BEFORE
THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
(NEPRA)

APPLICATION FOR A GENERATION LICENSE FOR HYDROPOWER GENERATION FACILITY

PURSUANT OF ENABLING PROVISIONS OF NEPRA ACT 1997

READ WITH ENABLING PROVISIONS OF RULES MADE THERE UNDER,

LICENSING (APPLICATION & MODIFICATION PROCEDURE) REGULATIONS 1999

LICENSING (GENERATION) RULES 2000

ON BEHALF OF
MANDI BAHA UD DIN ENERGY LIMITED

FOR NEPRA' S GRANT OF GENERATION LICENSE FOR
MANDI BAHA UD DIN ENERGY LIMITED

FOR A POWER PROJECT OF APPROXIMATELY 3.3 MW (THE PROJECT)

AT

LOWER JHELUM FEEDER CANAL, DISTRICT MANDI BAHA UD DIN

DATED: 28TH DECEMBER, 2016

MANDI BAHA UD DIN ENERGY LIMITED
ADDRESS: 156 BLOCK N, MODEL TOWN EXTENSION, LAHORE
PHONE #: 042-35161952-3
FAX #: 042-35161954

Mandi-Baha-UD-Din
Energy Limited

December 28, 2016
The Registrar
National Electric Power Regulatory Authority
2nd Floor, OPF Building,
Sector G-5/2,
Islamabad

Dear Sir,

Subject: **Application for grant of Generation License**

I, **Zain ul Abidin, Director of Mandi Baha ud Din Energy Limited,** being the duly authorized representative of **Mandi Baha ud Din Energy Limited** by virtue of **BOARD RESOLUTION** dated **13th December, 2016,** hereby apply to the **National Electric Power Regulatory Authority** for the grant of a **Generation License** to the Mandi Baha ud Din Energy Limited pursuant to section [3] of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

I certify that the documents-in-support attached with this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, and undertake to abide by the terms and provisions of the above-said regulations. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge and belief.

A **BANK DEMAND DRAFT No. DDLBT 00005088 dated 27th December, 2016** in the sum of Rs. **147,192/- Rupees One Hundred Forty Seven Thousand One Hundred Ninety Two Only,** being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

Zain ul Abidin - Director

Mandi-Baha-UD-Din Energy Limited

Head Office: 156-N Model Town, Ext. Lahore. Tel: +92-42-35161952-3, Fax: +92-42-35161954
Email: info@aseconsultant.com, Web: www.aseconssultant.com

Mandi-Baha-UD-Din
Energy Limited

EXTRACT OF THE RESOLUTION PASSED BY THE BOARD OF DIRECTORS OF MANDI BAHA UD DIN ENERGY LIMITED (THE "COMPANY") ON 13TH DECEMBER, 2016

PRESENT:

1. **Mr. Syed Muhammad Ali (Chief Executive Officer)**
2. **Mr. Zain ul Abidin (Director)**
3. **Mr. Ikhwan Younas (Director)**

The afforested directors of the Company have passed the following resolutions in writing, through circulation.

RESOLVED THAT

"The Company shall proceed with all acts necessary to comply with the legal and regularly requirements in relation to its business objects and activities."

FURTHER RESOLVED THAT

"**Mr. Zain ul Abidin** Director has been duly authorized to file (i) an application for grant of Generation License; (ii) any other clarification, submission, application, petition, of document on support thereof (iii) to make any oral or written representations on behalf of the Company; before the **National Electric Power Regulatory Authority** and any other body. Organization, department, judicial and quasi-judicial body in relation to the aforesaid filings; and to do all other acts, deeds, things and matters as may be deemed expedient in giving effect to the aforesaid resolution."

FURTHER RESOLVED THAT

"In addition to **Mr. Zain ul Abidin, Mr. Ikhwan Younas** Director of **Mandi Baha ud Din Energy Limited** shall also have the afforested powers."

FURTHER RESOLVED THAT

"**Mr. Zain ul Abidin** may further delegate the afforested powers, in writing, to one or more persons, as deemed expedient, from time to time."

Certified to be True Copy
Chief Executive Officer

Mandi-Baha-UD-Din Energy Limited

Head Office: 156-N Model Town, Ext. Lahore. Tel: +92-42-35161952-3, Fax: +92-42-35161954
Email: info@aseconsultant.com, Web: www.aseconssultant.com

Mandi-Baha-UD-Din
Energy Limited

CERTIFICATION

CERTIFIED, that, the above resolution was duly passed by circulation by the directors, who were at the time being entitled to receive notice of a meeting of Directors, with the requisite quorum of directors passing such resolution in writing, on 13th December, 2016. FURTHER CERTIFIED, that the said resolution has not been rescinded and is in operation and that this is a true copy thereof.

Mandi-Baha-UD-Din Energy Limited

Chief Executive Officer

Head Office: 156-N Model Town, Ext. Lahore. Tel: +92-42-35161952-3, Fax: +92-42-35161954
Email: info@aseconsultant.com, Web: www.aseconssultant.com

A022512

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

SECP

COMPANY REGISTRATION OFFICE, LAHORE

CERTIFICATE OF INCORPORATION

[Under section 32 of the Companies Ordinance, 1984 (XLVII of 1984)]

Corporate Universal Identification No. 0100639

I hereby certify that **MANDI BAHA UD DIN ENERGY LIMITED** is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is Limited by Shares.

Given under my hand at Lahore this Thirteenth day of July, Two Thousand and Sixteen.

Fee Rs.3,000/-

(SHAUKAT HAMEED)
Joint Registrar

CERTIFIED TO BE TRUE COPY

JOINT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE

No.ARL/ 301 DATED: 13-07-2016

PARTICULARS OF DIRECTORS AND OFFICERS, INCLUDING THE CHIEF EXECUTIVE, MANAGING AGENT, SECRETARY, CHIEF ACCOUNTANT, AUDITORS AND LEGAL ADVISERS, OR OF ANY CHANGE THEREIN

THE COMPANIES ORDINANCE, 1984 — **FORM 29**

[SECTION 205]

Save Form

Please Complete in typescript or in bold block capitals

1. Incorporation Number
2. Name of Company: MANDI BAHA UD DIN ENERGY LIMITED
3. Fee Paid (Rs.): 300.0 — Name and Branch of Bank: LAHORE, MCB - Ajmal House, Edgerton Road [0182]
4. Receipt No.: E-2016-463156 — Date (DD/MM/YYYY): 05/07/2016
5. Mode of Payment (Indicate): Bank Challan
6. **Particulars*:**

Company Registration Office Lahore — Securities and Exchange Commission of Pakistan

6.1. New Appointment/Election

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)
MUHAMMAD IKHWAN YOUNAS	37406-1630481-3	S/O MUHAMMAD YOUNAS	H # 245, St G-2, WAH Cantt, TAXILA TAXILA Punjab Pakistan 47080	Director	Pakistan		Since Incorporation.	
SYED MUHAMMAD ALI	42301-0373464-3	S/O SYED ASHFAQ ALI	H # 5D, 1st Gizri Lane, DHA Phase IV KARACHI Sindh Pakistan 75500	Director	Pakistan		Since Incorporation.	
ZAIN UL ABIDIN	42201-0622607-1	S/O FAZAL HUSSAIN AMIN	H # 537-A, STREET 11, TOWNSHIP LAHORE Punjab Pakistan 54000	Director	Pakistan		Since Incorporation.	

6.2. Ceasing of Officer/Retirement/Resignation

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

CERTIFIED TO BE TRUE COPY

JOINT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

6.3. Any other change in particulars relating to columns (a) to (g) above

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment	Mode of Appointement / change / any other remarks

	National (b)	Name (o)				(if any) (g)	or Change (h)	other remarks (i)

Name of Signatory: MUHAMMAD IKHWAN YOUNAS

Designation: Director

Signature of Chief Executive/Secretary:

Date (DD/MM/YYYY): 05/07/2016

Company Registration Office Lahore Securities and Exchange Commission of Pakistan

* In the case of a firm the full name address and above mentioned particulars of each partner and the date on which each became a partner

** In case the nationality is not the nationality of origin provide the nationality of origin as well.

*** Also provide particulars of other directorships or offices held, if any

Form 21

FORM 21

THE COMPANIES ORDINANCE, 1984
[SECTION 142]

NOTICE OF SITUATION OF REGISTERED OFFICE OR ANY CHANGE THEREIN

1. Incorporation Number	
2. Name of the Company	MANDI BAHA UD DIN ENERGY LIMITED
3. Fee Paid (Rs.)	300,00
Name & Branch of the Bank	LAHORE, MCB - Ajmal House, Edgerton Road [0182]
4. Receipt No.	E-2016-463166
5. The situation of registered office of the company was changed from (previous address)	
6. The Registered Office of the company is now situated at	156 N, MODEL TOWN EXTENSION LAHORE Punjab 54000
6.1. Telephone Nos	04237424020,03009499041
6.2. Fax No, if any	
6.3. Email Address	ca@kamranco.com.pk
7. With Effect from (date)	Since Incorporation
8. Signature of Chief Executive/Secretary	
9. Name of Signatory	MUHAMMAD IKHWAN YOUNAS
10. Designation	Director
11. NIC Number of Signatory	37406-1630481-3
12. Date (DD/MM/YYYY)	17/06/2016

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

CERTIFIED TO BE TRUE COPY

JOINT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

THE COMPANIES ORDINANCE, 1984

(COMPANY LIMITED BY SHARES)

Memorandum of Association

Of

MANDI BAHA UD DIN ENERGY LIMITED

I. The name of the Company is "MANDI BAHA UD DIN ENERGY LIMITED".

II. The Registered Office of the Company will be situated in the Province of the Punjab.

III. The objects for which the Company is established are all or any of the following:-

1. To generate, harness, develop, transmit, trade and accumulate electric power by setting up Hydel-Power Plants including gas-based, coal-based plants and all other types of power-plants like, Diesel-Power, Multi Fuel Based Power, Thermal Power, Mini-Hydel Power, Micro-Hydel Power and also to generate electric power by wind, solar, tidal and other sources of energy; and supply and distribute such generated power, either directly or through Distribution companies or others to consumers of electricity on commercial basis and to establish, construct and maintain necessary power stations and to generally generate, accumulate, bank, transform, distribute, transmit, trade, supply and deal in electricity subject to prior permission from NEPRA or any other relevant authority.

2. To carry on the business of electric power generation and supply and to construct, lay down, establish, fix and carry out all works for necessary power stations, cables, wires, lines, accumulators, lamps, works and to generate, accumulate, transmit, trade, distribute, and supply electricity and to light cities, towns, streets, docks, markets, theatres, buildings and places both public and private subject to prior permission from NEPRA or any other relevant authority.

3. To own, promote, set up, establish, develop, maintain, run, operate and manage generating company, generating station or stations of every kind and description [whether on a BOO (Build, Own Operate) basis or BOOT (Build, Own, Operate and Transfer) basis or BOLT (Build, Own, Lease and Transfer) basis or otherwise] for generating electricity from any source, whether conventional or non-conventional, whether now

existing or known or invented, developed, made known thereafter, including hydro, wind, solar, tidal, biogas, waste material whether liquid, gaseous or solid or any combination thereof, thermal, geo-thermal, coal, gas including liquefied natural gas, naphta, oil, diesel, or otherwise including any building and plant with step-up transformer, switch gear, switch yard, cables or other appurtenant equipment, if any, used for generating station, and any building used for housing the operating staff of a generating station, and where the electricity is generated by water-power, includes penstock, head and tail works, main and regulating reservoirs, dams and other hydraulic works subject to prior/necessary approval of the relevant/concerned authorities.

4. To carry on all or any of the businesses of generating, purchasing, importing, transforming, converting, distributing, supplying, exporting and dealing in electricity and all other forms of energy and products or services associated therewith and of promoting the conservation and efficient use of electricity and to perform all other acts which are necessary or incidental to the business of electricity generation, transmission, distribution and supply subject to prior/necessary approval of the relevant/concerned authorities.

5. To locate, establish, construct, equip, operate, use, manage and maintain thermal power plants and coal fired power plants, power grid station, transforming, switching, conversion, and transmission facilities, grid stations, cables, overhead lines, sub-stations, switching stations, tunnels, cable bridges, link boxes, heat pumps, plant and equipment for combined heat and power schemes, offices, computer centres, shops, dispensing machines for pre-payment cards and other devices, showrooms, depots, factories, workshops, plants, printing facilities, warehouses and other storage facilities subject to prior/necessary approval of the relevant/concerned authorities.

6. To carry on all or any of the businesses of wholesalers, retailers, traders, importers, exporters, suppliers, distributors, designers, developers, manufacturers, installer, filters, testers, repairers, maintainers, contractors, constructors, operators, users, inspectors, reconditioners, improvers, alterers, protectors, removers, hirers, replacers, importers and exporters of and dealers in, electrical appliances, systems, products and services used for energy conservation, equipments, machinery, materials and installations, including but not limited to cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity subject to prior/necessary approval of the relevant/concerned authorities.

7. To ascertain the tariff for bulk supply that will secure recovery of operating costs, interest charges and depreciation of assets, redemption at due time of loans other than those covered by depreciation, expansion projects, payment of taxes, and reasonable return on investment, to quote the tariff to bulk purchasers of electrical power, and to prefer petition to the appropriate authority for approval of the schedule of tariff and of adjustments or increases in its bulk supply tariff, where desirable or necessary.

8. To undertake any activity which the company is permitted to undertake, including as a generating company and a licensee, under the electricity laws for the time being in force and rules and regulations made thereunder.

9. To undertake any other ancillary business related to above.

10. For the purposes of achieving the above objects, the company is authorized:-

(a) to purchase/import raw materials and allied items required in connection thereto in any manner the company may think fit;

(b) to do and perform all other acts and things as are incidental or conducive to the attainment of the objects of the company;

(c) to own, establish or have and maintain shops, branches and agencies all over Pakistan or elsewhere for sale and distribution of cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity;

(d) to make known and give publicity to the business and products of the company by such means as the company may think fit;

(e) to purchase, acquire, protect, renew, improve, use and sell, whether in Pakistan or elsewhere any patent, right, invention, license, protection or concession which may appear advantageous or useful to the company for running the business;

(f) to pay all costs, charges and expenses, if any, incidental to the promotion, formation, registration and establishment of the company;

(g) to purchase, hold and get redeemed shares, debentures, bonds of any business, company, financial institution or any Government institutions;

h) To transact such other business as may be proper, necessar nd desirable for or in connection with the objects of the Company or of them.

i) To set up, erect, construct, purchase, take on lease, import, uy, install, run, operate and administer plants, machineries, her equipments and factories and to carry on all such functions and ss as are necessary and incidental to meet the objectives of the C ny and to dispose off such plants, machineries and spare parts whic ave become obsolete or worn out.

j) To manufacture, import, export, store, process, purchase and w materials, equipments, machineries, other equipments, spare or other articles of use required for or incidental to the manu re, preparation, adaptation, treatment, use or working of the fore or the packing, storing or otherwise for the purpose of carrying he business of the Company.

k) To acquire and undertake the whole or any part of the property and liabilities of any person or company carrying ny business which the Company is authorized to carry on, or poss of property suitable for the purposes of the Company.

l) To establish laboratories and research and development c to perform such research and development as the Company m m advisable or feasible.

m) To train personnel and workers, both in Pakistan and abroad, in technical proficiency in various specialties connected with th cts of the company or any of them.

n) To apply for, purchase or otherwise acquire any patents its invention, licences, concessions, and the like, conferring any ve or non-exclusive or limited right to use, or any secret er information as to any invention which may seem capable of ed for any of the purposes of the Company or the acquisition of ay seem calculated directly or indirectly to benefit the Compar to use, exercise, develop, or grant licences in respect of, or othe rn to account the property, rights or information so acquired.

o) To enter into partnership or into any arrangement for s g
profits, union of interest, co-operation, joint vent r
reciprocal concession, with any person or company, lo r
foreign, carrying on or engaged in any business or tran n
which this Company is authorized to carry on or be engage r
otherwise assist any such person or company, and to r
otherwise acquire shares and securities of any such compa d
to sell, hold, re-issue with or without guarantee, or ot e
deal with the same, except doing business as an inv t
company.

p) To take, or otherwise acquire, and hold shares in an r
company, having objects altogether or in part similar to f
this Company, or carrying on any business capable o g
conducted so as directly or indirectly to benefit this Comp t
not to act as an investment company.

q) To enter into arrangement with any Government or aut ,
supreme, national, municipal, local, railway, or otherwis c
or quasi-public bodies, or with any other persons, in a e
where the Company may have interest that may seem c e
to the objects of the Company or any of them and to obt n
any such Government, authorities or persons any rights, p s
and concessions which the Company may think fit to ob d
to carry out, exercise and comply with any such arran ,
rights, privileges and concessions.

r) To establish and support or aid in the establishment and t
of associations, institutions, funds, and conveniences c d
to benefit employees of the Company or the deper r
connections of such persons, and to grant pensi d
allowances, and to make payments towards their insuran

s) To amalgamate with any other company whose objects are and/or include objects similar to those of this Company, whether by sale or purchase (for fully paid-up shares) of the undertakings, subject to the liabilities of this or any such other company as aforesaid, with or without winding up or by sale or purchase (for fully paid-up shares) of all or a controlling interest in the shares or stock of this or any such other company as aforesaid, or by partnership, or any arrangement of the nature of partnership, or in any other manner.

t) To sell or dispose of the undertaking of the Company or any part thereof for such consideration as the Company may think fit and, in particular, for shares, debentures or securities of any other company having objects altogether or in part similar to those of this Company.

u) To purchase, take on lease or in exchange, hire or otherwise acquire, any movable or immovable property, and any rights or privileges which the Company may think necessary or convenient for the purpose of its business and, in particular, any land, buildings, easement, machinery, plant and stock-in-trade.

v) To construct, maintain and alter any buildings or works, necessary or convenient for the purposes of the Company.

w) To construct, improve, maintain, develop, work, manage, carry out, or control any manufactories, warehouses, shops, stores, and other works and conveniences which may seem calculated directly or indirectly to advance the Company's interests.

x) To sell, improve, manage, develop, exchange, mortgage, enfranchise, dispose of, turn to account, or otherwise deal with, all or any parts of the property and rights of the Company.

y) To invest and deal with the money of the Company, not immediately required, in such manner as may from time to time be determined, but not to act as an investment, finance, or banking company.

z) To advance money to such persons or companies and on such terms as may seem expedient and, in particular, to customers and others having dealings with the Company, but not to act as an investment, finance, or banking Company.

aa) To borrow or raise funds by means of loans or secure the payment of money from shareholders, directors, commercial banks and government approved agencies in such manner as the Company shall think fit for its manufacturing, trading and allied business and, in particular, by the issue of debentures or debenture-stock, perpetual or otherwise, charged upon all or any of the Company's property and other assets, both present and future, including its capital, and to purchase, redeem, or pay any such securities, but not to act as an investment, finance, or banking company.

ab) To guarantee the performance of contracts, agreements, obligations or discharge of any debt of the company in relation to the payment of any financial facility including but not limited to loan, advance, letter of credit or other obligations through creation of all types of mortgages, charges, pledges, hypothecation, on execution of the usual banking documents/instruments or otherwise encumbrance on any or all of the movable and immovable properties of the company, either present or future or both and issuance of any other securities or sureties by any other means in favour of banks, Non-Banking Finance Companies or any financial institutions and to borrow money for purposes of the company on such terms and conditions as may be considered proper.

ac) To open, close and operate banking accounts of the Company with any bank.

ad) To draw, make, accept, endorse, discount, execute and issue promissory notes, bills of exchange, bills of lading, warrants, debentures and other negotiable or transferable instruments, but not to act as an investment or banking company.

ae) To adopt such means of making known the products of the Company as may seem expedient, including, in particular, by advertisement in the press, circulars, purchase and exhibition of works of art or interests, publication of books and periodicals, and grant of prizes, rewards and donations.

af) To subscribe or contribute or otherwise to assist or to guarantee money to charitable, benevolent, religious, scientific, technical, national, public, or any other institutions, for its objects or purposes or for any exhibition.

ag) To apply for and obtain any provisional order or Act of legislature or any consents, permissions and licenses from the Government, central or provincial, and any agencies of the Government for enabling the Company to carry on any of its objects into effect, or for effecting any modification of the Company's constitution, or for any other purpose which may seem expedient, and to oppose any proceeding or application which may seem calculated, directly or indirectly, to prejudice the Company's interests.

ah) To sell any patent rights or privileges belonging to the Company or which may be acquired by it, or any interest in the same, and to grant licenses for the use and practice of the same or any of them and to let or allow to be used or otherwise deal with any inventions, patents or privileges in which the Company may be interested, and to do all such acts and things as may be deemed expedient for turning to account any inventions, patents and privileges in which the Company may be interested.

ai) To extend money on experimenting upon and testing and improving or securing any process or processes' patent, or protecting any invention or inventions which the Company may acquire or propose to acquire or deal with.

aj) To distribute among the members of the Company, in kind or otherwise, any property of the Company and, in particular, any shares, debentures or securities of other companies belonging to this Company, or of which this Company may have the power of disposing in the event of winding up of the company.

ak) To create any reserve fund, sinking fund, insurance fund or any other special fund, whether for depreciation or for repairing, insuring, improving, extending or maintaining any of the property of the Company or for any other purpose conducive to the interests of the Company.

11. It is, hereby, undertaken that the Company shall not engage in banking business or any business of investment company or non-banking finance company or insurance or leasing or business of managing agency or in any unlawful business and that nothing contained in the object clauses shall be so construed to entitle it to engage in such business directly or indirectly and the Company shall not launch multi-level marketing (MLM), P*yramid* and *Ponzi* schemes.

12. Notwithstanding anything stated in any object clause the company shall obtain such other approval or license from competent authority as may be required under any law for the time being in force to undertake a particular business.

IV. The liability of the members is limited.

V. The Authorised Capital of the Company is Rs. 500,000/- (Rupees Five Hundred Thousand only) divided into 50,000 (Fifty Thousand) ordinary shares of Rs. 10/- (Rupees Ten only) each with powers to increase and reduce the Capital of the Company and to divide the shares in the Capital for the time being into several classes in accordance with the provisions of the Companies Ordinance, 1984.

We, the several persons whose name and addresses are subscribed below, are desirous of being formed into a Company, in pursuance of this Memorandum of Association, and we respectively agree to take the number of shares in the Capital of Company as set opposite to our respective names.

Name and Surname (Present & Former) in Full (in Block Letters)	Father's / Husband's Name in Full	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each sub-scriber	Signature
1. Syed Muhammad Ali C.N.I.C. 42301-0373464-3	S/o Syed Ashfaq Ali	PAKISTANI	BUSINESS	5D, 1st Gizri Lana, DHA Phase IV, Karachi	20,000	
2. Muhammad Ikhwan Younas C.N.I.C. 37406-1630481-3	S/o Muhammad Younas	PAKITANI	BUSINESS	H# 245, Street G-2, WAH cantt, Taxila	15,000	
3. Zain ul abidin C.N.I.C. 42201-0622607-1	S/o Fazal Hussain Amin	PAKITANI	BUSINESS	H# 537-A, Street 11, Township Lahore	15,000	
				Total No. of Shares Taken	50,000 Fifty thousand only	

CERTIFIED TO BE TRUE COPY

Dated this 21 day of June 2016.

Witness to the above Signatures:

National Institutional Facilitation Technologies (Pvt.) Ltd.
5th Floor AWT Plaza,

I. I. Chundrigar Road, Karachi.

THE COMPANIES ORDINANCE, 1984

(PUBLIC COMPANY LIMITED BY SHARES)

Articles of Association

Of

MANDI BAHA UD DIN ENERGY LIMITED

PRELIMINARY

1. The regulations in Table "A" in the First Schedule to the Companies Ordinance, 1984 shall not apply to the Company except as reproduced herein : Table 'A' Not to apply.

2. In these Articles, unless the context or the subject matter otherwise requires : Interpretation

(a) "Articles" means these Articles as originally framed or as from time to time altered in accordance with law.
(b) "Board" means a meeting of the Directors duly called and constituted or as the case may be, the Directors assembled at a Board.
(c) "Company" means "**MANDI BAHA UD DIN ENERGY LIMITED**".
(d) "Directors" means the Directors for the time being of the Company or as the case may be, the Directors assembled at a Board.
(e) "Month" means calendar month according to the English Calendar.
(f) "Office" means the Registered Office for the time being of the Company.
(g) "Ordinance" means the Companies Ordinance, 1984 or any modification or re-enactment thereof for the time being in force.
(h) "Register" means, unless the context otherwise requires, the register of members to be kept pursuant to Section 147 of the Ordinance.
(i) "Seal" means the common or official Seal of the Company.
(j) "Section" means Section of the Ordinance.
(k) "Special Resolution" means the special resolution of the Company as defined in Section (2)(1)(36) of the Ordinance.

(l) Words importing masculine gender include the feminine gender.

(m) Words importing singular number include the plural number and vice versa.

(n) Expression referring to writing shall, unless the contrary intention appears, be construed as including references to printing, lithography, photography and other modes of representing or reproducing words in a visible form.

(o) Words importing persons shall include bodies corporate.

(p) The head notes are inserted for convenience and shall not affect the construction of these Articles.

(q) Unless the context otherwise requires words or expressions contained in these Articles shall bear the same meaning as in the Ordinance.

PUBLIC COMPANY

Public Company

3. The Company is a Public Company within the meanings of Section 2(1)(30) of the Companies Ordinance, 1984.

CAPITAL

Capital

4. The Authorised Capital of the Company is Rs. 500,000/- (Rupees Five Hundred Thousand only) divided into 50,000/- ordinary shares of Rs. 10/- (Rupees Ten only) each. The Company shall have the powers to increase, reduce or alter the capital in accordance with law.

Allotment of Shares

5. The Directors shall, as regards any allotment of shares duly comply with such of the Provisions of Section 68 to 73 as may be applicable to the Company. The minimum subscription upon which the Directors may proceed to make the first allotment has been fixed as Rs. 100,000/- (Rupees One Hundred Thousand only).

Shares Certificates

6. Every person whose name is entered as a member in the Register shall, without payment, be entitled to receive within ninety days after allotment or within forty-five days of the application for registration of transfer, a certificate under the Seal specifying the share or shares held by him and the amount paid up thereon. Provided that, in respect of a share or shares held jointly by several persons, the Company shall not be bound to issue more than one certificate, and delivery of a certificate for a share to one of several joint holders shall be sufficient delivery to all.

Issuance of new Certificates

7. If a Share Certificate is defaced, lost or destroyed, it may be renewed on payment of such fee, if any, not exceeding one rupee, and on such terms, if any, as to evidence and indemnity any payment of expenses incurred by the Company in investigating title as the Directors think fit.

Bar on use of Company Funds

8. Except to the extent and in the manner allowed by Section 95, no part of the funds of the Company shall be employed in the purchase of, or in loans upon the security of, the Company's shares.

TRANSFER OF SHARES

Transfer

9. The instrument of transfer of any share in the Company shall be executed both by the transferor and transferee and the transferor shall be deemed to remain holder of the share until the name of the transferee is entered in the Register in respect thereof.

Form of Transfer

10. Shares in the Company shall be transferred, without fee, in the following form, or in any usual or common form which the Directors shall approve ;

I.....of..... in consideration of the sum of Rs.....Paid to me by..... of.....(hereinafter called the "Transferee") do hereby transfer to the Transferee.....the share(s) numbered..... to .....inclusive, in "**MANDI BAHA UD DIN ENERGY LIMITED** to hold into the transferee, his executors, Administrators and assigns, subject to the several conditions on which I held the same at the time of the execution hereof, and I, the Transferee, do hereby agree to take the said share (or shares) subject to the conditions aforesaid.

As witness our hands this.....day of.....20

Transferor Signature _____ Transferee Signature _____

WITNESSES :

1. _____ (Signature)
Full Address : _____

2. _____ (Signature)
Full Address of _____

Non-refusal of Transfer of Shares

11. The Directors shall not refuse to transfer any fully paid shares unless the transfer deed is defective or invalid. The Directors may also suspend the registration of transfer prior to the determination of entitlement or rights of the shareholders by giving seven days previous notice in the manner provided in the Ordinance. The Directors may decline to recognize any instrument of transfer unless the duly stamped instrument of transfer is accompanied by the certificate of the shares to which it relates, and such other evidence as the Directors may reasonably require to show the right of the transferor to make the transfer.

Notice in case of Refusal

12. If the Directors refuse to register a transfer of shares, they shall within thirty (30) days after the date on which the transfer deed was lodged with the Company send to the transferee and the transferor notice of the refusal indicating the defect or invalidity to the transferee, who, shall, after removal of such defect or invalidity be entitled to re-lodge the transfer deed with the Company. The transferor or transferee or the person who gave intimation of the transmission by operation of law, as the case may be, may appeal to the commission against any refusal of the Company to register the transfer or transmission or against any failure on its parts within period as specified in Section 78 for which Section 78/A will be applicable.

TRANSMISSION OF SHARES

Transmission

13. The executors, administrators, heirs, or nominees as the case may be, of a deceased sole holder of a share shall be the only persons recognized by the Company as having any title to the shares. In the case of a share registered in the names of two or more holders, the survivor or survivors, or executors or administrators of the deceased survivor shall be the only persons recognized by the Company as having any title to the share.

Election to Register or Transfer

14. Any person becoming entitled to a share in consequence of the death or insolvency of a member shall, upon such evidence being produced as may from time to time be required by the Directors, have the right, either to be registered as a member in respect of the share or, instead of being registered himself, to make such transfer of the share as the deceased or insolvent person could have made ; but the Directors shall, in either case have the same right to decline or suspend registration as they would have had in the case of a transfer of the share by the deceased or insolvent person before the death or insolvency.

Rights of Person entitled by Transmission

15. A person becoming entitled to a share by reason of the death or insolvency of the holder shall be entitled to the same dividends and other advantages to which he would be entitled if he were the registered holder of the share, except that he shall not, before being registered as a member in respect of the share be entitled in respect of it to exercise any right conferred by membership in relation to meetings by the Company.

ALTERATION OF CAPITAL

Power to Increase Capital

16. The Company may from time to time, by special resolution increase the share capital by such sum, to be divided into shares of such amount, as the resolution shall prescribe.

Offer to existing Members

17. Subject to the Provisions of the Ordinance, all new shares shall, before issue be offered to such persons as at the date of the offer are entitled to receive notices from the Company of General Meetings in proportion, as nearly as the circumstances admit, to the amount of the existing shares to which they are entitled. The offer shall be made by notice specifying the number of shares offered, and limiting a time within which the offer if not accepted, will be deemed to be declined and after the expiration of that time, or on the receipt of an intimation from the person to whom the offer is made that he declines to accept the shares offered, the Directors may dispose of the same in such manner as they think most beneficial to the Company. The Directors may likewise so dispose of any new shares which (by reason of the ratio which the new shares bear to shares held by persons entitled to an offer of new shares) cannot, in the opinion of the Directors, be conveniently offered under this regulation.

Conversion of Loan to Ordinary shares

8. Subject to the provisions of Section 87 of the Ordinance, the Company may issue ordinary shares or grant option to convert into ordinary shares the outstanding balance of any loans advances or credit or other non-interest bearing securities and obligations or having a term of not less than three years in the manner provided in any contract with any scheduled bank or financial institution to the extent of twenty per cent (20%) of such balance.

Provisions applicable to new Shares

19. The new shares shall be subject to the same provisions with reference to transfer, transmission and otherwise as the shares in the original share capital.

Consolidation and Subdivision

20. The Company may, by ordinary resolution :

(a) Consolidate and divide its share capital into shares of larger amount than its existing shares ;

(b) Sub-divide its existing shares or any of them into shares of smaller amount than is fixed by the Company's Memorandum of Association, subject, nevertheless, to the provisions to clause (d) of sub-section (1) of Section (92).

(c) Cancel any shares which at the date of passing of the resolution have not been taken or agreed to be taken by any person.

Reduction of Share Capital

21. The Company may, by Special Resolution, reduce its share capital in any manner and with, and subject to any incident authorized and consent required by law.

GENERAL MEETINGS

Statutory Meeting

22. The Statutory General Meeting of the Company shall be held within the period required by Section 157.

Annual General Meeting

23. A General Meeting to be called Annual General Meeting, shall be held in accordance with provisions of Section 158, within a period of four months following the close of its financial year and not more than fifteen months after the holding of its last preceding Annual General Meeting as may be determined by the Directors.

Other Meetings

24. All General Meetings of the Company other than the Annual General Meeting shall be called Extraordinary General Meetings.

Extraordinary Meeting

25. The Directors may whenever they think fit, call an Extraordinary General Meeting, and Extraordinary General Meetings shall also be called on such requisition, or in default, may be called by such requisitionists, as is provided by Section 159. If at any time there are not within Pakistan sufficient Directors capable of acting to form a quorum, any Director of the Company may call an Extraordinary General Meeting in the same manner as nearly as possible as that in which Meetings may be called by the Directors.

NOTICE AND PROCEEDINGS OF GENERAL MEETINGS

Notice of Meeting

26. Twenty one days notice at least (exclusive of the day on which the notice is served or deemed to be served, but inclusive of the day for which notice is given) specifying the place, the day and the hour of Meeting and, in case of special business, the general nature of that business, shall be given in the manner provided by the Ordinance for the General Meeting, to such persons as are, under the Ordinance or the regulations of the Company, entitled to receive such notices from the Company ; but the accidental omission to give notice to, or the non-receipt of notice by, any member shall not invalidate the proceedings at any General Meeting.

Special Business

27. All business shall be deemed special that is transacted at an Extraordinary General Meeting, and also all that is transacted at an Annual General Meeting, with the exception of declaring a dividend, the consideration of the accounts, balance sheet and the reports of the Directors and auditors, the election of Directors, the appointment of and the fixing, of the remuneration of the auditors.

Quorum

28. No business shall be transacted at any General Meeting unless a Quorum of members is present at that time when the meeting proceeds to business. Two members present personally who represent not less than twenty five per cent of the total voting power, either on their own account or as proxies shall be a quorum.

Effect of Quorum Not being present

29. If within half an hour from the time appointed for the meeting a quorum is not present, the meeting, if called upon the requisition of members, shall be dissolved; in any other case, it shall stand adjourned to the same day in the next week at the same time and place, and, if at the adjourned meeting a quorum is not present within half an hour from the time appointed for the meeting, the members present, being not less than two, shall be a quorum.

Chairman of Meeting

30. The Chairman of the Board of Directors, if any, shall preside as Chairman at every General Meeting of the Company, but if there is no such Chairman, or if at any meeting he is not present within fifteen minutes after the time appointed for the meeting, or is unwilling to act as Chairman, any one of the Directors present may be elected to be Chairman, and if none of the Directors is present, or willing to act as Chairman, the members present shall choose one of their member to be Chairman.

Adjournment

31. The Chairman may, with the consent of any meeting at which a Quorum is present (and shall if so directed by the meeting), adjourn the meeting from time to time but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting.

Voting

32. At any General Meeting a resolution put to the vote of the meeting shall be decided on a show of hands unless a poll is (before or on the declaration of the result of the show of hands) demanded. Unless a poll is so demanded, a declaration by the Chairman that a resolution has, on a show of hands, been carried, or carried unanimously, or by a particular majority, or lost, and an entry to that effect in the book of the proceedings of the Company shall be conclusive evidence of the fact, without proof of the number or proportion or the votes recorded in favour of, or against, that resolution.

Demand for Poll

33. A Poll may be demanded only in accordance with the provisions of Section 167.

Manner of taking Poll

34. If a Poll is duly demanded it shall be taken in accordance with the manner laid down in Section 168 and the result of the Poll shall be deemed to be the resolution of the meeting at which the Poll was demanded.

Time of taking Poll

35. A Poll demanded on the election of Chairman or on a question of adjournment shall be taken at once.

Casting Vote

36. In the case of an equality of Votes, whether on a show of hands or on a poll, the Chairman of the meeting at which the show of hands takes place, or at which the Poll is demanded, shall have and exercise a second or Casting Vote.

VOTES OF MEMBERS

Right to Vote

37. On a show of hands every member present in person shall have one Vote except for election of Directors in which case the provisions of Section 178 shall apply. On a Poll every member shall have voting rights as laid down in Section 160.

Voting by Joint Holders

38. In case of Jointholders, the Vote of the senior who tenders a Vote, whether in person or by proxy, shall be accepted to the exclusion of the Votes of the other Jointholders ; and for this purpose seniority shall be determined by the order in which the names stand in the register.

Member of Unsound Mind

39. A member of unsound mind, or in respect of whom an order has been made by any Court having jurisdiction in lunacy, may vote, whether on show of hands or on a poll, by his committee or other legal guardian, and any such committee or guardian, on a poll vote by proxy.

Voting by Corporation Representations

40. On a poll vote may be given either personally or by proxy. Provided that nobody corporate shall vote by proxy as long as a resolution of its Directors in accordance with the provisions of Section 162 is in force.

Proxy to be in Writing

41. The instrument appointing a Proxy shall be in writing under the hand of the appointer or of his attorney duly authorized in writing. A Proxy must be a member of the Company.

Instrument appointing Proxy to be deposited

42. The Instrument appointing a Proxy and the power of attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power or authority, shall be deposited at the Registered Office not less than forty eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote and in default the instrument of proxy shall not be treated as valid.

43. An instrument appointing a proxy may be in the following form, or a form as near thereto as may be.

MANDI BAHA UD DIN ENERGY LIMITED

Form of Proxy

44 I/We ..... of ..... (full address) being the member(s) of '**MANDI BAHA UD DIN ENERGY LIMITED** hereby appoint Mr. / Mrs. / Miss ..... of ..... (who is also member of the Company vide Registered Folio No. ..... (being member of Company) as my / our Proxy to attend at and vote for my / us and on my / our behalf at the ..... Annual / Extra Ordinary General Meeting of the Company to be held at ..... on ..... at ..... and at any adjournment thereof.

Revocation of Authority

45. A vote given in accordance with the terms of an instrument of proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the proxy or of the authority under which the proxy was executed, or the transfer of the share in respect of which the proxy is given, provided that no intimation in writing of such death, insanity, revocation or transfer as aforesaid shall have been received by the Company at the office before the commencement of the meeting or adjourned meeting at which the proxy is used.

DIRECTORS

Number of Directors

46. Unless otherwise determined by the Company in General Meeting the number of Directors shall not be less than three and if the Company applies for listing on Stock Exchanges, then the number of Directors shall not be less than Seven.

Present Directors

47. The following are the present Directors of the Company who shall hold office uptil first Annual General Meeting and thereafter shall be eligible for re-election.

1. SYED MUHAMMAD ALI	**Director**
2. MUHAMMAD IKHWAN YOUNAS	**Director**
3. ZAIN UL ABIDIN	**Director**

Qualification of Directors

48. Save as provided in Section 187, no person shall be appointed as a Director unless he is a member of the Company and holds shares of the minimum value of Rs. 5,000/- in his own name relaxable in the case of Directors representing interest holding shares.

Remuneration of Directors

49. The remuneration of a Director for performing extra services, including holding of the office of Chairman, and the remuneration to be paid to any Director for attending the meetings of the Directors or a committee of Directors shall from time to time be determined by the Board of Directors in accordance with law.

CHAIRMAN

Chairman

50. The Directors may from time to time appoint one of their members to be the Chairman of the Company for a period not exceeding three years on such terms and conditions as they deem fit. The Chairman shall preside over the meetings of the Board of Directors and members of the Company. In his absence, the Directors may elect one of them to preside over the Board Meeting. The questions arising at the meeting of the Directors shall be decided by a majority of votes. In the case of equality of votes, the Chairman, or the Director presiding over the meeting, as the case may be, shall have a casting vote.

CHIEF EXECUTIVE

Chief Executive

51. The first Chief Executive of the Company will be appointed by the Board of Directors within fifteen days from the date of incorporation of the Company who shall hold office till the first Annual General Meeting.

POWERS AND DUTIES OF DIRECTORS

General Management Powers

52. The business of the Company shall be managed by the Directors, who may pay all expenses incurred in promoting and registering the Company, and may exercise all such powers of the Company as are not by the Ordinance or any statutory modification thereof for the time being in force, or by these regulations, required to be exercised by the Company in General Meeting, subject nevertheless to the provisions of the Ordinance or to any of these regulations, and such regulations being not inconsistent with the aforesaid provisions, as may be prescribed by the Company in General Meeting but no regulation made by the Company in General Meeting shall invalidate any prior act of the Directors which would have been valid if that regulation had not been made.

BORROWING POWERS

Borrowing Powers and giving of Securities

53. The Board may from time to time borrow any money for the purposes of the Company from its members or from any other person, firms, companies, corporations, Government Agencies, institutions or the Directors may themselves lend moneys to the Company.

Raising Moneys

54. The Board may raise and secure payment of such sums of money in such manner and upon such terms and conditions in all respects as it may think fit, and in particular by the issue of TFC's bonds, perpetual or redeemable debentures or by mortgage or charge or other security on the whole or any part of the property, assets and rights of the Company (both present and future), of the Company.

Condition of Bond/Securities

55. Any TFC's, bonds, debentures or other securities issued or to be issued by the Company shall be under the control of the Board which may issue them upon such terms and conditions and in such manner and for such consideration as shall be considered to be for the benefit of the Company.

Special Powers to Issue Securities

56. Any TFC's, bonds, debentures or other securities may be issued with any special privileges as to redemption, surrender, drawing, convertibility into shares, attending and voting at General Meetings of the Company, appointment of Directors, and otherwise, provided that debentures with the right to vote or to be converted into shares shall be issued with the consent of the Company in General Meeting in terms of Section 114 of the Ordinance.

Power to appoint Attorney

57. The Directors may from time to time, by Power of Attorney under the Company's seal, appoint any person or persons to be the Attorneys of the Company for such purposes and with such powers, authorities, and discretions (not exceeding those vested in, or exercisable by, the Directors under these presents) and for such period and subject to such conditions as the Directors may from time to time think fit. Any such attorney(s) may, if authorised by the Directors, delegate all or any of the powers vested in him/them.

Duties of Directors

58. The Directors shall duly comply with the provisions of the Ordinance and in particular with the provisions in regard to the registration of the particulars of mortgages and charges affecting the property of the Company or created by it, to the keeping of a register of the Directors, and to the sending to the Registrar of an annual list of members and a summary of particulars relating thereto and notice of any consolidation or increase of share capital, or sub-division of shares, and copies of Special Resolutions and a copy of the register of Directors and notifications of any changes therein.

Minutes Books

59. The Director shall cause minutes to be made in books provided for the purpose of :

(a) all appointments of officers made by the Directors ;
(b) the names of the Directors present at each meeting of the Directors and of any Committee of the Directors ;
(c) all resolutions and proceedings at all meetings of the Company and of the Directors and of Committees of Directors ;
(d) and every Director present at any meeting or Directors of Committee of Directors shall sign his name in a book to be kept for that purpose.

DISQUALIFICATION OF DIRECTORS

Disqualification of Directors

60. No person shall become a Director of the Company if he suffers from any of the disabilities or disqualifications mentioned in Section 187 and, if already a Director, shall cease to hold such office from the date he so becomes disqualified or disabled or provided, however, that no Director shall vacate his office by reason only of his being a member of any company which has entered into contracts with, or done any work for the Company but such Director shall not vote in respect of any such contract or work, and if he does so his vote shall not be counted.

PROCEEDINGS OF DIRECTORS

Meeting of Directors

61. The Directors may meet together for the despatch of business, adjourn and otherwise regulate their meetings, as they think fit. The quorum for a meeting of Directors shall not be less than one-third or two, whichever is greater. Questions arising at any meeting shall be decided by a majority of votes. In case of an equality of votes, the Chairman shall have and exercise a second or casting vote. A Director may, and the secretary on the requisition of a Director shall, at any time, summon a meeting of Directors. It shall not be necessary to give notice of a meeting of Directors to any Director for the time being absent from Pakistan.

Chairman of Directors Meetings

62. The Directors may elect a Chairman of their meetings and determine the period for which he is to hold office but, if no such Chairman is elected, or if at any meeting the Chairman is not present within ten minutes after the time appointed for holding the same or is unwilling to act as Chairman, the Directors present may choose one of their number to be Chairman of the meeting.

Committee

63. The Directors may delegate any of their powers not required to be exercised in their meeting to Committees consisting of such member or members of their body as they think fit. Any Committee so formed shall, in the exercise of the powers so delegated, conform to any restrictions that may be imposed on them by the Directors.

Chairman of Committee Members

64. A Committee may elect a Chairman of its meetings, but, if no such Chairman is elected, or if at any meeting the Chairman is not present within ten minutes after the time appointed for holding the same or is unwilling to act as Chairman, the members present may choose one of their number to be Chairman of the meeting.

Proceedings of Committee Members

65. A Committee may meet and adjourn as it thinks proper. Questions arising at any meetings shall be determined by a majority of votes of the members present. In case of an equality of votes, the Chairman shall have and exercise a second or casting vote.

Validity of Directors Acts

66. All acts done by any meeting of the Directors or of a committee of Directors, or by any person acting as a Director, shall, notwithstanding that it be afterwards discovered that there was some defect in the appointment of such Directors or persons acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed and was qualified to be a Director.

Resolution in Writing

67. A resolution in writing circulated to all the Directors signed by all the Directors or affirmed by them through telex or telegram shall be as valid and effectual as if it had been passed at a meeting of the Directors duly convened and held.

ELECTION AND REMOVAL OF DIRECTORS

Election & Term of Directors

68. At the first Annual General Meeting of the Company, all the Directors shall stand retired from office, and thereafter shall be re-elected in their place in accordance with Section 178 for a term of three years.

Eligibility for Re-election

69. A retiring Director shall be eligible for re-election.

Mode of Election

70. The Directors of the Company, unless the number of persons who offer themselves to be elected is not more than the number of Directors fixed by the Board of Directors, shall be elected to office by the members in General Meeting in the following manner :

(a) A member shall have such number of votes as is equal to the product of the number of voting shares or securities held by him and the number of Directors to be elected.
(b) A member may give all his votes to a single candidate or divide them between more than one of the candidates in such manner as he may choose.
(c) The candidate who gets the highest number of votes shall be declared elected as Director and then the candidate who gets the next highest number of votes shall be so declared and so on until the total number of Directors to be elected has been so elected.

Change in number of Directors

71. Subject to the provisions of the Ordinance, the Company may from time to time in General Meeting increase or decrease the number of Directors.

Filling of Casual Vacancy

72. Any Casual vacancy occurring on the Board of Directors may be filled up by the Directors, but the person so chosen shall be subject to retirement at the same time as if he had become a Director on the day on which the Director in whose place he is chosen was last elected as Director.

Removal of Director

73. The Company may remove a Director but only in accordance with the provisions of the Ordinance.

NOMINEE DIRECTOR

74. In addition to the elected Directors, the Financial Institutions shall be entitled, during the currency of their respective loan(s) to the Company, to appoint one person on the Board of Directors of the Company to be called Nominee Director and to recall and/or replace such a person from time to time. Such Nominee Director on the Board of Directors of the Company may not be holder of Share(s) in the Capital of the Company and the Articles 67 to 72 and other regulations and or rules pertaining to the election, retirement, qualification and/or disqualification of the Director shall not apply to him.

THE SEAL

Common Seal

75. The Directors shall provide a Common Seal of the Company which shall not be affixed to any instrument except by the authority of a resolution of the Board or by a committee of Directors authorised in that behalf by the Directors, and two Directors of one Director and the secretary of the Company shall sign every instrument to which the Common Seal is affixed.

Official Seal

76. The Directors may provide for the use in any territory, district or place not situated in Pakistan, of an Official Seal which shall be a facsimile of the Common Seal of the Company, with the addition on its face of the name of every territory, district or place where it is to be used. The provisions of Section 213 shall apply to the use of the Official Seal.

DIVIDENDS AND RESERVES

Declaration of Dividends

77. The Company in General Meeting may declare dividends but no dividend shall exceed the amount recommended by the Directors.

Interim Dividends

78. The Directors may from time to time pay to the members such interim dividends as appear to the Directors to be justified by the profits of the Company.

Dividends Payable out of Profits

79. No dividend shall be paid otherwise than out of profits of the year or any other undistributed profits.

Dividends Payable on Amount Paid on Shares

80. Subject to the rights of persons (if any) entitled to shares, all dividends shall be declared and paid according to the amounts paid on the shares, but if and so long as nothing is paid upon any of the shares in the Company, dividends may be declared and paid according to the amounts of the shares.

Reserve Fund

81. The Directors may, before recommending any dividend set aside out of the profits of the Company such sums as they think proper as a reserve or reserves which shall, at the discretion of the Directors, be applicable for meeting contingencies, or for equalizing dividends, or for any other purpose to which the profits of the Company may be properly applied, and pending such application may, at the like discretion, either be employed in the business of the Company or be invested in such investments (other than shares of the Company) as the Directors may, subject to the provisions of the Ordinance, from time to time think fit.

Profit carried Forward

82. The Directors may carry forward any profits which they may think prudent not to distribute, without setting them aside as a reserve.

Capitalization of Reserve

83. Any General Meeting may resolve that any moneys, investments, or other assets forming part of the undivided profits of the Company standing to the credit of any reserve or other fund or in the hands of the Company and available for dividend (or representing premiums received on the issue of shares and standing to the credit of the shares premium account) be capitalized and distributed amongst such of the shareholders as would be entitled to receive the same if distributed by way of dividend and in the same proportions on the footing that they become entitled thereto as capital and that all or any part of such capitalized fund be applied on behalf of such shareholders in paying up in full, any unissued shares, debentures or debenture-

stock of the Company which shall be distributed accordingly and that such distribution or payment shall be accepted by such shareholders in full satisfaction of their interest in the said capitalized sum.

Effect of Transfer

84. A transfer of shares shall not pass the right to any dividend declared thereon before the registration of the transfer.

Dividends to Joint Holders

85. If several persons are registered as jointholders of any share, any one of them may give effectual receipt for any dividend payable on the shares.

Notice of Dividend

86. Notice of any dividend that may have been declared shall be given in the manner hereinafter mentioned to the persons entitled to share therein.

Period for Payment of Dividend

87. The dividend shall be paid within the period laid down in Section 251.

Unclaimed Dividends

88. All dividends unclaimed for six years after having been declared shall be kept in trust by the Company but may be invested or otherwise made use of by the Directors for the benefit of the Company until claimed.

ACCOUNTS

Books of Account

89. The Directors shall cause to be kept proper Books of Account as required under Section 230.

Place where Books kept

90. The Books of Account shall be kept at the Registered Office of the Company or at such other place as the Directors shall think fit and shall be open to inspection by the Directors during business hours.

Inspection by Members

91. The Directors shall from time to time determine whether and to what extent and at what time and places and under what conditions or regulations the accounts and books or papers of the Company or any of them shall be open to the inspection of members not being Directors, and no member (not being a Director) shall have any right of inspecting any Account and Book or papers of the Company except as conferred by law or authorised by the Directors or by the Company in General Meeting.

Annual Accounts

92. The Directors shall as required by Sections 233 and 236 cause to be prepared and to be laid before the Company in General Meeting such Profit and Loss Accounts and Balance Sheets and reports as are referred to in those sections.

Balance Sheet and Profit and Loss Account

93. A Balance Sheet, Profit and Loss Account, and other reports referred to in the preceding Article shall be made out in every year and laid before the Company in the Annual General Meeting made up to a date not more than six months before such meeting. The Balance Sheet and Profit and Loss Account shall be accompanied by a report of the auditors of the Company and the report of Directors.

Copy of Accounts to be sent to Members

94. A copy of the Balance Sheet and Profit and Loss Account and reports of Directors and auditors shall, at least twenty one days preceding the meeting, be sent to the persons entitled to receive notices of General Meetings in the manner in which notices are to be given as hereinafter provided.

When Accounts Settled

95. Every Account of the Directors when audited and approved by a General Meeting shall be conclusive except as regards any errors discovered therein within three months next after the approval thereof. Whenever any such error is discovered within that period the account shall forthwith be corrected and thenceforth shall be conclusive.

Compliance with Ordinance

96. The Directors shall in all respect comply with the provisions of Sections 230 to 236.

AUDIT

Audits

97. Once at least every year the accounts of the Company shall be audited and the correctness of Profit and Loss Account and Balance Sheet ascertained by one or more Auditors. The Auditors shall be appointed and their duties regulated in accordance with Sections 252 to 255 of the Companies Ordinance 1984.

SECRETARY

Secretary

98. The Board may appoint a Secretary of the Company who shall perform such functions and duties as are required in these Articles, or as may be directed by the Board.

NOTICES

Notice to Members etc.

99. Notices shall be given by the Company to Members and Auditors of the Company and other persons entitled to receive notices in accordance with Section 50.

SECRECY

Secrecy

100. Every Director, Manager, Adviser, Auditor, Trustee, Member of a Committee, Officer, Servant, Agent, Accountant or other person employed in the business of the Company shall, if so, required by the Directors, before entering upon his duties, sign a declaration pledging himself to observe a strict secrecy respecting all transactions of the Company with its customers and the state of accounts with individuals and in matters relating thereto, and shall by such declaration pledge himself not to reveal any of the matters which may come to his knowledge in the discharge of his duties except when required to do so by the Directors or by any General Meeting or by any Court of Law and except so far as may be necessary in order to comply with any of the provisions in these presents.

Members access to Company premises

101. No member or other person (not being a Director) shall be entitled to enter upon the property of the Company or examine the Company's premises or properties without the permission of the Directors, and to require discovery of or any information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade, or secret process or of any matter whatsoever which may relate to the conduct of the business of the Company and which in the opinion of the Directors will be inexpedient, in the interest of the members of the Company to communicate.

RECONSTRUCTION

Reconstruction

102. On any sale of the undertakings of the Company the Directors or the liquidators on a winding up may, if authorised by a Special Resolution, accept fully paid shares, debentures or securities of any other company, either then existing or to be formed for the purchase in whole or in part of the property of the Company, and the Directors (if the profits of the Company permit), or the liquidators (in a winding up), may distribute such shares or securities, or any other properties of the Company amongst the members without realization, or vest the same in trustees for them and any Special Resolution may provide for the distribution or appropriation of the cash, shares or other securities, benefits or property, otherwise than in accordance with the strict legal rights of the members or contributories of the Company for the valuation of any such securities or property at such price and in such manner as the meeting may approve and all holders of shares shall be bound to accept and shall be bound by any valuation or distribution so authorised and waive all rights in relation thereto save only such statutory rights (if any) as are, in case the Company is proposed to be or in the course of being wound up, incapable of being varied or excluded by these presents.

