REPUBLIC ISLAMIC OF PAKISTAN
BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR IMPROVEMENT
OF
WATER SUPPLY
IN
FAISALABAD

MAY 2004

JAPAN INTERNATIONAL COOPERATION AGENCY
JAPAN TECHNO CO., LTD.

PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Water Supply in Faisalabad and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team from 9th December 2002 to 27th January 2003 and team from 2nd August 2003 to 16th September 2003.

The team held discussions with the officials concerned of the Government of the Islamic Republic of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss a draft basic design, from 16th to 29th March 2004, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the teams.

May 2004

Yasuo Matsui
Vice-President
Japan International Cooperation Agency

May 2004

LETTER OF TRANSMITTAL

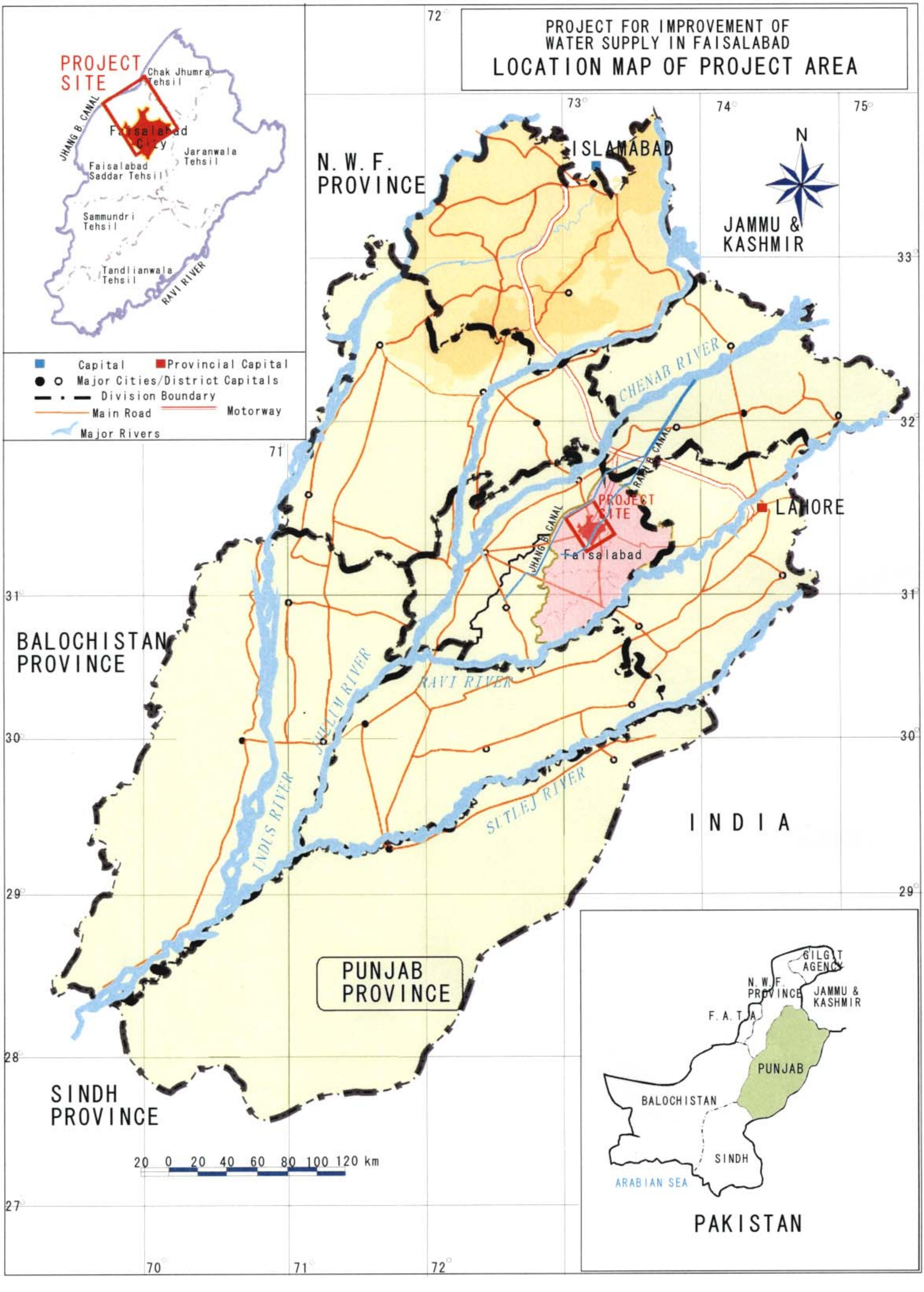
We are pleased to submit to you the basic design study report on the Project for Improvement of Water Supply in Faisalabad in the Islamic Republic of Pakistan.

This study was conducted by Japan Techno Co., Ltd, under a contract to JICA, during the period from December 2002 to May 2004. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Gambia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Tetsuji Niwano
Project Manager
Basic Design Study Team
The Project for Improvement of Water Supply in Faisalabad
The Islamic Republic of Pakistan
Japan Techno Co., Ltd.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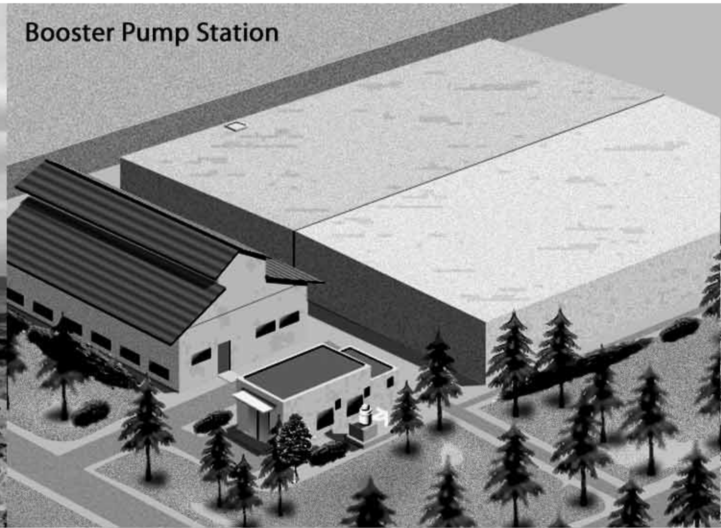

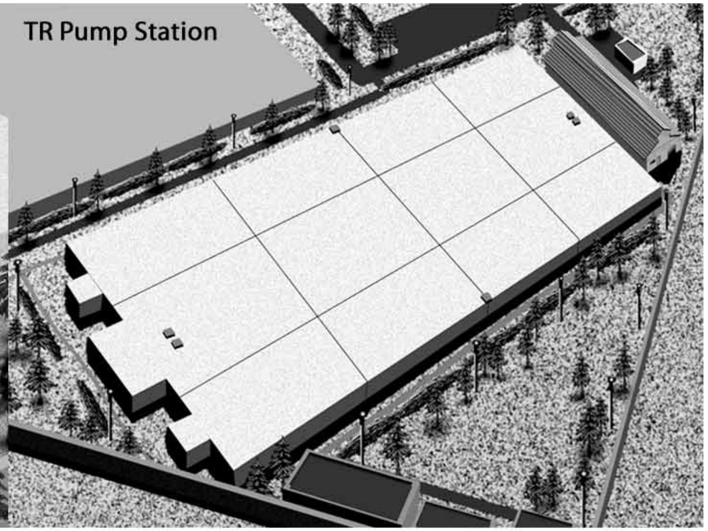

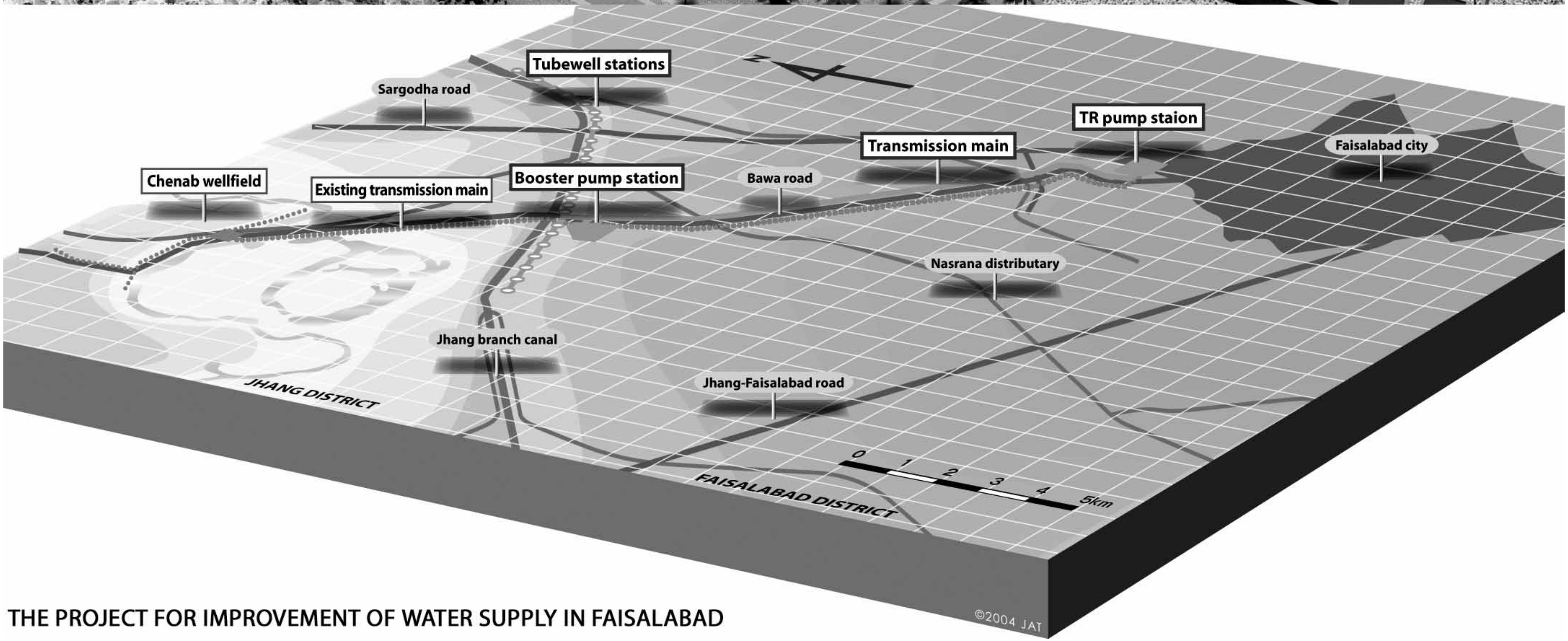

THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY IN FAISALABAD

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LIST OF ABBREVIATIONS

ACP	Asbestos Concrete Pipe
ADB	Asian Development Bank
A/P	Authorization to Pay
API	American Petroleum Institute
AWWA	American Water Works Association
B/A	Banking Arrangement
BS	British Standards
DfID	Department for International Development
DIN	Deutsches Institut für Normung e. V.
E/N	Exchange of Notes
FDA	Faisalabad Development Authority
GL	Ground Level
HUD/PH	Ministry of Housing, Urban Development and Primary Health)
HWL	High Water Level
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
LCC	Lower Chenab Canal
LWL	Low Water Level
PKR	Pakistan Rupees
PVC	Polyvinyl Chloride
REC	Republican Engineering Co.
TDS	Total Desolved Solids
T/R	Terminal Reservoir
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Agency
WHO	World Health Organization

SUMMARY

SUMMARY

The Islamic Republic of Pakistan is located in southwest Asia bordered by Iran and Afghanistan to the west, India to the east and the Arabian Sea to the south. Pakistan now has a population of about 150 million (2002, World Bank), two thirds of which are in the rural area, mostly engaging in agriculture forming the country's economic basis. Its GDP continued to grow yearly by 3.6% on average from 1990 to 2002. Yet a per capita GNI hovered around 420 US dollars, as the population growth kept a high rate of 2.4%. (World Bank). With 32.1% of the total population estimated at a poverty level in 2000, the government worked out its PRSP in 2003 aimed at an integrated development of national economy, leading to the improvement of living standards of the poor to extremely poor in the rural area.

In recent years, the country's major cities witnessed a large influx of the rural population. At present nearly 50% of the nation's entire urban population is crowded in seven largest cities such as Karachi with its population now over 10 million, Lahore with 5 million and Faisalabad with 2 million, the third largest in the country. One third of them are classified as the poor living in shanty towns and heavily squeeze fragile infrastructure. As a result, social service has been lagging behind in every sector of large cities.

Urban water sector has been widely affected as well. According to the government's ongoing Ten-Year Perspective Development Plan (2001- 2011), the average coverage of water supply in the country is estimated at a level as low as 63%. In Faisalabad, a city targeted for this project, households connected to city's water service was assessed to be 55% by the basic design study for the project in 2003, with the rest mostly relying upon groundwater sources available within the city. Tubewells with motorized pumps or hand pumps are widespread in the city, but there is a high risk of citizens' health in such popular use of contaminated sources. The city has grown as one of the major industrial cities through the development of textile industry, and groundwater within the city has heavily been polluted by industrial and domestic waste waters. In the social survey in selected colonies of the city during the study, more than 20% of respondents saw a risk of water borne diseases such as diarrhea, hepatitis, etc. as "Frequently occur". The development projects for the urban water sector in Pakistan have so far been

promoted, mainly depending upon foreign assistance. However, they have been unable to keep up with ever increasing demand due to rapidly growing population. As a result, water service in every city has been deteriorated, and Faisalabad is one of such typical examples. The first master plan for the city's water sector was worked out in 1976 with assistance of ADB, and the water supply facilities were completed in 1992 through the execution of Phase I of that plan financed by ADB. The completed system consisted of (a) water sources comprised of 25 tubewells in the wellfield along the Chenab river about 30 km north west of the city, (2) collector mains, (3) transmission facilities and (4) distribution facilities including a terminal reservoir and arterial mains about 50 km long in the city. By the time they were installed, however, the city was so largely transformed that the initial master plan was urgently updated in 1993 with the World Bank's assistance for a long term plan from 1993 to 2018. The execution of Phase II of the revised master plan from 1993 to 2000 was applied to the provincial government for the augmentation of water supply, and after the approval of concerned authorities, the federal government requested assistance to the project with grant aid to the government of Japan in 1996.

Japan responded to the request with a dispatch of the preliminary study team in November 1997. The study examined the alternative plans of (a) rehabilitation of the existing treatment plant withdrawing water from the canal penetrating through the city and (b) the development of additional groundwater source at a site near the existing Chenab wellfield to meet the immediate need of the city, and both sides agreed to take up the latter targeting a discharge of 91,000m^3/day, as it was judged more feasible, technically and economically. Based upon the conclusion, the Japan International Cooperation Agency (hereafter called "JICA") dispatched a basic design study team in February 1998. This study, however, was cancelled on the way, as Japan joined forces with other countries at that time to impose economic sanctions on Pakistan since it dared carry out nuclear testing to counter the one by India against international opposition. It was in 2001 after the lift of sanctions that Pakistan renewed its request to Japan for assistance to the project. In response, JICA sent a basic design study team in December 2002 to carry out the first stage of the study.

The planned wellfield for the project lies in a vast agricultural land irrigated with a network of canals extending from a headwork upstream along the Chenab river. Since present-day farming generally needs more water than canal supply, the trend to combine groundwater with it has lately been thriving all through the canal irrigated region in the Indus system. In and around the site, tubewells for irrigation are widespread as well. Under such circumstance, the preceding project for Phase I installed 25 tubewells for water supply in 1992, and has since been pumping out large quantities of groundwater. As the operation continued, groundwater level in and around the wellfield started to fall, and the influence expanded, resulting in abandonment of irrigation wells close to the wellfiled. Alarmed by the situation, villagers had hostile feeling toward the project. As a result, the preceding basic design study came across intense opposition to a new project by villages in the vicinity of the planned wellfield site.

For the first stage of the renewed study for the project in 2002, therefore, an alternative site was prepared for the examination. As the study was underway, however, alarm and hostility to the project was rekindled in the villages around this site as well, since both sites belonged to the same administrative region. Immediately after opposition by the villages surfaced, the Water and Sanitation Agency for Faisalabad, the executing agency of the project, (hereafter called "WASA") took steps to open dialogues with villagers with support and cooperation of the concerned districts and tehsils. Its efforts, however, failed to turn the situation around, and at the final stage, the provincial government intervened to hold a public meeting rallying all the concerned parties. The conclusion of the meeting was (a) WASA will withdraw its plan to develop an additional wellfield in the Chenab area and (b) it will shift a site to an area along the Jhang Branch Canal between the Chenab and Faisalabad city. Eventually it was proposed to the Japanese side to resume the study in this alternative site.

After the successive occurrences of hostile actions, the major difficulty for the Japanese side to accept such a proposal was that the willingness of stakeholders in the new site remained unknown. In addition, its technical feasibility for possible development was obscure. The study for the project was suspended, therefore, until WASA presented the documents to verify agreement of the representative stakeholders to the execution of the project as well as technical feasibility of the site based upon various studies in the past. Then it was in August 2003 that the second stage of the study started with presentation of required documents worked out by WASA's own efforts. Contrary to the preceding stage, the resumed study smoothly progressed without any obvious expression of opposition in the field, and completed all the works including the social survey of the concerned villages and a test drilling programme on September 14, 2003.

Just after the completion of the study, there occurred a minor demonstration of persistent anxiety of the concerned villages headed by a local parliament member, which was nationwide reported by one of the county's influential newspapers. The Japanese side quickly responded to the incident with a proposal to WASA and the authorities of the Punjab government to work out measures to protect against adverse effects of the project, if any, including possible compensations to the stakeholders. After it confirmed the letter that they were willing to respond to the requirement for ensuring the agreement of stakeholders, the mission for the explanation of the draft final report for the project was dispatched from March 16 to 29, 2004. During the discussions between both parties, particular attention was focused on the policy for risk management under the project. In this respect, they have agreed to (a) the Pakistani side shall prepare measures to compensate villages likely to be affected by the fall of groundwater level and (b) it shall hold public meetings to open all relevant information to the public and eventually to secure agreement of all the stakeholders. For the schedule for the implementation of the project, the Pakistani side pledged that it will take necessary steps to ensure the anticipatory approval of the PC-I by the ECNEC by the end of June 2004. This report was prepared including the results of study and all the proceedings related to the planning of the project summarized in the foregoing sections.

As a result of this study, the final candidate for the planned wellfield along the left bank of the Jhang Branch Canal proved to have a potential for groundwater development no less than that of the initially proposed sites along the Chenab river. Groundwater abounds throughout a huge tract in the reaches of the Indus system including the Chenab, where groundwater level is as high as a couple of meters beneath surface. This ample source was created through recharge by infiltration of canal water fed through an extensive network of canals all over the region, which had been installed during the British reign in the latter part of the 19th century. The Jhang Branch Canal is a secondary main of the Lower Chenab Canal, one the oldest channels of vital importance in the entire irrigation system for the Punjab province, which has been and will be sustained with utmost care by the authorities.

Since the lasting delivery of water through the channel guarantees the constant recharge of groundwater along its course, this project plans to install the tubewells as its source in the public land along the left bank of the Jhang Branch Canal under control of the Department of Power and Irrigation of the Punjab government. The results of the pumping test under the test drilling programme for the study indicates that the influence on the regional groundwater level by pumping at the project tubewells could be minimized, provided that their discharge rate is kept within a range of recharge from the canal. However, since the canal is regularly closed for one month every year for removal of silty deposits in water courses as well as for maintenance of facilities, groundwater level inevitably falls without any recharge from it during that period, if large quantities of withdrawal in the area continue. Moreover as the area is crowded with a plenty of existing tubewells for irrigation as well as those for water supply in the preceding project affecting each other, the lowering of groundwater level is likely to persist and expand as time passes. In this respect, WASA is required to establish a relevant monitoring system of regional groundwater level as well as quality in parallel with the operation of the project wells. WASA has agreed on the point through the discussions during the explanation of the draft final report.

