.7 dBA at day time while they were from 35.63 to 37 dBA at night time. Some results of day time noise measurements are higher than the permissible limit of 75 dBA (PEQS) mainly because of heavy traffic at day time.

(3) Social Environment

1) Population

Faisalabad City is the second largest city of Punjab Province and the third largest city of Pakistan.

According to the 2017 Census, the population of Faisalabad city is about 3.2 million with an annual population growth rate of about 3.3%.

2) Ethnic Groups and Religion

Faisalabad has many ethnic groups and the main ethnic groups are Arain, Baluch, Bodla, Chishti, Hans, Johiya, Kathia, Khagga, Kharal, Khichi, Langrial, Syal, Waince, Tarohly, and Wattu. The main languages are Punjabi and Urdu. As for religion, 97% of the population is Muslim and the rest are Hindu and Christian.

3) Medical and Public Health Facilities

Besides a District Headquarter Hospital at Faisalabad, there are Tehsil headquarter hospitals at each Tehsil headquarter along with Basic Health Units (BHU's) and Rural Health Centers (RHC). Also, there are a number of private clinics and small hospitals present in different locations. Names of some renowned institutions in Faisalabad city are given below.

Table 1-9 Medical Facilities in Faisalabad

Sr. No.	Name of Institution	Sector
1.	Allied Hospital	Government
2.	General Hospital, Ghulam Muhammad Abad	Government
3.	General Hospital, Saman Abad	Government
4.	Children Hospital, Jhang Road	Government
5.	Civil Hospital	Government
6.	Pakistan Institute of Nuclear Medicines (PINUM)	Government
7.	Faisalabad Institute of Cardiology (FIC)	Government
8.	Social Security Hospital	Government
9.	Shifa International Hospital	Private
10.	National Hospital	Private
11.	Aziz Fatima Trust Hospital	Private
12.	Mian Muhammad Trust Hospital	Private
13.	Sarriya Majeed Trust Hospital	Private
14.	Sahil Hospital	Private
15.	Chiniot General Hospital	Private
16.	Faisal Hospital	Private
17.	St. Rapheal Hospital	Private
18.	Mujahid Hospital	Private
19.	Crescent Hospital	Private
20.	Independent Hospital	Private

Common Diseases in the Project Area

Non-provision of safe drinking water and insufficient fulfilment of nutritional requirements have a significant influence on the health status of the local population. The diseases reported in the project area are not much different from other parts of the country. Hepatitis, diabetes, malaria, typhoid, blood pressure disorders, diarrhea and gastro related diseases are commonly occurring in the area.

Health condition is one of the major determinants of a society's social development and quality of life. Healthy manpower is imperative for economic growth. Good health is a basic social value of great

importance to the individual and society. Survey confirmed that health facilities in the form of basic health units, private clinics and government and private hospitals were available within 3-4 km distances from their residences. Due to difference in affordability levels of residents, the majority of low earning families prefer government hospitals such as the Civil Hospital because treatment cost there is not very high. However, due to the higher number of patients, the facilities provided do not meet the expectations of patients in many cases, so satisfaction with the services is not very high. Although private hospitals are easily accessible, the charges for treatment are too expensive to be afforded by most of the residents.

4) Water Supply

Groundwater of Faisalabad city is highly brackish, so it is not used for drinking purpose. However, it is used for utility water, washing and bathing. Water supply services are provided by WASA-F and in the project area, many people had WASA water connections. However, that water is not being used for drinking but only as utility water. In some areas, due to odor, many residents are unsatisfied with the water quality, and stop utilizing the water supplied by WASA-F.

For drinking purpose, people buy water from third party water suppliers whose main source is mostly tube wells or hand pumps installed along the canals. They fill cans there and transport them house to house on donkey carts or motorcycle carriages selling can water costing around 25 PKR (about 16 JPY) /can (about 30 liters). Some respondents reported that they fetch water from private water filtration plants available in their area.

Overall response from the project area reflected water quality as not satisfactory. Therefore, they welcomed the project without any objections when objectives of the proposed project were explained.

5) Sewage and Nightsoil Treatment

There are existing sewerage facilities in the city, but they are outdated and have low flow capacity. There is one wastewater treatment plant, but it does not have sufficient treatment capacity and the untreated sewage is used for irrigation. Sewage flows into the storm drains in the town and the drains join the Chenab or Rabi River downstream. About 92% of the residents of the project area confirmed the availability of sewerage service. The remaining 8% stated that at the moment the sewerage facility is unavailable in their area, but sewerage pipes have recently been laid and the service will soon be made available to them.

Satisfaction with sewerage and drainage services in terms of quality was medium to low. Often the issue with services occurs in the rainy seasons when rainwater is not properly drained from the streets leading to complaints from the residents.

6) Solid Waste

Concerning the availability and quality of solid waste management, almost 30% of the residents responded that solid waste is collected but not on a regular basis. There were heaps of waste in some of the surveyed areas suggesting that solid waste is not collected for a long time causing serious health

issues. Residents in some areas burn their solid waste in open spaces at some distance from their houses. Around 60% of the residents expressed satisfaction with regular collection and disposal of waste.

7) Economic Activities

Faisalabad City is the second largest city in Punjab and the third largest city in Pakistan. It is the fastest growing city in the country, with a strong export base in the textile industry. Faisalabad City was developed as an industrial town in the late 1930s. After independence, the city entered a phase of remarkable industrialization. Year by year, it was gradually transformed into a major industrial center of Pakistan with highways, railways, railway repair yards, processing mills, and engineering works. The Faisalabad City of today is known as a strong industrial base with many factories engaged in the manufacture and dyeing of textiles and the production of fertilizers, industrial chemicals, pulp and paper, printing, industrial goods, agricultural equipment, and so on. According to the Faisalabad Chamber of Commerce & Industries, in 2013, the export of textile products from the city totaled about 5 billion USD per year and exports from other sectors contributed about 1 billion USD.

About 2,000 factories and public facilities such as hospitals operate in Faisalabad City. Among them, about 528 facilities contribute significant amounts of pollution to wastewater without any proper treatment. These facilities are under the supervision of the Environmental Protection Agency in Faisalabad (EPA-F). Industrial effluent is discharged into storm drains and does not flow into the irrigation canal, the source of the water supply. The numbers of factories and public facilities are summarized in the table below.

Table 1-10 Number of Major Factories and Public Facilities in Faisalabad

No.	Type of Factory	Number	Percentage (%)
1	Textile, dyeing	350	66.3
2	Ice making, dairy product manufacturing	48	9.1
3	Milling	40	7.6
4	Hospital and medical facilities	37	7.0
5	Cotton cleaning and breaching	20	3.8
6	Soap	10	1.9
7	Meat processing	7	1.3
8	Sugar	5	0.9
9	Pulp and paper	5	0.9
10	Ghee and cooking oil	3	0.6
11	Fertilizer, etc.	3	0.6
	Total	528	100%

Source: Detailed Planning Survey on the M/P Study 2016 (based on interview to EPA-F)

8) Traffic and Roads

Faisalabad being the third largest city of the country is connected through air, road and railway links with other parts of the country. The national carrier Pakistan International Airlines (PIA) runs almost daily flights between Faisalabad and Karachi. It also operates to other places in Middle East. Faisalabad is also linked through railways to Wazirabad and Khanewal (two important junctions on the

main Peshawar-Karachi railway line). The construction of Motorway M-4 (Pindi Bhattian - Faisalabad - Multan) has reduced traveling time from Faisalabad to the Federal Capital (Islamabad), Provincial Capital (Lahore) and Multan.

9) Educational Institutions

Educational facilities in Faisalabad are mainly being provided by the Government of Punjab, the city government and the private sector as well as voluntary organizations. Punjab School Education Department manages the government schools within all of Punjab region. Faisalabad has significant research and educational institutions operated by public and private sectors as listed below.

Table 1-11 Educational Institutions in Faisalabad

Sr. No.	Name of Institution	Sector
1.	University of Agriculture Faisalabad (UAF)	Government
2.	Government College University (GCU)	Government
3.	Punjab Medical and Dental University	Government
4.	Nuclear Institute for Agriculture and Biology (NIAB)	Government
5.	National Institute for Biotechnology and Genetic Engineering (NIBGE)	Government
6.	Ayub Agricultural Research Institute	Government
7.	Punjab Forestry Research Institute	Government
8.	National University of Textile Engineering (NTU)	Government
9.	University of Engineering and Technology (UET) Faisalabad Campus	Government
10.	Virtual University (VU) Pakistan	Government
11.	NFC Institute of Engineering & Fertilizer Research	Government
12.	University of Sargodha, Faisalabad Campus	Government
13.	University of Faisalabad	Private
14.	National University of Computer and Emerging Sciences (FAST)	Private
15.	Ripah International University, Faisalabad Campus	Private
16.	Independent Medical College	Private
17.	University of Central Punjab, Faisalabad Campus	Private

10) Cultural, Historical and Heritage Sites

Through the field survey, the presence of numerous small mosques and the Jamia Masjid for Friday prayers were confirmed in the project area. Also, there is a Christian cemetery along Sudan Road. There are no temples and no historical buildings or heritage sites in the project area.

1-3-1-3 Institutional Structure for Environmental and Social Consideration of Pakistan

(1) Environmental Laws and Regulations

The laws and regulations related to environment of Pakistan and Punjab Province are summarized in the table below.

Table 1-12 Environmental Laws and Regulations of Pakistan and Punjab Province

Category	Laws and Regulations
Environmental Protection (Pakistan)	Pakistan Environmental Protection Ordinance, 1983
	Pakistan National Conservation Strategy (NSC), 1992

Category	Laws and Regulations
	Pakistan Environmental Protection Act (PEPA), 1997
	National Environmental Quality Standards (NEQS), 2000
Environmental Protection (Punjab Province)	Punjab Environmental Protection Act, 2012
	Punjab Environmental Quality Standards (PEQS), 2016
IEE/EIA	Pakistan Environmental Assessment Procedure, 1997
	Guidelines for Preparation and Review of Environmental Reports, 1997
	Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations, 2000
Land Acquisition and Resettlement	Land Acquisition Act (LAA), 1894
	Punjab Land Acquisition Rules, 1983
	Project Implementation and Resettlement of Affected Persons Ordinance, 2001

1) Laws and Regulations on Environmental Protection

Legal developments and policy decisions for environmental protection have been promoted in Pakistan from the late 1970's. A summary of the major laws and policies follows.

a) Pakistan Environmental Protection Ordinance, 1983

The Pakistan Environmental Protection Ordinance is the first ordinance with a specialized focus on environmental protection in Pakistan. After enacting this ordinance, the Federal Environmental Protection Agency was founded in 1984. According to the ordinance, deliberations on Pakistan's environmental policy in the latter half of the 1980s led to the drafting of the National Conservation Strategy in 1992. In addition, the county environmental protection offices were established in accordance with this ordinance at this time.

b) National Conservation Strategy, 1992

The National Environmental Conservation Strategy 1992 is a fundamental policy document for environmental problems in Pakistan approved by the Pakistan government. This Strategy consists of 14 key subsidiary strategies to be carried out over a 10-year period of planning and implementation. Some of the key strategies focus on:

- Maintaining the soil environment in upland fields
- Protecting the catchment environment
- Maintaining biodiversity
- Managing municipal waste
- Protecting cultural heritage

Rather than stating individual mitigation measures, the National Environmental Conservation Strategy enumerates the principles of protection, management, and conservation of the environment. The Biodiversity Action Plan was formulated based on the principles of this Strategy in 1992.

c) Pakistan Environmental Protection Act (PEPA) 1997

The Pakistan Environmental Protection Act (PEPA) 1997 is a comprehensive environmental protection law enacted in place of the earlier Pakistan Environment Protection Ordinance 1983. The Act provides a framework for the implementation of the upcoming National Environmental Conservation Strategy 1992. The objectives of the Act include the following: protection and

conservation of species, habitats of wildlife and biodiversity; conservation of renewable resources; establishment of air quality, water quality, and soil quality standards; establishment of environmental courts and appointment of environmental judges; the provision for implementation of the IEE and EIA; and promotion of residents' education and awareness through mass media on environmental issues.

PEPA 1997 authorizes the government to compose laws and regulations for environmental protection and deals with a wide range of environmental problems such as air, water, soil, sea area, noise and hazardous waste. It also stipulates penalties for violations of its own articles.

d) National Environmental Quality Standards (NEQS) 2000

The National Environmental Quality Standards (NEQS) 2000 are standards established to control environmental pollution and have been enacted for domestic wastewater, factory wastewater, factory exhaust gas, noise and gas emissions from automobiles, and drinking water. The NEQS were issued in 1993 and revised in 1995 and 2000.

e) Punjab Environmental Protection (Amended) Act, 2012

The Punjab Environmental Protection Act 1997 (Amended 2012) is a comprehensive legislation that provides the legislative framework for the protection, conservation, rehabilitation and improvement of the environment. The Act defines the environment as follows: (a) air, water and land; (b) all layers of the atmosphere; (c) all organic and inorganic matters and living organisms; (d) the ecosystem and ecological relationships; (e) buildings, structures, roads, facilities, and works; (f) all social and economic conditions affecting community life; and (g) the interrelationships between any of the factors specified in sub-clauses (a) to (f).

The notable points of the law are:

- No proponent of a Project shall commence construction or operation unless the proponent has filed an EIA with the Provincial Agency designated by the Provincial EPAs and has obtained approval;
- Establishment and formation of the Punjab Environmental Protection Council;
- Prohibition of certain discharges and emissions;
- Punjab Environmental Quality Standards (PEQS) for wastewater, air emissions and noise; and
- The Provincial Government can issue notices and enforce them to protect the environment.

In the recent amendment of 2012, the federal government grants legislatives powers related to the environment and ecology to the provincial governments. The provinces are required to enact their own legislation for environmental protection. The Government of Punjab is in the process of drafting new provincial rules and regulations for the environment. Other amendments include increases in the penalties for violations. The amended amounts of penalties are described in the Punjab Environmental Protection (Administrative Penalty) Rules 2013. The penalty for excessive emission of pollutants or importation of hazardous wastes, for example, was increased from a minimum of 1,000 PKR to 10,000 PKR for every day the contravention continues.

The Environmental Protection Department (EPD) / Environmental Protection Agency (EPA) and Government of Punjab (GoPb) are the concerned authorities of the Project. It is an important task that this Act functions properly for improvement of environmental administration.

f) Punjab Environmental Quality Standards (PEQS), 2016

The PEQS 2016 specify the following standards:

- Maximum allowable concentrations of pollutants in municipal and liquid industrial effluents discharged into inland waters, sewage treatment facilities, and the sea.
- Maximum allowable concentrations of pollutants (16 parameters) in gaseous emissions from industrial sources.
- Maximum allowable concentrations of pollutants (2 parameters) in gaseous emissions from vehicle exhaust and noise emission from vehicles.

PEQS have also been issued for drinking water, ambient air, exhaust and noise from motor vehicles, municipal and liquid industrial effluents, treatment of liquids, and disposal of biomedical waste.

2) Laws and Regulations on Environmental Impact Assessment

a) Pakistan Environmental Assessment Procedure (1997)

The Federal Environmental Protection Agency published the following guidelines on the implementation of environmental assessment and environmental management of different development projects.

- Policies and procedures for document preparation, reviews, and approvals for environmental assessment, 1997
- Guidelines for preparing and reviewing reports on the environment, 1997
- Guidelines on consultations with inhabitants, 1997

b) Guidelines for Preparation and Review of Environmental Reports, Government of Pakistan (1997)

The guidelines on the preparation and review of environmental reports specify the following for project proponents:

- The nature of the information to be included in environmental reports
- The minimum qualifications of the appointed EIA conductors
- The need to incorporate suitable mitigation measures at every stage of project implementation
- The need to specify monitoring procedures

The Terms of Reference (TOR) for the reports are to be prepared by the project proponents themselves. A report must contain baseline data on the project area, a detailed assessment thereof the project area, and mitigation measures.

c) Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations, 2000

The Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations 2000, a legislation developed by the Pak-EPA under the powers conferred upon it by the Act, provides the necessary details on the preparation, submission, and review of an IEE and EIA. One of the main components of the Regulations is categorization of the projects/schemes for an IEE and EIA. Projects/schemes have been classified on the basis of the expected degree of adverse environmental impacts. Project types listed in Schedule I are designated as potentially less damaging to the environment, while those listed in Schedule II are designated as having potentially serious adverse effects. Schedule I projects/schemes require an IEE to be conducted, provided they are not located in environmentally sensitive areas. For the Schedule II projects/schemes, conducting an EIA is necessary. In the case of a water supply facility and water purification plant construction project, for example, a project with a total cost of less than PKR 25 million is categorized as Schedule I of the Regulation, requiring an IEE, and a project costing more is categorized as Schedule II, requiring an EIA.

(2) Environmental Administration

The Ministry of Environment headed by a Federal Minister was formerly the main responsible authority for policymaking on environmental protection in Pakistan. After the 18th Amendment of the Constitution in 2010, however, the environmental responsibility was shifted to the provincial government. The organizations related to environmental administration of Faisalabad are summarized below.

1) Ministry of Environment

The Ministry of Environment is the main responsible organization for environmental administration in Pakistan. Under the Pakistan Environmental Protection Act, 1997 (PEPA 1997), the Ministry of Environment works in collaboration with the Pakistan Environmental Protection Council (PEPC) and the federal and provincial Environmental Protection Agency (EPA) or Environmental Protection Department (EPD). EPD was created in Punjab as a body to grant environmental approvals or detect pollution separately from the EPA. PEPC and the Federal Environmental Protection Agency (Pak-EPA) are primary responsible for administering the provisions of PEPA 1997. PEPC oversees the function of the Pak-EPA.

2) Pakistan Environmental Protection Council（PEPC）

The functions and powers of PEPC include formulation of national environmental policy, enforcement of PEPA 1997, approval of National Environmental Quality Standards (NEQS), incorporation of environmental considerations into national development plans and policies, and the provision of guidelines for the protection and conservation of biodiversity in general and the conservation of renewable and non-renewable resources.

3) Federal Environmental Protection Agency (Federal EPA or Pak-EPA)

The Federal EPA (Pak-EPA) is a body charged with a wide range of functions defined in PEPA 1997 under the leadership of the Director General. Pak-EPA has overall jurisdiction over EIA and IEE

issues. The following summarizes the scope of federal jurisdiction over the projects:

- Projects on federal land
- Military projects
- Projects involving trans-country impacts
- Projects bearing trans-province impacts.

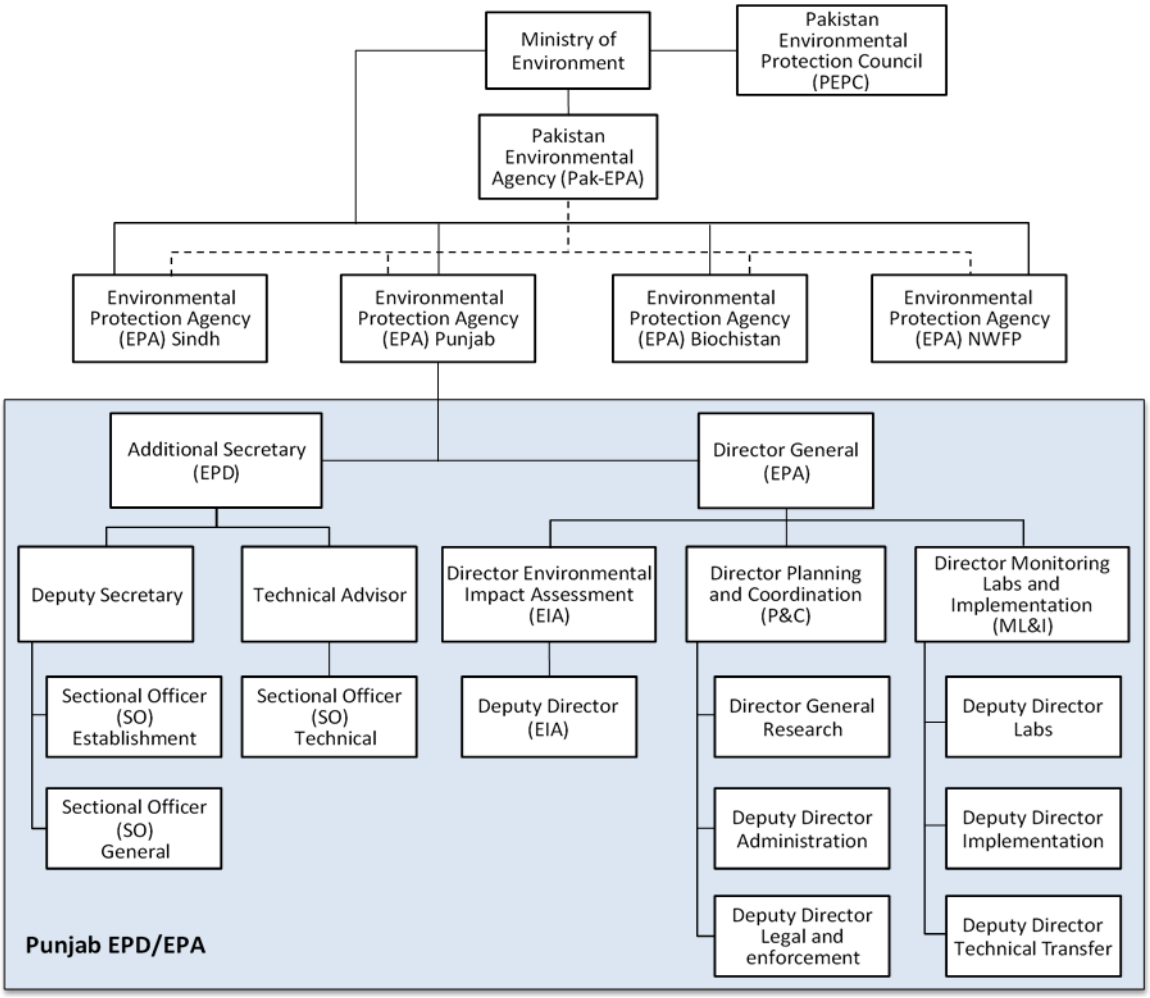
4) Punjab Environmental Protection Agency/Department (EPA/EPD)

Each provincial government has its own environmental protection institution responsible for pollution control. The provincial Environmental Protection Agencies or Environmental Protection Department (EPA/EPD) are the provincial counterparts of the Federal EPA (Pak-EPA) a body authorized to delegate powers to its provincial counterparts. EPA/EPD are formed by the respective provincial governments. A Director General who exercises powers delegated by the concerned provincial government heads the provincial EPA. The reports covering IEEs and EIAs are submitted to the concerned provincial EPA/EPD for approval.

The figure below depicts the organizational settings for the environment from the national level to provincial level. In Punjab Province only, the administrative function and technical function are respectively assigned to the EPD (Environmental Protection Department) and EPA (Environmental Protection Agency). EPD and EPA, therefore, are full-fledged departments under the Government of Punjab. EPD is under administrative control of the Secretary, Government of Punjab. The Director General of the EPA is positioned under the secretary of the EPD and heads all of EPA Punjab. All of the functions in PEPA 1997 are overseen by the Director General of the EPA.

5) District Environment Officer (DEO)

At the district level, the District Environment Officer (DEO) is assigned as the person responsible for supervising environmental issues in all sectors. The issues identified by the DEO are reported to the provincial EPA/EPD for legal processing. The DEO can take action against any development activity deemed to contribute to the environmental degradation of the country.



Source: Preparatory Study for Lahore Water Supply, Sewerage and Drainage Improvement Project, JICA

Figure 1-9 Organizational Settings for the Environment in Punjab

(3) Environmental Impact Assessment (EIA)

1) Projects Requiring EIA

The Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations classifies projects requiring IEE or EIA according to the significance of the environmental impact of the project. A list of projects in the water supply and sewerage/drainage sector is summarized in the table below.

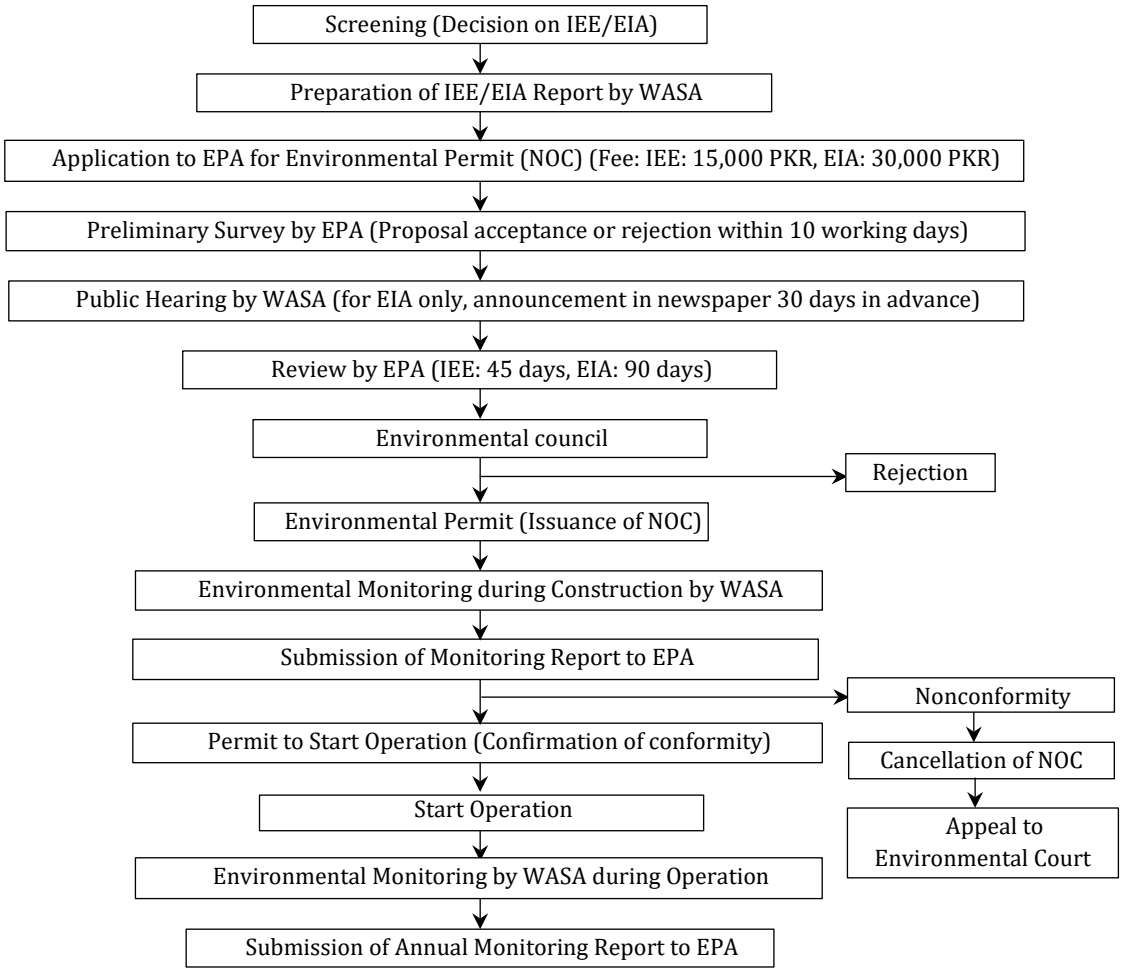
Table 1-13 Projects which Require IEE/EIA

Project	Necessity for IEE/EIA
Water management, dams, irrigation and flood projection ▪ Dams and reservoirs with storage volume less than 50 million cubic meters of surface area less than 8 square kilometers ▪ Irrigation and drainage projects serving less than 15,000 hectares ▪ Small-scale irrigation systems with total cost less than 59 million PKR **Water supply and treatment** ▪ Water supply schemes and treatment plants with total cost less than 25 million PKR	IEE is necessary
Water management, dams, irrigation and flood projection ▪ Dams and reservoirs with storage volume of 50 million cubic meters and above or surface area less than 8 square kilometers and above ▪ Irrigation and drainage projects serving 15,000 hectares and above	EIA is necessary

Project	Necessity for IEE/EIA
Water supply and treatment ▪ Water supply schemes and treatment plants with total cost of 25 million PKR and above	

2) EIA Procedure

The EIA procedure in Pakistan is as follows.



Source: Punjab EPA

Figure 1-10 EIA Implementation Process for Water Supply Project (WASA)

(4) Comparison of Pakistan Regulations with JICA Guidelines (2010)

By comparing the laws and regulations of Pakistan and Punjab Province with the JICA Guidelines for Environmental and Social Considerations (April 2010), the differences between the Pakistan legal system for the EIA and the JICA Guidelines were analyzed. As a result, no large gaps were confirmed between the JICA Guidelines and Pakistan/Punjab regulations.

Table 1-14 Comparison between JICA Guidelines and Pakistani Regulations

Item	JICA Guidelines for Environmental and Social Considerations	Pakistani Regulation	Gaps and Proposed Policy for this Project
Underlaying principles	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible	No proponent of a project shall commence construction or operation unless he has filed with EPA an IEE or	No large gaps.

Item	JICA Guidelines for Environmental and Social Considerations	Pakistani Regulation	Gaps and Proposed Policy for this Project
	planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. (JICA GL p28)	where the project is likely to cause an adverse environmental effect, an EIA, and has obtain from the EPA approval in respect thereof. (Punjab Act p12)	For this item, JICA Guidelines will be applied.
Impacts to be assessed	The impacts to be assessed include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement etc. (JICA GL p28-29)	Environment means: a) air, water and land, b) all layers of the atmosphere, c) all organic and inorganic matter and living organisms, d) the ecosystem and ecological relationship, e) buildings, structures, roads, facilities and works, f) all social and economic conditions affecting community life g) the inter-relationship between any of the factors above (Punjab Act p3)	No large gaps. For this item, JICA Guidelines will be applied.
Implementation of EIA	TOR includes understanding of needs, impacts to be assessed, study methods, analysis of alternatives, a schedule, etc. JICA conducts (at EIA level for Category A projects and at IEE level for Category B projects) environmental and social considerations studies, including mitigation measures to avoid, minimize, or compensate for adverse impacts; a monitoring plan; and an institutional arrangement. (JICA GL p26)	EIA means an environmental study comprising collection of data, prediction of qualitative and quantitative impacts, comparison of alternatives, evaluation of preventive, mitigatory and compensatory measures, formulation of environmental management and training plans and monitoring arrangements, and framing of recommendations and such other components as may be prescribed. (Punjab Act p3)	Punjab Act meets the requirements of JICA guidelines. For this item, JICA guidelines will be applied
Public consultation	For all Category A projects and Category B projects as needed, after disclosing scoping drafts, project proponents etc. conduct consultations with local stakeholders based on stakeholder analysis. (JICA GL p26) In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared; Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. (JICA GL p32)	Every review of an EIA shall be carried out with public participation and no information will be disclosed during the course of such public participation. (Punjab Act p12)	Although no major gaps exist, Punjab Act requires public consultation in all EIA processes.
Monitoring	Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. (JICA GL p31)	The proponent shall submit an annual report summarizing operational performance of the project, with reference to the condition of the maintenance and mitigatory measures. (Review IEE/EIA p6)	JICA guidelines require that monitoring results be disclosed, but the Pakistani law does not have any clear description. For this item, JICA guidelines will be applied.
Grievance redress	When third parties point out, in concrete terms, that environmental and social considerations are not being fully	The public can be involved formally or informally in monitoring activities, and may highlight inadequacies in	In JICA guidelines, when complaints on environmental and

Item	JICA Guidelines for Environmental and Social Considerations	Pakistani Regulation	Gaps and Proposed Policy for this Project
	undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. (JICA GL p31)	monitoring programs. They may also have practical suggestions to solve problems as they arise. (Guidelines for Public Consultation p12, EPA 1997). A complaint cell is active at Punjab EPA to address complaints by communities related to environmental and social aspects.	social considerations are raised, the solution shall be discussed and agreed in stakeholder consultation. In contrast, Pakistan's provision does not mention agreement on a solution in consultation. In this section, JICA GL is applied.
Information disclosure	EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them; EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted. (JICAGL p32)	The public will also be provided access to the EIA at the Headquarters of the Responsible Authority and at other designated locations. (Policy and procedures for the filing, review and approval of environmental assessments, p10)	Disclosure of information is not explicitly stated in Pakistani regulations but is only included in policy documents. For this item, JICA guidelines will be applied.
Ecosystem	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests. (JICA GL p30)	No proponent of a project shall commence construction or operation unless he has filed with the Provincial Agency an initial environmental examination or, where the project is likely to cause an adverse environmental effect, an environmental impact assessment, and has obtained from the Provincial Agency approval in respect thereof. (Punjab Act p12) "Adverse environmental effect" means impairment of, or damage to, the environment and includes: (a) impairment of, or damage to, human health and safety or to biodiversity or property (Punjab Act p2)	No large gaps. For this item, JICA Guidelines will be applied.

Note: Punjab Act: Punjab Environmental Protection Act, 1997 (Amended 2012)
Review IEE/EIA: Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations, 2000

1-3-1-4 Comparison of Alternative Options (Including Without Project Scenario)

Project alternatives were examined for the installation of Water Treatment Plant, Distribution Centers and Transmission Lines route. An analysis of the available alternatives is necessary to establish the most suitable management and technology options to be adopted for the project, while minimizing social and environmental impacts. This evaluation explains the selection of appropriate options required to ensure optimal results within a defined set of economic, environmental, health and safety constraints. The following alternatives are considered for the project:

1. Without Project Scenario
2. Alternatives for Facilities Components
3. Alternative Locations for Water Intake and Water Treatment Plant (WTP)
4. Alternative Locations for Distribution Center (GR and OHR) Construction
5. Alternative Methods of Canal Crossing for Transmission Line

(1) Without Project Scenario

Currently WASA water production is only 54 MGD which is nearly 50% of the design capacity (110 MGD). It has been estimated in the Master Plan of WASA Faisalabad that by the year 2038, water demand of Faisalabad City will be 275 MGD (WASA-F Master Plan 2018). Therefore, if no steps are taken at this stage, there will be a severe shortage of water supply in the city. Therefore, increasing the water supply is an urgent issue and implementation of this project is critical to solving the problem.

(2) Alternatives for Facilities Components

Three alternatives for facilities components of this project, namely, “Initial Plan”, “Alternative Plan 1” and “Alternative Plan 2”, were examined from perspectives of the request and project effects. The details of each alternative are shown in Table 2-2 in 2-2-1-1 Basic Approach.

The “Original Plan” is in line with the request of WASA-F, but the estimated project cost was higher than the allocated project budget. “Alternative 1” is to construct two Distribution Centers at Abudulah Pur and Madina Town No.2 as originally planned, and the reduced length of distribution mains will be installed and connected to the existing pipeline networks, while “Alternative 2” is to construct the Distribution Center at Madina Town No.2 only and Abudulah Pur area will receive water directly from the pumps in the WTP.

As a result of comparison, the component of "Alternative 1" matched the development priority of WASA-F (1) Water treatment plant, 2) transmission main, 3) distribution centers (2 locations), 4) distribution primary main, 5) distribution secondary main) with the estimated project cost being within the budget, and therefore, this alternative was judged to be the optimal. WASA-F agreed that the primary and secondary distribution mains, which were included in the “Original Plan” but will not be covered by this alternative, would be installed by WASA-F.

(3) Alternative Locations for Water Intake and WTP

The feasibility of the locations for the water intake and WTP was examined as follows. The Alternatives are, 1) use of the existing Old JK WTP land with water intake from RBC, and 2) acquiring new land for a new WTP with water intake from either Gugera Branch Canal (GBC) or Jhang Branch Canal (JBC).

In the case of Alternative 1), if the existing WTP site is used, it is not necessary to acquire the land and the permit for water intake has already been obtained from the Irrigation Department, but the existing WTP facilities need to be demolished and backfilled. For Alternative 2), since new land needs to be acquired and another irrigation canal must be used as the water source, in addition to the land

acquisition, a new water right and water intake permit from the Irrigation Department need to be obtained, and the extension of the transmission line is required. Also, negative impact on flora and fauna of the land is expected due to the land reclamation and excavation.

Rivers other than the above-mentioned irrigation canals and the surrounding sites for new WTP were also considered as candidates. However, due to the distance from the project area and the fluctuations in flow and water quality which affect the stability of water intake, these were excluded as alternatives.

As a result of comparison and evaluation of the alternatives, it was decided to adopt Alternative 1), the use of the existing WTP site from the perspectives of water rights, construction costs, and operation and maintenance costs.

Table 1-15 Alternative Locations for Water Intake and WTP

Item	Alternative 1	Alternative 2
Overview	Water intake from Rakh Branch Canal (RBC) at Existing Old JK WTP	Water Intake from Gugera Branch Canal (GBC) or Jhang Branch Canal (JBC) at New WTP site
Water source	Closed for maintenance for a period of two weeks once a year	Closed for maintenance for a period of two weeks once a year
Intake facility site	Existing water intake facilities can be used	Necessary to secure a land for the new water intake facility
Water rights	WASA has obtained a water intake permit for the existing facilities (including water intake for this project)	Necessary for WASA to obtain a new water intake permit from the Irrigation Department
WTP site	No land acquisition is required because the site of the existing facility will be used	New land acquisition is required
Natural Environment/Ecosystem	Since this alternative will be rehabilitation work within the existing WTP site, impact on the ecosystem will be small	Land reclamation and excavation of new land will have a negative impact on the flora and fauna.
Involuntary resettlement	No resettlement is required	Resettlement may be necessary for some locations
Construction costs	Demolishing and backfilling of existing facilities is necessary, which lead to rise in the cost	The length of the transmission line increases the cost of plumbing
Operation and maintenance costs	Lower than Alternative 2	Higher operating cost due to the long-distance pumping
Evaluation	◎	×

(4) Alternative Locations for Distribution Center (OHR/GR) Construction

Alternative locations were considered for the construction of the OHR and GR of specified capacities shown in Table 2-38 in 2-2-2-5 Distribution Center. However, land other than Madina Town No. 2 and Abudulah Pur were not available. In addition, at these sites, only a few relocation of the residents for WASA-F and FDA staff is required, which does not constitute “involuntary resettlement” and can be proceeded without any problems, and so these sites are deemed to be the most viable option.

(5) Alternative Methods of Canal Crossing for Transmission Line

There are three ways to lay the transmission line across the canal: 1) construction of a new water pipe

bridge, 2) installation to an existing bridge, and 3) underground crossing by the pipe-jacking/open-cut method.

For Alternative 1), the construction of a new water pipe bridge is advantageous from the view of construction cost and construction period, since there is no need to detour the pipe route and the width of the canal crossing is small. For Alternative 2), attaching the pipe to an existing bridge is advantageous in terms of workability and cost at crossing points, but it is uneconomical due to the additional cost for detouring of the pipe route. Underground crossings of pipes using the pipe-jacking and open-cutting methods are not applicable because they are not approved by the Irrigation Department.

By comparing these alternatives, Alternative 1), the construction of a new water pipe bridge, is adopted because of the overall advantage and economic aspects.

1-3-1-5 Scoping

Based on JICA Guidelines, upon conducting preliminary evaluations on the possible impacts, the scoping matrix was prepared.

Table 1-16 Scoping Matrix

		Impact Item	Overall Evaluation	During Planning/Before Construction			During Construction						During Operation		
				Preparatory Survey	Detailed Design (Tender documents)	Land Acquisition and Resettlement	Rehabilitation of Water Treatment Plant	Installation of Transmission and Distribution Mains	Construction of Water Distribution Plant	House Connections (Service pipes, meters)	Operation of Construction Vehicles and Machinery	Traffic Control	Operation and Maintenance of Water Supply Facilities	Water Supply Service Improvement by WASA-F	WASA-F Financial Improvement (Fee collection)
Pollution	1	Air Pollution	V								V				
	2	Water Pollution	V								V				
	3	Solid Waste	V				V	V	V	V			V		
	4	Soil Contamination	V				V	V							
	5	Nosie and Vibration	V								V		V		
	6	Land Subsidence													
	7	Offensive Odor													
	8	Bottom Sediments													
Natural	9	Natural Protected Areas													
	10	Ecosystem													
	11	Hydrological Situation	V				V						V		
	12	Topography & Geological Features													
Social	13	Involuntary Resettlement	V	V		V									
	14	The Poor	V											V	V
	15	Socially Vulnerable Groups such as Ethnic Minorities													

	Impact Item		Overall Evaluation	During Planning/Before Construction			During Construction						During Operation		
				Preparatory Survey	Detailed Design (Tender documents)	Land Acquisition and Resettlement	Rehabilitation of Water Treatment Plant	Installation of Transmission and Distribution Mains	Construction of Water Distribution Plant	House Connections (Service pipes, meters)	Operation of Construction Vehicles and Machinery	Traffic Control	Operation and Maintenance of Water Supply Facilities	Water Supply Service Improvement by WASA-F	WASA-F Financial Improvement (Fee collection)
	16	Local Economy (Employment, livelihood, etc.)	✓				✓	✓	✓	✓	✓	✓		✓	✓
	17	Land Use and Utilization of Local Resources													
	18	Water Use and Water Rights	✓	✓			✓						✓		
	19	Existing Social Infrastructures & Services	✓				✓	✓	✓	✓				✓	
	20	Social Institutions such as Social Assets and Local Decision Making Institutions.													
	21	Misdistribution of Benefits & Damages	✓			✓	✓	✓	✓	✓	✓	✓			
	22	Local Conflicts of Interest													
	23	Cultural Heritage													
	24	Landscape	✓				✓	✓	✓	✓					
	25	Infectious Diseases such as HIV/AIDS	✓				✓	✓	✓	✓			✓		
	26	Working Conditions	✓				✓	✓	✓	✓			✓		
	27	Accidents (Traffic accidents, etc.)	✓								✓	✓	✓		
	28	Trans-boundary Impact and Climate Change													

The following table shows the justifications for evaluation results of each impact item in the above scoping.

Table 1-17 Justification for Evaluation Results from Scoping

Impact Item		Scoping			Justification
		P	C	O	
Pollution					
1	Air Pollution		✓		C: Due to operation of construction machinery and vehicles, deterioration of air quality is expected temporarily. O: Since pumps and motors are driven by commercial power, air pollution is concerned.
2	Water Pollution		✓		C: Due to the construction of the water intake facility, temporary water pollution such as sediment runoff downstream is expected. In addition, there is a possibility of water pollution due to wastewater from construction machinery, vehicles and dormitories. O: Wastewater from the water treatment plant is planned to be returned to the treatment process for retreatment, and since the treated water discharged into the environment meets the effluent standards, water pollution is not a concern.
3	Solid Waste		✓	✓	C: Generation of construction waste and surplus soil is expected. O: The water treatment plant will generate sludge which is planned to be transported to the waste treatment plant.