WINDING UP

Division and Distribution of Assets upon Dissolution

103. If the Company is wound up, the liquidator may, with the sanction of a Special Resolution of the Company and any other sanction required by Ordinance, divide amongst the members in specie or kind the whole or any part of the assets of the Company (whether they consist of property of same kind or not) and may, for such purpose, set such value as he deems fair upon any property to be divided as aforesaid and may determine how such division shall be carried out as between the members or different classes of members. The liquidator may, with the like sanction, vest the whole or any part of such assets in trustees upon such trust for the benefit of the contributories, as the liquidator with the like sanction, shall think fit, but so that no member shall be compelled to accept any shares or other securities whereon there is any liability.

INDEMNITY

Indemnification

104. Every officer or agent for the time being of the Company may be indemnified out of the assets of the Company against any liability incurred by him indefending any proceedings, whether civil or criminal, arising out of his dealings in relation to the affairs of the Company, except those brought by the Company against him, in which judgement is given in his favour or in which he is acquitted, or in connection with any application under Section 488 in which relief is granted to him by the Court.

ARBITRATION

Difference to be Referred to Arbitrator(s)

105. Whenever any difference arises between the Company on the one hand and any of the members, their executors, administrators or assignees on the other hand, touching the true intent or construction, or the incident or consequences of these Articles or of the statutes or touching anything there or thereafter done, executed, omitted or suffered in pursuance of these Articles or of the statutes or touching any breach or alleged breach of these Articles, or any claim on account of any such breach or alleged breach, or otherwise relating to the premises, or to these Articles or to any statute affecting the Company or to any of the affairs of the Company, every such difference shall, as a condition precedent to any other action at law be referred in conformity with the Arbitration Act, 1940, or any statutory modification thereof and any rules made thereunder, to the decision of an Arbitrator to be appointed by the parties in difference or if they cannot agree upon a single Arbitrator to the decision of two Arbitrators of whom one shall be appointed by each of the parties in difference, or in the event of the two Arbitrators not agreeing, then of an umpire to be appointed by the two Arbitrators, in writing, before proceeding on the reference, and such decision shall be final and binding on the parties.

We, the several persons whose name and addresses are subscribed below, are desirous of being formed into a Company, in pursuance of this Articles of Association, and we respectively agree to take the number of shares in the Capital of Company as set opposite to our respective names.

Name and Surname (Present & Former) in Full (in Block Letters)	Father's / Husband's Name in Full	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each subscriber	Signature
1. Syed Muhammad Ali C.N.I.C. 42301-0373464-3	S/o Syed Ashfaq Ali	PAKISTANI	BUSINESS	5D, 1st Gizri Lana, DHA Phase IV, Karachi	20,000	
2. Muhammad Ikhwan Younas C.N.I.C. 37406-1630481-3	S/o Muhammad Younas	PAKITANI	BUSINESS	H # 245, Street G-2, WAH cantt, Taxila	15,000	
3. Zain ul abidin C.N.I.C. 42201-0622607-1	S/o Fazal Hussain Amin	PAKITANI	BUSINESS	H # 537-A, Street 11, Township Lahore	15,000	
				Total No. of Shares Taken	50,000 Fifty thousand only	

CERTIFIED TO BE TRUE COPY

Dated this 21 day of June 2016.

Witness to the above Signatures:
National Institutional Facilitation Technologies (Pvt.) Ltd.
5th Floor AWT Plaza,
I. I. Chundrigar Road, Karachi.

ANNEXURE – K
PROSPECTUS

PROSPECTUS

INTRODUCTION OF COMPANY:

Mandi Baha ud Din Energy Limited is a Company incorporated specifically for the development of 3.3MW Hydro Power Project located at Lower Jhelum Feeder Canal, District Mandi Baha ud Din. The company consists of below mentioned Consortium member companies who applied and got LOI of the said project on **18 April, 2016** for the development of 3.3MW Hydro power project from Punjab Power Development Board (PPDB).

- M/S China Sinogy Electric Investment Co Ltd (CSEIC) — Main Sponsor
- M/S China Sinogy Electric Engineering Co Ltd (CSEEC) — Member Company
- M/S NETCO Rental Services (NETCO) — Member Company
- M/S Habib Rafiq PVT ltd (HRL) — Member Company
- M/S Zhejiang Jinlun (JINLUN) — Member Company

The Company Registered office is located at **H.No 156 Block N Model Town Extension Lahore**.

The Company Board of Directors Detail is as under.

- Syed Muhammad Ali — Chief Executive Officer
- Muhammad Ikhwan Younas — Director
- Zain ul Abidin — Director

SALIENT FEATURES OF THE FACILITY:

Mandibahauddin Hydro Electric Power Project is located along RD 2+000 along lower Jhelum Canal Feeder near Rasul Barrage about 10 km from Mandibahauddin Town in District Mandibahauddin of the Punjab Province. The project has the capacity of 3.3 MW and will generate 19.007 GWh of energy annually. Powerhouse and bottom outlets would be located at RD 2+000 in the existing canal. The head available at RD 8+626 and RD 0+000 would be combined for development of this Hydro Electric Power Project. Two Pit type Kaplan Turbines would be installed. Three bottom outlets with hydraulically operated vertical gates would be provided as bypassing structure in case of load rejection on turbine units. NTDC 132 KV Grid at Mandibahauddin about 10 km from project site is used for interconnection through 11 KV line.

PROPOSAL INVESTMENT:

For equity portion the members of the Consortium have found financial background which can be assessed from their audited financial statements.

For Debt portion the company proposed to get 100 percent financing through local source. A revised Financing Scheme has been announced by State Bank of Pakistan through Circular No.

IH&SMEFD/REPP/2016-19201 dated August 09, 2016. The revised scheme aims to incentivize financing for large renewable energy projects (upto 50MW) as well as for small scale renewable energy solutions (less than 1 MW). Under the revised scheme, concessionary financing will be provided through banks at 6 percent. The tenure of the loan is 12 years.

SOCIAL & ENVIRONMENT IMPACT:

The IEE was conducted under Pakistan Environmental Protection Agency guidelines. There are no impacts to wildlife, fish and historical or archeological sites. Because of the existing falls and annual closure regime of the canal system, there are no significant fisheries and project will have no significant impacts on fish. The main impact is the removal of trees which will be compensated with tree planting program. All the project construction activities will take place on land associated with Government and will be leased, therefore no resettlement issues of the project.

The project will have limited environmental impacts and those impacts identified will be adequately mitigate by implementing the EMP. Therefore, a full EIA is not required for Mandibahauddin Hydro Electric Power Project.

ANNEXURE – L
SCHEDULE III

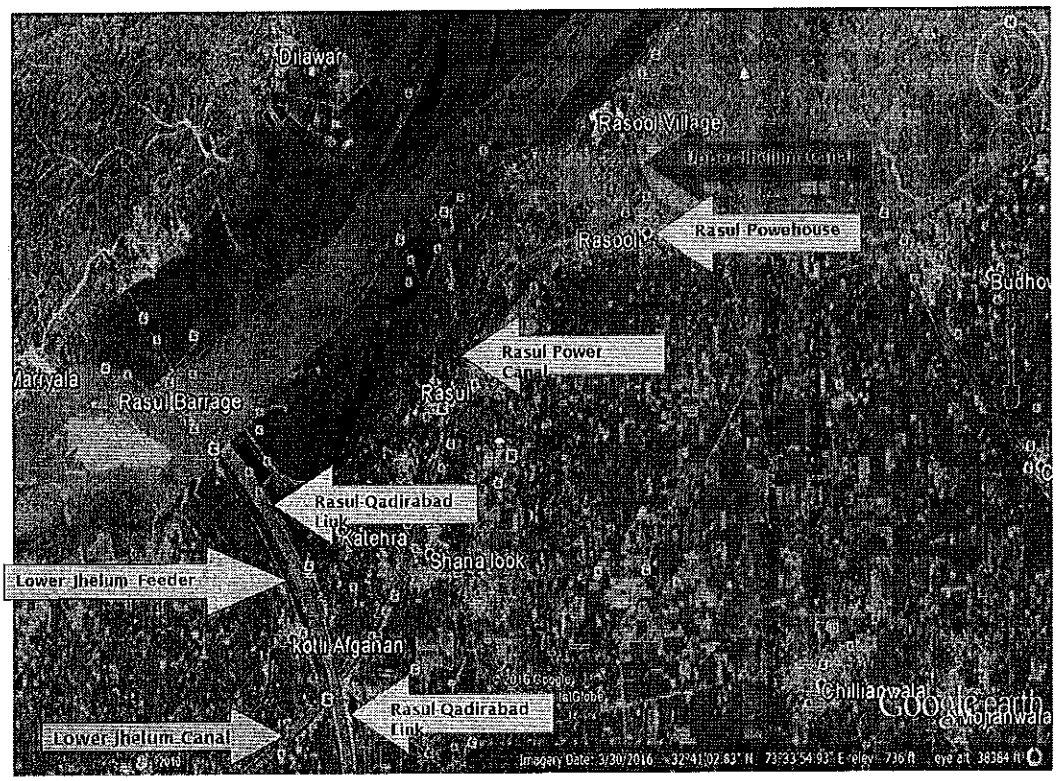
SCHEDULE III

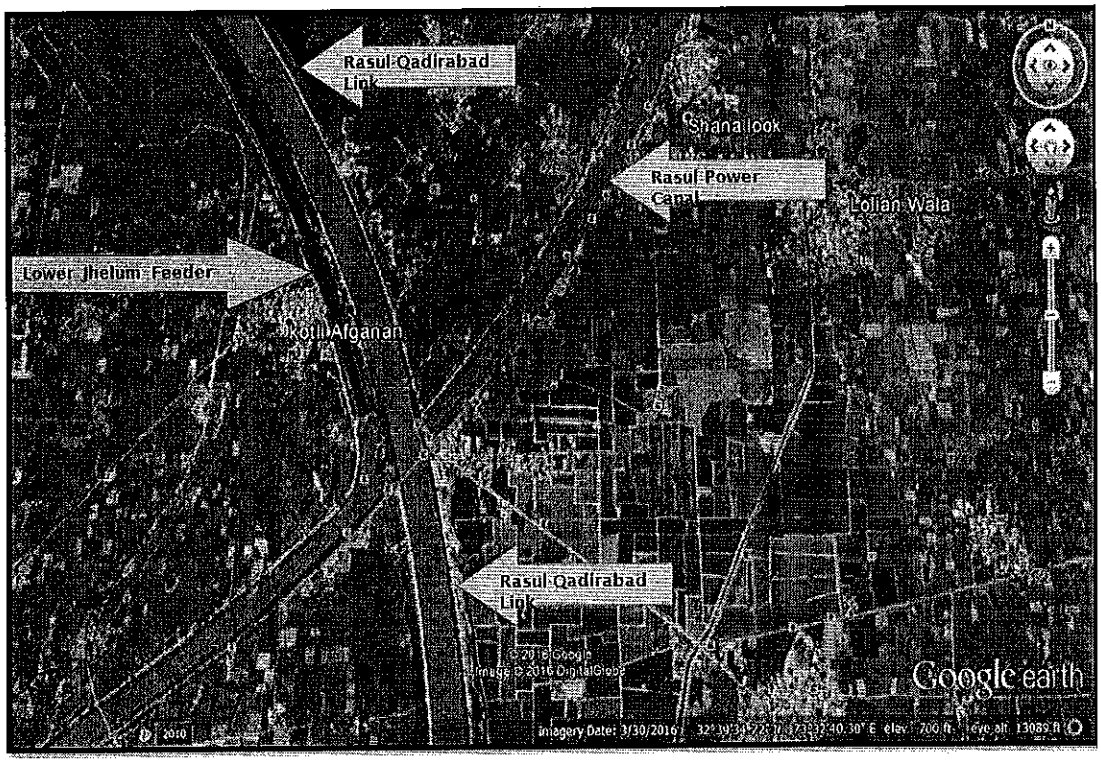
[(regulation 3(6)]

NEW GENERATION FACILITIES (HYDEL)

1. LOCATION

The project lies in District **Mandibahauddin** which is located in the south of Gujrat city. The project is located at the lower Jhelum Canal Feeder, which is off- taking from left Bank of Rasul Barrage along Jhelum River. The project is located in Upper Punjab which is heart of agriculture and Citrus fruit production. The project area is located about 210 km from Lahore, 157 km from Islamabad, 61 km from Gujrat, 10 km from **Mandibahauddin** city and 6 km south west of Rasul Town in Mandibahauddin District of Punjab Province. The project site is located at 73°32'11" Longitude and 32°39'30"Latitude with an average altitude around 213m.a.s.l. Project location/vicinity map is shown below.





LAND

The land required for project implementation would be on temporary and permanent basis. Land for dumping excavation earth material, diversion canal and Contractor camps will be required on the temporary basis and will be returned back to Irrigation Department after bringing into original Condition. Land for operation and maintenance staff residence colony is required on permanent basis. The land required for the project belongs to Irrigation Department, Government of Punjab and would be leased to the project sponsor. The total land area required for construction of project components is 64 acres which include 4.5 acre for permanent land use and 59.5 acres for temporary land use. The land required for both permanent and temporary use is under the control of Irrigation Department Government of Punjab and will be acquired following government land leasing regulation. No private land will have to be acquired for project construction. Land required for **Mandibahauddin** Hydro Electric Power Project is as.

No	Permanent Land use	Land (Acres)	Temporary land use	Land (Acres)
1	O & M Staff Colony	4.5	Diversion Canal	27.5
2			Soil dumping site	24
3			Contractor Camp	8

2. PLANT RUN OF RIVER, STORAGE, WEIR

The power house is classified as **Run of the Canal Scheme**, which shall be developed together with other facilities; on the Lower Jhelum Canal (LJC) Feeder off taking from the left bank of Rasul Barrage and at RD 2+500 combining the falls available at RD 0+000 and RD 8+626.

Two options (Spillway or Bottom outlet) for discharge by-passing structures in case of emergency shutdown of plants were considered to be employed for this project.

3. HEAD: MINIMUM, MAXIMUM

Gross Minimum Head	5.2 m
Gross Maximum Head	7.52m
Design Head	6.75m

4. TECHNOLOGY

Technology for plant is proposed as **Pit type Kaplan Turbine**

Capacity

Size of Hydropower plant is 3.3 MW

Number of Unit

Two (2) Pit type Kaplan turbines

5. TUNNEL (ID PROPOSED) : LENGTH, DIAMETER

As described above, the project is **Run of the Canal Scheme** and Low Head and has no tunnel.

6. ESSA (ENVIRONMENT AND SOCIAL SOUNDNESS ASSESSMENT)

A complete chapter regarding Environment has been prepared by TEAM Consultant and submitted to Environmental Protection Agency (EPA) of the Government of Punjab.

7. DETAILED FEASIBILITY REPORT

Detailed Feasibility Report has been prepared by TEAM Consultant and approved by Punjab Power Development Board in a Meeting of Panel of Experts (POEs) held on Thursday 1st December 2016. Volume 1 and 2 of the approved Feasibility Report is attached as **Annexure-II**.

8. RESETTLEMENT ISSUES

No resettlement is involved as land required for the project belongs to Punjab Irrigation Department and will be leased from Government of the Punjab as per Policy for Power Generation 2006 (Revised 2009).

9. CONSENTS

No consents will be required at the current stage. All the consents will be required during construction phase and will be acquired as and when basis.

10. INFRASTRUCTURE DEVELOPMENT

Infrastructure Development Includes roads and O & M staff colony. Operation and Maintenance staff colony proposed on two locations and construction would be started at any of these at time of Contractor's mobilization because land for both belongs to Irrigation Department Government of Punjab. The O&M Staff colony includes the rest house and other Civic facilities.

A 4.0 meter wide metaled road is constructed at the crest of the embankments along right and left bank of the headrace up to the proposed powerhouse. Road is provided over the powerhouse and bottom outlet draft tube to connect the right bank with left bank or vice versa.

11. INTERCONNECTION WITH NATIONAL GRID COMPANY, LENGTH OF TRANSMISSION LINE

The proposed interconnection scheme is to connect **Mandibahauddin** Hydro Electric Power Plant to the nearest 132/11kV WAPDA Grid station through 11 KV D/C Osprey conductor. The distance as verified from the site visit was 10 Km. The line will be constructed by GEPCO/NTDC. Interconnection Study has been prepared by Power Planners International Pvt Ltd and submitted in GEPCO.

12. PROJECT COST, INFORMATION REGARDING SOURCES AND AMOUNTS OF EQUITY AND DEBT

It is attached as **Annexure-M.** The project equity ratio is 75:25 as approved by NEPRA vide no. NEPRA/VTH-01/15031-15033 dated October 14, 2015. The project is proposed to be totally financed locally.

13. PROJECT SCHEDULE, EXPECTED LIFE.

Based on project implementation schedule, pre-requisition under LOI & LOS Construction qualities, sequence of activities and their dependence on expected canal closure, the total project implementation period includes:-

Activities under LOI	21 months
Activities to achieve financial close	12 months
Project Construction	36 months

Total Construction time is 36 months, however 73 months are required to complete the activities under LOI and to achieve financial close. The project schedule is attached as **Annexure-NO.** In case of hydropower project, useful life of the civil engineering work has been assumed to be 60 years and that of electrical and mechanical equipment 30 years. Analysis of the proposed hydropower plant has been done for a period of 30 years.

14. PEAK / BASE LOAD OPERATIVE

The plant is proposed to operate on base load and will generate an annual energy of 19.007 GWh.

15. PLANT CHARACTERISTICS

Generation voltage	6.3 kV
Power factor	0.9
Frequency	50 Hz
Automatic Generation control	yes
Ramping Rate	Gradual in the order of 10%
Control metering and Instrumentation	DCS/SCADA

16. SYSTEM STUDIES LOAD FLOW, SHORT CIRCUIT, STABILITY

The studies i.e. Load Flow, Short Circuit and Stability analysis has been done by Power Planners International Pvt Ltd and then submitted to GEPCO for approval. The Interconnection Study of **Mandibahauddin** HPP to evacuate its maximum power of 3.3 MW is envisaged and studied in detail by Power Planners International Pvt Ltd.

The substations of GEPCO available in the vicinity of Mandibahauddin HPP are Mandibahauddin, Phalia and Helan 132 KV.

In view of the above mentioned network available in the vicinity of the site of the **Mandibahauddin** HPP, the proposed interconnection scheme is to connect **Mandibahauddin** HPP to the nearest **Mandibahauddin** 132/11 KV grid station via 11KV Double Circuit of Osprey Conductor. The distance, as verified from site visit, was found out to be 10 km.

The Load Flow, Short Circuit and Stability analysis are attached as **Annexure-PQ.**

17. TRAINING & DEVELOPMENT

During project construction, pre-commissioning, erection, testing and commissioning tests and Defect Liability Period, the generation and O&M staff shall be trained for future operation of the powerhouse by Civil and O&M Contractors.

ANNEXURE – M

PROJECT COST ESTIMATION SHEET

MANDI BAHAUDDIN HYDRO ELECTRIC POWER PROJECT
LAYOUT ALTERNATIVE 1
POWERHOUSE WITH BOTTOM OUTLET IN CANAL
COST ESTIMATE

Code	Description	Unit	Rate (Pak. Rs.)	Qty	Total Amount (Pak. Rs.)	Local Amount (Pak. Rs.)	Foreign Amount (Pak. Rs.)
A	**Preliminary Works**						
A.1	Construction and Maintenance of Contractors Camps, Offices and Colony	10%	62,596,153	1	62,596,153	50,076,922	12,519,231
A.2	Mobilization and De-Mobilization	L.S.	15,000,000	1	15,000,000	3,000,000	12,000,000
	Total - A				**77,596,153**	**53,076,922**	**24,519,231**
B	**Environment & Resettlement Costs**						
B.1	Land Acquisition	Acers	800,000	59.50	47,600,000	47,600,000	-
B.2	Resettlement and Compensations etc	L.S.	3,000,000	1	3,000,000	3,000,000	-
	Total - B				**50,600,000**	**50,600,000**	
C	**Civil Works**						
C.1	**Diversion Canal**						
C.1.1	Excavation	m^3	290.10	67,948	19,711,715	18,726,129	985,586
C.1.2	Filling Including Compaction in Banks	m^2	93.24	19,594	1,826,945	1,735,598	91,347
C.1.3	Construction of Plug	m^3	93.24	3,760	352,447	334,825	17,622
	Section Total				21,891,107	20,796,552	1,094,555
	Other Misc. items @	2%			437,822	415,931	21,891
	Sub Total - 1				**22,328,929**	**21,212,483**	**1,116,446**
C.2	**Headrace Channel**						
C.2.1	Filling Including Compaction in Banks	m^3	93.24	135,895	12,670,850	12,037,308	633,542
C.2.2	Stone Pitching in Canal Bed	m^2	2,447.60	21,594	52,853,474	50,210,800	2,642,674
C.2.3	Stone Pitching in Canal Slopes	m^2	2,970.91	13,511	40,139,965	38,132,967	2,006,998
C.2.4	Dismantling of Plug	m^3	290.10	3,760	1,096,578	1,041,749	54,829
	Section Total				106,760,867	101,422,824	5,338,043
	Other Misc. items @	2%			2,135,217	2,028,456	106,761
	Sub Total - 2				**108,896,084**	**103,451,280**	**5,444,804**
C.3	**Construction of Bottom outlet**						
C.3.1	Excavation	m^3	290.10	28,172	8,172,697	7,764,062	408,635
C.3.2	Filling Including Compaction	m^3	93.24	3,381	315,244	299,482	15,762
C.3.3	Lean Concrete	m^3	9,999.83	94	939,984	892,985	46,999
C.3.4	Mass Concetre	m^3	12,847.93	2,102	27,006,349	25,656,032	1,350,317
C.3.5	Strutural Concrete	m^3	15,231.67	3,307	50,371,133	47,852,576	2,518,557
C.3.6	Reinforcing Steel (Grade - 60)	tonne	142,256.08	325	46,233,226	43,921,565	2,311,661
C.3.7	Cutoff wall	m^3	12,847.93	1,075	13,811,525	13,120,949	690,576
C.3.8	Stone Pitching in Canal Bed	m^2	2,971	2,725	8,095,975	7,691,176	404,799
C.3.9	Stone Pitching in Canal Slopes	m^2	2,448	1,360	3,329,280	3,162,816	166,464
C.3.10	Dewatering Pumps including Installation	Nos	336,969.36	22	7,413,326	7,042,660	370,666
C.3.11	Standby Pumps	Nos	77,700.00	5	388,500	369,075	19,425
C.3.12	Operation and Maintenance of Pumps	Hr	640.25	47,520	30,424,680	28,903,446	1,521,234
	Section Total				196,501,919	186,676,824	9,825,095
	Other Misc. items @	2%			3,930,038	3,733,536	196,502
	Sub Total - 3				**200,431,957**	**190,410,360**	**10,021,597**
C.4	**Construction Pit for Powerhouse**						
C.4.1	Excavation	m^3	290	30,238	8,769,020	8,330,569	438,451
C.4.2	Filling Including Compaction	m^3	93	3,629	337,497	320,622	16,875
C.4.3	Dewatering Pumps including Installation	Nos	336,969	38	12,804,822	12,164,581	640,241
C.4.4	Standby Pumps	Nos	77,700	6	466,200	442,890	23,310
C.4.5	Operation and Maintenance of Pumps	Hr	640	82,080	52,531,200	49,904,640	2,626,560
	Section Total				74,908,739	71,163,302	3,745,437
	Other Misc. items @	2%			1,498,175	1,423,266	74,909
	Sub Total - 4				**76,406,914**	**72,586,568**	**3,820,346**

MANDI BAHAUDDIN HYDRO ELECTRIC POWER PROJECT
LAYOUT ALTERNATIVE 1
POWERHOUSE WITH BOTTOM OUTLET IN CANAL
COST ESTIMATE

Code	Description	Unit	Rate (Pak. Rs.)	Qty	Total Amount (Pak. Rs.)	Local Amount (Pak. Rs.)	Foreign Amount (Pak. Rs.)
C.5	**Power House**						
C.5.1	Structural Concrete Class - A	m^3	17,562	347	6,094,014	5,789,313	304,701
C.5.2	Mass Concrete Class - B	m^3	15,232	3,375	51,408,000	48,837,600	2,570,400
C.5.3	Second Stage Concrete	m^3	17,562	338	5,935,956	5,639,158	296,798
C.5.4	Lean Concrete Class - D	m^3	10,000	120	1,200,000	1,140,000	60,000
C.5.5	Cut-off-Walls	m^3	12,236	1,035	12,664,384	12,031,165	633,219
C.5.6	Reinforcing Steel (Grade - 60)	tonne	142,256	244	34,710,464	32,974,941	1,735,523
C.5.7	Filling Including Compaction	tonne	93	6,048	562,464	534,341	28,123
C.5.8	Architectural Works	m^3	7,770,000	1	7,770,000	7,381,500	388,500
	Section Total				120,345,282	114,328,018	6,017,264
	Other Misc. Items @	5%			6,017,264	5,716,401	300,863
	Sub Total - 5				126,362,546	120,044,419	6,318,127
C.6	**Tailrace Channel**						
C.6.1	Excavation	m^3	290	69,297	20,096,130	19,091,324	1,004,806
C.6.2	Stone Pitching in Canal Bed	m^2	2,448	7,316	17,909,568	17,014,090	895,478
C.6.3	Stone Pitching in Canal Slopes	m^2	2,971	3,760	11,170,960	10,612,412	558,548
C.6.4	Dismantling of Plug	m^3	290	3,780	1,096,200	1,041,390	54,810
	Section Total				50,272,858	47,759,216	2,513,642
	Other Misc. Items @	2%			1,005,457	955,184	50,273
	Sub Total - 6				51,278,315	48,714,400	2,563,915
C.7	**Strengthening Existing Structures**						
	Protection Bridge Foundation at RD 5+000						
C.7.1	Excavation	m^3	290	45	13,050	12,398	652
C.7.2	Stone Pitching	m^2	2,971	50	148,550	141,123	7,427
C.7.3	Strutural Concrete	m^3	15,232	65	990,080	940,576	49,504
	Section Total				1,151,680	1,094,097	57,583
	Other Misc. Items @	2%			23,034	21,882	1,152
	Sub Total - 7				1,174,714	1,115,979	58,735
	Dismantling of Existing Structures						
C.7.4	Dismantling of Fall Structure at RD 8+626	LS	2,000,000	1	2,000,000	1,900,000	100,000
C.7.5	Protection Bridge Foundation at RD 8+626	LS	3,000,000	1	3,000,000	2,850,000	150,000
	Section Total				5,000,000	4,750,000	250,000
	Other Misc. Items @	2%			100,000	95,000	5,000
	Sub Total - 8				5,100,000	4,845,000	255,000
C.8	**Hydraulic Steel Structures**						
C.8.1	Trash Rack at Intake (8.87m x 5.7m)	Nos	4,395,701	2	8,791,402	7,912,262	879,140
C.8.2	Trash Rack at Bottom Outlet (7.65 m x 4.71 m)	Nos	3,138,884	3	9,416,652	8,474,987	941,665
C.8.3	Trash Rack Cleaner	Nos	5,860,900	1	5,860,900	5,274,810	586,090
C.8.4	Stoplog Set for Intake (7.65 m x 4.72 m)	Nos	6,312,581	2	12,625,162	11,362,646	1,262,516
C.8.5	Stoplog Set for Outlet bay (7.65 m x 4.72 m)	Nos	3,129,862	2	6,259,724	5,633,752	625,972
C.8.6	Bottom Outlet Gates (3.36 m x 3.74 m)	Nos	2,353,844	3	7,061,532	1,765,383	5,296,149
C.8.7	Stoplog Set for Bottom Outlet (3.36 m x 3.74 m)	Nos	2,257,536	1	2,257,536	564,384	1,693,152
C.8.8	Stoplogs Lifting Mechanism	Nos	2,933,952	1	2,933,952	2,640,557	293,395
	Section Total				55,206,860	43,628,781	11,578,079
	Other Items or Misc. Items @	2%			1,104,137	872,576	231,562
	Sub Total - 9				56,310,997	44,501,357	11,809,641
	Total Civil Work Cost - C				625,961,527	585,669,363	40,292,165

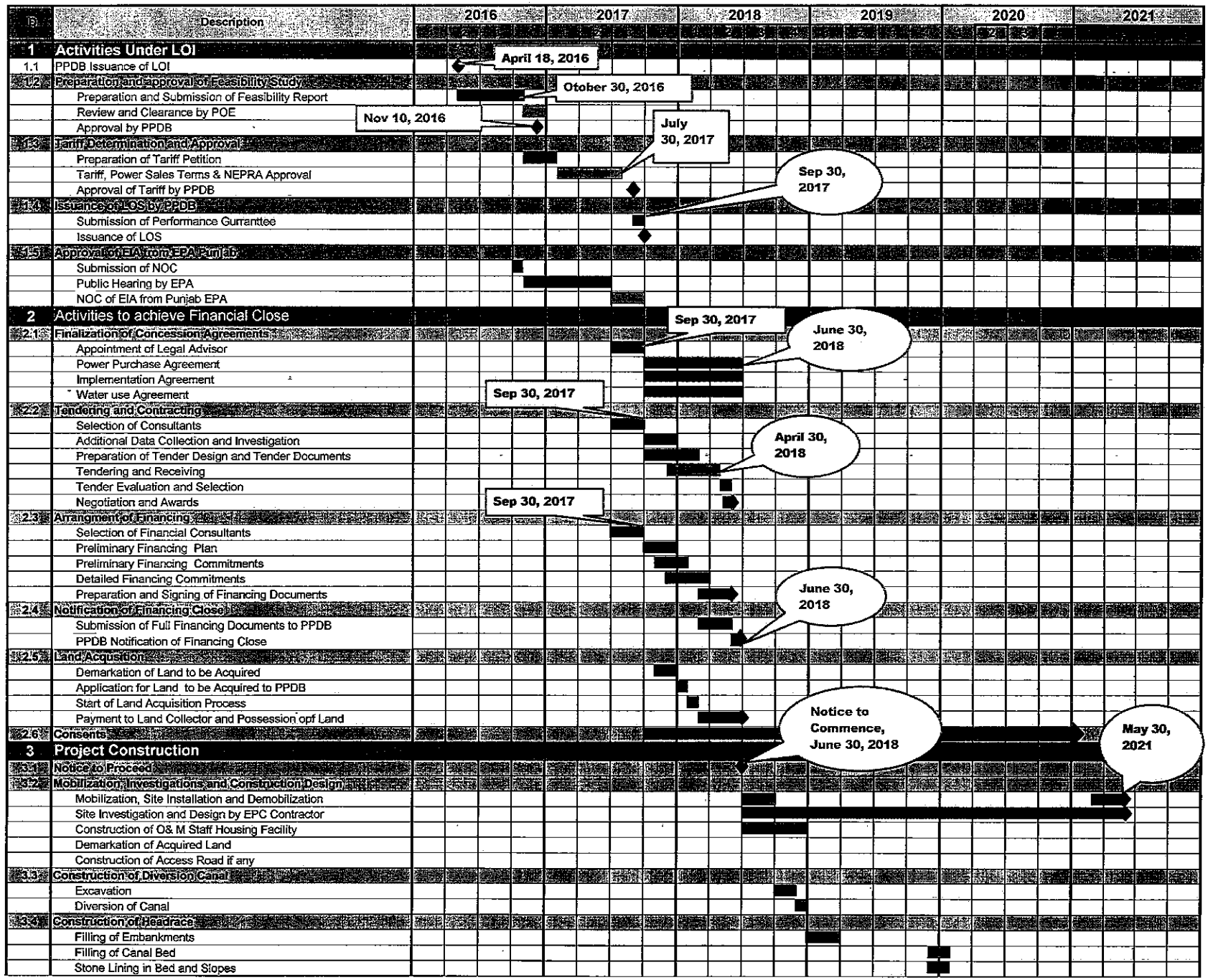
MANDI BAHAUDDIN HYDRO ELECTRIC POWER PROJECT
LAYOUT ALTERNATIVE 1
POWERHOUSE WITH BOTTOM OUTLET IN CANAL
COST ESTIMATE

Code	Description	Unit	Rate (Pak. Rs.)	Qty	Total Amount (Pak. Rs.)	Local Amount (Pak. Rs.)	Foreign Amount (Pak. Rs.)
D	**Electrical and Mechanical Works**						
D.1	**Hydro-Mechanical Equipment**						
D.1.2	Turbine, Governor	Nos	20,651,995	2	41,303,990	-	41,303,990
D.1.3	Ancillary Equipment	Nos	13,120,086	1	13,120,086	-	13,120,086
D.1.4	Generator and Exciter	Nos	28,645,360	2	57,290,720	-	57,290,720
D.1.5	Powerhouse Crane (30 Tonne)	Nos	5,157,157	1	5,157,157	-	5,157,157
	Sub Total - 1				116,871,953	-	116,871,953
D.2	**Powerhouse Mechanical Equipment**						
D.2.1	Elevator	L.S.	1,823,884	1	1,823,884	182,388	1,641,496
D.2.2	Fire Fighting System	L.S.	4,188,983	1	4,188,983	418,898	3,770,085
D.2.3	HVAC	L.S.	5,499,715	1	5,499,715	549,972	4,949,743
D.2.4	Workshop Equipment	L.S.	3,568,116	1	3,568,116	356,812	3,211,304
D.2.5	Miscellaneous Mechanical Systems	L.S.	3,765,717	1	3,765,717	376,572	3,389,145
D.2.6	Station Water Srvices System	L.S.	1,577,964	1	1,577,964	157,796	1,420,168
D.2.7	Oil Handling Equipment	L.S.	1,391,334	1	1,391,334	139,133	1,252,201
D.2.7	Station Compressed Air System	L.S.	1,376,564	1	1,376,564	137,656	1,238,908
	Sub Total - 2				23,192,277	2,319,227	20,873,050
D.3	**Powerhouse Electrical Equipment**						
D.3.1	Transformers	L.S.	16,706,769	1	16,706,769	5,012,031	11,694,738
D.3.2	Switchgears / Switchyard	L.S.	43,913,426	1	43,913,426	13,174,028	30,739,398
D.3.3	MV Switchgear	L.S.	6,904,342	1	6,904,342	2,071,303	4,833,039
D.3.4	LV Switchgear	L.S.	2,866,646	1	2,866,646	859,994	2,006,652
D.3.5	Control and Telecom System	L.S.	21,828,794	1	21,828,794	6,548,638	15,280,156
D.3.6	D.C System	L.S.	3,302,572	1	3,302,572	990,772	2,311,800
D.3.7	Cables	L.S.	5,136,268	1	5,136,268	1,540,880	3,595,388
D.3.8	Diesel Genrators	L.S.	2,238,499	1	2,238,499	223,850	2,014,649
	Sub Total - 3				102,897,316	30,421,496	72,475,820
D.4	**Transmission Line**						
	Transmission Line	KM	3,558,900	11	39,147,900	35,233,110	3,914,790
	Sub Total -4				39,147,900	35,233,110	3,914,790
	Sub Total E & M				282,109,446	67,973,833	214,135,613
D.5	Transportation and Erection Charges @	9%			25,389,850	6,117,645	19,272,205
	Total E & M Work Cost - D				307,499,296	74,091,478	233,407,818
E	**Total Cost (Total A+B+C+D)**				1,061,656,976	763,437,763	298,219,214
	Engineering Cost of EPC	5%			53,082,849	38,171,888	14,910,961
F	**Total EPC Cost (Total A+B+C+D+ E)**				1,114,739,825	801,609,651	313,130,176
G	**Client Engineering and Supervision**	3.00%			33,442,195	24,048,290	9,393,905
H	**Independent Engineer**	1.00%			11,147,398	8,016,097	3,131,302
I	**Administration, Audit and Accounts**	1.00%			11,147,398	8,016,097	3,131,302
J	**Legal Advisor Charges**	1.50%			16,721,097	12,024,145	4,696,953
K	**Financial Advisor Charges**	1.50%			16,721,097	12,024,145	4,696,953
L	**Pre-Construction Expenses**	1.50%			16,721,097	12,024,145	4,696,953
M	**Insurance during Construction**	1.35%			15,048,988	10,821,730	4,227,257
	Sub Total -				1,235,689,095	888,684,300	347,104,800
	Contingencies @	0%			-	-	-
	TOTAL BASE COST	Pak.Rs.			1,235,689,095	888,684,300	347,104,800
	TOTAL BASE COST (1 US $ = 105.50 Rs.)	US $			11,712,693	8,422,600	3,290,093

NO

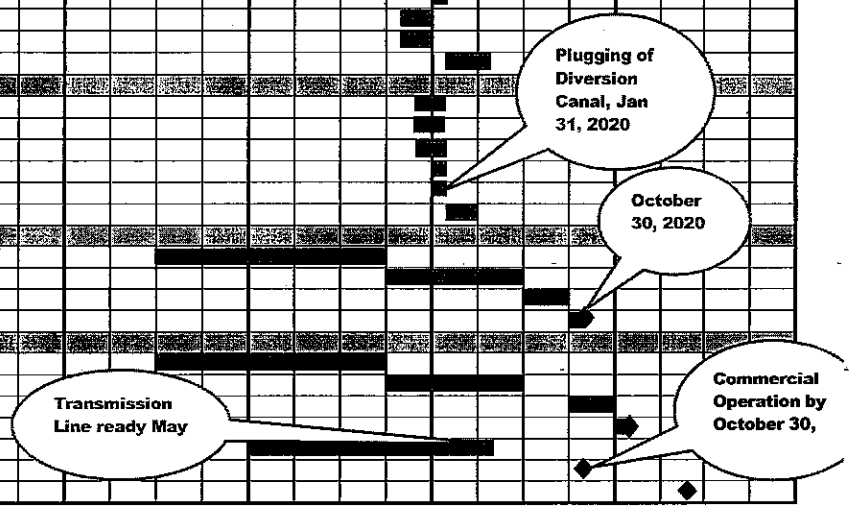
ANNEXURE – NO
PROJECT SCHEDULE

MANDIBAHAUDDIN HYDRO ELECTRIC POWER PROJECT
IMPLEMENTATION SCHEDULE



MANDIBAHAUDDIN HYDRO ELECTRIC POWER PROJECT
IMPLEMENTATION SCHEDULE

ID	Description	2016	2017	2018	2019	2020	2021
3.5	**Powerhouse and Bottom Oulets**						
	Excavation						
	Construction of Diaphargm Wall						
	Installation of Dewatering System						
	Running and Maintenance of Dewatering System						
	1st Stage Concrete						
	2nd Stage Concrete						
	Installation of Embedded Parts of Turbo-generator Unit-1						
	Installation of Embedded Parts of Turbo-generator Unit-2						
	Installation of Embedded Parts of Turbo-generator Unit-3						
	Installation of Embedded Parts of Cranes						
	Installation of Embedded Parts of Bottom Outlets Gates						
	Backfilling						
3.6	**Construction of Tailrace**						
	Excavation of Tailrace						
	Linning of Tailrace						
	Dismentalling of Concrete Fall Structure						
	Protection of Bridges Foundations						
	Plugging of Diversion Canal						
	Filling and Rehabilitation of Diversion Canal Land						
3.7	**Turbo-genetator Unit-1**						
	Design and Fabrication						
	Transportation						
	Installation						
	Wet testing and Commissioning						
3.8	**Turbo-genetator Unit-2**						
	Design and Fabrication						
	Transportation						
	Installation						
	Wet testing and Commissioning						
3.9	**Swicthyard and Transmission Line**						
3.10	**Start of Commercial Operation**						
3.11	**Taking over Certificate**						



PQ

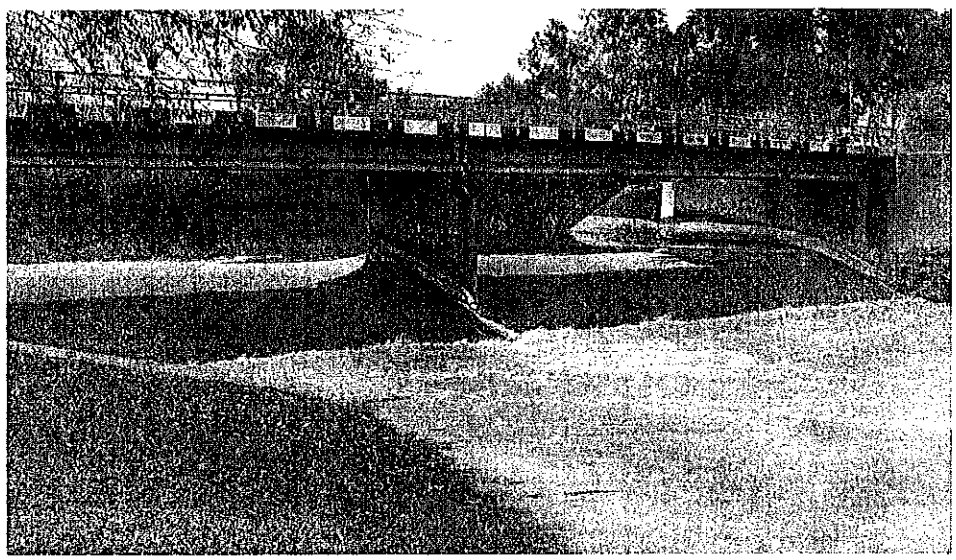
ANNEXURE – PQ
INTERCONNECTION STUDY
LOAD ANALYSIS, SHORT CIRCUIT ANALYSIS & STABILITY ANALYSIS

Report No. PPI-225.1-Draft/16

INTERCONNECTION STUDY

For

3.3 MW M.B.Din Hydro Power Project, District Mandi Bahauddin, Punjab



Draft Report
(November 2016)

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Executive Summary

- The study objective, approach and methodology have been described and the plant's data received from the client validated.
- The GEPCO system data, as available with PPI for other studies, has been used.
- The interconnection study of M.B.Din HPP to evacuate its maximum power of 3.3 MW is envisaged and studied in detail.
- The substations of GEPCO available in the vicinity of M.B.Din HPP are M.B.Din, Phalia and Helan 132 kV.
- In view of the above mentioned network available in the vicinity of the site of the M.B.Din HPP, the proposed interconnection scheme is to connect M.B.Din HPP to the nearest M.B.Din 132/11 kV grid station via 11 kV D/C of Osprey Conductor. The distance, as verified from site visit, was found out to be 10 km.
- Keeping in view the COD of the HPP which is expected to be second half of 2020, detailed load flow studies have been carried out for the peak load conditions of September 2020 (High Water Season) for all the proposed schemes under normal and N-1 contingency conditions to meet the reliability criteria.
- Steady state analysis by load flow reveals that proposed schemes are adequate for the evacuation of the maximum power of 3.3 MW of the plant, under normal and contingency conditions shown in Appendix - C.
- The short circuit analysis has been carried out to calculate maximum fault levels at M.B.Din HPP 11 kV and other 132 kV substations in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. It was found that there are no violations of exceeding the rating of the equipment due to contribution of fault current from M.B.Din HPP.
- The short circuit level at M.B.Din HPP 11 kV bus bar is 5.45 kA and 5.60 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA may be installed at the 11 kV substation of

M.B.Din HPP to accommodate future expansions of generation and transmission in this area.

- The dynamic stability analysis of proposed schemes of interconnection has been carried out. The stability check for the worst case of fault on the 11 kV bus bar of M.B.Din HPP substation, followed by the final trip of respective transformer has been performed for fault clearing of 9 cycles (180ms). The system was found to be strong enough to maintain its stability, and recovered with fast damping.
- The proposed schemes of interconnection have no technical constraints or problems under steady state load flow, short circuit currents and dynamic/transient conditions; and are therefore recommended to be adopted.

Report Contents

1. Introduction

1.1 Background

The proposed project is a Hydropower Plant to be located near 132 kV M.B.Din Grid Station, District Mandi Bahauddin, located in the concession area of Gujranwala Electric Power Company (GEPCO). The location of M.B.Din HPP is shown in Appendix-B. The net output planned to be generated from the site is about 3.3 MW of electrical power. The project is expected to start commercial operation by second half of 2020. The electricity generated from this plant will be supplied to the grid system of GEPCO through the 132/11 kV grids of GEPCO available in the vicinity of this plant.

1.2 Objectives

The overall objective of the Study is to evolve an interconnection scheme between M.B.Din HPP and GEPCO network, for stable and reliable evacuation of 3.3 MW of electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives are:

1. To develop schemes of interconnections of which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
3. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at M.B.Din HPP.
4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping after 3-phase faults on the system.

1.3 Planning Criteria

The planning criteria required to be fulfilled by the proposed interconnection is as follows:

Steady State:

Voltage	± 5 %, Normal Operating Condition
	± 10 %, Contingency Conditions
Frequency	50 Hz, Continuous, ± 1% variation steady state
	49.2 - 50.5 Hz, Short Time
Power Factor	0.8 Lagging; 0.9 Leading

Dynamic/Transient:

The system should revert back to normal conditions, after transients die out, with good damping, without losing synchronism.

- For 132 kV and above, the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 100 ms (5 cycles).

2. Assumptions of Data

The detailed electrical parameters of the generators at M.B.Din HPP are as follow:

2.1 M.B.Din HPP data

Generator data:

Number of Generating Units	= 2
Lump sum Net generating capacity	= 3.3 MW
Power factor	= 0.9 lagging
Generating Voltage	= 6.3 kV
Inertia Constant H (turbine + generator)	= 1.66 (MWs/MVA)

2.2 Network data

The surrounding networks available for interconnection to M.B.Din Hydro Power Plant are as shown in Sketches 1 and 2 in Appendix-B.

3. Study Approach and Methodology

3.1 Understanding of the Problem

M.B.Din HPP 3.3 MW is going to be a hydropower project located near 132 kV M.B.Din Grid Station, District Mandi Bahauddin, located in the concession area of Gujranwala Electricity Power Company (GEPCO)

This source of local power generation to be embedded in local distribution network shall provide great relief to the source substations in the vicinity and also help in terms of improving line losses and voltage profile.

The nearest substations of GEPCO, available in the vicinity of M.B.Din HPP, are M.B.Din, Phalia and Helan 132 kV. The adequacy of this system to absorb and transmit power as per the reliability criteria will be investigated in this study.

3.2 Approach to the problem

The consultant has applied the following approaches to the problem:

- A base case network model has been prepared for the year 2020, which is the commissioning year of M.B.Din HPP, comprising all 500kV, 220kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year, particularly in GEPCO.
- The month of September has been selected for the study because it is a high water season and it will allow us to judge the maximum impact of the plant on the network in these conditions.
- Interconnection schemes without any physical constraints, such as right of way or availability of space in the terminal substations, have been identified.
- Technical system studies for peak load conditions have been performed, to confirm technical feasibility of the interconnection schemes. The schemes have been subjected to standard analysis like load flow and short circuit, and transient stability study to check the strength of the machines and the proposed interconnection scheme under disturbed conditions.

- The relevant equipment for the proposed technically feasible schemes has been determined.
- The most technically feasible scheme of interconnection from the options considered has been recommended.

4. Development of Schemes of Interconnection

4.1 The Existing and Ongoing Network

It was found that the nearest existing GEPCO interconnection facilities at the time of commissioning of M.B.Din Hydro Power Project would be:

- M.B.Din 132 kV Substation
- Phalia 132 kV Substation

The existing 132 kV network in the vicinity of these grid stations, as well as the power plant, are shown in Sketch-2 in Appendix-B.

4.2 The Scheme of Interconnection of M.B.Din HPP

- In view of the above mentioned 132 kV network available in the vicinity of the site of M.B.Din HPP, the proposed interconnection scheme is to connect M.B.Din HPP to the nearest M.B.Din 132/11 kV grid station via 11 kV D/C of Osprey Conductor. The distance, as verified from site visit, was found out to be 10 km.

5. Detailed Load Flow Studies

5.1 Base Case 2020, Without M.B.Din HPP

A base case has been developed for the peak load of September 2020, which lies in the high water season and will allow us to judge the maximum impact of M.B.Din HPP on the GEPCO network during high water conditions, using the network data supplied/authorized by NTDC/GEPCO.

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-C. The system plotted in this Exhibit comprises of 132 kV network feeding Mandi Bahauddin, Phalia, Helan and its surrounding substations.

The load flow results for the normal case show that the power flows on all the circuits are within their normal rating. We find that there are no capacity constraints in terms of power flow or voltage ratings in the surrounding network available in the vicinity of M.B.Din HPP for its connectivity under normal conditions.

The following N-1 contingency tests were run:

Exhibit 0.1	Shahtaj to M.B.DIN 132 kV Single Circuit Out
Exhibit 0.2	Shahtaj to Phalia 132 kV Single Circuit Out
Exhibit 0.3	Helan to Rasul PP 132 kV Single Circuit Out
Exhibit 0.4	Dinga to Helan 132 kV Single Circuit Out
Exhibit 0.5	Rajar to Kharian 132 kV Single Circuit Out
Exhibit 0.6	Mangla to Nbongesc 132 kV Single Circuit Out

The load flow results also show that there are no capacity constraints in the area surrounding and the voltage rating of the bus bars remain within their limits.

5.2 Load Flow with M.B.Din HPP for September 2020

This proposed scheme of interconnection of M.B.Din HPP scheme is to connect M.B.Din HPP to the nearest M.B.Din 132/11 kV grid station via 11 kV D/C of Osprey Conductor. This interconnection scheme has been modeled in the load flow studies. The month of September has been selected because it is a high water season and it will allow us to observe the impact of the project when loadings on the lines are maximum.

The results of load flow with M.B.Din HPP interconnected as per proposed scheme are shown in Exhibit 1.0 in Appendix-C. The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % of the nominal.

We find no capacity constraints on adjoining circuits under normal conditions i.e. without any outages of circuits. N-1 contingency analysis has been carried and the plotted results are attached in Appendix – C as follows;

Exhibit 1.1	M.B.DIN HPP 11/6.3 kV Single Transformer Out
Exhibit 1.2	M.B.DIN HPP to T-2 11 kV Single Circuit Out
Exhibit 1.3	Shahtaj to M.B.DIN 132 kV Single Circuit Out
Exhibit 1.4	Shahtaj to Phalia 132 kV Single Circuit Out
Exhibit 1.5	Rasul PP to Helan 132 kV Single Circuit Out
Exhibit 1.6	Helan to Dinga 132 kV Single Circuit Out
Exhibit 1.7	Rajar to Kharian 132 kV Single Circuit Out
Exhibit 1.8	Mangla to Nbongesc 132 kV Single Circuit Out

N-1 contingency criteria is fulfilled in all the above contingency cases. Also, the bus bar voltages are well within the rated limits in the contingency events. Hence there are no additional constraints introduced in this scheme due to the interconnection of M.B.Din HPP.

5.3 Conclusion of Load Flow Analysis

From the analysis discussed above, we conclude that the proposed interconnection scheme of M.B.Din HPP with GEPCO is adequate to evacuate the power of M.B.Din HPP under normal as well as contingency conditions as shown in Appendix – C.

6. Short Circuit Analysis

6.1 Methodology and Assumptions

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies. The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the year 2020 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the transformers data are the same as mentioned in Ch.2 of this report.

6.2 Fault Current Calculations

6.2.1 September 2020 without M.B.Din HPP

In order to assess the short circuit strength of the network of 132 kV without M.B.Din HPP for the grid of GEPCO in the vicinity of the site of the plant, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions. These levels will not only give us the idea of the fault levels of M.B.Din 132kV and Dinga 132kV grid station and other grid stations in the vicinity without M.B.Din HPP but also would help us know as to how much the contribution of fault current later on from M.B.Din HPP may add to the existing levels.

The short circuit levels have been represented graphically on the bus bars of 132 kV which are shown in the Exhibit 3.0 attached in Appendix-D.

The fault currents in the Exhibit are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault current is shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-D for bus bars of our interest i.e. the substations lying close to M.B.Din HPP. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1.

Table 6.1

Maximum Short Circuit Levels without M.B.Din HPP

Substation	3-Phase Fault Current (kA)	1-Phase Fault Current (kA)
Helan 132 kV	4.24	4.44
Dinga 132 kV	4.69	4.97
M. B. Din 132 kV	4.64	5.20
Rasul-PP 132 kV	4.44	4.25
Shahtaj 132 kV	4.89	5.31
Phalia 132 kV	5.38	5.31
Shahana Lok 132 kV	3.70	4.16
Kharian 132 kV	15.62	13.64
Lalamusa 132 kV	16.44	15.91
Bhimber 132 kV	4.54	3.03
NBongesc 132 kV	21.99	19.75
Rajar 132 kV	10.27	8.09
Mangla 132 kV	34.78	36.97

6.2.2 September 2020 with M.B.Din HPP

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at the 11 kV bus bar of M.B.Din HPP itself and other bus bars of the 132 kV substations in the electrical vicinity of M.B.Din HPP. The graphic results are shown in Exhibit 3.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV bus bars of the network in the electrical vicinity of M.B.Din HPP are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2.

Table 6.2

Maximum Short Circuit Levels With M.B.Din HPP

Substation	3-Phase Fault Current (kA)	1-Phase Fault Current (kA)
M.B.Din HPP 11 kV	5.45	5.60
Helan 132 kV	4.25	4.45
Dinga 132 kV	4.70	4.98
M. B. Din 132 kV	4.66	5.25
Rasul-PP 132 kV	4.46	4.28
Shahtaj 132 kV	4.91	5.36
Phalia 132 kV	5.40	5.34
Shahana Lok 132 kV	3.71	4.16
Kharian 132 kV	15.62	13.64
Lalamusa 132 kV	16.44	15.91
Bhimber 132 kV	4.54	3.03
NBongesc 132 kV	21.99	19.75
Rajar 132 kV	10.27	8.09
Mangla 132 kV	34.78	36.97

Comparison of Tables 6.1 and 6.2 show slight difference in short circuit levels for three-phase and single – phase faults due to connection of M.B.Din HPP. We find that the resulting fault levels are much less than the rated short circuit values of the equipment installed on these substations. The short circuit level at M.B.Din HPP 11 kV bus bar is 5.45 kA and 5.60 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at the 11 kV substation of M.B.Din HPP. It would provide a sufficient margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

6.3 Conclusion of Short Circuit Analysis

The short circuit analysis results show that for the proposed schemes of interconnection of M.B.Din HPP, we don't find any problem of violations of short circuit ratings of the already installed equipment on the 132 kV equipment of substations in the vicinity of M.B.Din HPP due to fault current contributions from this power house under three-phase faults as well as single phase faults.