With such a consideration for water source development, this project is planned to provide an integrated water supply system composed of water source facilities to minimize the influence to the surroundings, transmission facilities for conveying the discharge of tubewells to the terminal reservoir in the city and distribution facilities delivering supply for the city, with all of them in an appropriate scale in compliance to the contents of the request by the Pakistani side. The discharge targeted by the project is 91,000m^3/day, which was intended to meet an urgently required demand of the city during the preliminary study in 1997. Since then WASA made its own efforts to augment water supply through the construction of 4 additional tubewells in the Chenab wellfield and the rehabilitation of existing tubewells installed along the Rakh Branch Canal running through the city in compliance with the proposals of the revised master plan for Phase II to Phase III. Presently, however, the fact is that the total volume of water supply turned out to be less than that at the onset of the operation of existing facilities in 1993. With its population constantly increasing, the city is now in dire need of substantial augmentation of the existing water supply.

The planned water system under the project is to be operated in combination with the existing one, and delivered simultaneously to the city through the existing distribution network. The examination of the existing system during this study revealed (a) daily supply is divided into three times, each time with supply hours restricted to 1 to 2 hours at the maximum, due to the shortage of water, (b) the east side of the city accounting for one third of its total area suffers from extremely inferior water service due to the drop of water pressure through arterial mains due mainly owing to the distance about 16 km long from the terminal reservoir, and (c) most of those suffering lack of piped water rely upon available groundwater source at tubewells with motorized or hand pumps within the city. Even if water supply is enhanced through the project, there is a risk of poor service persistent in the east side due to malfunctioning of the existing facilities. Accordingly this project plans to improve the existing system by providing additional sections to the existing arterial mains for a particular purpose of reinforcing water pressure in the area in question. Furthermore, equipment effective for operation and maintenance of facilities such as water analysis equipment, flow and pressure gauges for pipelines, voice communication system, etc is planned to be procured through the implementation of the project.

Table 1 Main Components of the Project

Categories	Facilities/equipment		Sepcifications
1. Water source/intake facility	1) Tubewells x 25 units		Basic drilling depth 160m Standby tubewells 2 units
	2) Tubewells pump stations		
		a. Tubewells pump stations x 25 units	Size: 45.4m^2
		b. Tubewell pumps x 25 units	Type: Electric-motor driven, vertical shaft turbine pump Unit discharge rate:200 m^3/hr
	3) Quarters for operators x 1 unit		Size: 170.0m^2
2.Collecting facility	1). Collector mains Dia. 400～900mm x 15.6 km long		Ductile cast iron pipes and spiral steel pipes with plastic coating
3.Trans-mitting facility	1) Booster pump station		
		a..Pump station x 1 unit	Size: 415.8m^2
		b. Booster pumps x 4 units	Capacity: 25.3m^3/min、 3.3kV, 190kW
		c. Chlorinator building x 1 unit	Consisting of chlorinators, device for hazard prevention, gas cylinders, building, etc.
		d. Secondary power and control facilities for electrical equipment in the station	11kV ～ 3.3kV ～ 400V, and single phase power source
	2) Reservoir x 1 unit		Capacity: 4,000m^3
	3) Operation control building and operators' quarters, each 1 unit		170.0m^2
	4) Transmission mains (Dia. 1,000mm x13 km long)		Spiral steel pipe with plastic coating

4. Distribution facility	1) Terminal reservoir	Capacity : 37,000m^3
	2) Terminal pump station	
	a. Pump station x 1 unit	Size: 545.8m^2
	b. Distribution pumps x 4 units	31.6m^3/min、3.3kV, 330kW
	c. Secondary power and control facilities for electrical equipment in the station	11kV ～ 3.3kV ～ 400V, and single phase power source
5.Reinforcement of existing arterial mains	Supplementary sections to arterial main Dia: 700～800mm x 6 km long x 6 km	Ductile cast iron pipe
6. Procurement of equipment for operation and maintenance	1) Water level meter x 12 units	Battery driven, portable
	2)Water analysis equipment x 1 unit	Photo-spectral analysis
	3) pH/EC gauge x 1 unit	Potable for field testing
	4) TDS gauge x 1 unit	Potable for field testing
	5) Ultra sonic flow meter x 1 unit	Potable type for field measuring and recording
	6) Automatic pressure recorder x 2units	Potable type for field measuring and recording
	7) Leak sound detector x 2 units	
	8) Voice communication system x 1 unit	VHF system, (Max. distance 30 km)

Since the main facilities of the project compose an integrated water system, it is necessary to implement the construction work on full turn-key basis over a period of several years. On the other hand, the reinforcement of the existing distribution network can be carried out independently of main works, and this part is proposed to be carried out separately as the first phase in a single year, with the main part following as a package for the second phase. The periods necessary for the detailed design and the construction work are 44 months. The cost for the project is estimated at 4,603 million yen with a share of the Japanese side at 4,053 million yen and that of the Pakistani side at 550 million yen).

The project is implemented with WASA, a wing of the Faisalabad Development Authority, as the executing agency overseen by the Department of Housing and Urban Development and Public Health Engineering of the Punjab government.

WASA is headed by managing director, divided into 8 divisions including those specialized in technical service for water and sewerage. The total number of its staff is about 1,500. Its financial status remains to be improved. The yearly deficit in recurrent cost for manpower and huge energy consumption has been balanced with government subsidies from a share of property tax. Its water tariff is low and ineffective, since it is charged on the basis of size of consumers' property regardless of consumed quantities like many other large cities in the country. In recent years, however, it is paying special efforts for increasing the revenue through a series of revisions of tariff with a plan to shift to a metered tariff system already in place.

This project is aimed at urgently improving public water service targeting the increased water supply and per capita supply rate for citizens including large numbers of the poor in a significantly big city of the country. It will contribute to improvement of their BHN and health environment. All these characteristics of the project, together with effects enumerated as follows, are deemed adequate for verifying feasibility of extending Japan's grant aid to the implementation of the project.

(1) Direct effects

a. The study for the project revealed that presently the water service coverage in Faisalabad is at a level of 55% with a served population of 1,272 thousand among an estimated population of 2,300 thousand, with a per capita daily average supply rate at 100 liters. After an additional water supply of 91,000m^3/day is secured through the implementation of the project in 2008, the coverage will increase to 60% with a served population of 1,564 thousand in the estimated 2,600 thousand with a per capita daily average enhanced to 130 liters.
b. Ongoing supply hours of 6 hours at the maximum can be switched to a continuous daily operation.
c. Extremely poor water service to the east side of the city with one third of the entire population can be improved with water pressure in the arterial mains in that area increased from current 0.5 kg/cm^2 at the maximum to 1.0 to 1.5 kg/cm^2.

(2) Indirect effects

a. The significant increase of safe and stable water supply can contribute to alleviating water-borne diseases such as hepatitis, diarrhea, etc., improving health environment for citizens.
b. The improved water service and awareness building of payment to the stakeholder can have effects to raise revenues as it may decrease arrears and

rejection of payments of water fees, illegal connections, forced withdrawals with consumers' own pumps, etc. The implementation of the project will offer WASA the best chance to shift to a metered water tariff.

Finally it is requested to WASA to take the following measures into account to enhance the effects of the project:

(1) Risk management

As a result of the study there is a risk of groundwater level lowering in the surroundings of the planned wellfield on the medium to long term basis. It is necessary to work out relevant measures for alleviating the adverse effect including possible compensation to the concerned villages. Constant contacts with stakeholders are required through public meetings and intimate dialogues to open information and to secure their agreement to the implementation of the project.

(2) Efficient water supply by means of reduction of leakage and improvement of distribution

In order to minimize loss of valued water, WASA is required to take aggressive actions to reduce leakage of pipelines which is reportedly at a level of 30%, though the real situation is unknown since house connections have no meters. It is recommended to select pilot areas as a first step to know the situation and work out a relevant plan for eradicating water loss.

As the project plans to undertake a partial remedy of the existing distribution network, WASA is requested to continue its own efforts for the improvement of distribution system such as reinforcement of secondary network and branches. Equipment procured under the project for testing flows and pressures of pipelines are requested to be effectively utilized in such undertakings for balanced water service through the city.

(3) Employment of metered tariff system

Augmentation of water supply can have its maximum financial effect under the metered tariff system. The shift of all the current consumers of about 100 thousand is estimated to take more than three years. Since its preparation seems likely to take time, at least WASA should start with new consumers from now on. Earlier realization of the plan is strongly recommended.

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CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

APPENDICES

CHAPTER 1
BACKGROUND OF THE PROJECT

Chapter 1 Background of the Project

1-1 Background of the Project

(1) Current Water Service in Faisalabad

The city of Faisalabad is located in the central part of the Punjab province with a greater part of its area of about 200,000km^2 devoted to agriculture. It started as a major trading center of agricultural products in the region, and has lately grown into one of the largest industrial cities in the country, with its principal line in textile industry. The national census in 1998 reported the city's population reached about 2 million by that year, raising it to the third largest scale behind Karachi and Lahore.

The city's water service has been undertaken by Water and Sanitation Authority, (FDA) Faisalabad (hereafter called "WASA"), established in the late 1970s by the Punjab government, as a wing of the Faisalabad Development Authority (hereafter called "FDA"). Major water facilities were completed in 1992 under Phase I of the first master plan with finance of ADB. The project provided a complete water supply system to the city, comprised of 25 tubewells as water sources in the wellfield along the left side of the Chenab river about 30 km northwest of the city, the inline booster pump station delivering discharge from tubewells, transmission main of 1,500mm in size about 20 km long, the terminal reservoir in the northern suburbs of the city and finally arterial mains for distribution to a major part of the city.

Soon after WASA started the operation of facilities completed in 1992, it was urged to expand the water supply system by ever-increasing demand of the city, and presented in 1995 an official request for assistance with grant aid for its project in Phase 2 to the government of Japan.

Although the Japanese side responded to that request in 1997, the studies for the project underwent critical influences from political and social conditions in the country and the project site. (The details of the proceedings to date are outlined in the following sections.)

Since 1992 WASA's water service has been relying mainly on the facilities installed under Phase I. At present, however, it has been faced with dire difficulties as described in the following table:

Table 1-1 Current Situation of Water Service in Faisalabad

	Problem	Present Situation	Cause	Effect
1.	Shortage in water production	The existing water facilities had a capacity of meeting demand of 60% of 1.6 million citizens in 1992. Without any effective work for expansion realized since then, water production has now fallen to a rate far less than its initial one. Mean- while, the population in 2003 is estimated to have reached 2.3 million with demand soaring high.	It is highly difficult for the agency to secure finance for a large-scale project.	(a) Stagnantly low water coverage in the city and decrease in per capita supply rate for consumers. b. Restrictions in supply hours
2	Unfair water service	Nearly one third of the city remote from the Terminal Reservoir fails to receive proper share of water supply, due to meager water pressure.	a. Malfunctioning of existing facilities b.Concentrated consumption during limited supply hours causes pressure to drop in trunk mains through the area remote from the Terminal Reservoir.	There is no way left but depend on purchase of water or any other available means for citizens in poor service areas. b. Citizens won't pay for poor service.

3	Poor financial performance	The agency in charge of service has been unable to recover operating cost with collection of water rates.	a. The water rate is dis- proportionately low to production cost. b. Water tariff is a fixed rate system based on the size of property of consumers.	a. Deficit in cost recovery is supplemented by subsidies. b. Projects are usually financed by governmental or foreign funds.

(2) Earlier Development of Water Service in Faisalabad

The city had taken several steps for development of water service before the request for assistance to Japan. They are summarized in the following table:

Table 1-2 Earlier Development of Water Supply in Faisalabad

	Year	Action	Content
1	1976	A master plan for city's water and sewerage was worked out with ADB's assistance.	It was a long-term plan from 1976 to 2000 . (The population in 1976 was about 800,000.)
2	1992	Water facilities in Phase I of ADB's master plan was completed and commissioned.	*WASA launched the operation of completed facilities in 1992. *The completed facilities had a capacity of meeting the demand of 60% of the then 1.6 million citizens.
3	1993	The initial master plan was revised with assistance of the World Bank.	The revised plan covered the period from 1993 to 2018, starting with Phase 2.
4	1995	WASA presented its request to Japan for financing a project for Phase 2, based upon the programme of the revised master plan.	*The requested amount was Rp. 12 million.
5	1996	The concept clearance paper for Phase 2 was approved by the ECNEC of the federal government.	*It proposed to execute Phase 2 in the framework of the 8th 5-Year Plan(1993/94～97/98).

The revised master plan targeted to develop the city's water supply through the installation of additional water sources, in particular around the existing Chenab wellfiled located about 30 km northwest of the city as well as the extension of distribution network. For an immediate measure in Phase II from 1993 to 2000, however, it recommended to start with the rehabilitation of the existing surface water treatment plant within the city along the Rakh Branch Canal. The request to Japan, therefore, put priority on the execution of that work.

(3) Results of Preliminary Study and Subsequent Basic Design Study

The government of Japan decided to respond to WASA's request、and the Japan International Cooperation Agency (hereafter called "JICA") dispatched a preliminary study team in November 1997. After the mission reviewed various plans as well as the one for rehabilitation work, proposed by the master plan, the study brought a conclusion as follows:

a. The site for the rehabilitation of the treatment plant is squeezed in the midst of the congested area of the city. Adequate space could not be secured for a new plant with a targeted production of 10 million gallons per day..
b. The plant withdraws irrigation water in the canal for its source. Every year in the winter season however, the channel is closed for one month for desilting and maintenance of canal facilities. During that period, the plant will have to be idling without any source.
c. Operation and maintenance of a newly upgraded treatment plant requires sophisticated technology. Moreover it was estimated to raise the cost of water production of water.
d. On the contrary, the development of a new wellfield, an alternative proposed by the master plan for Phase 3, would be more advantageous, since WASA has experience and expertise with the existing facilities completed in 1992 under Phase 1. This approach was estimated to be more economical, since the recurrent cost was by far less than the treatment of surface water, as groundwater was of good quality,
e. A site as a candidate for additional groundwater development is selected around the existing Chenab wellfiled, as proposed by the revised master plan.
f. The target for development is set at 91,000m^3/day, which can cover the then urgent need of citizens.

Based upon the conclusion of the preliminary study, JICA dispatched a basic design study team in 1998. The study proceeded as follows:

Table 1-3 Preceding Basic Design Study in 1998

		Study period	Activities
1	Stage 1	1998-2-23～3/23	Hydrogeological survey, survey for water supply facilities, planning for operation and maintenance, etc.
2	Stage 2	1998-4/20～5/7	Test drilling programme at planned wellfield to verify its potential.

In the second stage, the study was scheduled to carry out the test drilling programme in the planned wellfield along the Chenab river for obtaining basic information on groundwater potential. However, mobilization of drilling equipment to the site was rejected by villagers in the surrounding area, who opposed to a new project by WASA for fear that it would threaten regional groundwater to decrease or to be depleted. They had been acquainted with the effects of continued pumping in the existing Chenab wellfield since 1992, threatening irrigation wells in the surroundings to be abandoned due to the fall of groundwater level. The work, therefore, was for a while suspended

Meanwhile at that time Pakistan dared to execute nuclear testing in competition with India, which evoked international opposition. The situation led to the economic sanctions by major countries with which Japan joined forces, resulting in the suspension of its economic assistance to the country. Eventually all the projects including this one were canceled.

(4) Renewed Basic Design Study

After this incidence, WASA itself launch an attempt to alleviate the city's worsening water supply through the execution of proposals by the master plan such as (a) rehabilitation of existing wells along the Rakh Branch Canal within the city, and (2) installation of additional tubewells in the existing Chenab wellfield with funds from the Annual Development Programme of the Punjab government. Its efforts, however, ended up with less effects than had been anticipated. Under pressure from demand of citizens, WASA took the occasion of the lift of economic sanctions in 2001 to renew its request to Japan for resuming the study for the project. The proceedings after the renewed request is outlined in the following table:

Table 1-4 Progress after the Renewed Request

	Period	Steps Taken	Remarks
1	1998-5	As a result of the JICA preliminary study, WASA revised its previous concept clearance paper, putting priority on groundwater development..	The document was submitted to the provincial government and was approved by the concerned agency (PDWD).
2.	1998～2001	During the period of the international economic sanctions, WASA made its own efforts for augmenting water supply.	WASA carried out the construction of 4 additional tubewells in the Chenab wellfield and the rehabilitation of existing tubewells along the Rakh Branch Canal within the city.
2	2001	After the economic sanctions were lifted, WASA presented its request to the govenrnment of Japan for resuming the basic design study for the project.	
3	2002-12-9 ～2003-1-26	The first stage of this basic design study was carried out by JICA.	While the study was underway, the opposition of villagers in the planned wellfield was rekindled. As a result, the field survey for groundwater development was suspended, and eventually the Pakistani side decided to move the site to an alternative one located relatively near the city.
4.	2003-5	WASA requested the government of Japan to resume the study in the alternative site.	WASA responded to the requirement of the Japanese side to present agreement of stakeholders around the site as well as technical data for feasibility of the alternative site.
5	2003-8-2 ～9-14	After the submitted documents were reviewed, the second stage of the basic design study was carried out by JICA.	During this stage, all the required works for the study were completed, including test drilling programme.
6	2004-3-16 ～3-29	The basic design draft explanation mission was dispatched by JICA.	The Pakistani side agreed to formulate appropriate measures to prevent adverse effects of the project, in particular for villages in the vicinity of the wellfield.

The particulars during the first and second stages of this basic design study are as follows:

1) The first stage (Dec. 2002～Jan. 2003)
One of the specific strategies in the current basic design study was to carry out the social study in the villages in and around the site for groundwater development in view of breakout of opposition in the preceding study. On the other hand, WASA had taken its own measures to acquire a patch of land for test drilling programme in an upstream area for avoiding a conflict with villagers. Despite such measures, opposition burst out again around the alternative site, as drilling equipment moved there (Dec. 2002).

WASA reacted to this movement without delay, together with related agencies of the district and tehsir, opening the dialogue with concerned villagers and other stakeholders in the area. One of the difficulties was the site location in the Chenab area which belonged to Jhang District neighboring Faisalabad District. The administrative constraints further made the matter more complex, and negotiations reached an impasse. Finally the high-ranking officials of the provincial government overseeing the project paid a visit to the site to hold a public meeting with all the stakeholders including representatives of concerned villages. It turned out, however, that the villagers would not agree to the project executed in their place.

After the meeting, WASA decided to switch its initial site to another alternative along the left bank of the Jhang Branch Canal about 13 km from the city, running between the Chenab river and the city, and proposed it to the Japanese side for the study.

After a series of occurrences in the site during the study, the essential condition for resuming it in the newly proposed site was to secure overall consent of stakeholders in and around the site. Technical feasibility of the new site was also obscure at that moment. Under such unfavorable circumstances the Japanese side offered a counterproposal at a meeting chaired by the representative of the EAD of the central government on Jan. 24, 2003 that the study for a part of groundwater development be withdrawn in the then ongoing stage and that WASA renew its official request for a study in the new site, presenting such supporting documents as agreements of concerned stakeholders and technical information promising feasibility of the site. The first stage of this basic design study was thus closed with this meeting (Jan. 2003).

2) Second stage

With the conclusion of the first stage of the study, WASA launched its own survey of the wellfield along the left bank of the Jhang Branch Canal , and in May 2003 presented its renewed request for resuming the study for the project, together with agreements of the villagers and other stakeholeders in the vicinity of wellfield as well as the technical reports. The Japanese side responded to it with a dispatch of the study team for the second stage from August 2 to September 14, 2003. The field survey by the team including drilling program in the wellfield progressed without any interruption. The survey for collection of groundwater discharge, its transmission and distribution to the city was satisfactorily completed.

Despite smooth execution of the study, the following situation is needed to be taken into consideration to conclude it:

a. A social study was carried out in the same manner as in the first stage for the villages along the left bank of the Jhang Branch Canal. Its results revealed that villagers around this site had a different view of the project from those in the previous site of the Chenab wellfield. They saw themselves as members of the economic zone of Greater Faisalabad and felt rather sympathetic with the project. However, since the area's economy depended upon agriculture employing plenty of tubewells for irrigation, they naturally felt uneasy about the adverse effect of the project on them.

b. The study in the second stage was completed without any interruption by villagers. However, at its final moment, a part of villagers took to the streets in Faisalabad city. The incidence was reported nationwide. (Oct. 2003)

c. As a result of the study, the planned tubewells will hardly affect the existing agricultural wells for a short time. However, they are likely to be affected more or less by continued pumping of the project wells in large quantities, as detailed in this report. The Japanese side reported the range and dimensions of influences to WASA as well as to the concerned offices of the provincial government and requested them to take measures for such a predicted risk to avoid any conflict with local communities.

