ISLAMIC REPUBLIC OF PAKISTAN
FAISALABAD WATER AND SANITATION AGENCY

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR IN FAISALABAD
IN THE ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT

June 2015

Japan International Cooperation Agency (JICA)

Kokusai Kogyo Co., Ltd.

Summary

1. Background of the Project

Water supply coverage of Pakistan is 65% in the entire country, 85% in urban areas and 55% in rural areas (The Medium Term Development Framework 2005). Faisalabad is the third most populous city in Pakistan and the second most populous city in the Punjab Province (approximately 3.1 million) and its average population growth rate between 1990 and 2013 was approximately 3.2%, which is above the national average. This population growth is in part due to emerging industrial growth over the same period, particularly in the textile industry.

In Faisalabad City, Faisalabad Water and Sanitation Agency (hereinafter, FWASA) is responsible for water supply, which is about 98% dependent on groundwater as a water source. The FWASA has been developing, with the support of donors, water resources and water supply facilities such as the projects to develop the Chenab well field in 1992 with the support of ADB and the Jahn Branch Canal well field in 2012 with the support of Japan Grant Aid, as well as a French government sponsored project to develop well field and construct a purification plant and so on.

However, the served population in 2013 is only about 1.55 million people, corresponding to 50% of Faisalabad's urban inhabitants because of the high population growth rate. The FWASA is considering development of new water sources, however, no concrete progress has been made because there remains concern about the impact of groundwater development on local agricultural communities and that it will cause declining groundwater levels around the wells. Moreover, surface water development has been impeded because of the need for modifications in water rights.

The water facilities at Chenab are vital in terms of Faisalabad City's water supply, because they supply about 55% of the total water volume for the city. However, facilities at Chenab have been operating more than 20 years, and are aging. Distribution pumps at the Terminal Reservoir break down frequently and this affects the stability of the water supply; booster pumps at the Inline Booster Pump Station cannot transmit the total amount of water from Chenab well field; and energy efficiency has deteriorated, and costs associated with energy consumption have increased, by continuing to run these pumps. In recent years, population growth and economic growth have resulted in power shortages and rising electricity costs, worsening the financial situation of FWASA, which only secures about 45% of its operating costs from water and sewage bills. As of 2012, electricity costs accounted for about 39% of FWASA's operating costs. Under these circumstances, renewing the pump facilities at Chenab, stabilizing the supply of water, lowering the cost of water supply and ultimately improving the overall financial conditions of FWASA through more efficient energy consumption has become a matter of urgency.

In addition, there is a design problem at the Chenab Terminal Reservoir (hereinafter, T/R) that needs to be addressed. The installation position of distribution pumps is higher than the low water level of the reservoir, increasing the suction lift and causing cavitation when trying to utilize water from the lower

half of the reservoir, practically limiting the use of the reservoir to just half of its designed capacity. For this reason the supply from the reservoir cannot meet the peak demand of the day. Furthermore, water leakage from the aging wall of the T/R results in the loss of about 600 m3 of water per day.

Thus, Japan International Cooperation Agency (hereinafter "JICA") conducted a Preparatory Survey from August 2013 to October 2013, confirmed National Plans related to the water supply sector of Pakistan, the current situation of water supply facilities which FWASA maintains, and basic information about the capacity of those involved in operation and maintenance of the facilities, to confirm the need of strengthening the capacity of water supply facilities of FWASA and to consider the possibility of assistance by Japan. FWASA informed the preparatory survey that it needed to strengthen its current capacity for water supply, which stands at 398,250m3 per day (as of September 2013), to 765,000 m3 per day by 2017. The preparatory survey revealed that, while the strengthening of facility capacity and the development of water supply facilities by 67,500 m3 per day has been planned and implemented via French government assistance, the water supply capacity of the water supply facilities remain insufficient.

2. Conclusions by the Preparatory Survey and Components of this Project

In the Preparatory Survey, it was judged that it would be necessary to renew both the booster pumps at the Inline Booster Pump Station and the distribution pumps at the T/R, and take countermeasures against water leakages at the T/R. In addition, it was recommended that a new distribution pump station should be constructed for renewal of the distribution pumps at the T/R, in light of the construction process, safety, the need to turn off existing distribution pumps during construction, and other considerations. There was a request from Pakistani counterparts for generators to operate the booster pumps at the Inline Booster Pump Station and distribution pumps at the T/R in case of power failure, but it was not included in the scope of the Project since power is supplied to both locations by distribution lines independent from the substation.

The final scope of this Project, based on the above, is as follows: In terms of facility construction, the project will include the renewal of booster pumps at the Inline Booster Pump Station to transmit the water from Chenab well field to the T/R, construction of a new pump station and the renewal of distribution pumps at T/R, and countermeasures for water leakage from T/R in its scope. As for the Project's soft component, technical instruction on valve operation at the T/R, for pressure reduction after distribution by distribution pumps, will be given.

Table 1: Contents of Japanese Assistance

Items	Contents
1) Facilities	Renewal of booster pumps at inline booster pump station
	Construction of pump station at T/R
	Renewal of distribution pumps at T/R
	Leakage control of T/R
2) Soft components (Technical assistance)	Technical support and capacity building (Water pressure reduction technique by valve operation)

After the verification of the relevance of both the facility plan and soft component (technical assistance) plan and preparation of the final draft contents of the Project, a tour to explain the Draft Outline Design to Pakistani counterparts was conducted from April 9 to April 19, 2014. The outline of Japanese Assistance, planned facilities and soft component are shown in the tables below.

Table 2: Outline of the Facilities Plan

Chenab Well field	Design Intake Flow: 204,780 m^3 per day
Inline Booster Pump Station	Design Transmission Flow: 204,780 m^3 per day : 10,239 m^3 per hour
	Large Pump: 48.8 m^3 per minute ×4 units（3+1 back up）
	Small Pump: 24.4 m^3per minute ×2 units（1+1 back up）
	Incidental Equipment (Pipes, Control panels, Flow meter, etc.)
T/R Pump Station	Design Distribution Flow : 161,880 m^3 per day : 13,230 m^3 per hour (Pump) : 5,500 m^3 per hour (Gravity) Pump Operating Time : 6 hours Gravity Operating time : 15 hours
	New Pump Station (Reinforced Concrete)
	Rehabilitation of Water Leakage at T/R
	Large Pump: 63.0 m^3 per minute ×4 units（3 +1 back up）
	Small Pump: 31.5 m^3 per minute ×2 units（1+1 back up）
	Incidental Equipment (Pipes, Control panels, Flow meter, etc.)

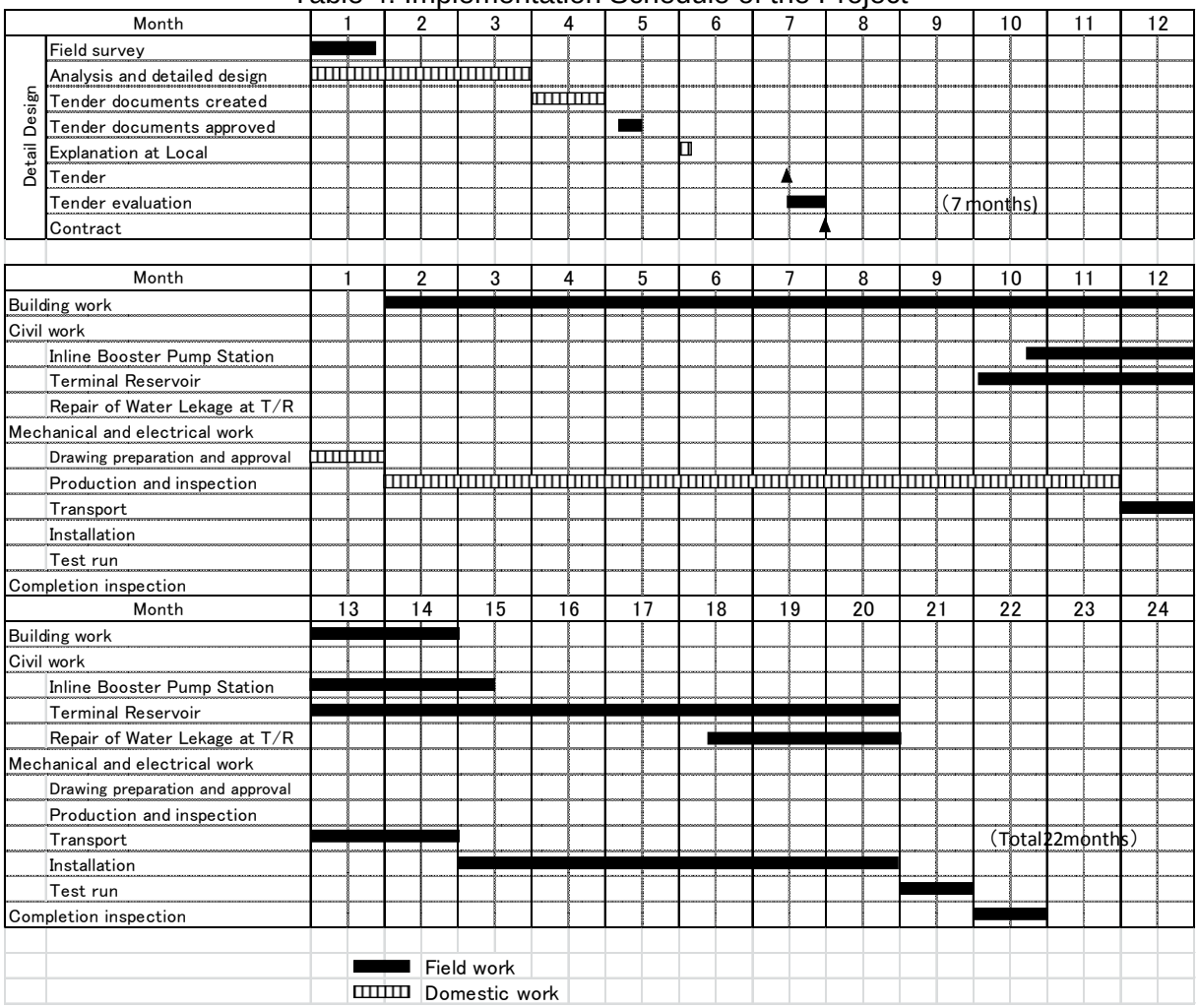
Table 3: Outline of Soft Component

Outputs	Objectively verifiable indicator	Means of verification
Reduction of water pressure is appropriately practiced on the secondary supply lines after the distribution of water	Understand the relationship between volume of water distribution and water pressure	Comprehension test
	Operate valves for depressurization in supply lines against the volume of water distribution	Measurements of water distribution volume and water pressure

3. Implementation Schedule

The implementation schedule of the Project is shown in the table below.

Table 4: Implementation Schedule of the Project



4. Project Evaluation

(1) Validity

Pakistan has formulated its National Drinking Water Policy in 2009, and has set a goal to provide safe drinking water to all citizens by 2025. The Punjab Drinking Water Policy (2010), against this backdrop, has set goals to protect water sources from water pollution and to give priority allocation of water resources to the drinking water supply, and to conduct organizational reform so that the Water and Sanitation Agencies (WASA) of five cities in the Punjab Province become independent agencies in both management and organization. However, increasing operating costs due to soaring electricity prices, especially the increase in the cost of providing power has become an obstacle for policy implementation. This Project aims to reduce the operational costs of FWASA through the improvement of energy efficiency, through the renewal of water supply facilities that are currently lowering the energy-cost

performance. The overall objective is to sustainably provide a stable water supply, and the need for this Project is high.

The Project includes the renewal of the pumps at the Inline Booster Pump Station and T/R as one of the cooperation. The existing pumps are made in Japan. For the new pumps to be renewed by the Project, it will be advantageous to install pumps with low failure rates, high energy efficiency and quality, and that undergo vigorous checks before being dispatched from factories. It is considered that Japanese products meet these requirements; thus, there is a demonstrable necessity and advantage in using Japanese technology in this Project. The facilities and equipment to be provided by the Project do not require excessively advanced technology in construction and operation. There are no negative environmental or social impacts that will hinder the implementation of this Project. Therefore, it is possible to carry out this Project by Japanese grant aid. Pakistan is able to carry out the operation and maintenance of the facility and equipment after the completion of the Project through their human resources and funds.

Japan has identified "ensuring human security and improvement of social infrastructure" as a priority area under its Country Assistance Strategy (April 2014) for Pakistan. This Project is positioned within the "program of ensuring water and sanitation" under the development challenge "health and environmental improvement". Within this program, this Project will work towards the improvement of access to safe water and improvement of hygienic environment, by supporting water and sewage facility development, organizational management improvement, securement of financial soundness, operation and maintenance improvement, and the strengthening of planning capacity.

In this way, this Project is consistent with, and highly relevant to, Japan's assistance policy and Pakistan’s development needs and policies.

(2) Effectiveness

1) The Quantitative Effects

The quantitative effects of the Project are expected as follows.

Table 5: Quantitative Effectiveness of the Project

Index	Reference Value (2013)	Target Value (2020:3 years after project completion)
Power Consumption of Booster, Distribution Pump (kW/m^3)	0.259	0.232
Hourly Maximum Water Supply (m^3/h)	8,418	13,230
Daily Maximum Water Supply (m^3/d)	149,508	161,880

2) The Qualitative Effects

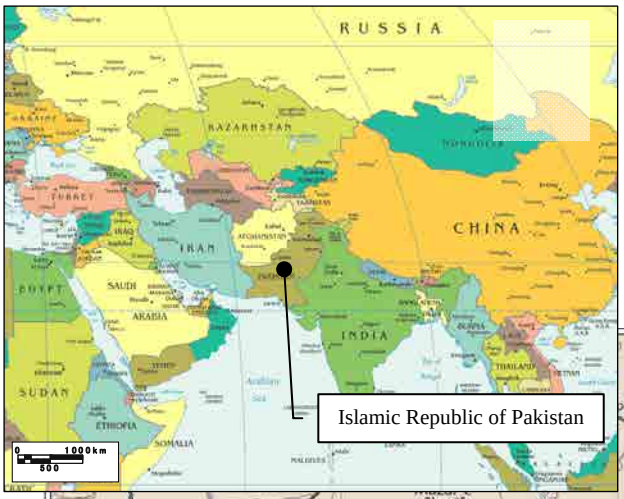
In terms of qualitative effects, improvement in the financial situation of FWASA through the reduction of power consumption, reduction of maintenance costs and stable operation of the equipment through the update of the pump equipment, reduction of the area where the residents cannot access

sufficient water, and mitigation of the effects of climate change may be expected from this Project.

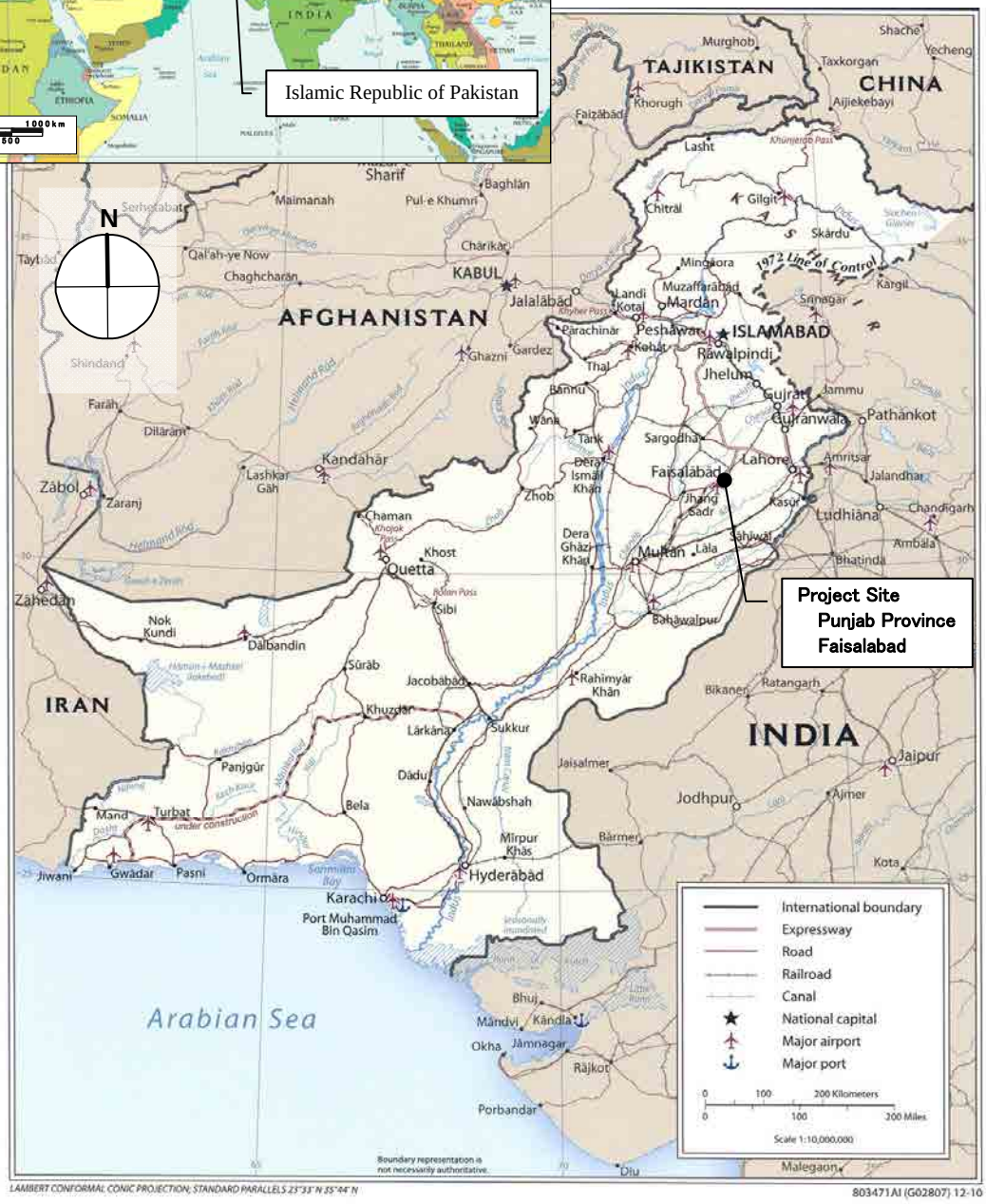
Relevance as well as the effectiveness of the Project is expected to be high, due to the above.

Contents

［Appendices］



Islamic Republic of Pakistan



LOCATION MAP
FOR PREPARATORY SURVEY
ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINELY
AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR

Perspective

List of Figures & Tables

Abbreviations

ADB	Asian Development Bank
A/P	Authorization to Pay
B/A	Banking Arrangement
BCP	Building Code of Pakistan
BIS	Bureau of Indian Standards
BS	British Standards
DfID	Department for International Development
DIN	Deutsche Industrie Normen
ECNEC	Executive Committee of National Economic Council
E/N	Exchange of Notes
FDA	Faisalabad Development Authority
FWASA	Faisalabad Water And Sanitation Agency
GDP	Gross Domestic Product
GL	Ground Level
GNI	Gross National Income
HUD&PHED	Housing, Urban Development and Public Health Engineering Department
HWL	High Water Level
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JBC	Jhang Branch Canal
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
LCC	Lower Chenab Canal
LWL	Low Water Level
PC-1	Planning Commission Document-1
P&D	Planning & Development Department, Government of the Punjab
PKR	Pakistan Rupees
T/R	Terminal Reservoir
USGS	United States Geological Survey
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Agency
WHO	World Health Organization

Chapter 1

Background of the Project

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1-1 Background of Grant Aid

1-1-1 Background of Preparatory Survey

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position of distribution pumps is higher than the low water level of the reservoir, increasing the suction lift and causing cavitation when trying to utilize water from the lower half of the reservoir, practically limiting the use of the reservoir to just half of its designed capacity. For this reason the supply from the reservoir cannot meet the peak demand of the day. Furthermore, water leakage from the aging wall of the T/R results in the loss of about 600 m^3 of water per day.

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1-1-2 Field Survey

In the field survey conducted from August 2013 to October 2013, it was reconfirmed that the objective of the Project is to renew the pumps of Chenab Inline Booster Pump Station and T/R, to stabilize the operation of water facilities, to increase the energy efficiency, to reduce the cost of water distribution, and to contribute to the realization of stable and sustainable water supply services. Requests from Pakistani Side confirmed in the field survey are shown in the following table.

In the initial request, the number of generators (1000kVA, 3.3kV) was set as four, however, after confirming the request letter from the FWASA, it was confirmed that the number of generators to be recorded in the minutes to be five generators.

As technical assistance, initial operation guidance of facilities and equipment, and the soft component related to the operation and maintenance was requested.

Table 1-1: Original and Final Request of Pakistani Side

Original Request	Final Request	Remarks
1) Facility		
Inline Booster Pump Station		
Booster Pump (27.2m³/min x 3nos., 51.0m³/min x 4 nos.)	No change	
Generator (700kVA, 3.3kV x 3 nos.)	No change	
Incidental Work (Pipeline, Control Panel, Flow Meter, etc..)	No change	
Terminal Reservoir		
Distribution Pump (27.2m³/min x 3 nos., 37.7m³/min x 7 nos.)	No change	
Generator (1000kVA, 3.3kV x 4 nos.)	Generator (1000kVA、3.3kV x 5 nos.)	
Incidental Work (Pipeline, Control Panel, Flow Meter, Rehabilitation of reservoir tank and pump station, etc.)	No change	
Cutting and removal of trees on the Project site		It will be borne by Pakistani Side
2) Design/Supervision		
Detail Design	No change	
Assistance in Tendering	No change	
Construction Supervision	No change	
Soft component	No change	

1-2 Natural Conditions

(1) Meteorological Condition

Pakistan faces the Himalaya Mountains to the north and the Arabian Sea to the south. The climate is desert climate (BW) in the south central area, steppe climate (BS) in the north area, and humid moderate climate with dry winter (Cw) in the northern mountainous area. The climatic and natural conditions vary vastly between regions. As a major feature, the Indus River, the headwaters of which are in the Himalayas, flows through the central part of Pakistan and has a major impact on the country's natural, social and economic conditions.

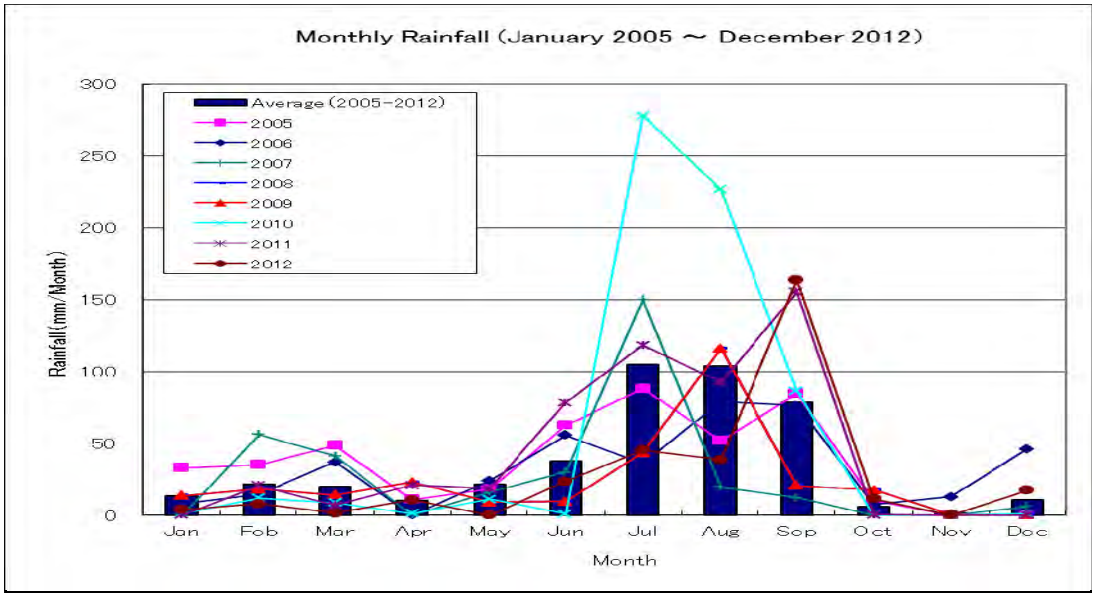
1) Rainfall

Compared to countries of Monsoon Asia in general, rainfall of Pakistan is less throughout the country, with rainfall in the target area less than 500 mm a year, climate is divided into rainy season (June to September) and dry season (October to May). Rainfall data at Faisalabad is recorded in the table below.

Table 1-2: Daily Rainfall at Faisalabad (mm)

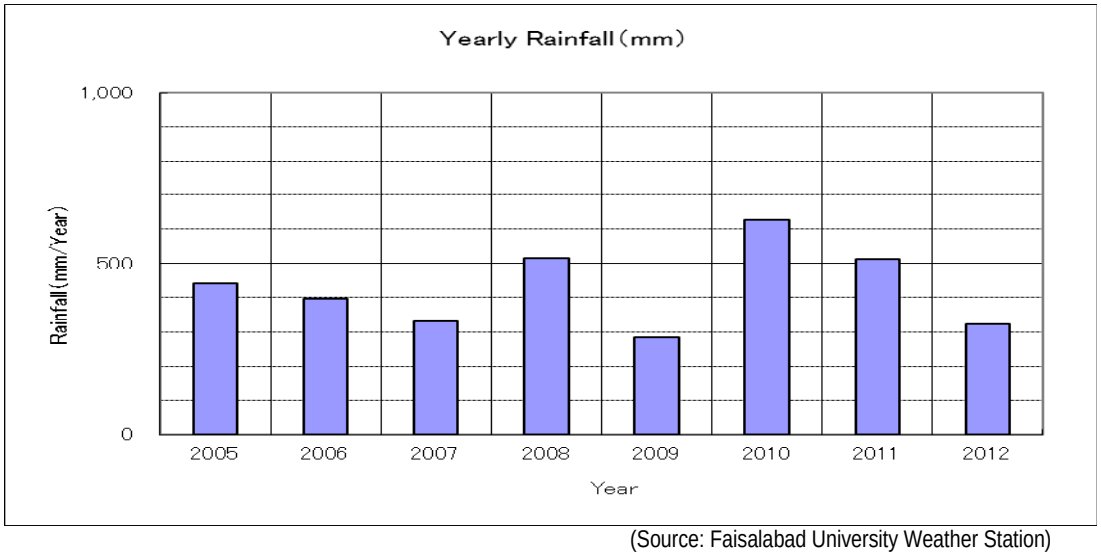
Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Average (2005-2012) Jan	2.5	1.0	0.0	0.0	0.4	0.0	0.0	0.4	0.9	3.4	0.0	0.0	0.1	0.0	0.0	0.6	0.4	1.7	0.3	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.1	0.9	0.0	0.0	0.0
Feb	0.0	0.0	0.7	0.0	0.3	0.0	2.6	0.3	1.2	2.3	4.3	0.3	0.5	2.3	0.6	1.7	0.0	0.0	0.3	0.2	0.6	0.0	0.7	0.0	0.0	1.6	1.1	0.1	0.0		
Mar	0.5	0.0	0.3	0.7	0.2	0.3	0.2	0.1	0.0	0.9	0.0	1.4	1.6	0.7	0.4	0.3	0.3	2.0	0.0	2.5	0.6	2.5	0.0	0.0	0.6	1.4	0.0	2.0	0.5	0.0	0.0
Apr	0.0	0.0	0.7	0.0	0.2	0.6	0.4	1.7	0.3	0.0	0.3	0.2	0.0	0.6	0.2	3.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.8	0.6	0.0	0.0	0.2	
May	0.1	0.0	0.0	2.9	0.1	1.5	0.2	2.3	0.3	0.0	0.2	0.0	0.0	1.4	0.0	0.0	2.4	0.0	0.0	0.0	0.0	3.2	0.0	0.0	1.6	4.4	0.0	1.0	0.0	0.0	0.0
Jun	3.0	0.0	1.5	0.0	0.0	0.1	0.0	0.0	0.0	0.6	1.6	0.0	1.1	0.6	0.0	1.9	0.3	2.1	2.2	1.9	1.1	0.5	0.0	0.0	0.0	0.0	0.0	4.7	8.8	6.1	
Jul	4.4	3.7	0.9	3.8	0.1	0.0	0.6	3.9	10.5	0.0	0.0	8.5	20.2	4.3	5.4	1.0	0.0	0.2	0.0	1.5	9.7	14.2	0.2	0.6	0.9	0.0	0.1	3.9	4.4	0.3	2.0
Aug	8.6	3.3	0.1	0.1	3.9	7.7	0.0	14.1	1.7	0.9	1.3	14.1	1.4	0.6	2.3	5.6	3.7	0.4	3.1	0.0	7.9	3.9	0.6	5.0	0.8	3.6	0.6	0.4	2.0	2.6	3.4
Sep	0.0	6.2	1.4	2.8	5.0	2.1	0.8	6.7	7.0	5.0	1.0	0.0	0.0	3.8	1.0	14.9	5.8	5.7	0.1	0.0	0.0	1.2	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Oct	0.0	0.0	0.0	0.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.6	0.9	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Dec	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.4	0.1	0.6	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.3	0.2	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.1	0.0
Total																															

(Source: Faisalabad University Weather Station)



(Source: Faisalabad University Weather Station)

Figure 1-1: Monthly Rainfall

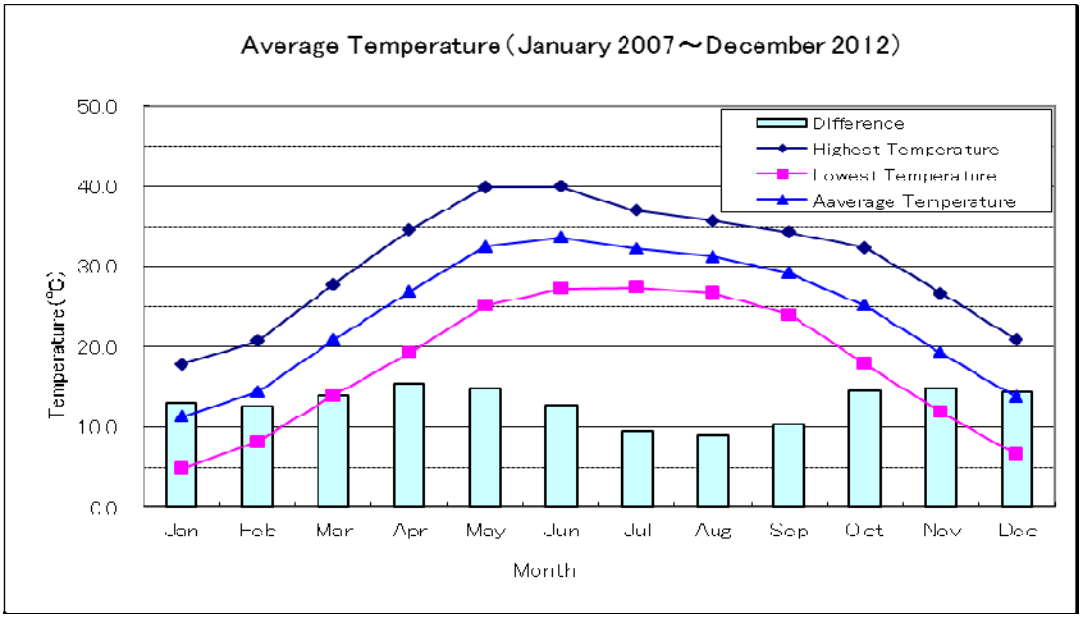


(Source: Faisalabad University Weather Station)

Figure 1-2: Yearly Rainfall

2) Air Temperature

The annual range and the daily range of air temperature are large. Air temperatures is over 30 degrees from April to October, maximum air temperature exceeds 40 degrees from May to June in particular. Meanwhile, minimum air temperature falls below 10 degrees from December to February, and air temperatures vary greatly throughout the year. Air temperature data at Faisalabad is recorded in the table below.



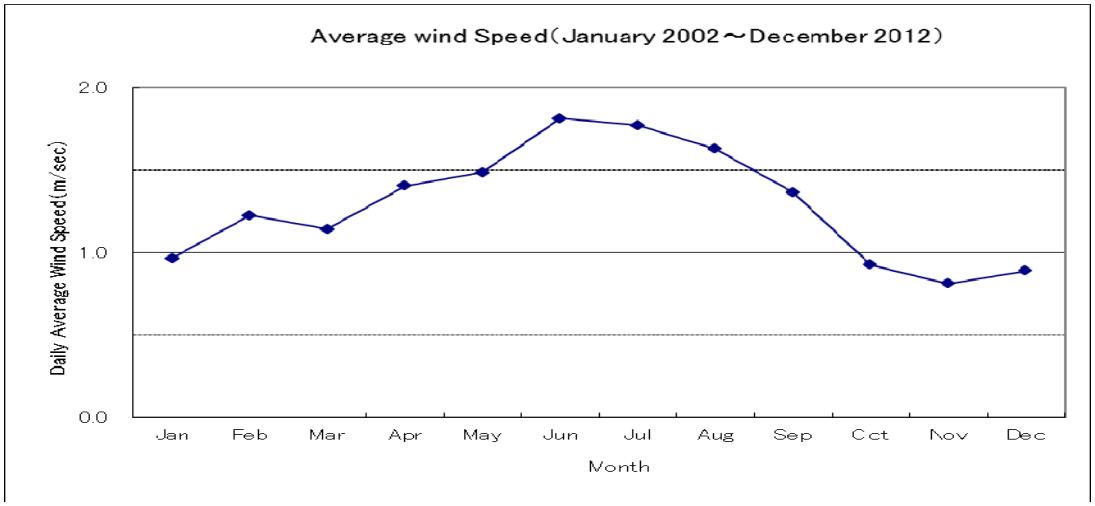
(Source: Faisalabad University Weather Station)

Figure 1-3: Air Temperature

3) Wind Speed

Around the project site, while the average wind speed increases between June and September during the rainy season, it is still less than 2m/sec. The wind is mild throughout the year.

Wind speed data at Faisalabad is recorded in the table below.



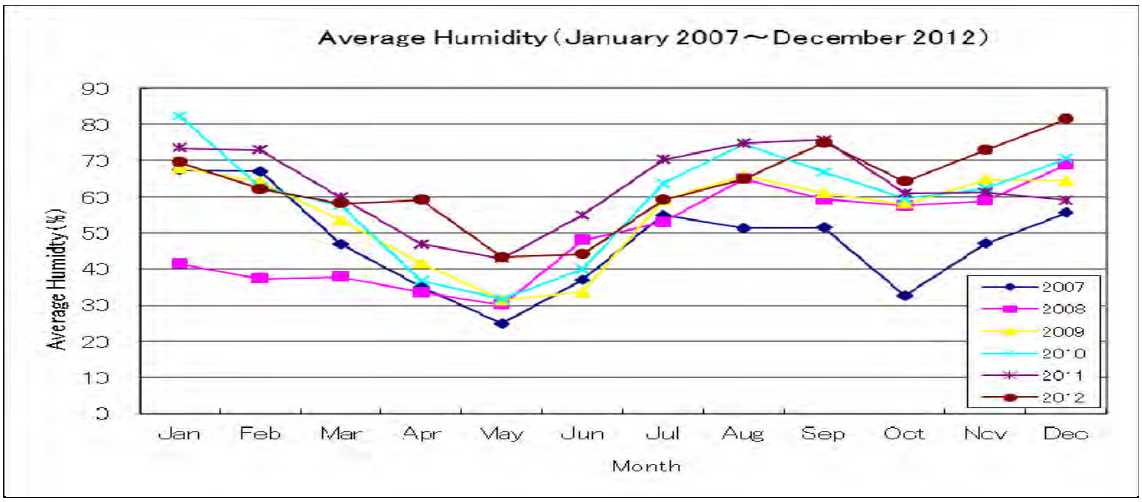
(Source: Faisalabad University Weather Station)

Figure 1-4: Wind Speed

4) Humidity

Humidity varies depending on the season, and changes according to precipitation. The rainy season is generally humid, and the dry season is generally dry.

Humidity data at Faisalabad is recorded in the table below.



(Source: Faisalabad University Weather Station)

Figure 1-5: Average Humidity

(2) Natural Disaster

1) Cyclone

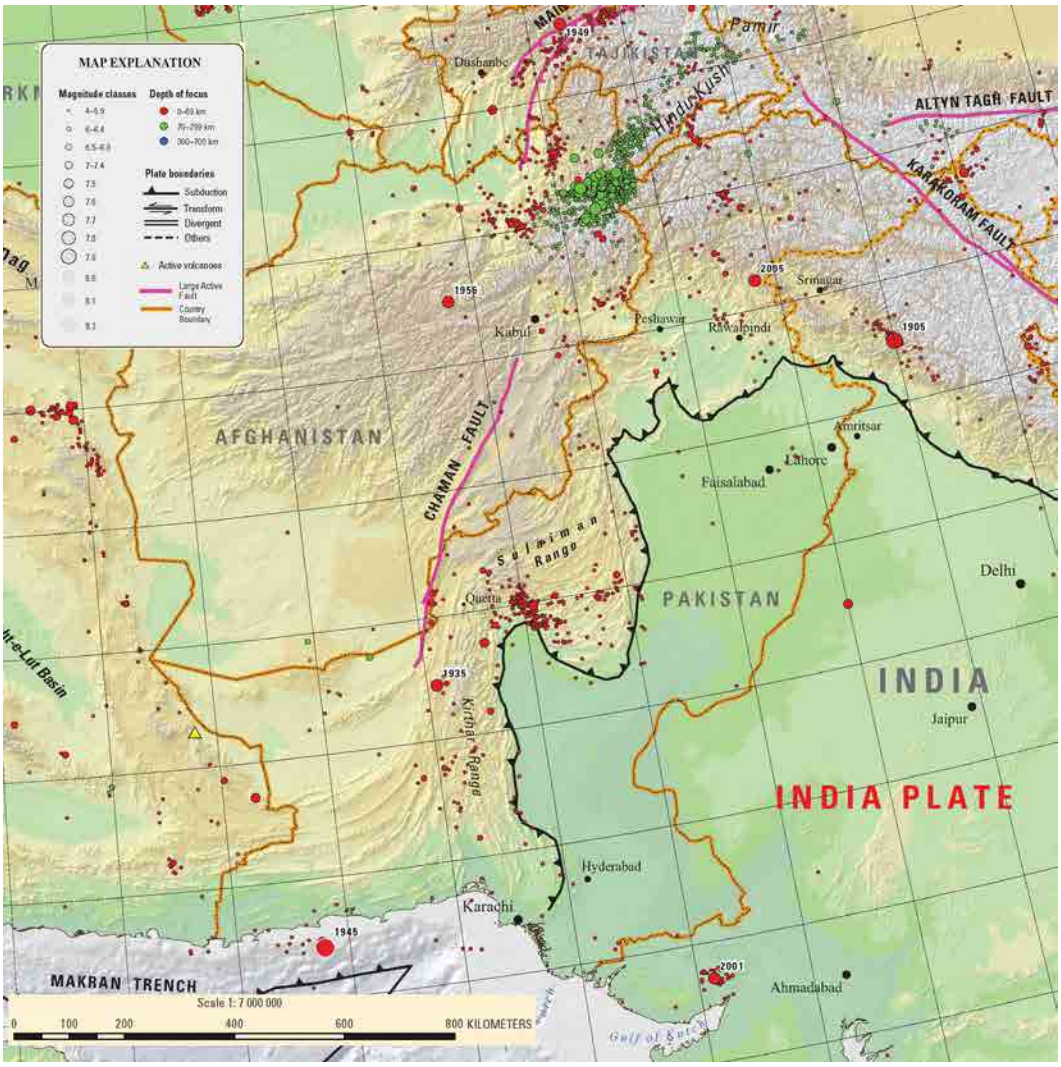
Pakistan experiences some cyclones which originate in the Arabian Sea, most are already in a weakened state by the time they reach the Pakistani coast, namely coastal areas Baluchistan and Sindh provinces. Therefore, Faisalabad city is not affected by cyclones.

2) Flood

Regarding the target site of the Chenab Inline Booster Pump Station and T/R, it has been confirmed by the staff of FWASA that it has never experienced any flood inundation damage.

3) Earthquake

The frequency of occurrence of earthquakes is high in Pakistan. Major earthquakes occur mainly in mountainous areas of northern and western Pakistan, and have caused extensive damage in the past. However, Faisalabad City experiences very few earthquakes. In addition, since the size of earthquakes in Faisalabad is also small, there has not been confirmed heavy damage caused by earthquakes in the past.



(Source: United States Geological Survey)

Figure 1-6: Location Map of Earthquake in and around Pakistan

Table 1-3: Magnitude of Earthquake in and around Pakistan (1900-2013)

Year	Magnitude in Richter scale								Total	Highest tremor
	Unknown	～ 3.0	3.0～3.9	4.0～4.9	5.0～5.9	6.0～6.9	7.0～7.9	8.0 ～		
1909							1		1	7.0
1928						1			1	6.6
1931						1	1		2	7.1
1935								1	1	8.1
1945								1	1	8.0
1947						1			1	6.9
1966					2	2			4	6.8
1972					3				3	5.9
1973				12	8				20	5.6
1974				8	5	2			15	6.2
1975				11	5				16	5.5
1976				4	1				5	5.3
1977				7	4				11	5.5
1978			1	9	5				15	5.5
1979				10					10	4.8
1980				12	3				15	5.4
1981				14	3				17	5.4
1982				8	4				12	5.2
1983			1	11					12	4.8
1984			1	18	7				26	5.6
1985				15	5				20	5.7
1986			1	12	2				15	5.3
1987			2	13	1				16	5.0
1988				17	2				19	5.5
1989				15					15	4.7
1990				27	8	1			36	6.0
1991			1	24	3				28	5.6
1992			10	29	10				49	5.9
1993			1	11	5				17	5.6
1994				8	2				10	5.5
1995			4	14	1				19	5.6
1996			7	17	3				27	5.2
1997			81	126	9	1	1		218	7.1
1998			8	29	3				40	5.4
1999			3	15	6				24	5.7
2000			4	14	1	1			20	6.0
2001			2	16	3				21	5.2
2002			6	26	1				33	5.8
2003			1	14	1				16	5.0
2004			3	21	5				29	5.5
2005		1	288	287	46	1	1		624	7.6
2006			77	47	3				127	5.2
2007			22	33	4				59	5.5
2008			87	80	7	2			176	6.4
2009			1	15	6				22	5.5
2010				19	8				27	5.4
2011				25	3		1		29	7.2
2012				28	3				31	5.4
2013			1	50	7	1	1		60	7.7
Total	0	1	613	1171	208	14	6	2	2015	–

(Source: United States Geological Survey)

(3) Topographical Condition

Faisalabad City is located at the center of the nearby vast Indus plain made up by the Indus River and four of its tributaries. Among them, Faisalabad City belongs to the plain called Rechna Doab,

sandwiched by two rivers, the Chenab River to the west and the Ravi River to the east.

Indus River has a history of repetitive massive flooding, which has created the vast and flat Indus plain from midstream to downstream. The plain continues from the Punjab Province to Sindh Province, occupying an area of approximately 200,000 km2 of the Punjab Province. Faisalabad City located in the center of the Rechna Doab is on the terrace where the geological epoch is older than the river plain areas to the east and west, and is slightly higher than the surrounding area. There is a gentle slope from the city down to the two rivers to the east and west respectively. This is why, even though it is sandwiched between two rivers, neither the water facilities of this project nor Faisalabad City have ever been damaged by flooding in the past.

(4) Geological Condition

The entire region of Rechna Doab is covered in thick sediment carried down from the Himalayas by rivers on both the east and west sides. The geological foundation is consolidated bedrock of Tertiary and Precambrian metamorphic rocks that outcrop on the right bank of the Chenab River, with unconsolidated alluvium such as sand, gravel, clay, silt, etc. of Pleistocene epoch and Holocene epoch of Quaternary deposited on top of this bedrock.

A hydrogeological investigation was conducted in the entire region by the "Pakistan Water and Power Development Authority" in the 1960s. According to the results of the drilling survey, the thickness of the alluvium on the bedlock varies by each area, but in the target areas and its surrounding is about 180 m. Regarding the constitution of these alluvium, the sand layer is the major constituent, in particular the fine sand with less than medium grain is prominent and it is confirmed that the groundwater is mainly found in those sand layers. In addition, in order to ensure the water source of Faisalabad City, the hydrogeological investigations were carried out in succession in these areas, so that the hydrogeological characteristics are reaffirmed. Through these studies, the clay layers as the impermeable layers are not developed in any horizontal and vertical direction in the alluvium, and it is clear the clay layers exist only partially, forming a lens. In addition, the World Bank master plan evaluates the plain forms a huge unconfined aquifer of 200 m depth from the fact that there is no impermeable layer clearly present in the alluvium.

1-3 Environmental and Social Considerations

(1) Environmental Considerations

The purpose of the Project is the replacement of the existing pumping facilities, and there is no foreseen development of new water sources nor increase in well yield. Accordingly, there will be no new impacts on the environment associated with the implementation of construction and facility replacement in the Project. Therefore, there are no adverse environmental impacts expected to arise from implementation of the Project, however, IEE by Pakistan side is required for the replacement of water supply facilities of the Project.

(2) Social Consideration

Since the replacement of the existing booster pumps will be implemented inside the Inline Booster Pump Station, there will be no negative impact resulting from land acquisition associated with the replacement of the facilities. In the same way, since the new pump station will be constructed in the same compound as the existing T/R and as the site is owned by FWASA, there will be no negative impact related to land acquisition.

The Project will implement the replacement of water facilities by utilizing the existing Chenab well field. Since the design intake flow is calculated by available water intake from well field in consideration of the amount of decrease in groundwater level calculated by the pumping tests and impacts on the surrounding agricultural wells, negative impacts on groundwater resources are expected to be extremely negligible, if any.

Chapter 2

Contents of the Project

Chapter 2. Contents of the Project

2-1 Basic Concept of the Project

(1) Overall Goal and Project Goal

The Project aim is to achieve sustainable and stable water supply services in Faisalabad City through stabilizing operation of the facilities, improving efficiency of energy consumption and reducing the cost of water supply by the replacement of the pump at the Inline Booster Pump Station and T/R Pump Station, namely facilities with a water source in the Chenab well field.

(2) Outline of the Project

Faisalabad is the third largest city in Pakistan (population of approximately 3.1 million), however, only 50% (1.55 million people) of the population can benefit from the water supply of 354,000 m3 of water per day in 2013.

In Faisalabad City, the FWASA is responsible for the management of water services, which depend on groundwater for about 98% of the water supply. In addition to the FWASA's own project, FWASA is developing water sources with the support of donors, water facilities such as Chenab, Jhang Branch Canal (hereinafter, JBC) developed by the Japanese government, Jhal Water Treatment Plant and Rakh Branch Canal Upstream Well-field financed by the French government which is currently in progress, and so on.

However, due to the high population growth rate (about 3.2% on average during 1990-2013), the current water sources are expected to be able to provide only about 60% of the water demanded in 2017.

Under these circumstances, the FWASA is considering development of new water sources. However, conspicuous progress is not seen due to the concern about the impact to the local agriculture and lowering of groundwater level around wells by groundwater development; moreover, issues surrounding water rights need to be overcome before development of surface water can progress.

On the other hand, Chenab water facilities, which are the main facilities of the FWASA and are more than 20 years old, provide about 55% of water distributed to Faisalabad City. Not only has the stability of the city's water supply service declined because of the frequent failure and performance decrement of the pumps at the Inline Booster Pump Station and T/R due to the aging, but also the energy efficiency of distribution by pump is getting worse. As a result, the operating cost by these pumps is increasing.

Furthermore, in recent years, the electricity price is rising because of power shortages due to population growth and economic growth, and this has worsened the financial situation of the FWASA, which only manages to cover about 45% of its operating costs with water and sewerage charges. Meanwhile the energy cost has reached about 39 % of total operating costs in 2012. Under such circumstances, renewing the pump facilities, stabilizing the operation of the existing facilities by the elimination of old machinery, reducing water supply costs through greater energy efficiency, and improving the management situation are the urgent issues.

In fact, the current faulty design of the T/R causes the cavitation due to a large suction lift when the pumps try to distribute the lower half of water of T/R to the city. Consequently only half of the water in the T/R is available to supply to Faisalabad City, and it is not enough to meet the peak hourly water demand.

Under such circumstances, the Project will: replace the pumps at the Inline Booster Pump Station and T/R, construct a new pump station at the T/R, repair water leaks at the T/R, and conduct the soft component to control the water pressure of distribution pipe in order to achieve the project goal.

Thereby, it is expected that the capacity of operation and maintenance of water facilities will improve and that it will become possible to supply safe water continuously to Faisalabad City.

The outline of the facilities planned in the Project is shown in the following table.

Table 2-1: Outline of the Project

Chenab Well field	Design Intake Flow: 204,780 m^3/day
Inline Booster Pump Station	Design Transmission Flow: 204,780 m^3/day : 10,239 m^3/hour
	Large Pump: 48.8 m^3/min ×4 nos.（3＋１back up）
	Small Pump: 24.4 m^3/min ×2 nos.（１＋１back up）
	Incidental Equipment (Pipes, Control panels, Flow meter, etc.)
T/R Pump Station	Design Distribution Flow : 161,880 m^3/day : 13,230 m^3/hour (Pump) : 5,500 m^3/hour (Gravity) Pump Operating Time : 6 hours Gravity Operating time : 15 hours
	New Pump Station (Reinforced Concrete)
	Rehabilitation of Water Leaking at T/R
	Large Pump : 63.0 m^3/min ×4 nos.（3＋１back up）
	Small Pump : 31.5 m^3/min ×2 nos.（１＋１back up）
	Incidental Equipment (Pipes, Control panels, Flow meter, etc.)

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Concept

2-2-1-1 Basic Concept

(1) Contents of the Project

1) Scope of Assistance

This Project is to rehabilitate the water supply facilities in the Chenab Inline Booster Pump Station and the Chenab T/R, which are more than twenty years old, by replacing the facilities consisting mainly of pump equipment. Because of aging, booster pumps of Chenab Inline Booster Pump Station and distribution pumps of T/R can't exert those capabilities, the water from the water source and Inline Booster Pump Station are limited. And because of the elevation of existing distribution pumps, whole volume of water of T/R can't be distributed by distribution pumps. In order to distribute the whole amount of water of the current water source to the Faisalabad city and in order to increase the hourly distribution volume and distribution hours, the need for renewal of facilities to improve the water supply condition of Faisalabad city was confirmed. Because of this, replacing the aging booster pumps and distribution pumps of both Inline Booster Pump Station and T/R and repairing the leaks at the T/R will be conducted. Specifically, implementation of the following functions can be achieved by the Project.

- The entire amount of water from Chenab well field will be able to be transmitted stably to the T/R by replacing the old booster pumping equipment of the Inline Booster Pump Station which can't exert those capabilities because of aging.
- The whole amount of water from the Inline Booster Pump Station will be able to be distributed stably to Faisalabad City – thereby ameliorating the situation whereby only half the capacity of the Chenab T/R is available due to cavitation – by replacing the old equipment of the distribution pumps at the T/R and constructing a new pump station where the replaced new distribution pumps are installed in a lower position.
- Water wasted in the distribution process will be mitigated by repairing the water leaks in the T/R, the operation of booster pump and distribution pump will ensure the function that the water is distributed in the city without wasting water.

In this Project, the main purpose is to build the facilities for supplying the entire amount of water from the Chenab well field to the Faisalabad City. Operation time of booster pump of the Inline Booster Pump Station is set as twenty hours to match the operation time of Chenab well field, existing booster pump station is to be used, only the replacement of mechanical and electrical equipment which is mainly the booster pump is carried out. About the T/R, it is necessary to lower the installation position of distribution pump to utilize the existing reservoir; therefore a new pump station will be constructed, in consideration of the workability, safety, effect of the distribution to

the city during the water outage because of construction. About the distribution pump, the specification will be set as to distribute the whole amount of water obtained from water sources within twelve hours of pumping.

2) Site Selection

Project Sites are the Chenab Inline Booster Pump Station at Chiniot City and T/R, which is located in the north of Faisalabad City. Some of work to connect the Inline Booster Pump Station to the existing pipe will be conducted outside of the Pump Station. However, most of work will be conducted within the compound of the Inline Booster Pump Station, therefore there is no particular problem about land acquisition. About the T/R, the compound is a vast area of about 44,000 m2. However, there are already existing reservoir tanks and pump stations, only a limited area will be remained to construct the new pump station.

For the location of the proposed pump station, the land of the T/R near the entrance is determined to be the most appropriate construction place, because the loading of materials and equipment access from the outside is easy. Therefore it will be easy to gain the cooperation of the operation with the existing JBC pump station, and it will be necessary to stop the water supply temporarily at the time of construction when the pipe is switched, but this will not cause much trouble to the operation of existing facilities.

(2) Concept for the outline design

The following figure shows the concept used when considering the effectiveness and relevance of the content of the outline design of the Project. The outline design is considered by the following figure, after understanding the current situation in accordance with the result of the study and clarification of design concept.

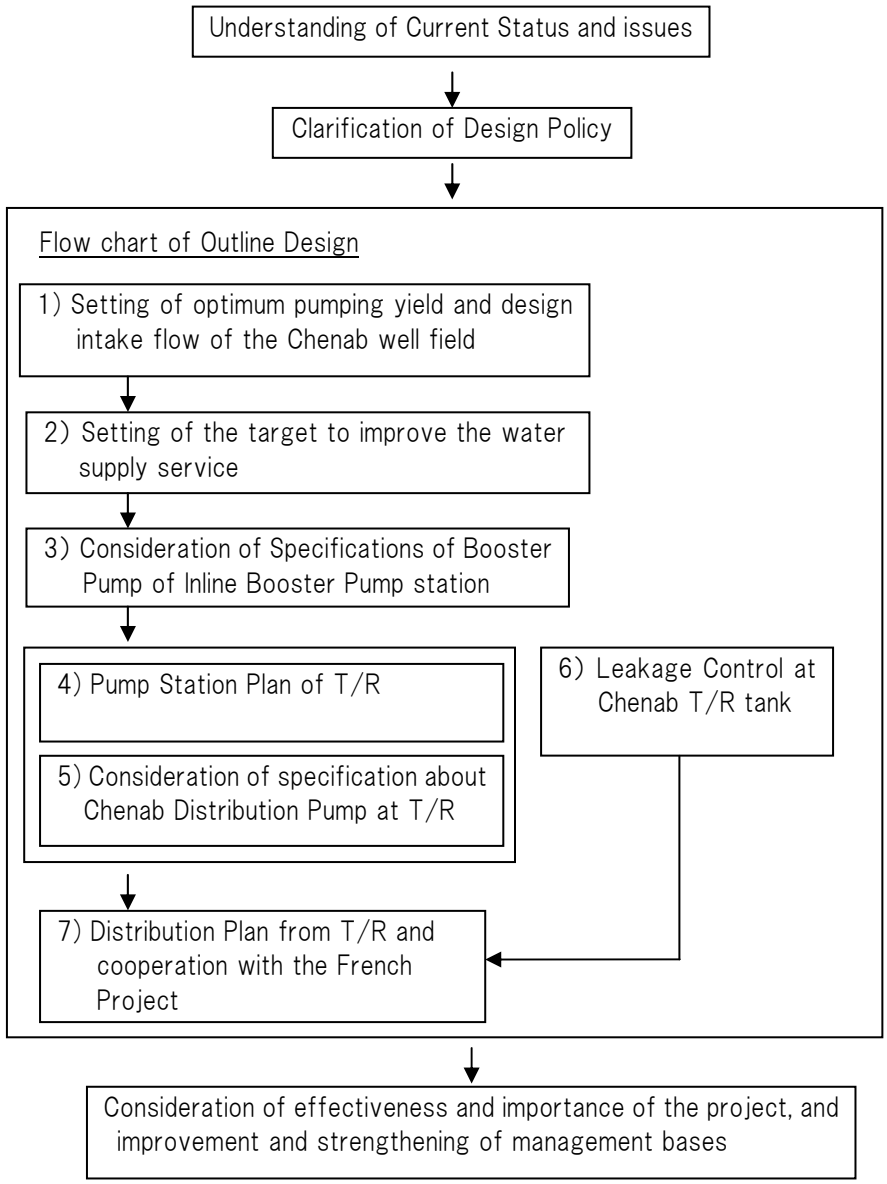


Figure 2-1: Concept for the Outline Design

1) Setting of optimum pumping yield and design intake flow of the Chenab well field

The water source of the Project is the existing Chenab well field. The Project does not renew the well field, moreover the Project sets the design intake flow by the current situation of the facilities of the well field. As the design concept, optimum pumping yield of Chenab well field is calculated based on the result of the pumping tests and considering the impact on surrounding irrigation wells. In addition, the design intake flow is set within the range of optimum pumping yield by calculating the amount of water which can be transmitted by existing water facilities channeled up to the Inline Booster Pump Station. This design intake flow becomes the basic value for consideration of the specifications of the booster pump and distribution pump.

2) Setting of the target to improve the water supply service

The design distribution flow is to be set based on the design intake flow, whole water demand and the future plan, by clarifying how much service of the water supply would be improved.

3) Consideration of Specifications of Booster Pump of Inline Booster Pump station

The specifications and number of the booster pump after replacement is planned by the design intake flow, the dynamic water head on the inflow side of the Inline Booster Pump Station and operation time of the well field, etc. The amount of water supplied in relation to the water demand of Faisalabad City reveals that about 61 % of demand is not being met (2012). Therefore, the amount of water transmitted from Inline Booster Pump station to T/R is to be set as the whole amount of design intake flow.

4) Pump Station Plan of T/R

Based on the design intake flow and the objective of water supply, the repair of the pump station and the construction of a new pump station are compared, and then pump station plan is set on the basis of the consideration results.

5) Consideration of specification about Chenab Distribution Pump at T/R

The specification and the number of replacements of new distribution pumps are planned based on the objective of water supply.

6) Leakage Control at Chenab T/R

The measure for reducing water leakage is planned by confirming the condition of water leakage at the existing Chenab T/R.

7) Distribution Plan from T/R and relativeness with the French government Project

Based on the planned distribution pump specifications, in addition to considering the water distribution plan after implementation of the project, the relevance in water distribution with the French government project (particularly newly constructed distribution pipes) is to be clarified.

2-2-1-2 Concept for Natural Conditions

The temperature of the Project site varies widely with the seasons, such as diurnal temperature exceeds 40 degrees Celsius with high temperature and humidity in summer, while the minimum temperature falls below 10 degrees Celsius in winter. Rainfall is relatively low, ranging from around 500 mm annually, and the area has around 100 mm a month of good rain from July to September which does not cause adverse effects on the works of the Project.

In this climatic condition, the whole area including from the Chenab well field to Faisalabad City belongs to the plain called Rechna Doab, which is nestled between the Chenab River in the west and the Ravi River in the east, and which is covered in a thick bank of sand flowed from the Himalayas . The source of groundwater is permanent water supply which originated from continuous-vast-flat land form, the plain nestled between the two rivers and percolation from the artificial agricultural waterway. In the Project, existing Chenab well field is taken as the main water source and the design intake flow is set to

minimize deterioration of groundwater level in consideration of rural areas utilizing surrounding agricultural wells.

Even though the Project site is nestled between said two rivers, incidences of floods have never been recorded so far at the T/R Pump Station and Faisalabad City. Since the elevation of T/R Pump Station is about twelve meters higher than the elevation of Chenab River, to consider the occurrence of flood is not realistic. Therefore, effects of flooding are not considered in the design concept of the facilities. Even though Faisalabad City has experienced quite a few earthquakes so far in Pakistan, the Pakistani building code takes into account the possibility of earthquakes. The pump station at T/R is designed by the seismic coefficient set in accordance with the building code of Pakistan taking into account the fact that the constructed pump station in the Project at the T/R Pump Station is a core facility of Faisalabad City's water supply.

2-2-1-3 Concept for Socioeconomic Conditions

In Pakistan, power supply is typically scarce and rolling blackouts of 10 hours a day have been implemented. The major facilities are powered by generators during outages in Faisalabad City.

However, regarding the water facilities, power is supplied by a dedicated power line independent of the regular power lines from the substation because of the importance of the facilities. While sudden power failures occur several times a month, rolling blackouts have not affected the facilities. During the survey there was one power failure at the T/R. This was thought to be due to an accident. Accordingly, the facilities are considered to have a stable supply of power for its operation, with the only interruptions being from sudden and unexpected events.

In this Project, there has been a request for the installation of generators to operate the pumps at the Inline Booster Pump Station and at the T/R. However, the Project will further investigate the actual necessity of generators at these facilities in consideration of the fact that the water supply facilities, in principle, receive a constant power supply and that the situation is different from in Faisalabad City. As a result, a new generator is not considered necessary and, therefore, is out of scope of this Project.

2-2-1-4 Policy Concept for Construction and Equipment Procurement

(1) Permission, Laws and Regulations related to implementation of the Project

For the implementation of the Project, it is required to undergo a preliminary review of development projects in Pakistan through the approval process of PC-1.

In regard of the construction authorization, FWASA would submit the necessary application forms for construction (inclusive of layout view, plan view and elevation view) to the administration in Faisalabad City with the cooperation of the contractor.

(2) Codes, Standards and Construction Methods in Building Design

Pakistan has its own building code (the Building Code of Pakistan) for construction of facilities. The Project performs the facility design using the code in principle. In addition, Japanese design criteria of

water supply is also referred to.

As for standards related to materials, because the British Standards and Bureau of Indian Standards are widely used, the Project adopts them.

(3) Procurement of Construction Materials and Equipment

Main construction materials, such as cement, aggregates, reinforcing bar, electric cables and pipes are to be procured in Pakistan as local procurement. It is planned to use pump equipment that is made in Japan, because of its low failure frequency, its excellence in energy efficiency and product quality. The materials and equipment procured from Japan, mainly pump equipment, are expected to be shipped to Karachi, which is the international port of Pakistan, and then be transported by road on a truck or by rail.

2-2-1-5 Concept for Utilization of Local Contractors

Local construction methods will be adopted in order to utilize local contractors. Local contractors in Pakistan are categorized by the Pakistan Engineering Council as C-A, which is the top, followed by C-B, C-1, C-2, and so on. Contractors categorized as C-A can participate to offer a tender of all the public construction works, contractors categorized as C-B can offer a tender no more than two billion Rs, contractors categorized as C-1 can offer a tender no more than 1 billion Rs, etc. Contractors in Pakistan have enough technical capabilities related to the construction of infrastructure such as highways. Contractors between C-A to C-2 have the capabilities and sufficient construction machines for subcontracting work under Japanese contractors if the construction is done using general methods.

Since grant aid projects have been implemented in Pakistan in the past, and some by FWASA such as ”Faisalabad water supply improvement plan”, “Faisalabad water supply expansion plan”, it is feasible to implement the Project construction by employing local constructors and local workers in accordance with the system of grant aid of Japan. Therefore, local contractors would be actively adopted in the Project in consideration of clarification by the above categories.

There are constructors who have experience implementing general construction works and civil engineering works and engineers who can perform supervision of construction works, however, there are no engineers that have experience installing the same type of pumps and associated machines and electrical equipment as those to be used in the Project. Thus, execution management engineers in charge of pumps installation work are to be dispatched from Japan.

2-2-1-6 Concept for Operation and Maintenance

FWASA, the executing agency has operated Chenab water facilities that started operation in 1992 and JBC water facilities that started operation in 2012, and has provided water supply services to Faisalabad City. The purpose of the Project is the replacement of the existing Chenab water facilities at the Inline Booster Pump Station and T/R, and the Project does not change the base of distribution systems. Therefore, it is expected that FWASA would be able to operate and maintain the facilities by making good use of its experience and knowledge even after completion of the Project.

On the other hand, since the distribution water volume per hour from the T/R will increase after

completion of the Project, FWASA will be given training on how to control the number of pumps for operation according to distribution water volume through trial operation and initial operational guidance on the completed facilities.

And since the increase of pump distribution volume, and main distribution pipeline will become two lines, the existing main distribution pipeline and the ones of the French government Project, water pressure in the main distribution pipe is necessary to be controlled in accordance with the volume of water distribution. For this reason, together with the initial operational guidance, the training of advancing skill for water pressure reduction will be conducted by the technical assistance.

2-2-1-7 Concept for Facility Design

It is prioritized that facilities are to be easy to operate and maintain so as to secure sustainability and continuation of the facility operation. And the new pumps and related equipment of the Project to replace existing facilities are to be selected by referring to the specifications of the existing equipment. In particular, the JBC reservoir and pump station were completed in 2012 at the T/R. Regarding the replacement of the T/R pump station, the basic structure of the Chenab pump station and its pump facilities are determined with reference to the JBC pump.

2-2-1-8 Concept for Quality Control and Responsibility

This Project does not require any unusual nor difficult construction methods. The work schedule is unlikely to be affected by the climate in Faisalabad City thanks to the low rainfall throughout the year. However, a delicate quality control by a Japanese company is expected especially to set an appropriate work schedule in order to ensure quality of construction in consideration of deterioration of work efficiency and negative impacts on concrete during hot summer.

Though the Project has two distant sites, the Inline Booster Pump Station and T/R, integrated service of both facilities is required for distribution of water to the city. As such, in order to secure smooth interaction of both facilities and to realize the responsibility, this Project should be handled by a contractor and, consequently, without dividing in several lots nor construction periods.

2-2-2 Basic Plan (Construction Plan)

2-2-2-1 Setting of the Optimum Pumping Yield and Design Intake Flow of Chenab Well Field

(1) Setting of the Critical Yield

The results of the pumping tests conducted at the time of Chenab well construction that were obtained in the Project show that, although pumping more than 600m^3/hour was carried out by the step drawdown test, a rapid change of the groundwater level accompanying the increase in a pump discharge was not seen, and the critical yield could not be confirmed. It means that the critical yield was more than 600m^3/hour.

About the result of the data for pumping discharge and groundwater level at the rehabilitation which was conducted for wells in 2009, aquifer loss coefficient is approximately the same as that of construction time, and the lowering of groundwater levels to pump discharge is almost equal. Therefore, it can be judged that critical yield of 2009 was almost equivalent to that at the time of well construction.

Based on the results of the pumping test conducted in this study, in the case whereby the aquifer loss coefficient is calculated similarly, the value was less than that at the time of construction and rehabilitation, it can be estimated critical yield has not changed even in the present. Therefore, the critical yield in the Project will be set at 600m^3 / hour, to proceed with further study.

(2) Setting of the Optimum Pumping Yield

By estimating the critical yield of Chenab well field as 600m^3 / hour or more, the optimum pumping yield is calculated as 420m^3/hour as 70% of the critical yield. Although this value is calculated by the current groundwater potential of Chenab well field, since the Chenab well field was designed using 400m^3/hour, the Project will set the maximum value of the optimum pumping yield as 400m^3/hour. Moreover, the optimum pumping yield of the Project is calculated in consideration of : the amount of pumping of Chenab well field corresponding to the groundwater level that can be pumped from the irrigation water well, and the pumping amount corresponding to the structure of the transmission line and Chenab well field.

1) Target Year

In case that the Project is carried out, the pumps of the Inline Booster Pump Station will be replaced and operation will be restarted in 2017. Just as the Inline Booster Pump Station sees the time of replacement after 20 years from the start of service, it is assumed that replacing time for new pump facilities will come around the year of 2037, 20 years after 2017. In addition, it is said the life of the well is around 30 to 50 years, and the age of the existing wells, which were constructed in 1992, will exceed 40 years in 2037. Therefore, the timing of when the pump facilities of the Project and existing wells will need to be replaced next are substantially overlapped. This means the possibility that next extensive replacement of the facilities will be carried out after 20 years, which in turn means that the facilities which are replaced by the Project will be utilized

for another 20 years from now. Therefore, the Project will consider the target year as 2037, for calculating of the optimum pumping yield.

2) The Range of the Permissible Dynamic Water Level

The pumps installed in the existing wells are turbine pumps manufactured by KSB. It is necessary to secure the following water levels, from the bottom of the upper casing for the permissible dynamic water level of the pump.

Table 2-2: Acceptable Length from the Bottom of the Upper Casing

Required minimum height from the first pump of the pump to the water surface	450 ㎜
Height of the pump inlet	365 ㎜
Clearance from the bottom of the pump inlet to the bottom of upper casing	200 ㎜
Total	1,015 ㎜

Among 29 wells, permissible dynamic water level of 5 wells shown in the construction record of FWASA at the time of the well construction is as follows. As well, according to the data in 2009, at the time of the rehabilitation of the pump except TW11 and from TW26 to TW29, the dynamic water level is in the range of 22.8 m to 31.7 m.

Table 2-3: Acceptable Dynamic water level of the Wells

Well Number	Well Depth (m)	Upper Casing Depth (m)	Acceptable Dynamic Water Level (m)
TW2	114.17	46.52	45.505
TW7	105.48	34.48	33.465
TW12	124.00	46.53	45.515
TW13	122.75	44.13	43.115
TW22	135.31	47.57	46.559

Among the 5 wells above, the well which permissible dynamic water level is shallowest is TW7 and the value is 33.47m. The data of the other 24 wells do not exist, therefore the Project will consider on the basis of TW7.

3) Calculation of the Amount of Decrease in Groundwater Level

The Project will conduct the long-term forecast of decrease in groundwater level by the Cooper Jacob method which took into consideration interference of 29 wells of the Chenab well field.

a) Pumping Discharge

Although the Design intake flow is 400m^3/hour per well, 20 hours operation per day, and 8000m^3/day, as far as operating record, it is rare for all the wells to operate for 20 hours or more per day.

According to the "Basic Design Study Report on the Project for Improvement of Water Supply

in Faisalabad (2004)", appendix 8-12, the average daily pumping amount is 158,946 m^3/day in December 2001, 162,916 m^3/day in June 2002, it can be surmised that the facility has been operating with the pump discharge of about 160,000m^3/day up until now.

There is no record about pumping discharge in FWASA, many of water meters, which are set in the wells have failed, or have not been calibrated, therefore to grasp the right pump discharge in each well is difficult. But pump discharge assumed by consideration based on the pump discharge from T/R included water leaks of around 130,000 to 170,000m^3/day. This seems to be the reason also for the lowering of groundwater level of Chenab well field, but since 6 hours per day of pump operation is conducted from the T/R, it is considered that only the amount of water required was pumped up. From the above, it is assumed that 6000m^3/day on the amount of water from one well was pumped up in the past.

In addition, 400m^3/hour of water is set as maximum pump discharge from one well, the Project will decide the volume of pump discharge as a value of 2037, with the condition that dynamic water level of TW7 will not become less than permissible dynamic water level.

On the other hand, groundwater level was measured in the observation well during the pumping test, the groundwater level of the observation well is shallower than the estimated groundwater level of the production well, measured at about 8m to 14m, and the static water level in the observation well is constant around the range of 14m to 19m. In addition, the drawdown of groundwater level is estimated to be about 2.0m in the future, as a result, in irrigation wells, it is necessary to take into consideration the existence of the well exceeding groundwater level GL-21m required for operation of the irrigation pump.

In order to use the irrigation wells continuously, it is necessary to suppress the groundwater level to less than GL-21m. In that case, on comparison of the possible pumping discharge and optimum pumping yield in TW7, definitive optimum pumping yield is made as a small value among both in the Project.

b) Transmissibility Coefficient, Storage Coefficient

Transmissibility coefficient and storage coefficient are the values calculated from the result of continuous pumping test and recovery test, and are values that represent the properties of the aquifer that are saturated with groundwater.

The amount of decrease of groundwater level of each well after pumping of a fixed amount for a fixed period from 29 wells of Chenab well field can be calculated by the Cooper Jacob formula, by using both coefficients obtained by pumping test of the study. In this way, it is possible to calculate the amount of decrease of groundwater level for each well in chronological order.

Transmissibility coefficient and storage coefficient calculated from pumping test are shown as follows.

Transmissibility Coefficient : 21164m^2/day

Storage Coefficient：0.00151

4) Result of Calculation

The result of the calculation, the maximum pump discharge in which the dynamic water level of TW7 is not less than allowable dynamic water level in 2037 is 7700 m^3/day. Since the pump operating time in Chenab well field is 20 hours per day, pumping discharge has been 385m^3/hour. In addition, the maximum pump discharge which can be found from the groundwater level required for irrigation well is 7200m^3/day per well, therefore the pumping discharge is 360m^3/hour. Therefore, in this Project, optimum pumping discharge of one well is planned as 7200m^3/day. The total pumping discharge from the 29 wells is 208,800m^3/day.