Impact Item		Scoping			Justification
		P	C	O	
4	Soil Contamination		✓		C: Depending on the results of the ground investigation, ground improvement may be required and at the scoping stage, the impacts on the soil is unknown. Also, there is a possibility of soil contamination due to fuel and oil spills from construction equipment and vehicles.
5	Nosie and Vibration		✓	✓	C: Noise and vibration are expected due to construction machinery and vehicles. O: Generation of noise due to pump operation is concerned.
6	Land Subsidence				The water source for this project is surface water, and groundwater intake or construction works which may cause land subsidence are not included.
7	Offensive Odor				Construction works and facilities which may cause offensive odor are not particularly included.
8	Bottom Sediments				Since the intake facility will be installed in the existing irrigation canal, quality of bottom sediments will not be affected.
Natural Environment					
9	Natural Protected Areas				National parks and nature reserves do not exist in and around the project area.
10	Ecosystem				Endangered fauna or flora species are not found in and around the project area, and no impact on the ecosystem is expected.
11	Hydrological Situation		✓	✓	C: Temporary impacts on the flow and water level of the irrigation canal is expected due to construction of the intake facility. O: As the water intake from this project is about 5% of the total irrigation amount as calculated in the M/P, serious impacts are not expected. However, since the water volume may decrease drastically in drought years, limiting the amount of water intake may become necessary.
12	Topography & Geological Features				This project will rehabilitate the existing water treatment plant and improve transmission and distribution main networks, and does not include large scale earth cutting or embankments that may impact topography or geology.
Social Environment					
13	Involuntary Resettlement	✓			C: The water treatment plant and water distribution plant are located on public land and are under the control of WASA-F, but since WASA-F staff reside in the proposed distribution plant site, the staff need to be resettled before the construction can start. Based on the Civil Servants Act, new housing will be prepared, and so it is not considered as involuntary resettlement, but confirmation of the procedures and budget will be required.
14	The Poor			✓	O: Improvement of the water supply service will provide access to water at a rate lower than vendors, but change of tariff system may increase the burden on the poor. Introduction of a metered tariff system needs consideration of the poor.
15	Socially Vulnerable Groups such as Ethnic Minorities				Although many ethnic groups are living together in the project area, there is no problem with discrimination against ethnic minorities or indigenous peoples.
16	Local Economy (Livelihood, Employment, etc.)		✓	✓	C: Employing local residents as construction workers will have positive impacts on the local economy, while traffic restrictions due to pipe laying works will make access to offices and shops difficult resulting in temporary negative impacts on the local economy. O: Impacts on existing water vendors are limited, and the improvement of the water supply service can be expected to have a large positive impact on the local economy due to the reduction of electricity costs needed for pumping groundwater and lower water fees.
17	Land Use and Utilization of Local Resources				Since the planned sites for this project (water treatment plant, water distribution plant and pipelines) are located on public land, no impacts from land use or utilization of local resources are expected.
18	Water Use and Water Rights	✓	✓	✓	P/C: Water source for this project is the irrigation canal which needs coordination with the irrigation authority concerning water rights. Also, a construction permit from the Irrigation Department needs to be obtained and impacts on the downstream need to be notified in advance. O: Since the water intake from this project will reduce the amount of downstream irrigation water, the negative impacts from this is concerned.

Impact Item		Scoping			Justification
		P	C	O	
19	Existing Social Infrastructures & Services		✓	✓	C: Construction of water treatment plant and laying of transmission and distribution mains may cause traffic congestion and traffic restrictions to temporarily impede access to social infrastructures. O: Improvement of water supply services may have positive impacts.
20	Social Institutions such as Social Assets and Local Decision Making Institutions.				Since the proposed project site is under the control of WASA-F, there will be no impacts to social institutions such as decision-making institutions.
21	Misdistribution of Benefits & Damages	✓	✓		P/C: The proposed project site is public land, but operation of construction machinery and vehicles may infringe on the site and damage buildings, and therefore, consideration is necessary.
22	Local Conflicts of Interest				No conflict of interests is expected in the region.
23	Cultural Heritage				There are no cultural heritage sites in and around the project area.
24	Landscape		✓		C: Excavation of soil and temporary storage of piping materials may impact the landscape. O: The construction of the water treatment plant and overhead reservoir may slightly change the original landscape, but this will not have a significant impact.
25	Infectious Diseases such as HIV/AIDS		✓	✓	C: Inflow of workers from outside is expected to increase the chances of spreading infectious diseases. O: There are concerns on the breeding of mosquitoes and resulting spread of infectious diseases at the water treatment plant and water distribution plant.
26	Working Conditions		✓	✓	C: Construction workers are under the risk of accidents and injuries. O: Proper facilities design is required to minimize operator accident risks.
27	Accidents (Traffic accidents, etc.)		✓	✓	C: Traffic accidents and accidents caused by construction machinery are concerned. O: Measures are needed to prevent accidents by operators falling from facilities.
28	Trans-boundary Impact and Climate Change				Since this project is rehabilitation of the existing water treatment plant and construction of water transmission and distribution mains, and the scale of the facilities is not so large, impacts on trans-boundary and climate change are not expected.

Note: 1) Phase of Activity: P: During planning & preparation, C: During construction, O: During operation
2) Rating: A+/-: Significant positive/negative impact is expected, B+/-: Positive/negative impact is expected to some extent, C: Extent of impact is unknown (A further examination is needed, and the impact could be clarified as the study progresses), D: No impact is expected

1-3-1-6 TOR for Environmental and Social Consideration Study

The items having impacts above in the previous scoping will be studied and evaluated. The study items and study methods for each impact item are shown below. If other items are anticipated to be impacted through confirmation of new facts in the design and implementation processes of the project, those items will be included in the study and evaluated.

Table 1-18 Summary of Environmental and Social Consideration Study

Impact Item		Study Item	Study Method
1	Air Pollution	1) Environmental standard 2) Present air quality of project site 3) Scope of impact during construction	1) Literature survey and interview with related organizations 2) On-site measurements 3) Collection of information on construction works, construction methods, period, construction machineries, etc.
2	Water Pollution	1) Environmental standard 2) Present water quality of project site 3) Scope of impact during construction	1) Literature survey and interview with related organizations 2) On-site sampling and analyses

Impact Item		Study Item	Study Method
			3) Collection of information on construction works, construction methods, period, construction machineries, etc.
3	Solid Waste	1) Present waste treatment method and state of waste treatment plant	1) Interview with related organizations 2) Field inspection
4	Soil Contamination	1) Soil strength and ground improvement method suitable for the facility site 2) Measures to prevent oil leaks during construction	1) Literature survey and interview with related organizations 2) Geotechnical survey 3) Collection of information on construction works, construction methods, period, construction machineries, etc.
5	Noise and Vibration	1) Environmental standard 2) Present noise/vibration of project site 3) Scope of impact during construction	1) Literature survey and interview with related organizations 2) Field inspection and on-site measurements 3) Collection of information on construction works, construction methods, period, construction machineries, etc.
11	Hydrological Conditions	1) Identification of hydrological condition of target area	1) Literature survey and interview with related organizations 2) Field inspection
13	Involuntary Resettlement and Land Acquisition	1) Resettlement laws and regulations 2) Affected number of households and persons, assets/land, family finance/living conditions 3) Scope of compensation and livelihood recovery support	1) Literature survey and interview with related organizations 2) Field inspection
14	The Poor	1) Impact of collecting water fees	1) Interview with stakeholders
16	Local Economy (Livelihood, Employment, etc.)	1) Livelihood means and employment status around the project area 2) Impact from project implementation	1) Interview with stakeholders 2) Field inspection
17	Land Use & Utilization of Local Resources	1) Related laws of Pakistan and Punjab 2) Land use conditions of project area	1) Literature survey and interview with related organizations 2) Field inspection
18	Water Use and Water Rights	1) Related laws of Pakistan and Punjab 2) Water use and water rights conditions of project area	1) Literature survey and interview with related organizations 2) Field inspection
19	Existing Social Infrastructure & Services	1) Infrastructure service conditions of project area	1) Interviews with related organizations 2) Field inspection
21	Misdistribution of Benefits and Damage	1) Information on benefits and damages to users due to project implementation	1) Interview with stakeholders
24	Landscape	1) Landscape around project area	1) Field inspection 2) Collection of information on construction works, construction methods, period, construction machineries, etc.
25	Infectious Diseases such as HIV/AIDS	1) Cases of infectious diseases of similar projects 2) Measures against infectious diseases	1) Literature survey and interview with related organizations
26	Working Conditions	1) Labour related laws and regulations 2) Occupational safety measures of similar projects	1) Literature survey and interview with related organizations
27	Accidents (Traffic accidents, etc.)	1) Accident history of similar projects 2) Traffic safety measures	1) Literature survey and interview with related organizations

1-3-1-7 Results of Environmental and Social Consideration Study (Including Prediction Results)

The results of environmental and social consideration study carried out based on the above TOR are listed below.

Table 1-19 Results of Environmental and Social Consideration Study

<table>
<tr><th>Impact Item</th><th>Study Results</th></tr>
<tr><td>Air Pollution</td><td>
The results of air quality measurements made during the study and environmental standards of Pakistan and Japan are shown below.
<table>
<tr><th rowspan="2">Location</th><th>CO
(mg/m^3)</th><th>NO
(μg/m^3)</th><th>NO$_2$
(μg/m^3)</th><th>NOx
(μg/m^3)</th><th>SO$_2$
(μg/m^3)</th><th>PM$_{10}$
(μg/m^3)</th></tr>
<tr><th>24 hrs</th><th>24 hrs</th><th>24 hrs</th><th>24 hrs</th><th>24 hrs</th><th>24 hrs</th></tr>
<tr><td>Jhal WTP</td><td>0.98</td><td>12.15</td><td>22.36</td><td>34.52</td><td>23.45</td><td>136.67</td></tr>
<tr><td>Madina Town OHR-2</td><td>0.52</td><td>20.98</td><td>12.16</td><td>33.15</td><td>21.07</td><td>122.38</td></tr>
<tr><td>PEQS</td><td>5.0</td><td>80</td><td>40</td><td>120</td><td>120</td><td>150</td></tr>
<tr><td>Japanese Standards</td><td>11.5</td><td>—</td><td>113</td><td>—</td><td>105</td><td>100</td></tr>
</table>
Source: JICA Preparatory Survey Team (Measured on June 22-24, 2019)
The 24-hour measurement values were significantly lower than the standard values for air quality according to PEQS for 5 items excluding PM$_{10}$. Air environment in Faisalabad is showing a trend of degradation due to the increase in population and vehicles accompanying the expansion of the city, and the pollution level may exceed the standard values depending on the weather.
During construction, exhaust gas discharged from construction machineries and material transport vehicles is expected to impact the surrounding area.
</td></tr>
<tr><td>Water Pollution</td><td>
The results of water quality analyses carried out during the study, the environmental standards of Pakistan and WHO guidelines are shown below.
<table>
<tr><th>No</th><th>Parameters</th><th>Unit</th><th>PEQS</th><th>WHO DWQGL</th><th>Surface Water</th><th>Ground Water-1</th><th>Ground Water-2</th></tr>
<tr><td colspan="8">Chemical Parameters</td></tr>
<tr><td>1</td><td>pH</td><td>-</td><td>6.5-8.5</td><td>—</td><td>7.10</td><td>7.08</td><td>7.03</td></tr>
<tr><td>2</td><td>Odor</td><td>-</td><td>NO</td><td>NO</td><td>Odorless</td><td>Odorless</td><td>Odorless</td></tr>
<tr><td>3</td><td>Taste</td><td>-</td><td>NO</td><td>NO</td><td>Sweet</td><td>Sweet</td><td>Sweet</td></tr>
<tr><td>4</td><td>Color</td><td>Pt-Co</td><td>≤15 TCU</td><td>≤15 TCU</td><td>12.0</td><td><1.0</td><td><1.0</td></tr>
<tr><td>5</td><td>Turbidity</td><td>NTU</td><td><5 NTU</td><td><5 NTU</td><td>1.0</td><td>ND</td><td>ND</td></tr>
<tr><td>6</td><td>Total Hardness</td><td>mg/L</td><td>< 500 mg/l</td><td>—</td><td>74.48</td><td>168.56</td><td>148.96</td></tr>
<tr><td>7</td><td>TDS</td><td>mg/L</td><td><1000</td><td>—</td><td>105.0</td><td>347.0</td><td>476.0</td></tr>
<tr><td>8</td><td>Chloride (Cl)</td><td>mg/L</td><td>< 250</td><td>—</td><td>3.82</td><td>24.88</td><td>44.02</td></tr>
<tr><td>9</td><td>Cyanide (CN)</td><td>mg/L</td><td>≤0.05</td><td>0.07</td><td><0.01</td><td><0.01</td><td><0.01</td></tr>
<tr><td>10</td><td>Fluoride (F)</td><td>mg/L</td><td>≤ 1.5</td><td>1.5</td><td><0.01</td><td><0.01</td><td><0.01</td></tr>
<tr><td>11</td><td>Nitrite (NO_2^-)</td><td>mg/L</td><td>≤3</td><td>3</td><td><0.01</td><td><0.01</td><td><0.01</td></tr>
<tr><td>12</td><td>Nitrate (NO_3^-)</td><td>mg/L</td><td>≤ 50</td><td>50</td><td>0.5</td><td>0.4</td><td>0.5</td></tr>
<tr><td>13</td><td>Phenolic Compounds</td><td>mg/L</td><td>—</td><td>0.002</td><td><0.01</td><td><0.01</td><td><0.01</td></tr>
<tr><td>14</td><td>Residual Chlorine</td><td>mg/L</td><td>0.2-0.5</td><td>—</td><td><0.1</td><td><0.1</td><td><0.1</td></tr>
<tr><td>15</td><td>Aluminum (Al)</td><td>mg/L</td><td>≤ 0.2</td><td>0.2</td><td><0.028</td><td><0.028</td><td><0.028</td></tr>
<tr><td>16</td><td>Pesticides</td><td>mg/L</td><td>—</td><td></td><td>ND</td><td>ND</td><td>ND</td></tr>
<tr><td>17</td><td>Cadmium (Cd)</td><td>mg/L</td><td>0.01</td><td>0.003</td><td><0.0028</td><td><0.0028</td><td><0.0028</td></tr>
<tr><td>18</td><td>Copper (Cu)</td><td>mg/L</td><td>2</td><td>2</td><td>0.03</td><td>0.09</td><td>0.16</td></tr>
<tr><td>19</td><td>Chromium (Cr)</td><td>mg/L</td><td>≤ 0.05</td><td>0.05</td><td><0.0054</td><td><0.0054</td><td><0.0054</td></tr>
<tr><td>20</td><td>Mercury (Hg)</td><td>mg/L</td><td>≤ 0.001</td><td>0.006</td><td><0.0008</td><td><0.0008</td><td><0.0008</td></tr>
<tr><td>21</td><td>Antimony (Sb)</td><td>mg/L</td><td>≤ 0.005</td><td>0.02</td><td>ND</td><td>ND</td><td>ND</td></tr>
<tr><td>22</td><td>Nickel (Ni)</td><td>mg/L</td><td>≤ 0.02</td><td>0.07</td><td><0.008</td><td><0.008</td><td><0.008</td></tr>
<tr><td>23</td><td>Zinc (Zn)</td><td>mg/L</td><td>5.0</td><td>3</td><td>0.76</td><td>1.02</td><td>1.49</td></tr>
<tr><td>24</td><td>Arsenic (As)</td><td>mg/L</td><td>≤ 0.05</td><td>0.01</td><td><0.01</td><td><0.01</td><td><0.01</td></tr>
<tr><td>25</td><td>Barium (Ba)</td><td>mg/L</td><td>0.7</td><td>0.7</td><td><0.031</td><td><0.031</td><td><0.031</td></tr>
<tr><td>26</td><td>Manganese (Mn)</td><td>mg/L</td><td>≤ 0.5</td><td>0.4</td><td><0.0016</td><td><0.0016</td><td><0.0016</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Impact Item</th><th>Study Results</th></tr>
<tr><td></td><td>
<table>
<tr><td>27</td><td>Boron (B)</td><td>mg/L</td><td>0.3</td><td>2.4</td><td><0.1</td><td><0.1</td><td><0.1</td></tr>
<tr><td>28</td><td>Lead (Pb)</td><td>mg/L</td><td>≤ 0.05</td><td>0.01</td><td><0.013</td><td><0.013</td><td><0.013</td></tr>
<tr><td>29</td><td>Selenium (Se)</td><td>mg/L</td><td>0.01</td><td>0.01</td><td>ND</td><td>ND</td><td>ND</td></tr>
<tr><td colspan="3">Microbiological Parameters</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>30</td><td>Total Coliforms</td><td>CFU</td><td>0/100ml</td><td>0/100ml</td><td>TNTC</td><td>Absent</td><td>Absent</td></tr>
<tr><td>31</td><td>Faecal Coliforms (E-Coli)</td><td>CFU</td><td>0/100ml</td><td>0/100ml</td><td>TNTC</td><td>Absent</td><td>Absent</td></tr>
</table>
NO: Non-Objectionable, ND: Not Detected, TNTC: Too Numerous to Count
DWQGL: Drinking Water Quality Guideline (WHO, 2011)
Source: JICA Preparatory Survey Team (Sampled on June 23-24, 2019)
The above results show that all parameters other than total coliform and E-coli in surface water are in conformity with environmental standards PEQS, and so, the water quality can be treated by a general treatment method.
During construction of the intake facility, the increase in suspended solids is concerned and water quality is expected to deteriorate due to wastewater from the construction dormitories.
During operation, effluent from the water treatment plant is expected, but since backwash effluent is planned to be returned to the treatment process, the risk of contamination is considered to be low.
</td></tr>
<tr><td>Solid Waste</td><td>Solid wastes expected to be generated during construction work are surplus soil excavated from the treatment plant and pipelines as well as concrete waste from demolition of existing facilities. The expected amounts of soil are, 142,300m^3 of generated soil, 102,300m^3 of backfilled soil, and 40,000m^3 of surplus soil for disposal. These wastes are planned to be transported to an existing waste disposal site located about 20km outside of Faisalabad City for disposal, of which WASA-F has obtained approval from FWMC.
Wastes expected to be generated during operation include sludge from the treatment plan and riverbed sediment from the water intake facility. The estimated amount of waste is about 3m^3 per day. These wastes are planned to be transported to the waste disposal site located in the suburbs of Faisalabad City.</td></tr>
<tr><td>Soil Contamination</td><td>The results of the geotechnical survey indicate that the ground at the main facility site is sufficiently strong that no ground improvement is required. Therefore, the project does not include any work that would cause soil contamination.
The effects of soil contamination due to fuel and oil spills from construction equipment and vehicles during construction can be prevented by proper storage of fuel and oil, and regular checkup and maintenance of construction equipment by the contractor.</td></tr>
<tr><td>Noise and Vibration</td><td>Pakistan does not have environmental standards for noise and vibration, but there is a standard for emission of noise generated by vehicles, and this will be used as the limit. Japan’s standard value for noise during construction is 85 dBA. (Standards for controlling noise generated by specific construction work, MOE)
<table>
<tr><th rowspan="2">No</th><th rowspan="2">Category of Area/Zone</th><th colspan="2">Noise Level (dBA)*</th></tr>
<tr><th>Daytime</th><th>Nighttime</th></tr>
<tr><td>1</td><td>Residential Area (A)</td><td>55</td><td>45</td></tr>
<tr><td>2</td><td>Commerical Area (B)</td><td>65</td><td>55</td></tr>
<tr><td>3</td><td>Industrial Area (C)</td><td>75</td><td>65</td></tr>
<tr><td>4</td><td>Quiet Area (D)</td><td>50</td><td>45</td></tr>
</table>
Source: PEQS 2016
* Equivalent continuous A-weighted sound pressure level
Since noise data in the project area is limited, noise levels were measured in this study. As shown below, the results revealed values of 55.3 to 85.7 dBA. Noise levels at 3 out of 5 measured points exceeded the maximum noise limit of 75dBA in the industrial area during the day.
<table>
<tr><th colspan="5">Noise Levels (dBA)</th></tr>
<tr><th>Within JK WTP Boundary</th><th>Outside JK WTP Boundary</th><th>At Abudulah Pur OHR</th><th>Outside Abudulah Pur OHR</th><th>At Madina Town OHR-2</th></tr>
<tr><td>55.3</td><td>75.7</td><td>85.7</td><td>81.3</td><td>53.7</td></tr>
</table>
JK WTP: Jhal KhanuwanaWater Treatment Plant
Source: JICA Preparatory Survey Team (Measured on June 22-24, 2019)
During construction, noise and vibration are expected to be generated by construction machineries and vehicles. These impacts can be alleviated to some extent by instructing workers and drivers to obey speed limits and night driving regulations.
During operation, noise and vibration are generated by the pump operation, but since the pump is basically installed inside the building, impacts to the outside of the site is considered to be minimal.</td></tr>
<tr><td>Hydrological Conditions</td><td>Since this project will use the irrigation canal as the water source, flow conditions and water level are expected to change temporarily during construction. Also, during operation, the amount of water in the irrigation</td></tr>
</table>

Impact Item	Study Results
	canal will decrease due to water intake from this project, and this may have some impact on the downstream users. However, the impact is limited since the intake amount is about 5% of the irrigation amount.
The Poor	Improvement of the water supply service through this project will have a positive impact on the poor as it will provide safer and less expensive water than from water vendors. However, change of water tariff system may increase the burden on the poor. Therefore, for introducing a metered tariff system, the household income of the poor shall be considered. For example, measures such as setting the minimum fee to 3-5% of household income to reduce the burden on low-income households are necessary.
Local Economy (Livelihood, Employment, etc.)	The pipe laying work in this project may impede access to shops and offices along the road to temporarily affect commercial activities. Also, temporary reduction of productivity is concerned due to traffic congestion from traffic restrictions to increase time needed by residents to pass through the construction area. On the other hand, since workers will most likely be hired from local residents, local employment may become activated. As for existing water vendors, since the project will improve water supply service only in some areas, the vendors can continue their business in other areas and therefore, there will be no significant impacts.
Land Use & Utilization of Local Resources	This project plans to rehabilitate existing water treatment plant, rehabilitate water distribution plant and lay water transmission and distribution mains, and construction will be done on public land of existing facilities. Therefore, significant impacts on land use and utilization of local resources are not expected.
Water Use and Water Rights	During construction, there is concern for the impact on the downstream from water quality deterioration due to construction of facilities along the canal. Also, during operation, canal water volume is expected to decrease due to intake from the canal. However, in 1953, the Irrigation Department gave consent to WASA-F for allocating the canal water of 20 cusec (48,930 m^3/day) at Old Jhal Khanuana Chowk where the Old JK WTP is located. The Irrigation Department re-confirmed this consent to be effective in the letter issued on 31st July 2018. The effectiveness of the consent shall be re-confirmed during the detailed design stage. During droughts, since water may become extremely deficit, the required flow rate may not be secured due to intake from this project.
Existing Social Infrastructure & Services	Since traffic in the target area is so heavy, pipe laying work may cause traffic restrictions and congestion that temporarily obstruct or restrict access to social infrastructures and social services. In addition, the water supply service to some areas may be temporarily cut off due to demolition of existing facilities and connections to existing pipes.
Misdistribution of Benefits and Damage	Although the construction of facilities will be carried out on public land, since some areas are narrow, construction machineries and vehicles may temporarily slip out of the project area to infringe on the surrounding residences. However, the residents that may be affected by such adverse effects are very limited and a large number will benefit from the improved water supply. Therefore, it does not lead to uneven distribution of wealth.
Landscape	During construction, landscape may be temporarily affected by storage of excavated surplus soil and pipes during construction. In addition, although a new reservoir is planned to be constructed at the water distribution plant, at both of the targeted 2 sites, the new reservoirs will be constructed after demolishing the existing overhead reservoirs. Therefore, the landscape will not be significantly changed due to this project.
Infectious Diseases such as HIV/AIDS	The risk of spreading infectious diseases is expected due to the inflow of workers from outside. The risk can be reduced through appropriate health guidance to the workers. Also, since some parts of the water treatment plant and water distribution plant are open and not covered, breeding of mosquitoes as media for infectious diseases is concerned. WASA-F regularly conducts health promotion campaigns on raising awareness of residents to reduce the risk of infectious diseases such as malaria and dengue fever.
Working Conditions	Based on the Employment and Labour Law, the working environmental of construction workers is protected and the Labour and Human Resources Department is the responsible organization for the working environment. The main labour acts and regulations are as follows. – Factories Act, 1934 – West Pakistan Shops and Establishment Ordinance, 1969 – Payment of Wages Act, 1936 – Industrial Relations Ordinance, 2002 – Employment of Children Act, 1991 – Minimum Wage Ordinance, 1961 (adapted in 2012) There will be no problem in this respect, because the safety of workers is ensured by these laws and this project observes these national laws.
Accidents (Traffic accidents, etc.)	Contractors need to submit a traffic management plan describing measures to avoid traffic accidents and traffic jams during construction to the Traffic Engineering and Planning Agency (TEPA). Also, appropriate safety education for construction workers and drivers, and installation of construction panels and safety signs are under the responsibility of the contractor. For the facility construction, appropriate safety protection measures such as stairs and handrails are to be installed at the water treatment plant and overhead reservoirs to reduce the risk of accidents during construction and operation.

1-3-1-8 Environmental Evaluation

Based on the above study results, impacts of project implementation evaluated in the scoping were re-evaluated. The results are summarized in the following table.

Table 1-20 Evaluation of Expected Impacts

Impact Item		Scoping			Rating from Study			Reason
		P	C	O	P	C	O	
Pollution								
1	Air Pollution		✓		**D**	**B-**	**D**	C: Temporary deterioration of air quality is expected due to operation of construction machineries and vehicles. O: Since pumps and motors are powered by commercial electricity, air pollution is not of concern.
2	Water Pollution		✓		**D**	**B-**	**D**	C: Due to construction of the intake facility, temporary water pollution such as soil runoff downstream is expected. O: Since wastewater from the water treatment plant is planned to be recycled to the treatment process for retreatment, and treated water discharged into the environment meets the effluent standards, water pollution is not concerned.
3	Solid Waste		✓	✓	**D**	**B-**	**B-**	C: Generation of construction debris and waste materials is expected. O: Sludge will be generated from the water treatment plant, and the generated sludge is planned to be transported to the waste treatment plant as waste.
4	Soil Contamination		✓		**D**	**B-**	**D**	C: Results of the geotechnical survey indicate that ground improvement is not necessary, and construction work which may cause soil contamination is not undertaken. However, there is a possibility of soil contamination due to fuel and oil spills from construction equipment and vehicles O: Since this project is for water supply, operation which may cause soil contamination is not expected.
5	Noise and Vibration		✓	✓	**D**	**B-**	**B-**	C: Noise and vibration caused by construction machineries and vehicles are expected. O: Operation of pumps may generate noise and vibration.
6	Land Subsidence				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
7	Offensive Odor				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
8	Bottom Sediments				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
Natural Environment								
9	Natural Protected Areas				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
10	Ecosystem				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
11	Hydrological Situation		✓	✓	**D**	**B-**	**B-**	C: Construction of the intake facility is expected to have temporary impact on irrigation canal flow and water level. O: Since the water intake form this project is about 5% of the total irrigation water amount as calculated by the M/P, significant impacts are not expected. However, the amount of water may decrease drastically during drought years, and therefore, the intake amount needs to be limited.
12	Topography & Geological Features				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
Social Environment								
13	Involuntary Resettlement	✓			**B-**	**D**	**D**	C: Although the water treatment plant and water distribution plants are on public land and are managed by WASA-F, WASA-F staff reside at the proposed water distribution plant sites, and so these staff must be resettled before starting construction. Since new residences will be prepared based on the Civil Servants Act, this is not an involuntary resettlement, but procedures and budget confirmation will be required.
14	The Poor			✓	**D**	**D**	**B-**	O: Improvement of the water supply service will provide access to water at a lower price than vendors, but change of

Impact Item		Scoping			Rating from Study			Reason
		P	C	O	P	C	O	
								tariff system may increase the burden on the poor. Introduction of a metered tariff system needs consideration of the poor.
15	Socially Vulnerable Groups such as Ethnic Minorities				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
16	Local Economy (Livelihood, Employment, etc.)		✓	✓	**D**	**B±**	**B+**	C: Employing local residents as construction workers will have positive impacts on the local economy, while traffic restrictions due to pipe laying will cause difficulties to access offices and shops, which may cause temporary negative impacts on the local economy. O: Impacts on existing water vendors are limited and improvement of water supply services is expected to have significant positive impacts on the local economy due to reduction in electricity costs for groundwater pumps and lower water fees.
17	Land Use and Utilization of Local Resources				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
18	Water Use and Water Rights	✓	✓	✓	**B-**	**B-**	**B-**	P/C: Water source for this project is irrigation canal which need to be coordinated with the Irrigation Department regarding water rights. Also, a construction permit needs to be obtained from the Irrigation Department and downstream impacts need to be announced in advance. O: Water intake from this project will reduce the amount of irrigation water downstream, and therefore, negative impacts are of concern. However, WASA-F has already gained the water right for the intake.
19	Existing Social Infrastructures & Services		✓	✓	**D**	**B-**	**B+**	C: The construction of the water treatment plant and water distribution plant as well as laying of transmission and distribution mains may cause traffic congestions and generate traffic restrictions to temporarily reduce access to social infrastructures. O: Water supply services will improve and have positive impacts.
20	Social Institutions such as Social Assets and Local Decision Making Institutions.				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
21	Misdistribution of Benefits & Damages	✓	✓		**D**	**D**	**D**	P/C: Construction in narrower areas may temporarily encroach on surrounding residences with construction machines and vehicles looming over them. However, such adverse impacts are very limited and do not lead to uneven distribution of wealth as a large number of residents would benefit from improved water supply.
22	Local Conflicts of Interest				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
23	Cultural Heritage				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected
24	Landscape		✓		**D**	**B-**	**D**	C: Temporary impact on the landscape is of concern due to temporary storage of excavated surplus soil and pipes. O: Due to construction of the water treatment plant and new overhead reservoirs, the original landscape may change slightly, but will not have a significant impact.
25	Infectious Diseases such as HIV/AIDS		✓	✓	**D**	**B-**	**B-**	C: The influx of workers from outside is expected to increase the chances of spreading infectious diseases. O: The occurrence of mosquitoes and resulting increase of infectious diseases in the water treatment plant and water distribution plant are of concern.
26	Working Conditions		✓	✓	**D**	**B-**	**D**	C: There are risks of accidents and injuries to construction workers. O: Proper facilities design such as handrails and protective fences are included to minimize the risks of accidents to operators.
27	Accidents (Traffic accidents, etc.)		✓	✓	**D**	**B-**	**D**	C: Traffic accidents and construction machineries are of concern.

Impact Item		Scoping			Rating from Study			Reason
		P	C	O	P	C	O	
								O: Measures are taken to prevent accidents caused by operators falling from facilities.
28	Trans-boundary Impact and Climate Change				**D**	**D**	**D**	Same evaluation as scoping, no impacts expected

Note: 1) Phase of Activity: P: During planning & preparation, C: During construction, O: During operation
2) Rating: A+/-: Significant positive/negative impact is expected, B+/-: Positive/negative impact is expected to some extent, C: Extent of impact is unknown (A further examination is needed, and the impact could be clarified as the study progresses), D: No impact is expected

1-3-1-9 Mitigation Measures and their Cost for Implementation

Since mitigation measures and costs for minimizing the impacts of project implementation should be a social responsibility of WASA-F and the contractor, the costs should be included in the construction and O&M costs. Therefore, no special cost is required for environmental and social considerations.

Based on the results of the environmental and social considerations survey and the results of the impact assessment, necessary mitigation measures are shown in the table below.

Table 1-21 Mitigation Measure

Impact Item	Mitigation Measure	Implementing Body	Responsible Organization	Cost
Preparation and Construction Phase				
Air Pollution	▪ Use of construction equipment with exhaust gas emission control ▪ Careful operation and self-regulation of speed of construction machineries and vehicles ▪ Watering to prevent dust	Contractor	PIU/WASA-F	Not required due to measures taken in construction plan and construction methods
Water Pollution	▪ Control of soil flown out to RBC from the working area of intake facility ▪ Preventive maintenance of construction machineries and vehicles ▪ Wastewater control at accommodation for workers	Contractor	PIU/WASA-F	Not required due to measures taken in construction plan and construction methods
Solid Waste	▪ Proper waste handling at waste disposal site and treatment plant ▪ Guidance to workers on construction site cleaning	Contractor	PIU/WASA-F	Not required due to measures taken in construction plan and construction methods
Soil Contamination	▪ Assurance of the safety of fuel and oil storage and disposal ▪ Prevention of oil leaks through proper inspection and maintenance of construction machineries	Contractor	PIU/WASA-F	Not required due to measures taken in construction plan and construction methods
Noise and Vibration	▪ Active use of low-noise and low-vibration construction machineries ▪ Careful operation and self-regulation of night operation of construction machineries and vehicles	Contractor	PIU/WASA-F	Not required due to measures taken in construction plan and construction methods
Hydrological Situation	▪ Intake design having minimal impact on hydrology ▪ Proper use of construction methods and machineries	Contractor	PIU/WASA-F	Not required due to measures taken in construction plan and construction methods
Local Economy (Livelihood, Employment, etc.)	▪ Efficient traffic regulation to reduce impact on local economy ▪ Use of construction signs and other means to ensure traffic safety	Contractor	PIU/WASA-F	Included in construction cost
Water Use and Water Rights	▪ Water intake restrictions during droughts ▪ Stakeholders meetings on water use	WASA-F	PIU/WASA-F	Not required since WASA-F is responsible

Impact Item	Mitigation Measure	Implementing Body	Responsible Organization	Cost
Existing Social Infrastructures & Services	▪ Assuring access to existing infrastructures ▪ Advance notification during construction period	Contractor	PIU/WASA-F	Included in construction cost
Landscape	▪ Installation of fencing to blind off temporary storage of excavated surplus soil and pipes	Contractor	PIU/WASA-F	Included in construction cost
Infectious Diseases such as HIV/AIDS	▪ Awareness raising and guidance to workers on infection prevention	Contractor	PIU/WASA-F	Not required since contractor is responsible
Working Conditions	▪ Preparation and execution of occupational safety and health guidance ▪ Execution of regular safety meetings for workers ▪ Installation of safety signs ▪ Water sprinkling to prevent dust and use of cover when transporting soil	Contractor	PIU/WASA-F	Not required since contractor is responsible
Accidents (Traffic accidents, etc.)	▪ Careful operation and self-regulation of speed of construction vehicles (30km/hr or less) ▪ Notification of construction details and traffic regulations ▪ Arrangement of traffic control staff and warning signs ▪ Safety management guidance for workers	Contractor	PIU/WASA-F	Not required since contractor is responsible
Operation Phase				
Solid Waste	▪ Proper removal and disposal of sludge generated from the water treatment plant	WASA-F	PIU/WASA-F	Included in the Q&M costs of WASA-F
Noise and Vibration	▪ Active use of low-noise and low-vibration construction machineries	WASA-F	PIU/WASA-F	Included in the Q&M costs of WASA-F
The Poor	▪ Introduction of a fee structure which considers income	WASA-F	PIU/WASA-F	Included in the Q&M costs of WASA-F
Water Use and Water Rights	▪ Coordination with Irrigation Department on water use balance between drinking water and irrigation water	WASA-F	PIU/WASA-F	Included in the Q&M costs of WASA-F

1-3-1-10 Monitoring Plan

The Project Implementation Unit (PIU) headed by the WASA-F project manager is responsible for implementation of mitigation measures and monitoring of environmental and social impacts from this project. Monitoring during construction is to be carried out mainly by the contractor and the results are periodically reported to PIU of WASA-F. Since impacts during construction are expected for only a short period, rapid submission of results is more important than requiring high accuracy level of measurement results. Impact measurement methods were considered with this in mind. The monitoring plan (draft) is shown in the table below.

Table 1-22 Monitoring Plan (Draft)

Impact Item	Monitoring Parameter	Measurement Method	Frequency	Monitoring Organization	Cost
Preparation and Construction Phase					
Air Pollution	▪ Presence of dust during construction ▪ Air quality measurement CO <5 (mg/m^3), SOx<120, NOx <80, PM_{10} <150 ($\mu g/m^3$)	▪ Physical observation ▪ Air quality measurement	Four times a year	Contractor	Included in construction cost

Impact Item	Monitoring Parameter	Measurement Method	Frequency	Monitoring Organization	Cost
Water Pollution	▪ Effluent water quality analyses COD <150, SS <200 (mg/L) ▪ Drinking water quality standard (31 parameters)	▪ Water quality analysis	Twice a year	Contractor	Included in construction cost
Solid Waste	▪ Proper waste handling at waste disposal site and treatment plant ▪ Guidance to workers on construction site cleaning	▪ Physical observation	Monthly	Contractor	Not required due to confirmation by site inspection only
Soil Contamination	▪ Confirmation on soil inflow of fuel, oil, grease, etc.	▪ Physical observation	Monthly	Contractor	Not required due to confirmation by site inspection only
Noise and Vibration	▪ Noise level (Industrial area during daytime <75dB)	▪ Sound level meter	Twice a year	Contractor	Included in construction cost
Hydrological Situation	▪ Water level near intake point	▪ Water level measurement	Weekly	Contractor	Not required due to confirmation by site inspection only
Local Economy (Livelihood, Employment, etc.)	▪ Efficient traffic regulation to reduce impact on local economy	▪ Inquiries to relevant persons	Weekly	Contractor	Not required due to confirmation by site inspection only
Water Use and Water Rights	▪ Fluctuations in water quantity and quality in canal due to the construction of water intake facilities	▪ Inquiries to relevant persons ▪ Physical observation	Weekly	WASA-F	Not required due to inquiries done by WASA-F staff only
Existing Social Infrastructures & Services	▪ Existence of traffic obstruction or reduced access to existing infrastructures	▪ Inquiries to relevant persons ▪ Physical observation	Weekly	Contractor	Not required due to confirmation by site inspection only
Landscape	▪ Changes in landscape around construction site	▪ Physical observation	Monthly	Contractor	Not required due to confirmation by site inspection only
Infectious Diseases such as HIV/AIDS	▪ Presence of infectious diseases ▪ Implementation of guidance on the prevention of infectious diseases	▪ Physical observation	Monthly	Contractor	Not required due to internal training
Working Conditions	▪ Execution status of occupational safety and health guidance and regular safety meetings	▪ Physical observation ▪ Reports on workshops and meetings	Weekly	Contractor	Not required due to internal training
Accidents (Traffic accidents, etc.)	▪ Occurrence of accidents	▪ Inquiries to relevant persons ▪ Physical observation	Weekly	Contractor	Not required due to confirmation by site inspection only
Operation Phase					
Solid Waste	▪ Status on proper removal and disposal of generated sludge	▪ Physical observation	Monthly	WASA-F	Not required due to confirmation by site inspection only
Noise and Vibration	▪ Noise level (Industrial area during daytime <75dB)	▪ Portable sound level meter	Every 6 months	WASA-F	Not required due to confirmation by staff
The Poor	▪ Impact from water tariff system to household economy of poverty group	▪ Inquiries to relevant person	Every 6 months	WASA-F	Not required due to confirmation by staff
Water Use and Water Rights	▪ Changes in amounts of irrigation water to downstream agricultural lands especially during drought periods	▪ Physical observation ▪ Inquiries to Irrigation Dept.	Quarterly	WASA-F	Not required due to confirmation by site inspection only

1-3-1-11 Stakeholders Meetings

The Pakistan Environmental Protection Act 1997 (Section 12(3)) highlights that "every review of an environmental impact assessment shall be carried out with public participation."

The overall objectives of stakeholders meetings are as follows:

- To provide with stakeholders the information related to proposed project activities;
- To facilitate and maintain dialogues and gain the consent of all stakeholders on carrying out project activities in the area;
- To seek participation of all interested parties and identify stakeholder interests and issues;
- To create solutions for addressing these concerns and integrating them into project design, operations and management;
- To enhance the project publicness and sustainability by learning from, and incorporating, the expertise of individuals, professionals, communities and organizations; and
- To encourage transparency and inculcate trust among various stakeholders to promote cooperation and partnership with the communities, local leadership and NGOs

The identification of stakeholders is important for the sustainability of a development project and helps to evaluate and envisage the role of stakeholders. The influence or impact of stakeholders on the project can be elaborated in the form of a matrix and the mitigation measures are proposed accordingly. The stakeholders that are likely to be influenced by the project activities or would have interest in participating in the project will include:

- Residents of the surrounding areas;
- Non-Governmental Organizations (NGOs) and Community Based Organizations active in the area;
- Government Organizations.

Stakeholders can be classified as primary and secondary stakeholders as follows depending on the influence level to the project activities.

- *Primary Stakeholders:* People, groups or institutions directly affected by the project and can influence the project outcome. (e.g., residents who will be positively affected by improved water services and water vendors who will be negatively affected by reduced sales)
- *Secondary Stakeholders:* People, groups, or institutions that are indirectly affected by the project and can influence the project delivery process. (e.g., relevant institutions whose development plans are affected by the project, and local authorities that assist in the administrative procedures)

Stakeholder consultation is a two-way flow of information and dialogue between the project proponent and stakeholders, specifically aimed at developing ideas that can help shape project design, resolve conflicts at an early stage, assist in implementing solutions and monitor ongoing activities. Various techniques are used worldwide to carry out the stakeholders consultation that include

discussions, meetings and field visits. The results of consultations are as follows.

(1) Consultation with Primary Stakeholders

Concerns of the primary stakeholders on the proposed project were solicited and collected in the following manner:

- A field visit was arranged to contact the communities nearby the project area by the project consultant team.
- Notices of holding individual group discussions on the project were provided verbally to request participation by the residents.
- A brief description of the proposed project was provided verbally to the stakeholders and they were asked to express their concerns regarding the proposed project.
- Concerns, complaints and suggestions from the stakeholders were recorded.

Consultation sessions were held at 13 areas from June 18 to 20, 2019. The date visited and number of participants from each locality is given in the table below. Due to cultural and social norms, females were not involved.

Table 1-23 Number of Participants in Each Area Visited

Area Visited	Number of Participants	Date of Consultation
Ghareeb Abad	8	18/06/2019
Fateh Abad	8	18/06/2019
Abudulah Pur	8	18/06/2019
Kharassan Wala	5	18/06/2019
Factory Area	8	19/06/2019
Jilani Pura	8	19/06/2019
Jhal Khanuwana	9	19/06/2019
Suhail Abad	9	19/06/2019
Railway Colony	9	20/06/2019
Officer's Colony No. 1	5	20/06/2019
Officer's Colony No. 2	6	20/06/2019
Muhammadia Colony	9	20/06/2019
Kohinoor Town	8	20/06/2019

Generally, all the areas visited had severe issues of safe and clean drinking water availability. So residents had to rely on their own resources or had to buy water from third party suppliers. Therefore, the general public welcomed the project when the goals and objectives of the project were explained. They did not express any major concern regarding the proposed project. The summarized comments from the general public are as follows:

- Clean drinkable water should be provided in their area. (All areas near project site)
- WASA service should be improved to avoid the common issue of sewage being mixing in the water supply.
- Water supply time and pressure should be improved.
- WASA should create employment opportunities for the local residents.

(2) Consultation with Secondary Stakeholders

Concerns of the secondary stakeholders of the proposed project were solicited and collected in the following manner:

- Meetings were arranged with the secondary stakeholders with a team including a focal person from WASA Faisalabad (Proponent) in order to obtain their concerns.
- Government officials and an NGO were contacted by the WASA-F staff to arrange the date and time of each separate meeting.
- A brief description of the proposed project was provided verbally as well as graphically, and they were asked to express their concerns regarding the proposed project.
- Concerns, complaints and suggestions from the stakeholders were recorded.

Meetings were conducted with secondary stakeholders individually at their offices. The stakeholder consultation team consisted of Mr. Faizan Shakoor, Assistant Director of WASA, along with the project consultants. The following officials from Government Departments and an NGO were visited for the secondary stakeholder meetings:

Government Organizations

- Mr. Hassan Zaheer, Deputy Director, Faisalabad Development Authority (FDA)
- Mr. Muhammad Tahir, Deputy Director, Environment Protection Agency (EPA)
- Mr. Usman Akram, Director Admin, Parks & Horticulture Authority (PHA)
- Mr. Muhammad Saleem Bhatti, Superintending Engineer, Irrigation Department
- Mr. Muhammad Khalid, Director Infrastructure, Municipal Corporation (MC)
- Mr. Muhammad Ijaz, Senior Manager Operations, Faisalabad Waste Management Company (FWMC)

NGO

- Mr. Muhammad Abudulah, Coordinator, World Wildlife Fund (WWF)

Details of the respondents for the secondary stakeholders' consultations are given in the table below.