3) Mission for explanation of basic design draft report

As a final stage of the study, JICA dispatched a mission for explanation of basic design draft report in March 2004. Aside from the technical matters, the mission underscored the importance and necessity of measures for environmental risk. As a conclusion it was agreed between both sides:

a. The Pakistani side shall work out appropriate measures for environmental risk.
b. It shall hold a public meeting to make all the stakeholders acquainted with necessary information, negotiate with them and secure their agreement to the execution of the project.

1-2 Summary of the Project

(1) Contents of the Project

The contents of the final plan is comprised of the following components, based upon WASA's official request for the project and the agreement between WASA and the study team concluded in the second stage of the study carried out in August and September 2003.

1) Objectives of the Project

a. The project is aimed at improving the water supply system in Faisalabad city, the third largest in the country with an estimated population of about 2.3 million in 2003.

b. The project is aimed mainly at providing facilities for the augmentation of water source in the system to alleviate acute shortage of water in the city. While demand is fast increasing, the discharge from the existing tubewells in the Chenab wellfield (initially 25 with an addition of 4 in 2000) is obviously decreasing after they were installed in 1992 under the project financed by ADB.

c. The project plans to reinforce a part of existing arterial mains to remedy currently ongoing unbalanced distribution in the city so that water augmented by the project could be enjoyed by as many citizens as possible.

2) Components of the Plan

The main facilities in the plan for the project are comprised of the following:

a. Tubewells along the left side of Jhang Branch Canal

* Number of tubewells	25 No.
* Targeted discharge	91,000 m^3/day

b. Collector mains (from the tubewells to the booster pump station)

*Diameter	400 to 900 mm
*Total length	about 15,600m

c. Booster pump station

(Jhang Branch Canal pump station, hereafter called "JBC" pump station)

*Number	1 No.

d. Transmission main (from JBC pump station to the terminal reservoir in the city)

*Diameter	1,000mm
*Total length	about 13,000m

e. Terminal reservoir (hereafter called "T/R)

consisting of:

*Terminal reservor	37,000m^3 x 1 No.
*Terminal pump station	1 No.

f. Chlorinator 1 complete unit

(installed in an annex to JBC pump station)

g. Reinforcement of arterial mains

*Diameter	700 to 800 mm
*Total length	6,000 m

h. Procurement of maintenance equipment

*Water analysis equipment	1 set
*Pipeline testing equipment	1 set
*Voice communication system	1 set

3) Executing Agency

The executing agency of the project is Water and Sanitation Agency (WASA), Faisalabad Development Authority (FDA), to be overseen by the Ministry of Housing, Urban Development and Public Health Engineering (hereafter called "HUD&PHE") of the

Punjab government.

4) Financial Arrangements

The project is to be financed by grant aid from the government of Japan for the construction of planned water facilities and procurement of equipment and materials. The Pakistani side is responsible for provision of facilities for primary power supply, acquisition of land, construction of accesses and others.

(2) Effects of the Project

Through the provision of additional water facilities by the project, WASA's ongoing water service could be expected to have the following improvements:

a. The current coverage of water supply in Faisalabad is estimated to hover at around 55%, and an average supply rate to 1.27 million presently served is about 100 liters per capita per day. After the project is completed, a served population will increase to 1.56 million in total with an average rate rising to 130 liters per capita per day.

b. WASA has long been restricting water supply with pumps to 6 hours a day at the maximum (separated into 3 times, each 2 hours at the maximum) due to shortage of water source and other reasons. This practice can be improved into continuous supply with pumps through the provision of additional facilities.

c. Citizens in the east side of the city have long been suffering from unbalanced supply to their area. After the reinforcement of trunk mains for distribution, they could enjoy improved water supply.

(3) Feasibility of the Project

WASA's water service has been far from satisfying current demand of citizens, despite its efforts to implement proposals of the World Bank's master plan such as the installation of additional 4 tubewells in the Chenab wellfield, rehabilitation of tubewells along the Rakh Branch Canal within the city, rehabilitation and installation of secondary mains for distribution, etc. Under persistent shortage of water, a greater part of households and most of industries heavily depend upon tubewells and hand-pump wells in their premises. Water vending is also thriving for drinking within the city. Since groundwater source in the city area is intensively deteriorated through artificial contamination, the situation has resulted in chronic incidence of water-borne diseases among citizens.

Under such circumstances, this project is the first step since 1992 that can substantially meet urgent need for water in the city, although it is far from the program of the World Bank's master plan. The project can contribute to improving the BHN of a great number of citizens through its implementation. In this view, the project is judged suitable for the implementation with Japan's grant aid.

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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

As a result of the preliminary study carried out in 1997, this Project initially aimed at contributing to a target of Phase 2 from the year 1993 to 2000 of the revised mater plan for the water and sewerage of Faisalabad city to achieve a coverage of 70% of citizens as an overall goal. According to this basic design study from 2002 to 2003, however, the current water supply by WASA is estimated to serve about 55 % of the population, with an average per capita daily consumption hovering around 100 liters. These indicators show that the water service has been worsening, straying away from the framework and targets of the master plan as an overall goal, while the population is estimated to have grown to 2.3 million in 2003.

It was agreed during the 1997 preliminary study to contribute to WASA's efforts through the provision of additional water with Japanese assistance by 91,000 m^3/day, which was the then immediate need for citizens. The site for development of water sources was selected in an area around the existing Chenab wellfield, as proposed by the master plan.

The plan, however, met persistent opposition of villagers around the site, since they were afraid of adverse effect of pumping at the project wells on their irrigation wells abounding in this vast agricultural land in which the site was located. Eventually WASA had to shift the initial candidate to an alternative one. Although the last site has proven to have as much potential as the initial one for development, WASA is now aware that the development of water sources in this project and in the future entails proper consideration and arrangements for the environment of the region to win cooperation of concerned stakeholders. In this view, WASA and the provincial government have agreed to take necessary steps to coordinate with concerned villages in and around the wellfield.

With the project purpose for augmenting water sources under such circumstances, this study proposes to ensure the initially agreed amount of additional water, namely 91,000m^3. As a result of the study, this rate is in a maximum level of development in the site along the Jhang Branch Canal. It corresponds to nearly 40% of the existing water production rate, and can substantially contribute to relieving acute shortage of water in the city, increasing served population of 1275 thousand in 2003 to 1530 thousand in 2008 with a per capita average daily supply raised from 100 liters to 130 liters.

2-1-2 Basic Concept of the Project

For achieving the project purpose as set forth in the previous section, Japan undertakes the construction work of water sources to the distribution facilities in the city including reinforcement of the existing arterial mains, while the Pakistani side is in charge of installation of primary electric power and the construction of roads for access to the completed facilities. While the implementation of the project is underway, WASA is required to expand new connections and to acquire new consumers. It is in charge of operation and maintenance of completed facilities with newly organized teams, and is responsible for offering effective and efficient water service to citizens through the combined operation of the existing and new facilities. The following table summarizes the input and activities necessary for the successful implementation of the project, together with its anticipated effects.

Table 2-1 Logical Framework of the Project (Project Design Matrix:PDM)

Name of the Project: Project for Improvement of Water Supply in Faisalabad　　Project Site: Faisalabad city　　Ver. 1
Period: From August 2004
Target Group: Faisalabad citizens (About 1,564 thousand)　　Prepared: in May 2004

Project Summary	Indicators	Means of verification	Important Assumptions
Overall Goal ☐ Water service rate in Faisalabad is improved.	☐ (The coverage rises to 75% in 2010.)	☐ Consumers log Record of installation of house connections/additional network sections	
Project Purpose ☐ Water supply in Faisalabad is improved.	☐ Served population reach 1,564 thousand in 2008. ☐ Water service rate rises to 60% in 2008. ☐ An average per capita daily supply rate is not less than 130 lit/capita/day in 2008. ☐ The operation for daily supply continues through 24 hours in 2008. ☐ One third of the population in the East Side of the city can enjoy improved distribution of water supply. ☐ The tubewells under this project provides an additional water production of 91,000m^3／day at maximum.	☐ WASA's daily pumping records at existing and new tubewells. ☐ WASA's daily record for supply at the existing flow meter and the one from the new pumping stations (the booster pump station and the terminal reservoir pumping station.). ☐ WASA's operation record at the Terminal Reservoir. ☐ Census of population and consumer survey report ☐	☐ WASA secure well-organized operation and maintenance system. ☐ WASA continues its efforts to expand facilities for effective and efficient water supply (based upon the master plan)
Output			

<table>
<tr>
<td>1. Additional water sources are installed.

2. Facilities for effective distribution of increased water are installed.

3. The existing distribution system is improved with reinforcement under this project.

4. House connections increase.

5. A new team for operation and maintenance is organized.</td>
<td>1-1 25 pumping stations with tubewells are installed by 2008.
1-2 An additional water production of 91,000m^3/day is pumped at these pumping stations.
1-3 Collector mains (15.6km), transmission facilities consisting of a booster pump station and transmission mains 13 km long and distribution facilities of a terminal reservoir and pumping station is constructed by 2008.
3-1 Supplementary sections (6km) to arterial mains are installed by 2008.
4-1 Collection of water fees is improved.
5-1 A new team is staffed by 2008</td>
<td>1-1 Project completion report
1-2 Record of (test) operation of facilities constructed under the project

1-3 Project completion report

2-1 Record of (test) operation of facilities constructed under the project

3-1 Project completion report

4-1 WASA’s annual budgetary report

5-1 Record of (test) operation of facilities constructed under the project</td>
<td>☐ There is no drastic change in the population of the city.
☐ The environment of the wellfield remains intact.(No industrialization and resulting pollution of environment)
☐ There is no large scale disaster to affect natural environment of the wellfield.
☐ The canals continue recharge to groundwater in the same level as they currently do.
☐ Political, social, economic conditions of the country stay stable.
☐ WASA can ensure financial assistance of The government in case its financial balance worsens.</td>
</tr>
<tr>
<td colspan="2"><u>Activities</u>

<u>1. Construction of facilities/procurement of equipment</u>
1-1 To construct water sources/pumping stations.
1-2 To construct collector mains, transmission and distribution facilities.
1-3 To reinforce and expand the distribution network in the city (including works undertaken by WASA).
1-4 To procure equipment for operation and maintenance of facilities.
1-5 To train engineers/operators for new facilities on their operation and maintenance.

<u>2. Understakings of the Pakistani side</u>
2-1 To provide primary power connections to facilities.
2-2 To acquire land for the construction of facilities
2-3 To level and grade land for construction of facilities
2-4 To construct access roads to facilities
2-5 To undertake expansion of network.
2-6 To undertake sustainable operation and maintenance of facilities
2-7 To acquire new contracts and install house connections</td>
<td><u>Input</u>

【Japanese side】
Manpower：
Basic design study team, detailed design team, resident engineers of the consultant、expert for O/M Contractor
Materials and equipment：
Those for construction of facilities
Those for operation and maintenance
Fund：
Grant aid

【Pakistani side】
Manpower：
WASA’s couterpart engineers
Operation and maintenance team
Materials and equipment：
For expansion of network/house connections
Fund：
Public Sector Development Programme (PSDP)</td>
<td><u>Precondition</u>

☐ Agreement is concluded with villages in the vicinity of the wellfield for their cooperation in the implementation of the project.</td>
</tr>
</table>

Remarks for the indicators in the above table are as follows:

a. The overall goal of the project is the master plan revised with assistance of the World Bank in 1993. The coverage of water service as an indicator in the table is tentatively shown as reference in compliance with the target of that plan for Phase III from 2005 to 2010. However, it is now of vital importance to review and revise it to adapt it to the latest situation in the city.

Difficulty to attain to that goal is for one part in securing water sources, as the expansion of the Chenab wellfield proposed by the master plan was now rejected by the villages in the surroudings. Alternative measures for the moment seem to depend solely upon the efficient water use by such efforts as to decrease leakage, to use effectively existing water sources along the Rakh Branch Canal or to rehabilitate existing tubewells in the Chenab wellfield. Such practical efforts can have effect to hold the coverage of 60% anticipated to be achieved by this project or raise it slightly for a short to medium term.

2) This study estimated the current coverage of water service, based upon the dimensions of areas where WASA had installed pipelines for distribution, as detailed later in Section 2-2-2-2, (2)-3). Although the rate is normally estimated by the registered number of households having connections, it is actually in an incredibly low level, probably due to widespread illegal connections. To evaluate the coverage in the future, it will be necessary to review all the related factors such as WASA's performance in the extension of the network, installation of house connections with consumers log, etc.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

(1) Basic policy

1) Extent of assistance

As the basic policy of Japanese assistance, the target of groundwater discharge for the project is set at 91,000m^3/day, which was agreed in 1997 between WASA and JICA's preliminary study team. This target has since then been in WASA's plan for its repeated requests to Japan.

The initial stage of this basic design study in 2002, therefore, targeted the same amount. Finally it was confirmed and agreed between WASA and the study team during the second stage in August 2003, as indicated in "Technical Note" in Appendix.

That discharge is now far less than the target of the World Bank's master plan in 1993 due to lapse of time. However, environment has since been changed dramatically, with increasing pressure from the regional communities devoted to agriculture consuming large quantities of groundwater to supplement shortages of canal water. Increase of discharge now demands a great deal of social and environmental consideration

As a result of the study in the second stage in 2003, the scope of assistance by the Japanese side is proposed to include facilities from those for water source development, collector mains, an intermediate pump station, transmission main, to the terminal reservoir. They are to be combined with the existing facilities for effective water service. The components are basically the same as those planned during the first stage in 2002, but include some modifications as listed in the following table (Refer to Fig. 2-1 for their planned locations.)

Table 2-2 Comparison of Major Components in the Studies of the Two Stages

Facilities	Preceding Basic Design Study in 1998 and the first stage of this study in 2002	The second stage of this Basic Design Study in 2003
Water source	The wellfield sites were mainly private farmland along the Chenab river about 30 km northwest of the city.	The well field is basically government-owned land along the left side of theJhang Branch Canal about 13km northwest of the city
Intermediate pump station	Inside the premise of the existing inline booster pump station	In government-owned land along the Jhang Branch Canal
Transmission main	Size: 1,000mm Total length: 25 km	Size: 1,000mm Total length: 13 km
Facilities for distribution	To be constructed in the premise of the existing terminal reservoir	No change

Meanwhile the first stage of the study in 2002 found the city's east side, lying at the end of arterial mains more than 15 km from the terminal reservoir, had been suffering from unbalanced supply and that there was a risk water, even if augmented through this project, might not reach this area in a satisfactory manner.

Since WASA took steps to include the study for this problem in its renewed official request in 2003, it was examined in detail during the second stage. Findings were as follows:

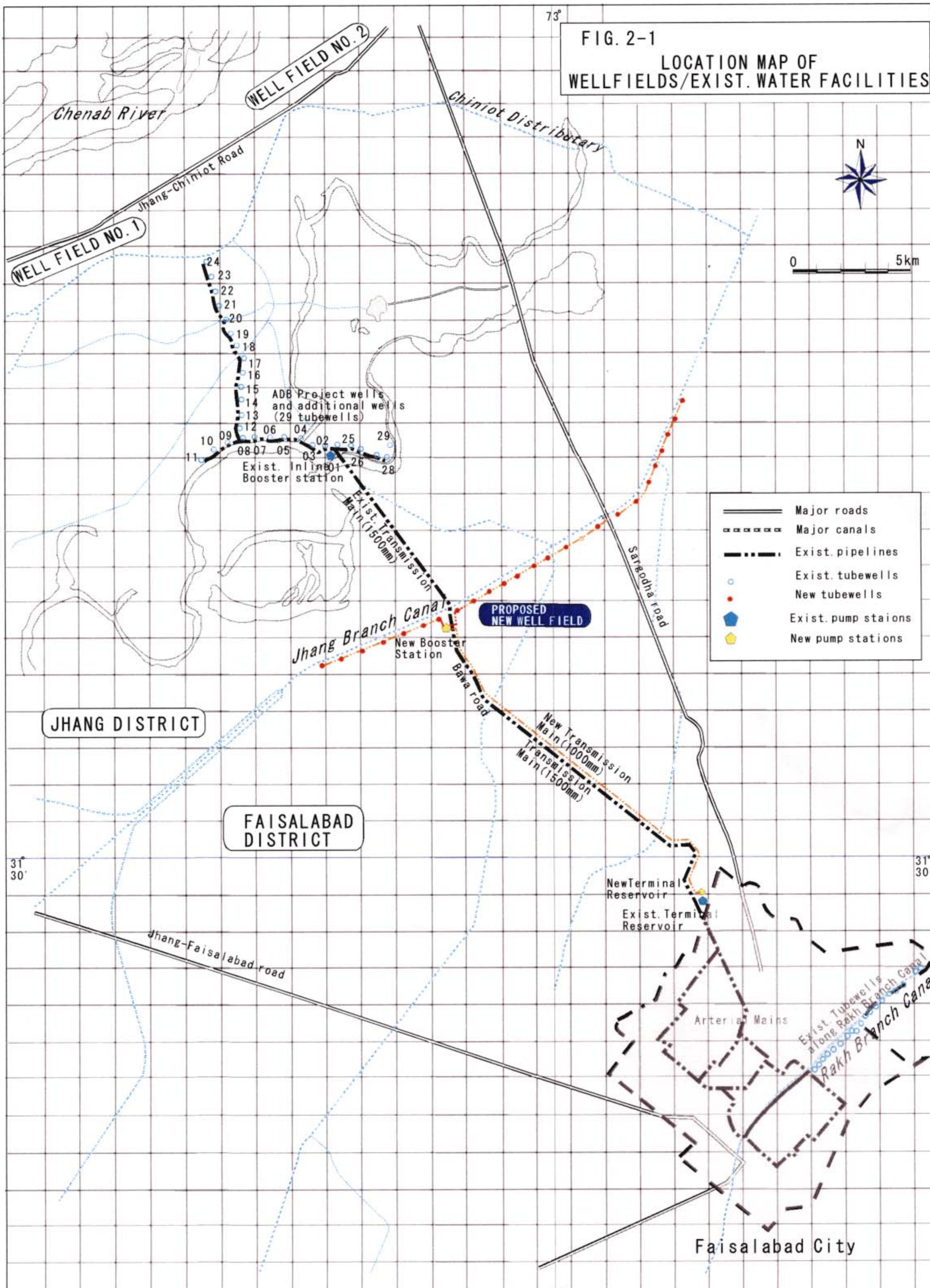


FIG. 2-1
LOCATION MAP OF
WELLFIELDS/EXIST. WATER FACILITIES
WELL FIELD NO. 2
WELL FIELD NO. 1
Chenab River
Jhang-Chiniot Road
Chiniot Distributary
N
0
5km
ADB Project wells
and additional wells
(29 tubewells)
Exist. Inline
Booster station
Exist. Transmission
Main (1500mm)
Sargodha road
Major roads
Major canals
Exist. pipelines
Exist. tubewells
New tubewells
Exist. pump staions
New pump stations
PROPOSED
NEW WELL FIELD
Jhang Branch Canal
New Booster
Station
Bawa road
JHANG DISTRICT
New Transmission
Main (1000mm)
Transmission
Main (1500mm)
FAISALABAD
DISTRICT
NewTerminal
Reservoir
Exist. Terminal
Reservoir
Jhang-Faisalabad road
Arterial Mains
Exist. Tubewells
along Rakh Branch Canal
Rakh Branch Canal
Faisalabad City
73°
31°
30'

a. WASA had been in practice to supply water with pumps three times a day, each for 1.5 to 2 hours. One of the reasons for this restricted service is shortage of water source. Every household waited for the start of water supply with its taps fully opened, and a major part of supply tended to be consumed in the west side of the city where pressure was high before it reached the east.
b. Mechanical capacity of pumps and hydraulic features of lengthy arterial mains were severely damaged by this extraordinary consumption pattern. Each facility could not function properly as it was designed.