(3) Setting of the Design Intake Flow

From the previous section, although the total amount of 208,800m^3/day of water is possible for taking from all of the wells, it means 360m^3/hour from each well. On the other hand, the groundwater level of the Chenab well field is lower than at the time of construction, with the lowering of the groundwater level, amount of water pumped from the wells is limited.

The possible pump discharge of each well was calculated based on: the specifications of existing pumps installed in the wells, groundwater level of each well, and the specification of transmission line from each well to the Inline Booster Pump Station, if the amount of water intake which is determined by the property of current structure, and flow of the water in the transmission pipe are calculated by the hydraulic analysis. The results are shown in the following table.

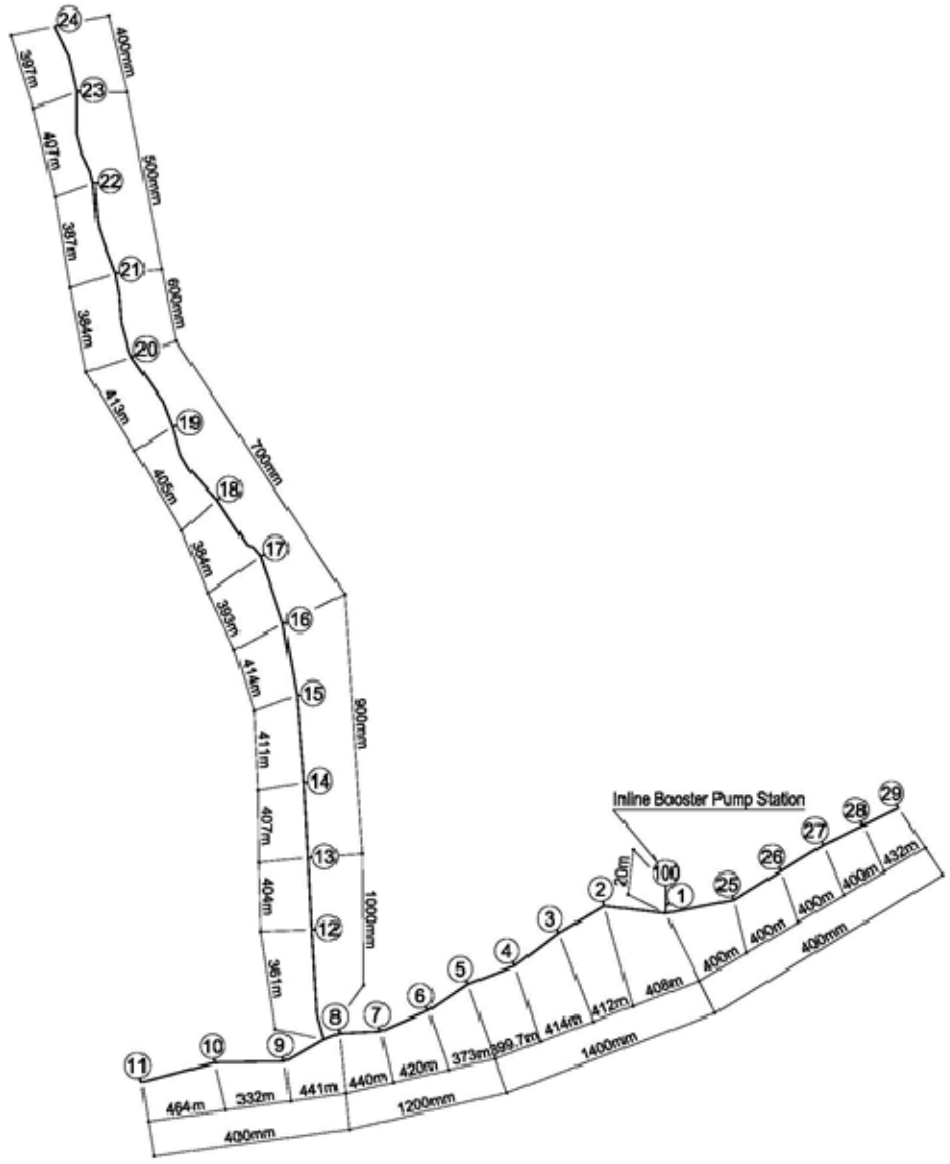


Figure 2-2: Layout of wells and transmission line

Table 2-4: Optimum Pump Discharge from each Well

Node	Pumping Amount		Pump Head	Dynamic Level	①Head of Spout	②Necessary Head	①-②
Num	(m3/h)	(m3/s)	(m)	(m)	(m)	(m)	(m)
1	464	0.13	33.27	-27.84	5.09	5.06	0.03
2	458	0.13	34.31	-27.97	6.01	5.86	0.15
3	458	0.13	34.31	-27.36	6.62	6.60	0.02
4	450	0.13	35.64	-28.00	7.32	7.25	0.07
5	444	0.12	36.57	-28.43	7.83	7.82	0.01
6	438	0.12	37.50	-28.27	8.92	8.82	0.11
7	431	0.12	38.54	-28.36	9.88	9.80	0.08
8	419	0.12	40.29	-29.20	10.81	10.70	0.11
9	369	0.10	46.28	-27.28	18.78	18.68	0.10
10	348	0.10	47.54	-25.99	21.35	21.31	0.03
11	309	0.09	48.25	-25.84	22.24	22.23	0.02
12	407	0.11	42.00	-29.90	11.84	11.75	0.09
13	396	0.11	43.46	-30.47	12.74	12.72	0.01
14	391	0.11	44.08	-29.68	14.16	14.06	0.09
15	383	0.11	44.97	-29.51	15.22	15.15	0.07
16	376	0.10	45.66	-29.38	16.05	16.00	0.05
17	356	0.10	47.15	-28.85	18.09	18.08	0.01
18	336	0.09	47.91	-28.12	19.60	19.57	0.04
19	302	0.08	48.29	-27.42	20.71	20.67	0.04
20	284	0.08	48.41	-26.83	21.44	21.44	0.00
21	264	0.07	48.73	-26.20	22.41	22.40	0.01
22	253	0.07	49.04	-25.14	23.79	23.76	0.03
23	253	0.07	49.04	-24.45	24.48	24.44	0.04
24	255	0.07	48.98	-23.82	25.04	24.98	0.06
25	393	0.11	43.83	-24.59	18.99	18.85	0.14
26	316	0.09	48.20	-22.22	25.81	25.78	0.03
27	242	0.07	49.52	-20.15	29.26	29.22	0.05
28	224	0.06	52.78	-19.68	33.01	30.75	2.26
29	220	0.06	52.78	-19.58	33.12	31.17	1.95
100	Inline Booster Pump Station					5.00	0.00

Pumping Amount: 10239 (m^3/h)、 204780(m3/day:20 hours operation)

The above table shows pumping discharge of each well at Chenab well field that are calculated based on the specification of the transmission line from each well, as water head at the inflow side of Inline Booster Pump Station is about 5 m. The number of each well for calculation is same as well number, the number of Inline Booster Pump Stations is set as 100.

Although the pumping discharge from each well is designed as 400m^3/hour at Chenab well field, at present, pumping discharge from each well have varied by lowering of groundwater level and loss of water head of transmission line. The result of calculation makes the total pumping discharge from each well 204,780m^3/day.

Table 2-5: Hydraulic Calculation of the Transmission Line

Line	Node Num		Diameter	Length	Flow Rate	Velocity	H-W Coefficient	Hydraulic Gradient	Head loss
Num	Start	End	(m)	(m)	(m3/s)	(m/s)	C	(‰)	(m)
1	24	23	0.4	397.0	0.07	0.56	100	1.377	0.55
2	23	22	0.5	407.0	0.14	0.72	100	1.662	0.68
3	22	21	0.5	387.0	0.21	1.08	100	3.511	1.36
4	21	20	0.6	384.0	0.28	1.01	100	2.507	0.96
5	20	19	0.7	413.0	0.36	0.94	100	1.860	0.77
6	19	18	0.7	405.0	0.45	1.16	100	2.731	1.11
7	18	17	0.7	384.0	0.54	1.41	100	3.877	1.49
8	17	16	0.7	393.0	0.64	1.66	100	5.290	2.08
9	16	15	0.9	414.0	0.74	1.17	100	2.058	0.85
10	15	14	0.9	411.0	0.85	1.34	100	2.635	1.08
11	14	13	0.9	407.0	0.96	1.51	100	3.291	1.34
12	13	12	1.0	404.0	1.07	1.36	100	2.408	0.97
13	12	8	1.0	361.0	1.18	1.51	100	2.901	1.05
14	11	10	0.4	464.0	0.09	0.68	100	1.964	0.91
15	10	9	0.4	332.0	0.18	1.45	100	7.931	2.63
16	9	8	0.4	441.0	0.29	2.27	100	18.090	7.98
17	8	7	1.2	440.0	1.58	1.40	100	2.050	0.90
18	7	6	1.2	420.0	1.70	1.51	100	2.346	0.99
19	6	5	1.2	373.0	1.83	1.61	100	2.665	0.99
20	5	4	1.4	399.7	1.95	1.27	100	1.420	0.57
21	4	3	1.4	414.0	2.07	1.35	100	1.593	0.66
22	3	2	1.4	412.0	2.20	1.43	100	1.778	0.73
23	2	1	1.4	408.0	2.33	1.51	100	1.973	0.81
24	29	28	0.4	400.0	0.06	0.49	100	1.048	0.42
25	28	27	0.4	400.0	0.12	0.98	100	3.841	1.54
26	27	26	0.4	400.0	0.19	1.52	100	8.590	3.44
27	26	25	0.4	400.0	0.28	2.21	100	17.315	6.93
28	25	1	0.4	432.0	0.39	3.08	100	31.935	13.80
29	1	100	1.4	20.0	2.84	1.85	100	2.859	0.06

The above table shows the flow volume, velocity, hydraulic gradient and loss of water head of each transmission line that is calculated based on the specification of the transmission line from each well of Chenab well field to the Inline Booster Pump Station. Fluctuation of the pumping discharge of each well has an impact on loss of water head on each route, and the head loss of routes where the hydraulic gradient exceeds 5 per cent is more than 2 meters. This is the reason why the pump discharge from Chena well field is limited.

Analysis is carried out based on the expected water level in 2017 when the facilities of the Project start service. Since the current groundwater level is down compared to the groundwater level of 1992, when the service of Chenab well field started. The water head at the spout of the pump is expected to decrease, and the diameter of transmission pipe from wells to Inline Booster Pump Station is too small for the water head of 2017. In addition, even though the optimum pump yield from the well is 360m^3/hour, some pumps cannot discharge 360m^3/hour of water when every pump is operated. Therefore, the facilities cannot meet the specified optimum pumping yield of 208,800m^3/day of groundwater.

In order to pump up the optimum pumping yield, 208,800m^3/day, it is necessary to upgrade the intake

pump to bigger pump than existing pump, or upgrade the transmission line to a bigger diameter. However, there is no plan regarding the upgrade of these facilities in FWASA, therefore, as the design intake flow of the Project, it is appropriate not to set the plan at the optimum pumping yield of 208,800m^3/day but 204,780m^3/day which can be determined by the institutional structure.

Therefore, the Project will carry forward the facilities planning that design intake flow is 204,780 m^3/day.

2-2-2-2 Target Setting of the Water Supply Services in the Implementation of the Project

The water demand of Faisalabad is increasing, however, the amount of water supply is insufficient. Therefore, the total amount of design intake flow from Chenab well field needs to be distributed to the city at least. However, at T/R which is the main water supply facility, distribution pumps installed in the existing Chenab pump station cause cavitation because of the water level situation of T/R and the current installation height of pumps. Because of the need to avoid this cavitation, the Chenab T/R has been able to use only about half of its capacity.

If the effective capacity of T/R tank cannot be used adequately and in case the hourly distribution volume is less, it is possible to distribute the total design intake flow with sufficient water pressure by operating the pumps for a longer period of time. However distribution to meet peak demand is not possible. Further, increasing the distribution flow from the pump to match the demand of the peak, the operating time of the pump is restricted, water distribution is possible by gravity flow, but it means that the amount of water with secured water pressure that can be distributed in one day is limited. At present, although it takes six hours to distribute the water by the pump to the city because of an increase in electricity prices and financial circumstances of FWASA, and due to the current water level of the T/R tank and distribution volume from the T/R by the distribution pump, it turns out that about 21% of design intake flow cannot be supplied, as shown in the following table.

Table 2-6: Distribution Flow from T/R

	Current Water Distribution Operation
Water Supply time (Pump distribution)	6 hours
Pump Distribution Amount per Hour	10,422m^3/hour
Number of Operating Pump	Large Pump:3 nos, Small Pump: 1 nos
Distribution Hours by Gravity Flow	18 hours
Pump Distribution Amount	62,532 m^3/day
Distribution Amount by Gravity Flow	99,000 m^3/day
Total Distribution Amount	161,532 m^3/day
Design Intake flow	204,780 m^3/day
Percentage of Distribution Amount with Design Intake Flow	Approximately79%
Minimum Water Level of Reservoir Tank	GL+185.60m

To solve this problem, if it is possible to take full advantage of capacity of T/ R tank and it is possible to supply the total amount of water from T/R tank that flows from water source to T/R, it will be possible, under current conditions, to improve the water services. Namely, it will be possible to increase the supplied water volume at a stable pressure and expand the water supply time using the distribution pump.

Therefore, as targets of water supply in the Project, three years after the completion: “Expansion of operating hours to 9 hours from the current 6 hours of JBC distribution pump and increase of the water volume per hour from Chenab distribution pump”, and in the future: "Expansion to 12 hours from the current 6 hours of the Chenab distribution pump” is set for improvement of water supply services which will increase the amount of water distributed by the pump and expand the pump operating time. In this case, if the replacement distribution pump will be on the same floor level as the existing pump station, it is not possible to avoid cavitation during the pump operation. Therefore, in order to take full advantage of the effective capacity of T/R, the floor level of the existing pump station needs to be lowered, or a new pump station that can ensure the building depth to avoid cavitations will be needed.

2-2-2-3 Specifications of Booster Pump at Inline Booster Pump Station

(1) Setting of Number of Pumps and Discharge Rate

The design transmission flow to determine the specification of the booster pump is 204,780m^3/day, same as the design intake flow.

The number of the existing booster pumps is seven, but 4 large pumps and 2 small pumps would be installed for the Project in consideration of the set designed volume of delivering water and the discharge volume per one booster pump.

With regard to the discharge rate, the longer pump operation time per day means a lower transmission flow per hour. As a result, head loss becomes small and pump head can be suppressed. By taking into account operational aspect of the Chenab well field and Inline Booster Pump Station, operation time would be set at 20 hours a day.

If the discharge volume of booster pump is regulated at the same level as the existing booster pump, and one small pump is to be installed (two pumps including a back up), the discharge volume of small pump is regulated to half of the large pump, discharge volume and number of large and small booster pumps are shown in the table below. As well, since the space for the possibility of expansion is secured at the Inline Booster Pump Station, future expansion is possible.

Table 2-7: Design Transmission Flow, specification and Number of Booster Pumps

Specification of the Existing Booster Pump	Specification of the Replaced Booster Pump
Large pump 51.0 m^3/min ×4 nos. (3 + 1 back up)	Large pump 48.8 m^3/min ×4 nos. (3 + 1 back up)
Small pump 27.2 m^3/min ×3 (2 + 1 back up)	Small pump 24.4 m^3/min ×2 (1 + 1 back up)
Pump Head:20m in the specification Design Transmission Flow: 12,444 m^3/hour	Design Transmission Flow: 204,780 m^3/day 10,239 m^3/hour

(2) Setting of Total Pump Head

The total pump head of the booster pump is set at 34 m, as per the following table.

Table 2-8: Setting of the Total Head of the Booster Pump

	Specification	Remarks
Design Transmission Flow per Hour	10,239 m^3/h	
① Gross Head	8.79 m	H.W.L (188.2m) at T/R – Elevation (179.41m) of Booster Pump
② Head Loss of Transmission Line	29.0 m	Length:17,100m, Diameter:1500mm
③ Head Loss of around the Pump	1.21	
④ Water Head of Inflow side	5.0 m	Water head of inflow side of the booster pump
Total Head	34.0 m	①＋②＋③－④

(3) Installation of a Flow Meter for Transmission Line

At present, flow meter is installed at neither inflow side nor the outflow side of the Inline Booster Pump Station. Since the flow meter installed in each well in Chenab well field hardly works due to their breakdown, flow volume from water sources and transmission flow from Inline Booster Pump Station to T/R are not able to be checked directly. Therefore, the system that transmission flow to T/R is able to be checked directly would be established by installing a new flow meter at the second side of the Inline Booster Pump Station.

(4) Consideration for Setting of Generator

At the request of the Project, generators are required in the Inline Booster Pump Station to operate the booster pump. Although rolling blackouts are conducted for up to 10 hours a day in Faisalabad City, Chenab well field and Inline Booster Pump Station have the independent power line laid from the substation, therefore they experience no rolling blackouts. Actually, a few accidental blackouts occur in a month, but in principal, the electricity is always delivered. In this situation, installation of generators is out of target on replacement of facilities due to its low need.

2-2-2-4 Pump station Plan of T/R

The current operation time of distribution pumps at T/R is 6 hours per day, in order to supply the total amount of the design intake flow to the city, the maximum distribution flow is 17000m3/hour over 12 hours operation of the distribution pump in a day. Then, Figure 2-3 shows the water level of Chenab T/R; 1) when the connection pipe between Chenab and JBC T/R is closed (the minimum water level of

the reservoir is GL+182.90) and 2) when the connection pipe between Chenab and JBC T/R is open (the minimum water level of the reservoir is GL+184.00).

In both cases, water level becomes lower than the operating water level (water level that cavitation occurs). Therefore, the setting level of distribution pumps replaced by the Project should be lower than the current water level. In order to lower the installation position of the distribution pumps, as described later, there are two proposed methods, one is to construct a new pump station with lower floor and another method is to lower the floor of existing pump station. These two proposals are compared.

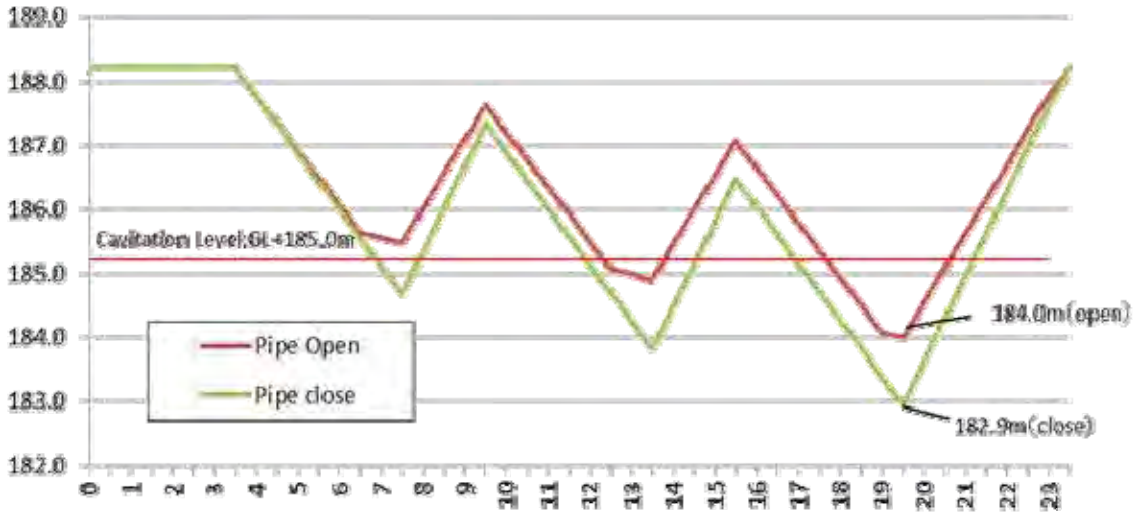


Figure 2-3: Temporal variation of Water Level of T/R by the Situation of connection Pipe

(1) Comparison of the Methods due to the Change of the Installation Position of the Distribution Pump

In order to lower the installation position of the distribution pumps, two methods are considered: to build a new pump station with a lower floor and alternatively to lower the floor of the existing pump station. In case of excavation to lower the floor of the existing pump station, poor construction quality and deterioration of facilities, which was confirmed in the field study, is a concern. And also, it is necessary to consider the length of the water supply outage for replacement of pump equipment. In the following table, the construction of a new pump station and excavation of existing pump station are compared from three points of view, construction performance and safety, economy, and the length of the water supply outage.

Table 2-9: Comparison of construction of new pump station and excavating existing pump station

	Digging Existing Pump station	Construction of New Pump Station
Workability, Safety	Not Good	Good
	Facilities decrepit Work in narrow places Cumbersome temporary works	General Construction
Economy	Good	Not Good
Water supply outage	Not Good	Good
	About six months	About one month

As shown in the table above, the construction of a new pump station is advantageous, except from an economic perspective. When considering excavating the floor of existing pump station, the following can be said as specific problems about workability and safety, economic efficiency, and water supply outage.

1. The existing pump station is more than 20 years old, so there is concern that vibrations from demolition of concrete and digging up the floor during rehabilitation will affect the structure of the building. Since the wall of the existing pump station is constructed of brick, in particular, the possibility of collapse of the wall by the vibration cannot be ruled out.
2. In the case of digging the existing pump station, it is necessary to dig and replace the pumps one by one, and it is necessary to dig the floor of existing pump station in a limited space. In that case, temporary works that take into account the influence of the pump is required, and it becomes very complicated. Thus, for dealing with lowering the floor level, digging the floor after removing all of the existing pumps is suitable, in which case, it is necessary to secure the amount of distribution water separately, now it is distributed from the Chenab distribution pump.
3. The construction cost of a new pump station is 1.3 times higher than the cost of digging the existing pump station. About economy, although the cost of a new pump station is larger, the existing pump station is more than 20 years old. Therefore, if lowering the floor of existing pump station is selected by the Project, the repair of brick wall and roof will be needed on a regular basis because of deterioration of the existing pump station. For economic efficiency by comparing construction costs, the digging of existing pump station is advantageous, but if it considers even the maintenance costs for the future, it cannot be said that the digging of the existing pump station would be more economically advantageous.
4. The period of the removal of all distribution pumps, digging the existing pump station, and installing the new distribution pumps is six months. During this period, only JBC distribution pump is running. In this situation, if all of the pumps including the back up pump of JBC are operated, only 15,168 m^3/hour of water can be secured, and the maximum flow rate record of the

past of about 16,000 m^3/hour to 21,000 m^3/hour cannot be secured.

5. In order to ensure the amount of distribution water during the construction period, it is necessary to install the additional pumps in the JBC pump station or temporary pumps outdoors. However, it takes a long period to procure and set up temporary pumps, and there is concern that this will cause delays to the start of construction and cause a major impact on the entire construction period.

Since the potential risks associated with the renovation of old facilities like the existing pump station are high, it is necessary to increase safety measures and temporary works for minimizing risks, which results in higher construction costs. Therefore, it is cost effective to construct a new pump station instead to improve the position of distribution pump.

(2) Facility Location Planning

For construction of a new pump station, as candidate sites, it is considered in three places, 1. Open space near the entrance, 2. Land adjacent to the existing pump station, 3. Land on the south side.

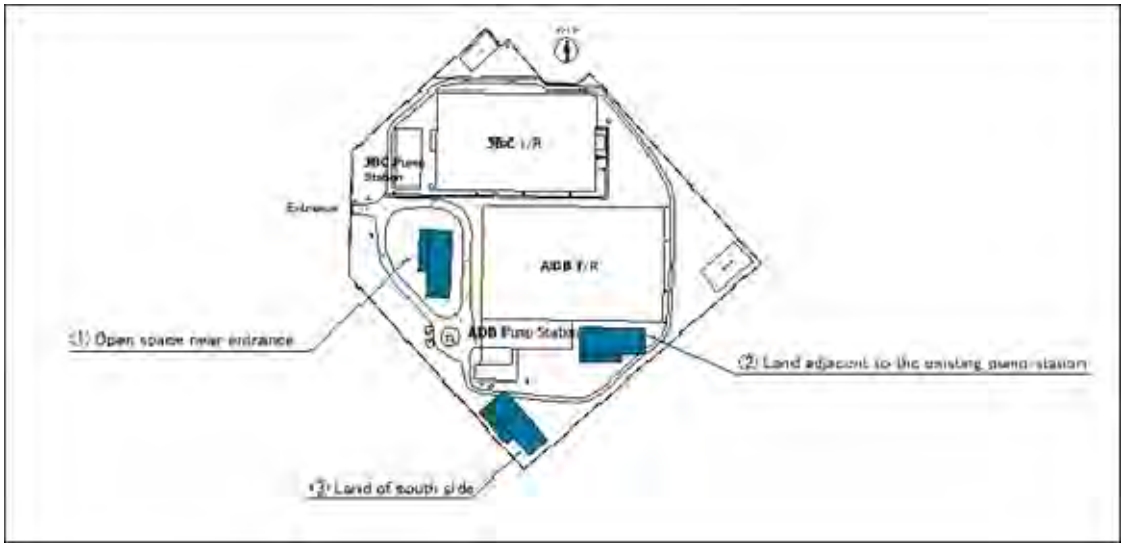


Figure 2-4: Candidate Sites of New Pump Station

The comparison table of the three candidate sites is shown as follows.

Table 2-10: Comparison of three candidate sites

	1. Open space near entrance	2. Land adjacent to the existing pump station	3. Land on south side
Traffic line	Good	Not Good	Not Good
	Close to the entrance Close to the JBC pump station	Far from the entrance Far from the JBC pump station	Far from the entrance Far from the JBC pump station
Workability	Good	Not Good	Not Good
	Loading of equipment is easy Good for access of heavy machinery	The construction site is small, the size of the temporary works becomes large Not good for access of heavy machine	The construction site is small, the size of the temporary works becomes large Not good for access of heavy machine
Other concerns	Moderate	Moderate	Not Good
	Necessary to break a part of existing pump station Necessary to replace and removal of some pipes	Necessary to replace the connecting pipe	Necessary to replace the connecting pipe There are concerns about security (access from the outside can be easily)

If the new pump station is planned at the open space near the entrance, it is near to the JBC pump station, so movement between both facilities becomes easy. On the other hand, the land adjacent to the existing pump station and the land of south side are not good with regard to traffic access when maintenance is needed. In addition, every candidate site needs the removal of existing facilities, replacement of pipes, therefore construction scale of them is comparable. As a result of the overall judgment based on the above, the location of the new pump station will be planned to be in the open space near the entrance.

(3) Building Plan

1) Architectural Plan

In order to achieve the necessary capacity of facilities under a limited budget, the target facility will be composed of the minimum rooms required. Specifically, it will be made up of a pump room, platform and electrical room.

Pump room will be designed as subsurface structure to set the level of distribution pump as same level as existing distribution pipe from Chenab T/R. At this time, center level of distribution pump will be designed as the same level as the center level of distribution pipe from Chenab T/R.

The platform for loading and unloading of distribution pump due to malfunction, repair, etc. will be set. In order to ride in the trucks directly in a pump station and in order to make the structure which can load and unload the pump by hoist crane, the platform will be designed as an overhang from inside of pump station.

The electrical room will be designed in order to place the pump control panels that control the distribution pumps. Distributing pumps are operated every day, and the electrical room needs to be accessed frequently, therefore the placement of the electrical room will be planned on the ground

floor. At this time, the walls between the pump room and electrical room will be designed with glass windows, so that the visibility of the distribution pumps becomes possible from the pump control panels.

Table 2-11: Summary of Planned Facilities

Room name		Utilization	Floor size (sq.m)
Pump station (basement)	Pump room	To be used for setting the distribution pumps and pipeline.	622.5
	Sub total		622.5
Pump station (Ground Floor)	Platform	To be used for riding in the truck, loading and unloading of distribution pumps.	75.0
	Electrical Room	To be used for setting the power receiving equipment and pump control panels.	156.0
	Sub total		231.0
Total			853.5

2) Section Plan

In a section plan, securing natural ventilation and natural lighting, and the prevention of intrusion of rain water will be considered. In order to secure the space to lift and move the distribution pumps and natural ventilation, the sufficient ceiling height will be secured.

Movement to the pump room corresponds by installing steel stairs in a platform. Moreover, pipeline from each distribution pump will be set in the pump room, therefore, movement on the basement floor will be difficult. For this reason, the steel catwalks will be connected to steel stairs, to make the movement to each distribution pump easy.

3) Structural Plan

The Project will adopt the Rahmen (rigid frame) structure with column and beams made by reinforced concrete for the construction. In terms of the roof of pump station, the Project plans flat roof with reinforced concrete. As for its foundation, the Project uses spread foundation generally adopted in Pakistan, because the soil condition of the Project site has been recognized as sandy soil including silt and there is plenty of soil bearing.

The Project will determine the wind load and seismic load of facilities based on a structural statement in Japan using concerned coefficient defined in Pakistani standard.

4) Building Equipment Plan

a) Lifting equipment

The distributing pumps installed by the Project are heavy machines, and since those pumps are set in a basement, it is necessary to consider the loading and unloading of distribution pumps. Therefore the Project will plan the installation of a hoist crane.

b) Electrical Power Supply

Currently, 11kV electric power line is drawn to both the Inline Booster Pump Station and T/R

station to run the pumps. Since even after the replacement of the facilities by the Project, the electric power supply from the existing power line is possible, no new electric power line is planned to be installed. Therefore, the existing power line will be used to supply electric power in the Project.

c) Lighting Fixtures

About lighting fixtures, the Project will adopt mercury lamp installed in the pump room, as is the case at existing pump stations, since the height of pump room is high. Fluorescent light will be adopted in the electrical room.

d) Water Supply System

The project will adopt the water tap in front of the pump station to supply water to the pump station.

e) Drainage System

The Project will plan a drainage system to discharge the water from pump room. The catchment for drainage will be installed beside the pump station, and drainage will be connected to the existing ditch.

f) Ventilation System

The structure of the new pump station will employ natural ventilation, i.e. wind, through the installation of louvers on the upper sections of the walls.

5) Construction Material Plan

The Project will adopt the design concept as below with consideration of the climate of Faisalabad, natural features, construction situation, construction period, construction costs, maintenance system of FWASA, etc.

- The Project will aim to shorten the construction period and reduce construction costs by using local materials as much as possible.
- The Project will aim to reduce maintenance costs by selecting the materials which suit the climate and natural features, have excellent durability, and are weather resistant and are easily maintained.

a) Roofing Material

Asbestos is used for the roof material in the existing pump station. However, because it has a serious impact on human health, the Project will adopt reinforced concrete for the roof. The roof of reinforced concrete is a common method in Pakistan, therefore there is no problem for the construction.

b) External Wall Material

The Project will adopt reinforced concrete for the structure of external walls, adopt brick finish

according to the existing pump station.

c) Internal Wall Material

The Project will adopt reinforced concrete for internal walls.

d) Fixtures

The Project will design windows on the external wall for lighting, ventilation of the pump station, and design windows on the internal wall between pump room and electrical room for confirming the situation of distribution pumps from the electrical room while the distribution pump is operated. The Project will adopt steel material for window frames, doors, etc. which are commonly available in Pakistan.

Table 2-12: Comparison Table of Methods and Materials

Member	Example of Similar Facilities	Design for Project	Reason for Adoption
Roofing	Concrete Corrugated slate Metal sheet	Reinforced concrete	They have the advantage for heat insulation, noise reduction and weather proofing
External Wall	Concrete Brick masonry	Reinforced concrete	They have the advantage for quake resistance and durability.
Internal Wall	Concrete Brick masonry	Reinforced concrete	They have the advantage for quake resistance and durability.
Fixtures	Steel fixtures Wooden fixtures	Steel fixtures	They have the advantage for durability and weather resistance.

Table 2-13: Summary of Planned Facilities

Building	Item	External Finishing
Pump station	Roof	Reinforced concrete slab
	External Wall	Reinforced concrete, Brick finish
	Internal Wall	Reinforced concrete
	Doors and Windows	Steel door, steel sash

2-2-2-5 Consideration of the Specification of the Distribution Pump at T/R

(1) Facility Capacity of the Existing Chenab Distribution Pump

Chenab distribution pumps were designed as 7 large pumps and 3 small pumps in the construction period, however, now over 20 years has past, and the current facility capacity of Chenab distribution pumps, which is past the appropriate time to be updated, is as follows.

Table 2-14: Facility Capacity of Chenab Distribution Pumps (Current conditions)

	Original Specifications	Current Conditions
Specifications and number of Pump	Q=37.7m^3/min, H=45m (Large Pump: 7) Q=27.2m^3/min, H=45m (Small Pump: 3)	Same as on the left
Number of pumps that can operate	Large Pump: 7 (5+2 standby) Small Pump: 3 (2+1 standby)	Large Pump: 4 (3+1 standby) Small Pump: 2 (1+1 standby) (3large pumps, 1small pump are breakdown)
Distribution capability of pump	14,574 m^3/hour	8,418 m^3/hour

In the current situation, 4 distribution pumps out of 10 pumps are not operational due to breakdown. Therefore the current Chenab distribution capability, which is calculated by the distribution pumps that can be operated, is 8418 m^3/hour. However, even the distribution pumps that are running, the life expectancy of normal machinery is about from 15 years to 20 years, so those pumps are past the period of time that can be used and have almost no residual value, which is calculated from the life expectancy.

(2) Setting of Design Distribution Flow based on the Distribution Time of Pump

Currently, operating time of existing Chenab and JBC distribution pump is six hours per day. The JBC distribution pump was designed as twelve hours of pump operation, but it is not operated for twelve hours per day because the significant cost of electricity is a management burden to FWASA. For payment of electricity charges, what was 319 million Rs in 2011, has become about 1.5 times, 470 million Rs, in 2012. In addition, for water charge, FWASA has applied for the price increase of water rates to the Punjab government. But it has not been approved, and currently the decision is on hold. Therefore, the operating balance (income minus expenditure) of FWASA has been negative in both fiscal years of 2011 and 2012. (Minus 76 million Rs in 2011 and minus 104 million Rs in 2012)

On the other hand, water supply quantity of all water facilities FWASA managed is only about 61% for the water demand of Faisalabad City, and Chenabu water facilities have about 55% of the water source. Although the improvement of business management is an important challenge for FWASA, it is also the important issues to ensure the water source for better service to the city and to distribute the water properly to the city without waste.

Therefore, in this project, the plan is determined to distribute whole of water from the Inline Booster Pump Station to the city, and this volume is set as design distribution flow. In addition, the operating time of the distribution pump is 6 hours per day at present, the rest of the time, water is distributed to the city by gravity flow from the T/R. As a result, including the eastern part of the city, water pressure is very low, it is a situation whereby adequate water pressure cannot be secured.

To improve this situation, as the water distribution plan in the future of this project, the operation time of Chenab distribution pump is set as twelve hours per day. This takes into consideration the replacement of the pump with the ability of distributing the design distribution flow by 12 hours.

However, in the current business management conditions of FWASA, which is a negative balance of

payments, it is difficult to distribute the water to the city by the pump operating 12 hours in a day immediately. For this reason, water facility is planned as a pump operation of 12 hours, however, in order to realize this pump operation, the water distribution plan is set taking into consideration increasing the pumping time and distribution volume by pump to the city in a step-by–step manner, along with the improvement of business management.

Distribution flow, which the time of pump distribution is expanded to 12 hours and which fully exploits the effective capacity of the T/R, is 17,000m^3/hour. In this case, the daily maximum distribution amount is almost the same as the design intake flow, about 100% of design intake flow can be distributed to the city. Further, the lowest water level of T/R becomes 182.9m. This means about 88% of effective capacity of the T/R is utilized, and that it is possible to improve the current state (about 50%) significantly. However, as described above, it is difficult to distribute the whole amount of the design intake flow to the city by the pump immediately, therefore the Project will make the distribution plan from T/R as follows.

Table 2-15: Setting of the Design Distribution flow

Design Intake Flow	204,780 m³/day
Design Distribution Flow	
Pump Distribution	13,230 m³/hour
Gravity flow	5,500 m³/hour
Pump Operation Time	6hours
Gravity Flow Time	15hours
Daily Maximum Distribution Amount	Total 161,880 m³/day
Pump Distribution	79,380 m³/hour
Gravity flow	82,500 m³/hour

The height of the connection pipe is GL+184.30m at the top of the pipe. In the future, if the hourly distribution flow is increased, the water level of T/R will become lower than the height of connection pipe. Therefore, if water is pumped with the vent pipe in its existing location, air will be mixed into the connection pipe from the vent pipe, and the distribution pump will not be able to operate while the water of both T/R flow freely. Therefore, the new valve will be set in the vent pipe so as not to mix the water and the air from the vent pipe. In addition, if the air accumulates in the connecting pipe, it is possible to discharge air by opening the valve set in the vent pipe. In this way, the function of the vent pipe can be secured as before.

(3) Setting of the Specifications and the Number of Pumps

If the Project selects large capacity pumps, it can decrease the number and setting area of pumps, but the adjustment to the time change of water distribution is difficult. On the other hand, small capacity pumps can adjust to the time change of water distribution, but it requires the larger area and complicated operation due to increased pumps. In consideration of the above and the specifications of JBC pumps, the specifications and number of the distribution pumps of T/R are determined as shown in the following

table. The total head of the pump will be 45m in accordance with the JBC, but since the current water distribution is provided by the water head of 20m, the distribution pumps are planned to be operated at 45m or less of the total head in order to reduce the energy consumption. Specifically, it is dealt with by replacing the head of the pump with an impeller head when the total head becomes 35m or less.

Table 2-16: Setting of Numbers and Specification of Chenab Distribution Pump

	Specifications	Remarks
Large Pump	Q=63.0m^3/min: 4 units.	3+1 back up
Small Pump	Q=31.5m^3/min: 2 units.	1+1 back up
Extended Pump	Large Pump:1	To be extended in the future
Design Distribution Flow	13,230 m^3/hour	Large Pump:3, Small Pump:1

When the management of FWASA has been enhanced and the design distribution flow has been provided in the future, large pumps will be operated without a spare pump. In the Project, the spare pump space for extension is provided in order that the large spare pump can be installed by FWASA in the future.

(4) Transmission and distribution planning

In the future, the pump operation time will be set as 12 hours, however from the current situation of management of FWASA, to implement this pump operation immediately is difficult. Therefore, it is considered best to increase the distribution volume by pumps and distribution time in stages.

The following tables show 1) the distribution and transmission flow based on the current facility capacity (2013) and 2) the distribution and transmission flow based on the facility three years after completion of the Project (2020). In the current situation where the total amount of design intake flow of the Chenab and JBC does not meet the water demand of Faisalabad City; and moreover there is a limited number of working pumps and there is insufficient budget to cover electricity costs, it is judged that only about 73% of design intake flow can be used.

Table 2-17: Transmission and Distribution Flow at the Present, 2013

Operation Condition of Transmission

	Hourly Transmission Flow (m^3/h)	Operation time (h/d)	Daily Transmission Volume (m^3/d)
Chenab	8,076	20	161,520
JBC (from operation record)			51,988
Total			213,508

Operation Condition of Distribution

	Hourly Distribution Flow (m^3/h)		Operation time (h/d)	Daily Distribution Volume (m^3/d)	
	Dist. Pump	Gravity Flow		Dist. Pump	Gravity Flow
Chenab	8,418		6	50,508	
		5,500	18		99,000
JBC	9,480		6	56,880	
Total	17,898	5,500		107,388	99,000
Daily Volume (Total)					206,388
Daily Volume (Chenab Total)					149,508
Daily Volume (JBC Total)					56,880

In order to improve the current situation and to use the water of water sources effectively, the water distribution plan three years after completion of the Project (2020) is set. As the water distribution plan, based on the six hour operation of the current state, the amount of water distribution per hour of the Chenab distribution pump will increase to 4,812 m^3/hour (from 8,418m^3/hour to 13,230m^3/hour), the amount of the hourly water distribution from the T/R will increase by 27%. And, in order to improve the situation of JBC distribution pump, which was planned in 12 hours of operation per day, but is running only six hours, the operating hours of JBC distribution pump will be extended from six hours to nine hours per day with the aim of increasing the total amount of water supply per day (see the table below).

Table 2-18: Transmission and Distribution Flow Three Years after Project Completion, 2020

Operation Condition of Transmission

	Hourly Transmission Flow (m^3/h)	Operation time (h/d)	Daily Transmission Volume (m^3/d)
Chenab	10,239	20	204,780
JBC (from operation record)			70,000
Total			274,780

Operation Condition of Distribution

	Hourly Distribution Flow (m^3/h)		Operation time (h/d)	Daily Distribution Volume (m^3/d)	
	Dist. Pump	Gravity Flow		Dist. Pump	Gravity Flow
Chenab	13,230		6	79,380	
		5,500	15		82,500
JBC	9,480		9	85,320	
Total	22,710	5,500		164,700	82,500
Daily Volume (Total)					247,200
Daily Volume (Chenab Total)					161,880
Daily Volume (JBC Total)					85,320

In the future, the repair of water leaks in pipelines, facility improvements such as installation of water meters, financial improvement by the loan from the World Bank and the subsidy from the Punjab government, and revision of water charges and improvement of the fee collection rate will be gradually conducted in order to improve the facility management and increase the operating time of facilities. Finally, the total amount of the design intake flow will be distributed to Faisalabad City.

(5) Consideration for Setting of Generator

As with the generator in the Inline Booster Pump Station, generators to operate for the distribution pumps are also requested in the T/R pump station. However, the T/R pump station is continuously supplied with power from an independent electric line from the substation so that the scheduled blackouts have not been planned. Moreover, in the T/R pump station, some limited volume of water is supplied to the city by gravity flow when the pumps are stopped. From the above, there is no need to install generators in the T/R pump station and the generators are excluded from the component of the Project.

2-2-2-6 Leakage Control of T/R Pump Station

(1) The Necessity of Leakage Control

At present, the daily water leakage from the T/R tank of the Chenab is recorded at least about 600 ~ 900 m3.

This leakage has occurred in the joints of the concrete wall, and the leakage is caused by deterioration and damage of joints and waterproof lining of the tank. Water leakage of 600 to 900 m3/day in the amount is less from the viewpoint of the design distribution flow, but the amount of water leakage from the T/R tank corresponds to about 5,300 to 8,000 people on the basis of the 112L/person/day, and loss of electricity equivalent toabout 23MWh～35MWh per year.

The water leakage has occurred in the pipelines of Faisalabad City rather than from the T/R so that the repair of T/R will not have a dramatic effect on the overall improvement.

However, in spite of the replacement of existing pumps, the construction of the pump station and the construction of facilities in order to take full advantage of the effective capacity of the Chenab T/R, to leave the water leakage is to reduce development impact of the Project, which is intended to reduce the power consumption.

The reduction of water leakage of the T/R contributes to effective use of water resources and the reduction of power consumption. Therefore, this Project includes repair of the existing T/R to reduce water leakage.

(2) The method of waterproofing for leakage of water

By the visual inspection of leakage of water, it is found that the main leakage of T/R is from concrete joints, the Project will achieve the reduction of the total amount of leakage of water by conducting the

repair of concrete joints. The T/R is separated into two rooms by a partition, and the repair of leakage of water will be conducted one by one. Concrete joints and waterproof coating will be removed after emptying one of the T/R (the other continues to supply water), and then, concrete surface and joint portion are cleaned. After that, target parts will be kept dry and the joints filled up with silicon, etc., and a waterproofing coat will be painted. After finishing repair of one of the rooms, the repair of the other room of T/R will be carried out similarly. During the period of repair, the amount of distribution water in the T/R will be limited because of drying one of the T/R. Therefore, the schedule of repair of T/R will coincide with that of other work that also necessitates stopping of the water supply so that this period of stoppage is minimized.

2-2-2-7 Relevance of French government Project and distribution plan from the T/R

(1) Outline of French government Project

Currently, the French government is providing financing to support FWASA to improve water facilities of Faisalabad City. In this French project, in addition to construction of the new surface water treatment plant, the expansion of the well, the plan to set the new water distribution mains of 1000mm are also included. This distribution mains is connected to the pipe from JBC pump station, the water is also distributed to the city as a separate line. For this reason, T-shaped member (1500mm × 1200mm) was installed at the time of the JBC pump station was constructed, by connecting the French distribution mains to the branch pipe, the water of existing distribution main flows to the west side of the city, the water of distribution mains by the French project flows to the east side of the city, it is planned to supply water to the east side that were not previously able to have enough water and water pressure. While two systems of water facilities are running, because it is not possible to supply the design distribution flow to the city only using the existing 1600mm distribution main, by using a double distribution mains it will be possible to improve the water distribution situation in Faisalabad City.

According to the confirmation in this Study, the schedule of the construction of distribution mains of 1000mm is delayed, the construction will start in Feburualy 2015.

The outline of the French project is as below.

- Surface Water Treatment Plant (10MGD): Jhal Khanuana
- New Arterial Main (1,000mm, L=7.2km): Connected to JBC pipeline
- Well Field (10 units, 5MGD): Rakh Branch Canal
- Transmission Main (300mm-600mm, L=13km): Rakh Branch Canal
- Replacement of Pumps (12 units.)
- Leak Detection and Repair studies for improvement in network efficiency (L=1,056km)
- Bulk Flow Meter with Data Loggers（51 units.）
- Commercial/ Domestic Meters (1”-3”, 585 units.)
- Domestic Meters (1/2”, 20,000 units.)

About double distribution mains by the French project, it is not possible to distribute the water from the JBC pump station to the city by only 1000mm of new arterial main, it is necessary to distribute water from both of the water distribution mains. Therefore, in this Project, the pipe connected from the JBC pump station to the Chenab distribution main is continued to be used in the future.

(2) Hydraulic situation of distribution pipes in the city

When the pump head of the distribution pump of T/R is assumed to be 45m, the maximum static head of the distribution pipes in the city is calculated as 48.4m.

It is also about 45m near the outlet of the T/R as dynamic head, but maximum dynamic head in the city is about 36m, most of the city is less than 20m. Ductile cast iron pipe and asbestos-cement pipe (ACP) are mainly used in the city, about 45m - 55m is expected in general as water hammer pressure associated with the operation and stopping of the distribution pump. For cast iron pipe, even in the water pressure of about 100m, which is sum of water hammer pressure and static water head, almost no impact to cause the rupture of the pipe. But about asbestos pipe, in view of the fact that leakage is occurring at this time and the pipe is aging, if the water pressure is raised in the city under the current conditions, there is a greater risk of leakage and damaging pipes than the currently level. Therefore, at this time, it is necessary to keep the discharge pressure of about 20m from the T/R, and along with the replacement of the ACP in the city, it is necessary to raise the pressure gradually to eliminate the negative pressure in the water pipe in the city.

2-2-3 Outline Design Drawing

The following pages present the outline design drawings of the facilities by the Project.

Table 2-19: Outline Design Drawings

No.	Drawing Title
1	Plan of Pipe Works for Inline Booster Pump Station
2	Single-line Diagram for Inline Booster Pump Station
3	Control Panels for Inline Booster Pump Station
4	Plan of Terminal Reservoir
5	Elevation of Terminal Reservoir Pump Station
6	Plan for Basement Floor of Terminal Reservoir Pump Station
7	Plan for Ground Floor of Terminal Reservoir Pump Station
8	Section Details A-A of Terminal Reservoir Pump Station
9	Section Details B-B of Terminal Reservoir Pump Station
10	Plan of Pipe Works for Terminal Reservoir Pump Station
11	Single-line Diagram for Terminal Reservoir Pump Station
12	Control Panels for Terminal Reservoir Pump Station

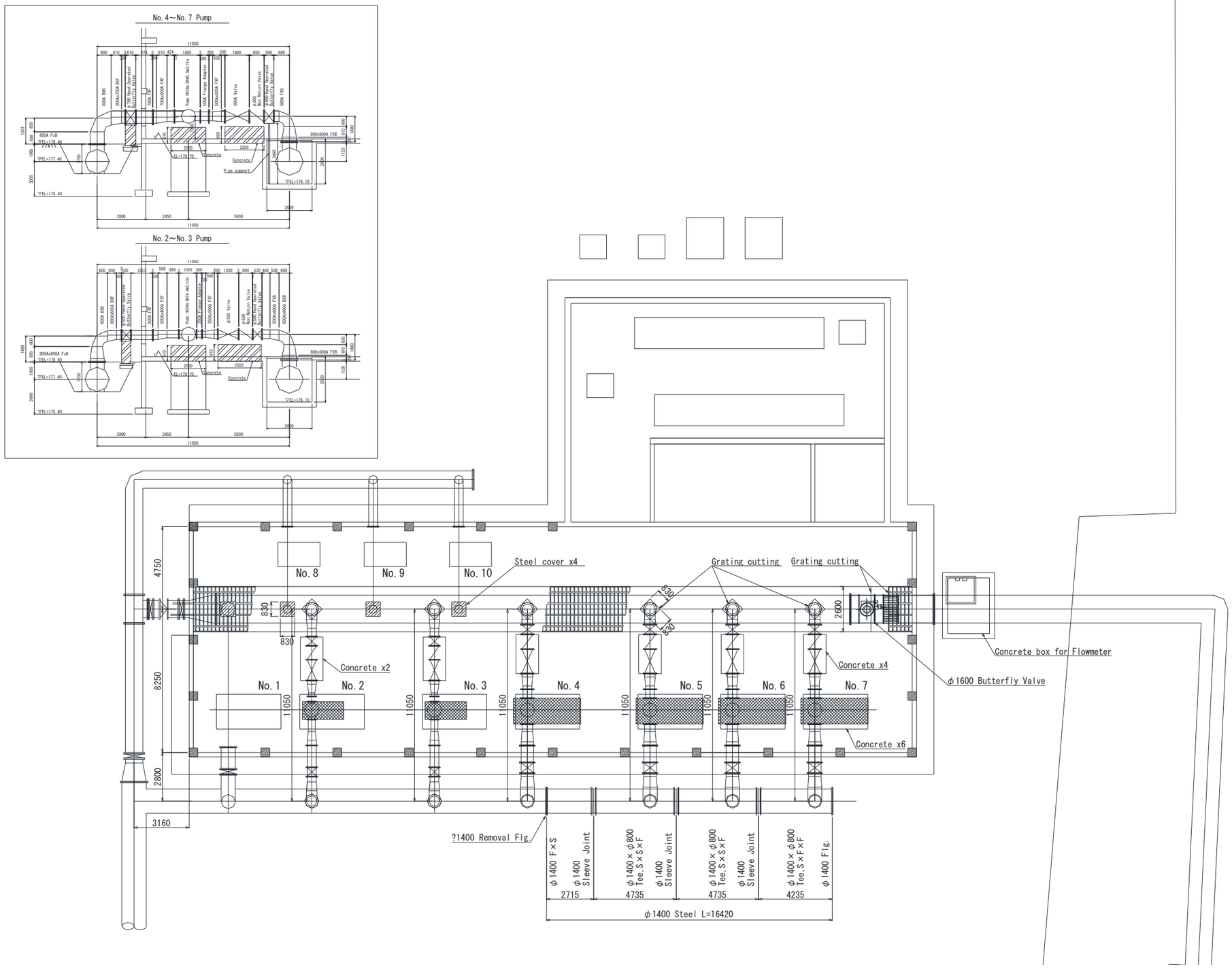


Figure 2-5: Plan of pipe works for Inline Booster Pump Station

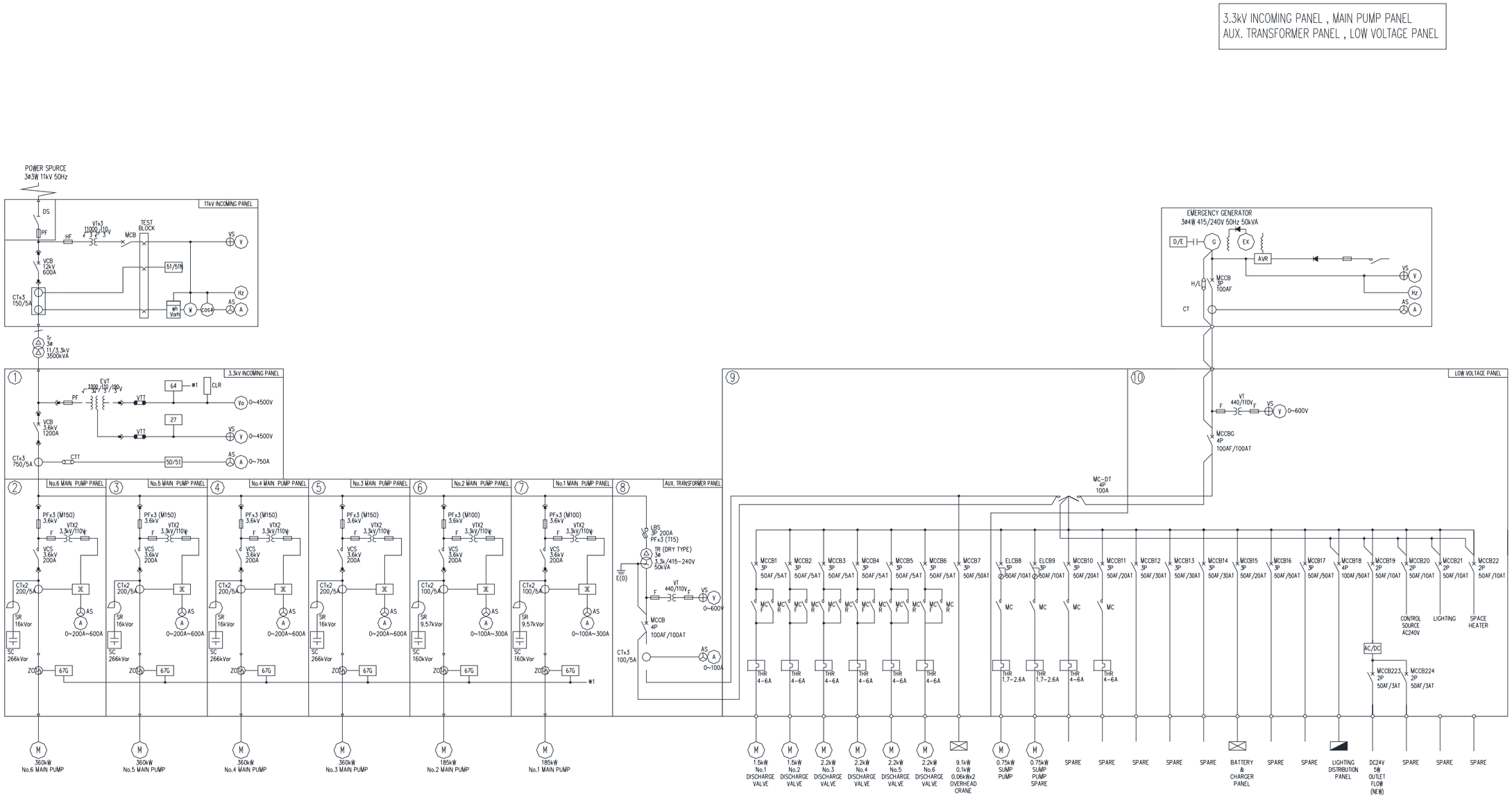
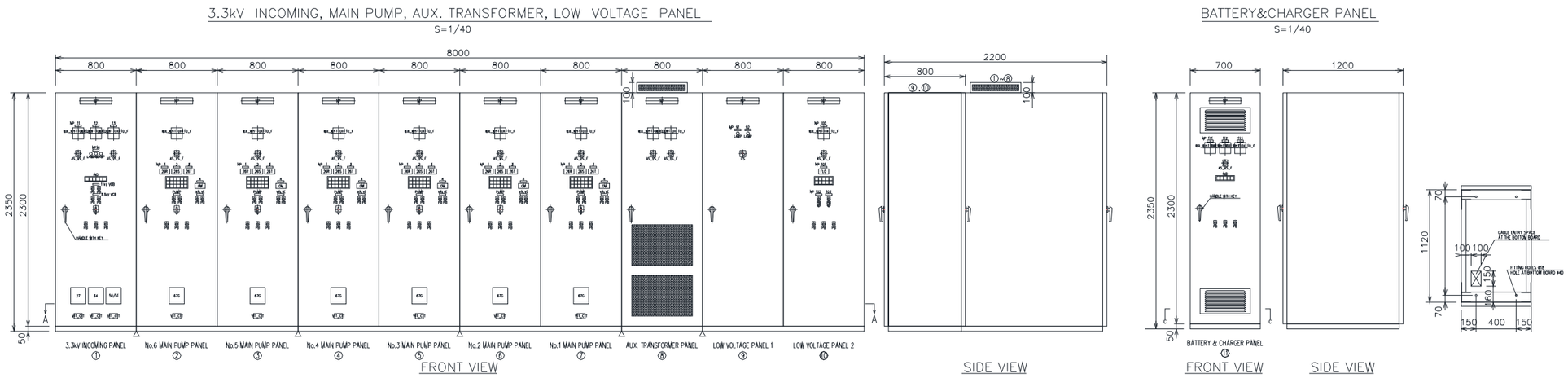
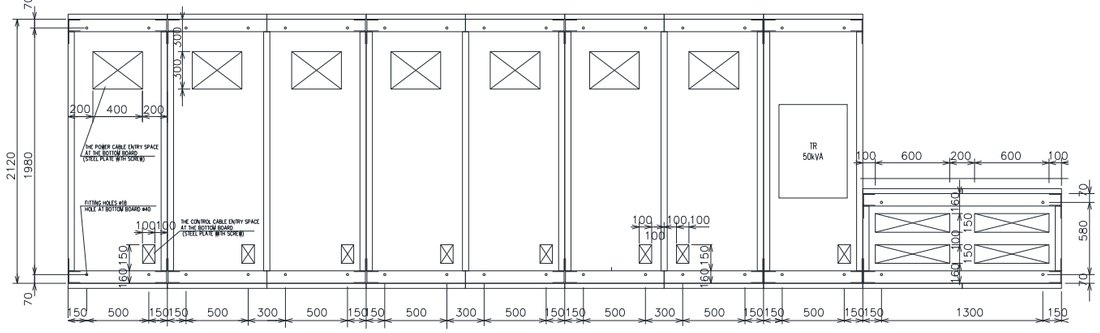
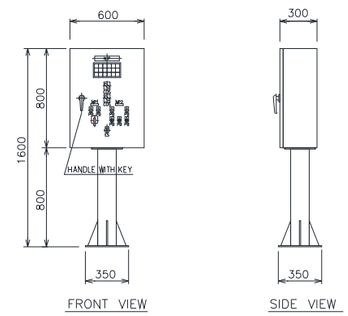


Figure 2-6: Single-line Diagram for Inline Booster Pump Station







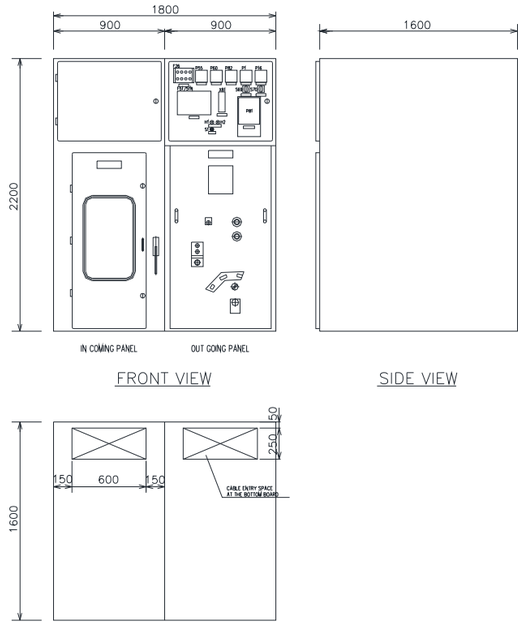


Figure 2-7: Control Panels for Inline Booster Pump Station

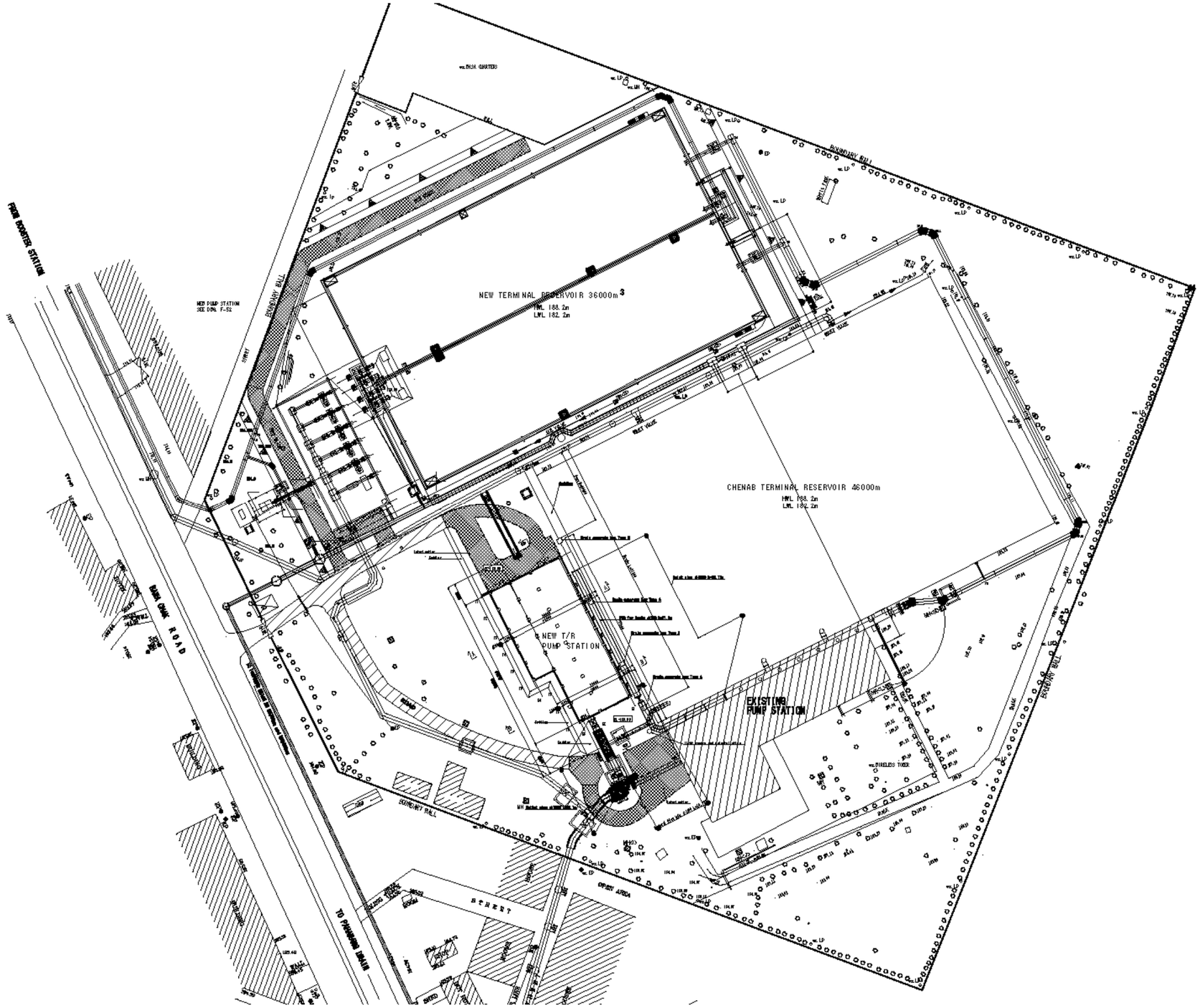
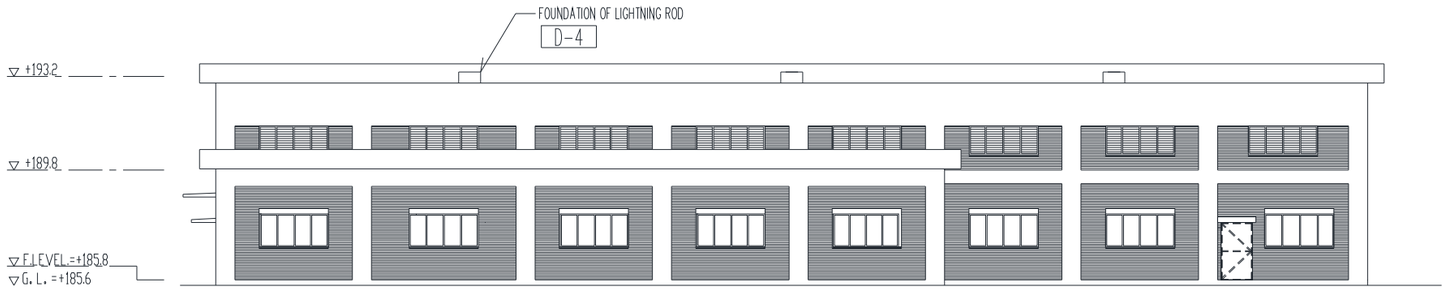
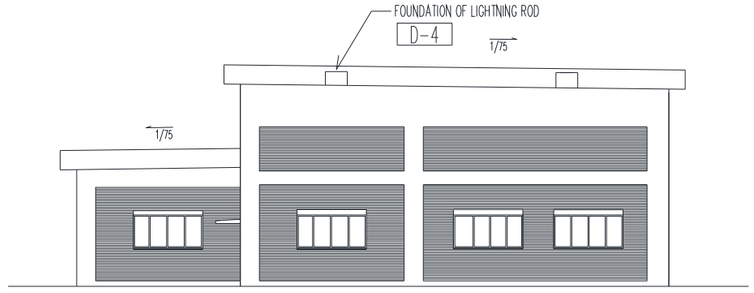


Figure 2-8: Plan of Terminal Reservoir

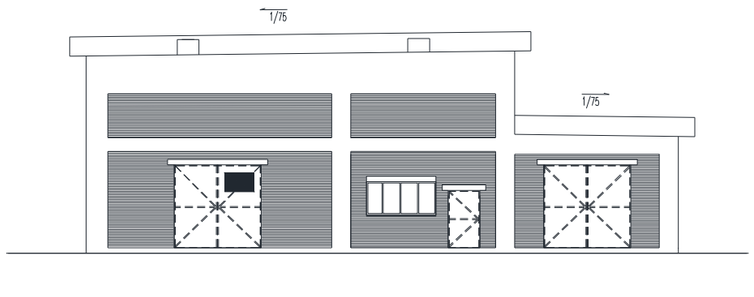


ELEVATION - 1



ELEVATION - 2

ELEVATION - 3



ELEVATION - 4

Figure 2-9: Elevation of Terminal Reservoir Pump Station

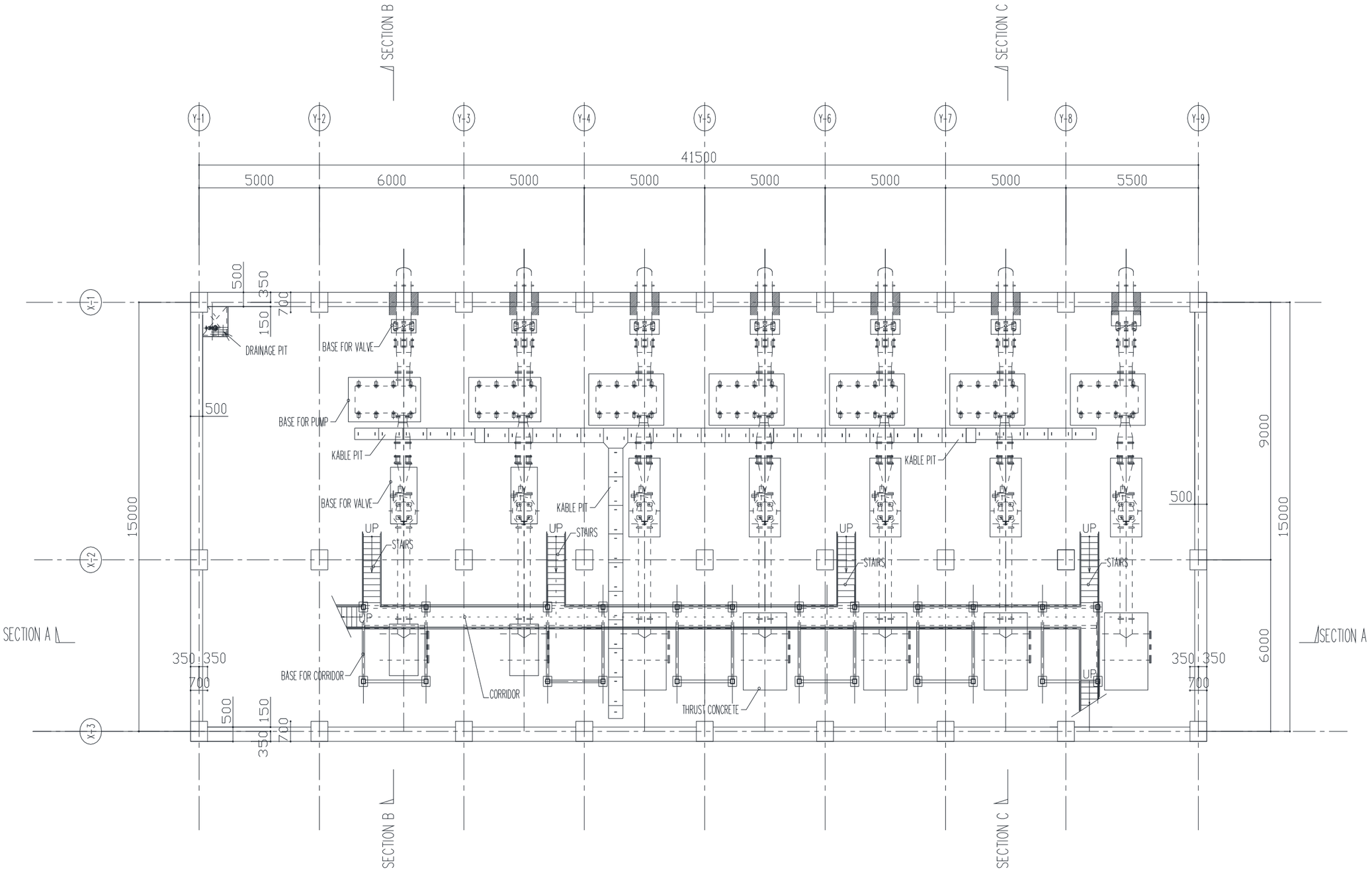


Figure 2-10: Plan for Basement Floor of Terminal Reservoir Pump Station

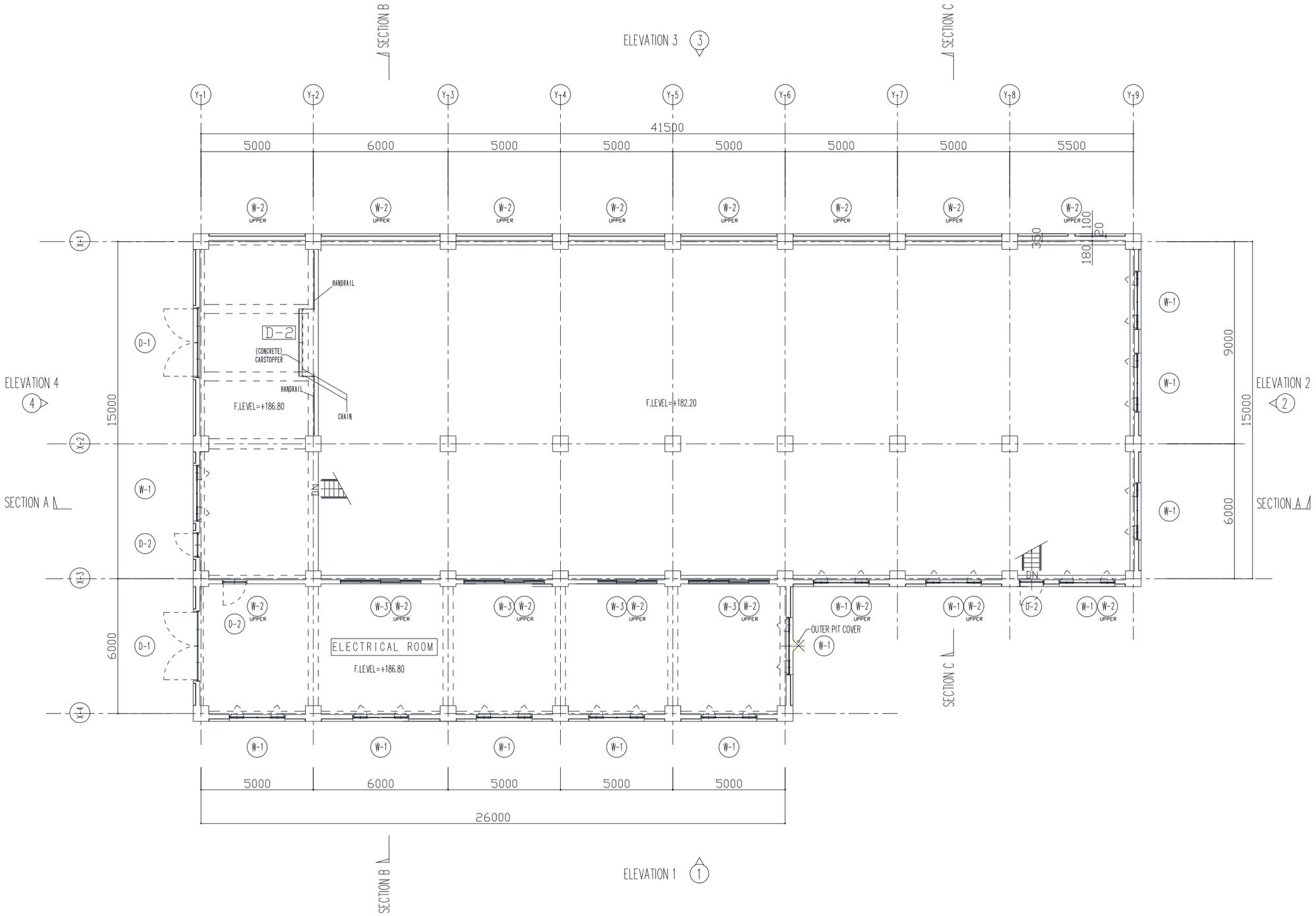


Figure 2-11: Plan for Ground Floor of Terminal Reservoir Pump Station

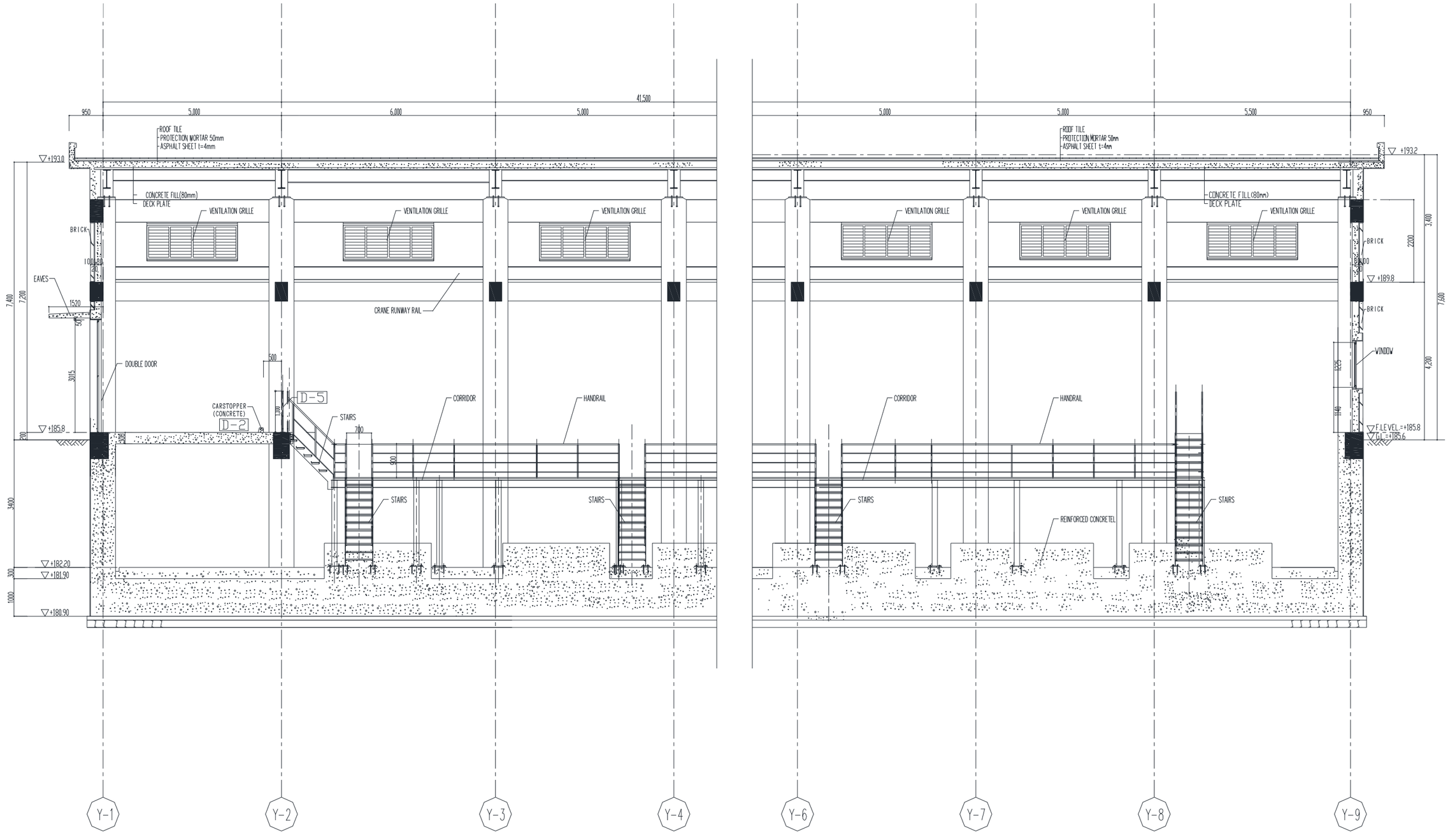
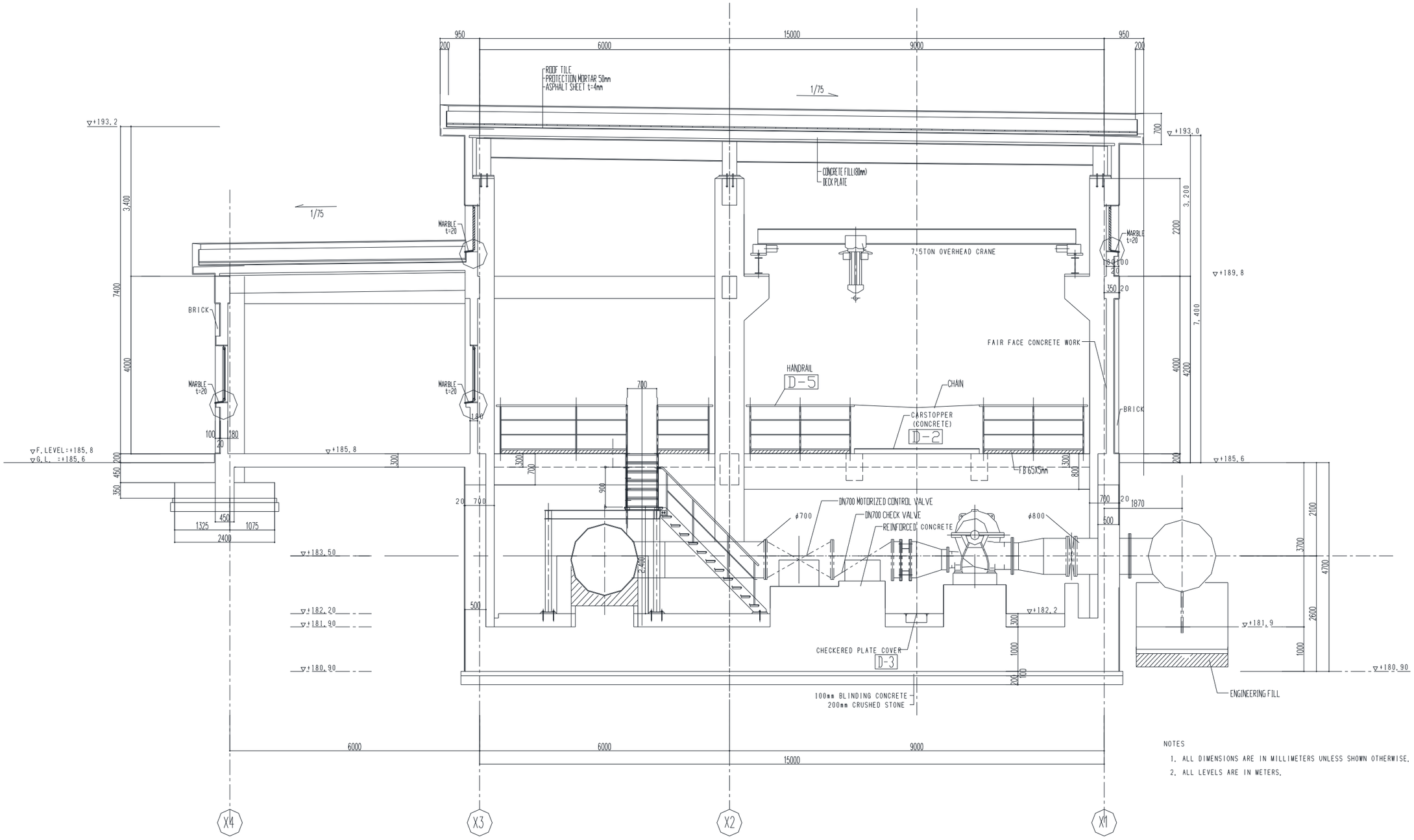


Figure 2-12: Section Details A-A of Terminal Reservoir Pump Station



NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS SHOWN OTHERWISE.
2. ALL LEVELS ARE IN METERS.