Table 1-24 Details of Secondary Stakeholders Consultation Meetings

	Department/Organization	Designation	Name	Govt./Private	Venue	Date	Time
1	Faisalabad Development Authority (FDA)	Deputy Director	Hassan Zaheer	Government	FDA Office	18-06-19	13:00
2	Environment Protection Agency (EPA)	Deputy Director	Muhammad Tahir	Government	DD EPA Office, EPA FSD.	18-06-19	12:15
3	Parks & Horticulture Authority (PHA)	Director Admin	Usman Akram	Government	Director Admin Office, PHA, FSD.	18-06-19	12:45
4	Municipal Corporation (MC)	Director Infrastructure	Muhammad Khalid	Government	Director Infrastructure Office, MC, FSD.	20-06-19	14:30
5	Irrigation Department	Superintending Engineer	Muhammad Saleem Bhatti	Government	SE Office, Irrigation Department, FSD	22-06-19	11:15

	Department/Organization	Designation	Name	Govt./Private	Venue	Date	Time
6	Faisalabad Waste Management Company (FWMC)	Senior Manager Operations	Muhammad Ijaz	Government	SMO Office, FWMC FSD.	22-06-19	10:45
7	World Wildlife Fund (WWF)	Coordinator	Muhammad Abudulah	NGO	WWF Site Office, FSD.	24-06-19	12:30

The meetings started with a round of introduction and a brief description and then the process of the proposed project was presented to the government representatives. The officials of government departments did not express any major concern regarding the new project by WASA. They all welcomed the project as it will be a good step in overcoming the water supply shortage to the residents of Faisalabad City. The concerns and suggestions expressed during the meetings are as follows:

1. Mr. Hassan Zaheer, (FDA) inquired about the details of areas served by this project and completion time of the project.
2. Mr. Muhammad Tahir (EPA) shared his views that Faisalabad City is facing a severe issue regarding availability of clean water, so this project is a good step towards handling this issue.
3. Mr. Usman Akram (PHA) inquired about the process to handle sludge produced in the water treatment plant.
4. Mr. Muhammad Saleem Bhatti (Irrigation Department) appreciated the efforts of WASA for the improvement of their services for the residents of Faisalabad.
5. Mr. Muhammad Khalid (TMO) appreciated the steps taken by WASA to improve their services for the city of Faisalabad.
6. Mr. Muhmmad Ijaz (FWMC) expressed no concerns regarding the project. He inquired about the status of sludge disposal and quality of raw water.
7. Mr. Muhammad Abudulah (WWF) highly appreciated the project as it is a good step towards handling the scarcity of clean drinking water availability to residents of Faisalabad.

The responses provided for the above comments are as follows:

- The amount of sludge produced in the water treatment plant will not be very large, but it is planned to be treated by thickening and sun-drying, and the dried sludge generated can be used for horticultural purposes.
- The areas that will benefit in phase-1 are Abudulah Pur, Officers Colony No. 1 & 2, Muhammadi Colony, Kohinoor Town, Nemat Colony No. 1 & 2, Daud Colony, and some areas of Madina Town Y-Block. The expected completion of the project is year 2023.
- The water source is canal water and hold no major health issues.

(3) Joint Session of Stakeholders Meeting

In addition to individual meetings with the stakeholders, a joint session at Serena Hotel Faisalabad was arranged on December 14, 2019 where all the key stakeholders as well as general public representatives were invited. Notice of this meeting was given by sending invitation letters a week in

advance, along with telephone calls to the parties involved. The purpose of this session was the same as individual stakeholders' consultations, to seek input from the participants through their comments and suggestions to improve the proposed project execution environmentally as well as socially. The record of discussion is given below.

Mr. Faqir Muhammad Ch. (MD WASA-F) welcomed the participants of the meeting and shared the opening remarks of the session with the details of challenges faced by WASA Faisalabad and the on-going as well as upcoming projects to tackle them. Then, Dr. Nobuyuki Sato, team leader of the project, shared brief information of the current project and its importance for Faisalabad City.

1) Points Discussed

Mr. Adnan Nisar Khan (Director WASA-F) explained the following points.

- The purpose of the meeting is to brief the stakeholders about the project and seek input from the stakeholders through their comments and suggestions regarding social and environmental impact aspects of the project.
- Groundwater of Faisalabad City is brackish. Tubewells are installed in canals to collect seepage water and supply drinkable water to the residents of Faisalabad city.
- The challenges faced by WASA are poor service quality, low level of customer satisfaction leading to low revenue recovery, old pipelines and water treatment plant, and water connections not metered.
- The scope of the current project is:
  - Renewal of the Old JK WTP from slow sand filtration (3.5MGD) to Rapid Sand Filtration (10 MGD in two phases).
  - Installation of GRs and OHRs at Madina Town and Abudulah Pur
  - Installation of distribution pipelines to deliver water from the WTP to Distribution centers and service area.
- The areas that will benefit from the current project will be Madina Town (Block Y-Z), Officers Colony (1 & 2), Nemat Colony, Hassan Pura (Partially), Muhammadi Colony, Pind Kharrassanwala, Kohinoor City and Kohinoor Town which are currently suffering from very low water pressure as well as water contamination issues. Targets of the Project are:
  - Improvement of water supply in the target area
  - Reduce non-revenue water
  - Increase customer satisfaction
  - Increase revenue recovery
- Environmentally this project is important as it will reduce impact on groundwater by reducing its usage.
- Social impacts of the project include land acquisition for the construction of structures and relocation of a very small population from construction sites. The impact is very small as the

land to be acquired is already owned by WASA.

- Issues during project implementation will be noise, dust and traffic congestion. However, it will be ensured that necessary actions will be taken to mitigate the issues and minimize their effects.

2) Questions and Answers

The questions asked and answered during the meeting were as follows.

Table 1-25 Questions and Answers during Stakeholders Meeting

Inquirer	Question	Respondent	Answer
Mr. Farrukh Habib (Public Representative NA 108).	Is this project part of the Master Plan of WASA Faisalabad?	Mr. Faqir Muhammad Chaudhary (MD WASA-F)	This is the Priority Project proposed in the M/P.
Mr. Riaz Kamoka (Public Representative NA-109)	Provide details of areas to be benefitted from the project.	Mr. Adnan Nisar (Director WASA-F)	In the first phase of the project, beneficiaries are Madina Town (Block Y-Z), Officers Colony (1 & 2), Nemat Colony, Hassan Pura (Partial), Muhammadi Colony, Pind Kharrassanwala, Kohinoor City and Kohinoor Town.
		Mr. Faqir Muhammad Ch.	The routes of the distribution pipes to the project area as well as potential beneficiaries from Phase 2 of the project were explained
Arif Mehmood (Assistant Director EPA)	What is the population being served in the current project?	Mr. Adnan Nisar	It is almost 80,000
Mr. Muhammad Rafi (Director Construction, WASA-F)	Explain the contingency plan for the canal closure period as the treatment plant uses canal water.	Mr. Faqir Muhammad Ch.	During canal closure period, there is a water storage system that will be sufficient for almost 21 days. In addition, for continuous water supply to the city, groundwater pumps installed along the canal will remain operational and water sharing amongst supply zones as proposed in M/P will be implemented.
	What are the social impacts if water is supplied 24/7. He explained that if abundant water is supplied for a longer duration, the consumption will be higher, however there will not be any impact on WASA-F Revenue.	Mr. Adnan Nisar	To attain 24/7 water supply, certain measures will surely be taken such as water meters installation and billing on metered rate. Steps like this will help to reduce the overconsumption of water as well as non-revenue water.
	The operation and maintenance cost per unit water treated was inquired.	Mr. Faqir Muhammad Ch.	The per unit water treatment cost as per existing New Jhal Water Treatment Plant is 4 paisa/gallon.
Mr. Abdul Raouf Butt (DD Finance, WASA-F)	Explain the management of 24/7 water supply at fixed	Mr. Adnan Nisar	The current project at the moment is only managing the

Inquirer	Question	Respondent	Answer
	tariff rate in the current project.		water supply system. However, in the future, while shifting to continuous supply for 24/7, steps will be undertaken such as water meter installation and metered billing.

1-3-2 Land Acquisition and Involuntary Resettlement

1-3-2-1 Necessity for Land Acquisition and Involuntary Resettlement

(1) Land Acquisition

Since the proposed project sites for the WTP, distribution centers and pipelines are basically public land, land acquisition will not be necessary and will not cause any environmental and social problems. However, since parts of the pipeline are planned to be laid along the railway land (L=1.4 km, W=1.0 m) and across the irrigation canal, arrangements have been made by WASA-F with the relevant authorities to use these locations.

(2) Involuntary Resettlement

Among the above locations, existing OHRs have been constructed at the proposed water distribution sites and WASA-F and FDA staff housing are found in the premise. These households will need to be resettled for the project, but the Civil Servants Act of Pakistan stipulates that civil servants can be removed to another location in accordance with the relocation order of WASA-F and FDA who are the employers. Therefore, this activity is not classified as involuntary resettlement. Regarding the resettlement of staff households, WASA-F has agreed to secure new residences and complete the resettlement.

1-3-2-2 Legal Framework for Land Acquisition and Involuntary Resettlement

Legal framework and procedures for land acquisition and resettlement are stipulated by the following laws and regulations.

- Land Acquisition Act (LAA), 1894
- Punjab Land Acquisition Rules, 1983
- Project Implementation and Resettlement of Affected Persons Ordinance, 2001

(1) Land Acquisition Act (LAA), 1894

The concept of land acquisition was introduced by the British before independence. The Land Acquisition Act (LAA) 1894 was promulgated to govern the acquisition of private land for public purposes. The Act and successive amendments remain the primary laws of land acquisition in Pakistan. Land acquisition is the responsibility of the province, and the province may only transfer land to another entity after the province itself has acquired it. The rights of titled landowners are fully safeguarded

under the Act. Land and crops are compensated in cash at the current market rate to the landowners. Specified formalities and notifications are required for entering private land or carrying out surveys and investigations for calculating the land value. If affected landowners are unsatisfied, they can contest the compensation in a Court of Law.

(2) Punjab Land Acquisition Rules, 1983

For the purposes of acquisition of land in the Province of Punjab, the government of Punjab has also framed the Punjab Land Acquisition Rules, 1983. These Rules were published in the Gazette of the Punjab Extraordinary, setting out the procedure for land acquisition in accordance with provincial-specific conditions. These rules apply in Punjab Province.

(3) Project Implementation and Resettlement of Affected Persons Ordinance, 2001

Referred to as the “Resettlement Ordinance," this ordinance was promulgated in 2001 by the federal government and was enacted by provincial and local governments after incorporating local requirements. The ordinance was developed as a document to supplement the LAA and other laws of Pakistan, and to conform with the resettlement policy wherever applicable. The ordinance establishes that the rehabilitation and resettlement of disrupted populations and the restoration of their livelihoods shall be carried out as a matter of right and not by way of charity or any such sentiment. Also, the Affected Persons (APs) shall be accepted as special groups who have accepted or undergone involuntary displacement in the supreme interest of the country.

(4) Comparison between JICA Guidelines and Pakistani Regulations

Table 1-26 Comparison between JICA Guidelines and Pakistani Regulations

Item	JICA Guidelines for Environmental and Social Considerations	Pakistani Regulation	Gaps and Proposed Policy for this Project
Resettlement Action Plan (RAP)	For projects that entail large-scale involuntary resettlement, RAPs must be prepared and made available to the public. (JICA GL p30)	In case the impact of the project is severe such that more than 200 people are displaced by the project, RAP for each component will be prepared. (NRP p 22)	No large gaps exist and both are in accordance with World Bank OP 4.12.
Recipients of compensation	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by project proponents etc. in timely manner. (JICA GL p30)	Absence of a formal legal title to land by some affected persons should not be a bar to qualify for compensation of his/her lost assets, business and incomes, including rehabilitation of assistance measures. (NRP p9)	No large gaps exist and both are in accordance with World Bank OP 4.12.
Compensation based on replacement cost	Compensation must be based on the full replacement cost as much as possible. (JICA GL p30) Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL p30)	Full cost of resettlement and compensation shall be included in the project costs and benefits. (NRP p9) N.B. Federal EPA under the support by ADB developed the National Resettlement Policy (NRP) which refers the World Bank Safeguard Policy. Therefore definition of full	No large gaps exist and both are in accordance with World Bank OP 4.12.

Item	JICA Guidelines for Environmental and Social Considerations	Pakistani Regulation	Gaps and Proposed Policy for this Project
		replacement cost has no discrepancy with JICA GL.	
Livelihood recovery support	Host countries must make effort to enable people affected by projects and to improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels. (JICA GL p30)	Aps losing their incomes, jobs and employment, should get additional development assistance that enables them to improve their incomes to maintain their standard of living to pre-project level. (NRP p9)	No large gaps exist and both are in accordance with World Bank OP 4.12.
Support to socially vulnerable	Particular attention must be paid to the needs of the vulnerable groups such as women, children, elderly, poor and ethnic minorities. (JICA GL p29)	Special provisions should be made for the vulnerable groups in a project, over and above their entitlements for compensation and other assistance. (NRP p9)	No large gaps exist and both are in accordance with World Bank OP 4.12.
Consultations with the affected people	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL p30)	For meaningful consultation with and participation of the indigenous people; (i) the information dissemination should be in the local language; (ii) the community leaders should always be present in all discussions; (iii) all the meetings and discussions will be properly documented and shared with the concerned people's groups. (NRP p15)	No large gaps exist and both are in accordance with World Bank OP 4.12.
Resident participation promotion in resettlement plan formulation and during its implementation	Appropriate participation of affected people must be promoted in the planning, implementation, and monitoring of resettlement action plans. (JICA GL p30)	Key stakeholders are fully consulted regarding the project's design, implementation and operation and all activities are carried out through participatory process. (NRP p9)	No large gaps exist and both are in accordance with World Bank OP 4.12.
Grievance handling	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL p30)	A clear mechanism of grievance redress should form part of resettlement and rehabilitation process. (NRP p10)	No large gaps exist and both are in accordance with World Bank OP 4.12.

Note: NRP: Pakistan National Resettlement Policy, 2002

1-3-2-3 Scale and Scope of Land Acquisition and Involuntary Resettlement

Although land acquisition and involuntary resettlement do not apply to this project, resettlement of WASA-F and FDA staff residing at the water distribution plant is needed. Since these staff members are employed by the implementing agency, this will be treated as relocation of residences due to transfer of duties. WASA-F and FDA need to secure new residences and resettle their staff. The eligible WASA-F and FDA staff and their families are from a total of 8 households consisting 55 persons, of which 7 households are located at the Madina Town OHR and 1 household at the Abudulah Pur OHR site. The target households are shown below.

Table 1-27 Staff List of WASA-F and FDA

	Position	Affiliation	Household Size	Location
1	DD admin	UD Wing-FDA	7	Madina Town No. 2 OHR
2	Driver	UD Wing-FDA	5	
3	Sub Engineer	UD Wing-FDA	4	
4	Naib Qasid	UD Wing-FDA	11	
5	Sanitary Worker	UD Wing-FDA	5	
6	Tracer	O&M East WASA	9	
7	Sewerman	O&M East WASA	10	
8	Sewerman	O&M East WASA	4	Abudulah Pur OHR
TOTAL			55	

1-3-2-4 Specific Measures for Compensation and Support

Negotiations for the final compensation will continue until all residents and owners agree. The amount of compensation is calculated based on the full replacement cost of the land on the date of issuance as stipulated in the Land Acquisition Act (LAA) established in 1984. However, in the case of a project in which a large number of residents are affected by land acquisition and reaching an agreement on compensation is difficult, the compensation rate is determined by the market price on the commencement date of impact assessment (cut-off date). The price includes transaction costs but does not include depreciation of construction materials. The actual payment of compensation is made at the stage of project implementation.

According to Article 5 of the LAA, any person may file an objection in writing within 30 days after issuance of the land acquisition notification. The District Collector will hold a hearing on the objection and conduct further surveys as necessary, and then submit a report containing recommendations to the Executive District Officer (Revenue). Upon reviewing the case, the Executive District Officer (Revenue) will make a final decision.

In this Project, there are no residents for the compensation other than WASA-F and FDA staff mentioned above.

1-3-2-5 Mechanism for Grievance Adjustment

Opportunities for grievances are given to all APs. Daily grievances are required to be resolved at the project level. First, negotiations are carried out between the complainant, the AP stakeholders, the project proponent, and the person in charge at the project site. If the grievance cannot be resolved at the field level, the provincial government will establish a district-level Grievance Redress Committee (GRC), which is comprised of the implementing agency, project manager, complaints representative, and AP stakeholders. After reviewing the grievance, the GRC determines the qualifications and compensation details in accordance with the LAA.

1-3-2-6 Implementation Structure (Institutions involved and their Responsibilities)

Although not applicable to this project, when involuntary resettlement and land acquisition are

required in water supply projects, WASA-F and EPA will be responsible in cooperation with the Punjab Provincial Government and Faisalabad District Government. In the case of land acquisition, WASA-F becomes the Requiring Body (RB) and the District Revenue Department is the Acquiring Body (AB).

(1) Requiring Body (RB): WASA-F

The responsibility of the Requiring Body (RB) is to provide technical information in the land acquisition process. As the RB, WASA-F is required to justify the needs of the land for public works by submitting the following information regarding application for land acquisition.

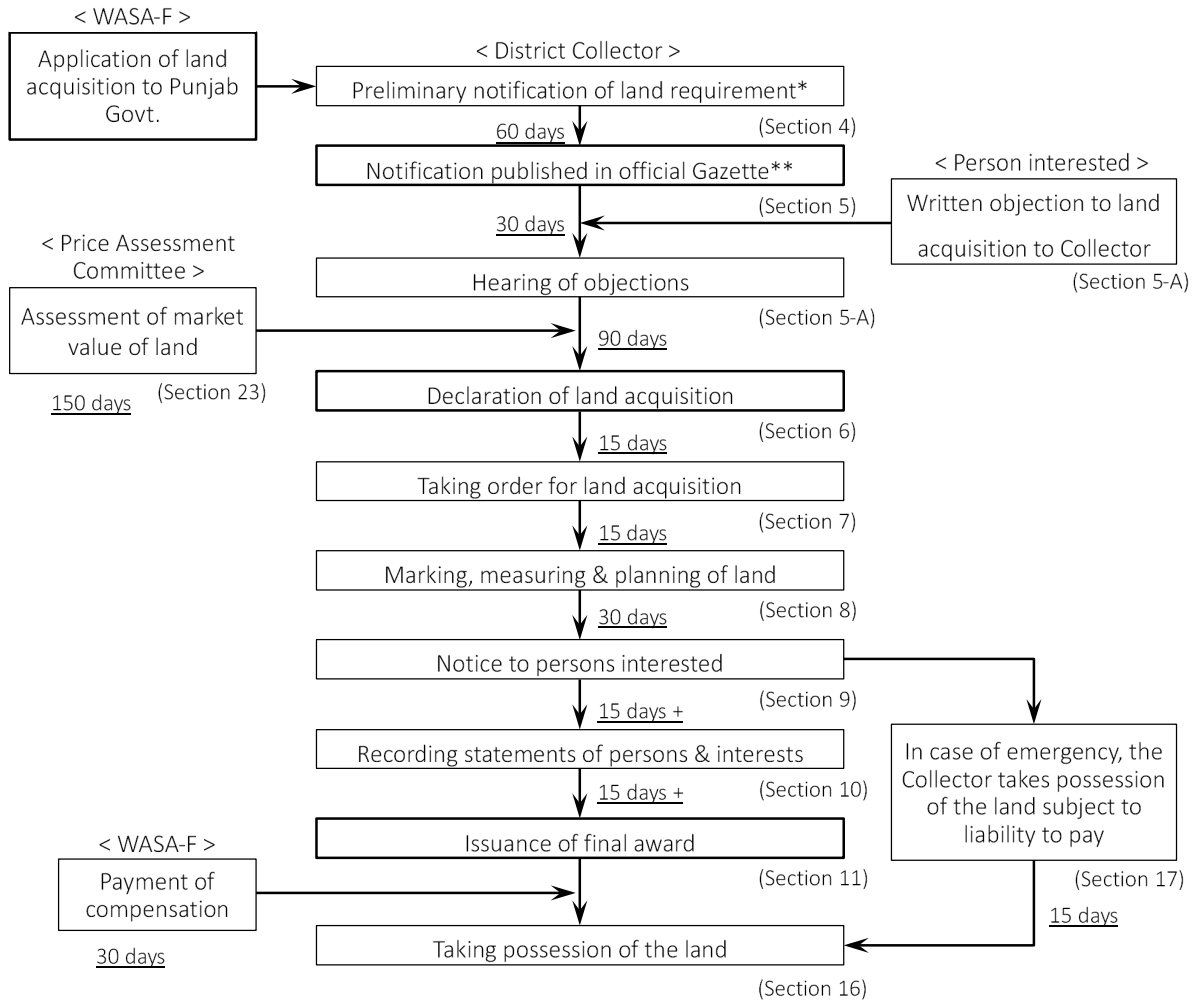
Request documents containing information such as required land area, implementation schedule and objective

- Request documents containing information such as required land area, implementation schedule and objective
- Layout drawing showing the project location
- Detailed site drawing showing the area on a map
- Land register including land classification and plot ownership
- Minimum requirements certificate

(2) Acquiring Body (AB): Provincial Revenue Board

The responsibility of the Acquiring Body (AB) is to exercise legal authority in the land acquisition process. The processing of land acquisition is under the responsibility of the district collector or district revenue officer who has been delegated authority by the Provincial Revenue Board.

The land acquisition process stipulated in LAA is the following.



Note:

*: Preliminary notifications shall be published for at least 7 days in the official newspaper and public notice by the District Collector to inform conducting of the survey to the community in the said locality.

**: Formal notification shall be published for at least 7 days in the official newspaper by the District Collector when land is to be acquired for a public purpose

Figure 1-11 Land Acquisition Process Stipulated in Land Acquisition Act (LAA)

1-3-2-7 Implementation Schedule for Staff Relocation (Commencement of Actual Resettlement after Completion of Payment of Compensation for Lost Assets)

The WASA-F and FDA staff households residing in the proposed sites for water distribution plant must be removed. The schedule is shown below.

Table 1-28 Implementation Schedule

Year	2019	2020											2021	
Month	-	-	3	4	5	6	7	8	9	10	11	12	1	2
Preparatory Survey														
Explanation of Draft Final Report									★					
Coordination by WASA-F														
Consultation with Staff & Agreement				★										
Securing Budget														
Resettlement														
Resettlement Completed														★
Monitoring														

1-3-2-8 Costs and Financial Sources

Although land acquisition and involuntary resettlement do not apply to this project, WASA-F is considering to construct new housing for resettlement of WASA-F staff living in the proposed water distribution site, and the financial resources for this are planned to be included in the PC-1 as the cost to be borne by the Pakistani side for this project. The required budget is determined by the size and specifications of the housing to be designed by WASA-F.

1-3-2-9 Monitoring Form for Staff Relocation

Monitoring will be carried out by WASA-F regarding the resettlement status of WASA-F and FDA staff residing at the distribution centers as well as the requests and complaints from residents and their responses by the monitoring forms shown in Table 1-29 and Table 1-30.

Table 1-29 Monitoring Form (Resettlement Status of Staff Residing at Distribution Centers)

Period (/ - /)		Number Achieved during Period		Progress Rate (%)		Scheduled Completion Date
Description	Number	This Period	Total before This Period	Until Previous Period	Achievement for This Period	
Agreed to resettle						
Budget for resettling house construction secured						
Construction of resettling house						
Moving to new house						
Demolition of old housing						

Table 1-30 Monitoring Form (Requests and Complaints from Staff Residing at Distribution Centers)

No.	Content of Request/Complaint	Received Date	Response to Request/Complaint	Response Date
1				
2				
3				

1-3-2-10 Consultation with the Residents in WASA Premises

WASA-F has already explained to the residents, i.e. WASA-F and FDA staff, who are living at the planned distribution center sites about the necessity of relocation under the project. The consultation and the agreement on relocation to new allotments was completed in April 2020.

1-3-3 Others

1-3-3-1 Monitoring Form (Draft)

The monitoring form (draft) for each item based on the monitoring plan (see Table 1-22) is as follows.

(1) Pollution Control Measures

1) Air Pollution: During Construction

a) Observation

Monitoring Item	Remarks
Dust generated at construction site	Construction site, Four times/year, Physical observation (existence of dust)

b) Measurement (Environmental Standard)

Item (Unit)	Measured Value (Mean)	Measured Value (Maximum)	Local Standard	Japanese Standard	Remarks (Measurement point, frequency, method)
CO (mg/m^3)			<5	<11.5	Air quality measurement around construction site, Four times/year, Air quality measurement
SO_2 ($\mu g/m^3$)			<120	<105	
NOx ($\mu g/m^3$)			<80	—	
PM_{10} (($\mu g/m^3$)			<150	<100	

2) Water Pollution (Effluent/Drinking Water Quality Standard): During Construction

Item (Unit)	Measured Value (Mean)	Measured Value (Maximum)	Local Standard	Japanese Standard	Remarks (Measurement point, frequency, method)
COD (mg/L)			<150	≤160	Effluent quality measurement around construction site, Twice/year, Water quality analysis
SS (mg/L)			<200	≤200	
pH			6.5-8.5	5.8-8.6	Drinking water quality downstream of construction site at intake facility, Twice/year, Water quality analysis
Odour			NO	NO	
Taste			NO	NO	
Colour (Pt-Co)			≤15 TCU	≤5 CU	
Turbidity (NTU)			<5	≤2	
Total Hardness (mg/L)			< 500	≤300	
TDS (mg/L)			<1000	≤500	
Cl (mg/L)			< 250	≤200	
CN (mg/L)			≤0.05	≤0.01	
F (mg/L)			≤ 1.5	≤0.8	
NO_2^- (mg/L)			≤3	≤0.04 (as N)	
NO_3^- (mg/L)			≤ 50	≤10 (NO_3^--N + NO_2^--N)	
Phenol (mg/L)			—	≤0.005	
Residual Cl (mg/L)			0.2-0.5	—	
Al (mg/L)			≤ 0.2	≤0.2	
Pesticides (mg/L)			—	—	

Item (Unit)	Measured Value (Mean)	Measured Value (Maximum)	Local Standard	Japanese Standard	Remarks (Measurement point, frequency, method)
Cd (mg/L)			0.01	≤0.003	
Cu (mg/L)			2	≤1.0	
Cr (mg/L)			≤ 0.05	≤0.02 (Cr^{6+})	
Hg (mg/L)			≤ 0.001	≤0.0005	
Sb (mg/L)			≤ 0.005	—	
Ni (mg/L)			≤ 0.02	—	
Zn (mg/L)			5.0	≤1.0	
As (mg/L)			≤ 0.05	≤0.01	
Ba (mg/L)			0.7	—	
Mn (mg/L)			≤ 0.5	≤0.05	
B (mg/L)			0.3	≤1.0	
Pb (mg/L)			≤ 0.05	≤0.01	
Se (mg/L)			0.01	≤0.01	
Total Coliforms			0/100ml	≤100/1ml (Common bacteria)	
Faecal Coliforms			0/100ml	Not to be detected (E. Coli)	

3) Solid Waste

a) During Construction

Monitoring Item	Remarks
• Proper waste handling at disposal site and treatment plant • Cleaning of construction site by workers	Construction site and disposal site, Once/month, Physical observation (proper disposal, cleaning situation)

b) During Operation

Monitoring Item	Remarks
Proper removal and disposal of generated sludge	Water treatment plant, Once/month, Physical observation (status of sludge removal and disposal)

4) Soil Contamination: During Construction

Monitoring Item	Remarks
Proper storage and disposal of fuel, soil etc.	Construction site, Once/month, Physical observation (status of fuel and oil storage and disposal.)

5) Noise and Vibration: During Construction/During Operation

Item (Unit)	Measured Value (Mean)	Measured Value (Maximum)	Local Standard	Japanese Standard	Remarks (Measurement point, frequency, method)
Noise Level (dB)			<75	<85	During construction: Daytime industrial area surrounding construction site, Twice/year, Sound level meter

Item (Unit)	Measured Value (Mean)	Measured Value (Maximum)	Local Standard	Japanese Standard	Remarks (Measurement point, frequency, method)
					During operation: Daytime industrial area surrounding water treatment plant. Every 6 months, Sound level meter

(2) Natural Environment

Hydrological Conditions: During Construction

Monitoring Item	Remarks
Water level near intake mouth	Around intake, Once/week, Water level measurement

(3) Social Environment

1) Local Economy (Livelihood, Employment, etc.): During Construction

Monitoring Item	Remarks
Efficient traffic regulation to reduce impact on local economy	Around construction site, Once/week, Inquiries to relevant persons (residents, local businesses, shop owners, etc.) and physical observation (conducting of traffic control and installation of signboards)
Economic impact on shops and offices due to reduced access due to the construction	Around construction site, Once/week, Inquiries to relevant persons (residents, local businesses, shop owners, etc.) and physical observation (existence of temporary closure of shops and offices)

2) Water Use and Water Rights

a) During Construction

Monitoring Item	Remarks
Fluctuations in water quantity and quality in canal due to the construction of intake facility	Canal downstream the intake of WTP Once/week, Inquiries to relevant person and physical observation (fluctuation in water quantity and quality in canal)

b) During Operation

Monitoring Item	Remarks
Changes in amounts of irrigation water to downstream agricultural lands especially during drought periods	Agricultural lands downstream the intake of WTP, Quarterly, Physical observation and inquiries to the Irrigation Department (change in amount of irrigation water)

3) Existing Social Infrastructures and Social Services: During Construction

Monitoring Item	Remarks
Traffic obstacles and reduced access to existing infrastructures	Around construction site, Once/week, Inquiries to relevant persons and physical observation (existence of traffic obstacles and reduced access to existing infrastructure)

4) Landscape: During Construction

Monitoring Item	Remarks
Changes in landscape around construction site	Around construction site, Once/month, Physical observation (change in landscape)

5) Infectious Diseases such as HIV/AIDS : During Construction

Monitoring Item	Remarks
Implementation of guidance on prevention of infectious diseases	In the construction site, Once/month, Physical observation (execution status of guidance)

6) Working Conditions: During Construction

Monitoring Item	Remarks
Execution of occupational safety and health guidance and periodic safety meetings	In the construction site, Once/week, Physical observation (execution status of guidance and meetings) and reports on workshops and safety meetings

7) Accidents: During Construction

Monitoring Item	Remarks
Installation of safety measures such as fences and warning signs	Around construction site, Once/week, Inquiries to relevant persons and physical observation (Installation of safety measures)

8) The Poor: During Operation

Monitoring Item	Remarks
Impact from water tariff system to household economy of poverty group	In the project site, Every 6 months, Inquiries to relevant persons (impact from water tariff system to the poverty group)

1-3-3-2 Environmental Checklist

The description of environmental and social considerations for this preparatory survey and results of confirming their progress are shown below in the JICA environmental checklist for water supply projects.

Table 1-31 JICA Environmental Checklist for Water Supply Projects

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) N (d) N	(a) WASA-F will prepare an EIA report and submit it to EPA during the present survey. (b) As of March 2020, an EIA report is being finalized. (c) Special conditions are not imposed for EIA approval. (d) Other environmental permits are not required.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) A stakeholders meeting was held with local administration in June 2019 to explain the outline of the project and expected negative environmental and social impacts and received opinions from local governments. Also, a joint session stakeholders meeting was held in December 2019. (b) Comments made during the above meetings were reflected in the project.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Alternatives for facility components, location of distribution centers, construction methods of crossing the canal were considered.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution? Are any mitigating measures taken? (b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	(a) N (b) Y	(a) Since sodium hypochlorite is applied for chlorination, a negative impact to the air is negligible. (b) Chlorine is used for cleaning the pipe after installation and in the water treatment process, but since the concentration is low and the amount is small, this will not be a problem. Also, the dosing method is safe in line with safety standards.
	(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	(a) Y	(a) Wastewater generated from the water treatment plant will be properly treated and discharged into the drainage canal in accordance with the country's wastewater standards.
	(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country's regulations?	(a) Y	(a) Sludge generated from the water treatment plant will be dewatered and then transported to the designated disposal site to be disposed.
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	(a) Y	(a) Since all pumps are to be installed inside the building, noise and vibration from the pumps will be minimal and consistent with the country's standards.
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a) N	(a) Groundwater will not be pumped up in this project.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
3 Natural Environment	(1) Protected Areas	(a) Is the project site or discharge area located in protected areas designated by the country's laws or international treaties and conventions? (b) Is there a possibility that the project will affect the protected areas?	(a) N (b) N	(a) (b) Since the project site is in an urban area, protected areas are not existent.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site or discharge area encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) N (c) N (d) N	(a) Since the project site is in an urban residential area, ecologically significant nature, flora and fauna do not exist. (b) The project site does not include habitats for precious species needed to be protected by laws and international treaties of this country. (c) Since the project site is in an already developed area, significant impacts on the ecosystem are not concerned. (d) Since the water intake from the irrigation canal for this project accounts for only a small percentage of the irrigation water volume planned by the Irrigation Department, the impact on the surrounding aquatic environment is extremely limited.
	(3) Hydrology	(a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	(a) N	(a) Since water intake for this project is irrigation canal and the amount of water withdrawn is limited compared to the amount of water used for irrigation, influence on the flow of surface water and groundwater is negligible.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? Does the	(a) N (b) n/a (c) n/a (d) n/a (e) n/a (f) n/a (g) n/a (h) n/a (i) n/a (j) n/a	(a) There is no need for land acquisition since the proposed project sites are owned by WASA-F. Although some households of WASA-F and FDA staff are living at the site of the proposed water distribution centers, they will be provided with new housing at different locations by WASA-F under the project. Therefore, there will be no involuntary resettlement. (b)(c)(d)(e)(f)(g)(h)(i)(j) Not applicable

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?		
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	(a) Y (b) Y	(a) Businesses and shops along the pipeline route will temporarily be impeded from access to their working area due to the construction, which would have negative impacts on commercial activities. Impacts can be minimized by mitigating measures such as assuring access traffic and detours during construction and prior notice to businesses in areas where roads will be temporarily closed. (b) Water intake from this project is expected to have some impact on the downstream irrigation water use, but this will be coordinated with the Irrigation Department to minimize the impact.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archaeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) Archaeological, historical, cultural, religious or heritage sites do not exist around the project site.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) Landscapes needing special consideration in the target area are not found.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) N	(a) Components that may affect ethnic minorities or indigenous peoples are not existent. (b) Not applicable.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) Since the working environment is assured by laws including the national labor law, no problems will arise. (b) The above labor law requires the safety of workers, and safety measure will be taken by the contractor in charge of the construction work. (c) The contractor will prepare safety and health plans and carry out safety education for workers. (d) Educational guidance for security personnel will be provided by the contractor.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	(a) Y (b) Y (c) Y (d) Y	(a) The mitigation plan is through proper selection of construction equipment and vehicles, careful operation and maintenance, and proper construction methods. In addition, efforts will be made to minimize impacts by establishing a claims window and respond to complaints. (b) Since the project area is an area that has already been developed, construction will have almost no impact on the natural environment. (c) Possible impacts include the problems of security and the increase of infectious diseases associated with the entry and exist of construction workers from outside. The contractor will prepare plans for prevention of crimes and infectious diseases, and carry out awareness education and security measures. (d) When laying pipes along the main trunk road, traffic congestion may occur. Traffic congestion may be alleviated by securing detour roads and one-sided traffic, installing traffic signs and control staff, and advance notice of construction details and traffic regulations.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that	(a) Y (b) Y	(a) Monitoring will be carried out according to the proposed monitoring plan.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(c) Y (d) Y	(b) The environmental monitoring plan will set the methods and frequency for necessary environmental and social items. (c) WASA-F will secure the necessary budget for implementation of the environmental monitoring and will request the contractor to conduct proper monitoring. (d) These are specified in the environmental monitoring plan.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	(a) n/a	(a) None of these items are applicable to this project.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) Impacts on transboundary or global issues are not expected.

Note:

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
   In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item considering the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

CHAPTER 2
CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

It is an urgent issue for WASA-F to improve its water supply services as mentioned in "1-1 Background and Basic Concept of the Project". Through the M/P Project, a master plan for water supply, sewerage and drainage development was formulated with a target year of 2038. A part of the priority project in the master plan is this Project, which includes renewing and expanding the Old JK WTP and developing transmission and distribution facilities.

The following is the overall goal and the project purpose.

Overall goal: Water supply facilities are developed according to the M/P Project through the financial improvement of WASA-F as a result of an increase in income by increasing customers and water tariff collection rate.

Project purpose: Living environment in Faisalabad is improved through an improvement of the water supply capacity by renewing and expanding the existing WTP and development of transmission and distribution facilities.

2-1-2 Outline of the Project

The Project consists of renewing and expanding the Old JK WTP and developing transmission and distribution facilities in order to achieve the overall goal and the project purpose as mentioned above. Main components of the Project are summarized in Table 2-1. Through the Project implementation, WASA-F will be able to provide an improved water service with sufficient volume and appropriate pressure.

Table 2-1 Main Components of Project

Facility	Detail	Major Specification / Contents
Intake	Intake mouth, branch valve chamber	Reinforced concrete structure Width 0.6m x water depth 1.0m x 2 nos. Raw water transmission pipe: DCIP DN800
	Raw water pump station	Reinforced concrete structure Pump well: width 3.6m x length 19.6m x water depth 5.3m x 1 unit Pump room: width 7.4m x length 20.0m Electric room: width 4.2m x length 20.0m Raw water transmission pump: 3 unit (stand-by 1 unit)
Water Treatment Plant	Receiving and distribution tank	Reinforced concrete structure Width 3.0m x length 3.7m x water depth 5.5m x 2 units
	Mixing tank Flocculation tank	Mixing tank Reinforced concrete structure

Facility	Detail	Major Specification / Contents
	Settling tank	Water flow energy type (freefall from weir) Receiving: width 3.0m x length 3.0m x water depth 4.5m x 1 unit Mixing: width 3.0m x length 0.8m x water depth 2.8m x 1 unit Flocculation tank Reinforced concrete structure Up-and-down type, Width 1.85m x length 9.7m x 4 stages x water depth 3.5~3.8m x 2units Settling tank Reinforced concrete structure Inclined pipe type Width 8.4m x length 13.75m x water depth 3.5m x 2 units
	Rapid sand filter	Reinforced concrete structure Single filter medium, constant rate filtration Filtration rate: 140m/day Width 4.5m x length 9.4m x 4 units Filtration area: 42.3 m^2 x 4 units Air-wash and backwash
	Clear water reservoir	Reinforced concrete structure Width 15.8m x length 17.2m x water depth 4.5m x 2 units Effective volume: 2,440m^3 Retention time: 1.2 hours for 10 MGD
	Transmission pump station	Reinforced concrete structure Pump room: width 9.4m x length 32.4m Electric room: width 4.2m x length 32.4m Transmission pump: 3 units (stand-by 1 unit)
	Waste water tank and sludge tank	Waste water tank Reinforced concrete structure Width 4.2m x length 20.0m x water depth 2.5m x 2 units Transfer pump: 2 units (stand-by 1 unit) Recycle pump: 4 units (stand-by 2 units) Sludge tank Reinforced concrete structure Width 4.2m x length 20.0m x water depth 3.0m x 2 units Transfer pump: 4 units (stand-by 2 units)
	Sludge thickener	Reinforced concrete structure Dia. 12.8m x water depth 4.0m x 1 unit
	Sludge extraction pump station	Reinforced concrete structure Pump room: width 5.0m x length 12.0m Electric room: width 5.0m x length 12.0m Transfer pump: 2 units (stand-by 1 unit)
	Sludge drying bed	Masonry retaining wall and reinforced concrete structure Width 20.0m x length 30.0m x 4 units
	Chemical building	Reinforced concrete structure Single story, width 8.2m x length 29.4m Dosing equipment for aluminum sulfate Dosing equipment for polymer Dosing equipment for sodium hypochlorite
	Administration building	Reinforced concrete structure Single story, width 18.0m x length 20.0m SCADA Equipment for water quality analysis
	Power receiving and transforming, and generator house	Reinforced concrete structure Single story, width 13.0m x length 11.0m Generator: 1,000kVA
	Electricity meter house	Reinforced concrete structure Single story, width 3.5m x length 5.0m
Distribution Center	Ground reservoir	Abudulah Pur Distribution Center Reinforced concrete structure

Facility	Detail	Major Specification / Contents
		Width 7.5m x length 15.4m x water depth 6.0m x 2 units Effective volume: 1,390m^3 Retention time: 4.0 hours Lift pump: 4 units (stand-by 1 unit) Generator: 300 kVA <u>Madina Town No. 2 Distribution Center</u> Reinforced concrete structure Width 13.1m x length 21.1m x water depth 4.8m x 2 units Effective volume: 2,650m^3 Retention time: 4.0 hours Lift pump: 4 units (stand-by 1 unit) Generator: 300 kVA
	Overhead reservoir	<u>Abudulah Pur Distribution Center</u> Reinforced concrete structure Dia. 10.8m x water depth 5.5m x 1 unit Effective volume: 500m^3 Retention time: 1.5 hours Low-water-level: 25m from formation ground level <u>Madina Town No. 2 Distribution Center</u> Reinforced concrete structure Dia. 14.7m x water depth 5.5m x 1 unit Effective volume: 933m^3 Retention time: 1.5 hours Low-water-level: 25m from formation ground level
Transmission and Distribution Main (Applicable to transmit a capacity of 10MGD partially)	Transmission main	DCIP DN600, L=990m HDPE DN450, L=1,730m HDPE DN400, L=1,270m HDPE DN300, L=60m Pipe bridge DN500, L=40m 1 no. Total length: L=4,090m
	Distribution primary main	HDPE DN450, L=590m HDPE DN350, L=630m Total length: L=1,220m
	Distribution secondary main	Part of DMA I-1, DMA II-2 HDPE DN200, L=800m HDPE DN150, L=1,100m Total length: L=1,900m District meter: 2 nos. (DMA I-1, II-2)
Soft Component	O&M of water treatment plant	Water production in accordance with the water demand plan Operation method of Old JK WTP under unusual circumstances Maintenance of water treatment facilities
	O&M of transmission and distribution facilities	Efficient pump operation with adjustment of flow rate according to changes in demand Continuous water transmission/distribution during the RBC closure

2-2 Outline Design of the Japanese Assistance

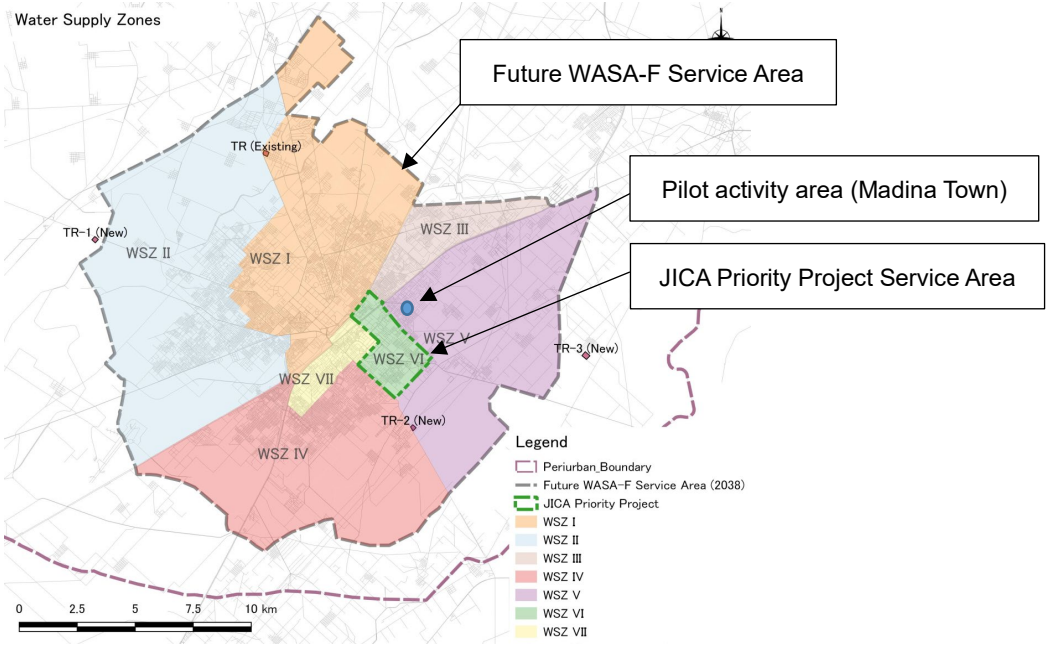
2-2-1 Design Policy

2-2-1-1 Basic Approach

(1) Scope of the Project

1) Development Plan and Priority Project in M/P Project

The M/P Project developed a four-phased development plan with a target year of 2038. The plan includes the development of seven water supply zones (WSZ) in the city of Faisalabad (see Figure 2-1). WSZs are divided into 56 Distribution Zones (DZs).