WASA is now planning to switch its tariff from a fixed rate based on property size of household to a metered one to contain a trend of excessive consumption in part of the city. On the other hand this study has led to another measure to cope with the situation, namely to change the flow pattern by adding supplementary sections to the existing mains so that pressure could be maintained in the east side. This plan will compose a part of cooperation by this project.

2) Wellfield Site

The initially proposed site for the wellfield for the project was located along the Chenab river about 30 km northwest of Faisalabad city in the neighborhood of the existing Chenab wellfield. Potential of groundwater in this area had been verified by the existing wellfield installed in the preceding project for Phase I. However, continuous pumping of large quantities of water from 25 tubewells there resulted in the fall of regional groundwater level affecting the surrounding agricultural wells.

Faced with persistent opposition by villages in the planned wellfield during this study, the candidate for the project was shifted to an area along the left side of the Jhang Branch Canal about 13 km west of the city. As a result of the second stage of the study, the new site has turned out to have as high a potential of groundwater of good quality as the previous site does. Thanks to ample recharge from the canal, planned tubewells there are anticipated to maintain the estimated production capacity and good quality.

The Jhang Branch Canal is a secondary main of the Lower Chenab Canal (hereafter called "LLC") withdrawing the flow of the Chenab at the Khanki Head Works, the oldest weir of the country, about 150 km upstream the project area. The authorities now plan to rehabilitate the head works and channels of this system to increase and ensure its sustainable supply, since it has now been aged. One of the measures in planning is to carry out the lining of existing channels to reduce leakage. It was confirmed, however, such works are intended for smaller channels of distributaries and their downstream. In the future, therefore, the canal is expected to be able to feed more water to farms, while groundwater is likely to receive constant recharge along the main channels of the canal including the Jhang Branch Canal. This situation indicates the planned wellfield along the canal can ensure sustainable development of groundwater for the city's water system.

Meanwhile, in view of environmental conditions in and around the site hostile to groundwater withdrawal by WASA, proper measures should be taken to contain influences to a minimum level both in technical design and public relations. (Refer to item 3) "Policy for social and economic conditions")

3) Design policy for facilities

i.. Transmission Main

Since Faisalabad has the third largest population among the county, each of water facilities requires a larger capacity and size. Among them, the transmission main from the wellfield at a long distance from the city to the terminal reservoir in the suburbs of the city (hereafter called "T/R") requires special attention, technically and financially.

The existing tubewells in the Chenab wellfield are further away from the city, extending 5 to 10 km north of the Jhang Branch Canal. The existing transmission main with a diameter of 1,500mm lies along BAWA road from the inline booster pump station across the Jhang Branch Canal to the T/R (Refer to the map in Fig. 2-1)

The course of the transmission main for this project from the Jhang Branch Canal is conceived to be laid in parallel to the existing line along BAWA road as the shortest route from the canal area. Apart from installing a new line, a possibility to utilize the existing 1,500mm line was examined since the route is the same. As a result of the study, it was revealed that the existing line has an allowance to combine discharges from the Chenab wellfield and the Jhang Branch Canal wellfield. WASA showed an interest in the idea, but requested to compare the costs of operation and maintenance of separate lines and a single line, since it had been suffering from the burden of electrical cost for pump operation. (Refer to Appendix, "Technical Note".)
The results of the comparison are shown in the following table:

Table 2-3 Comparison of Methods of Transmission

	Plan A :Combined. transmission	Plan B: Separate transmission
Technical examination	Pressure of the existing pumps at the inline booster station is insufficient for conveying through discharge of tubewells in Chenab to the T/R, in case discharge from the Jhang Branch Canal wellfield joins the former in the existing transmission main on the way.	No particular technical difficulty is posed.
Composition of facilities	a. Pump station *Inline booster pump station (replacement of 3 units of existing pumps plus one standby) *Jhang Branch Canal pump station (3 units of new pumps plus one standby) b. Transmission main *Existing transmission main (1,500mm dia. x 18km) *New transmission main (Short connection line to the existing transmission main)	a. Pump station *Inline booster station (No change with 3 units of existing pumps plus one standby) *Jhang Branch Canal pump station (3 units of new pumps plus one standby) b, Transmission main *Existing transmission main (No change) *New transmission main (1,000mm dia. x 13 km)
Economic comparison	a. Construction cost Less than Plan "B" (plus – replacement of exist. pumps minus- new transmission main) b. O/M cost Larger than Plan "B" (plus – Increase of electrical cost due to high power of replaced pumps at the inline booster pump station. Electrical cost of new pumps in Jhang Branch Canal pump station is the same as Plan "B".)	a. Construction cost Higher than Plan "A" (plus- installation of new transmission main 1,000mm x 13km) b. O/M cost Considerably less than Plan "B" (Yearly difference in costs of Plans "A" and "B" amounts to about Rs 10 million.

If the project life is assumed to be 40 years, Plan "B" becomes more economical than Plan "A" due to the difference in the electrical costs. As a conclusion, the study proposes transmission by separate lines.

ii. Improvement of Existing Distribution system

As described in the previous section 2-1-1 "Scope of Cooperation", the study plans to improve the existing distribution system through the project to exert a maximum effect of the augmentation of water supply.

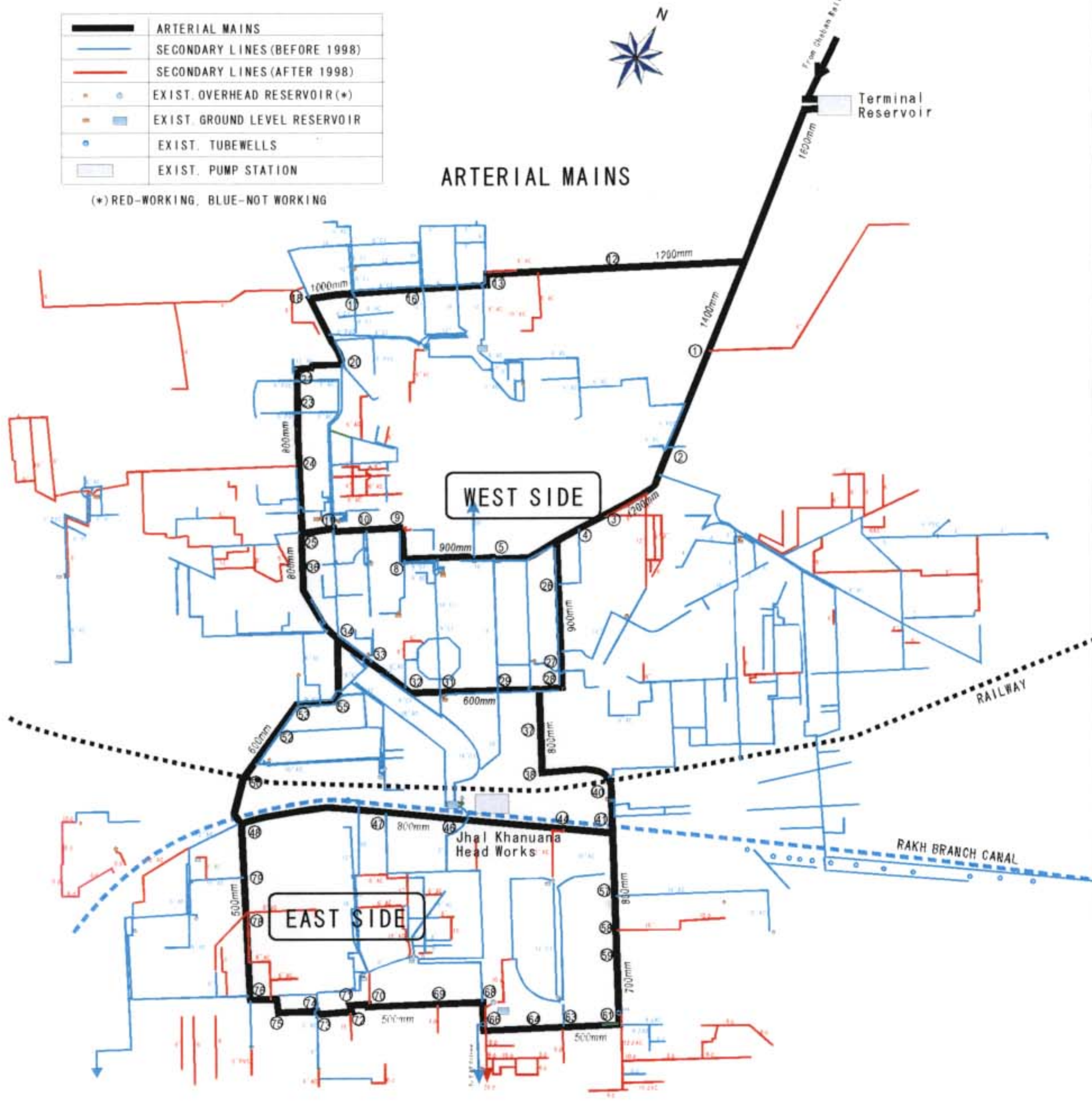
a. Existing distribution system

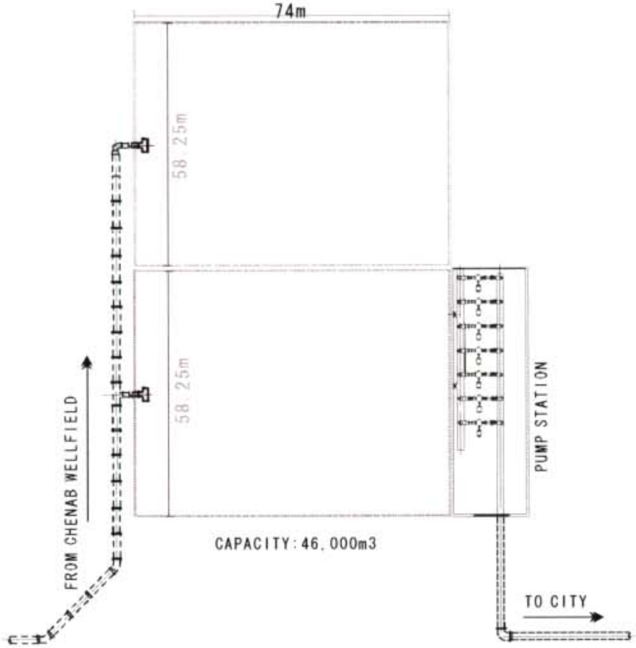
The existing distribution system in the city is comprised of the following three components as shown in Fig. 2-2.

* Terminal Reservoir (hereafter called "T/R"), which is located in the northwestern suburbs of the city. It receives water from the existing Chenab wellfield. It was constructed under Phase I.
* Arterial Mains, which distribute water from T/R to the city. It also receives supply from the treatment plant at Jhal Khanuwana Head Works and existing tubewells along the Rakh Branch Canal within the city. The total length of this trunk main is about 49 km with the sizes ranging from 1,600mm to 500mm. They were constructed under Phase I.
* Storage facilities, secondary distribution lines and house connections
  There are 38 overhead and ground reservoirs as storage facilities, most of which were constructed by the government before Phase I. After the completion of Phase I, those located close to T/R have been out of use, since pressure in arterial mains is adequate for direct supply to consumers, while areas remote from T/R suffer lack of proper pressure through the arterial mains and depend upon the supply from overhead tanks.

b. Current service condition

* Supply with pumps from T/R is restricted to three times a day, each for a period of 1 to 2 hours due to acute shortages of water.
* Each time supply starts, its larger part is concentratedly consumed in the west side of the city close to T/R (refer to Fig. 2-2). As a result, water pressure drops by the time it reaches the east side remote from T/R. During the supply hours, pressure in the arterial mains through the latter is only 0.5 kg/cm^2, and further drops nearly to 0 by the time supply reaches households in that area.
* While pumps are idle, water in T/R flows by gravity through arterial mains, since T/R is located a couple of meters higher than the city area. The total volume of this gravity supply amounts to $4{,}000m^3/hr$. However, pressure in the arterial mains in the east side remains zero during idling periods.
* For consumers in the east side, current water service is thus far from satisfying A greater part of them rely upon purchased water for drinking and refuses to pay tariff.





TERMINAL RESERVOIR

FIG. 2-2

EXIST. DISTRIBUTION SYSTEM

c. Measures for improvement

It is feared that the unbalanced service condition could not be much improved even after water supply is augmented by this project, although it can increase share in the east side to a certain extent. The matter was discussed with WASA during the second stage of the study, which proposed its own idea as follows: (Refer to Appendix 4-2 "Technical Note.)

* WASA's main station in the east side is in Jhal Khanuana Headwork where a treatment plant of slow sand filtration system, although deteriorated, is still on duty. The construction of a reservoir of large capacity with a pumping station can effectively improve distribution within the east side.

* The existing arterial mains cover major parts of the city. However, since the respective loops are of larger size, most of pressure tends to be lost towards the end of loops. To improve the situation, the installation of additional sections to the arterial mains is anticipated to help to keep pressure loss to a minimum level. (The proposed sections are shown in Fig. 2-3. WASA's first priority is on Section (1) in the map.)

As a result of the examination of WASA's proposal through the study, the basic policy for Japanese assistance is to adopt a cost-effective plan for improvement of arterial mains, since the reinforcement of Jhal Khanuwana Headwork is inconsistent with the purpose of the project to augment the water source.

According to the network analysis, Section (1) in WASA's proposal is the most effective for improvement. Since the east side was in focus for improvement, another additional line, Section 4, will increase the effect, doubling the present pressure of 0.5 kg/cm^2. Accordingly this project plans to install two sections, Sections (1) and (4) about 6 km in total.

(2) Policy for natural condition

Water supply in this project for Faisalabad with a population of about 2 million utilizes mainly groundwater as its water source like provincial capital, Lahore, with a population of 5 million. For the city this source is rich in quantity and good in quality, and has an advantage over any other types of sources in that it can be served only with chlorination, making the cost by far less. This ample source is mainly produced through recharge of artificial canals as one of specific features in a

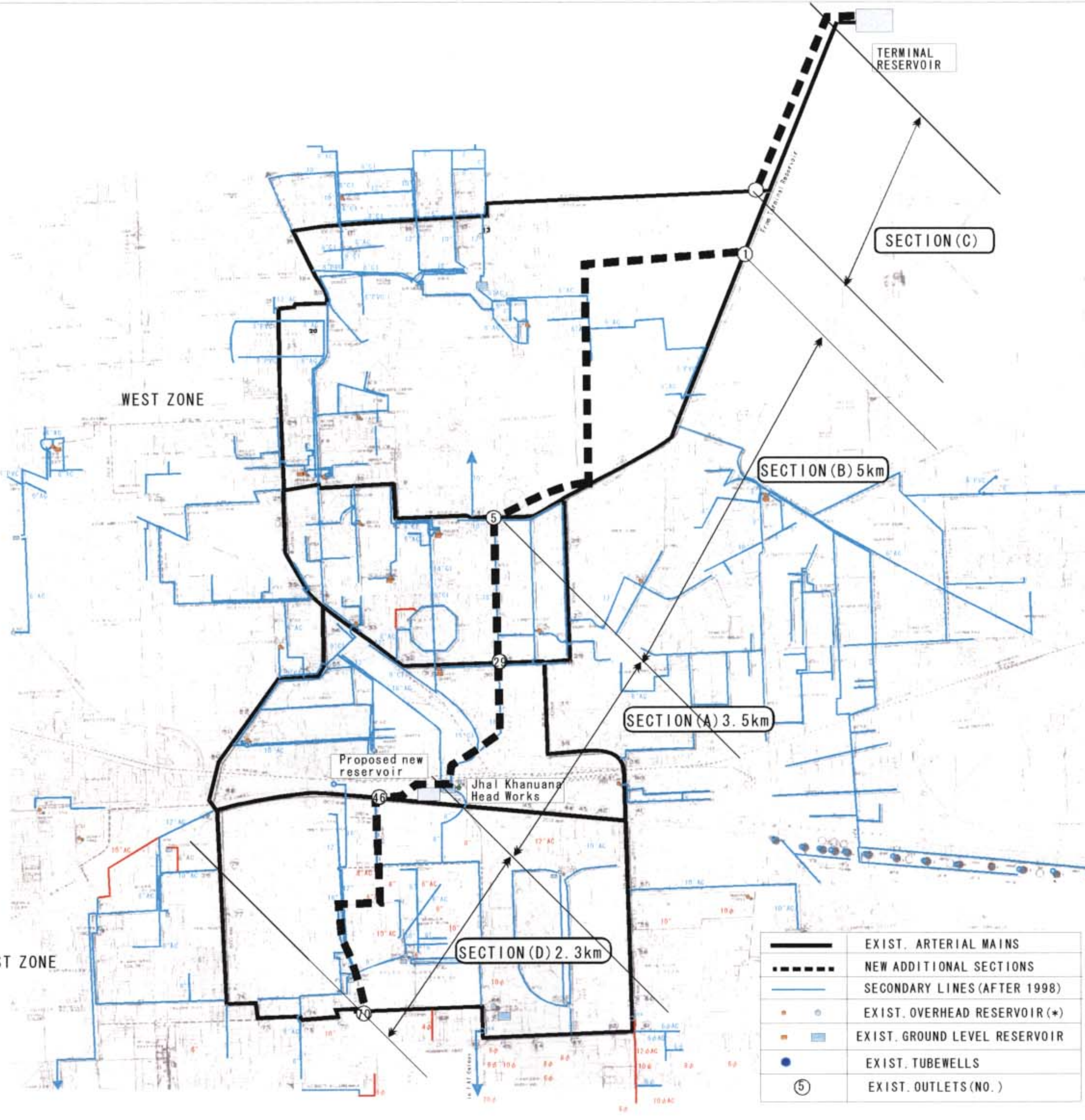


FIG. 2-3

PROPOSED IMPROVEMENT OF EXISTING NETWORK vast tract of Indus plain where agriculture is thriving thanks to widespread network of canals.

Since the planned wellfield for this project lies in a belt-like zone close to the Jhang Branch Canal, production from tubewells in the site can be guaranteed. The number of tubewells and the spacing between them

The policy for design for the layout of planned tubewells, therefore, pays respect to the recharge of the canal. Major elements, such the numbers of tubewells to ensure the targeted discharge, their spacing are decided, based upon the test results of the canal infiltration, which have been made available through the efforts by WASA.

Since these factors are closely related to groundwater level, which has been a focus among concerned villages, a unit discharge rate from one tubewell is to be decided within an allowable range of recharge from the canal to keep the fall of groundwater level to a minimum level.

(3) Policy for socio-economic condition

The project site where groundwater development is planned is one of typical agricultural areas in the Punjab province, which took shape through colonization after the network of canals from the Indus system was installed during the British reign in the latter part of the 19th century. Although agriculture in Indus plain has mainly been relying upon canals, canal water distribution is said to be basically inadequate. For such a reason, the combined use of canal water and groundwater from tubewells has lately gained force. In fact irrigation tubewells abound in the project site. According to the survey by WASA, there is one such tubewell in 1 km^2 of the area surrounding the wellfield on average. The development of groundwater in such an area crowded with existing tubewells necessitates due consideration to regional agriculture.

One of such measures is the design for the wellfield and tubewells, based upon the test results of the canal infiltration as explained in the foregoing section 3). Notwithstanding the detailed hydrogeological analysis of the study alarms risk of probable fall of regional groundwater level on a medium to long term basis. Therefore, the study recommends WASA to take the following actions:

a. WASA will put into practice an appropriate monitoring programme of groundwater level and quality in the region from the onset of the operation of its tubewells to examine any change in these factors for assessment of influence.

b. WASA will work out appropriate measures including compensation for management of real risk of occurrence of influence against to which villages in the surroundings have been alarmed. (WASA considers a critical range of fall of level is 3 m, more or less.)

c. WASA will hold public meetings involving all the stakeholders around the wellfield to provide them with necessary information and ensure their agreement through discussions.

(These measures were agreed between both parties during this study, and WASA is now examining possible measures for compensation such as increase of canal water distribution.)