The short circuit level at M.B.Din HPP 11 kV bus bar is 5.45 kA and 5.60 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the

short circuit rating of 25 kA would be fine to be installed at the 11 kV substation of M.B.Din HPP taking care of any future generation additions in its electrical vicinity.

7. Dynamic Stability Analysis

7.1 Assumptions & Methodology

7.1.1 Dynamic Models

The assumptions about the generator and its parameters are the same as mentioned in Ch.2 of this report.

We have employed the generic dynamic models available in the PSS/E model library for dynamic modeling of the generator, exciter and the governor as follows;

Generator	GENSAL
Excitation System	EXST1
Speed Governing System	HYGOV

7.1.2 System Conditions

We have used the system conditions of September 2020, which represents the high water season. Most of the hydel generators would be running nearly at their full output.

We have carried out the Dynamic Stability analysis for M.B.Din HPP with the proposed interconnection scheme. All the power plants of NTDC from Tarbela to Hub have been dynamically represented in the simulation model.

7.1.3 Presentation of Results

The plotted results of the simulation runs are placed in Appendix-E. Each simulation is run for its first one second for the steady state conditions of the system prior to fault or disturbance. This is to establish that the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for nine seconds.

7.1.4 Worst Fault Cases

Three phase faults are considered as the worst disturbances in the system. Normally we apply 3 phase fault on the bus bar of the power plant, followed by tripping of a circuit emanating from that bus, and trip one of the generators of the plant and / or trip one of the inter-bus transformers if there are two voltage levels in the switching

station of the plant. For M.B.Din 11 kV bus bar, we applied single phase fault right on the bus bar of M.B.Din HPP for 9 cycles (180 ms) followed by trip of the respective T/F.

7.2 Dynamic Stability Simulation Results (Year 2020)

7.2.1 Single-Phase Fault at 11 kV M.B.Din-HPP: Trip of respective T/F

We applied single-phase fault on M.B.Din HPP 11 kV bus bar, cleared fault in 9 cycles (180 ms) followed by the tripping of respective T/F. We monitored different quantities for one second before the fault (pre-fault) and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 1.1 Bus Voltages

The bus voltages of 6.3 kV bus bar of M.B.Din, 11 kV bus bar of M.B.Din-HPP and 132 kV bus bars of Dinga, Helan, M.B.Din and Phalia are plotted. The results show recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Generators of M.B.Din HPP

The pre-fault output of generators at M.B.Din HPP was 3.3 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 1.4 Speed and mechanical power of Generators at M.B.Din HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 1.5 MW/MVAR Flow on M.B.Din 11/6.3 kV Transformer

Followed by clearing of fault, the trip of the 11/6.3 kV transformer at M.B.Din-HPP caused the entire output of 3.3 MW to flow through the sole remaining intact 11/6.3 kV transformer at M.B.Din. We plotted the flows of MW and MVAR on this intact

transformer and observe that the power flows on this circuit attain a steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of M.B.Din HPP 6.3 kV, Shahtaj 11 kV, Mangla 132 kV, Allai 220 kV and Rasul-PP 6.3 kV are plotted relative to machine at Allai 220 kV. The results show that the rotor angle of M.B.Din HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing a little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.2 M.B.Din and Shahtaj Three-Phase Fault at 132 kV M.B.Din: Trip of 132 kV circuit between M.B.Din and Shahtaj

We applied three-phase fault on M.B.Din 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by the tripping of 132 kV circuit between M.B.Din and Shahtaj. We monitored different quantities for one second before the fault (pre-fault) and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 2.1 Bus Voltages

The bus voltages of 6.3 kV bus bar of M.B.Din, 11 kV bus bar of M.B.Din-HPP and 132 kV bus bars of Dinga, Helan, M.B.Din and Phalia are plotted. The results show recovery of the voltages after clearing of fault.

Fig. 2.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 2.3 MW/MVAR Output of Generators of M.B.Din HPP

The pre-fault output of generators at M.B.Din HPP was 3.3 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 2.4 Speed and mechanical power of Generators at M.B.Din HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 2.5 MW/MVAR Flows on Shahtaj to M.B.Din 132 kV circuit

Followed by clearing of fault, 132 kV circuit from Shahtaj to M.B.Din was tripped, we plotted the flows of MW and MVAR for 132 kV single circuit between Rasul-PP and M.B.Din and saw that the power flows on this circuit attain a steady state level with power swings damping down fast.

Fig. 2.6 Rotor Angles

The rotor angles of the generators of M.B.Din HPP 6.3 kV, Shahtaj 11 kV, Mangla 132 kV, Allai 220 kV and Rasul-PP 6.3 kV are plotted relative to machine at Allai 220 kV. The results show that the rotor angle of M.B.Din HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing a little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.3 M.B.Din and Shahtaj Single-Phase Fault at 132 kV M.B.Din: Trip of 132 kV circuit between M.B.Din and Shahtaj

We applied single-phase fault on M.B.Din 132 kV bus bar, cleared fault in 9 cycles (180 ms) followed by the tripping of 132 kV circuit between M.B.Din and Shahtaj. We monitored different quantities for one second before the fault (pre-fault) and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 3.1 Bus Voltages

The bus voltages of 6.3 kV bus bar of M.B.Din, 11 kV bus bar of M.B.Din-HPP and 132 kV bus bars of Dinga, Helan, M.B.Din and Phalia are plotted. The results show recovery of the voltages after clearing of fault.

Fig. 3.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

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Fig. 3.6 Rotor Angles

The rotor angles of the generators of M.B.Din HPP 6.3 kV, Shahtaj 11 kV, Mangla 132 kV, Allai 220 kV and Rasul-PP 6.3 kV are plotted relative to machine at Allai 220 kV. The results show that the rotor angle of M.B.Din HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing a little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.3 Conclusion of Dynamic Stability Analysis

The results of dynamic stability show that the system is very strong and stable for the proposed schemes for the severest possible faults at 11 kV bus bar of M.B.Din HPP. Therefore there is no problem of dynamic stability for interconnection of M.B.Din HPP; it fulfills all the criteria of dynamic stability.

8. Conclusions

- Interconnection study of 3.3 MW M.B.Din HPP has been carried out. Keeping in view the network available in the vicinity of the site of the M.B.Din HPP, the proposed interconnection scheme is to connect M.B.Din HPP to the nearest M.B.Din 132/11 kV grid station via 11 kV D/C of Osprey Conductor. The distance, as verified from site visit, was found out to be 10 km.
- Keeping in view the COD of the HPP which is expected to be second half of 2020, detailed load flow studies have been carried out for the peak load conditions of September 2020 (High Water Season) for all the proposed schemes under normal and N-1 contingency conditions to meet the reliability criteria.
- Steady state analysis by load flow reveals that proposed schemes are adequate for the evacuation of the maximum power of 3.3 MW of the plant, under normal and contingency conditions shown in Appendix - C.
- The short circuit analysis has been carried out to calculate maximum fault levels at M.B.Din HPP 11 kV and other 132 kV substations in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. It was found that there are no violations of exceeding the rating of the equipment due to contribution of fault current from M.B.Din HPP.
- The short circuit level at M.B.Din HPP 11 kV bus bar is 5.45 kA and 5.60 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA may be installed at the 11 kV substation of M.B.Din HPP to accommodate future expansions of generation and transmission in this area.
- The dynamic stability analysis of proposed schemes of interconnection has been carried out. The stability check for the worst case of fault on the 11 kV bus bar of M.B.Din HPP substation, followed by the final trip of respective transformer has been performed for fault clearing of 9 cycles (180ms). The system was found to be strong enough to maintain its stability, and recovered with fast damping.

- The proposed schemes of interconnection have no technical constraints or problems under steady state load flow, short circuit currents and dynamic/transient conditions; and are therefore recommended to be adopted.

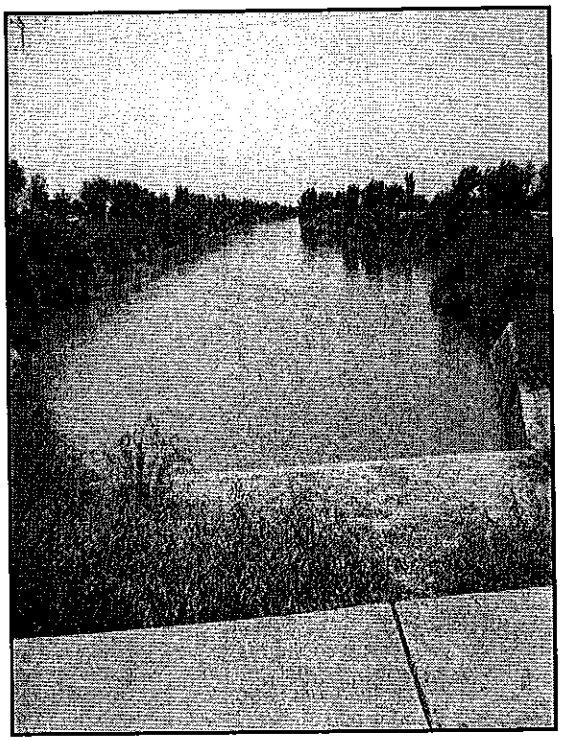
ANNEXURE – R

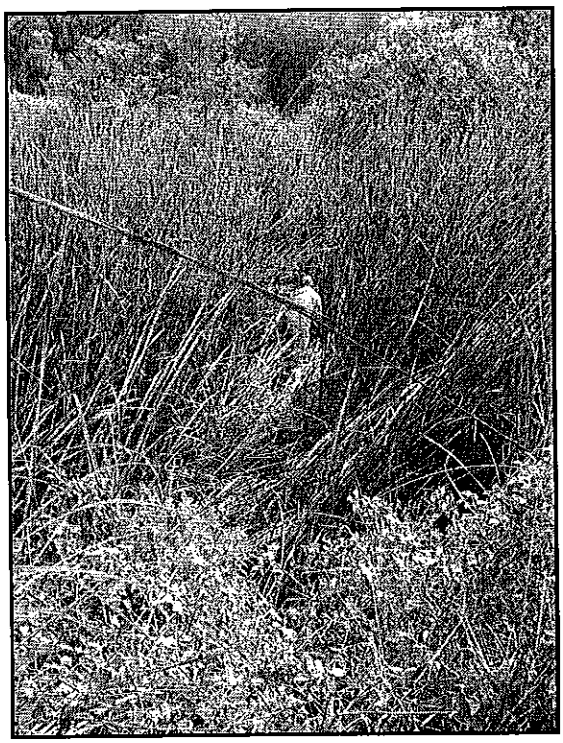
INITIAL ENVIRONMENTAL EXAMINATION REPORT

PUNJAB HYDRO POWER COMPANY PVT. LTD.
GOVERNMENT OF THE PUNJAB

MANDI BAHAUDDIN HYDRO ELECTRIC POWER PROJECT

FEASIBILITY STUDY REPORT





INITIAL ENVIRONMENTAL EXAMINATION (IEE)

Technical, Engineering and Management (TEAM) Consultants, Pakistan

December 2016

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INITIAL ENVIRONMENTAL EXAMINATION (IEE) REPORT

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
GR	Game Reserve
GWh	Giga Watt hour
IEE	Initial Environmental Examination
KV	Kilo Volt
LJC	Lower Jhelum Canal
MPC	Mandibahauddin Power Company
MHEPP	Mandibahauddin Hydro Electric Power Project
MW	Mega Watt
NEPRA	National Electric Power Regulatory Authority

NEQS	National Environmental Quality Standards
NOx	Oxides of Nitrogen
NTDC	National Transmission Dispatch Company
PM	Particulate Matter
SC	Supervision Consultant
SO2	Sulfur dioxide
WS	Wildlife Sanctuaries
RQ Link	Rasul Qadirabad Link
US$ 1.00 = Rs. 104.46	Currency Equivalents

WEIGHTS AND MEASURES

ac	acre
dB	decibel
ft	feet/foot
ft^3	cubic foot
ha	hectare
km	kilo meter
m	meter
mm	millimeter

TEXT

INITIAL ENVIRONMENTAL EXAMINATION (IEE)

A. EXECUTIVE SUMMARY

1. Title and Location of the Project

The project in the name "Mandibahauddin Hydro Electric Power Project" is located along RD 2+000 along Lower Jhelum Canal Feeder near Rasul Barrage about 10 km from Mandibahauddin Town in District Mandibahauddin in the Punjab Province. The project has the capacity of 3.3 MW and will generate 19.007 GWh of energy annually. Powerhouse and bottom outlets would be located at RD 2+000 in the existing canal. The head available at RD 8+626 and RD 0+000 would be combined for the development of this Hydro Electric Power Project.

2. Project Status and Proponent

Mandibahauddin Power Company got the Letter of Interest (LOI) on April 18, 2016 from Punjab Private Power Development Board (PPDB). The PPDB's authorization is in accordance with the Government of Punjab's "Punjab Power Generation Policy, year 2006" (the Policy) revised during 2009 to encourage private-sector infrastructure investments. The proposed project has to be developed along lower Jhelum Canal Feeder RD 8+626 where a fall having head of 3.66 m exists.

3. Project Consultants

Mandibahauddin Power Company, Lahore hired the service of M/S Technical, Engineering and Management –TEAM Consultants Pakistan, as Consultants to conduct feasibility studies for the Mandibahauddin Hydro Electric Power Project as per terms and conditions given in the LOI.

4. Brief Outline of the Proposal

TEAM Consultants, Pakistan carried out feasibility study to develop a hydropower project by utilizing head available at existing fall at RD 0+000 + RD 8+626 and flows of LJC Feeder and this also included the environmental assessment of the project. So the environmental assessment is also undertaken to meet the requirements of Pakistan Environmental Laws.

Mandibahauddin Hydro Electric Power Project is a small hydropower project (3.3 MW) which will be placed in an existing irrigation canal at RD 2+000. Two Pit type Kaplan Turbines would be installed. Three bottom outlets with hydraulically operated vertical gates would be provided as bypass structure in case of load rejection on turbine units. NTDC 132 KV Grid at Mandibahauddin about 10 km from project site will be used for interconnection through 11KV line.

The project falls under category B of schedule 1 (Regulation 3) of Pakistan Environmental Protection Agency (review of IEE and EIA) Regulations, 2000 and subject to an Initial Environmental Examination (IEE). It is also prepared under guidelines of ADB to seek loan funding from International Donor.

The project will be constructed using a temporary diversion canal on the right bank of the Lower Jhelum Canal Feeder. Temporary cofferdams will be constructed to enclose an area in which powerhouse and bottom outlets is to be built. After completion of powerhouse, cofferdams will be removed and diversion canal will be backfilled and renovated with plantation. The embankments of the headrace will be raised upto its RD 2+000 where the proposed powerhouse be constructed.

5. Environmental Impacts

The main potential environmental impacts are related to the construction activities including construction of project components, diversion canal, permanent staff colony and a temporary camp for labour and reduced water quantity and quality during construction. The major impact associated with the project is the loss of trees during the construction of diversion canal and staff colony and from the camps and soil dumping sites which will be compensated with tree planting program as described in detail in the mitigation measures. The likely impacts of all these activities are assessed and mitigation measures have been proposed in the EMP. No resettlement is involved as land required for the project belong to Punjab Irrigation Department and will be leased from government for the project and the negative environmental impacts are minimal.

6. Environmental Mitigation

The mitigation measures identified are related to the construction of project components, staff colony, camp and diversion canal. Mitigation cost has been also proposed for the replantation/ tree loss compensation. All mitigations measures identified are part of the detailed EMP given in the report.

7. Proposed Monitoring

Mandibahauddin Power Company as an implementing agency will implement and monitor the measures given in the EMP and forward the monitoring reports on the regular basis to the provincial EPA.

8. Conclusions

The project will have minimal negative environmental impacts and these can be successfully mitigated by implementing EMP attached with IEE. The IEE and EMP are sufficient to ensure compliance with Government of Pakistan environmental policies. On the basis of this IEE, there is no need of detailed Environmental Impact Assessment. However, the Mandibahauddin Power Company (MPC) as an implementing agency has to implement and monitor the measures during and after construction as given in the EMP.

B. INTRODUCTION

1. Purpose and Scope of Environmental Report

This environmental assessment is undertaken as part of the overall feasibility study of Mandibahauddin Hydro Electric Power Project and is designed to meet the requirement of environmental assessment laws of Pakistan and the guidelines of ADB. Project company in the name of "Mandibahauddin Power Company" will submit this report for review and approval by the Punjab Environmental Protection Agency as required by the Pakistan Environmental Protection Act, 1997.

The Mandibahauddin Hydro Electric Power Project is a base load plant and will contribute during peak hours also. It will generate electricity throughout year except during closure period when canal is closed for annual repair and maintenance. The ultimate capacity of the project is 3.3 MW.

The Mandibahauddin Hydro Electric Power Project falls in schedule B as specified by the Pak-EPA "Policy and Procedures for filing, Review and Approval of Environmental Assessment", 2000, which deals with project where range of environmental issues are comparatively narrow and issues can be understood and managed through less extensive analysis and states that hydropower electric generation below 50 MW will require an IEE report submission.

The objectives of the IEE are to:

- Assess the existing environmental conditions of the area where project is located including the identification and information of environmentally sensitive areas;
- Assess the proposed activities, identify and evaluate the potential impacts and determine their significance; and
- Propose appropriate mitigation measures that can be incorporated into the proposed activities to minimize any adverse impacts, ensure that impacts are acceptable and to propose appropriate monitoring requirements.

2. Identification of Project and Proponent

The Mandibahauddin Hydro Electric power Project is being pursued by a consortium of M/S China Sinogy Electric Investment Co. Ltd (CSEIC) Main Sponsor along with M/S China Sinogy Electric Engineering Co. Ltd. (CSEEC), M/S Habib Rafiq (Pvt.) Limited (HRL) and NETCO Rental Service (NETCO) under the terms of an LOI issued on April 18, 2016 by Punjab Power Development Board (PPDB). The PPDB authorization is in accordance with the policy to encourage private sector investment in developing infrastructure projects. The LOI provides the above mentioned Consortium with the first right to the development of the site, assuming with diligently proceeds with feasibility investigation required for the completion of this Feasibility Report.

3. Details of Consultants

The consultants for this assignment is M/S Technical, Engineering and Management-TEAM Consultants, Pakistan. The expertise and technical resources of the TEAM shall play a key role in completing the assignment.

The consultants team is managed by a highly experienced project manager, who possesses over 35 years of rich experience in the management of water resources projects which includes techno-management of several major projects within Pakistan. He would be the overall in-charge of the assignment. He is assisted with specialists dealing in different fields such as: hydrology, sedimentation, hydraulics, geology, planning, E & M equipment selection, economics and documentation. These specialists are of the level of chief engineers and acting as the head of their team comprising of Principal and Senior Engineers/ personnel's. The Project Manager and the Specialists have formed a strong Project Management Group on behalf of Consultants project team.

The management of the Consultants is conferred upon a Board of Management (BOM), which consists of five associate's members each from hydropower, geo-technical, E&M, environmental and economical and financial field. The BOM gas the overall role of monitoring activities of the Project Team.

The main sponsor invited a number of consulting firms for provision of Consultancy Services for preparation of feasibility study as per issued LOI by PPDB. After lengthy deliberations, a Contract Agreement between M/S Consortium and M/S Technical, Engineering and Management-TEAM Consultants, Pakistan for consultancy services for the assignment "Mandibahauddin Hydro Electric Power Project"- feasibility study report was assigned on May 2, 2016 and services were commenced from the same date. M/S Technical, Engineering and Management Consultants, Pakistan for brevity is called, the Consultants throughout this report are required to prepare the Feasibility Study within the 4 months from the commencement date. However, initially the LOI was given for revision of Feasibility Report prepared by first sponsor for which LOI was cancelled. During meeting with MD PPDB, it was agreed that Sponsor would be given more time than 4 months to prepare a new Feasibility Report.

Upon signing of the Contract Agreement with the Client, the Consultants immediately undertook the assignment and are rendering services in accordance with the TOR given in the Contract agreement.

Environmental assessment was conducted by the TEAM consultants, as part of the overall feasibility report. The information and data required to file this report was collected through field surveys, secondary source of information and public consultation undertaken specifically for this project. A full list of those organizations contacted is given in Annex 1, written statements of these organization were not collected being not needed.

4. Description of Nature, Size and Location of the Project

Mandibahauddin Hydro Electric Power Project is located along RD 2+000 along Lower Jhelum Canal Feeder near Rasul Barrage about 10 km from Mandibahauddin Town in District Mandibahauddin in the Punjab Province. The project has the capacity of 3.3 MW and will generate 19.007 GWh of energy annually. Powerhouse and bottom outlets would be located at RD 2+000 in the existing canal. The head available at RD 8+626 and RD 0+000 would be combined for the development of this Hydro Electric Power Project.

The project makes use of existing water flow and falls in an established canal system. It will not change the water flow characteristics and hydrological regime of the area. This study presents environmental assessment regarding design, construction and operation of the proposed Hydro Electric Power Project. This Initial Environmental Examination (IEE) has been carried out to ensure that the potential adverse environmental impacts are appropriately addressed in line with EPA, 1997 and ADB Guidelines.

C. DESCRIPTION OF THE PROJECT

1. Type and Category of the Project

The project because of its relatively small size 3.3MW is classified as "Category B" Project in accordance with ADB "Guidelines for Environmental Assessment, 2003" and Pak-EPA. The proponent of a project has to file a detailed environmental impact assessment (EIA) in case of potential adverse effects. But in this case only Initial Environmental Examination(IEE) is required to assess the likely impacts.

2. Objectives of the Project

This project is designed to augment the power supply and distribution system in Punjab and also will help to meet the overall national power needs. Another objective is to generate power under green energy program to avoid adverse impacts of the non-renewable resources.

3. CONSIDERATION OF ALTERNATIVES

Firstly, the proposed project was considered to place on the left bank of the Feeder. Placing the power house on left side of the Lower Jhelum Feeder Canal has restrictions due to space limitation and due to exposure of the phreatic line because of the bed level difference of the two canals. On the right side of the Feeder, there is no restriction of space. The canal bank road is running along right bank from RD 0+000 to RD 8+626. Land along right side of the Feeder is Scrubs and small forest upto RD 4+400 and from downstream the land is under agriculture. The right of the way of the canal is 250 ft. on right side. However, land along right having width of 646m (21207 ft.) starting from RD 0+000 to RD 4+400 belongs to irrigation department and covered with scrubs of thin forest. There is small village near fall at RD 8+626 of the Feeder, which is located in right of way of canal.

Another alternative consideration is the placement of powerhouse inside the existing canal or in the right bank permanent diversion canal. Placing the powerhouse inside the existing canal reduces the amount of permanent land leased for the project as the diversion canal can be returned back to its original state after completion of the project and also reduce the number of trees to be removed. Table 1 showing the avoidance of impacts constructing the powerhouse in the existing canal by considering the layout 1 rather than on the diversion canal by following alternative 2.

Table-1 Alternative Designs and Impacts of MHEPP

No	Potentially Affected Assets	Unit	Layout Alternative 2	Layout Alternative 1	Avoidance of Impacts
1	Leased Land	Acres	40	-	40
2	Affected Trees	Number	8120	5560	2560

4. Project Location and Site Layout

The project lies in district Mandibahauddin which is located in the south of Gujrat city. The project is located at the Lower Jhelum Canal Feeder, which is off-taking from left bank of Rasul Barrage along Jhelum River. The project is located in Upper Punjab which is heart of agriculture and citrus fruit production. The project area is located about 175 km from Lahore, 157 km from Islamabad, 61 km from Gujrat, 10 km from Mandibahauddin and 6 km south west of Rasul town in Mandibahauddin District of Punjab Province. The project site is located at 73° 32' 11" longitude and 32° 39' 30" latitude with an average altitude around 213 m.a.s.l. Project location/ vicinity map is shown in **Drawing: 1** and **Drawing 4.**

Mandibahauddin Hydro Electric Power Project is proposed to be constructed at RD 2+000 of lower Jhelum Canal Feeder. Lower Jhelum Canal Feeder and Rasul Qadirabad Link Canal run parallel up to RD 10+000. The space between two canals varies from 137 m to 61 m in width. However, near proposed power house this distance is about 107m. Photos of the project site are given in Annex 5.

The selected layout of the powerhouse with bottom outlet in the existing canal in given in the **Drawing 2.**

5. Land Use on the Site

The land required for project implementation would be on temporary and permanent basis. Land for dumping excavation earth material, diversion canal and contractor camps will be required on the temporary basis and will be returned back to Irrigation Department after bringing into original condition. Requirement of land for temporary purpose is to place the temporary facilities mentioned earlier only during construction of project and not required during operational phase. Land for operation and maintenance staff residence colony is required on permanent basis. The headrace, powerhouse and tailrace lies in the existing alignment of LJC Feeder. The switchyard is proposed on land between LJC Feeder and Rasul Qadirabad Link, therefore no additional land is required for it. The estimated land required will be about 64 acres which include 4.5 acres for permanent land use and 59.5 acres for temporary land use. Proposed location for the O & M staff colony, construction camp and soil dumping site is shown in **Drawing 3.**

As mentioned above, the land required for Project belongs to Punjab Irrigation Department; the land belong to Government of Punjab would be leased to sponsor as given in Power Generation Policy 2006 (Revised 2009).

6. Road Access

The project site and area is accessible by air, good roads and railway networks. The project area is located about 10 km from Mandibahauddin, 61 km from Gujrat, 175 km from Lahore and 157 km from Islamabad. A 4.50 m wide access road is constructed over the left bank of the Rasul Qadirabad Link Canal to access the Rasul Barrage. From Rasul Barrage a 4.5 m road to access powerhouse would be constructed on both banks of LJC Feeder. An un-metaled road along right bank of LJC Feeder exist up to RD 8+626.

The nearest railway station is Mandibahauddin which lies on Gujrat –Sargodha line. The other nearest railway stations where loading and unloading of heavy equipment is possible include Gujrat, Wazirabad, Sialkot dry port, Sargodha and Lahore. Loading and unloading facility are available at all stations but cranes of suitable capacity are not available at these stations except Lahore.

Pakistan is also linked with international community via sea and at present three shipping ports are operating i.e. Karachi port and Port Qasim in Karachi and Gwadar port in Balochistan. These ports are linked with other parts of country through good networks of roads.

A number of national and international airports are operating in Pakistan. The nearest airports for the project area are:

- Allama Iqbal International Airport Lahore;
- International Airport Faisalabad;
- International Airport at Sialkot; and
- Benazir Bhutto Shaheed International Airport Islamabad.

The road distances from these airports are:

- Lahore to Mandibahauddin via Gujrat GT Road = 175 km
- Lahore to Mandibahauddin via Motorway M2 Salam = 250 km
- Faisalabad to Mandibahauddin via Motorway M3, M2 Salam = 198 km
- Islamabad to Mandibahauddin via GT Road Sarai Alamgir = 157 km
- Islamabad to Mandibahauddin via GT Road Kharian = 182 km
- Islamabad to Mandibahauddin via Motorway M2 Bhira = 235 km
- Islamabad to Mandibahauddin via Motorway M2 Salam = 261 km
- Sialkot to Mandibahauddin via Wazirabad-Gujrat-GT Road = 135 km

7. Vegetation Features of the Site

The project area has vegetation cover and trees, which is sub-tropical and semi-arid. It is dominated by rural suburbs and with various productive fields of monocultures that now dominate the agro-ecosystems present in the project area. Common floral species with rooted vegetation are also present near most of the water bodies of the area.

Vegetation of the district has been greatly modified by human intervention of the old open forests of small trees and shrubs. There remain only a few Rakhs or portions of

forest which are kept as grazing ground for cattle etc. Among trees the most important are Kikars (Acacia arbica), Shisham (Dalbergia sissoo), Phulahi (Acacia Modesta), toot (Morus marlaccae) and eucalyptus.

8. Cost and Magnitude of the Operation

The Total Base Cost of Mandibahauddin Hydro Power Project is 1,235,689,095 Pakistan Rs. The proposed estimated quantity of steels is 569 tonnes, concrete quantity is 9748 m^3 and that of excavation is 195,700 m^3. Estimated cost of the Excavation, steel, concrete and environment is 56,762,612, 80,943,690,143,945,516 and 643,632 Pakistani Rs.

9. Project Implementation Schedule

The project implementation time is 54 months, 18 months for preparation and approval of feasibility report, tariff from NEPRA and achievement of financial close and 36 months for construction.

10. Description of Project

The proposed Hydro Electric Power Project has installed capacity of 3.3 MW and would generate 19 GWh annually. Project has been proposed near RD 2+000 of Lower Jhelum Canal Feeder by combining head available at its head-regulator RD 0+000 and at fall structure at RD 8+626. It would be equipped with 2 Pit type turbines each has capacity of 1.65 MW. The project would be connected to NTDC 132 KV Grid at Mandibahauddin which is about 10 km from project site.

Mandibahauddin Hydro Electric Power Project is a low head and runoff river project; no reservoir has been seen so inflow and outflows through the turbine remain same. Further the project is to built along irrigation canal where irrigation is prime and power is secondary objective.

The main features of the project are

- Headrace and intake bay having length of 610.0 m
- Power house machine hall structure housing 2Pit type turbines and generators and three bottom outlets
- No separate loading bay is provided. The space available at top of bottom outlets would be used as service and loading bay.
- Three bottom outlets have been provided to meet the emergency requirements during load rejection. The bottom outlet operation would be controlled through hydraulically operated vertical gates.
- Tailrace and outlet bay
- Main unit transformers and switchgears
- Switchyard, transmission lines and interconnection facilities
- Access roads along the both banks up to RD 3+000
- Operation and Maintenance Staff colony

11. Restoration and Rehabilitation Plans

As the project construction will involve the excavation of the soil for diversion canal construction, dumping of this soil on dumping sites and also cutting of the trees along the banks, from diversion canal and colony area. So following restoration and rehabilitation measures will be taken on the completion of the project.

- The diversion canal will be backfilled and replanted with endemic species of trees after removal of the cofferdams in the main canal.
- Soil dumping sites and temporary camps facilities will also be planted with endemic tree species to restore to its original condition and to avoid soil erosion.
- Trees will be planted along the banks of the canal after the completion of the project.

Details of tree planting program and cost of plantation is given in the mitigation measures and also discussed in the Environmental Management Plan along with other restoration and rehabilitation measures given at the end of the report.

12. Government Approval Requirements

The Government of Pakistan has exactly the same Environmental Assessment requirements as ADB for hydropower project of less than 50 MW. A full scale Environmental Impact Assessment (EIA) is mandatory only for project bigger than 50 MW. This project falls under category B of schedule 1 (Regulation 3) of Pakistan Environmental Protection Agency (review of IEE and EIA) Regulations, 2000. An IEE is required to submit to Punjab EPA by Mandibahauddin Power Company for approval prior to commence construction work.

D. DESCRIPTION OF THE ENVIRONMENT

1. Provincial Context

Punjab forms part of Indus basin watershed System. The landscape of the whole province has been so changed by human activity that hardly any of the original habitat of thorn forest, swamps or riverine plantation remains. The irrigated plains of Punjab today constitute the largest canal system in the world and with conversion of habitat to agriculture, a number of highly distinctive agro-ecosystems exist and the forestry master plan of 1992 identifies 9 such zones.

Various protected areas are spread across Punjab province are mentioned below. One (Daphar plantation) is in district Mandibahauddin but not in the vicinity of project site.

- Changa Manga forest plantation (WS)
- Daphar and Pakhowal Forest Plantation (WS)
- Kundian forest plantation (WS)
- Lal Suhanra National Park (NP)
- Bhagat forest plantation (GR)
- Shorkot forest plantation (WS)

- Kamalia plantation (WS)
- Cheechawatni forest plantation (WS)
- Kathar, District Rawalpindi (GR)
- Potential areas for wildlife in District Attock i.e., Kala Chitta, Mahora, Kheri Murat and Kali Dauli (GR)

2. Physical Environment

The project area is a part of vast alluvial plain of Chaj Doab in upper Indus basin, which can further be classified into three units namely active flood plains, abandoned flood plain and bar uplands. Main rivers in the area are Chenab and Jhelum. These rivers and their canals are the main sources of surface water supplies for irrigation as well as for recharge of groundwater. The elevation in area varies from 215 to 221 m above mean sea level. The area has gentle slope toward south.

The alluvial deposits are composed of clay, silt and sand extending in general to a depth of 300 m and are overlaid by recent surface coarser deposits along the river channels. The area where power house has been envisaged is comprised of thick alluvial sub-recent deposits of earthy brown to grey color clayey silt, silty sand and sand.

The project site is located in the upper part of Punjab plains which is characterized by low to moderate level of seismicity. The collisional zone of Indian tectonic plates lies about 100-150 km north of project site in the Himalayan mountains. The historic and instrumental data of earthquake in the region is not expected to cause appreciable shaking in the project site.

The climate of the project area is semi-arid. It is characterized by four distinct seasons, summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months. The average annual rain is about 759.7 mm and mean monthly rainfall is less than 3.0 mm.

The temperature of the area varies from hottest months (May, June, July and August) to cold months (November, December, January and February). The mean temperature (maximum) remain more than 30 C^0 during the months of April, May, June, July, August, September and October while mean monthly minimum is less than 10 C^0 in the months of January, February, March, November and December.Overall, the temperature will not affect the construction activities throughout the year.

Predominant wind direction is north to northwest from October to May, while during the monsoon period, it is from east to southeast. Average maximum wind speed recorded has been 30 km/hr in May during year 2005. Project area has a good humidity conditions with high humidity in the month of January.

Water will be required during the construction of the project as well as for the mixing and compaction for various materials. Water is also required during project operation for cooling and drinking purposes. Water needed to complete project task and for labor work forces is readily available from canal water and ground water at the project site. The water used for concrete mixing and drinking must be clean and free

of toxic materials. Two vertical boreholes BH1 and BH2 for the assessment of foundation conditions at the powerhouse and water outlet area was drilled down to variable depth of 40 m from natural surface level. Piezo-meters have been installed in the boreholes for future monitoring of ground water levels. The quality of groundwater observed from boreholes and canal water is generally fresh having total dissolved solids ranging from 170 to 300 ppm. All other parameters investigated in Annex 2 to check the water quality falls under National Environmental Quality Standards for municipal water.

3. Ecological Resources

3.1. Wildlife

Because of extensive cultivation, high population and human activities, there is little wildlife in the project area. Wildlife department of Mandibahauddin has no official record of wildlife in district. However, in Pakistan limited work has been carried out by some authors on identification of wildlife species in irrigated forest plantation and sub-mountainous tract.

Irrigated forest plantation provide a potential habitat for a variety of wildlife species. These plantations have been raised clearing the thorn forest. Though relics of natural vegetation typical of tropical thorn forest co-exist with irrigated plantation in the form of grooves and patches. For the protection of wildlife, these plantation and sub-mountainous tract has been declared Wildlife Sanctuaries (WS) and Game Reserves (GR) under Punjab Wildlife Act, 1974. Among various plantation in Punjab, Daphar forest plantation is in tehsil Malikwal, District Mandibahauddin. According to the M. Anwar Maan and A. Aleem Chaudhry, 2001 research, following wildlife species found in Daphar Plantation:

- **Mammals**

Among mammals, Indian gerbil, field mouse, wild hare, porcupine, jackal, jungle cat, mongoose and wild board were observed. Few hog deerwere also reported in Daphar Forest Plantation.

- **Birds**

Fifty-six (56) species of birds were reported by the researchers in the Daphar Plantation. The commonly found birds around the project site are variety of sparrow species, partridge, bank myna, Red vented bulbul and black crow. A large variety of waterfowl and migratory birds also visit the area because of Rasul Barrage.

- **Reptiles**

Among reptiles, prints of snakes (un-identified) seemed to be of Krait were observed at two different points. Lizard and snake are reported near project site by the locals.

3.2. Forest Resources

Mandibahauddin district has a reserved forest known as Daphar Plantation at the intersection of latitude32°-26' north and longitude 73°-11' east in the Malikwal Tehsil. It is irrigated by Bhalwal distributries with a sanctioned discharge of 86 cusecs. The soil of Daphar plantation is in general the gift of river action. It is on the whole alluvium with varying proportion of clay and sand. The area was a typical dry forest known as 'Rakh' before it felled from 1882 to 1901. The original vegetation consisted mainly of Van (*Salvadora oleoides Done*), Jand (Prosopis cineraria Linn.), Karir (*Capparis decidua Pax.*), Mallah (*Zizyphus nummularia W& A.*) Ber (*Zizyphus mauritiana Lamk.*), Chamror (*Ehretia laevis Roxb.*), Rehru (*Acacia leucophloea Wild.*), Lahura (*Tecoma undulata* (Smith Seem.), Frash (*Tamarix aphylla Karst.*), Kangu (*Lycium europaeum Linn.*), etc. These species occurred in groves and patches with sufficient space in between. The general height of trees varied from 4.5 m to 9 m (15 feet to 30 feet). There were mounds and depressions. The mounds were covered with Xerophytic species while Dhak (*Butea monosperma, Lamk Taub.*), Lasura (*Cordia dichotoma*), Jangli-anar (*Punica granatum Linn.*), Phagwara (*Ficus palmate Forsk.*), etc. were found in depressions. A few trees of Kikar and Shisham could also be found on relatively favorable sites. Presently Shisham and Mulberry are the principle species growing in mixtures over a major portion of the plantation area. Other species growing are Eucalyptus, hybrid-poplar, semal, bakain and kikar. Bamboo are also grown on experimental basis. Every year about 300 acres are being afforested or regenerated.

Entire area near project site has no natural forest. The canal bank and road sides have endemic tree species plantation like Eucalyptus, poplar, Kikar (*Prosopis juliflora*) and few immature rosewood trees (*Dalbergia sisso*).

3.3. Fish Resources

It is reported by the Mirza *et al.*, 2006 that main fish species found at Rasul Barrage and downstream are Gulfam (*Cyprinus caprio*), Singhari (*Sperata sarwari*), Mullee (*Wallago attu*), Keengar (*Mystus vittatus*), Teengara (*Mystus cavasius*), Goonch (*Bagarius bagarius*), Gageeta (*Gagata cenia*), Nama Shisha (*Chanda nama*), Choti Chal (*Salmophasia bacaila*) and Punjabi Chal (*Salmophasia punjabensis*). According to locals, the fish found in the canal are Gulfam, Rahu, Sol and Khagha.

4. Socio-Economical and Cultural Environment

The closest villages to the project site is Kotli Afghana near RD 7+000 and Rasul barrage colony constructed for the Rasul barrage staff situated along right side of Lower Jhelum Canal. A sample questionnaire to carry out socio-economic survey is added in Annex 3.

The Kotli Aghana village consists of 450 households with an estimated population of 2500 and average household size is of 5 persons. All are native Punjabis living in the area since long. About 8 households migrated to cities for better opportunities of education or jobs as reported by the villagers. The relatively small household size indicates a predominant nuclear family trend in the village. Kolti Afghana is compact village having cemented houses, only 4 are mud/soil houses. The religion of majority population is Islam with 99% Sunni Muslim and 1% Ahmadi.

The adult population of the village is not well educated, only 45% of male and 16% female are educated. Child literacy rate is far higher than the adult with 88% boys and 66% girls are enrolled in the schools. The village has two school, one is Government Primary School and one is private named as Nadir Memorial School. For getting higher education, the villagers have to travel to nearby cities like Mandibahauddin, Rasul, etc.

Village is easily accessible through paved road and regular transport service. It has two shops for selling groceries, milk, egg, etc. Although villagers are not suffering from any contagious and prevalent disease, only seasonal illness like cold, flue and diarrhea prevailed for not more than a week. But there is no basic health facility in the village but nearest city Mandibahauddin has all modern health facilities. The village has 100% domestic electrification provided by the nearby Grid of Rasul Powerhouse. But majority of population use firewood, kerosene and LPG for cooking, water and space heating relatively of high charges of electricity than firewood. Both domestic and livestock water source is groundwater through borehole and reported to be of good quality by the locals.

The villagers practice mixed cropping pattern with wheat, rice and sugarcane. Majority people are small landowners growing crops for subsistence. About 66% of the people of village own land which is below the minimum economic unit of 5 ha. A few are large landowners growing crops for subsistence and to sale to cities. Majority of the population has to depend on the varying degree of alternative sources of income. They work as labor in construction and in private and public organizations. About 58% of population is working as labor. Women are housewife or busy in house chores and few help in farming as well.

Beside farming few households are also earning income though livestock products like milk and meat. Poultry is also very common in the village where every household has 5 to 10 hens for egg and meat. People of the village also enjoy fishing from the canal during July and August and few persons have fishing contracts for fishing at Rasul Barrage and pay 10% of the contract. Main recreational site near village is Rasul Barrage which offer boating and food to enjoy.

Few people also associated with sand mining business. Sand is excavated from Jhelum River at village Mong which is about 5km from Kotli Afghana. This sand is sold to villagers to use in construction and other nearby villages and town. About 3,6500,000 ft^3 sand mining is done annually at a tax of 1,210,000 Rs.

The residents of the Rasul Barrage Colony are the government employees consists of skilled and unskilled workers. Colony consists of 12 households with an estimated population of 70 persons. Average household size is of 7 persons. The religion followed by the population is Islam. The adult literacy rate for male is 46% and for female is 40%. Child literacy rate is higher with 85% for boys and 80% for girls. There is no school/college in the colony and people have to go to nearby village school or city school/college. There is also no health facility in the colony. But the residents have good health conditions and not suffering from any contagious and incurable disease.

Household heads are the government employees working under irrigation department. Few are also associated with subsistence farming, livestock and poultry to

meet their basic requirements. Households have 100% electricity supplied by the Rasul Powerhouse Grid. Water supply is mainly through tap water from boreholes and also proper sewerage system with flush latrine. Recreational site is Rasul Barrage. There is also a rest house for the strangers to stay.

E. SCREENING OF ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

This section of IEE discusses the potential environmental impacts of proposed project and identify the mitigation measures to minimize the impacts in the design, construction and operation phases. The process of impact prediction is the core of environmental assessment process and it is critical that recommendations and mitigation measures are carried out during construction and operation of the project in accordance with EPA's environmental regulations.

1. Project Location and Design Impacts and Mitigation Measures

1.1. Loss of Land and Compensation

The total land area required for construction of project components is 64 acres which include 4.5 acres for permanent land use and 59.5 acres for temporary land use. The land required for both permanent and temporary use is under irrigation department and will be acquired following government land leasing regulation. No private land will have to acquire for project construction.

Table-2 Land Required for Mandibahauddin Power Project

No.	Permanent Land Use	Land (Acres)	Temporary Land Use	Land (Acres)
1	O & M Staff Colony	4.5	Diversion canal	27.5
2			Soil dumping site	24
3			Contractor camp	8

1.2. Loss of Trees and Tree Planting Programme

There are trees effected by the project and these are in existing irrigation department right of way. About 12,280 trees of varying size will be removed for the construction of diversion canal, colony, contractor camp and from soil dumping site (Table 3) and this loss will be compensated with a tree planting program for 64 acres by Mandibahauddin Power Company using its own management resources or though forestry department. Plantation will be done on the soil dumping site, along the bank of the lower Jhelum canal and to renovate the land of diversion canal when it is backfilled. Only indigenous tree species will be selected for replacement and no invasive species will be used.

Table-3 Number of Affected Trees of Mandibahauddin Power Project

No.	Project components	Affected Trees (No.)
1	O & M Staff Colony	670
2	Diversion Canal	5560
3	Soil Dumping Site	4780
4	Contractor Camp	1270
	Total	**12,280**

About 27,840 trees will be planted against tree uprooted. The cost of plantation and look after is given in the Table 4.

Table-4 Cost Estimates for Raising One Acre Tree Plantation

No.	Particulars	Work Days	Amount (Rs)
1.	Digging of 435 pits, 10x10 ft spacing, 1.5 ft deep, & Planting of 435 saplings @ Rs. 500/day	4.4	2200
2.	Procurement of 435 plants @ Rs. 5/plant	-	2175
	i. Sub-Total		**4375**
3.	Beating up of 30% failure in the 2nd year, 131 plants		
a.	Re-opening of 131 pits, 1.5 ft deep, and planting of 131 saplings @ Rs. 500/day	1.3	650
b.	Procurement of 131 plants, @ 5/plant	-	655
	ii. Sub-Total		**1305**
4.	Beating up of 15% failure in the 3rd year, 65 plants		
a.	Re-opening of 65 pits, 1.5 ft deep, & planting of 65 saplings @ Rs. 250/day	1.3	325
b.	Procurement of 65 plants @ Rs. 5/plant		325
	iii. Sub-Total		**650**
	TOTAL		**6330**
	TOTAL COST OF PLANTATION AT 64 ACRES		**4,05,120**

2. Construction Impacts and Mitigations

2.1. Materials

The project will require various materials for construction. The requirement of aggregate (fine, coarse, boulder) for construction of various project structures will be procured from suitable quarry within or nearest project area. Excavated material will also be used as construction material where filling is required.

2.2. Construction Activities

Construction of the project involves the excavation and movement of materials for:

- Excavation of the temporary diversion canal on right bank and raising of banks and bed of headrace portions of existing canal,
- Making of temporary cofferdams up and down stream of the proposed powerhouse in the bed of the existing canal,
- Removal of cofferdams when the powerhouse and spillway are complete
- Filling and completion of temporary diversion canal
- Excavation of LJC Feeder bed between RD 2+000 and RD 8+626.

Disposal of excavated Material: Project implementation will involve excavation of material as very significant activity. The excavation material will consist of broken stones, clay, sand and top soil and will be dump at a specified dumping sites as defined in Drawing 3 without affecting settlements, agricultural activities, communication lines etc.

Soil erosion will be caused due to the construction of different project components such as diversion canal, headrace banks and access road. Vegetation and forestation are the most effective long term and economic measures to avoid soil erosion. The affected areas should be planted with grass cover, tiny bushes and trees.

2.3. Access and Traffic management

Project site is easily accessible by 10 km road from Mandibahaudddin to Rasul barrage. From Rasul Barrage a 4.5 m road to access power house would be constructed on both banks of LJC Feeder.

The construction related traffic on road may disrupt existing traffic and may also create safety hazards for the villagers. However, the project is small in nature, the transportation of cement, steel and manpower is required for which no detail traffic management is needed. Managing traffic at a construction workplace is an important part of ensuring the workplace is without risk to health and safety. Vehicles moving in and around project site, reversing, loading and unloading are often linked with death and injuries to the workers and public. The most effective way to avoid these risks is through designing a traffic management plan, and by implementing through construction contractor. The main objective of the plan shall be to maximize the safety of the workforce and the travelling public. The second objective will be to keep traffic flowing as freely as possible.

Traffic Management Plan

The key components of traffic management plan are:

- Hiring the qualified and trained drivers for construction work, managing the activities of visiting drivers and by training the drivers.
- Providing separate traffic routes for pedestrians and vehicles.
- Designating specific parking areas for workers and visitor's vehicles outside the construction area.
- Providing clearly signed and lit crossing points where walkways cross roadways, so drivers and pedestrians can see each other clearly.
- Scheduling work so vehicles, powered mobile plant and pedestrians are not in the same area at the same time.
- Minimizing vehicle movement around a workplace by providing loading and un-loading away from the work area.
- Where possible, avoid the need for vehicles to reverse as this is a major cause of fatal incidents.
- Ensuring a signal person wearing high visibility clothing assists the driver who cannot see clearly behind their vehicle.
- Ensuring workers and other people are familiar with reversing areas and these areas are clearly marked.
- Traffic routes should be clearly signed to indicate restricted parking, visitor parking, headroom, speed limits, vehicle movement, key site areas and other route hazards. Standard road signs should be used where possible and speed limits should be implemented and enforced.
- Assign duties to the people at site to control and manage the traffic.
- Train the staff to handle the traffic in case of emergency situations.
- Implement and monitor the effectiveness the traffic management plan.

2.4. Construction Site and Camp Impacts and Mitigations

2.4.1. Water supply, Sanitation and solid waste management

To meet the demand of the drinking water supply and sanitation during construction period, it is recommended that proper water supply system should be provided at the site through water pump installation.

Environmental protection act 1997 require that all the municipal and industrial waste should be treated for surface discharge to any stream or open land should comply with NEQs standards. For proper sanitation facilities, pour flush type latrines with septic tank are recommended. Also proper arrangements of solid waste management should be made in construction camps.

Solid Waste Management Plan

Solid waste generated from the construction activities, worker camps and during operational phase from the power house and staff colony need to be properly managed and disposed off. Main steps involve in the waste management are

- Segregation of waste at the source

- Collection of waste
- Transportation of waste
- Proper disposal according to the standards

It is recommended to provide specified colored bins to segregate different type of waste like plastics, glass, paper and kitchen waste (also known as bio-degradable waste) at the source and then transported to a properly designed disposal site (a landfill and composting site).

Trained the workers about three Rs to manage the solid waste properly. These 3 Rs are

- Reduce; aware the workers to reduce their consumption of plastic bags and other resources as much as possible by producing less waste.
- Re-use the material such as glass bottles and plastic bag instead of throwing them away.
- Recycle the used items like compost the kitchen waste and yard waste to make fertilizers. Paper and broken glass can also be recycled so instead of throwing them away, provide to recycling facility.

2.4.2. Leakage and exhaust pollution during construction

Many toxic and hazardous materials are used during construction like oils, fuel, paints, gases, cut pieces of plastic cable sheathings etc. Separate stores should be built to store toxic materials and strict regulations should be followed and utmost care must be taken to handle these materials.

Proper handling measure should take to transport the liquid materials such as fuel to avoid their leakage on the construction site, because all mostly fuels are carcinogenic and they not only contaminate soil but also carried away in canal/river water with surface water flow. Thus it may cause damages to existing fauna and flora.

Gaseous emissions and dusty environment will result from movement of heavy vehicle for transportation of equipment and construction material. Similar effects could be caused by construction machinery so the contractors must control these emissions by construction management techniques as per NEQs.

Construction related activities would result in negative but short lived impacts in term of noise, dust and exhaust pollution on nearby settlements and labor working.

2.4.3. Dust impacts

Most of the construction work will generate dust during excavation for diversion canal. Among the variety of option to control dust emissions (particulate matter) from construction sites, most effective is the wet suppression. Spraying water on exposed surfaces and soil with adequate frequency to keep soil moist at all times can reduce the total dust emission from the project by as much as 75%. The following mitigation measures will be implemented during construction to control emission of dust;

i. Water will be sprayed daily on all exposed surfaces sufficient to suppress emissions of dust. The frequency of spraying will be increased as necessary but

controlled such that surface remains just moist at all times, particularly when air is blowing toward nearby village.

ii. Dust emission from soil and aggregate storage stockpiles used for construction will be reduced by appropriate measures. These will include:

- Covering the pile with thick plastic sheets when not in use at the end of working day.
- Keeping the material moist by spraying water at appropriate interval to prevent emissions.

iii. The construction vehicles will maintain a speed limit of 20 km/h or less on all unpaved areas within the construction route. Speed limit signpost will be erected in highly visible positions along the access road and within the route and maintained for the duration of the construction. Speed bumps will be constructed near all sensitive receptors such as village, where there is a risk that vehicle may exceed the speed limit.

iv. Construction materials will be transported to the route and around the route in trucks securely covered with tarpaulin to prevent dust emissions during transportation

2.4.4. Noise

Operation of construction machinery and vehicles can be nuisance for the nearby village (Kotli Afghana), Rasul barrage colony and the site workers. Excessive noise level cause damage to eardrums, lungs and even effect the nervous system of the workers. The permissible noise level is 85dB. Noise can be minimized by

- Preventing contrition work during night time
- Prevention of horn blowing by the vehicles except in emergencies
- Use of powered mechanical equipment that is acoustically insulated to reduce noise impacts
- Tuning and proper maintenance of construction equipment and vehicles.

2.4.5. Public Health and Safety of Workers

The contractors shall provide on-site safety induction training for his personnel upon starting of construction work.

- The contractor shall provide personal protective equipment, including hard hats, protective gloves, mask, goggles, safety shoes etc. and such other equipment and shall take all measures and actions for safety and protection of personnel.
- Non-metallic hard hats shall be worn all times by the personnel at the site with the exception of those areas where engineer has indicated it not necessary to do so.
- Safety glasses if required shall meet international standards and be available for use and worn in specified worksite areas. As a minimum, safety glasses shall be worn for the following type of work; hammering, chipping, welding, grinding, use of electricity powered equipment, insulation handling, spray painting, working with solvents and other jobs where the potential of an eye injury exists.

- Personnel shall not be permitted to work whilst wearing personal clothing or footwear likely to be hazardous to themselves or others.
- Hearing protection, including ear muffs, plugs or combination thereof shall be provided for all personnel operating in areas where noise level exceeds 90 decibels.
- The contractor should encourage employees to wear substantial work gloves whenever it is practical.

Public health and safety measures will also be undertaken such as barriers and warning signs at required places. All safety, health, environmental and other safety notices and signs shall be clearly displayed and written in both Urdu and English.

2.5. Impact On Water Quantity and Quality

The construction works are likely to affect the water quality temporarily by increasing the silt content in it. Construction of the project will be phased to ensure that the cofferdams are completed in the down time in the canal system. This will minimize the need to work in the water and minimize impacts on water quality. However, the canal water is not used for drinking purposes. Therefore, any significant impact on the water quality is not anticipated during construction period.