Source: M/P Project

Figure 2-1 Service Area of the development plan in the M/P

The M/P Project also selected the development of WSZ VI as the priority project based on the following reasons.

a) The development of WSZ VI is expected to improve water distribution management through supplying water with a stable and sufficient volume and appropriate quality and pressure, which is one of the main purposes of the M/P.

b) Among the first phase projects in the M/P, which are urgent projects in terms of addressing the increasing demand, the development of WSZ VI does not have any commitment by donors for assistance or the financial arrangement by the Pakistani side.

c) The water source for WSZ VI is surface water, which is consistent with the strategy in the M/P to shift the source of water supply from groundwater to surface water.

d) The size of WSZ VI is feasible in consideration of the current O&M level of WASA-F.

e) The development of WSZ VI is expected to effectively reproduce the outcome of the pilot activity in the M/P project because the target area is adjacent. (Madina Town).

The priority project is to develop three DZs in WSZ VI and each DZ is divided into multiple district metered areas (DMAs). In the distribution zones, the daily maximum water demand in 2038 is projected to be 10 MGD (approximately 45,500 m^3/day). In order to satisfy the demand, new facilities such as a water intake facility, a water treatment plant (Old JK WTP changed from slow-sand filtration system to rapid sand filtration system), transmission mains, distribution centers (GRs and OHRs), and distribution mains are planned.

Each DZ is hydraulically isolated from the adjacent DZs. Hydraulic separation makes it possible to supply a sufficient amount of water with desirable pressure. The M/P intends to achieve a virtuous cycle: i) improvement in water supply services in terms of water quantity and pressure, ii) increase in customer satisfaction, iii) increase in payment of water bills, and iv) financial improvement of WASA-F. The priority project aims at achieving the realization of a part of this virtuous cycle.

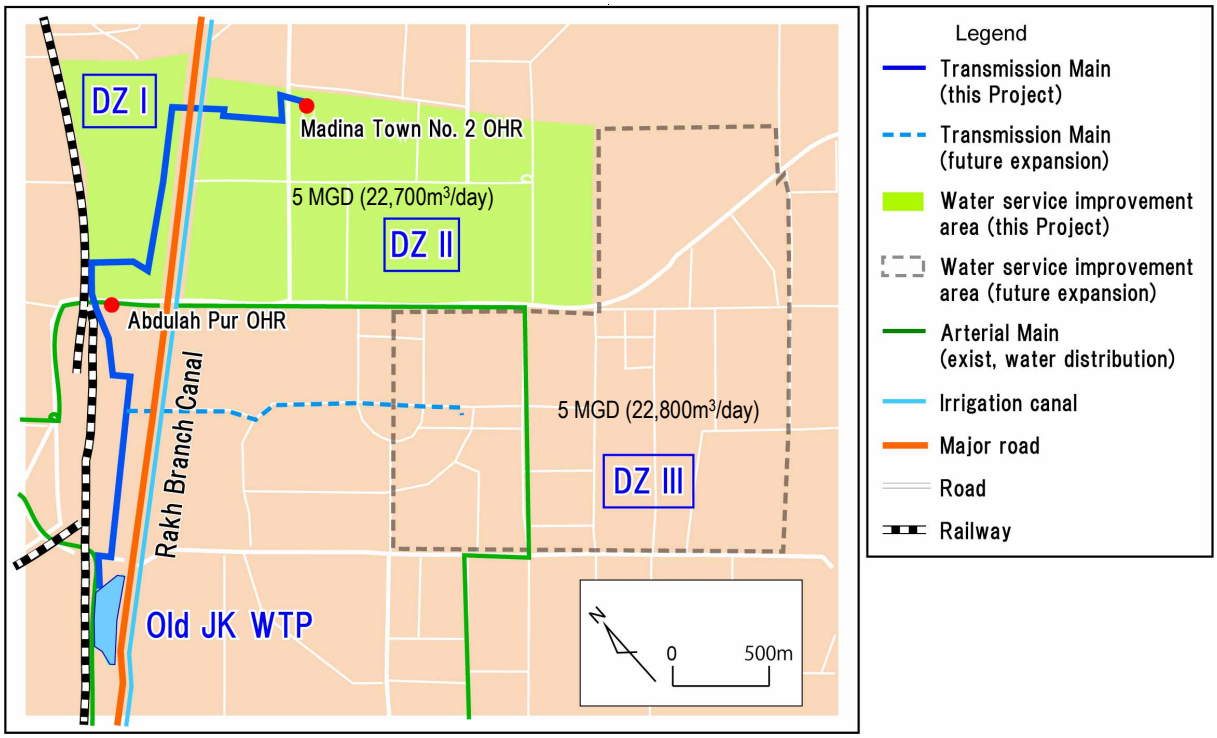
Regarding the customer satisfaction, it is expected to be increased through the improvement in water supply services for the following reasons.

a) Improved water pressure increases the customer's tap flow rate substantially as well as allows water to reach their second floors. Additionally, having a consistent water pressure will make water contamination from groundwater and sewerage less likely to occur.
b) As water quantity improves, customers will be able to use the water for longer hours. An increase in water supply hours will reduce the hour of negative pressure in the distribution pipes, and improve water quality.

2) Request from the Pakistani Side

The request from the Pakistani side for this Project was the construction of facilities to supply water to two DZs (DZ I and DZ II) as shown in Figure 2-2, which are a part of the Priority Project selected by the M/P Project. The two DZs of the three DZs were selected for the following reasons.

a) DZ I is the oldest town of the three DZs, and therefore has many leaks and water contamination due to aging distribution pipes.
b) DZ I and DZ II have lower pressure compared to DZ III.
c) Since DZ II and the pilot activity area of the M/P Project are adjacent, and are operated by the same staff of WASA-F, it is easy to utilize their know-how for the Project.



Source: JICA Study Team based on M/P Project (values are estimated water demand for 2038)

Figure 2-2 Planned Service Area of this Project

The process of water supply system is shown in Figure 2-3. Water is taken from the RBC by the intake mouth, stored in the raw water reservoirs, and then purified by the rapid sand filtration system in the Old JK WTP. The capacity of the WTP is 5 MGD (22,700 m^3 per day). The treated water is transmitted from the WTP to Abudulah Pur distribution center (hereinafter referred to as "Abudulah Pur DC") and Madina Town No. 2 distribution center (hereinafter referred to as "Madina Town No. 2 DC"), pumped to OHRs at the distribution centers, and distributed from OHRs to DZs by gravity.

In order to supply sufficient water volume with appropriate pressure to the target area, District Metered Areas (DMA) are planned to form 6 DMAs in 2 DZs hydraulically isolated from the surrounding area.

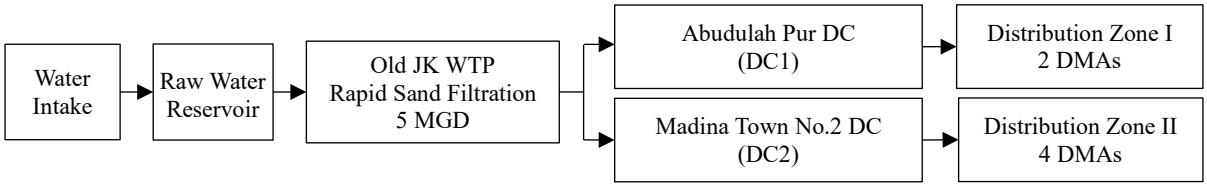


Figure 2-3 Outline of Water Supply System

3) Objective of the Project

In order for all citizens of Faisalabad to improve access a safe and sufficient volume of drinking water, the improvement of water supply facilities throughout WASA-F's service area is required. To this end, the financial condition of WASA-F needs to be improved. The concept is illustrated in Figure 2-4.

In the Project, water supply facilities are developed in order to improve the water pressure, supply

hours and supply volume in Abudulah Pur (DZ I) and Madina Town No. 2 (DZ II). As a result, the financial condition of WASA-F is expected to improve through i) an increase in customer satisfaction, and ii) an increase in new customers and water tariff collection rate from the current customers in the DZs.

The financial improvement will allow some budget to be used to generate similar outcomes in the other areas selected by the M/P Project, which will further contribute to the improvement of WASA-F's financial conditions.

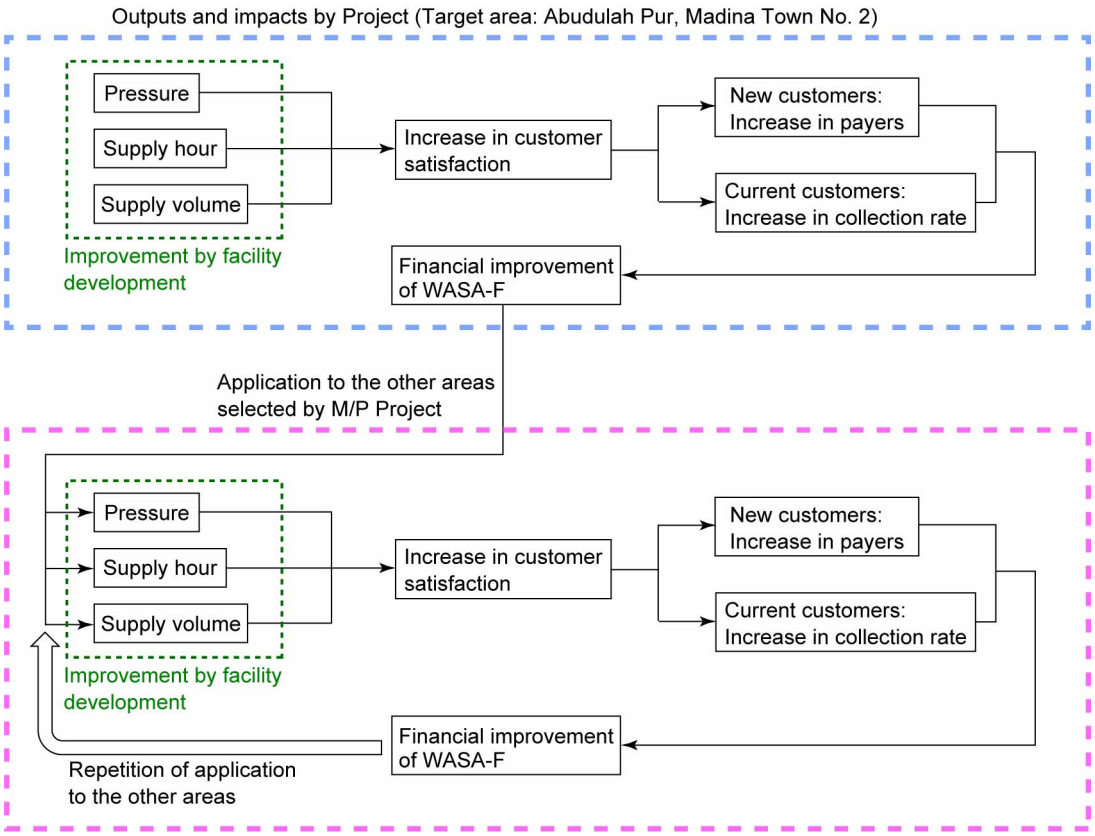


Figure 2-4 Concept of Development Effectiveness

4) Scope of the Project

Based on the objective of the Project, the request from the Pakistani side was examined. As a result of reviewing the request from the Pakistani side and considering the approaches mentioned above, the project size was deemed to be too excessive for the Japan's Grant Aid. Therefore, alternative plans were considered to make the size applicable for the Grant Aid. A comparison table of the alternatives is shown in Table 2-2. Through a discussion with the Pakistani side, Alternative 1 was selected as the scope of the Project.

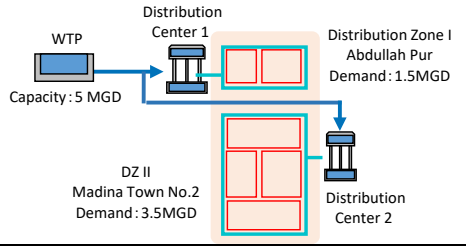
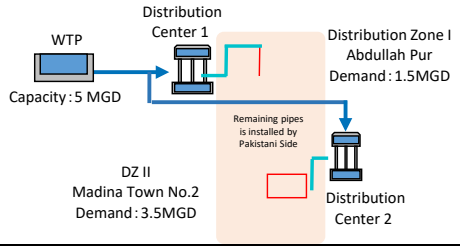
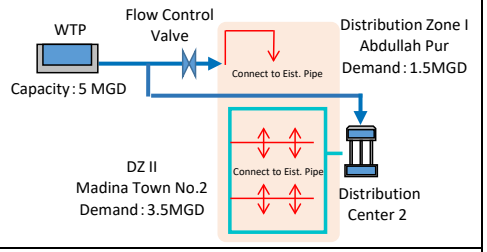
The main points of Alternative 1 are as follows.

- Target service areas are Abudulah Pur and Madina Town No. 2 as requested.
- The capacity of the WTP is 5 MGD (22,700 m^3/day) as requested.
- Each facility in the WTP is considered for applicability of the future expansion to 10 MGD

(45,500 m^3/day) as requested.

- Two distribution centers and transmission mains are installed as requested.
- Distribution primary and secondary mains are installed partially by the Japanese side.
- The remaining distribution primary and secondary mains will be installed by the Pakistani side. The Pakistani side will also connect new distribution mains to the existing mains, and separate DZs and DMAs in the target service areas. The installation of the distribution mains has been already planned by the Pakistani side, and is therefore not included in the obligations of recipient country in the Project.
- High density polyethylene pipe (HDPE) is used partially for transmission mains instead of ductile cast iron pipe (DCIP).
- Sodium hypochlorite is used for oxidation and disinfecting agents at the WTP instead of liquid chlorine.

Table 2-2　Comparison Table of Alternatives for Scope of the Project

		Original plan	Alternative 1	Alternative 2
Water Supply Diagram				
Service Area		DZ I, DZ II	Same as left	Same as left
Component	WTP	5 MGD (considering future expansions to 10 MGD)	Same as left	Same as left
	Transmission mains	5 MGD (considering future extensions to 10 MGD)	Same as left	Same as left
	Distribution center	5 MGD (2 nos.)	Same as left	3.5 MGD (Madina Town No. 2 only)
	Primary mains	DZ I, DZ II (approx. 11km)	Part of DZ I・DZ II	DZ II only
	Secondary mains	DZ I, DZ II (approx. 20km)	Part of DZ I・DZ II	Part of DZ I・DZ II
	Isolation of Distribution zone	Isolation of both DZ I, DZ II	None (but DZ I is likely to be already isolated from surrounding area)	DZ II only isolated (DZ I is likely to be already isolated from surrounding area)
Project Cost		Excessive as Japanese Grant Aid Project	Moderate as Japanese Grant Aid Project	Moderate as Japanese Grant Aid Project
Project by Pakistani side		-	Installation of primary and secondary mains and water meters in parallel with the project. Connection between the primary and secondary mains installed by the Japanese side.	Installation of Abudulah Pur DC, distribution primary and secondary mains, and water meters after Japanese side connects to existing pipes.
Relevance to M/P	Improvement of water treatment capacity	• Target water treatment capacity can be achieved.	Same as left	Same as left
	Improvement of supply volume and pressure in the planned service area	• Target supply volume and pressure can be achieved.	• It can be expected to improve supply volume and pressure in DZ I compared with Alternative 2. • Improving supply volume and pressure is less certain than Alternative 2 in DZ II due to the large amount of pipe works by the Pakistani side.	• Since DZ I is distributed directly by the pumps in WTP, there is a possibility that the adequate water supply pressure is not ensured due to the fluctuation of the water demand. In case of power failure, supply pressure will decrease until generator operation. • The supply volume and pressure in DZ II will improve more than Alternative 1 since DZ II is isolated from surrounding area.
Others		Japanese grant aid cannot be adopted because of its excessive project scale.	The Pakistani side has technical capacity for installation of distribution mains.	The construction of the DC with adequate quality is not easy for Pakistan.
Decision			Selected	

(2) Target Year

As the M/P Project formulated the phasing projects with the target year of 2038, the capacity of the WTP in the phasing project is planned at the demand of the distribution area in 2038. The expansion of the Old JK WTP is also a part of the phasing projects. Therefore, the target year of the Project is designed as 2038.

The operation of the facilities is planned from 2024 as described in "2-2-4-9 Implementation Schedule". Ex-post evaluation is scheduled in 2027, which is 3 years after the completion of the Project.

(3) Service Area

The service area in the Project is DZ I and DZ II as shown in Figure 2-2.

(4) Design Capacity of Facilities

The facilities are designed at a capacity of 5 MGD (22,700 m^3/day) to accommodate the water supply to DZ I and DZ II in principal. However, the future expansion is considered to supply water of 5 MGD to DZ III, which was selected as a service area of the Priority Project in the M/P. As a result, some facilities are designed at a capacity of 10 MGD. The following are the basic concepts on selecting the capacity of 10 MGD.

i) Due to the limited space, it would be difficult to expand the capacity to 10 MGD if the facility was designed for 5 MGD at this time.
ii) The complication of O&M would be expected if two independent systems of 5MGD were to be constructed to expand the capacity to 10 MGD in the future.

By applying the above concepts, the capacity of each facility is selected with local concerns. The detail is described below and in Table 2-3.

a) Permission from Irrigation Department

A new intake mouth should be constructed since the existing intake mouth is difficult to be used for the Project, as described in “2-2-2-3 Intake and Raw Water Transmission Facilities, (2) Permission for Construction”. Also, there is no significant difference in size and cost of the intake mouth between 5 MGD and 10 MGD.

In addition, there is no requirement by the Irrigation Department to issue another water right permit to WASA-F for the construction of the new intake mouth as described in “2-2-2-2 Water Source of the WTP, (1) Water Rights”.

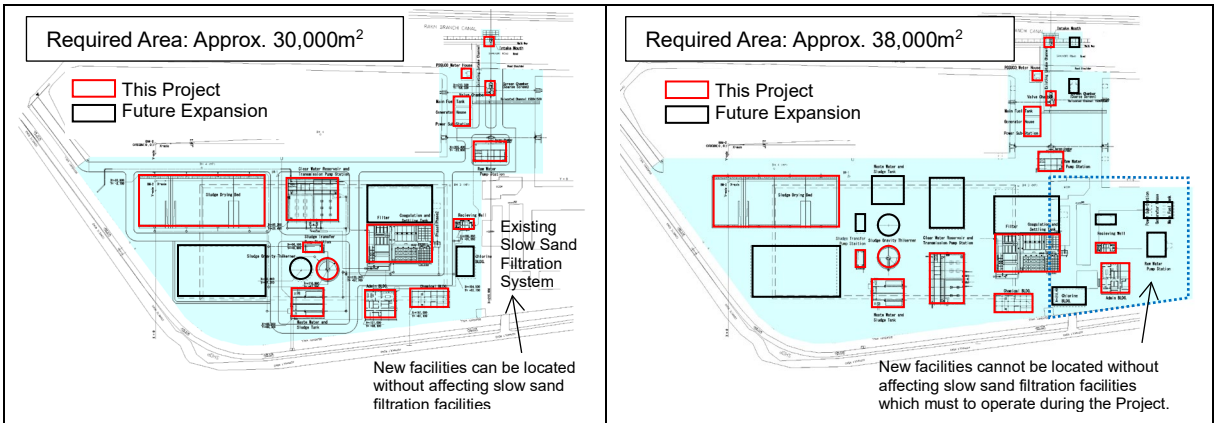
Therefore, the intake facility is planned at a capacity of 10 MGD.

b) Limited Space in Old JK WTP

The Old JK WTP does not have enough space for the new WTP at a capacity of 5MGD. In order to

have enough space for the new WTP, existing facilities such as rapid filtration facilities and other buildings need to be dismantled and the raw water reservoir needs to be backfilled. This space is just sufficient for one WTP of 10 MGD, but not enough for two separate WTPs with the typical layout of 5 MGD. If two independent WTPs of 5 MGD are planned, the area 1.3 times larger than that for one WTP of 10 MGD is required. The layouts of both plans are illustrated in Figure 2-5.

Therefore, a capacity of 10 MGD is applied to some structures such as water tanks, pumping rooms, and electric rooms. On the other hand, a capacity of 5 MGD is applied to mechanical and electrical equipment such as pumping equipment, chemical injecting equipment and power equipment which are installed inside the structures.



One independent system: 10MGD x 1 system	Two separate systems: 5 MGD x 2 systems

Figure 2-5 Comparison of Necessary Space for One Independent and Two Separate Systems for a Capacity of 10 MGD at Old JK WTP

c) Future Operation of WTP

Administration building

The administration building accommodates i) a monitoring/operation room where SCADA is installed, ii) water quality laboratory, iii) staff room, etc. If these facilities were located in different places, the operation would become complicated. In addition, the building size for 10 MGD is almost the same as that for 5 MGD. Therefore, the administration building is planned for 10 MGD.

Power receiving and transforming facility and generator

If the power receiving and transforming facility and the generator at the WTP are installed at a capacity of 5 MGD in the Project, and 5 MGD added in the future separately, the system configuration and the operation will be complicated with potential of causing electrical accidents. The detail is described in "2-2-2-7 Electrical Equipment and Instrumentation, (1) Substation Facilities". Therefore, the receiving and transforming facility and the generator are planned at a capacity of 10 MGD.

d) Permission from Pakistan Railways

The route for the transmission main is planned inside the property of Pakistan Railways. Installation

of the pipes requires permission from Pakistan Railways. There are two alternatives for the installation as follows:

i) Alt. 1 is to plan the pipe at a capacity of 5 MGD (DN 450mm).

ii) Alt. 2 is to plan the pipe at a capacity of 10 MGD (DN 600mm).

For the future extension, the transmission main will be branched at the Peoples Colony DC located at the downstream side of the property of Pakistan Railways (see Figure 2-27 Planned Route of Transmission Main). Therefore, if Alt. 1 is applied, another pipeline needs to be installed at the property of the Pakistan Railways with additional permission. However, it is not sure whether Pakistan Railways will give permission for the installation of another pipeline in the future. Therefore, Alt. 2 is selected for the installation of the transmission main from the Old JK WTP to the future branch point at People Colony.

Table 2-3 Concept of Capacity for Each Facility

Site	Facilities	Capacity		Reasons for setting capacity of 10 MGD			
		Structure	M/E *1	Permission from Irrigation Dept.	Site Restriction in WTP	WTP O&M in Future	Permission from Pakistan Railways
Intake	Intake mouth, branch valve chamber	10	-	X	-	-	-
	Raw water pump station	10	5	-	X	-	-
WTP	Receiving and distribution tank	10	5	-	X	-	-
	Mixing tank, flocculation tank and settling tank	5	5	-	-	-	-
	Rapid sand filter	5	5	-	-	-	-
	Clear water reservoir	10	-	-	X	-	-
	Transmission pump station	10	5	-	X	-	-
	Waste and sludge tank	10	5	-	X	-	-
	Sludge thickener	5	5	-	-	-	-
	Sludge extraction pump station	10	5	-	X	-	-
	Sludge drying bed	5	-	-	-	-	-
	Chemical building	10	5	-	X	-	-
	Administration building	10	5	-	X	X	-
	Power receiving and transforming, and generator house	10	10	-	X	X	-
	Electricity meter house	10	10	-	X	X	-
DC	Ground reservoir	5	5	-	-	-	-
	Overhead reservoir	5	5	-	-	-	-
Pipeline	Transmission main	10*2	-	-	-	-	X
	Distribution primary main	5	-	-	-	-	-
	Distribution secondary main	5	-	-	-	-	-

Note:

*1: Mechanical and electrical equipment

*2: 1.0 km of transmission main out of 4.1 km in the total will have a capacity of 10 MGD.

(5) Design Standards

The following design standards and water quality guidelines are applied in this outline design.

- Technical and Service Delivery Standards for Water Supply and Sanitation Sectors, April 2008, Punjab Devolved Social Services Programme, Government of the Punjab ("Punjab Guidelines")
- Pakistan National Standards for Drinking Water Quality, 2008 ("Pakistani Standard")
- Guidelines for Drinking-water Quality 4th ed., 2011, WHO ("WHO Guidelines ")
- Building Code of Pakistan – Seismic Provisions-2007 ("Pakistani Building Coad")

As supplemental standards, the following Japanese standards are applied.

- Design Criteria for Water Supply Facilities 2012, Japan Water Works Association ("Japanese Design Guidelines")
- Guidelines for Waterworks Technical Management 2016, Japan Water Works Association ("Japanese Management Guidelines")

(6) Soft Component (Technical Assistance)

The technical training (or soft component) will be provided by the consultant in order to ensure the proper operation and maintenance of the WTP and distribution centers constructed in the Project. The major reasons for implementing the soft component are as follows.

The New JK WTP is the only one operated with a rapid sand filtration system by WASA-F. Since its operation started in 2016, WASA-F is required to have more experience in operating the rapid sand filtration system. Thus, it is necessary to provide the training on O&M of the rapid sand filtration system installed by the Project.

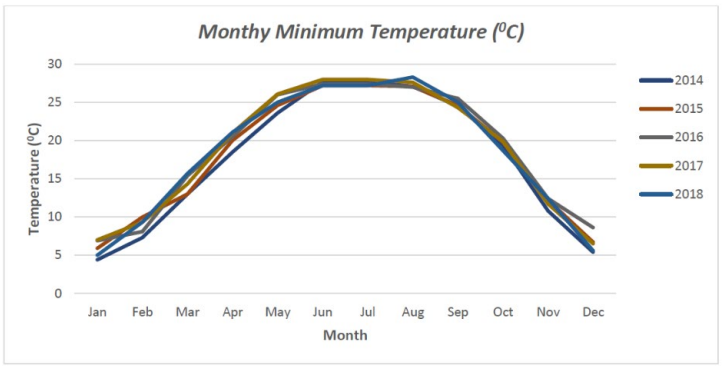
The operation of transmission pumps in the Old JK WTP and lift pumps in the distribution centers shall be properly controlled according to the water demand fluctuations and water level of the GRs or the OHRs. For the proper control, there is a requirement for obtaining additional skill by WASA-F. Therefore, it is necessary to provide the training for proper operation and maintenance (inspection and repair wok) of the transmission and distribution facilities constructed by the Project.

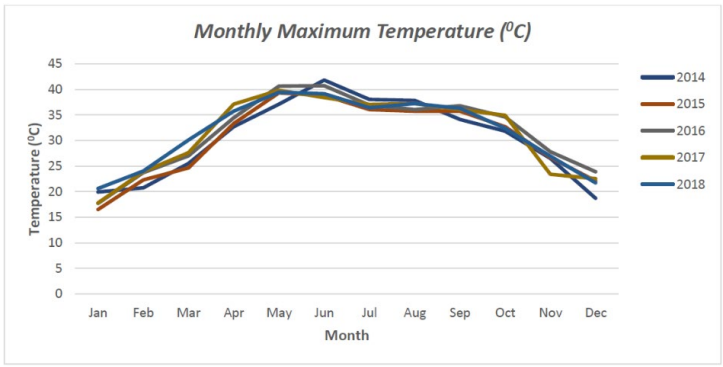
2-2-1-2 Environmental Factors

(1) Temperature and Rainfall

Faisalabad is located in an arid weather regions, with seasonal changes in climate. In summer, the temperature becomes 40 ˚C or higher with high humidity in the daytime, while in winter, the minimum temperature becomes 5 ˚C or lower.

Since the maximum temperature is around 40 ˚C from May to July as shown in Figure 2-6, attention should be paid to the deteriorations in work efficiency and concrete quality. Therefore, it is required that the contractor manage the construction schedule and quality in consideration of this climate.

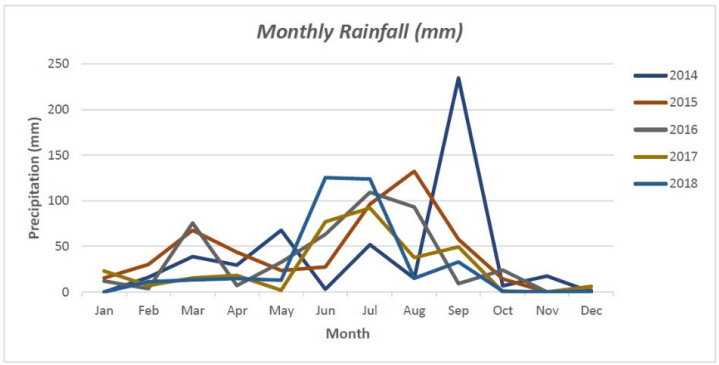




Source: Pakistan Meteorological Department

Figure 2-6 Mean of Monthly Minimum and Maximum Temperatures from 2014 to 2018

Figure 2-7 shows the monthly rainfall from 2014 to 2018. The amount of monthly rainfall is relatively small at about 100mm even in the rainy season from July to September. Therefore, the impact on the construction schedule is limited.



Source: Pakistan Meteorological Department

Figure 2-7 Monthly Rainfall from 2014 to 2018

(2) Climate Change Adaptation

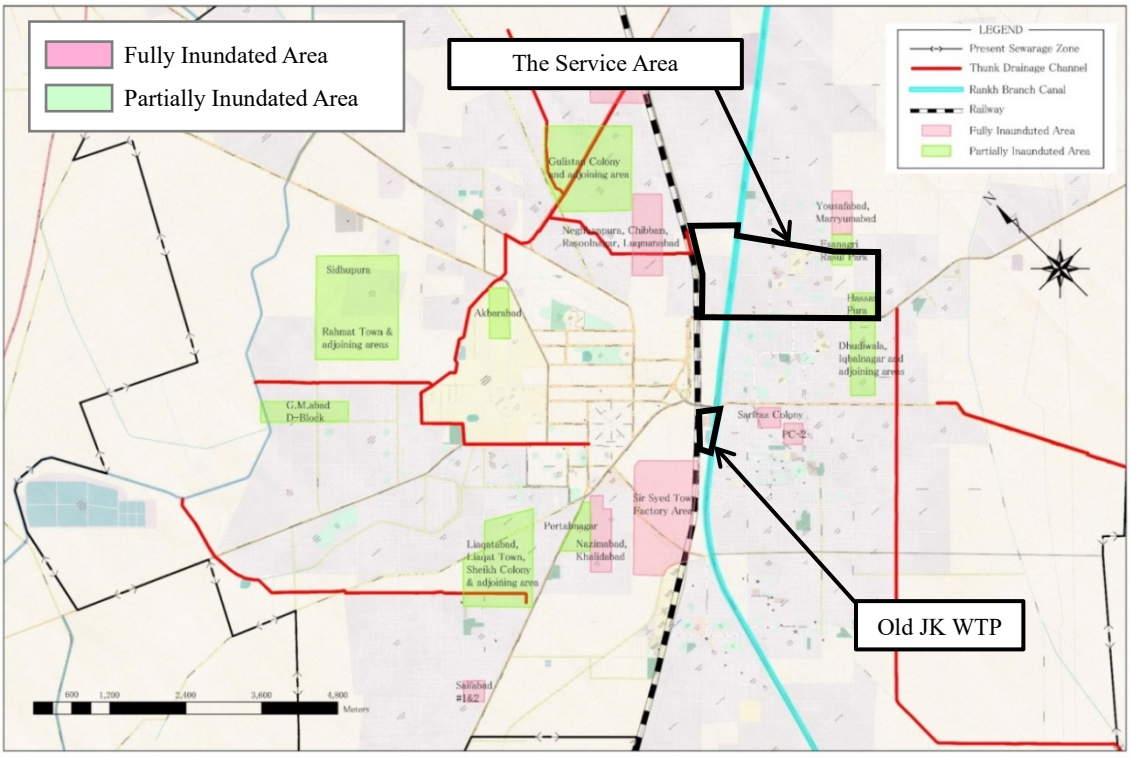
1) Consideration to Inundation

a) Inundation Risk Map

Figure 2-8 is an inundation risk map for Faisalabad City. According to the map, the Old JK WTP is not designated as an inundation prone area. On the other hand, some areas in the service area of Madina

Town No. 2 are designated as inundation prone areas. Therefore, facilities in Madina Town No. 2 area shall be designed to reduce the risk of inundation (see "2-2-2-7 Electrical Equipment and Instrumentation, (6) Measures against Inundation").

The inundation risk at the Old JK WTP is examined based on recent rainfall as follows.

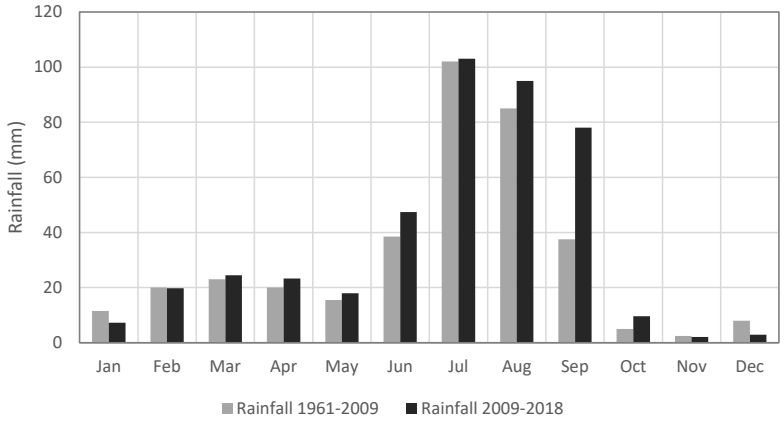


Source: M/P Project

Figure 2-8 Inundation Risk Map

b) Rainfall

Figure 2-9 shows the mean of monthly rainfall for 49 years from 1961 to 2009 and the last 10 years from 2009 to 2018 in Faisalabad. In the rainy season from June to September, the amount of rainfall in the last 10 years is more than the last 49 years. However, the amount of rainfall in July, which is the highest in a year, does not show any difference between the last 10 years and 49 years.



Source: 1961-2009: M/P Project, 2009-2018: Pakistan Meteorological Department

Figure 2-9 Mean of Monthly Rainfall from 1961 to 2018

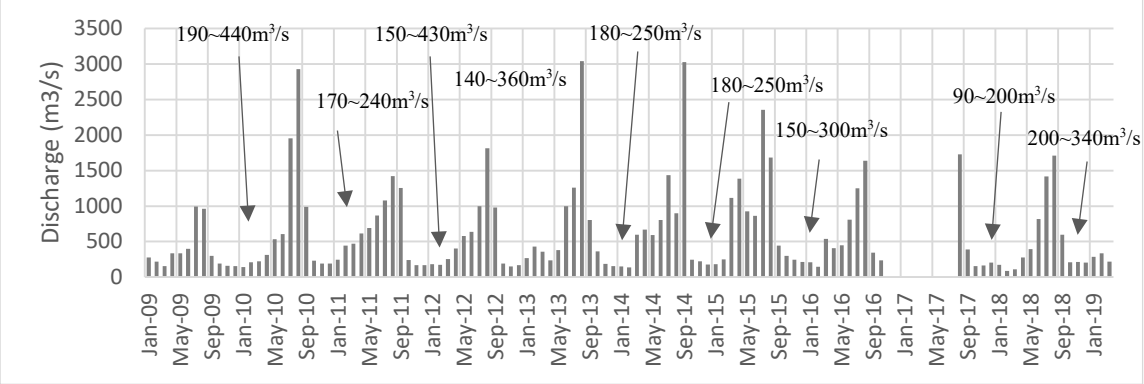
c) Conclusion

Based on the inundation risk map and the rainfall data, it is not necessary to apply the adaptation measures to climate change concerning inundation to the area of the Old JK WTP.

2) Consideration to Drought

a) Discharge of the Chenab River

The RBC, the water source of the Old JK WTP, is branched from the Khanki head works of the Chenab River (see Figure 2-12). Figure 2-10 shows discharge records from 2009 to 2019 at the Khanki head works. The discharge from October to February has the lowest volume in a year. However, any tendency to increase or decrease in the discharge is not observed in the period of October to February from 2009 to 2019.



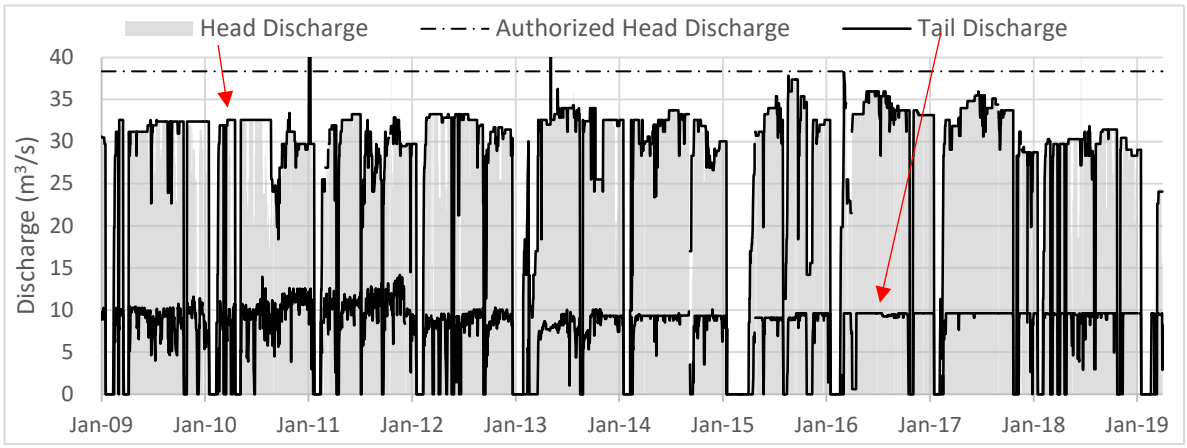
Source: Irrigation Department, note: no record from November 2016 to January 2017

Figure 2-10 Monthly Mean Discharge at the Khanki Head Works from 2009 to 2019

b) Discharge of the RBC

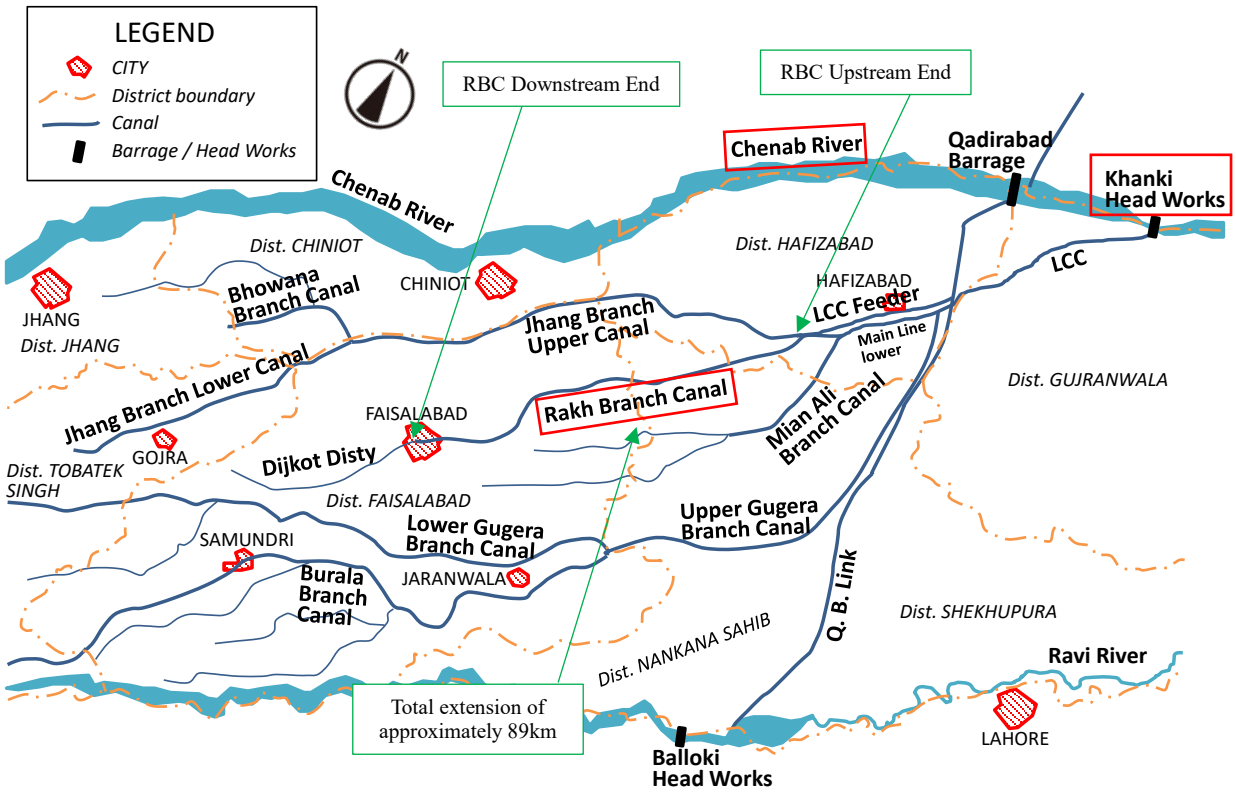
Figure 2-11 shows discharge records of the RBC from 2009 to 2018. The discharge of the RBC is measured at two points, the upstream end (Head Discharge) and downstream end (Tail Discharge) (see Figure 2-12). The intake of the Old JK WTP is located at the downstream of the RBC. The flow rate for the last 10 years is about 30 m^3/sec or more in the upstream end, and about 10 m^3/sec in the downstream end.

The period of "without any discharge" is mainly the closing period of the RBC in January every year (see "(3) Closing Period of the RBC" described later). The rest of "without any discharge" is data "not available".



Source: Irrigation Department

Figure 2-11 Discharge of the RBC from 2009 to 2019

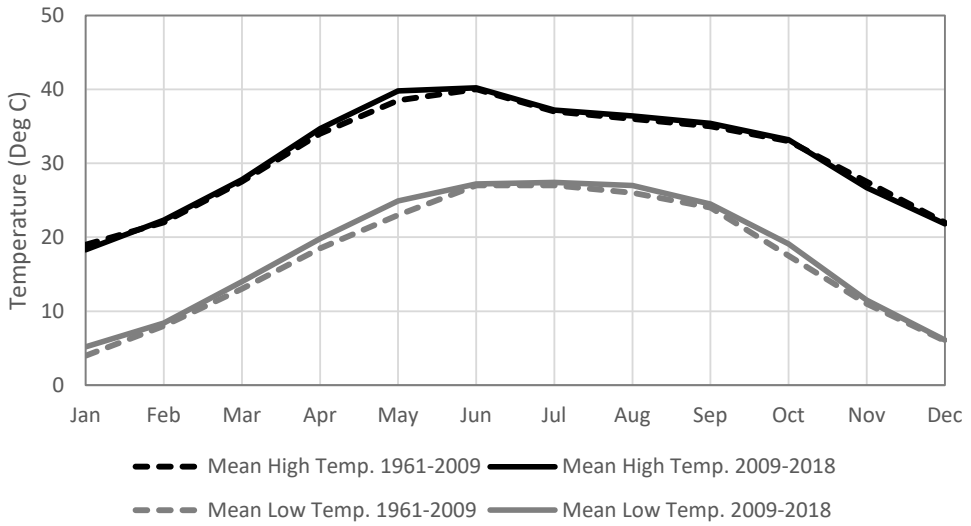


Source: Added to the figure of the M/P Project.

Figure 2-12 Location map of the Chenab River and the RBC

c) Temperature

An increase in temperature may cause an increase in the drought risk. The historical trend of temperature is analyzed by reviewing the mean of monthly maximum and minimum temperatures from 1961 to 2009 and from 2009 to 2015 in Faisalabad as shown in Figure 2-13. As a result of the review, there is no significant difference between both periods.



Source: 1961-2009 M/P Project, 2009-2018 Pakistan Meteorological Department

Figure 2-13 Mean of Monthly Maximum and Monthly Minimum Temperatures

d) Conclusion

It is not necessary to apply the adaptation measures to climate change concerning drought based on no significant change of i) discharge of the Chenab River and the RBC (see Figure 2-11) and ii) temperature (see Figure 2-13).