Figure 2-13: Section Details B-B of Terminal Reservoir Pump Station

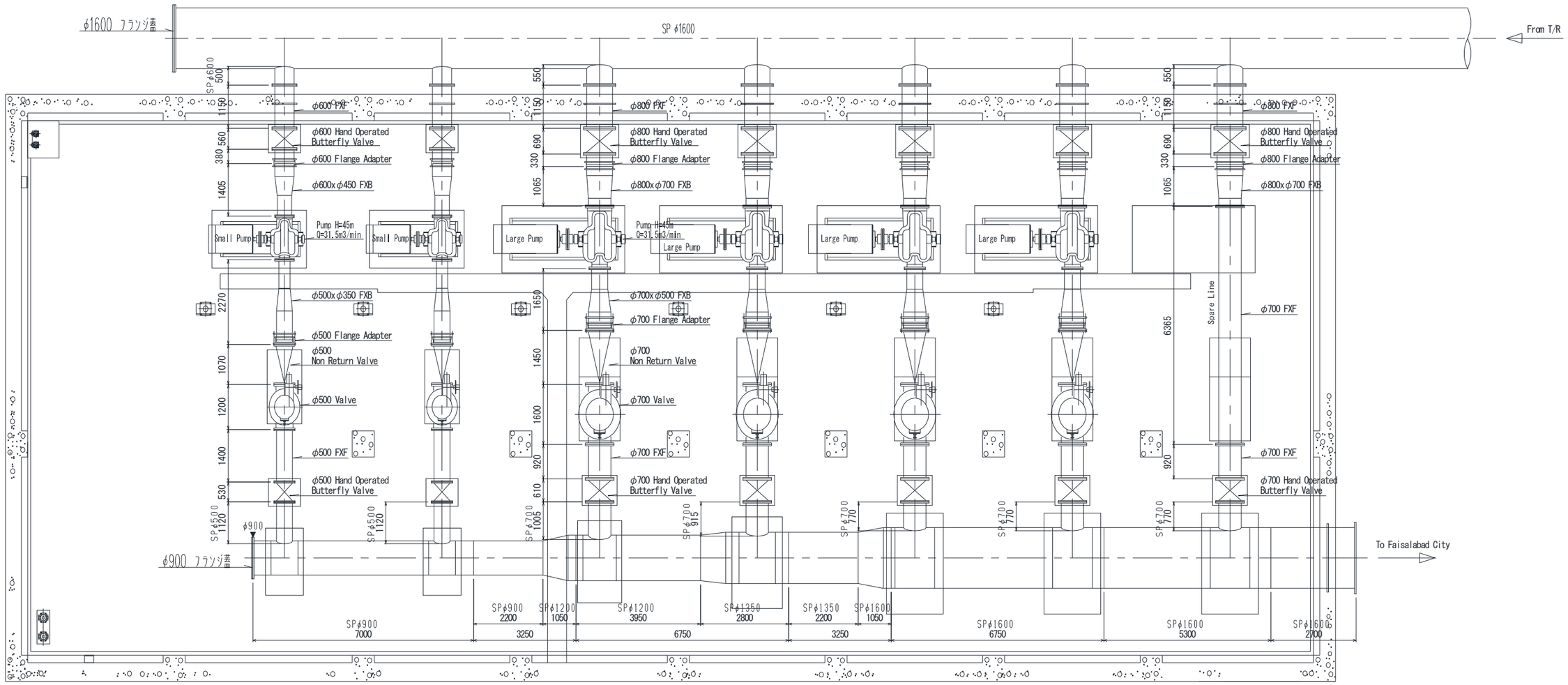


Figure 2-14: Plan of pipe works for Terminal Reservoir Pump Station

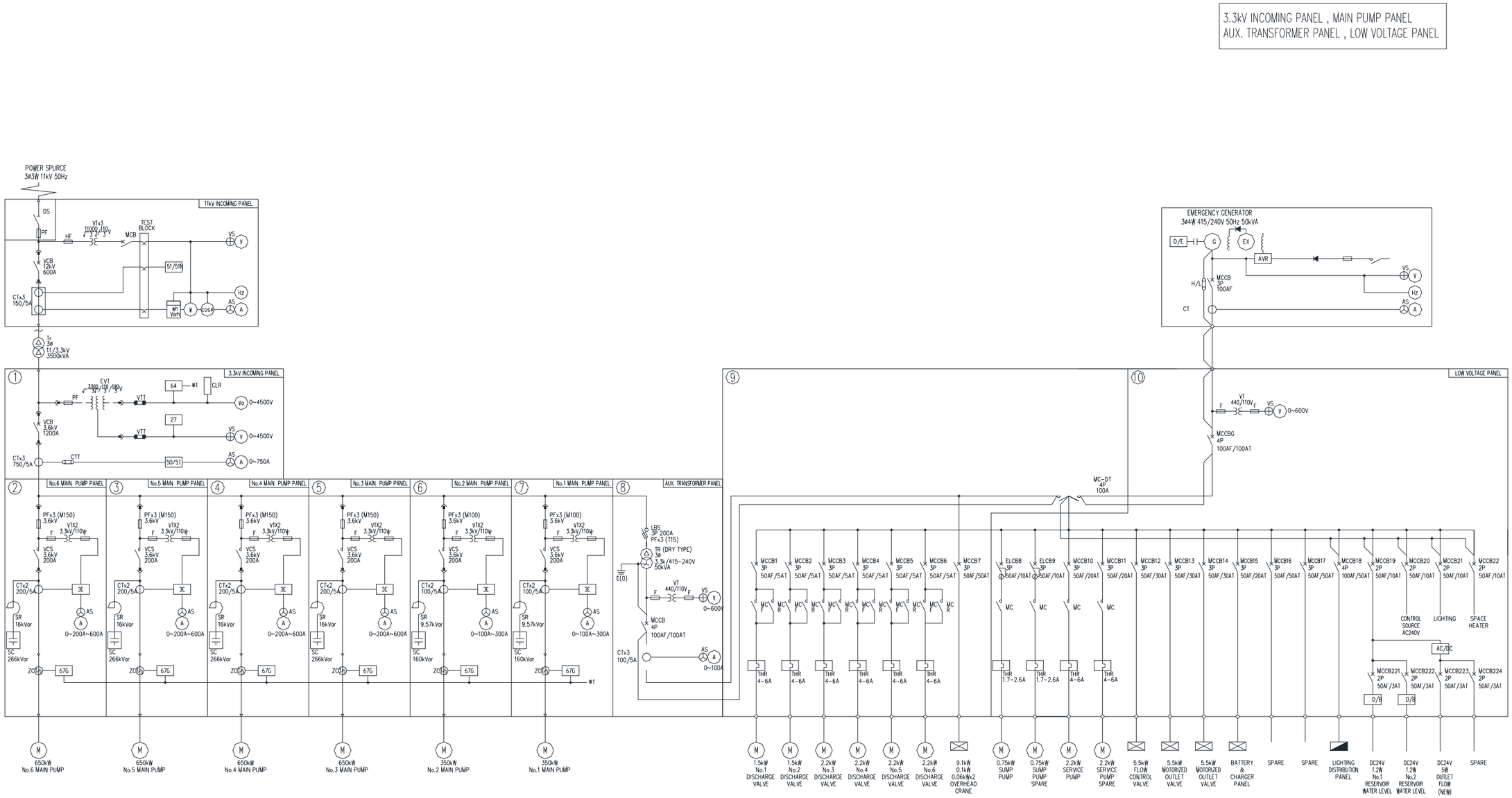
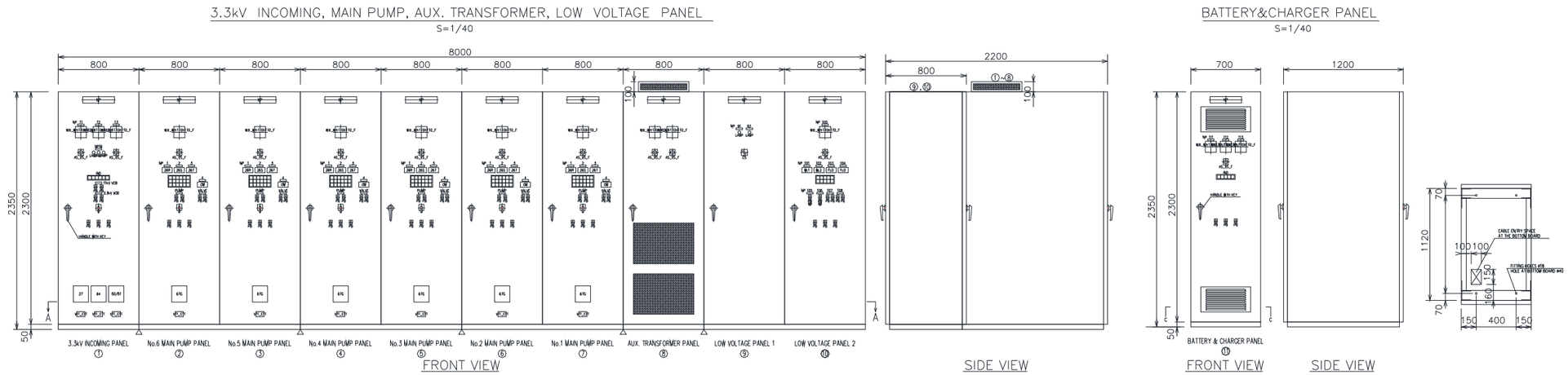
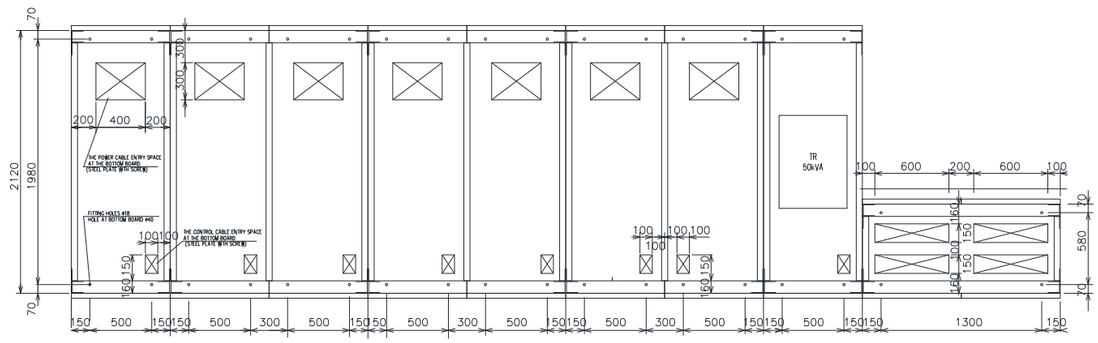
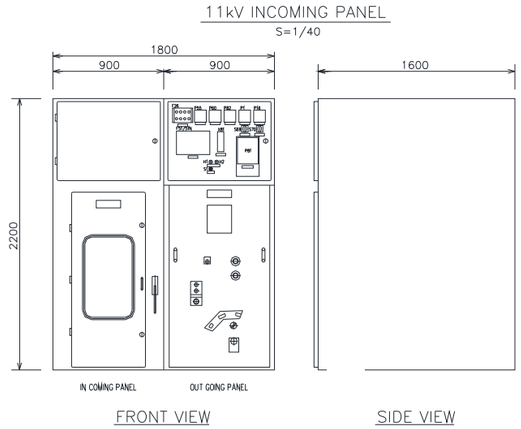
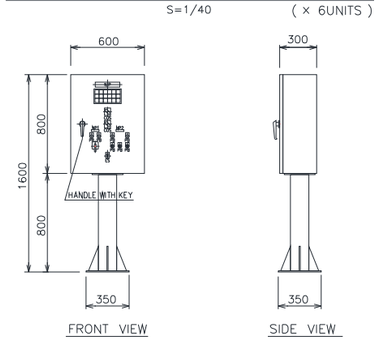


Figure 2-15: Single-line Diagram for Terminal Reservoir Pump Station









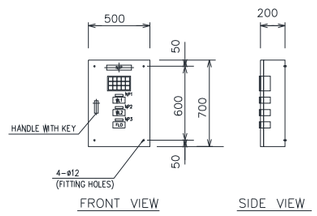


Figure 2-16: Control Panels for Terminal Reservoir Pump Station

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Basic concept

The Project shall be implemented in accordance with the scheme of the Japanese Grant Aid. The Grant Aid shall be used for the procurement of the products and services for the Project which is agreed upon in the Exchange of Notes (hereinafter referred to as the "E/N") between the Government of Japan and the Government of Pakistan.

Following the E/N, the Grant Agreement (hereinafter referred to as the "G/A") of the Project shall be concluded between the Government of Pakistan and JICA. The application of Grant Aid to a particular project funded by the Grant will be stipulated in the G/A.

The rights and obligations of the Government of Pakistan and the providers of the products and services for the Project are governed by the tender documents, and by the contracts signed by the Government of Pakistan with the providers of the products and services.

The roles of the concerned parties, including the Government of Japan, JICA, consultants and contractors in relation to the implementation of the Project under the Grant Aid are understood as follows.

1) The Government of Japan decides the Grant to be extended to the Government of Pakistan in accordance with the relevant laws and regulations of Japan.
2) JICA extends the Grant to the Government of Pakistan in accordance with the relevant laws and regulations of Japan and within the scope of the E/N and pays serious attention to ensure the accountability on proper and effective use of the Grant for the Project.
3) The Government of Pakistan is the recipient of the Grant, and is responsible for the execution of the Project. As the client or the buyer, the Government of Pakistan conducts the procurement of the products and services necessary for the Project implementation using the Grant provided by JICA.
4) The Consultant is the firm who renders services to the Government of Pakistan with regard to designing, cost estimating, tendering and supervising the procurement and the construction works for the Project in accordance with the contract with FWASA.
5) The Contractor is the firm who provides the products and services necessary for the Project in accordance with the contract with the Government of Pakistan.

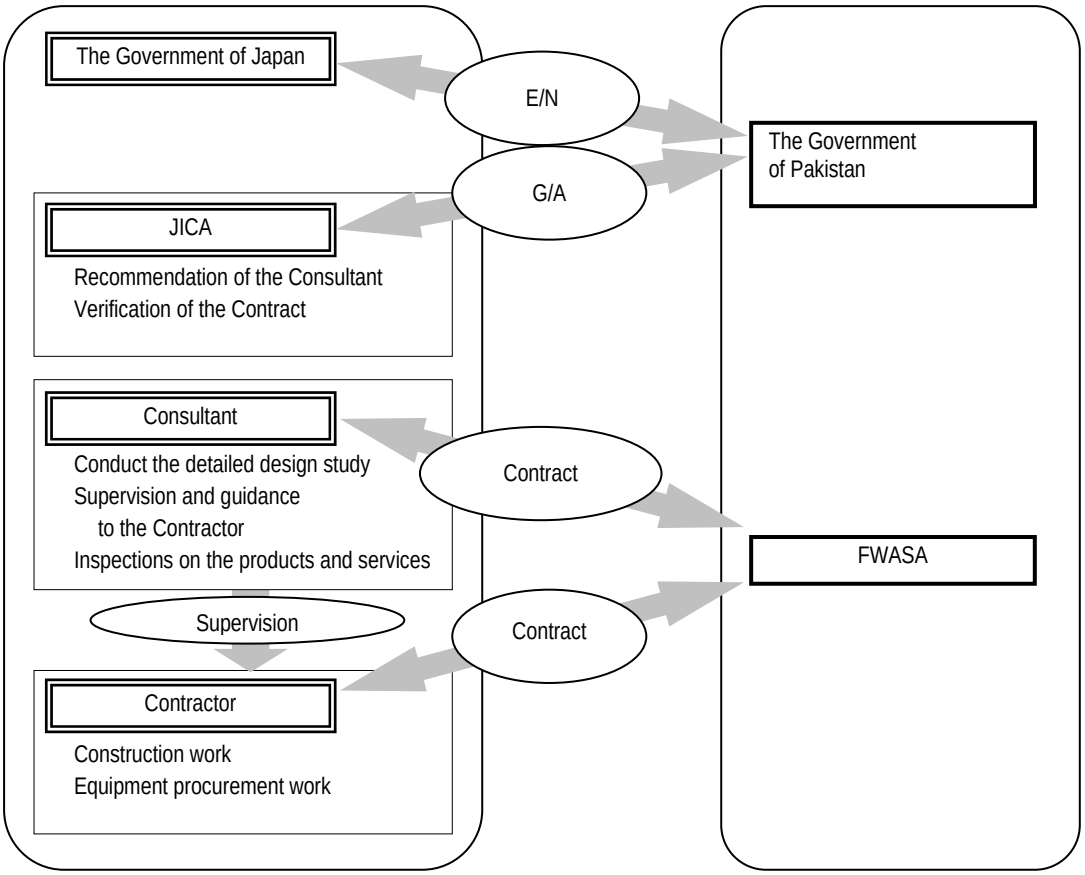


Figure 2-17: The Roles of the Concerned Parties

The major components of the Project are shown in the following table.

Table 2-20: The Major Components of the Project

Item	Facilities	Specification
Work in the Inline Booster Pump Station	Replacement of inline booster pumps and incidental facilities: 6 units.	48.8m^3/min: 4 units. 24.4m^3/min: 2 units.
	Pipeline work	Dia. 500 to 1600mm
Work in T/R Pump Station	Replacement of T/R pumps and incidental facilities :6 units.	63.0m^3/min: 4units. 31.5m^3/min: 2units.
	Pipeline work	Dia. 350 to 1600mm
	Building work of T/R pump station	Reinforced Concrete, Total floor area: 870.81 m^2
	Repair of water leakage of T/R tank	Repair of concrete joints: 102m
Consultancy work	Detail design	Civil and building work
	Supervision	Civil and building work
	Soft component	Training of operation

The construction period is planned as 22 months, including a preparation period in Japan for one month. The critical path is the period required to manufacture and install the pump and ancillary equipment.

(2) Implementing Organization of the Pakistani Side

The executing agency of the Pakistani Side of the Project is HUD&PHED and the implementing agency is FWASA. For the smooth progress of the Project, the Pakistan Side shall contact and consult closely among the Consultant and Contractor. Accordingly, the Pakistani Side shall need to assign responsible persons in charge of the Project. Responsible persons shall understand the roles and duties of the Project and to implement Pakistani obligations such as land clearing.

(3) Consultant

The Consultant of the Project shall conclude a contract regarding services for detail design study, tendering and construction/procurement supervising works with FWASA. In accordance with Japan's Grant Aid scheme, the Consultant shall form a project team in order to design and supervise the correct progress of the construction works, following the prescriptions made at the point of outline design. The service contents of each step shall be as follows.

1) Services before the tender

The Consultant will review the Study results produced by the outline design of the Project, and carry out the detail design and cost estimation with a consistent level of service.

2) Services in the tender stage

The Consultant will execute the following services in the tender stage of the Project;

- Compiling service of the tender documents
- Supporting service of the tender
- Supporting for clarification and amendment of the tender document
- Evaluation and reporting of technical proposal
- Evaluation and reporting of financial proposal and supporting of the contract negotiation

3) Services in the stages of construction supervising works

The Consultant will dispatch Japanese engineers to Pakistan to ensure the construction qualities of the Project. Therefore, the Consultant will place a resident engineer in Pakistan for coordinating work among concerned persons on the Pakistani Side and the contractor's side, and also for supervising works of the implementation stage of the Project.

The consultant will supervise the contractor in order to execute the Project properly and smoothly. The objective of the supervision will be to supervise work in conformity with specifications and drawings and to control the quality, specifications and progress in conformity with the contract.

In addition, the consultant will supervise the contractor's documentation such as quality control, site photographs and progress record. The consultant will inspect the materials and equipment to be produced, manufactured and procured in order to prevent troubles after delivering the materials and equipment.

(4) Contractors

According to Japan's Grant Aid scheme, Japanese contractors who are selected through a tendering procedure will implement the construction works and equipment procurement for the Project.

Even after the handover of the facilities, it is still necessary to contact the contractor for one year warranty period for repairs and maintenance.

1) Necessity of Engineer Dispatch

The construction works in the Project include material and equipment procurement, transportation and construction, which require coordination between the parties concerned. Also, it is necessary to dispatch a chief engineer from Japan to manage and supervise construction, including the schedule, quality, and safety. This person will also arrange and manage the schedule of sub-contractors, in order to make the most effective use of them under the Project.

2) Policy to Ensure the Construction Works

The Project policy to ensure the construction work goes smoothly in a timely manner and that costs are kept to a minimum is to use local materials and construction methods whenever possible. In line with this policy, it is recommended that the Japanese contractor will use sub-contractors as there are companies capable of conducting the type of large-scale construction work necessary in Faisalabad, Lahore and Islamabad.

2-2-4-2 Implementation Conditions

(1) Construction Condition

It is possible to procure general construction materials, equipment and machines around the Project site. However, there are no concrete production plants in Faisalabad so it is necessary to procure the concrete by job mixed. Besides, the Project will need to carry out advance preparations carefully to prevent the delay of procurements because the Project will use much of cement, aggregate and reinforcing bars.

To avoid delays to these material procurements, it is required to prepare systems for their orders in the early stage of the commencement of construction works. Thus, on the consideration of the production terms of materials to be used for the Project, it will be important to urge the contractor to start their advance preparations for the procurement of the materials and equipment.

(2) Safety Measures

At construction sites, it is necessary to consider safety measures for construction workers. The construction works will involve work in high places such as roofing, so there is a possibility of falling accidents. Consequently, the Project will need to prepare concrete measures to ensure worker safety, such as the work will be prohibited downstairs below where work is being conducted directly upstairs to prevent accidents caused by falling objects, installation of a safe handrail and a safety net, and the wearing of helmets, safety shoes and safety belts.

The Project places the security guard in order to prevent the accident with the third person at the entrance of the Inline Booster Pump Station and T/R by the construction vehicle. In addition, the staff of FWASA is operating the pumps near the construction site, the Project manages so that the staff of FWASA can not approach the construction site.

2-2-4-3 Demarcation of Works

(1) Demarcation of Works for Construction

1) Preparation of the Project Site

The Project site is possessed by FWASA so that there is no disadvantage for utilization. However, since there are trees around and within the site, the Pakistani Side will need to remove them.

2) Infrastructure

a) Electric Power

There are existing electric distribution facilities on the site, which will be used for the project continuously. However, incoming panel, which Faisalabad Electric Supply Company (hereinafter, FESCO) manages, is installed in the existing pump station. FESCO will need to relocate this incoming panel to the new pump station, therefore it is assumed that the Pakistan side will pay the necessary expenses.

In addition, installation of power distribution facilities and wiring work except for that which FESCO manages will be included as scope of works.

b) Water Supply

The Project will provide the water supply system in the new pump station. The pipeline between the main pipe to the water tap in front of the new pump station is included in the scope of the work.

c) Drainage

The Project will provide the drainage system from the inside of the new pump station at the T/R Pump Station to existing drainage in order to pump out discharged water from the new pump station.

3) Application for Permission

a) Construction Permission

The Pakistan side shall be responsible for applying for and obtaining the construction permits. The Japan side will be responsible for preparing drawings only.

b) PC-1

In the implementation of the Project, it is necessary to obtain the approval of the PC-1 by CDWP (Central Development Working Party). The Pakistan side shall be responsible for obtaining the PC-1.

(2) Demarcation of Works for the Project

Demarcation of works is shown as below.

Table 2-21: Demarcation of Responsibilities of Works to Be Conducted by the Japanese and Pakistani Sides

Works	Japan	Pakistan
1. Securing of the Project site, Removal of the existing facilities and trees at the Project site, Leveling of the site		○
2. Construction		
(1) Inline Booster Pump Station (booster pump)	○	
(2) Terminal Reservoir (Pump station)	○	
(3) Terminal Reservoir (Distribution pump)	○	
(4) Terminal Reservoir (Pipes)	○	
(5) Terminal Reservoir (Repair of water leakage of tank)	○	
3. Infrastructure		
(1) Electric power		
1) Installation of the transformer at the Project site, site wiring, lighting/outlets	○	
(2) Water Supply		
1) Water supply facility (Pump Stations)	○	
(3) Drainage		
1) Drain facility (Pump Stations)	○	
(4) Furniture and equipment		○
4. Transportation, Customs clearance		
(1) Marine transportation of the Products	○	
(2) Tax exemption and customs clearance of the products at the port of disembarkation		○
(3) Internal transportation from the port of disembarkation to the Project site	○	
5. Exemption of customs duties, internal taxes and other fiscal levies		○
6. To accord Japanese nationals for their entry into Pakistan and stay therein		○
7. Proper and effective use of facilities and equipment of the Project		○
8. Other necessary procedures and expenses for the project		○
9. Banking Arrangement, Authorization to pay		
(1) Advising commission of A/P		○
(2) Payment commission		○
10. Procedures concerning environmental and social consideration		○

2-2-4-4 Construction Supervision

(1) Basic Concept

In order to complete the whole schedule of the Project, it is important to confirm and supervise the progress of each construction work. Moreover, it is also important to always confirm the working progress to be borne by the Pakistani side because such tasks are vital to the smooth progress of the whole schedule. For example, if the hand-over of the site to the contractor delayed, the whole schedule is delayed. So it is necessary to carry out the ground leveling quickly.

The Project will include various types of works such as material and equipment procurement work, temporary work, foundation work, structural work, mechanical work, finishing work and so on. The consultant will execute their supervising work in cooperation with the implementing organization of the Project.

(2) Construction Supervision Plan

1) Dispatch of the Consultant

As regards the consultant supervision of the Project, the consultant will assign a resident supervisor who has experienced construction supervising works abroad. The consultant will also dispatch the engineer properly in accordance with the type of works as described in the following table.

Table 2-22: Dispatching of the Consultant for Construction Works

Consultant	Working Contents	Timing (Total Term)
Project Manager	Supervision of the whole project, attendance at the commencement, final completion of the Project, etc.	When necessary (1.0 M/M)
Resident Supervisor	Supervision of the whole construction work, negotiation and consultation with organizations concerned with the Project, confirmation of design / shop drawings and specifications.	During The Project implementation (21.0 M/M)
Mechanical and Electrical Engineer (for pump equipment)	Supervision of pump systems	When necessary (2.0 M/M)
Architectural Engineer	Supervision of building works	When necessary (1.0 M/M)
Mechanical and Electrical Engineer (for building works)	Supervision of equipment and electrical system of building works	When necessary (1.0 M/M)
Completion inspector	Final inspection after the completion	When necessary (0.23 M/M)

2) Construction Management by the Contractor

In order to control the quality of the works within the work period, it is desirable for the work to be managed by a Japanese engineer. Therefore, an experienced Japanese engineer will be stationed at the construction site for the whole period of construction. Moreover, particular engineers such as mechanical and electrical engineer will also be dispatched according to the progress of the Project. Other necessary engineers will be hired locally. During the construction period, the Japanese engineers are expected to transfer their construction skills and technology to Pakistani engineers. Considering the scale of the construction in this Project, at least the engineers listed below will be necessary.

Table 2-23: Personnel Dispatching by the Contractor

Contractor	Working Contents	Timing (Total Term)
Project Manager (Site Representative)	Manage the whole work, obtain approval, manage procurement of material, equipment and accessories, manage workers, and site works	During the Project implementation (21.0 M/M)
Architectural Engineer	Supervision of building works	During the work (13.0 M/M)
Mechanical and Electrical Engineer (building work)	Supervision of equipment and electrical system works	When necessary (1.0 M/M)
Civil engineer 1	Supervision of civil works of Inline Booster Station	During the work (4.8 M/M)
Civil engineer 2	Supervision of civil works of T/R station	During the work (10.9 M/M)
Mechanical Engineer	Supervision of pump systems	During the work (7.0 M/M)
Electrical Engineer	Supervision of pump systems	During the work (7.0 M/M)
Administrator	Manage procurement of material, equipment and accessories, workers, and do the accounting	During the Project implementation (21.0 M/M)

3) Schedule Control

The consultant will compare the implementation progress of the construction to be planned at the time of their contracts with those to be carried out actually in order for the observance of deadlines prescribed in the contracts signed by the contractors of the Project. The consultant will encourage the contractor to keep strictly to the schedule and request the contractor to submit proposed measures and implement these against the issues when schedule delays are predicted, in order that the construction and equipment delivery can be completed on time. The items to be compared with the schedule are as follows.

- Overall progress (progress of the material and equipment procurement, and construction work)
- Material and equipment delivery (material, equipment and accessories for construction)
- Temporary work and provision of construction machines (accordingly)
- The number of engineers, technicians, general workers, etc.

4) Quality Control and Inspection of Actual Shape

The consultant will supervise whether or not the facilities to be constructed by the Project and its construction materials meet the required quality, specifications and actual dimensions as per the contract documents. If the consultant finds any issues with the quality or faults in the contractor's workmanship in the process of their confirming and inspecting work, the consultant will require the

contractors to correct, change and modify them immediately. The items to be controlled are as follows.

- Examination of shop drawings and specifications of construction work
- Examination of shop drawings and specifications of materials and equipment
- Attendance to the production place of the materials and equipment or examination of the inspection results
- Examination of plans and methods of equipment installation
- Inspection and confirmation of performance and actual dimensions

5) Safety Control

By discussing and cooperating with the responsible persons of the contractors for safety control, the consultant will supervise the contractors to prevent industrial accidents, injuries and accidents to third persons at the Project site during the implementation term. Important points for the safety control at the site will be as follows.

- Formulation of safety control regulations and selection of responsible persons for safety controls
- Avoidance of accidents by the regular inspection of construction machines
- Formulation of the operational routes of vehicles for construction and transporting machines and thoroughness in their safe driving
- Setting of facilities and equipment for safety controls and their regular checks
- Welfare measures for construction workers and encouragement to take days off

2-2-4-5 Quality Control Plan

It is feasible to procure the materials, equipment and machines for the construction domestically. However, as Pakistan has imported many goods from neighboring countries, the quality of them varies. Therefore, the specifications and performance of the materials, equipment and machines used for this Project require careful examinations before they are approved. For the quality control of reinforcement bars, concrete, mortar, etc., which will be processed at the construction site, must follow the rules specified in the construction method to be specified during implementation of the Project.

When concrete temperatures are high, there is a possibility of increased risk of slump declines and cracks by rapid vaporization of surface moisture on the concrete. Accordingly, the Project will need to reduce the temperature of the concrete by placing concrete in short time, adjusting the placing volume of concrete and keeping the concrete wet condition by watering during curing works.

To examine concrete quality, the Project will carry out the compressive strength test of concrete at public institutions in Pakistan. In terms of reinforcement bars, the Project will carry out their quality controls by confirming their inspection certificates. As for the tensile strength test of reinforcing bars, the Project will carry out the test at public institutions.

To ensure the quality of the construction works, the Project will need the following quality controls in terms of the major works of the construction.

Table 2-24: Items of Quality Controls and Methods of Major Works

Works	Item of Quality Control	Method of Quality Control
Temporary work	Locations of the permanent and temporary facilities, etc.	Staking out inspection, confirmation of benchmark
Earth work	Excavation	Confirmation of bearing stratum
Reinforcement bar work	Material	Tensile strength test, confirmation of inspection certificate
	Arrangement	Confirmation of diameter, numbers, binding, etc.
Concrete work	Fresh concrete	Confirmation of slump, air content, temperature, etc.
	Concrete placement	Confirmation of placing situation
	Formwork	Visual inspection of forming
	Concrete strength	Confirmation of compressive strength test
Roofing work	Water leakage	Visual inspection, sprinkling inspection
Plastering work	Flatness, unevenness	Visual inspection of finishing
Door and window work	Installation	Visual inspection
Painting work	Surface finishing, color	Visual inspection
Electric power system work	Performance, operation	Confirmation of factory inspection result, operation test
Piping works	Bending, twist, support pitch	Visual inspection
Wiring work	Damage	Measurement of resistance value, visual inspection
Lighting work	Performance, operation	Visual inspection

2-2-4-6 Procurement Plan

(1) Procurement Method

Most of the materials, equipment and construction machinery needed in the Project are possible to be procured in Pakistan. However, pump facilities at the Inline Booster Pump Station and the T/R Pump station will be procured from Japan because these are impossible to procure in Pakistan and the quality of such products should be kept high.

Main materials such as cement, aggregates, reinforcement bars and forms will be procured in Pakistan. The decision on which cement is to be adopted will be based on the results of concrete quality tests of the applicable materials procured in Faisalabad. Faisalabad is an industrial city and materials distribution is always stable, therefore there should be no particular problems regarding the procurement of materials.

There is a large quarry where aggregates can be obtained about 30 km from Faisalabad down the stream of Chiniot Bridge on the Chenab River. In Faisalabad and near Chenab River there are companies that can supply aggregate of sufficient quantity and quality to satisfy the specifications of the Project. The contractor will select and procure aggregates in conformity with the specifications of the Project.

The raw materials for reinforcing steel bars are imported and processed by domestic manufacturers to meet the demand. In this project, the domestic products will be used. Forms for concrete structure will be easy to procure in Pakistan. They can be fabricated by processing the materials that are domestically

available.

As a construction situation of Pakistan, since large scale civil engineering and construction projects have been implemented in recent years, it is possible to procure construction machinery in Pakistan. In addition, Japanese manufacturers assemble vehicles and trucks locally, therefore there is no particular problem for the procurement. The Japanese contractor is expected to procure or lease these machines, such as backhoe, crane and batcher plant.

Table 2-25: Country of Origin

Items	Country			Remarks
	Pakistan	Japan	Third country	
Cement	○			
Fine aggregate	○			
Coarse aggregate	○			
Steel products	○			
Formwork	○			
Wood materials	○			
Pipes	○		○	
Valves	○		○	
Pumps		○		
Control panel		○		

(2) Transport Plan

As a transportation method for procurement of materials and equipment from Japan, there are shipping service and aviation service. However, the transportation of materials and equipment from Japan normally uses shipping service unless there are special circumstances. Therefore, in this Project, since the materials and equipment procurement from Japan are large and mainly they are pump equipments, transport plan will be shipping service.

The procurement time of materials and equipments for pump facilities will be in the last half of the Project. It will take about eight weeks by the shipping service, from departure of Japan to arrive in Pakistan. The customs clearance is carried out in Karachi which is the port of discharge.

Customs clearance, disembarkation and inland transportation of materials and equipment procurement from Karachi to Faisalabad will take around four weeks because of the large quantity of materials and equipment and equipment such as the pumps are large and pump control panels are precision instruments, therefore there is a need to pay attention to the transport. The distance from Karachi to Faisalabad is around 1200km. Therefore, it will be expected to take totally three months for the transportation from Japan to the sites.

2-2-4-7 Operational Guidance Plan

The Project involves the replacement of existing water facilities at the Inline Booster Pump Station

and T/R Pump Station, therefore the main water supply system of the Project is same as the existing water supply system. The staff of FWASA is operating the existing facilities so far, it is considered that the current skill level of FWASA can operate the facilities after the new facilities are installed. However, in the Project, it is planned to increase the volume of water for distribution from the T/R Pump Station. Therefore it is necessary to control the distribution flow rate and number of operating pumps in accordance with the distribution amount. For this reason, when commissioning by the contractor, operational guidance for the control of water distribution flow rate should be given due to a change in the number of operating units of the pump.

Further, in this project, it is expected to install impellers with low pump heads in addition to normal impellers, therefore it will be necessary to dismantle the pump and replace the impeller. FWASA has been in charge of repairing the pump so far and has a repair technology and knowledge, including the ability to dismantle pumps. Replacement of the impeller is possible with current technology of FWASA, however, because it does not have any actual experience in this it will be undertaken under the guidance of the contractor.

2-2-4-8 Soft Component (Technical Assistance) Plan

(1) Background of Soft Component

This Project aims to reduce the cost of distribution of water through stabilizing operation of the facility and promoting the efficiency of energy consumption by the replacement of the pumps at the Inline Booster Pump Station and T/R where originated from Chenab well field in Chiniot City. The scope of the Project consists of the replacement of the pump facilities at Chenab Inline Booster Pump Station, replacement of the pump facilities and corresponding construction of the pump station at T/R and repair of water leakage at T/R.

1) Current Situation

Chenab systems targeted in the Project pump up the water from Chenab well field to T/R through the Inline Booster Pump Station, and then distribute the water to the city from T/R. In addition to the Chenab water facilities, T/R and pump facilities of JBC water facilities are located in the same compound of T/R. In the future, water originated from both Chenab system and JBC system plans to be distributed to the city from the T/R Pump Station in two distribution pipes upon completion of the ongoing project financed by the government of France in contrast to the current single distribution pipe.

Now some of the pumps installed at Inline Booster Pump Station and T/R Pump Station are suspended due to breakdown as they were installed more than 20 years ago and are overdue for replacement. The booster pumps at the Inline Booster Pump Station do not meet the needs for entire available water intake in Chenab well field due to a decrease in pump efficiency and stabilization of supply is deteriorated at T/R Pump Station due to the high occurrence frequency of breakdown of distribution pumps. Some of the pumps are no longer operational due to cavitation caused by the

improper location of distribution pumps at the T/R Pump Station, and therefore do not meet the demand for water supply at peak times of the day.

2) Necessity of Soft Component

The Project will aim to improve the operation skill of the counterparts in reducing the water pressure of the being distributed from the T/R pumping station in the soft component of the Project.

It is essential to assist in launching the facility smoothly through the training of parallel operation of Chenab and JBC water supply facilities and dual systematization of main distributing pipe and control of pressure of water distribution as well as the training of the said initial operation in order to distribute water to the city with proper water pressure.

The Project will enable the entire available water intake from Chenab source system to be distributed to the city by distribution pump and accordingly water supply environment would be improved. In this case, the amount of pump distribution and number of operating pumps per hour are different from the current operating situation, so that the trial and initial operation after installation will be trained to FWASA members in order to operate and maintain pumps based on the amount of water distribution and number of operating pumps per hour. Although water is distributed to the city after depressurizing it up to around 20m against the pump head of 45m in order to reduce water leakage when distributing pump water, it is necessary to appropriately change control of depressurization by valves because the volume of water distribution in the city increases owing to the Project. The current volume of water which is distributed through only Chenab distribution pipes would be divided into the current distribution pipe and the other pipe financed by the government of France. For the reasons above, the current volume of water flowing through distributing pipes would be changed, the control of pressure is necessary based on volume of water distribution. Even though currently the respective pumps at the T/R Pump Station of Chenab and JBC are operating, technical level is not sufficient enough in order to practice parallel operation with pressure of control of water distribution and control pressures of water distribution owing to converting to the dual system.

(2) Purpose of Soft Component

The purpose of the soft component of the Project is to give assistance in controlling water pressure in accordance with the volume of water distribution. As a result of the counterparts of gaining such skills it would enable the implementing agency to distribute water to Faisalabad city in a stable manner after completion of the Project.

(3) Outputs of Soft Component

The outcome of soft component is that that implementing agency personnel acquire the skills necessary to manage the water pumping pressure (by reducing it as appropriate) from the T/R pumping station.

(4) Means of Output Verification

Indicators and means to verify the said achievement of outcomes are as follows.

Table 2-26: Means of Output Verification

Outputs	Objectively verifiable indicator	Means of verification
Reduction of water pressure leaving the T/R pumping station is conducted appropriately	To understand the relationship between volume of water distribution and water pressure	Comprehension test
	To operate valves for depressurizing in line with the volume of water distribution	Measure for volume of water distribution and water pressure

(5) Activity of Soft Component (Input Plan)

1) Besic concept

The person in charge of soft components will implement the soft component to control the water pressure in conjunction with the operation of the JBC distribution pump, and confirm the achievement of outcomes about soft components and submit the completion report of the soft component to Pakistan responsible authorities, implementing agencies and authorities of Japan.

2) Summary

The practical training of valve operation and regulation of the service pressure in line with the volume of water distribution will be implemented through on-the-job training as part of the soft component. The following table shows the planned activities to achieve the outputs of the soft component.

Table 2-27: Activities of Soft Component

Output: Reduction of water pressure leaving the T/R pumping station is conducted appropriately		
Implementation year: the final year of the Project		
Required skill and field of expertise of the Japanese side expert(s)		Water distribution planning, experience of management on water pressure
Technical level required of the Pakistan side counterparts to participate in the soft component		The counterparts will need to have experience of valve operation and knowledge of the relationship between opening/closing of valves and water pressure.
Participants		Operation department (valve operation planning(1 person), valve operation (2 person))
Method of implementation		On-the-job training
Activities	Preparation of documents	Drawing up plans of soft components ・Explaining soft components to FWASA ・Verifying existing facilities, review of the operating manual of the JBC-based distribution pump ・Drawing up plans and approved by FWASA Drawing up questionnaires and comprehension tests
	Introduction	Lecture on theory for water distribution plans, management of water pressure ・Explaining facility outline, facility capacity ・Explaining water distributing plans of facilities (Chenab, JBC) ・Explaining water volume and water pressure on water distribution plan ・Explaining way to reduce service pressure, according to water volume Clarifying roles and areas of responsibility of person in charge Conducting questionnaires and comprehension tests
	Planning and drawing up way of water pressure management	Planning of valve operation instructions (valve operation planning) ・Confirming condition of the existing valves ・Developing plan of valve operation ・Drawing up operation instructions Developing a system of recording valve operations
	Guidance for valve operation	Practical guidance on valve operation (mainly for the participants of valve operation) ・Regulation of valves in line with volume of water distribution ・Managing water pressure associated with valve operation ・ Guidance on how to take records of valve operation
	Do, monitoring	Operating by the FWASA staff ・Regulating of valves in line with volume of water distribution ・Managing water pressure associated with valve operation ・Completing records of valve operation Drawing up valve operation manual
	Verification of outcome and recommendation to implementation agency	Reviewing the records of valve operation Confirming through valve operation Conducting comprehension tests Recommending to FWASA
Implementation resource	Person in charge	Japanese consultant (1 person)
	Period	In Faisalabad: 1.00 M/M
Type of Outcome		Valve operation manual, result of questionnaires to the staff of implementing agencies, final report (completion report of the soft component in English), completion report of the soft component in Japanese, documents to verify implementation of activities (inclusive of photos of soft component implementation)

(6) Procurement Methods of Implementation Resources of Soft Component

The Japanese consultant in charge of water pressure reduction will be assigned to the soft component,

because valve control to manage the pressure of water distribution in accordance with the existing facilities, and determination of the pressure of water distribution in accordance with condition of facilities and volume of water distribution requires the advanced knowledge and skill. The person in charge of the soft component of FWASA will be assigned individually, because duty, position and expertise for each staff under the FWASA operation system are clarified.

(7) Implementation Schedule of Soft Component

Soft components are implemented upon a trial operation of the pump facilities after completion of the construction. Outline of the implementation process is as follows.

Table 2-28: Implementation Schedule of Soft Component

Outcome		Contents	Activities	M / D	1 (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30)	Remarks
Outcome 1	Technology on reduction of water pressure after distribution		Local business		Departure … Return	
		preparaqtion of documents	・Creating a software component plan	1		
			・Creating questionnaire, of comprehension test	1		
		Introduction	・Conducting questionnaires and comprehension tests	2		
			・Lecture of theory for water distribution plans, management of water pressure	2		
		Planning water pressure management	・Creating records of valve operation and valve operation instruction	10		
		Guidance of valve operation	・The guidance by practice in accordance with the valve operation	5		
		Implementation・monitoring	・The operation with FWASA staff	5		
		Verification of outcome and recommendation to implementation agency	・Reviews of valve operation records	1		
			・Confirmation by the implementation of valve operation	2		
			・Reporting, proposals to FWASA	2		

(8) Output Materials of Soft Component

Output of soft component is as follows.

Table 2-29: Output Materials of Soft Component (Draft)

Item	Submission to	Remarks
Final report (completion report of soft component in English)	FWASA, JICA	
Completion report of soft component in Japanese	JICA	
Documents to verify implementation of activities (inclusive of local photos)	JICA	
Result of questionnaires and comprehension tests to participants	JICA	
Valve operation guidance	Client, JICA	Refer to attached sheets

The valve operation manual for managing water pressure is an effective documents to enable the acquisition of basic skills and knowledge in the soft component. They are to be compiled in Urdu as well as in English to be used for soft component.

(9) Responsibilities of the Implementing Organization of the Pakistan side

The following activities are needed to be continuously implemented by Pakistan side in order to achieve the goal of the soft component.

- To secure personnel and training facilities required for the soft component
- To keep the staff trained in the soft component employed at the same facility in the long term
- To comply with way to reduce water pressure in line with valve operation guidance

2-2-4-9 Implementation Schedule

As the Project is implemented under Japan's Grant Aid, the implementation schedule until the commencement of construction works is as follows.

- E/N is signed between the government of Pakistan and Japan, and G/A is signed between the government of Pakistan and JICA.
- JICA recommends a Japanese consultant to the government of Pakistan.
- The agreement of consulting services for the Project is concluded between FWASA and the consultant.
- The construction work is commenced after the detailed design, tender in Japan and conclusion of the contract with the Contractor.

(1) Detailed Design Phase

The consultant prepares the detailed design document and the tender document based on the Outline Study, which consist of detailed design drawings, specifications and tender documents, etc. The consultant has close talks and meetings with FWASA at the beginning and the end of the detailed design phase, and completes the detailed design after submission of the work products.

(2) Tender Assistant / Supervision Phase

After detailed design phase, the prequalification (P/Q) of the facilities construction tender will be announced in Japan. According to the result of evaluation of P/Q, FWASA will invite construction

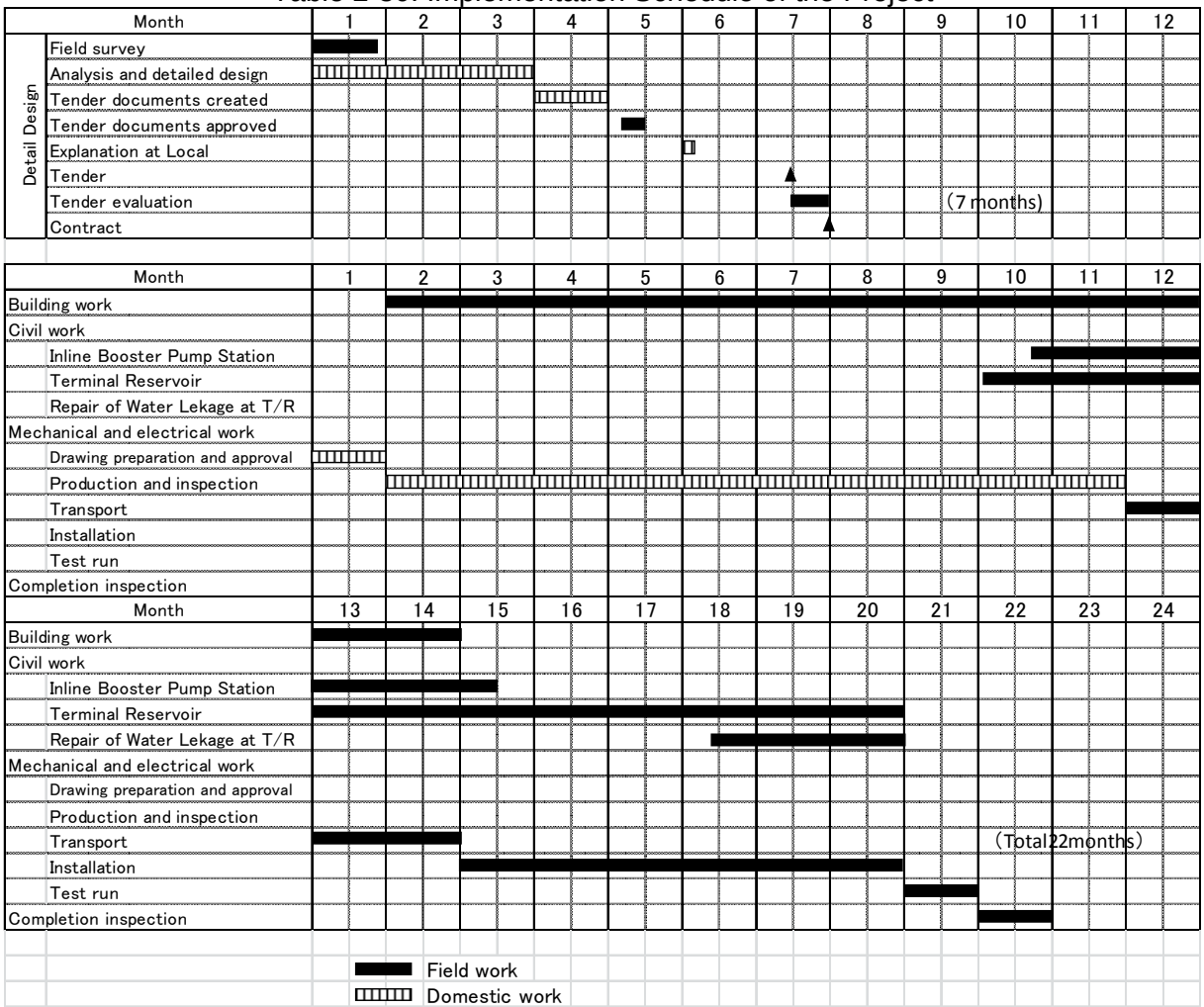
contractors. Then FWASA will conduct the tenders in the presence of persons involved. The tenderer who bids the lowest price will make a contract as the winning bidders with FWASA.

(3) Construction Phase

The contractor will be verified by JICA and commence the construction work. It will be needed smooth procurement of building materials and equipment, prompt execution of relevant procedures by the Pakistani Side and implementation of the tasks demarcated as being the responsibility of the Pakistani side.

The implementation schedule of the Project is shown in the table below. Seven months are expected for the detail design, tender and contract, twenty two months are expected for construction after the contract. Twenty two months are required for the production, transportation and installation of booster pump and distribution pump, it is critical in the whole process. For this reason, the prior works such as building frame of the pump station and pipeline work will be completed prior to the procurement of the said equipment.

Table 2-30: Implementation Schedule of the Project



2-3 Obligations of Recipient Country

(1) Special Items for the Project

The following special items are required to be undertaken by the Pakistani Side when carrying out the Project.

1) To submit the application for construction works, and others related to the Project if any, and to obtain permission for these.
2) To conduct the Initial Environmental Examination.
3) To prepare the land, remove trees and other preparatory construction related to the Project.
4) To relocate the incoming panel managed by FESCO
5) To secure the personnel to operate and maintain the facilities and equipment related to the Project.
6) To procure furniture and equipment related to the Project.
7) To secure the budget to operate and maintain the facilities and equipment related to the Project.
8) To atend the beginning, mid term and complete inspection of the construction.
9) To secure the land for office and storage of materials and equipments to the contractor.

(2) General Items

In the implementation of Japan's Grant Aid Scheme, the Pakistani Side is required to undertake certain measures as follows. To contact and make delineation to the related institutions concerned directly or indirectly with the Project.

1) To contact and explain the outline to related jurisdiction involved directly or indirectly in this project
2) To provide the data necessary for the Project and permit the Project team (consultant) to take the data back to Japan.
3) To ensure prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid.
4) To exempt from customs duties, internal taxes and other fiscal levies, this will be imposed in the recipient country with respect to the supply of the products and services under the verified contracts.
5) To accord Japanese nationals, whose services may be required in connection with the supply of the products and services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work
6) To assure the safety of the said Japanese nationals and provide full-time police accompaniment at sites where security is highly suspicious.
7) To assign the staff necessary for the operation and maintenance and to operate and maintain the facilities constructed under the Grant Aid properly and effectively.
8) To bear all the expenses except those covered by the Grant Aid.
9) To not re-export the products and materials which are purchased on the basis of the Grant Aid to any other countries.
10) To bear the commissions paid to the bank for banking services based upon the B/A.

(3) Operability for Obligations of Recipient Country

This project contributes to human security and is regarded as the project with high priority in the Pakistan government. For the budget according to project implementation, it will be ensured by the approval of PC-1 by CDWP. PC-1 will be prepared by FWASA. FWASA has experience of preparation of the PC-1 in a previous project, “the Project for the Expansion of Water Supply System in Faisalabad in Islamic Republic of Pakistan”, and the project was conducted after approval of PC-1. In view of the circumstances that the PC-1 for water supply project has been approved without particular trouble so far, it is considered that the possibility of approval of PC-1 and ensuring budget for this project is high. In addition, this PC-1 system is in conformity with Japan’s Grant Aid scheme, and it is considered to be appropriate.

2-4 Project Operation Plan

(1) Organization and Staff Plan

The purpose of the Project is to replace the Chenab existing water facilities at the Inline Booster Pump Station and T/R, and there is no change in the fundamental distribution system. Therefore, the same system and personnel in the existing water facilities will be applied for the operation and maintenance of the facilities after the completion of the Project.

(2) Budget

Currently, a large part of expenditure of FWASA is made up of the personnel cost (payment of salary to the staff) and electricity charges, and the income from water and sewerage charge receipts, a major revenue source, covers only the personnel cost. Even though some of the shortfall of the financial balance is covered by the Punjab government subsidies, the balance is still deficit.

Table 2-31: Balance of FWASA's Operating Expenses for the Past Two Years and for the Next Fiscal Year

Million Rs.

	2011-2012	2012-2013	2013-2014 (Plan)
1. Income			
Water and sewerage charges	431	543	630
UIP Tax	140	224	300
Subsidy from the Punjab government	179	262	262
Subsidy from World Bank	—	—	292
Other revenue	83	70	83
Total	833	1099	1567
2.Expenditure			
Personnel cost	420	543	587
Electricity charge	319	470	510
Operation and maintenance expense	170	190	220
Total	909	1203	1317
Balance	-76	-104	250

Source: Financial data of FWASA and direct interviews

The above table shows the balance of FWASA's operating expenses for the past two years, that is fiscal years 2011 and 2012, as well as the planned balance for the next fiscal year of 2013. In fiscal years 2011 and 2012, the subsidy of 179 million Rs and 262 million Rs was obtained respectively from the Punjab government, however, the operating balance was still in deficit. In fiscal year 2013, a loan from the World Bank was obtained in addition to the subsidy from the Punjab government so that surplus in the operating balance is expected. By the implementation of the Project, it is possible to contribute to reducing electricity charges by reducing power consumption, but their contribution is not large from the viewpoint of FWASA's overall electricity charges. It is vital to improve and strengthen both facilities and management through the surplus of the operating balance with the subsidies from the Punjab government and the World Bank. For the improvement and strengthening of the operation and maintenance system, it is necessary to implement the measures to increase the income of FWASA.

(3) Collection of Water Charge

The current ratio of collection of water charge by FWASA is about 40% (2012/2013: FWASA). Such a low ratio is considered to be due to the unpaid customers including illegal connections without using

a water meter (ratio of collection of water charge: the proportion of the paid customer for all households including the households use the water by illegal connections. However, FWASA does not grasp the number of illegal connections, so actual ratio of collection of water charge is the proportion of the paid customer for registered customer). The invoice is delivered every two months to the customers, and overdue fees are demanded in cases of delays in payment. However, even if the delinquency is continued, FWASA does not stop water supply, therefore the customer can use water despite not having paid their water charge.

Moreover, although the payment system of water charges is set according to a metered rate at some factories, the payment system for most factories is that they pay water charge at a flat rate in accordance with the size of their premises. For this reason, even if the customer uses the more than necessary water, consumption is not reflected to the water charge. Such an unfair water charge collection system with a flat rate depending on the size of the premises regardless of the quantity of water consumed is thought to be resulting in an unwillingness to pay water charges by some. In addition, this is also thought to be exasperating the current situation whereby the amount of distribution of water to the city is not satisfying the water demand and where there is not enough water available because of low water pressure.

(4) System of Collection of Water Charge

In order to improve the water charge collection, it is necessary 1) to increase the unit price of water, 2) to improve the bill collection method, and 3) install water meters and apply volumetric rates. At this moment, it is necessary to compensate for the shortfall of operating balance by subsidies from other agencies, including the Punjab government. Currently, it is unlikely that the operating balance will not be fall into deficit because the facilities of FWASA are operated with the subsidies from the Punjab government and the World Bank. However, the subsidy from the World Bank is limited to a fixed period of five years. Therefore, FWASA should increase the income in order to be able to manage the water facilities independently. To increase the unit price of water charges requires the permission of the Punjab government. However, the Punjab government has rejected the application of price increase of water charges by FWASA in spite of the increased electricity and gas rates. Under such circumstances whereby it is difficult to increase the unit price of water charges, the alternative is to increase the collection rate of water charges in order to improve the management situation of FWASA. The increase of the collection rate of water charges requires the appropriate pricing according to the actual water consumption. Therefore, the collection of water charges at the metered rate is needed. About 20,000 water meters will be installed in some areas by the project assisted by the French government. The necessary measures for further installation of water meters and early change to water charges at a metered rate should be taken, which, together with the subsidies, will cover the operating cost, and thereby achieve independent management.

(5) Level of Skills and Technology

New operating skills are required for the Project, such as corresponding to the increase of volume of distribution water and the water pressure management of the dual distribution main system. For this reason, enough technical level is ensured by the implementation of distribution flow control at the initial operation guidance at the time of trial operation after the completion of construction and service pressure control at the technical assistance as soft component. In this way, operation and maintenance of facilities would be possible. However, it is necessary to keep the operation and maintenance management system fully functional and pass on the necessary skills in the long term to ensure sustainability of the Project.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) Cost to be borne by the Pakistani Side

The costs to be borne by the Pakistani Side are shown in the tables below. Those cost have been estimated with the conditions mentioned below.

Table 2-32: Approximate Estimation of the Costs Borne by the Pakistani Side

Items	Price (Rs)
Electrical work to install incoming panel of FESCO	1,600,000
Land clearing	3,000,000
Environmental impact assessment	1,000,000
Bank commission	5,000,000
Total	10,600,000

(2) Condition of Cost Estimation

1) Time of Cost Estimation

The Project cost was estimated in September 2013 when the field survey of the Outline Survey was completed.

2) Exchange Rate

The Project cost was calculated using the average rate in three months from June 1, 2014 to August 31, 2014.

- USD 1=99.38 Yen
- PKR 1=0.05 USD
- PKR 1=1.13 Yen

3) Schedule

The schedule is shown in the implementation schedule in chapter 2-2-4-9.

4) Others

The project cost was estimated according to the Guideline of Japanese Grant Aid.

2-5-2 Operation and Maintenance Cost

(1) Effect and impact of the Project by reduction of power consumption

Results of provisional calculations of power consumption and electricity rate of the Project components, calculated under four scenarios; the current operation before the Project (case 1), the operation situation after the Project has been completed (case 2), and when the service hours are extended (3 years after the Project is completed) and a water supply equivalent to the designed capacity is distributed (case 3), are shown in the following table. In addition, the result of 12 hours operation of the Chenab distribution pump is shown as case 4. As can be seen by comparing cases one and two, there is a power saving obtained through the Project, however, with the extended distribution hours and the distribution designed volume of water, the power consumption would be increased and eventually increased electricity costs would be inevitable (case 3).

Table 2-33: Power consumption and electricity costs of each case

		Case1 (2013)	Case2 (2018)	Case3 (2020)	Case4 (After 2020)
Pump Operation		Current Situation	After implementation		Reference
			Same Operation with Current Situation	Operation of Water Supply to its Designed Capacity	Chenab Dist. Pump Operation:12h/d
Water Distribution Conditions	Chenab Booster Pump	7588m³/h 20 hours/d 0.101kW/m³	7588m³/h 20 hours/d 0.109kW/m³	10239m³/h 20 hours/d 0.109kW/m³	10239m³/h 20 hours/d 0.109kW/m³
	Chenab Dist. Pump	8418m³/h 6 hours/d 0.158kW/m³	8418m³/h 6 hours/d 0.123kW/m³	13230m³/h 6 hours/d 0.123kW/m³	13230m³/h 12 hours/d 0.123kW/m³
	JBC Dist. Pump	7140m³/h 6 hours/d 0.170kW/m³	7140m³/h 6 hours/d 0.170kW/m³	9480m³/h 9 hours/d 0.170kW/m³	9480m³/h 9 hours/d 0.170kW/m³
Pump efficiency		77.4%	85.0%	85.0%	85.0%
Power consumption (MWh)	Chenab Booster Pump	2,615	2,810	3,792	3,792
	Chenab Dist. Pump	2,667	2,079	3,267	6,535
	JBC Dist. Pump	2,182	2,182	3,273	3,273
	Total	7,464	7,070	10,332	13,600
Electricity cost (million Rs.)		97.0	91.9	134.3	176.8
Unit cost (Rs./m³)		2.85	2.70	2.23	1.98

Reference : Drawn on the basis of FWASA's operation management record

Remark 1) Electricity charges are estimated with 13Rs./kWh of unit rate.

The following diagram shows the electricity costs of cases 1, 2 and 3 against the total expenditure and the effects of the expenditure reduction based on the expenditure of the year 2012. From the following diagram, the electricity costs of the Project components are about 8 % of the total expenditure, thus the reduction of power consumption in the Project will not have a significant enough impact to improve the current management situation. However, the operating cost of FWASA can be reduced by providing

assistance in improving energy efficiency. Therefore, the necessity of replacing the facilities in the Project is important to provide sustainable water services.

In addition, in the future, in case FWASA aims to increase the length of time it offers water supply services (case 3), despite the increase in FWASA's expenditure on electricity, it will also receive about 25% additional income from water charges as a result of the increased water distribution volume. Therefore, it is calculated that it will be possible to cover the electricity costs of the Project and labor costs of FWASA.

However, as a prerequisite of the calculation above, it is necessary to abolish the current flat rate system and to introduce comprehensively the volumetric water rate system. Moreover, the installation of water meters at some areas is planned by the French project, therefore, the early transition to the volumetric system is strongly required.

In addition, if it is possible to improve the fee collection rate as a result of the installation of water meters, it can also be envisaged in the future that it will be possible to improve the current situation whereby FWASA can only cover about half of its operating expenses on water and sewerage from the fees it collects for water and sewerage services. This is understood from the result of case 4; the increase of the water and sewerage charges is higher than the increase of electricity charges expected with the increase of the amount of water distributed by pump. Therefore, it will be necessary to work to improve and strengthen the management foundation along with the drastic improvement of the water supply services in the future.