(4) Policy for local contractors/products

This project will be implemented, employing locally produced basic materials for civil and architectural works such as cement. Moreover, since the country now produces high-quality industrial products that can be employed for the project such as pumps and piping materials as a result of efforts for industrialization promoted by the government policy, suitable materials and equipment are expected to be selected from the local market.

The preceding project, Phase I, was accomplished by local contractors selected as a result of the international tenders. With Faisalabad located close to the provincial capital, Lahore, the market in this economic zone is ready to provide qualified and capable contractors for drilling, civil and architectural works. For successful implementation of the project, the employment of local contractors is highly recommended.

(5) Policy for grade of facilities and equipment

All the facilities and equipment comprising the planned water supply system in this project are of similar typed and graded to those installed under the preceding project of Phase I, which have satisfactorily been operated and maintained by WASA since 1992. This policy will ensure consistency of the combined operation of the existing and the new systems by WASA.

The study found all the existing pumps for tubewells and pump stations properly functioning for intended operation. (The existing tubewell pumps are of vertical shaft type locally manufactured with license of a European maker, while those for the pump stations are of double-suction volute type of Japanese make.) Similar types of pumps are proposed for this project as well.

The existing and the newly completed systems can be operated independently until T/R, to which all water from the existing and the new wellfields is transmitted and then pumped out to the arterial mains for distribution to the city with the existing and the new pumps simultaneously working. Parallel operation of pumps transforms the performance of the pumps into a combined one. Difficulty arises here in adapting pump operation to fluctuating demand of consumers, and the existing pumps have been unable to function properly due to extremely concentrated consumption during supply hours. It is feared that the simultaneous operation of the existing and new pumps may risk a similar malfunctioning since the trend in city's consumption is unknown and appears difficult to control. In order to minimize such a risk, the pumps to be installed under the project are to be equipped with a manual speed control of the electric motors. The proposed control system is a liquid control device. Since the preceding project employed a similar control system of mechanical type for motors with the inline booster pumps, WASA has already experiences with this type of control for its operation and maintenance, and is supposed to adapt it to a new system without difficulty.

(6) Policy for Implementation Schedule

The respective facilities composing this project are all large-sized and function as a whole, not separately, for efficient and effective water supply. In this view, although Japan's grant aid system is executed on a single fiscal-year basis, it becomes necessary to plan the construction of all the facilities in full turn-key basis over several years. However, its one part for the improvement of the existing network, can be undertaken separately from the main work. within a single year. This consideration leads to a conclusion for the schedule of project implementation to divide into two phases as follows:

a. First phase: Works for the improvement of the existing network
b. Second phase: Main works of the project from the construction of water sources to the facilities for the terminal reservoir.

2-2-2 Basic Plan

2-2-2-1 Water source planning

(1) Hydrogeological study for the project

1) Objectives

The study for groundwater development was performed for collecting relevant information and data on the following elements for water sources planning:

a. Optimum rate of discharge from one tubewell
b. Drawdown at a design rate of discharge
c. Layout of group tubewells
d, Extent of influence of pumping at group tubewells to the surrounding area
e. Prospect on regional groundwater level lowering
f. Groundwater quality at the planned tubewells

2) Components of the Study

The groundwater development study consisted of the following components:

Table 2-4 List of Components of the Study for Groundwater Development

	Components	Study period	Contents	Reference in report
1	Hydrogeological study	1st & 2nd stages	includes inspection of more than 100 existing tubewells	
2	Geophysical survey	2nd stage	Surface relative resistivity survey at 24 points along the canal	2-2-1-2 (3) Appendix 5-3
3.	Test drilling	2nd stage	Test well (150 m x 1 No.) Observation well (120m x 2 Nos)	2-2-1-2 (4) Appendix 5-4
4.	Aquifer test	2nd stage	A series of pumping tests were undertaken at the test well and 2 observation wells plus 3 observation wells provided by WASA	2-2-1-2-(5) Appendix 5-6

5	Water analysis	1st & 2nd stages	Field test by the study team and analysis by WASA Laboratory	2-2-1-2 (6) Appendix 5-11

WASA and the study team agreed that the results of the former studies in the area should be referred to. The studies include the following ones:

a. Study by WAPDA in 1960s
b. Study by Binnie and Partners in 1975
c. Study by Republican Engineering Co. (hereafter called "REC") in 1981

Further it was agreed between both sides that the results of seepage test undertaken by WASA in 2003 for the project should be closely examined. (Fig. 2-4 shows the locations of the survey areas in these studies including the one for the present study.)

3) Outline of the study results

The details of each component of the study are described in appendices. Important findings were as follows:

a. Geophysical survey

*. The survey was made at 24 stations to a depth of 200m in the planned wellfield along the left side of the Jhang Branch Canal. According to the analysis of the survey results, the subsurface geological section to a depth of 200m is largely divided into 3 groups, among which the second section appears the main aquifer of the area.

* The survey results tell that a basic drilling depth in the well field is 160m on average. The exact depths of the respective tubewells should be confirmed during the detailed design stage by the geophysical study at the very points decided for drilling.

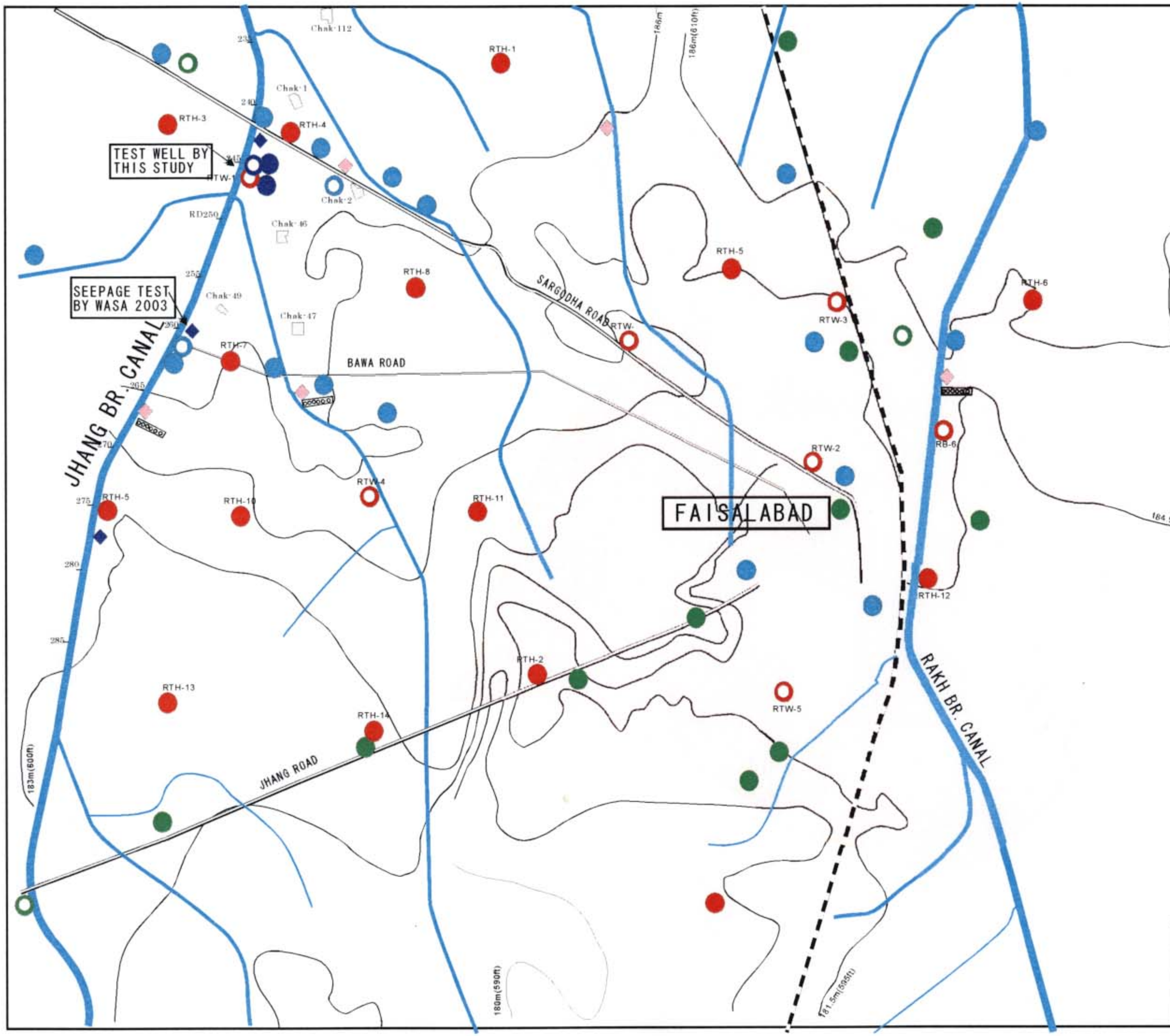


FIG. 2-4
SITE INVESTIGATION MAP

* Details are described in Appendix.

b. Test drilling

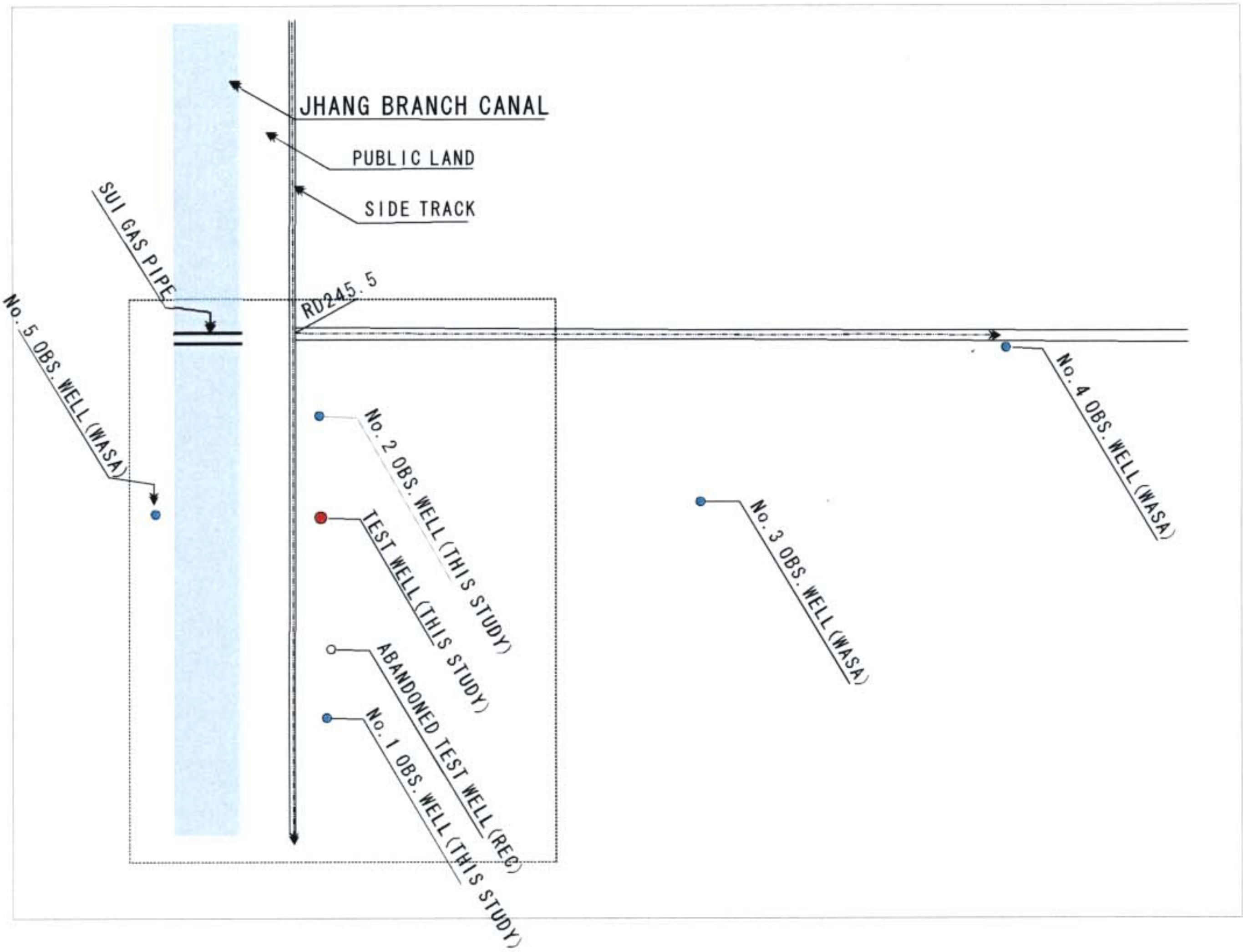
* The locations of the test well with observation wells are shown in Fig. 2-5
* The geological section and the structure of the test well installed under the study are shown in Fig. 2-6.
* Particulars of the test drilling programme are described in Appendix.

c. Aquifer test

* The water levels at the test well and observation wells were stabilized in about 360 minutes ater pumping started during testing due to apparently forced recharge from the Jhang Branch Canal.
* The analysis of the test results indicates that pumping at the planned tubewells would hardly affect groundwater level in the surroundings thanks to constant recharge from the canal, provided that an appropriate unit discharge rate is employed, with adequate spacing set between tubewells. During the closure of the canal in winter season when no recharge occurs, however, the level tends to gradually fall down, and eventually is likely to affect the surroundings on the medium to long term basis.

c. The test results are described in detail in the following section (2), with further details appearing in Appendix 5-6.

FIG. 2-5 TEST DRILLING SITE ALONG JHANG BRANCH CANAL



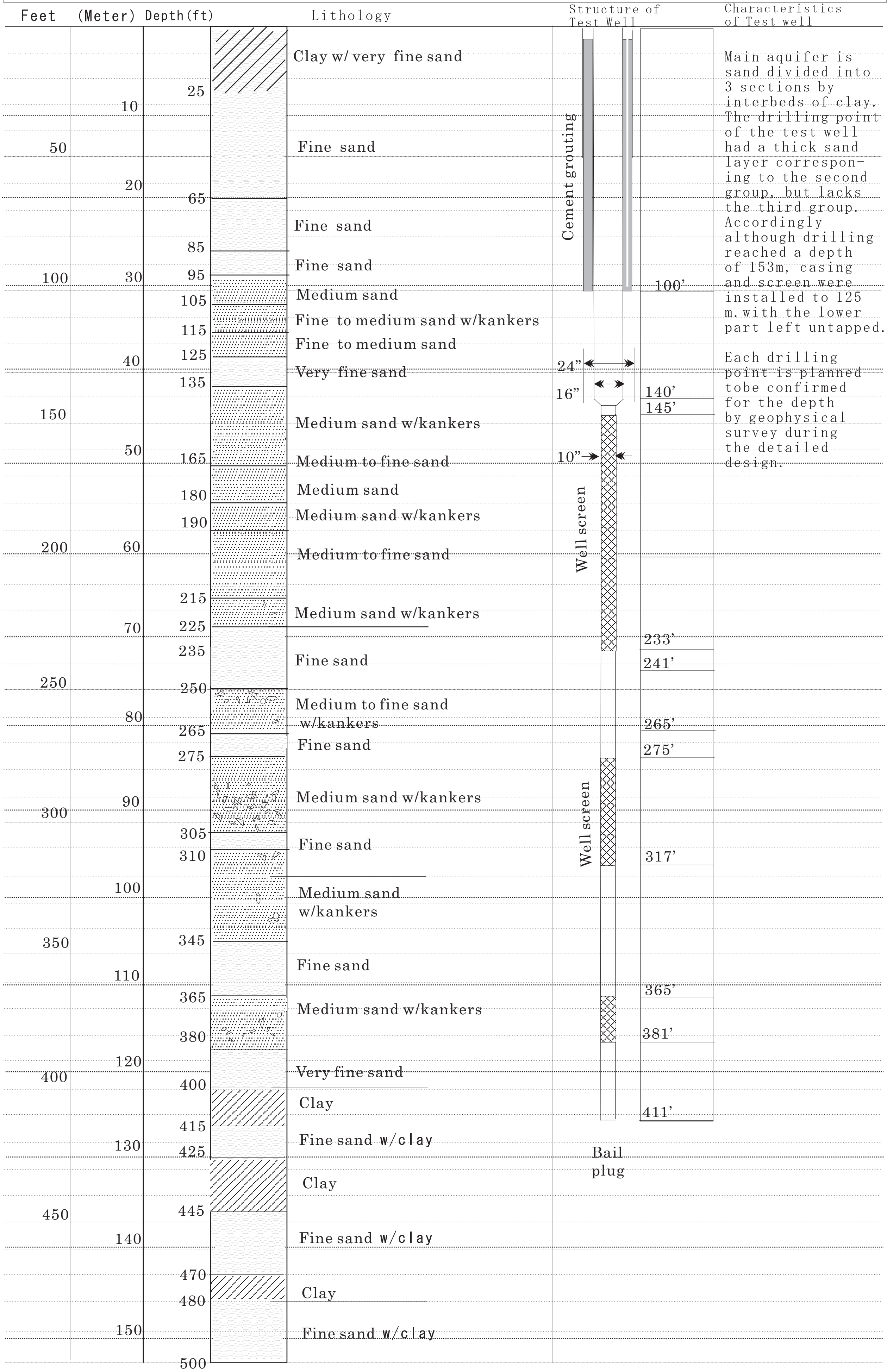
DRILLING SITE FOR THIS STUDY

Drilling machine is working for test well drilling. The tripod behind is for observation well No. 2.

The green belt on the left is the left bank of the canal.

Fig. 2-6 STRUCTURE OF THE TEST WELL FOR B/D STUDY

Well No. Test well (2003)	Construction Date: 4 - 09 -2003 ～ 07 - 09 - 2003	
S. W. L.= 5.4 m	Q = 3 cusec (=300 m3/hr)	

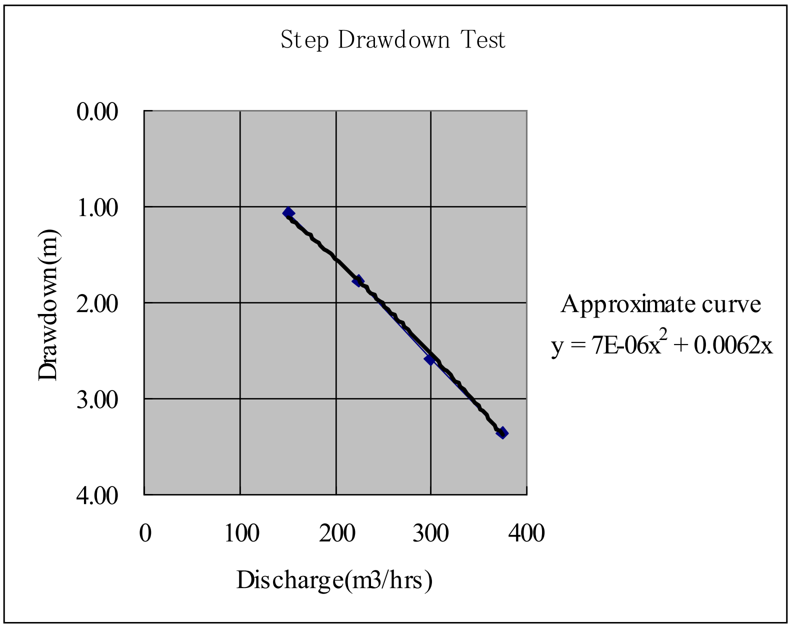


(2) Water sources planning

1) Discharge

REC, which conducted an extensive survey for groundwater development from the Jhang Branch Canal to the city, recommended a discharge of one tubewell to be within a range of 2 to 4 cusec. During the step drawdown test in this study, 4 incremental discharges within the said range were employed to examine an optimum rate. The results indicating the respective discharge rates versus drawdown are plotted in the following graph:

Fig. 2-7 Step drawdown graph



A plotted curve on log-log graph is almost straight without any abrupt change in its gradient, indicating that the ratio of drawdown to discharge is nearly proportional to each other. While any discharge keeps such a proportional relation with drawdown, it is defined as “safe yield”, and can be pumped without risking eventual depletion of the source. The results of the step drawdown test justifies REC’s former estimate of a unit discharge rate, ranging from 2 cusec to 4 cusec.