(3) Closing Period of the RBC

The RBC is closed by the Irrigation Department for maintenance purpose. The closing period is 3-4 weeks from January to February each year as shown in Table 2-4. During the closing period of the RBC, there is no flow in the RBC. At the Old JK WTP, there are two raw water reservoirs for storing water. However, the capacity of the reservoirs is 90,000 m^3, which is just for a 4-day operation of the Old JK WTP (water demand (daily maximum): 22,700 m^3/day). Therefore, the facilities are planned for achieving the continuous supply of water in the period of the canal closure (see "2-2-2-9 Water Supply Plan during Closing Period of RBC").

Table 2-4 Closing Period of the RBC

Year	Start (month/day)	End (month/day)	Period (days)
2007	1/14	2/5	23
2008	1/15	2/4	21
2009	1/15	2/11	28
2010	1/15	2/9	26
2011	1/21	2/11	22
2012	1/17	2/8	23
2013	12/20 (year: 2012)	1/26	38
2014	1/16	2/7	23
2015	1/14	4/1	78

Year	Start (month/day)	End (month/day)	Period (days)
2016	1/15	2/18	35
2017	1/15	2/3	20
2018	1/15	2/1	18
2019	1/15	2/18	35

Source: M/P Project, Irrigation Department

(4) Earthquake and wind power

With regard to structure design, Pakistan Building Code mentions that the peak ground surface acceleration by earthquake in Faisalabad is 0.08 to 0.16g, and the wind power is 120km/h at 10m above ground. Since these values are not large, the outline design does not give special consideration to earthquakes and wind power. The facility structure is designed by referring to major dimensions and cross sections of similar structures in other projects.

(5) Topography and geology

As mentioned earlier, topographic and geotechnical surveys were carried out at the Project sites to obtain the basic data during this preparatory survey. The survey results from the M/P Project are also utilized for the designing of the facilities.

1) Topographic Survey

Topographic survey was carried out at the planning site of the intake mouth, the Old JK WTP, and the transmission and distribution mains. For the distribution centers, the data surveyed during the M/P Project is used. These survey data are applied for the outline design of the facilities in the Project (see Appendix 7 (5)).

Since the topography of the project site is relatively flat, no special consideration is required for design, construction, operation and maintenance.

However, there is an existing raw water reservoir with a depth of approximately 4m at the Old JK WTP, and as shown in "2-2-2-4 Water Treatment Facilities", there is not enough space in the project site. Therefore, the existing raw water reservoir shall be abandoned for constructing new facilities. After the construction, the area is backfilled to the current ground level. In the facilities layout plan, the basement of facilities with large load shall be placed near or below the bottom of the raw water reservoir.

2) Geotechnical Survey

During the preparatory survey two borings were conducted at the planning site for pipe bridge of the transmission main, and two borings at the raw water reservoir A of the Old JK WTP. The survey included field investigations and laboratory tests. In addition, the data of four borings at Old JK WTP and one boring in each distribution center obtained from the geotechnical survey in the M/P project are also utilized. Appendix 7 (2) includes the result of the surveys applied to the outline design of the

facilities in the Project.

Regarding the geotechnical condition at the Old JK WTP, clay and silty soil forms the stratum from 2 to 4m below the ground level. Sandy soil with an N-value of 23 or more is located under the clay and silty soil. The main facilities of the WTP are designed with a direct foundation on this sandy soil as a bearing stratum.

At the Abudulah Pur DC, clay soil forms the stratum down to a depth of 2 m from the ground level. Sandy soil is located deeper than 2m. Sandy soil with an N-value of 26 or more is located at 6 m below the ground level. The GR and OHR are designed with direct foundations on this sandy soil as a bearing stratum.

At the Madina Town No. 2 DC, clay soil was observed down to a depth of 4 m from the ground level. Sandy soil with an N-value of 30 or more was observed under the clay soil. The GR and OHR are designed with direct foundations on this sandy soil as a bearing stratum.

At the pipe bridge of the transmission main, clay soil is formed down to a depth of 6m from the ground level. Sandy soil is located deeper than the clay soil. Since the abutments of the pipe bridge are of small-scale and low-load structure, they are designed with direct foundations on the clay soil stratum.

(6) Buried Infrastructure Including Existing Pipes on Route of Transmission and Distribution Mains

WASA-F uses GIS for managing information of existing pipes. Since the as-built drawings are not properly managed, all data of GIS may not be accurate. Therefore, the survey was conducted to identify the buried infrastructures including existing pipes along the transmission and distribution mains through the trial pit excavations of 48 locations. The survey quantities are shown in Table 2-5. Detailed information is attached to Appendix 7 (3).

Table 2-5 Quantities of Trial Excavation Survey

Pit Area	Depth	Number of locations	
1.5m^2 (1. 0m×1. 5m)	About 2.0m	46 locations	48 locations
3.0m^2 or more (expanded to identify the target existing pipes)	About 2.0m	2 locations	

Based on the locations of existing distribution tertiary main identified in the trial pits, the connection points of the new distribution secondary main and exiting distribution tertiary main are determined.

Buried pipes such as water supply pipes, sewer pipes, gas pipes, and communication cables were found in the trial pits. In the outline design of the transmission and distribution pipes, the locations of manhole and hand-hole covers were identified by the topographic survey, and the pipe laying positions were determined so as not to interfere with the buried pipes that were assumed from the locations of covers. However, since not all buried pipes were identified, appropriate care should be taken not to damage these buried pipes during excavation for the construction of transmission and distribution pipes.

The existing pavement has multiple layers to raise the road surface to prevent inundation due to

rainfall. Two to four layers of pavement were identified in this survey. The quantity of pavement removal for excavation is calculated by using these results.

2-2-1-3 Socio Economic Factors

1) Approach for future water demand projection

In the M/P Project, a social condition survey was conducted for 200 households in the Madina Town (X-Block) area adjoining the service area of the Project. Table 2-6 and Table 2-7 show the results of the survey, which are strongly related to the future water demand. The following points should be noted according to the results.

- 61.0% of the respondents obtain water for daily household use from private borehole pumps.
- 52.5% of the respondents pay above 3,000 PKR/month for electricity bills.
- 43.0% of the respondents are connected to WASA-F's water supply services, and 57.0% are not connected. Among the respondents without connection, 73.8% answered that they were "willing to connect".
- 83.1% of respondents are willing to pay "200 PKR/month or less" to WASA-F if the service level becomes better.
- 98.5% of respondents answered "6 hours or less" for the current daily water supply hours.
- 78.5% of respondents answered "18.1-24 hours" for the desired supply hours.
- About 50% requested "more water pressure" and "longer supply hours".

Table 2-6 Results of Social Conditions Survey

How to obtain water for daily household use	WASA	WASA and private borehole pump	**Private borehole pump**				Total
	10.5%	28.5%	**61.0%**				100%
Expense for electricity per month	≤ 1,500 PKR	1,501 - 3,000 PKR	**> 3000 PKR**	No response			Total
	0.5%	46.0%	**52.5%**	1.0%			100%
Willingness to connect to WASA-F water supply services	**Yes**	No	I don't know.	**Already connected**			Total
	42.0%	12.5%	2.5%	**43.0%**			100%
(Percentage without answer with "Already connected")	**(73.8%)**	(21.9%)	(4.4%)				(100%)
Willingness to pay for water supply services if the service level becomes better	**No willingness**	**1 - 200 PKR/month**	201 - 300 PKR/month	301 - 400 PKR/month	> 400 PKR/month	No response	Total
	11.5%	18.0%	5.5%	0.5%	0.0%	64.5%	100%
(Percentage without answer with "No response")	(32.4%)	(50.7%)	(15.5%)	(1.4%)	(0.0%)		(100%)
	(83.1%)						
Current supply hours per day by WASA-F	**< 2 hours**	**2-4 hours**	**4.1-6 hours**	6.1-12 hours	I don't know.		Total
	9.5%	13.0%	10.0%	0.5%	67.0%		100%
(Percentage without answer with "I don't know")	(28.8%)	(39.4%)	(30.3%)	(1.5%)			(100%)
	(98.5%)						

Desired supply hours per day by WASA-F	6 hours	6.1-12 hours	12.1-18 hours	**18.1-24 hours**	No response	Total
	0.5%	4.5%	4.0%	33.0%	58.0%	100%
(Percentage without answer with "No response")	1.2%	10.7%	9.5%	**78.5%**		(100%)

Source: M/P Project

Table 2-7 Requests for Water Supply Services by WASA-F

Request Description	Response Ratio
More quantity (volume)	29.5%
More water pressure	52.5%
Less smell in water	47.5%
No turbidity / color	39.5%
Longer supply hours	52.5%
Lower tariff level	12.5%
Less time to repair if pipe is leaked	18.0%
Better attitude of staff	15.5%
Other requests	7.5%
No request	22.5%
No response	5.0%

Source: M/P Project

These results show i) the high cost of electricity in comparison to the willingness to pay for water supply services, ii) the high willingness to connect to WASA-F's water supply services, and iii) the demand for higher pressure and longer supply hours. From the results, it is expected that water consumption and new customers are increased if water supply services such as the pressure and the supply hours are improved. Therefore, the target supply volume is planned by estimating the increases in the service ratio and consumption per day in years.

2) Installation of Generator

Power outages occur, about four hours per month around the Old JK WTP and seven hours per week around the distribution centers. The WTP and the distribution centers must continue operation as many hours as possible even during a power outage in order to provide continuous and stable water supply services. Therefore, emergency power generators are planned to be installed at the WTP and the distribution centers.

2-2-1-4 Construction and Procurement Factors

(1) Permissions and Approvals for Project Implementation

The pipelines, intake mouth and pipe bridge are to be constructed in the road site and in the property of Irrigation Department. Therefore, as shown in Table 2-8, it is necessary to obtain the respective construction permissions from concerned authorities.

WASA-F already obtained some approvals from the road management authorities and Irrigation Department during the Preparatory Survey.

However, there is a possibility that site conditions or the approval by the concerned authorities may change by the time of construction. Therefore, WASA-F shall confirm them again at the detailed design stage and before commencement of construction work.

Table 2-8 Permissions and Approvals for Project Implementation

Facility	Authority	Status of Permits and Approvals
Pipelines (transmission main, distribution main)	FDA, Municipal Corporation, Pakistan Railway, etc.	• Permission for burying pipelines and temporary removal of pavement are necessary. • Regarding the permission for burying pipelines, WASA-F obtained approval from the concerned authorities for burying pipelines to the planned route (see Appendix 6 (2)). Since there is a possibility that site conditions or the situation of the authorities may change before the construction, confirmation of the permission again is necessary at the detailed design stage. • For temporary removal of pavement, application for permission at the detailed design stage is necessary, since the application will be made after removal area is determined and construction schedule have been finalized.
Intake mouth Pipe bridge	Irrigation Department	• The intake mouth and pipe bridge will be constructed within the site of the RBC, so permits for construction must be obtained. • In the preparatory survey, WASA-F applied for the construction permission (see Appendix 6 (3)) and Irrigation Department had no objection on the application. Since there is a possibility that site conditions or the situation of the Irrigation Department may change before the construction, confirmation of the permission again at the detailed design stage and before commencement of construction work is needed.

(2) Procurement Factors

Construction materials such as concrete material, reinforcing bars and electric wires are basically procured locally because they are available.

As for pipes, HDPE and steel pipes can be procured locally, while DCIPs are imported from third countries, which are more price competitive than those made in Japan.

While general-purpose mechanical and electrical equipment can be procured locally, higher specification equipment, will be basically procured from Japan or third countries. Procurement of pipes, and mechanical and electrical equipment is considered for quality, ease of procurement and cost.

2-2-1-5 Utilization of Local Contractors

(1) Capacity of Local Contractor

1) General construction work

For the construction under Japanese Grant Aid Projects in Pakistan, Japanese contractors work with subcontracted local contractors in Pakistan. Including working experiences with Japanese contractors, these local contractors have sufficient experience on general construction works, and own machineries

used for general earthwork and concrete work.

2) Construction of water supply facilities

Water supply facilities in Faisalabad have been constructed by Japanese contractors with Pakistani subcontractors under the Japanese Grant Aid Projects. In addition, WASAs in Punjab including WASA-F have employed local contractors for the rehabilitation and installation of water distribution pipes and water meters under their own projects.

(2) Policies on Utilization of Local Contractors

Local construction companies have experiences in general and water supply facility construction for domestic and Japanese Grant Aid Projects. Having sufficient experiences, it is considered that local construction companies are qualified to be subcontractors of Japanese construction companies.

2-2-1-6 Policy on Utilization of Japanese Companies

As indicated in "2-2-4-6 Procurement Plan", some of the mechanical and electrical equipment such as valves, pumps, motors, control panels, and instrumentation are planned to be procured from Japan based on the quality.

2-2-1-7 Operation, Maintenance and Management

(1) Organization of WASA-F

Major duties of WASA-F are; i) planning, design, and construction of water supply, sewerage, and drainage facilities for new construction works and rehabilitation/augmentation of the existing facilities, ii) operation and maintenance of the water supply, sewerage, and drainage system, iii) billing and collection of revenue for the services provided to consumers. The number of regular and contract staff is about 1,450 and 300, respectively.

(2) Consideration for Facility Design

O&M costs of the WTP and distribution centers including power, chemicals, repairs, and labor will be borne by WASA-F. Since WASA-F needs to improve its financial conditions, the facilities and equipment will be planned with consideration for saving O&M costs such as energy and labor costs in operation.

Regarding technical levels, WASA-F has experience in operation of rapid sand filtration, as the New JK WTP with rapid sand filtration has been in service since 2016.

For WASA-F to carry out safe and reliable O&M, use of general-purpose equipment, on-site operation, and remote monitoring by SCADA were considered in designing the facilities.

In addition, the facilities are planned for achieving the continuous supply of water even in the period of the canal closure (see “2-2-2-9 Water Supply Plan during Closing Period of RBC”).

(3) Soft Component

It is necessary for WASA-F to learn the proper skills for operation and maintenance of the WTP and distribution centers as described in "2-2-1-1 Basic Approach, (6) Soft Component (Technical Assistance)". The necessary knowledge to be obtained is shown in Table 2-9.

The initial operation guidance for each device is provided by the contractor. However, the guidance is not sufficient for WASA-F personnel to acquire the operation and maintenance knowledge (daily check and repair plan) on the facilities. Therefore, the training will be carried out by the consultant through the soft component of the Project.

Table 2-9 Operation and Maintenance for the Facilities to be Learned by WASA-F

Facility	Contents to be learned
O&M of WTP	Water is supplied stably and efficiently while satisfying the requirements of water quantity and quality. • Execute water treatment in accordance with water demand plan • Operation of the WTP process under unusual circumstances (power failure, water intake stoppage, equipment failure and stoppage for inspections) • Maintenance work (daily check, repair) of the facilities
O&M of Transmission and Distribution Facilities	Stable and efficient pump operation and water supply volume control are implemented. • Efficient pump operation and flow rate control in accordance with demand fluctuation • Continuous water transmission/distribution during the RBC closure

(4) Staffing of Operation Staff

Since the Old JK WTP is renewed from the current slow filtration system to the rapid filtration system, the number of staff needs to be increased. Due to the treatment system being the same, the staffing at the New JK WTP is referred from the Old JK WTP.

With regard to the distribution centers, pump operators are currently on duty for 24 hours a day. In addition, the pilot project activities of the M/P Project at the distribution centers of Fawara Chowk and Madina Town proved that the current staffing arrangement can sufficiently manage the operation at 24 hours a day. Therefore, employment of additional staff is not required for the distribution centers.

Regarding work related to water distribution pipes, the Water Distribution Maintenance Section (about 200 staff) is responsible. The detail of the work is to connect new customers, operate distribution centers, manage water distribution, replace old pipes, and repair water leakage. After the installation of distribution pipelines by WASA-F and the Project, tasks of the Water Distribution Maintenance Section will increase such as leakage repair works by the increased water pressure and installation of connection pipes to new customers. Therefore, the staff of the section needs to be increased.

2-2-1-8 Grade of Facilities and Equipment to be installed

Based on the above-mentioned factors, the following policy shall be adopted for the grade of facilities

and equipment to be installed.

- Water treatment system is rapid filtration system, the same as the New JK WTP.
- The facilities shall be considered such that WASA-F can continue safe and reliable operation and maintenance including the use of general-purpose equipment, on-site operation, and remote monitoring by SCADA.
- Emergency power generators shall be provided at the WTP and distribution centers for the continuous service of water supply even in the period of a power outage.
- Construction materials are procured locally in principle.
- Procurement of pipes, mechanical and electrical equipment is planned in consideration of quality, ease of procurement, cost, etc. Some of valves, pumps, motors, control panels, and instrumentation with requirement of highly reliable quality shall be procured in Japan.
- Local construction companies are applicable as subcontractors of Japanese construction companies.

2-2-1-9 Construction/Procurement Method and Construction Period

(1) Construction and Procurement Method

Table 2-10 shows the construction and procurement methods for the major construction components. The Project consists of ordinary structural works, pipeline works, and mechanical and electrical equipment works.

Table 2-10 Construction and Procurement Methods

Construction Component	Construction site	Construction method	Procurement method
Structural works	Intake mouths, WTP, and distribution centers	Ordinary civil work (mainly earth work and reinforced concrete work)	Procured in Pakistan
Pipeline works	WTP, distribution centers, raw water/treated water transmission mains, distribution main	Ordinary open-cut method	DCIPs are procured from Japan or third countries, and other pipe materials are procured in Pakistan or third countries
Mechanical and electrical works	WTP and distribution centers	Installation work of mechanical equipment such as pumps and chemical injection equipment, and accompanying electrical and instrumentation equipment	Procured in Pakistan, third countries, or Japan in consideration of required quality for each equipment.

(2) Construction period

In Faisalabad, the amount of rainfall is relatively low even in the rainy season from July to September. Therefore, the impact on the construction process by rain is not significant.

The WTP and distribution centers consist of several facilities. Therefore, their construction works, such as i) structural works, ii) pipeline works, iii) mechanical and electrical works, and iv)

commissioning works, need to be carried out in the planned stages. Construction times are planned to be as minimal as possible by considering simultaneous constructions, while maintaining the high safety and quality standards..

Civil works such as earth works and concrete works at the Old JK WTP and the distribution centers are to be carried out simultaneously by multiple parties considering the number of construction machines that can be operated safely on the site. Also, installation works of the transmission and distribution mains are conducted simultaneously at several sites along the route.

For construction of the intake mouth, temporary cofferdam work by large-sized sandbags is necessary in order to create a dry conditions in the RBC. The installation work of large-sized sandbags shall be conducted during the closing period of the RBC in January (approximately three weeks) as discussed with the Irrigation Department.

2-2-1-10 Construction Supervision

The project includes various kinds of construction works such as structural works, pipeline works, mechanical and electrical works, and commissioning work of the Old JK WTP and the distribution centers. Also a couple of types of works will be carried out simultaneously.

In the construction supervision, the requirement of chief supervisor is to have experiences on civil engineering, pipelines, machinery, electrical instrumentation, and test operation adjustment, etc. for smooth implementation of the works.

2-2-1-11 Safety Measures

Faisalabad is relatively a safe city. However, it is necessary that security measures be taken by the contractors and consultants in accordance with the guidance of the Embassy of Japan in Pakistan and JICA Pakistan office.

As locational characteristics of the Project, the Old JK WTP and distribution centers are located in urban areas. These pipes are installed under public roads. In order to ensure the safety, armed security guards will ride on vehicles together with the contractors and the consultants. In addition to the armed security guards, traffic guides are planned to be allocated at the construction site as safety measures.

Concerning infectious diseases such as the new type of coronavirus, it is necessary to apply the preventive measures and countermeasures against the spread of infection based on the instructions by Japanese and Pakistani authorities.

2-2-2 Basic Plan (Construction Plan)

2-2-2-1 Service Population and Water Supply volume

(1) Basic Approach

The planned population to be served and the water supply volume are referred to from the M/P Project.

The target year is 2038. Operation commencement is expected in 2024, and ex-post evaluation in 2027. In the M/P Project, water demand is projected for every five years in 2023, 2028, 2033, and 2038. The values for in-between years are calculated by linear interpolation.

(2) Service Population in the Project Area of the M/P Project

Population to be served is projected as shown in Table 2-11.

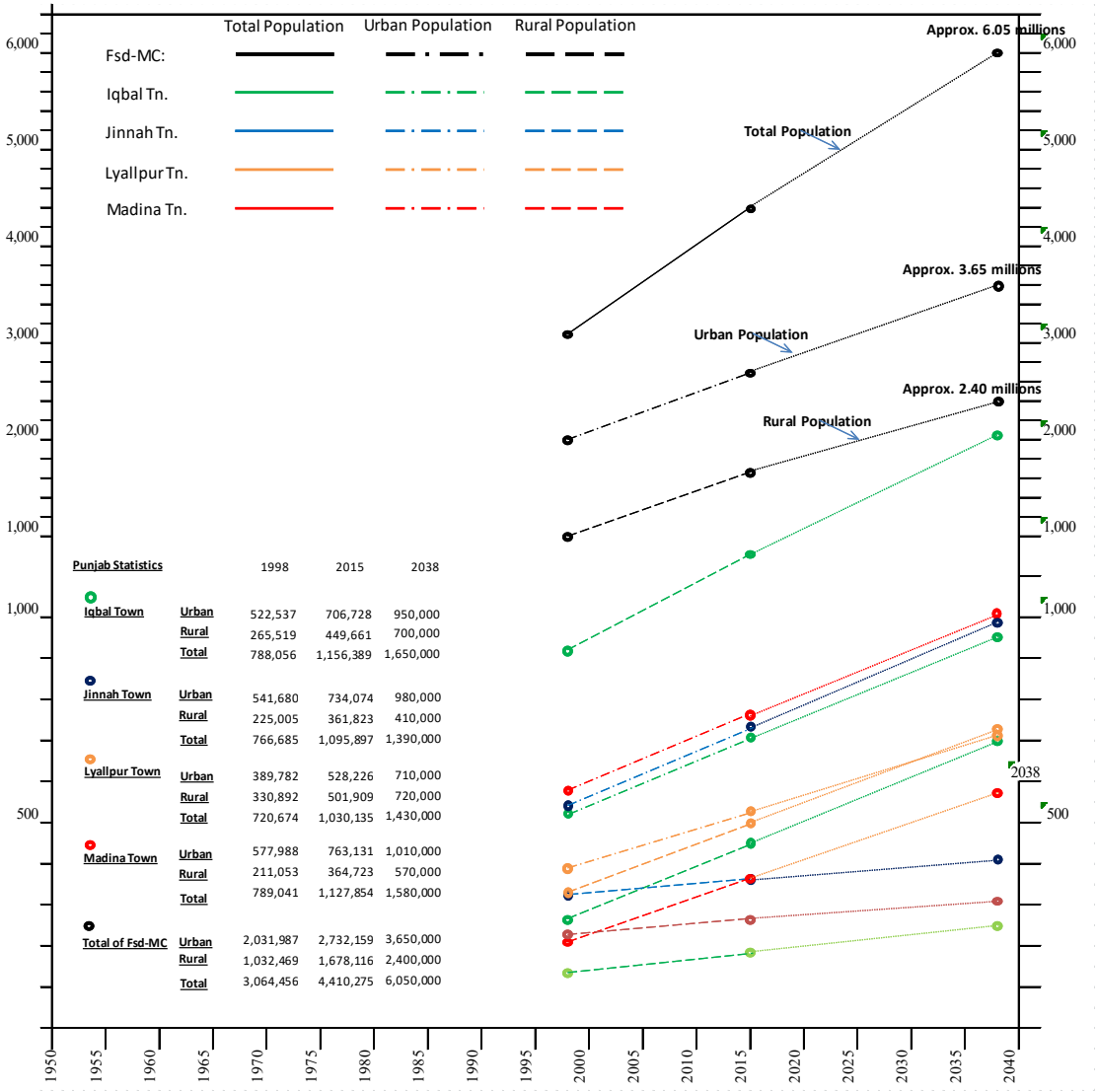
Table 2-11 Population Projection for the Project Area of M/P Project

Item	1998	2015	2023	2028	2033	2038
Total population	2,952,328	3,743,080	4,175,410	4,489,580	4,783,120	5,386,120
Population in service area	-	2,428,904	3,026,190	3,399,500	3,772,800	4,146,110
Service ratio	-	42%	60%	75%	90%	100%
Supplied population	-	1,008,000	1,815,700	2,549,600	3,395,500	4,146,100

Source: M/P Project

1) Total Population and Population in Service Area

The population in the urban and rural areas of Faisalabad has increased rapidly due to the high growth of the economy. The population has increased by about 1.35 times in 17 years from 3,064,456 in 1998 to 4,410,275 in 2015. Expecting a similar increase in the future, the annual population is estimated increase of 1.27% in urban areas and 1.60% in rural areas. Based on the increase rate, the total population is estimated at approximately 6.05 million in 2038 as shown in Figure 2-14.



Source: M/P Project

Figure 2-14 Population Projection in the Project Area of the M/P (2015 to 2038)

Based on the above projection, it is estimated that the population increase rate will be moderate in the union councils (administrative units) with a density of 500 people/ha or more.

As a result, the total population in the project area of the M/P Project is estimated at about 5.39 million in 2038. In addition, the population in the service area of the Project is estimated at about 4.15 million in 2038.

2) Service Ratio and Service Population

The service population is calculated by multiplying of the population in the service area with the service ratio. The service ratio in the project area is 42% in 2015. The value is estimated to increase to 100% by 2038. This estimation is based on proven evidence that the pilot activities in the M/P Project led to increases in new customers and payment rates by improving water supply services such as supply hours and pressure.

(3) Basic Planning Parameters

The future water demand is estimated based on the basic planning parameters as shown in Table 2-12.

Table 2-12 Basic Planning Parameters for Water Demand Estimation

Description	Unit	2015	2023	2028	2033	2038
Per-capita Consumption for Domestic Use	L/day	128	133	145	145	145
Ratio of Non-Domestic Use against Total Consumption	%	10	20	30	30	30
Physical Loss	%	40	45	30	25	20
Peak Factor	-	1.3	1.20	1.15	1.15	1.15
Members per household	person	7.20	7.15	7.10	7.05	7.00

Source: M/P Project

1) Per-capita Consumption for Domestic Use

As shown in Table 2-12, the per-capita consumption for domestic use is 128 L/day and 145 L/day in 2015 and 2038, respectively. The consumption in 2038 is estimated according to the Punjab Guidelines, which describes the average distribution volume per capita as 180 L/capita/day (40 gallons/capita/day). In addition, the guideline mentions the occurrence of physical loss at 20% of the distribution volume. After deducting the physical loss, the remaining is 145 L/capita/day (32 gallons/capita/day), which is the estimated value of the per-capita consumption for domestic use in 2038.

2) Ratio of Non-Domestic against Total Consumption

Non-domestic consumption is for commercial and industrial use, and is estimated at about 10% of total consumption in 2015. In the future, the ratio of the non-domestic consumption to the total consumption is expected to increase to 30% in 2038. This estimation is made in consideration of increases in water consumption of current customers and number of new customers by switching from private wells to WASA-F water supply services. The detail calculation for the estimation is described in Table 2-13.

Table 2-13 Estimation on Ratio of Non-Domestic against Total Consumption

Item	Calculation formula	Value
Domestic consumption	Calculated from 145 L/capita/day	397,000m^3/day
Ordinary consumers	(20,500 connections) x (4 2m^3 /connection/day)	86,000m^3/day
Bulk water users	(1,000 connections) x (51m^3/connection/day)	51,000m^3/day
Aquifer users	(500 connections) x (50 to 100m^3/connection/day)	25,000 ~ 50,000m^3/day
Non-domestic total		162,000 ~ 187,000m^3/day
Total consumption	397,000 + (162,000 ~ 187,000)	559,000 ~ 584,000m^3/day
Ratio	(162,000 ~ 187,000) / (559,000 ~ 584,000)	29 ~ 32%

Source: M/P Project

3) Physical Loss

The physical loss was estimated at 40% in 2015. In the future, it is expected to increase to 45% because of higher pressure through the improvements of water supply facilities. Then the loss is planned to be reduced gradually by replacing the currently installed asbestos pipes. The physical loss is targeted at 20% by 2038.

4) Peak Factor

The max factor, which is the ratio of daily maximum to daily average demand, is estimated at 1.3 in 2015. This ratio is generally smaller for larger cities. In the future, the factor is estimated at 1.15 after 2028 in consideration of increase in population.

5) Members per Household

The members per household was estimated at 7.3 and 7.2 in 1998 and 2015. The impact on urbanization is considered as the main reason for the decrease. Due to the continuous urbanization, the members per household is estimated at 7.0 in 2038.

(4) Service Population

The M/P Project estimated the service population for each union council, DMA, and DZ. Table 2-14 presents the service population in DZ I and DZ II, which are the service areas of the Project, and DZ III, which is the future expansion. The name of DMA in the table is used only for planning purposes.

In the M/P Project, population and service population are estimated for every five years in 2023, 2028, 2033, and 2038. The values other than these years are calculated by linear interpolation.

Table 2-14 Estimated Population and Supplied Population

Zone / DMA	2023 (Reference)		2024 (Start of Operation)		2027 (Ex-post Evaluation)		2028 (Reference)		2038 (Target year)	
	Population	Service Population	Population	Service Population	Population	Service Population	Population	Service Population	Population	Service Population
Abudulah Pur (DZ I)										
DMA I-1	11,280	6,570	11,450	7,080	11,960	8,620	12,130	9,130	14,060	14,060
DMA I-2	10,410	6,070	10,570	6,540	11,030	7,960	11,190	8,430	12,970	12,970
Madina Town No. 2 (DZ II)										
DMA II-1	13,990	8,150	14,160	8,750	14,650	10,550	14,820	11,150	16,470	16,470
DMA II-2	8,030	4,680	8,130	5,020	8,410	6,060	8,510	6,400	9,460	9,460
DMA II-3	8,680	5,060	8,780	5,430	9,100	6,550	9,200	6,920	10,230	10,230
DMA II-4	13,350	7,780	13,510	8,350	13,980	10,070	14,140	10,640	15,720	15,720
Total in this Project	65,740	38,310	66,600	41,170	69,130	49,810	69,990	52,670	78,910	78,910
Peoples Colony 2 (DZ III)										
DMA III-1	9,570	5,580	9,680	5,990	10,030	7,220	10,140	7,630	11,280	11,280
DMA III-2	11,290	6,580	11,420	7,060	11,830	8,520	11,960	9,000	13,300	13,300
DMA III-3	9,220	5,370	9,330	5,770	9,660	6,950	9,770	7,350	10,860	10,860
DMA III-4	9,200	5,360	9,310	5,750	9,630	6,940	9,740	7,330	10,830	10,830
DMA III-5	13,610	7,930	13,770	8,510	14,250	10,260	14,410	10,840	16,020	16,020
DMA III-6	12,320	7,180	12,470	7,710	12,900	9,290	13,050	9,820	14,500	14,500
Total Future Expansion	65,210	38,000	65,980	40,790	68,300	49,180	69,070	51,970	76,790	76,790
Total	130,950	76,310	132,580	81,960	137,430	98,990	139,060	104,640	155,700	155,700

Source: 2023, 2028 and 2038 from M/P Project; 2024 and 2027 by linear interpolation.
Note: The name of DMA is used for planning purposes only.

(5) Number of Connections

The number of connections is calculated by dividing the population served by the members per household. Table 2-15 shows the estimated number of connections.

Table 2-15 Estimated Number of Water Supply Connections (Locations)

District DMA	2023 (Reference)	2024 (Start of Operation)	2027 (Ex-post Evaluation)	2028 (Reference)	2038 (Target year)
Abudulah Pur (DZ I)					
DMA I-1	920	990	1,210	1,290	2,010
DMA I-2	850	920	1,120	1,190	1,850
Madina Town No. 2 (DZ II)					
DMA II-1	1,140	1,230	1,480	1,570	2,350
DMA II-2	660	700	850	900	1,350
DMA II-3	710	760	920	980	1,460
DMA II-4	1,090	1,170	1,420	1,500	2,250
Total in this Project	5,370	5,770	7,000	7,430	11,270

District DMA	2023 (Reference)	2024 (Start of Operation)	2027 (Ex-post Evaluation)	2028 (Reference)	2038 (Target year)
Peoples Colony 2 (DZ III)					
DMA III-1	780	840	1,020	1,080	1,610
DMA III-2	920	990	1,200	1,270	1,900
DMA III-3	750	810	980	1,040	1,550
DMA III-4	750	810	980	1,030	1,550
DMA III-5	1,110	1,190	1,440	1,530	2,290
DMA III-6	1,000	1,080	1,310	1,380	2,070
Total Future Expansion	5,310	5,720	6,930	7,330	10,970
Total	10,680	11,490	13,930	14,760	22,240

Source: 2023, 2028 and 2038 from M/P Project; 2024 and 2027 by linear interpolation.
Note: The name of DMA is used for planning purposes only.

(6) Daily Average and Maximum Demands

The daily average and maximum demands are calculated by the following equations.

- Domestic consumption = Supplied population x Per-capita consumption
- Total consumption = Domestic consumption / (1 – ratio of non-domestic consumption to total consumption)
- Daily average demand = Total consumption / (1 – Physical loss)
- Daily maximum demand= Daily average demand × Max factor

Table 2-16 shows the estimated daily average and maximum demands. The daily maximum demand in 2038 is estimated at 23,520 m^3/day for the service area of the Project (Abudulah Pur, Madina Town No. 2) and 46,390 m^3/day for the service area of the Project and the future expansion area (Peoples Colony 2).

As a result of discussion with WASA-F, the daily maximum demand of the Project is set at 5 MGD (22,700 m^3/day) in 2038. The daily maximum demand including the expansion area is set at 10 MGD (45,500m^3/day).

Table 2-16 Estimated Daily Average and Maximum Demands

Zone DMA	2023 (Reference)		2024 (Start of Operation)		2027 (Ex-post Evaluation)		2028 (Reference)		2038 (Target year)	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Abudulah Pur (DZ I)										
DMA I-1	1,990	2,380	2,130	2,530	2,570	2,980	2,720	3,130	3,650	4,190
DMA I-2	1,830	2,200	1,970	2,340	2,370	2,750	2,510	2,890	3,360	3,870
Madina Town No. 2 (DZ II)										
DMA II-1	2,460	2,950	2,630	3,120	3,130	3,620	3,300	3,790	4,270	4,910
DMA II-2	1,410	1,700	1,510	1,790	1,800	2,080	1,890	2,180	2,450	2,820
DMA II-3	1,530	1,840	1,630	1,940	1,940	2,250	2,050	2,350	2,650	3,050
DMA II-4	2,360	2,830	2,520	2,990	2,990	3,460	3,150	3,620	4,070	4,680
Total in this Project	11,580	13,900	12,390	14,710	14,800	17,140	15,620	17,960	20,450	23,520

Zone / DMA	2023 (Reference)		2024 (Start of Operation)		2027 (Ex-post Evaluation)		2028 (Reference)		2038 (Target year)	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Peoples Colony 2 (DZ III)										
DMA III-1	1,690	2,030	1,800	2,140	2,140	2,480	2,260	2,600	2,920	3,360
DMA III-2	2,000	2,400	2,140	2,540	2,530	2,930	2,670	3,070	3,440	3,960
DMA III-3	1,630	1,950	1,740	2,060	2,070	2,390	2,180	2,500	2,810	3,230
DMA III-4	1,610	1,940	1,720	2,050	2,060	2,380	2,170	2,490	2,810	3,230
DMA III-5	2,380	2,860	2,550	3,030	3,040	3,520	3,200	3,680	4,150	4,770
DMA III-6	2,170	2,600	2,320	2,750	2,760	3,200	2,910	3,340	3,760	4,320
Total for Future Expansion	11,480	13,780	12,270	14,570	14,600	16,900	15,390	17,680	19,890	22,870
Total	23,060	27,680	24,660	29,280	29,400	34,040	31,010	35,640	40,340	46,390

Source: 2023, 2028 and 2038 from M/P Project; 2024 and 2027 by linear interpolation.
Note: The name of DMA is used for planning purposes only.

(7) Peak factor

The planned hourly maximum distribution volume is applied to design the distribution primary and secondary mains. The volume is calculated by multiplying the planned daily maximum water supply (converted into hourly volume) by the peak factor.

According to the Punjab Guidelines, the peak factor is 1.5 for the distribution primary main and 1.7 for the distribution secondary main.

For reference, the peak factor calculated by the regression formula in the Japanese Design Guidelines is 1.7, which is equivalent to the factor adopted by the Project.

- $K=1.7764\ (Q/24)^{-0.0066}$ (This formula is applicable for mainly residential areas), K: Peak factor, Q: Daily maximum demand
- Abudulah Pur: Q=8,060m^3/day, K=1.7s
- Madina Town No.2: Q=15,460m^3/day, K=1.7

2-2-2-2 Water Source of the WTP

(1) Water Rights

Water source for the Old JK WTP is water from the RBC managed by the Irrigation Department. In 1953, the Irrigation Department gave consent to WASA-F for allocating the canal water of 20 cusec (0.5663m^3/s = 48,930 m^3/day) at Old Jhal Khanuana Chowk where the Old JK WTP is located. The Irrigation Department re-confirmed in the letter issued on 31st July 2018 that this consent was still effective. This consent is effective even if the Old JK WTP is upgraded. Therefore, there is no need for the Irrigation Department to issue another water right permit to WASA-F. This was confirmed in the discussion with the Irrigation Department.

(2) Volume of Water Source

The discharge at the intake point of the RBC is around 10 m^3/sec throughout the year except for the closing period described in "2-2-1-2 Environmental Factors, (2) Climate Change Adaptation". The

intake flow rate of the Project is designed at approximately 0.55 m^3/sec as described in the next section. The discharge is about 18 times of the design intake flow rate, thus the volume of water source is sufficient.

2-2-2-3 Intake and Raw Water Transmission Facilities

(1) Design Intake Flow

Intake facilities are designed based on the future requirement in the year 2038. Its design capacity is 47,900 m^3/d including losses in the treatment process as follows:

- Daily maximum demand in the future = 45,500 m^3/day
- Daily maximum intake capacity = 45,500 m^3/d ÷ 0.95 = 47,900 m^3/day

The raw water pump facility is designed at a capacity necessary to treat the daily maximum demand of 22,700m^3/day, which does not include the future expansion. Therefore, the actual capacity is 23,900 m^3/day as shown below.

- Daily maximum demand = 22,700 m^3/day
- Daily maximum intake capacity = 22,700 m^3/d ÷ 0.95 = 23,900 m^3/day (approximately 0.55 m^3/sec)

(2) Permission for Construction

Intake facilities are existing at site. However, it is difficult for the Project to utilize them due to the following reasons. Therefore, new intake facilities need to be constructed.

- The structure of the existing intake is a conduit having a brick wall of 1.23m width and 0.90m height with no shut-off device on the inlet from the RBC. There is no facility to close the mouth when water intake is stopped.
- An open channel of 1.23m width and 0.45m height from the RBC to the WTP is covered only by a concrete lid. Its structural capacity has to be enhanced especially due to the presence of heavy traffic on Canal Express Way along this section and the long term utilization of the intake.

Since the intake facilities are constructed in the managing property of the Irrigation Department, WASA-F has already obtained the respective construction permissions (see Appendix 6 (3)). However, it is highly recommended to update and re-confirm the permission status with the Irrigation Department during the detailed design stage.

(3) Intake and Raw Water Transmission Facilities Plan

1) Current Situation of RBC

The source of intake water is the RBC, which is constructed about 20 m southeast of the Old JK WTP in parallel with the boundary fence. The city's main road runs between the irrigation canal and the WTP. There is a 1.5m wide sidewalk between the canal and the main road.

During the closing time of the RBC in the preparatory survey, a considerable amount of plastics and

plants were observed at the bottom of the canal as shown in Figure 2-15. It is necessary to prevent such debris from entering the WTP.

Figure 2-15 Picture of RBC during the Closing Period

The cross section of the canal at the intake point has a bottom width of 12 m, and the lining is not provided at the canal bed. The sidewalls have a slope of 1:1.5 and concrete lining is provided. According to the local topographical survey data, the water level of the canal is estimated to be at +184.86m and its bottom height to be at +183.32m. Therefore, the water depth of the canal is about 1.5m and the cross section is about 22m^2. From the present planned water flow of 11.27 m^3/s, provided by the Irrigation Department, the average flow velocity in the canal is calculated to be about 0.51 m/s.

According to the staff of the Old JK WTP, the water level in the canal is stable with small fluctuations. As shown in the below topographic map of the intake point (Figure 2-16), the canal is located 1.2 m down from the sidewalk and a 1.6 m wide non-paved flat ground spreads to the shoulder of the canal sidewall.

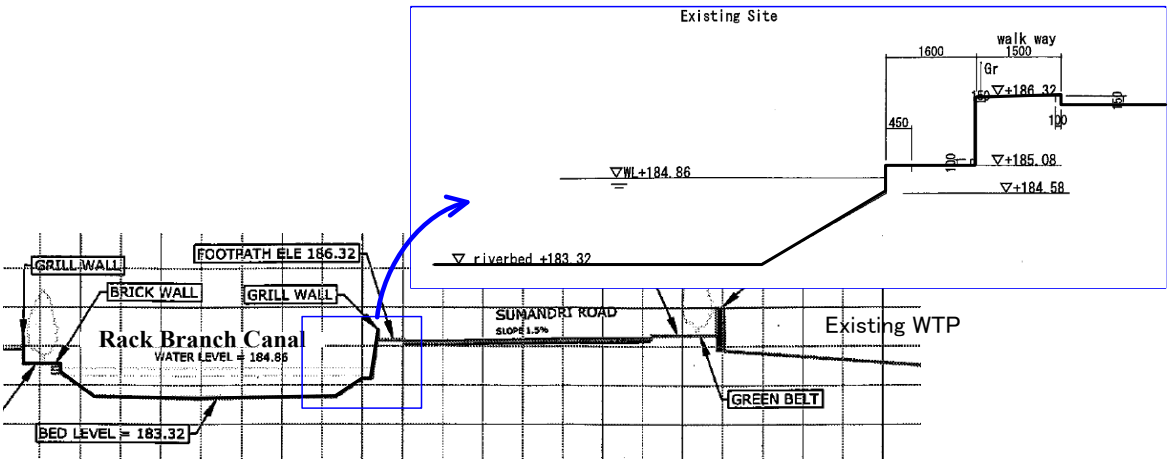


Figure 2-16 Topography of Intake Point

2) Outline of the Intake and Raw Water Transmission Facilities

Since the RBC has a shallow water depth of about 1.5 m and a slow flow velocity of about 0.5 m/s, it is suitable to adopt the intake conduit/pipe method (the method for installing water mouth and conducting water by intake pipe).

Next to the water intake structure, a raw water transmission facility is installed in the water treatment plant. After intake, the irrigation water is conducted to two existing raw water reservoirs A and B which are located along the southeast border fence. Then, the water is conducted to the water treatment facility by the raw water transmission pump after the turbidity of irrigation water is reduced in the raw water reservoirs.

The raw water transmission facility consists of a coarse screen with a branch valve chamber, inlet/outlet pipes which are installed in the raw water reservoirs, and raw water transmission pump station. Figure 2-17 shows the process of the intake and raw water transmission.