2.6. Impacts on Fish and Mitigation Measures

As there are series of existing falls on the canal and because water flow in the canal system is completely closed off for a minimum period of two months (December and January) each year. There is no significant fish population in the canal and there will be no significant impacts on fish either in the construction or operation phase of the project.

As the workforce during the implementation of the project could have an increasing demand for the fish so there must be some measures to consider to control the overfishing and production of the fish in the barrage and canal. One way to increase the fish production can be through increasing the supplies of the fish.

3. Impacts and Mitigation During Operational Phase

3.1. Impacts and Mitigation of Transmission Lines

Upon its commissioning, the powerhouse will be connected to NTDC Grid by 10 km long transmission line and will pass along the existing pathway. No private land will need to be acquired.

The transmission line will not pass through any protected area, ecological reserve or wildlife habitat. No demolition of structures will be required and environmental impacts of the transmission line will be minimal.

3.2. Impacts on Fish and Mitigation Measures

Major issue with fish during operational phase is entrapment of fish at the water intake. Protection of fish should be made against entrapment and impingement by installing screen devices at the intake which will divert the fish from the water intake.

4. Potential Environmental Enhancement Measures

4.1 Positive Impacts

The proposed 3.3 MW Hydro Electric Power Project will be important for bridging the widening gap between demand and supply. The electricity generated through this project will supply the national grid along with hydropower project in the region and will benefit the wider population in Punjab as well the country.

Availability of power would reduce consumption of fuel wood and other fossil fuels by villagers for cooking, heating and other domestic purposes, thus will conserve the resources.

The project will provide unskilled jobs during the construction phase and limited number of skilled job in operation to the locals. This will be a bonus to the men who have to travel to distant parts of country for employment.

Hydropower is a clean and renewable source of energy than thermal power and its use reduce emission of pollutants such as carbon dioxide (CO_2), Sulphur dioxide (SO_2), particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NOx) and hydrocarbons. The following table provides a comparative analysis of estimated emissions of CO_2 from a power station generating same amount of energy as Mandibahauddin Hydro Electric Power Project over a 30-year period using oil, gas and coal as a fuel source. Between 0.17 to 0.23 million tons of carbon dioxide emissions are saved over the 30 years of the project by using hydropower rather than fossil fuels.

Table-5 Comparative Analysis of CO_2 Emission using Oil, Gas and Coal for Generation

Fuel source	Oil	Gas	Coal
Grams CO_2/kwh	297	232	410
Total Saving (Million Tons CO_2)	0.17	0.13	0.23

Note: Assume generation of 19 Gwh per year over a 30-year project life = 570 Gwh

F. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN AND INSTITUTIONAL REQUIREMENTS

Mandibahauddin Power Company will also obtain approvals from EPA Punjab and then monitor the project and forward monitoring reports on a regular basis to the provincial EPA as per the requirements of the federal EPA regulations. The IEE and EMP can form the basis of a submission for environmental approval to the EPA Punjab.

The EMP is developed in Table 8 ENVIRONMENTAL MANAGEMENT PLAN. Supervision and implementation of EMP will be undertaken by Mandibahauddin Power Company (MPC) in conjunction with a proposed implementation specialist.

Mandibahauddin Power Company will ensure that conditions are included in project construction contract documents. It will also ensure that during construction phase, environmental mitigation measures as per the EMP, are effective and are implemented. The EMP implementation will be coordinated with concerned Government Agencies.

An environment officer will be employed by the Mandibahauddin Power Company (MPC). This officer will work in close cooperation with the respective field based office on the day-to-day activities of EMP implementation.

As MPC does not yet have the expertise and capacity required for implementing the IEE, it will have to depend on additional external technical assistance and will, therefore, hire additional expertise in the form of:

- A part time implementation consultant who will be directly hired by MPC, to provide technical assistance in implementation of the IIE and;
- Another part-time Consultant (External monitoring) who will be hired to conduct the external monitoring and evaluation of the effectiveness of the implementation of EMP.

The Implementation Consultant (TOR in Annex 4) will carry out an internal on-job training and an institutional capacity building for MPC in general. In this way, MPC will acquire the necessary expertise to implement the EMP. The cost of Implementation Consultants is also included in the Table 7.

Summary of Impacts and Their Mitigations

The impacts identified in the report are the land use changes resulted in the loss of vegetation and trees of the area which will be mitigated as much as possible by placing the powerhouse in the main canal. As placement of powerhouse in the diversion canal which required more land and hence may result in the more tree loss. Other direct and indirect impacts associated with the project is the dust, noise, water quality, leakage and exhaust pollution which will be mitigate by following the measures described in detail in the EMP.

Equipment Maintenance

This project is a small hydro power project and incorporated small machinery needed low maintenance cost. However, equipment maintenance staff will be hired to maintain and organize the machinery during construction and operation of project.

ENVIRONMENTAL BUDGET

For the implementation of IEE and EMP, it is proposed to hire implementation and monitoring specialist. The estimated cost of EMP implementation for project is given in Table 6.

Table-6 Estimated Cost of EMP Implementation for MHEPP, Punjab

No.	Description of Expense	Unit	Quantity	Avg. Rate (Rs.)	Total Amount (Rs.)	Total Amount (US$)
1	Environment Specialist (Package)	Man-Days	30	5,000	150,000	1435.89
2	Environment Monitoring Evaluation	Man-Days	5	6,000	30,000	287.18
Sub-Total Environmental Expertise:					**180,000**	**1723.07**
3	Contingencies (10%)				18,000	172.31
	TOTAL ESTIMATED COSTS				**198,000**	**1895.38**

Project mitigation measures and costing for the project are indicated in Table 7 proposed mitigation cost

Table-7 Proposed Mitigation Costs

No.	Mitigation Measure	Total (Rs)	Total $US
1	Environment Expertise	180,000	1723.07
2	Plantation of endemic tree species 64 acres along canal, soil dumping site, contractor camp and rehabilitated diversion canal	405,120	3878.23
3	**Sub-Total**	**585,120**	**5601.30**
4	Contingencies (10%)	**58,512**	**560.13**
5	**Total Estimated Costs**	**643,632**	**6161.43**

Exchange Rate: US $ 1.00 =Rs. 104.46

G. CONCLUSION, FINDINGS AND RECOMMENDATION

The Mandibahauddin Hydro Electric Power Project is on existing canal in the Mandibahauddin district. The proposed project will produce 19 GWh energy annually. The project will use a temporary diversion canal on the right bank of LJC to divert the exiting water of the canal, while a power house is constructed in the existing canal bed. The diversion canal will be filled, leveled and replanted after the completion of the powerhouse and water will again flow in the original canal. A colony will be constructed for the operation and maintenance staff of the powerhouse.

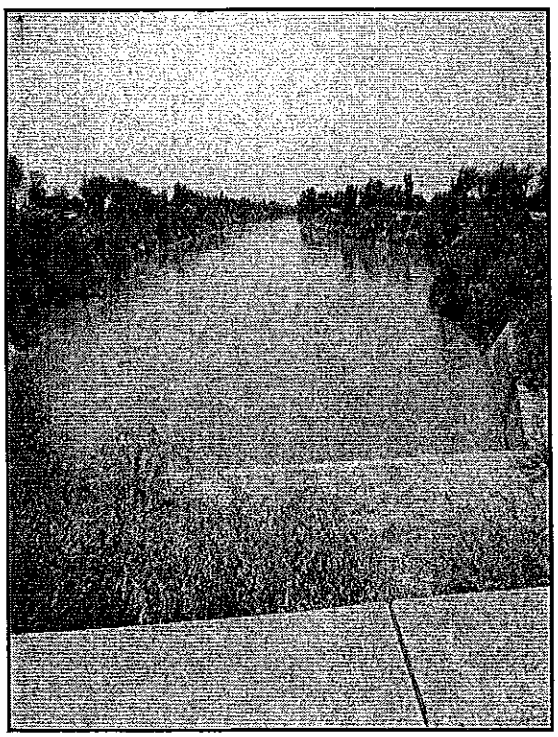
The IEE was conducted under Pakistan Environmental Protection Agency guidelines. There are no impacts to wildlife, fish and historical or archeological sites. Because of the existing falls and annual closure regime of the canal system, there is no significant fisheries and project will have no significant impacts on fish. The main impact is the removal of trees which will be compensated with tree planting program. All the project construction activities will take place on land associated with Government and will be leased, therefore no resettlement issues of the project.

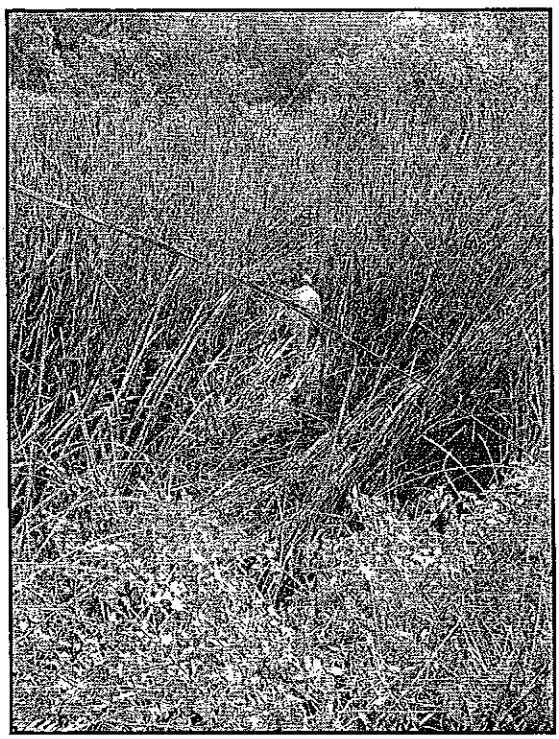
The project will have limited environmental impacts and those impacts identified will be adequately mitigate by implementing the EMP. Therefore, a full EIA is not required for Mandibahauddin Hydro Electric Power Project. It is important, however, that Mandibahauddin Power Company as the implementing agency develop its capacity to implement and monitor the measures in EMP. This has been designed into the project by requiring the appointment of an Environmental Officer in MPC and the appointment of an Environmental Specialist and the hiring of an independent monitor.

MANDI BAHA UD DIN ENERGY LIMITED.
FACILITATED BY
PUNJAB POWER DEVELOPMENT BOARD

MANDI BAHAUDDIN HYDRO ELECTRIC POWER PROJECT

FEASIBILITY STUDY REPORT





MAIN REPORT (VOL-I)

Technical, Engineering And Management (TEAM) Consultants, Pakistan
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CHAPTER - 1

EXECUTIVE SUMMARY

CHAPTER - 1

EXECUTIVE SUMMARY

1.0 General

Mandibahauddin Hydro Electric Power Project is located along RD 2+000 along Lower Jhelum Canal Feeder near Rasul Barrage about 10 km from Mandibahauddin Town in District Mandibahauddin of the Punjab Province. The project has the capacity of 3.3 MW and will generate 19.007 GWh of energy annually. Powerhouse and bottom outlets would be located at RD 2+000 in the existing canal. The head available at RD 8+626 and RD 0+000 would be combined for development of this Hydro Electric Power Project. Two Pit type Kaplan Turbines would be installed. Three bottom outlets with hydraulically operated vertical gates would be provided as bypassing structure in case of load rejection on turbine units. NTDC 132 KV Grid at Mandibahauddin about 10 km from project site be used for interconnection through 11 KV line.

1.1. Project Status

Mandibahauddin Power Company got the Letter of Interest (LOI) on April 18, 2016from Punjab Private Power Development Board (PPDB). The PPDB's authorization is in accordance with the Government of Punjab's "Punjab Power Generation Policy, Year 2006" (the Policy) revised during 2009 to encourage private-sector infrastructure investments. The proposed project has to be developed along Lower Jhelum Canal Feeder RD 8+626 where a fall having head of 3.66 m exists.

1.2. Project Consultants

Mandibahauddin Power Company, Lahore, hired the Services of M/S Technical, Engineering and Management – TEAM Consultants Pakistan, as Consultants to conduct feasibility studies for the Mandibahauddin Hydro Electric Power Project as per terms and conditions given the LOI.

1.3. Project Site Communication and Access

Mandibahauddin Hydro Electric Project site is located in District Mandibahauddin, Panjab Province. The project is accessible by air, good roads and railway network. The project area is located about 10 km from Mandibahauddin,61 km from Gujrat, 175 km from Lahoreand 157 km from Islamabad. The nearest Railway station is Mandibahauddin. Allama Iqbal International Airport Lahore and Benazir Bhutto International Airport Islamabad are the nearest airports. The site is accessible via Motorway M2 and GT road from Lahore, Islamabad and Karachi.

1.4. Lower Jhelum Canal and its Feeding System

Lower Jhelum Canal irrigates well known citrus producing area in Mandibahauddin, Pahlia and Sargodha District.It is a perennial canal. It was off-taking from Rasul Headwork left bank and its operation was started during 1867 when Rasul Headworks constructed along Jhelum River.

After construction of Rasul Barrage about 1 km downstream from Rasul Headworks and Rasul Hydropower Station, it is being fed from Lower Jhelum Canal Feeder off-taking from Rasul Barrage left bank and Rasul Power Channel off-taking from Upper Jhelum Canal. Lower Jhelum Canal Feeder is operating to augment the flows of Lower Jhelum in addition to flows from Rasul Power Channel. The flows in Lower Jhelum Canal Feeder from October 24, 2014 are almost acceptable, because the spillway at Rasul Hydropower Station is in operation from this date without any mal-functioning.

1.5. Meteorology, Hydrology and Sediment

The discharge data of LJC Feeder, LJC and Rasul Power Canal was collected and processed for flow duration curve and hydrograph. It is concluded that LJC Feeder flows from October 24, 2014 are actual because the spillway at Rasul Hydropower Station has started its operation with any mal-functioning. The design capacity of LJC Feeder is 187 m^3/s, however, canal run most of the time around 85 m^3/s.

The sediment entering into canal are smaller in size and hence not considered harmful to turbines and other parts. However, sediment data will be given to turbinemanufacturers at the time of bidding.

Downstream rating curve collected from field office was checked with the help of observed data and both curves were found in good agreement. A modified downstream rating curve was developed after canal bed lowering at RD 2+000 which was used to develop downstream water level required for head calculation. The upstream level will be kept at designed Normal Pond Level or above as per historic operation. The canal normally remained closed during December and January every year, however, abnormal closure were also noted, especially in the month of October and April.

The climate of the project area is semi-arid. Summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months.

1.6. Surveying and Mapping Investigation

During the feasibility study, topographic survey and hydrographic survey was conducted. Canal cross-section was observed at every RD starting from RD 0+000 to RD 10+000. This data was use in engineering design and planning and ultimately is quantities analysis.

1.7. Project Preliminary Locations and Alternatives Layout Study

Two falls exist along Lower Jhelum Canal Feeder at RD 0+000 and RD 8+626. Development of independent hydro project at each fall was not considered due to less head than commercial viable under present tariff regime. Development of project near RD 0+000 or RD 8+626 was studied after combination of heads available at bot falls. It was found that development of hydro project near RD 0+000 has more merits than at RD 8+626, therefore selected for layout alternative studies. Any hydropower project requires flow bypassing structure in case

generating units are shut-down due to load rejection or any fault on generating unit or in transmission line. Standard gated spillway and bottom outlet was considered for this project. Bottom outlet as bypassing structure was selected on the basis of less construction cost and land requirement.

The following layout alternatives were studied in detail and alternative giving less cost was taken for further engineering studies on the basis of field investigation.

- **Layout Alternative: 1 Powerhouse with Bottom Outlets in the Existing Canal.**
- **Layout Alternative: 2 Powerhouse with Bottom Outlets in bypass Canal**

Quantities and cost estimation were mad after preparing detail engineering design for each alternative. Alternative-1 is less costly than alternative -2 and also loss of land in case of alternative-1 is nills. Therefore, Alternative-1 is selected for elaboration in Chapter 11.

1.8. Initial Environmental Examination

The IEE was conducted under Pakistan Environmental Protection Agency guidelines. There are no impacts to wildlife, fish and historical or archeological sites. Because of the existing falls and annual closure regime of the canal system, there are no significant fisheries and project will have no significant impacts on fish. The main impact is the removal of trees which will be compensated with tree planting program. All the project construction activities will take place on land associated with Government and will be leased, therefore no resettlement issues of the project.

The project will have limited environmental impacts and those impacts identified will be adequately mitigate by implementing the EMP. Therefore, a full EIA is not required for Mandibahauddin Hydro Electric Power Project. It is important, however, that Mandibahauddin Power Company (MPC) as the implementing agency develop its capacity to implement and monitor the measures in EMP. This has been designed into the project by requiring the appointment of an Environmental Officer in MPC and the appointment of an Environmental Specialist and the hiring of an independent monitor.

1.9. Geology and Geo-technical Investigation

The Project area is located in the so-called Chaj Doab formation of the Sub-continent. Geographically, the formation is bounded by Chenab River in the southeast and the Jhelum River on the southwest.Two borehole were drilled to 40 m depth each. Permeability and SPT tests were performed to ascertain the properties of foundation soil. The sub – surface lithology is mainly comprised of fine to medium grained sands, with silt and clay mixed with mudstone along with kankars in some places. Gravel of small size in cemented sand is occasionally found at various depths. It is concluded from the previous and present subsoil investigations that the subsoil beneath the powerhouse foundation is silty sand and medium dens and good for raft foundation. Sands form the principal water yielding aquifer.The average permeability is 3.0×10^{-3} cm/s.

1.10. Seismic Hazard Study

The seismic hazard evaluation for the project was conducted through the study of regional geological, tectonic information collected from the available literature & maps and collection of historical & instrumental earthquake records. It was concluded that the project lies is minor hazard zone. However, during detailed design analysis a detail analysis would be made and parameter so established be used in structural and foundation design. The equipment design would also take care of seismic parameters. The peak ground acceleration of 0.20g is recommended for dynamic analysis.

1.11. The Project Layout

Mandibahauddin Hydro Electric Power Project comprises of headrace having length of 599 m. The bed width is 36 m with 2:1 side slopes. Bed and side slopes are protected with stones over geo-textile. Intake bay provides transition between headrace and powerhouse and consists of concrete slab having slope toward powerhouse intake and bounded by concrete vertical retaining walls. Machine hall house the two pit type turbines and three bottom outlets. Two bottom outlets are placed along right and one along left side of turbine blocks. Bottom outlet gates are vertical hydraulic operated. Space on top of bottom outlets would be used as loading and unloading bay. Outlet bay link the powerhouse with tailrace and consists of concrete slab sloping upward from powerhouse draft tube to bed of tailrace. About 200 m length of the tailrace would be protected with stone over geo-textile. Powerhouse is equipped with two pit type turbines and generators, unit transformer, auxiliaries' equipment and system for E&M Equipment required for robust operation of powerhouse.

The hydropower generating capacity and the dimensions of the major components of the facility have been selected based on detailed planning analysis, economic decision criteria, internationally accepted practice, and safety considerations. O&M staff colony having all civic facility would be provided along

1.12. Power and Energy Studies

Estimation of power and energy were performed using daily flow for year 2015. Head data for four option were investigated. Constant efficiencies for turbine (90%), generator (95%),gearing (98%) and transformer (99%) were used in power and energy estimation. The estimated average annual energy delivery to the power purchaser, at the project switchyard, is 19.007GWh, 19.09 GWh, 20.80 GWh and 23.03 GWh per year for using different heads and discharge. However, 19.007 GWh on the basis of historic flow and head was recommended for economic and financial analysis.

1.13. Project Cost and Schedule

It is anticipated that the project will be constructed under the terms of turnkey contract, with the expectation that construction of the civil works, equipment supply and installation would be carried out in a period of about 36 months. Project construction will start from April 30, 2018 and project would be completed by May 2021. The period from approval of feasibility study report to April 30, 2018 will be

utilized for finalization of LOS, security documents, tariff approval, detailed design, tender document, selection of EPC Contractor and financial close.

1.14. Economic Analysis

An economic evaluation of the proposed project clearly indicates that it can provide electricity at a long-term cost that is competitive with other electrical generation alternatives that could be implemented to serve electrical demand in the area. In the analysis, the total life-cycle economic costs of the hydroelectric project are compared to the total life-cycle economic costs of generating an equivalent amount of electricity from combined-cycle gas turbine stations. Benefit cost ratios greater than one were obtained for all conditions and alternatives investigated.

1.15. Financial Analysis

The financial analysis was designed primarily to establish a revenue stream meeting minimum criteria for financial feasibility, and to identify a tariff for generating the needed revenue. The main controlling criterion is the minimum acceptable rate of return on equity investment. A pretax rate of 18 percent was used in the analysis.

The required tariff is based on a number of factors that are uncertain at this time. The Feasibility Report describes a potential scenario and the associated tariff required. Based on a 36 months construction period, debt financing at an aggregate rate of 9.56 percent, with a 80/20 debt equity ratio, 2.5 percent for foreign and 6.5 percent for local annual escalation during the development period, and other certain assumptions, the required average 25-year energy-based tariff is 12.395 US cent (US$) per kilowatt hour (kWh). The calculated levelized 25-year energy-based tariff calculated using a 10 percent discount rate is 11.748 US cents per kWh.

The tariffs will trend downward as the project ages, not upward as is the case with a thermal facility. Investment in the hydro option is an investment in the long-term efficient utilization of Pakistan's resources.

1.16. Power Grid Interconnection

As per Policy, the construction of transmission lines is the responsibility of the power purchaser, or NTDC. Mandibahauddin Hydro Electric Power Project would be interconnected with 132 KV NTDC Grid at Mandibahauddin about 10 km from project site. One 11 kV double circuit transmission lines have been proposed. Steel reinforced (ACSR) Osprey conductor with steel lactic towers are foreseen which are according to the national standard. Synchronizing with NTDC grid system is done in the powerhouse control room. The powerhouse switchyard is the point of energy delivery to the NTDC. Power meters are located at the switchyard for measurement of energy delivered to NTDC.

The proposed 11kV transmission line is equipped with directional distance protection system with relays in the 132 kV Mandibahauddin Substation and in the powerhouse. A back-up protection at both stations with directional over current

relays is included. Additional lightning arrestors are installed at the outgoing section of Power Plant.

1.17. Conclusions and Recommendations

Mandibahauddin Hydro Electric Project is found to be technically sound, environmentally manageable, economically viable, and financially workable. The next steps of the project development should include:

- Establishing third-party services agreements for professional engineering, financial, and legal advisory services necessary to support on-going development efforts.
- Negotiating a preliminary power purchase agreement with Power Purchaser or NTDC, with transparency provisions to permit an adjusted tariff based on an agreed upon rate of return and procedure, once the project financing and procurement contracts are in place. This approach is required to avoid the fixing a tariff that cannot support financial feasibility, and is beneficial to both NTDC and Client.
- Tariff approval from NEPRA and PPDB
- Coordination with the Irrigation Department for acquisition of land required for the project on lease or equity contribution basis.
- Approaching Government of Punjab for managing and securing all necessary government clearances required for the project,
- Soliciting and securing preliminary financing commitments for the debt portion of the financing plan,
- Conduct any additional studies and investigations as may be necessary to minimize design and construction risks, and prepare tender documents for construction services and equipment procurement. Soliciting prequalification for the EPC Contractor,
- Establishing an aggressive, but reasonable, project completion schedule to minimize interest costs accumulating during construction.
- Finalizing contractor selection, concession documents, financial closure and tariff determination and proceeding with the construction, testing and commissioning of the facility as expeditiously as possible.
- The preliminary designs completed as part of this Feasibility Report are, in many respects, at a stage beyond what is customarily considered feasibility-level. Procurement can proceed based in part on the criteria, preliminary descriptions, and the drawings presented in this Feasibility Report. However, detailed performance specifications and testing guidelines need to be prepared.
- The project is consistent with current national Policy, which promotes development of economically feasible indigenous energy resources, and encourages private sector investment. The results of the financial analysis indicate that the tariffs required to support financial feasibility are in line with

the real costs of other generating technologies that are available to Power Purchaser/NTDC.

SALIENT FEATURES

Mandibahauddin Hydro Electric Power Project

Location of the Project	**Plant Factor**
Located 10 km from Mandibahauddin, and 157 km north of Lahore.	64%
Head Race Canal	**TailraceCanal**
Bed Width = 36 m Side Slopes = 2 : 1	Bed Width = 36 m Side Slopes = 2 : 1
Powerhouse – Machine Hall	**Economic & Financial Analysis**
Length = 36 m Width = 8.97 m	EIRR = 20.39 % FIRR = 17.92 % BC Ratio = 1.51:1
Hydro Mechanical Equipment	**Project Cost**
No. of Units = 2 Installed Capacity = 3.3 MW Energy Potential = 19GWh Type of Turbine = Horizontal Pit Type Runner Dia= 2.1 m Unit Speed = 317.4 rpm UnitDisch. = 30 m^3/Sec Rated Head = 6.75 m	Base Cost = 1747.167M Rs. Base Cost = 16.561 M US$ Cost/MW = 6.39 M US$ Project Cost = 2225.666M Rs. with IDC and taxes 1US$ = 105.5Rs
Bottom Outlet	**Tariff**
Design Discharge = 187 m^3/sec No. of Gates = 3 Type of Gate = Hydraulic Vertical	Levelized tariff 11.748 US Cents kWh or 12.395Rs. per kWh

CHAPTER – 2

INTRODUCTION

CHAPTER - 2

INTRODUCTION

2.1. Introduction

This Feasibility Study Report contains the Consultants' report on the feasibility studies of the Mandibahauddin Hydro Electric Power Project. The Government of Punjab in order to encourage the private investment in the electricity generation sector has awarded development concessions for number of projects along canal fall and barrages.

This Feasibility Report addresses the Mandibahauddin Hydro Electric Power Project, which would develop hydroelectric potential of the fall at RD 8+626 of Lower Jhelum Canal (LJC) Feeder, located near the town of Rasul, District Mandibahauddin of Punjab Province. The upstream limit of the project is constrained by the headregulator of Lower Jhelum Canal Feeder or Rasul Barrage while the downstream is the confluence of Rasul Power Canal (Tailrace) with Lower Jhelum Canal Feeder from where Lower Jhelum Canal (LJC) starts.

The project is being pursued by a Consortium of M/s China Sinogy Electric Investment Co. Ltd (CSEIC) Main Sponsor along with M/S China Sinogy Electric Engineering Co. Ltd. (CSEEC), M/s Habib Rafiq (Pvt.) Limited (HRL) and NETCO Rental Services (NETCO) under the terms of an LOI issued on April 18, 2016 by Punjab Power Development Board (PPDB). The PPDB authorization is in accordance with the Punjab Power Generation Policy 2006 (Revised 2009) to encourage private sector investment in developing infrastructure projects. The LOI provides the above mentioned Consortium with a first right to the development of the site, assuming it diligently proceeds with feasibility investigation required for the completion of this Feasibility Report.

During the course of the Feasibility Study and prior to the completion of this feasibility Report, a number of interim reports were to be produced. These reports were prepared and delivered to keep reviewing agencies, particularly PPDB and its Panel of Experts (POE), appraised of the progress of the work. The reports delivered during the course of the feasibility study included: Appendix A - Topographic Survey, Geotechnical Investigation, Updated Hydrology Studies and Power Potential Studies, Appendix B - Selection of Final Layout, Sizing of HPP, Optimization of selected layout and finalization of feasibility level design, and Appendix C - Construction Planning, Project Costing, Financial and Economic Analysis. These submitted reports were presented to POE and comments were received which were incorporated in the Draft Feasibility Study Report.

The Draft Feasibility Study Report were presented to POE on December 2, 2016. The report were discussed in length and was approved for submission as Final Feasibility Study Report subject to deletion of Chapters for economic and financial analysis and submission of approval interconnection study and environment examination studies which were already submitted to respect department for their approvals.

As these reports were interim in nature, the content of this Feasibility Study Report superseded all prior reports as prepared as part of this feasibility studies and investigation. Relevant information from prior report is incorporated into this study report.

2.2. Objectives of the Study

Out of 11 raw sites advertised for Expression of Interest submission date June 17, 2015, the above mentioned Consortium selected this site for its development and submitted the pre-qualification document to PPDB along with pre-feasibility study as pre-requisite for issuance of Letter of Interest (LOI) for conducting feasibility study and ultimately development through its financing. PPDB issued LOI on April 18, 2016 after evaluations of pre-qualification proposals and approval from the PPDB Board.

As per Terms of Reference attached to the LOI, the sponsors are required to carry out activities for preparation of Feasibility Study Report of Mandibahauddin Hydro Electric Power Project located along Lower Jhelum Canal Feeder. The activities involve studies and investigation to demonstrate that the site is technical sound and feasible, environmental friendly, economical viable and financial workable project.

Further, studies should meet acceptability criteria of the International and National Financing Institutions for funding of the Project. These studies shall be carried out to select a suitable project layout and to optimize hydropower potential along Lower Jhelum Canal Feeder and other related studies required to prepare a full scale feasibility of the selected project layout. Location map of the Project area is shown in **Drawing 2.1 and 2.2**.

2.3. The Consultants

The Consultants for this assignment is M/S Technical, Engineering and Management (TEAM) - TEAM Consultants, Pakistan. The expertise and technical resources of the TEAM had played a key role in completing the assignment.

The Consultants team was managed by a highly experienced Project Manager, who possesses over 20 years of rich experience in the management of water resources projects which includes techno-management of several major projects within Pakistan. He would be the overall in-charge of the assignment. He was assisted with specialties dealing with different fields such as: hydrology, sedimentation, hydraulics, geology, planning, E&M equipment selection, economics and documentation. These Specialists were of the level of Chief Engineers and acting as head of their team comprising of Principal and Senior Engineers & other personnel's. The Project Manager and the Specialists have formed a strong Project Management Group on behalf of the Consultants' project team.

The Management of the Consultant is conferred upon a Board of Management (BOM), which consists of five associate's members each from, hydropower, geo-technical, E&M, environmental and economic and financial field. The BOM has the overall role of monitoring activities of the Project Team.

The Main Sponsor invited a number consulting firms for provision of Consultancy Services for preparation of feasibility study as per issued LOI by PPDB. After lengthy deliberations, a Contract Agreement between M/s Consortium and M/S Technical, Engineering and Management - TEAM Consultants, Pakistan for Consultancy Services for the assignment "Mandibahauddin Hydro Electric Power Project - Feasibility Study Report was signed on May 2, 2016 and services were commencement from the same date. M/S Technical, Engineering and Management Consultants, Pakistan for brevity is called, the Consultants throughout this Report.

Upon signing of the Contract Agreement with the Client, the Consultants immediately undertook the assignment and rendered services in accordance with the TOR given in the Contract Agreement.

The Sponsor are in process of establishing Mandibahauddin Electric Power Company as SPV with Security Exchange Commission of Pakistan (SECP) for its development and operation in near future.

2.4. Electric Power Development in the Country

WAPDA and KESC being public sector utilities were responsible for electric power development and distribution in the country. WAPDA was responsible for whole of the country while KESC was for city of Karachi. However the gap between demand and supply remain increasing due to budgetary constraints and unsatisfactory performance of both public sector entities. Therefore reforms of the electric power sector through restructuring and deregulation and involvement of private sector was initiated. KESC has been privatized while WAPDA had been de-bundled into 10 distribution companies (DISCOs), 3 thermal generation companies (GENCOs), National Transmission & Dispatch Company (NTDC) and Central Power Purchase Agency (CPPA).

A number of policies had been made during the past by the Government of Pakistan (GOP) such as:

- Mega Hydel Policy 2016, emphasising development of Hydel Potential on PPP mode.
- Energy Policy 2013, emphasising development of Hydel and natural resources
- 2005: A long-term integrated "Energy Security Plan (ESP)", covering the period up to 2030; approved by GOP in March 2005.
- 2002: "Policy for Power Generation Projects Year 2002"; approved by the GOP in October 2002.
- 2002: Hydro Power Development Plan (Vision 2025) by WAPDA
- 1998: "Policy of New Private Independent Power Producers"
- 1997: NEPRA Act: Establishing of National Electric Power Regulatory Authority
- 1995: "Policy Framework and Package of Incentives for Private Sector Hydro Power Generation Projects in Pakistan"
- 1994: "Policy Framework and Package of Incentive for Private Sector Power Generation Projects in Pakistan" – Thermal.

All policies refer to emphasis the domestic resources; coal and hydel. However, emphasis is placed for cheaper and environment friendly hydropower resources as

compared to the costly and environmentally critical thermal plants. Involvement of private sector is also on top of GOP agenda.

Government of Pakistan (GOP) has set up the Private Power Infrastructure Board (PPIB) for the implementation of electric power generation projects in the private sector and the National Electrical Power Regulatory Authority (NEPRA) to regulate tariffs and to safeguard the interests of all stakeholders' on win-win basis. Provinces are also allowed to make their own policies for energy and power development.

2.5. Electric Power Development in Punjab

The provincial governments have also been authorized under the Constitution of Pakistan and Federal Policy for Power Generation 2002 to undertake activities in the sector of electric power generation. As such, the Government of the Punjab set up the Punjab Power Development Board (PPDB) under Irrigation and Power Department in 1995 for development of power projects through private and public sector participation. Government of Punjab also announced Policy "Punjab Power Generation Policy Year 2006" to involve Private Sector in the development of hydroelectric and other source of electric power. The Policy was updated in 2009.

Now Government of Punjab established Energy department headed by Independent Secretary. Presently about 4 projects are under construction in hydel sector and 1000 MW Quid-e-Azam Solar Park by Government of Punjab. About seventeen (17) hydel projects with total installed capacity of 350 MW are being under taken by private sector on BOOT basis.

2.6. Organization of the Feasibility Report

This Report is divided into several chapters covering the topics studied and investigated during the preparation of the Feasibility Study Report. These chapters contain text, tables, figures, drawings and annexures. The final feasibility study report is bounded in two volume. Volume 1 mainly contains 16 Chapters along with tables and figures. Volume 2 consists of drawings and annexures.

This Feasibility Report (Volume-1) spread over sixteen chapters as listed below:

Chapter 1. Executive Summary - Summarizes the studies carried out from May 19, 2016 through the conclusion of the final feasibility studies and investigations in December 20, 2016.

Chapter 2. Introduction - This introduction.

Chapter 3. Project Site Communications and Access: This Section present project communication means, ways and routs. Project Communication contains details about different rout of roads and railways and other ways of communication to reach and access at proposed project site.

Chapter4. Lower Jhelum Canal and its Feeding System: For proper understanding of the discharge feeding system, Lower Jhelum Canal Feeder, Rasul Power Canal, Upper Jhelum Canal, Jhelum River and Lower Jhelum Canal and data relating to all is presented in this Chapter.

Chapter5. Meteorology, Hydrology and Sediment: This Chapter contains the results of the hydrological studies, including climatic data analysis, canal flows and sediment transport analysis. Analysis of upstream and downstream water level is also carried out for establishment of alternative head available by using fixed pond level or proposed pond level or as per historic pond level. Analysis of climatic data is also part of this Chapter. The results and conclusions of these studies form the basis for the layout and operational characteristics of the proposed project.

Chapter 6. Project Preliminary Locations and Alternatives Layout Study: In this chapter, the initial analysis carried out to evaluate possible Project location alternatives, alternatives layout, alternatives structures and hydro-turbine-generator-equipment, concluding with a recommendation for a specific development concept presented in this Feasibility Study Report.

Chapter 7. Surveying and Mapping: Summarizes the survey and mapping investigations in the field and present the computer generated contour maps. These maps was used for the preparation of drawings for the selected project layout studies.

Chapter 8. Environmental Impact Study: Summary of the findings from the Environmental Impact Assessment, including impact on the existing population centres, the acquisition of land required, and the estimated overall budgets for compensation is presented in this section. Initial Environment Examination contains the complete Environmental Impact Assessment to fulfil the requirement of the Government of Punjab Environmental Protection Agency.

Chapter 9. Geology, Geo-technical Investigation and Construction Material: In this Chapter, the geology of the surrounding area and geotechnical investigation leading to interpretations of geotechnical information collected during the field geological subsurface investigation program conduct during this feasibility study. This chapter also describes the source, availability and characteristic of the materials intended for use to construct the project.

Chapter10. Seismic Hazard Analysis: Contains the seismic hazard analysis based on instrumental data and geological features of the area. This chapter contains the values of g on operation base earthquake and maximum credible earthquake.

Chapter11. Project Selected Layout: Consists of the selected layout of the proposed project facilities considering the hydrological and geological characteristics of the proposed site. This contains the main civil structures and main electro-mechanical equipment. Means type of powerhouse, spillway, type of turbines, generators, main power transformers, spillway gates. The physical configuration of the project as described in this section became the basis for the project cost estimate and the environmental impact analysis and intended for use as a guide in the technical and procurement related activities required for the next phase of project development work.

Chapter 12. Hydro Power Potential and Energy Generation Estimation: Presents details regarding power and energy estimation based upon selected hydrological parameters, water levels and plant characteristics.

Chapter13. Selected Layout Quantities and Costs: Presents the estimated development cost of the project, including construction and the "soft costs" associated with private project development. The process of establishing unit rates for construction of the civil works is explained, and the method used for determining the cost of the electrical and mechanical works is also presented.

Chapter 14. Selected Layout Constructions Planning and Budgeting: Feasibility level implementation schedule for project development from the current phase of feasibility studies to project start-up and commissioning is presented in this chapter. The schedule shows the sequence, duration and interrelation among the main implementation and construction activities. This also includes six (6) monthly budgetary requirements on the basis of project construction schedule.

Chapter 15. Project Tariff – This Chapter presents a study for determination of tariff, its components based on benefits and cost. Cost will include O&M cost and interest during construction and till repayment of debt. Return of equity will be also part of tariff.

Volume: 2

The Volume 2 of the feasibility study report contains, Tables, Drawings, Annexures and Appendix of the respective Chapters. These are placed as per Volume-1 chapter sequence.

CHAPTER – 3

PROJECT SITE COMMUNICATIONS AND ACCESS

CHAPTER - 3

PROJECT SITE COMMUNICATIONS AND ACCESS

3.1. Introduction

This chapter of the report deals with the access routes considering road and railways starting from Karachi Port to the project area and site. The other communication links such as telephone, telegraph, internet, etc., available in the project area.

It is stated that project is located in District Mandibahauddin of Punjab Province which is well populated and rich in agriculture. Actually, district of Mandibahauddin and Sargodha are world famous in production of citrus fruits. **Figure: 3.1** and **Figure: 3.2** through light of City of Mandibahauddin, the district headquarter.

Figure: 3.1 Office of the Deputy Commissioner Mandibahauddin

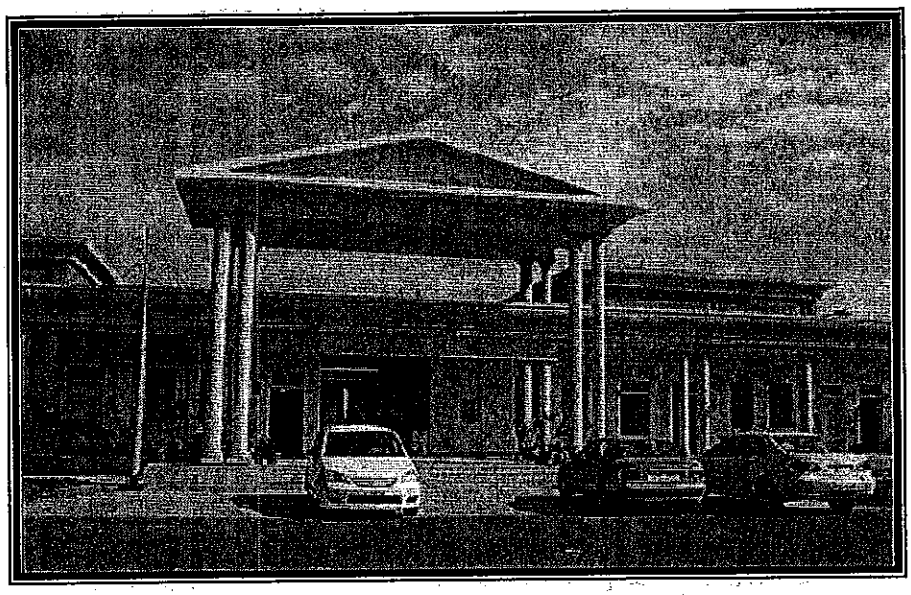
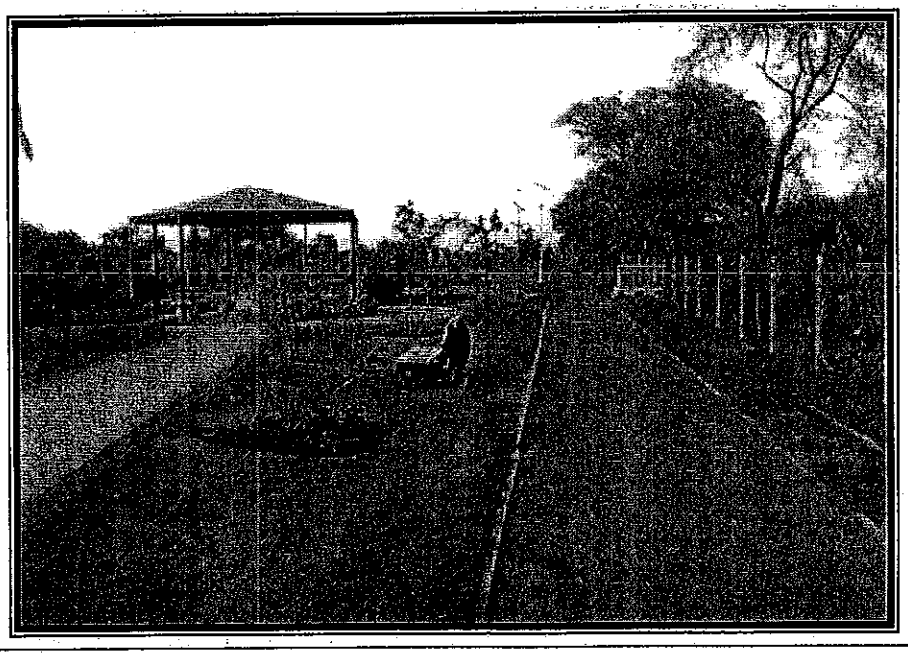


Figure: 3-2 Park in Mandibahauddin City



3.2. Project Location

The project lies in District Mandibahauddin which is some 220 meters above sea level and is located in central Punjab between the rivers Jhelum (north 12 km) and Chenab (south 39 km). The project is located along the Lower Jhelum Canal Feeder, which is off-taking from left bank of Rasul Barrage (**Figure: 3.3**). The Barrage is along Jhelum River and be the first river flow controlling structure, about 72 km downstream from Mangla Dam.

The site is located in central Punjab which is the heart of agriculture and citrus production. The project location map is place in **Drawing: 3.1.**

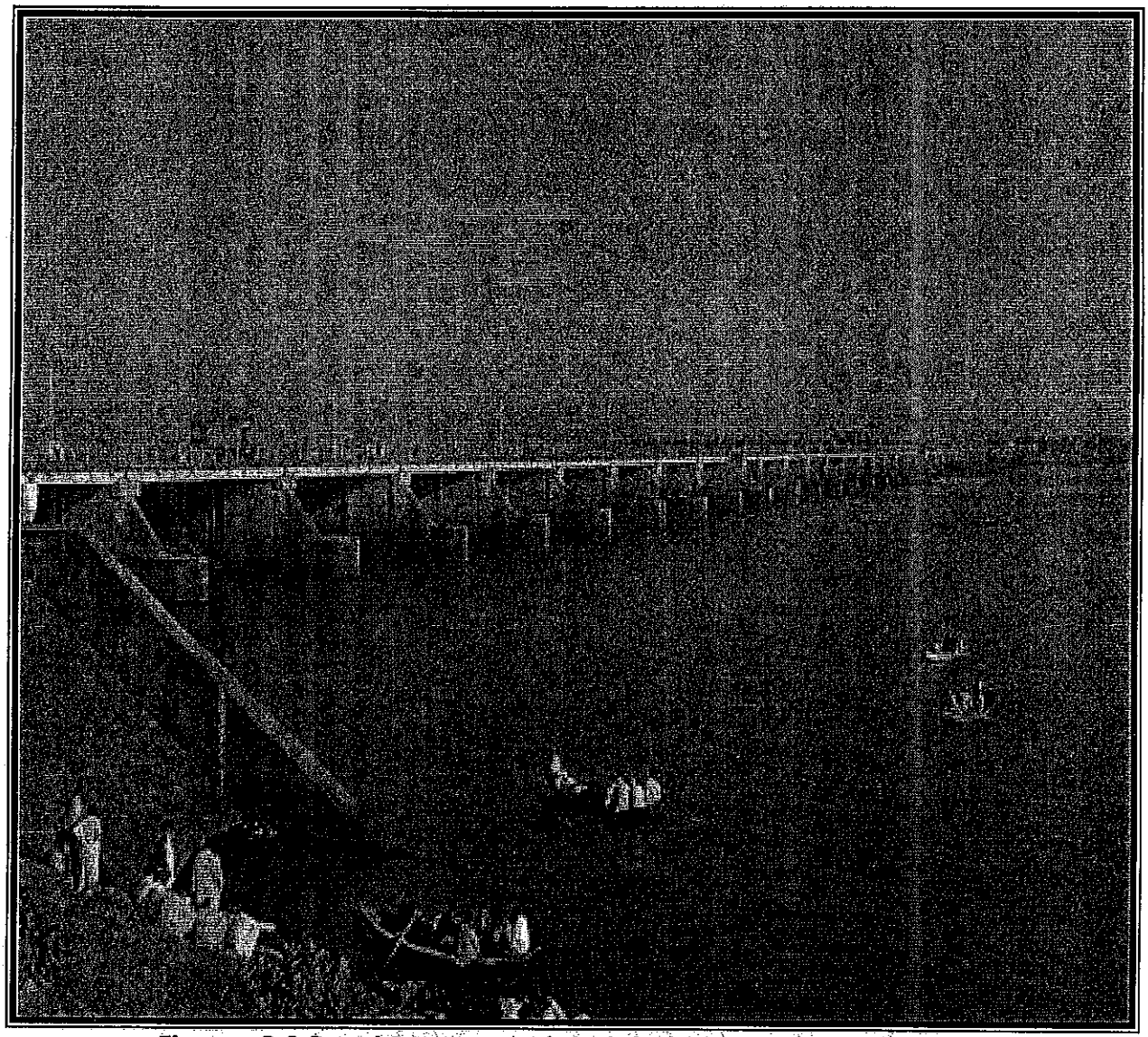


Figure: 3.3 Rasul Barrage – Pictorial View from Downstream

The project vicinity map is placed in **Drawing: 3.2** which shows that project area is located about 210 km from Lahore, 61 km from Gujrat, 10 km from Mandibahauddin and 157 km from Islamabad.

3.3. Project Access

The project site and area is accessible by air, good roads and railway network (**Drawing: 3.2**). The air, road and railway access routes which are best to approach the site are defined below;

3.3.1. Ports of Shipment

Pakistan is also linked with International community via sea and at present three shipping ports are operating.

Karachi port and Port Qasim are near the port city of Karachi and Port of Gwadar is in Province of Baluchistan. All of these ports are being operated by Port Trust and capable of handling all types of ships and cargo. Port of Qasim is presently the largest and is capable of handling all types of cargos and goods. It is a deep sea port and all kinds of ships can enter the port.

Gwadar is the second largest port and is in process of expansion. It is planned to be the biggest port in South Asia and is expected to serve China, Russia and Central Asian States in future.

All these ports are linked with other parts of the country through good network of railway and roads.

3.3.2. Railways Network

The nearest railway station is Mandibahauddin (**Figure: 3.4**) which lies on the Gujrat-Sargodha main line.

The other nearest railway stations where loading and unloading of heavy equipment is possible include Mandibahauddin, Gujrat (**Figure: 3.5**), Wazirabad (**Figure: 3.6**), Kharian (**Figure: 3.7**), Sialkot dry port, Sargodha and Lahore.

Figure: 3.4 Railway station Mandibahauddin

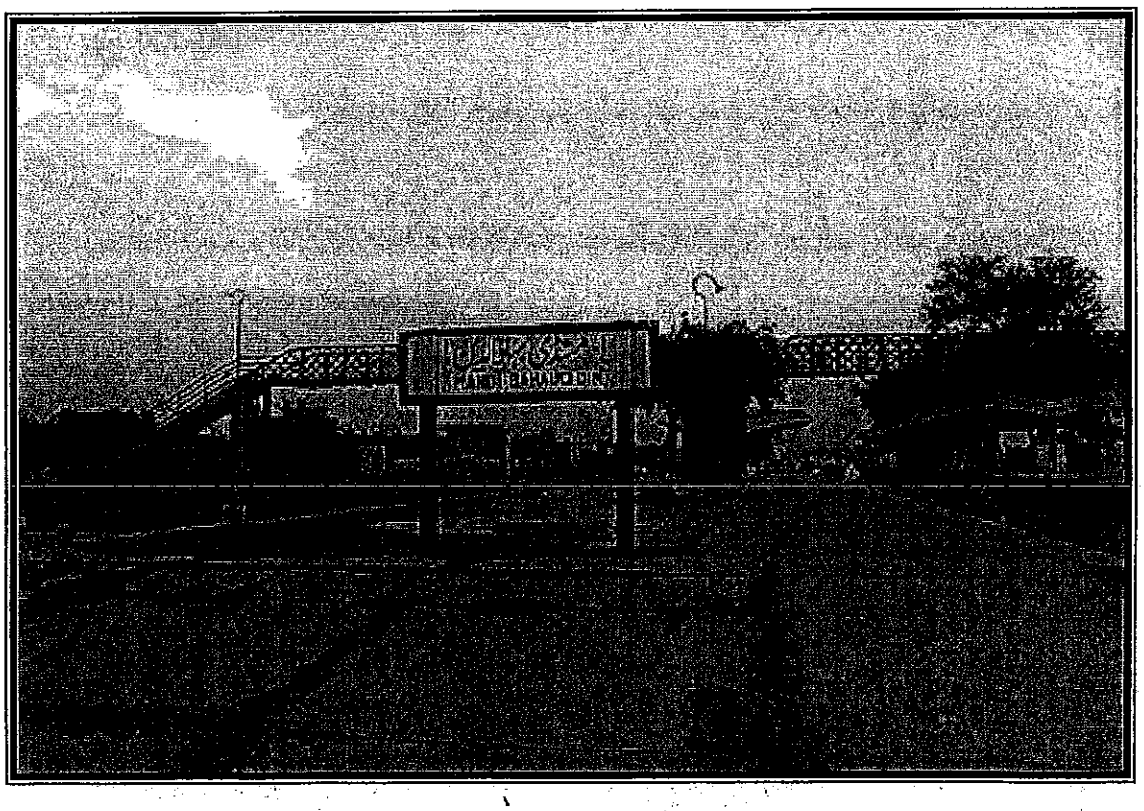
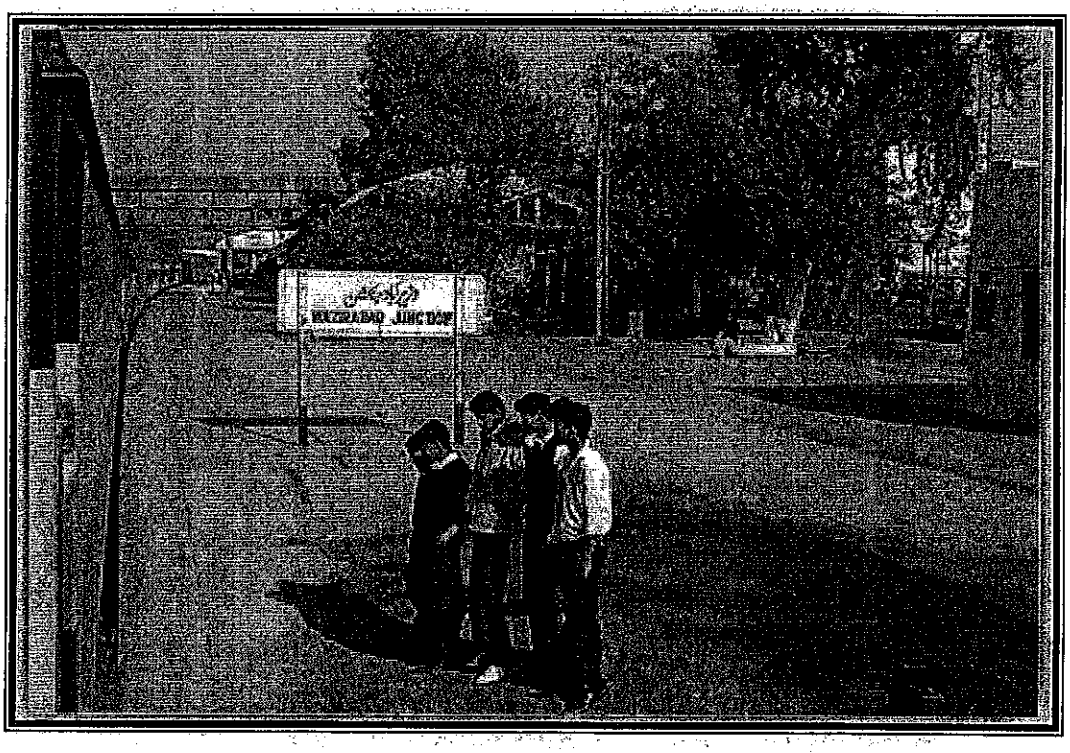


Figure: 3.5 Gujrat - Railway Station

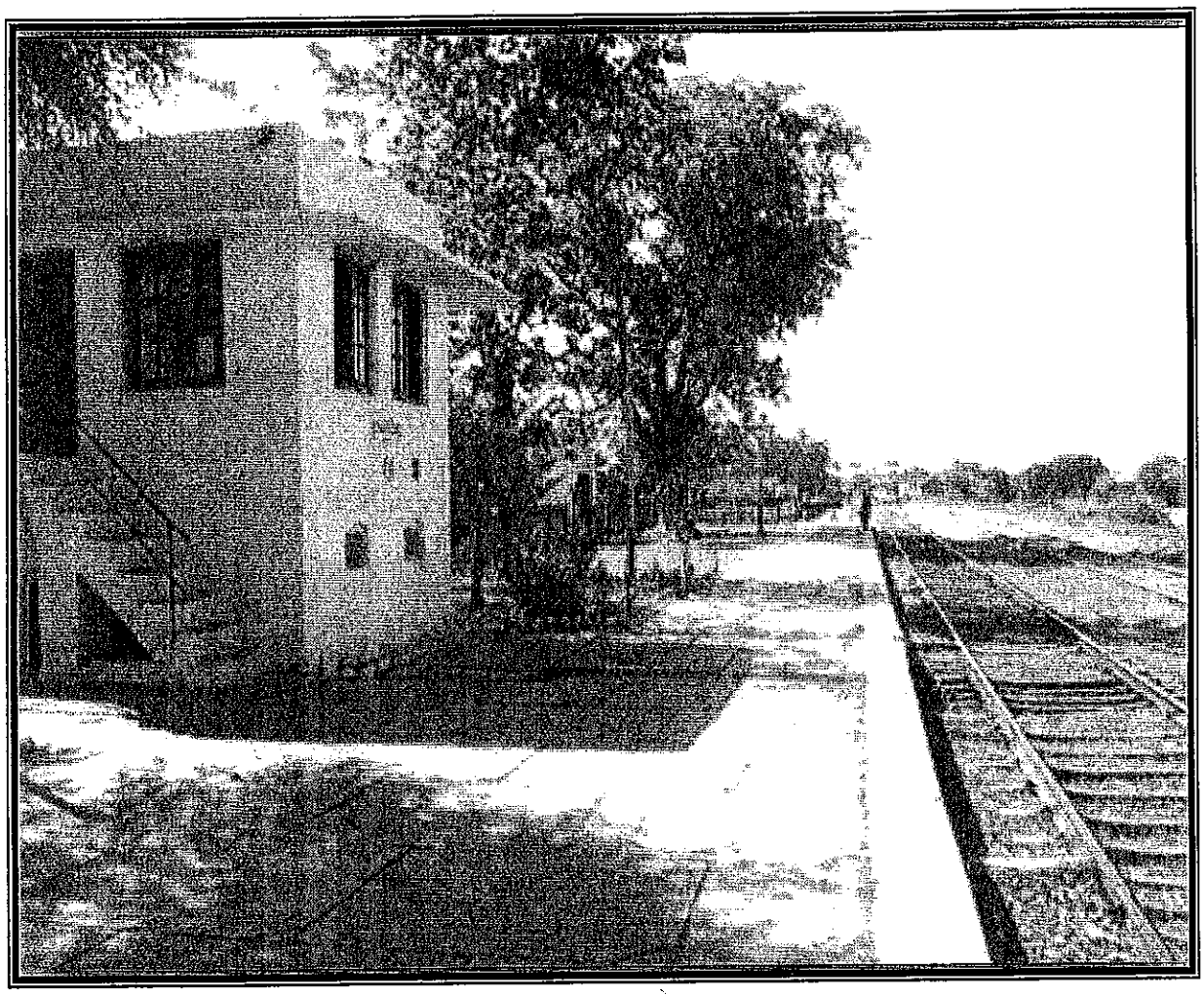
Figure: 3.6 Wazirabad - Railway Station



Loading and unloading facility is available at Mandibahauddin, Gujrat, Wazirabad and Sargodha Railway stations but cranes of suitable capacity are not available at these railway stations. Usually consignee is responsible for the

arrangements of crane if required from local market. However, Lahore railway station has a dry port as well as all kinds of loading and unloading facilities, which may be utilized.