For the determination of a unit rate of discharge per well, the following conditions were taken into account:

a. The pumping water level at a tubewell gradually recovers to its initial static water level after pumping is stopped, depending upon the condition of recharge to the aquifer. In this study, it took about 6 hours for the test well pumped at a constant rate of 3 cusec to restore its initial level. It is not economical to idle 20 or more wells for 6 hours a day.

b. The existing tubewells in the Chenab wellfield discharge 4 cusec from one well. The daily idling is 4 hours. The continuous operation under these conditions has resulted in ever-increasing lowering of groundwater level in the wellfield and its vicinity.

c. From the experiences so far, the unit rate for the project is proposed to be less than 3 cusec. As for the idling period, 4 hours are proposed since the duration has been in WASA's ongoing practice. The rate to meet such requirements is 2 cusec (approximately 2 m^3/hr). Although the recovery time to the initial level was not exactly confirmed through the test, it is estimated to be close to 4 hours.

2) Number of tubewells

a. Calculation of the number of tubewells

The factors to determine the required number of tubewells are as follows:

* Targeted total discharge	91,000m^3/day
* Unit rate of discharge from one well	200 m^3/hr/well (approx. 2cusec)
* Duration of pumping a day	20 hours/well (4-hour idling)

Based upon these factors,
the required number of tubewells is:

91,000 (m^3/day) ／ (200 (m^3/hr) x 20 (hrs)) = <u>22.75 (say 23) wells</u>

In addition, standby tubewells are required for maintenance and repair. If 10% of the total number is assumed, it is 2 wells. As a result, the required number of tubewells totals "25".

3) Distance between adjacent tubewells

i.. Estimate of seepage

The tubewells for the project are to be installed in a belt-like wellfield along the left side of the Jhang Branch Canal where artificial recharge from seepage of the canal can be anticipated. If their total discharge is less than an amount of estimated seepage, their water level can recover to the initial one during a proper idling period after it once lowered during pumping. A cycle of pumping and idling can maintain the regional groundwater level.

For the project WASA examined a range of seepage to the proposed wellfield along the canal in 2003. The past study by REC for the area also included this type of test. The results are shown in the following table:

Table 2-5 Results of Seepage Tests along the Jhang Branch Canal

<table>
<tr><th></th><th>Client</th><th>Tested by:</th><th>Year</th><th>Estimated seepage rate</th></tr>
<tr><td>1</td><td>FDA/REC</td><td rowspan="2">Irrigation Research Institute</td><td>1981</td><td>633 m^3/hr/km (of channel) =15,192 m^3/day/km</td></tr>
<tr><td>2</td><td>WASA</td><td>2003</td><td>437m^3/hr/km (of channel) =10,488 m^3/day/km</td></tr>
<tr><td>3</td><td colspan="2"></td><td>Average</td><td>535m^3/hr/km (of channel) =12,840 m^3/day/km</td></tr>
</table>

Seepage tests are likely to result in a wide range of differences in the estimated rates, depending upon methodologies employed, physical properties of tested channels, etc. Therefore, an average rate of the two tests is employed for this project. The rate can function as an index for the discharge of groundwater along the canal.

ii. Discharge of tubewells for irrigation

The existing tubewells for irrigation in and around the wellfield have been utilizing groundwater deriving from seepage. The amount of their discharge is estimated as follows:

a. According to the field survey by WASA for the project, there are 108 tubewells existing in an area about 20 km long and 3 km wide along the canal including the site for the proposed wellfield.

b. An average discharge from a tubewell is estimated as 1 cusec (102m^3/hr), based upon the practice of drilling for irrigation wells and capacities of pumps.

c. Their running hours are normally 10 hours daily. In addition, during two months in the rainy season every year, most of them are closed. This practice leads to an average operating ratio of 40%.

d. An approximate total discharge of 108 tubewells are estimated as follows:

- Daily discharge along a section of 1 km of the canal
  = ((108 wells) x (102 m^3/hr/well) x 24 hours x 0.4)／ (20km) =5,287 m^3/day/km

The total estimated discharge of irrigation tubewells accounts for about 40% of an average seepage rate of 12,840.

iii. Distances of proposed tubewells

Based upon the results of the foregoing estimate, the spacing between 2 tubewells for 23 regularly in operation is calculated as follows:

a. Total amount of seepage a day available for groundwater discharge in the area
(It is assumed 90% of the estimated seepage can be utilized for the purpose.)
= 12,840 x 0.9 =11,556 m^3/day/km

b. Total amount of seepage a day allowable for groundwater discharge by the proposed tubewells
= (a) − (discharge by irrigation wells) = 11,556 − 5,287 = 6,269 m^3/day/km

c. Daily discharge rate of one tubewell for the project
= 200 m^3/hr x 20 hrs/day = 4,000 m^3/day

d. Length of the canal that can recharge the discharge rate (c)
= (c) ／ (d) = 638m

As a result of this estimate, a distance between two wells should be <u>600 m</u> as a minimum requirement. The total distance of the wellfield with 25 tubewells along the canal is, therefore,

(25−1) x 0.6m = 14.4 km.

The major parameters for planning water sources for the project, defined in the foregoing estimates, are summarized in the following table.

Table 2-6 Major Parameters for Water Source Planning

	Parameters	Target
1.	Planned daily maximum discharge	91,000 m^3/day
2.	Planned daily discharge／one well	200 m^3/hr =4,000 m^3/day
3.	Total number of tubewells	23 + 2 as standby
4.	Daily running hours	20 hrs/day
5.	Distance between 2 wells in the well-field along the canal	600 m

4) Examination of Level Lowering and Extent of Influence

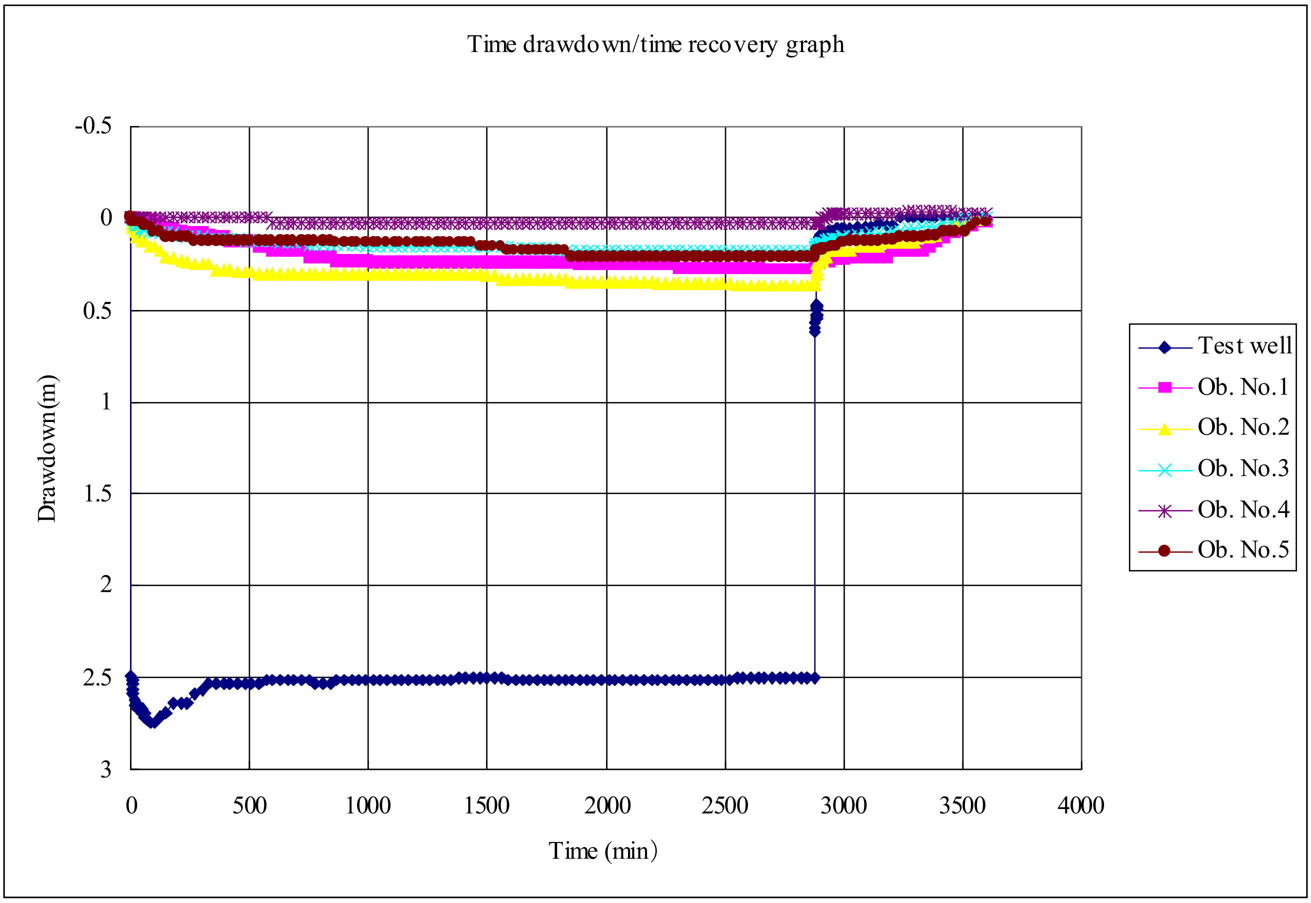
An extensive farming area spreads south of the Jhang Branch Canal, growing mainly sugar cane with delivery of canal water, together with groundwater discharge from private tubewells for irrigation. Since the operation of proposed tubewells on completion of the project has been feared by the local communities to affect their tubewells, lowering regional groundwater level, the extent of their influence is examined as follows:

i.. Results of the time drawdown test

Drawdown at tubewells by pumping and its influence on their vicinity can be estimated by hydraulic calculation and graphical analyses, employing the values of “T” and “S” produced through the analysis of the results of time drawdown test.

The time drawdown test for this study was carried out at a constant discharge rate of 3 cusec (about 300m^3/hr) for successive 48 hours, and was followed by the time recovery test after pumping stopped to confirm the recovery of levels. The members for the test consisted of one test well and five observation wells where the changes of water levels were measured simultaneously at predetermined intervals of time. The results of the time drawdown test are shown in Fig. 2-8, with drawdown on vertical axis and elapsed time of pumping on horizontal axis.

Fig. 2-8 Time drawdown/time recovery graph



The plotted graph shows specific features of the test as follows:

a. The static water level at the test well was 5.334m before starting pumping. In about 360 minutes after pumping started, the level stabilized at 7.83m, without any further drawdown until the end of pumping in 2,880 minutes. The thus stabilized level indicates the occurrence of direct recharge from the nearby canal

b. The water levels at 5 observation wells lowered little by little as pumping proceeded. All of them reached stabilization in 300 minutes after pumping at the test well started.

c. The drawdown at No. 4 observation well at a maximum distance of 357m from the test well was recorded as 20mm at the end of 48-hour successive pumping at the test well. The location of this well and beyond seemed to undergo no substantial influence by pumping at the test well.

d. The recovery of the level at the test well to the static water level took 6 hours after pumping stopped, while those at 5 observation wells, more or less 10 to 12 hours.

ii. Calculation of Coefficients of Aquifer

As described in the foregoing section, the test well seems to have received recharge from the canal during a greater part of its pumping period. The data consisting of stabilized level for most part offers no significant information on the features of aquifer function. The analysis, therefore, mainly depended upon the data before substantial recharge occurred, using the relation of drawdown to time and distances of the test well and 5 observation wells. The process of calculation for the coefficients of the aquifer "T" and "S" are referred to Appendix. The results are summarized in the following table, together with reference to the data obtained through the past studies covering the same area and its vicinity.

Table 2-7 List of Coefficients of Aquifer in the Study Area

Test wells	Method for calculation	Coefficient of Transmissibility, "T" (m^2/day)	Coefficient of Storage "S" (non dimentional)
This study (one test well & 5 observation wells)	*Distance-drawdown analysis(1) of 5 observation wells	15,686	3.22E−0.2
	*Distance-drawdown analysis(2) of one test well/5 observation wells	2,840	3.88E−0.2
	*Recovery method (No. 2 well)	13,071	8.47E−0.3
	*Recovery method (No. 3 well)	24,674	1.40E−0.2
Study by REC	*Recovery method (RTW1 well)	5,312	2.50E−0.2
	*Recovery method (RTW2 well)	7,080	1.27E−0.2
ADB tubewells in the Chenab	*Pumping test (No. 18 well)	11,094	
	*Recovery method (No. 18 well)	9,861	

Note: The data for the ADB tubewells is from the report of completion of drilling works. The coefficient of storage is not calculated. The report shows that an average value of "T" from the pumping tests at 23 tubewells was 12,000m^3 /day.

The calculated values of T and S in this study differ widely, probably due to intensive influence of direct recharge from the canal. However, in comparison to those in the previous studies, they are interpreted to fall within an acceptable range.

iii. Prediction of extent of influence

Using the values of "T" and "S" thus obtained and the relation of distance from the test well to the observation wells with drawdown, the extent of influence of pumping at the proposed tubewells was examined. The detailed process of calculation is shown in Appendix. The summary of the analysis is described as follows:

a. The tubebwells are to be installed at intervals of 600m along the canal. Interference among the tubewells occur in case the influence of pumping at one well extends beyond a radius of 300m. The hydraulic analysis predicts that the radius of influence remains within a radius of that limit during 20 hours of daily pumping at a well, thanks to constant recharge from the canal which equals discharge. Accordingly pumping at the proposed tubewells will not exert any adverse influence on surrounding tubewells for irrigation.

b. All canals are closed every year for about one month for their maintenance and repairing works. During this period, they have no delivery from the headwork, and there is no recharge from them. As a result, water level at pumping wells continues to lower with a larger rate of drawdown than during the normal period. The influence of pumping can extend beyond the radius of 300m. At the end of closure in about one month, the radius of influence is likely to extend to 2.5 km at the minimum from pumping wells and as far as 5 km in the worst case, depending upon the values of T and S. Influence of a middle range between the minimum and the maximum is likely to occur in the actual scene.

c. The amounts of lowering of level are predicted, based upon the assumption described in the foregoing section as follows:

*In case of the minimum influence:

The radius of influence reaches 2.5 km from pumping wells.

Groundwater level at a distance of 730m from wells is calculated to lower by 0.25m after 30 days of canal closure.

*In the worst case

The radius of influence will enlarge to a distance of 5,000m from pumping wells. Groundwater level at a distance of 1,500m from wells is to lower by 0.25m after 30 days of canal closure.

d. To make the matter worse, lowering of level is likely to be almost doubled due to interference between two adjacent pumping wells, since the influence from each well extends beyond the limit of 300m.

If influence of a middle range of two extremes is assumed, such effect of influence will result in lowering of groundwater level by 0.5m at a distance of 1.3 km from the wells.

e. Once groundwater level is thus lowered, it will not be able to return to the former one even after the canals restart delivery, since it was assumed to utilize seepage to its full extent for discharge of existing tubewells for irrigation as well as for the project. The lowered level will probably persist, and the closure of canals each year will further deepen the level. This assumption leads to a prediction that within 5 years after the tubewells for the project starts the operation, groundwater level at a distance of 1 km from them will be 1 m deeper than the initial one.

f. There is another risk of influence from 28 tubewells in the Chenab wellfield, where groundwater level has continuously been lowering for the past 10 years. This study included the estimate of their influence to the wellfield along the Jhang Branch Canal. The analysis indicates the influence soon reaches this area and that within 10 years will lower the level in this area by 2 to 3 meters. The details are referred to Appendix.

iv. Groundwater Monitoring Program

The hydraulic analysis indicates regional groundwater level will probably be affected by the operation of the tubewells for the project, and within a couple of years after the commencement of operation a part of tubewells for irrigation close to the project wells may face difficulty in pumping.

However, since the prediction of this study is based upon the results of aquifer test at a single tubewell, it goes without saying its accuracy is in a limited extent. It is recommended, therefore, that WASA establish a properly constructed monitoring system and launch measurements of level at its own tubewells as well as at monitoring stations with reference to the following remarks.

a. Monitoring wells should comply with WASA's standard design. (The design is shown in Appendix)
b. Monitoring wells should be installed along three lines, one at a distance of 500m from the canal, the other at 1,000m, and another 2000 to 3000m. Each line should have 5 monitoring wells at the minimum.
c. The tubewells for the project should be subject to daily measurements of static water level and the dynamic one at the respective wells just before pumps are stopped. Discharges should also be recorded by flow meters installed in the respective stations.
d. Measurements of levels at the monitoring wells should be undertaken by operators at the nearby tubewell stations. During one month after pumping from the tubewells starts, levels at the monitoring wells along a line of 500 m distance should be measured in particular as frequently as practicable, at the intervals of 30 minutes to 1 hour or the like. If influence tends to expand more than expected, such measurements should be extended to those along a line of 1,000m. After one month, measurements at monitoring wells may be taken at a less frequency, say several times a day.

If laborious monitoring is continued for one year after commissioning, the data for predicting precisely the extent and size of influence of pumping wells could be collected, at least for the period when canals continues to deliver water.

During the period of canal closure, the extent of measurements at monitoring wells may expand to a line of 2,000 to 3,000km.

It is further recommended that WASA should develop friendly relations with local communities for risk management concerning the security of regional groundwater through the establishment of a liaison committee consisting of representatives of stakeholders in the area including those from WASA and local administration. Representatives from concerned villages should be responsible for preparing the inventory of tubewells in their areas and regularly reporting their conditions. The committee could intervene when any conflict arises among stakeholders.

5) Water Quality

Water quality in the study area extending about 30 km long from the left bank of the Chenab to Faisalabad was examined in detail by the previous studies. Its features are reported to be as follows:

a. Groundwater quality is good to fair in an area along the Chenab where fresh deposits continues to the bedrock at a depth of about 180 to 200m, with its content of TDS ranging from 500 to 1,000 mg/lit.

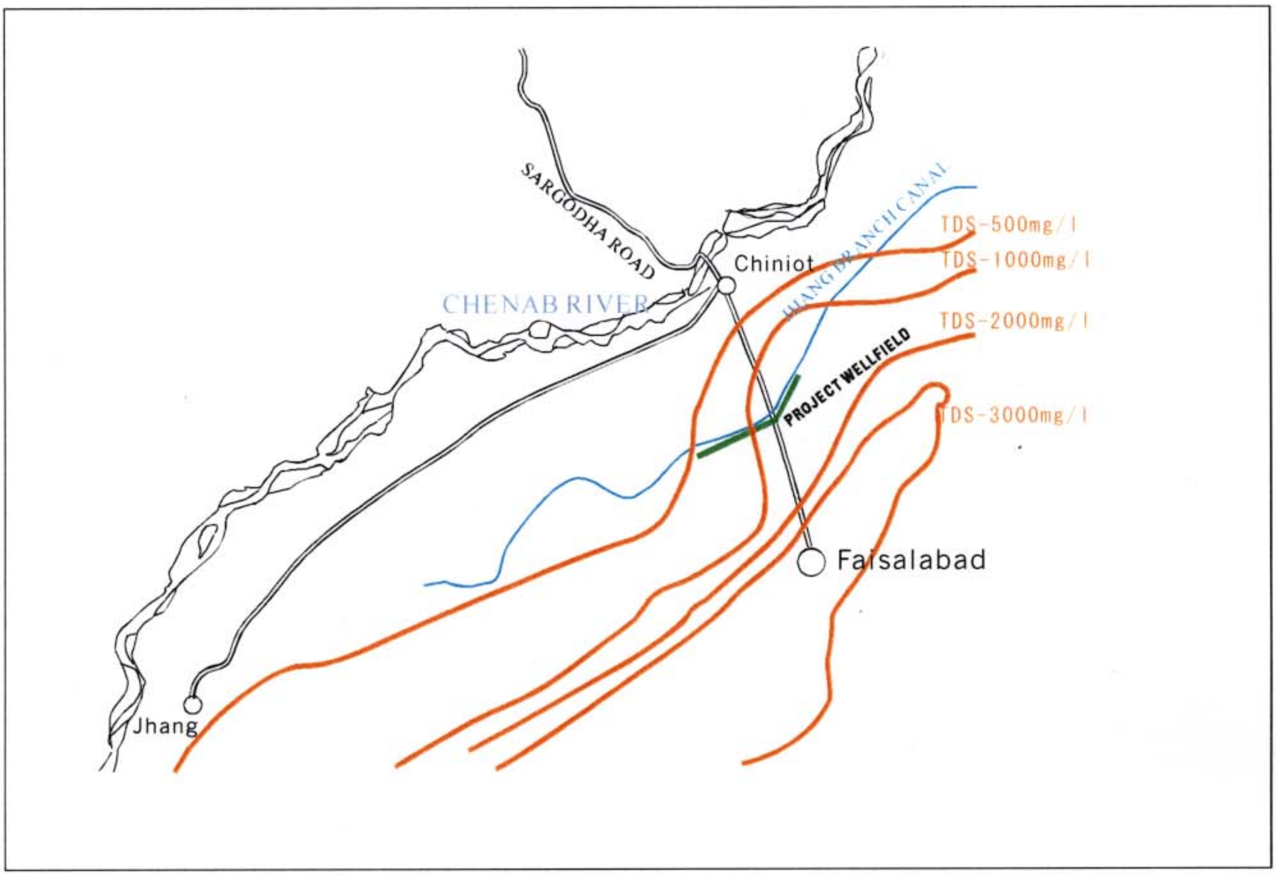
b. Discharge from WASA's existing tubewells in the Chenab wellfield has maintained good quality with its TDS at a level of more or less 500 mg/lit since their commissioning in 1992. The Chenab wellfield is located where one of old channels of the Chenab runs with fresh deposits continuing towards the present course of the stream.

c. On the contrary, quality tends to get deteriorated in the direction towards the city, where older deposits with an increasing content of salt become predominant. Moreover shallow groundwater there has entirely been contaminated artificially.

d. The city keeps one exceptional wellfield along the Rakh Branch Canal where groundwater with good quality can be secured. Fresh water with its TDS ranging from 500 to 1,000 mg/lit occurs in lenses in a belt-like zone along both sides of the canal, thanks to seepage of the canal. WASA presently operates about 20 tubewells in this wellfield, after it rehabilitated old ones that had one time amounted to as many as 50 in number.

e. The isograms of TDS in the study area as the results of the previous study are shown in Fig. 2-9 for reference.