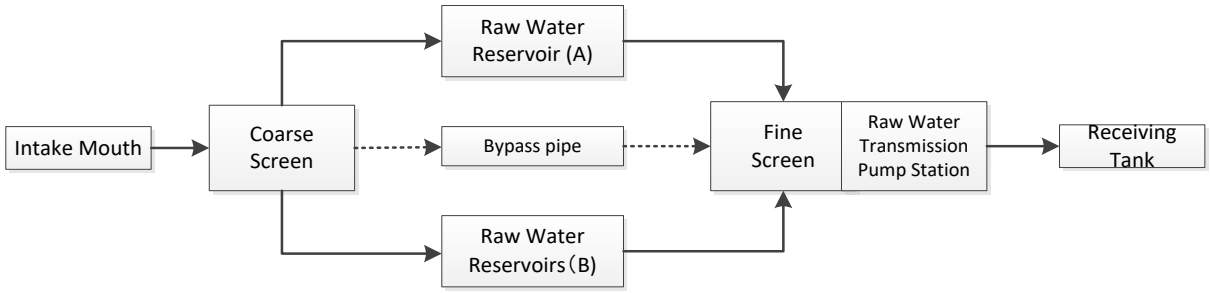


Figure 2-17 Flow Diagram of Intake and Raw Water Transmission

3) Structure of Intake Mouth

The intake mouth is made of reinforced concrete, and the water intake apron is provided at 50 cm higher than the bottom of the canal to prevent soil from entering. The inflow velocity at the intake mouth is 0.4 to 0.8 m/s, and the two gates have the opening width of 60 cm /gates. The front of the intake bottom is covered with gabions to prevent scouring. A flashboard is installed at each intake mouth to close the mouth when water intake is stopped. DCIP having diameter of 800 mm is used as the raw water transmission main from the intake mouth.

Large sandbags are installed as a temporary cofferdam in order to create dry conditions during the closing period of about 3 to 4 weeks in a year. After the installation, the intake mouth is constructed during the operational period of the RBC.

4) Coarse Screen / Branch Valve Chamber

Due to the limited space available at the site of the intake mouth, the coarse screen is located in the WTP site. The coarse screen is installed before the water flows into the raw water reservoir to prevent entry of large floating materials in the reservoir. The screen is a bar screen and driven manually. The

bar screen is a flat bar with a center spacing of 60 mm (net spacing of about 50 mm). Inside the branch valve chamber, three butterfly valves are installed to the raw water reservoirs A and B, and the receiving chamber of the raw water transmission pump station. The diameter is 800 mm considering the amount of water to be transmitted to one raw water reservoir or raw water transmission pump station.

5) Raw Water Storage Reservoir Inlet and Outlet Facility

With regard to the inlet to the raw water reservoir, a concrete pipe having a diameter of 900 mm is installed along the length of the pond as a guide facility to prevent a short-circuit flow between the inlet and outlet and to effectively use the capacity of the raw water reservoir.

As for the outlet part, a weir is installed in the outlet chamber considering intake of water from near the surface of the reservoir where turbidity is usually low. Submerged weir is adopted to reduce outlet loss. In addition, in order to use the capacity of the raw water reservoir when the water level of raw water reservoir is dropped due to the closure of the RBC, water is taken through a sluice gate which is installed at the bottom of the outlet chamber to utilize full volume of water in the raw water reservoir. The size of the gate is 600 x 600 mm to be operated manually, under assumption that two raw water reservoirs are used simultaneously.

6) Raw Water Transmission Pump Station

The raw water transmission pump station consists of a raw water receiving chamber, pump well, pump room and an electric room. The raw water inlet chamber is connected to the raw water reservoir by an inlet pipe from the raw water reservoir and a bypass pipe from the intake mouth, and then the raw water flows into the screen channel.

The screen is a vertical net screen (mesh width of about 12 mm) to prevent the intrusion of floating thin objects such as vinyl sheets that have passed through the coarse screen into the water treatment facility. The screen is self-driving. Gates are installed at the inflow and outflow ends of the screen for screen maintenance. The reason to apply the self-driving screen is that a large volume of floating objects were observed at the existing New JK WTP whose intake point is located about 1 km downstream of the RBC~~,~~. The New JK WTP utilizes self-driving screen, which is operated every hour by on-off operation. Therefore, WASA-F recommended to utilize self-driving screen under the Project as well.

The size and shape of the pump well and the pump room is decided based on the selection (number of units, capacity) of the raw water transmission pump and its layout plan. The size and shape of the pump well is determined with a retention time of about 10 minutes.

7) Facility Layout and Hydraulic Profile

The layout and hydraulic profile of intake facilities are shown in Figure 2-18 and Figure 2-19. The

raw water transmission facility is installed in the space between the existing raw water reservoirs A and B.

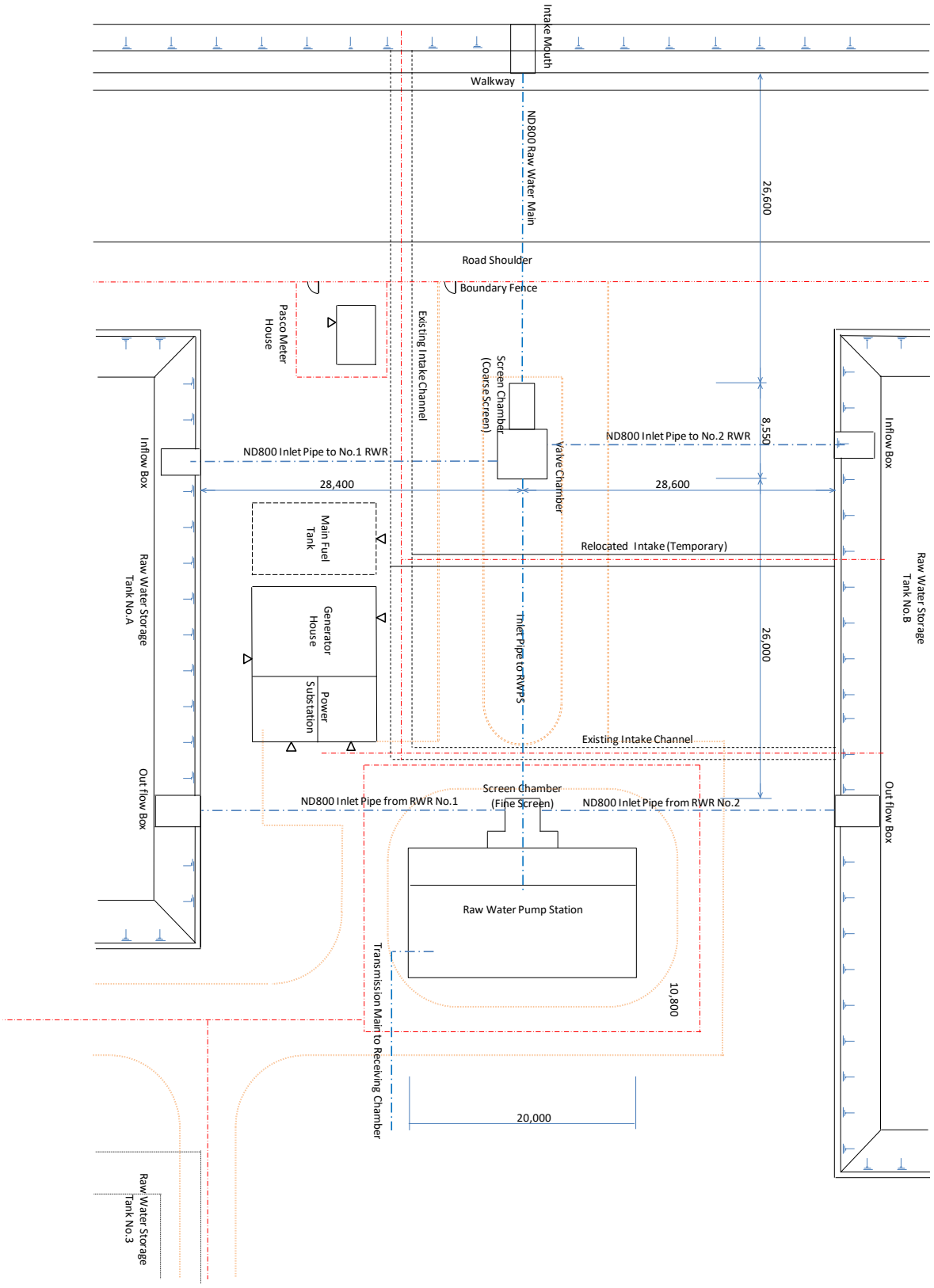


Figure 2-18 Plan of Intake and Raw Water Transmission Facilities

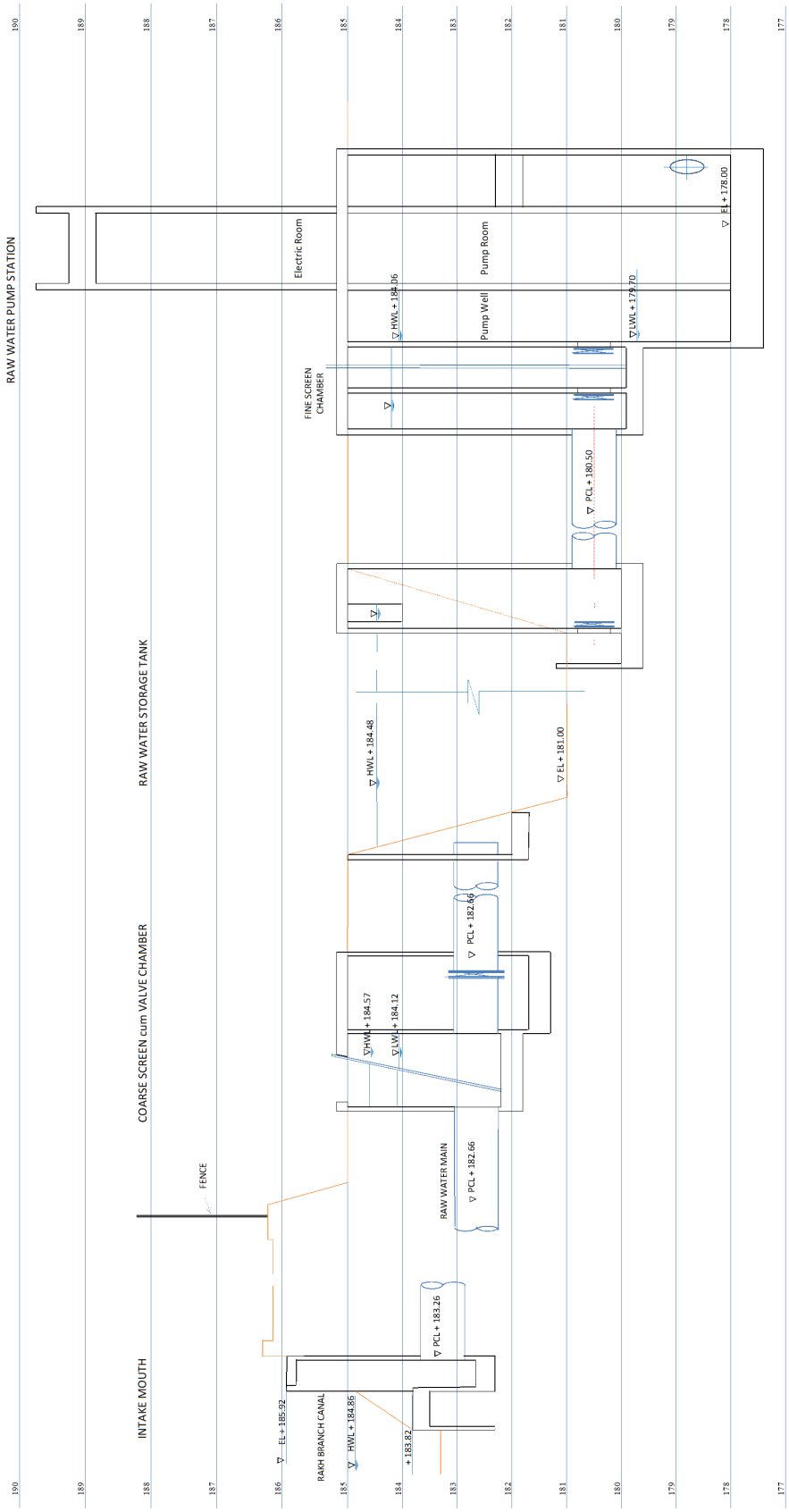


Figure 2-19 Hydraulic Profile of Intake and Raw Water Transmission Facilities

8) Technical Parameter of Intake and Transmission Facilities

Technical parameters of the intake and raw water transmission facilities are presented in Table 2-17 below.

Table 2-17 Technical Parameter of Intake and Raw Water Transmission Facilities

Sr. No.	Facilities			Unit	Dimensions	Quantities This Plan	Quantities Future Plan	Note
1	**Intake**							
	Water Source				Rakh Branch Canal			
	Intake Capacity			m^3/d		23,900	47,900	loss in treatment process at 5%
	Intake Water Level			m		+184.86	+184.86	topographic survey result at site
2	**Intake Mouth**					1	-	gravity flow
	Width			m	0.6			2 nos.
	Water Depth			m	1.01			
	Velocity			m/s	0.457			
	Appurtenant Facilities				Stop Logs			2 sets
3	**Raw Water Transmission Main**					1	-	
3.1	Intake Mouth ~ Screen/valve chamber							branch to raw water storage reservoir
	Pipe Materials				Ductile Cast Iron			
	Nominal Diameter			mm	800			
	Velocity			m/s	1.10			
3.2	Screen/valve chamber							
	Screen	Type			Coarse Screen			bar screen, manual operation
		Number		unit	1			
		Dimensions	width	m	1.6			
			height	m	3			
			spacing	mm	60			between bars
	Branch Valves		number	nos.	3			ex.two RWSR and R.W. T.P.Sta.
			type		Butterfly Valve			manual operation
			nominal dia.	mm	800			
3.3	Existing Raw Water Storage Reservoir (RWSR)							per one RWSR
	Inlet Pipe		pipe materials		R.C Pipe			prevent short cut from inflow to
			nominal dia.	mm	900			out flow
	Outflow Chamber		intake method	m	Weir 1 x 2 nos.			intake at surface water
			Gate	mm	600 x 600			use at the intake stop
		Out flow pipe			1			
			pipe materials		Ductile Cast Iron			
			nominal dia.	mm	800			
3.4	RWSR ~ Raw Water Pump Station							
	Outlet Pipe		pipe materials		Ductile Cast Iron			
			nominal dia.	mm	800			
4	**Raw Water Pump Station**							
4.1	Receiving Chamber							
	Dimensions		width	m	1.15			
			length	m	1.6			
			water depth	m	5.4			
	Inlet Gate		Size	mm	600 x 600	2	-	
	Screen	Type			Fine Screen			mesh screen (vertical), automatic operation
		Number		unit	2			
		Dimensions	width	m	1			
			height	m	5.3			
			mesh size	mm	12			
4.2	Pump Well							
	Dimensions		width	m	3.6			
			length	m	19.6			
			water depth	m	5.3			

Sr. No.	Facilities			Unit	Dimensions		Quantities This Plan	Quantities Future Plan	Note
4.3	Pump Room/Electric Room								
	Dimensions		width	m		4.2			
			length	m		20.0			
			height	m		6.6			below beam bottom, pump room
				m		3.5			below beam bottom, electric room
4.4	Raw Water Transmission Main (R.W. Transmission Pump Sta.)						1	-	in pump room
	Pipe materials				Ductile Cast Iron				
	Nominal Diameter			mm		700			
	Flow Meter		type		Electro-magnetic				
			nominal dia.	mm		500			
	Flow Control Valve								
			type		Butterfly Valve				
			nominal dia.	mm		500			

(4) Raw Water Pump Facility

The raw water pump is a centrifugal type, which has excellent efficiency and maintainability. As a safety measure against malfunctioning of the pump, one unit of standby pump is included. Including the standby, the number of pumps is selected.

Table 2-18 indicates the comparison of the pump arrangement. The alternatives are 3 pump units in total including 1 standby, and 4 pump units in total including 1 standby. The advantage of having 4 units is to ensure a wider range of flow rate control in comparison with 3 units. The initial cost of 4 units is slightly higher than 3 units, but the running cost of 4 units, which is mainly power consumption, is lower than 3 units because the flow rate can be controlled within a small range. As a result, the overall cost including construction and running cost is almost the same for both alternatives for the operation period of fifteen years. Therefore, 4 units are selected at the raw water pump facility.

Table 2-18 Comparison of Raw water pump unit number

Number of units	3 units (including 1 standby)	4 units (including 1 standby)
Specification	Type : Centrifugal type pump Discharge rate : 0.28m^3/sec 3(1) units Total head: 10m Motor power: 45kW	Type: Centrifugal type pump Discharge rate: Small 0.14m^3/sec 2 units Large 0.28m^3/sec 2(1) units Total head: 10m Motor power: Small 30 kW Large 45kW
Flow rate control range	Narrower range Adjustable flow range: 0.28m^3/sec～0.56m^3/sec （50%～100%） Good	Wider range Adjustable flow range: 0.14m^3/sec～0.56m^3/sec （25%～100%） Excellent
Layout space	Excellent	Good
Cost	Construction cost: Excellent Operation cost: Good	Construction cost: Good Operation cost: Excellent
Number of units	This project: 2(1) units Future: 3(1) units	This project: Small 2 units, Large 1(1) units Future: Small 2 units, Large 2(1) units
Determination		Selected

2-2-2-4 Old JK WTP

(1) Treatment Capacity

As mentioned under "2-2-2-3 Intake and Raw Water Transmission Facilities" above, the daily maximum treatment capacity is set to the daily maximum demand plus 5% of water intake for process water and miscellaneous water amount used in the water treatment plant. (see Table 2-19).

Table 2-19 Planned Treatment Capacity

	This Project	Future Expansion
Daily Maximum Demand	22,700 m^3/day	45,500 m^3/day
Daily Maximum Treatment Capacity	23,900 m^3/day	47,900 m^3/day

(2) Treatment Method

1) Site Limitation of Old JK WTP

The Old JK WTP is located in a vast site with an area of about 7.3 ha. Currently, the main facilities are comprised of three raw water reservoirs, a slow sand filtration plant and a rapid sand filtration plant. Figure 2-20 shows a ground plan of the existing Old JK WTP.

The raw water reservoirs are constructed for the purpose of reducing high turbidity of raw water from the RBC to the acceptable level for slow sand filtration. The area for these reservoirs is about 4.0 ha, which occupies 54% of the site area. The slow sand filtration plant consists of seven slow sand filters, two clear water reservoirs, two treated water transmission pump stations and a storage facility for materials and equipment. The site area of the slow sand filtration plant is about 1.3 ha, accounting for 18% of the total site area.

The rapid sand filtration plant consists of a coagulant storage/dosage chamber, hydraulic mixing tanks, horizontal flow chemical sedimentation tanks and rapid sand filters. The raw water is also pumped up from the raw water reservoir to the facility. These facilities cover approximately 0.5 ha, which is 7% of the total site area.

The remaining 21% of the site area is mainly comprised of material storage, channels and internal roads. A general plan of the existing water treatment plant is shown in Figure 2-20.

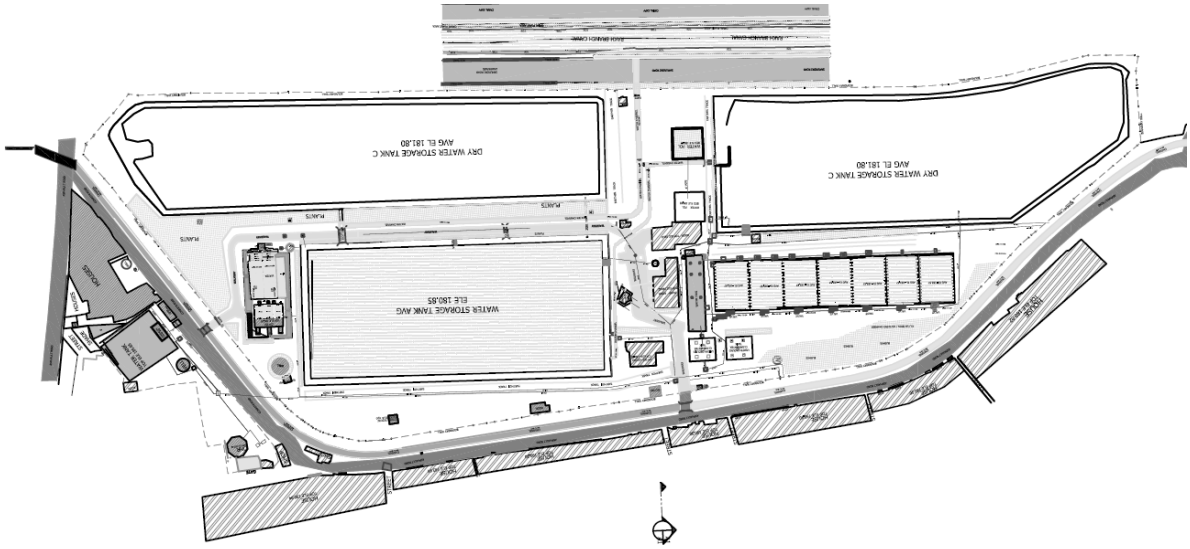


Figure 2-20　Ground Plan of the Existing Old JK WTP

Under this project, existing two raw water reservoirs are used for the reduction and stabilization of the RBC turbidity. Besides, since these reservoirs have a total capacity of 90,000m^3, these can be useful for storing some amounts of water especially when the RBC is closed for maintenance (about 3 to 4 weeks a year). The slow sand filtration plant will continue to operate until the completion of the new water treatment facility under this Project.

Meanwhile, operation of the existing rapid sand filtration plant is currently suspended due to deterioration of the facility, and it has been agreed with WASA-F that it will subsequently be abolished. Therefore, the site area that can be used for the new water treatment facility is about 2 ha including the raw water reservoir C.

In general, the water treatment system is roughly divided into slow sand filtration method and rapid sand filtration method. The slow sand filtration method is easy to operate and maintain and its construction cost is low, but it requires a large area. According to the facility standard in Punjab, the filtration speed of the slow sand filtration rate is very low at 2 m/d (4-5 m/d as per the Japanese Design Guidelines).

This slow filtration speed seems to be due to the fact that slow sand filtration facilities in Faisalabad use raw water from irrigation canals, thereby requiring to reduce its high turbidity and control turbidity fluctuations.

According to the standard of Punjab, required filtration area for the design water volume of the water treatment plant having production capacity of 22,700 m^3/d is about 1.14 ha; that is, filtration area of 2.28 ha will be needed in the future when the capacity is expanded. Taking into account the other necessary facilities such as clear water reservoir, treated water transmission pump station, administration building, power receiving and transforming house, sand storage area, waste water treatment, the current site area

is not sufficient. Moreover, the Old JK WTP is located in the central area of Faisalabad and it is difficult to expand the site around it.

Therefore, in view of existing site limitations, the slow sand filtration method cannot be adopted.

2) Raw Water Quality

The water quality test for RBC was conducted in both wet and dry season during the M/P Project. The result is presented in Table 2-20 together with the standard value of the guidelines in Pakistan and the WHO guidelines. According to the result, the water quality of RBC is applicable as the drinking water source.

Table 2-20 Water Quality Test Results in the M/P Project

No.	Parameter	Unit	PEQS (2016)	WHO Guideline (2011)	SW 3 (RBC)	SW 3 (RBC)
Sampling Date					2016-09-23	2016-11-16
1	Temperature	˚C	-	-	27	18.8
2	Turbidity	NTU	5	5	57	36
3	Colour	TCU	15	15	5.5	0.8
4	pH		6.5-8.5	(6.5-8.5)[1)]	8.2	8.83
5	EC	µS/cm	-	-	193	197
6	Hardness	mg/L	500	-	88	104
7	Total alkalinity	mg/L	-	-	70	120
8	Chloride (Cl^-)	mg/L	250	(250) [2)]	70	30
9	Total dissolved solids (TDS)	mg/L	1,000	(1,000) [3)]	140	141
10	DO	mg/L	-	-	5.64	5.04
11	Nitrite-N (NO_2^-)	mg/L	NO_2^--N:0.9 NO_2^-:3	NO_2^--N:0.9 NO_2^-:3	0.19	0.05
12	Nitrate-N (NO_3^-)	mg/L	NO_3^--N:19 NO_3^-:50	NO_3^--N:11 NO_3^-:50	5.5	4.9
13	Ammonia	mg/L	-	-	<0.01	<0.01
14	COD_{Cr}	mg/L	-	-	32	22
15	Sulphate ($SO4^{2-}$)	mg/L	-	(500)[4)]	22	32
16	Fluoride (F^-)	mg/L	1.5	1.5	4.8 (0.95)[8)]	0.11
17	Manganese (Mn)	mg/L	0.5	(0.4)[5)]	< 0.01	< 0.010
18	Iron (Fe)	mg/L	0.3	-	1.83	0.36
19	Calcium (Ca)	mg/L	-	-	21	30
20	Sodium (Na)	mg/L	-	(200)[2)]	55	13.8
21	Magnesium (Mg)	mg/L	-	-	<0.01	7
22	Aluminium (Al)	mg/L	0.2	0.2	<0.020	<0.020
23	Antimony (Sb)	mg/L	0.005	0.02	0.139	0.298
24	Barium (Ba)	mg/L	0.7	0.7	< 0.70	< 0.70
25	Cadmium (Cd)	mg/L	0.01	0.003	< 0.002	< 0.002
26	Chromium (Cr)	mg/L	0.05	0.05	0.30	<0.01
27	Copper (Cu)	mg/L	2	2	< 0.002	< 0.002
28	Lead (Pb)	mg/L	0.05	0.01	< 0.01	< 0.01
29	Mercury (Hg)	mg/L	0.001	0.006	< 0.001	< 0.001
30	Nickel (Ni)	mg/L	0.02	0.07	< 0.02	< 0.02
31	Selenium (Se)	µg/L	10	10	0.35	<0.04
32	Zinc (Zn)	mg/L	5	(3) [6)]	< 0.05	< 0.05
33	Cyanide (CN^-)	mg/L	0.05	(0.07) [5)]	< 0.002	< 0.002
34	Total Arsenic (As) [7)]	mg/L	0.05	0.01	0.002	0.002
	Soluble Arsenic (As) [7)]	mg/L	-	-	0.002	0.002
35	Standard plate count bacteria	MPN/ 100mL	-	-	120	4.1×10^2

No.	Parameter	Unit	PEQS (2016)	WHO Guideline (2011)	SW 3 (RBC)	SW 3 (RBC)
Sampling Date					2016-09-23	2016-11-16
36	E. coli	MPN/ 100mL	0	0	5.1×10^2	2.5×10^2
Remarks					3-point composite sample	3-point composite sample

1) Value for corrosion control in pipeline, 2) Value for taste, 3) Guideline value in the year 1984, 4) Recommended value from the viewpoint of gastrointestinal effects, 5) Guideline value in the year 2004, 6) Recommended value from the viewpoint of acceptability to consumers, 7) Analyzed in Japan, 8) Values from a supplementary survey conducted on Sep. 24, 2017.
PEQS: Punjab Environmental Quality Standards, 2016
Source: M/P Project

The characteristics of the raw water quality are i) large variations in water temperature and turbidity throughout the year, ii) high values of pH and alkalinity, and iii) low values of ammonium, iron and manganese. As for the turbidity, there is a huge fluctuation on its values between the dry and wet seasons.

Table 2-21 presents data of water temperature, pH, and turbidity (2017/18) obtained from the existing New JK WTP.

Table 2-21 Water Temperature, pH and Turbidity as Raw Water Quality at New JK WTP

	Season	Rainy season						Average
	Month	4	5	6	7	8	9	
Water temperature (°C)	Maximum	28.3	28.2	30.2	28.5	30.4	28.0	30.2
	Average	26.1	26.3	27.9	27.4	28.5	27.6	27.3
	Minimum	24.6	24.4	25.8	26.0	27.1	26.8	24.4
pH	Maximum	8.1	8.1	8.2	8.6	8.7	8.7	8.7
	Average	8.0	8.1	8.1	8.6	8.6	8.1	8.2
	Minimum	8.0	7.8	8.0	8.5	8.6	7.6	7.6
Turbidity (NTU)	Maximum	231	240	655	1436	1365	431	1436
	Average	153	142	276	603	571	187	322
	Minimum	101	32	92	298	221	102	32
	Season	Dry season						Average
	Month	10	11	12	1	2	3	
Water temperature (°C)	Maximum	26.9	22.3	17.5	15.1	20.4	22.9	26.9
	Average	26.1	18.9	15.1	13.3	16.4	21.4	18.5
	Minimum	24.8	17.2	12.7	11.2	13.4	18.9	11.2
pH	Maximum	7.9	8.7	8.3	8.5	8.4	8.6	8.6
	Average	7.8	8.1	8.1	8.2	8.3	8.1	8.1
	Minimum	7.7	8.0	8.0	8.0	8.2	8.1	7.7
Turbidity (NTU)	Maximum	109	77	140	91	125	130	140
	Average	76	48	44	52	39	88	58
	Minimum	45	31	22	28	20	26	20

Due to the limited availability of data on alkalinity, ammonia, iron and manganese, the values in Table 2-22 are obtained from those measured at the rainy and dry seasons during the M/P project and also by other tests conducted in the past including Environmental Monitoring of River Chenab, conducted by EPA Laboratory, Punjab in 2009, Feasibility Study for Extension of Water Resources of JBC for Faisalabad, 2016 and WASA-F Central Laboratory for RBC, 2013 - 16.

Table 2-22 Water Quality Data Tested from the M/P Project (unit: mg/L)

Season	Date of Sampling	Alkalinity	Ammonium	Iron	Manganese
Source: RBC[*1]					
Wet Season	2016/9/23	70	< 0.01	1.83	< 0.01
Dry Season	2016/11/16	120	< 0.01	0.36	< 0.01
Source: Chenab River[*1]					
Wet Season	2016/9/23	110	< 0.01	0.32	< 0.01
Dry Season	2016/11/16	133	< 0.01	0.18	0.01
Source: Chenab River[*2]					
	2009	-	-	0.81 ~ 0.88	0.02
Source: JBC[*3]					
	2016	-	-	-	0.11
Source: RBC[*4]					
	2013 ~ 2016	-	0.1 ~ 0.5	-	-

Note [*1] Data Source: Report for Water Supply, Sewerage and Drainage Master Plan of Faisalabad, JICA 2016 - 2019
[*2] Chenab River is the source of JBC and RBC, Data Source: Environmental Monitoring of River Chenab, EPA Laboratory, Punjab 2009
[*3] Jang Branch Canal, Data Source: Feasibility Study for Extension of Water Resources for Faisalabad City Phase II, 2016
[*4] Rakh Branch Canal, Data Source: WASA-F Central Laboratory, 2013 - 2016

As shown in Table 2-22, pH is high in the range of 7.6 to 8.7 and there are no large differences between wet and dry seasons, whereas turbidity is widely fluctuated between 20 to 1400 NTU. The high turbidity values are expected to be decreased significantly by utilizing the existing raw water reservoirs.

Alkalinity values are also high ranging from 70 to 120 mg/L, and especially high during the dry season. Ammonium and Manganese are as low as 0.01 mg/L. Iron has moderate concentration of 0.36 to 1.83 mg/L. As a reference, water quality values pertaining to alkalinity and manganese were compared to the values obtained from other water bodies in the surrounding area such as the Chenab River (source of the JBC and the RBC) and the JBC. These values were slightly higher than those of the RBC as indicated in Table 2-22.

These values of pH, turbidity, iron, manganese, and ammonia are within the range that can be processed by a normal rapid sand filtration method (coagulation sedimentation, sand filtration). The rapid sand filtration method is the same method that is being adopted at the New JK WTP operated by WASA-F. Thus, the proposed method is considered suitable in terms of the operation and maintenance capacity of WASA-F.

3) Water Treatment Method

The rapid sand filtration method is adopted as the water treatment method based on the site limitations of the Old JK WTP and the raw water quality. Figure 2-21 shows the process of water treatment and waste water treatment.

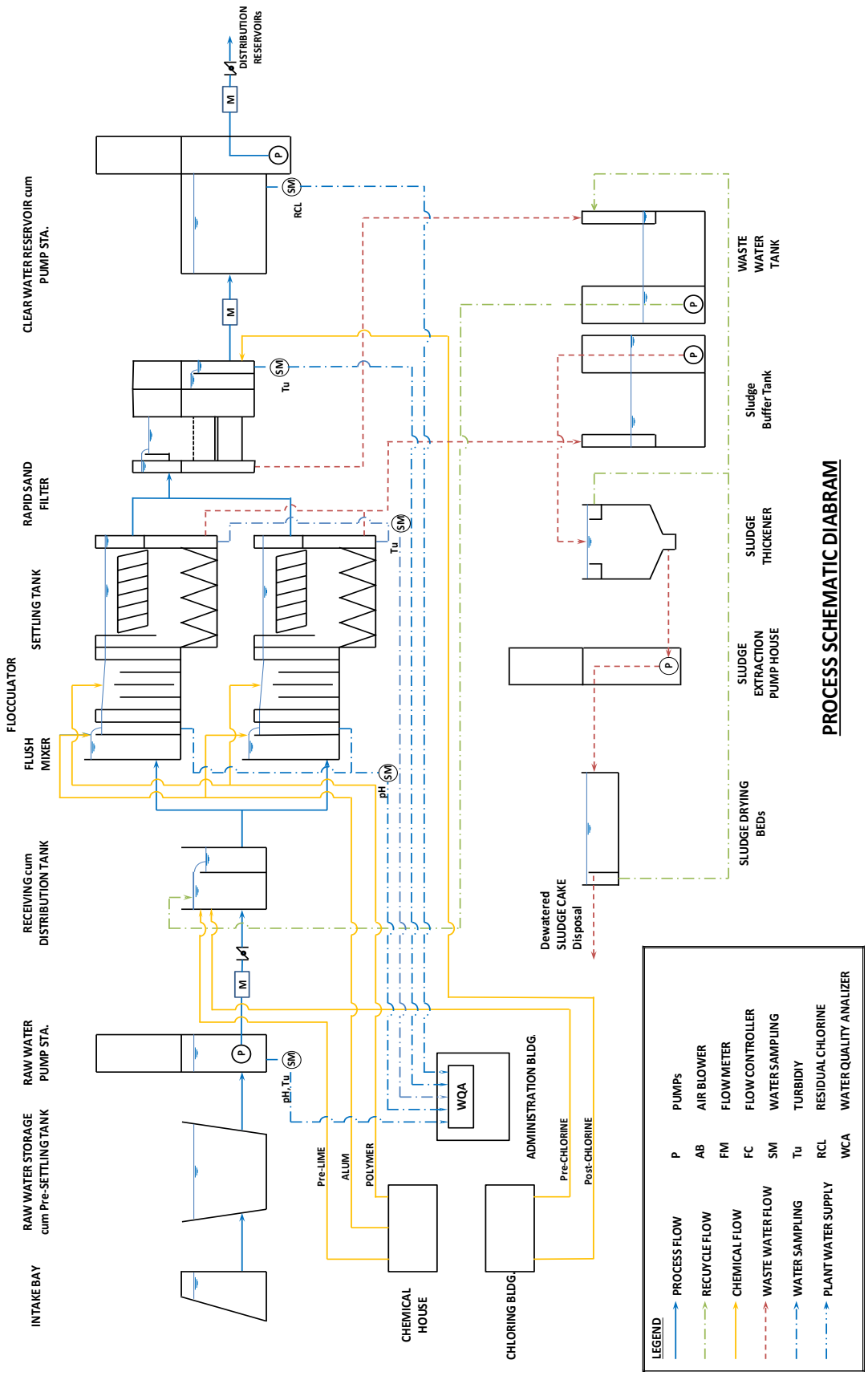


Figure 2-21 Water Treatment Flow Diagram

(3) Water Treatment Facility Plan

1) Composition of Water Treatment Facility

While planning for the water treatment facility, the types of water treatment facilities and its arrangement were determined in consideration of the site limitations of the Old JK WTP. In addition, the water treatment system of the New JK WTP was also referred.

As shown in the flow diagram above, the water treatment facility consists of a receiving tank, flash mixing tank, flocculation tank, sedimentation tank, rapid sand filter, and clear water reservoir. The plan for each facility is shown below.

2) Receiving Tank

The capacity of the receiving tank is planned to be 45,500m^3/day taking into consideration of the future expansion from the viewpoint of existing site limitation. The outlet pipe for the future expansion will be provided as shown in Figure 2-22.

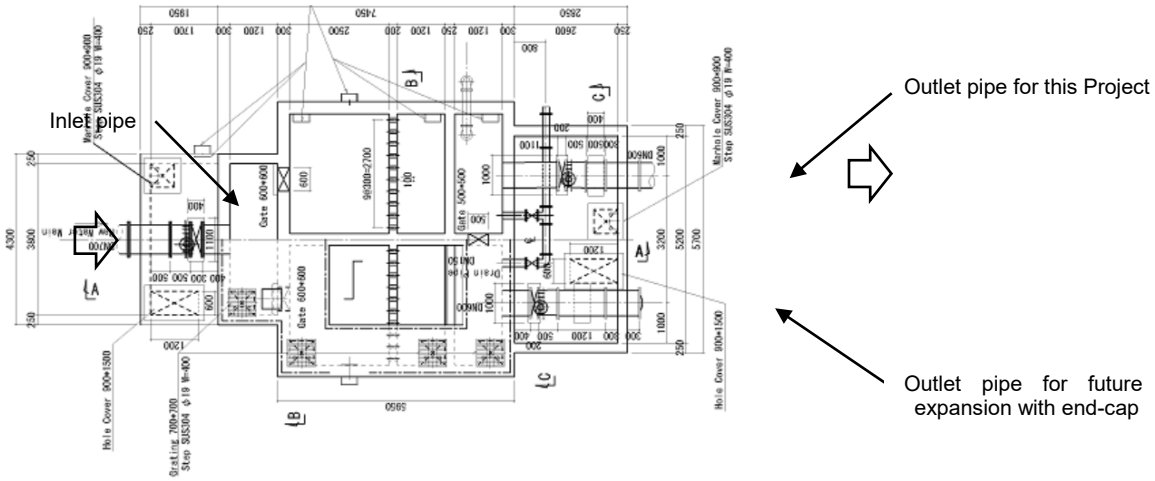


Figure 2-22 Structure of Receiving and Distribution Tank

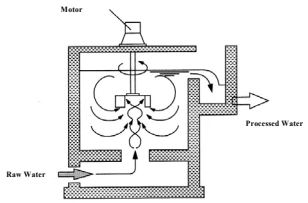
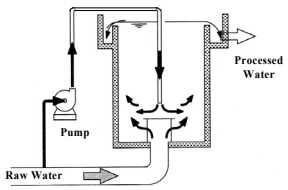
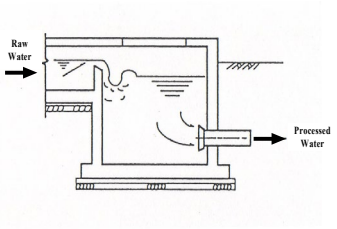
3) Flash Mixing Tank

In order to perform sufficient and effective coagulation, the added coagulant must be rapidly and uniformly mixed with the raw water in a thorough manner. The mixing method is roughly divided into two types: i) mixing method that uses externally applied energy and ii) mixing method that uses energy generated through turbulence or water freefall. The following common methods are compared and examined.

- Mechanical mixing method
- Pump mixing method
- Water freefall energy utilization method

As shown in Table 2-23, “Water freefall energy utilization method” is adopted as it is easy to maintain due to lack of any mechanical working parts, and its construction, operation and maintenance cost is the lowest.

Table 2-23　Comparison of Flash Mixing Methods

	Mechanical mixing method		Pump mixing method		Water freefall energy utilization method	
Structure						
G value (1/sec)	500					
Detention time (minutes)	1～5（Based on the Japanese Design Guidelines）					
Mixing Effect	Adjusting the rotation speed of the stirrer to obtain a reliable effect	Excellent	Adjust the amount of water circulation to obtain a mixing effect	Excellent	Large mixing effect	Excellent
Flow rate fluctuation	Mixing intensity (G value) can be kept constant by adjusting the rotation speed of the stirrer.	Excellent	Slightly affected by fluctuations in water flow.	Good	Mixing strength fluctuates slightly due to water flow fluctuation	Good
O&M cost	Maintenance of mechanical parts and regular replacement are required	Average	Maintenance of mechanical parts and regular replacement are required	Good	No breakdown, easy maintenance and cheap	Excellent
Installation Area	Small	Excellent	Large：Pump room is needed	Average	Small	Excellent
Construction cost*	1.0	Good	1.6	Average	0.1	Excellent
Total Evaluation	Good		Average		Excellent	

Note: The mechanical mixer, which is widely used in water treatment plants in Japan, is set to 1.0, and other methods are shown numerically in comparison with this.

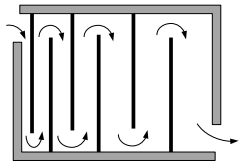
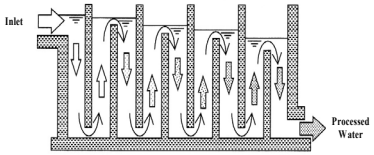
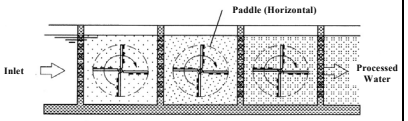
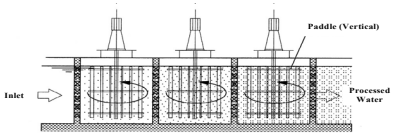
4)　Flocculation Tank

The flocculation tank is installed for the purpose of allowing the micro flocs generated in the flash mixing tank to be gently mixed to grow large and to be efficiently separated and settled out in the sedimentation tank.　It is desirable that water is conducted into the flocculation tank immediately after flash mixing in order to prevent the fine flocs formed in the rapid mixing tank from being destroyed by excessive flow or settling out in the middle of the process.

Mixing equipment must be installed to provide the energy required for floc formation. There are the mechanical mixing method and the hydraulic mixing method in which a baffle plate is provided at the flowing water channel. Under the mechanical mixing method, there are the horizontal and vertical paddle types. Under the hydraulic mixing method, there are horizontal and vertical flow types. Table 2-24 shows a comparative study of the above mentioned methods.

Comparing the mechanical mixing method and the vertical flow type of hydraulic mixing method, the vertical flow type of hydraulic mixing method is adopted since its mechanical cost as well as operation and maintenance cost is less as it does not require any mechanical working parts.

Table 2-24 Comparison of Mixing Methods of Flocculation Tank

	Hydraulic Mixing Method				Mechanical Mixing Method			
	Horizontal type		Vertical Type		Horizontal Paddle Type		Vertical Paddle Type	
Structure								
G value (1/sec)	20~75							
GT value	23,000~210,000							
Detention time (minutes)	20~40							
Mixing Effect	Appropriate water level difference is required to obtain sufficient stirring effect.	○ *3)	Appropriate water level difference is required to obtain sufficient stirring effect.	○	Mixing strength can be easily adjusted by changing the number of revolutions between the first and second stages.	◎	Mixing strength can be easily adjusted by changing the number of revolutions between the first and second stages.	◎
Flow rate fluctuation	Mixing intensity (G value *1)) changes due to fluctuations in water flow. It is difficult to adjust the mixing strength。	△	Mixing intensity (G value) fluctuates due to fluctuations in water flow (the Mixing intensity is higher than that of the horizontal method for the same area). (Adjust by using baffle plate as flash board)	○	The Mixing intensity (G value) can be adjusted to a constant value by adjusting the number of rotations, which has little effect.	◎	The Mixing intensity (G value) can be adjusted to a constant value by adjusting the number of rotations, which has little effect.	◎
O&M cost	No Breakdown and low O&M costs	◎	No Breakdown and low O&M costs	◎	Maintenance of the mechanical drive part and periodic replacement are required. The driving part is submerged and the durability is slightly inferior.	△	Maintenance of the mechanical drive part and periodic replacement are required. Durability is better because the drive part is set above water.	○
Installation Area	Large	△	Medium	○	Small	◎	Small	◎
Installation Cost *2)	0.3	◎	0.2	◎	1.0	△	0.6	○
Total Evaluation	Good		Excellent		Good		Good	

Note: *1) G value: Mixing gradient, which is an index of mixing strength.
*2) Regarding economic efficiency, the horizontal paddle type, which is used relatively often in water treatment plants in Japan, is set as 1.0, which is the standard, and other methods are numerically shown.
*3) ◎: Excellent, ○: Good, △: Average

5) Sedimentation Tank

a) Classification of Sedimentation Tank

The sedimentation tank is installed in order to reduce treatment load for the filtration tank by separating and removing suspended matters and flocs through gravity settling. The settling velocity of suspended matters and flocs are expressed as the overflow rate (flow rate/surface area), where settling effect is presented by the overflow rate times settling efficiency. Following are the means to increase the removal rate and improve the settling efficiency;

- Increase tank area
- Reduce flow rate
- Increase floc settling speed.