Figure: 3.7 Kharian Railway Station - Loading & Unloading Bay



3.3.3. Airport and Air Links

A number of national and international airports are operating in Pakistan. Allama Iqbal International Airport Lahore, International Airport Faisalabad, International Airport at Sialkot and Benazir Bhutto Shaheed International Airport Islamabad are the nearest airports for the project area and site.

The road distances from these airports are:

i.	Lahore to Mandibahauddin via Gujrat GT Road	=	210 km
ii.	Lahore to Mandibahauddin via Motorway M2 Salam	=	250 km
iii.	Faisalabad to Mandibahauddin via Motorway M3, M2 Salam	=	198km
iv.	Islamabad to Mandibahauddin via GT Road Saraialamgir	=	157 km
v.	Islamabad to Mandibahauddin via GT Road Kharian	=	182 km
vi.	Islamabad to Mandibahauddin via Motorway M2 Bhera	=	235 km
vii.	Islamabad to Mandibahauddin via Motorway M2 Salam	=	261 km

viii. Sialkot to Mandibahauddin via Wazirabad-Gujrat-GT Road = 135 km

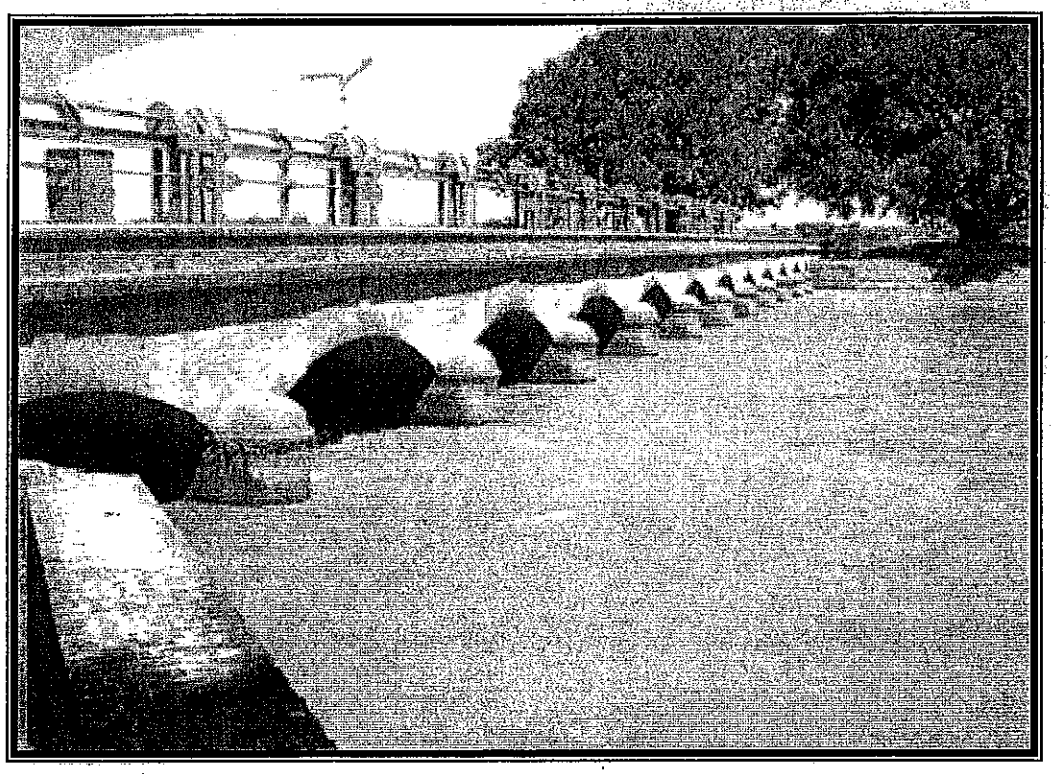
3.3.4. Roads Access Network

The following four (4) most suitable road routes are available to access the Project area and project site from port city of Karachi. Although, there are some other options available but are not considered suitable and hence not discussed.

3.3.4.1. Roads Route 1 (Lahore-Gujrat-Kharian-Mandibahauddin Via GT Road)

Lahore to Mandibahauddin is 210 km via Lahore-Gujrat-Kharian GT Road, a dual carriage road having two lanes each of good quality is being maintained and controlled by the National Highway Authority (NHA). The GT Road between Lahore and Gujranwala is dual carriage with four lanes each of good quality has recently been constructed by the NHA. From Kharian on main GT Road to Mandibahauddin (40 km), a single carriage two lane road exists, which goes through the famous town of Rasul. Rasul is the seat of the oldest Technology College imparting education in the field of civil engineering for more than a century.

Figure: 3,8 Bridge along Upper Jhelum Canal RD 255+086-Downstream View



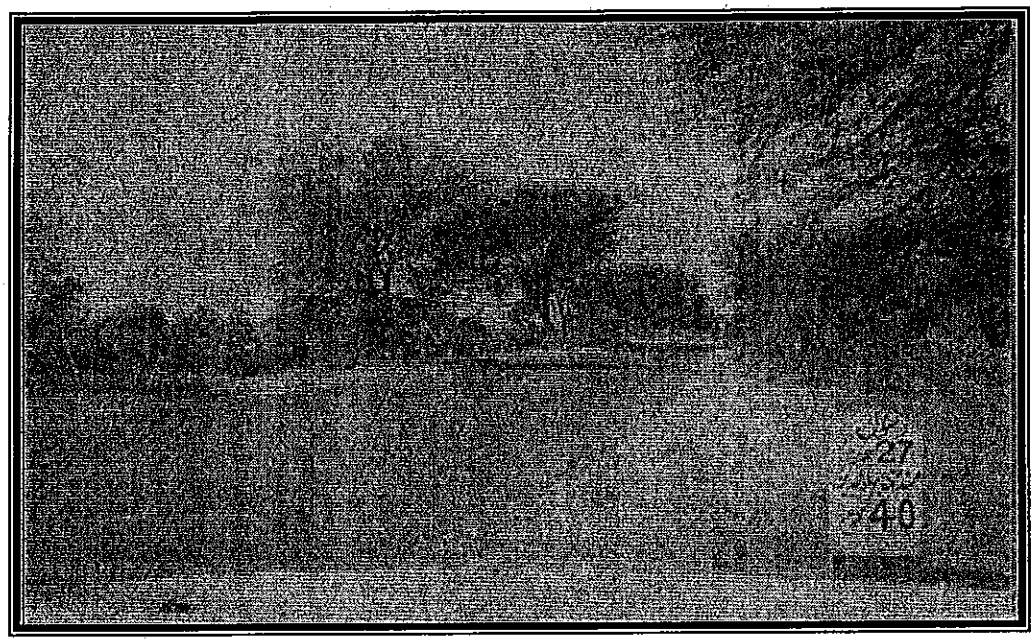
Kharian - Mandibahauddin road crosses Upper Jhelum Canal at Khokhara Bridge at RD 255+080 (**Figure: 3.8**). This is an old bridge constructed at the time of canal construction, which may not be suitable for heavy traffic.

The road from Rasul town to Rasul Barrage is along the left bank of Rasul-Qadirabad Link Canal which is a two lane single carriageway road of good quality. This road also connects Rasul town to Ghariabwal and other towns and villages in salt range located on the right bank of River Jhelum.

3.3.4.2. Roads Route 2 (Islamabad-Saraialamgir-Mandibahauddin Via Upper Jhelum Canal)

This route is from Islamabad to Saraialamgir (127km) via Lahore-Peshawar GT Road and then turning right on Saraialamgir to Mandibahauddin along the right bank of Upper Jhelum Canal (**Figure: 3.9**). Saraialamgir to Mandibahauddin is a good quality two lane road (about 50 km) being maintained by Punjab Highway Department.

Figure: 3.9 Road along Upper Jhelum Canal between Rasul and Saraialamgir



The road from Rasul-Rasul Barrage is along the left bank of Rasul-Qadirabad Link (**Figure: 3.10**), which is also a two lane good quality road. This road also connects Rasul town to Ghariabwal and other towns and villages in salt range as mentioned previously.

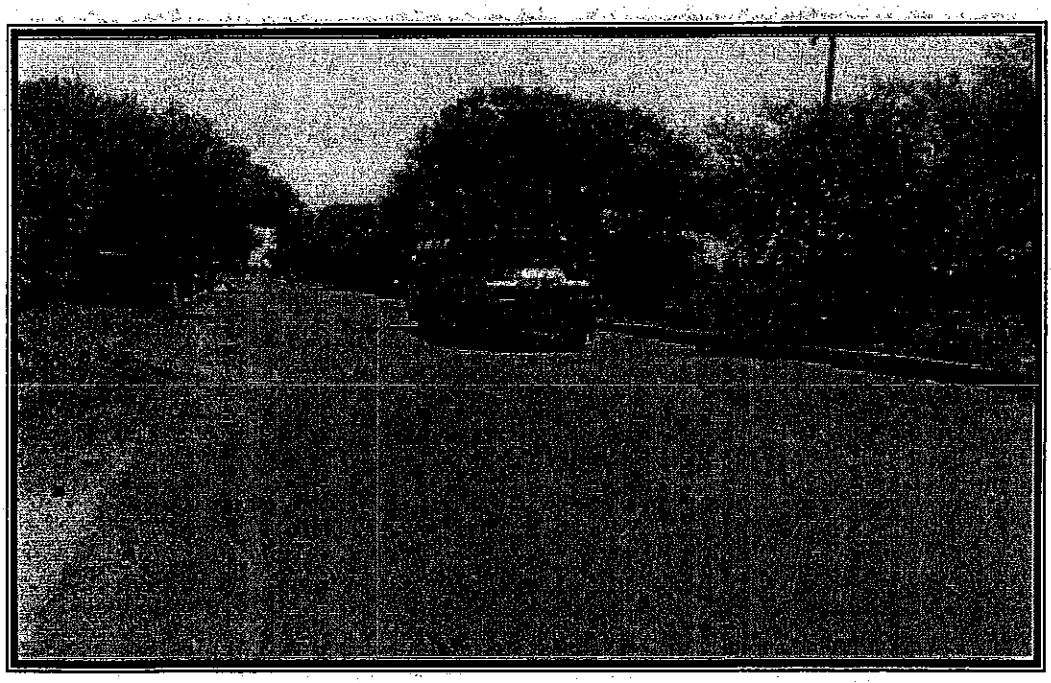


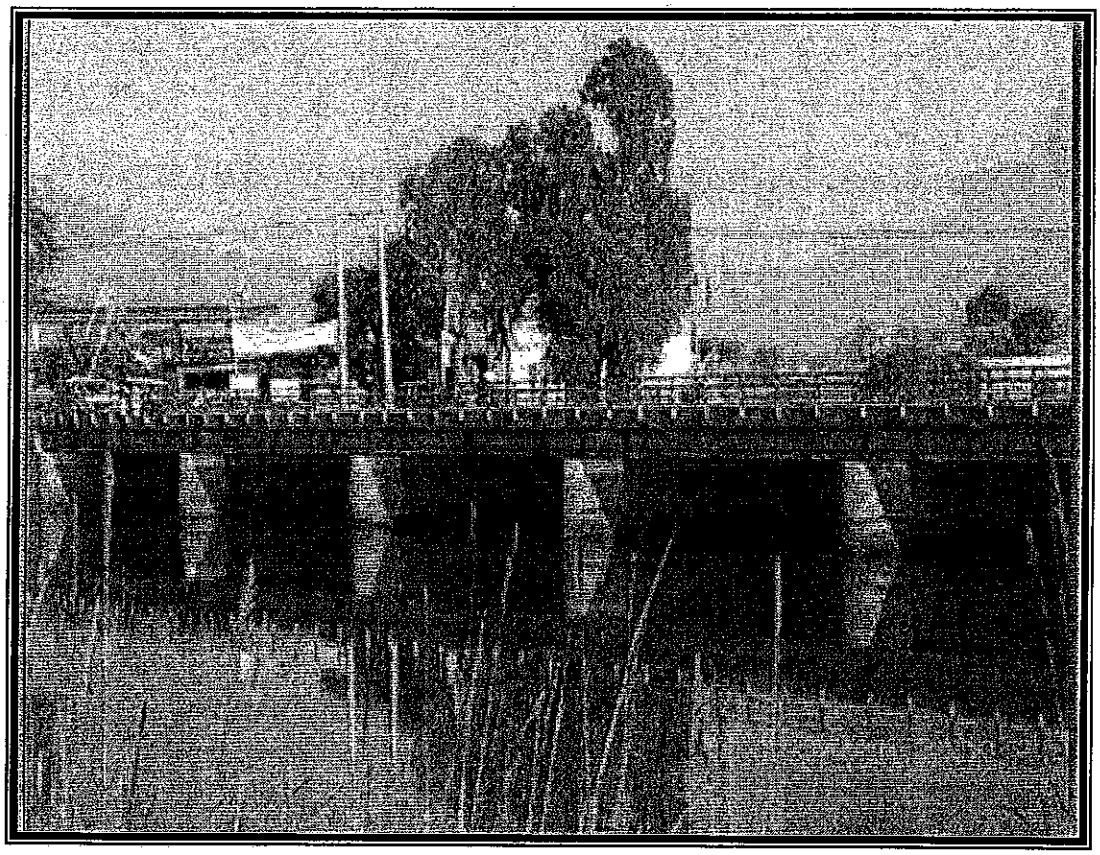
Figure: 3.10 Rasul-Rasul Barrage-Ghariabwal Road along Left Bank of R-Q Link

3.3.4.3. Roads Route 3 (Lahore-Salam-Mandibahauddin Via Motorway M2)

Lahore to Salam Interchange on Motorway M2 is a dual carriage motorway of international standards having three lanes on each side is being controlled, operated and maintained by the National Highway Authority and National Motorway and Highway Police. The distance between Lahore and Salam Interchange is about 180 km. From Salam Interchange to Mandibahauddin, a single carriage two lane good quality road exists with newly constructed bridges having required loading capacities. The distance between Salam Interchange and Mandibahauddin is about 71 km and Rasul Barrage is further 13 km away. Considering, the good quality of road and all types of loading and unloading facilities available at Lahore Railway Station, this route is preferred over the other available routes.

The Salam-Mandibahauddin-Rasul Road crosses Rasul-Qadirabad Link at its RD 10+000 (**Figure: 3.11**) where a bridge of heavy loading capacity in good condition exists. From this bridge the road leads to Rasul Barrage (3.1 km) along left bank of R-Q Link.

Figure: 3.11 Bridge at RD 10+000 OF Rasul-Qadirabad Link



3.3.4.4. Roads Route 4 (Multan-Faisalabad-Salam-Mandibahauddin Via M3 and M2)

Multan is located on the National Highway route connecting Lahore and Karachi and is also located on the main railway route between Karachi Port and Lahore. Multan is about 335 km short of Lahore. Multan is connected with Faisalabad through a two lane National Highway of good quality and further from Faisalabad to Salam Interchange through motorways of international standards (4 lane M3 and 6 lanes M2) is available for transportation.

From Salam Interchange to Mandibahauddin, a two lane good quality road with newly constructed bridges having required loading capacity is available as mentioned previously and the site can be accessed without any problem.

3.4. Entertainment /Television

A number of television channels are being operated in Pakistan other than Pakistan Television Network. These are available via cable or dish. International channels are also available in the Project area.

Cinemas are also available in Mandibahauddin for watching movies.

3.5. Telephone/Internet

Telephone, telegraph and fax facilities are available in the project area, especially in the town of Rasul and Mandibahauddin. Rasul Hydro Hydel Power Station which is about 3 km from proposed project site is connected to national grid of NTDC and also have the connection to all prominent towns via telephone. The city of Rasul and Mandibahauddin is connected with other main towns of the country through the nationwide dialling system. International direct dialling (IDD) exists, too. Internet access is available with limited speed through the telephone network. Fast speed connections do exist in the Mandibahauddin town.

Further a number of Mobile Phone Companies and wireless phone companies are also operating in the project area. Now a day's mobile connection and its operation is much easier and cheaper in Pakistan.

3.6. Petrol, Diesel and Lubricants

In the town of Rasul, Shell Pakistan and Pakistan State Oil are both operating fueling stations. These stations are along Kharian-Mandibahauddin-Salam road. Both companies' fueling stations are located near RD 10+000 of Rasul-Qadirabad Link Canal. Shell and PSO fueling stations are on the right bank and left bank of R-Q Link Canal, respectively. The distance between project and these stations is about 3.1 km and are approachable via Rasul-Rasul Barrage-Ghariabwal road which is running along left bank of R-Q Link Canal.

3.7. Drinking Water

Drinking water of good quality is available in the Project area. A huge pond is available at Rasul Barrage which is being operated as re-regulating reservoir when Mangla Power station is operated as peaking plant.

Ground water is also available at shallow depths and is of good quality due to existence of open water bodies in form of canals and Jhelum River. However, its quality would be tested during geo-technical drilling and environmental investigations. Result are presented in **Chapter: 9**.

3.8. Rest Houses

Two rest houses are being operated by the Punjab Irrigation Department. About 4 bed rooms are available. For booking Executive Engineer Rasul Barrage may be approached. Few small hotels are available in Rasul and Mandibahauddin but living conditions are not hygienic.

CHAPTER – 4

LOWER JHELUM CANAL AND ITS FEEDING SYSTEM

CHAPTER - 4

LOWER JHELUM CANAL AND ITS FEEDING SYSTEM

4.1. Introduction

The water availability analysis of Lower Jhelum Canal Feeder and Lower Jhelum Canal requires complete picture of the water conveying system of both canals. Therefore, it is necessary to elaborate the existing canal and river system in details so that a common reader who did not have any information about Lower Jhelum Canal Feeder and its feeding system, prior to this report can understand in its entirety. Lower Jhelum Canal is getting water from Jhelum River which is being diverted at Mangla Dam in Upper Jhelum Canal through Rasul Power Canal and at Rasul Barrage in Lower Jhelum Canal Feeder. This section therefore deals with Lower Jhelum Canal Feeder, Rasul Barrage, Lower Jhelum Canal, Upper Jhelum Canal, Rasul Power Canal and Jhelum River.

4.2. Lower Jhelum Canal

The lower Jhelum Canal (LJC) is the oldest irrigation system in Punjab and was opened in 1901 with original design discharge capacity of 102.03 m^3/s. It was off-taking from Old Rasul Headwork which was also put in operation during 1867 in British era.

Figure: 4.1 Lower Jhelum Canal Feeding System

The Lower Jhelum Canal (LJC) was irrigating areas of Chajj Doab in Districts of Sargodha, Mandibahauddin and Jhang in Punjab Province of British India. The gross command area of LJC is 0.657 million hectares, cultivable command area is 0.610 million hectares and cropping intensity is 121%. The New Rasul Barrage was few hundred meters downstream of Old Rasul Headwork and New Rasul Barrage was constructed during 1968 as part of Indus Basin Replacement Works under Indus Water Treaty.

After construction of Rasul Power Station 1951 on Upper Jhelum Canal, the Lower Jhelum Canal is getting water from Rasul Power Canal (**Figure: 4.1**) in addition to Lower Jhelum Canal Feeder which is off-taking from new Rasul Barrage. In case Rasul Power Station is closed, the full demand of Lower Jhelum Canal is fed from Lower Jhelum Canal Feeder. Lower Jhelum Canal Feeder and Rasul Power Canal meet at RD 10+000 of Qadirabad-Balloki Link Canal from where Lower Jhelum Canal starts.

The capacity of Lower Jhelum Canal was increased during 2002 to 156 m^3/s due to meet the increased irrigation water demand. Irrigation Department of Punjab has further proposed to increase discharge carrying capacity to 187.0 m^3/s for which remodelling of the canal is being done. The length of the canal is 60 km.

The salient features of Lower Jhelum Canal is given in **Table 4.1**.

Table: 4.1 Lower Jhelum Canal - Salient Features

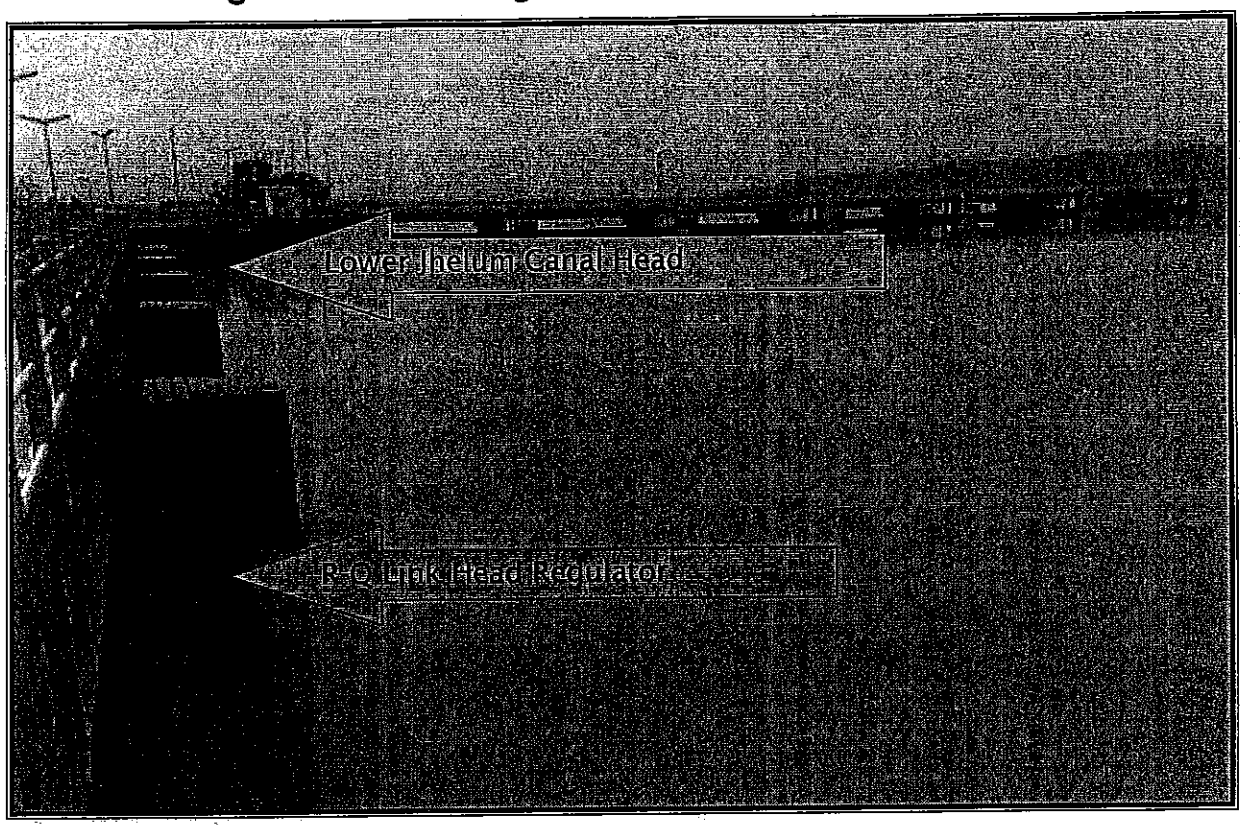
Description	Unit	Designed
Bed level at Siphon outlet	masl	211.27
Full Supply Level	masl	214.27
Bed width	m	58.82
Full supply depth	m	3.0
Discharge	m^3/s	186.91

4.3. Lower Jhelum Canal Feeder System

4.3.1. Lower Jhelum Canal Feeder - Introduction

Lower Jhelum Canal (LJC) Feeder is off taking from the left bank of Rasul Barrage along with Rasul-Qadirabad(RQ) Link (**Figure: 4.2**).

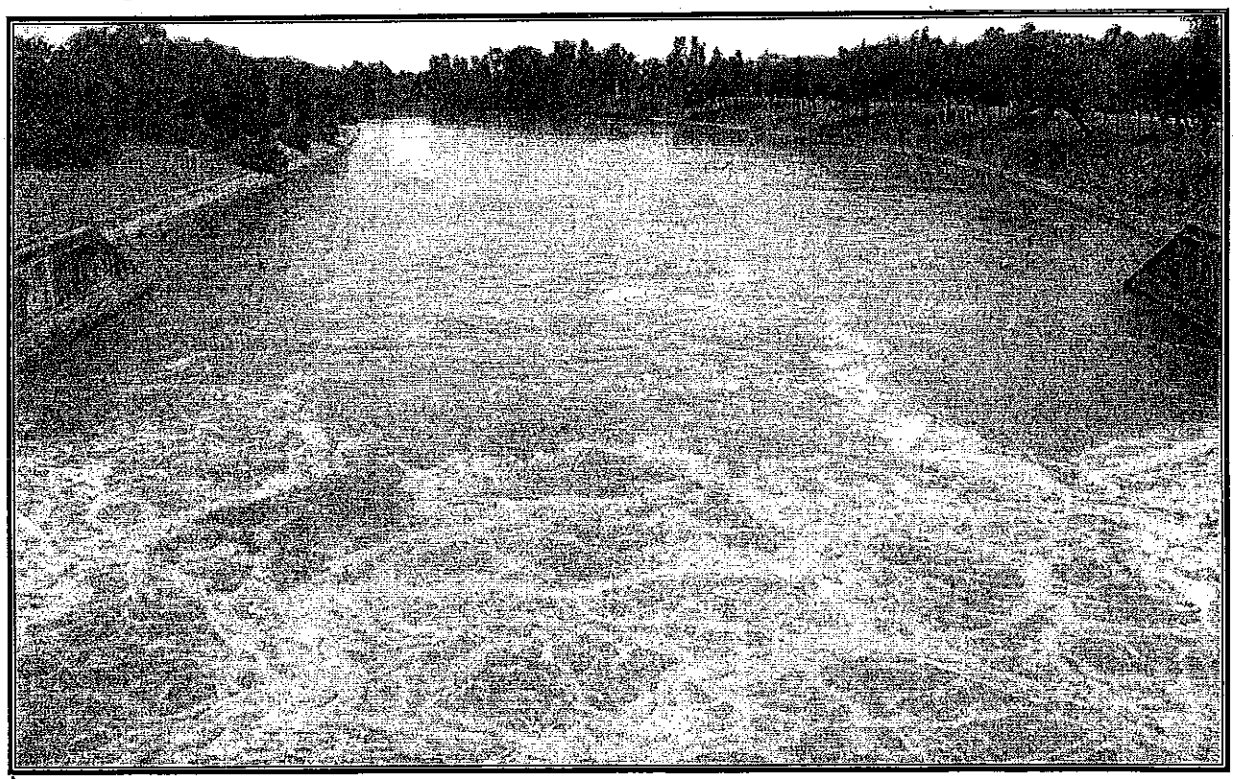
Figure: 4.2 Headregulator of LJC Feeder and RQ Link



LJC Feeder was constructed along with New Rasul Barrage and R-Q Link during 1968. The length of the LJC Feeder is up to RD 10+000. It run parallel with R-Q Link before Kharian-Mandibahauddin-Sargodha road crosses the R-Q Link.

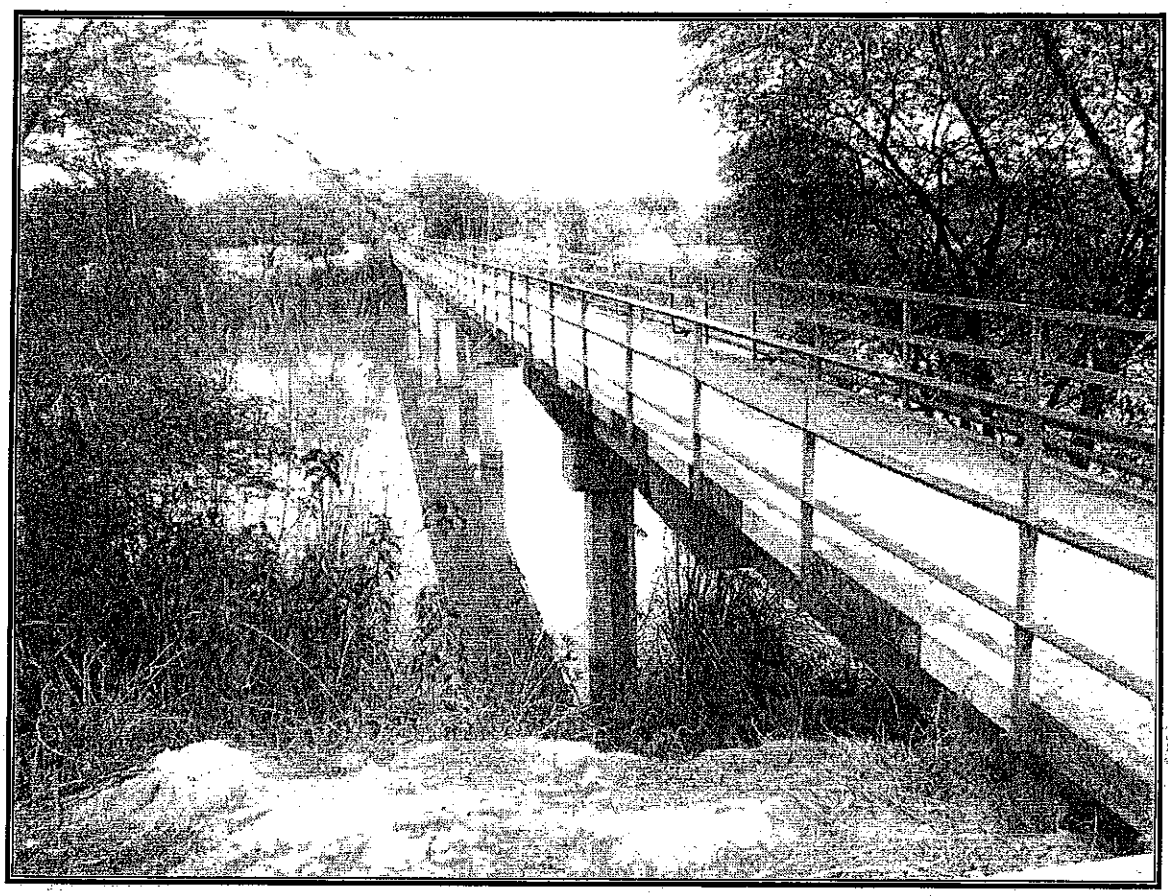
It run in almost straight alignment except downstream of headregulator where it is in curve (**Figure: 4.3**).

Figure: 4.3 LJC Feeder - Looking Downstream from Head-regulator



A foot bridge **(Figure: 4.4)** resting on concrete piles and village road bridge cum fall **(Figure: 4.6)** structure exist at RD 5+650 and RD 8+626 of LJC Feeder, respectively.

Figure: 4.4 Foot Bridge at RD 5+650



The canal is protected with stone on both banks between RD 0+000 & RD 2+000 and RD 5+000 & RD 10+000. Canal banks between RD 2+000 and RD 5+000 are without stone protection. No off-taking distributaries/minors exist between headregulator and Village Road Bridge cum fall structure at RD 8+626.

The LJC Feeder has been designed for discharge 186.92 m^3/s. At present canal flows are being controlled at head-regulator to meet the irrigation demand in excess of Rasul Power Canal (Tailrace) having capacity of 102.63 m^3/s. The canal is in cut starting from Headregulator to RD 10+000. Haider Town (Kotli Afghanan) exists on canal right bank some 220 m upstream from Village Road Bridge Cum Fall at RD 8+626. No road access available along left bank of the canal.

The layout plan of Lower Jhelum Canal Feeding System is shown in **Drawing No. 4.1**.

4.3.2. Headregulator of Lower Jhelum Canal Feeder

The Headregulator of LJC Feeder having width of 26.21 m with two bays each 12.2 m wide equipped with power and manually operated radial steel gates **(Figure: 4.5)**. Mandibahauddin-Rasul Barrage-Ghariabwal road passes over the Headregulator Bridge which is placed toward downstream of gates and gate operating mechanism. The right of way from centre line of LJC Feeder on its right bank is 68.58 m (225 ft). A head of about 1.25 m is available which can be used for power generation.

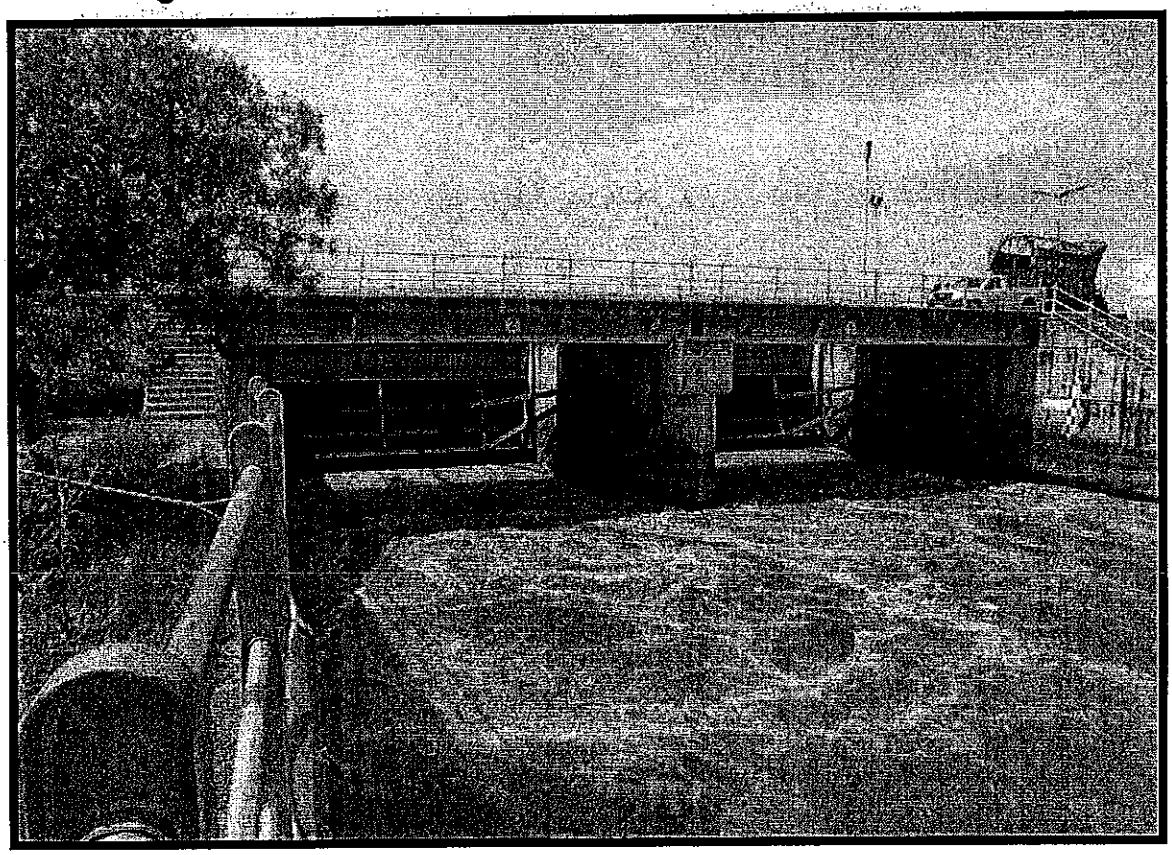
The basic hydraulic design data of Headregulator at RD 0+000 of LJC Feeder is summarized in **Table: 4.2**.

Table: 4.2 Hydraulic Data of Headregulator of LJC Feeder

Description	Unit	Designed
U/S Full Supply Level	masl	219.15
D/S Bed level	masl	214.89
D/S Full Supply Level	masl	217.90
D/S Bed width	m	58.82
D/S Full supply depth	m	3.0
D/S Discharge	m^3/s	186.92
Free Board	m	0.914
Bed Slope	%0	0.120

The headregulator has been constructed during 1965-67 and is in good conditions.

Figure: 4.5 LJC Feeder Headregulator - Downstream View



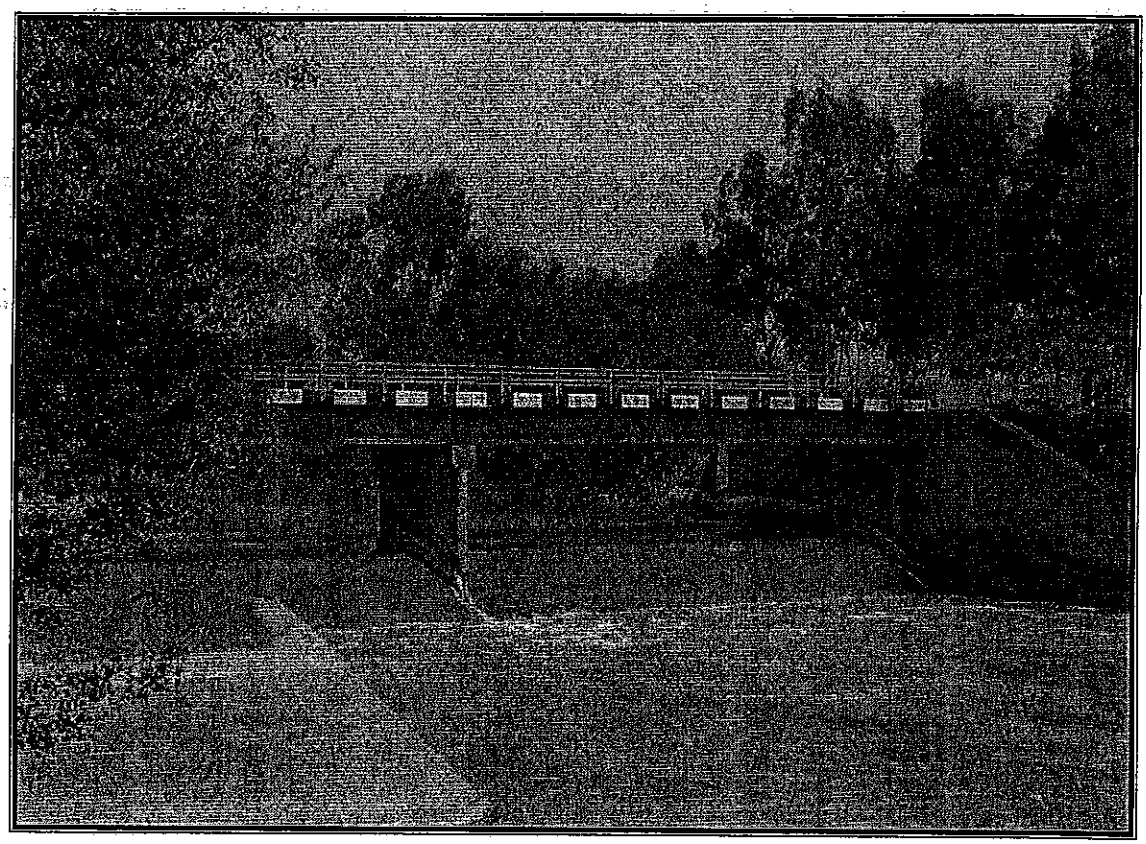
4.3.3. Bridge Cum Fall Structure At RD 8+626

An un-gated fall cum village road bridge structure (**Figure: 4.6**) along RD 8+626 has two spans each with 12.2 m width. The total width of fall is 26.21 m. Bridge rest on concrete piles. This structure was constructed in the bed of canal during canal construction. The hydraulic design data of fall structures at RD 8+626 is summarized as in **Table: 4.3**. The head available at this fall is about 3.66 m which would create a possibility to construct hydropower project for energy generation.

Table: 4.3 Hydraulic Data of Fall Structure at RD 8+626

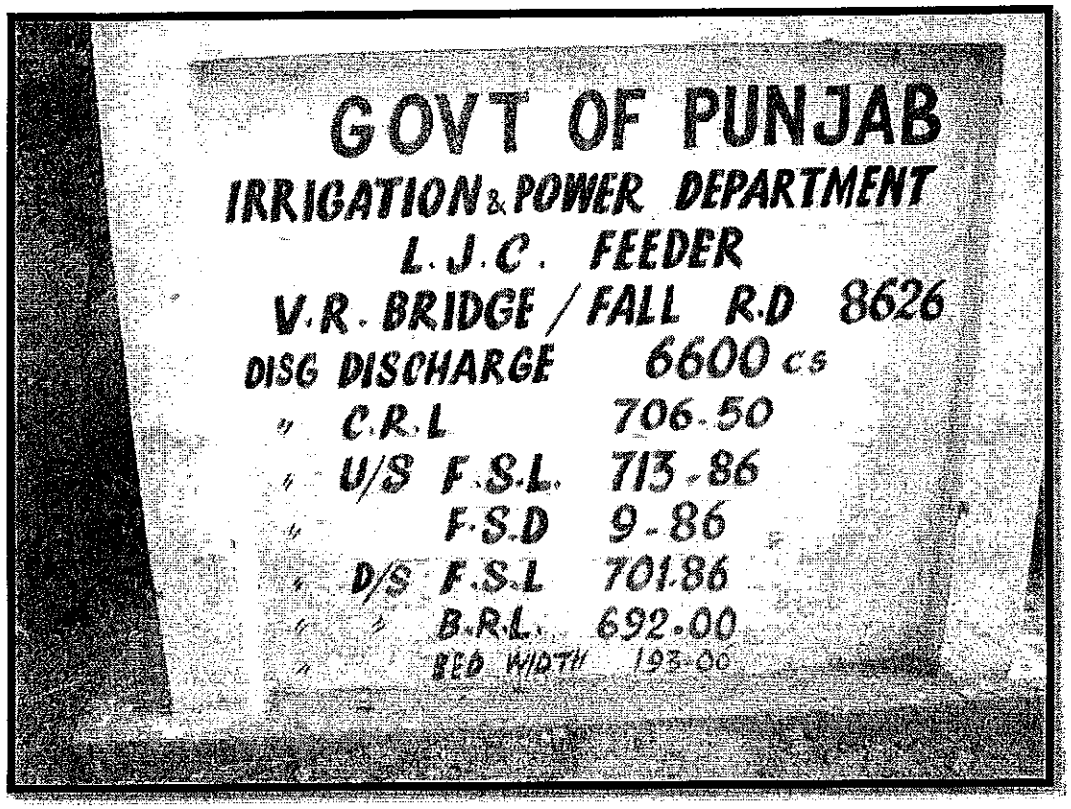
Description	Unit	Designed
U/S Bed level	masl	214.58
U/S FSL	masl	217.58
D/S Bed level	masl	210.92
D/S FSL	masl	213.92
D/S Bed width	M	58.82
D/S Full supply depth	M	3.00
D/S Discharge	m^3/s	186.92

Figure: 4.6 Fall Structure at RD 8+626 Looking From Downstream



The hydraulic design data of the fall structure is mentioned on the concrete plaque (**Figure: 4.7**) constructed on the bank of the LJC Feeder near RD 8+626.

Figure: 4.7 Village Road Bridge Plaque - Data



It is noted that downstream bed level 210.92 m (692.00 ft) written at fall structure is the level of concrete floor and therefore the downstream full supply level is 213.93 m (701.87 ft) written at fall structure.

4.4. Upper Jhelum Canal System

4.4.1. Upper Jhelum Canal

Upper Jhelum Canal off-takes from Mangla Power Station tail pond and after feeding Rasul Power Station (RD 244+000), Gujarat Branch (RD 255+080) and few other distributaries and Shadiwal Power Station (RD 417+805) falls (RD 418+000) in to Chenab River upstream of Khanki Headwork. The Khanki Headwork is being constructed as Khanki Barrage by Irrigation Department Government of Punjab and will be put in operation during 2017. The canal originally designed as a feeder canal to pass surplus water from Jhelum River to Chenab River. Upper Jhelum Canal (UJC) is part of the extensive irrigation system of the Punjab province constructed in 1912 in British Era.

The canal had been designed for a discharge capacity of 354.00 m^3/s (12,500 ft^3/s) taking its supply directly from the Jhelum River, through a head regulator downstream (**Figure: 4.8**) of Mangla Dam site before construction of Mangla Dam. With the commissioning of the Mangla Dam Project, the tail water level for Mangla Powerhouse had to be lowered from the Jhelum River bed level necessitating the abandonment of the UJC head regulator and construction of Bong canal.

Figure: 4.8 Old Headregulator of Upper Jhelum Canal

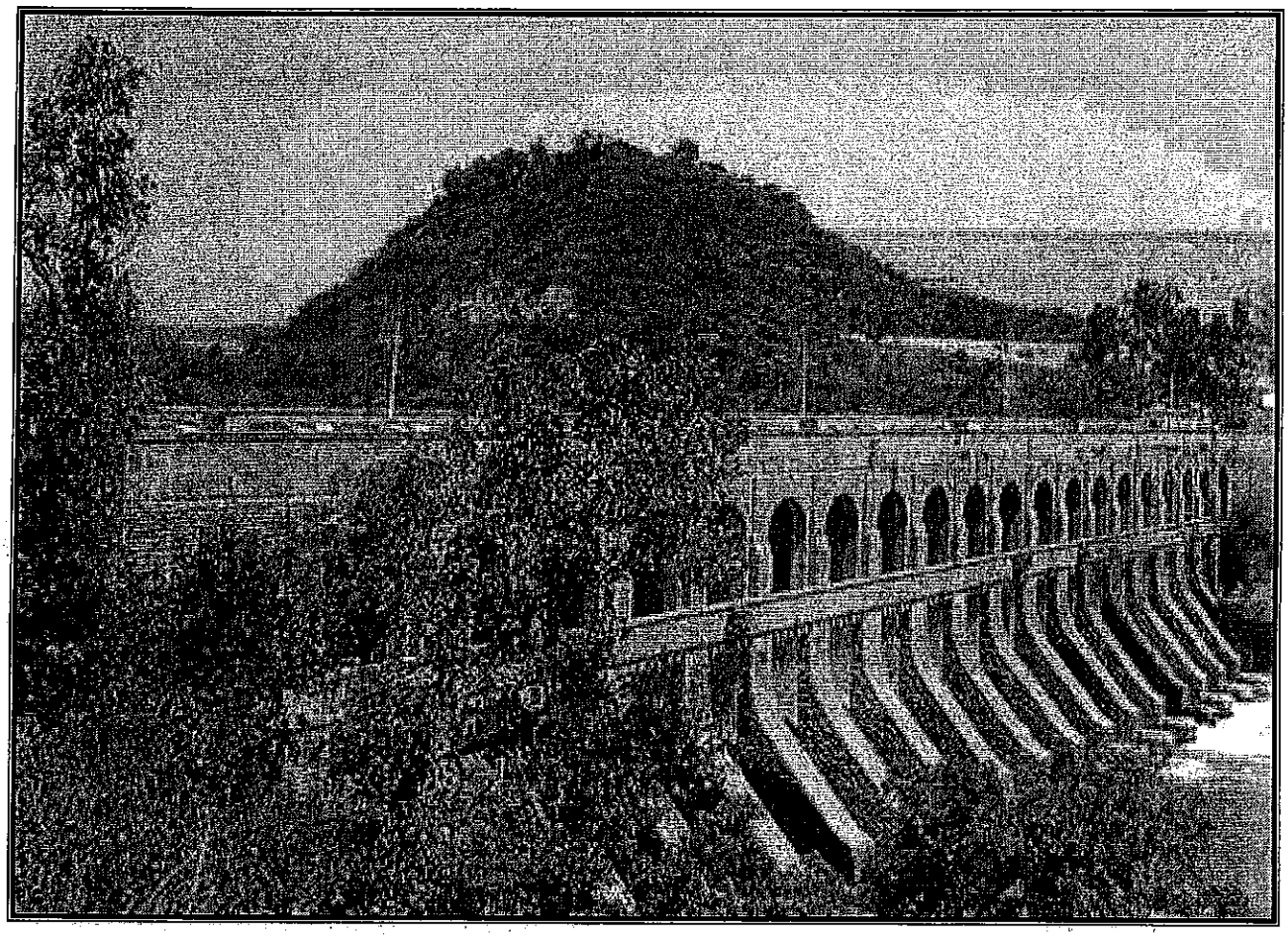


Figure: 4.9 Old Bong Escape Structure Looking Downstream

Water releases from Mangla Power Station are now carried by the Bong Canal up to RD 25 + 100 of Upper Jhelum Canal where surplus water, over and above UJC requirements, is diverted into Jhelum River through New Bong Escape Structure. The Old Bong Escape Structure (**Figure: 4.9**) is placed at RD 26+100 along right bank of Upper Jhelum Canal will escape surplus water coming from left bank Jabar Nullah having catchment of 12.5 Sq. miles.

The structure called Bong Fall located at RD 27+500 is now acting as Head-regulator of the UJC. The upstream and downstream water levels are 254.38 m (834.60 ft) and 253.30 m (831.04 ft), respectively. The crest level is at 252.34 m.a.s.l (827.88 f.a.s.l) while total width of regulator is 85.344 m (280 ft). It is equipped with manual operated gates. A road bridge is provided over the pier of the structure. This structure was built during 1935 along with Old Bong Escape in order to stop the silt entering in to UJC, coming with flash flood of Jabbar Nullah.

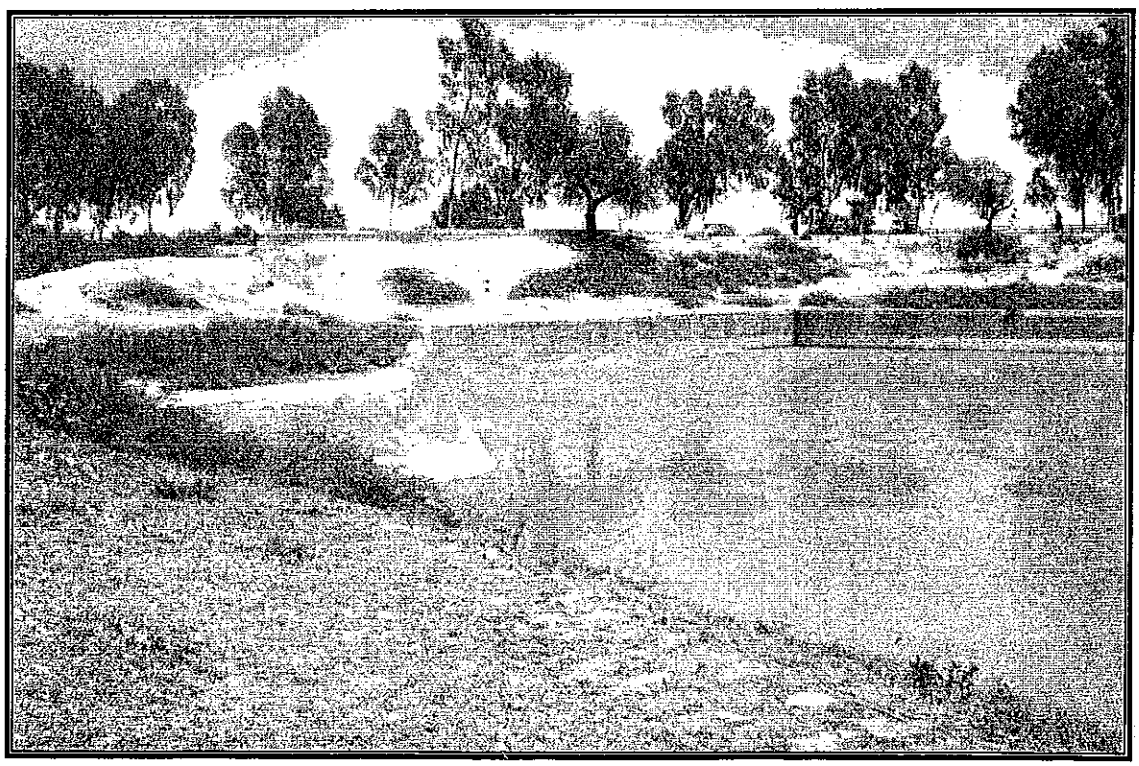
As the UJC is running parallel to Jhelum River along its left bank, a numbers of cross drainage structure were constructed to cater with the flows coming from left side hill torrents. Falls are provided in the canal at these crossings which are:

- Old Bong Escape RD 26+100
- Jatli Level Crossing RD 78+696
- Rehman Level Crossing RD 89+000
- Headless Meter Flumes RD 107+100
- Jaggu Level Crossing RD 123+000

4.4.2. Rasul Hydel Power Station - Headrace and Tailrace

Rasul Hydel Power Station headrace off-takes from right bank of Upper Jhelum Canal from its RD 244+000 and supply discharges to Rasul Power Station. The length of Rasul headrace is about 1.6 km.