During the first and the second stages of this study, water quality of existing tubewells was extensively examined. A part of samples were analyzed by WASA Laboratory. Appendix shows the results of water analysis on the field as well as by the laboratory of tubewells for irrigation, together with data for WASA's Chenab tubewells.



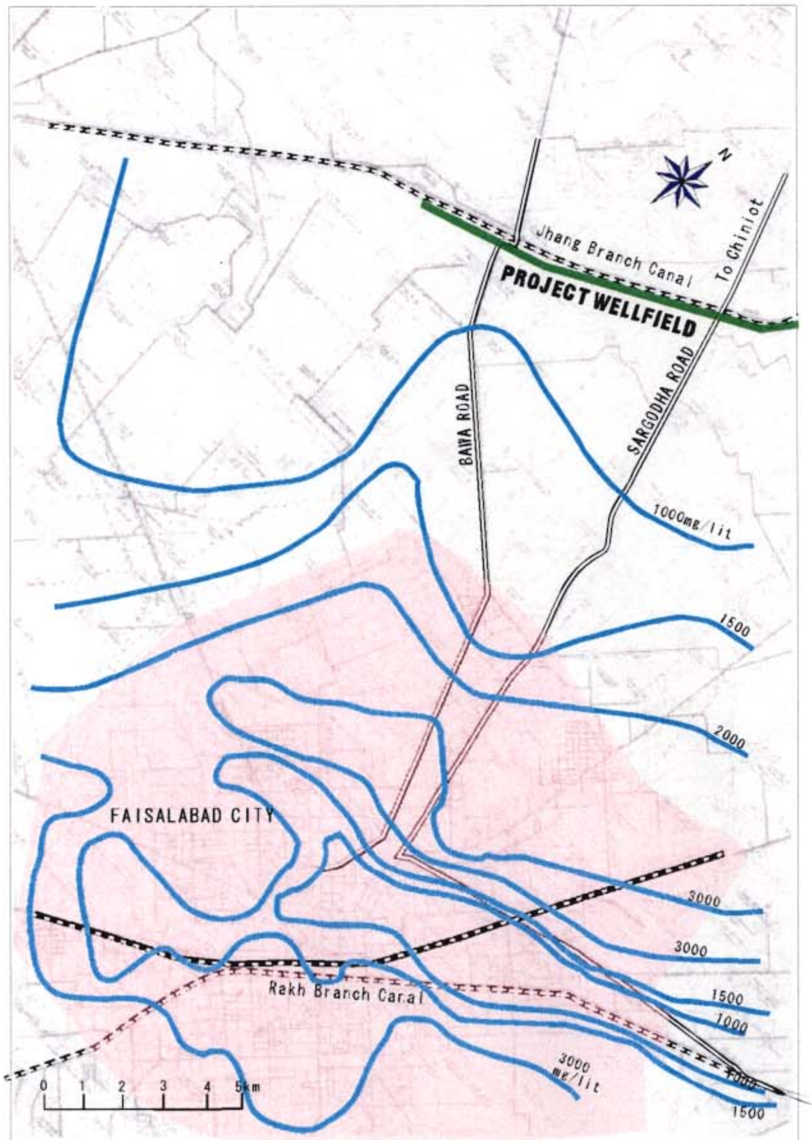


FIG.2-9

TDS ISOGRAMS BY THE PAST STUDIES

TOP:
TDS Isograms in 1993 by the World Bank's Master Plan

LEFT:
TDS Isograms in 1981 by the Republic Engineering Corporation

To examine water quality at the tubewells for the project, samples were taken from the test well at the end of time drawdown test during the second stage of the study. The results analyzed by WASA labolatory is shown in Table 2-8, together with data of tubewells for irrigation existing within a distance of 100m from the wellfield. All the data indicates the occurrence of groundwater with good quality in the proposed wellfield.

Good quality can be guaranteed through ample seepage from the canal as is the case with the city's wellfield along the Rakh Branch Canal. The area around the Jhang Branch Canal is considered to have been a periphery zone of the old river course of the Chenab, where fresh deposits prevails, leading to good quality of groundwater occuring in them. This geological features of this wellfield differ from that along the Rakh Branch Canal where old deposits with deteriorated quality of groundwater dominates. However, in order to maintain good quality, periodical monitoring will required for quality as well as groundwater level.

Fig. 2-10 shows the isograms of TDS in the study area, based upon the results of water analysis on site and by WASA laboratory through the first and second stages of the study. Compared to the previous maps in 1970s and 1980s shown in Fig. 2-9, the deterioration of groundwater quality is now in progress.

The World Bank's master plan anticipated good quality could be preserved in the reach of the Chenab, and assigned the area for another wellfield. According to this study, however, quality is worsening in villages just beside the left bank of the Chenab, at least in shallow groundwater, probably due to discharge of raw sewage from Chiniot City with a population of 250,000 to a channel running along the left bank of the Chenab

To the south of the proposed wellfield are many villages of large scale, each with a population close to 10,000. Daily life and active farming in these villages have resulted in artificial contamination of shallow groundwater in the surrounding areas through discharge of large quantities of waste water.

Particularly all domestic sewage and waste water flow into lower land within villages, creating a large pond of waste storage. Such a situation seems to highly contribute to the progressive deterioration of groundwater quality, with its TDS rising to an extraordinary higher range than that in the surrounding area. (In Fig. 2-10, tubewells No. 2, No.3, No. 34 and No. 112 are typical examples.)

Table 2-8 Water Analysis for the Test Well and Tubewells in Its Vicinity

		Period of analysis	T ℃	pH	EC μM/cm	Turbi-dity NTU	TDS mg/ℓ	Ca mg/ℓ	Mg mg/ℓ	Total hardness mg/ℓ	Cl mg/ℓ	Total iron mg/ℓ	Total Nitrogen mg/ℓ	NO3 mg/ℓ	NO4 mg/ℓ	P mg/ℓ	SO4 mg/ℓ
1	Test well (101)	Sep. 2003	24.0	7.80	230	1.5	480	24	10	100	36.0	0	0	0	0	0	0
2	Exist. Tubewell (102)	Dec. 2002	22.3	7.91	260	0	194	32	41	244	29.7	-	0	0	0	0	-
3	Exist Tubewell (103)	Aug. 2003	23.2	8.30	247	0	200	54	26	240	50	-	0	0	0	0.04	-
4	Canal water (for reference)	Aug. 2003 at time of sampling at No.3 well	27.9		160												

Remarks
1) For the locations of the wells with a number, refer to the map in Fig. 2-10.
2)Temperature and EC were measured on site at time of sampling.
3) Samples from the test well were analyzed at an official laboratory in Lahore.
4) Samples from irrigation wells (102 &103) were analyzed by WASA laboratory.

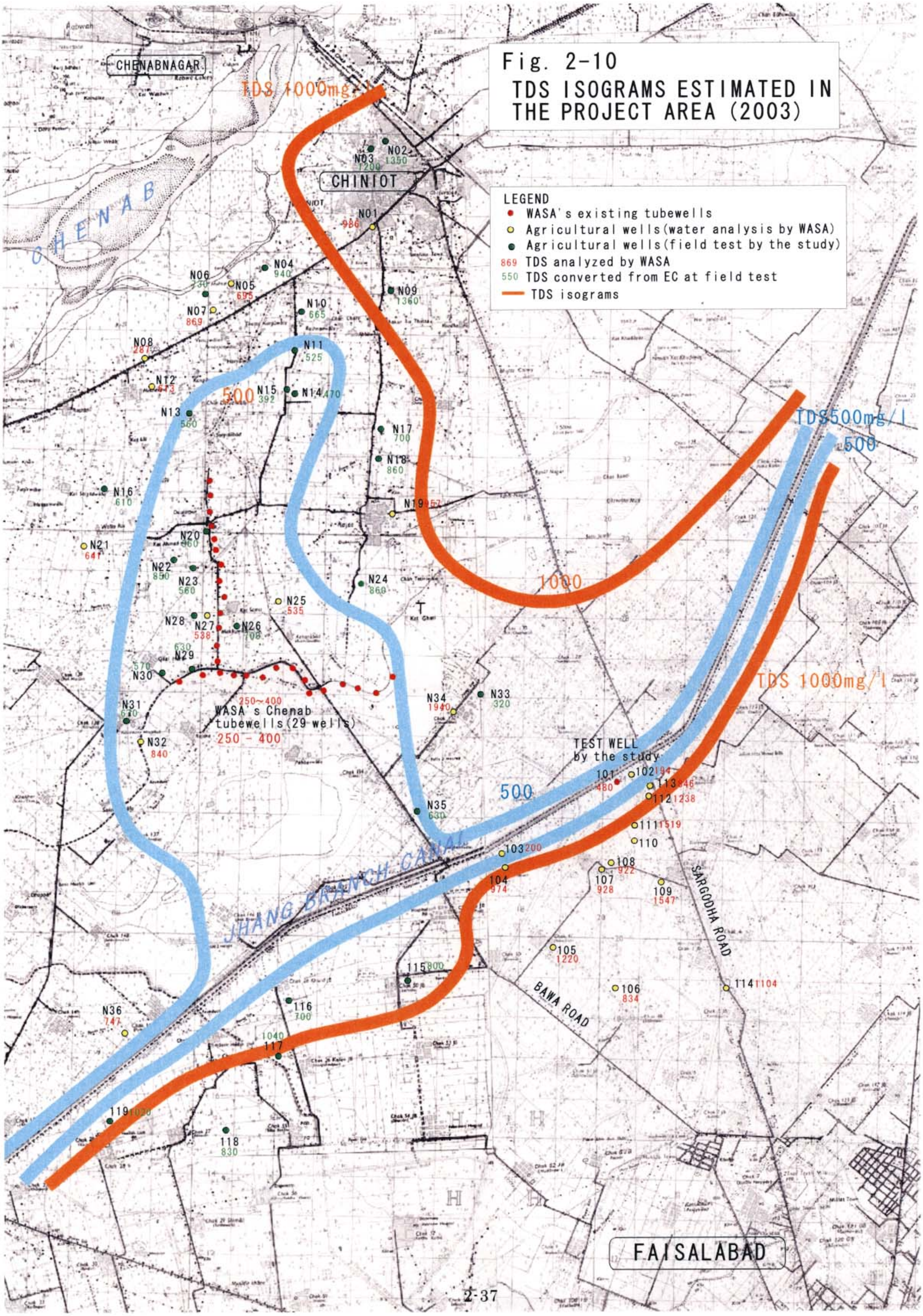


Fig. 2-10 TDS ISOGRAMS ESTIMATED IN THE PROJECT AREA (2003)

The study also examined the influence of fertilizers in groundwater. Samples were tested in Japan. The analysis shows groundwater is still free from contamination by fertilizers. However, precaution is necessary for protecting against chemical contamination.

In such environment, while the wellfield along the Jhang Branch Canal may continue to secure good quality thanks to seepage from the canal, shallow groundwater in and around villages, which is main source of domestic water, seems to be increasingly contaminated. As a result, the area is really in need of measures for protecting its environment.

2-2-2-2 Water Supply Planning

(1) Characteristics of the Project Area

The population of Faisalabad in Punjab Province was 1.1 million in 1981. According to the Census conducted in 1998 it has now grown to 2 million, thus becoming the third largest city in Pakistan behind Karachi and Lahore. The population growth ratio during this period was as high as 3.7%. Since the motorway "Route M3" was lately linked to M2 connecting Provincial capital of Lahore and national capital of Islamabad in 2003, it is highly probable that the growth rate will further rise. Faisalabad in the past served as a regional agricultural center of Punjab, but in recent years textile industry has flourished and it has now grown to be one of major industrial cities in Pakistan.

Through the reform of local administration in 2002, the District of Faisalabad, in which the city is located, was reorganized into 1 city and 4 sub-districts called "*Tehsil*". On that occasion, the administrative area of the city was defined as approx. 130 km^2, and was divided into 106 Union Councils, each composing a unit of constituency for elections. Tehsil Faisalabad is in charge of the city's administration, while Faisalabad Development Authority (FDA) operates the development program for the city, with water supply and sewerage under responsibility of one of its wings, Water and Sanitation Agency, Faisalabad (WASA).

The main source of the existing water system is the tubewells in the Chenab wellfield about 20km northwest of the city, and the water pumped there is transmitted via a booster pump station to the Terminal Reservoir (hereinafter called as "T/R"), situated in the northwestern suburbs of the city. The water is then supplied to the city through arterial mains extending toward the east to southeast side of the city. However, they remain yet to cover the whole area, although a greater part of the city has been urbanized. Even in this limited service area the shortage of water supply has recently been acute, and as the population in the city further increases, the situation will be aggravated.

The service area is divided into two main zones, the west and the east sides, by the Rakh Branch Canal and the railway penetrating through the city A larger part of the east side, covering one-third of the whole city, remains yet to be served Fig. 2-1 shows the zoning of 106 Union Councils within the city, together with the layout of arterial mains and outlets along them. The colored zones indicate WASA's service area, with secondary distribution lines and service lines to households. The characteristic conditions of water supply in the east and west sides are outlined in the following table:

Table 2-9 Water Supply Conditions in Faisalabad

Area	Characteristics	Area	Characteristics
West side	There is a base for city's water supply, "T/R", in this area. The water supply condition is fairly good during 6 hours of pump operation a day (average water pressure of the main pipeline is above 1.0kg/cm^2) in this area, except for the city center congested with shops and small factories.	East side	The area is separated from the west side by the railway and the Rakh Branch Canal. Since this area is far away from T/R, water pressure through the loop of arterial mains drops there to 0.5kg/cm^2 at the maximum. Distribution in this area, therefore, utilizes overhead tanks, contrary to direct distribution from the arterial mains in the West side. The waters from Jhal Kanuana Plant and the Rhak Branch Canal wellfield are fed into the mains in this area to supplement shortage, but not enough. Alongside the Rakh Branch Canal in this area are relatively large factories, but most of them make use of their own tubewells for their industrial water.
Northern part	With the University of Agriculture occupying an area of 2,000 ha and a lot of public institutions, the area is characterized by large land space. The water supply conditions are fairly good. Since there are many residential areas under development, demand is expected to rise.	Northern part	A greater part of residents in this area are of middle to upper classes. Overhead tanks function to cover low water pressure in the distribution system. Further to the east along the fringe of the distribution network remain some unsupplied areas.

		The northernmost area forms the fringe of the western service area, and the water is supplied via overhead tanks. The newly developed area of Milat town is an independent service area supplied from a treatment plant of canal water with a slow filtration method.			
	South-ern part : (City center)	Commercial center of the city, crowded with shops, family industries and small residential houses. A part of the area suffers shortage of water supply. In the south a new residential area is emerging.		South-ern part	Poor service condition is prevailing in this area, densely populated with many small houses at the fringe of the service area. Supply is from overhead tanks only due to low pressure along the arterial mains in this area. A large area remains yet to be served.

(2) Examination of the Basic Factors for Water Supply Planning

1) Population

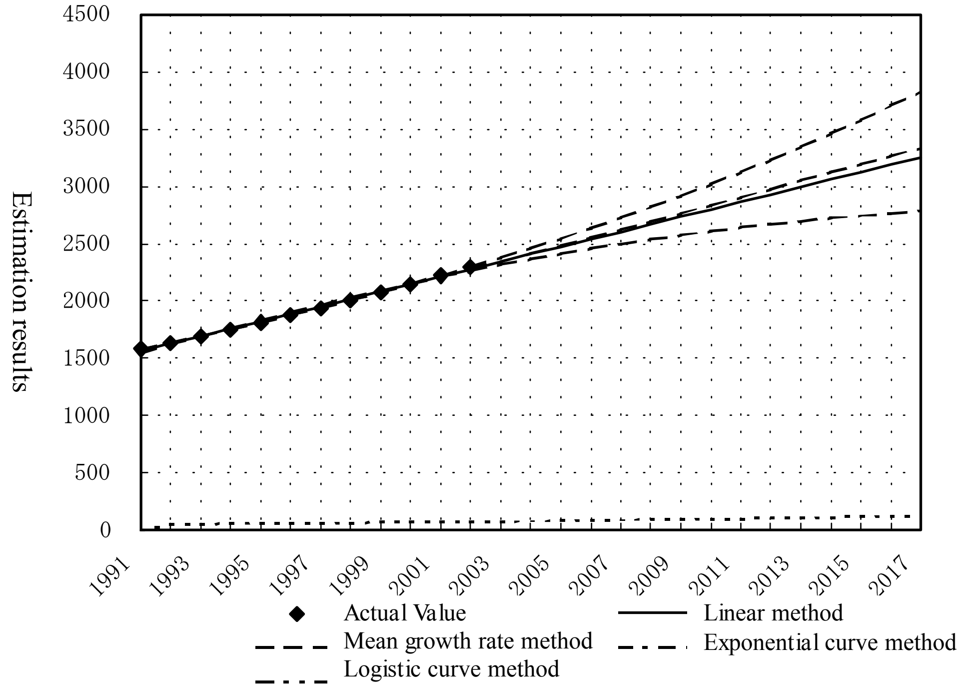
The national census in 1998 indicated that the population of Faisalabad city reached 1,997million in that year. Based on the past statistical data, the future population of Faisalabad was projected for the study using four estimation formulas. The results of four estimates are plotted in Fig. 2-11 for graphical comparison. Among them, the values calculated with the "mean increase number method" (linear method) show an intermediate range, and is considered to provide a suitable basis for the study. Assuming this forecast, the population of the city is estimated to reach 2.6million by 2008.

Table 2-10 Past (actual) and future (estimation) population of Faisalabad

(1,000people)

year	Actual						Estimated		
	1981 (census)	1991 (census)	1995	1998 (census)	2000	2001	2006	2008	2010
Projected Population	1,104	1,583	1,875	1,997	2,020	2,200	2,490	2,607	2,724

Fig. 2-11 Administrative District Population (thousands)



The detailed data for population forecast is shown in Annex 5-11.