Classification of sedimentation tanks in relation to the above methods is explained in the Table 2-25 below.

Table 2-25 Classification of Sedimentation Tank

Category	Subcategory		Concept for improving settling efficiency
Horizontal Flow Sedimentation Tank	Single Layer Type (Intermediate withdraw)		Reduce flow rate
	Multi-layer Type	Dual Layer Type	Increase the surface area of the tank
	Inclining Plate Type	Horizontal Flow	
Vertical Flow Sedimentation Tank	Inclining Tube Type	Vertical Flow	
High Rate Sedimentation Tank	Slurry Circulation Type (Ex. Accelerator)		Increase floc settling speed
	Sludge Blanket Type (Ex. Pulsator)		

b) Classification of Sludge Extraction Method

The method of discharging sludge from the sedimentation tank is also an important factor to consider when selecting the type of sedimentation tank. As for the sludge extraction methods, there are manual, mechanical (using a sludge scraper) and hydraulic sludge extraction methods.

- **Manual extraction method:** If the amount of treated water in the sedimentation tank becomes large or the turbidity of the raw water becomes high, the frequency of sludge removal will be increased and much labor will be required. The planned treatment capacity of this project will be 12,000 m^3 per tank, and the number of tanks will be 4 tanks (in the future). Sludge disposal by human will not be practical.
- **Mechanical extraction method:** Under this method, a sludge scraper (link belt or rope traction type) is required. The initial investment is large and proper maintenance will be essential.
- **Hydraulic extraction method:** A hopper is installed at the bottom of the tank to collect sludge and the sludge is extracted through a sludge pipe by utilizing the difference in water level between the sedimentation tank and the sludge extraction destination. Initial investment is small in comparison with the mechanical type. In addition, maintenance is easier than mechanical extraction method.

c) Examination of Each Method

The three methods for the sedimentation tank are examined below.

- Horizontal Flow Sedimentation Tank: The surface area of the sedimentation tank will be reduced due to increase in overflow rate when intermediate extraction is applied. If intermediate withdrawal is applied for half of the tank, the area will be reduced to half in that portion. As a result, the overall surface area becomes 75% of ordinary (single layer) horizontal flow sedimentation tank with no intermediate withdrawal (A=0.5＋0.5/2), or overall overflow rate will increase about 1.2 times with 90% of efficiency to the ordinary type of horizontal flow sedimentation tank. The overflow rate of horizontal flow intermediate withdrawal is still smaller at 17-24% of other types of sedimentation tanks with overflow rates of 5-7m/h.

  The length of the tank should be 5 to 8 times longer than the width in order to stabilize the tank flow and maintain the settling efficiency. The treatment flow per tank under this project is 500 m^3/h, and considering this flow rate, the shape of the tank will be about 12 m wide x 40 m long including effluent zone with troughs and clarified water channel.

- Horizontal Flow Inclining Plate Type Sedimentation Tank is a type that enlarges the sedimentation tank area by bending the PVC plate multiple times at a height of about 1 m inside the tank. By increasing the number of stages, the overflow rate can be increased and the tank area can be reduced. Usually, the maximum number of stages is 4 and the height is about 3.5m. For enabling inspection/maintenance, a space of about 1.5m is required from the bottom of the inclining plate to the bottom of the tank. A sludge removal device is installed in this space, and generally a sludge scraper is used.

- Vertical Flow Inclining Tube Type Sedimentation Tank is equipped with only one stage of inclining tube (PVC) with a height of about 1 m, and the lower part of the inclined tube has a space of about 1.5 m for inspection and maintenance. A sludge scraper or a sludge hopper is installed in the lower part to discharge sludge.
  The maximum overflow rate under this method is 0.84 m/hour, but the rising velocity of the tank is limited to about 5 m/hour. Therefore, if the treated water amount per tank is 500 m^3/h, the area of the inclined tube section will be about 100 m^2.

- There are two types of High Rate Sedimentation tanks, which are slurry circulation type and sludge blanket type. The high rate sedimentation tank can reduce the area of the tank by increasing the overflow rate achieved due to the increase in the settling speed by circulating and growing flocs. However, this method is effective only when the raw water quality is stable. Skilled operation management such as management of excess sludge is required. A mixing chamber for the floc formation is installed in the tank. This chamber is generally made of steel. Inspection and repair of the painted surface is required. Generally, it is not suitable for operating

only during the daytime or for a short time. Also, the concentration of sludge is low and it is necessary to pay attention to the waste water treatment process.

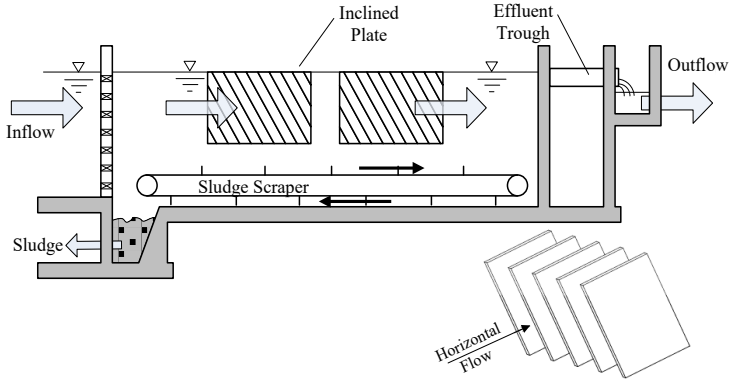
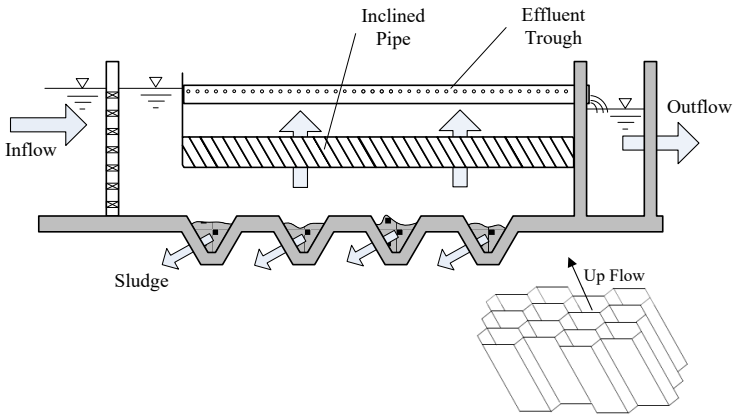
- In the sludge blanket type, the flocs are formed by pulsation at the bottom of a tank and a sludge blanket zone is formed between the clarified water collection device such as troughs or pipes and the bottom of the tank. Thereby, suspended matters can be separated. Under this method, the balance of the sludge zone is lost due to fluctuations in the flow rate and there is an outflow of flocs due to expansion of the sludge zone caused by changes in water temperature by sunlight.

Based on the above examinations, Horizontal Flow Sedimentation Tank and High-Rate Sedimentation tank are excluded from the selection, and Horizontal Flow Inclining Plate Type or Vertical Flow Inclining Tube Type Sedimentation Tank is adopted as its treatment effect is relatively stable even if there are fluctuations in raw water quality and no special operation is required.

Note that the New JK WTP uses an upflow inclining plate sedimentation tank and the treatment results are observed to be good. A hopper type is used for the sludge extraction method.

Table 2-26 shows a comparison between the two. Under the Project, the Vertical Flow Inclined Pipe Type, which is advantageous in terms of its maintenance and economy, is adopted.

Table 2-26 Comparison of Sedimentation tank

	Horizontal Flow Inclining Plate Type Sedimentation tank		Vertical Flow Inclining Tube Type Sedimentation tank	
Structure				
Detention time	About 1 hour		About 1 hour	
Overflow Rate	4～9 ㎜/ min		7～14 ㎜/min	
Flow Velocity	0.6m/min or less		0.08m/min (upflow velocity) or less	
Tank Depth	4-5m (3-4 stages of inclining plate)		4-5m (including sludge pit)	
Installation Area	1.0	Excellent	1.0	Excellent
Turbidity of Supernatant Water	Settling device can reduce the turbidity of the supernatant water.	Excellent	Settling device can reduce the turbidity of the supernatant water.	Excellent
Correspondence to the fluctuation	Resistant to changes in raw water turbidity. Resistant to changes in raw water temperature. Resistant to fluctuations in treated water volume.	Excellent	Resistant to changes in raw water turbidity. Resistant to changes in raw water temperature. Resistant to fluctuations in treated water volume.	Excellent
O&M	Sludge flocs may accumulate on the surface between the sloping plates, requiring regular cleaning. Cleaning takes labor and time such as for removing the device. Provision for washing flocs adhered to plate is required.	Average	Sludge flocs may adhere to the inclined pipes and require regular cleaning. However, cleaning is relatively easy. Provision for washing flocs adhered to tube is required.	Good
Sludge extraction	Mechanical type (link belt or rope tow type)	Average	Hopper type	Good
Construction Cost *	1.3	Average	1.0	Good
Total Evaluation	Good		Excellent	

Note: The design specifications were based on the Japanese Design Guidelines.

* Regarding economic efficiency, the horizontal flow sedimentation tank is set as the standard at 1.0, and other methods are shown numerically in comparison with this. In this project, construction cost is prioritized.

6) Rapid Sand Filters

The rapid sand filter is positioned as the final stage of suspended solid removal in the water treatment process. Removal of suspended solids is done by adhering to the filter sand particle and sieving in the filter sand layer. The rapid sand filtration can be divided into flow control method and water level control method. The following typical types are compared and examined.

- **Filtered water flow control type**: The flow rate is controlled on the outflow side of the filter. The amount of filtered water and the water level of the filter are constant.
- **Equal split of inflow type**: Evenly distributes the inflow of the filter. The water level in the filter tank rises as the filter sand clogs.
- **Declining-rate filtration type**: No filtration flow rate/water level control. The filtration flow rate of each filter varies depending on the filter clogging degree.
- **Self-balancing type**: Evenly distributes the inflow of the filter. The water level in the filter tank rises as the filter sand clogs. The backwash water uses the filtration flow rate of the other filters.

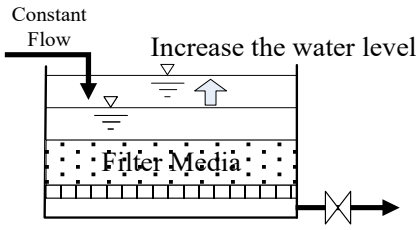
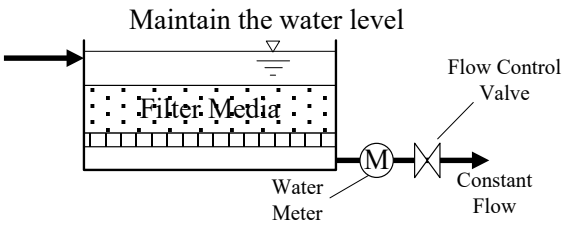
Among the above filtration methods, Declining-rate filtration and Self-balancing type filtration are not considered due to the following reasons.

- **Declining-rate filtration:** This method does not control the filtration flow rate and water level, and the water flow is automatically distributed to each filter depending on the clogging condition of the filter sand. This method requires a certain number of filters. That is, when the number of filters is small, the inflow from other filters increases and the water level of the filters rise excessively when washing. Normally, the number of filters is 6 or more. Under the Project, there are 4 filters (8 in the future), and thus, this method will not be adopted.
- **Self-balancing type filtration**: This is a method in which the inflow to each filter basin is evenly distributed and the filtration flow is used for backwash water. As mentioned above, a sufficient backwash flow cannot be secured with four filters. Therefore, this method is not adopted.

Based on the above, a comparative study was conducted between the Filtered water flow control type and the Equal split of inflow type.

As shown in the comparison table under Table 2-27, Equal Split of Inflow type, which is advantageous in terms of its maintenance costs, is adopted.

Table 2-27 Comparison of Filters

	Equal Split of Inflow Type	Filtered Water Flow Control Type
Structure		
Control Method	There is no flow control mechanism and the inflow water is evenly distributed to each filter in the inflow part (usually by weir), and the inflow rate and the outflow rate are naturally balanced.	Constant control of the filtration flow at outflow side of the filter.
Equipment, Flow control	The water level in the tank rises in response to the increase in head loss of filtration.	Flowmeter/motorized control valve and automatic control circuit (The number of devices increases.)
Civil structure	Concrete structure is about 1-2m deeper than the flow control method。	Concrete structure is about 1-2 m shallower than the equal split of inflow method.
OM cost	Less repair/replacement cost than Conventional Type	More repair/replacement cost than equal split type. (Flow meter/control valve replacement is required after the lapse of service life)
Construction Cost*	Civil construction cost: 1.05 Mechanical equipment cost: 0.9 (no flow meter, motorized valve On/Off) Electric instrumentation cost: 0.9 (without flow control circuit)	Civil construction cost: 1.0 Mechanical equipment cost: 1.0 (flow meter, electric control valve) Electric instrumentation cost: 1.0 (flow control circuit)
Total Evaluation	Excellent	Good

Note: * Regarding economical efficiency, the flow rate control type is set as 1.0 as a standard, and other methods are shown in comparison with this.

7) Clear Water Reservoir

The capacity of the clear water reservoir is planned to be for the production of 45,500m^3/day including the future expansion from the viewpoint of site limitation. The Detention time of the clear water reservoir is specified to be equivalent to more than one hour of design production flow as per the Japanese Design Guidelines. Meanwhile, it should be considered that water is being received at the clear water reservoir from the existing arterial main during the closing period of the RBC (see "2-2-2-9 Water Supply Plan during Closing Period of RBC"). It is estimated that the water demand is at its lowest during the winter period when the RBC is suspended, which is about 75% of the daily maximum demand. Since the existing arterial main is currently being operated for about 6 hours a day, increasing the capacity of the clear water reservoir as much as possible will result in increase in the supply hours from the Old JK WTP during the RBC closing period. Under this Project, from the viewpoint of site limitation, the capacity is proposed to be equivalent to 1.2 hours of 45,500 m^3/day. Due to the above increase of capacity, water supply will be extended by about 18 hr/day for the minimum water demand during winter season in 2028.

8) Technical Parameters of Water Treatment Facilities

Technical parameters of the water treatment facilities are summarized in Table 2-28 below.

Table 2-28 Technical Parameter of Water Treatment Facilities

Sr. No.	Facilities			Unit	Dimensions		Quantities This Plan	Quantities Future Plan	Note
1	**Water Treatment Facilities**								
1.1	**Production Capacity**			m^3/d			22,750	45,500	
1.2	**Treatment Capacity**			m^3/d			23,900	47,900	loss in treatment process at 5%
2	**Receiving/Distribution Tank**							-	
	Number of Tank			nos.			2	-	compartment
	Detention time			min		3.6			
	Dimensions	Width		m		3.0			
		Length		m		3.7			
		Water depth		m		5.5			
		Volume		m^3		61			per compartment
	Appurtenant Facilities								
	Inlet Pipe		nominal dia.	mm		700	1	-	Ductile Cast Iron (DCI)
	Inlet Gate		size	mm		600 x 600	2	-	Cast Iron (square)
	Bypass Gate		size	mm		500 x 500	1	-	CI
	Outlet Pipe		nominal dia.	mm		600	1	1	DCIP
	Drain Pipe		nominal dia.	mm		150	1	-	DCIP
3	**Pre-Treatment Facilities**								
3.1	**Mixing Tank**								
	Number of tank						1	1	
	Mixing Method						Free fall		freefall depth at 0.6m
	Mixing Intensity			sec^{-1}		500			
	Dimensions				Receiving	Mixing			
		Width		m	3.0	3.0			
		Length		m	3.0	0.8			
		Water depth		m	4.5	2.8			
		Volume		m^3	41	6.7			
	Detention Time of Mixing Part			sec	146	24			
3.2	**Flocculation Tank**								
	Number of Tank						2	2	
	Mixing Method					Up-and-Down Flow			
	Dimensions	Width		m		1.85			
		Length		m		9.7			
		Water depth		m		3.5 ~ 3.8			
		Volume		m^3		253			
	Detention Time			min		30			
	Head Loss			m		0.36			
	Mixing Intensity			sec^{-1}		32 ~ 61			
	G-Value			-		81,000			
3.3	**Settling Tank**								
	Number of Tank						2	2	
	Type					Inclining Tube			
	Surface Loading			$m^3/h/m^2$		1.0			
		Efficiency		%		80			
	Inclining	Size of tube		mm		80			typical criteria
	Tube	Installation angle		deg.		60			to horizontal
		Effective area		m^2/m		0.577			
		Module of tube		m		1.0 x 1.0			
		Number of modules		unit		> 87			

Sr. No.	Facilities			Unit	Dimensions		Quantities This Plan	Quantities Future Plan	Note
	Dimensions of Tank								
		Width		m		8.4			2 compartments per tank
		Length		m		13.75			incl. wall at inflow
			Inlet zone	m		1.5			net width (exclude wall thickness)
			Inclining tube	m		12			
		Water depth		m		3.5			effective water depth
			above tube	m		0.8			
			height of tube	m		1.2			including support (0.2m)
			height under tube	m		1.5			
			free board	m		0.4			
		Total water depth		m		3.9			excluding height of sludge hopper
	Clarified Water Extraction								
		Method			Pipe and effluent channel				
		Intake pipe	number	nos.		4			per compartment
			nominal dia.	mm		200			SUS 316
		Weir loading		$m^3/d/m$		< 200			
		Effluent channel width		m		0.8			RC structure, locate between compartments
	Clarified Water		width	m		1.5			net width (exclude wall thickness)
	Outlet Channel		height	m		4.85			underneath - pipe gallery of sludge extraction
	Sludge Extraction								
	Flocculation Tank								
		Slit pipe	nominal dia.	mm		250			in tank
		Sludge extraction	nominal dia.	mm		150 ~ 200			in pipe gallery
	Sedimentation Tank								
		Sludge hopper		nos.		16			per tank
		extracting pipe	nominal dia.	mm		150			in tank
		header pipe	nominal dia.	mm		200			in tank
		header main	nominal dia.	mm		250			in pipe gallery
		extraction main	nominal dia.	mm		300			outlet channel underneath
3.4	**Rapid Sand Filter**								
	Treatment Capacity			m^3/d		46,900			loss in treatment process at 3%
	Number of filter						4	4	
	Type	Filter media				single sand layer			
		Filtration				constant flow			
		Flow control				equal split of inflow			by weir at filter inlet
	Filter Media								
		Filter sand	effective size	mm		0.9			
			uniformity coefficient	-		1.4			
			thickness	cm		100			
		Gravel	diameter	mm		2 ~ 50			4 layers
			thickness	cm		20			
	Underdrain	Type				nozzle type			
		Max. head loss		cm		< 70			
	Dimensions	Width		m		4.5			per filter cell
		Length		m		9.4			
		Filtration area		m^2		42.3			filtration rate : 139 m/d
		Height	above sand	m		1.25			total height : 5.75 m
			clogging	m		1.30			
		thickness of filter media		m		1.2			filter sand and gravel
			underdrain	m		1.1			include false slab
			fee board	m		0.9			
	Filter	Method				Air + Backwash			
	Washing	Air scour	rate	m/min		0.9 ~ 1.0			
			time	min		10			
		initial backwash	rate	m/min		0.25			air + water
			time	min		2 ~ 3			
		backwash	rate	m/min		0.5			
			time	min		8 ~ 10			

Sr. No.	Facilities			Unit	Dimensions	Quantities This Plan	Quantities Future Plan	Note
	Pipes and Gates/Valves							
		Inlet		mm	300 x 300			motorized gate
		Backwash drain		mm	600 x 600			motorized gate
		Filtered water		mm	250			motorized valve (butterfly)
		Air scouring		mm	250			motorized valve (butterfly)
		Backwash		mm	450			motorized valve (butterfly)
		Drain		mm	150			manual gate valve
	Backwash	Trough	number	nos.	4			per filter
	Drain		width	cm	40			net width
			depth	cm	40			net depth
		Drain gutter	width	m	0.9			
			height	m	2.9			
		Drain pipe	nominal dia.	mm	600			800 mm after drain manhole
3.5	**Clear Water Reservoir**					1	-	composed of 2 compartments
	Detention time			h	1.25			
	Volume			m^3	1,190			per compartment
	Number of compartment			nos.	2			
	Dimensions	Width		m	15.8			
		Length		m	17.2			
		Water depth		m	4.5			effective depth
	Piping							
		Inlet	nominal dia.	mm	600			
		Outlet	nominal dia.	mm	600			
		Overflow	nominal dia.	mm	400			
		Drain	nominal dia.	mm	200			

(4) Waste Water Treatment Facility Plan

1) Outline of Waste Water Treatment Facilities

The waste water treatment facility consists of a storage facility for sludge from the sedimentation tank, the washing and drainage of the rapid sand filter, facility for thickening of sludge and transporting the thickened sludge and a dehydration treatment facility (sludge drying beds). It is planned that the dewatered sludge cake is transported to the disposal site located in outside of Faisalabad city.

Under this Project, a closed system will be adopted because of effective use of raw water and lack of existence of drainage having suitable capacity in the surrounding area. Under normal operation, the filter wash water will be returned to the receiving tank together with the supernatant water from the sludge thickener and the sludge drying bed. In order to avoid concentration of dissolved substances (iron, manganese, etc.) in the raw water, a bypass pipe will be installed to switch the return destination from receiving tank to the raw water reservoir.

2) Waste Water Tank and Sludge Tank

The sludge tank and waste water tank are composed of two tanks respectively, and they are used alternately. In ordinary operation, the frequency of sludge extraction from sedimentation tank and filter washing is set as four (4) times a day for planned treated water. If the sludge in the sedimentation tank increases at high turbidity, the simultaneous use of the backup tank is allowed.

In the waste water tank, in addition to the filter wash water, the supernatant water from the sludge thickener / sludge drying beds and the overflowing water from the clear water reservoir and others are accepted. At the time of excess inflows of waste water, the simultaneous use of the backup tank is

allowed.

Submersible mixers are installed in the sludge tank and waste water tank to ensure uniform concentration of sludge and effluent, and pumps are used to pump sludge from the sludge tank to the sludge thickener or from the waste water tank to the receiving tank as the water level rises. In addition, drain pumps to convey water to the raw water reservoir A will be installed in the waste water tank in case the water level rises due to the inflow of overflow water.

The capacity of the sludge tank shall be the capacity to receive the sludge from one sedimentation tank. The capacity of the waste water tank shall be the capacity to receive the washing waste water for one filter. Since the operation will be the same in the future, there is no need to install any additional tanks.

The turbidity of the receiving tank increases due to the return of the filter washing water, supernatant of sludge thickener and sludge drying bed to the receiving tank. The average turbidity of return water is expected to be about 200 mg/L. Therefore, the turbidity of raw water changes, as shown in the table below, depending on the degree of turbidity of the raw water which rises due to the inflow of return water. The degree of change increases as the raw water turbidity decreases, but the increased turbidity is not so high.

Other water quality items (iron, manganese, etc.) will not increase greatly as their concentration rates are small. Therefore, the impact on the water treatment by the recycle use is limited.

Table 2-29 Change in Raw Water Turbidity

	Water Quantity (m^3/day)	Turbidity (mg/L)		
		Year Minimum	Year Average	High Turbidity
Raw Water	45,500 (95%)	20	48	100
Return Water	2,400 (5%)	200	200	200
Mixed Water	47,800 (100%)	29	56	105

3) Sludge Thickener and Sludge Extraction Pump Station

The sludge thickener will be a gravity type and will have a RC structure. The concentrated sludge is transferred to the sludge drying bed through the sludge extraction pump station. The sludge thickener will treat half the amount of sludge during high turbidity period of raw water from July to August, and the rest will be sent directly to the sludge drying bed. As a result, the scale of the sludge thickener can be reduced.

4) Sludge Drying Bed

Considering high temperature, high evaporation and low precipitation at the site, sludge drying bed is selected for dewatering of sludge.

The sludge drying bed receives the sludge from the sludge thickener. The supernatant water is returned to the waste water tank. Under the Project, four units of the sludge drying bed shall be

constructed having a total production capacity of 22,700m^3/day. It is possible to treat 45,500m^3/day in the future by adding three units.

5) Technical Parameters of Waste Water Treatment Facilities

Technical parameters of the waste water treatment facilities are presented in Table 2-30 below.

Table 2-30 Technical Parameters of Waste Water Treatment Facilities

Sr. No.	Facilities			Unit	Dimensions	Quantities This Plan	Quantities Future Plan	Note
1	**Waste and Sludge Tank**							
1.1	**Waster Water Tank (WWT)**							
	Number of Tank			nos.	2	2	-	include 1 standby
	Inflow							
		Filter backwash waste water		m^3	210			per backwashing, 4timesday
	Tank Volume			m^3	210			
	Dimensions		width	m	4.2			
			length	m	20			
			water depth	m	2.5			
		depth of sludge deposit		m	0.5			
			free board	m	1.7			
	Piping	Inlet pipe	materials		Ductile cast iron			
			nominal dia.	mm	800			
		Inlet gate	materials		Cast iron			
			size	mm	600 x 600			
	Appertenant Equipment							
		Transfer pump						waste water tank→RWST (#A)
			Type		Submersible pump			for waste water
			number	unit	2			working 1 + standby 1
		Recycle pump						waste wate tankr→receiving tank
			Type		Submersible pump			for waste water
			number	unit	4			working 2 + standby 2
		Mixier						
			Type		submersible mixer			
			number	unit	2			per tank
1.2	**Sludge Holding Tank (SHT)**					2	-	
	Number of Tank				2			including 1 standby
	Sludge inflow			m^3	300			per tank, 4times/day
	Volume			m^3	250			
	Dimensions		width	m	4.2			per tank
			length	m	20			
			water depth	m	3.0			
		depth of sludge deposit		m	0.5			
			free board	m	1.2			
	Piping	Inlet pipe	materials		ductile cast iron			
			nominal dia.	mm	300			
		Inlet gate	materials		cast iron			
			size	mm	300 x 300			
		Overflow weir	width	m	0.4			outflow to Waste water tank
			length	m	4.2			per tank
	Appurtenant Equipment							
		Transfer pump						sludge holding tank→sludge thickener
			type		Submersible pump			for waste water
			number	unit	4			working 2 + standby 2
		Mixer						
			type		submersible mixer			
			number	unit	2			per tank
1.3	**Pump Room**			l.s	1			common for WWT and SHT
		monorail hoist		l.s	1			

Sr. No.	Facilities			Unit	Dimensions		Quantities This Plan	Quantities Future Plan	Note
2	**Sludge Thickener**								
	Solid Weight			kg/d		5,040			
	Sludge Loading			kg/d		20			
	Type					center feed			
	Number						1	1	
	Dimensions		diameter	m		12.8			
			water depth	m		4.0			
			free board	m		0.7			
		depth of sludge deposit		m		0.5			slope 10% (lean concrete)
	Appurtenant Equipment								
		Sludge scraper					1	1	by manufacturer's criteria
	Piping	Inlet Pipe	materials			Ductile cast iron			
			nominal dia.	mm		150			
		Supernatant	materials			Ductile cast iron			
			nominal dia.	mm		150			
		Sludge extraction	materials			Ductile cast iron			
			nominal dia.	mm		150			
3	**Sludge Transfer Pump Station**								
	Structure					RC structure			
	Dimensions	Basement	width	m		5.0			pump room
			length	m		12.0			
			height	m		5.55			
		Ground FL	width	m		5.0			electric room
			length	m		12.0			
			height	m		3.5			from bottom of beam
	Appurtenant Equipment								
		Transfer pump	Type			screw pump			to sludge drying bed
			number			4	2	2	working 2 + standby 2
4	**Sludge Drying Bed**								
	Solid Weight			ton/year		991.4			
	Sludge loading			kg/m^2		240			
	Area			m^2		4,200			
	number of beds			bed		7	4	3	
	Dimensions	width		m		20			per bed
		length		m		30			
		height	filter bed	m		0.5			sand : 30cm + gravel: 20cm
			water depth	m		1.5			
		free board		m		0.5			

(5) Chemical Application

1) Applied Chemicals

The chemicals applied in the New JK WTP are aluminum sulfate (Alum), slaked lime, polymer and liquid chlorine. The parameters affected to chlorine consumption in the raw water are described in sub-section "(2) Treatment Method". These include range of turbidity, high alkalinity, relatively low contents of ammonium, iron and manganese. Based on this raw water quality, following chemicals are planned.

- Aluminum sulfate as coagulant (solid),
- Polymer as coagulant aid,
- Sodium hypochlorite as oxidization and disinfection

Slaked lime is not considered because of its high pH value and content of alkalinity in raw water. It is noted that slaked lime is not used even though its dosing equipment is provided in the New JK WTP.

Regarding coagulant, although Poly Aluminum Chloride (PAC) is considered as being effective due to its high pH, Alum is planned to be applied since the cost of PAC is rather high in Pakistan. As method adopted and equipment required are similar for dosing both Alum and PAC, the same dosage equipment used for Alum can also be used for PAC in case it becomes advantage (cost wise) to use PAC in the future.

Regarding use of liquid chlorine and Sodium hypochlorite for chlorination, the former requires strict safety provisions but its chemical cost is cheaper. The risk of using Sodium hypochlorite is lower compared with liquid chlorine. At the New JK WTP, there was an incident involving leakage of chlorine. Thus, the operators are nervous to use liquid chlorine. Considering the above factors, it is planned to use Sodium Hypochlorite for chlorination under the Project. In future, when a chlorine building is constructed and chlorination switched to liquid chlorine, the sodium hypochlorite dosage equipment will be relocated to the chlorine building and used as a backup for post-chlorination.

JICA Study Team discussed with WASA-F about the selection of chemicals during the second field survey. WASA-F requested the use of Alum as coagulant and liquefied chlorine as the chlorine agent due to their operating costs. However, regarding chlorine agents, from the perspective of reducing facility construction costs, WASA-F understood the situation and agreed to use Sodium hypochlorite under the Project ("2-2-1-1 Basic Approach, (1) Scope of the Project").

Based on this, sodium hypochlorite dosage equipment will be installed in the chemical building at its storage space which will be separated from the Alum dosage equipment by constructing a partition wall to prevent the risk of Alum and Sodium Hypochlorite mixture. Also, considering future use of liquid chlorine equipment, the site for construction of the chlorine building will also be secured (see Figure 2-23 shown in "(7) Plant Layout and Hydraulic Profile").

A comparison of the above chemical costs is shown in Table 2-31 below.

Table 2-31 Comparison of Chemical Costs

Item	Chemicals	Unit Cost	Dosage rate	Dosage quantity		Chemical cost	Select
		PKR/kg	mg/L	kg/day	1000kg/ year	Million PKR/year	
Coagulant	Aluminum sulfate (solid) Al_2O_3 16～17%	60.5	23	377	138	8.35	X
	Poly Aluminum Chloride (PAC) (powder) Al_2O_3 28～30%	135	15	246	90	12.15	
Oxidation/ sterilization	Liquefied chlorine Cl_2 100%	29.3	1.5	24.6	9	0.26	
	Sodium hypochlorite Cl_2 19～20%	33.6	7.9	129.6	47	1.58	X

Note: daily average supply: 16,400 m^3/day, annual average turbidity: 48 NTU

2) Chemical Dosage

Chemical dosage is calculated in accordance with the present data and future estimation of important raw water quality parameters. The present data, collected for examination of chemical dosage, include water temperature, pH, turbidity, alkalinity, ammonium, iron and manganese. Daily record of water temperature, pH and turbidity were obtained from the existing New JK WTP data (2017/18). For other parameters, water quality survey data from the master plan study were used.

Especially regarding turbidity, its reduction effect in the raw water reservoir was estimated. The reduction of turbidity by the raw water reservoir was analyzed using 2012 to 2014 data obtained from WASA-F. The data shows high rate of reduction of the canal water in the raw water reservoir. The records show an average reduction rate of 88 % for turbidity of 50 NTU or less, and extremely high rate of 96 to 97 % for high turbidity (500 ~ 800 NTU) in the canal water. These high rates of turbidity reduction may be affected by the low flow rate and the long detention time in the raw water reservoir. For other water quality parameters, no significant changes were considered.

To estimate a more realistic reduction of turbidity in the raw water reservoir, settling test of canal water was conducted during the second field survey. The 24 hours settling test result shows the reduction rate of 90 % when the turbidity is high (> 400 NTU). The reduction was 70 % in case of moderate turbidity (80 NTU). From the above test, the effect of the raw water reservoir was estimated with consideration for the settling efficiency as mentioned in the table below.

Raw Water Turbidity (NTU)	< 50	100	150	250	> 500
Reduction Rate	60%	65%	70%	75%	80%

From the present and estimated future raw water quality as well as the estimated turbidity in the raw water reservoir, Table 2-32 presents raw water quality for chemical dosage used for the design.

Table 2-32 Design Raw Water Quality

Water Quality Parameter	Unit	RBC			Raw Water Storage Reservoir		
		Maximum	Average	Minimum	Maximum	Average	Minimum
Water Temperature	℃	30	23	11	30	23	11
pH	-	8.7	8.2	7.6	8.7	8.2	7.6
Turbidity*1	NTU	1000	190	20	200	48	10
Alkalinity	mg/L	120	90	70	120	90	70
Ammonium	mg/L	0.05	0.03	0.01	0.05	0.03	0.01
Iron	mg/L	0.8	0.5	0.3	0.8	0.5	0.3
Manganese	mg/L	0.05	0.02	0.01	0.05	0.02	0.01

Note*1 Past turbidity data（2017～2019) show high turbidity of more than 1000 NTU for about 1～5 times in a year during wet season in July～August, where highest turbidity was 1,400 NTU. The planned maximum turbidity for design is set at 1,000 NTU taking temporary intake restriction and economy into account.

The dosage rates of chemicals are set as shown in Table 2-33 below.

Table 2-33 Chemical Dosage Rate

		Coagulation	Coagulation Aid	Oxidization	Disinfection	Total
	Unit	Alum	Polymer	Sodium Hypochlorite		
Maximum	mg/L	38	1	1.1	1.0	2.1
Average	mg/L	23	0.5	0.7	1.0	1.7

3) Chemical Dosing Facility

Dosage equipment is determined based on the selection of chemicals and the dosage rate shown above. For oxidization and disinfection, sodium hypochlorite is used initially, and its dosage equipment is installed in the chemical building.

The dosing points of each chemical are i) Alum at the mixing tank, ii) polymer at the flocculation tank, and iii) hypochlorite at the receiving tank and the rapid sand filter.

(6) Major Buildings

The buildings in the Old JK WTP consist of the administration building, the chemical building, the power receiving and transforming/generator house, and the electricity meter house. Their capacities were determined considering future expansion. Also, there are electrical rooms attached to the raw water pump station, the rapid sand filter, the transmission pump station, the sludge extraction pump station, and the waste water tank and sludge tank. The chlorine building will be constructed in the future. The technical parameters for major buildings are presented in Table 2-34 below.

Table 2-34 Technical Parameters of Major Buildings

Sr. No.	Facilities			Unit	Dimensions		Quantities		Note
							This Plan	Future Plan	
1	**Administration Building**								
	Structure					RC structure			single story
	Dimensions		width	m		18.0			
			length	m		20.0			
			height	m		3.5			below bottom of beam
	Floor Area	Rooms		m^2		360			
			entrance hall	m^2		21.6			
			chief room	m^2		18.0			
			office	m^2		60.0			
			meeting room	m^2		42.0			
			duty room	m^2		23.0			
			wash rooms	m^2		16.6			
			storage	m^2		10.5			
			mechanical room	m^2		15.0			
			monitor & operation room	m^2		38.4			
			laboratory	m^2		90.0			
			kitchen	m^2		2.9			
			corridor	m^2		22.0			
2	**Chemical Building**								
	Structure					RC structure			single story
	Dimensions		width	m		8.2			
			length	m		29.4			
			height	m		6.6			Alum solution room
						4.6			dosage & storage room
	Floor Area	Rooms		m^2		241.1			
			Alum solution room	m^2		68.9			$^{w}8.2 \times {}^{l}8.4$
			Chemical dosage and storage	m^2		172.2			$^{w}8.2 \times {}^{l}21.0$ (include monitoring room)
3	**Power Receiving and Transforming, and Generator house**								
3.1	**Power Receiving and Transforming**								
	Structure					RC structure			single story
	Dimensions		width	m		5.5			
			length	m		11.0			
			height	m		3.5			
	Floor Area	Rooms		m^2		241.1			
			Transformer room	m^2		27.5			$^{w}5.5 \times {}^{l}5.0$
			Power receiving room	m^2		32.0			$^{w}5.5 \times {}^{l}6.0$
3.2	**Generator**								
	Structure					RC structure			single story
	Dimensions		width	m		7.5			
			length	m		11.0			
			height	m		3.5			below bottom of beam
	Floor Area			m^2		82.5			
4	**Electricity meter house**								
	Structure					RC structure	1	-	single story
	Dimensions		width	m		3.5			
			length	m		5.0			
			height	m		3.5			below bottom of beam
	Floor Area			m^2		17.5			
5	**Electric Room of Raw Water Pump Station**								above pump room
	Structure					RC structure	1	-	
	Dimensions		width	m		4.2			
			length	m		20.0			
			height	m		3.5			below bottom of beam
	Floor Area		electric room	m^2		84.0			above ground

Sr. No.	Facilities			Unit	Dimensions		Quantities This Plan	Quantities Future Plan	Note
6	**Electric Room of Rapid Sand Filter**								above pump room
	Structure					RC structure	1	1	
	Dimensions	short side	width	m		4.4			
			length	m		14.2			
		long side	width	m		4.4			
			length	m		25.4			
			height	m		3.5			below bottom of beam
	Floor Area		electric room	m^2		174.3			
7	**Electric Room of Transmission Pump Station**								
	Structure					RC structure	1	-	above pump room
	Dimensions		width	m		4.2			above ground
			length	m		32.4			
			height	m		3.5			below bottom of beam
	Floor Area			m^2		136.1			
8	**Electric Room of Sludge Etraction Pump Station**								
	Structure					RC structure	1	-	above pump room
	Dimensions		width	m		5.0			above ground
			length	m		15.0			
			height	m		3.5			below bottom of beam
	Floor Area			m^2		75.0			
9	**Electric Room of Waste and Sludge Tank**								
	Structure					RC structure	1	-	above pump room
	Dimensions		width	m		3.4			above ground
			length	m		9.0			
			height	m		3.5			below bottom of beam
	Floor Area			m^2		30.6			
10	**Chlorine Building (Future)**								future plan
	Structure					RC structure			single story
	Dimensions		width	m		11.0			
			length	m		20.0			
			height	m		4.0			below bottom of beam
	Floor Area	Rooms		m^2		220.0			
			Hatch room	m^2		22.0			$^{w}4.0 \times {}^{l}5.5$
		Chlorine cylinder room		m^2		88.0			$^{w}16.0 \times {}^{l}5.5$
			chlorinator r	m^2		16.5			$^{w}3.0 \times {}^{l}5.5$
		booster pump room		m^2		33.0			$^{w}6.0 \times {}^{l}5.5$ (include sodium hypochlorite)
		neutralization room		m^2		44.0			$^{w}8.0 \times {}^{l}5.5$
		monitor & control room		m^2		16.5			$^{w}3.0 \times {}^{l}5.5$

(7) Plant Layout and Hydraulic Profile

1) Plant Layout and Hydraulic Profile

The existing water treatment plant consists of two treating units which are slow sand filtration and small scale rapid sand filtration. Amongst the two plant facilities, the rapid sand filtration plant has affected on the layout of the new treatment plant, although it is being operated at much less frequency. Therefore, this facility is planned to be demolished for the Project as agreed with WASA-F. On the other hand, the slow sand filtration plant will be operated continuously until the completion of construction of the new facility under the Project. Therefore, one of the three existing raw water reservoirs will be reclaimed and used as the construction site for the new water treatment facility.

Figure 2-23 shows layout of the water treatment facilities. The main facilities comprise receiving tank, flash mixing tank, flocculation tank, sedimentation tank, rapid sand filters, clear water reservoir,

transmission pump station, waste water and sludge tank, sludge thickener, sludge extraction pump station and sludge drying bed. In addition, administration building and chemical building are included as main buildings.

The following site conditions are considered for the layout plan.

- The bed of the raw water reservoir is about 4 m below the ground level
- It is difficult to arrange all facilities within the available area of the raw water reservoir.

Based on the above site conditions, facilities are planned within the reservoir C where foundation levels are about the same or at a lower level than the reservoir bed. These facilities include flash mixing tank, flocculation tank, sedimentation tank, rapid sand filters, clear water reservoir, transmission pump station, waste water and sludge tanks, sludge thickener and sludge extraction pump station. Remaining facilities and buildings are placed at the surrounding area of the reservoir C. These include receiving tank, administration building, chemical building and chlorine building (future). The sludge drying bed will be located at the remaining area considering the layout of the above facilities.

Water levels of facilities are planned based on the ground level of +185.0 m and the reservoir bed of +181.0m. Based on these elevations, the water level of receiving tank is designed at +188.86m and water level of the clear water reservoir is set at +183.78m. Thus, the difference of levels between the receiving tank and clear water reservoir is about 5.1 m.

The layout plan and the hydraulic profile of water treatment facilities and buildings are shown in Figure 2-23 and Figure 2-24, respectively.

2) Backfilling in the raw water reservoir C

Regarding the backfilling in the raw water reservoir C, it may be backfilled and compacted before the construction work. However, only the sludge drying bed, the administration building, and the chemical building are designed to be installed on the reservoir. The area of these facilities is only 15 % of the reservoir as indicated in yellow-green color in Figure 2-23. In addition, the basements of the other facilities are at the same or lower than the bottom level of the reservoir. Therefore, the construction work can be commenced without any backfilling to the raw water reservoir C.