Figure: 4.10 Rasul Tailrace Siphon under R-Q Link-Downstream View



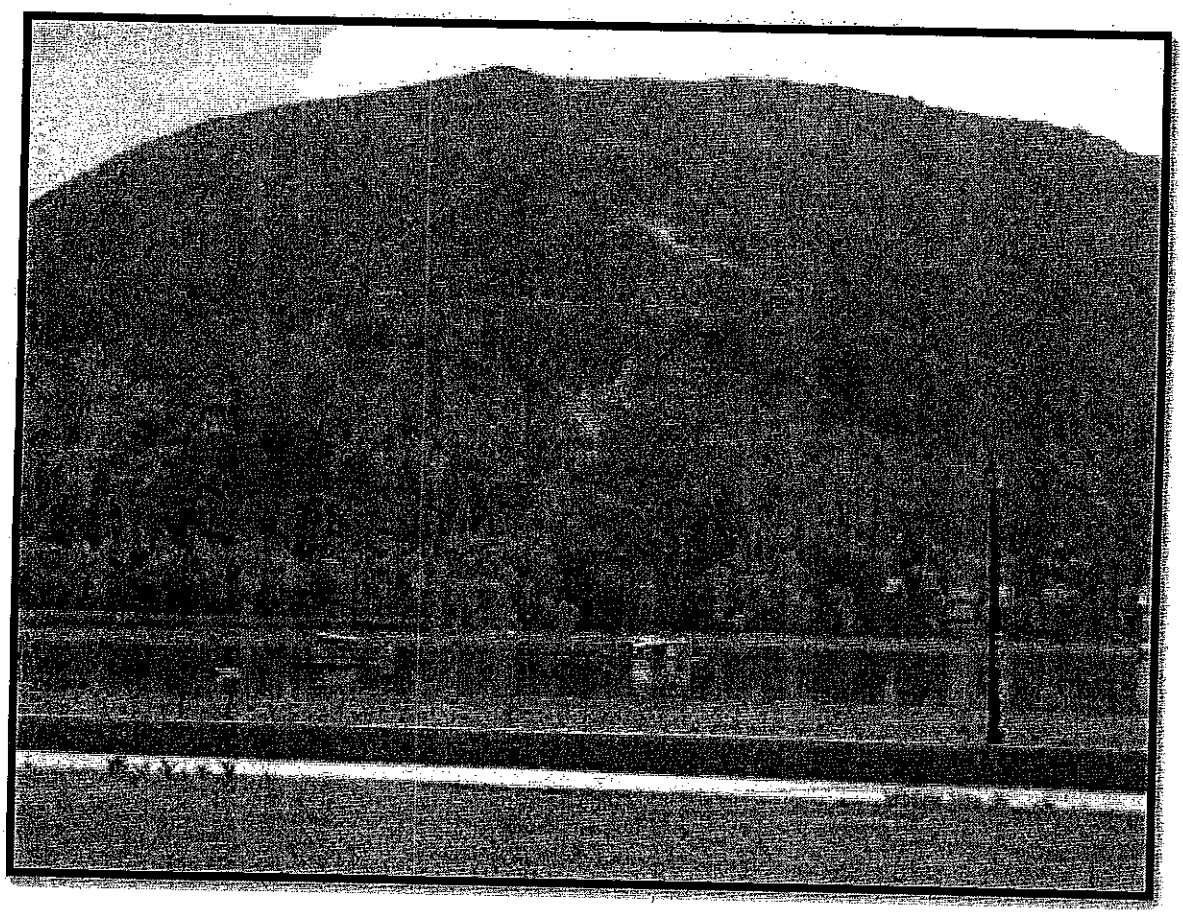
After running the two turbo-generators at Rasul Power Station, the flows enter Rasul Power Station tailrace and discharge in to Lower Jhelum Canal at RD 10+000 of Qadirabad-Balloki Link Canal. At this point, Rasul Power Station Tailrace passes through a siphon under the bed of the Rasul-Qadirabad Link Canal (**Figure: 4.10**). The discharging capacity of the Rasul Tailrace is 102.63 m^3/s (3624 ft^3/s). After joining the Lower Jhelum Canal Feeder and Rasul Powerhouse Tailrace, the canal named Lower Jhelum Canal, which irrigates the area in the district of Mandibahauddin, Sargodha and Jhang. The layout of Lower Jhelum Canal Feeding system is presented in **Drawings: 4.1**.

Rasul Power Station was without spillway from its start and in case of turbines tripping or power plants shut down, the discharges passing through the power plants have to accommodate in the lower reach of Upper Jhelum Canal. Therefore, the Upper Jhelum Canal was running with less capacity equal to the discharge capacity of Rasul Power Station in order to avoid the chance of canal breach. Now the spillway is put in to operation from October 24, 2014, therefore, the Rasul Power Station is running at its designed capacity most of the time.

4.5. Jhelum River

Jhelum River is one of the big rivers of Indus Basin and contributes a good part of water supply to the irrigated agriculture system of Pakistan especially Punjab Province. It originate in the form of two main stream namely Ahan and Sandran from the almost same altitude 4,200 m.a.s.l and join below Anantnag.

Figure: 4.11 Wular Lake View



The combined river flows in a north-westerly direction across a wide alluvial plain through Srinagar until it enters the Wular Lake (**Figure: 4.11)** which is the largest fresh water lake in the Indo-Pak subcontinent. After the Wular Lake River assumes south-westerly direction down to Baramula where it enters in the Azad Jammu and Kashmir Tertiary.

After entering in Azad Jammu and Kashmir tertiary, river flows north-westerly direction till to Muzaffarabad, the Capital city of the State of the Azad Jammu and Kashmir. From here it form a syntax bend and starts flowing toward south till it join Chenab River. Neelum River join the Jhelum River from its right bank in the City of Muzaffarabad. Further down another major river Kunhar join from right bank near the town of Rahra. Kanshi River a right bank tributary of Jhelum join near Bathar. Two left bank tributaries Mahl and Punch join the Jhelum River at altitude of 2,299 m.a.s.l and 2,291 m.a.s.l, respectively.

The Mangla Dam is constructed at an altitude of 2,265 m.a.s.l. Catchments of the Jhelum River at Mangla is 36,111 Sq. Km and mean annual flow is 2.8 x 1010 m^3. The Mangla Dam was completed in1967 and having crest length of 3,352 m and height 115.82 m. After Mangla Dam it receives waters of Jabba, Sukkater, Gaggu and other torrents of Pabbi hills it reach at Rasul Barrage **(Figure: 4.12)**.

After transverse of 873 km (620 km in Pakistan and 253 km in Occupied Jammu and Kashmir) the Jhelum River finally joins Chenab River at Trimmu Headwork about 25 km to the south of Jhang Town.

At present there exists only two controlling structures (Mangla Dam and Rasul Barrage) along Jhelum River in Pakistan and Azad Jammu and Kashmir. However, a number of hydropower project along its main stem and its tributaries are planned and would be constructed in the years to come.

4.6. Rasul Barrage

The barrage was constructed in 1967 on the River Jhelum downstream of Mangla Dam. It has design discharge capacity of 24, 073 m^3/s and length including under-sluices is 978.10 m **(Figure: 4.12)**. Rasul-Qadirabad Links and Lower Jhelum Canal Feeder off-take on the left abutment.

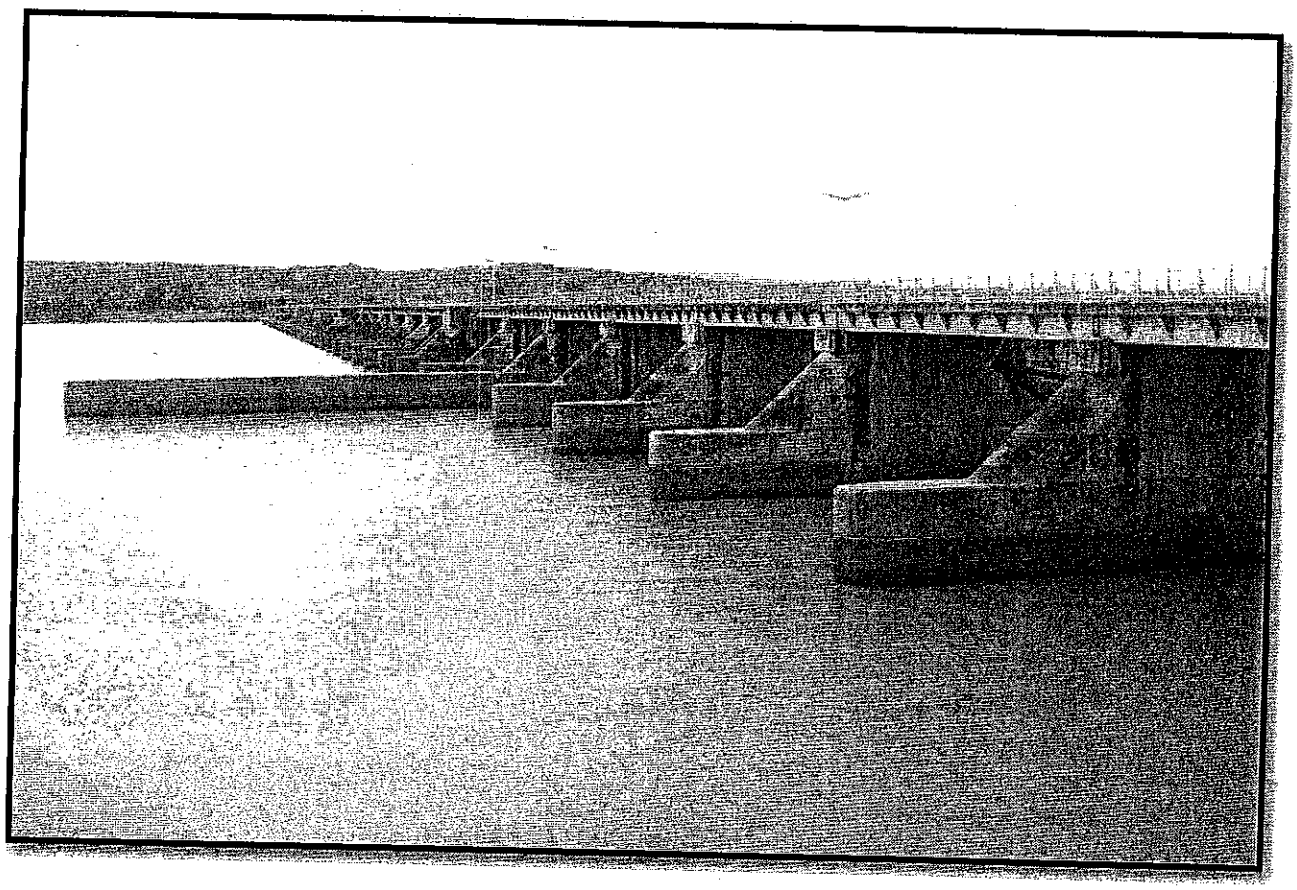
The salient features of the barrage are;

- Length of Barrage = 978.35m
- Main Weir – Number of Bays = 44
- Main Weir – Crest Length = 804.67 m
- Main Weir – Crest Level = 214.27 m.a.s.l
- Under Sluices – Right side Bays = 6
- Main Weir – Crest Length = 109.74 m
- Main Weir – Crest Level = 212.90 m.a.s.l
- Under Sluices – Left side Bays = 6
- Main Weir – Crest Length = 109.74 m
- Main Weir – Crest Level = 212.90 m.a.s.l
- Normal Pond Level = 219.15 m.a.s.l
- High Flood Level = 220.79 m.a.s.l

Figure: 4.12 Rasul Barrage – Looking From Right Bank toward Rasul Pond

The view of Rasul Barrage from left bank toward downstream is shown in **Figure: 4.13.**

Figure: 4.13 Rasul Barrage – Looking From Left Bank toward Downstream



4.7. Rasul-Qadirabad Link Canal

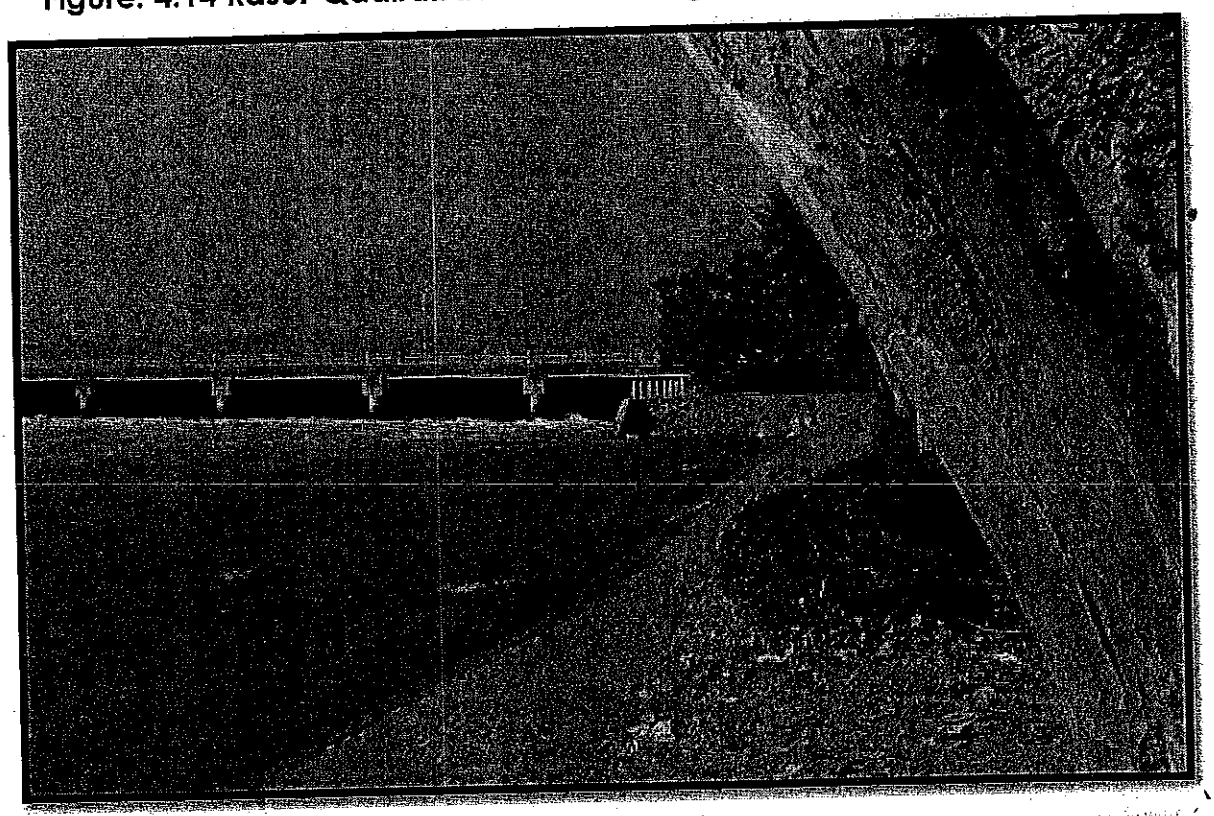
Rasul-Qadirabad (R-Q) Link Canal off-takes from left abutment of the Rasul Barrage. The headregulator of R-Q (**Figure: 4.14)** is a gated structure and have 6 bays of 21.26 m wide. The discharging capacity of the R-Q Link is 538.02 m^3/s. The bed width of the canal is 100.58 m. R-Q Link is part of links system which ultimately transfer Jhelum river water to Sutlej via, Rasul-Qadirabad Link, Qadirabad-Balloki Link and Balloki-Sulemanki Link. These links were constructed under Indus Basin Replacement Works as a results of signing of Indus Water Treaty between India and Pakistan under the office of World Bank.

The salient feature of the headregulator and R-Q Link are given in the **Table: 4.4** below;

Table: 4.4 Hydraulic Design Data of R-Q Link Headregulator

Description	Unit	Designed
U/S Normal Level	masl	219.15
D/S Bed level	masl	214.30
D/S FSL	masl	218.54
D/S Bed width	m	100.58
D/S Full supply depth	m	4.27

Figure: 4.14 Rasul-Qadirabad Link Headregulator - Looking Downstream



CHAPTER – 5

METEOROLOGY, HYDROLOGY AND SEDIMENT

CHAPTER - 5

METEOROLOGY, HYDROLOGY AND SEDIMENT

5.1. General

This chapter presents meteorology, hydrological and sediment data and studies comprises of data collection regarding temperature, rainfall, wind speed, humidity, discharge, water level, sediment and their analyses.

Rasul Barrage is constructed along River Jhelum about 72 km downstream from Mangla Dam (water storage project). Rasul Barrage is used to control water flow in the River Jhelum for irrigation and is also being used as discharge re-regulating structure when Mangla Dam is operating to meet peak demand of electricity in peak hours. At present, two canals are off-taking from Rasul Barrage left Bank. Rasul-Qadirabad Link and Lower Jhelum Canal Feeder. Rasul-Qadirabad is just transferring water of Jhelum River to Chenab River, while Lower Jhelum Canal Feeder is supplying water to Lower Jhelum Canal for irrigating the area of Mandibahauddin, Sargodha and Jhang District. Jalalpur Canal is planned to off-take from Rasul Barrage right bank to irrigate the land lying in foot of salt range.

Rasul-Qadirabad Link Canal and Lower Jhelum Canal (LJC) Feeder runs parallel up to RD 10+000. At RD 10+000 Tailrace of Rasul Power Station joins the Lower Jhelum Canal Feeder then becomes Lower Jhelum Canal (LJC). The flows in LJC are drawn mainly from the Rasul Power Channel (RPC), off-taking from RD 244+000 of Upper Jhelum Canal (UJC). The indented requirements of LJC are primarily fulfilled through the releases of Rasul Power House (RPH) and its spillway and the remaining demand is met through the LJC Feeder.

PPPDB issued letter of Intent to a consortium of five firms lead by M/S China Sinogy Electric Investment Co. Limited to develop a hydropower project by utilizing head available at existing fall exists at RD 8+626 and flows of LJC Feeder. The project site is located at 73^0 32' 11" longitude and 32^0 39' 30" latitude with an average altitude around 213 m.a.s.l. The site is located about 210 km North West of Lahore Town the Capital city of Punjab Province and about 6 Km south west of Rasul town in Mandibahauddin District of the Punjab Province.

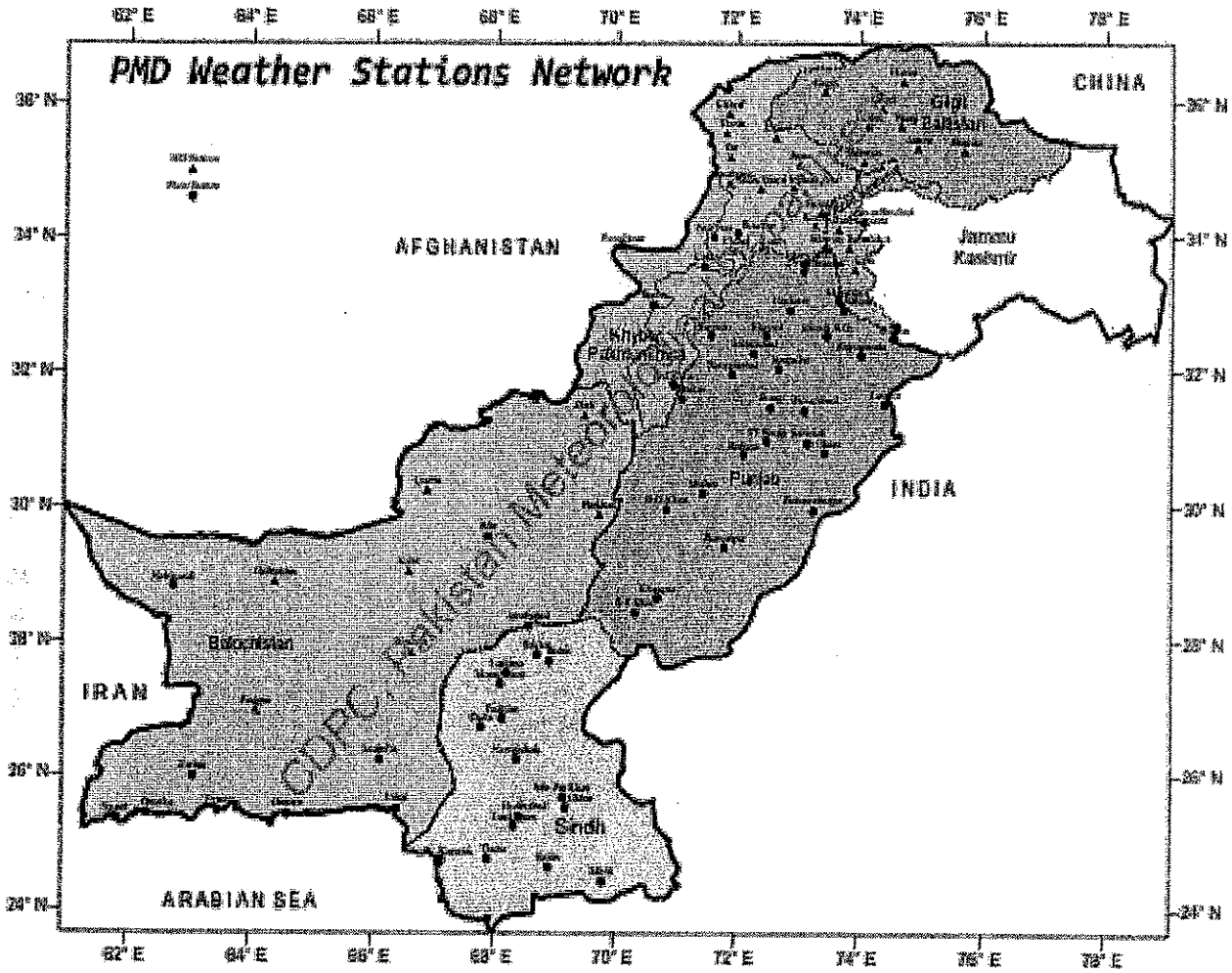
5.2. Meteorological Data Collection and Analysis

5.2.1. General

Metrological data for humidity, Rainfall, Wind Speed and temperature was collected from Pakistan Metrological Department, Lahore. The location of meteorological stations **(Figure: 5.1)** shows that there are number of meteorological stations (Gujranwala, Jhelum, Chakwal, Sargodha, Mandibahauddin and Mureed) are being operated by PMD in surrounding area of the project site. Mandibahauddin about 12 km from site is nearby meteorological station. The second station of Jhelum city is about 34 km from Rasul Barrage. The other stations are more than 60 km from site. Therefore, meteorological data of Mandibahauddin station was collected from the office of the Director, Pakistan Metrological

Department Lahore for the last 12 years (2004-2015) and consider sufficient. The meteorological data would not be used for discharge estimation because, this did not contribute to the flows coming in the Rasul Barrage or Lower Jhelum Canal Feeder. This data is important for upcoming construction contractors and operator of the power plant. This data may also be important to check the closer of canal. Normally during long rainy season, canals remained closed.

Figure: 5.1 Meteorological Stations of Pakistan Metrological Department



5.2.2. Climate of Surrounding Area

Four seasons are being experienced in the project area (winter, spring, summer and autumn). The climate of the project area is semi-arid. Summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months.

5.2.3. Humidity

Data collected shows **(Annexure: 5.1 and Annexure: 5.2)** that humidity data is measured at 0800 Hrs in the morning and 1700 Hrs in the evening. The collected data has been processed for mean, maximum and minimum value of humidity. Mean Maximum (maximum and minimum) monthly humidity is shown in **Table: 5.1**

and **Table: 5.2**, at 0800 Hrs and 1700 Hrs, respectively. **Table: 5.1** shows that extreme minimum is 64% while maximum is 100% while in **Table: 5.2** it is 38% and maximum 100%. Mean Minimum (maximum and minimum) Monthly humidity is presented in **Table: 5.3** and **Table 5.4**. These tables shows that extreme minimum at 0800 Hrs and 1700 Hrs varies between 10% to 13%, respectively and is in the Month of May while extreme maximum at 0800 Hrs. and 1700 Hrs. varies between 41% and 23%, respectively.

Mean monthly maximum (mean, maximum and minimum) humidity for the period 2004-2015 are compiled in **Figure: 5.2** and **Figure: 5.3** recorded at 0800 and 1700, respectively.

Figure: 5.2 Mean Monthly Maximum (maximum) Humidity at 8 am

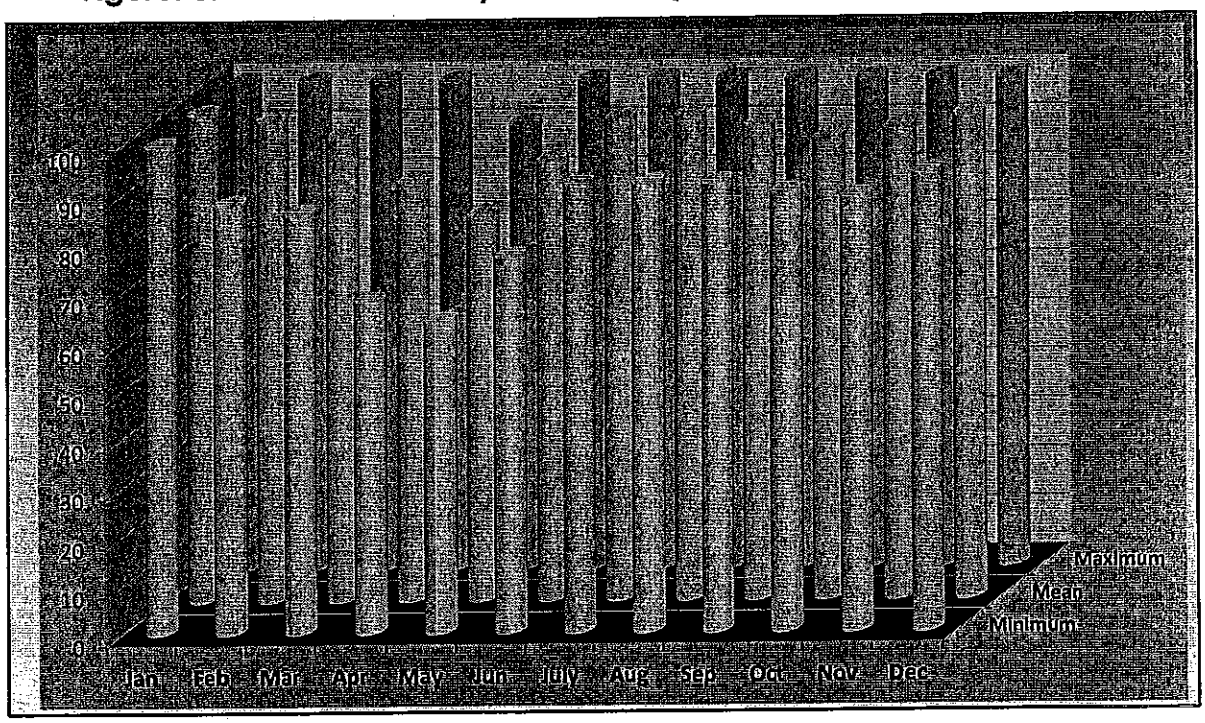
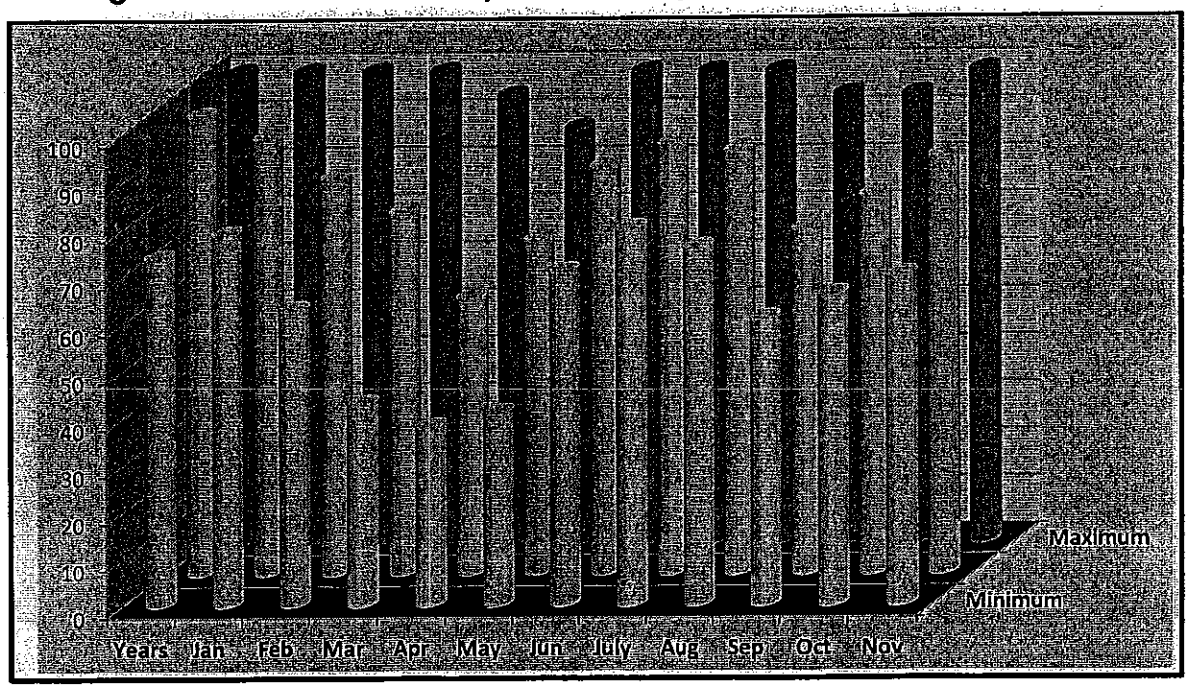


Figure: 5.3 Mean Monthly Maximum (minimum) Humidity at 5pm



Mean monthly minimum (mean, maximum and minimum) humidity for the period 2004-2015 are compiled in **Figure: 5.4** and **Figure: 5.5** recorded at 0800 and 1700, respectively.

Figure: 5.4 Mean Monthly Minimum (maximum) Humidity at 8am

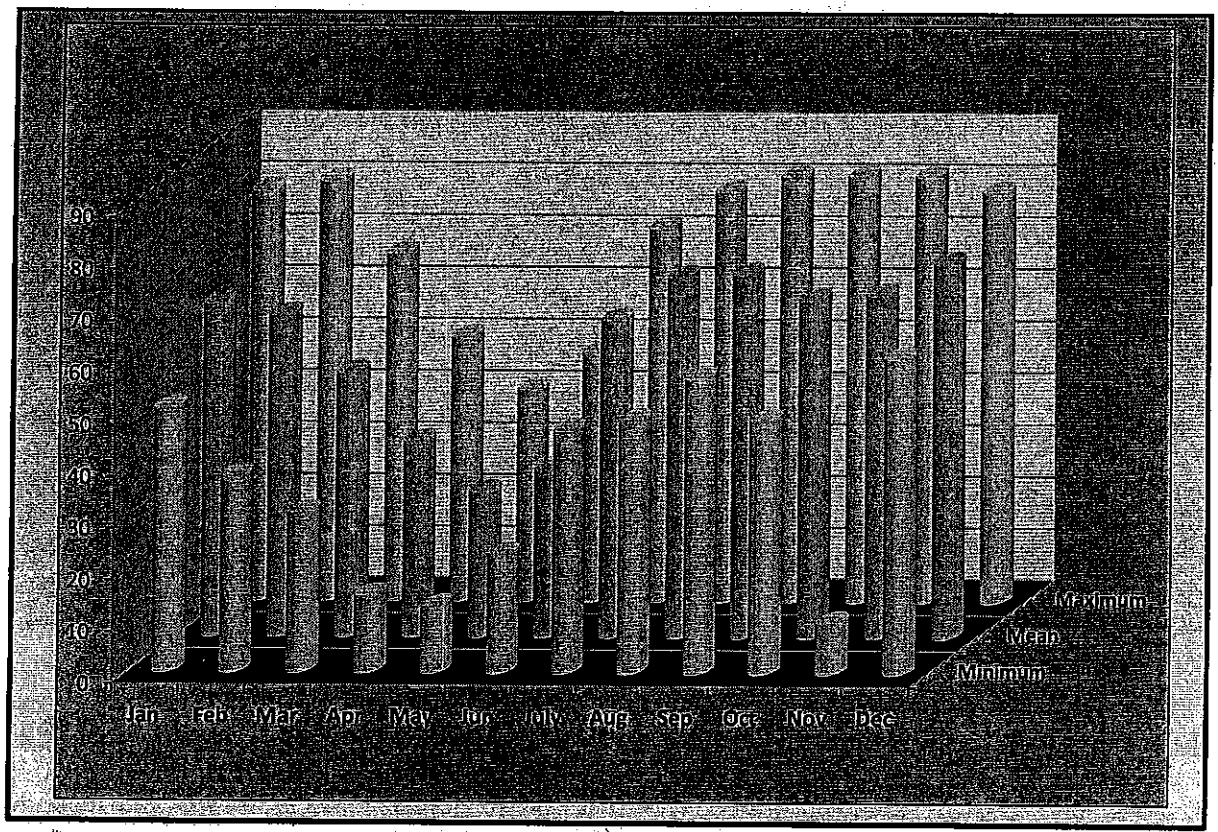
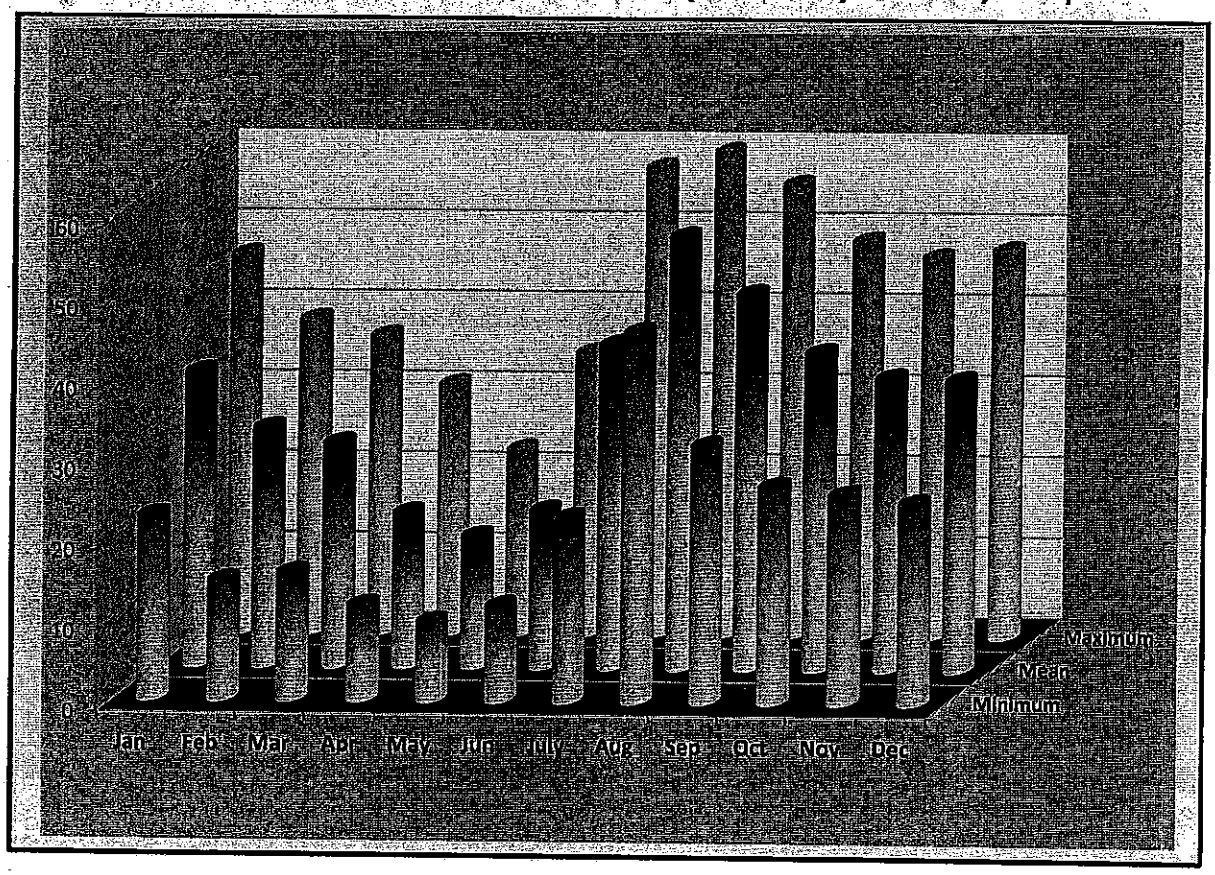


Figure: 5.5 Mean Monthly Minimum (minimum) Humidity at 5pm



These figures indicating variation in humidity ranging from 55% in May to 100% in January and August. It is noted that the month of April, May and June are months of minimum and months of December, January, July and August are the months of maximum humidity. Average relative humidity varies from 43 to 69 %.

Figure: 5.6 Mean Monthly Maximum Humidity at 8 AM and 5 PM

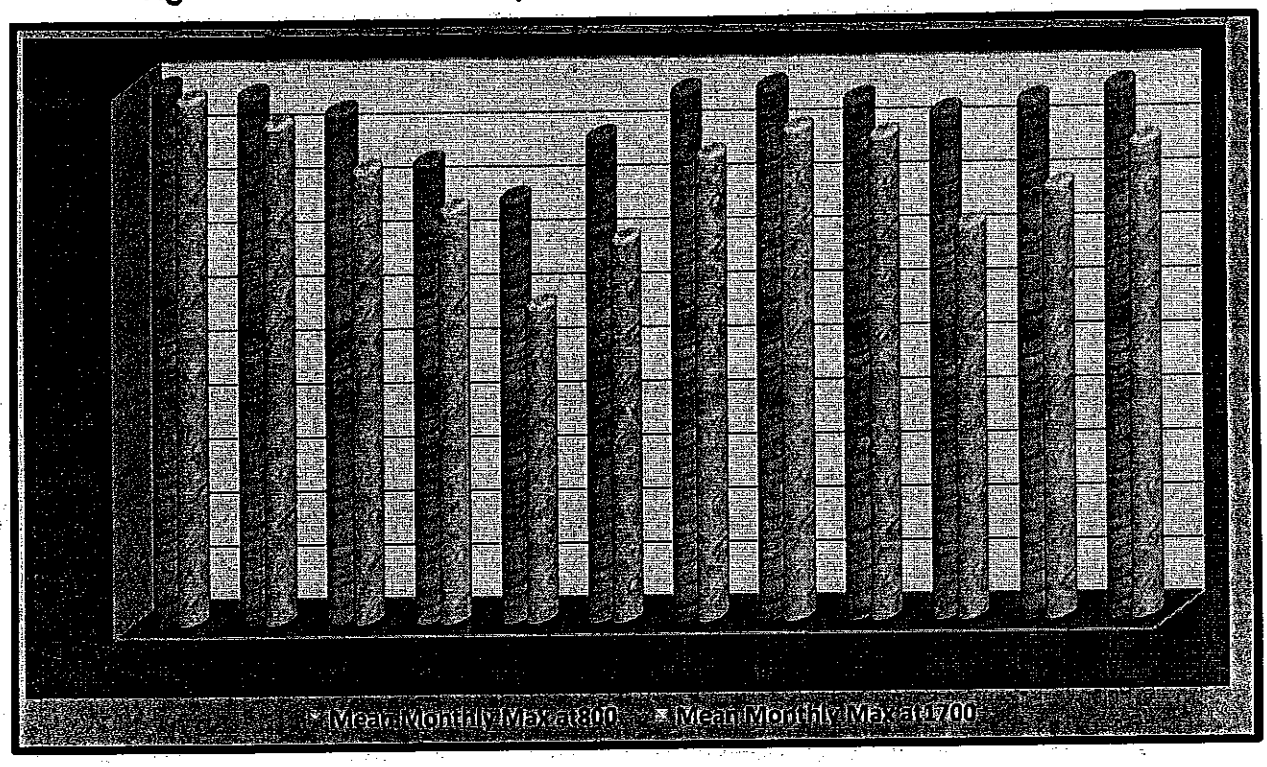


Figure: 5.7 Mean Monthly Minimum Humidity at 8 AM and 5 PM

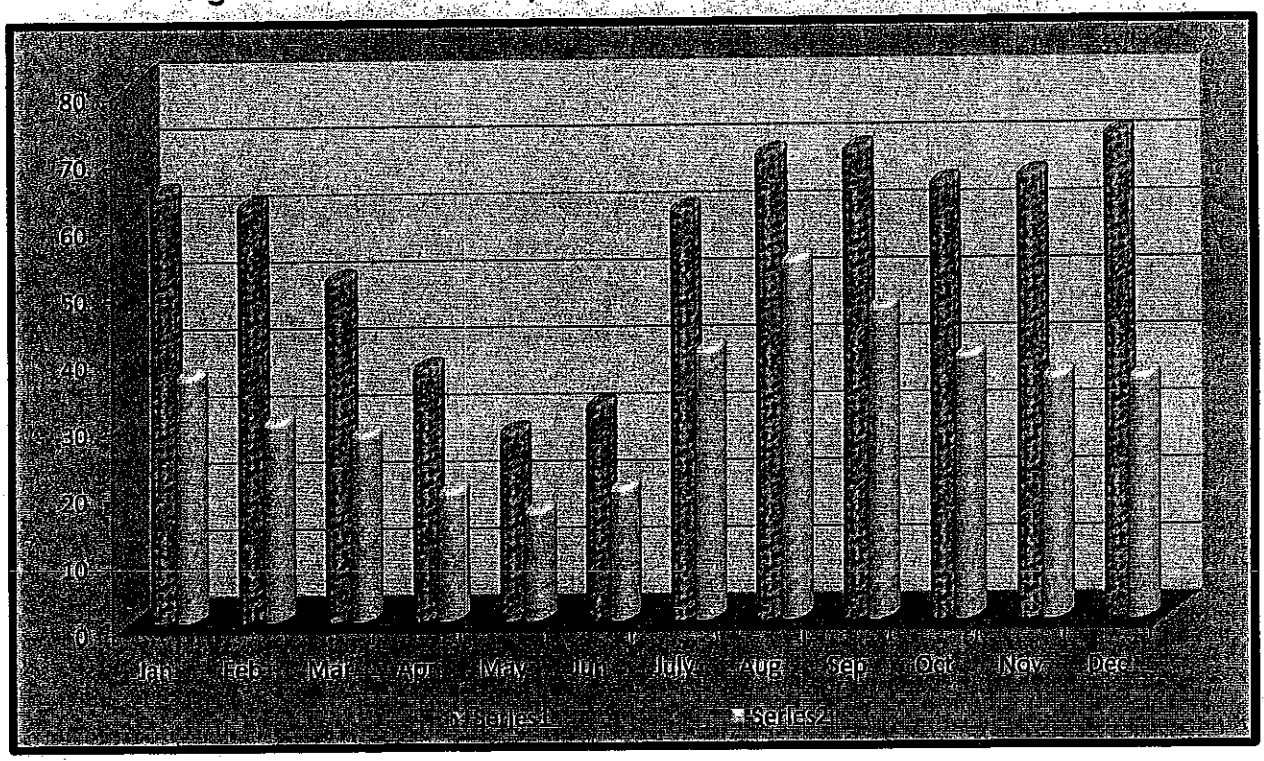


Figure: 5.6 and **Figure: 5.7** represent the mean data of maximum and minimum humidity at 0800 and 1700, respectively. This shows that relative humidity is more

during morning and less during evening. The month of May is the month of extreme minimum and the month of January is the extreme maximum humidity.

5.2.4. Wind speed

The mean daily wind speed data in knot recorded at 8 AM and 5 PM for 2005-2015 at Mandibahauddin collected and presented in **Annexure: 5.3 and 5.4**. This data has been processed for maximum at 8 AM and 5 PM and presented in **Table: 5.5** and **Table: 5.6**, respectively. This data further processed for maximum, minimum and mean. Mean Monthly Mean, Maximum and minimum is presented in **Figure: 5.8** and **Figure 5.9** for period of 2005 to 2015 at 8 AM and 5PM, respectively.

Fig: 5.8 Mean Monthly Maximum Wind Speed at 8 AM (2005-15)

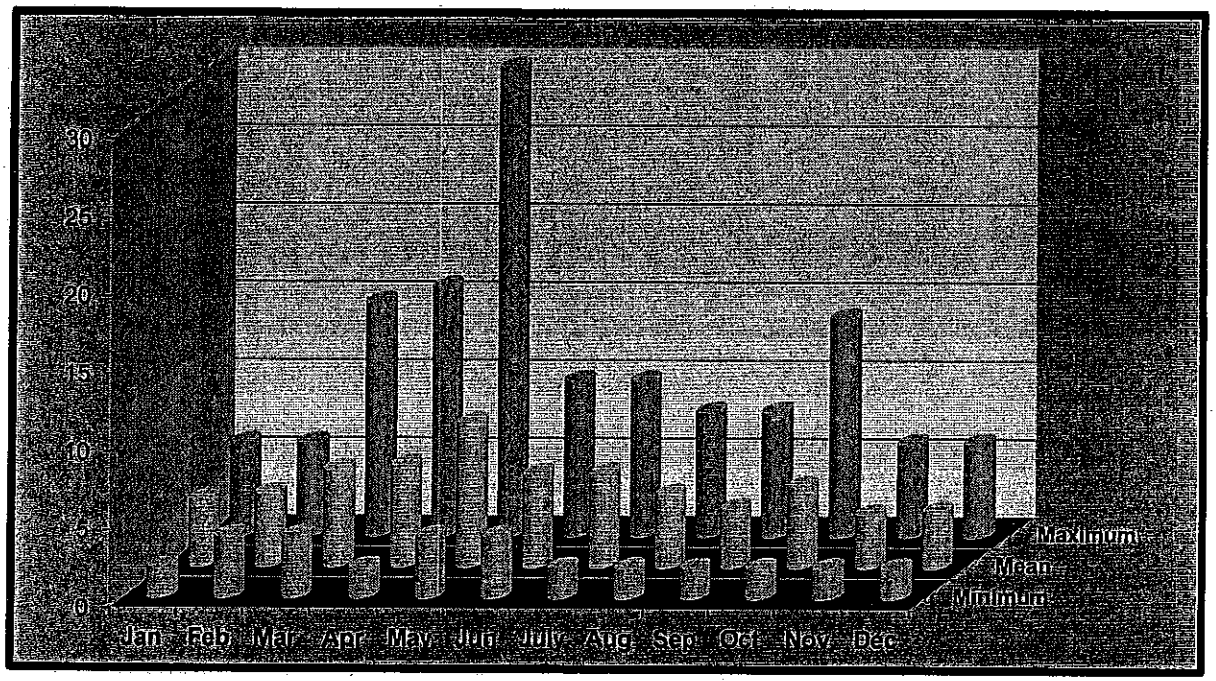
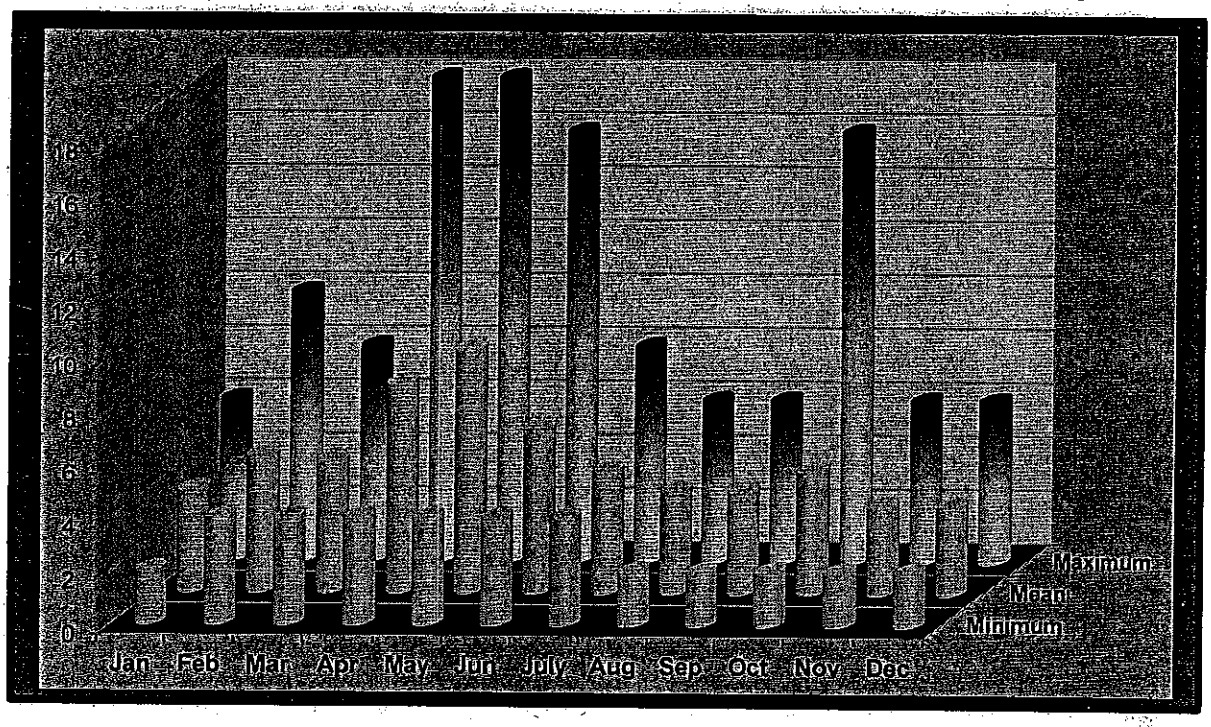


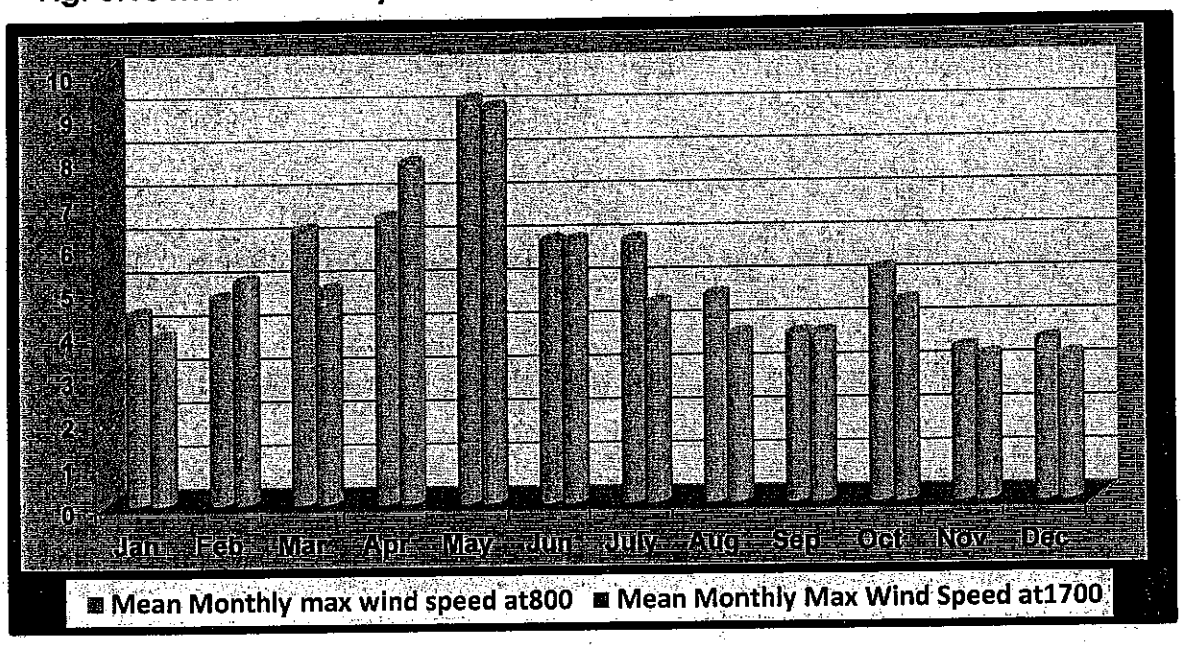
Fig:5.9 Mean Monthly Maximum Wind Speed at 5 PM (2005-15)



Predominant wind direction is north to northwest from October to May, while during the monsoon period (June to September), it is from east to southeast. Average maximum wind speed recorded has been 30 km/hr in May during year 2005 (**Figure: 5.8**). The mean monthly maximum wind speed is presented in **Figure: 5.10** recorded at 0800 and 1700.

Figure: 5.10 shows that wind speed is higher in the morning than in the evening in every month. However, in the month of April it is less than evening speed.