2) Water sources

Upon the completion of this project, the discharge of water sources will increase by 91,000m^3/day compared to the current quantity. The present status of the discharges of the existing water sources is reported as follows:

a. Chenab Wellfield

In the ADB project Phase I, completed in 1992, 25 tubewells were constructed in the Chenab wellfield. In 2000, WASA added 4 more in their own effort and began their operation. (However, the pumping facilities were not installed for 1 tubewell, making the number of wells in actual operation to 28)

The design discharge rate from this wellfield was 225,000m^3/day. As a result of this study, the actual rate in recent years was found to have been in a range of

180,000m^3/day at the maximum, with the daily average being around 160,000m^3/day, even though the maximum daily discharge had once registered 200,000m^3/day in the first quarter of 2001 immediately after 4 more tubewells were added. The decrease in the discharge stems from (a) decrease of the number of running wells a day because of maintenance works and/or breakdown of equipment (mainly electrical), and (b) decrease in duration of the daily operation by about 20%.

The study found also that while the discharge rate has been getting less, the water levels at the tubewells were steadily going down. Continued pumping at the design rate would have aggravated drawdown in the wellfield and its vicinity expanding the extent of influence in the surroundings.

Taking the current conditions of this source into account, this study assumes that the latest level of the discharge rate from the Chenab wellfield can be maintained by WASA for the foreseeable future without further decrease.

b. Rakh Branch Canal wellfield

Until the completion of the Chenab wellfield, the water supply for the city entirely relied on the tubewells constructed alongside the Rakh Branch Canal running across tthe east side of the city. In the early 1990s the number of wells alongside had totaled more than 50. Tubewells concentrated in this zone since the quality of groundwater along the narrow strip along the canal was acceptable, contrary to the ones in other areas within the city where TDS was well over 2,000mg/lit, unacceptable for drinking mainly due to salinity. The city's wellfiled thus had been overly developed.

The World Bank master plan suggested to limit the total discharge in this strip to a range of the seepage amount from the canal to preserve proper quality and quantity. In compliance with this recommendation, WASA rehabilitated the existing tubewells by 2001. As a result, old and new tubewells of 19 in total are presently in operation in this strip. The design discharge of this source is 1 cusec

(=102m^3/hour) for each tubewell. The respective tubewells serve independently to their surrounding areas., and their operation hours vary, depending upon the targeted areas. On the average, the total discharge from this wellfield is now around 50% of the quantity developable estimated by the World Bank study.

c. Jhal Khanuana water treatment plant

The Jhal Khanuana water treatment plant, situated in the central part of the east side, on the left bank of the Rakh Branch Canal, withdraws the canal water, and feed it to the arterial mains after processing it through slow filtration. Although the design capacity is 17,000m^3/day, it decreased in the recent years to about one-third due to deterioration of facilities. To supplement its current capacity, of this, WASA is combining the filtered water with the water from the tubewells in the plant site. The average production rate at the plant is now about 5,000m^3/day.

d. Millat Town water treatment plant

The treatment method is slow filtration just like Jhal Khanuwana plant, and withdraws surface water from one of the distributaries of Jhan Branch Canal located away from the city. It produces about 5,000m^3/day. This treatment plant independently supplies water to the new residential area of Millat Town.

The total production from these water sources is currently about 230,000m^3/day. The summary is listed in the table below.

Table 2-11 Existing Water Sources

Water source	Production rate(m^3/d)			Supply area	Remarks
Year	1993 (WB MP)	1998 (JICA B/D)	2001 (This survey)		
Chenab wellfield	225,000	205,000	200,000 (max. daily intake)	The whole city	Originally 25 wells 4 new wells added 28 wells in operation (The new wells installed in the year 2000)
Rakh Branch Canal wellfield	*83,008 (note)	20,200	20,000	Mainly for the east side	100m^3/hour/well commenced 2002

Jhal Kanuana water treatment plant (incl. 2 wells)	*17,000	6,800	5,000	Central part, east side	Rakh Branch Canal Withdrawal of the canal water and filtration
Milat town treatment plant (independent supply unit)	—	—	5,000	Northern part, western unit	Jhan Branch Canal Withdrawal of the canal water and filtration
Total Productin	325,000	232,000	230,000		

(*) note : The design production rate of the Rakh Branch Canal in the World Bank's master plan, estimated through the review of the results of the seepage test of the canal (However, the actual production rate has been limited to the present level due to land problems and water quality). The water treatment capacity of Jhal Khanuana plant is also based on the initial design capacity.

3) Water service rate and served population

WASA charges for its service on a fixed tariff system based on the sizes of the properties in a similar manner to those in other major cities of the country. All the households in the city are without water meters. Accurate water consumption, therefore, remains unknown. Furthermore accurate data for served population is not available. In 1992 the World Bank conducted a household survey of 5,400 for its task of revising the master plan for the city's water service, and estimated the water coverage at 60%. On the other hand, the consumer survey conducted about the same time by FDA for 16,000 households reported it was about 50%.

To examine the current coverage rate for this study, WASA recommended to estimate it by calculating the extent of its service area where secondary distribution lines and house connections have already been installed. The calculated service area based upon the data provided by WASA accounts for about 50% of the city's entire administrative area. Since pipelines were installed mainly in the populous area, the ratio of the citizens living in the service area to the entire population of the city is likely to be more than the ratio of the two areas thus compared. This study assumes 10% for a rate of additional population, taking into account various factors affecting the estimate such as the ongoing daily water supply rate, average per capita daily consumption, etc. Consequently the estimated coverage rate of

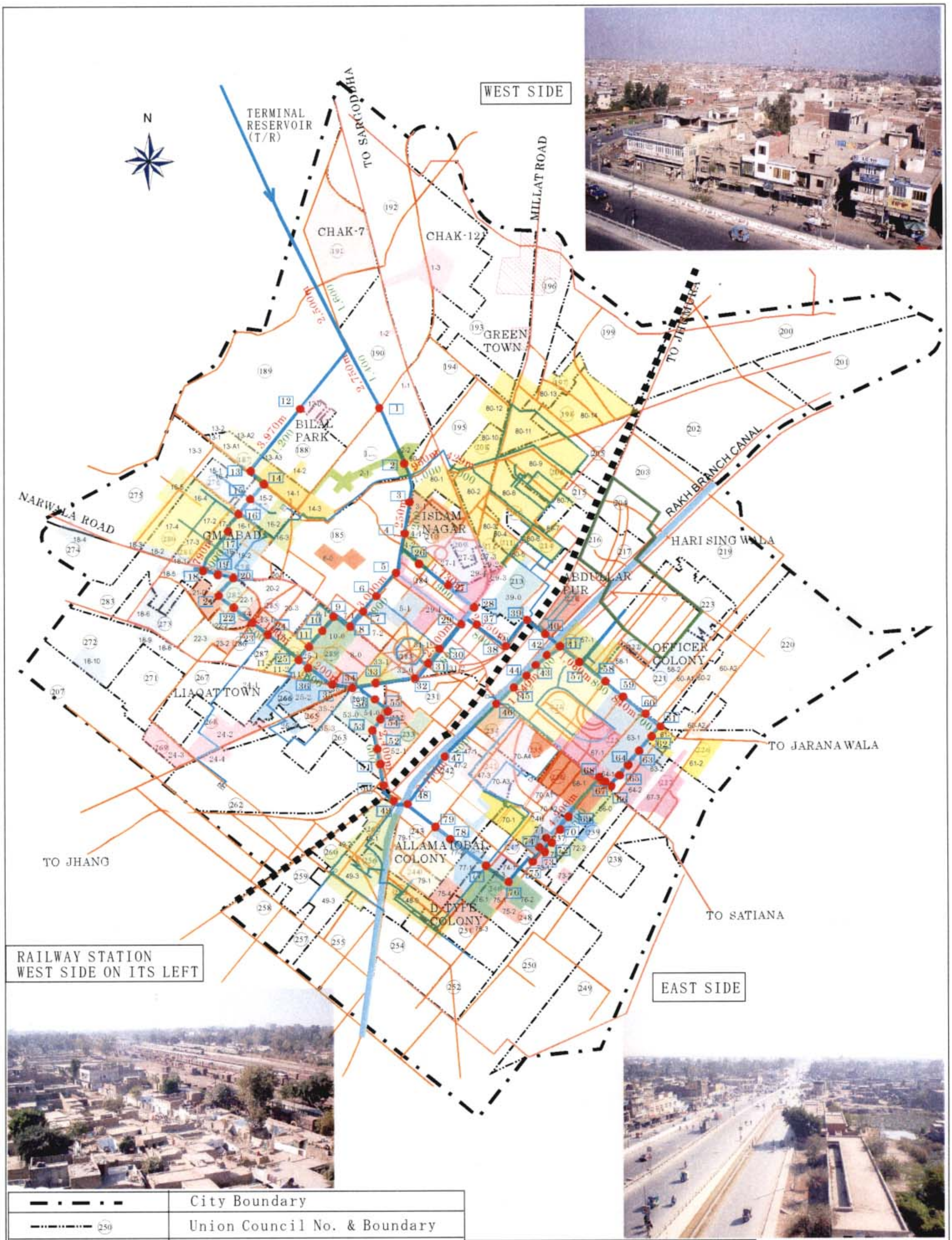


FIG. 2-12

WASA'S SERVICE AREA

WASA's water service is 55%. (WASA' s service area is indicated in Fig. 2-12). Since the estimated population of Faisalabad is now 2.3million (2003), the current served present population is 1.265 million, taking a rate thus estimated. In future the prospect of enhanced water supply through this project is likely to invite more new customers than in the past at a rate of 1 % annually. According to this assumption, at the time of completion of this project in 2008, the water coverage rate can rise to 60%, with the served population increasing to 1.554 million among the entire population of 2.59 million.

According to the results of 1998 national census, the number of households in the city was 279 thousand with the average number of family members at 7.1. On the other hand the number of the households connected to the water service in 2002 was 98 thousand, indicating the water service coverage accounted for only 35% of the total households. The reasons for the difference are not clear, but one of guesses is that more than one household are illegally connected to single service lines. Connections of this type may be widespread, since unregistered households need not pay the fixed rate of water tariff to be charged upon their property sizes. Although the number of house connections can provide useful information for estimating the water coverage rate, the current figure of registered connections cannot tell the real situation in Faisalabad. It is strongly recommended to WASA, therefore, to survey the conditions of current service connections for collecting the exact data on the actual situation of its water service. When WASA moves to shift its fixed water tariff to the metered one, such data is indispensable for planning an effective method for execution.

The number of water supply connections is shown as a reference in the table below:

Table 2-12 Number of connections (February 2002)

Type		Number of connections
Households		98,000
Industrial	Industrial	90
	Commercial	1,700
Total		100,000

WASA classifies the categories of consumers usage into (a) Household use, (b) Industrial use and (c) Commercial use. The industrial use is the one by large consumers such as factories, public institutions, banks, hospitals and schools. The number of consumers in this category was 78 in December 2002. The commercial use is for consumers with 1/4" diameter pipes (same as households), and the number of connections was about 850 during the same period. WASA estimates that the consumption of these two categories accounts for about 15 % of the total. The study was made to examine the actual situation, based upon WASA's computerized billing log as follows:

a. Industrial use

According to the billing record of December 2002, the monthly consumption of this type is estimated at 250,000m^3/month. The number of connections was 78, all of them large consumers such as top textile plants, public institutions, banks, hospitals and hotels. The 21 users among them were paying the bills for metered volumes, which accounted for a greater part of charges in this category. The remaining users were charged on the assumed volumes of consumption determined by WASA in its tariff system, depending upon the diameters of their connections. They are paying for the consumed amounts of water, but the rates of consumption are fixed.

b. Commercial use

All the users in this category are served with unmetered connections of the same diameter, 1/4"as domestic users, but their tariff rate is about 4 times higher than that for the latter, since they are assumed to consume more. There are 850 users in this category, but without meters, the amount of consumption is only a guess.. Assuming the daily consumption of one connection to be 2 m^3, the monthly consumption from 850 connections is 51,000 m^3 in total.

The total consumption in the two categories amounts to 310,000 m^3 per month, indicating that their average daily consumptions are around 10,000 m^3. The estimated consumption rate corresponds to around 6% of the total water supply rate, but this share needs some adjustment because the data based for this estimation is of December 2002, namely the increase on demand in summer time and data correction. Thus it is assumed that about 10% of the total effective water supply is consumed for the industrial and commercial usage.

As WASA gives priority to the general public in its inadequate supply condition, most of the industrial users installed their own tubewells on their premises to secure necessary water. (The World Bank estimated in the Master Plan report, 1992.that 95% of industrial users had their own sources). However, the withdrawal of groundwater even from their own sources is not free. It is charged by WASA as "Aquifer Charges" set in its tariff system, and it is one of important sources of income for WASA. Although WASA is anxious to respond to the increasing demand in the industry as it can contribute to WASA's revenue with a tariff rate 3 times higher than that for domestic use, it is highly difficult to increase the share of this sector under the current level of water supply. As for the commercial use, since a great majority of uses in this category are engaged in family business of small scale, the average consumption rate is supposed to be in a similar level as that of domestic usage, both categories using the same connection size of 1/4". Accordingly the consumers in the commercial use may be treated together with ordinary domestic users in respect of demand.

As far as the present water supply continues, the increase of supply for the industrial sector will be frozen. Even after the supply rate increases in 2008, much cannot be expected for the sector if the public demand is prioritized, and dependency on private tubewells should be maintained.

4) Study on the supply rate

a. Actual daily supply rate

Based upon the operational records of WASA, the daily maximum supply rate during the last 2 years is estimated at 230,000 m^3 and the daily average supply at 210,000 m^3. (For reference, the production and supply logs of the Chenab system in December 2001 and June 2002 (in the first stage of this study) and logs of the supplies from T/R during June to August 2003 (the second stage of the study) are given in Appendix 5-13.)

b. Unaccounted-for water

The past studies such as the World Bank Master Plan estimated that there was about 30% loss of water supply in the system due to leakage, and based upon this estimate, WASA currently assumes the effective rate of water supply at 70%. The inspection of the existing pipelines within the city during this study tells that leakage rarely occurs in the arterial mains thanks to their relatively young age and good quality in material as well as workmanship. However, the distribution pipes from the secondary mains to service lines, which are a combination of recent and older installations, seemed to be leaky. Interviews to citizens in the east side of the city during the social survey for this study revealed that they had experiences with drinking water contaminated with sewage. The examination of the existing distribution pipes to collect data on the extent of defective sections is essentially necessary for improvement of the system leading to the effective usage of the ongoing and additional supplies.

During the discussions with WASA in this study, it expressed its policy to rehabilitate and reinforce the existing distribution pipes. If such a measure is undertaken, the effective water rate is anticipated to rise around 5% by 2008.

c. Average per capita daily supply

The actual average daily supply rate per capita including industrial and commercial uses is calculated as follows, using the current actual supply, served population and the effective ratio described in the foregoing sections.

(daily average water supply x effective ratio)／(current population x water coverage ratio) ＝ Daily average water supply per capita

(210,000m^3/day x 0.7)／(2.3 million x 0.55)) ＝ 107 lit/capita/day

Subtracting the estimated 10% of the industrial and commercial use results in the daily average supply per capita for household, as follows:

((daily average water supply x effective ratio)－(industrial and commercial use))／(current population x water coverage ratio) ＝ Daily average water supply per capita

((210,000 m^3/day x 0.7)x0.9)／(2.3 million x 0.55)) ＝ 96 lit/capita/day

The calculation indicates the current per capita average supply is in the level of around 100 liters per capita per day. The estimated level is quite low among the standards of other cities in Pakistan, which is 30gal (=135 liters) and more. This situation shows the acute shortage of water in the city.

d. Daily maximum supply rate

The water supply to the city has been restricted to 3 cycles of pump operation a day totaling 6 hours at the maximum so that the actual demand of consumers remains unknown. This situation makes it difficult to determine various factors for planning including a ratio for determining the daily maximum supply rate. As a measure to address the task, this study takes the present consumption pattern for reference, since the target of the project is now to urgently alleviate the current shortage of water in the city rather than undertake a plan targeted by the World Bank's master plan.

Assuming this policy, the load factor, which is the ratio of the daily maximum supply to the daily average supply, is obtained, based upon the recent performance in supply from T/R in December 2001 and June 2002 as shown in table 2-13.

Table 2-13 Typical actual water supply from T/R of recent years

	Date	Supply rate (m^3/day)
Average daily supply rate	Winter (Dec. 2001)	155,929
Average daily supply rate	Summer (June 2002)	159,737
Maximum daily supply rate	Dec. 8, 2001	178,500

The calculation is presented as follows:

(Daily maximum supply rate =180,000m^3/day)

／(Daily average supply rate=160,000 m^3/day)= 1.13

Although the calculated ratio seems to be in a lower range for the real demand of the city over a long term, the project employs it as reflecting the past and current consumption patterns of the city, taking into account the nature of this project to meet the urgent need.

e. Peak hour factor

The peak hour factor determines the design hourly maximum supply rate. It is again difficult to obtain the reliable range of this value as is the case with the daily maximum supply rate. Although the World Bank employed a ratio of 1.9 to the daily maximum supply rate, based upon the demand projection, this project prefers a ratio of 1.5, which is the standard level for cities of the same size as Faisalabad.

f. Design average daily water supply rate

In the early stage of water supply planning for the city, the ADB master plan in 1970s determined on 135 lit/day/capita as the average water supply rate in 2000 and the World Bank master plan, based on a consumption pattern survey conducted as part of the household survey, set the rate by income levels and proposed 135, 180, 320 lit/capita/day for low, middle and high income families respectively. The average rate across different income levels is 175 lit/capita/day. For the third largest city in the country, the supply standard given by the World Bank may be preferable. However, the real situation in supply is that only demand has been soaring with constantly increasing population as the plan of Phase II to augment water for the year 2000, proposed by the World Bank's master plan, was not realized. As a result, the shortage of water is now so acute that even the amount of supply augmented through the implementation of this project cannot meet the rates formerly proposed by the World Bank.

Table 2-15 shows the result of the projection of the water supply after the completion of this project, based upon the factors previously examined. According to this forecast, the per capita daily average supply rate will be 130 lit. in 2008, provided the industrial and commercial demand is kept at the present level, and presuming the water coverage rate will increase from the present 55% to 60%, Furthermore, in order to maintain this level as the population grows after 2008, possible measures to increase the supply such as the decrease of leakage, rehabilitation of the Jhal Khanuana Head Water Works, more effective use of the existing tubewells in the Rakh Branch Canal wellfield, etc. will have to be taken. For reference the projection of water supply in Table 2-15 includes the results of the calculation assuming such contributions as the decreased leakage and increased supply from the tubewells along the Rakh Branch Canal.

Table 2-14 Water supply projection

FY	①Estimated population	Daily maximum supply rate (m³／day)				Daily average supply rate (m³／day)			
		②intake rate	③effective water	④industrial and commercial	⑤household	⑥household	⑦per capita	⑧served population	⑨water coverage
2003	2,313,000	230,000	161,000	16,100	144,900	128,230	0.101	1,272,150	0.550
2004	2,371,000	230,000	161,000	16,100	144,900	128,230	0.097	1,327,760	0.560
2005	2,430,000	230,000	161,000	16,100	144,900	128,230	0.093	1,385,100	0.570
2006	2,489,000	230,000	161,000	16,100	144,900	128,230	0.089	1,443,620	0.580
2007	2,548,000	230,000	161,000	16,100	144,900	128,230	0.086	1,503,320	0.590
2008	2,607,000	321,000	243,800	16,100	224,650	200,580	0.130	1,564,200	0.600
2009	2.666,000	331,000	254,870	16,100	238,770	213,188	0.131	1,626,260	0.610
2010	2,724,000	331,000	258,180	16,100	242,080	216,143	0.128	1,688,880	0.611
		Supply increased by this project in '08. Increase of water supply from Rakh Canal source in '09	The present leakage at a rate of 30% is improved to 25% in '08	④=10% of ③ Assumed to keep the same level after 2008	⑤=③－④	⑥=⑤/1.13 It is a multiplier to the present average supply rate.	⑦=⑥/⑧	⑧=①x③	55% in 2003. Annual increase of 1% is assumed.