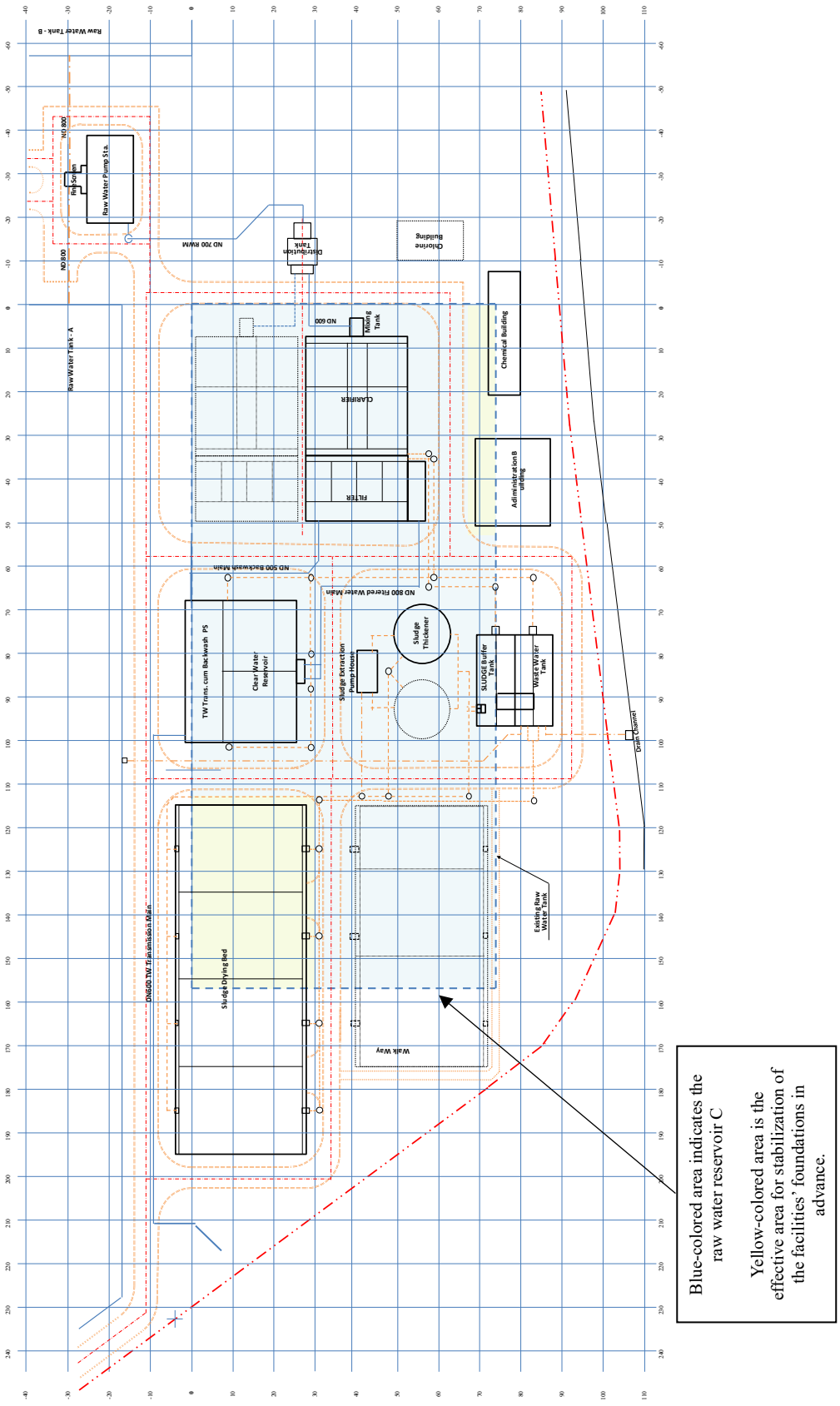


Figure 2-23 Layout Plan of Water Treatments Facilities

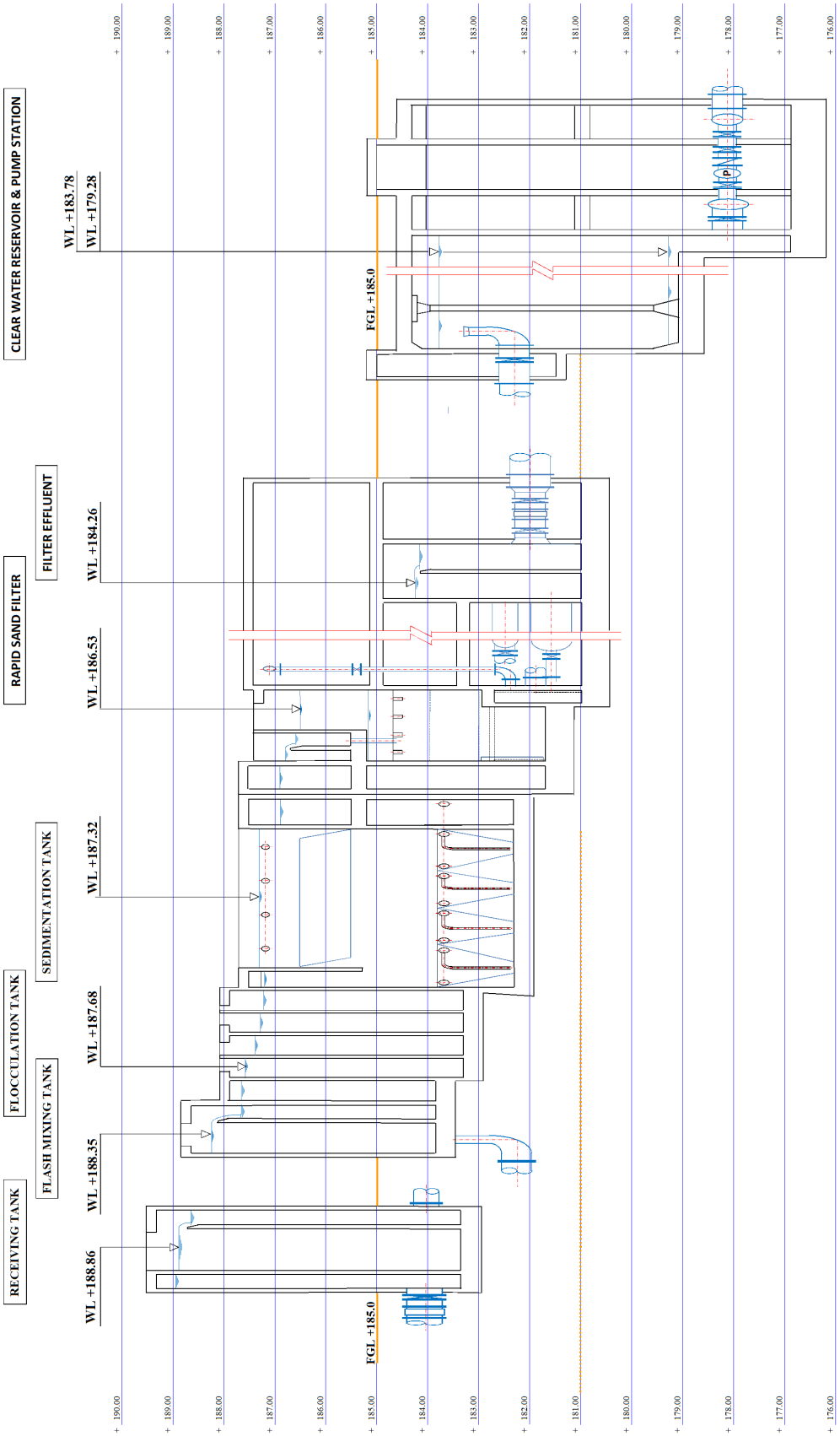


Figure 2-24 Hydraulic Profile of Water Treatment Facilities

(8) Transmission Pump Facility

The transmission pump is of centrifugal type, which has excellent efficiency and maintainability. As a safety measure against malfunctioning of the pump, one unit of standby pump is included. Including the standby, the number of pumps is selected.

The number of pumps is selected through the comparison described in Table 2-35. The alternatives are 3 pump units in total including 1 standby, and 4 pump units in total including 1 standby. The advantage of having 4 units is to ensure a wider range of flow rate control in comparison with 3 units. Regarding the cost, the initial cost of 4 units is slightly higher than 3 units. But the running cost of 4 units, which is mainly power consumption, is lower than 3 units because the flow rate is controlled by a small range. As a result, the overall cost including construction and running cost is almost the same for both alternatives during the operation period of fifteen years. Therefore, 4 units are selected as the transmission pump facility.

Table 2-35 Comparison of transmission pump unit number

Number of units	3 units (including 1 standby)	4 units (including 1 standby)
Specification	Type : Centrifugal type pump Discharge rate : 0.26m^3/sec 3(1) units Total head: 36m Motor power: 150kW	Type: Centrifugal type pump Discharge rate: Small 0.13m^3/sec 2 units Large 0.26m^3/sec 2(1) units Total head: 36m Motor power: Small 90 kW Large 150 kW
Flow control range	Narrower range Adjustable flow range: 0.26m^3/sec～0.52m^3/sec （50%～100%） Good	Wider range Adjustable flow range: 0.13m^3/sec～0.52m^3/sec （25%～100%） Excellent
Layout space	Excellent	Good
Cost	Construction cost: Excellent Operation cost: Good	Construction cost: Good Operation cost: Excellent
Number of units	This project：2(1) units Future：3(1) units	This project: Small 2 units, Large 1(1) units Future: Small 2 units, Large 2(1) units
Determination		Selected

2-2-2-5 Distribution Center

(1) Water Transmission and Distribution System

1) Water Transmission and Distribution Plan of the M/P

As mentioned under "2-2-1-1 Basic Approach" above, in the water transmission and distribution plan presented in the M/P, the water supply area is divided into seven WSZs, and each zone has its own water source (wells or water treatment plants).

In the large-scale zone, water is distributed to multiple distribution areas by the arterial main network, and in each distribution area, water is distributed by gravity flow using distribution reservoirs, lifting pumps and OHRs.

With this arterial main network, the existing arterial main can be effectively used for the maximum daily flow rate with some extent of reinforcement to the network. With inclusion of responding blackouts, this system is conductive to ensure a stable water supply using gravity flow from the OHR and for ensuring a simple and stable operation.

Under the M/P, within 7 water supply zones, a small WSZ VII having three DZs and a planned water supply of 10 MGD (45,500 m^3/d) was selected as the priority project. Under the Project, 2 distribution centers (Abudulah Pur DC and Madina Town No. 2 DC) out of three with a capacity of 5 MGD (22,750 m^3/d) will be constructed.

2) Water Transmission and Distribution System Plan

Water is conveyed from the Old JK WTP to the above two distribution centers through water transmission mains and is supplied to the DZs. The following are the three methods for an efficient water transmission and distribution system.

(1) Old JK WTP → Distribution centers (GR → Water distribution pump) → DZs
(2) Old JK WTP → Distribution centers (GR → Lifting pump→ OHR) → DZs
(3) Old JK WTP → Distribution centers (OHR) → DZs

At present, power outages occur seven hours per week around the service area. Many ACPs have been installed for the existing distribution mains in the districts, and due to its low elasticity and water tightness, it is estimated that there are many water leakages (of about 40%) despite the current hourly water supply (3 times a day, total 6 hours) and low water pressure.

Therefore, whenever water supply is restarted, it is necessary to keep a certain amount of water pressure in the water supply area in order to prevent the inflow of waste water. In addition, WASA-F does not have any experience in water distribution by direct pumping to small water supply areas.
Based on the above, a comparative study of the above water transmission and distribution methods is presented herein under.

Method (1) is a direct distribution method using a water distribution pump. Due to short-term power

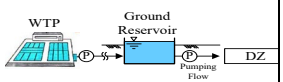
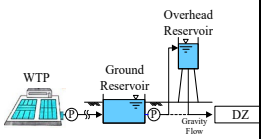
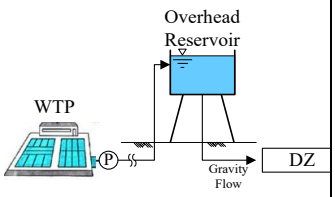
outages, pump operation is frequently disrupted, and WASA-F has no experience for direct pump delivery. Thus, there are concerns on stable water supply and operation and maintenance of pump facilities.

Both methods (2) and (3) are gravity flow water distribution systems using OHRs. Under these methods, a stable water supply is secured. Under method (2), water is transmitted from the Old JK WTP to the DC, then stored in the GR and is finally pumped to the OHR by the lifting pumps. The capacity of the OHR is small and the head of the water transmission pump is about 35m. Moreover, a large capacity of GR is required. The lifting pump is operated according to the water level of the OHR, which is relatively a simple pump operation and WASA-F has experience for such operation.

Under Method (3), water is transmitted directly from the Old JK WTP to the OHR. The capacity of the OHR is large, and the head of the water transmission pump is as large as 65m, but a lifting pump is not required.

Table 2-36 shows a comparison among the three options. Considering the prioritization to stable water supply and the ease of operation and maintenance of pump equipment, gravity flow distribution using OHR is adopted. According to the cost comparison between the water transmission and distribution methods (2) and (3), the cost for method (2) is slightly higher than method (3). The water transmission and distribution method (2) is selected due to its ease in operation and maintenance of the pump equipment.

Table 2-36 Comparison of Water Transmission and Distribution System

	Method(1)	Method(2)	Method(3)
System			
Water supply during power outage, pump equipment O&M	Average	Excellent	Good
Monitoring/Control	Good	Excellent	Good
Cost	—	1.00	0.98
Evaluation	Average	Excellent	Good

(2) Planned Distribution Flow

The design flow of the distribution centers is determined in Table 2-37 below.

Table 2-37 Distribution Flow of Distribution Center

	Abudulah Pur	Madina Town No. 2
Daily Maximum Demand	8,060 m^3/day	15,460 m^3/day
Hourly Factor	1.5	1.5
Hourly Maximum Demand	504 m^3/hr	966 m^3/hr

(3) Design Parameter of Distribution Center

Each DC consists of facilities such as a GR, an OHR, a pump room, an electric room, and a hypochlorite dosing room as shown in Figure 2-25.

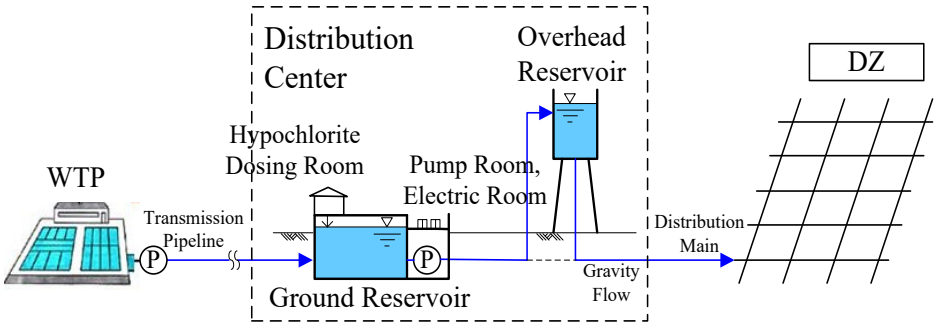


Figure 2-25 Distribution Center

The GR and OHR are planned as described herein under.

1) Ground Reservoir

The GR possesses a function to absorb the hourly fluctuation in distribution flow. Since water supply in Faisalabad is currently only for about 6 hours a day, it is impossible to measure the time variation data over a 24-hourly water supply which is required for an accurate calculation of the required capacity. The required capacity is calculated to be 3.6 hours based on the general condition of 1.5 as hourly factor and variation of hourly flow rate as defined under the Japanese Design Guidelines (Figure 2-26). Therefore, the capacity of the GR is set to be four hours of the daily maximum demand.

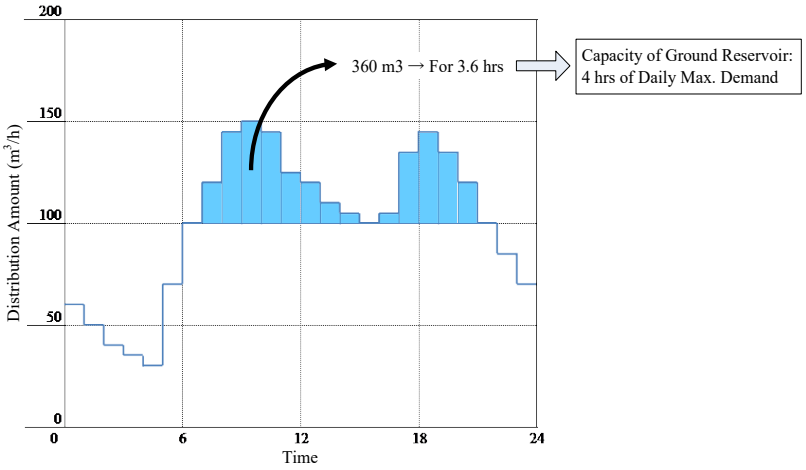


Figure 2-26 Required Capacity of Ground Reservoir

2) Overhead Reservoir

The Japanese Design Guidelines specify that the standard capacity of OHR is 30 minutes of hourly maximum demand in case GR has enough capacity for absorption of hourly fluctuation during distribution flow. On the other hand, considering the time lag from electric outage to operation of the generator, it is desirable to have the capacity of the OHR as large as possible.

Under the Project, the capacity of the OHRs shall be 60 minutes of the hourly maximum demand (1.5 hours of daily maximum demand).

3) Technical Parameters of Distribution Centers

Technical Parameters of Distribution Centers are as presented in Table 2-38 below.

Table 2-38 Technical Parameters of Distribution Center

Sr. No.	Facilities			Unit	Dimensions		Quantities This Plan	Quantities Future Plan	Note
Abudulah Pur Distribution Zone (DZ I)							1	-	
1	**Water Demand**								
	Daily Maximum Water Demand			m^3/d		8,060			
	Hourly Maximum Water Demand			m^3/h		504			
2	**Facilities of Distribution Center**								
2.1	Ground Reservoir								
	Detention Time			h		4			
	Volume			m^3		1,386			
	Number of Compartment			nos.		2			
	Dimensions		width	m		7.5			
			length	m		15.4			
			water depth	m		6.0			
	Piping	Inlet pipe	nominal dia.	mm		250			
		water level control valve		mm		250			float valve (butterfly type)
		Outlet pipe	nominal dia.	mm		250			pump suction pipe
		Overflow pipe	nominal dia.	mm		250			
		Drain pipe	nominal dia.	mm		150			
2.2	Pump and Electric Room								
	Dimensions		width	m		7.5			
			length	m		7.5			
			height	m		8.0			below bottom of beam, pump room
						3.5			below bottom of beam, electric room
2.3	Chemical Room								
	Dimensions		width	m		3.0			
			length	m		6.0			
			height	m		3.4			
2.4	Overhead Reservoir								
	Detention Time			h		1.5			
	Volume			m^3		504.0			
	Number of Compartment			池		1.0			
	Dimensions		diameter	m		10.8			
			water depth	m		5.5			
		low water level		m		25			from formation ground level
	Piping	Inlet pipe	diameter	mm		350			
		water level control valve		mm		350			float valve (butterfly type)
		Outlet pipe	nominal dia.	mm		350			
		Overflow pipe	nominal dia.	mm		300			
		Drain pipe	nominal dia.	mm		150			
2.5	Yard Piping								
	Inlet Pipe		nominal dia.	mm		250			
		Flow meter	nominal dia.	mm		250			electro-magnetic flow meter
	Flow control valve		nominal dia.	mm		250			butterfly valve
	Outlet Pipe		nominal dia.	mm		350			distribution primary main
		Flow meter	nominal dia.	mm		300			electro-magnetic flow meter

Sr. No.	Facilities			Unit	Dimensions		Quantities		Note
							This Plan	Future Plan	
Madina Town Distribution Zone (DZ II)							1	-	
1	**Water Demand**								
	Daily Maximum Water Demand			m^3/d		15,460			
	Hourly Maximum Water Demand			m^3/h		966.0			
2	**Facilities of Distribution Center**								
2.1	Ground Reservoir								
	Detention Time			h		4			
	Volume			m^3		2,577			
	Number of Compartment			池		2			
	Dimensions		width	m		13.1			
			length	m		21.1			
			water depth	m		4.8			
	Piping	Inlet pipe	nominal dia.	mm		300			
		water level control valve		mm		300			float valve (butterfly type)
		Outlet pipe	nominal dia.	mm		300			pump suction pipe
		Overflow pipe	nominal dia.	mm		300			
		Drain pipe	nominal dia.	mm		150			
2.2	Pump and Electric Room								
	Dimensions		width	m		5.6			
			length	m		17.2			
			height	m		6.5			below bottom of beam, pump room
						3.5			below bottom of beam, electric room
2.3	Chemical Room								
	Dimensions		width	m		4.1			
			length	m		6.1			
			height	m		3.2			
2.4	Overhead Reservoir								
	Detention Time			h		1.5			
	Volume			m^3		933			
	Number of Compartment			池		1.0			
	Dimensions		diameter	m		14.7			
			water depth	m		5.5			
			low water level	m		25			from formation ground level
	Piping	Inlet pipe	diameter	mm		450			
		water level control valve		mm		450			float valve (butterfly type)
		Outlet pipe	nominal dia.	mm		450			
		Overflow pipe	nominal dia.	mm		350			
		Drain pipe	nominal dia.	mm		150			
2.5	Yard Piping								
	Inlet Pipe		nominal dia.	mm		400			
		Flow meter	nominal dia.	mm		350			electro-magnetic flow meter
	Flow control valve		nominal dia.	mm		350			butterfly valve
	Outlet Pipe		nominal dia.	mm		450			distribution primary main
		Flow meter	nominal dia.	mm		350			electro^magnetic flow meter

(4) Lift Pump Facility

The lift pump is of centrifugal type, which has excellent efficiency and maintainability. The number of pumps is selected through the comparison described in Table 2-39. The alternatives are 3 pump units in total including 1 standby, and 4 pump units in total including 1 standby. The advantage of having 4 units is to ensure a wider range of the flow rate control in comparison with 3 units. Regarding the cost, the initial cost of 4 units is slightly higher than 3 units. But the running cost of 4 units, which is mainly power consumption, is lower than 3 units because the flow rate is controlled by a small range. As a result, the overall cost including construction and running cost is almost the same for both alternatives during the operation period of fifteen years. Therefore, 4 units are selected at the lift pump facility.

Table 2-39 Comparison of Lift Pump unit number

Number of units	3 units (including 1 standby)	4 units (including 1 standby)
Specification	Abudulah Pur Type: Centrifugal type pump Discharge rate: 4.2m^3/min 3(1) units Total head: 37m Motor power: 55kW Madina Town No. 2 Type: Centrifugal type pump Discharge rate: 8.1m^3/min 3(1) units Total head: 35m Motor power: 90kW	Abudulah Pur Type: Centrifugal type pump Discharge rate: 2.8m^3/min 4(1) units Total head: 37m Motor power: 30kW Madina Town No. 2 Type: Centrifugal type pump Discharge rate: 5.4m^3/min 4(1) units Total head: 35m Motor power: 55kW
Flow rate control range	Narrower range Adjustable flow range: Abudulah Pur 4.2m^3/min～8.4m^3/min （50%～100%） Madina Town No. 2 4.2m^3/min～8.4m^3/min （50%～100%） Good	Wider range Adjustable flow range: Abudulah Pur 2.8m^3/min～8.4m^3/min （33%～100%） Madina Town No. 2 2.8m^3/min～16.2m^3/min （33%～100%） Excellent
Layout space	Excellent	Good
Cost	Construction cost: Excellent Operation cost: Good	Construction cost: Good Operation cost: Excellent
Number of units	3(1) units	4(1) units
Determination		Selected

2-2-2-6 Transmission and Distribution Mains

(1) Description of Treated Water Transmission and Distribution System

1) Treated Water Transmission Pipeline

In WASA-F's water system, the Arterial Main serves as a transmission and distribution mains. The water is fed from the terminal reservoir, the New JK WTP, and the well field located along the RBC, and distributed to the entire service area.

Each service zone or area is fed from the arterial main network either directly or through an OHR by

gravity.

Under the Project, transmission and distribution are being planned separately as per their function. Water is transmitted through the transmission main to the distribution centers, and is then conveyed to the supply area from the distribution centers through the distribution main. Therefore, the function of the transmission pipeline system is to feed treated water only to the respective distribution centers.

2) Distribution Pipelines

Under the present distribution system, water being fed from the Arterial Main is distributed through either the distribution primary mains (DN 300mm or larger) or the distribution secondary mains (DN 150~250mm). These distribution mains do not necessarily form a network.

In the target DZs of the Project, as mentioned above, there are existing distribution pipelines. The majority of these distribution pipelines are asbestos cement pipes (ACP). ACP is characterized by weakness in pipe strength and less flexibility at their joints. The M/P recommended gradual shifting of the pipelines from ACP to another type such as HDPE.

Under the water distribution plan in M/P project, the following water distribution systems is planned to be established.

Distribution Primary Main:	Distribute water to entire DZ having pipe network. DN 300 ~ 500mm
Distribution Secondary Main:	Distribute water in multiple DMAs having pipe network. DN 150~250mm
Distribution Tertiary Main:	Branch from Secondary Main to supply water to customers. DN 75~100mm. Branch from secondary main is, in principal, to connect with tertiary main of DN100mm.
District Meter:	A district meter is installed on the branch of primary main for the purpose to monitor the service conditions (pressure and flow), tendency of demand and physical loss by comparing consumption measured by water meters of customers

Out of the total required length and appurtenant works for primary and secondary distribution network including installation of district meters in two distribution districts of Abudulah Pur District (DZ I) and Madina Town District (DZ II) (see Figure 2-28 and Figure 2-30), only a portion of the pipeline works and appurtenant works will be carried out by the Japanese side due to a budget constraint. The rest of pipe installation and appurtenant works will be carried out by WASA-F.

Table 2-40 summarizes the change of work scope for the transmission main and distribution networks.

Table 2-40 Plan for Transmission Main and Distribution Network

Works Item	Original Plan	Revised Plan
Transmission Main	Transmission Main from Old JK WTP to Abudulah Pur DC and Madina Town No.2 DC.	Not changed
Distribution Primary Network	Primary networks in both Abudulah Pur DZ I and Madina Town No.2 DZ II are constructed.	Abudulah Pur DZ I: Primary main from DC to district meter chamber of DMA I-1 Madina Town DZ II: Primary Main from DC to district meter chamber of DMA II-2.
Distribution Secondary Network	Secondary networks in both Abudulah Pur DZ I (2 DMAs) and Madina Town DZ.2 (4 DMAs) are constructed.	Abudulah Pur DZ I: Secondary main from DMA I-1 to existing secondary mains (DN 200mm) Madina Town DZ II: Secondary network for DMA II-2 up to the limit of budget. Regarding connecting to existing secondary mains, Japanese side installs pipes until the branch valves. The connecting work is to be conducted by Pakistani side.
Distribution Tertiary Network	Not included.	Not included.
District Meter	Abudulah Pur DZ I: 2 district meters. Madina Town DZ II: 4 district meters.	Abudulah Pur DZ I: one district meter for DMA I-1. Madina Town DZ II: one district meter for DMA II-2.

(2) Design Criteria

The design criteria for transmission main and distribution network is determined as described hereinafter.

1) Pipe Materials

Transmission Main

The transmission main is the most important part among the system, having large size of pipe. For the pipe materials with diameter 600mm, as the result of comparison in view of their strength, durability, workability, economy etc., DCIP was selected due to following reasons:

When pipe materials of DCIP and SP are compared, both materials have enough strength and durability. However, SP's coating is weak against external impact load especially and its welding works can be significantly affected by climate (rain and winds). As a result, it requires careful pipe handling which will result in the longer construction period than DCIP. Also, SP is not used in Faisalabad except for ones with smaller diameter. For HDPE, there were no experienced contractors available in Faisalabad to install as large size as 600mm. Also it costs slightly higher than DCIP.

On the other hand, HDPE is selected for DN 450 and 400mm considering past experiences of use in construction in Pakistan as well as its advantages on durability, workability and economy.

Distribution Main

For its moderate sizes, HDPE is selected for its durability and workability.

2) Pipe Size

The diameter of the pipe is determined through hydraulic analysis by using the Hazen-William formula. The following friction co-efficient (C-value) was applied while carrying out the analysis.

- Transmission main: 130
- Distribution main: 120

3) Pressure

Rated pressures of transmission main and distribution main shall be PN 10.

Design minimum pressures for each category of distribution main are determined as follows:

- Distribution primary main: 18 m
- Distribution secondary main: 14 m
- Water tap: 12 m (in accordance with the Punjab Guidelines)

The above design minimum pressure was determined based on the original plan for distribution network. The dynamic pressure at the outlet of DC was set at about 25m as the minimum pressure (low water level of OHR at 25m above ground level). It shall be noted that the above minimum pressure may not be necessarily secured as it would depend on the actual pipe installation works carried out by WASA-F and the existing tertiary network conditions.

4) Earth Cover

- Transmission main: 1.2 m
- Distribution primary main: 1.2 m
- Distribution secondary main: 0.9 m (Punjab Guidelines)

5) Appurtenant Facilities

Appurtenant facilities such as valves, air valve, blow-off, etc. for the transmission main and the distribution network are designed using the Japanese Design Guidelines as follows:

Valves	• Maintenance valve, in general, is installed on the branch pipe and at the downstream of the main pipe. For long distance pipelines, at least one valve is provided for every 2 km of pipeline length. • At the boundary between the DMAs, boundary valves are installed at appropriate locations for use during emergencies. They are kept closed during ordinary operation of the network. • Gate valve is used for pipe diameter of DN 250mm or smaller, and butterfly valve (short body) is used for DN 300mm or larger pipes.
Air valve	• Air valve is provided at the convex point of the pipeline. It is installed generally between the maintenance valves.
Blow-off	• Blow-off is provided at the upstream of the maintenance valve. • When adequate drain channel or gutter is not available, adjacent manhole of sewer will be utilized.

(3) Installation Route for Transmission and Distribution Mains

1) Overview

Under this preparatory survey, field survey and topographic survey were carried out along the planned route of the transmission and distribution mains for the purpose of proposing the optimal route. Regarding the requisite permission for installing pipes along the proposed route, WASA-F had made inquiries to the relevant authorities for their opinions and it was obtained accordingly (refer to Appendix 6 (2)). This permission was obtained for the original proposal which included all of the transmission and distribution mains throughout the service area, i.e. including the primary and secondary distribution mains to be carried out by the local Pakistani side. The scope of the Japanese side will cover a part of this proposal. Table 2-41 shows the outline of construction works for the Japanese side. The scope of the local Pakistani side is shown in Appendix 6 (4).

Table 2-41 Outline of Transmission and Distribution Mains

Facility	Construction method	Specification	Quantity	Remarks
Transmission Main	Open cut	DCIP DN600	985m	
		HDPE DN450	1,727m	
		HDPE DN400	1,274m	
		HDPE DN300	63m	
	Pipe bridge	Steel Pipe DN500, Bridge length 21.6m, Pipe beam type, L=38m including the piping before and after the pipe bridge	1 no. 38m	
		Total	4,087m	
Distribution Primary Main	Open cut	HDPE DN450	594m	Part of DZ II
		HDPE DN350	633m	Part of DZ I
		Total	1,227m	
Distribution Secondary Main	Open cut	HDPE DN200	797m	Part of DMA I-1, II-2
		HDPE DN150	1,095m	Part of DMA II-2
		Total	1,892m	
District Meter	-	Flow meter, Pressure gauge, meter box	2 nos.	DMA I-1, DMA II-2

NOTE: DZ: Distribution Zone, DZ-1: Abudulah Pur area, DZ-2: Madina Town No. 2 area, DMA: District metered area.

It should be noted that there is a possibility that the site condition and/or the situation of the concerned authorities may change before the implementation, and therefore it is necessary to confirm the requisite permission again during the detailed design stage. For temporary removal of pavement, application for permission during the detailed design stage is necessary as this application will be made only after the determination of the detailed removal area and construction schedule have been finalized.

2) Planned Route of Transmission Main

The transmission main will be installed from the Old JK WTP to the Abudulah Pur DC and the Madina

Town No. 2 DC. Moreover, branch for the Peoples Colony 2 DC, which will be constructed in the future, will also be installed. The planned route is divided into three sections as shown in Figure 2-27.

- Section-1: Starting from the WTP and after crossing the fly-over, the pipeline will be laid on the Jaranwala Road shoulder. This road is owned by the Pakistan Railways, but installing new pipes has already been approved by them. A branch pipe will be installed at approximately 1.0km from the WTP for the Peoples Colony 2 DC to be constructed in the future. The length of this section is about 1.6km. It will branch to the Abudulah Pur DC at the Jaranwala Road and will reach the DC at a distance of about 0.1 kilometers.
- Section-2: After laying about 0.3 kilometers along the railway from the Jaranwala Road, the proposed route turns right, and after passing through the residential area in the Abudulah Pur distribution zone, it will reach the Canal Expressway along the RBC. After that, it will be laid for about 0.9km on the service road of the Canal Expway and then will turn right. The length of this section is about 1.5km.
- Section-3: After turning right, the proposed route crosses the Canal Expressway and the RBC, passes through the residential area, and run approximately for a length of 0.9km to the Madina Town No. 2 DC. A pipe bridge will be installed to cross the RBC.

3) Planned Route of Distribution Main

Water pipes will be installed in each of the Abudulah Pur and the Madina Town No. 2 DZs, which are the planned water service areas. Figure 2-28 shows the planned route in the Abudulah Pur DZ and Figure 2-29 to Figure 2-31 show the planned route in the Madina Town No. 2 DZ. Among these, the scope under the Project is described below.

a) Abudulah Pur Distribution Zone

Figure 2-28 shows the planned route in the Abudulah Pur. The primary main will start from the Abudulah Pur DC, cross the Jaranwala Road, and will be laid on the road shoulder along the railway line to the location where the district meter is proposed to be installed. The secondary main will be laid from the district meter location along the road in the residential area. Two branch valves to connect the existing distribution mains shall be installed. The detail calculation of the distribution main is described in Appendix 7 (4).

b) Madina Town No. 2 Distribution Zone

Figure 2-29 to Figure 2-31 show the planned route in the Madina Town No. 2. The primary main will be laid from the Madina Town No. 2 DC along the shoulder of the Green Belt Road up to the location where the district meter is proposed to be installed. The secondary main will be laid from the district meter location along the shoulder of the Green Belt Road and along the roads in the residential area. Three branch valves to connect the existing distribution mains shall be installed. The detail calculation of the distribution main is described in Appendix 7 (4).

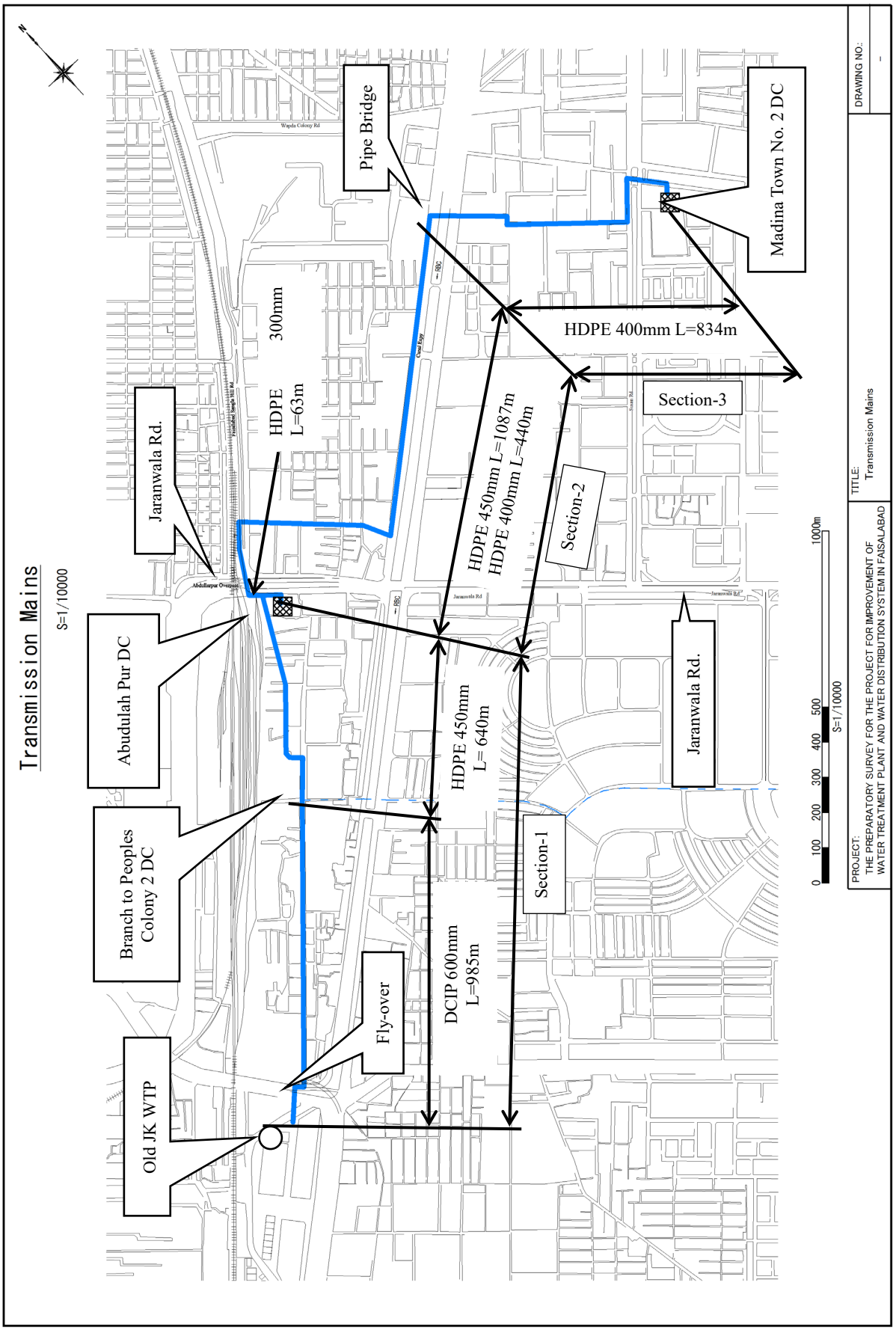


Figure 2-27 Planned Route of Transmission Main

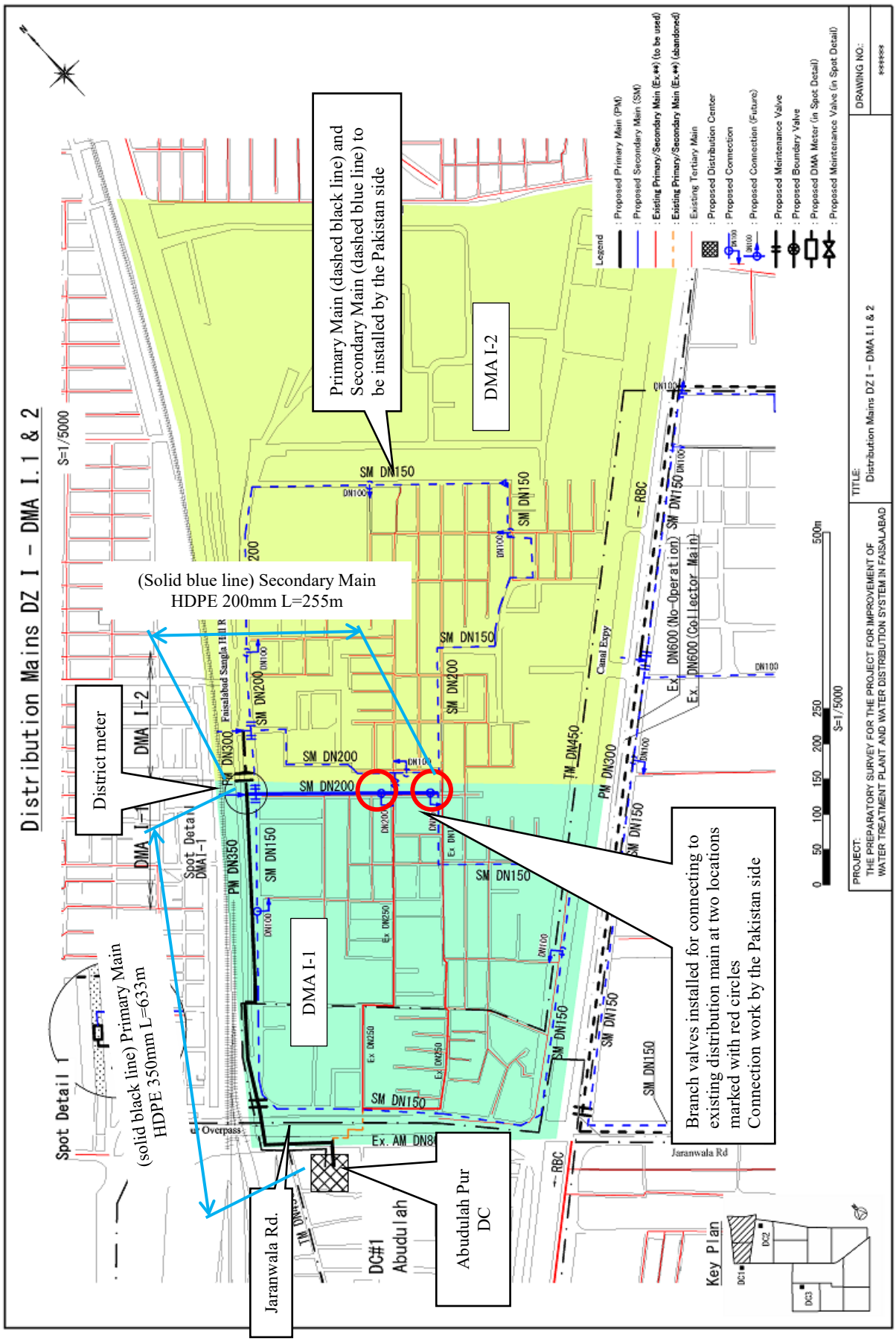


Figure 2-28 Planned Route of Distribution Main, Abudulah Pur DZ

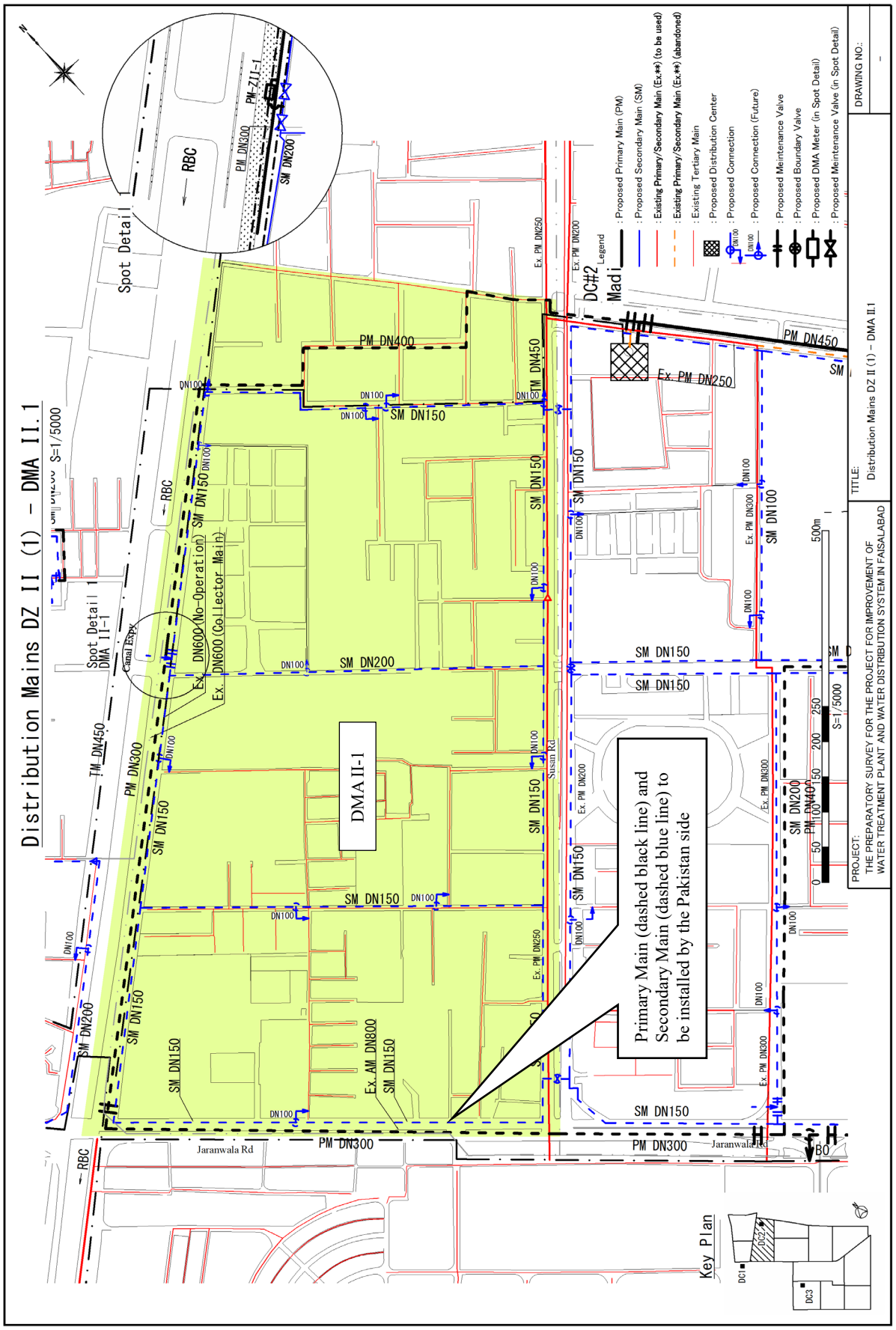


Figure 2-29 Plannned Route of Distribution Main, Madina Town No. 2 DZ (1)