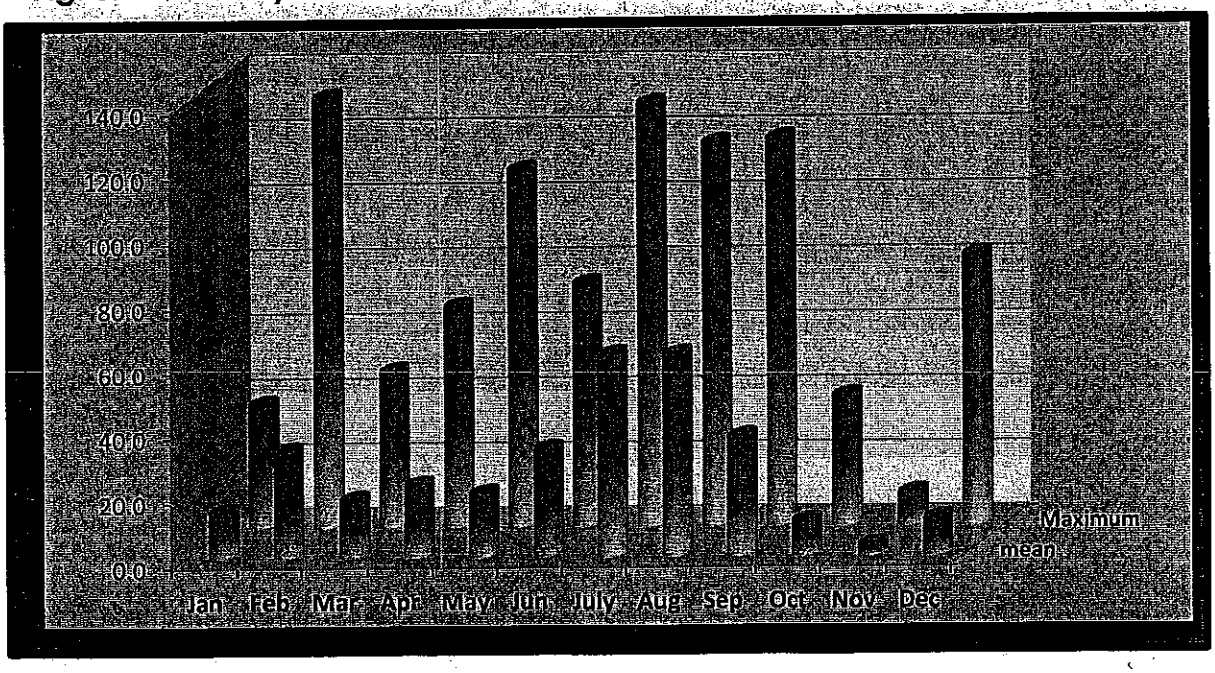
Fig: 5.10 Mean Monthly Maximum Wind Speed at 8 AM&5 PM (2005 -15)



5.2.5. Rainfall

Mean Daily rainfall (mm) data for Mandibahauddin was collected and presented in **Annexure: 5.5**. The data of rainfall has been processed on maximum monthly basis for the years 2004 through 2015 and placed in **Table: 5.7**.

Fig: 5.11 Monthly Maximum and Mean Rainfall (mm) for the years 2005 -15



The rainfall has been processed for mean monthly and maximum monthly and presented in **Figure: 5.11**. **Figure 5.11** shows that Monsoons hit the area in July, August and September. Heavy rains are falling in these months. Considerable rains are also expected in January, February and March. Average monthly rainfall for (2004-2015) is presented in **Table: 5.7**. Monthly maximum rainfall in all years is presented in **Figure: 5.12**. It shows that maximum rainfall occurred in the month of January 2013 and second peak is in the month of September 2014. It is also clear from **Figure: 5.12** most of the rainfall occurs during the summer monsoon period (June to September). November is the month of minimum rainfall and August is the month of maximum rainfall (**Figure: 5.12**).

Fig: 5.12 Monthly Maximum Rainfall (mm) for the years 2004 -15

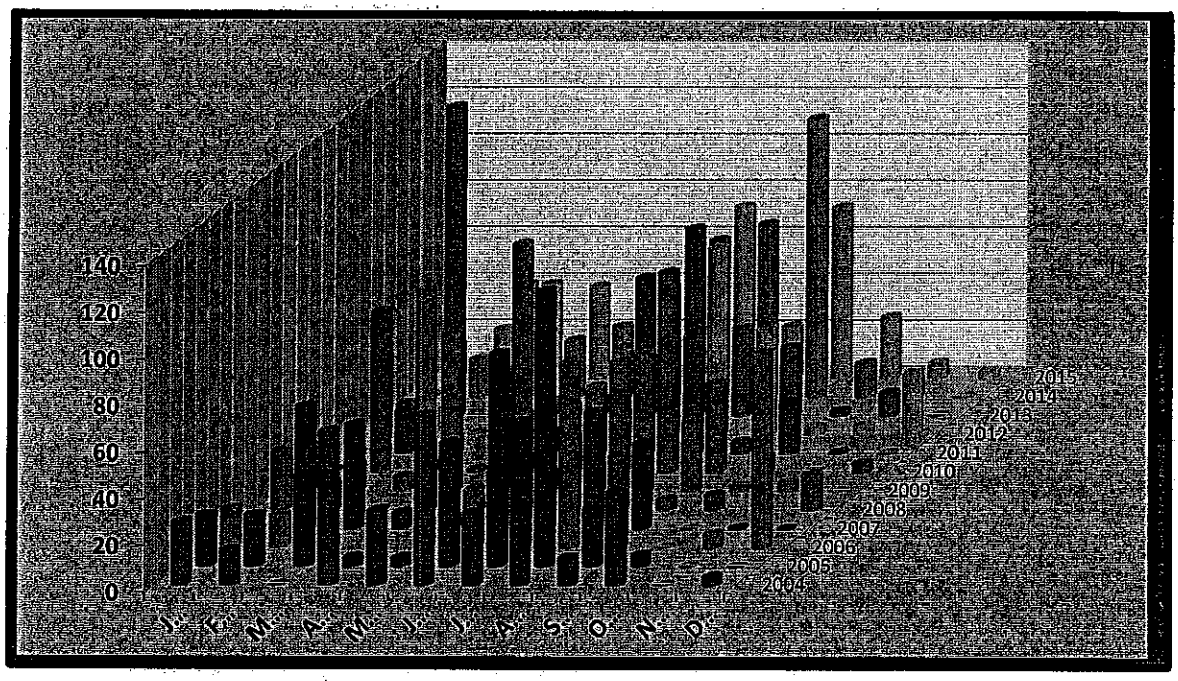


Figure: 5.13 Annual Rainfall (mm) for the years 2004 to 2015

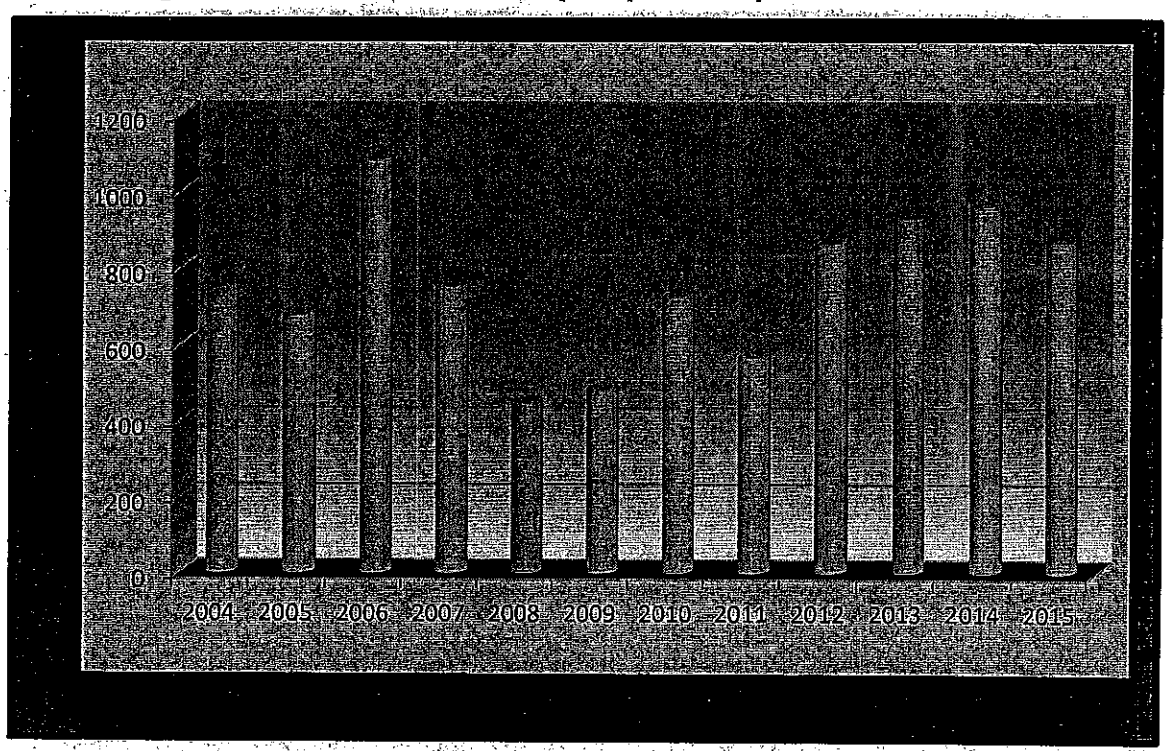
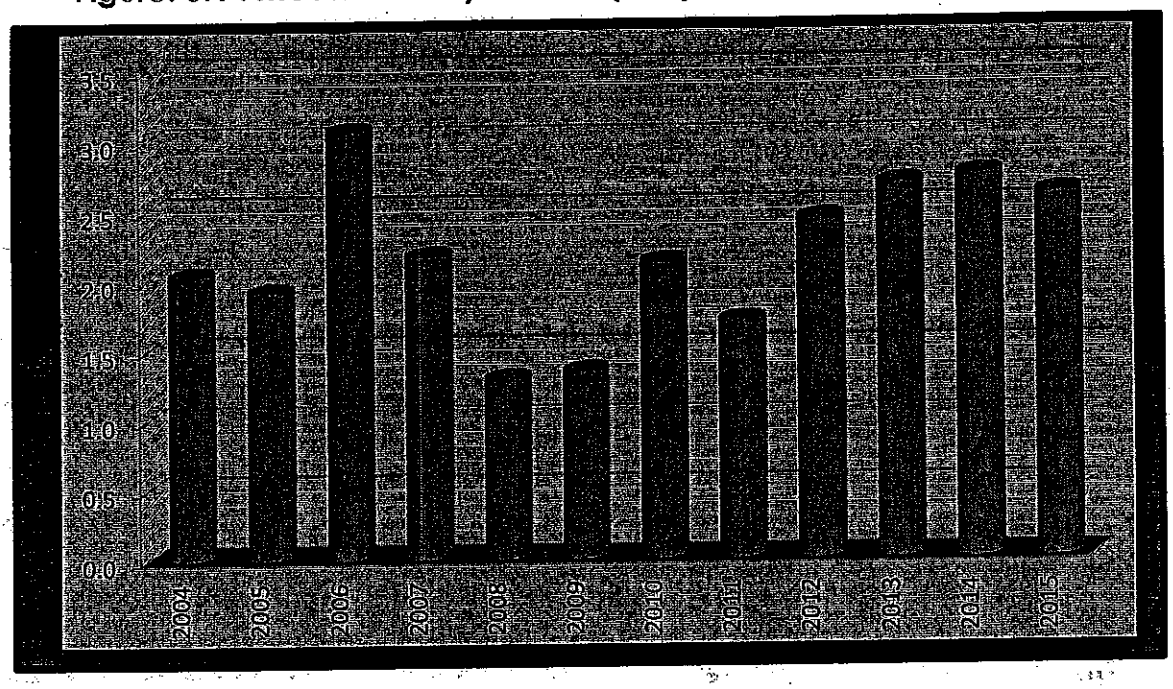


Figure: 5.13 shows that maximum rain occurred during the year 2006 while the years 2008 is the month of minimum rain. The avaerage annual rain is about 759.7 mm. **Figure: 5.14** shows that mean monthly rainfall is less than 3.0 mm it means semi arid area.

Figure: 5.14 Mean Monthly Rainfall (mm) for the years 2004 to 2015



5.2.6. Temperature

Daily mean maximum and mean minimum temperature data for Mandibahauddin climate station was collected and presented in **Annexure: 5.6** and **Annexure: 5.7.** Each year data has been processed for mean monthly, daily maximum and minimum values and presented in **Table: 5.9, Table: 5.10, Table: 5.11** and **Table: 5.12,** and in **Figure: 5.15& Figure: 5.16,** respectively.

Figure: 5.15 Mean Maximum (Maxi) Monthly Temperature(C⁰) years 2004 to 2015

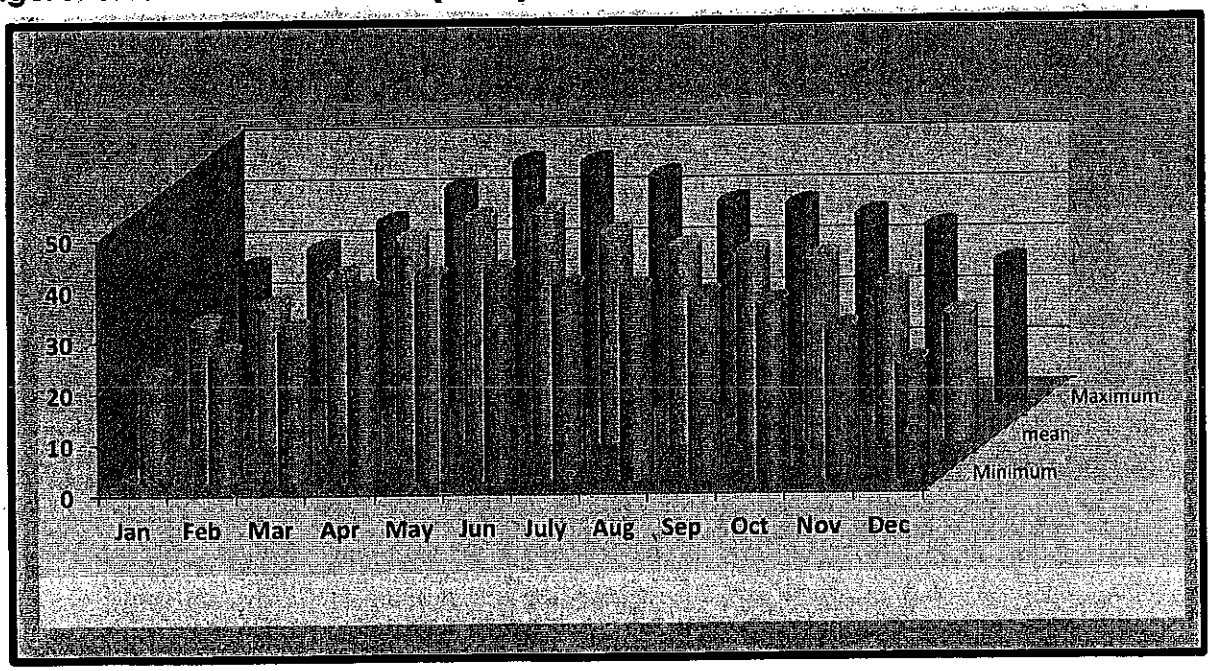
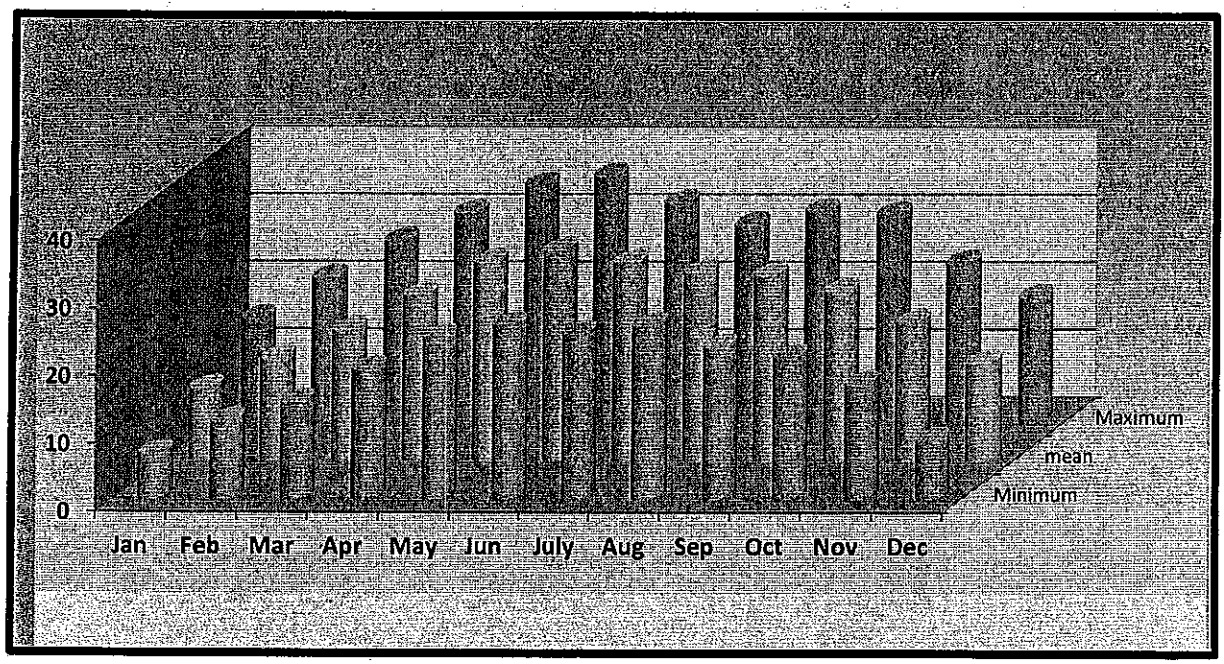


Figure: 5.16 Mean Maximum (Min) Monthly Temperature (C⁰) years 2004 to 2015



Tables: 5.9 & **Table: 5.10** and **Figure: 5.15** & **Figure: 5.16** show that the hottest months are May, June, July and August while November, December, January and February are the months of less temperature. Months of April, September and October are the months of normal temperature. Based on the data for the period 2004 through 2015, the lowest and the highest values of mean monthly maximum temperature are 20.5 C and 47.5 C for the month of January and May respectively.

The mean minimum temperature data was also processed in mean, maximum and minimum for the period of 2004 to 2015 and presented in **Table: 5.11** and **Table: 5.12** and **Figure: 5.17** & **Figure: 5.18**.

Figure:5.17 Mean Minimum (Max) Monthly Temperature (C⁰) years 2004 to 2015

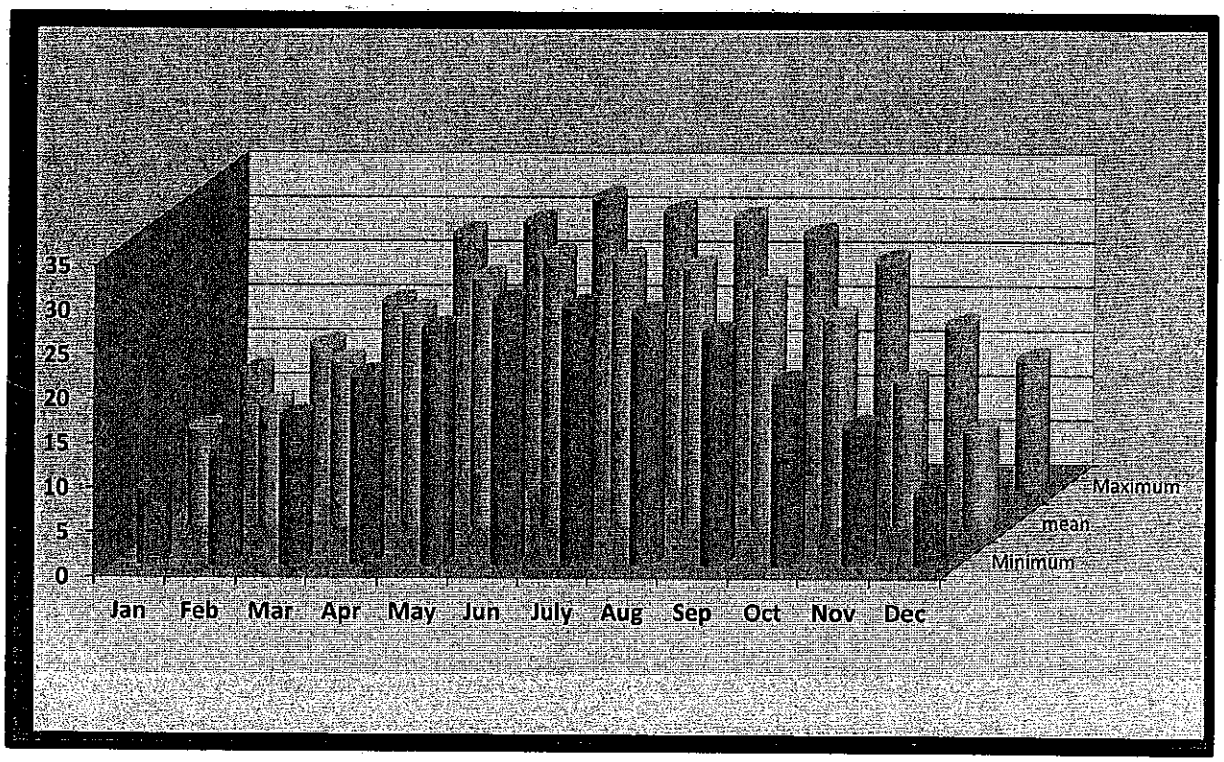
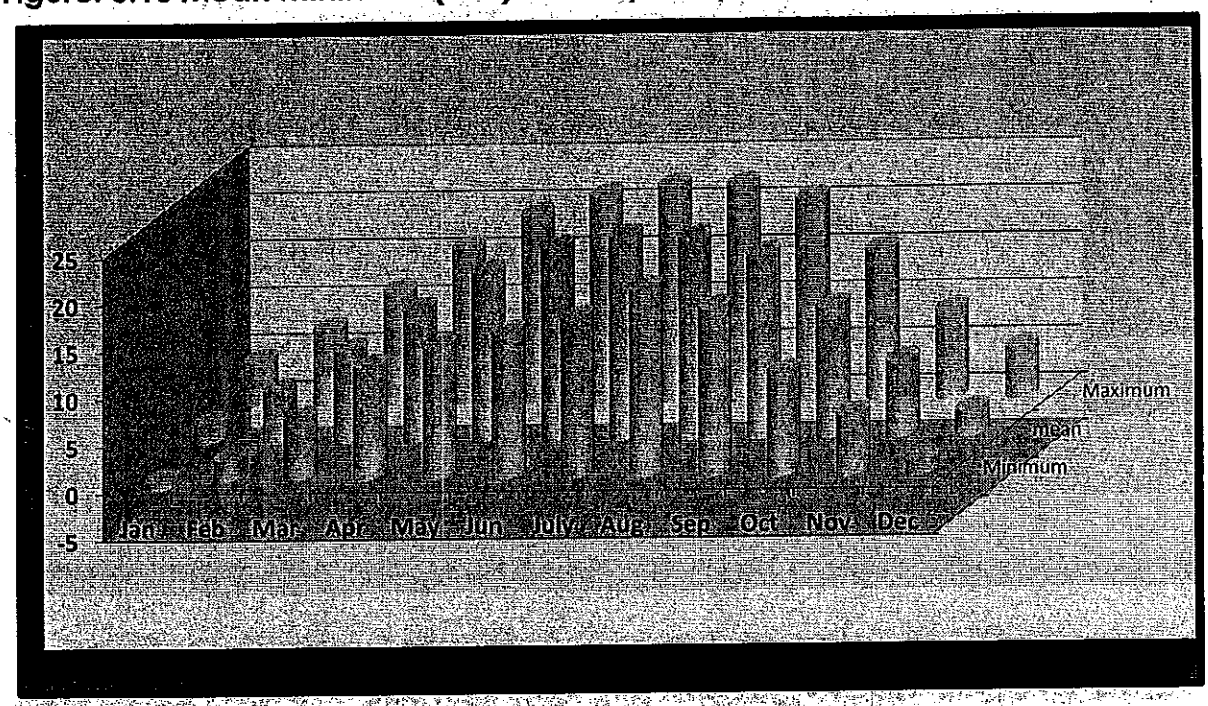


Figure: 5.18 Mean Minimum (Min) Monthly Temperature (C⁰) years 2004 to 2015



Tables: 5.11 & **Table: 5.12** and **Figure: 5.17** & **Figure: 5.18** show that the coldest months are January, February, November and December while June, July, August and September are the months of high temperature. Months of April and October are the months of normal temperature. Based on the data for the period 2004 through 2015, the lowest temperature is in the month of January is -1 C⁰. The mean minimum (maxi) temperature is 32.5 C⁰ in the month of June.

The mean monthly temperature for mean maximum and mean minimum is also processed and presented in the **Figure: 5.19.**

Figure: 5.19 Mean Minimum (Min) Monthly Temperature (C⁰) years 2004 to 2015

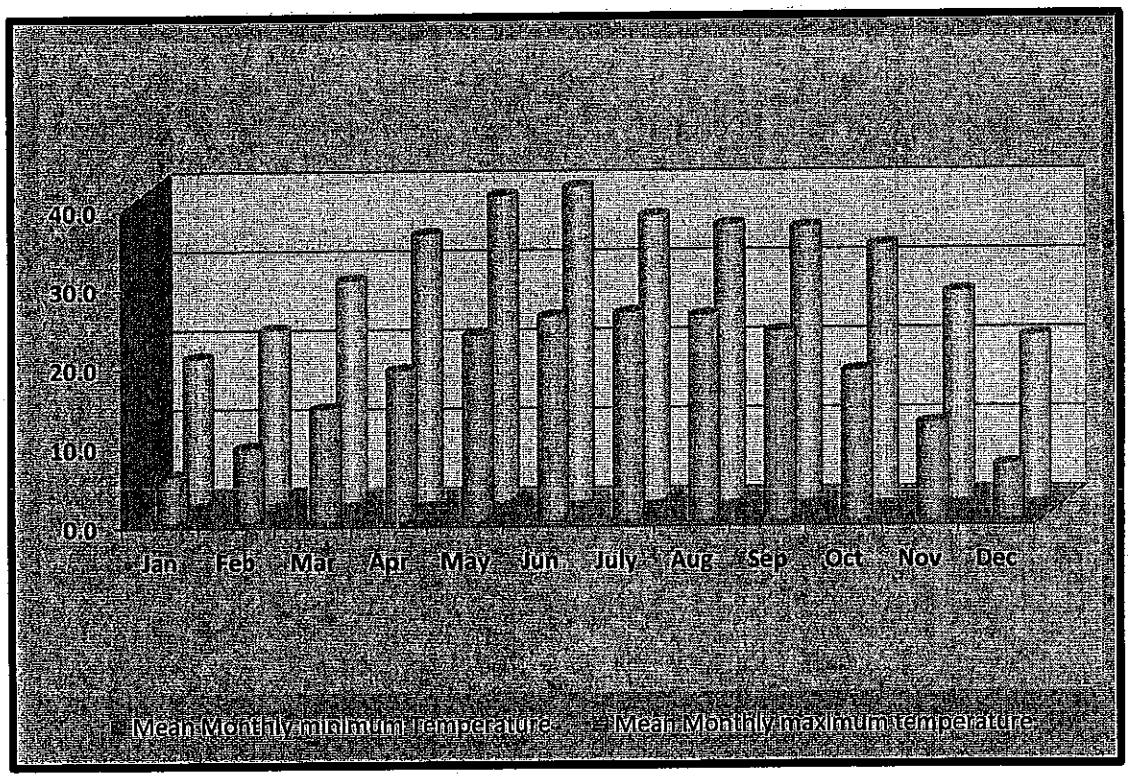


Figure: 5.19 shows that mean temperature (maximum) remain more than 30 C⁰ during the months of April, May, June, July, August, September and October while mean monthly minimum is less than 10 C⁰ in the months of January, February, March, November and December.

5.3. Hydrology

5.3.1. Discharge Data Collection

The daily discharge data of Lower Jhelum Canal Feeder on downstream of its head regulator, Rasul Barrage Downstream flows and Rasul Power Channel have been collected from the office of Executive Engineer and Sub Divisional Officer LJC, Irrigation and Power (I&P) Department, Government of Punjab at Rasul Barrage. Few information about hydrological data was also collected from Discharge Division, Irrigation and Power Department, Government of Punjab from Lahore offices. The collected data along with respective period is mentioned in **Table: 5.13.**

Table: 5.13 Discharge Data

Sr. #	Site / Location	Description	Period	Source
1.	LJC at Head	Discharge on daily basis	1987– 2015	I & P Punjab
2.	RPC	Discharge on daily basis	1987– 2015	I & P Punjab
3.	Rasul Barrage	D/S Discharge on daily basis	1987– 2015	I & P Punjab

During data processing for quality, it was found that discharge and water level data from 1987 to 2002 cannot be used for further analysis due to incomplete and having a lot of discrepancies. Therefore, data for the period 2003 through 2015 was entered into computer files for processing. The processed discharge data is presented **Annexure: 5.8**, for LJC Feeder, **Annexure: 5.9** for LJC discharge and **Annexure: 5.10** of Rasul Power Canal, respectively.

5.3.2. Water Levels Data

Gauge data recorded at upstream of Rasul Barrage was collected from the site office of Sub Divisional Officer, Irrigation and Power Department, Govt. of Punjab for the period 1987-2015. The collected data along with respective period is mentioned in **Table: 5.14.**

Table: 5.14 Water Level Data

#	Site / Location	Description	Period	Source
1.	Rasul Barrage	Pond Level and D/S Water Level	1987– 2015	I & P Punjab

The data for the period 1987 to 2002 was not processed due to incomplete and a lot of discrepancies. Therefore, data for the period 2003 through 2015 was

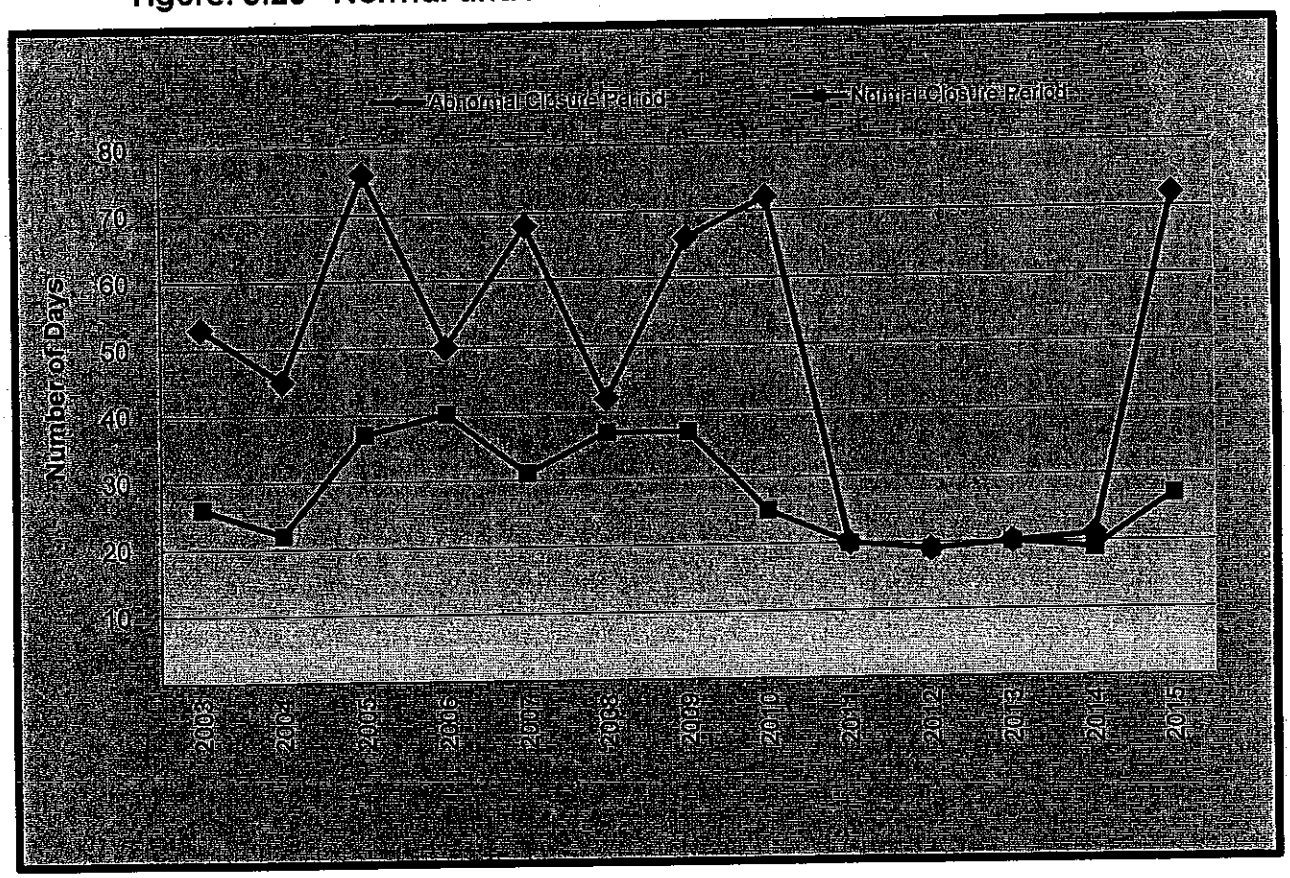
processed. The processed water level data is presented in **Annexure: 5.11** for Rasul Barrage Pond. Downstream water level of LJC Head-regulator and RQ Link is not available with Irrigation and Power Department. Discharge rating curve for RQ link and LJC Feeder is also not available at site. Discharge measurement into Link and Feeder is being controlled by gate opening and by using rating curve and Gibson coefficient for Rasul Barrage with hit and trail method.

5.3.3. Closure periods of LJC Feeder

It is well known that the irrigation system of Punjab remains closed from last week of December to second last week or end of January every year for maintenance. The same is with Lower Jhelum Canal Feeder. Mostly the Lower Jhelum Canal Feeder remains closed for maintenance purposes for about 22 to 40 days in the months of December and January. The canal closure usually starts from the last week of December till the end of January. This closure is named as normal closure period because the analysis of data for the period 2003-2015 shows that canal also remained close in other parts of the year.

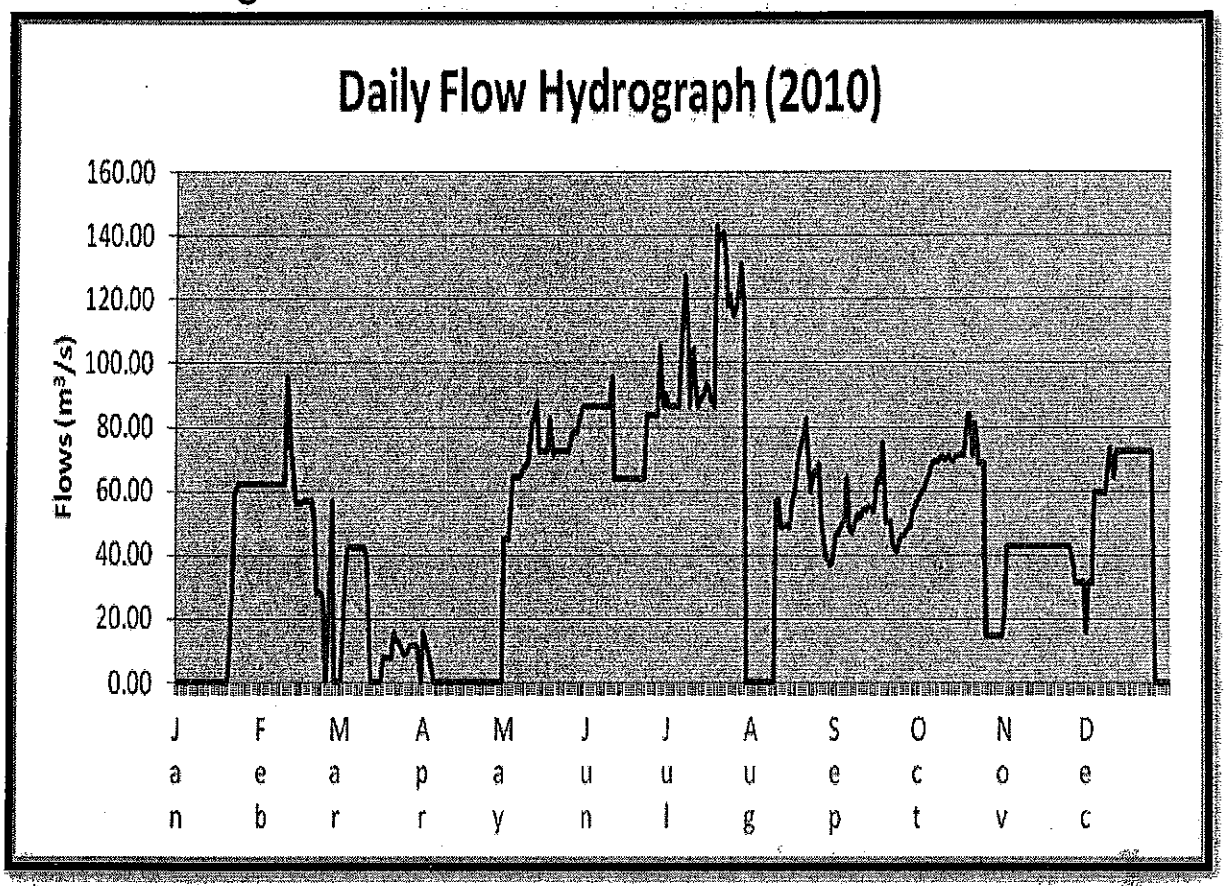
Figure: 5.20 shows that the feeder closure normally ranges from 22-40 days, which invariably starts from 26th of December each year and end at January. The average normal closure period is 33 days.

Figure: 5.20 Normal and Abnormal Closure Periods of LJC Feeder



Canal also remained closed in other months as can be seen in data period 2003-2015, this is abnormal closure which may be due to rain in the area of irrigation. The abnormal closure period is ranging between 5 to 47 days per year. However, average abnormal closure period is 28 days per year. The detail of the normal and abnormal closures for the period 2003-2015 is also shown graphically in **Figure: 5.20.**

Figure: 5.21 Abnormal Closure Periods of LJC Feeder



Pattern of typical abnormal closures is shown in **Figure: 5.21** for the year 2010. However, due to unknown reasons, there is a repeated abnormal closure of LJC feeder during the months of March/April/August shown in **Figure: 5.21**. It can be seen from **Table: 5.15** that canal never remained close during the months of May, June and November for period 2003-2015.

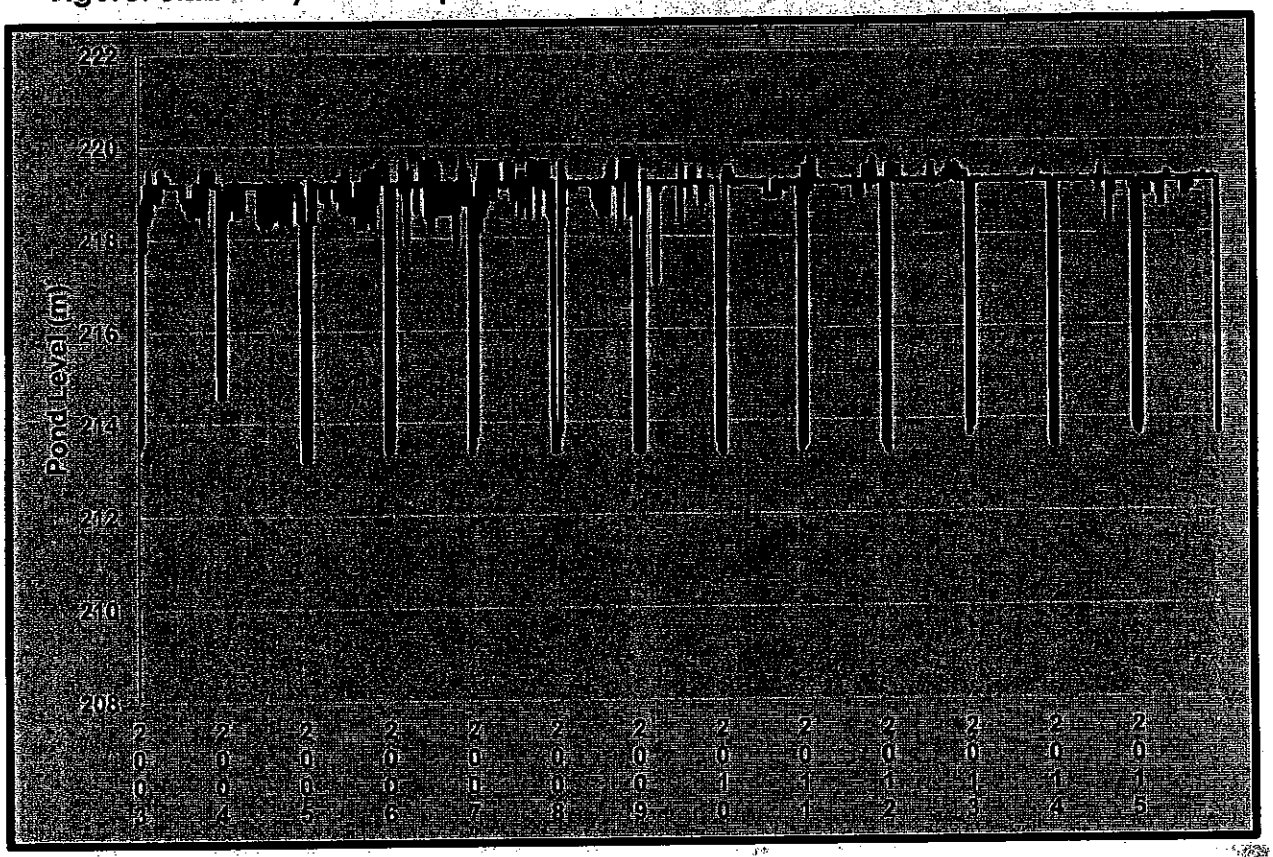
5.3.4. Water Level Data Analysis

5.3.4.1. Upstream Water Level

The collected daily gauge data from Executive Engineer Rasul Barrage Office at Rasul for Rasul Barrage was digitized and processed for the period 2003-2015which is presented in **Annexure: 5.12**. It has been observed from the upstream water levels of Rasul Barrage that Barrage pond has a fluctuation of up to 0.15 m (6 inches) between the water levels observed during morning and evening. This may be attributed to the peaking flows generated at Mangla Power House, which are stored in the Rasul Barrage Pond for further regulation in the canals or downstream to meet the irrigation requirement as per Indus River System Authority (IRSA) indent. The daily upstream pond levels are presented in **Figure: 5.22. Figure: 5.22** shows that pond level varies between 213.25 m to 219.75 m.

Comparison of upstream pond levels at Rasul Barrage during various years is presented in **Figures: 5.23, Figures: 5.24** and **Figure: 5.25.** The pond level remains minimum during the months of January and December because of the canal closure period.

Figure: 5.22 Daily Mean Upstream Pond Levels of Rasul Barrage (2003-2015)



Below Figures shows that during the month of July, August and September the Pond level is less than 219.00. The same trend is also seen during the month of February, March and April. During the months of November and December the pond levels are at maximum. However, the pond level remains around 219.00 most of the time.

Figure: 5.23 Comparison of Daily Pond Levels of Rasul Barrage (2003-2006)

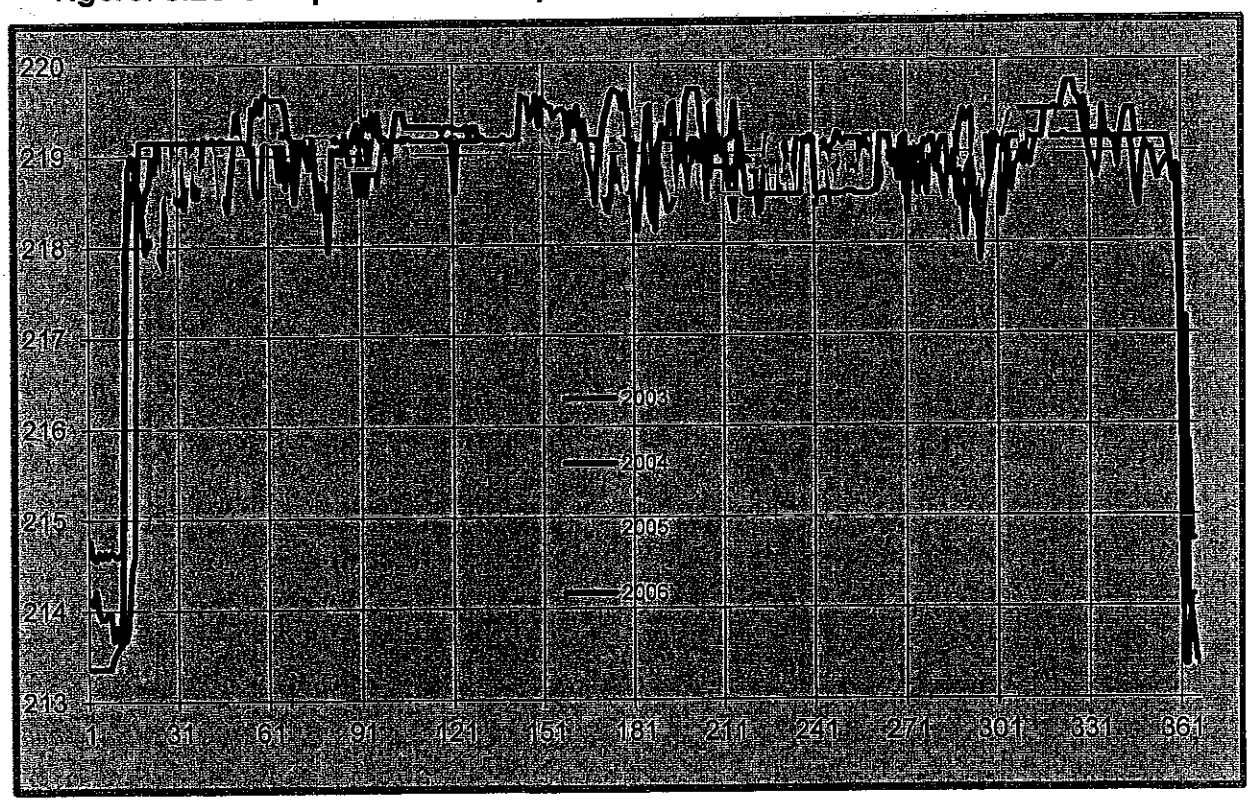


Figure: 5.24 Comparison of Daily Pond Levels of Rasul Barrage (2007-2010)

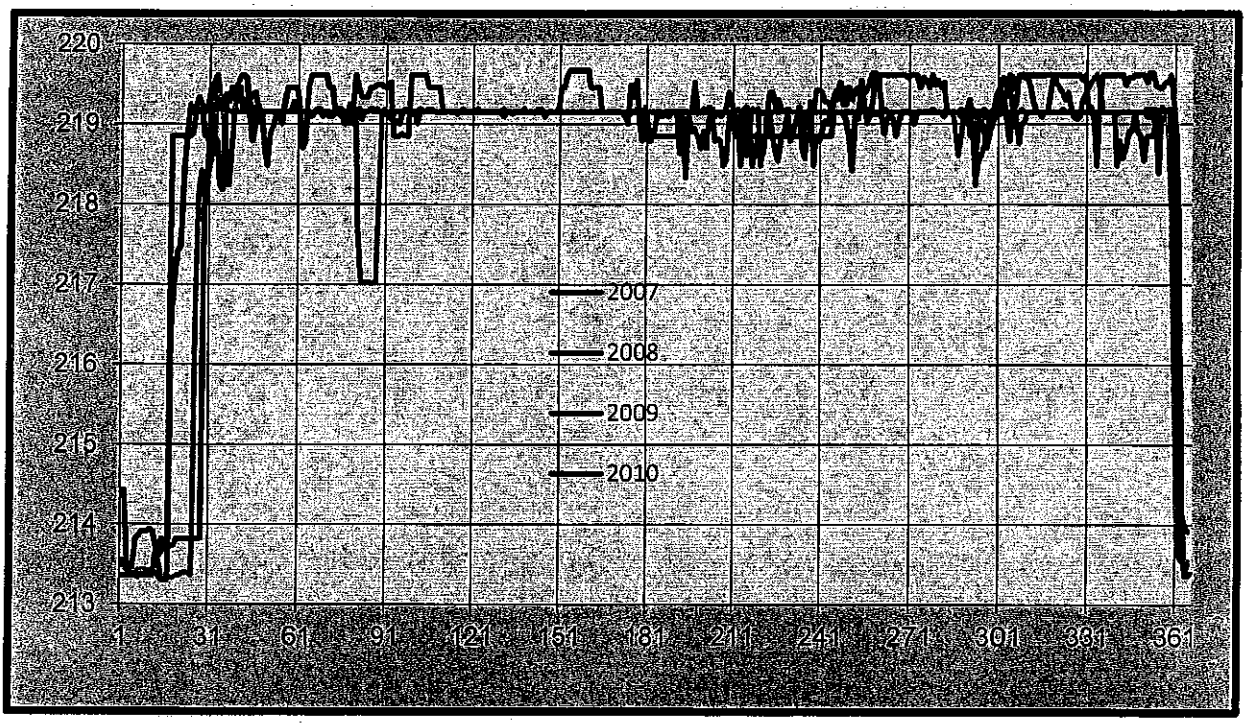
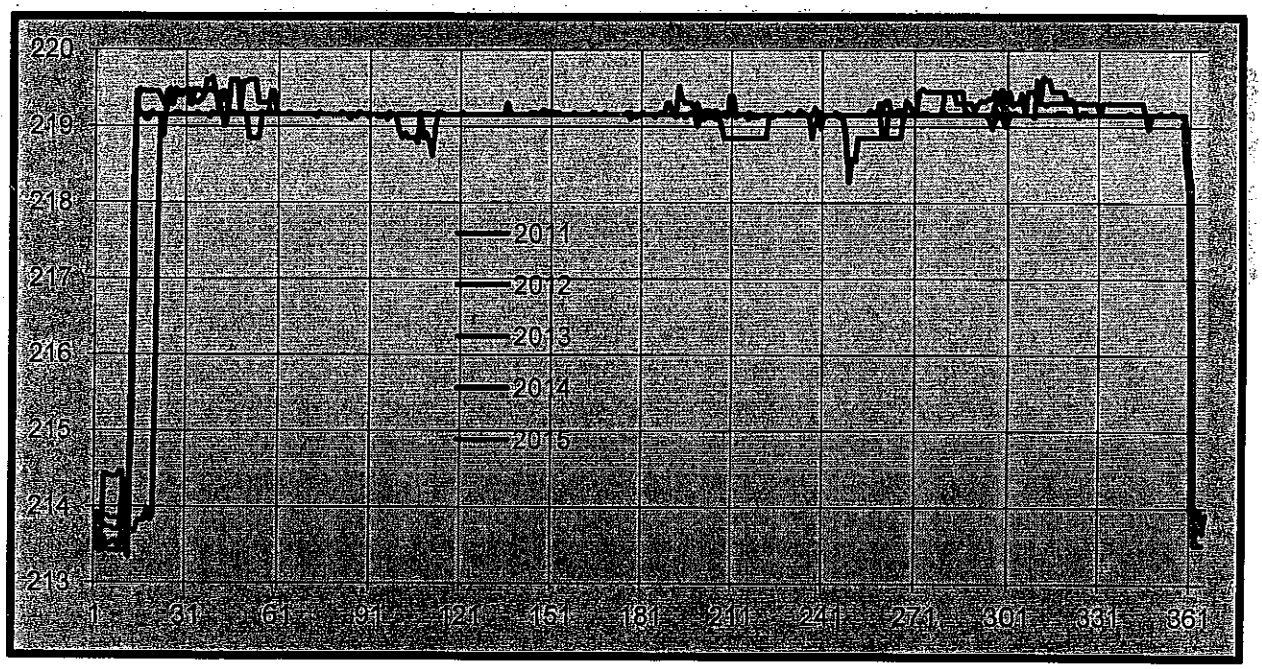


Figure: 5.25 Comparison of Daily Pond Levels of Rasul Barrage (2011-2015)

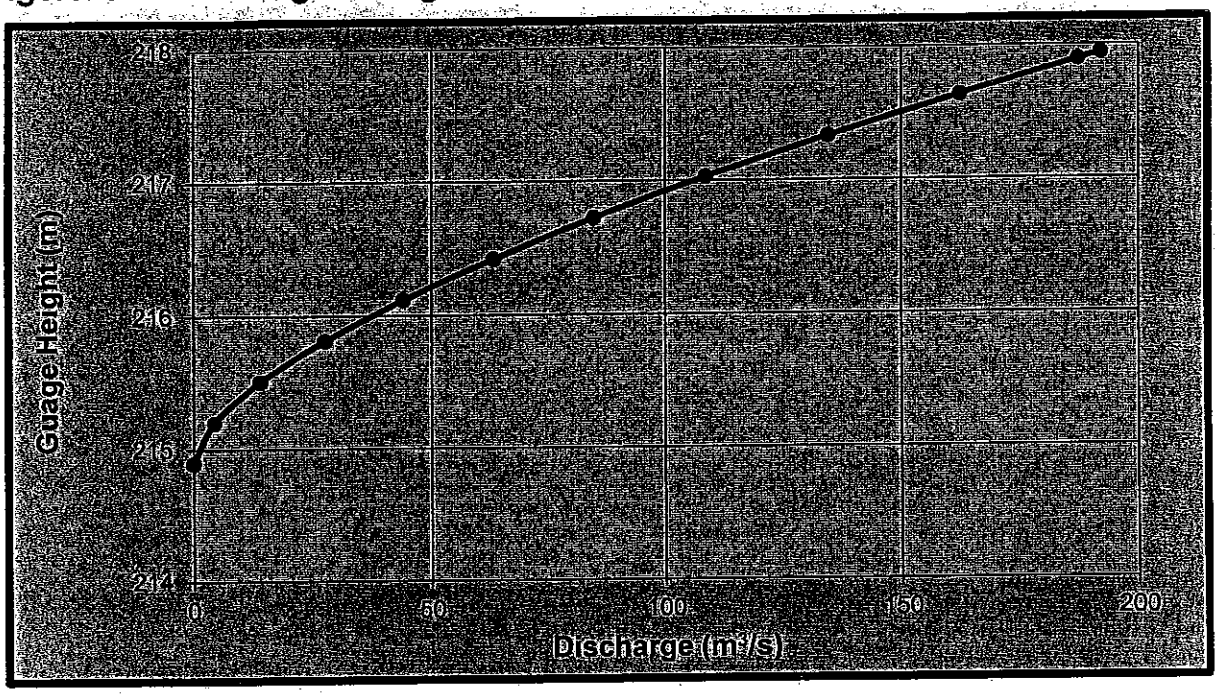


5.3.4.2. Downstream Water Level at Head Regulator of LJC Feeder

The measurement gauge is installed on the downstream of Head-regulator of Lower Jhelum Canal Feeder. However, no water level is being recorded downstream of LJC Feeder Headregulator. This rating curve is shown in **Figure: 5.26** has been verified by comparing with actual observed data of discharges, which showed a reasonable agreement. However, as mentioned above no downstream rating curve is available for LJC Feeder for measuring discharge from measured downstream water level. Discharge into LJC Feeder and RQ Link is being controlled

by gate opening and gating opening is being fixed by using Rasul Barrage Rating Table and Gibson coefficients.