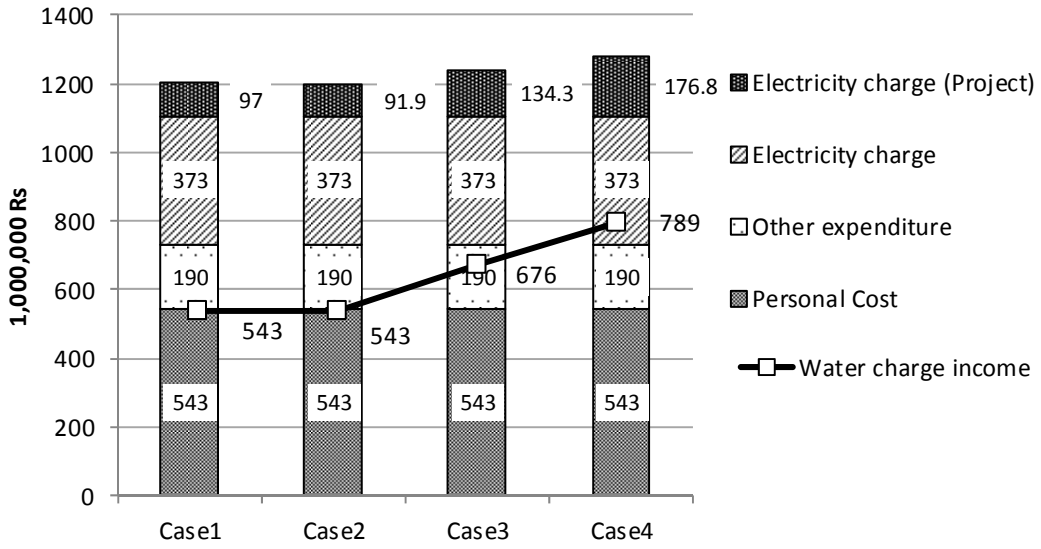


Figure 2-18: Reduction Impact on the Total Expenditure through the Japanese Grant Aid

(2) Necessary Actions for Improvement and Strengthening of Management and Impact through the Project

As mentioned above, the water and sewerage rate income against the management expenditure are not enough and it is necessary to significantly increase the water and sewerage rate income and reduce the

expenditure as much as possible in order to improve and strengthen the management foundation. Currently FWASA's water charges are charged at a flat rate according to the size of one's residence and its collection rate remains at about 40% against the number of water bills, and non revenue water rate is also high, at about 38% (2012/2013: FWASA).

The increase in the water charge income is expected if the collection rate of water charge is improved from the current rate of about 50% to 100%. However, in fact the water supply facility in Faisalabad is not capable of supplying sufficient amount of water to meet the demand and it does not provide a satisfactory service such as the quantity of water and water pressure to the users.

Under such circumstances, it is obvious that the users are not willing to pay the bills even if they are forced to pay water bills with a flat rate under the condition of insufficient service. The improvement of collection rate is not expected due to the fact that the users are not willing to pay for the water supply service unless the service is improved (quantity of water and water pressure). A flat rate system charges a fixed fee regardless of the quantity of water used. In this case, areas close to the water distribution bases are at an advantage because of a greater water pressure and quantity of water, while areas nearer to the ends of water supply pipes rarely will be able to use running water due to shortages of quantity of water and water pressure. In the situation that there is such an inequity even in the same areas, the introduction of a flat rate system would lead to much discomfort of users and it could reduce the collection rate as well.

In this context, in order to fundamentally improve and strengthen the management foundation, it is essential to shift to a metered rate of water charge system and penalizing those who do not pay, namely "soft" or non-physical measures, as well as improving water supply services such as by improving quantity of water and water pressure on the "hard" or physical side to satisfy the users (refer to the following chart).

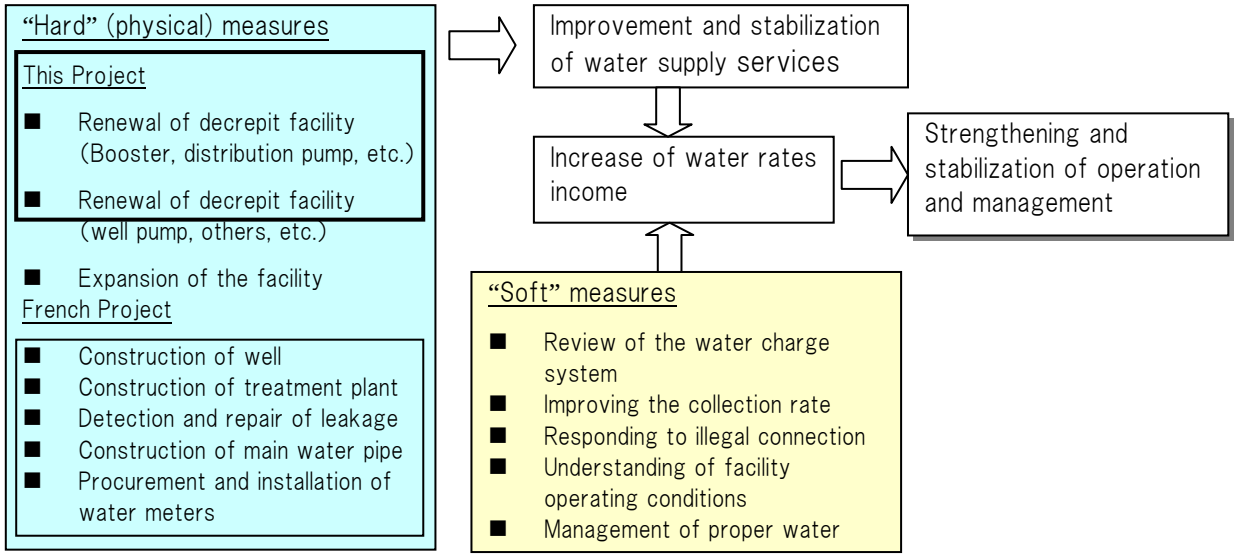


Figure 2-19: Action for Improvement and Strengthening of the Management Bases and Status of the Project

Under such a situation, JICA dispatched experts as an organizational improvement advisor of FWASA. Two-year plan to work with the aim of strengthening the management of water services of FWASA (first year: planning, second year: implementation) is presently being implemented.

Currently, the work of the first year has been completed, including: development of organizational management structure, improvement of financial structure, identification of problems and understanding the current situation on strengthening customer responsiveness, formulation of a midterm management plan, financial analysis, creation of a roadmap of water rate revision and establishment of a customer care center. Based on these plans, specific activities aimed at the improvement of the business management and the financial strength of FWASA will be carried out in the future. And also, improvement and strengthening of FWASA's management foundation will be implemented.

Construction is costly due to the large scale of FWASA's infrastructure. Currently, FWASA's financial condition is so unstable that it is not able to secure the replacement costs of its core facilities. In particular, the purpose of the Project is to recover the capacity of facilities to initial conditions and to improve the infrastructure for water supply services for the citizen. The facilities, especially machinery equipment such as pumps, which is the target for replacement are aging, so that the replacement of those facilities is needed immediately. These facilities account for approximately 86% of the total water supply and if the water supply from the core facilities needs to be suspended for some reason before such facilities are replaced, there would be a significant negative impact on citizens of Faisalabad City and FWASA.

In the situation in which FWASA is not able to handle the situation due to its unstable financial management, it is crucial to implement the Project to improve facilities in order to secure stable water supply and strengthen the management foundation. The project financed by France is also assisting to improve the facilities such as construction of tubewells at Rakh Branch Canal, treatment plant of Jhal Khanuana and new distribution main, procurement of water meters and investigation of water leaks in distribution main (FWASA is responsible for the implementation of repairs). In this way, improvement of water supply service by the abovementioned construction and that FWASA takes ownership for managing the services are required in the situation that water facilities of FWASA is gradually enhanced by other projects not only this Project. As the project of France is loan aid and requires reimbursement, in particular, it is necessary to carry out the reimbursement by steadily increasing the revenue of water and sewerage bills.

So far, FWASA has compensated the fund shortage by grants from the Punjab government. However, it has been determined under the five-year plan that a loan from the World Bank will be available from 2013. By allocating these grants to the cost of operation and maintenance, it becomes possible to aim for the immediate financial improvement of FWASA. In addition, FWASA can improve and distribute the amount of water from the water source to the city by proper operation of water supply facilities after the replacement and improvement of facilities by this Project and the French project. After the current situations regarding water supply facilities and management are improved, the rate of fee collection will

be improved with the review of water rates and repair of pipelines. Accordingly, further improvement of management foundation and further improvement of the water supply service is achieved through the increased incomes. Thus, it would become possible in the future to provide adequate service of both water distribution volume and water pressure, by distribution of the whole of the designed distribution flow and extension of pump operating time that is the final goal of this project.

2-6 Other Relevant Issues

Another relevant issue affecting smooth implementation of the Project shall be considered as follows.

(1) Customs Clearance and Tax Exemption

The facilities to be constructed and the equipment to be procured by the Project shall be used to resolve an issue of urgency in Pakistan. It is necessary to take care so that customs clearance and tax exemption procedures may be carried out promptly and implementation schedule may not be affected.

(2) Securing the Project Site

It is necessary to secure the Project site including leveling and removal of existing facilities and trees located in the construction area of the Project prior to the commencement of the construction works of the Project.

(3) Securing Safety on the Project Site

The construction works of the Project will be executed on the site where existing facilities are located. It is necessary to secure safety in the construction area, as well as neighboring areas and existing facilities in the Project site.

Chapter 3

Project Evaluation

Chapter 3. Project Evaluation

3-1 Recommendations

3-1-1 Precondition to Implement the Project

For the smooth implementation of the Project, the Pakistani Side shall be responsible for the preconditions listed in the table below. It is necessary to be implemented with certainty and at the appropriate timing.

Table 3-1: Precondition to Implement the Project

Contents	Timing
To Submit applications for construction works, and others related to the Project if any, and to get those permissions.	Prior to the commencement of construction works
To remove existing trees on the Project site	Prior to the commencement of construction works
To secure the personnel who will be assigned to the Project, and to secure	Before implementation of soft component (technical assistance)
To procure furniture and equipment related to the Project	Before the completion of construction works
To secure the budget to operate and maintain the facilities and equipment related to the Project	Before the completion of construction works
To attend the inspections at the beginning, mid-term and completion of the construction	Accordingly

3-1-2 Preconditions to Achieve Project Purpose

For preconditions to achieve and sustain the Project effect, the Pakistani Side shall solve the issues listed below.

(1) Establishment of Operation and Maintenance System

The Project will newly establish water supply facilities. It is necessary to establish a new operation and maintenance system to realize adequate and sustainable operation and maintenance of the facilities and equipment after the completion of the construction works of the Project.

(2) Establishment of Technology for Water Pressure Reduction

The amount of water distributed by pump will increases by renewal of the distribution pump implemented by this Project and two distribution mains from the Terminal Reservoir developed by the French Project. For this reason, it is necessary to reduce the pressure by valve control suitably. Although the soft component will be conducted after the completion of the construction as technical assistance, it is expected to establish their own appropriate pressure reduction techniques depending on the distribution amount through the operation and maintenance after the completion of the Project.

3-1-3 Important Assumptions to Achieve Project Purpose

As the external conditions to achieve and continue the effect of the Project, the followings are mentioned.

(1) Prerequisite for Project Implementation

The procedure to secure the budget for this Project (PC-1) will progress smoothly.

(2) External Conditions to achieve the overall plan of the Project

It is required that the public peace and political conditions should not be extremely deteriorated. And it is also required that the service of water supply should be continued. For example, if there are electric power shortages or power cuts, electric power will be supplied preferentially as is the present case, and if there are extreme rises in electricity charges, the provincial government will pay the electricity charges that exceed the capacity of FWASA, etc.

3-2 Project Evaluation

3-2-1 Relevance of the Project

Under the current conditions that the booster pumps and distribution pumps are aging and can't exert their capabilities, this Project is highly relevant to meet the high priority needs of maintaining stable and sustainable water supply services and reducing power consumption by installing the new pumps. The Project aims to contribute to water supply sustainability and stability by reducing the operating costs through improving energy efficiency by replacing the pumps at Inline Booster Pump Station and T/R.

There is a possibility that the total electric consumption in the future will increase according to increase of the distribution amount of water after the Project. However, electric consumption to produce a unit water volume will be slightly reduced and stable operation of facilities will be expected by renewal of aging facilities.

The rationale behind this Project objective lies in the fact that high operating costs, particularly electricity costs, of WASAs as a result of soaring power bills is hindering the implementation of the Punjab Drinking Water Policy (2010). This policy comes under the National Drinking Water Policy (2009) of Pakistan, which aims to provide safe drinking water to all citizens by 2025. The Punjab policy aims to protect water sources from water pollution, prioritize water resources to be used for the supply of drinking water, and to conduct organizational reform so that the WASAs of five cities in Punjab Province become independent agencies, both executively and organizationally.

In this Project the existing pumps are replaced at the Inline Booster Pump Station and Terminal Reservoir. The existing pumps were made in Japan, so in this Project, it is considered to adopt the Japanese product with low failure frequency and excellent in energy efficiency and quality. Therefore, there is a necessity and advantage of using the technology of Japan to conduct the Project. In addition, it does not require an excessively advanced technology in the construction and operation of the target facilities. Also, the Project will not cause adverse environmental or social impacts. Therefore, it is possible to carry out this Project by the Japanese grant aid. In addition, after the completion of the Project, the operation and maintenance of the aforementioned facilities by the human resources and funds of Pakistan is possible.

Japan has made "ensuring human security and improving social infrastructure" as priority areas of its

Pakistan assistance strategy. This Project is positioned under the "program of ensuring water and sanitation" under the development challenges of the policy of "health and environmental improvement". Under this program, this Project aims at improving access to safe water and improving the hygienic environment. This Project is supporting water and sewage facility development, organization management improvement, securement of financial soundness, improvement of operation and maintenance, and the strengthening of planning capacity.

Moreover, the implementation of the Project is expected to have the following impacts:

1) It is possible to avoid the situation where most of the water supply is stopped immediately due to the failure of aging pumps.

   The durability of the machinery is usually from 15 to 20 years. However, more than 20 years has passed since 1992, the completion of construction of the target facilities of this Project. The time of renewal of facilities has already passed. Also, every pump of the Inline Booster Pump Station and T/R was repaired according to its malfunctions. Especially, the Chenab distribution pump of T/R, pump body is cracked due to the influence of cavitation, and the crack damages are repaired by backing process. These pumps are in a condition whereby they could stop working anytime due to malfunctions.

2) Management improvements in the future and the installation of a water distribution pump which can respond to the expansion of water supply capacity by leakage control.

   The concrete plan to improve the water facilities of FWASA could not be confirmed. However, it is confirmed that FWASA is working on repairs of the pipelines that were abandoned in the city. If the reparation of the existing facilities continues to be carried out, it will make possible to develop the water facilities by this Project and will fully meet its function.

In this way, this project is consistent with Japan's assistance policy and development needs and policy of Pakistan. Therefore, it is judged that the validity concerning enforcement of this enterprise is high.

3-2-2 Effectiveness

Following the above policy, target facilities are expected to contribute to the human security of Pakistan. By implementation of the Project, the following quantitative effectiveness is expected.

Table 3-2: Quantitative Effectiveness of the Project

Index	Reference Value (2013)	Target Value (2020:3 years after project completion)
Power Consumption of Booster, Distribution Pump (kW/m^3)	0.259	0.232
Hourly Maximum Water Supply (m^3/h)	8,418	13,230
Daily Maximum Water Supply (m^3/d)	149,508	161,880

As qualitative effectiveness, it is expected that the financial situation improvement of FWASA by

reducing power consumption, reduction of maintenance costs and stable operation of the equipment by the update of the pump equipment, reduction of the areas which cannot use water, and appeasement of climate change, etc. Since the above quantitative and qualitative effectiveness are expected, it is considered that the validity of the project is high.

3-2-3 Conclusion

It is judged that the relevance of the Project is high and the Project is expected to be effective.

[Appendices]

1. Member List of the Study Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions
5. Soft Component (Technical Assistance) Plan
6. References
7. Other Relevant Data

[Appendices]

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Appendix 1

Member List of the Study Team

1. Member List of the Study Team

(1) Field Survey (from August 21, 2013 to October 13, 2013)

	Name	Job Title	Organization
1	Mr. Yoshiki OMURA	Team Leader	Japan International Cooperation Agency
2	Mr. Hidetake AOKI	Planning Management	Japan International Cooperation Agency
3	Mr. Kenji SHINODA	Chief Consultant / Water Facility Planning / Opertion and Maintenance Planning	Kokusai Kogyo Co., Ltd.
4	Mr. Takeshi ABE	Sub Chief Consultant / Construction and Supply Planning / Cost Estimation	Kokusai Kogyo Co., Ltd.
5	Mr. Tamotsu ISHII	Machinery Equipment / Electrical Equipment	Ogino Kenko Co., Ltd.
6	Mr. Daisuke SAKAMOTO	Facility Planning, Design 1 / Temporary Work Planning	Kokusai Kogyo Co., Ltd.
7	Mr. Satoshi ISHIDA	Facility Planning, Design 2 / Groundwater Management	Kokusai Kogyo Co., Ltd.

(2) Explanation of Draft Outline Design (from April 9, 2014 to April 19, 2014)

	Name	Job Title	Organization
1	Mr. Hidetake AOKI	Team Leader	Japan International Cooperation Agency
2	Mr. Kenji SHINODA	Chief Consultant / Water Facility Planning / Opertion and Maintenance Planning	Kokusai Kogyo Co., Ltd.
3	Mr. Takeshi ABE	Sub Chief Consultant / Construction and Supply Planning / Cost Estimation	Kokusai Kogyo Co., Ltd.

Appendix 2

Study Schedule

2. Study Schedule

(1) Field Survey (from August 21, 2013 to October 13, 2013)

No	Date	JICA		Consultant				
		Team Leader	Planning Management	Chief Consultant / Water Facility Planning / Operation and Maintenance Planning	Sub Chief Consultant / Construction and Supply Planning / Cost Estimation	Machinery Equipment / Electrical Equipment	Facility Planning, Design 1 / Temporary Work Planning	Facility Planning, Design 2 / Groundwater Management
		Mr. Omura	Mr. Aoki	Mr. Shinoda	Mr. Abe	Mr. Ishii	Mr. Sakamoto	Mr. Ishida
1	21-Aug	Narita to Lahore						
2	22-Aug	Courtesy call and meeting with HUD&PHED, P&D, Lahore WASA, Faisalabad WASA, Lahore to Faisalabad						
3	23-Aug	Courtesy call and meeting with Faisalabad WASA						
4	24-Aug	Site Visit(Chenab well field, Inline Booster Pump Station, Terminal Reservoir, Existing Water Facilities of Japan's Grant Aid)						
5	25-Aug	Internal Meeting						
6	26-Aug	Meeting with Faisalabad WASA, Faisalabad to Lahore				Meeting with Faisalabad WASA	Meeting with Faisalabad WASA, Faisalabad to Lahore	
7	27-Aug	Meeting and signing on of Minutes of Discussion with HUD&PHED				Existing facility survey	Local subcontracting preparation	
8	28-Aug	Lahore to Islamabad, Signing on of Minutes of Discussion with EAD, Meeting with ADB, Report to Japanese embassy and JICA Islamabad to Narita		Lahore to Islamabad, Signing on of Minutes of Discussion with EAD, Meeting with ADB, Report to Japanese embassy and JICA		Existing facility survey	Local subcontracting preparation, Lahore to Faisalabad	
9	29-Aug	to Narita		Interviews with the Japanese companies, Islamabad to Faisalabad		Existing facility survey	Collecting data	Collecting data
10	30-Aug			Existing facility survey	Existing facility survey	Existing facility survey	Collecting data	Collecting data
11	31-Aug			Existing facility survey	Existing facility survey	Existing facility survey	Existing facility survey	Existing facility survey
12	1-Sep			Internal Meeting, Material review				
13	2-Sep			Existing facility survey	Existing facility survey	Existing facility survey	Faisalabad to Lahore, Local subcontracting preparation	Existing facility survey
14	3-Sep			Existing facility survey	Existing facility survey	Existing facility survey	Local subcontracting preparation, Contract	Existing facility survey
15	4-Sep			Existing facility survey	Existing facility survey	Existing facility survey	Lahore to Faisalabad	Existing facility survey
16	5-Sep			Other donor survey	Existing facility survey	Existing facility survey	Other donor survey	Faisalabad to Lahore, Local subcontracting preparation
17	6-Sep			Operation and Maintenance system survey	Local subcontracting management	Existing facility survey	Existing facility survey	Local subcontracting contract
18	7-Sep			Operation and Maintenance system survey	Local subcontracting management	Existing facility survey	Existing facility survey	Lahore to Faisalabad
19	8-Sep			Internal Meeting, Material review				
20	9-Sep			Well field survey	Local subcontracting management	Existing facility survey	Well field survey	Well field survey
21	10-Sep			Well field survey	Local subcontracting management	Existing facility survey	Well field survey	Well field survey
22	11-Sep			Well field survey	Local subcontracting management	Existing facility survey	Well field survey	Well field survey
23	12-Sep			Existing facility survey	Faisalabad to Lahore, Market survey	Existing facility survey	Local subcontracting management	Local subcontracting management
24	13-Sep			Existing facility survey	Market survey	Existing facility survey	Local subcontracting management	Faisalabad to Lahore, Local subcontracting management
25	14-Sep			Faisalabad to Lahore, Local subcontracting management	Market survey	Existing facility survey	Local subcontracting management	Local subcontracting management, Lahore to Faisalabad
26	15-Sep			Local subcontracting management, Lahore to Faisalabad	Lahore to Islamabad, Market survey	Internal Meeting, Material review		Material review
27	16-Sep			Existing facility survey	Market survey	Existing facility survey	Existing facility survey	Existing facility survey
28	17-Sep			Existing facility survey	Market survey, Islamabad to Faisalabad	Existing facility survey	Existing facility survey	Existing facility survey
29	18-Sep			Existing facility survey	Procurement survey	Existing facility survey	Other donor survey	Existing facility survey
30	19-Sep			Existing facility survey	Procurement survey	Existing facility survey	Existing facility survey	Existing facility survey
31	20-Sep			Burden matter review	Burden matter review	Existing facility survey	Existing facility survey	Existing facility survey
32	21-Sep			Burden matter review	Burden matter review	Existing facility survey	Existing facility survey	Construction planning survey
33	22-Sep			Internal Meeting, Material review				
34	23-Sep			Project contents survey	Construction planning survey	Facilities and equipment planning survey	Facility planning survey	Local subcontracting preparation
35	24-Sep			Project contents survey	Construction planning survey	Facilities and equipment planning survey	Facility planning survey	Local subcontracting preparation
36	25-Sep			Local subcontracting contract	Construction planning survey	Facilities and equipment planning survey	Facility planning survey	Local subcontracting contract
37	26-Sep			Project contents survey	Construction planning survey	Facilities and equipment planning survey	Facility planning survey	Well field survey
38	27-Sep			Project contents survey	Faisalabad to Islamabad, Report to JICA	Material review	Material review	Well field survey
39	28-Sep			Project contents survey	Market survey, Islamabad to Narita	Faisalabad to Lahore, Lahore to Narita		Well field survey
40	29-Sep			Material review	to Narita	to Narita	to Narita	Material review
41	30-Sep			Material review				Local subcontracting management
42	1-Oct			Material review				Local subcontracting management
43	2-Oct			Local subcontracting management				Local subcontracting management
44	3-Oct			Local subcontracting management				Local subcontracting management
45	4-Oct			Faisalabad to Islamabad, Report to JICA, Islamabad to Narita				Local subcontracting management
46	5-Oct			to Narita				Local subcontracting management
47	6-Oct							Local subcontracting management
48	7-Oct							Local subcontracting management
49	8-Oct							Local subcontracting management
50	9-Oct							Local subcontracting management
51	10-Oct							Local subcontracting management
52	11-Oct							Local subcontracting management
53	12-Oct							Faisalabad to Lahore, Lahore to Narita
54	13-Oct							to Narita

(2) Explanation of Draft Outline Design (from April 9, 2014 to April 19, 2014)

No	Date	JICA	Consultant	
		Team Leader	Chief Consultant / Water Facility Planning / Operation and Maintenance Planning	Sub Chief Consultant / Construction and Supply Planning / Cost Estimation
		Mr. Aoki	Mr. Shinoda	Mr. Abe
1	9-Apr		Narita to Lahore	
2	10-Apr		Lahore to Faisalabad, Courtesy call to Faisalabad WASA and FDA, Meeting with Faisalabad WASA	
3	11-Apr		Meeting with Faisalabad WASA	
4	12-Apr		Meeting with Faisalabad WASA	
5	13-Apr		Faisalabad to Lahore	
6	14-Apr	Narita to Lahore	Courtesy call and meeting with HUD&PHED	
7	15-Apr	Courtesy call and meeting with HUD&PHED, Courtesy call and meeting with Faisalabad WASA		
8	16-Apr	Lahore to Faisalabad, Meeting with Faisalabad WASA, Courtesy call to FDA, Faisalabad to Lahore		
9	17-Apr	Meeting with P&D, HUD&PHED, Faisalabad WASA, Signing on of Minutes of Discussion, Lahore to Islamabad		
10	18-Apr	Courtesy call and meeting with EAD, Report to JICA, Japanese Embassy, Islamabad to Narita		
11	19-Apr	to Narita		

Appendix 3

List of Parties Concerned in the Recipient Country

3. List of Parties Concerned in the Recipient Country

（1） Faisalabad Water and Sanitation Agency (Faisalabad WASA)

Mr. Syed Zahid Aziz	Managing Director
Dr. Ijaz Ahmad Randhawa	Project Director (JICA)
Mr. Muhammad Aslam	Deputy Managing Director (Engineering)
Mr. Waseem Ahmad Hashmi	Deputy Managing Director (Service)
Mr. Muhammad Shoukat	Deputy Managing Director (Service)
Mr. Pervaiz Iqbal	Director, Planning & Design
Mr. Muhammad Ashraf	Director, Water Resources
Mr. Noor Muhammad	Director, Water Resources
Mr. Usman Latif	Deputy Director, Water Resources
Mr. Asghar Ali	Director, Construction Ⅱ
Mr. Faqir Muhammad Ch.	Project Director (French)
Mr. Muhammad Adnan	Assistant Director (JICA

（2） Faisalabad Development Authority (FDA)

Mr. Noor ul Amin Mengal	District General

（3） Lahore Water and Sanitation Agency (Lahore WASA)

Dr. Javed Iqbal	Managing Director
Mr. Aftab Ahmad	Deputy Managing Director (Engineering)
Mr. Shakeel Ahmed Kashmiri	Director (P&E)

（4） Housing Urban Development and Public Health Engineering Department (HUD&PHED), Government of Punjab

Mr. Waseem Mukhtar	Secretary
Mr. Liaqat Ali Khalique	Additional Secretary (A&H)
Mr. Muazzam Jamil	Deputy Secretary (UD)

（5） Planning and Development Department (P&D), Government of Punjab

Mr. Afir Anwar Baloch	Secretary
Ms. Bushra Aman	Member (Social Infrastructure)
Mr. Sohil Akhtar Shahzad	Senior Chief (UD)
Mr. Khalid Sultan	Chief (ECA)
Ms. Aatqa Mahmood	Assistant Chief (ECA)
Mr. Amjad Duraiz	Assistant Chief (ECA)

（6） The Urban Unit, Planning and Development (UU), Government of Punjab

Dr. Kiran Farhan	Senior SWM Specialist
Mr. Farhat Saeed	Senior GIS Specialist
Dr. M. Tahseen Duraiz	Senior WS Specialist

（7） Economic Affairs Division (EAD), Government of Pakistan

Mr. Iftikhar Amijad	Deputy Secretary
Mr. Qumar Sarwar Abbsasi	Joint Secretary
Mr. Asghar Ali	Section Officer

（8） Asian Development Bank

Mr. Mian S. Shafi	Unit Head, Urban, Water, and Emergency Assistance Pakistan Resident Mission

（9） Faisalabad Electric Supply Company (FESCO)

Mr. Pervaiz Akhtar Shah	Managing Director
Mr. Muddassan Sahail	Director (Grid Station)

（10） University of Agriculture, Faisalabad-Pakistan

Dr. Muhammad Arshad Mirza	Professor, Department of Irrigation & Drainage

（11） Embassy of Japan in Pakistan

Mr. Akira Kono	Minister DCM
Mr. Yuichi Kuroda	First Secretary
Mr. Naoki Kamoshida	Counselor (Economic & Development)

（１２）Japan International Cooperation Agency Pakistan Office

Mr. Mitsuyoshi Kawasaki	Chief Representative
Mr. Ken Kato	Senior Representative
Mr. Tomohiro Azegami	Representative
Mr. Satoshi Hamano	Representative

（１３）JICA Expert (Institutional Improvement)

Mr. Kunimasa Nishigaya	JICA Expert
Mr. Yarai Sato	JICA Expert

Appendix 4

Minutes of Discussions

Minutes of Discussions

August 27, 2013

4. Minutes of Discussions

(1) Signed Minutes of Discussions on August 27, 2013 at Field Survey

MINUTES OF DISCUSSIONS
ON THE PREPARATORY SURVEY (OUTLINE DESIGN SURVEY)
ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY
AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR
IN FAISALABAD
IN THE ISLAMIC REPUBLIC OF PAKISTAN

Lahore, August 27, 2013

Mr. Syed Zahid Aziz
Managing Director
Water and Sanitation Agency
Faisalabad Development Authority

Mr. Yoshiki Omura
Leader,
Preparatory Survey (Outline Design Survey)
Team,
Japan International Cooperation Agency

Mr. Waseem Mukhtar
Secretary
Housing Urban Development and Public
Health Engineering Department,
Government of Punjab

Mr. Arif Anwar Baloch
Secretary
Planning and Development Department,
Government of Punjab

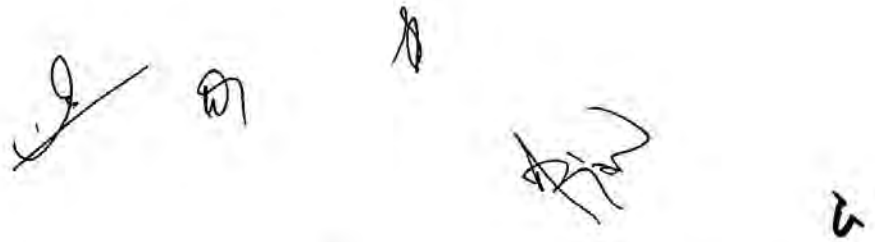
Dr. Iftikhar Amjad
Deputy Secretary
Economic Affairs Division,
Government of Pakistan

In response to a request from the Government of the Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") for the Project for Replacement of Pumping Machinery at Inline Booster Pumping Station & Terminal Reservoir in Faisalabad (hereinafter referred to as "the Project"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") sent the Preparatory Survey Team (hereinafter referred to as "the Team") for the Outline Design Survey on the Project to Pakistan from August 21 to September 29, 2013.

The Team held a series of discussions with relevant organizations on the Inception Report of the study and conducted field visits to develop scope and implementing arrangements of a further survey. In the course of discussions, the Pakistani side agreed the contents of the Inception Report in principle and both sides confirmed the items described on the main points discussed in the Appendix 1. The tentative schedule of the Preparatory Survey is attached in the Appendix 3. The Japan's Grant Aid Scheme is described in the Appendix 4.

It should be noted that implementation of the Outline Design Survey does not imply any decision or commitment by JICA to extend its grant for the Project at this stage.

Appendix 1: Main Points Discussed
Appendix 2: Attendant list
Appendix 3: Tentative schedule
Appendix 4: Japan's Grant Aid Scheme



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Appendix 1

MAIN POINTS DISCUSSED

1. Objectives of the Project

The Pakistani side understood that the Project is an emergency measure against a decrease in production of water due to aging, outdating and inefficiency of existing pumps so that the objectives of the Project are to restore capacity of pumps of the main water supply system and to improve energy efficiency for reduction of operation and maintenance cost.

2. Request for the Grant Aid Project

Both sides confirmed the request for the Japan's Grant Aid Project as follows:

(i) Project Site
Within the service area of Faisalabad WASA, in Faisalabad, Punjab

(ii) Civil / Mechanical works
Water Facilities, Equipment:
Inline Booster Pumping Station:
Booster Pumps (27.2 m^3 / min×3 nos., 51.0 m^3 / min×4 nos.)
Terminal Reservoir Pumping station:
Distribution Pumps (27.2 m^3 / min×3 nos., 37.7 m^3 / min×7 nos.)
Generator:
700 kVA, 3.3 kV×3 nos.; 1,000 kVA, 3.3 kV×5 nos.
Miscellaneous Work:
Yard piping, panels, water flow meters, rehabilitation of reservoir leakage and pump house, etc.

(iii) Consulting Services
- Detailed design
- Assistance for tendering
- Construction supervision
- Technical assistance (soft component)

The Pakistani side understands to be responsible for improvement of distribution networks, functionalization of the existing overhead reservoirs in particular.

3. Specification of Inline Booster Pumps and Distribution Pumps

The Team mentioned that a well production study would be conducted during the survey. According to the existing pumping data, groundwater abstraction has been decreased due to lowering of groundwater level, deterioration of pumps, curtailing operational hours to save energy cost and to lessen influence to farming shallow wells. Therefore both sides agreed that specification of inline booster pumps depends on the results of the above study and may not be determined to restore the initial well capacity in order to operate Chenab water supply system sustainably. The Team requested that the Pakistani side provide information of boreholes such as static and dynamic water levels, pumping discharge, lowering history of groundwater level.

The Pakistani side explained that WASA was distributing water from the terminal reservoir for less than 12 hours to optimize operational cost, so the Team requested WASA to provide the operating record and a future plan of operational hours of distribution pumps. Both sides agreed that distribution pumps with appropriate capacity would be selected in sufficient quantity so as to make their operation sustainable and achieve high efficiency of energy consumption, although 10 pumps were officially requested.

The Pakistani side also explained that the major purpose of operating generators would be maintaining a minimum water supply during power shutdowns.

Both sides agreed that specification and number of pumps and generators would be determined based on the results of the pumping test, operation plan and efficiency of operation.

4. Natural condition survey

The Team explained that the Team would conduct soil investigation in the terminal reservoir premises, pumping test some of the production wells and topographical survey in the inline booster pumping station and terminal reservoir premises. Both sides agreed to the methodology, number of samples and duration of each study.

5. Design of the terminal reservoir pumping station

The Team explained that a design of the terminal reservoir pumping station (ADB component) would be determined upon such factors as the result of soil investigation, availability of space to accommodate pumps, efficiency of daily operation, durability of the existing building, and cost.

Both sides agreed that the Project works require suspension of pumping for a certain period. To this regard, the Pakistani side requested the Team to propose some alternative methods to make suspension time as short as practical, and to program the suspension period in winter season.

6. Management improvement with the Japanese technical cooperation

The Team referred to THE PUNJAB DRINKING WATER POLICY that the government of Punjab was conducting Institutional Reform Program in the Urban Water Service Providing Government Agencies not only for improving service delivery but also addressing multi issues such as rationalization of tariff, improvement in management of organization and introduction of performance monitoring systems so as to ensure that the WASAs are transformed into progressive, accountable and financially viable institutions by the year 2016.

The Team explained that the Project would contribute to cost cut by a technical approach for reduction of energy consumption by replacement of pumps, but it was still necessary for WASA to make efforts to reduce operational expenditure and rationalize water tariff to improve the financial status. The Pakistani side promised to make efforts regarding the above issues cooperating with the activities of the Institutional Reform Advisor and the Project for Improving the Capacity of WASAs in Punjab Province of the Japanese technical cooperation.

7. The French government funded project

The Pakistani side explained about the project financed by the French government that an additional clear water new transmission pipeline of 1,000 mm and 6.5 km proposed to connect the new terminal reservoir (Japanese Grant) and distribution network at the beginning of 800 mm dia. reinforcement pipeline to improve service pressure in town, particularly the Eastern area.

8. Possibility of procurement from the third countries

The Pakistani side agreed that there would be a possibility of procurement from other than Japan or Pakistan due to such reasons as availability of products, easiness and cost in both countries, and some other reasons. The Team explained that it is clearly mentioned in the relevant paragraph of Grant Agreement which would be signed by both sides after an approval of the Project by the Japanese government as quoted below and also in the item 3. Japan's Grant Aid Scheme (3) of Appendix 4 of this Minutes of Discussions.

Grant Agreement

Article 3 Use of the Grant

(1) The Grant shall be used by the Government of the Islamic Republic of Pakistan properly and exclusively for the purchase of such products of Japan or the Islamic Republic of Pakistan and such services of Japanese or Pakistani nationals necessary for the implementation of the Project as listed below (The term "nationals" whenever used in the G/A means Japanese physical persons or Japanese juridical persons controlled by Japanese physical persons in the case of Japanese nationals and Pakistani physical or juridical persons controlled by Pakistani physical persons in the case of Pakistani nationals.):

(a)equipment and services necessary for the procurement and the installation thereof;

(b)services necessary for the transportation of the products referred to in (a) above to ports in the Islamic Republic of Pakistan and those for internal transportation therein; and

(c)services necessary for the training in operating the equipment referred to in (a) above and the guidance in managing the equipment referred to in (a) above .

(2) Notwithstanding the provisions of sub-paragraph (1) above, when JICA and the Authority deem it necessary, the Grant may be used for the purchase of the products of the kind referred to in (a) of sub-paragraph (1) above, which are products of countries other than Japan or the Islamic Republic of Pakistan and the services of the kind referred to in (a),(b) and (c) of sub-paragraph (1) above, which are services of nationals of countries other than Japan or the Islamic Republic of Pakistan.

9. Undertakings to be taken by the Pakistani side for the project implementation

(i) Procedure of PC-1 approval

The Pakistani side agreed to coordinate the procedure for PC-1 immediately after the explanation of a draft final report of Outline Survey, so that the Japanese government could proceed with an approval process of the Project. The Pakistani side explained a procedure of approval by the Central Development Working Party / the Executive Committee of National Economic Council (CDWP / ECNEC).

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(ii) Coordination for Environmental and social issues

The Pakistani side agreed to undertake necessary procedures with Department of Environment / Environmental Protection Agency of Punjab (EPA) to implement the Project especially an approval of reconstruction of the pumping station of the terminal reservoir.

(iii) Clearance and permission for the natural condition survey

The Pakistani side agreed to undertake necessary procedures for clearance and permission for the natural condition survey.

(iv) Land acquisition (land use agreement / temporary construction permission)

The Pakistani side agreed to obtain the relevant approval documents on land use agreement and temporary construction permission from respective government department in a timely manner, if land acquisition is to be necessary in the further survey.

(v) Tax exemption arrangement

The Pakistani side agreed to undertake necessary procedures for tax exemption and customs clearance of the products at the port of disembarkation.

10. Consultation

JICA and Faisalabad WASA will consult with each other in respect of any matter that may arise from or in connection with the Preparatory Survey (Outline Design Survey).

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Appendix 2

ATTENDANT LIST

<Pakistani Side>

Faisalabad Water and Sanitation Agency (WASA Faisalabad, FDA)

Mr. Syed Zahid Aziz	Managing Director
Dr. Ijaz Ahmad Randhawa	Deputy Managing Director (Finance)
Mr. Muhammad Aslam	Deputy Managing Director (Engineering)
Mr. Waseem Ahmad Hashmi	Deputy Managing Director (Services)
Mr. Pervaiz Iqbal	Director, Planning & Design
Mr. Muhammad Ashraf	Director, Water Resources
Mr. Asghar Ali	Director, Construction II
Mr. Faqir Muhammad Ch.	Project Director (French)

Housing Urban Development and Public Health Engineering Department (HUD&PHED), Government of Punjab

Mr. Liaqat Ali Khalique	Additional Secretary (A &H)
Mr. Muazzam Jamil	Deputy Secretary (UD)

Planning and Development Department (P&D), Government of Punjab

Mr. Arif Anwar Baloch	Secretary
Ms. Bushra Aman	Member (Social Infrastructure)
Mr. Sohail Akhtar Shahzad	Senior Chief (UD)
Mr. Khalid Sultan	Chief (ECA)
Ms. Aatqa Mahmood	Asstt. Chief (ECA)
Mr. Amjad Duraiz	Asstt. Chief (ECA)

The Urban Unit, Planning and Development Department (P&D), Government of Punjab

Dr. Kiran Farhan	Senior SWM Specialist
Mr. Farhat Saeed	Senior GIS specialist
Dr. M. Tahseen Aslam	Senior WS specialist

<Japanese Side>

Mr. Yoshiki Omura	Leader of the Preparatory Survey Team / Senior Advisor of JICA
Mr. Hidetake Aoki	Planning Management / Staff of JICA Headquarter
Mr. Kenji Shinoda	Chief Consultant / WS Planner / O&M Planner
Mr. Takeshi Abe	Deputy Chief Consultant / Construction and Procurement Planner / Cost Estimator
Mr. Tamotsu Ishii	Machinery and Electric Planner
Mr. Daisuke Sakamoto	Facility Planner & Designer
Mr. Satoshi Ishida	Facility Planner & Designer / Groundwater Management Specialist

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Appendix 3

TENTATIVE SCHEDULE

Year	2013						2014							
Month	7	8	9	10	11	12	1	2	3	4	5	6	7	8
Preparation in Japan														
Work in Pakistan														
Work in Japan														
Explanation of the draft of Outline Design Survey report														
Preparation of the Outline Design Survey report														
Report	*1)						*2)						*3)	

*1) IC/R: Inception Report
*2) DOD/R: Draft of Outline Design Report
*3) F/R: Final Report

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Appendix 4

JAPAN'S GRANT AID SCHEME

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on the law and the decision of the Government of Japan (hereinafter referred to as "the GOJ"), JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

The Grant Aid is non-reimbursable fund to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures

The Japanese Grant Aid is conducted as follows-

- Preparatory Survey (hereinafter referred to as "the Survey")
  - The Survey conducted by JICA
- Appraisal &Approval
  - Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet
- Determination of Implementation
  - The Notes exchanged between the GOJ and a recipient country
- Grant Agreement (hereinafter referred to as "the G/A")
  - Agreement concluded between JICA and a recipient country
- Implementation
  - Implementation of the Project on the basis of the G/A

2. Preparatory Survey

(1) Contents of the Survey

The aim of the Survey is to provide a basic document necessary for the appraisal of the Project by JICA and the GOJ. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of agencies concerned of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed on by both parties concerning the basic concept of the Project.
- Preparation of a basic design of the Project.
- Estimation of costs of the Project.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed considering the guidelines of the Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures are

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necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

(2) Selection of Consultants
For smooth implementation of the Survey, JICA uses (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey
The Report on the Survey is reviewed by JICA, and after the appropriateness of the Project is confirmed, JICA recommends the GOJ to appraise the implementation of the Project.

3. Japan's Grant Aid Scheme

(1) The E/N and the G/A
After the Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as "the E/N") will be signed between the GOJ and the Government of the recipient country to make a plead for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants
The consultant firm(s) used for the Survey will be recommended by JICA to the recipient country to also work on the Project's implementation after the E/N and the G/A, in order to maintain technical consistency.

(3) Eligible source country
Under the Japanese Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"
The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country
In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as Annex.

(6) "Proper Use"
The Government of the recipient country is required to maintain and use the facilities constructed and the equipment purchased under the Grant Aid properly and effectively and

to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"
The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)
a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in a bank of Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)
The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions to the Bank.

(10) Social and Environmental Considerations
A recipient country must ensure the social and environmental considerations for the Project and must follow the environmental regulation of the recipient country and JICA socio-environmental guidelines.

(End)

Annex

Major Undertakings to be taken by Each Government

NO	Items	To be covered by the Grant	To be covered by Recipient side
1	To secure land		•
2	To clear, level and reclaim the site when needed		•
3	To construct gates and fences in and around the site		•
4	To construct the parking lot		•
5	To construct roads		
	1) Within the site	•	
	2) Outside the site		•
6	To construct the building	•	
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities		
	1)Electricity		
	a.The distributing line to the site		•
	b.The drop wiring and internal wiring within the site	•	
	c.The main circuit breaker and transformer	•	
	2)Water Supply		
	a.The city water distribution main to the site		•
	b.The supply system within the site (receiving and/or elevated tanks)	•	
	3)Drainage		
	a.The city drainage main (for storm, sewer and others) to the site		•
	b.The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	•	
	4)Gas Supply		
	a.The city gas main to the site		•
	b.The gas supply system within the site	•	
	5)Telephone System		
	a.The telephone trunk line to the main distribution frame / panel (MDF) of the building		•
	b.The MDF and the extension after the frame / panel	•	
	6)Furniture and Equipment		
	a.General furniture		•
	b.Project equipment	•	
8	To bear the following commissions to a bank of Japan for the banking services based upon the B/A		
	1) Advising commission of A/P		•
	2) Payment commission		•
9	To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country		
	1) Marine(Air) transportation of the products from Japan to the recipient country	•	
	2) Tax exemption and customs clearance of the products at the port of disembarkation		•
	3) Internal transportation from the port of disembarkation to the project site	(•)	(•)
10	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		•
11	To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contract		•
12	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		•
13	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities as well as for the transportation and installation of the equipment		•

B/A: Banking Arrangement, A/P: Authorization to pay

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Minutes of Discussions
April 17, 2014

(2) Signed Minutes of Discussions on April 17, 2014 at Explanation of Draft Outline Design

MINUTES OF DISCUSSIONS
ON THE PREPARATORY SURVEY (THE OUTLINE DESIGN)
ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY
AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR
IN FAISALABAD
IN THE ISLAMIC REPUBLIC OF PAKISTAN
(EXPLANATION OF THE DRAFT REPORT)

Lahore, April 17, 2014

Mr. Syed Zahid Aziz
Managing Director
Water and Sanitation Agency
Faisalabad Development Authority

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Secretary
Planning and Development Department,
Government of Punjab

Mr. Shahid Ahmed Vakil
Deputy Secretary
Economic Affairs Division,
Government of Pakistan

The Japan International Cooperation Agency (hereinafter referred to as "JICA") has conducted the Preparatory Survey (the Outline Design) on THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR IN FAISALABAD (hereinafter referred to as "the Project"). Through discussions, field surveys, and technical examination of the study results in Japan, JICA prepared a draft final report of the survey.

In order to explain and to consult with the Government of the Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") on the components of the draft final report, JICA dispatched to Pakistan the Draft Final Report Explanation Team (hereinafter referred to as "the Team"), headed by Mr. Hidetake Aoki, Deputy Director, Water Resources Management Division 1, Global Environment Department, JICA from the 10th to the 18th of April 2014.

As a result of discussions, both sides confirmed the main items described in the attached sheet.

ATTACHMENT

1. Components of the Draft Final Report

The Pakistani side agreed and accepted in principle the components of the draft final report explained by the Team. The project sites map and components are shown in Annex-1 and Annex-2.

2. Responsible and implementation agency

2-1). The Responsible Agency is the Housing Urban Development and Public Health Engineering Department, Government of Punjab (hereinafter referred to as "HUD&PHED").

2-2). The Implementing Agency is the Water and Sanitation Agency, Faisalabad Development Authority (hereinafter referred to as "Faisalabad WASA").

3. Submission of the Final Report

JICA will complete the final report in accordance with the confirmed items and send it to the Government of Pakistan in August 2014.

4. Japan's Grant Aid Scheme

4-1). The Pakistani side understood the Japan's Grant Aid Scheme explained by the Team, as described in Attachment 1 for Annex-5.

4-2). The Pakistani side will take the necessary measures, as described in Attachment 2 for Annex-5, for smooth implementation of the Project, as a condition for the Japanese Grant Aid to be implemented.

5. Other Relevant Issues

5-1) Design of Pumping operation hours

Pumping operation hours at present are 6 hours per day each for the terminal reservoir pumping stations of both the Chenab and the Jhang Branch Canal water supply systems. Based on the discussions, it is proposed in the preparatory survey that operating hours of both pumping stations be 6 and 9 hours per day respectively for 2020 due to affordability of bearing cost for additional operation hour and little revenue rise with extension of operation hour under the fixed billing system. First of all, the Team proposed that they should be 9 and 12 hours per day after the completion of the Project for the Chenab system and as designed in "THE PROJECT FOR THE EXPANSION OF WATER SUPPLY SYSTEM IN FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN" for the Jhang Branch Canal system. The Pakistani side explained that introduction of metered billing system would be partially in progress with deployment of meters by the project financed by the French government and others. Faisalabad WASA is meeting with the water demand in principle in the current water service area and cannot expect a rise of revenue with

increase of water production under the current fixed billing system. By serving more areas as well as by installation of meters the revenue may increase. Furthermore, Faisalabad WASA and Government of the Punjab are striving to use water more efficiently and enhancing the coverage through this project by the French government. Faisalabad WASA promised to improve its management by raising the revenue and extend pumping operation hours of the terminal reservoir stations as designed, so that both facilities with cooperation of the Project and the above project would be appropriately utilized and water supply service would be improved.

5-2) Project cost estimation and fairness

The Team explained to the Pakistani side the estimated project cost as attached in Annex-3. Both sides confirmed that this cost estimation is provisional and would be examined further by the Government of Japan for its final approval. Furthermore, both sides confirmed that this project cost estimation is CONFIDENTIAL, and should not be duplicated in any forms or released to any other parties until the relevant contracts are awarded, in order to secure fairness of tender procedure.

5-3) Necessary budget to be covered by the Pakistani side

The Japanese side explained necessary project cost to be covered by the Pakistani side as attached in Annex-3. The Pakistani side agreed to secure necessary budget in order to bear necessary annual operation and maintenance cost.

5-4) Tax Exemption

The both sides confirmed that the tax exemption including Value Added Tax (VAT), customs duty, and any other taxes and fiscal levies in Pakistan, which is to be imposed in relation to the Project activities, will be ensured by the Pakistani side. Faisalabad WASA will take any necessary procedures for tax exemption, and in case that tax exemption is not secured, the cost of tax will be borne by Faisalabad WASA. The Pakistani side agreed to undertake necessary procedures for tax exemption and customs clearance of the products at the port of disembarkation.

5-5) Undertakings of the Pakistani side

The Team explained to the Pakistani side its undertakings as listed in Attachment 2 for Annex-5 and the Pakistani side understood and agreed to execute them. The following items are to be emphasized:

1) Approval procedure of Planning Commission - I (PC-I) for the Project

The Pakistani side explained that Faisalabad WASA would prepare and submit a PC-I document to HUD&PHED/P&D Board, Government of the Punjab and PC-I needed to be approved by the CDWP / Executive Committee of National Economic Council (ECNEC), the Government of Pakistan by the end of September 2014. The Pakistani side agreed to take necessary procedures to secure its approval.

2) Procedure of Initial Environmental Examination (IEE)

The Pakistani side agreed to complete necessary procedure of IEE with Department of Environment / Environmental Protection Agency of Punjab (EPA) by the end of January 2015 in

accordance with "the Environmental Protection Act 2012" of the Punjab province.

3) Technical assistance ("Soft Component") of the Project

Both sides confirmed that the technical assistance ("Soft Component") on the distribution pump operation for water pressure control in the distribution network was designed under the Project. To secure the effectiveness of the soft component, Faisalabad WASA agreed to assign competent and appropriate staff who can acquire the necessary skills and knowledge to apply to their job.

4) Relocation of incoming panel

The team explained that it is necessary to relocate the incoming panel at Terminal Reservoir which is managed by Faisalabad Electric Supply Company (FESCO). The Pakistani side agreed to it.

5) Secure the budget for operation and maintenance

The team explained that in order to operate the facilities that would have been developed by the Project effectively, it is necessary to secure the budget.

5-6) Specification of Inline Booster Pump and Distribution Pump

The team explained that the specification of Inline Booster Pumps was designed by consideration of designed intake flow and twenty-hour operation in a day. The team also explained that the specification of the Distribution Pumps was designed to distribute the whole of water volume from the Chenab well field by the pumps.

5-7) Design of Terminal Reservoir Pump Station

The Pakistani side had originally requested the rehabilitation of existing pump station to replace the distribution pumps. The team explained that a new pump station would be constructed near the entrance of the compound of Terminal Reservoir Pump station instead of rehabilitation of the existing pump station because of construction safety and minimum water supply outage.

5-8) Possibility of procurement from the third countries

The Pakistani side agreed that there would be a possibility of procurement from other than Japan or Pakistan due to such reasons as availability of products, easiness and cost in both countries, and others. The Team explained that it is clearly mentioned in the relevant paragraph of Grant Agreement which would be signed by both sides after an approval of the Project by the Japanese government as quoted below and also in the item 3. Japan's Grant Aid Scheme (3) of Appendix 5 of this Minutes of Discussions.

Grant Agreement

Article 3 Use of the Grant

(1) The Grant shall be used by the Government of the Islamic Republic of Pakistan properly and exclusively for the purchase of such products of Japan or the Islamic Republic of Pakistan and such services of Japanese or Pakistani nationals necessary for the implementation of the Project as listed below (The term "nationals" whenever used in the

G/A means Japanese physical persons or Japanese juridical persons controlled by Japanese physical persons in the case of Japanese nationals and Pakistani physical or juridical persons controlled by Pakistani physical persons in the case of Pakistani nationals.):

(a)equipment and services necessary for the procurement and the installation thereof;

(b)services necessary for the transportation of the products referred to in (a) above to ports in the Islamic Republic of Pakistan and those for internal transportation therein; and

(c)services necessary for the training in operating the equipment referred to in (a) above and the guidance in managing the equipment referred to in (a) above .

(2) Notwithstanding the provisions of sub-paragraph (1) above, when JICA and the Authority deem it necessary, the Grant may be used for the purchase of the products of the kind referred to in (a) of sub-paragraph (1) above, which are products of countries other than Japan or the Islamic Republic of Pakistan and the services of the kind referred to in (a),(b) and (c) of sub-paragraph (1) above, which are services of nationals of countries other than Japan or the Islamic Republic of Pakistan.

5-9) Distribution pump operation for water pressure control in the distribution network

The Pakistani side understood that increase of capacity of distribution pumps would improve distribution amount and pressure during peak time in a day. On the other hand, the distribution network facilities had been updated partially under the French project for leakage reduction and control and would need to be improved so that Faisalabad WASA could distribute more water with higher pressure. The Team explained that Faisalabad WASA needed to execute a water pressure management plan to operate the pumps appropriately in order to avoid an increase of water leakage and burst of distribution pipes based on the Technical assistance ("Soft Component") of the Project. Both sides agreed with it.

5-10) Asset management in the distribution network

As discussed above, Faisalabad WASA explained to execute asset management and proper investment in the distribution network to reduce leakage and distribute more water with higher pressure in order to improve water supply service quality so that the revenue with water supply would rise.

5-11) Management improvement

The Team mentioned referring THE PUNJAB DRINKING WATER POLICY that the government of Punjab was conducting Institutional Reform Program in the Urban Water Service Providing Government Agencies in order to not only improve service delivery but also address allied issues such as introduction of metered rate system, rationalization of tariff, improvement of tariff collection rate, improvement in management of organization and introduction of performance monitoring systems so as to ensure that the WASAs are transformed into a progressive; accountable and financially viable institution by the year 2016.

The Team pointed out that the operational loss had recently been increasing as the total operational expenditure had grown as shown in Annex-4. The Team explained that the Project would contribute to cost reduction by a technical approach for reduction of energy consumption

by replacement of pumps, but it was still necessary for Faisalabad WASA to make efforts to reduce operational expenditure and for the Government of Punjab to rationalize water tariff or continue to provide subsidy to improve the financial status.

Annex-1	Project Sites map
Annex-2	Components of the Project and designed pump operation hours
Annex-3	Project cost to be borne by each government
Annex-4	Financial status of Faisalabad WASA
Annex-5	Japan's Grant Aid Scheme

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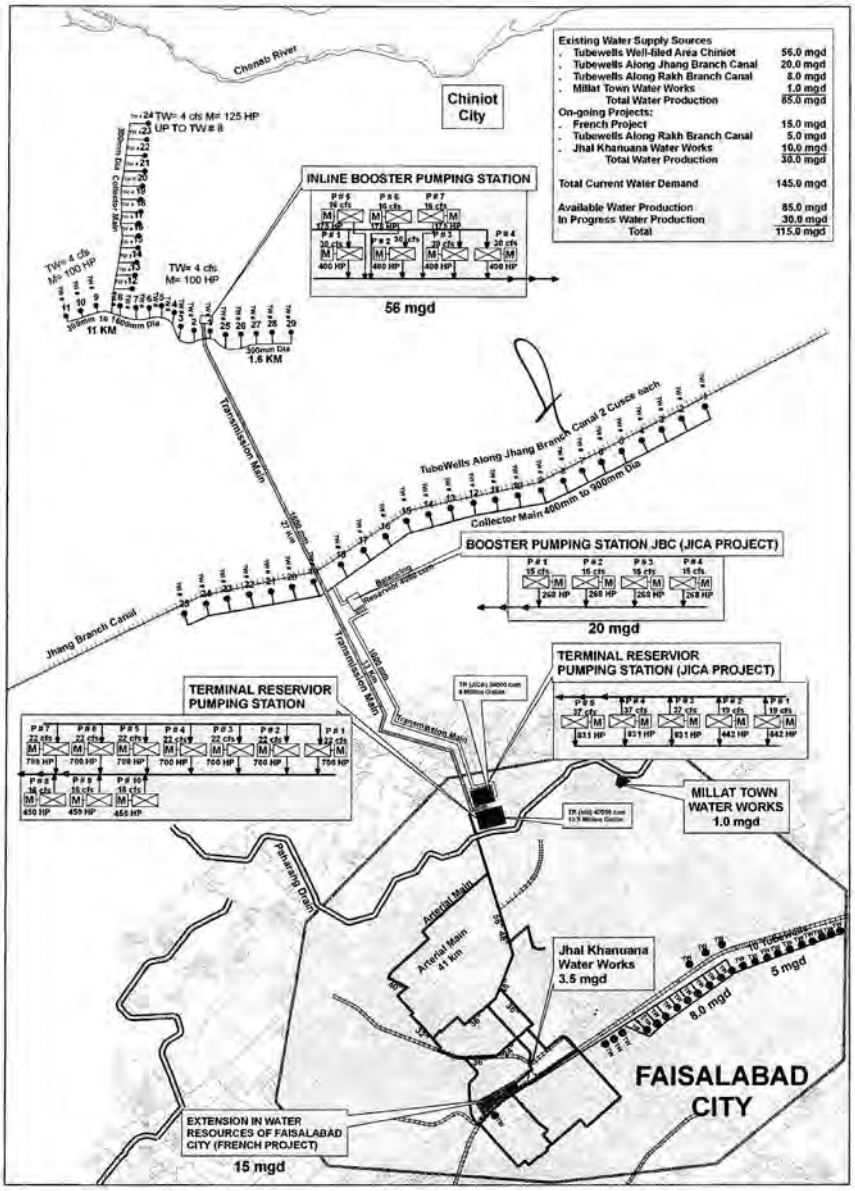
Annex- 1

PROJECT SITES MAP



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Annex- 2

COMPONENTS OF THE PROJECT AND DESIGNED PUMP OPERATION HOURS

1. COMPONENTS OF THE PROJECT

(i) Project Site

Within the service area for Faisalabad WASA, in Faisalabad, Punjab

(ii) Civil/Mechanical works

Water Facilities, Equipment:

Inline Booster Pump station:

Booster Pumps (48.8 m3/min ×4 nos., 24.4 m3/min ×2 nos.)

Miscellaneous Works:

Yard Piping, Transformer, Panels, Flow meter, and Hoist crane, etc.

Terminal Reservoir Pump station:

Distribution Pumps (63.0 m3/min ×4 nos., 31.5 m3/min ×2 nos.)

Pump station (included the pump room and electrical room)

Miscellaneous Works:

Yard Piping, Transformer, Panels, Flow meter, Hoist crane, and Rehabilitation of Reservoir leakage, etc.

(iii) Consulting Services

- Detailed design
- Assistance for tendering
- Construction supervision
- Technical assistance (soft component)

2. DESIGNED PUMPING OPERATION HOURS FOR THE TERMINAL RESERVOIRS

Chenab water supply system: 6 hours per day

Jhang Branch Canal water supply system: 9 hours per day

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This page is closed due to the confidentially.

Annex- 3

Confidential

PROJECT COST TO BE BORNE BY EACH GOVERNMENT

1. Project Cost by the Japanese Grant Aid
   Total Project Cost to be borne by Japan Grant Aid: Approximately [redacted]
   - Constructions and Procurement of equipment [redacted]
   - Soft Component [redacted]
   - Detailed Design and Construction Supervision [redacted]

2. Project Cost by the Pakistani Government
   Total Project Cost to be borne by the Pakistani Government: Approximately JPY12.0 Million.
   (equivalent to approx. PKR 10.6 Million).
   - Banking arrangement
   - Relocating the incoming panel at Terminal Reservoir
   - Public awareness campaign for water conservation

(Applied conversion rate: PKR 1 = JPY 1.13)

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Annex- 4

FINANCIAL STATUS OF FAISALABAD WASA

Million Rs.

	2011-2012	2012-2013	2013-2014 (Plan)
1. Income			
Water and sewerage charges	431	543	630
UIP Tax	140	224	300
Subsidy from the Punjab government	179	262	262
Subsidy from World Bank	–	–	292
Other revenue	83	70	83
Total	833	1099	1567
2.Expenditure			
Personnel cost	420	543	587
Electricity charge	319	470	510
Operation and maintenance expense	170	190	220
Total	909	1203	1317
Balance	-76	-104	250

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Annex- 5

JAPAN'S GRANT AID SCHEME

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as part of this realignment, JICA was re-organized on October 1, 2008. After the re-organization of JICA, following the decision of the GOJ, Grant Aid for General Project is extended by JICA.

Grant Aid is non-reimbursable fund to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures (Attachment 1)

Japanese Grant Aid is conducted as follows:

- Preparatory Survey (hereinafter referred to as "the Survey")
  - The Survey conducted by JICA
- Appraisal & Approval
  - -Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet
- Determination of Implementation
  - -The Notes exchanged between the GOJ and a recipient country
- Grant Agreement (hereinafter referred to as "the G/A")
  - -Agreement concluded between JICA and a recipient country
- Implementation
  - -Implementation of the Project on the basis of the G/A

2. Preparatory Survey

(1) Contents of the Survey

The aim of the Survey is to provide a basic document necessary for the appraisal of the Project by JICA and the GOJ. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of agencies concerned of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed on by both parties concerning the basic concept of the Project.
- Preparation of an outline design of the Project.
- Estimation of costs of the Project.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Outline Design of the Project is confirmed considering the guidelines of the Japan's Grant Aid scheme.

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JICA requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA uses (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

The Report on the Survey is reviewed by JICA, and after the appropriateness of the Project is confirmed, JICA recommends the GOJ to appraise the implementation of the Project.

3. Japan's Grant Aid Scheme

(1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the E/N will be singed between the GOJ and the Government of the recipient country to make a plead for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

The consultant firm(s) used for the Survey will be recommended by JICA to the recipient country to also work on the Project's implementation after the E/N and the G/A, in order to maintain technical consistency.

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality.)

(4) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as Attachment 2

(6) Proper Use

The Government of recipient country is required to maintain and use the facilities

constructed and the equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

(7) Export and Re-export

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

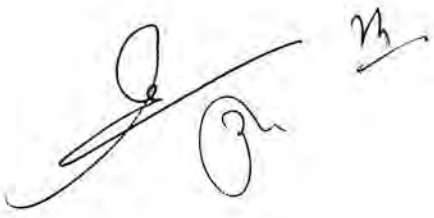
b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions to the Bank.

(10) Social and Environmental Considerations

A recipient country must ensure the social and environmental considerations for the Project and must follow the environmental regulation of the recipient country and JICA socio-environmental guideline.



Appendix 5

Soft Component
(Technical Assistance) Plan

5. Soft Component (Technical Assistance) Plan

5-1 Background of the Soft Component (Technical Assistance)

This Project aims to reduce the cost of distribution of water through stabilizing operation of the facility and promoting the efficiency of energy consumption by the replacement of the pumps at the Inline Booster Pump Station and T/R where originated from Chenab well field in Faisalabad City, the third largest city of Pakistan. The scope of the Project consists of the replacement of the pump facilities at Chenab Inline Booster Pump Station, replacement of the pump facilities and corresponding construction of the pump station at T/R and repair of water leakage at T/R tank.

(1) Current Situation

Chenab water supply facilities targeted in the Project pump up the water from Chenab well field to T/R through the Inline Booster Pump Station, and then distribute the water to the city from T/R. In addition to the Chenab water facilities, T/R and pump facilities of JBC water facilities are located in the same compound of T/R. In the future, water originated from both Chenab system and JBC system plans to be distributed to the city from the T/R Pump Station in two distribution pipes upon completion of the ongoing project financed by the government of France in contrast to the current single distribution pipe.

Now some of the pumps installed at Inline Booster Pump Station and T/R Pump Station are suspended due to breakdown as they were installed more than 20 years ago and are overdue for replacement. The booster pumps at the Inline Booster Pump Station do not meet the needs for entire available water intake in Chenab well field due to a decrease in pump efficiency and stabilization of supply is deteriorated at T/R Pump Station due to the high frequency of breakdowns of distribution pumps. Some of the pumps are no longer operational due to cavitation caused by the improper location of distribution pumps at the T/R Pump Station, and therefore do not meet the demand for water supply at peak times during the day.

(2) Necessity of Soft Component

The Project will enable the entire available water intake from Chenab source system to be distributed to the city by distribution pump and accordingly water supply environment would be improved. In this case, the amount of pump distribution and number of operating pumps per hour are different from the current operating situation, so that the trial and initial operation after installation will be trained to FWASA members in order to operate and maintain pumps based on the amount of water distribution and number of operating pumps per hour. Although water is distributed to the city after depressurizing it up to around 20 m against the pump head of 45 m in order to reduce water leakage when distributing pump water, it is necessary to appropriately change control of depressurization by valves because the volume of water distribution in the city increases owing to the Project. The current volume of water which is distributed through only Chenab distribution pipes would be divided into the current distribution pipe and the other pipe financed by

the government of France. For the reasons above, the current volume of water flowing through distributing pipes would be changed, the control of pressure is necessary based on volume of water distribution. Even though currently the respective pumps at the T/R Pump Station of Chenab and JBC are operating, technical level is not sufficient enough in order to practice parallel operation with pressure of control of water distribution and control pressures of water distribution owing to converting to the dual system.

It is essential to assist in launching the facility smoothly through the training of parallel operation of Chenab and JBC water supply facilities and dual systematization of main distributing pipe and control of pressure of water distribution as well as the training of the said initial operation in order to distribute water to the city with proper water pressure. Thus, “improvement of operation skill in reduction of water pressure on secondary side after distribution water” as a soft component, will be conducted by the Project.

5-2 Purpose of Soft Component

It would be feasible to distribute water to the city with the management of the water pressure through continuous activities practiced by the implementing agency after completion of the Project. Therefore, “Assistance in controlling of water pressure in accordance with the volume of water distribution" will be set as objective of the soft component.

5-3 Outputs of Soft Component

The outcome of soft components is “Skill to manage the appropriate reduction of water pressure in secondary side after distributing water is acquired”

5-4 Means of Output Verification

Indicators and means to verify the said achievement of outcomes are as follows.

Table 1: Means of Output Verification

Outputs	Objectively verifiable indicator	Means of verification
Reduction of water pressure is appropriately practiced in secondary side after distributing water	To understand the relationship between volume of water distribution and water pressure	Comprehension test
	To operate valves for depressurizing in line with the volume of water distribution	Measure for volume of water distribution and water pressure

5-5 Activity of Soft Component (Input Plan)

(1) Besic concept

The person in charge of soft components will implement the soft component to control the water pressure in conjunction with the operation of the JBC distribution pump, and confirm the achievement of outcomes about soft components and submit the completion report of the soft component to Pakistan responsible authorities, implementing agencies and authorities of Japan.

(2) Summary

The practical training of valve operation and valve regulation in line with the volume of water distribution will be implemented through on-the-job training as soft component. The following table shows input plan and activities.

Table 2: Activities of Soft Component

Output: Reduction of water pressure is appropriately practiced in secondary side after distributing water		
Implementation year: the final year of the Project		
Required skill and field of expertise from Japanese side		Water distribution planning, Experience of management on water pressure
Current technical level and required technical level from the Pakistan side		Water is distributed to the city with regulation of valves fixed at present. The required technical level is operating experience of valve and knowledge of the relationship between opening/closing of valves and water pressure.
Trainee		Operation department (valve operation planning(1 P), valve operation (2P))
Method of implementation		On-the-job training
Activities	Preparation of documents	Drawing up plans of soft components ・Explaining soft components to FWASA ・Verifying existing facilities, review of the operating manual of the JBC-based distribution pump ・Drawing up plans and approved by FWASA Drawing up questionnaires and comprehension tests
	Introduction	Lecture on theory for water distribution plans, management of water pressure ・Explaining facility outline, facility capacity ・Explaining water distributing plans of facilities (Chenab, JBC) ・Explaining water volume and water pressure on water distribution plan ・Explaining way to reduce water pressure, according to water volume Clarifying roles and areas of responsibility of person in charge Conducting questionnaires and comprehension tests
	Planning and drawing up way of water pressure management	Planning of valve operation instruction (valve operation planning) ・Confirming condition of the existing valves ・Developing plan of valve operation ・Drawing up operation instruction Planning and drawing up records of valve operation
	Guidance for valve operation	Practical guidance on valve operation (mainly valve operation) ・Regulating of valves in line with volume of water distribution ・Managing water pressure associated with valve operation ・Completing records of valve operation
	Do・monitoring	Operating by the FWASA staff ・Regulating of valves in line with volume of water distribution ・Managing water pressure associated with valve operation ・Completing records of valve operation Drawing up valve operation instruction
	Verification of outcome and recommendation to implementation agency	Reviewing the records of valve operation Confirming through valve operation Conducting comprehension tests Recommending to implementing agencies
Implementation resource	Person in charge	Japanese consultant (1P)
	Period	Local: 1.00 M/M

Type of Outcome	Valve operation guidance, result of questionnaires to the staff of implementing agencies, final report (completion report of the soft component in English), completion report of the soft component in Japanese, documents to verify implementation of activities (inclusive of local photos)

5-6 Procurement Methods of Implementation Resources of Soft Component

To manage the pressure of water distribution appropriately by controlling valves in line with the volume of water distribution is required in order to implement water distribution in accordance with the plan into the future. Since valve control to manage the pressure of water distribution in accordance with the existing facilities, and determination of the pressure of water distribution in accordance with condition of facilities and volume of water distribution requires the advanced knowledge and skill, the Japanese consultant will be assigned to the soft component. Duty, position and expertise for each staff under the FWASA operation system are clarified so that the person in charge of the soft component of FWASA shall be assigned individually. A Japanese consultant is assigned as a person in charge of water pressure reduction.

5-7 Implementation Schedule of Soft Component

Soft components are implemented upon a trial operation of the pump facilities after completion of the construction. Outline of the implementation process is as follows.

Table 3: Implementation Schedule of Soft Component

Outcome		Contents	Activities	M / D	1 (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30)	Remarks
Outcome 1	Technology on reduction of water pressure after distribution		Local business		Departure … Return	
		preparaqtion of documents	・Creating a software component plan	1		
			・Creating questionnaire, of comprehension test	1		
		Introduction	・Conducting questionnaires and comprehension tests	2		
			・Lecture of theory for water distribution plans, management of water pressure	2		
		Planning water pressure management	・Creating records of valve operation and valve operation instruction	10		
		Guidance of valve operation	・The guidance by practice in accordance with the valve operation	5		
		Implementation・monitoring	・The operation with FWASA staff	5		
		Verification of outcome and recommendation to implementation agency	・Reviews of valve operation records	1		
			・Confirmation by the implementation of valve operation	2		
			・Reporting, proposals to FWASA	2		

5-8 Output Materials of Soft Component

Output of soft component is as follows.

Table 4: Output Materials of Soft Component (Draft)

Item	Submission to	Remarks
Final report (completion report of soft component in English)	Client, JICA	
Completion report of soft component in Japanese	JICA	
Documents to verify implementation of activities (inclusive of local photos)	JICA	
Result of questionnaires to office staff of implementing agencies	JICA	
Valve operation guidance	Client, JICA	Refer to attached sheets

The guidebook for managing water pressure is an effective document to enable the acquisition of basic skills and knowledge in the soft component. They are to be compiled in Urdu as well as in English to be used for soft components.

5-9 Responsibilities of the Implementing Organization of the Pakistani Side

The following activities are needed to be continuously implemented by Pakistani Side in order to achieve the goal of the soft component.

- To secure personnel and training facilities required for soft component
- To keep the staff trained in the soft components employed at the same facility in the long term
- To comply with way to reduce water pressure in line with valve operation guidance

Annex 1

Valve Operation Manual (Draft)

The plan of valve operation manual includes the following items.

Table 5: Valve Operation Manual (Draft)

Item	Contents
Measures for valve operation management	• Appointed valve operation planning, valve operation • Responsibility of the person in charge • Supervision, operation, guidance and reporting of the entire valve operation • Operation of the valve, industrial accident prevention, guidance and training of workers • Preparation of valve operation records
Plan of valve operation	• Short-term fluctuation of water demand, method of operation for water pressure management and valve operation associated with the seasonal variation
Implementation of valve operation management	• Confirmation of valve operation（Operation date, Valve No, Distribution volume, Water pressure, etc.）
Emergency measures	• Contact system. Response to factors
Preparation of documents, account books	• Completing records of valve operation

Appendix 6

References

6. References

No	Title	Type Book/Video/Photo/Etc	Original/Copy	Issuing Institution	Year
1	Presentation on WASA(FDA) Faisalabad	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
2	Presentation on Project for Extension of Water Resources for Faisalabad City Phase-I (French Funded Project)	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013. 1
3	Presentation on Project for Extension of Water Resources for Faisalabad City Phase-I (French Funded Project)	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013. 7
4	Arterial Main Additional Calculation Note	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
5	Extension of Water Resources for Faisalabad City Phase-I, Modified PC-I	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2009
6	Plan of Arterial Main	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
7	Pakistan Economic Survey 2012-13	Book	Copy	Ministry of Finance	2013
8	Faisalabad Environmental Infrastructure Master Plan Study Final Report	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	1993
9	Contract 12W-A, Chlorination Facilities	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2011
10	Contract 12W-B, Inline Booster Pump Station	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2011
11	Contract 16W, Terminal Reservoir Pump Station	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2011
12	Electric Bill for JBC Booster Pump Station and TW	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
13	Electric Bill for ADB Booster Pump Station and TW	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
14	Electric Bill for TR (ADB and JBC)	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
15	Executive Summary of Annual Plan_2012-2013	Book	Copy	Government of Pakistan	2012
16	Punjab Drinking Water Policy	Book	Copy	Government of Punjab	2010
17	Monthly Progress Report	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
18	Summary of Development Budget	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
19	Water Supply Sources, Current and Proposed	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
20	Connection Details Domestic, Commercial and Industrial	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013

No	Title	Type Book/Video/Photo/Etc	Original/Copy	Issuing Institution	Year
21	Tariff for Water supply	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
22	Non Development Budget	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
23	Operational Receipts	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
24	Abstract of Posts Budget	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
25	Budget Targets and Operating Expenditures	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
26	Concept Clearance Paper for the project	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
27	Proposed Tariff	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
28	Summary of Non Development Budget	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
29	Pump Operation Record of Chenab TW	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2012
30	Pump Operation Record of Chenab Inline Booster Pump Station	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
31	Pump Operation Record of JBC Inline Booster Pump Station	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
32	Pump Operation Record of Terminal Reservoir	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
33	Location Map of Collector Main	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
34	Location Map of Transmmission Main	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013
35	Building Code of Pakistan Seismic Provision - 2007	Book	Copy	Water and Sanitation Agency, FDA, Faisalabad	2013

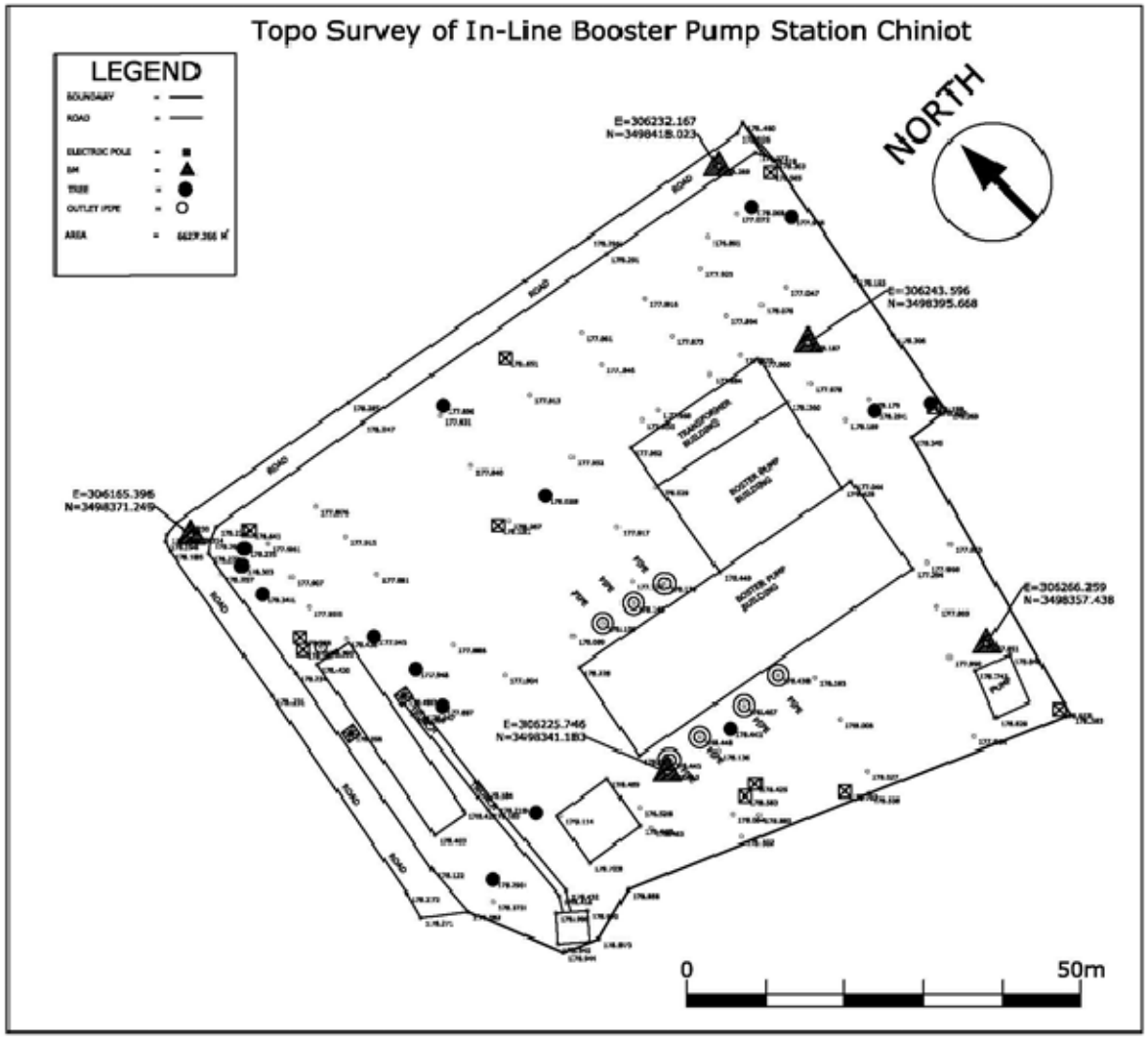
Appendix 7

Other Relevant Data

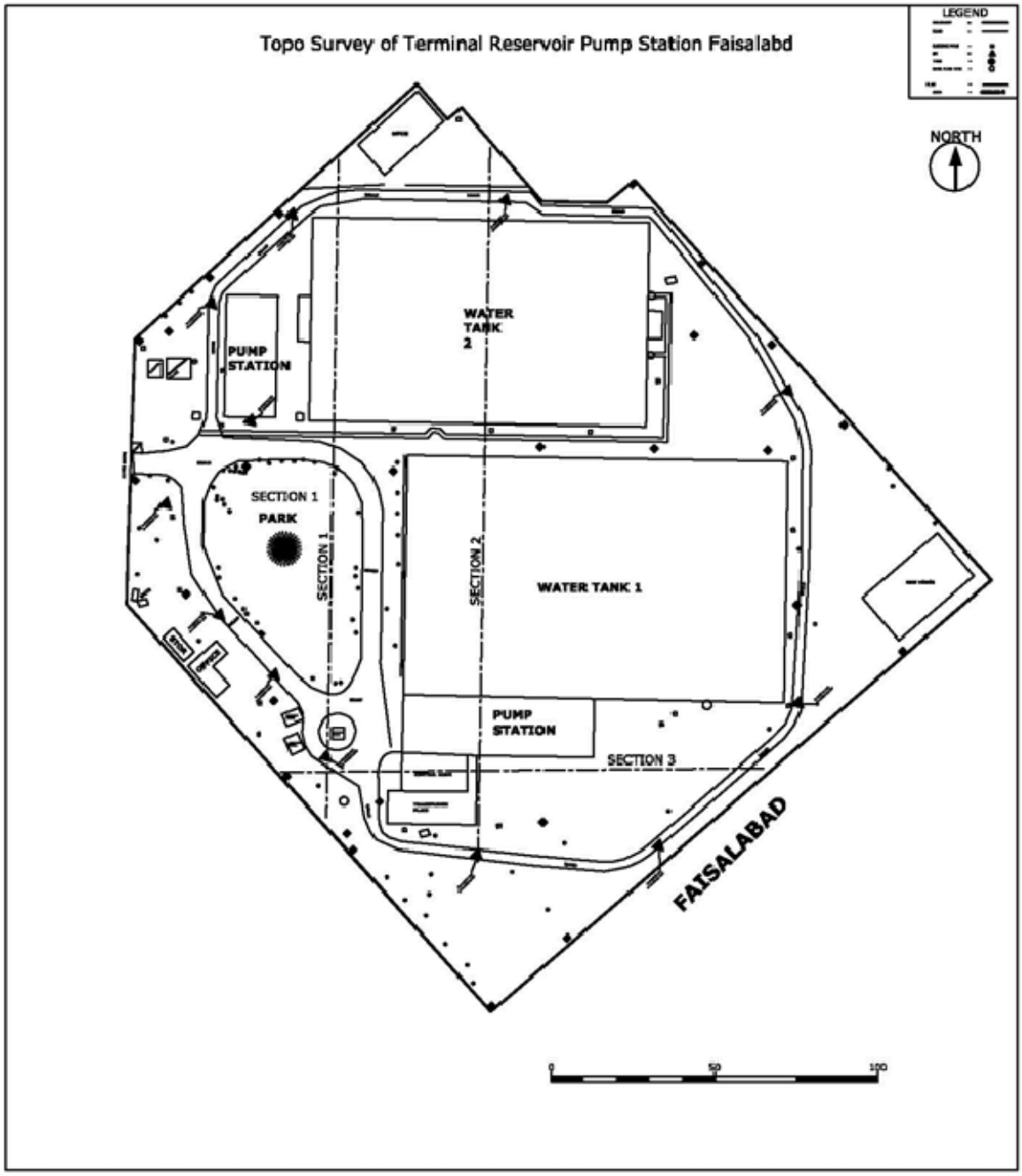
7. Other Relevant Data

(1) Topographic Survey Result

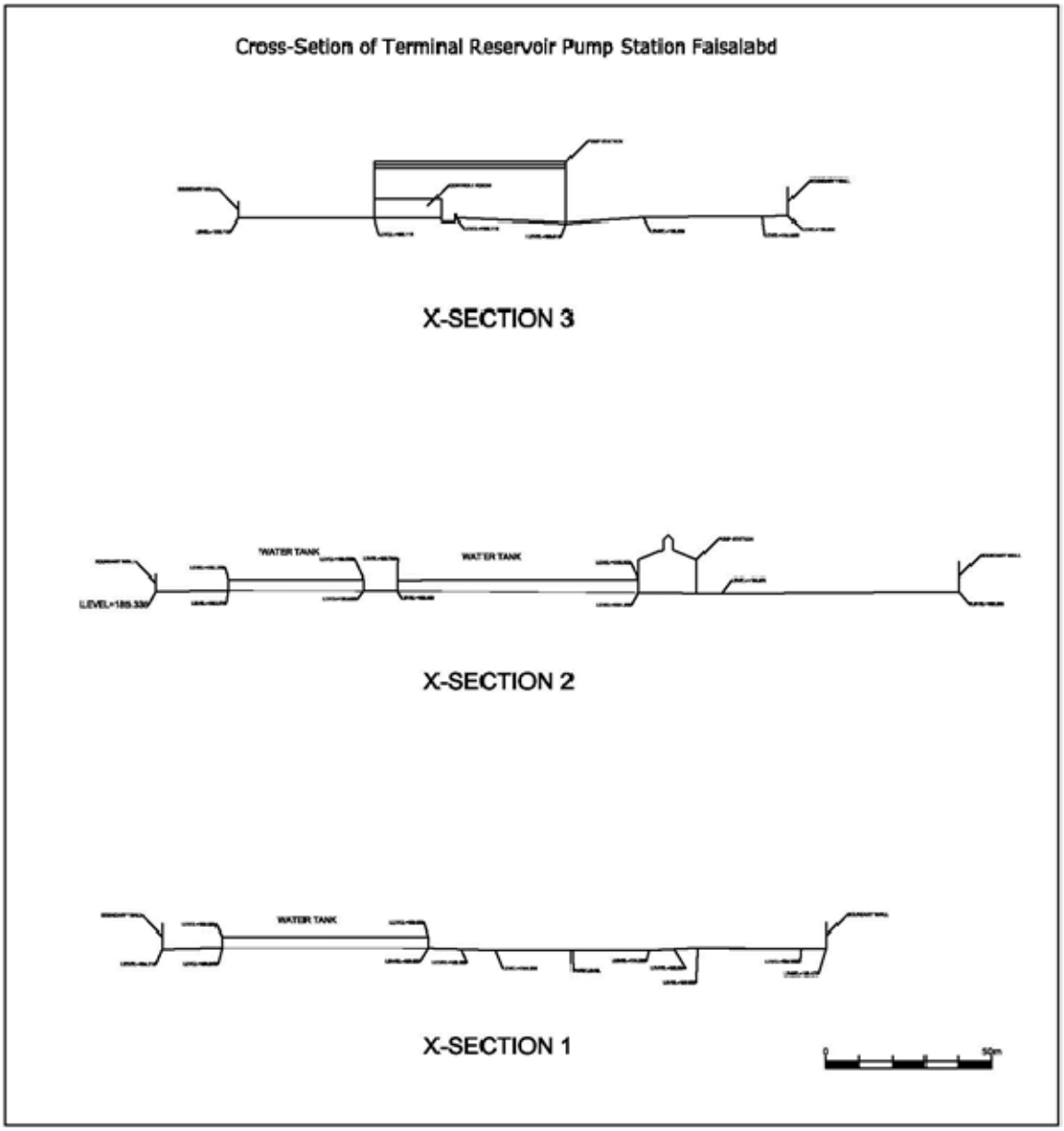
1) Plan View : Chenab Inline Booster Pump Station



2) Plan View : Terminal Reservoir



3) Lateral Profile : Terminal Reservoir



(2) Geographic Survey Result

SUBSURFACE EXPLORATION SURVEY REPORT

FOR

THE OUTLINE DESIGN STUDY ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR IN FAISALABAD IN THE ISLAMIC REPUBLIC OF PAKISTAN

Consultant

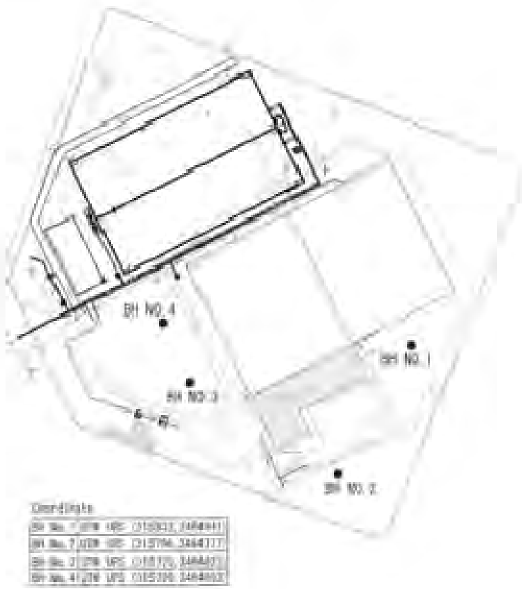
M/s Kokusai Kogyo Co., Ltd.
Tokyo Japan

SEPTEMBER 2013

NOON GEO TECH
Soil & Foundation Engineers
[illegible]-A, Public Health Engineering Society, LDA Avenue-I, Raiwind Road Lahore
Tel: (042) 35029651, 0300-4237551, e-mail: noongeotech@hotmail.com

Table of Contents

LOCATION OF BOREHOLE POINTS



SUBSURFACE EXPLORATION SURVEY

FOR

THE OUTLINE DESIGN STUDY ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL RESERVOIR IN FAISALABAD IN THE ISLAMIC REPUBLIC OF PAKISTAN

A. INTRODUCTION

M/s Kokusai Kogyo Co., Ltd., Tokyo, Japan have desired a design study on the project for *Replacement of Pumping Machinery at Inline Booster Pumping Station & Terminal Reservoir in Faisalabad in the Islamic Republic of Pakistan*, to improve the facility of drinking water for the inhabitants of Faisalabad City. The site is located at Chak 7 in Faisalabad city.

Therefore, the services of ***M/s Noon Geo Tech***, Lahore had been hired for the performance of in-situ test i.e. Standard Penetration Test for N-Value. The field work was carried out during the month of September 2013.

B. SITE VISIT

The site was visited on 06.09.2013. The locations for test were marked by the consultant's representative Mr. Daisuke Sakamoto Professional Engineer, in

the presence of M/s Kenji Shinoda Civil Engineer and Takeshi Abe Civil Engineer from M/s Kokusai Kogyo Co., Ltd., Tokyo, Japan.

Engr. Muhammad Adnan, Assistant Director WASA and representative of M/s Noon Geo Tech were also present during site visit and it was decided that the site would be explored on 07.09.2013 and 08.09.2013.

C. SCHEDULE OF FIELD WORK

Two boring points for SPT (Point No.1 & 2) were drilled on 07.09.2013 and the other two boring points were explored on the next day i.e. 08.09.2013.

D. SCOPE OF WORK

As per TOR for Subsurface Exploration Survey at site, following scope of work was given by the Consultant:

1. Execution of four (4) boreholes up to maximum depth of 10-meter depth in overburden soil by hand auger drilling method including backfilling of boreholes to their original position.
2. To perform SPT's at 1-meter interval up to the drilled depth.
3. To perform density test.
4. To log soil strata of boreholes as per ASTM D-2488.
5. To locate water table.
6. Preparation of Final Report.

E. FIELD INVESTIGATIONS

The field investigation was carried out on 07.09.2013 and 08.09.2013 under the supervision of Mr. Takeshi Abe Civil Engineer on both days.

E-1 DRILLING

As per recommended practice of ASTM D-420, the site was explored with percussion method. The holes were advanced by chopping the subsoil and then cleaning it by bailing out the soil with the bailer attached with the percussion string.

F. STANDARD PENETRATION TEST

F-1 METHODOLOGY

Standard Penetration Tests (SPTs) were performed in the boreholes in accordance with ASTM D1586.

The exploratory borings were drilled using hand auger drilling method.

F-2 OBJECTIVE

The objective of this test is to ascertain the resistance afforded to the penetration apparatus in order to obtain an estimate of the in-situ properties. The test gives valuable information about the degree of compactness of the soil. As per TOR, this test was performed up to maximum 10-meter depth at

an interval of 1-meter. The N-values of strata are given below as well as on logs (Annexure-1).

BORE HOLE – 1

Depth (*meter*)	SPT N-Value	Compactness	Consistency
1	4+5+5=10	-	Stiff
2	2+3+3=8	-	Firm
3	3+4+5=9	-	Stiff
4	3+4+6=10	-	Stiff
5	7+9+10=19	Medium Dense	-
6	7+8+10=18	Medium Dense	-
7	8+9+11=20	Medium Dense	-
8	9+9+10=19	Medium Dense	-
9	8+11+12=23	Medium Dense	-
10	5+11+13=24	Medium Dense	-

BORE HOLE – 2

Depth (*meter*)	SPT N-Value	Compactness	Consistency
1	3+4+5=9	-	Stiff
2	3+3+5=8	-	Stiff
3	3+4+6=10	-	Stiff
4	3+4+5=9	-	Stiff
5	5+7+8=15	-	Stiff
6	4+5+7=12	-	Stiff
7	7+8+10=19	Medium Dense	-
8	6+7+9=16	Medium Dense	-
9	6+8+10=18	Medium Dense	-
10	8+10+12=22	Medium Dense	-

BORE HOLE – 3

Depth (*meter*)	SPT N-Value	Compactness	Consistency
1	2+3+3=6	-	Firm
2	4+5+6=11	-	Stiff
3	3+5+6=11	-	Stiff
4	3+5+7=12	-	Stiff
5	7+10+11=21	Medium Dense	-
6	7+9+11=20	Medium Dense	-
7	6+10+11=21	Medium Dense	-
8	9+11+12=23	Medium Dense	-
9	10+12+13=25	Medium Dense	-
10	10+11+13=24	Medium Dense	-

BORE HOLE – 4

Depth (*meter*)	SPT N-Value	Compactness	Consistency
1	3+4+5=9	-	Stiff
2	3+5+6=11	-	Stiff
3	4+5+6=11	Medium Dense	-
4	5+7+7=14	Medium Dense	-
5	5+8+9=17	Medium Dense	-
6	6+10+11=21	Medium Dense	-
7	7+9+11=20	Medium Dense	-
8	8+11+12=23	Medium Dense	-
9	9+11+13=24	Medium Dense	-
10	10+11+13=24	Medium Dense	-

G. BULK DENSITY, FIELD M.C. %AGE

The samples collected from boreholes have been subjected for determination of their bulk density and field moisture content. The values are given below:

Sr. No.	Bore Hole No.	Depth (meter)	Bulk density (g/cc)	Moisture Content (%)
1	1	5.5	1.534	1.87
2	2	5.5	1.957	8.32
3	3	4.5	1.611	2.14
4	3	5.5	1.525	2.03
5	4	5.5	1.593	1.94

H. WATER TABLE

The water table at proposed site was not encountered up to drilled depth from the existing ground level during September 2013.

I. BEARING CAPACITY ANALYSIS

The consultant has desired to calculate allowable bearing capacity at 5-meter depth. Taking into consideration the width/depth (B/D) ratio, it is assumed that the foundation will be moderately deep where strip or column footing may become uneconomical for load spreading. Further it has been desired to calculate footing on the basis of N-Value. The formula taken from "Bowl" Book "Foundation Analysis & Design" (5th Edition) for 25mm, 40mm, 50mm & 60mm settlement. The following relation has been adopted to calculate allowable load for Raft footing.

q_a = $N_{cr}/0.08\ (\Delta H_a/25)\ kd$ (kpa)

Where

q_a = Allowable bearing load (kN/m²) TSF

N_{cr} = Corrected average SPT N-value = 13

ΔH_a = Desired settlement

kd = $1 + 0.33\ D/B \leq 1.33$

D = Depth of footing = 5m = 16.4 feet from EGL

B = Width of footing

= 20 feet (minimum dimension assumed)

Rw = Water table correction = Rw'

Depth of footing (D)	Corrected average N-value	kd	Allowable load at (q_a) Settlement (TSF)			
			25mm	40mm	50mm	60mm
5 meter (16.4-ft) below from EGL for BH-1, BH-3 & BH-4	14	1.4	2.28	3.64	4.56	5.47
5 meter (16.4-ft) below from EGL for BH-2	12	1.4	2.10	3.36	4.20	5.04

1 TSF = 107.2512 kN/m²

Note: ***In case water table is close or within the foundation influence zone or there is excessive seepage of water through footing, the allowable load must be considered half of the calculated.***

J. PRECAUTION

Following safety measures be taken:

1) The compaction of foundation trenches must be ensured to a minimum level of 95% modified proctor in accordance with ASTM/AASHTO Standards prior to the placement of foundation.

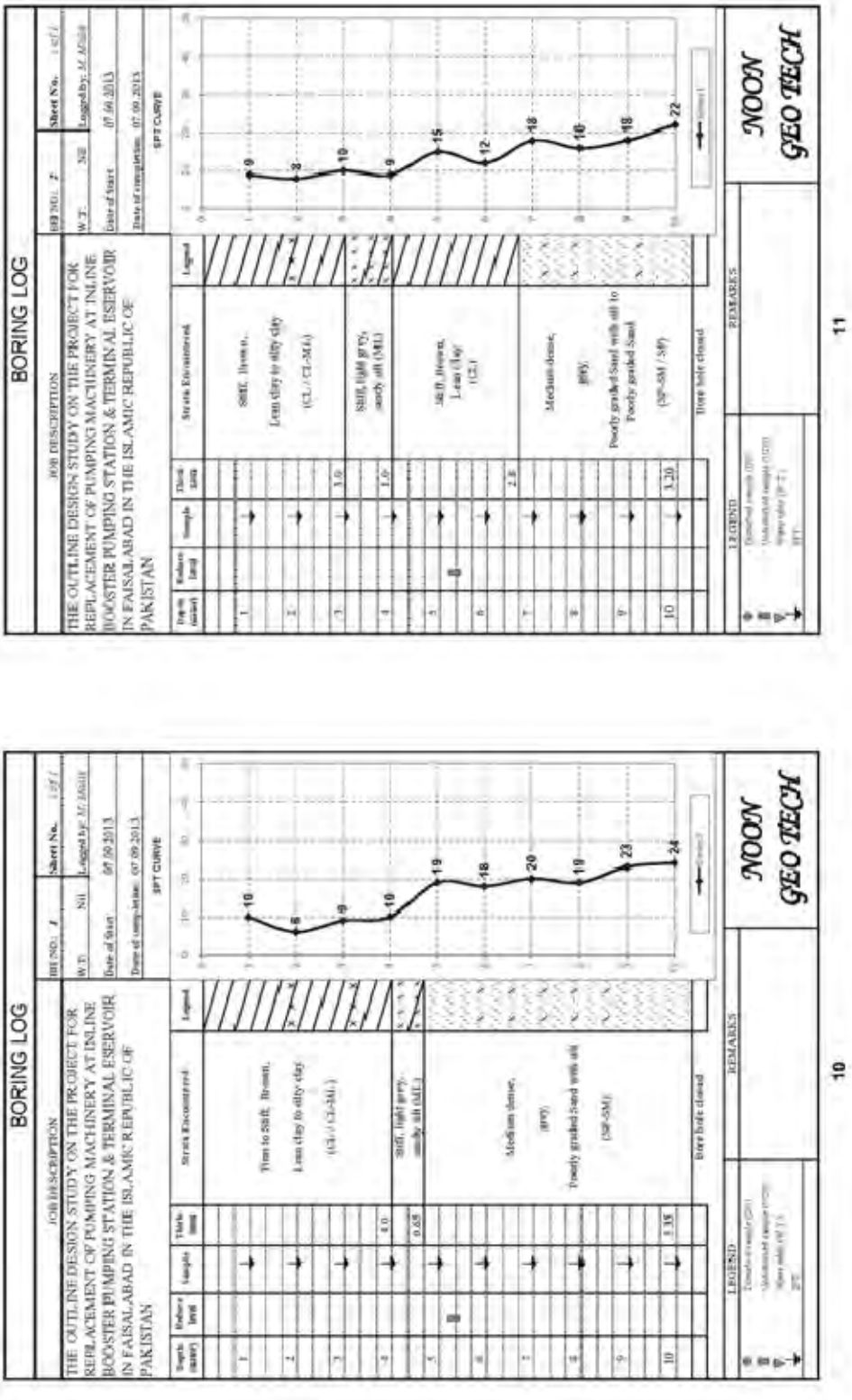
2) The area around the building should be suitably drained. Ingress of moisture from any source will be harmful to the foundation. There should be no leakage of water and sewerage lines. These lines should be sufficiently away from the foundations.

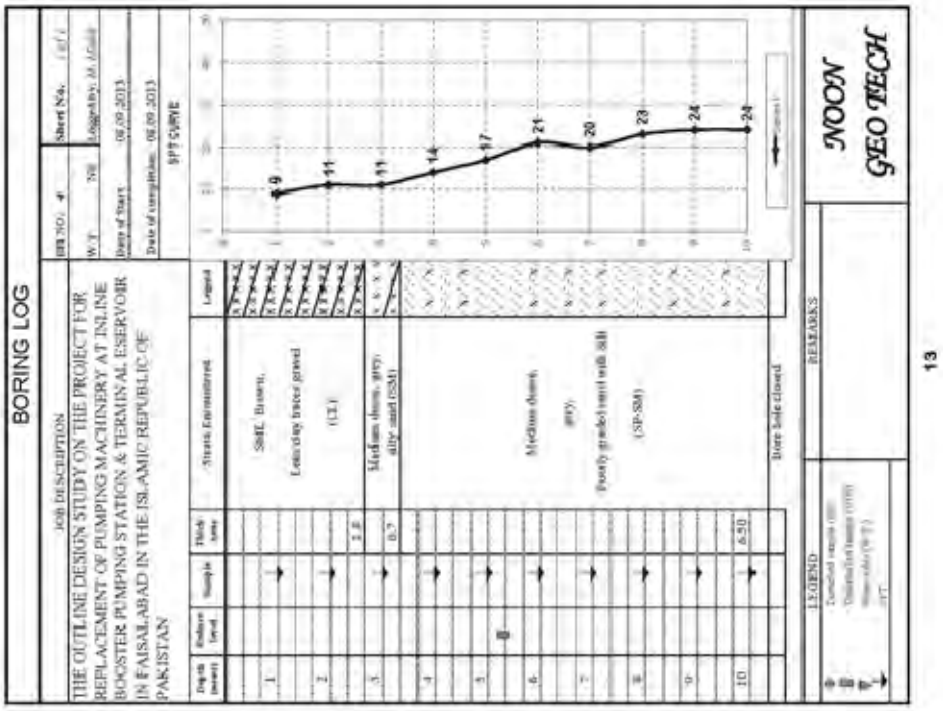
3) The foundations should not be laid on any loose pocket or filling.

DIRECTOR
4/- NOON GEO TECH

ANNEXURE-1

BORING LOGS


BORING LOG
JOB DESCRIPTION
THE OUTLINE DESIGN STUDY ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL ESERVOIR IN FAISALABAD IN THE ISLAMIC REPUBLIC OF PAKISTAN
BH NO: 1
W.T: Nil
Date of Start 07.09.2013
Date of completion 07.09.2013
Sheet No. 1 of 1
Logged by: M.Abdul
SPT CURVE
Depth (feet)
Reduce Level
Sample
Thickness
Strata Encountered
Legend
Firm to stiff, Brown, Lean clay to silty clay (CL / CL-ML)
Stiff, light grey, sandy silt (ML)
Medium dense, grey, Poorly graded Sand with silt (SP-SM)
Bore hole closed
LEGEND
REMARKS
NOOR GEO TECH
10
11


BORING LOG
JOB DESCRIPTION
THE OUTLINE DESIGN STUDY ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL ESERVOIR IN FAISALABAD IN THE ISLAMIC REPUBLIC OF PAKISTAN
SPT CURVE
Strata Encountered
Firm, Brown, Lean clay to silty clay (CL / CL-ML)
Soft, light grey, Slushy Silt (ML)
Medium dense, grey, Silty Sand to Poorly graded Sand with silt (SM / SP-SM)
Bore hole closed
LEGEND
REMARKS
NOOR GEO TECH
12
BORING LOG
JOB DESCRIPTION
THE OUTLINE DESIGN STUDY ON THE PROJECT FOR REPLACEMENT OF PUMPING MACHINERY AT INLINE BOOSTER PUMPING STATION & TERMINAL ESERVOIR IN FAISALABAD IN THE ISLAMIC REPUBLIC OF PAKISTAN
SPT CURVE
Strata Encountered
SME, Brown, Lean clay trace gravel (CL)
Medium dense, grey, silty sand (SM)
Medium dense, grey, Poorly graded sand with Silt (SP-SM)
Bore hole closed
LEGEND
REMARKS
NOOR GEO TECH
13

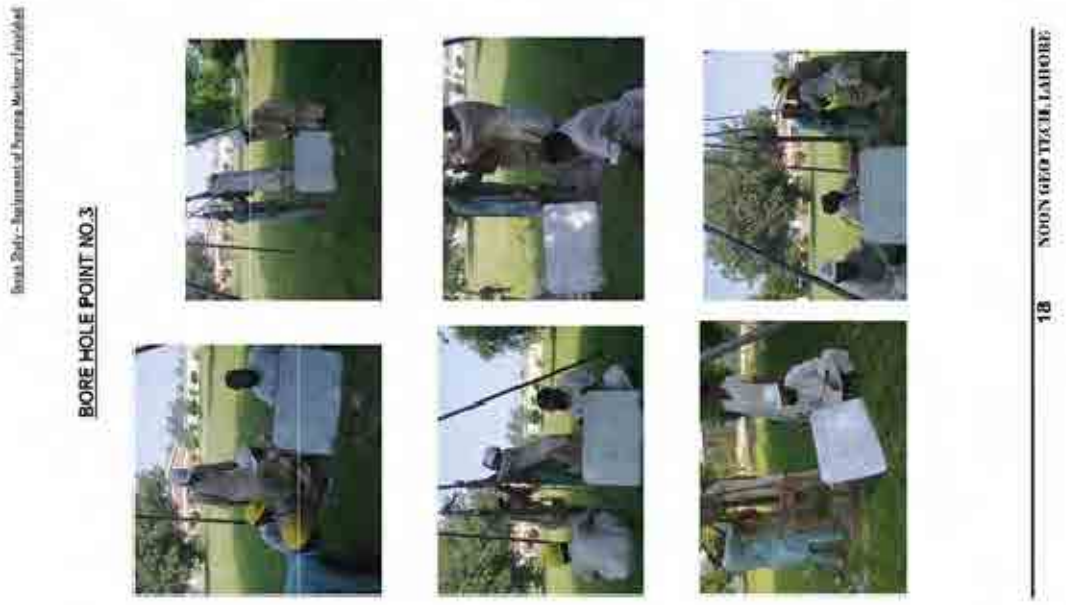
ANNEXURE-II

PICTORIAL VIEW

BORE HOLE POINT NO.1


BORE HOLE POINT NO.2
16 NOON GEO TECH. LAHORE


15 NOON GEO TECH. LAHORE


BORE HOLE POINT NO.3
18 NOON GEO TECH, LAHORE


17 NOON GEO TECH, LAHORE


BORE HOLE POINT NO.4
20 NOON GEO TECH, LAHORE


19 NOON GEO TECH, LAHORE

(3) Pumping Test Result

PUMP OUT TEST ANALYSIS REPORTFORTUBEWELLS

IN FAISALABAD WELL FIELD

1. INTRODUCTION

Pump out tests were carried out on four existing tube-wells, 2, 8, 13 and 23 of Faisalabad water supply well field. The tests are:

i) Constant discharge test for a period of 4 hours. Water levels during the test were observed in a single observation well located at a distance of 4.0 meters.
ii) After four hour pumping, recovery phase started and during this phase water levels were observed in the observation well.
iii) A step test was also carried on the same well. Duration of each step was one hour. Water levels could not be measured within the tube-well. However, water levels, during the test, were observed in the observation well.
iv) During pumping phase of all the tube well, water levels were also observed in a nearby tube-well to estimate the interference effect.

Objectives of the tests were to estimate:

- Transmissibility of the aquifer;
- Hydraulic conductivity of the aquifer material;
- Storage coefficient;
- Radius of influence.

2. PREVIOUS STUDY

During the well construction period, pump out test data of Well-2 was analyzed. Results of the analysis are given below:

i)	Well Number :	**Well-02**	**Well-13**	
ii)	Date:	Mar-10-1986	Jan-06-1986	
iii)	Depth of Well:	118.9	126.9	m
iv)	Design discharge:	408	408	m^3/hr
v)	Screen length:	49.5	49.4	m
vi)	Screen diameter:	200	200	mm
vii)	Screen material:	SS Steel	SS Steel	
viii)	Static water level:	2.54	4.93	m
ix)	Test discharge:	510	510	m^3/hr
x)	Pumping water level after two hours:	8.25	10.11	m
xi)	Drawdown after two hours:	5.71	5.18	m
xii)	Specific capacity:	89.2	98.43	$m^3/hr/m$
xiii)	Transmissibility:	14,690	17,633	m^2/day
xiv)	Hydraulic conductivity:	0.00339	0.00413	m/sec
xv)	Hydraulic conductivity:	293	357	m/day

3. TUBEWELL DATA

Detailed pump out test data for the tested wells is attached as **Appendix-A**. Salient features of the tests are given below:

i) Salient features of the constant pumping test are given in Table-1.
ii) Salient features of the step test are given in Table-2.
iii) Water level observation data for the constant discharge tests is given in Table-3.
iv) Water level observation data for step test is given in Table-4.
v) Water level observation data, during recovery phase, is given in Table-5.

4. PUMP OUT TEST ANALYSIS

The pump test data given above was analyzed by the following methods:

i) Constant discharge test (Pumping Phase): Theis curve matching method and Cooper Jacob straight line method.
ii) Constant discharge test (Recovery Phase): Straight line method.
iii) Step test (Step 1 only): Theis curve matching method and Cooper Jacob straight line method.

4.1 Theis Curve-Matching Method

Drawdown in a single full penetrating well, for steady flow in confined and unconfined aquifers that are homogeneous, isotropic and infinite in the horizontal extent, is given by the following relationship developed by Theis (1935):

Confined Case:

$(H-hw) = Q/(4\pi T)*W(u)$ (Eq.1)

Where:

$(H-h_w)$ = drawdown (s_w) in the well

Q = Discharge of well

u = $r^2S/4nTt$

T = transmissibility of the aquifer

t = time of pumping

W(u) = Theis well function and is expressed by the following series:

$W(u) = -0.5772-\ln(u)+u-u^2/(2*2!)+u^3/(3*3!)-u^4/(4*4!)$..... **(Eq.2)**

Relationship for drawdown in an observation well at a distance "r" from the pumped well is:

$s= Q/(4\pi T)*W(u)$ **(Eq.3)**

After rearranging:

$T = Q/(4\pi s)*W(u)$ **(Eq.4)**

Relationship for storage coefficient "S" is:

$S = 4Ttu/r^2$ **(Eq.5)**

Analysis of the constant pumping test data, by using Theis method, is given in Graphs 1 to 4. Similarly, analysis of the step pumping test data, by using Theis method, is given in Graphs 5 to 8.

4.2 Cooper-Jacob Straight Line Method

The value of W(u) is the sum of an infinite series. When the value of "u" is small, less than 0.01, the higher order terms of infinite series are negligible and can be ignored. With the Cooper-Jacob assumption, drawdown is:

$(H-hw)= Q/4\pi T*(-0.5772-\ln(u))$ **(Eq.6)**

$(H-hw)= Q/4\pi T * \ln(2.25Tt/r^2S)$ **(Eq.7)**

The result of this simplification is that the integral expression of the Theis equation is replaced by a much simplefunction. The other benefit of this simplification is that the plot of time on x-axis as a logarithmic scale and drawdown on the y-axis as a linear scale give straight line which is east to analyze.

For the estimation of transmissibility, the following relationship is used:

$T = 2.3Q/(4\pi\Delta s)$ **(Eq.8)**

Where:

Δs is drawdown per log cycles of plot

For storage coefficient:

$S = 2.25Tt_o/r^2$ **(Eq.9)**

Where:

't_o' is time for zero drawdown in the observations well

'r' is the distance of observation well from the pumped well.

Analysis of the constant pumping test data,by using Cooper-Jacob method, is given in Graphs 9 to 12.Similarly, analysis of the step pumping test data, by using Cooper-Jacob method, is given in Graphs 13 to 16.

4.3 Theis Method Using Recovery Data

Transmissibility can be estimated from the following relationship by using recovery data:

$T = 2.3Q/4\pi s' \log(t/t')$ **(Eq.10)**

Where:

Q is the discharge of well during pumping phase

t is time since pumping starts

t' is time since pumping stops

s' is the residual drawdown

Analysis of the constant pumping test by using recovery data is given in Graphs 17 to 20.

5. PUMP OUT TEST RESULTS

Aquifer parameters estimated through the above stated methods are given in Table 6. Summary of the results is:

Well Number 2: Transmissibility values range from 16394to 50420 m^2/day. Hydraulic conductivity is worked out after dividing transmissibility values by aquifer thickness which is assumed to be 50 meters. The hydraulic conductivity values range from 328 to 1008 m/day. Values of estimated storage coefficient range from 8.75E-09 to 1.34E-03.

Well Number 8: Transmissibility values range from 18123 to 33824 m^2/day. The hydraulic conductivity values range from 362 to 676 m/day. Values of estimated storage coefficient range from 5.80E-10 to 5.84E-05.

Data collected during constant pumping is not reliable as there is too much fluctuation of drawdown.

Well Number 13: Transmissibility values range from 19415 to 25758 m^2/day. The hydraulic conductivity values range from 388 to 516 m/day. Values of estimated storage coefficient range from 6.40E-10 to 6.23E-07.

Well Number 23: Transmissibility values range from 32415 to 63749 m^2/day. The hydraulic conductivity values range from 648 to 1275 m/day. Values of estimated storage coefficient range from 9.98E-11 to 1.02E-08.

Data collected during step test shows a decreasing drawdown as the pumping time increases.

6. RADIUS OF INFLUENCE

To check the radius of influence of the pumping wells, water levels in two observation points at various distances, was observed while pumping was performed in the well. Observations do not indicate any interference effect at a distance of 500 and 1000 meters.

7. CONCLUSIONS

Conclusions derived from the pump out test analysis are:

Transmissibility: It ranges from 16394 to 63749m^2/day with a median value of 24919 m^2/day.

Hydraulic Conductivity: Transmissibility divided by aquifer thickness (assumed equal to well screen length, 50 meters) comes out to be 328 to 1275 m/day with a median value of 498m/day, which in FPS units is 0.0189ft/sec. Hydrogeological investigations were carried out by WAPDA, in Punjab Region, with the help of US Geological Survey. Forty nine pump out tests were carried out during nineteen sixties. Hydraulic conductivity values estimated in Rechna Doab area ranged from 0.0009 to 0.0101ft/sec with an average value of 0.0056 ft/sec. The hydraulic conductivity values estimated during the current tests are outside of the range estimated by WAPDA.

Storage Coefficient: This parameter ranges from 9.98E-11 to 6.29E-03, which indicates confined aquifer conditions. During hydrogeological investigations carried out by WAPDA, in Punjab Region, it was observed that Punjab aquifers behave as confined aquifers during early time of pumping. But after three to four days of pumping, these aquifers behave as unconfined aquifers and their specific yield of Rechna Doab aquifer varies from 0.01 to 0.33 with an average value of 0.13.

Specific Yield is the ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil.

Storage Coefficient or Storativity is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In an unconfined aquifer, the storage coefficient is equal to the specific yield.

Interference Between Wells: To check the radius of influence of the pumping wells, water levels in two observation points at various distances, was observed while pumping was performed in a the well. Observed data indicates that there is no interference between wells.

Well Losses and Well Efficiency: Water levels could not be measured within the tubewells. Therefore, well losses and well efficiency cannot be estimated.

Radius of Influence: The radius of influence of a pumping well can be estimated if drawdown data for three or more than three observation wells, located at different distances, is available. But in current tests drawdown is available in only one observation well. Therefore, radius of influence cannot be worked out from this data.

However, by the use of Sichardt equation some estimate can be made. The equation is:

$$R = 3000 * DD * (K)^{0.5} \quad \text{(Eq.11)}$$

Where:

R is radius of influence in meters,

DD is drawdown in the well in meters,

K is the hydraulic conductivity in m/sec

Assuming that drawdown within the well ranges between 1.0 to 2.0 meters. By applying Sichardt equation, values of estimated radii of influence are:

Serial Number	K (m/day)	K (m/sec)	DD (m)	R (m)	R (ft)
1	353	0.0041	0.50	96	315
2	353	0.0041	1.00	192	629
3	353	0.0041	1.50	288	944
4	353	0.0041	2.00	384	1259
5	458	0.0058	0.50	114	374
6	458	0.0058	1.00	228	747
7	458	0.0058	1.50	342	1121
8	458	0.0058	2.00	456	1494

8. FINAL REMARKS

i) During pump out tests, drawdown was observed in an observation well located at a distance of 4.0 meters.

ii) Drawdown within the well could not be observed as there was no space available to lower the measuring device.

iii) Drawdowns observed seem to be on lower side with the result, the estimated values of transmissibility and hydraulic conductivity are too high.

iv) If this data is to be used for future design, then it is suggested that the minimum values of transmissibility and hydraulic conductivity estimated herein, be used.

v) During the construction of these tubewells, pump out tests were carried out on Well-02 and Well-13. The results of these tests are more realistic and are close to the minimum values estimated during the current tests. Therefore, these results can also be adopted for future application. For comparisons of previous and recent results are given below.

Well Number	Well-02	Well-13	
Transmissibility (1983)	19,694	17,633	m^2/day
Transmissibility (minimum for 2013)	16,094	10,411	m^2/day

TABLE-1: CONSTANT DISCHARGE TEST DATA

Well Number:		2	8	13	23
Test Date:		Oct-04-2013	Oct-6-2013	Oct-08-2013	Oct-10-2013
Design Discharge:	cusec	4.0	4.0	4.0	4.0
Test Discharge (Q):	m^3/hour	330	253	349	401
Thickness of Aquifer:	m	50	50	50	50
Length of Well Screen (Ls)	m	48.8	48.8	48.8	48.8
Static Water level:	m	13.92	16.62	18.83	16.18
Pumping Water Level:	m	14.28	16.95	19.53	16.52
Maximum Drawdown:	m	0.36	0.33	0.70	0.34
Test Duration:	minutes	240	240	240	240

TABLE-2: STEP DISCHARGE TEST DATA

Well Number:		2	8	13	23
Test Date:		Oct-04-2013	Oct-6-2013	Oct-08-2013	Oct-10-2013
Design Discharge:	cusec	4.0	4.0	4.0	4.0
Test Discharge (Q):	m^3/hour	209	152	159	152
Thickness of Aquifer:	m	50	50	50	50
Length of Well Screen (Ls)	m	48.8	48.8	48.8	48.8
Static Water Level:	m	23.86	16.57	18.78	16.18
Pumping Water Level:	m	24.07	16.79	19.07	16.28
Maximum Drawdown:	m	0.21	0.22	0.29	0.10
Test Duration:	minutes	60	60	60	60

TABLE-3: WATER LEVEL DATA FOR CONSTANT PUMPING TESTS

Elapsed Time	Drawdown (meters)			
(min)	TW-2	TW-8	TW-13	TW-23
0	0.000	0.000	0.000	0.000
1	0.180	0.270	0.540	0.280
2	0.220	0.290	0.560	0.285
3	0.235	0.310	0.570	0.280
4	0.235	0.310	0.580	0.280
5	0.260	0.310	0.590	0.285
6	0.260	0.310	0.590	0.285
7	0.270	0.310	0.590	0.285
8	0.275	0.320	0.600	0.290
9	0.275	0.320	0.610	0.290
10	0.280	0.320	0.610	0.285
12	0.280	0.320	0.620	0.290
14	0.285	0.320	0.620	0.290
16	0.285	0.330	0.620	0.300
18	0.290	0.330	0.630	0.300
20	0.295	0.330	0.630	0.300
25	0.300	0.330	0.630	0.300
30	0.305	0.330	0.630	0.305
35	0.310	0.330	0.640	0.310
40	0.315	0.320	0.640	0.315
45	0.320	0.330	0.650	0.310
50	0.295	0.310	0.650	0.310
55	0.295	0.370	0.660	0.310
60	0.295	0.350	0.660	0.310
70	0.300	0.370	0.670	0.310
80	0.300	0.380	0.670	0.315
90	0.330	0.370	0.670	0.320
100	0.330	0.325	0.680	0.320
110	0.330	0.325	0.680	0.320
120	0.310	0.310	0.690	0.320
120	0.310	0.330	0.690	0.320
140	0.315	0.330	0.690	0.325
160	0.320	0.330	0.700	0.325
180	0.320	0.330	0.700	0.325
200	0.320	0.330	0.700	0.335
220	0.360	0.330	0.700	0.335
240	0.360	0.330	0.700	0.340

TABLE-4: WATER LEVEL DATA FOR STEP PUMPING TESTS

Elapsed Time	Drawdown (meters)			
(min)	TW-2	TW-8	TW-13	TW-23
0	0.000	0.000	0.000	0.000
1	0.160	0.190	0.270	0.080
2	0.160	0.190	0.270	0.210
3	0.160	0.190	0.260	0.160
4	0.160	0.190	0.260	0.140
5	0.165	0.190	0.260	0.120
6	0.165	0.190	0.270	0.110
7	0.170	0.190	0.270	0.110
8	0.170	0.190	0.270	0.110
9	0.170	0.190	0.270	0.110
10	0.170	0.200	0.270	0.110
12	0.170	0.210	0.270	0.110
14	0.175	0.210	0.275	0.100
16	0.175	0.210	0.275	0.100
18	0.190	0.220	0.275	0.105
20	0.190	0.220	0.280	0.110
25	0.190	0.220	0.280	0.100
30	0.195	0.220	0.290	0.100
35	0.200	0.225	0.290	0.100
40	0.200	0.225	0.290	0.100
45	0.200	0.225	0.290	0.100
50	0.205	0.230	0.290	0.100
55	0.210	0.230	0.290	0.100
60	0.210	0.220	0.290	0.100

TABLE-5: WATER LEVEL DATA DURING RECOVERY TESTS

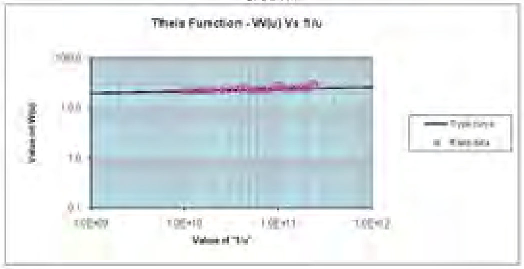
Elapsed Time (min)	Residual Drawdown			
	TW-2	TW-8	TW-13	TW-23
0	0.360	0.370	0.700	0.340
1	0.205	0.160	0.160	0.110
2	0.165	0.110	0.130	0.090
3	0.130	0.090	0.120	0.070
4	0.115	0.080	0.120	0.070
5	0.110	0.070	0.120	0.060
6	0.100	0.060	0.080	0.060
7	0.095	0.060	0.090	0.060
8	0.090	0.060	0.090	0.060
9	0.085	0.050	0.080	0.050
10	0.080	0.050	0.080	0.050
11	0.075	0.050	0.070	0.050
14	0.070	0.050	0.060	0.040
16	0.065	0.040	0.060	0.040
18	0.065	0.040	0.050	0.040
20	0.060	0.040	0.050	0.040
25	0.050	0.030	0.050	0.030
30	0.045	0.030	0.050	0.030
35	0.040	0.030	0.040	0.020
40	0.035	0.020	0.040	0.020
45	0.030	0.020	0.030	0.020
50	0.025	0.010	0.030	0.020
55	0.020	0.010	0.030	0.010
60	0.020	0.000	0.030	0.010

TABLE-6: PUMP OUT TEST RESULTS

Wel Number	Method Used	Transmissibility (m2/day)	Hydraulic Conductivity (m/day)	Storage Coefficient
Well-2	Constant discharge-Theis	30,420	1008	8.75 E-09
Well-2	Constant discharge-Cooper Jacob	18,408	368	6.29 E-08
Well-2	Constant discharge-Recovery	16,394	328	4.65 E-06
Well-2	Step test-Theis	25,147	503	4.37 E-08
Well-2	Step test-Cooper Jacob	22,028	442	1.24 E-09
Mean		**22,028**	**441**	
Well-8	Constant discharge-Theis	33,824	676	5.67 E-08
Well-8	Constant discharge-Cooper Jacob	26,814	536	4.89 E-07
Well-8	Constant discharge-Recovery	18,215	364	1.44 E-09
Well-8	Step test-Theis	33,394	668	5.00 E-10
Well-8	Step test-Cooper Jacob	18,123	362	5.84 E-06
Mean		**33,384**	**668**	
Well-13	Constant discharge-Theis	23,995	480	4.17 E-09
Well-13	Constant discharge-Cooper Jacob	22,193	444	4.64 E-08
Well-13	Constant discharge-Recovery	19,413	388	6.23 E-07
Well-13	Step test-Theis	25,783	516	4.48 E-10
Well-13	Step test-Cooper Jacob	24,890	498	1.60 E-09
Mean		**23,995**	**480**	
Well-23	Constant discharge-Theis	58,971	1179	1.02 E-08
Well-23	Constant discharge-Cooper Jacob	63,359	1273	1.81 E-09
Well-23	Constant discharge-Recovery	32,415	648	9.98 E-11
Well-23	Step test-Theis	-	-	-
Well-23	Step test-Cooper Jacob	-		-
Mean		**58,971**	**1179**	

FAISALABAD PUMP TEST
THEIS METHOD FOR CONSTANT PUMPING TEST

GRAPH-1



DATA

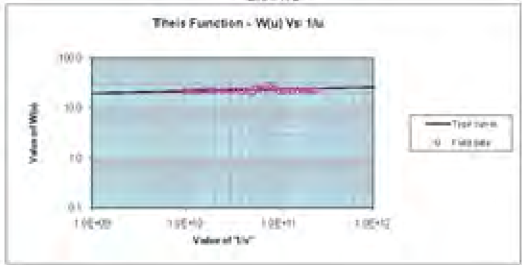
Well Number	2	
Test Date	Oct-04-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	330	m^3/hr
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	13.92	m
Pumping Water Level	14.28	m
Maximum Drawdown	0.36	m
Test Duration	240	minutes

RESULTS
Match Point

1/u	1.0E+10	
W (1/u)	22.4466	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.281	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility		
Transmissibility	**2101**	m^2/hr
Transmissibility	**50,420**	m^2/day
Hydraulic Conductivity	**1,008**	m/d
	$=4T\tau u/r^2$	
Storage Coefficient	**8.70E-09**	

FAISALABAD PUMP TEST
THEIS METHOD FOR CONSTANT PUMPING TEST

GRAPH-2



DATA

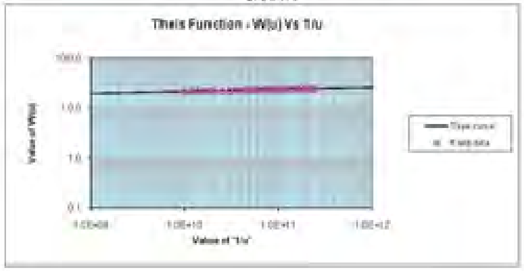
Well Number	9	
Test Date	Oct-05-2012	
Design Discharge	4.0	cusec
Test Discharge (Q)	253	m^3/hr
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	16.62	m
Pumping Water Level	16.95	m
Maximum Drawdown	0.33	m
Test Duration	240	minutes

RESULTS
Match Point

1/u	1.0E+10	
W (1/u)	22.4486	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.221	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility		
Transmissibility	**1409**	m^2/hr
Transmissibility	**33,824**	m^2/day
Hydraulic Conductivity	**676**	m/d
	$=4T\tau u/r^2$	
Storage Coefficient	**5.87E-09**	

FAISALABAD PUMP TEST
THEIS METHOD FOR CONSTANT PUMPING TEST

GRAPH-3



DATA

Well Number	13	
Test Date	Oct-08-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	849	m^3/hr
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.83	m
Pumping Water Level	19.53	m
Maximum Drawdown	0.70	m
Test Duration	340	minutes

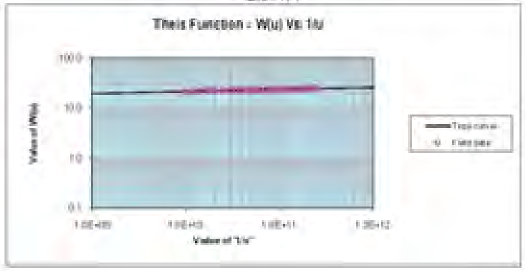
RESULTS

Match Point

1/u	1.0E+10	
W (1/u)	22.4486	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.624	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility	=Q/4π*W(1/u)	
Transmissibility	**1000**	m^2/hr
Transmissibility	**23,996**	m^2/day
Hydraulic Conductivity	**480**	m/d
Storage Coefficient	**=4Tt/ur²**	
Storage Coefficient	**4.17E-09**	

FAISALABAD PUMP TEST
THEIS METHOD FOR CONSTANT PUMPING TEST

GRAPH-4



DATA

Well Number	23	
Test Date	Oct-10-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	401	m^3/hr
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.18	m
Pumping Water Level	18.52	m
Maximum Drawdown	0.34	m
Test Duration	240	minutes

RESULTS

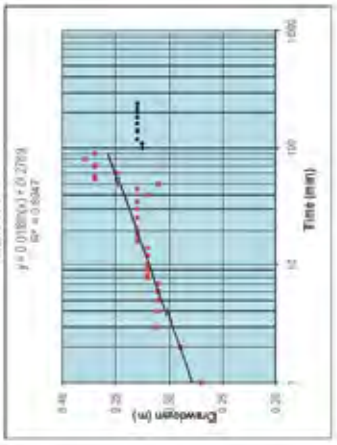
Match Point

1/u	1.0E+10	
W (1/u)	23.4486	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.292	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility		
Transmissibility	**2457**	m^2/hr
Transmissibility	**58,971**	m^2/day
Hydraulic Conductivity	**1,179**	m/d
	=4Tt/ur²	
Storage Coefficient	**1.02E-08**	

FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
COOPER-JACOB METHOD

DATA		
Well Number	8	
Test Date	03-06-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	259	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (L s)	50	m
Static Water Level	16.70	m
Pumping Water Level	16.95	m
Maximum Drawdown	0.53	m
Test Duration	240	minutes
RESULTS		
Data 0 (s)	0.041	m
Transmissibility (T)		m^2/hr
T = 2.30*Q/(4*Pi*Δs)	1117	m^2/hr
Transmissibility (T)	26.614	m^3/day
Hydraulic Conductivity	186	m/day
Distance of Observation well	4.0	m
Time for 0 drawdown	1.97E-07	min
Time for 0 drawdown	2.115E-09	Yr
Specific yield (S)	=2.251*s_0	
Specific yield (S)	4.89E-07	

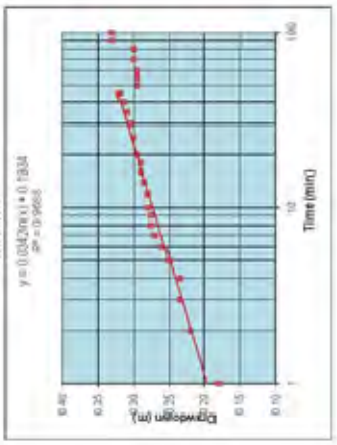
GRAPH-6



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
COOPER-JACOB METHOD

DATA		
Well Number	2	
Test Date	07-04-2013	
Design Discharge	4	cusec
Test Discharge (Q)	330	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (L s)	50	m
Static Water Level	43.92	m
Pumping Water Level	54.26	m
Maximum Drawdown	0.36	m
Test Duration	240	minutes
RESULTS		
Data 0 (s)	0.079	m
Transmissibility (T)		m^2/hr
T = 2.30*Q/(4*Pi*Δs)	267	m^2/hr
Transmissibility (T)	6.406	m^3/day
Hydraulic Conductivity	308	m/day
Distance of Observation well	4.0	m
Time for 0 drawdown	3.60E-03	min
Time for 0 drawdown	5.83E-06	Yr
Specific yield (S)	=2.251*s_0	
Specific yield (S)	8.29E-03	

GRAPH-5



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
COOPER-JACOB METHOD

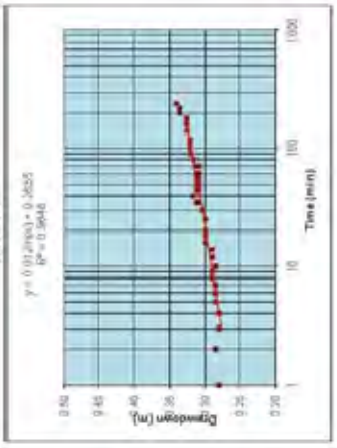
DATA

Well Number	28	
Test Date	03-10-2013	
Design Discharge	4.0	(cusec)
Test Discharge (Q)	901	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.18	m
Pumping Water Level	18.53	m
Maximum Drawdown	0.34	m
Test Duration	360	min/day

RESULTS

Delta S (ds)	0.025	m
		m^2/hr
Transmissibility (T)	2856	m^2/hr
T=2.303*Q/4*PI*ds	80,744	ft^2/day
Transmissibility (T)	1,295	m/day
Hydraulic Conductivity	4.0	m
Distance of Observation well	2.87E-10	min
Time for 0 drawdown	4.46E-12	hr
Time for 0 drawdown		ft^2/hr
Specific yield (S)	<2.257E-2	ft^3/day
Specific yield (S)	1.68E-08	m/day

GRAPH-8



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
COOPER-JACOB METHOD

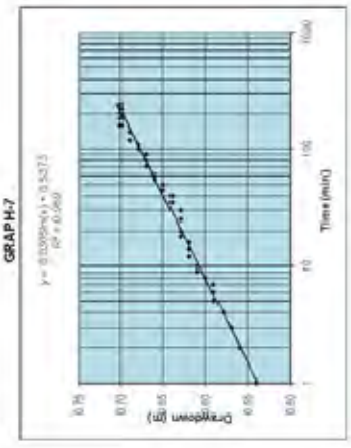
DATA

Well Number	13	
Test Date	Oct-10-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	349	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.83	m
Pumping Water Level	19.53	m
Maximum Drawdown	0.70	m
Test Duration	240	min/day

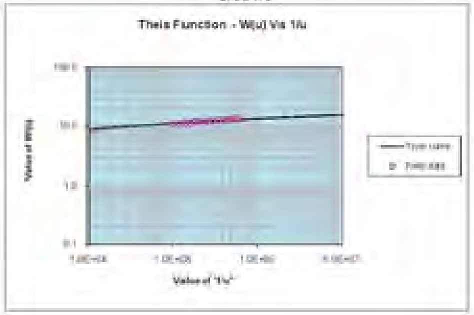
RESULTS

Delta S (ds)	0.169	m
		m^2/hr
Transmissibility (T)		m^2/hr
T=2.303*Q/4*PI*ds	805	ft^2/day
Transmissibility (T)	22,193	m/day
Hydraulic Conductivity	444	m
Distance of Observation well	4.0	min
Time for 0 drawdown	2.24E-09	hr
Time for 0 drawdown	3.73E-10	ft^2/hr
Specific yield (S)	<2.257E-2	ft^3/day
Specific yield (S)	8.64E-06	m/day

GRAPH H-7



FAISALABAD PUMP TEST
STEP TEST
THEIS METHOD
GRAPH-9



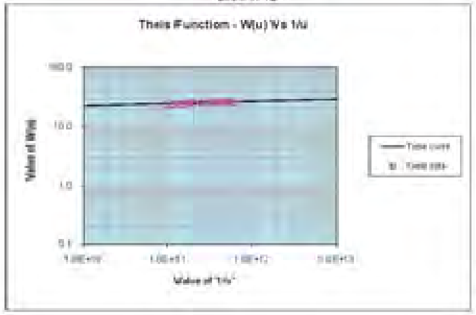
DATA

Well Number	2	
Test Date	Oct-04-2013	
Design Discharge	4	cusec
Test Discharge (Q)	209	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	13.66	m
Pumping Water Level	13.87	m
Maximum Drawdown	0.21	m
Test Duration	60	minutes

RESULTS
Match Point

1/u	1.0E+06	
W (1/u)	10.9357	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.174	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility	=Q/4πT*W(1/u)	
Transmissibility	**1048**	m^2/hr
Transmissibility	**25,147**	m^2/day
Hydraulic Conductivity	**503**	m/d
Storage Coefficient	**=4Ttu/r²**	
Storage Coefficient	**4.37E-04**	

FAISALABAD PUMP TEST
STEP TEST
THEIS METHOD
GRAPH-10



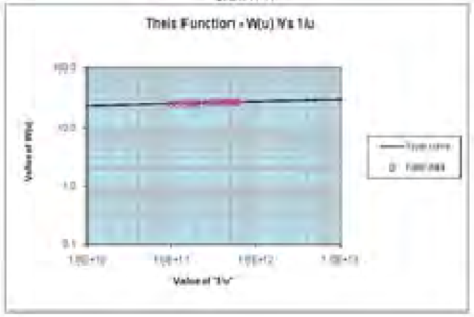
DATA

Well Number	9	
Test Date	Oct-06-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	152	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	15.57	m
Pumping Water Level	15.79	m
Maximum Drawdown	0.22	m
Test Duration	60	minutes

RESULTS
Match Point

1/u	1.0E+11	
W(1/u)	24.7512	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.215	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility	=Q/4πT*W(1/u)	
Transmissibility	**1391**	m^2/hr
Transmissibility	**33,384**	m^2/day
Hydraulic Conductivity	**668**	m/d
Storage Coefficient	**=4Ttu/r²**	
Storage Coefficient	**5.80E-10**	

FAISALABAD PUMP TEST
STEP TEST
THEIS METHOD
GRAPH-11



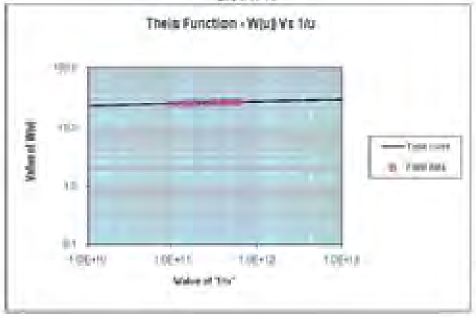
DATA

Well Number	13	
Test Date	Oct-08-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	150	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.78	m
Pumping Water Level	19.07	m
Maximum Drawdown	0.29	m
Test Duration	60	minutes

RESULTS
Match Point

1/u	1.0E+11	
W (1/u)	24.7512	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.275	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility	=Q/4πs*W(1/u)	
Transmissibility	**1074**	m^2/hr
Transmissibility	**25,783**	m^2/day
Hydraulic Conductivity	**516**	m/d
Storage Coefficient	**=4Ttu/r²**	
Storage Coefficient	**4.48E-10**	

FAISALABAD PUMP TEST
STEP TEST
THEIS METHOD
GRAPH-11



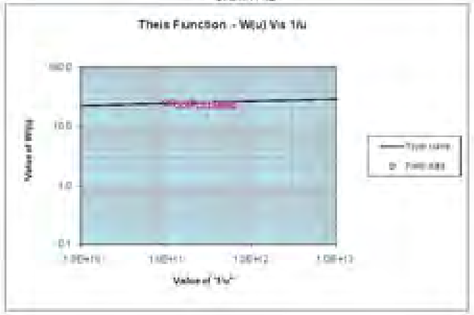
DATA

Well Number	13	
Test Date	Oct-08-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	150	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.78	m
Pumping Water Level	19.07	m
Maximum Drawdown	0.29	m
Test Duration	60	minutes

RESULTS
Match Point

1/u	1.0E+11	
W (1/u)	24.7512	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.275	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility	=Q/4πs*W(1/u)	
Transmissibility	**1074**	m^2/hr
Transmissibility	**25,783**	m^2/day
Hydraulic Conductivity	**516**	m/d
Storage Coefficient	**=4Ttu/r²**	
Storage Coefficient	**4.48E-10**	

FAISALABAD PUMP TEST
STEP TEST
THEIS METHOD
GRAPH-12



DATA

Well Number	23	
Test Date	Oct-10-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	152	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	15.18	m
Pumping Water Level	15.28	m
Maximum Drawdown	0.10	m
Test Duration	60	minutes

RESULTS
Match Point

1/u	1.0E+11	
W (1/u)	24.7512	
Time	10.0	min
Time	1.67E-01	hr
Drawdown (s)	0.159	m
Transmissibility		
Distance of Piezometer	4.0	m
Transmissibility	=Q/4s)*W(1/u)	
Transmissibility	**2782**	m^2/hr
Transmissibility	**66,769**	m^2/day
Hydraulic Conductivity	**1,336**	m/d
Storage Coefficient	**=4Ttu/r²**	
Storage Coefficient	**1.16E-09**	

FAISALABAD PUMP OUT TEST DATA
STEP TEST
COOPER-JACOB METHOD

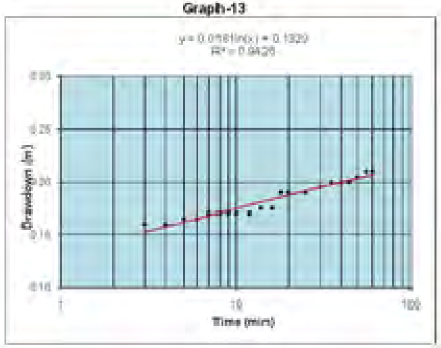
DATA

Well Number	2	
Test Date	12/04/2013	
Design Discharge	4	cusec
Test Discharge (Q)	209	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	13.86	m
Pumping Water Level	14.07	m
Maximum Drawdown	0.21	m
Test Duration	60	minutes

RESULTS

Delta S (ds)	0.082	m
Transmissibility (T)		
T=2.303*Q/(4*PI*ds)		
Transmissibility (T)	918	m^2/hr
Transmissibility (T)	22,028	m^2/day
Hydraulic Conductivity	441	m/day
Distance of P1	4.0	m
Time for 0-drawdown	6.22E-04	min
Time for 0-drawdown	1.04E-05	hr
Specific yield (S)	=2.25Tt/r²	
Specific yield (S)	1.34E-03	

Graph-13



FAISALABAD PUMP OUT TEST DATA
STEP TEST
COOPER-JACOB METHOD

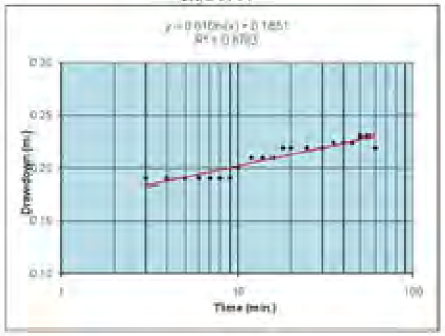
DATA

Well Number	6	
Test Date	03-06-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	152	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	16.57	m
Pumping Water Level	16.79	m
Maximum Drawdown	0.22	m
Test Duration	60	minutes

RESULTS

Delta S (Δs)	0.037	m
Transmissibility (T)		
T=2.303*Q/(4*Pi*Δs)		
Transmissibility (T)	755	m^2/hr
Transmissibility (T)	18,123	m^2/day
Hydraulic Conductivity	362	m/day
Distance of P1	4.0	m
Time for 0 drawdown	3.30E-05	min
Time for 0 drawdown	5.50E-07	hr
Specific yield (S)	$=2.25Tt/r_s^2$	
Specific yield (S)	5.84E-05	

GRAPH-14



FAISALABAD PUMP OUT TEST DATA
STEP TEST
COOPER-JACOB METHOD

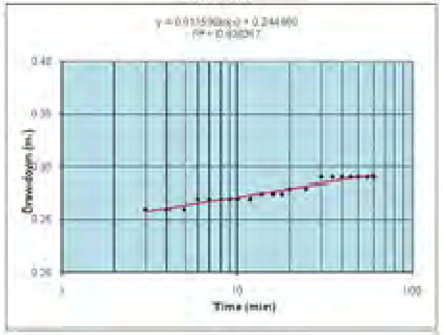
DATA

Well Number	13	
Test Date	03-06-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	150	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	18.78	m
Pumping Water Level	19.07	m
Maximum Drawdown	0.29	m
Test Duration	60	minutes

RESULTS

Delta S (Δs)	0.027	m
Transmissibility (T)		
T=2.303*Q/(4*Pi*Δs)		
Transmissibility (T)	1029	m^2/hr
Transmissibility (T)	24,690	m^2/day
Hydraulic Conductivity	494	m/day
Distance of P1	4.0	m
Time for 0 drawdown	6.60E-10	min
Time for 0 drawdown	1.10E-11	hr
Specific yield (S)	$=2.25Tt/r_s^2$	
Specific yield (S)	1.80E-09	

GRAPH-15



FAISALABAD PUMP OUT TEST DATA
STEP TEST
COOPER-JACOB METHOD

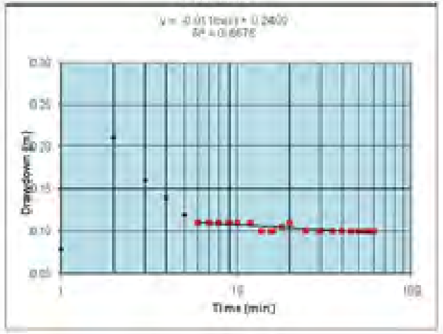
DATA

Well Number	23	
Test Date	03-10-2013	
Design Discharge	4.6	cusec
Test Discharge (Q)	152	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	16.18	m
Pumping Water Level	16.28	m
Maximum Drawdown	0.10	m
Test Duration	60	minutes

RESULTS

Delta S (Δs)	-0.025	m
Transmissibility (T)		
T=2.303*Q/(4*Pi*Δs)		
Transmissibility (T)	-1096	m^2/hr
Transmissibility (T)	-26,301	m^2/day
Hydraulic Conductivity	-527	m/day
Distance of P1	4.0	m
Time for 0 drawdown	3.23E-10	min
Time for 0 drawdown	5.38E-12	hr
Specific yield (S)	$=2.25Tt_0/r^2$	
Specific yield (S)	-8.84E-10	

GRAPH-16



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
RECOVERY METHOD

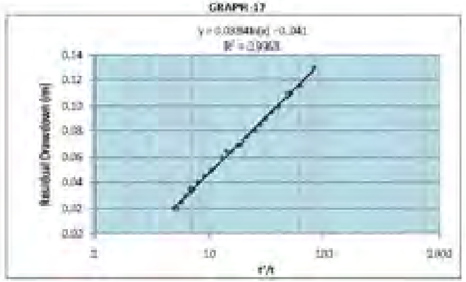
DATA

Well Number	2	
Test Date	Oct-04-2013	
Design Discharge	4.0	cusec
Test Discharge (Q)	330	m^3/hour
Thickness of Aquifer	150	m
Length of Well Screen (Ls)	50	m
Static Water Level	13.92	m
Pumping Water Level	14.28	m
Maximum Drawdown	0.36	m
Distance of observation well	4.00	m
Pumping Duration Duration	240	minutes
Recovery Duration	60.0	minutes

RESULTS

Drawdown over log Cycle	0.088	m
Test Discharge (Q)	330	m^3/hr
Test Discharge (Q)	7920	m^3/day
Transmissibility (T)	$=2.30Q/4\pi\Delta s'$	
Transmissibility (T)	16394	m^2/day
Hydraulic Conductivity (K)	328	m/day
Time when pumping was stopped	240	minutes
Drawdown when pumping was stopped	0.70	m
Storage coefficient	$=(2.25T*tp/r^2)*10^{(...)}$	
Storage coefficient	4.65E-06	

GRAPH-17



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
RECOVERY METHOD

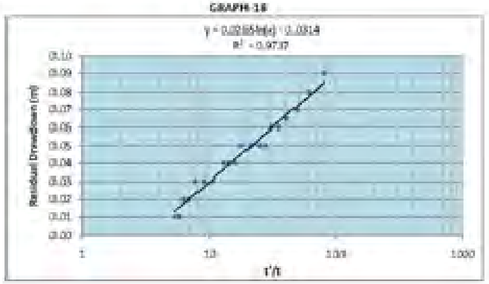
DATA

Well Number:	8	
Test Date:	Oct-08-2013	
Design Discharge:	4.0	cusec
Test Discharge (Q):	253	m^3/hour
Thickness of Aquifer:	150	m
Length of Well Screen (Ls):	50	m
Static Water Level:	16.62	m
Pumping Water Level:	16.95	m
Maximum Drawdown:	0.33	m
Distance of observation well:	4.00	m
Pumping Duration: Duration:	240	minutes
Recovery Duration:	60.0	minutes

RESULTS

Drawdown over log Cycle:	0.061	m
Test Discharge (Q):	253	m^3/hr
Test Discharge (Q):	6072	m^3/day
Transmissibility (T):	=2.3Q/4πΔs'	
Transmissibility (T):	18213	m^2/day
Hydraulic Conductivity (K):	364	m/day
Time when pumping was stopped:	240	minutes
Drawdown when pumping was stopped:	0.70	m
Storage coefficient:	=(2.25T*tp/r²)*10^(-s/Δs)	
Storage coefficient:	1.44E-09	

GRAPH-18



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
RECOVERY METHOD

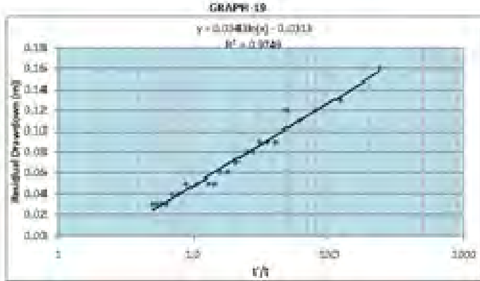
DATA

Well Number:	13	
Test Date:	Oct-08-2013	
Design Discharge:	4.0	cusec
Test Discharge (Q):	349	m^3/hour
Thickness of Aquifer:	150	m
Length of Well Screen (Ls):	50	m
Static Water Level:	18.83	m
Pumping Water Level:	19.53	m
Maximum Drawdown:	0.70	m
Distance of observation well:	4.00	m
Pumping Duration: Duration:	240	minutes
Recovery Duration:	60.0	minutes

RESULTS

Drawdown over log Cycle:	0.079	m
Test Discharge (Q):	349	m^3/hr
Test Discharge (Q):	8376	m^3/day
Transmissibility (T):	=2.3Q/4πΔs'	
Transmissibility (T):	19411	m^2/day
Hydraulic Conductivity (K):	388	m/day
Time when pumping was stopped:	240	minutes
Drawdown when pumping was stopped:	0.70	m
Storage coefficient:	=(2.25T*tp/r²)*10^(-s/Δs)	
Storage coefficient:	6.23E-07	

GRAPH-19



FAISALABAD PUMP OUT TEST DATA
CONSTANT DISCHARGE TEST
RECOVERY METHOD

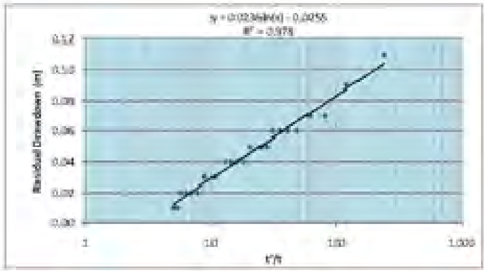
DATA

Well Number:	23	
Test Date:	Oct-10-2013	
Design Discharge:	4.0	cusec
Test Discharge (Q):	401	m^3/hour
Thickness of Aquifer:	150	m
Length of Well Screen (L):	50	m
Static Water Level:	16.18	m
Pumping Water Level:	16.52	m
Maximum Drawdown:	0.34	m
Distance of observation well:	4.00	m
Pumping Duration Duration:	240	minutes
Recovery Duration:	600	minutes

RESULTS

Drawdown over log Cycle:	0.094	m
Test Discharge (Q):	349	m^3/hr
Test Discharge (Q):	9624	m^3/day
Transmissibility (T):	$=2.3Q/4\pi\Delta s'$	
Transmissibility (T):	32415	m^2/day
Hydraulic Conductivity (K):	648	m/day
Time when pumping was stopped:	240	minutes
Drawdown when pumping was stopped:	0.20	m
Storage coefficient:	$=(2.25T*t_0/r^2)*10^{[illegible]}$	
Storage coefficient:	9.98E-11	

GRAPH-20



APPENDIX-A

TEST DATA

Date 4-Oct-13

Step Drawdown Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #2
Static Water Level : 13.86 m	

1st Step		Discharge Rate (Q) 200 m^3/hour							
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #3) Water level s (m)	(TW #3) Drawdown ⊿s (m)	
4-Oct-13	6:00	0	0	0.0	13.86	0.00	14.39	0.00	
		1	1	208.1	14.02	0.16	14.39	0.00	
		2	2	199.4	14.02	0.16	14.39	0.00	
		3	3	203.4	14.02	0.16	14.39	0.00	
		4	4	204.1	14.02	0.16	14.39	0.00	
		5	5	198.6	14.03	0.17	14.39	0.00	
		6	6	200.5	14.03	0.17	14.39	0.00	
		7	7	199.8	14.03	0.17	14.39	0.00	
		8	8	201.8	14.03	0.17	14.39	0.00	
		9	9	203.6	14.03	0.17	14.39	0.00	
		10	10	199.7	14.03	0.17	14.39	0.00	
		12	12	201.6	14.03	0.17	14.39	0.00	
		14	14	201.9	14.04	0.18	14.39	0.00	
		16	16	206.9	14.04	0.18	14.39	0.00	
		18	18	209.9	14.05	0.19	14.39	0.00	
		20	20	208.7	14.05	0.19	14.39	0.00	
		25	25	210.6	14.05	0.19	14.39	0.00	
		30	30	215.5	14.06	0.20	14.39	0.00	
		35	35	215.3	14.06	0.20	14.39	0.00	
		40	40	220.8	14.06	0.20	14.39	0.00	
		45	45	217.6	14.06	0.20	14.39	0.00	
		50	50	226.4	14.07	0.21	14.39	0.00	
		55	55	227.3	14.07	0.21	14.39	0.00	
	7:00	60	60	226.0	14.07	0.21	14.39	0.00	

Date 4-Oct-13

Step Drawdown Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #2
Static Water Level : 13.86 m	

2nd Step		Discharge Rate (Q) 250 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #3) Water level s (m)	(TW #3) Drawdown ⊿s (m)
4-Oct-13	7:00	60	0	226.0	14.07	0.21	14.39	0.00
		61	1	248.1	14.08	0.22	14.39	0.00
		62	2	247.3	14.08	0.22	14.39	0.00
		63	3	248.5	14.08	0.22	14.39	0.00
		64	4	247.3	14.08	0.22	14.39	0.00
		65	5	252.1	14.09	0.23	14.39	0.00
		66	6	250.8	14.09	0.23	14.39	0.00
		67	7	250.7	14.09	0.23	14.39	0.00
		68	8	251.3	14.09	0.23	14.39	0.00
		69	9	248.6	14.09	0.23	14.39	0.00
		70	10	252.9	14.09	0.23	14.39	0.00
		72	12	249.8	14.09	0.23	14.39	0.00
		74	14	252.1	14.10	0.24	14.39	0.00
		76	16	255.1	14.10	0.24	14.39	0.00
		78	18	253.3	14.10	0.24	14.39	0.00
		80	20	254.0	14.10	0.24	14.39	0.00
		85	25	249.4	14.10	0.24	14.39	0.00
		90	30	252.1	14.10	0.24	14.39	0.00
		95	35	251.3	14.10	0.24	14.39	0.00
		100	40	250.7	14.10	0.24	14.39	0.00
		105	45	250.2	14.11	0.25	14.39	0.00
		110	50	251.6	14.11	0.25	14.39	0.00
		115	55	251.9	14.11	0.25	14.39	0.00
	7:00	120	60	254.0	14.11	0.25	14.39	0.00

Date 4-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #2
Static Water Level: 13.86 m	

3rd Step		Discharge Rate (Q): 300 m^3/hour							
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #8) Water level s (m)	(TW #8) Drawdown ⊿s (m)	
4-Oct-13	8:00	120	0	254.0	14.11	0.25	14.39	0.00	
		121	1	301.2	14.13	0.27	14.39	0.00	
		122	2	301.0	14.14	0.28	14.39	0.00	
		123	3	300.0	14.14	0.28	14.39	0.00	
		124	4	302.4	14.15	0.29	14.39	0.00	
		125	5	304.4	14.15	0.29	14.39	0.00	
		126	6	301.7	14.15	0.29	14.39	0.00	
		127	7	306.6	14.15	0.29	14.39	0.00	
		128	8	303.1	14.15	0.29	14.39	0.00	
		129	9	299.8	14.15	0.29	14.39	0.00	
		130	10	302.2	14.15	0.29	14.39	0.00	
		132	12	298.7	14.15	0.29	14.39	0.00	
		134	14	302.2	14.15	0.29	14.39	0.00	
		136	16	298.7	14.15	0.29	14.39	0.00	
		138	18	300.2	14.15	0.29	14.39	0.00	
		140	20	304.8	14.15	0.29	14.39	0.00	
		145	25	303.9	14.16	0.30	14.39	0.00	
		150	30	304.1	14.16	0.30	14.39	0.00	
		155	35	307.8	14.16	0.30	14.39	0.00	
		160	40	308.5	14.16	0.30	14.39	0.00	
		165	45	307.6	14.17	0.31	14.39	0.00	
		170	50	309.2	14.17	0.31	14.39	0.00	
		175	55	308.1	14.17	0.31	14.39	0.00	
	9:00	180	60	308.5	14.17	0.31	14.39	0.00	

Date 4-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #2
Static Water Level: 13.86 m	

4th Step		Discharge Rate (Q): 350 m^3/hour							
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #8) Water level s (m)	(TW #8) Drawdown ⊿s (m)	
4-Oct-13	9:00	180	0	308.5	14.17	0.31	14.39	0.00	
		181	1	343.0	14.18	0.32	14.39	-0.01	
		182	2	343.5	14.19	0.33	14.39	-0.01	
		183	3	350.4	14.19	0.33	14.38	-0.01	
		184	4	345.4	14.19	0.33	14.38	-0.01	
		185	5	349.8	14.20	0.34	14.38	-0.01	
		186	6	352.9	14.20	0.34	14.38	-0.01	
		187	7	352.3	14.20	0.34	14.38	-0.01	
		188	8	351.1	14.20	0.34	14.38	-0.01	
		189	9	352.8	14.20	0.34	14.38	-0.01	
		190	10	350.0	14.20	0.34	14.38	-0.01	
		192	12	347.2	14.20	0.34	14.38	-0.01	
		194	14	353.6	14.20	0.34	14.38	-0.01	
		196	16	353.7	14.20	0.34	14.38	-0.01	
		198	18	349.9	14.20	0.34	14.38	-0.01	
		200	20	350.5	14.20	0.34	14.38	-0.01	
		205	25	348.8	14.21	0.35	14.38	-0.01	
		210	30	352.1	14.21	0.35	14.38	-0.01	
		215	35	348.3	14.21	0.35	14.38	-0.01	
		220	40	350.0	14.22	0.36	14.38	-0.01	
		225	45	351.1	14.22	0.36	14.38	-0.01	
		230	50	309.8	14.22	0.36	14.38	-0.01	
		235	55	349.0	14.23	0.37	14.38	-0.01	
	10:00	240	60	351.7	14.24	0.38	14.38	-0.01	

Date 4-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #2
Static Water Level: 13.95 m	

5th Step		Discharge Rate (Q) Maximum (Valve Full Opened)						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #3) Water level s (m)	(TW #3) Drawdown ⊿s (m)
4-Oct-13	10:00	240	0	351.7	14.24	0.38	14.38	-0.01
		241	1	352.5	14.25	0.39	14.38	-0.01
		242	2	353.1	14.25	0.39	14.38	-0.01
		243	3	356.4	14.25	0.39	14.38	-0.01
		244	4	359.7	14.25	0.39	14.38	-0.01
		245	5	361.1	14.25	0.39	14.38	-0.01
		246	6	356.6	14.25	0.39	14.38	-0.01
		247	7	357.0	14.25	0.39	14.38	-0.01
		248	8	356.9	14.25	0.39	14.38	-0.01
		249	9	359.0	14.25	0.39	14.38	-0.01
		250	10	357.7	14.25	0.39	14.38	-0.02
		252	12	361.1	14.26	0.40	14.38	-0.02
		254	14	353.3	14.26	0.40	14.38	-0.02
		256	16	362.1	14.26	0.40	14.38	-0.02
		258	18	360.0	14.26	0.40	14.37	-0.02
		260	20	353.2	14.26	0.40	14.37	-0.02
		265	25	350.8	14.26	0.40	14.37	-0.02
		270	30	353.4	14.26	0.40	14.37	-0.02
		275	35	351.2	14.26	0.40	14.37	-0.02
		280	40	333.4	14.26	0.40	14.37	-0.02
		285	45	340.2	14.26	0.40	14.37	-0.02
		290	50	354.3	14.26	0.40	14.37	-0.02
		295	55	343.7	14.27	0.41	14.37	-0.02
	11:00	300	60	348.3	14.27	0.41	14.37	-0.02

Date 4-Oct-13

Continuous Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #2
Static Water Level: 13.92 m	

Discharge Rate (Q) Maximum (Valve Full Opened)								
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #3) Water level s (m)	(TW #3) Drawdown ⊿s (m)
4-Oct-13	12:00	0	0	0.0	13.92	0.00	14.37	0.00
		1	1	325.6	14.10	0.18	14.36	-0.01
		2	2	345.2	14.14	0.22	14.36	-0.01
		3	3	330.9	14.16	0.23	14.36	-0.01
		4	4	352.1	14.16	0.23	14.36	-0.01
		5	5	325.5	14.17	0.25	14.36	-0.01
		6	6	349.4	14.18	0.26	14.36	-0.01
		7	7	334.3	14.19	0.27	14.36	-0.01
		8	8	350.7	14.20	0.28	14.36	-0.01
		9	9	329.3	14.20	0.28	14.36	-0.01
		10	10	347.6	14.20	0.29	14.36	-0.01
		12	12	347.0	14.20	0.28	14.36	-0.01
		14	14	344.0	14.21	0.29	14.36	-0.01
		16	16	347.9	14.21	0.29	14.36	-0.01
		18	18	343.3	14.21	0.29	14.36	-0.01
		20	20	344.4	14.22	0.30	14.36	-0.01
		25	25	328.3	14.22	0.30	14.36	-0.01
		30	30	344.3	14.23	0.31	14.36	-0.01
		35	35	326.9	14.23	0.31	14.36	-0.01
		40	40	348.3	14.24	0.32	14.36	-0.01
		45	45	328.4	14.24	0.32	14.36	-0.01
		50	50	307.9	14.22	0.30	14.36	-0.01
		55	55	311.0	14.22	0.30	14.36	-0.01
	13:00	60	60	304.6	14.22	0.30	14.36	-0.01
		70	70	306.7	14.22	0.30	14.36	-0.01
		80	80	300.8	14.22	0.30	14.36	-0.01
		90	90	313.1	14.25	0.33	14.36	-0.01
		100	100	315.1	14.25	0.33	14.36	-0.01
		110	110	300.2	14.25	0.33	14.36	-0.01
	14:00	120	120	317.1	14.23	0.31	14.35	-0.02

Date 4-Oct-13

Continuous Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad			Well No: TW #2
Static Water Level	13.92	m	

Discharge Rate (Q): Maximum (Valve Full Opened)								
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown Δs (m)	(TW #3) Water level s (m)	(TW #3) Drawdown Δs (m)
		120	120	317.1	14.25	0.33	14.35	-0.02
		140	140	309.3	14.24	0.32	14.35	-0.02
		160	160	319.6	14.24	0.32	14.35	-0.02
	15:00	180	180	328.0	14.24	0.32	14.35	-0.02
		200	200	311.8	14.24	0.32	14.35	-0.02
		220	220	357.4	14.26	0.34	14.35	-0.02
	16:00	240	240	372.8	14.28	0.36	14.35	-0.02

Date 4-Oct-13

Recovery Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad			Well No: TW #2
Static Water Level	13.92	m	

Date	Time	Elapsed time (min) t	Recovery time for each step (min) t'	t/t'	Water level s (m)	Residual Drawdown s' (m)	(TW #3) Water level s (m)	(TW #3) Residual Drawdown s' (m)
4-Oct-13	15:00	240	0		14.28	0.36	14.35	-0.02
		241	1	241	14.13	0.21	14.35	-0.02
		242	2	121	14.09	0.16	14.35	-0.02
		243	3	81	14.05	0.13	14.35	-0.02
		244	4	61	14.04	0.12	14.35	-0.02
		245	5	49	14.03	0.11	14.35	-0.02
		246	6	41	14.02	0.10	14.35	-0.02
		247	7	35	14.02	0.10	14.35	-0.02
		248	8	31	14.01	0.09	14.35	-0.02
		249	9	28	14.01	0.09	14.35	-0.02
		250	10	25	14.00	0.08	14.35	-0.02
		252	12	21	14.00	0.07	14.35	-0.02
		254	14	18	13.99	0.07	14.35	-0.02
		256	16	16	13.99	0.06	14.35	-0.02
		258	18	14	13.99	0.06	14.35	-0.02
		260	20	13	13.98	0.06	14.35	-0.02
		265	25	11	13.97	0.05	14.35	-0.02
		270	30	9	13.97	0.04	14.35	-0.02
		275	35	8	13.96	0.04	14.35	-0.02
		280	40	7	13.96	0.04	14.35	-0.02
		285	45	6	13.95	0.03	14.35	-0.02
		290	50	6	13.95	0.03	14.35	-0.02
		295	55	5	13.94	0.02	14.35	-0.02
	17:00	300	60	5	13.94	0.02	14.35	-0.02

Date 5-Oct-13

Well Interference Test Record

Site Name: Chenab Well Field Area, WASA-Faisalabad	Well No. TW #2
Static Water Level TW #2: 13.81 m	Static Water Level TW #3: 14.35 m

Pattern 2

Date	Time	Elapsed time (min)	Time of each step (min)	TW #2 Pumping rate (m^3/hour)	TW #2 Pumping water level s (m)	TW #2 Drawdown ⊿s (m)	TW #3 Pumping rate (m^3/hour)	TW #3 Pumping water level s (m)	TW #3 Drawdown ⊿s (m)	TW #4 Pumping rate (m^3/hour)
5-Oct-13	6:00	0	0	0.0	13.81	0.00	0.0	14.35	0.00	0.0
		1	1	0.0	13.81	0.00	0.0	14.35	0.00	350.6
		2	2	0.0	13.81	0.00	0.0	14.35	0.00	365.3
		3	3	0.0	13.81	0.00	0.0	14.35	0.00	352.0
		4	4	0.0	13.81	0.00	0.0	14.35	0.00	354.8
		5	5	0.0	13.81	0.00	0.0	14.35	0.00	357.9
		6	6	0.0	13.81	0.00	0.0	14.35	0.00	391.4
		7	7	0.0	13.81	0.00	0.0	14.35	0.00	378.8
		8	8	0.0	13.81	0.00	0.0	14.35	0.00	377.0
		9	9	0.0	13.81	0.00	0.0	14.35	0.00	381.6
		10	10	0.0	13.81	0.00	0.0	14.35	0.00	377.2
		12	12	0.0	13.81	0.00	0.0	14.35	0.00	380.1
		14	14	0.0	13.81	0.00	0.0	14.35	0.00	376.1
		16	16	0.0	13.81	0.00	0.0	14.35	0.00	378.9
		18	18	0.0	13.81	0.00	0.0	14.35	0.00	386.7
		20	20	0.0	13.81	0.00	0.0	14.35	0.00	374.8
		25	25	0.0	13.81	0.00	0.0	14.35	0.00	375.9
		30	30	0.0	13.80	-0.01	0.0	14.35	0.00	374.0
		35	35	0.0	13.80	-0.01	0.0	14.35	0.00	378.8
		40	40	0.0	13.80	-0.01	0.0	14.35	0.00	379.4
		45	45	0.0	13.80	-0.01	0.0	14.35	0.00	371.6
		50	50	0.0	13.80	-0.01	0.0	14.34	-0.01	374.2
		55	55	0.0	13.80	-0.01	0.0	14.34	-0.01	370.3
	7:00	60	60	0.0	13.80	-0.01	0.0	14.34	-0.01	366.8

Date 5-Oct-13

Well Interference Test Record

Site Name: Chenab Well Field Area, WASA-Faisalabad	Well No. TW #3
Static Water Level TW #2: 13.81 m	Static Water Level TW #3: 14.35 m

Recovery

Date	Time	Elapsed time (min)	Time of each step (min)	TW #2 Pumping rate (m^3/hour)	TW #2 Pumping water level s (m)	TW #2 Drawdown ⊿s (m)	TW #3 Pumping rate (m^3/hour)	TW #3 Pumping water level s (m)	TW #3 Drawdown ⊿s (m)	TW #4 Pumping rate (m^3/hour)
5-Oct-13	7:00	60	0	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		61	1	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		62	2	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		63	3	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		64	4	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		65	5	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		66	6	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		67	7	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		68	8	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		69	9	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		70	10	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		72	12	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		74	14	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		76	16	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		78	18	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		80	20	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		85	25	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		90	30	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		95	35	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		100	40	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		105	45	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		110	50	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		115	55	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
	8:00	120	60	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0

Date 5-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #2
Static Water Level TW #2: 13.81 m	Static Water Level TW #3: 14.35 m

Pattern 3

Date	Time	Elapsed time (min)	Time of each step (min)	TW #2 Pumping rate (m³/hour)	TW #2 Pumping water level s (m)	TW #2 Drawdown ⊿s (m)	TW #3 Pumping rate (m³/hour)	TW #3 Pumping water level s (m)	TW #3 Drawdown ⊿s (m)	TW #4 Pumping rate (m³/hour)
5-Oct-13	8:00	120	0	0.0	13.80	-0.01	0.0	14.34	-0.01	0.0
		121	1	0.0	13.80	-0.01	257.8	14.41	0.06	0.0
		122	2	0.0	13.80	-0.01	255.1	14.44	0.09	0.0
		123	3	0.0	13.80	0.01	258.0	14.45	0.10	0.0
		124	4	0.0	13.80	-0.01	258.3	14.46	0.11	0.0
		125	5	0.0	13.80	-0.01	260.3	14.47	0.12	0.0
		126	6	0.0	13.80	-0.01	259.5	14.48	0.12	0.0
		127	7	0.0	13.80	-0.01	255.8	14.48	0.13	0.0
		128	8	0.0	13.80	-0.01	251.4	14.48	0.13	0.0
		129	9	0.0	13.80	-0.01	243.9	14.49	0.14	0.0
		130	10	0.0	13.80	-0.01	246.8	14.49	0.14	0.0
		132	12	0.0	13.80	-0.01	240.1	14.49	0.14	0.0
		134	14	0.0	13.80	-0.01	244.8	14.49	0.14	0.0
		136	16	0.0	13.80	-0.01	242.2	14.49	0.14	0.0
		138	18	0.0	13.80	-0.01	238.4	14.49	0.14	0.0
		140	20	0.0	12.80	-0.01	228.1	14.49	0.14	0.0
		145	25	0.0	13.80	-0.01	227.1	14.49	0.14	0.0
		150	30	0.0	13.80	-0.01	243.4	14.49	0.14	0.0
		155	35	0.0	13.80	-0.01	250.8	14.50	0.15	0.0
		160	40	0.0	13.80	-0.01	246.8	14.50	0.15	0.0
		165	45	0.0	13.80	-0.01	245.8	14.51	0.16	0.0
		170	50	0.0	13.80	-0.01	249.8	14.51	0.16	0.0
		175	55	0.0	13.80	-0.01	237.8	14.51	0.16	0.0
	9:00	180	60	0.0	13.80	-0.01	250.1	14.51	0.16	0.0

Date 5-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #3
Static Water Level TW #2: 13.81 m	Static Water Level TW #3: 14.35 m

Pattern 4

Date	Time	Elapsed time (min)	Time of each step (min)	TW #2 Pumping rate (m³/hour)	TW #2 Pumping water level s (m)	TW #2 Drawdown ⊿s (m)	TW #3 Pumping rate (m³/hour)	TW #3 Pumping water level s (m)	TW #3 Drawdown ⊿s (m)	TW #4 Pumping rate (m³/hour)
5-Oct-13	9:00	180	0	0.0	13.80	-0.01	250.1	14.51	0.16	0.0
		181	1	442.1	13.99	0.18	232.2	14.51	0.16	0.0
		182	2	378.9	14.01	0.20	238.2	14.51	0.16	0.0
		183	3	378.9	14.03	0.22	258.5	14.51	0.16	0.0
		184	4	442.1	14.04	0.23	236.2	14.51	0.16	0.0
		185	5	378.9	14.05	0.24	250.0	14.51	0.16	0.0
		186	6	442.1	14.05	0.24	216.6	14.51	0.16	0.0
		187	7	378.9	14.06	0.25	234.4	14.51	0.16	0.0
		188	8	442.1	14.07	0.26	289.4	14.51	0.16	0.0
		189	9	378.9	14.07	0.26	235.2	14.51	0.16	0.0
		190	10	442.1	14.07	0.26	224.1	14.50	0.15	0.0
		192	12	378.9	14.07	0.26	204.6	14.50	0.15	0.0
		194	14	410.5	14.08	0.27	255.7	14.50	0.15	0.0
		196	16	410.5	14.09	0.28	259.3	14.50	0.15	0.0
		198	18	442.1	14.10	0.29	259.7	14.52	0.17	0.0
		200	20	410.5	14.10	0.29	252.9	14.52	0.17	0.0
		205	25	416.8	14.11	0.30	249.6	14.53	0.18	0.0
		210	30	429.5	14.12	0.31	254.8	14.53	0.19	0.0
		215	35	429.5	14.13	0.32	252.1	14.53	0.18	0.0
		220	40	416.8	14.14	0.33	269.4	14.53	0.18	0.0
		225	45	429.5	14.15	0.34	252.7	14.53	0.18	0.0
		230	50	429.5	14.15	0.34	251.2	14.53	0.18	0.0
		235	55	429.5	14.15	0.34	274.6	14.53	0.18	0.0
	10:00	240	60	429.5	14.16	0.35	270.7	14.54	0.19	0.0

Date 5-Oct-13

Well Interference Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No. TW #2
Static Water Level TW #2: 53.81 m	Static Water Level TW #3: 14.35 m

Pattern 5

Date	Time	Elapsed time (min)	Time of each step (min)	TW #2 Pumping rate (m^3/hour)	TW #2 Pumping water level s (m)	TW #2 Drawdown ⊿s (m)	TW #3 Pumping rate (m^3/hour)	TW #3 Pumping water level s (m)	TW #3 Drawdown ⊿s (m)	TW #4 Pumping rate (m^3/hour)
5-Oct-13	10:00	240	0	429.5	54.16	0.35	270.7	14.54	0.19	335.5
		241	1	442.1	54.16	0.35	265.7	14.54	0.19	329.8
		242	2	378.9	54.16	0.35	250.7	14.54	0.19	351.7
		243	3	442.1	54.16	0.35	340.8	14.54	0.19	349.0
		244	4	442.1	54.16	0.35	248.8	14.54	0.19	332.7
		245	5	378.9	54.16	0.35	280.7	14.54	0.19	348.2
		246	6	442.1	54.16	0.35	252.5	14.54	0.19	358.4
		247	7	442.1	54.16	0.35	266.7	14.54	0.19	351.1
		248	8	378.9	54.16	0.35	248.7	14.54	0.19	339.6
		249	9	442.1	54.16	0.35	262.8	14.54	0.19	332.7
		250	10	442.1	54.17	0.36	250.8	14.54	0.19	343.2
		252	12	419.5	54.17	0.36	246.5	14.54	0.19	319.6
		254	14	410.5	54.17	0.36	253.3	14.54	0.19	342.4
		256	16	442.1	54.17	0.36	250.1	14.54	0.19	337.0
		258	18	410.5	54.17	0.36	264.7	14.54	0.19	344.3
		260	20	442.1	54.17	0.36	249.2	14.53	0.18	338.5
		265	25	416.8	54.16	0.35	258.9	14.53	0.18	300.9
		270	30	378.0	54.15	0.34	261.3	14.52	0.17	289.7
		275	35	416.8	54.18	0.37	257.5	14.54	0.19	348.1
		280	40	416.8	54.18	0.37	251.6	14.54	0.19	336.2
		285	45	429.5	54.19	0.38	340.6	14.55	0.20	358.5
		290	50	429.5	54.19	0.38	256.9	14.55	0.20	351.4
		295	55	416.8	54.19	0.38	281.8	14.55	0.20	340.0
	11:00	300	60	429.5	54.19	0.38	257.9	14.55	0.20	338.9

Date 6-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No.: TW #3
Static Water Level: 16.57 m	

1st Step — Discharge Rate (Q) 150 m^3/hour

Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿h (m)
6-Oct-13	6:00	0	0	0.0	16.57	0.00	16.43	0.00
		1	1	152.0	16.76	0.19	16.43	0.00
		2	2	149.1	16.76	0.19	16.43	0.00
		3	3	156.9	16.76	0.19	16.43	0.00
		4	4	150.7	16.76	0.19	16.43	0.00
		5	5	158.2	16.76	0.19	16.43	0.00
		6	6	146.7	16.76	0.19	16.43	0.00
		7	7	142.6	16.76	0.19	16.43	0.00
		8	8	146.0	16.76	0.19	16.43	0.00
		9	9	148.0	16.76	0.19	16.43	0.00
		10	10	153.0	16.77	0.20	16.43	0.00
		12	12	154.0	16.78	0.21	16.43	0.00
		14	14	152.0	16.78	0.21	16.43	0.00
		16	16	156.0	16.78	0.21	16.43	0.00
		18	18	152.0	16.79	0.22	16.43	0.00
		20	20	152.0	16.79	0.22	16.43	0.00
		25	25	154.4	16.79	0.22	16.43	0.00
		30	30	151.4	16.79	0.22	16.43	0.00
		35	35	154.5	16.80	0.23	16.43	0.00
		40	40	152.2	16.80	0.23	16.43	0.00
		45	45	150.3	16.80	0.23	16.43	0.00
		50	50	148.1	16.80	0.23	16.43	0.00
		55	55	156.4	16.80	0.23	16.43	0.00
	7:00	60	60	150.1	16.80	0.23	16.43	0.00

Date 6-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #8
Static Water Level: 16.57 m	

2nd Step		Discharge Rate (Q): 200 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿s (m)
6-Oct-13	7:00	60	0	159.1	16.79	0.22	16.43	0.00
		61	1	204.0	16.84	0.27	16.43	0.00
		62	2	202.0	16.85	0.28	16.43	0.00
		63	3	199.0	16.85	0.28	16.43	0.00
		64	4	199.0	16.85	0.29	16.43	0.00
		65	5	202.6	16.86	0.29	16.43	0.00
		66	6	198.4	16.86	0.29	16.43	0.00
		67	7	203.3	16.86	0.29	16.43	0.00
		68	8	197.0	16.87	0.29	16.43	0.00
		69	9	199.3	16.87	0.30	16.43	0.00
		70	10	200.6	16.87	0.30	16.43	0.00
		72	12	202.0	16.88	0.31	16.43	0.00
		74	14	202.0	16.88	0.31	16.43	0.00
		76	16	203.0	16.88	0.31	16.43	0.00
		78	18	204.0	16.88	0.31	16.44	0.00
		80	20	200.0	16.88	0.31	16.44	0.00
		85	25	206.0	16.90	0.33	16.44	0.00
		90	30	203.1	16.90	0.33	16.44	0.00
		95	35	205.0	16.90	0.33	16.43	0.00
		100	40	204.0	16.90	0.33	16.43	0.00
		105	45	206.1	16.90	0.33	16.43	0.00
		110	50	207.3	16.90	0.33	16.43	0.00
		115	55	200.0	16.90	0.33	16.43	0.00
	7:00	120	60	199.0	16.91	0.34	16.43	0.00

Date 6-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #8
Static Water Level: 16.57 m	

3rd Step		Discharge Rate (Q): 250 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿s (m)
6-Oct-13	8:00	120	0	199.9	16.91	0.34	16.43	0.00
		121	1	251.0	16.95	0.38	16.43	0.00
		122	2	252.0	16.96	0.39	16.43	0.00
		123	3	254.0	16.97	0.40	16.43	0.00
		124	4	251.0	16.98	0.41	16.43	0.00
		125	5	249.0	16.98	0.41	16.43	0.00
		126	6	248.0	16.99	0.42	16.43	0.00
		127	7	254.0	16.99	0.42	16.43	0.00
		128	8	253.0	16.99	0.42	16.43	0.00
		129	9	257.0	16.99	0.42	16.43	0.00
		130	10	251.0	16.99	0.42	16.43	0.00
		132	12	253.0	17.00	0.43	16.43	0.00
		134	14	249.0	17.00	0.43	16.43	0.00
		136	16	252.0	17.00	0.43	16.43	0.00
		138	18	248.0	17.00	0.43	16.43	0.00
		140	20	254.0	16.99	0.42	16.43	0.00
		145	25	248.0	17.00	0.43	16.43	0.00
		150	30	248.0	17.00	0.43	16.43	0.00
		155	35	251.0	17.00	0.43	16.43	0.00
		160	40	249.0	17.00	0.43	16.43	0.00
		165	45	248.0	17.01	0.44	16.43	0.00
		170	50	250.0	17.02	0.45	16.43	0.00
		175	55	249.0	17.01	0.44	16.43	0.00
	9:00	180	60	249.0	17.02	0.45	16.43	0.00

Date 8-Oct-13

Step Drawdown Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #8
Static Water Level : 16.57 m	

4th Step		Discharge Rate (Q) 300 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿s (m)
8-Oct-13	9:00	180	0	249.9	17.02	0.45	16.43	0.00
		181	1	268.9	17.05	0.48	16.43	0.00
		182	2	267.2	17.04	0.47	16.43	0.00
		183	3	266.0	17.04	0.47	16.43	0.00
		184	4	270.0	17.04	0.47	16.43	0.00
		185	5	267.3	17.04	0.47	16.43	0.00
		186	6	268.0	17.04	0.47	16.43	0.00
		187	7	269.5	17.05	0.48	16.43	0.00
		188	8	Generator Breakdown			16.43	0.00
		189	9				16.43	0.00
		190	10	280.0	17.02	0.45	16.43	0.00
		192	12	291.5	17.04	0.47	16.43	0.00
		194	14	291.0	17.05	0.48	16.43	0.00
		196	16	293.0	17.05	0.48	16.43	0.00
		198	18	289.5	17.05	0.48	16.43	0.00
		200	20	291.5	17.05	0.48	16.43	0.00
		205	25	290.3	17.05	0.48	16.43	0.00
		210	30	291.2	17.05	0.48	16.43	0.00
		215	35	297.2	17.05	0.48	16.43	0.00
		220	40	292.2	17.05	0.48	16.43	0.00
		225	45	301.3	17.05	0.48	16.43	0.00
		230	50	299.0	17.05	0.48	16.43	0.00
		235	55	293.0	17.05	0.48	16.43	0.00
	10:00	240	60	287.0	17.05	0.48	16.43	0.00

Date 8-Oct-13

Step Drawdown Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #8
Static Water Level : 16.57 m	

5th Step		Discharge Rate (Q) 250 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿s (m)
8-Oct-13	10:00	240	0	287.0	17.06	0.49	16.43	0.00
		241	1	255.0	17.03	0.46	16.43	0.00
		242	2	256.0	17.03	0.46	16.43	0.00
		243	3	260.0	17.02	0.45	16.43	0.00
		244	4	254.0	17.02	0.45	16.43	0.00
		245	5	252.0	17.02	0.45	16.43	0.00
		246	6	252.0	17.02	0.45	16.43	0.00
		247	7	255.0	17.02	0.45	16.43	0.00
		248	8	255.0	17.02	0.45	16.43	0.00
		249	9	249.0	17.01	0.44	16.43	0.00
		250	10	250.0	17.01	0.44	16.43	0.00
		252	12	252.0	17.01	0.44	16.43	0.00
		254	14	254.0	17.02	0.45	16.43	0.00
		256	16	252.0	17.02	0.45	16.43	0.00
		258	18	253.0	17.02	0.45	16.43	0.00
		260	20	252.0	17.02	0.45	16.43	0.00
		265	25	253.0	17.02	0.45	16.43	0.00
		270	30	253.0	17.02	0.45	16.43	0.00
		275	35	252.0	17.03	0.46	16.43	0.00
		280	40	252.0	17.02	0.45	16.43	0.00
		285	45	253.0	17.02	0.45	16.43	0.00
		290	50	253.0	17.02	0.45	16.43	0.00
		295	55	253.0	17.02	0.45	16.43	0.00
	11:00	300	60	253.0	17.03	0.45	16.43	0.00

Date: 6-05-13

Continuous Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #8
Static Water Level: 16.62 m	

Discharge Rate (Q): 250 m^3/hour

Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿s (m)
6-05-13	12:00	0	0	0.0	16.62	0.00	16.42	0.00
		1	1	247.0	16.89	0.27	16.42	0.00
		2	2	251.2	16.91	0.29	16.43	0.00
		3	3	252.0	16.93	0.31	16.42	0.00
		4	4	252.0	16.93	0.31	16.42	0.00
		5	5	253.0	16.93	0.31	16.42	0.00
		6	6	251.0	16.93	0.31	16.42	0.00
		7	7	250.0	16.93	0.31	16.42	0.00
		8	8	253.0	16.94	0.32	16.42	0.00
		9	9	253.0	16.94	0.32	16.42	0.00
		10	10	253.0	16.94	0.32	16.42	0.00
		12	12	253.0	16.94	0.32	16.42	0.00
		14	14	253.0	16.94	0.32	16.42	0.00
		16	16	253.0	16.95	0.33	16.42	0.00
		18	18	253.0	16.95	0.33	16.42	0.00
		20	20	253.0	16.95	0.33	16.42	0.00
		25	25	252.0	16.95	0.33	16.42	0.00
		30	30	253.0	16.95	0.33	16.42	0.00
		35	35	254.0	16.95	0.33	16.42	0.00
		40	40	246.0	16.94	0.32	16.42	0.00
		45	45	247.0	16.95	0.33	16.42	0.00
		50	50	247.5	16.93	0.31	16.42	0.00
		55	55	259.0	16.99	0.37	16.42	0.00
	13:00	60	60	256.0	16.97	0.35	16.42	0.00
		70	70	257.0	16.99	0.37	16.42	0.00
		80	80	252.2	17.00	0.38	16.42	-0.01
		90	90	258.0	16.99	0.37	16.42	-0.01
		100	100	258.0	16.95	0.32	16.42	0.00
		110	110	253.0	16.95	0.32	16.42	0.00
	14:00	120	120	255.0	16.95	0.33	16.42	0.00

Date: 6-05-13

Continuous Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #8
Static Water Level: 16.62 m	

Discharge Rate (Q): 250 m^3/hour

Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #9) Water level s (m)	(TW #9) Drawdown ⊿s (m)
		120	120	255.0	16.95	0.33	16.42	0.00
		140	140	250.0	16.95	0.33	16.42	-0.01
		160	160	252.0	16.95	0.33	16.43	-0.01
	15:00	180	180	259.0	16.95	0.33	16.42	-0.01
		200	200	256.0	16.95	0.33	16.43	-0.01
		220	220	259.7	16.95	0.33	16.42	0.00
	16:00	240	240	254.0	16.95	0.33	16.42	0.00

Date 6-Oct-13

Recovery Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #8
Static Water Level : 16.62 m	

Date	Time	Elapsed time (min) t	Recovery time for each step (min) t'	t/t'	Water level s (m)	Residual Drawdown s' (m)	[TW #9] Water level s (m)	[TW #9] Residual Drawdown s' (m)
6-Oct-13	16:00	240	0		16.95	0.33	16.42	0.00
		241	1	241	16.78	0.16	16.43	0.00
		242	2	121	16.73	0.11	16.42	0.00
		243	3	81	16.71	0.09	16.42	0.00
		244	4	61	16.70	0.08	16.42	0.00
		245	5	49	16.69	0.07	16.42	0.00
		246	6	41	16.79	0.10	16.42	0.00
		247	7	35	16.68	0.06	16.42	0.00
		248	8	31	16.68	0.05	16.42	0.00
		249	9	28	16.67	0.05	16.42	0.00
		250	10	25	16.67	0.05	16.42	0.00
		252	12	21	16.67	0.05	16.42	0.00
		254	14	18	16.67	0.05	16.42	0.00
		256	16	16	16.65	0.04	16.42	0.00
		258	18	14	16.66	0.04	16.42	0.00
		260	20	13	16.65	0.04	16.42	0.00
		265	25	11	16.65	0.03	16.42	0.00
		270	30	9	16.65	0.03	16.42	0.00
		275	35	8	16.65	0.03	16.42	0.00
		280	40	7	16.64	0.02	16.43	0.00
		285	45	6	16.64	0.02	16.42	0.00
		290	50	6	16.63	0.01	16.42	0.00
		295	55	5	16.63	0.01	16.42	0.00
	17:00	300	60	5	16.62	0.00	16.42	0.00

Date 7-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No : TW #8
Static Water Level TW #8 : 16.50 m	Static Water Level TW #9 : 16.41 m

Pattern 2

Date	Time	Elapsed time (min)	Time of each step (min)	TW #8 Pumping rate (m³/hour)	TW #8 Pumping water level s (m)	TW #8 Drawdown ⊿s (m)	TW #9 Pumping rate (m³/hour)	TW #9 Pumping water level s (m)	TW #9 Drawdown ⊿s (m)	TW #10 Pumping rate (m³/hour)
7-Oct-13	6:00	0	0	0.0	16.50	0.00	0.0	16.41	0.00	0.0
		1	1	0.0	16.50	0.00	0.0	16.41	0.00	424.6
		2	2	0.0	16.49	-0.01	0.0	16.41	0.00	434.6
		3	3	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		4	4	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		5	5	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		6	6	0.0	16.49	-0.01	0.0	16.41	0.00	424.6
		7	7	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		8	8	0.0	16.49	-0.01	0.0	16.41	0.00	424.6
		9	9	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		10	10	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		12	12	0.0	16.49	-0.01	0.0	16.41	0.00	398.2
		14	14	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		16	16	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		18	18	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		20	20	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		25	25	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		30	30	0.0	16.49	-0.01	0.0	16.41	0.00	382.8
		35	35	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		40	40	0.0	16.49	-0.01	0.0	16.41	0.00	382.8
		45	45	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		50	50	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
		55	55	0.0	16.49	-0.01	0.0	16.41	0.00	371.7
	7:00	60	60	0.0	16.49	-0.01	0.0	16.41	0.00	382.8

Date: 7-Oct-13

Well Interference Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad			Well No: TW #8		
Static Water Level TW #8:	16.50	m	Static Water Level TW #9:	16.41	m

Recovery

Date	Time	Elapsed time (min)	Time of each step (min)	TW #8			TW #9			TW #10
				Pumping rate (m^3/hour)	Pumping water level s (m)	Drawdown Δs (m)	Pumping rate (m^3/hour)	Pumping water level s (m)	Drawdown Δs (m)	Pumping rate (m^3/hour)
7-Oct-13	7:00	60	0	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		61	1	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		62	2	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		63	3	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		64	4	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		65	5	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		66	6	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		67	7	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		68	8	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		69	9	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		70	10	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		72	12	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		74	14	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		76	16	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		78	18	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		80	20	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		85	25	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		90	30	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		95	35	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		100	40	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		105	45	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		110	50	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		115	55	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
	8:00	120	60	0.0	16.49	-0.01	0.0	16.41	0.00	0.0

Date: 7-Oct-13

Well Interference Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad			Well No: TW #8		
Static Water Level TW #8:	16.50	m	Static Water Level TW #9:	16.41	m

Pattern 3

Date	Time	Elapsed time (min)	Time of each step (min)	TW #8			TW #9			TW #10
				Pumping rate (m^3/hour)	Pumping water level s (m)	Drawdown Δs (m)	Pumping rate (m^3/hour)	Pumping water level s (m)	Drawdown Δs (m)	Pumping rate (m^3/hour)
7-Oct-13	8:00	120	0	0.0	16.49	-0.01	0.0	16.41	0.00	0.0
		121	1	0.0	16.49	-0.01	279.1	16.57	0.16	0.0
		122	2	0.0	16.49	-0.01	325.6	16.63	0.22	0.0
		123	3	0.0	16.49	-0.01	279.1	16.65	0.24	0.0
		124	4	0.0	16.49	-0.02	279.1	16.66	0.25	0.0
		125	5	0.0	16.49	-0.01	279.1	16.67	0.26	0.0
		126	6	0.0	16.49	-0.01	279.1	16.68	0.27	0.0
		127	7	0.0	16.49	-0.01	325.6	16.68	0.27	0.0
		128	8	0.0	16.49	-0.01	279.1	16.68	0.27	0.0
		129	9	0.0	16.49	-0.01	279.1	16.69	0.28	0.0
		130	10	0.0	16.49	-0.01	279.1	16.69	0.28	0.0
		132	12	0.0	16.49	-0.01	279.1	16.70	0.29	0.0
		134	14	0.0	16.49	-0.01	279.1	16.70	0.29	0.0
		136	16	0.0	16.49	-0.01	302.3	16.70	0.29	0.0
		138	18	0.0	16.49	-0.01	279.1	16.71	0.29	0.0
		140	20	0.0	16.49	-0.01	279.1	16.71	0.30	0.0
		145	25	0.0	16.49	-0.01	288.4	16.72	0.31	0.0
		150	30	0.0	16.49	-0.01	288.4	16.72	0.31	0.0
		155	35	0.0	16.48	-0.02	288.4	16.73	0.32	0.0
		160	40	0.0	16.48	-0.02	279.1	16.73	0.32	0.0
		165	45	0.0	16.48	-0.02	288.4	16.73	0.32	0.0
		170	50	0.0	16.48	-0.02	279.1	16.73	0.32	0.0
		175	55	0.0	16.48	-0.02	288.4	16.74	0.33	0.0
	9:00	180	60	0.0	16.66	0.16	288.4	16.75	0.34	0.0

Date 7-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad		Well No. TW #8	
Static Water Level TW #8	16.50 m	Static Water Level TW #9	16.41 m

Pattern 4

Date	Time	Elapsed time (min)	Time of each step (min)	TW #8 Pumping rate (m³/hour)	TW #8 Pumping water level s (m)	TW #8 Drawdown ⊿h (m)	TW #9 Pumping rate (m³/hour)	TW #9 Pumping water level s (m)	TW #9 Drawdown ⊿h (m)	TW #10 Pumping rate (m³/hour)
7-Oct-13	9:00	180	0	0.0	16.66	0.16	288.4	16.75	0.34	0.0
		181	1	277.0	16.75	0.25	279.1	16.75	0.34	0.0
		182	2	273.0	16.78	0.28	279.1	16.75	0.34	0.0
		183	3	273.0	16.81	0.31	279.1	16.75	0.34	0.0
		184	4	210.0	16.78	0.28	279.1	16.73	0.32	0.0
		185	5	220.0	16.77	0.27	232.8	16.72	0.31	0.0
		186	6	211.0	16.77	0.27	232.8	16.73	0.32	0.0
		187	7	213.0	16.78	0.28	279.1	16.72	0.31	0.0
		188	8	287.0	16.84	0.34	232.8	16.75	0.34	0.0
		189	9	289.0	16.85	0.35	325.8	16.75	0.34	0.0
		190	10	290.0	16.87	0.37	279.1	16.76	0.35	0.0
		192	12	291.0	16.88	0.38	302.3	16.77	0.36	0.0
		194	14	287.0	16.89	0.39	302.3	16.77	0.36	0.0
		196	16	292.0	16.89	0.39	302.3	16.77	0.36	0.0
		198	18	287.0	16.89	0.39	279.1	16.77	0.36	0.0
		200	20	288.0	16.90	0.40	279.1	16.77	0.36	0.0
		205	25	288.0	16.90	0.40	297.7	16.77	0.36	0.0
		210	30	290.0	16.90	0.40	297.7	16.78	0.36	0.0
		215	35	293.0	16.92	0.42	297.7	16.78	0.37	0.0
		220	40	290.0	16.92	0.42	298.1	16.78	0.37	0.0
		225	45	287.0	16.93	0.43	288.4	16.78	0.37	0.0
		230	50	293.0	16.93	0.43	297.7	16.79	0.38	0.0
		235	55	290.0	16.93	0.43	288.4	16.79	0.38	0.0
	10:00	240	60	288.5	16.93	0.43	288.4	16.79	0.38	0.0

Date 7-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad		Well No. TW #8	
Static Water Level TW #8	16.50 m	Static Water Level TW #9	16.41 m

Pattern 5

Date	Time	Elapsed time (min)	Time of each step (min)	TW #8 Pumping rate (m³/hour)	TW #8 Pumping water level s (m)	TW #8 Drawdown ⊿h (m)	TW #9 Pumping rate (m³/hour)	TW #9 Pumping water level s (m)	TW #9 Drawdown ⊿h (m)	TW #10 Pumping rate (m³/hour)
7-Oct-13	10:00	240	0	288.5	16.93	0.43	288.4	16.79	0.38	0.0
		241	1	276.0	16.93	0.43	279.1	16.78	0.37	318.6
		242	2	282.0	16.93	0.43	279.1	16.76	0.36	371.7
		243	3	284.0	16.93	0.43	279.1	16.76	0.36	371.7
		244	4	281.0	16.93	0.43	279.1	16.76	0.36	318.6
		245	5	280.0	16.93	0.43	279.1	16.76	0.36	371.7
		246	6	282.0	16.92	0.42	279.1	16.77	0.37	371.7
		247	7	275.0	16.92	0.42	279.1	16.78	0.37	371.7
		248	8	276.0	16.92	0.42	279.1	16.78	0.37	424.8
		249	9	270.0	16.92	0.42	279.1	16.77	0.37	371.7
		250	10	275.0	16.92	0.42	279.1	16.76	0.37	371.7
		252	12	270.0	16.92	0.42	279.1	16.78	0.37	345.1
		254	14	278.0	16.92	0.42	279.1	16.78	0.37	371.7
		256	16	275.3	16.93	0.43	279.1	16.78	0.37	371.7
		258	18	278.0	16.93	0.43	279.1	16.78	0.37	345.1
		260	20	275.4	16.93	0.43	279.1	16.79	0.38	371.7
		265	25	275.0	16.93	0.43	279.1	16.76	0.36	361.1
		270	30	278.4	16.94	0.44	279.1	16.78	0.37	361.1
		275	35	277.4	16.94	0.44	279.1	16.76	0.37	361.1
		280	40	275.0	16.94	0.44	279.1	16.78	0.37	361.1
		285	45	278.4	16.94	0.44	279.1	16.76	0.37	361.1
		290	50	281.4	16.95	0.45	279.1	16.76	0.37	361.1
		295	55	278.0	16.95	0.45	279.1	16.79	0.38	361.1
	11:00	300	60	289.0	16.95	0.45	279.1	16.79	0.38	361.1

Date 9-Oct-13

Step Drawdown Test Record

Site Name	Chenab Well Field Area, WASA Faisalabad	Well No.	TW #13
Static Water Level	18.78 m		

1st Step		Discharge Rate (Q): 150 m³/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m³/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
8-Oct-13	8:00	0	0	0.0	18.78	0.00	18.90	0.00
		1	1	154.0	19.05	0.27	18.90	0.00
		2	2	150.0	19.05	0.27	18.90	0.00
		3	3	150.0	19.04	0.26	18.90	0.00
		4	4	150.0	19.04	0.26	18.90	0.00
		5	5	149.0	19.04	0.26	18.90	0.00
		6	6	148.0	19.05	0.27	18.90	0.00
		7	7	150.0	19.05	0.27	18.90	0.00
		8	8	150.0	19.05	0.27	18.90	0.00
		9	9	151.0	19.05	0.27	18.90	0.00
		10	10	151.0	19.05	0.27	18.90	0.00
		12	12	150.0	19.05	0.27	18.90	0.00
		14	14	149.0	19.05	0.27	18.90	0.00
		16	16	150.0	19.05	0.27	18.90	0.00
		18	18	148.0	19.05	0.27	18.90	0.00
		20	20	145.0	19.06	0.28	18.90	0.00
		25	25	153.0	19.06	0.28	18.90	0.00
		30	30	147.0	19.07	0.29	18.90	0.00
		35	35	153.0	19.07	0.29	18.90	0.00
		40	40	148.0	19.07	0.29	18.90	0.00
		45	45	146.0	19.07	0.29	18.90	0.00
		50	50	153.0	19.07	0.29	18.89	-0.01
		55	55	148.0	19.07	0.29	18.89	-0.01
	7:00	60	60	151.0	19.07	0.29	18.89	-0.01

Date 8-Oct-13

Step Drawdown Test Record

Site Name	Chenab Well Field Area, WASA Faisalabad	Well No.	TW #13
Static Water Level	18.78 m		

2nd Step		Discharge Rate (Q): 200 m³/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m³/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
8-Oct-13	7:00	60	0	151.0	19.17	0.39	18.89	-0.01
		61	1	202.0	19.16	0.38	18.89	-0.01
		62	2	201.0	19.16	0.38	18.89	-0.01
		63	3	200.0	19.16	0.38	18.89	-0.01
		64	4	203.0	19.17	0.38	18.89	-0.01
		65	5	204.0	19.17	0.38	18.89	-0.01
		66	6	202.0	19.17	0.38	18.89	-0.01
		67	7	199.0	19.17	0.39	18.89	-0.01
		68	8	200.0	19.17	0.39	18.89	-0.01
		69	9	200.0	19.17	0.39	18.89	-0.01
		70	10	204.0	19.17	0.39	18.89	-0.01
		72	12	198.0	19.17	0.39	18.88	-0.02
		74	14	201.0	19.17	0.39	18.88	-0.02
		76	16	199.0	19.17	0.39	18.88	-0.02
		78	18	204.0	19.18	0.40	18.88	-0.02
		80	20	198.0	19.18	0.40	18.88	-0.02
		85	25	200.0	19.18	0.40	18.88	-0.02
		90	30	199.0	19.18	0.40	18.88	-0.02
		95	35	198.0	19.18	0.40	18.88	-0.02
		100	40	202.0	19.18	0.40	18.88	-0.02
		105	45	202.0	19.19	0.41	18.88	-0.02
		110	50	202.0	19.19	0.41	18.88	-0.02
		115	55	204.0	19.19	0.41	18.88	-0.02
	7:00	120	60	200.0	19.19	0.41	18.88	-0.02

Date 8-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #13
Static Water Level: 18.78 m	

3rd Step		Discharge Rate (Q)	250 m^3/hour					
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
8-Oct-13	8:00	120	0	200.0	19.10	0.41	18.88	-0.02
		121	1	246.0	19.25	0.47	18.88	-0.02
		122	2	253.0	19.27	0.49	18.88	-0.02
		123	3	253.0	19.27	0.49	18.88	-0.02
		124	4	253.0	19.27	0.49	18.88	-0.02
		125	5	250.0	19.27	0.49	18.88	-0.02
		126	6	252.0	19.27	0.49	18.88	-0.02
		127	7	252.0	19.27	0.49	18.88	-0.02
		128	8	252.0	19.27	0.49	18.88	-0.02
		129	9	252.0	19.27	0.49	18.88	-0.02
		130	10	252.0	19.28	0.50	18.88	-0.02
		132	12	252.0	19.28	0.50	18.88	-0.02
		134	14	253.0	19.28	0.50	18.88	-0.02
		136	16	253.0	19.28	0.50	18.88	-0.02
		138	18	254.0	19.29	0.51	18.88	-0.02
		140	20	254.0	19.29	0.51	18.88	-0.02
		145	25	254.0	19.29	0.51	18.88	-0.02
		150	30	254.0	19.29	0.51	18.88	-0.02
		155	35	255.0	19.29	0.51	18.88	-0.02
		160	40	253.0	19.30	0.52	18.88	-0.02
		165	45	254.0	19.30	0.52	18.88	-0.02
		170	50	251.0	19.29	0.51	18.87	-0.03
		175	55	251.0	19.29	0.51	18.87	-0.03
	9:00	180	60	251.0	19.30	0.52	18.87	-0.03

Date 8-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #13
Static Water Level: 18.78 m	

4th Step		Discharge Rate (Q)	300 m^3/hour					
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
8-Oct-13	9:00	180	0	251.0	19.30	0.52	18.87	-0.03
		181	1	310.0	19.37	0.59	18.87	-0.03
		182	2	303.0	19.38	0.60	18.87	-0.03
		183	3	300.0	19.38	0.60	18.87	-0.03
		184	4	305.0	19.38	0.60	18.87	-0.03
		185	5	300.0	19.38	0.60	18.87	-0.03
		186	6	310.0	19.39	0.61	18.87	-0.03
		187	7	301.0	19.39	0.61	18.87	-0.03
		188	8	298.0	19.39	0.61	18.87	-0.03
		189	9	304.0	19.39	0.61	18.87	-0.03
		190	10	302.0	19.39	0.61	18.87	-0.03
		192	12	297.0	19.39	0.61	18.87	-0.03
		194	14	300.0	19.39	0.61	18.87	-0.03
		196	16	304.0	19.39	0.61	18.87	-0.03
		198	18	299.0	19.39	0.61	18.87	-0.03
		200	20	295.0	19.39	0.61	18.87	-0.03
		205	25	309.0	19.39	0.61	18.87	-0.03
		210	30	299.0	19.39	0.61	18.87	-0.03
		215	35	310.0	19.39	0.61	18.87	-0.04
		220	40	310.0	19.40	0.62	18.87	-0.04
		225	45	305.0	19.40	0.62	18.87	-0.03
		230	50	306.0	19.40	0.62	18.87	-0.03
		235	55	310.0	19.40	0.62	18.87	-0.03
	10:00	240	60	298.0	19.40	0.63	18.87	-0.03

Date 8-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #13
Static Water Level: 18.78 m	

5th Step		Discharge Rate (Q): Maximum (Valve Full Opened)						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
8-Oct-13	10:00	240	0	298.0	19.40	0.62	18.87	-0.03
		241	1	378.0	19.53	0.75	18.87	-0.03
		242	2	382.0	19.53	0.75	18.87	-0.03
		243	3	383.0	19.53	0.75	18.87	-0.03
		244	4	375.0	19.54	0.76	18.87	-0.03
		245	5	389.0	19.54	0.76	18.87	-0.03
		246	6	375.0	19.54	0.76	18.87	-0.03
		247	7	390.0	19.54	0.76	18.87	-0.04
		248	8	373.0	19.54	0.76	18.87	-0.04
		249	9	389.0	19.54	0.76	18.87	-0.04
		250	10	374.0	19.54	0.76	18.87	-0.04
		252	12	372.0	19.54	0.76	18.87	-0.04
		254	14	372.0	19.54	0.76	18.87	-0.04
		256	16	373.0	19.55	0.77	18.87	-0.04
		258	18	374.0	19.55	0.77	18.87	-0.04
		260	20	374.0	19.55	0.77	18.87	-0.04
		265	25	384.0	19.55	0.77	18.87	-0.04
		270	30	392.0	19.55	0.77	18.87	-0.04
		275	35	376.0	19.55	0.77	18.86	-0.04
		280	40	389.0	19.56	0.78	18.86	-0.04
		285	45	391.0	19.56	0.78	18.86	-0.04
		290	50	374.0	19.56	0.78	18.86	-0.04
		295	55	390.0	19.56	0.78	18.86	-0.04
	11:00	300	60	392.0	19.57	0.79	18.86	-0.04

Date 8-Oct-13

Continuous Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #13
Static Water Level: 18.83 m	

Discharge Rate (Q): 350 m^3/hour								
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
8-Oct-13	12:00	0	0	0.0	18.83	0.00	18.85	0.00
		1	1	365.0	19.37	0.54	18.85	0.00
		2	2	340.0	19.39	0.56	18.85	0.00
		3	3	343.0	19.40	0.57	18.85	0.00
		4	4	350.0	19.41	0.58	18.85	0.00
		5	5	352.0	19.42	0.59	18.85	0.00
		6	6	352.0	19.42	0.59	18.85	0.00
		7	7	343.0	19.42	0.59	18.85	0.00
		8	8	349.0	19.43	0.60	18.85	0.00
		9	9	349.0	19.44	0.61	18.85	0.00
		10	10	350.0	19.44	0.61	18.85	-0.01
		12	12	347.0	19.45	0.62	18.85	-0.01
		14	14	359.0	19.45	0.62	18.85	-0.01
		16	16	344.0	19.45	0.62	18.85	-0.01
		18	18	348.0	19.46	0.63	18.85	-0.01
		20	20	355.0	19.46	0.63	18.85	-0.01
		25	25	356.0	19.46	0.63	18.85	-0.01
		30	30	356.0	19.46	0.63	18.84	-0.01
		35	35	349.0	19.47	0.64	18.84	-0.01
		40	40	345.0	19.47	0.64	18.84	-0.01
		45	45	346.0	19.48	0.65	18.84	-0.01
		50	50	349.0	19.48	0.65	18.84	-0.01
		55	55	349.0	19.49	0.66	18.84	-0.01
	13:00	60	60	345.0	19.49	0.66	18.84	-0.01
		70	70	347.0	19.50	0.67	18.84	-0.01
		80	80	349.0	19.50	0.67	18.84	-0.01
		90	90	347.0	19.50	0.67	18.84	-0.01
		100	100	348.0	19.51	0.68	18.84	-0.01
		110	110	347.0	19.51	0.68	18.84	-0.01
	14:00	120	120	348.0	19.52	0.69	18.84	-0.01

Date 8-Oct-13

Continuous Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No. TW #13
Static Water Level: 18.82 m	

Discharge Rate (Q): 259 m³/hour

Date	Time	Elapsed time (min)	Time at each step (min)	Pumping rate (m³/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #14) Water level s (m)	(TW #14) Drawdown ⊿s (m)
		120	120	348.0	19.52	0.69	18.84	-0.01
		140	140	349.0	19.52	0.69	18.84	-0.02
		160	160	355.0	19.58	0.70	18.83	-0.02
	15:00	180	180	351.0	19.53	0.70	18.83	-0.02
		200	200	350.0	19.53	0.70	18.83	-0.02
		220	220	327.0	19.53	0.70	18.83	-0.02
	16:00	240	240	332.0	19.53	0.70	18.83	-0.03

Date 8-Oct-13

Recovery Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No. TW #12
Static Water Level: 18.82 m	

Date	Time	Elapsed time (min) t	Recovery time for each step (min) t'	t/t'	Water level s (m)	Residual Drawdown s' (m)	(TW #14) Water level s (m)	(TW #14) Residual Drawdown s' (m)
8-Oct-13	16:00	240	0		19.53	0.70	18.83	-0.03
		241	1	241	18.99	0.16	18.83	-0.03
		242	2	121	18.96	0.13	18.83	-0.03
		243	3	81	18.95	0.12	18.83	-0.03
		244	4	61	18.94	0.11	18.83	-0.03
		245	5	49	18.95	0.12	18.83	-0.03
		246	6	41	18.92	0.09	18.83	-0.03
		247	7	35	18.92	0.09	18.83	-0.03
		248	8	31	18.92	0.09	18.82	-0.03
		249	9	28	18.91	0.08	18.82	-0.03
		250	10	25	18.91	0.08	18.82	-0.03
		252	12	21	18.90	0.07	18.82	-0.03
		254	14	18	18.89	0.06	18.82	-0.03
		256	16	16	18.89	0.06	18.82	-0.03
		258	18	14	18.88	0.05	18.82	-0.03
		260	20	13	18.88	0.05	18.82	-0.03
		265	25	11	18.88	0.05	18.82	-0.03
		270	30	9	18.88	0.05	18.82	-0.03
		275	35	8	18.87	0.04	18.82	-0.03
		280	40	7	18.87	0.04	18.82	-0.03
		285	45	6	18.86	0.03	18.82	-0.03
		290	50	6	18.86	0.03	18.82	-0.03
		295	55	5	18.86	0.03	18.82	-0.03
	17:00	300	60	5	18.86	0.03	18.82	-0.03

Date 9-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #13
Static Water Level TW #13 18.72 m	Static Water Level TW #14 18.82 m

Pattern 2

Date	Time	Elapsed time (min)	Time of each step (min)	TW #13 Pumping rate (m³/hour)	TW #13 Pumping water level s (m)	TW #13 Drawdown ⊿s (m)	TW #14 Pumping rate (m³/hour)	TW #14 Pumping water level s (m)	TW #14 Drawdown ⊿s (m)	TW #15 Pumping rate (m³/hour)
9-Oct-13	6:00	0	0	0.0	18.72	0.00	0.0	18.82	0.00	397.0
		1	1	0.0	18.72	0.00	0.0	18.82	0.00	373.0
		2	2	0.0	18.72	0.00	0.0	18.82	0.00	370.0
		3	3	0.0	18.72	0.00	0.0	18.82	0.00	381.0
		4	4	0.0	18.73	0.01	0.0	18.82	0.00	382.0
		5	5	0.0	18.73	0.01	0.0	18.82	0.00	372.0
		6	6	0.0	18.72	0.00	0.0	18.82	0.00	370.0
		7	7	0.0	18.72	0.00	0.0	18.82	0.00	433.0
		8	8	0.0	18.72	0.00	0.0	18.82	0.00	403.0
		9	9	0.0	18.72	0.00	0.0	18.82	0.00	440.0
		10	10	0.0	18.72	0.00	0.0	18.82	0.00	433.0
		12	12	0.0	18.72	0.00	0.0	18.82	0.00	444.0
		14	14	0.0	18.72	0.00	0.0	18.82	0.00	440.0
		16	16	0.0	18.72	0.00	0.0	18.82	0.00	440.0
		18	18	0.0	18.72	0.00	0.0	18.82	0.00	443.0
		20	20	0.0	18.72	0.00	0.0	18.82	0.00	432.0
		25	25	0.0	18.72	0.00	0.0	18.82	0.00	385.0
		30	30	0.0	18.72	0.00	0.0	18.82	0.00	375.0
		35	35	0.0	18.72	0.00	0.0	18.82	0.00	375.0
		40	40	0.0	18.72	0.00	0.0	18.82	0.00	375.0
		45	45	0.0	18.72	0.00	0.0	18.82	0.00	375.0
		50	50	0.0	18.72	0.00	0.0	18.82	0.00	375.0
		55	55	0.0	18.72	0.00	0.0	18.82	0.00	400.0
	7:00	60	60	0.0	18.72	0.00	0.0	18.82	0.00	417.0

Date 9-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #13
Static Water Level TW #13 18.72 m	Static Water Level TW #14 18.82 m

Recovery

Date	Time	Elapsed time (min)	Time of each step (min)	TW #13 Pumping rate (m³/hour)	TW #13 Pumping water level s (m)	TW #13 Drawdown ⊿s (m)	TW #14 Pumping rate (m³/hour)	TW #14 Pumping water level s (m)	TW #14 Drawdown ⊿s (m)	TW #15 Pumping rate (m³/hour)
9-Oct-13	7:00	60	0	0.0	18.72	0.00	0.0	18.82	0.00	0.0
		61	1	0.0	18.72	0.00	0.0	18.82	0.00	0.0
		62	2	0.0	18.72	0.00	0.0	18.82	0.00	0.0
		63	3	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		64	4	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		65	5	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		66	6	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		67	7	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		68	8	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		69	9	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		70	10	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		72	12	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		74	14	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		76	16	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		78	18	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		80	20	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		85	25	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		90	30	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		95	35	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		100	40	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		105	45	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		110	50	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
		115	55	0.0	18.72	0.00	0.0	18.81	-0.01	0.0
	8:00	120	60	0.0	18.71	-0.01	0.0	18.81	-0.01	0.0

Date 9-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #13
Static Water Level TW #12 18.72 m	Static Water Level TW #14 18.82 m

Pattern 3

Date	Time	Elapsed time (min)	Time of each step (min)	TW #13 Pumping rate (m³/hour)	TW #13 Pumping water level s (m)	TW #13 Drawdown ⊿s (m)	TW #14 Pumping rate (m³/hour)	TW #14 Pumping water level s (m)	TW #14 Drawdown ⊿s (m)	TW #15 Pumping rate (m³/hour)
9-Oct-13	8:00	120	0	0.0	18.71	-0.01	0.0	18.81	-0.01	0.0
		121	1	0.0	18.71	-0.01	336.0	19.14	0.32	0.0
		122	2	0.0	18.71	-0.01	337.0	19.15	0.33	0.0
		123	3	0.0	18.71	-0.01	341.0	19.18	0.36	0.0
		124	4	0.0	18.71	-0.01	340.0	19.19	0.37	0.0
		125	5	0.0	18.71	-0.01	332.0	19.20	0.38	0.0
		126	6	0.0	18.71	-0.01	329.0	19.20	0.38	0.0
		127	7	0.0	18.71	-0.01	326.0	19.20	0.38	0.0
		128	8	0.0	18.71	-0.01	327.0	19.21	0.39	0.0
		129	9	0.0	18.71	-0.01	327.0	19.21	0.39	0.0
		130	10	0.0	18.71	-0.01	328.0	19.21	0.39	0.0
		132	12	0.0	18.71	-0.01	340.0	19.23	0.41	0.0
		134	14	0.0	18.71	-0.01	341.0	19.24	0.42	0.0
		136	16	0.0	18.72	0.00	334.0	19.23	0.41	0.0
		138	18	0.0	18.72	0.00	332.0	19.23	0.41	0.0
		140	20	0.0	18.72	0.00	333.0	19.23	0.41	0.0
		145	25	0.0	18.72	0.00	326.0	19.24	0.42	0.0
		150	30	0.0	18.72	0.00	332.0	19.25	0.43	0.0
		155	35	0.0	18.72	0.00	335.0	19.26	0.44	0.0
		160	40	0.0	18.72	0.00	327.0	19.26	0.44	0.0
		165	45	0.0	18.72	0.00	336.0	19.26	0.44	0.0
		170	50	0.0	18.72	0.00	334.0	19.26	0.44	0.0
		175	55	0.0	18.72	0.00	331.0	19.27	0.45	0.0
	9:00	180	60	0.0	18.72	0.00	331.0	19.27	0.45	0.0

Date 9-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #13
Static Water Level TW #12 18.72 m	Static Water Level TW #14 18.82 m

Pattern 4

Date	Time	Elapsed time (min)	Time of each step (min)	TW #13 Pumping rate (m³/hour)	TW #13 Pumping water level s (m)	TW #13 Drawdown ⊿s (m)	TW #14 Pumping rate (m³/hour)	TW #14 Pumping water level s (m)	TW #14 Drawdown ⊿s (m)	TW #15 Pumping rate (m³/hour)
9-Oct-13	9:00	180	0	0.0	18.72	0.00	331.0	19.27	0.45	0.0
		181	1	352.9	19.22	0.50	317.0	19.27	0.45	0.0
		182	2	352.9	19.25	0.53	321.0	19.26	0.44	0.0
		183	3	352.9	19.29	0.57	327.0	19.27	0.45	0.0
		184	4	352.9	19.31	0.59	313.0	19.26	0.44	0.0
		185	5	352.9	19.32	0.60	312.0	19.26	0.44	0.0
		186	6	352.9	19.33	0.61	320.0	19.27	0.45	0.0
		187	7	352.9	19.33	0.61	317.0	19.27	0.45	0.0
		188	8	411.8	19.34	0.62	324.0	19.27	0.45	0.0
		189	9	352.9	19.35	0.63	300.0	19.26	0.44	0.0
		190	10	352.9	19.35	0.63	313.0	19.26	0.44	0.0
		192	12	352.9	19.35	0.63	307.0	19.26	0.43	0.0
		194	14	352.4	19.36	0.64	309.0	19.26	0.44	0.0
		196	16	352.9	19.36	0.64	309.0	19.26	0.44	0.0
		198	18	352.4	19.37	0.65	308.0	19.26	0.44	0.0
		200	20	352.9	19.37	0.65	306.0	19.26	0.43	0.0
		205	25	376.5	19.37	0.65	319.0	19.27	0.45	0.0
		210	30	364.7	19.38	0.66	314.0	19.27	0.45	0.0
		215	35	376.5	19.39	0.67	314.0	19.26	0.46	0.0
		220	40	376.5	19.40	0.68	309.0	19.27	0.45	0.0
		225	45	341.2	19.40	0.68	306.0	19.27	0.45	0.0
		230	50	364.7	19.40	0.68	311.0	19.26	0.46	0.0
		235	55	364.7	19.41	0.69	313.0	19.26	0.46	0.0
	10:00	240	60	352.9	19.41	0.69	300.0	19.27	0.45	0.0

Date 9-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #13
Static Water Level TW #13 19.72 m	Static Water Level TW #14 19.82 m

Pattern 5

Date	Time	Elapsed time (min)	Time of each step (min)	TW #13 Pumping rate (m³/hour)	TW #13 Pumping water level s (m)	TW #13 Drawdown ⊿s (m)	TW #14 Pumping rate (m³/hour)	TW #14 Pumping water level s (m)	TW #14 Drawdown ⊿s (m)	TW #15 Pumping rate (m³/hour)
9-Oct-13	10:00	240	0	352.9	19.41	0.69	300.0	19.27	0.45	332.0
		241	1	352.9	19.40	0.68	290.0	19.26	0.44	335.0
		242	2	352.9	19.40	0.68	293.0	19.26	0.44	341.0
		243	3	352.0	19.39	0.67	284.0	19.26	0.44	330.0
		244	4	352.9	19.40	0.68	293.0	19.26	0.44	330.0
		245	5	352.9	19.40	0.68	292.0	19.26	0.44	342.0
		246	6	352.9	19.40	0.68	290.0	19.26	0.44	345.0
		247	7	352.9	19.41	0.69	284.0	19.26	0.44	341.0
		248	8	352.9	19.41	0.69	295.0	19.26	0.44	330.0
		249	9	352.9	19.41	0.69	292.0	19.26	0.46	330.0
		250	10	352.9	19.40	0.68	292.0	19.26	0.44	325.0
		252	12	352.4	19.40	0.68	293.0	19.26	0.44	334.0
		254	14	323.5	19.41	0.69	292.0	19.26	0.44	330.0
		256	16	352.4	19.41	0.69	295.0	19.26	0.44	333.0
		258	18	352.9	19.41	0.69	293.0	19.26	0.44	335.0
		260	20	352.9	19.41	0.69	293.9	19.26	0.44	324.0
		265	25	352.9	19.41	0.69	294.0	19.26	0.44	336.0
		270	30	352.0	19.41	0.69	293.0	19.27	0.45	330.0
		275	35	352.9	19.41	0.69	293.0	19.27	0.45	346.0
		280	40	352.9	19.41	0.69	292.9	19.27	0.45	332.0
		285	45	352.9	19.42	0.70	292.0	19.27	0.45	371.0
		290	50	352.9	19.42	0.70	293.0	19.27	0.45	345.6
		295	55	352.0	19.43	0.71	293.0	19.27	0.45	330.0
	11:00	300	60	352.9	19.43	0.71	295.0	19.27	0.45	335.0

Date 10-Oct-13

Step Drawdown Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #23
Static Water Level 16.18 m	

1st Step — Discharge Rate (Q) 150 m³/hour

Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m³/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
10-Oct-13	6:00	0	0	0.0	16.18	0.00	18.86	0.00
		1	1	154.0	16.26	0.08	18.86	0.00
		2	2	157.0	16.39	0.21	18.86	0.00
		3	3	155.0	16.34	0.16	18.86	0.00
		4	4	153.0	16.32	0.14	18.86	0.00
		5	5	150.0	16.30	0.12	18.86	0.00
		6	6	155.0	16.29	0.11	18.86	0.00
		7	7	152.0	16.29	0.11	18.86	0.00
		8	8	151.0	16.29	0.11	18.86	0.00
		9	9	152.0	16.29	0.11	18.86	0.00
		10	10	152.0	16.29	0.11	18.86	0.00
		12	12	148.0	16.29	0.11	18.86	0.00
		14	14	150.0	16.28	0.10	18.86	0.00
		16	16	151.0	16.28	0.10	18.86	0.00
		18	18	152.0	16.29	0.11	18.86	0.00
		20	20	149.0	16.29	0.11	18.85	-0.01
		25	25	152.0	16.28	0.10	18.85	-0.01
		30	30	151.0	16.28	0.10	18.85	-0.01
		35	35	150.0	16.28	0.10	18.85	-0.01
		40	40	152.0	16.28	0.10	18.85	-0.01
		45	45	154.0	16.28	0.10	18.85	-0.01
		50	50	150.0	16.28	0.10	18.85	-0.01
		55	55	153.0	16.28	0.10	18.85	-0.01
	7:00	60	60	149.0	16.28	0.10	18.85	-0.01

Date 10-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #23
Static Water Level: 16.18 m	

2nd Step		Discharge Rate (Q) 200 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
10-Oct-13	7:00	60	0	149.0	16.28	0.10	16.85	-0.01
		61	1	202.0	16.28	0.10	16.85	-0.01
		62	2	201.0	16.30	0.12	16.85	-0.01
		63	3	203.0	16.31	0.13	16.85	-0.01
		64	4	201.0	16.31	0.13	16.85	-0.01
		65	5	200.0	16.31	0.13	16.85	-0.01
		66	6	205.0	16.32	0.14	16.85	-0.01
		67	7	204.0	16.32	0.14	16.85	-0.01
		68	8	202.0	16.32	0.14	16.85	-0.01
		69	9	201.0	16.32	0.14	16.85	-0.01
		70	10	204.0	16.32	0.14	16.85	-0.01
		72	12	210.0	16.32	0.14	16.85	-0.01
		74	14	198.0	16.32	0.14	16.85	-0.01
		76	16	198.0	16.32	0.14	16.85	-0.01
		78	18	199.0	16.32	0.14	16.85	-0.01
		80	20	198.0	16.32	0.14	16.85	-0.01
		85	25	196.0	16.31	0.13	16.85	-0.01
		90	30	196.0	16.31	0.13	16.85	-0.01
		95	35	197.0	16.31	0.13	16.85	-0.01
		100	40	199.0	16.32	0.14	16.85	-0.01
		105	45	197.0	16.31	0.13	16.85	-0.01
		110	50	197.0	16.31	0.13	16.85	-0.01
		115	55	198.0	16.31	0.13	16.85	-0.01
	7:00	120	60	197.0	16.33	0.14	16.85	-0.01

Date 10-Oct-13

Step Drawdown Test Record

Site Name: Chenab Well Field Area, WASA Faisalabad	Well No: TW #23
Static Water Level: 16.18 m	

3rd Step		Discharge Rate (Q) 250 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
10-Oct-13	8:00	120	0	197.0	16.32	0.14	16.85	-0.01
		121	1	249.0	16.34	0.16	16.85	-0.01
		122	2	251.0	16.35	0.17	16.85	-0.01
		123	3	249.0	16.35	0.17	16.85	-0.01
		124	4	251.0	16.35	0.17	16.85	-0.01
		125	5	251.0	16.35	0.17	16.85	-0.01
		126	6	252.0	16.35	0.17	16.85	-0.01
		127	7	252.0	16.35	0.17	16.85	-0.01
		128	8	251.0	16.35	0.17	16.85	-0.01
		129	9	252.0	16.35	0.17	16.85	-0.01
		130	10	256.0	16.36	0.18	16.85	-0.01
		132	12	255.0	16.36	0.18	16.85	-0.01
		134	14	250.0	16.36	0.18	16.85	-0.01
		136	16	251.0	16.36	0.18	16.85	-0.01
		138	18	250.0	16.36	0.18	16.85	-0.01
		140	20	253.0	16.36	0.18	16.85	-0.01
		145	25	250.0	16.36	0.18	16.85	-0.01
		150	30	253.0	16.36	0.18	16.85	-0.01
		155	35	256.0	16.36	0.18	16.85	-0.01
		160	40	252.0	16.36	0.18	16.86	0.00
		165	45	251.0	16.36	0.18	16.86	0.00
		170	50	251.0	16.36	0.18	16.86	0.00
		175	55	249.0	16.36	0.18	16.86	0.00
	8:00	180	60	253.0	16.36	0.18	16.84	-0.02

Date 10-Oct-13

Step Drawdown Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #23
Static Water Level : 16.18 m	

4th Step		Discharge Rate (Q) : 300 m^3/hour						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
10-Oct-13	9:00	180	0	255.0	16.36	0.18	16.84	-0.02
		181	1	309.0	16.38	0.20	16.84	-0.02
		182	2	301.0	16.39	0.21	16.84	-0.02
		183	3	303.0	16.39	0.21	16.84	-0.02
		184	4	304.0	16.40	0.22	16.84	-0.02
		185	5	302.0	16.40	0.22	16.84	-0.02
		186	6	302.0	16.40	0.22	16.84	-0.02
		187	7	301.0	16.40	0.22	16.84	-0.02
		188	8	301.0	16.40	0.22	16.84	-0.02
		189	9	302.0	16.40	0.22	16.84	-0.02
		190	10	303.0	16.40	0.22	16.84	-0.02
		192	12	299.0	16.40	0.22	16.84	-0.02
		194	14	303.0	16.40	0.22	16.84	-0.02
		196	16	302.0	16.40	0.22	16.84	-0.02
		198	18	304.0	16.40	0.22	16.84	-0.02
		200	20	303.0	16.40	0.22	16.84	-0.02
		205	25	302.0	16.40	0.22	16.84	-0.02
		210	30	302.0	16.40	0.22	16.84	-0.02
		215	35	304.0	16.40	0.22	16.84	-0.02
		220	40	303.0	16.40	0.22	16.84	-0.02
		225	45	304.0	16.41	0.23	16.84	-0.02
		230	50	302.0	16.41	0.23	16.84	-0.02
		235	55	301.0	16.41	0.23	16.84	-0.02
	10:00	240	60	301.0	16.41	0.23	16.84	-0.02

Date 10-Oct-13

Step Drawdown Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #23
Static Water Level : 16.18 m	

5th Step		Discharge Rate (Q) : Maximum (Valve Full Opened)						
Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
10-Oct-13	10:00	240	0	301.0	16.41	0.23	16.84	-0.02
		241	1	480.0	16.51	0.33	16.84	-0.02
		242	2	482.0	16.53	0.34	16.84	-0.02
		243	3	482.0	16.54	0.36	16.84	-0.02
		244	4	482.0	16.54	0.36	16.84	-0.02
		245	5	482.0	16.54	0.36	16.84	-0.02
		246	6	482.0	16.54	0.36	16.84	-0.02
		247	7	482.0	16.55	0.37	16.84	-0.02
		248	8	482.0	16.55	0.37	16.84	-0.02
		249	9	482.0	16.55	0.37	16.84	-0.02
		250	10	482.0	16.55	0.37	16.84	-0.02
		252	12	482.0	16.55	0.37	16.84	-0.02
		254	14	482.0	16.55	0.37	16.84	-0.02
		256	16	482.0	16.55	0.37	16.84	-0.02
		258	18	482.0	16.55	0.37	16.84	-0.02
		260	20	482.0	16.55	0.37	16.84	-0.02
		265	25	482.0	16.56	0.38	16.84	-0.02
		270	30	440.0	16.53	0.35	16.84	-0.02
		275	35	482.0	16.56	0.38	16.83	-0.03
		280	40	482.0	16.56	0.38	16.83	-0.03
		285	45	484.0	16.56	0.38	16.83	-0.03
		290	50	485.0	16.57	0.39	16.83	-0.03
		295	55	483.0	16.57	0.39	16.83	-0.03
	11:00	300	60	480.0	16.57	0.39	16.83	-0.03

Date 10-Oct-13

Continuous Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #23
Static Water Level : 16.18 m	

Discharge Rate (Q) 400 m^3/hour

Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
10-Oct-13	12:00	0	0	0.0	16.18	0.00	16.83	0.00
		1	1	406.0	16.46	0.28	16.83	0.00
		2	2	408.0	16.47	0.29	16.83	0.00
		3	3	396.0	16.46	0.28	16.83	0.00
		4	4	400.0	16.46	0.28	16.83	0.00
		5	5	398.0	16.47	0.29	16.83	0.00
		6	6	400.0	16.47	0.29	16.83	0.00
		7	7	400.0	16.47	0.29	16.83	0.00
		8	8	400.0	16.47	0.29	16.83	0.00
		9	9	399.0	16.47	0.29	16.83	0.00
		10	10	380.0	16.47	0.29	16.83	0.00
		12	12	401.0	16.47	0.29	16.83	0.00
		14	14	397.0	16.47	0.29	16.83	0.00
		16	16	412.0	16.48	0.30	16.83	0.00
		18	18	406.0	16.48	0.30	16.83	0.00
		20	20	400.0	16.48	0.30	16.83	0.00
		25	25	402.0	16.48	0.30	16.83	0.00
		30	30	402.0	16.49	0.31	16.82	-0.01
		35	35	413.0	16.49	0.31	16.82	-0.01
		40	40	408.0	16.50	0.32	16.82	-0.01
		45	45	397.0	16.49	0.31	16.82	-0.01
		50	50	400.0	16.49	0.31	16.82	-0.01
		55	55	403.0	16.49	0.31	16.82	-0.01
	13:00	60	60	406.0	16.49	0.31	16.82	-0.01
		70	70	400.0	16.49	0.31	16.82	-0.01
		80	80	397.0	16.50	0.32	16.82	-0.01
		90	90	402.0	16.50	0.32	16.82	-0.01
		100	100	401.0	16.50	0.32	16.82	-0.01
		110	110	401.0	16.50	0.32	16.82	-0.01
	14:00	120	120	398.0	16.50	0.32	16.82	-0.01

Date 10-Oct-13

Continuous Test Record

Site Name : Chenab Well Field Area, WASA Faisalabad	Well No : TW #23
Static Water Level : 16.18 m	

Discharge Rate (Q) 400 m^3/hour

Date	Time	Elapsed time (min)	Time of each step (min)	Pumping rate (m^3/hour)	Water level s (m)	Drawdown ⊿s (m)	(TW #22) Water level s (m)	(TW #22) Drawdown ⊿s (m)
		120	120	398.0	16.50	0.32	16.82	-0.01
		140	140	400.0	16.51	0.32	16.82	-0.01
		160	160	398.0	16.51	0.32	16.82	-0.01
	15:00	180	180	397.0	16.51	0.32	16.82	-0.01
		200	200	401.0	16.52	0.34	16.82	-0.01
		220	220	402.0	16.52	0.34	16.81	-0.02
	16:00	240	240	400.0	16.52	0.34	16.81	-0.02

Date 15-Oct-13

Recovery Test Record

Site Name: Chanab Well Field Area, WASA Faisalabad			Well No: TW #23
Static Water Level	16.29	m	

Date	Time	Elapsed time (min) t	Recovery time for each step (min) t'	s/t'	Water level s (m)	Residual Drawdown s' (m)	(TW #22) Water level s (m)	(TW #22) Residual Drawdown s' (m)
10-Oct-13	16:00	240	0		16.52	0.34	16.81	-0.02
		241	1	241	16.29	0.11	16.81	-0.02
		242	2	121	16.28	0.09	16.81	-0.02
		243	3	81	16.25	0.07	16.81	-0.02
		244	4	61	16.25	0.07	16.81	-0.02
		245	5	49	16.24	0.06	16.81	-0.02
		246	6	41	16.24	0.06	16.81	-0.02
		247	7	35	16.24	0.06	16.81	-0.02
		248	8	31	16.24	0.06	16.81	-0.02
		249	9	28	16.23	0.05	16.81	-0.02
		250	10	25	16.23	0.05	16.81	-0.02
		252	12	21	16.23	0.05	16.81	-0.02
		254	14	18	16.22	0.04	16.81	-0.02
		256	16	16	16.22	0.04	16.81	-0.02
		258	18	14	16.22	0.04	16.81	-0.02
		260	20	13	16.22	0.04	16.81	-0.02
		265	25	11	16.21	0.03	16.81	-0.02
		270	30	9	16.21	0.03	16.81	-0.02
		275	35	8	16.20	0.02	16.81	-0.02
		280	40	7	16.20	0.02	16.81	-0.02
		285	45	6	16.20	0.02	16.81	-0.02
		290	50	6	16.20	0.02	16.81	-0.02
		295	55	5	16.19	0.01	16.81	-0.02
	17:00	300	60	5	16.19	0.01	16.81	-0.02

Date 11-Oct-13

Well Interference Test Record

Site Name: Chanab Well Field Area, WASA Faisalabad			Well No: TW #23		
Static Water Level TW #23	16.12	m	Static Water Level TW #22	16.80	m

Pattern 2

Date	Time	Elapsed time (min)	Time s/t' each step (min)	TW #23 Pumping rate (m^3/hour)	TW #23 Pumping water level s (m)	TW #23 Drawdown Δs (m)	TW #22 Pumping rate (m^3/hour)	TW #22 Pumping water level s (m)	TW #22 Drawdown Δs (m)	TW #21 Pumping rate (m^3/hour)
11-Oct-13	5:00	0	0	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		1	1	0.0	16.12	0.00	0.0	16.80	0.00	370.0
		2	2	0.0	16.12	0.00	0.0	16.80	0.00	403.0
		3	3	0.0	16.12	0.00	0.0	16.80	0.00	408.0
		4	4	0.0	16.12	0.00	0.0	16.80	0.00	403.0
		5	5	0.0	16.12	0.00	0.0	16.80	0.00	403.0
		6	6	0.0	16.12	0.00	0.0	16.80	0.00	405.0
		7	7	0.0	16.12	0.00	0.0	16.80	0.00	405.0
		8	8	0.0	16.12	0.00	0.0	16.80	0.00	408.0
		9	9	0.0	16.12	0.00	0.0	16.80	0.00	396.0
		10	10	0.0	16.12	0.00	0.0	16.80	0.00	417.0
		12	12	0.0	16.12	0.00	0.0	16.80	0.00	418.0
		14	14	0.0	16.12	0.00	0.0	16.80	0.00	418.0
		16	16	0.0	16.12	0.00	0.0	16.80	0.00	418.0
		18	18	0.0	16.12	0.00	0.0	16.80	0.00	397.0
		20	20	0.0	16.12	0.00	0.0	16.80	0.00	397.0
		25	25	0.0	16.12	0.00	0.0	16.80	0.00	415.0
		30	30	0.0	16.12	0.00	0.0	16.80	0.00	417.0
		35	35	0.0	16.12	0.00	0.0	16.80	0.00	416.0
		40	40	0.0	16.12	0.00	0.0	16.80	0.00	416.0
		45	45	0.0	16.12	0.00	0.0	16.80	0.00	416.0
		50	50	0.0	16.12	0.00	0.0	16.80	0.00	419.0
		55	55	0.0	16.12	0.00	0.0	16.80	0.00	402.0
	7:00	60	60	0.0	16.12	0.00	0.0	16.80	0.00	399.0

Date 11-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #23
Static Water Level TW #23 16.12 m	Static Water Level TW #22 16.80 m

Recovery

Date	Time	Elapsed time (min)	Time of each step (min)	TW #23 Pumping rate (m³/hour)	TW #23 Pumping water level s (m)	TW #23 Drawdown ⊿s (m)	TW #22 Pumping rate (m³/hour)	TW #22 Pumping water level s (m)	TW #22 Drawdown ⊿s (m)	TW #21 Pumping rate (m³/hour)
11-Oct-13	7:00	60	0	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		61	1	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		62	2	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		63	3	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		64	4	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		65	5	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		66	6	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		67	7	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		68	8	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		69	9	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		70	10	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		72	12	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		74	14	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		76	16	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		78	18	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		80	20	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		85	25	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		90	30	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		95	35	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		100	40	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		105	45	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		110	50	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		115	55	0.0	16.12	0.00	0.0	16.80	0.00	0.0
	8:00	120	60	0.0	16.12	0.00	0.0	16.80	0.00	0.0

Date 11-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No. TW #23
Static Water Level TW #23 16.12 m	Static Water Level TW #22 16.80 m

Pattern 3

Date	Time	Elapsed time (min)	Time of each step (min)	TW #23 Pumping rate (m³/hour)	TW #23 Pumping water level s (m)	TW #23 Drawdown ⊿s (m)	TW #22 Pumping rate (m³/hour)	TW #22 Pumping water level s (m)	TW #22 Drawdown ⊿s (m)	TW #21 Pumping rate (m³/hour)
11-Oct-13	8:00	120	0	0.0	16.12	0.00	0.0	16.80	0.00	0.0
		121	1	0.0	16.12	0.00	426.0	16.96	0.16	0.0
		122	2	0.0	16.12	0.00	420.0	16.99	0.19	0.0
		123	3	0.0	16.12	0.00	418.0	17.00	0.20	0.0
		124	4	0.0	16.12	0.00	415.0	17.02	0.22	0.0
		125	5	0.0	16.12	0.00	412.0	17.03	0.23	0.0
		126	6	0.0	16.12	0.00	410.0	17.03	0.23	0.0
		127	7	0.0	16.12	0.00	407.0	17.03	0.23	0.0
		128	8	0.0	16.12	0.00	407.0	17.03	0.23	0.0
		129	9	0.0	16.12	0.00	410.0	17.03	0.23	0.0
		130	10	0.0	16.12	0.00	409.0	17.03	0.23	0.0
		132	12	0.0	16.12	0.00	410.0	17.04	0.24	0.0
		134	14	0.0	16.12	0.00	407.0	17.04	0.24	0.0
		136	16	0.0	16.12	0.00	409.0	17.04	0.24	0.0
		138	18	0.0	16.11	-0.01	415.0	17.04	0.24	0.0
		140	20	0.0	16.11	-0.01	416.0	17.04	0.24	0.0
		145	25	0.0	16.11	-0.01	414.0	17.05	0.25	0.0
		150	30	0.0	16.11	-0.01	416.0	17.05	0.25	0.0
		155	35	0.0	16.11	-0.01	415.0	17.05	0.25	0.0
		160	40	0.0	16.11	-0.01	412.0	17.05	0.25	0.0
		165	45	0.0	16.12	-0.01	413.0	17.06	0.26	0.0
		170	50	0.0	16.12	-0.01	410.0	17.06	0.26	0.0
		175	55	0.0	16.12	-0.01	411.0	17.06	0.26	0.0
	9:00	180	60	0.0	16.12	-0.01	412.0	17.06	0.26	0.0

Date 11-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No TW #23
Static Water Level TW #23 16.12 m	Static Water Level TW #22 16.80 m

Pattern 4

Date	Time	Elapsed time	Time of each step	TW #23			TW #22			TW #21
				Pumping rate	Pumping water level	Drawdown	Pumping rate	Pumping water level	Drawdown	Pumping rate
		(min)	(min)	(m^3/hour)	s (m)	Δs (m)	(m^3/hour)	s (m)	Δs (m)	(m^3/hour)
11-Oct-13	9:00	180	0	0.0	16.12	-0.01	412.0	17.06	0.26	0.0
		181	1	0.0	16.15	-0.01	413.0	17.06	0.26	0.0
		182	2	0.0	16.12	-0.01	416.0	17.06	0.26	0.0
		183	3	0.0	16.13	0.01	417.0	17.03	0.37	0.0
		184	4	309.3	16.34	0.22	374.0	17.05	0.25	0.0
		185	5	433.0	16.40	0.28	385.0	17.05	0.25	0.0
		186	6	433.0	16.41	0.29	387.0	17.05	0.25	0.0
		187	7	433.0	16.41	0.29	387.0	17.05	0.25	0.0
		188	8	433.0	16.42	0.30	387.0	17.05	0.25	0.0
		189	9	433.0	16.43	0.31	385.0	17.05	0.25	0.0
		190	10	433.0	16.43	0.31	381.0	17.05	0.25	0.0
		192	12	433.0	16.44	0.32	382.0	17.05	0.25	0.0
		194	14	433.0	16.44	0.32	377.0	17.05	0.25	0.0
		196	16	433.0	16.44	0.32	384.0	17.05	0.25	0.0
		198	18	433.0	16.44	0.32	382.0	17.05	0.25	0.0
		200	20	433.0	16.45	0.32	383.0	17.05	0.25	0.0
		205	25	408.2	16.45	0.33	380.0	17.05	0.25	0.0
		210	30	445.4	16.46	0.34	375.0	17.05	0.25	0.0
		215	35	420.6	16.46	0.34	380.0	17.05	0.25	0.0
		220	40	420.6	16.46	0.34	382.0	17.05	0.25	0.0
		225	45	457.7	16.46	0.34	371.0	17.05	0.25	0.0
		230	50	408.2	16.47	0.35	381.0	17.05	0.25	0.0
		235	55	420.6	16.47	0.35	381.0	17.05	0.25	0.0
	10:00	240	60	433.0	16.47	0.35	381.0	17.05	0.25	0.0

Date 11-Oct-13

Well Interference Test Record

Site Name Chenab Well Field Area, WASA Faisalabad	Well No TW #23
Static Water Level TW #23 16.12 m	Static Water Level TW #22 16.80 m

Pattern 5

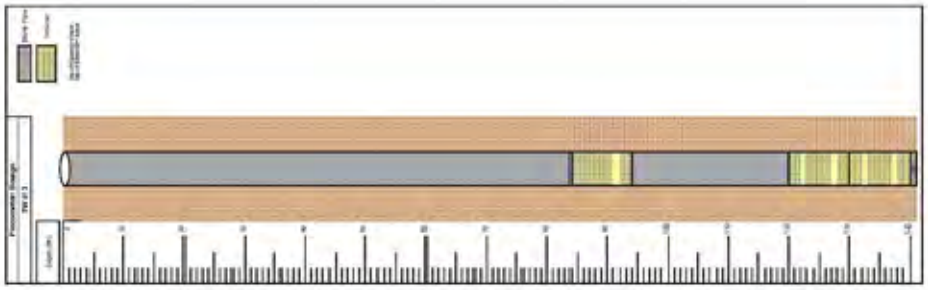
Date	Time	Elapsed time	Time of each step	TW #23			TW #22			TW #21
				Pumping rate	Pumping water level	Drawdown	Pumping rate	Pumping water level	Drawdown	Pumping rate
		(min)	(min)	(m^3/hour)	s (m)	Δs (m)	(m^3/hour)	s (m)	Δs (m)	(m^3/hour)
11-Oct-13	10:00	240	0	433.0	16.47	0.35	381.0	17.05	0.25	387.0
		241	1	433.0	16.47	0.35	381.0	17.06	0.26	393.0
		242	2	433.0	16.47	0.35	381.0	17.06	0.26	391.0
		243	3	464.8	16.47	0.35	384.0	17.06	0.26	392.0
		244	4	433.0	16.47	0.35	381.0	17.06	0.26	395.0
		245	5	371.1	16.47	0.35	379.0	17.05	0.26	397.0
		246	6	433.0	16.48	0.36	375.0	17.05	0.25	391.0
		247	7	433.0	16.47	0.34	329.0	17.04	0.24	394.0
		248	8	433.0	16.46	0.34	339.0	17.04	0.24	394.0
		249	9	371.1	16.46	0.34	345.0	17.04	0.24	390.0
		250	10	433.0	16.46	0.34	350.0	17.04	0.24	352.0
		252	12	402.1	16.46	0.34	348.0	17.04	0.24	391.0
		254	14	402.1	16.46	0.34	346.0	17.04	0.24	392.0
		256	16	402.1	16.46	0.34	355.0	17.04	0.24	394.0
		258	18	433.0	16.46	0.34	359.0	17.04	0.24	393.0
		260	20	402.1	16.47	0.24	387.0	17.04	0.24	395.0
		265	25	408.2	16.47	0.35	371.0	17.04	0.24	393.0
		270	30	408.2	16.47	0.35	369.0	17.04	0.24	394.0
		275	35	420.6	16.47	0.35	374.0	17.04	0.24	394.0
		280	40	408.2	16.47	0.35	380.0	17.05	0.25	397.0
		285	45	408.2	16.48	0.36	382.0	17.05	0.25	395.0
		290	50	420.6	16.48	0.36	365.0	17.05	0.25	391.0
		295	55	408.2	16.48	0.36	370.0	17.04	0.24	392.0
	11:00	300	60	420.6	16.48	0.36	358.0	17.04	0.24	391.0

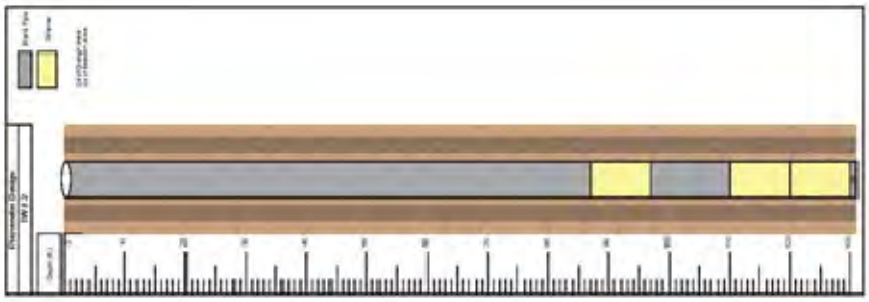
APPENDIX-B

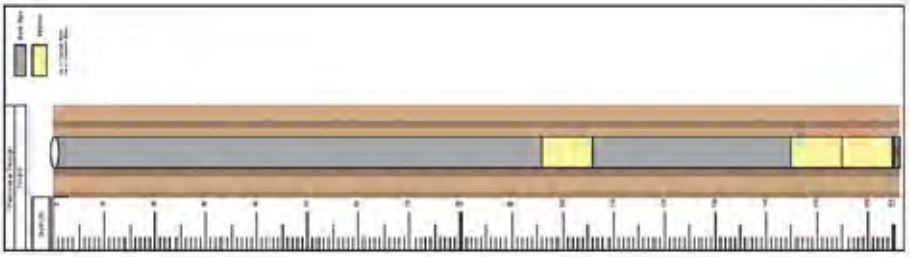
DESIGN & INSTALLATION OF PIEZOMETER

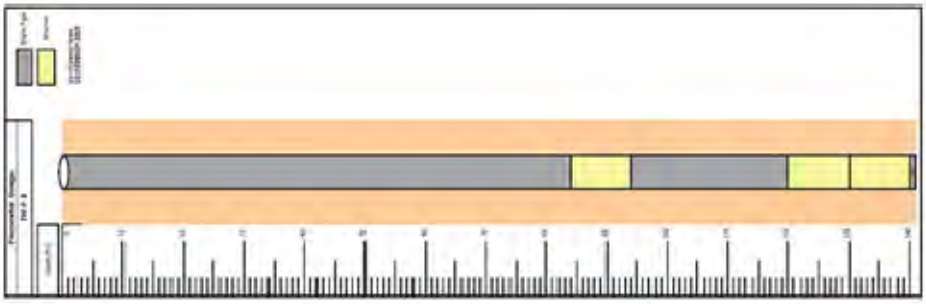
DESIGN & INSTALLATION OF PIEZOMETER

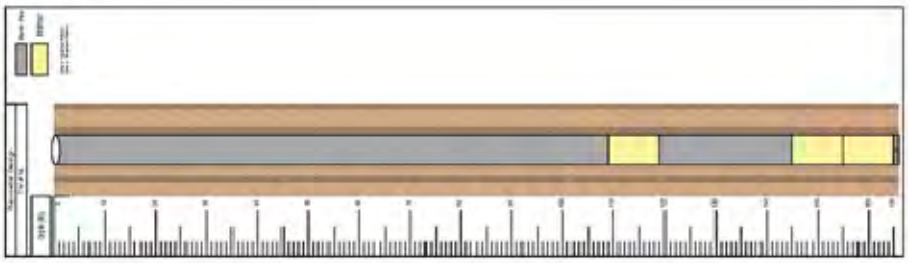
KSB installed each one (1) Piezometer at TW#2, TW#3, TW#8, TW#9, TW#13, TW#14, TW#22 and TW#23 as per required specifications in order to measure water level during pumping test.

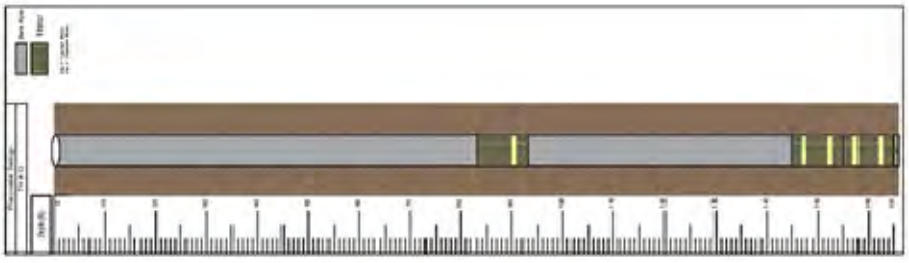


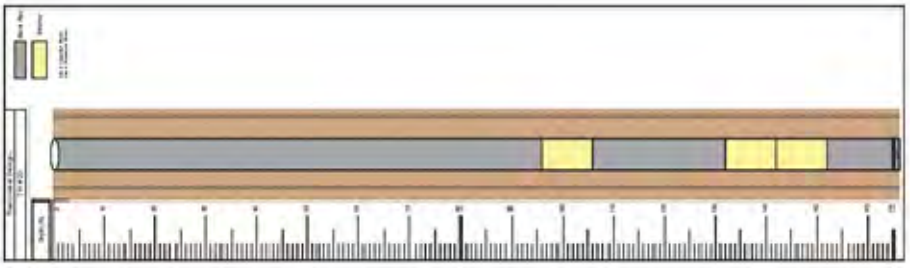


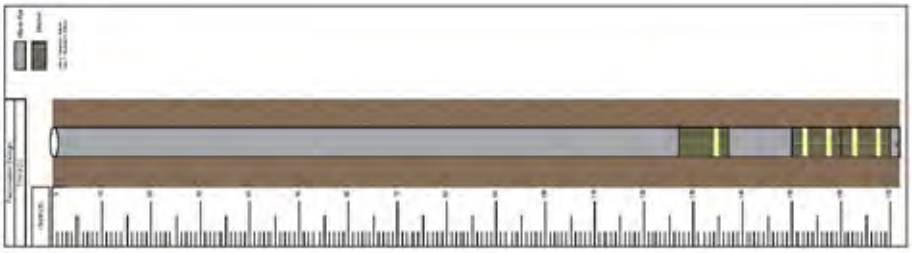












(4) Meteorological Survey Result

1) Air Temperature

a) Daily Maximum Temperature (deg C)

Yr/mth \ Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2007	Jan	22.0	21.5	21.0	19.0	20.0	19.5	20.0	20.0	20.0	20.5	17.5	20.0	20.0	19.5	19.0	19.0	19.0	19.0	19.0	19.0	19.0	20.0	20.0	21.0	21.0	20.0	24.5	24.0	25.0	26.0	26.0	20.7
	Feb	25.5	25.0	26.0	25.0	25.0	22.0	20.0	23.0	22.5	19.0	18.5	19.0	15.0	16.5	17.0	18.0	18.0	19.0	20.0	18.0	20.0	20.5	22.0	22.0	23.0	23.0	22.0	17.0				20.8
	Mar	19.0	20.0	23.0	23.0	24.0	22.0	25.5	27.0	29.0	20.0	22.0	17.5	18.0	20.5	21.0	22.5	23.5	26.0	27.0	27.0	26.0	23.0	27.0	29.0	30.0	30.0	30.0	30.5	33.0	34.5	35.0	25.3
	Apr	32.5	31.5	30.0	29.5	32.5	32.5	32.5	33.5	34.0	35.0	36.5	37.5	39.5	40.5	40.5	41.5	42.0	39.5	37.5	38.0	38.0	38.5	39.0	40.0	39.0	39.0	41.0	41.5	43.0	44.0		37.5
	May	45.0	45.0	44.0	37.5	38.0	40.5	41.0	41.5	39.5	37.0	40.5	39.0	40.0	41.5	45.0	42.0	41.5	42.0	41.0	40.0	40.0	39.0	41.0	39.5	39.0	36.5	37.0	36.0	39.5	38.0	39.5	40.2
	Jun	40.5	43.0	43.0	41.0	40.0	41.5	40.5	42.5	45.5	48.5	48.5	45.5	43.0	43.0	43.0	35.0	35.0	31.0	35.0	34.5	37.0	39.0	38.5	37.5	39.0	40.0	36.0	37.0	39.0	32.5		39.8
	Jul	40.5	36.0	36.0	35.5	35.5	40.0	37.5	34.5	33.0	35.5	38.0	38.5	40.0	35.0	36.0	32.0	35.5	36.5	37.0	37.0	36.0	36.0	34.0	34.0	33.5	38.0	37.0	38.0	37.5	37.5	36.5	36.4
	Aug	39.0	39.0	36.5	36.5	37.0	35.0	33.0	36.0	37.5	36.0	38.0	38.5	38.0	37.5	37.0	36.0	38.5	37.5	38.0	38.5	34.5	38.0	37.5	36.5	37.5	37.5	38.0	37.5	39.0	36.5	36.5	37.2
	Sep	37.0	35.5	36.0	36.5	39.0	34.0	31.0	34.0	35.0	36.5	36.5	32.5	34.5	34.5	35.0	35.5	35.5	36.5	37.0	37.0	37.0	36.5	28.0	30.0	34.5	34.0	36.0	36.0	33.5	34.5		35.0
	Oct	34.0	35.0	34.5	34.5	24.5	34.5	34.5	34.0	34.0	34.0	34.5	33.0	34.0	33.0	34.0	33.0	34.0	32.5	32.0	32.0	31.5	31.0	30.5	32.0	32.5	33.0	32.5	33.0	31.5	31.5	31.5	32.8
	Nov	31.0	30.5	31.5	31.5	30.0	29.0	30.0	29.5	30.0	29.0	27.0	28.0	27.0	26.5	26.5	26.0	26.5	26.5	26.0	26.0	25.0	26.5	26.5	26.5	26.0	25.5	25.0	24.0	26.0	23.5		27.4
	Dec	21.5	22.0	22.0	22.5	23.0	21.5	20.5	20.5	20.0	19.0	19.0	17.0	17.0	19.0	19.0	20.5	20.0	21.5	18.5	19.0	21.5	22.5	23.0	24.0	24.5	24.0	21.0	20.5	20.0	19.0	19.0	20.7

Yr/mth \ Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2008	Jan	19.0	19.5	18.5	18.0	19.0	15.0	18.5	18.5	14.0	17.0	16.0	16.0	18.0	18.5	19.0	21.5	17.0	13.0	16.0	17.5	16.5	15.0	15.0	14.5	17.0	14.5	15.5	16.0	17.0	19.0	19.0	17.0
	Feb	18.5	19.0	16.0	13.5	14.5	16.0	16.0	11.5	14.5	16.0	19.0	19.5	19.0	19.5	22.5	24.0	23.5	23.0	24.0	26.0	27.0	21.0	20.5	22.0	23.5	23.0	25.5	28.0	29.5			20.5
	Mar	29.5	28.0	28.5	29.0	28.0	30.0	30.0	28.0	27.5	29.0	29.5	29.0	30.0	30.0	30.0	31.0	33.0	33.5	33.0	33.0	31.5	30.5	31.0	32.0	33.0	33.0	32.5	34.0	32.5	34.0	35.0	30.9
	Apr	30.0	32.0	31.5	22.5	26.0	25.0	25.0	29.0	32.5	31.5	31.5	32.0	33.5	31.5	31.5	31.5	28.5	31.0	34.0	36.5	36.5	37.5	40.0	37.5	40.0	40.0	39.5	38.5	41.0	41.5		33.3
	May	43.0	42.0	43.0	44.0	42.5	41.0	38.5	40.5	36.0	33.5	37.0	39.0	40.0	38.0	37.0	40.0	42.0	43.0	42.0	38.5	36.0	36.5	33.5	36.5	35.0	33.0	33.5	32.0	35.5	39.0	40.0	38.4
	Jun	41.0	39.0	36.5	40.5	41.5	41.0	40.0	40.0	40.5	37.5	36.0	38.5	39.5	39.5	40.5	38.5	34.5	40.0	36.0	37.0	31.5	39.0	35.0	38.0	38.5	40.0	42.0	39.0	37.0	34.5		38.4
	Jul	36.5	37.0	40.0	41.0	39.0	39.0	37.5	35.5	36.0	34.0	37.0	37.5	31.5	34.5	35.0	38.5	39.0	38.0	38.5	39.0	37.0	34.5	36.0	38.0	38.5	38.5	39.0	40.5	37.0	39.0	40.0	37.5
	Aug	36.0	29.0	34.5	34.5	33.5	29.5	33.5	36.0	35.5	34.0	35.0	35.0	30.0	32.0	33.5	33.0	33.5	33.5	37.0	36.0	36.5	37.0	38.0	38.0	38.0	40.0	39.5	39.0	37.0	36.0	34.0	35.1
	Sep	32.5	34.0	36.5	36.5	37.0	37.5	30.0	30.0	33.5	35.0	36.0	36.0	37.0	37.5	38.0	36.0	37.0	33.0	34.0	34.0	33.0	34.0	33.0	30.0	31.5	33.5	34.5	34.0	31.0	36.0		34.4
	Oct	36.0	36.5	37.5	36.5	36.0	36.0	33.5	34.5	34.0	34.0	35.0	35.0	36.0	36.0	34.0	28.0	29.5	30.5	32.5	30.5	32.0	32.0	32.5	32.5	32.0	32.0	31.5	29.5	31.5	30.0	29.5	33.1
	Nov	30.0	32.0	32.5	32.0	32.0	31.5	31.5	31.0	30.5	31.0	29.5	30.0	28.0	26.0	23.5	23.0	23.5	24.0	24.0	25.5	21.5	24.0	24.5	24.5	25.5	25.0	25.0	24.5	26.0	27.0		27.3
	Dec	27.0	26.0	24.5	24.0	25.0	19.0	25.0	24.0	21.0	22.0	22.0	23.0	21.5	22.5	22.0	21.5	20.0	24.0	27.5	20.0	20.0	21.0	21.0	21.5	22.0	21.5	20.5	19.0	19.0	15.0	18.0	21.9

Yr/mth \ Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2009	Jan	21.0	22.0	22.0	18.0	17.5	18.0	18.0	17.5	18.0	17.0	20.5	20.0	20.0	20.5	22.0	20.0	15.0	19.5	17.5	18.0	19.5	21.0	22.0	22.0	23.0	19.5	16.5	19.5	21.0	22.0	21.0	19.6
	Feb	23.0	23.0	22.0	23.0	23.5	19.5	20.0	20.5	22.5	20.0	18.5	20.0	21.0	22.0	21.0	20.5	21.5	22.5	23.0	20.0	22.0	25.0	22.0	26.0	24.0	24.5	24.0	25.0				22.1
	Mar	25.0	27.0	27.5	26.0	28.0	27.5	29.0	26.0	28.0	25.0	27.0	27.5	28.5	31.0	30.0	29.5	31.0	29.5	31.0	30.0	29.0	28.0	28.0	29.0	24.5	24.5	27.0	22.5	21.0	27.0	27.5	27.5
	Apr	29.5	34.0	30.5	31.5	30.5	30.0	25.0	29.5	23.5	26.0	30.0	33.5	35.0	35.0	37.0	32.0	33.0	34.0	36.0	39.0	37.5	34.5	35.0	35.0	35.0	37.0	38.5	38.5	38.5	39.5		33.5
	May	40.5	41.5	40.5	39.0	32.0	31.0	32.5	36.0	37.0	40.0	37.0	37.5	39.0	42.0	43.0	41.0	42.0	43.0	44.0	45.0	41.5	44.0	43.0	42.0	42.0	42.0	37.0	40.0	43.0	43.0	40.0	40.1
	Jun	39.0	38.5	40.5	40.0	42.0	41.0	38.0	40.5	41.5	41.5	42.5	42.0	41.0	41.5	37.0	35.0	34.0	36.0	39.5	40.5	41.5	42.0	45.0	45.0	43.5	37.0	43.5	45.0	45.0	43.0		40.7
	Jul	37.0	35.0	36.0	34.0	37.0	39.5	42.0	43.0	43.5	40.0	38.0	38.0	40.0	39.5	32.0	39.0	39.0	41.0	38.0	39.0	40.0	40.0	38.0	31.0	37.0	39.5	39.5	38.0	35.5	32.5	36.0	38.0
	Aug	38.5	39.0	39.5	39.5	39.0	39.5	38.5	37.5	40.0	39.0	40.0	40.0	41.0	39.0	37.0	37.0	36.0	33.5	33.0	32.0	36.0	26.5	34.0	33.5	34.0	38.0	30.0	34.0	35.0	39.0	36.5	36.6
	Sep	30.0	34.5	34.5	34.5	31.5	34.0	34.0	35.5	35.0	35.0	36.0	33.0	34.0	37.0	36.0	36.0	37.0	38.5	40.0	38.5	38.5	38.5	38.5	41.5	41.0	38.0	35.0	37.0	36.0	39.0		36.3
	Oct	38.0	37.0	36.0	37.0	28.5	31.0	32.0	32.0	35.0	33.0	34.0	34.0	34.5	34.0	35.0	34.0	34.0	32.0	32.0	32.5	32.0	30.0	30.5	31.0	31.0	31.0	31.0	30.0	31.0	30.0	30.0	32.7
	Nov	32.0	31.0	30.0	29.0	29.0	28.0	29.0	28.0	25.0	23.0	24.0	25.0	26.5	23.5	25.5	25.0	25.5	25.0	24.0	24.0	24.0	24.0	24.0	22.5	24.5	25.0	23.5	22.5	24.0	24.5		25.7
	Dec	25.5	23.0	25.0	26.5	26.0	22.5	22.5	23.0	25.5	24.0	21.0	22.0	20.5	22.0	20.0	22.0	22.0	23.0	22.0	22.0	20.5	21.5	21.5	22.5	21.0	21.5	20.0	20.0	18.0	18.0	19.5	22.1

Yr/mth \ Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2010	Jan	21.0	21.0	20.5	17.0	17.5	15.0	11.5	11.5	14.0	14.0	13.5	12.5	10.0	18.0	16.5	18.0	19.0	14.5	12.5	1.5	13.5	12.0	16.5	16.5	17.0	20.0	21.5	23.0	22.5	21.0	21.0	16.2
	Feb	21.0	21.5	21.5	22.0	22.0	20.5	20.0	17.0	17.5	17.0	18.5	20.0	21.0	20.5	22.0	22.0	19.0	21.5	22.0	23.5	24.0	26.5	25.5	26.0	26.5	25.0	26.0	26.0				22.0
	Mar	28.0	28.0	27.0	20.0	23.0	25.0	20.0	23.0	26.0	27.5	28.0	29.0	28.5	29.5	31.5	33.0	33.0	33.0	33.0	32.5	35.0	35.0	36.0	35.0	34.5	36.0	34.5	34.0	35.0	35.5	34.5	30.4
	Apr	34.0	35.0	32.5	36.0	35.0	35.0	36.5	38.0	40.0	39.0	39.5	40.5	38.0	40.0	41.5	43.0	42.0	43.0	40.0	40.0	38.0	37.0	35.0	37.5	38.0	41.0	41.0	39.0	39.5	38.0		38.4
	May	35.5	38.5	42.0	43.5	43.5	32.0	33.0	38.5	37.0	38.0	40.0	39.0	41.0	38.0	41.0	42.5	44.0	40.0	36.0	39.0	41.0	45.5	45.5	45.5	45.0	45.0	48.5	46.0	38.0	40.0	40.0	40.7
	Jun	43.0	43.0	43.0	38.0	39.0	37.0	38.5	35.5	35.0	37.0	38.0	40.5	41.5	42.0	34.0	36.0	38.5	40.0	42.0	45.0	46.0	47.0	42.0	40.0	40.0	37.0	40.5	42.0	42.5	40.5		40.1
	Jul	37.0	40.0	36.0	40.0	40.0	36.0	36.0	36.5	39.0	41.5	42.0	37.5	32.0	33.5	35.5	39.0	39.5	38.5	37.5	36.5	27.5	30.0	30.0	33.5	35.0	40.0	36.5	31.5	30.5	32.5	34.5	36.0
	Aug	39.0	36.0	34.5	34.5	36.0	35.0	32.0	37.0	33.5	35.0	36.5	34.0	35.0	36.0	34.5	33.0	32.5	35.5	35.0	35.0	36.3	37.0	37.0	36.0	36.0	30.0	30.0	34.5	35.0	36.0	35.0	34.9
	Sep	35.0	36.0	38.0	36.0	34.0	35.0	35.0	37.0	32.5	34.5	35.0	36.0	33.5	34.5	31.0	32.5	34.0	33.0	32.0	31.0	32.0	29.0	32.5	32.5	32.0	33.0	35.5	36.0	35.5	34.5		33.9
	Oct	35.5	35.0	35.5	36.0	35.5	35.0	35.0	35.0	34.0	34.0	33.5	32.5	34.0	35.0	35.0	35.0	35.0	34.0	32.5	33.0	33.0	32.5	28.0	29.0	28.0	30.0	31.0	29.0	29.5	30.0	29.5	32.9
	Nov	30.5	30.0	29.0	29.0	29.5	29.5	30.5	28.0	30.0	28.0	28.5	27.0	27.0	27.0	26.5	27.5	27.0	28.0	26.5	26.5	26.5	26.5	23.0	24.0	24.5	25.0	26.0	24.0	24.0	23.5		27.1
	Dec	24.0	24.0	23.0	23.0	21.0	21.0	24.0	21.0	20.0	20.5	20.0	23.0	20.0	21.0	21.0	21.0	20.0	20.0	19.5	20.0	20.5	22.0	19.0	18.5	20.0	21.0	20.0	19.0	21.0	19.0	17.0	20.8

Yr/mth \ Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2011	Jan	15.0	16.0	10.0	10.0	10.5	10.0	10.5	10.0	10.0	12.0	14.0	17.0	20.0	20.0	15.0	15.0	15.5	15.5	16.5	18.5	18.0	19.5	19.5	20.5	20.0	18.5	19.0	20.0	20.5	17.5	18.5	15.9
	Feb	21.0	21.5	24.0	24.0	22.0	22.0	21.0	19.0	18.0	19.5	22.0	22.0	19.5	18.5	19.0	19.5	19.5	20.0	20.0	19.0	14.5	19.5	20.5	19.0	20.5	20.0	20.0	19.5				20.2
	Mar	16.0	17.5	14.0	18.0	20.0	22.0	23.0	23.5	23.0	26.0	26.0	26.0	28.0	28.0	29.5	29.5	29.5	31.0	28.0	29.0	29.0	30.0	30.5	30.0	30.0	31.0	33.0	33.0	27.5	28.0	28.0	26.4
	Apr	30.0	28.5	26.0	28.0	29.0	28.0	27.0	29.0	31.0	29.5	27.0	23.0	29.0	32.0	35.5	33.0	28.5	28.5	31.0	30.5	33.0	33.5	35.0	38.0	39.0	40.0	40.0	39.0	40.0	39.0		32.0
	May	39.0	39.0	40.5	43.0	42.0	40.0	34.0	36.5	40.0	41.0	40.0	41.5	41.0	40.5	41.0	44.0	43.5	45.0	46.5	46.0	40.0	39.0	34.0	38.0	40.0	42.0	40.5	39.0	40.5	43.0	40.0	40.6
	Jun	41.0	28.0	34.0	38.5	40.5	43.0	44.0	44.0	40.5	39.0	38.0	40.0	38.5	41.0	43.0	40.0	40.0	38.0	32.0	39.0	32.0	39.0	39.5	41.0	42.0	40.5	38.0	37.0	33.0	33.0		38.6
	Jul	36.0	28.0	33.0	31.5	34.0	37.5	37.0	32.0	30.0	32.0	34.5	36.5	38.5	39.0	34.0	31.5	31.0	35.0	36.5	36.5	39.0	36.5	38.0	38.5	35.0	35.0	35.0	37.0	32.0	34.0	33.0	34.7
	Aug	36.0	38.0	38.5	37.5	35.0	35.0	35.5	35.0	29.0	32.5	35.0	34.0	32.0	29.5	33.5	33.0	30.0	31.5	34.5	35.0	32.0	36.0	36.0	38.5	33.0	33.0	34.5	36.5	30.0	33.5	35.0	34.1
	Sep	36.0	33.0	35.0	36.5	36.0	30.0	30.5	31.0	32.0	33.0	32.0	34.0	34.0	35.0	32.5	33.0	24.5	30.0	31.5	30.5	31.5	34.5	34.5	34.0	34.5	34.5	33.5	34.0	33.5	33.0		32.9
	Oct	34.0	35.5	35.0	34.5	34.0	34.5	33.5	33.0	33.0	33.0	33.0	34.0	34.0	34.0	34.0	33.0	33.5	33.5	32.5	33.0	33.0	32.0	29.0	24.5	28.0	28.0	29.0	30.0	30.0	30.0	30.5	32.2
	Nov	30.0	29.5	29.5	31.0	29.0	31.5	32.0	30.0	30.0	25.0	29.0	30.0	30.5	28.5	27.5	28.0	26.0	28.0	27.0	27.0	27.5	26.5	26.5	26.0	25.0	25.0	24.5	23.0	22.0	24.0		27.6
	Dec	25.0	23.0	23.0	28.0	27.0	26.0	25.0	22.0	22.0	22.0	22.0	22.0	22.0	20.0	22.0	20.0	19.0	19.0	20.0	19.0	17.0	17.0	17.5	17.5	18.0	18.0	20.0	18.0	16.0	19.5	20.0	20.9

Yr/mth \ Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2012	Jan	19.0	19.5	19.0	19.0	18.0	18.0	15.0	14.5	14.0	15.0	15.0	16.0	18.0	18.5	17.5	17.0	16.5	17.0	17.0	16.5	15.0	15.0	15.0	17.0	16.5	20.0	19.0	18.5	20.0	20.0	20.0	17.3
	Feb	19.5	20.0	21.0	19.0	10.0	16.5	18.0	15.0	19.0	21.0	18.5	18.0	20.0	19.5	17.0	16.5	17.5	17.0	18.5	19.0	20.0	18.0	18.5	18.0	18.0	18.0	21.0	22.0	22.0			18.4
	Mar	24.0	24.5	24.5	26.0	25.0	23.5	24.0	24.0	21.0	22.0	25.0	25.0	21.0	22.0	22.0	25.5	27.5	29.0	30.0	32.0	19.5	22.0	28.0	29.0	29.0	30.0	30.0	28.0	28.0	30.0	33.0	25.9
	Apr	33.0	33.5	34.0	34.0	36.0	36.0	35.0	35.0	35.0	35.0	33.5	30.0	31.0	31.0	31.0	32.0	29.5	31.0	32.0	32.0	33.0	33.0	33.5	32.0	32.0	32.0	32.0	31.0	31.0	32.0		32.7
	May	34.0	35.0	35.0	35.0	38.0	38.0	38.0	38.0	40.0	39.5	40.0	36.0	36.5	37.0	39.0	41.0	40.0	40.0	39.0	40.0	39.5	39.0	40.0	41.0	38.0	39.0	40.0	41.0	43.0	44.0	46.0	38.9
	Jun	45.0	45.0	43.0	45.0	43.0	42.0	38.0	39.0	40.0	40.0	39.0	41.0	40.0	39.0	43.0	44.0	44.0	44.0	45.0	44.0	44.0	44.0	43.5	44.0	43.0	39.0	40.0	40.0	41.0	39.0		42.0
	Jul	43.0	43.0	44.0	46.0	45.0	42.0	42.0	38.5	37.0	36.5	36.5	38.5	39.0	35.5	34.0	34.0	38.0	39.0	38.5	38.0	38.0	38.0	38.0	40.0	39.5	38.0	40.0	38.5	38.0	41.0	40.0	39.1
	Aug	40.0	39.0	38.0	37.0	36.0	33.0	35.0	39.0	38.0	37.0	36.0	34.0	34.0	36.0	33.0	32.0	33.0	38.5	38.0	39.0	36.5	39.0	39.0	38.0	36.0	35.0	35.0	34.0	33.0	35.0	36.0	36.2
	Sep	34.0	36.0	37.0	35.0	33.0	30.0	27.0	32.0	30.0	30.0	33.0	34.0	35.0	35.0	34.0	33.0	30.0	27.0	30.0	31.0	34.0	35.0	35.0	35.0	35.0	35.0	35.0	33.0	33.5	35.0		33.1
	Oct	36.0	35.0	35.0	35.0	33.0	33.0	34.0	33.0	32.0	32.0	32.0	31.0	31.0	32.0	32.0	20.0	26.0	28.0	29.0	28.0	27.0	27.0	28.0	26.0	28.0	29.0	29.0	29.0	28.5	28.5	28.0	30.2
	Nov	28.0	28.0	28.0	28.0	28.0	27.0	27.0	26.0	26.0	26.0	25.0	25.0	25.0	24.0	24.0	24.0	24.0	24.0	24.5	24.0	24.0	23.0	23.0	23.0	23.0	23.0	22.0	22.0	22.0	23.0		24.8
	Dec	21.0	21.0	21.0	21.0	22.0	23.0	23.0	24.0	25.0	24.0	23.0	18.0	18.0	18.0	14.0	17.0	18.0	17.5	18.0	19.0	19.0	19.0	19.0	20.0	20.0	20.0	14.5	11.0	11.0	11.5	11.5	18.8

b) Daily Minimum Temperature (deg C)

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2007	Jan	5.0	4.0	1.5	2.0	2.0	1.0	1.0	0.8	0.5	1.5	3.0	4.0	3.0	3.0	5.0	3.5	3.0	3.0	4.0	6.0	6.0	5.0	4.0	5.0	5.0	8.0	10.0	7.0	9.5	10.5	8.0	4.3
	Feb	8.0	9.5	10.0	9.5	10.0	11.0	10.0	11.0	14.0	14.0	12.0	12.0	11.0	10.5	9.0	8.0	8.5	8.5	8.0	8.0	8.0	9.0	8.0	10.0	11.0	11.0	14.0	13.0				10.2
	Mar	12.0	10.0	12.0	12.0	11.5	11.0	11.5	10.5	15.0	11.0	13.5	13.5	10.0	9.5	9.5	10.0	14.5	14.0	11.0	15.0	16.0	12.0	14.5	16.0	14.0	14.0	15.0	16.0	18.0	20.0	22.0	13.4
	Apr	20.0	24.0	14.0	16.0	17.0	17.5	18.0	19.5	20.0	20.0	20.0	20.5	20.5	20.0	20.0	23.0	22.5	25.0	22.5	21.5	23.0	23.5	22.0	22.0	20.0	21.0	21.0	22.0	24.0	24.5		20.8
	May	24.0	24.0	26.0	22.5	25.0	26.0	25.5	27.0	25.0	24.0	21.5	23.0	26.0	27.0	28.0	28.5	28.5	30.0	26.0	25.0	23.0	25.0	27.0	23.0	26.0	24.0	24.0	22.5	23.5	24.0	26.0	25.2
	Jun	26.0	27.0	24.0	29.0	27.0	28.5	28.0	31.5	32.0	33.0	33.0	32.0	31.0	33.0	28.0	23.0	23.0	24.0	25.0	27.0	26.0	29.0	29.0	23.0	31.0	30.0	29.0	30.0	25.0	25.5		28.1
	Jul	27.0	26.0	28.0	28.0	28.5	30.0	31.0	25.0	26.5	27.5	30.0	29.5	23.0	23.0	21.5	24.5	27.0	29.0	29.5	29.0	30.0	26.0	25.0	29.0	26.5	30.0	27.0	28.5	27.0	29.5	28.0	27.4
	Aug	31.0	30.0	27.0	28.0	26.0	28.0	25.5	29.0	30.0	29.0	30.5	30.0	26.0	28.5	28.0	29.0	27.0	31.0	28.0	28.0	27.0	28.0	26.5	27.5	28.0	27.5	28.0	28.0	29.0	24.5	28.0	28.1
	Sep	28.5	28.5	28.0	29.0	30.0	26.0	22.5	25.0	25.5	26.0	22.0	23.5	24.0	26.0	26.0	27.0	28.0	27.0	26.5	28.0	26.0	26.0	21.0	24.5	23.0	23.0	24.0	22.0	22.0	23.0		25.4
	Oct	21.0	20.0	21.0	21.0	19.0	18.0	18.0	17.0	17.0	15.0	16.0	16.0	17.0	16.0	15.0	15.0	15.5	17.0	16.0	18.5	16.0	18.0	16.0	16.0	17.0	17.0	17.0	16.0	15.0	14.0	13.0	16.9
	Nov	13.0	13.0	14.5	13.0	14.5	14.0	18.0	17.0	15.0	14.0	14.5	14.0	14.0	14.5	14.5	13.5	12.0	12.5	12.0	12.5	11.0	11.5	11.0	11.0	12.0	11.5	12.0	13.0	12.0	13.0		13.3
	Dec	12.0	12.0	11.5	8.5	8.0	7.5	8.0	6.5	9.0	13.0	8.0	9.5	7.0	7.0	7.0	6.0	5.5	7.0	4.5	6.0	6.5	6.0	5.5	6.5	6.0	5.0	5.5	5.0	4.0	4.0	3.0	7.1

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2008	Jan	3.0	3.0	2.5	3.0	7.0	5.5	8.0	10.0	11.0	10.5	5.0	6.0	4.0	6.0	4.0	9.0	11.0	7.5	0.0	0.0	(0.5)	(1.0)	(0.5)	(2.0)	(1.5)	(3.0)	0.0	4.0	2.0	1.0	0.5	3.7
	Feb	0.0	3.5	5.0	7.0	2.0	5.0	9.0	7.5	2.0	3.0	0.5	1.5	2.5	3.5	4.5	7.0	8.0	8.0	8.0	6.0	9.5	8.0	8.5	7.5	6.5	8.0	7.5	8.0	9.5			5.7
	Mar	11.5	12.5	13.5	14.0	12.5	12.0	14.5	12.0	12.5	12.5	13.0	14.0	13.5	15.0	15.0	14.0	17.0	18.0	14.5	14.5	14.5	13.5	14.0	16.0	16.0	16.0	17.0	18.0	15.5	15.5	18.0	14.5
	Apr	17.0	19.0	15.0	13.5	14.5	13.0	16.0	20.0	18.0	19.5	19.0	19.0	20.0	20.0	20.0	15.5	15.0	16.0	18.0	20.0	20.0	27.5	21.0	21.5	20.5	22.0	20.0	19.5	21.5	21.5		18.8
	May	23.0	25.0	23.0	25.0	27.0	24.5	24.0	26.0	21.0	22.0	22.0	24.0	26.0	18.0	25.0	25.0	25.0	25.5	28.0	27.0	25.0	21.0	24.5	23.0	22.0	19.0	24.5	21.0	23.0	25.0	25.5	23.9
	Jun	28.0	28.0	26.5	28.0	30.0	32.0	30.0	29.5	28.5	27.5	23.0	28.0	29.0	25.0	28.5	27.0	27.0	28.0	23.0	24.0	23.5	24.0	28.0	28.5	29.5	30.5	32.0	28.0	27.0	21.5		27.4
	Jul	27.0	29.0	31.0	31.5	30.5	28.5	26.0	29.5	26.0	27.0	28.5	23.0	23.0	24.0	27.0	30.0	30.0	30.0	30.0	30.5	24.5	24.0	28.5	29.0	30.0	28.0	30.0	30.0	29.0	30.5	30.5	28.3
	Aug	26.0	25.5	28.0	26.5	24.0	26.5	28.0	28.5	27.0	27.0	28.0	24.0	23.0	26.5	25.5	27.0	26.5	26.0	27.0	29.0	28.0	28.0	27.5	28.0	27.0	27.0	27.5	28.5	27.5	28.0	23.0	26.8
	Sep	24.0	25.5	26.5	26.5	27.0	20.0	21.0	21.0	22.0	23.0	24.5	24.0	24.5	25.5	26.0	27.0	25.0	25.0	23.5	21.5	21.0	24.0	18.0	22.0	23.0	24.0	23.5	23.0	25.5	24.0		23.7
	Oct	25.0	25.0	25.0	24.5	26.0	25.0	24.5	24.0	22.0	21.0	22.0	21.5	21.0	21.5	21.0	19.0	17.0	17.0	18.0	18.0	18.0	19.0	18.5	17.5	17.0	16.5	16.0	16.0	17.0	17.0	17.0	20.2
	Nov	15.0	15.5	15.5	16.0	14.0	14.0	15.5	14.0	14.0	14.0	15.0	14.0	15.0	13.5	11.0	11.5	10.5	11.0	9.5	11.0	9.0	9.0	9.5	9.0	10.5	9.5	10.0	8.5	10.0	10.0		12.2
	Dec	8.5	8.0	7.0	8.0	8.0	9.0	12.0	14.0	10.0	12.0	11.0	10.0	7.5	7.5	7.0	7.5	10.0	14.5	16.0	14.5	10.0	8.0	8.0	6.0	7.0	6.5	6.5	6.5	6.5	8.0	8.0	9.1

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2009	Jan	7.0	4.0	8.0	8.5	6.0	5.0	4.0	3.5	4.0	3.5	6.0	5.0	6.0	6.5	8.5	12.0	10.5	11.0	8.5	6.5	5.5	5.5	5.5	7.5	11.0	11.0	11.0	8.5	8.5	9.0	10.0	7.3
	Feb	8.5	8.0	9.0	11.5	12.5	9.5	7.0	6.0	9.5	9.0	9.5	9.0	10.0	11.0	7.5	8.0	8.5	10.0	10.5	11.0	12.5	12.0	7.0	14.0	12.0	12.5	11.0	11.0				9.9
	Mar	12.0	12.5	15.5	13.0	13.0	13.0	16.0	13.5	8.0	12.0	10.0	11.5	12.0	14.0	15.0	14.5	15.0	15.5	17.0	16.0	14.5	15.0	15.0	18.5	14.5	13.5	16.5	14.5	14.0	14.0	16.5	14.0
	Apr	17.5	18.0	18.0	18.0	20.0	17.0	16.0	15.5	15.0	14.5	14.5	19.5	21.0	23.5	20.5	18.0	17.0	18.0	20.0	23.5	23.5	20.0	18.0	17.5	17.5	19.0	19.0	19.0	23.0	25.0	24.0	19.1
	May	23.5	24.0	25.0	20.0	20.0	19.0	23.0	24.0	24.0	22.0	22.5	21.5	23.0	25.5	23.0	28.0	27.5	27.0	30.5	29.5	28.0	27.0	27.0	27.0	26.0	23.0	25.0	25.0	25.0	26.0	27.0	24.8
	Jun	25.5	28.0	23.0	29.0	30.0	26.0	25.0	24.5	24.0	25.0	25.0	29.0	31.0	31.0	27.5	23.5	24.0	25.5	25.0	21.5	25.0	27.0	28.0	27.0	30.5	26.0	31.0	29.5	32.0	29.5		27.0
	Jul	22.0	26.0	23.5	25.0	25.0	26.5	29.0	32.0	30.5	29.0	29.0	29.0	29.0	23.0	26.0	29.0	30.0	30.5	30.5	32.0	30.0	29.0	26.0	28.0	31.0	31.0	31.0	30.0	24.0	24.0	24.0	27.9
	Aug	29.5	28.5	30.0	30.5	30.5	30.0	30.0	27.0	29.5	30.0	30.0	31.0	30.0	30.0	31.0	26.0	28.0	27.5	23.0	25.0	21.0	21.5	26.5	23.0	26.0	27.5	25.0	27.0	28.0	28.0	25.0	27.6
	Sep	26.0	26.5	21.0	21.0	22.0	22.5	24.0	24.0	26.0	25.0	24.0	24.0	24.0	26.0	24.0	26.5	23.5	24.0	25.0	25.5	26.0	26.5	26.0	25.0	26.0	25.0	24.0	24.0	23.5	22.5		24.4
	Oct	23.0	25.5	26.0	16.5	19.0	20.5	21.0	20.0	19.5	20.0	18.0	18.0	17.5	17.0	17.0	17.5	17.0	17.5	16.0	15.5	14.5	15.0	13.0	12.0	12.0	12.0	12.0	13.0	14.0	14.5	15.0	17.1
	Nov	14.0	15.0	15.0	16.0	15.0	15.0	14.0	12.0	11.0	11.5	9.0	7.0	12.0	15.0	12.0	7.5	12.0	10.5	9.5	7.0	8.0	9.0	9.0	8.0	11.0	10.0	6.0	7.5	7.5	6.5		10.8
	Dec	8.5	8.0	7.5	8.5	9.0	6.0	5.0	5.0	8.0	10.5	8.0	8.0	9.0	8.0	9.5	7.0	6.5	6.0	7.0	7.0	5.5	8.5	6.0	6.5	5.5	6.0	6.0	6.0	5.0	5.0	5.5	7.0

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2010	Jan	6.5	5.0	5.5	5.5	6.0	6.5	7.5	7.5	6.0	6.0	7.0	3.5	6.0	3.0	6.0	5.0	6.0	6.5	6.0	3.5	4.5	6.0	6.0	6.0	4.0	5.0	6.0	9.0	11.0	8.0	7.0	6.0
	Feb	6.5	6.5	7.0	8.0	9.0	10.5	13.0	13.0	10.0	5.0	5.0	6.0	7.0	8.0	10.0	7.0	5.5	6.0	8.0	8.0	12.5	11.5	13.5	12.5	13.0	14.0	15.0	15.0				9.5
	Mar	15.5	16.0	16.0	14.5	13.0	14.0	12.0	13.0	13.0	14.0	14.0	14.0	14.5	16.0	16.5	15.5	16.5	17.0	17.0	19.0	19.0	17.0	20.0	20.0	19.0	19.5	19.5	18.0	19.0	20.0	18.5	16.5
	Apr	18.0	19.0	18.0	20.0	20.0	18.5	17.0	19.0	20.0	21.0	21.0	26.0	20.0	21.0	21.0	23.5	23.5	25.0	24.5	25.0	23.0	22.5	19.0	20.5	22.0	22.0	22.0	25.0	24.0	22.0		21.4
	May	23.0	29.0	24.0	27.0	29.0	21.5	23.0	19.5	23.0	25.0	24.0	23.0	25.0	23.0	27.0	25.5	25.0	26.0	24.0	24.0	23.0	29.5	31.0	28.0	27.5	25.0	31.0	29.5	24.0	24.0	24.5	25.4
	Jun	26.5	31.0	26.0	28.0	25.0	24.5	24.0	24.0	26.0	24.0	27.0	27.0	28.0	27.5	25.5	26.0	26.0	27.0	30.0	31.0	30.0	33.0	32.5	27.5	26.5	27.0	31.5	30.0	32.5	25.0		27.7
	Jul	37.5	39.5	25.0	27.0	26.0	26.0	27.0	30.0	31.0	31.0	32.0	23.5	22.0	26.0	28.0	30.0	31.0	29.5	29.0	23.5	24.0	22.5	25.0	25.5	28.0	29.0	28.5	26.0	26.0	26.5	29.0	27.9
	Aug	26.0	27.0	28.5	28.0	28.5	28.0	27.0	25.0	26.5	28.0	28.5	24.0	25.5	27.5	28.0	26.0	26.0	28.0	29.0	28.0	26.0	24.5	26.5	21.5	22.0	22.0	22.5	23.0	24.5	27.0	27.0	26.1
	Sep	27.5	27.5	27.0	28.5	25.5	27.0	28.5	24.5	25.0	22.0	24.0	23.0	22.5	22.5	17.0	23.0	24.0	18.0	18.0	19.0	24.5	24.0	25.0	23.5	23.0	22.0	21.0	21.0	20.5	21.0		23.3
	Oct	22.0	23.0	23.0	22.0	22.0	22.5	22.0	22.0	22.0	22.0	21.0	21.5	20.0	19.0	21.0	22.0	22.0	22.0	23.0	22.0	21.0	20.0	14.0	15.0	14.0	14.0	14.0	15.0	15.0	16.0	16.0	19.7
	Nov	15.5	18.0	13.5	13.5	14.5	13.0	12.0	13.0	12.0	12.0	10.5	12.0	13.0	11.0	10.0	8.0	8.0	8.0	8.5	8.0	7.0	8.5	10.0	8.0	8.0	10.0	7.0	8.0	8.0	7.0		10.5
	Dec	7.0	7.0	6.0	6.5	6.0	6.0	6.5	5.5	5.5	5.0	6.5	6.5	6.5	7.0	5.0	6.0	5.5	5.5	6.0	4.5	5.0	5.5	6.0	7.0	5.0	5.0	4.0	4.5	5.0	7.5	7.0	5.9

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2011	Jan	6.0	5.5	7.0	8.0	5.5	0.5	2.0	6.0	4.5	1.5	3.0	3.0	6.0	6.0	2.0	2.0	1.0	0.5	2.5	4.0	7.0	5.5	5.5	4.0	4.0	6.0	6.0	5.0	5.0	5.0	4.5	4.3
	Feb	5.0	8.0	8.5	11.0	9.0	12.0	10.0	7.0	6.5	9.0	8.0	11.0	12.5	11.5	9.0	7.0	7.5	7.0	7.0	9.0	7.5	9.0	9.5	7.0	10.0	6.5	9.0	8.5				8.7
	Mar	9.0	9.0	9.0	8.0	8.0	10.0	10.5	12.0	10.0	10.0	10.0	9.0	10.5	12.5	13.0	14.5	16.5	18.0	17.5	13.5	18.5	18.0	17.5	13.0	18.5	15.0	16.0	17.5	14.0	14.0	15.0	13.1
	Apr	14.0	14.5	10.5	14.0	15.0	14.0	14.0	14.0	15.5	18.5	16.0	14.0	16.0	16.0	21.0	16.0	19.5	17.0	15.5	15.5	19.0	18.0	18.0	18.5	19.0	20.0	24.0	22.0	24.0	22.0		17.2
	May	22.0	21.0	24.0	24.0	25.0	22.0	20.5	21.0	23.0	25.5	24.0	25.5	25.0	21.5	24.5	26.5	27.0	27.5	27.0	29.5	29.0	20.0	22.5	25.0	28.0	27.0	25.0	26.0	29.0	27.5	25.5	24.9
	Jun	18.0	20.0	22.0	24.0	29.0	28.0	26.0	28.0	28.0	26.0	28.0	24.0	26.0	29.0	29.0	28.0	29.0	23.5	25.5	28.0	21.0	26.5	30.0	31.0	30.0	28.5	27.0	22.0	22.5	23.0		26.0
	Jul	21.5	23.0	26.0	19.0	25.5	28.0	29.0	27.0	23.0	26.0	27.0	28.0	29.0	29.5	22.5	24.0	26.0	26.0	26.5	28.0	28.5	29.0	28.0	27.0	28.0	27.0	28.0	22.5	22.5	27.5	23.0	26.0
	Aug	25.0	28.0	29.0	28.0	23.0	25.0	27.0	27.0	23.0	27.0	26.5	26.5	23.0	24.0	24.5	23.5	19.0	20.0	26.0	26.0	26.0	26.0	27.0	28.5	25.5	27.0	26.5	27.0	24.5	26.0	26.5	25.5
	Sep	25.0	25.0	27.0	27.0	24.0	21.5	24.0	25.5	24.0	24.0	26.0	26.0	25.0	26.0	25.0	23.0	20.0	22.0	24.0	22.0	24.0	22.5	21.0	21.0	23.0	22.0	23.0	22.5	22.0	21.5		23.6
	Oct	22.5	22.5	20.0	22.0	21.5	21.0	22.5	21.0	20.0	21.0	21.0	19.0	17.5	18.0	16.0	16.0	15.0	14.5	15.0	15.5	16.0	16.0	18.0	15.0	14.0	12.0	11.0	13.0	12.0	11.5	13.0	17.2
	Nov	13.5	13.5	16.0	16.0	16.5	14.5	17.0	16.0	16.5	18.0	16.0	12.0	13.0	12.0	14.0	13.0	12.0	12.0	12.5	12.0	12.5	12.5	12.5	13.0	11.5	10.5	10.5	10.5	10.0	10.0		13.3
	Dec	11.0	9.0	8.5	8.0	8.5	10.0	7.5	8.5	5.0	4.5	4.0	4.0	4.5	5.0	2.0	2.0	2.5	4.0	3.5	6.0	4.0	1.0	1.0	1.0	0.0	0.5	1.0	0.5	1.0	1.0	1.0	4.2

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2012	Jan	1.0	2.0	1.5	4.0	4.5	5.0	3.0	2.0	1.0	0.5	1.5	3.0	2.0	4.0	6.0	9.0	5.0	2.0	4.0	2.0	0.5	2.5	5.5	2.0	5.0	3.0	4.0	4.0	3.0	3.0	3.5	3.2
	Feb	4.0	5.0	7.0	6.0	6.0	3.0	0.0	0.5	0.5	1.5	3.5	6.5	8.5	8.0	1.0	1.0	2.0	5.0	6.0	7.0	10.0	8.5	4.0	3.0	3.0	3.0	4.0	8.0	7.0			4.6
	Mar	8.5	7.0	7.5	8.5	12.0	9.0	9.0	8.0	7.0	9.0	9.0	9.0	10.0	9.0	13.0	12.5	13.0	14.0	15.0	13.0	11.0	11.0	12.0	12.5	13.0	14.0	18.0	18.5	16.0	16.0	18.0	11.7
	Apr	18.0	18.5	17.5	20.0	18.0	18.0	18.0	18.0	18.0	21.0	16.0	18.0	19.0	18.0	16.0	15.0	18.5	20.0	19.0	17.0	16.0	16.0	16.5	18.5	18.0	19.0	19.0	19.0	18.0	17.0		18.0
	May	15.0	17.0	18.0	19.0	22.0	22.0	23.0	22.5	22.0	27.0	25.0	24.0	23.0	23.0	23.0	26.5	27.0	24.0	24.0	24.0	24.0	25.0	23.0	23.0	26.0	38.0	39.0	40.0	43.0	44.0	46.0	26.5
	Jun	28.0	29.0	30.0	30.0	26.0	25.0	27.0	23.0	25.0	25.0	22.0	27.0	28.0	28.0	27.0	29.0	31.0	32.0	26.0	29.0	29.0	29.0	30.0	30.0	26.0	30.0	28.0	28.0	21.0	27.0		27.5
	Jul	27.0	27.0	29.0	29.0	31.0	31.0	31.0	20.5	22.0	28.0	25.0	25.0	29.0	24.0	24.0	24.0	26.0	27.0	27.0	27.0	23.0	25.0	27.0	29.0	29.0	27.0	26.0	29.0	30.0	30.0	29.0	27.0
	Aug	28.0	29.0	29.0	29.0	23.0	25.0	27.0	28.0	28.0	25.0	22.0	24.0	24.0	28.0	27.0	26.0	26.0	28.5	28.0	30.0	24.5	26.5	28.5	26.0	28.0	26.0	25.0	25.0	26.0	26.0	22.0	26.4
	Sep	25.0	27.0	27.0	27.0	24.0	25.0	24.0	26.0	24.0	24.0	25.0	25.0	27.0	27.0	28.0	24.0	22.0	22.0	22.0	22.0	21.0	21.0	21.0	21.0	20.0	20.0	21.0	23.0	22.0	21.0		23.6
	Oct	21.0	20.0	19.0	19.0	18.5	18.0	17.0	17.0	17.5	17.0	18.5	19.0	20.0	19.0	15.0	15.0	16.0	16.0	15.0	15.0	15.0	15.0	16.0	11.5	13.5	13.5	13.0	13.0	13.0	12.5	13.0	16.2
	Nov	13.0	13.0	13.0	13.5	13.5	13.0	14.0	13.0	13.0	13.0	12.0	11.5	11.5	11.0	10.0	10.0	11.0	10.0	10.0	11.0	12.0	9.0	9.0	8.0	7.0	6.5	7.0	9.0	8.0	7.0		10.8
	Dec	5.0	4.5	4.0	4.5	4.5	4.5	8.0	7.0	5.0	5.0	5.0	9.0	13.0	9.0	9.0	7.0	6.5	9.0	7.0	6.5	6.0	5.0	5.0	5.0	5.0	5.0	6.0	8.0	3.5	3.0	3.5	6.1

2) Humidity (Daily Average Humidity :%)

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2007	Jan	70	70	71	75	73	75	72	78	72	68	72	70	75	70	73	75	70	68	65	61	57	55	50	56	55	52	60	70	72	71	67	67.4
	Feb	68	70	66	62	64	65	68	70	68	72	70	72	75	71	80	80	75	70	70	65	60	60	55	54	52	51	75	70				67.1
	Mar	80	58	53	50	48	40	36	34	47	55	70	64	46	42	40	50	52	56	58	51	47	42	37	33	37	37	37	35	38	42	41	47.0
	Apr	57	32	31	40	47	44	44	42	42	38	41	34	50	32	35	34	32	36	49	43	32	33	32	30	25	20	20	20	17	22		35.1
	May	15	17	21	33	27	25	25	29	31	28	25	23	26	26	21	31	30	31	30	28	28	28	23	18	15	16	21	26	32	26	19	25.0
	Jun	20	19	22	26	27	27	26	25	19	23	29	31	38	37	28	40	38	43	54	45	47	41	46	45	43	45	53	57	58	57		37.0
	Jul	56	59	60	54	53	47	53	60	58	56	47	49	49	57	56	50	65	52	49	48	47	65	75	62	64	48	53	54	53	53	49	54.9
	Aug	46	45	53	55	61	58	59	53	56	58	51	53	50	51	53	56	44	51	47	50	49	43	59	52	51	50	40	47	41	53	54	51.3
	Sep	50	60	61	62	46	58	62	55	52	48	61	51	52	49	52	45	47	50	65	48	53	53	56	56	45	44	49	36	38	38		51.4
	Oct	41	33	30	31	36	26	29	29	20	21	26	21	34	34	32	36	37	42	32	34	35	40	35	36	32	34	33	32	34	37	39	32.6
	Nov	28	26	27	23	33	38	32	41	44	46	47	53	55	62	57	45	52	51	55	58	50	51	57	54	54	52	63	59	49	49		47.0
	Dec	57	51	51	33	33	49	44	46	51	50	50	59	61	48	39	50	47	56	54	70	63	60	62	70	66	56	67	68	85	64	62	55.5

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2008	Jan	25	33	36	30	30	44	37	57	63	68	57	39	32	58	50	50	70	80	54	29	29	38	29	37	19	46	26	22	27	37	35	41.5
	Feb	28	38	51	50	56	38	43	36	54	38	25	26	16	30	36	31	30	52	43	49	32	37	36	43	35	26	28	37	39			37.3
	Mar	44	44	48	49	38	40	40	40	45	40	42	40	34	29	35	36	38	33	34	37	44	39	37	30	24	31	41	39	34	33	35	37.8
	Apr	34	37	43	61	53	57	56	41	44	40	40	42	40	35	41	39	34	29	26	21	24	23	23	23	20	19	15	17	14	16		33.6
	May	13	16	14	11	18	17	16	19	44	32	27	22	36	35	34	27	23	23	23	36	40	50	50	44	42	49	43	45	33	25	28	30.2
	Jun	30	33	37	33	30	32	43	38	43	45	60	48	47	40	51	50	55	54	59	50	65	45	60	52	54	49	48	66	66	57		48.0
	Jul	46	51	43	44	51	47	63	57	63	56	50	56	63	78	71	64	48	47	47	47	58	65	54	48	47	44	42	46	53	47	46	53.0
	Aug	62	67	59	61	69	76	66	70	74	71	74	80	84	74	69	75	72	65	56	64	55	58	57	67	52	46	49	55	61	57	70	65.0
	Sep	70	59	49	53	54	64	62	56	56	55	45	50	49	50	49	58	50	66	64	59	68	62	71	66	65	68	63	61	74	64		59.3
	Oct	62	60	60	52	50	52	58	49	59	56	58	60	52	55	56	60	58	57	53	55	56	63	59	60	59	63	65	67	53	61		57.6
	Nov	59	55	62	67	52	48	49	54	58	58	59	59	60	56	66	72	71	66	64	62	54	59	59	55	59	62	62	63	63	45	47	58.9
	Dec	57	63	62	64	61	80	51	71	74	68	64	55	54	55	66	56	88	69	60	88	72	65	65	67	68	69	85	84	85	86	83	68.9

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2009	Jan	81	63	60	68	69	65	60	66	68	70	66	64	61	60	54	69	93	74	83	64	64	76	65	65	55	75	81	72	70	66	62	68.0
	Feb	67	65	64	60	61	70	63	66	67	81	79	69	62	76	64	64	58	62	56	71	68	48	60	54	63	63	55	60				64.1
	Mar	47	48	49	60	56	48	36	41	40	49	45	44	48	44	43	50	49	56	50	63	61	35	61	57	76	63	60	66	81	78	55	53.5
	Apr	57	54	57	49	49	55	66	61	70	71	51	43	42	39	42	46	34	31	32	27	28	34	25	25	29	27	26	26	25	29		41.7
	May	38	32	34	43	53	51	45	37	40	40	32	20	25	27	31	31	31	20	27	27	28	20	35	28	26	26	26	23	23	30	25	31.4
	Jun	32	37	39	29	18	36	33	23	21	30	27	27	26	28	52	49	50	46	38	43	29	23	25	31	32	39	33	32	36	44		33.6
	Jul	61	67	50	52	49	49	43	38	44	55	57	53	51	78	70	62	57	55	61	52	53	60	76	78	73	60	62	60	73	72	58	59.0
	Aug	58	56	58	59	59	59	57	61	57	51	56	54	57	56	50	68	89	69	79	78	75	82	72	86	78	72	82	69	66	59	67	65.8
	Sep	78	67	76	69	77	78	84	60	67	66	68	66	63	46	55	41	56	56	66	57	54	55	60	58	50	61	44	57	47	48		61.0
	Oct	47	58	62	70	68	68	64	62	37	58	46	58	56	57	54	61	54	61	56	60	59	67	58	58	58	55	58	60	55	54	56	57.9
	Nov	50	51	68	78	76	77	79	75	66	73	48	54	64	73	75	82	80	74	53	52	72	65	75	67	58	61	42	40	62	50		64.7
	Dec	61	67	67	65	67	65	62	57	61	58	67	61	60	61	65	66	66	54	54	70	67	55	61	69	69	65	66	69	65	78	79	64.4

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2010	Jan	81	80	77	87	83	85	87	87	93	88	85	85	90	81	84	79	73	85	90	88	82	90	89	86	85	81	80	73	73	63	62	82.3
	Feb	62	68	67	69	65	60	72	85	66	67	65	54	64	62	67	59	55	49	54	47	48	60	58	65	68	66	64	69				62.7
	Mar	72	69	59	86	81	69	82	63	58	35	54	55	56	52	53	47	59	62	59	54	58	51	50	57	61	45	42	50	51	46	48	57.5
	Apr	44	44	48	46	46	44	39	38	35	38	35	44	43	32	25	26	29	24	30	27	46	40	46	36	34	25	27	30	30	53		36.8
	May	36	33	26	28	28	57	50	42	39	38	42	28	24	28	24	24	22	28	38	30	26	27	29	22	20	23	25	34	45	38	30	31.7
	Jun	31	25	33	37	54	41	52	51	41	45	39	36	36	35	48	38	34	35	34	32	28	30	45	46	52	44	38	40	45	54		40.0
	Jul	40	49	59	45	53	58	54	59	49	51	55	76	88	66	62	56	57	66	60	82	89	80	60	70	60	59	63	82	80	75	69	63.6
	Aug	63	68	74	67	67	84	79	84	70	71	79	84	80	79	80	90	87	72	71	76	77	77	64	75	79	84	76	69	61	62	65	74.6
	Sep	67	65	70	73	75	66	65	80	71	70	70	72	75	76	73	68	65	64	56	61	64	78	72	73	67	65	60	46	46	50		66.8
	Oct	56	57	55	50	50	61	53	58	62	62	61	65	52	54	49	51	48	65	74	69	66	58	74	62	61	60	61	64	64	64	61	59.6
	Nov	62	59	55	52	55	61	61	60	59	57	65	68	65	63	64	66	65	65	68	64	69	67	72	72	61	55	54	62	61	61		62.3
	Dec	61	61	70	71	73	76	79	79	66	65	65	64	63	69	75	72	74	79	71	62	72	73	79	78	69	67	68	74	71	65	82	70.5

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2011	Jan	92	80	93	93	93	94	90	86	86	87	86	76	70	81	97	61	62	66	57	61	57	62	64	62	66	62	58	51	67	59	64	73.4
	Feb	71	67	63	72	76	74	86	72	72	60	66	59	81	87	77	77	73	71	78	78	80	72	68	67	71	92	71	68				73.0
	Mar	88	78	92	80	72	65	62	64	55	54	55	53	53	55	53	60	63	61	65	56	46	50	50	46	51	51	56	52	65	56	56	59.8
	Apr	46	50	47	37	35	41	42	39	48	61	71	75	54	41	47	58	72	60	56	49	44	43	41	39	36	30	43	36	35	39		47.0
	May	37	34	37	37	41	49	51	43	35	38	37	36	40	39	36	36	34	35	41	52	53	62	58	49	50	44	48	49	44	45	50	43.0
	Jun	48	68	51	40	43	44	39	45	52	51	52	53	54	45	47	59	59	67	74	54	65	52	51	52	53	53	65	70	80	68		55.0
	Jul	79	79	72	81	66	59	61	77	77	81	70	62	55	58	77	76	79	68	65	64	59	65	61	64	69	69	73	86	75	78	81	70.3
	Aug	67	64	61	67	78	82	74	82	87	71	70	74	85	82	80	83	89	74	72	72	78	64	66	64	77	75	77	84	77	77	73	74.7
	Sep	80	74	69	64	75	82	85	81	79	92	79	75	69	76	92	88	98	81	79	79	76	70	62	63	67	67	74	71	72	61		75.8
	Oct	66	68	66	62	72	71	65	63	58	61	60	56	60	57	53	53	46	49	56	53	59	60	68	66	66	67	61	60	65	66	66	61.0
	Nov	57	61	58	57	58	52	51	52	58	68	57	50	58	59	58	59	61	64	63	60	63	66	71	69	68	66	67	68	71	66		61.2
	Dec	49	64	57	58	59	55	57	54	61	51	49	58	59	54	61	63	62	68	67	62	57	58	55	56	62	65	56	63	61	65	65	59.1

Yr/mth	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
2012	Jan	73	68	68	64	70	75	91	78	79	70	62	66	70	73	82	85	75	71	70	74	76	72	63	69	66	71	54	60	54	53	56	69.6
	Feb	69	64	68	66	93	55	57	48	48	54	66	76	66	55	62	58	60	66	67	77	78	65	56	57	55	55	59	52	50			62.1
	Mar	50	54	66	68	86	65	53	50	56	54	59	70	57	60	55	55	58	59	57	61	59	55	56	54	50	51	54	55	57	59	62	58.2
	Apr	51	55	60	57	54	49	57	61	52	65	62	62	58	63	69	65	60	58	55	53	52	55	55	58	60	63	62	69	74	60		59.1
	May	54	51	51	48	44	47	48	46	47	44	41	51	47	36	37	41	41	41	32	37	34	38	35	34	38	44	48	49	44	45	50	43.3
	Jun	36	36	35	42	47	46	39	51	43	35	45	42	40	41	37	45	42	35	33	40	42	47	53	46	55	52	50	53	61	54		44.1
	Jul	44	43	52	52	53	59	56	85	65	63	65	68	74	61	53	56	59	52	51	63	64	57	51	61	56	73	61	64	59	56	59	59.2
	Aug	56	58	63	73	58	64	61	52	54	64	83	67	54	75	89	88	75	62	59	58	65	70	64	68	61	59	68	62	69	65	56	65.0
	Sep	75	68	68	73	94	85	75	78	92	76	73	70	70	67	84	85	100	82	75	78	70	69	69	70	72	69	69	63	67	63		75.0
	Oct	61	55	58	58	59	62	60	62	64	55	62	62	59	61	93	55	68	63	67	71	71	62	64	72	66	63	63	69	70	70	68	64.3
	Nov	69	63	69	67	70	70	72	74	74	78	80	80	81	74	78	74	71	74	71	68	63	65	72	83	73	73	72	72	84	76		73.0
	Dec	75	75	75	73	77	80	73	74	71	70	76	89	89	94	81	76	78	77	76	70	76	73	73	88	89	89	97	100	100	98	94	81.5

3) Rainfall (Faisalabad University meteorological station, Unit :mm)

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2005	Jan	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.4	0.0	0.0	0.0	0.4	7.0	0.0	0.0	0.0	32.8
	Feb	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	1.0	8.0	7.5	0.0	0.0	0.0	5.0	5.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.1
	Mar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	1.6	2.2	15.6	0.0	0.2	2.6	20.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.6
	Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	4.8	0.0	0.0	0.0	0.0	10.8
	May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.4
	Jun	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.0	19.0	0.0	62.5
	Jul	18.2	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	42.0	16.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.0
	Aug	1.5	8.5	0.0	0.0	0.0	0.0	0.0	12.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	24.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.6
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	16.0	0.0	0.0	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.6
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total																																442.4

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2006	Jan	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2
	Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0	14.6
	Mar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	3.2	0.4	0.0	0.0	0.0	4.2	0.8	0.0	0.0	0.0	0.0	11.2	0.0	12.0	0.0	0.0	0.0	37.0
	Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	24.0
	Jun	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	2.4	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	28.4	0.0	55.6
	Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8	2.4	36.0
	Aug	0.0	0.0	0.0	0.4	0.0	28.0	0.0	10.2	0.0	7.2	0.0	0.0	0.0	0.0	15.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	79.2
	Sep	0.0	49.4	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.2
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8
	Dec	0.0	0.0	0.0	0.0	43.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	46.2
	Total																																397.2

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2007	Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	26.5	0.0	0.0	0.0	0.0	8.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.4	0.0	0.0	0.0	55.9
	Mar	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	1.3	0.0	11.4	12.4	0.0	0.0	0.0	0.0	0.0	0.0	15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.3
	Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	May	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1
	Jun	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	2.5	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	1.5	0.3	0.0	29.9
	Jul	0.0	5.0	0.3	0.0	0.0	0.0	0.0	1.5	70.0	0.0	0.0	0.0	7.0	4.6	38.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	1.3	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	149.7
	Aug	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0.0	19.5
	Sep	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
	Total																																330.6

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2008	Jan	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.8	6.8	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.6
	Feb	0.0	0.0	5.6	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
	Mar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Apr	0.0	0.2	5.2	0.0	1.4	0.6	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.2	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
	May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0	0.2	8.0	35.5	0.0	7.7	0.0	0.0	0.0	75.5
	Jun	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	15.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	41.7
	Jul	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	13.4	0.0	0.0	10.1	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	1.2	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.6
	Aug	54.5	18.0	0.0	0.0	25.5	26.0	0.0	0.0	0.0	0.0	2.0	62.1	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	204.5
	Sep	0.0	0.0	0.0	0.0	0.0	6.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.8
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6
	Total																																516.1

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2009	Jan	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.7	1.9	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	13.5
	Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	16.2	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2
	Mar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	4.5	0.0	0.0	4.3	4.0	0.0	0.0	14.0
	Apr	0.0	0.0	0.0	0.0	0.0	3.8	2.6	13.4	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.9
	May	0.0	0.0	0.0	8.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
	Jun	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6
	Jul	5.5	0.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	13.5	0.2	0.0	43.5
	Aug	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.5	25.0	0.0	54.0	6.3	0.0	18.6	0.0	0.0	1.6	0.0	0.0	0.0	0.0	116.0
	Sep	0.0	0.0	11.4	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.6
	Oct	0.0	0.0	0.0	6.5	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total																																285.6

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2010	Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.8
	Feb	0.0	0.0	0.0	0.0	0.0	1.1	2.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9
	Mar	0.0	0.0	0.0	5.0	0.0	2.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
	Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	1.3
	May	0.8	0.0	0.0	0.0	9.7	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2
	Jun	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.7	0.0	1.0
	Jul	0.0	4.3	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	16.2	101.6	0.0	0.0	0.0	0.0	0.0	0.0	11.6	73.0	51.0	0.0	0.0	0.0	0.0	0.0	1.3	16.7	1.1	0.0	277.8
	Aug	0.0	0.0	1.0	0.6	0.0	0.2	0.0	90.0	0.0	0.0	3.3	50.7	5.7	0.8	0.0	22.4	10.6	0.0	0.0	0.0	0.0	0.0	0.1	11.2	6.6	23.4	0.0	0.0	0.0	0.0	0.0	226.6
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	14.9	0.0	0.0	0.0	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.5
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Total																																626.9

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2011	Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Feb	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	20.6
	Mar	4.3	0.0	2.1	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
	Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.0	0.0	17.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.9
	May	0.0	0.0	0.0	0.0	0.0	2.5	1.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.6
	Jun	23.1	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0	28.5	1.2	0.0	0.0	78.3
	Jul	11.2	19.6	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	5.3	0.0	13.2	118.1
	Aug	12.5	0.0	0.0	0.0	0.0	7.5	0.0	0.0	10.1	0.0	0.0	0.0	1.1	0.0	3.0	19.5	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	3.0	3.5	0.0	7.4	11.0	92.6
	Sep	0.0	0.0	0.0	11.0	25.2	4.8	0.0	15.5	7.7	0.2	0.0	0.0	0.2	0.0	1.0	89.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.1
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total																																511.4

	Month \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
2012	Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
	Feb	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
	Mar	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
	Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	2.5	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.7	0.0	0.0	0.0	0.0	0.0	10.5
	May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Jun	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	23.6
	Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	10.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.4
	Aug	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	4.0	0.5	2.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	38.5
	Sep	0.0	0.0	0.0	0.0	15.0	4.7	5.0	0.0	48.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	46.5	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	163.7
	Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5
	Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	17.2
	Total																																323.7

4) Wind (Daily Average Wind Speed, Unit: m/sec)

Yr/Day \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002 1	0.6	0.8	1.0	1.5	1.6	1.8	2.4	1.1	2.4	0.8	0.7	0.7
2	1.0	0.8	0.8	0.6	1.6	3.6	3.3	0.9	1.8	1.2	0.6	0.8
3	0.5	1.1	1.0	1.3	0.9	2.1	3.6	1.2	1.3	0.9	0.6	0.6
4	0.3	1.2	1.2	0.2	1.3	2.8	3.5	2.4	1.5	1.1	0.4	0.7
5	0.3	0.8	1.1	1.9	1.3	3.9	3.9	2.5	1.3	1.3	0.4	0.7
6	0.3	0.8	0.5	1.5	1.2	2.8	4.0	1.9	0.8	0.6	0.8	0.8
7	0.4	1.3	1.1	2.0	1.9	2.0	3.9	2.4	0.6	0.8	0.8	1.3
8	0.7	1.3	1.4	1.5	1.5	3.3	1.9	1.7	2.0	0.7	1.5	0.8
9	0.9	1.1	1.8	1.6	0.7	3.2	1.5	1.8	1.3	0.8	1.2	0.8
10	1.0	1.1	1.4	1.0	0.8	3.8	4.2	1.4	1.5	0.8	1.3	1.6
11	0.7	1.2	1.2	0.8	2.2	2.2	2.2	1.4	0.9	0.9	1.3	1.3
12	1.3	1.6	1.3	0.8	2.2	5.1	2.3	1.9	1.1	1.0	2.0	0.5
13	1.0	1.6	1.2	1.1	0.8	3.5	3.1	2.1	1.5	0.9	1.8	0.6
14	2.8	1.4	1.3	1.0	1.5	4.2	3.7	2.6	2.4	1.9	1.7	1.1
15	1.2	1.0	0.7	1.7	2.8	2.5	3.5	1.1	1.9	0.8	1.5	0.6
16	1.1	1.0	1.0	2.0	1.3	4.0	2.9	1.1	1.1	0.6	1.1	0.9
17	0.8	1.4	1.1	0.4	0.8	7.5	2.6	0.6	1.7	0.6	0.7	0.5
18	1.1	1.7	1.5	0.8	0.9	6.8	3.0	0.8	2.0	0.7	1.0	0.4
19	0.7	1.2	0.8	1.0	1.6	2.9	2.1	0.6	1.7	0.6	0.7	0.5
20	0.6	1.5	0.7	1.0	0.3	1.8	3.3	0.9	0.9	1.6	1.4	0.5
21	0.6	1.3	0.8	1.0	1.4	0.8	4.2	1.2	0.9	2.5	1.3	0.6
22	0.6	1.8	0.8	1.1	1.1	1.9	3.9	1.5	0.8	2.1	0.4	0.6
23	1.4	1.0	0.9	1.5	1.4	3.7	4.2	1.4	0.8	2.4	0.9	0.6
24	1.2	0.9	1.1	2.8	0.8	4.6	1.6	1.5	1.1	0.9	1.4	2.1
25	1.4	1.0	1.2	3.1	1.2	5.4	2.4	2.1	1.7	0.6	1.0	1.6
26	1.1	1.1	0.5	2.0	2.3	5.4	3.1	1.9	1.3	1.8	1.3	1.3
27	1.0	1.5	0.6	1.9	3.1	3.9	2.7	1.8	1.1	0.6	0.5	1.1
28	1.0	1.5	0.4	1.8	2.3	4.0	2.2	0.9	1.2	0.7	0.5	1.5
29	0.9		0.5	2.0	3.1	3.4	2.9	1.3	0.9	0.8	0.4	1.0
30	0.8		0.8	2.8	1.2	2.0	2.2	2.1	0.7	1.1	1.0	0.5
31	1.2		0.8		1.7		2.8	2.2		0.8		0.5

Yr/Day \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003 1	1.0	1.2	1.8	0.7	1.9	1.5	1.3	2.0	0.7	0.6	0.7	0.6
2	0.8	1.0	2.5	1.4	2.1	0.7	1.0	0.6	1.4	0.6	0.9	0.9
3	1.2	1.0	2.4	1.5	2.8	0.8	1.4	1.5	1.6	1.0	0.8	0.6
4	1.4	0.6	2.2	1.9	1.8	1.3	1.2	2.0	1.3	0.9	0.7	0.6
5	1.3	1.2	1.9	1.4	1.1	0.8	2.0	1.0	0.9	0.9	1.6	0.8
6	1.0	1.0	1.5	1.2	0.8	0.7	3.5	0.9	1.7	1.0	1.2	1.0
7	1.2	0.8	1.0	1.3	1.2	1.4	1.4	0.7	0.8	1.3	0.6	1.5
8	1.0	1.0	1.7	1.5	1.3	1.9	0.6	0.7	0.7	0.4	0.6	1.0
9	1.1	1.4	1.3	1.0	0.9	3.7	1.5	0.6	0.8	1.2	1.3	1.0
10	1.4	1.0	1.9	1.2	1.3	2.0	1.8	2.0	0.6	0.9	2.0	1.7
11	1.3	0.6	2.1	1.3	1.7	1.2	1.9	1.5	0.8	0.6	1.6	1.4
12	1.4	1.0	1.1	1.2	1.8	1.6	2.0	0.7	0.7	0.6	0.6	0.5
13	1.4	1.3	0.4	0.6	1.7	1.4	2.4	1.0	0.9	0.6	0.5	0.8
14	0.8	1.3	0.7	1.9	1.9	0.8	1.6	1.0	0.2	0.8	0.5	1.2
15	0.4	1.2	1.2	1.4	1.8	1.0	0.4	0.6	0.9	0.8	0.5	0.7
16	1.0	2.1	1.0	1.9	1.0	1.0	2.4	0.6	0.8	0.6	1.1	0.3
17	0.8	1.8	1.5	1.0	1.0	1.0	2.0	0.6	0.8	0.7	2.1	1.4
18	0.8	1.6	0.9	1.3	1.0	2.6	2.0	1.3	0.8	0.8	1.4	0.9
19	0.8	1.4	1.0	2.8	1.0	1.2	1.4	2.0	0.6	1.0	1.5	0.6
20	1.0	1.8	0.7	2.0	1.1	1.7	1.1	1.4	0.7	0.7	0.9	0.6
21	0.8	1.0	1.0	1.6	1.1	1.5	1.6	1.8	1.0	0.6	0.9	0.9
22	0.6	1.7	1.5	1.1	1.0	2.4	1.8	0.9	0.9	0.6	0.6	1.0
23	0.6	1.3	1.2	1.3	2.8	1.1	0.7	0.6	1.1	0.6	0.8	1.0
24	0.6	0.8	1.6	0.8	3.6	1.5	1.0	0.7	1.5	0.8	0.9	1.3
25	0.6	0.9	1.0	1.5	2.0	1.0	1.4	0.5	2.6	0.8	1.0	1.3
26	1.1	0.7	0.7	2.2	2.1	1.3	0.6	0.9	2.5	0.6	1.3	1.0
27	1.2	1.0	0.8	1.5	0.8	1.9	0.9	0.9	1.0	0.6	0.6	0.8
28	1.5	1.2	1.2	2.0	1.4	2.4	0.6	1.3	1.2	0.5	0.6	0.7
29	1.0		1.5	1.1	1.5	2.1	2.0	0.9	1.4	0.5	0.9	1.0
30	1.0		1.1	1.1	1.0	2.0	2.0	0.9	0.7	1.0	0.7	1.0
31	1.5		1.3		0.8		1.1	1.0		0.8		0.9

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	1	1.1	0.8	1.0	1.0	1.5	1.1	1.5	1.9	1.2	0.8	0.8	1.0
	2	1.0	1.6	1.2	1.2	1.5	2.9	1.5	1.2	1.2	1.1	1.1	1.2
	3	1.0	2.1	1.1	1.2	0.8	1.5	1.1	1.4	1.2	0.8	1.0	0.6
	4	0.6	1.7	1.0	0.9	1.0	1.1	1.6	0.9	1.3	0.8	0.8	0.6
	5	0.7	0.9	2.0	0.9	1.0	1.0	2.0	0.8	1.0	1.0	0.5	1.5
	6	0.6	1.3	1.0	0.4	0.6	1.9	1.6	1.2	1.2	0.6	0.6	1.5
	7	0.6	1.8	2.0	1.3	0.7	2.2	1.0	1.7	1.3	0.6	0.6	1.0
	8	1.0	0.9	1.3	1.6	1.9	1.3	0.9	2.0	0.9	1.1	0.6	0.7
	9	1.8	2.0	1.8	1.2	1.9	1.5	1.9	1.8	1.0	2.2	0.4	0.7
	10	1.6	1.7	1.6	1.4	1.8	0.9	1.5	0.9	0.9	2.4	0.6	1.5
	11	0.6	1.6	1.0	0.8	1.9	1.5	1.3	1.3	0.8	1.9	0.7	0.6
	12	1.0	1.4	0.8	0.8	0.7	0.7	2.1	1.2	1.0	1.7	0.8	0.6
	13	1.4	1.3	1.0	1.1	1.0	1.4	2.0	0.5	1.0	0.8	0.7	0.4
	14	0.8	0.7	1.0	1.0	1.5	1.9	2.1	0.9	1.2	1.1	0.5	1.5
	15	0.8	1.6	0.8	0.6	1.5	2.0	1.6	1.3	1.5	1.0	1.2	1.4
	16	0.8	1.5	0.9	0.6	1.5	1.4	2.5	1.0	2.6	0.5	0.7	1.4
	17	1.9	1.1	0.6	1.4	1.4	2.6	1.7	1.9	1.2	0.8	0.5	1.0
	18	1.0	1.6	0.8	1.4	1.3	2.9	1.6	2.0	0.6	0.7	0.3	0.6
	19	1.3	1.0	1.0	0.7	1.4	2.8	1.6	0.9	0.6	1.3	0.5	1.2
	20	0.6	0.7	1.0	1.5	1.3	2.0	2.2	1.1	0.6	1.3	0.7	2.0
	21	0.8	1.0	1.0	1.4	1.0	2.2	2.1	1.1	1.9	1.0	0.8	0.8
	22	0.8	1.3	1.3	1.8	0.9	1.9	0.8	1.0	1.6	1.1	0.6	0.8
	23	1.0	1.8	1.5	1.9	2.4	1.7	1.0	1.5	0.6	1.0	0.6	0.7
	24	1.0	1.5	1.5	1.3	2.5	1.5	0.8	0.7	0.6	0.7	0.8	0.6
	25	1.2	1.1	1.0	1.5	1.1	1.2	1.1	1.0	0.6	0.5	0.7	0.7
	26	1.0	0.9	0.7	2.1	1.8	1.2	1.3	1.0	0.5	0.9	0.7	1.0
	27	1.0	2.0	0.7	1.6	2.5	1.1	1.6	1.0	0.9	1.0	0.8	2.2
	28	1.1	0.9	0.6	1.9	1.1	1.2	1.8	1.3	0.8	0.7	0.8	0.7
	29	1.4	1.2	0.8	0.7	1.0	1.0	1.3	0.6	1.4	2.0	1.1	0.7
	30	1.0		0.7	2.2	1.2	0.8	2.3	0.8	1.5	0.7	1.3	0.4
	31	1.0		0.7		1.1		2.4	1.3		0.8		1.3

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	1	2.8	0.8	0.9	1.0	1.9	1.2	1.9	0.8	1.2	0.7	1.3	1.3
	2	0.6	0.5	0.8	1.0	1.0	0.8	1.5	1.2	1.3	0.8	1.2	1.1
	3	0.6	1.0	1.0	0.6	1.2	0.8	1.5	1.1	1.0	1.3	1.2	0.6
	4	0.6	0.6	1.6	1.0	1.5	0.8	1.4	1.6	1.0	1.6	0.8	0.8
	5	0.9	1.5	1.0	1.7	0.9	0.7	1.3	1.4	1.5	1.0	0.5	0.9
	6	1.3	0.6	1.1	2.4	1.0	2.9	0.9	2.1	1.9	0.9	0.3	1.0
	7	1.0	1.0	0.9	2.0	1.1	2.6	1.1	2.0	1.8	1.0	0.5	0.5
	8	1.6	0.6	0.6	2.5	1.8	1.8	2.0	2.5	2.0	1.2	0.8	0.5
	9	0.6	1.0	1.0	2.3	1.8	1.7	1.7	0.6	1.5	1.9	0.5	0.5
	10	0.9	1.0	1.0	1.8	0.9	1.4	1.5	0.9	1.9	0.9	0.5	0.6
	11	0.8	1.4	0.6	1.4	1.1	0.9	1.2	1.2	1.0	0.6	1.0	0.8
	12	0.8	0.8	1.0	1.1	1.1	1.2	2.3	1.3	1.3	1.9	0.9	0.5
	13	0.8	1.0	0.8	1.1	1.3	2.0	1.4	1.0	1.8	0.4	0.9	0.5
	14	0.9	0.6	0.9	1.2	2.0	1.3	1.0	1.2	2.1	0.6	1.0	1.3
	15	1.0	0.8	0.6	1.5	0.8	0.9	1.9	1.5	2.6	0.7	0.5	1.0
	16	1.0	1.3	0.6	1.5	1.4	1.5	2.0	2.1	1.2	1.9	1.1	0.7
	17	0.9	1.0	1.0	1.2	1.3	1.0	1.2	1.5	1.8	2.1	1.2	1.0
	18	0.9	1.5	2.0	1.0	2.5	0.7	1.6	1.0	2.4	0.8	1.6	0.5
	19	0.7	1.4	1.9	0.9	2.5	0.6	1.0	1.5	1.0	1.0	0.8	1.0
	20	1.0	0.6	1.0	0.8	2.4	0.5	1.3	1.5	0.8	0.6	0.3	0.5
	21	1.8	1.0	1.2	0.6	1.2	1.3	1.5	1.7	0.9	0.5	0.5	0.3
	22	1.0	1.3	2.2	1.0	1.3	1.2	1.8	1.0	1.3	0.7	0.3	0.3
	23	1.4	1.1	1.1	1.4	1.9	2.0	1.7	0.6	1.9	0.8	0.4	0.4
	24	1.1	0.9	0.7	1.3	1.4	2.1	1.6	1.3	1.7	0.7	0.6	0.5
	25	1.0	1.2	0.7	2.4	0.9	1.5	1.0	1.5	1.0	0.8	0.6	0.7
	26	1.1	1.3	1.1	2.0	1.9	1.0	1.5	1.0	1.0	0.5	0.4	0.9
	27	1.1	1.3	1.2	2.0	1.5	2.0	2.3	1.0	0.9	0.8	1.0	0.8
	28	1.2	1.0	1.1	1.5	1.3	1.7	2.3	1.5	0.8	0.5	1.4	0.5
	29	1.0		1.0	0.6	2.0	3.0	1.7	1.5	0.8	0.6	1.8	0.6
	30	1.1		0.7	0.9	1.4	0.8	1.6	1.2	0.5	1.3	1.3	0.7
	31	0.8		1.2		1.5		0.7	1.4		0.7		0.5

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	1	1.8	0.4	1.3	1.1	1.5	2.4	0.5	1.1	0.6	0.9	0.5	0.6
	2	1.3	0.5	0.8	1.1	1.6	1.7	1.0	1.6	1.7	0.7	0.5	0.4
	3	0.7	1.4	0.6	1.1	1.4	1.5	1.2	1.9	2.4	0.9	0.5	0.7
	4	0.7	1.8	0.7	0.5	1.3	1.4	2.0	1.7	1.0	0.5	0.4	1.4
	5	2.5	1.4	0.5	0.8	0.9	1.3	1.5	2.0	0.7	0.4	0.3	0.7
	6	1.4	0.4	1.2	1.1	1.0	1.3	1.9	1.9	0.6	0.3	0.5	0.8
	7	1.5	0.5	1.3	0.8	0.9	1.3	1.5	1.5	0.9	0.3	1.0	0.6
	8	0.5	0.8	1.9	0.6	0.9	1.2	1.6	1.0	1.0	0.3	0.8	0.5
	9	0.5	0.7	1.8	2.0	2.5	1.1	1.9	1.0	0.8	0.6	0.6	0.6
	10	0.4	0.6	1.3	2.6	1.2	0.9	2.3	1.0	1.0	0.8	0.6	0.6
	11	1.2	0.7	1.1	2.4	1.0	1.0	1.4	0.6	0.6	1.0	0.6	0.4
	12	0.8	0.8	1.0	1.9	1.0	1.3	1.0	1.0	1.0	0.8	0.8	0.8
	13	0.3	1.0	1.0	1.4	0.7	2.0	1.7	0.9	0.8	1.4	1.0	0.7
	14	0.6	0.6	1.2	1.6	0.8	1.5	2.0	1.0	1.0	2.5	0.9	1.0
	15	0.2	1.0	0.8	1.7	2.2	1.5	0.6	1.1	0.6	0.5	1.0	0.8
	16	1.2	0.9	0.8	2.2	1.9	1.8	0.6	0.8	0.6	0.7	1.1	0.8
	17	0.7	0.8	0.6	1.5	2.2	3.1	1.0	0.8	1.0	0.6	1.5	0.8
	18	0.5	0.6	1.0	1.3	1.3	0.9	1.7	0.6	1.0	0.6	1.0	1.1
	19	0.7	0.5	1.4	1.7	1.1	1.0	1.7	0.8	0.9	0.6	0.6	1.0
	20	0.8	0.4	2.2	1.7	2.6	1.0	2.0	1.1	1.1	2.4	1.5	0.4
	21	1.4	0.6	1.4	1.4	1.0	0.6	2.2	2.0	0.6	1.0	1.0	0.6
	22	1.0	0.6	1.1	1.1	1.4	0.8	1.7	1.0	0.7	0.9	1.0	0.4
	23	1.5	1.5	1.4	1.5	1.2	0.8	1.8	1.0	1.6	0.8	0.8	0.4
	24	1.2	0.8	1.4	1.4	1.1	1.2	1.8	1.0	0.6	0.8	1.0	0.5
	25	0.3	0.7	1.4	0.8	1.4	1.9	2.7	1.3	0.6	0.9	1.0	0.6
	26	1.1	0.6	1.7	0.9	1.2	2.8	2.0	1.2	0.6	0.7	1.1	0.7
	27	0.6	0.9	1.5	0.9	0.6	1.8	1.9	1.5	1.2	0.6	1.0	0.8
	28	0.6	1.6	1.5	0.6	1.2	2.4	2.0	1.8	0.6	0.6	0.8	0.6
	29	0.4		1.1	1.4	3.0	1.6	2.0	1.2	0.5	0.6	0.6	0.6
	30	0.6		1.2	1.5	2.0	2.2	1.8	0.6	0.5	0.6	0.6	0.6
	31	0.6		0.7		0.8		0.9	0.6		0.6		0.5

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	1	0.4	0.3	0.7	1.1	0.6	0.6	0.6	3.4	2.2	0.6	0.6	2.7
	2	0.4	0.3	0.6	1.1	0.8	0.3	0.3	2.6	2.8	0.5	1.3	2.0
	3	0.6	0.1	0.5	1.1	2.5	0.5	0.8	2.7	2.7	0.5	0.8	2.2
	4	0.6	0.6	1.3	0.3	0.7	0.8	1.0	3.6	1.2	0.5	1.2	1.6
	5	0.6	0.3	1.3	0.3	0.6	0.2	0.9	2.2	3.1	0.6	0.4	1.4
	6	0.8	0.3	1.1	0.3	0.3	0.7	0.9	2.2	5.6	0.1	0.3	0.5
	7	0.3	0.3	1.1	0.4	0.7	0.8	0.8	3.0	4.5	0.4	2.8	0.8
	8	0.6	0.1	0.9	0.3	1.9	0.6	0.7	2.4	3.1	0.3	0.2	1.0
	9	0.6	0.8	1.6	0.6	0.7	0.2	0.9	3.3	2.0	0.5	0.5	1.7
	10	0.8	1.4	1.7	0.0	0.6	0.7	0.6	2.3	2.2	0.3	0.3	2.0
	11	0.6	1.0	1.4	0.6	0.6	0.3	0.6	3.1	3.8	0.3	0.0	2.3
	12	0.3	0.3	1.0	1.1	0.5	0.5	0.6	2.9	1.2	0.4	1.0	2.0
	13	0.3	0.6	0.7	1.1	0.6	0.8	1.1	3.8	1.6	0.3	0.8	1.2
	14	0.1	0.7	0.6	0.7	0.6	0.6	1.1	3.8	1.1	0.4	0.6	1.8
	15	0.3	0.4	0.8	0.7	0.6	1.1	1.1	4.3	2.2	0.4	0.5	0.6
	16	0.4	0.4	0.5	0.8	0.7	0.3	0.7	2.1	1.3	0.3	0.1	2.0
	17	0.4	0.3	0.9	0.7	0.4	0.4	0.8	2.2	1.2	0.5	0.8	1.9
	18	0.4	0.7	0.7	1.0	0.4	0.5	0.5	3.4	1.5	0.1	0.2	2.1
	19	0.3	0.1	0.6	0.6	0.7	0.3	1.4	2.3	2.1	0.3	0.4	0.8
	20	0.3	0.8	1.8	0.3	0.6	0.7	1.0	3.0	1.9	0.3	0.0	1.2
	21	0.3	0.6	0.9	0.3	0.6	0.5	1.1	2.0	3.1	0.3	0.8	1.3
	22	0.3	0.7	1.0	0.6	0.5	0.7	1.2	2.6	2.5	0.7	0.0	1.8
	23	0.3	0.4	0.9	1.1	0.6	1.1	0.5	2.5	1.2	0.1	0.4	1.0
	24	0.3	0.3	1.0	0.7	0.7	1.0	0.6	2.9	1.3	0.2	0.6	1.1
	25	0.8	0.3	0.6	0.6	1.0	0.9	0.6	3.2	1.1	0.3	0.5	0.7
	26	0.3	0.3	0.8	0.3	1.2	0.9	0.9	3.4	0.9	0.3	0.5	0.6
	27	0.4	1.1	0.8	0.3	0.8	0.9	0.9	3.5	1.5	0.3	0.2	1.0
	28	0.3	0.4	0.7	1.4	0.6	0.8	0.5	2.9	2.4	0.3	0.4	0.4
	29	0.3		0.8	0.6	0.4	1.5	0.9	3.0	2.0	0.2	1.7	1.2
	30	0.3		0.7	0.6	0.6	0.9	1.2	2.7	3.0	0.3	2.0	1.3
	31	0.3		1.5		0.4		0.8	1.5		0.1		1.6

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	1	2.4	1.5	1.7	2.0	1.2	2.0	1.9	3.0	1.8	1.1	0.7	0.2
	2	0.5	1.6	1.3	0.3	2.4	0.9	1.5	2.0	1.3	1.2	0.8	0.2
	3	1.3	1.8	1.6	1.5	1.2	2.8	2.1	1.7	1.9	1.5	0.7	0.2
	4	1.5	2.3	1.8	2.3	2.4	1.2	2.5	1.8	2.3	1.2	0.8	0.1
	5	1.0	2.2	1.9	2.0	2.1	2.7	3.0	1.6	1.6	2.4	1.6	0.1
	6	0.5	1.6	1.3	3.3	2.7	1.9	2.1	1.6	2.5	2.5	0.5	1.4
	7	0.5	2.5	1.0	1.3	2.8	1.0	1.8	1.1	2.5	2.2	0.1	1.2
	8	0.6	1.0	2.0	2.5	1.2	2.5	2.7	1.4	1.5	1.4	0.3	3.0
	9	1.1	2.8	1.5	1.7	4.0	3.6	2.0	4.1	1.4	1.3	0.5	1.2
	10	1.0	3.9	1.2	3.1	1.8	3.2	1.7	1.3	1.6	1.7	0.2	1.3
	11	1.5	2.8	0.8	2.2	2.1	1.0	1.0	1.2	0.7	1.0	0.4	1.1
	12	2.6	1.8	1.4	1.5	1.8	2.0	2.2	2.2	0.9	1.2	0.7	1.0
	13	1.3	2.4	1.5	1.5	2.0	1.7	1.0	2.1	1.1	1.0	2.2	0.7
	14	1.0	0.8	1.6	1.4	4.0	2.6	2.1	1.8	1.3	1.5	1.3	0.5
	15	0.0	1.8	1.4	2.4	1.8	2.1	2.0	1.3	1.0	3.5	1.0	0.3
	16	0.2	0.9	1.7	2.6	1.4	2.6	1.9	1.3	1.0	3.3	0.5	1.2
	17	0.9	1.9	0.8	2.3	1.9	1.8	1.3	1.7	1.3	1.2	0.6	1.1
	18	1.9	1.4	1.3	1.3	1.7	2.4	2.2	1.6	1.0	1.1	0.5	0.1
	19	0.7	0.6	1.3	0.4	2.0	2.8	1.5	2.2	3.0	1.2	0.1	1.0
	20	1.3	0.7	1.1	1.5	3.1	2.1	1.1	1.0	1.3	1.9	0.3	2.4
	21	0.9	1.4	1.4	1.7	2.7	1.7	1.8	1.8	1.9	1.5	1.3	0.7
	22	1.3	1.2	0.9	1.6	3.4	1.5	2.0	0.9	2.2	1.2	0.7	1.0
	23	2.2	2.3	1.0	1.8	1.2	2.0	1.3	1.5	3.0	0.5	0.3	0.9
	24	0.2	2.1	1.7	1.4	1.6	2.3	1.6	1.7	1.0	0.2	0.5	0.9
	25	0.6	1.4	1.5	1.3	2.3	1.5	1.8	0.9	1.4	0.5	0.2	0.9
	26	0.9	3.4	2.1	2.7	1.8	2.1	2.2	1.0	0.9	0.5	0.8	0.3
	27	2.1	2.6	1.4	1.4	1.0	1.8	1.9	1.4	0.5	0.7	0.1	1.0
	28	1.5	1.5	0.5	1.3	0.5	3.6	2.2	2.9	1.5	0.5	0.2	0.7
	29	1.2	0.7	2.0	1.4	0.6	3.4	2.3	1.6	2.1	2.5	1.1	0.5
	30	0.6		0.3	1.1	1.1	1.9	1.7	1.5	1.6	0.6	0.9	1.1
	31	1.6		2.0		1.5		2.6	1.6		0.7		0.7

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	1	0.4	0.4	0.5	0.8	0.5	2.5	2.1	2.5	2.3	2.3	0.9	0.7
	2	0.7	0.3	0.3	0.7	1.3	0.1	1.5	1.9	0.6	0.9	0.5	0.9
	3	1.1	0.6	0.3	1.2	0.9	1.2	2.9	2.5	2.5	1.4	0.6	0.8
	4	0.5	1.4	0.2	1.0	1.9	0.9	2.0	3.1	2.4	0.7	0.4	0.8
	5	0.4	0.7	0.2	1.3	2.7	3.2	2.2	2.3	1.2	0.2	0.6	0.9
	6	0.1	1.2	0.4	2.3	1.1	2.6	2.0	2.7	3.5	0.1	0.6	1.4
	7	0.4	1.4	0.1	1.0	1.0	1.0	1.6	3.2	0.3	0.4	0.8	1.1
	8	0.4	1.3	0.1	2.9	0.9	0.9	2.4	1.8	0.8	0.7	1.1	0.7
	9	0.1	1.4	1.1	1.8	2.0	2.9	1.7	2.9	2.5	1.9	1.2	0.6
	10	0.1	1.3	0.1	0.4	1.3	0.9	2.5	2.0	1.0	2.2	1.3	0.7
	11	0.3	1.5	0.2	2.1	1.7	0.8	2.0	1.5	1.8	1.0	1.2	0.2
	12	0.9	1.3	0.1	0.9	1.3	1.3	1.9	1.8	1.4	0.9	1.1	0.2
	13	0.4	2.9	0.2	0.3	1.8	3.2	2.3	3.1	1.3	1.1	0.6	1.1
	14	0.8	3.5	0.2	1.1	1.2	2.2	2.9	2.6	1.5	0.9	0.8	0.9
	15	1.6	1.1	0.1	2.9	1.2	4.0	0.1	4.0	1.7	1.2	0.5	0.2
	16	0.1	1.2	0.2	1.5	1.3	2.2	1.8	2.3	2.8	0.8	1.1	0.2
	17	1.6	1.1	0.1	2.6	1.5	1.0	0.4	1.7	0.8	1.0	0.7	1.0
	18	0.6	0.1	0.5	1.4	1.5	0.7	1.5	2.3	2.0	1.4	1.1	0.9
	19	1.4	0.5	1.3	2.2	1.1	0.8	2.3	3.5	2.4	1.7	1.8	0.7
	20	2.5	0.3	0.5	0.4	1.3	2.5	2.9	2.1	1.6	1.0	1.3	0.6
	21	1.2	0.2	2.1	1.9	0.9	3.3	2.5	2.1	2.0	1.1	0.6	1.0
	22	1.4	0.6	0.5	1.2	2.9	3.9	3.0	3.3	1.1	0.8	0.7	2.5
	23	0.5	0.3	0.1	2.1	2.4	2.2	1.3	2.1	1.6	0.7	0.6	0.2
	24	0.7	1.3	1.2	1.2	1.7	2.8	1.6	1.1	1.5	1.3	1.1	1.0
	25	0.5	0.1	2.1	0.2	2.9	2.5	1.7	2.0	2.3	1.0	1.4	1.0
	26	0.5	0.4	0.2	0.5	2.0	2.0	1.8	1.5	1.4	0.6	1.4	0.5
	27	0.3	0.3	1.2	0.2	1.3	2.8	1.8	2.0	1.5	0.9	1.4	0.2
	28	0.3	0.4	1.7	0.5	0.4	2.5	2.9	1.4	0.3	0.9	0.4	1.0
	29	1.5		0.6	0.4	0.3	2.0	2.8	1.4	2.2	0.7	1.2	0.7
	30	1.5		0.9	0.8	2.3	1.8	2.8	1.4	2.2	1.1	0.9	0.3
	31	2.0		1.3		1.7		3.0	2.8		1.2		1.2

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1	1.1	1.2	0.2	1.1	1.6	1.9	1.9	1.4	1.0	0.6	1.1	0.6
	2	1.0	0.8	1.5	1.6	1.5	3.8	3.1	1.5	1.2	0.5	0.2	0.2
	3	0.5	0.5	0.5	1.3	1.4	2.4	2.3	2.1	0.2	0.6	0.7	0.9
	4	1.1	0.5	0.7	1.1	0.9	3.1	2.7	2.4	1.1	1.2	2.0	0.9
	5	1.6	0.8	0.7	1.2	1.9	2.4	4.3	2.7	2.7	0.5	0.9	1.1
	6	1.1	1.7	1.7	1.8	1.7	1.3	2.5	2.6	1.7	0.2	0.8	0.5
	7	0.8	1.4	0.7	1.5	1.8	1.7	2.9	1.7	1.0	0.9	1.0	1.2
	8	0.9	3.2	1.7	1.8	1.2	2.4	2.1	0.3	3.4	1.0	0.8	0.5
	9	1.3	3.9	0.5	1.1	1.8	2.1	2.1	2.4	2.5	0.5	0.9	2.3
	10	0.8	3.5	1.2	1.4	0.9	3.0	2.1	1.6	1.7	1.2	1.1	0.6
	11	1.5	1.9	1.3	1.4	1.5	1.7	2.2	1.5	1.3	1.1	0.7	1.7
	12	1.5	0.9	0.7	1.5	1.6	1.6	3.2	2.7	1.3	2.1	0.8	1.2
	13	2.3	1.7	1.3	1.3	0.6	1.9	3.1	2.2	1.4	1.6	0.9	0.2
	14	1.8	1.9	0.5	1.3	1.8	2.9	2.2	1.1	0.7	1.3	0.7	0.5
	15	1.5	2.4	1.1	2.1	1.2	3.3	1.9	1.7	1.5	0.3	0.2	0.2
	16	1.9	1.6	2.1	1.8	2.6	1.6	1.7	2.3	0.5	0.7	0.3	1.9
	17	1.4	1.6	0.7	1.4	2.5	2.2	1.6	1.3	0.9	1.0	0.3	2.4
	18	1.7	1.9	0.4	2.5	1.7	3.7	1.5	0.2	3.4	0.5	0.3	1.4
	19	1.7	0.2	1.4	1.4	1.4	1.0	4.4	0.2	1.3	0.1	0.2	0.5
	20	1.1	0.5	1.0	2.2	1.7	0.5	2.5	1.5	1.6	0.6	0.4	0.6
	21	1.3	0.7	0.9	3.0	1.1	2.5	1.9	1.0	1.5	0.8	0.4	1.0
	22	1.3	1.1	1.3	2.2	3.6	2.1	0.9	1.4	1.2	2.8	0.2	0.1
	23	1.1	1.8	1.1	1.6	1.3	2.0	0.9	1.7	2.8	0.8	0.8	0.1
	24	1.5	0.5	1.2	1.5	1.4	2.2	1.3	2.3	1.6	2.1	0.4	1.4
	25	1.2	0.6	0.6	1.6	1.1	3.2	0.8	3.0	1.5	1.0	1.1	0.7
	26	0.6	0.7	0.3	1.3	1.8	2.1	2.1	2.9	2.5	0.9	1.3	0.5
	27	0.2	0.6	1.2	1.6	3.2	2.3	3.2	2.1	1.2	0.1	1.5	0.4
	28	0.2	0.5	1.5	1.6	2.3	2.1	3.1	2.6	2.0	1.3	0.7	0.8
	29	2.0		1.4	1.8	1.3	3.1	3.2	2.4	1.7	1.1	0.5	0.2
	30	1.0		1.2	1.7	1.3	0.3	1.3	1.2	1.3	0.7	0.3	1.7
	31	1.3		0.3		3.6		1.1	2.3		0.5		1.8

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	1	2.2	1.7	2.3	2.1	1.9	2.8	2.6	0.8	1.0	1.1	0.8	0.5
	2	1.5	1.8	1.3	3.2	1.7	2.3	0.6	1.4	0.7	1.3	0.6	0.6
	3	1.2	1.0	0.5	4.0	1.3	1.2	2.9	2.0	0.8	1.3	0.6	1.0
	4	1.5	0.2	0.7	1.7	2.0	1.0	0.6	2.3	1.6	1.4	0.8	0.4
	5	1.7	1.9	1.1	3.6	1.6	1.7	1.5	0.9	0.7	1.0	0.6	0.3
	6	1.2	2.1	1.1	2.7	3.3	2.1	1.3	1.6	0.7	0.8	1.3	0.6
	7	0.9	1.2	1.6	1.3	2.7	1.2	2.2	1.1	0.3	1.2	1.0	0.8
	8	0.3	2.2	1.5	1.8	0.7	1.7	1.9	1.8	0.8	0.3	0.9	0.7
	9	0.7	1.6	3.0	2.6	1.5	0.6	1.3	0.7	1.3	0.7	0.6	0.6
	10	1.2	1.6	2.5	1.0	2.7	1.7	0.9	1.7	0.5	0.8	0.9	1.6
	11	0.7	2.0	0.7	2.9	2.8	1.3	1.0	1.5	0.4	1.6	1.9	1.0
	12	0.4	2.7	1.1	2.8	2.9	2.8	1.5	2.4	1.3	1.2	1.7	0.9
	13	0.6	2.5	1.2	1.2	2.9	1.7	1.4	1.3	1.8	1.2	0.8	0.6
	14	1.2	2.3	2.2	1.0	1.2	0.5	2.4	1.3	0.8	0.9	0.8	0.6
	15	1.7	3.2	1.9	0.7	1.8	0.7	1.5	1.3	1.4	0.8	0.9	0.2
	16	1.6	2.3	1.8	4.2	2.1	1.3	1.6	1.1	1.1	0.8	1.2	1.9
	17	0.8	1.7	1.0	2.5	2.0	1.7	1.6	1.1	0.7	0.9	0.9	2.4
	18	0.2	1.2	1.7	1.7	1.9	3.5	1.1	1.4	0.9	0.8	0.3	1.4
	19	2.3	1.8	1.5	1.7	2.0	1.8	1.0	0.9	1.9	0.8	0.6	0.5
	20	1.1	1.9	2.9	0.7	1.0	2.1	1.9	2.6	0.8	1.3	0.7	0.6
	21	1.6	2.5	2.1	0.5	1.9	1.1	1.4	0.3	0.8	0.5	0.8	1.0
	22	1.2	1.8	2.2	1.6	5.5	1.0	1.0	0.8	1.2	1.3	0.1	0.1
	23	0.5	0.7	1.7	1.2	2.1	0.8	2.2	1.3	1.8	2.0	0.3	0.1
	24	0.7	1.7	1.6	1.7	1.7	0.4	2.2	2.4	1.1	0.8	0.3	1.4
	25	1.0	1.6	1.4	2.0	5.2	0.3	2.2	1.4	1.4	0.9	0.6	0.7
	26	1.3	1.6	1.2	2.2	1.7	2.0	1.1	0.5	1.0	0.9	0.3	0.5
	27	2.1	1.0	1.3	1.3	4.0	2.1	1.1	1.8	1.3	1.6	0.5	0.4
	28	2.3	0.7	2.2	2.3	1.7	2.4	1.4	1.5	1.4	0.8	0.4	0.8
	29	1.3		1.4	2.2	2.0	1.3	1.0	1.2	1.5	0.9	0.6	0.2
	30	1.2		1.6	1.8	1.9	1.7	0.6	0.1	1.5	1.0	0.6	0.4
	31	0.9		1.8		1.0		0.7	0.5		0.8		0.6

Yr/Day \ Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	1	0.5	1.3	0.9	0.7	1.1	3.2	0.6	1.9	1.5	0.6	0.7	1.5
	2	0.6	1.4	1.1	1.1	0.5	1.9	1.8	2.5	1.0	1.0	0.9	0.5
	3	1.0	0.9	1.0	0.8	0.6	2.0	2.1	2.9	1.0	1.0	1.4	0.5
	4	0.7	1.2	2.2	1.1	0.7	1.9	2.5	2.1	1.3	0.8	0.9	1.2
	5	0.3	2.1	1.6	1.1	1.4	1.9	3.3	1.2	1.1	0.7	1.2	1.4
	6	0.8	2.2	1.4	1.2	0.6	2.1	1.8	0.6	1.1	1.4	0.7	1.0
	7	0.8	2.4	3.2	1.0	0.9	1.1	3.1	0.9	1.3	1.3	0.8	1.1
	8	0.1	1.7	1.5	1.1	0.6	0.8	1.0	1.2	2.8	1.0	0.7	0.8
	9	1.1	1.9	1.0	1.1	1.8	2.0	0.9	1.6	0.8	1.1	1.3	0.6
	10	0.8	1.4	0.8	1.1	0.9	2.5	1.1	1.9	2.1	1.7	0.8	0.8
	11	1.3	0.9	0.9	1.6	1.3	1.1	2.2	1.3	0.8	0.6	0.5	0.7
	12	1.5	1.2	1.1	1.4	2.1	1.0	1.3	1.6	0.7	1.1	0.4	1.0
	13	0.5	1.3	1.3	1.2	0.9	1.5	1.9	1.2	0.9	1.5	0.3	1.2
	14	0.5	0.8	1.2	1.1	1.1	2.2	2.1	1.8	1.6	0.8	1.0	0.3
	15	1.6	1.9	1.1	1.4	2.5	1.5	2.1	1.5	2.4	1.9	1.1	0.7
	16	0.9	1.3	0.9	2.0	0.9	1.8	1.2	0.9	1.8	0.4	0.6	0.7
	17	0.9	1.1	0.6	1.5	0.9	2.3	1.5	0.9	1.1	0.6	0.5	1.3
	18	1.5	2.0	0.6	0.9	0.8	1.8	2.5	1.5	0.4	0.8	0.7	0.9
	19	0.8	1.4	2.1	1.0	0.9	0.9	2.1	2.3	0.5	0.8	1.2	1.9
	20	0.6	0.9	3.1	2.9	1.1	1.8	2.0	1.0	1.1	0.3	1.5	1.1
	21	0.9	1.0	1.0	1.1	0.7	2.4	3.5	2.1	1.1	0.9	0.7	1.1
	22	0.8	1.9	1.8	2.1	0.7	2.8	1.3	2.7	1.2	0.8	0.9	0.9
	23	1.7	1.2	0.9	1.7	0.5	2.0	1.1	1.8	0.4	1.6	0.9	0.8
	24	0.6	2.1	1.8	0.9	0.7	2.7	2.1	1.0	0.9	0.6	0.8	0.7
	25	1.1	1.6	0.7	1.0	1.6	1.6	1.6	1.7	1.1	0.8	1.3	0.9
	26	1.3	2.3	1.1	0.9	0.4	1.3	1.8	1.9	1.3	0.3	0.6	0.8
	27	1.8	2.4	1.1	1.1	0.8	1.4	0.9	1.3	0.9	0.4	1.3	0.8
	28	1.6	1.7	1.4	1.0	0.7	1.1	0.9	2.4	1.0	0.7	0.9	0.8
	29	1.3	1.2	2.1	2.7	0.7	1.4	1.1	1.2	0.9	0.8	1.1	0.6
	30	1.6		1.3	1.6	0.9	2.1	1.0	0.8	0.6	0.6	1.4	0.5
	31	1.3		1.8		0.9		1.1	1.1		0.6		0.7

5) Natural Disaster

The Number Classified by Seismic Intensity of the Earthquake Observed in Pakistan (1900 to 2013)

Year	Magnitude in Richter scale								Total	Highest tremor
	Unknown	～ 3.0	3.0～3.9	4.0～4.9	5.0～5.9	6.0～6.9	7.0～7.9	8.0 ～		
1909							1		1	7.0
1928						1			1	6.6
1931						1	1		2	7.1
1935								1	1	8.1
1945								1	1	8.0
1947						1			1	6.9
1966					2	2			4	6.8
1972					3				3	5.9
1973				12	8				20	5.6
1974				8	5	2			15	6.2
1975				11	5				16	5.5
1976				4	1				5	5.3
1977				7	4				11	5.5
1978			1	9	5				15	5.5
1979				10					10	4.8
1980				12	3				15	5.4
1981				14	3				17	5.4
1982				8	4				12	5.2
1983			1	11					12	4.8
1984			1	18	7				26	5.6
1985				15	5				20	5.7
1986			1	12	2				15	5.3
1987			2	13	1				16	5.0
1988				17	2				19	5.5
1989				15					15	4.7
1990				27	8	1			36	6.0
1991			1	24	3				28	5.6
1992			10	29	10				49	5.9
1993			1	11	5				17	5.6
1994				8	2				10	5.5
1995			4	14	1				19	5.6
1996			7	17	3				27	5.2
1997			81	126	9	1	1		218	7.1
1998			8	29	3				40	5.4
1999			3	15	6				24	5.7
2000			4	14	1	1			20	6.0
2001			2	16	3				21	5.2
2002			6	26	1				33	5.8
2003			1	14	1				16	5.0
2004			3	21	5				29	5.5
2005		1	288	287	46	1	1		624	7.6
2006			77	47	3				127	5.2
2007			22	33	4				59	5.5
2008			87	80	7	2			176	6.4
2009			1	15	6				22	5.5
2010				19	8				27	5.4
2011				25	3		1		29	7.2
2012				28	3				31	5.4
2013			1	50	7	1	1		60	7.7
Total	0	1	613	1171	208	14	6	2	2015	－