Figure: 5.26 Discharge Rating Curve – Downstream of LJC Feeder Headregulator



The data of this rating curve is presented in **Table: 5.16.**

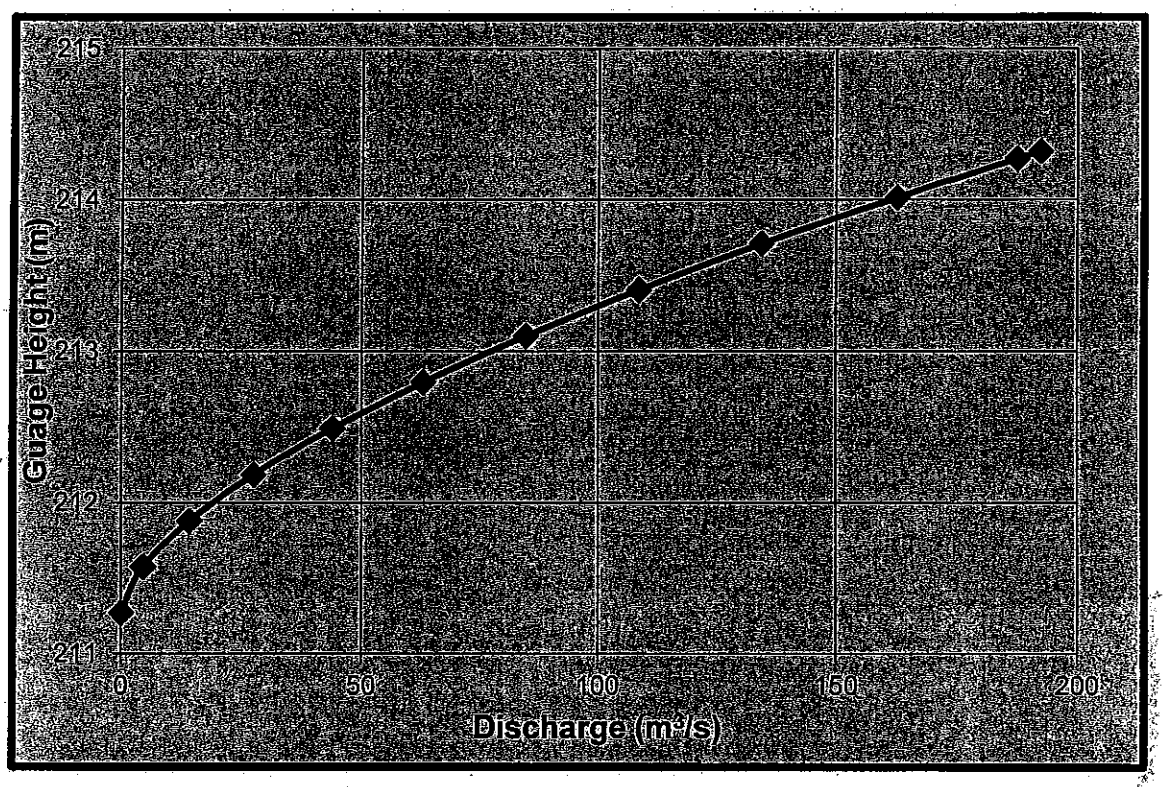
Table: 5.16 Discharge Rating Table at D/S of Head-regulator of LJC Feeder

Gauge (ft)	Discharge (ft³/s)	Gauge (m)	Discharge (m³/s)
705.03	0	214.89	0
706.03	159	215.20	4.50
707.03	499	215.50	14.13
708.03	970	215.81	27.47
709.03	1551	216.11	43.92
710.03	2228	216.42	63.09
711.03	2991	216.72	84.71
712.03	3834	217.03	108.58
713.03	4751	217.33	134.54
714.03	5737	217.64	162.46
714.87	6615	217.89	187.35
715.03	6788	217.94	192.24

5.3.4.3. Downstream Water Level at RD 10+000 of LJCF

A rating curve has been developed for RD 10+000 of the LJC Feeder, which is shown in **Figure: 5.27**. The rating curve has been developed on the basis of head-regulator downstream rating curve by using the bed level of LJC Feeder canal at RD 10+000.

Figure: 5.27 Discharge Rating Curve at RD 10+000 of LJC Feeder



The rating curve **Figure: 5.27** will be used to determine the tail water rating curve downstream of proposed power house after bed lowering between powerhouse and RD 8+626.

5.3.4.4. Head Losses in the Head Race Channel

The preferred location for the power house is at RD 2+000 of the LJC Feeder. The portion of LJC feeder from upstream its head regulator up to the upstream side of power house has been termed as the head race for the proposed powerhouse. The upstream water level at the power house can be determined by deducting the head losses in the head race from the pond level of Rasul Barrage.

A major head loss in the head race of power house occurs when the flow passes through the head regulator of the Feeder. This loss is due to the fact that the head regulator acts as a major constriction in flow area. A head across is essential for the passage of flows through this contraction. In addition, there will be head loss due to friction and bed profile of the LJC Feeder which is a minimum.

5.3.4.5. Upstream Water Levels at Proposed Powerhouse at RD 2+000

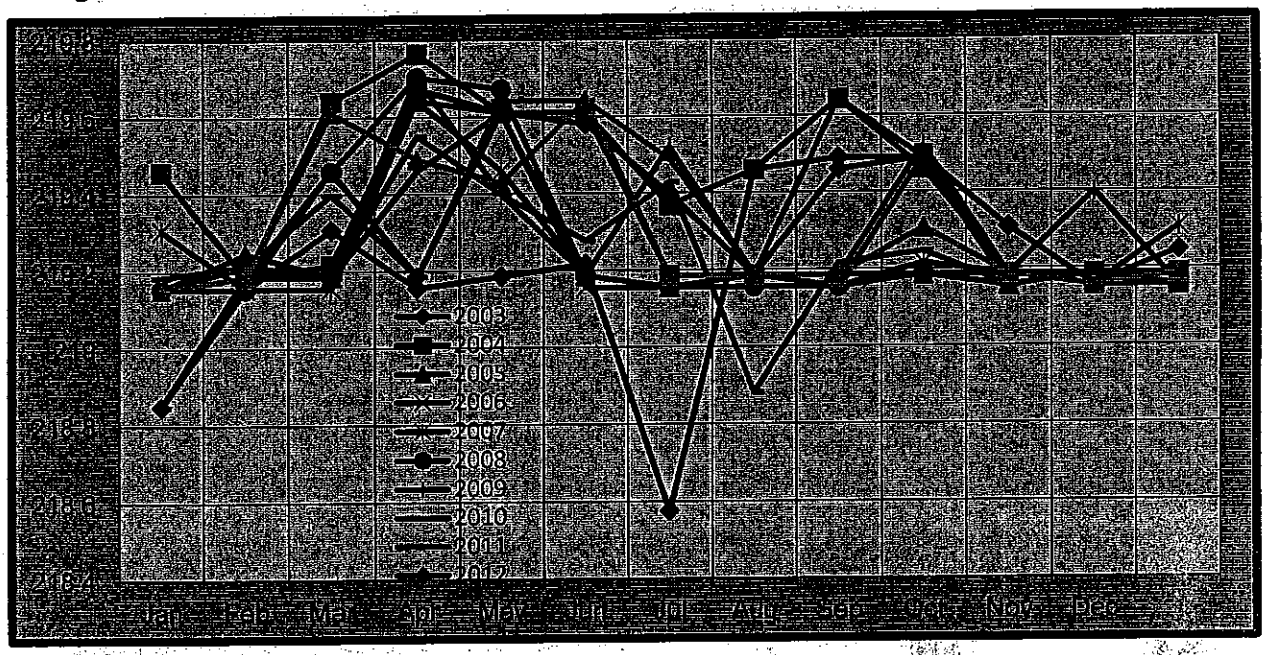
It has been concluded that head available at headregulator and RD 8+626 would be combined. It would be done by excavating the bed of LJC Feeder between RD

8+626 & proposed powerhouse location (RD 2+000) and extending the Rasul Barrage Pond level by raising the canal bed and banks of LJC Feeder between headregulator and proposed powerhouse.

To maximize the power and energy potential of the proposed hydroelectric power project, two options as below for upstream pond level would be studie:

- Option 1: Historic Pond levels
- Option 2: Pond level Constant at 219.40 m.a.s.l

Figure: 5.28 Maximum Mean Daily Pond Levels of Rasul Barrage (2003-2015)



The possibility of having a fixed upstream pond level at Rasul Barrage was explored. It was noted that morning and evening pond variation is in the tune of 0.15 m which shows that pond is acting as re-regulating reservoir in case of Mangla Powerhouse is operating under peaking load conditions.

The maximum pond level variation for the years 2003 through 2015 have been examined critically from **Figure: 6.28** and concluded that average maximum pond levels varies between 219.20 m.a.s.l and 219.40 m.a.s.l most of the time except the months of October through December and February. Maximum pond level during years 2006 remained about 219.5 m.a.s.l most of the time except October when it lower down to 219.20 m.a.s.l. However, pond levels during 2007 remained 219.60 m.a.s.l most of the time except July and August when it dropped to 219.40 m.a.s.l.

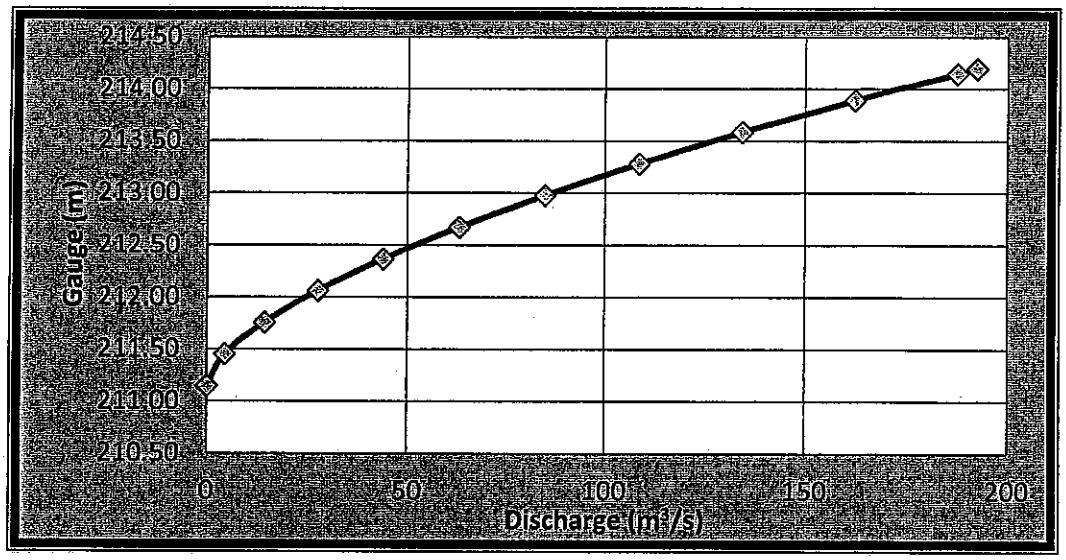
Therefore it is concluded that pond levels of the Rasul Barrage should be operated at 219.40 m.a.s.l and in case of peaking operation of Mangla Power Station it could be raised up to 219.55 m.a.s.l which is still lower than the highest level observed 219.70 m.a.s.l.

5.3.4.6. Downstream Water Levels at Proposed Powerhouse at RD 2+000

For downstream water level the modified rating curve on the basis of canal bed lowering between RD 8+626 and proposed powerhouse may be at RD 2+000. The existing rating curve being used for level and discharge measurement at Lower Jhelum Canal Feeder head regulator would be modified in such a way that all level

would be lowered, equalize to excavated depth between RD 8+626 and RD 2+000, the location of the proposed powerhouse. The rating curve so established is shown in **Figure: 5.29**, which will be used for calculation of gross head available for power generation.

Figure: 5.29 Discharge Rating Curve D/S of Power House at RD 2+000 of LJC Feeder



The data of this rating curve is presented in **Table: 5.17.**

Table: 5.17 Discharge Rating Table at D/S of Proposed Powerhouse at RD 2+000

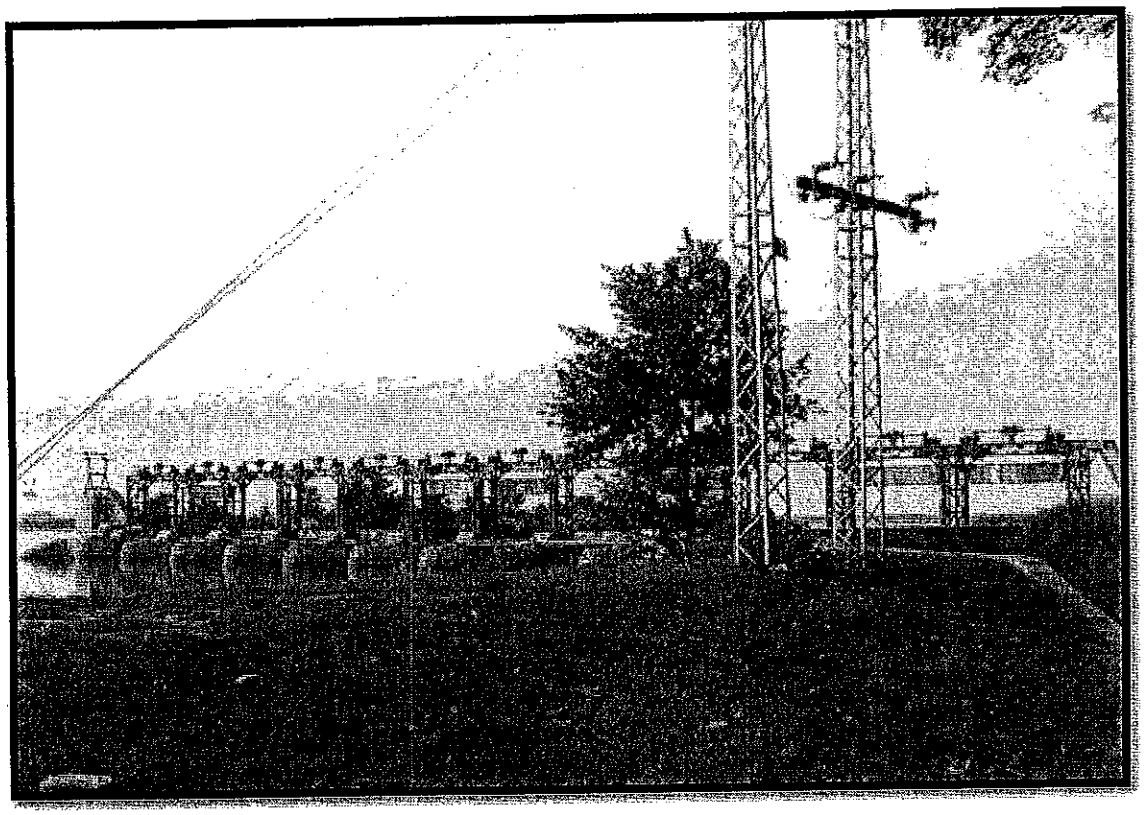
Gauge (ft)	Discharge (ft³/s)	Gauge (m)	Discharge (m³/s)
693.88	0	211.49	0
694.88	159	211.80	4.50
695.88	499	212.10	14.13
696.88	970	212.41	27.47
697.88	1551	212.71	43.92
698.88	2228	213.02	63.09
699.88	2991	213.32	84.71
700.88	3834	213.63	108.58
701.88	4751	213.93	134.54
702.88	5737	214.24	162.46
703.72	6615	214.49	187.35
703.88	6788	214.54	192.24

5.4. Lower Jhelum Canal Feeder - Flows Availability Analysis

5.4.1. General

Rasul Barrage and its canal system is one of the oldest system built during 1910 in sub-continent. Initially, only Lower Jhelum Canal was off-taking from Rasul Head Works (**Figure: 5.30**) from its left pocket.

Figure: 5.30 View of Old Rasul Headwork



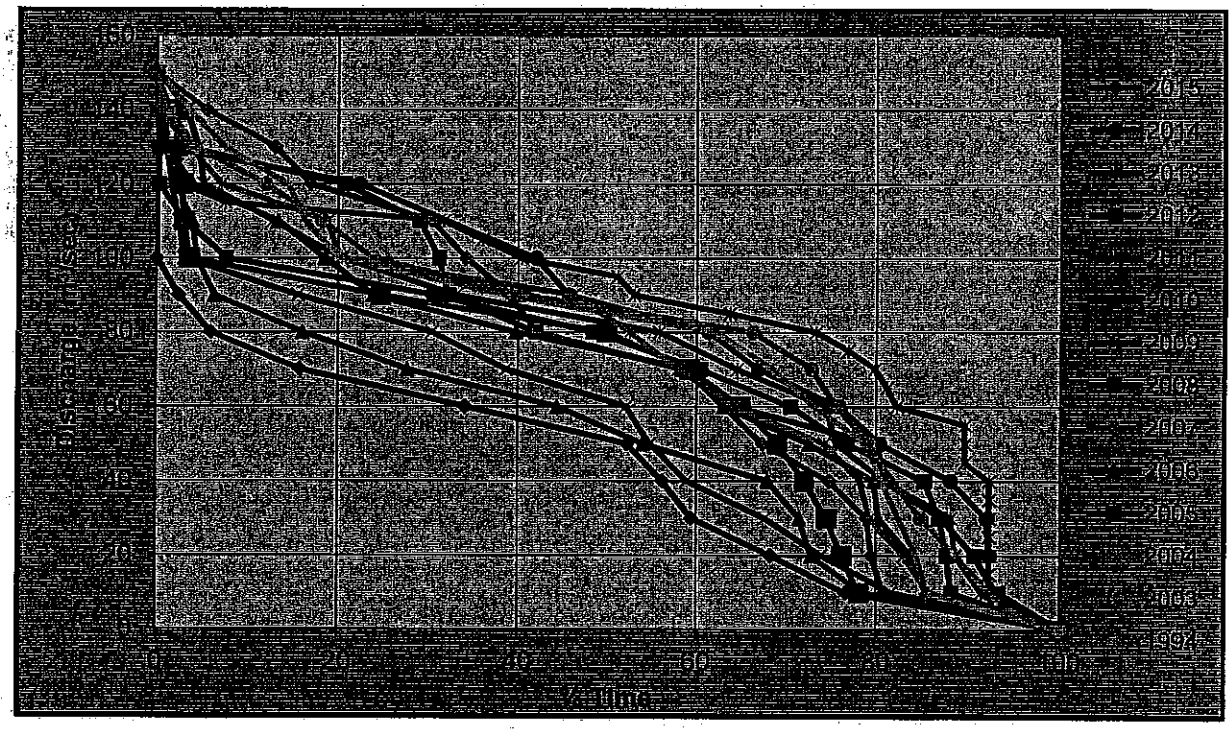
The Old Rasul Headwork was replaced during 1967 by new Rasul Barrage being aged structure and also to meet the water supplies of the Eastern River as result of Indus Basin Treaty between Pakistan and India. Therefore Rasul Barrage was constructed some km downstream of Old Headwork. Rasul Barrage along with Rasul-Qadirabad link canal which transfer the waters of Jhelum River in to River Chenab, River Ravi and hence to River Sutlej via link system also constructed as Indus Basin Replacement works. Rasul-Qadirabad Link is also off-taking from left pocket of the Barrage.

The designed capacity of Lower Jhelum Canal Feeder is 187 m^3/s. But after construction of Rasul Hydropower Station, it is operating to augment the flows requirement of Lower Jhelum Canal in addition to flows of Tailrace of Rasul Power Station which is joining at RD10+000 of Lower Jhelum Canal Feeder. Therefore, the part of Lower Jhelum Canal between Head-regulator and RD 10+000 is now acting as feeder canal to meet the irrigation requirements of the Lower Jhelum Canal in addition to flows from Rasul Power Station. Rasul Power Station is being fed from Upper Jhelum Canal which is off-taking from Bong Canal just downstream of Mangla Dam.

It is well known fact that the Upper Jhelum Canal (UJC) was not operating at full capacity due to non-availability of spillway at Rasul Power Station for bypassing the water flows during the shutdown of the power station and has to accommodate these flows of Rasul Power Station in lower part of Upper Jhelum Canal resulting in silting up of UJC downstream of Rasul Power Channel. Therefore, the additional requirements of flows in Lower Jhelum Canal were met through Lower Jhelum Canal Feeder.

Now the spillway at Rasul Power Station had been constructed and Rasul Power Station is being operated safely at its full Capacity. It is important to note that due to aging of turbo-generator units, the Rasul Power unit can utilize full allocated discharge (3600 ft^3/s) but can produce only 18 MW instead of 22 MW installed capacity. Therefore, less discharges are being passed through Lower Jhelum Canal Feeder since the construction of RPH spillway in 2005. However, it is well known fact that Rasul Spillway starts function properly from August 22, 2014 after conversion of siphon spillway into gated spillway. This has been proved during analysis of historic operation of the Upper Jhelum Canal System and Lower Jhelum Canal Feeder. Flows analysis is presented in **Figure: 5.31**. **Figure: 5.31** shows that discharges in Lower Jhelum Canal Feeder during the year of 1994 are higher than the discharges during 2003 through 2015 except the flows in years 2013 & 2014. The flows in year 2015 are the lowest than other years (**Figure: 5.31**).

Figure: 5.31 Comparison of Flows from 2005-2015 with 1994



Therefore analysis of historic flows from 1994 through 2015 show that Lower Jhelum Canal Feeder has two operation scenarios such as:

- Scenario-1: Flows before Construction of Spillway at Rasul Power Station
- Scenario-2: Flows after Construction of Spillway at Rasul Power Station
- Scenario-3: Flows after Actual Operation of Spillway at Rasul Power Station

A third scenario, namely the proposed scenario, will also be considered to analyze LJC Feeder flows, keeping in view, enhanced availability of flows after Mangla Dam

Raising Project in the irrigation system or operation of LJC Feeder during Canal Closure. In these scenario, future modifications like any remodeling of LJC, refurbishment of RPH (up-gradation of electro-mechanical equipment etc.) or addition of third unit at Rasul Power Station and the remodeling of Upper Jhelum Canal may have to be considered.

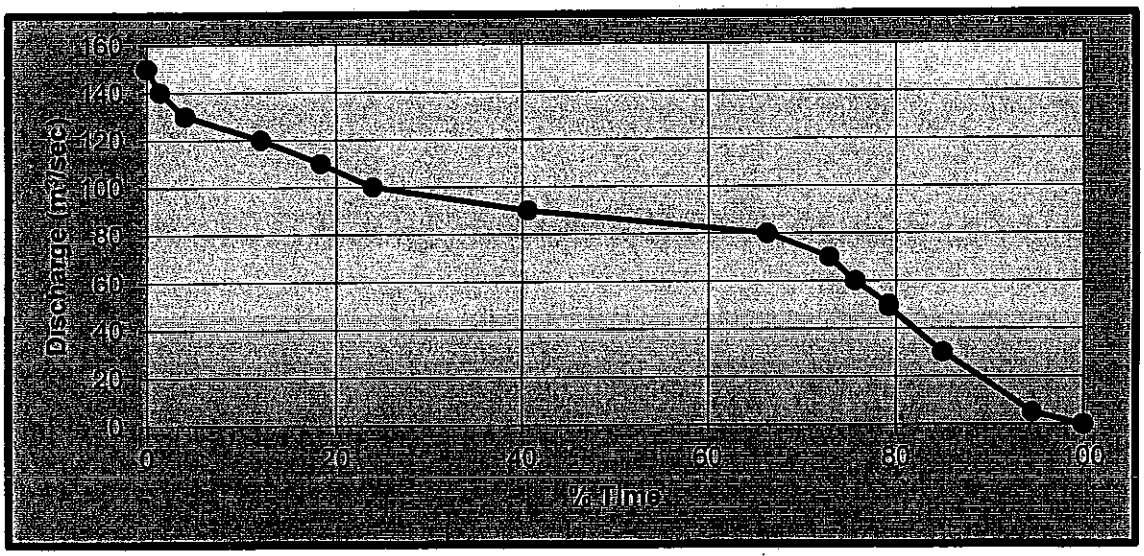
All these possibilities would be discussed with Irrigation and Power Department Government of Punjab and with Hydel Operation of WAPDA, before making any conclusions.

5.4.2. Flow Duration Analysis before Construction of Spillway at Rasul Power Station

Prior to construction and commissioning of spillway at Rasul Power Station, most of the indented demands of Lower Jhelum Canal were being met through headregulator of Lower Jhelum Canal Feeder. This was because Upper Jhelum Canal was being operated at about 1000 ft^3/s less discharge in order to absorb in lower reach of Upper Jhelum Canal, flows generated due to tripping of turbine at Rasul Power Station. It is clearly noted from **Figure: 5.31** that Lower Jhelum Canal Feeder flows for the year 1994 are higher than the flows for the period 2003 through 2015. Analysis of flows for the year 1994 (**Figure: 5.32**) shows:

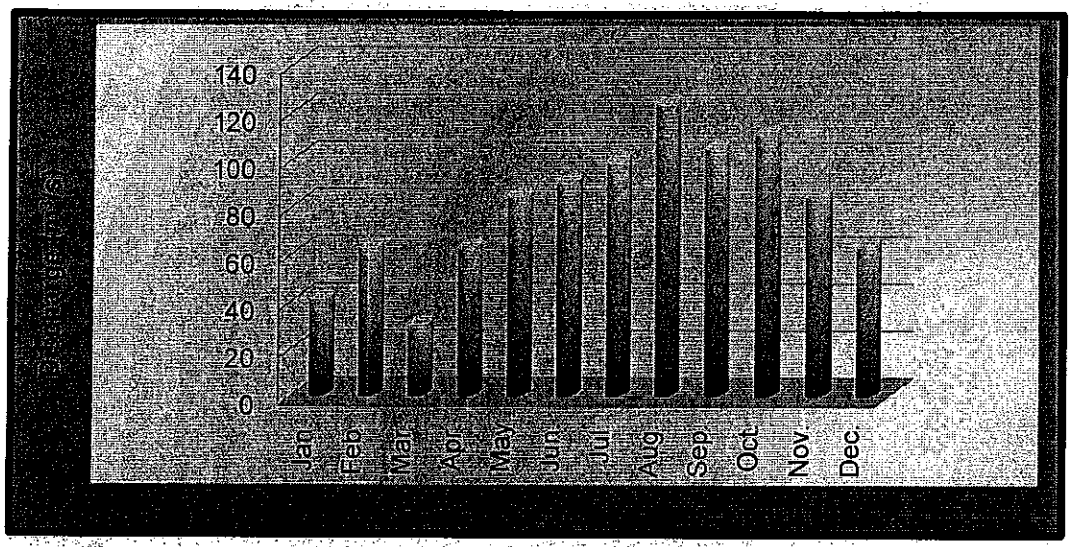
- The canal remained close for 5% of the time
- After canal closure canal discharges remain 25 m^3/s for about 10 % of the time;
- The canal flows changes from 25 m3/s to 80 m^3/s within 15 % of the time;
- The canal flows varies between 80 m3/s to 100 m^3/s for about 45% of the time;
- The canal flows varies from 100 m3/s to 120 m^3/s for about 20 % of the time; and
- The maximum flow passes in the canal was 145 m^3/s.

Figure: 5.32 Flow Duration Analysis for 1994 of Lower Jhelum Canal Feeder



The mean monthly hydrograph for the same year is presented in **Figure: 5.33**. This hydrograph shows that maximum flows were passed during the month of August which is more than 120 m^3/s. Flows remained more than 80 m^3/s for the months of May through November. The flows for the months of February, March and April remained less than 60 m^3/s.

Figure: 5.33 Mean Monthly Hydrograph of LJC Feeder (1994)

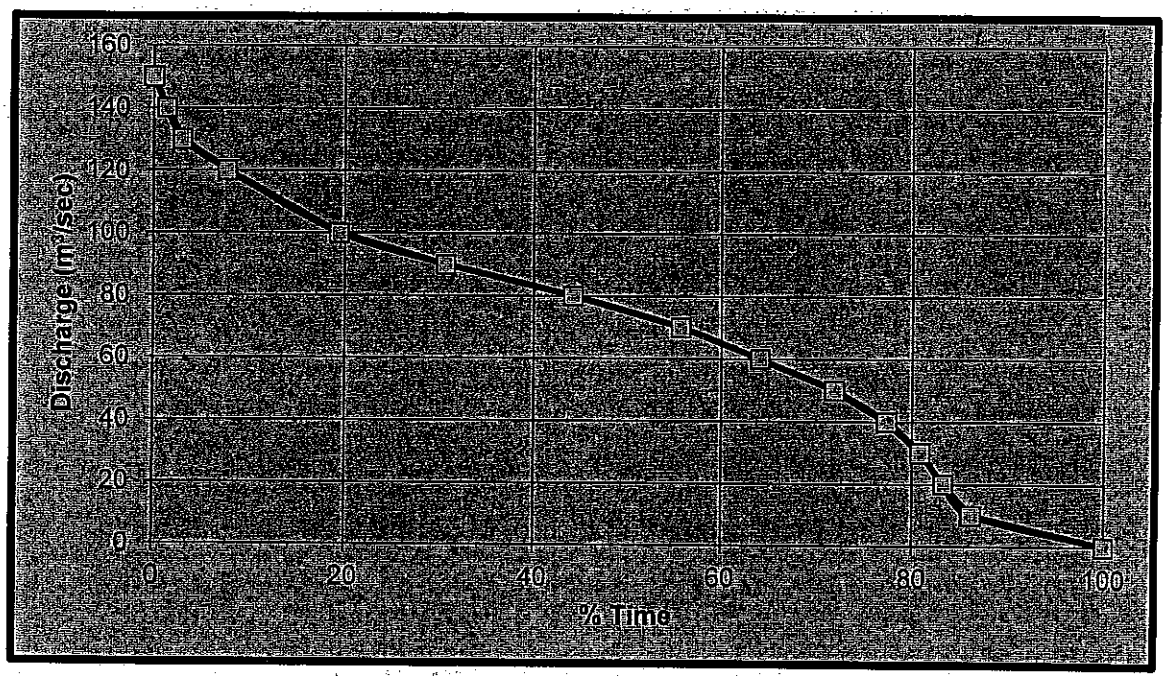


5.4.3. Analysis of Flows in LJC Feeder after Construction of Spillway at Rasul Power Station

The collected data from 2003 to 2015 was processed for hydrograph and flow duration analysis on daily basis for each year (**Annexure: 5.8** & **Annexure: 5.9**). Close examination of the flow duration curves and hydrographs reveals that the flows for the period 2003 through 2015 are almost similar with some decrease or increase depending upon water availability or water demand.

In this case flow duration analysis is made on daily basis using data for the period 2003-2015; the flow duration curve so achieved is shown in **Figure: 5.34**. The flow duration and hydrograph analysis on daily basis for each year was also developed and presented in **Annexure: 5.8** & **Annexure: 5.9**.

Figure: 5.34 Flow Duration Analysis (Daily Basis) for the Period 2003-2015



The flow duration analysis for different scenario such as 2003-2015, 2006-2015, 2006-2014 and 2010-2014 were made and presented in **Figure: 5.35**.

Figure: 5.35 Flow Duration Analysis for Different Scenarios

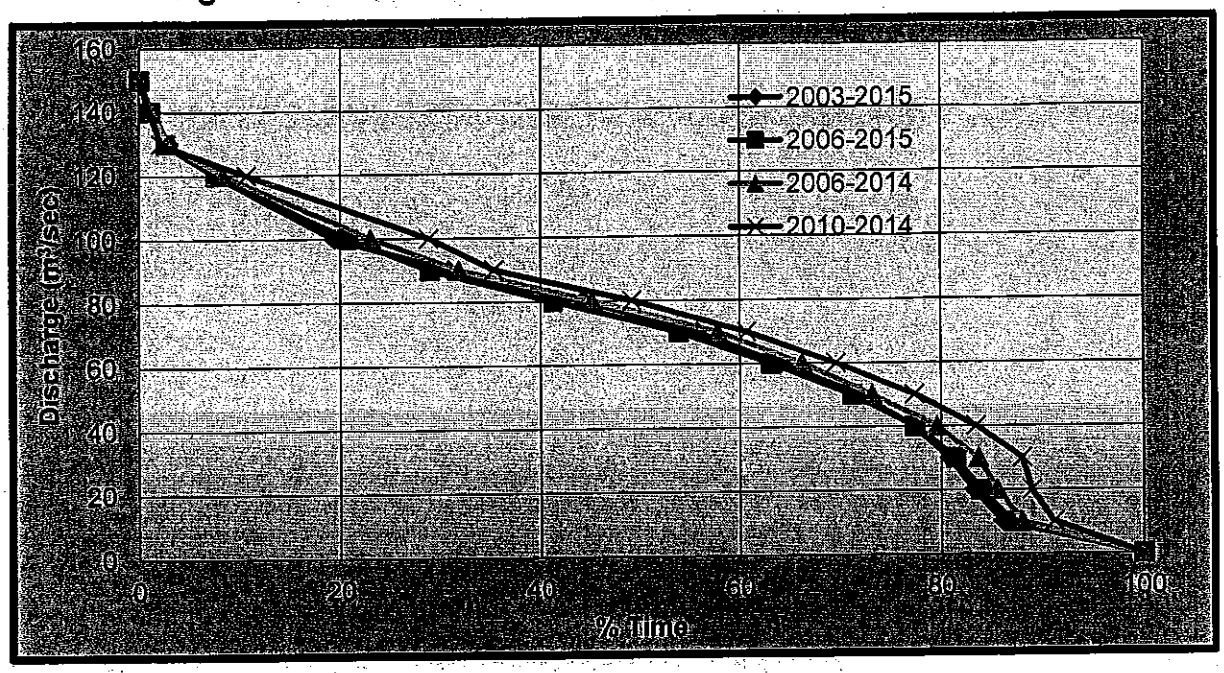
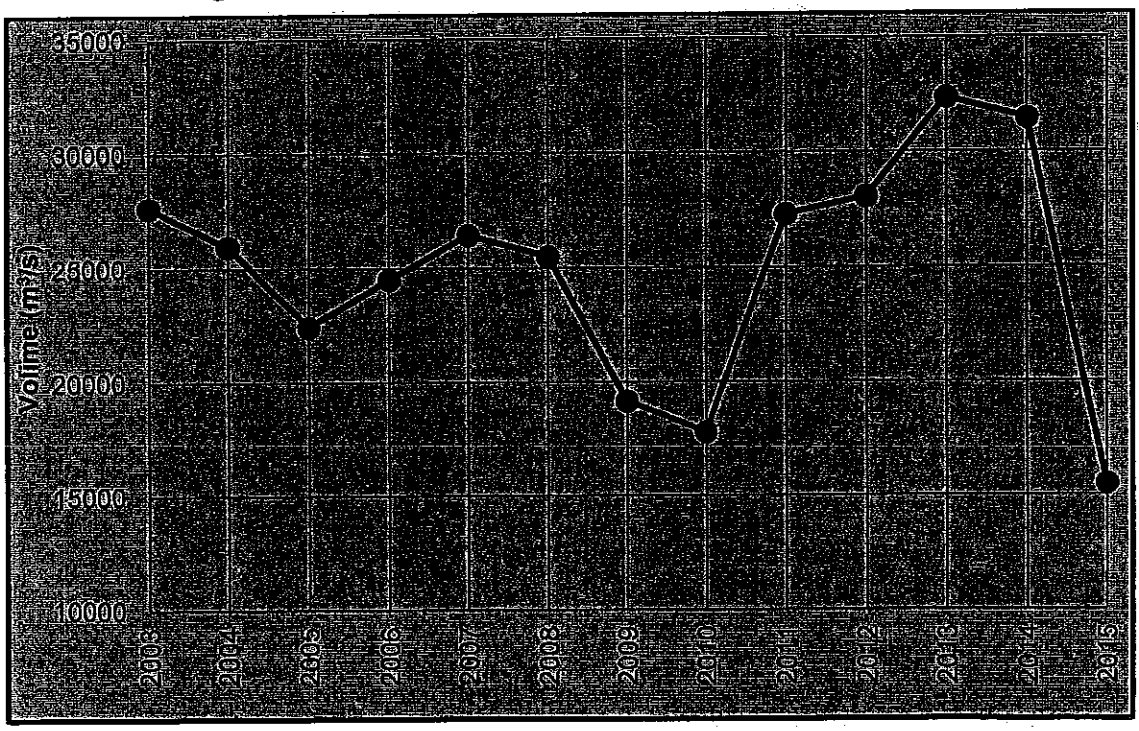


Figure: 5.33 shows that flow availability for period 2010-2014 is the highest while for period 2003-2015 and 2006-2015 is almost similar. However, the flow availability for period 2006-2014 is in the middle of other two scenarios.

5.4.3.1. Analysis of Flows for Dry, Wet and Mean Year

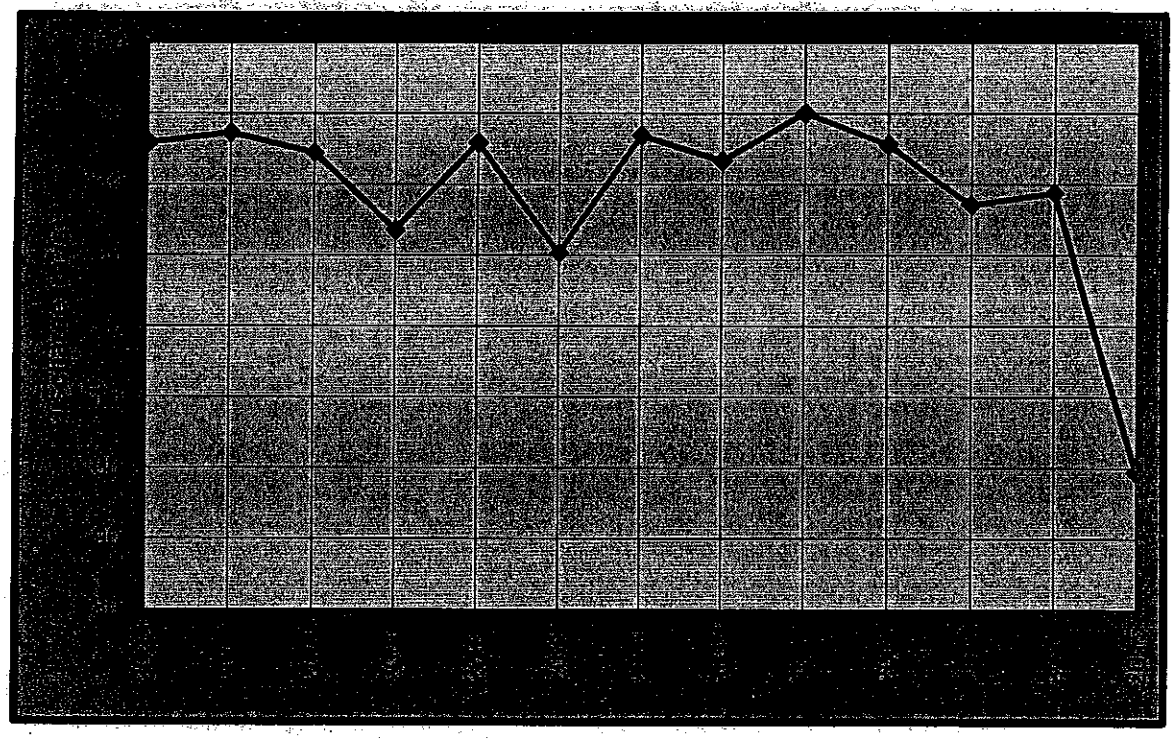
The collected data for the period 2003-2015 is also processed for volume of flows (**Figure: 5.36**) in a year in order to determine dry, wet and mean years. The **Figure: 5.36** shows that the flows in year 2015 is the minimum and thus be considered as dry (**Figure: 5.39**), while 2013 gives the maximum and termed as wet year (**Figure: 5.38**). The year 2006 is the mean year (**Figure: 5.40**).

Figure: 5.36 Yearly Volume of Water in LJC Feeder



The maximum flows through the LJC Feeder are usually during the months of July and August, however, in some year it is in months of May, June and September.

Figure: 5.37 Daily Maximum Discharge in LJC Feeder



During the period of 2003-2015, the daily maximum flows in the Feeder for each year are shown in **Figure: 5.37.** The figure shows that maximum flow passed through the feeder during this period is 150.65 m^3/s on August 6, 2003.

The daily flow duration analysis for wet, dry and average years are presented in **Figures: 5.38**, **Figure: 5.39** and **Figure: 5.40**, respectively.

Figure: 5.38 Flow Duration Analysis for Wet Year (2013)

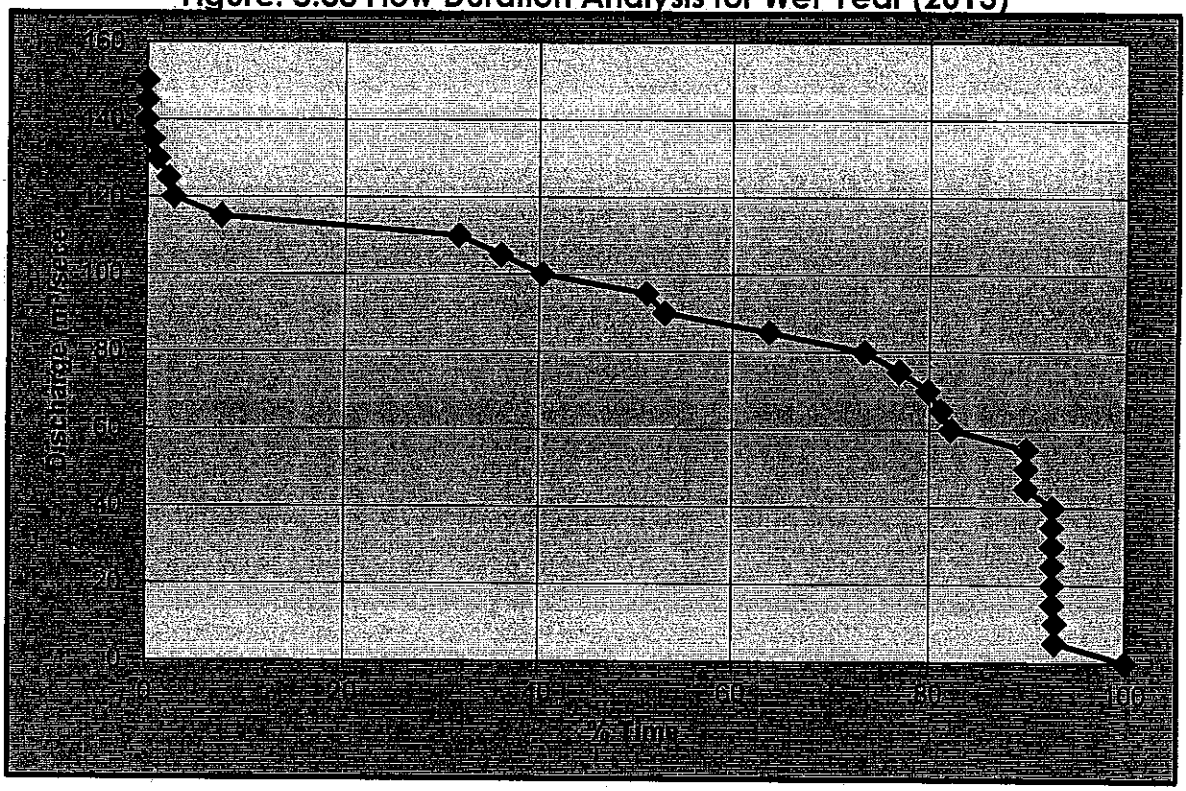


Figure: 5.39 Flow Duration Analysis for Dry Year (2015)

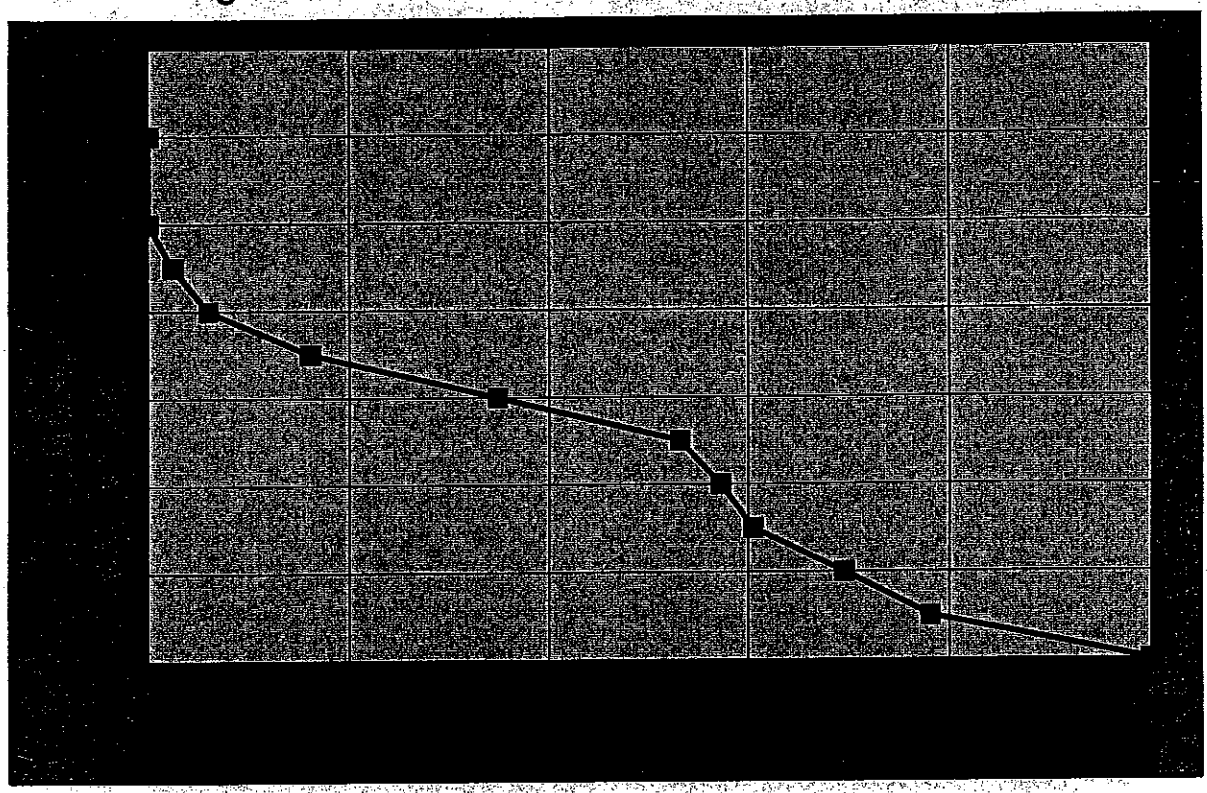
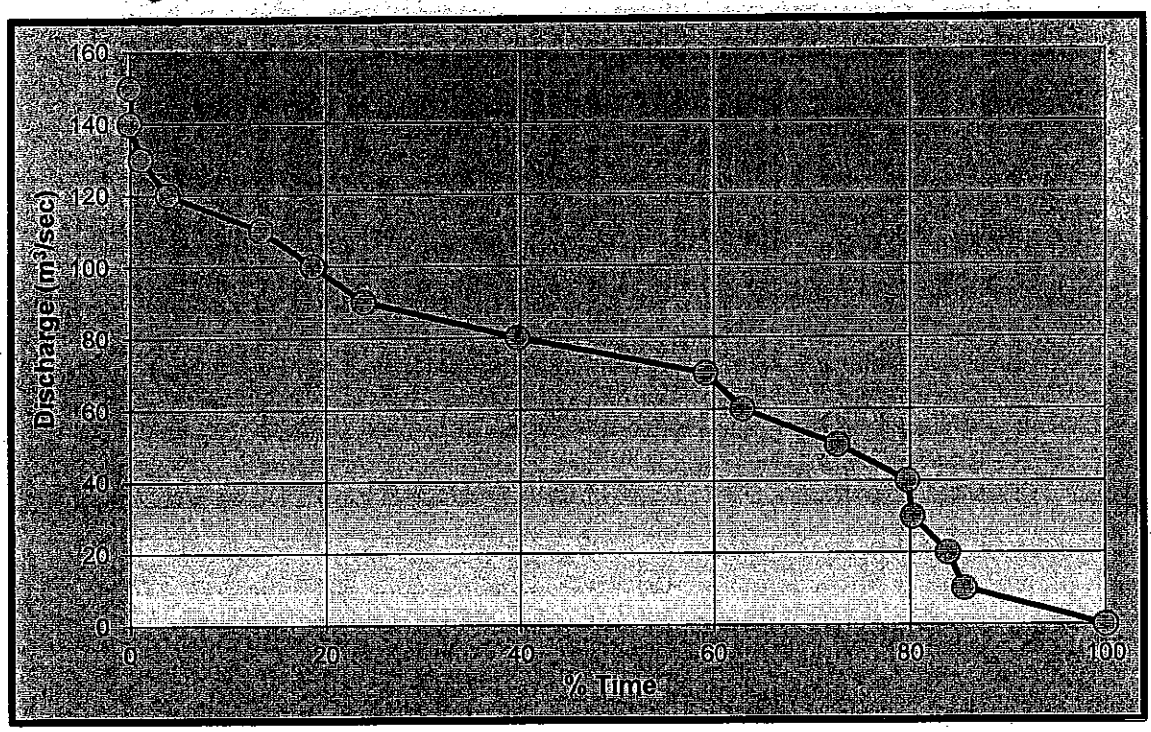


Figure: 5.40 Flow Duration Analysis for Average Year (2006)



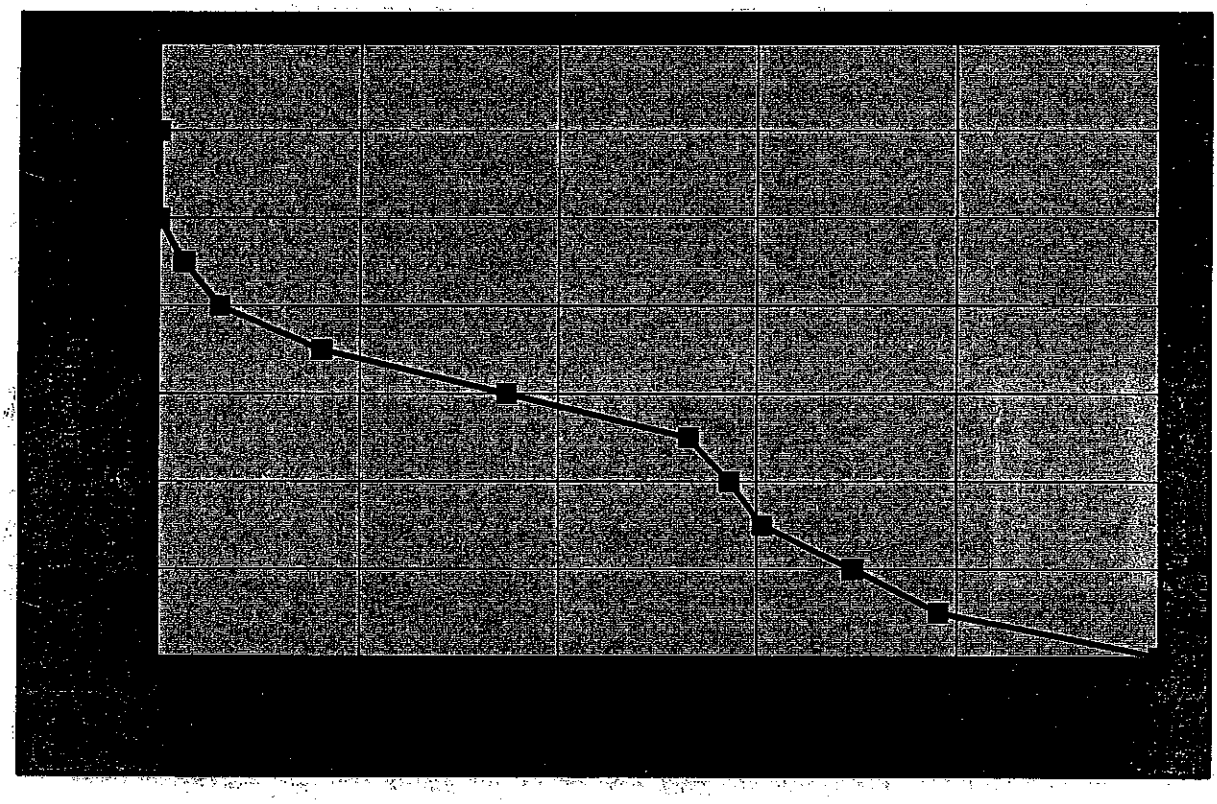
5.4.4. Analysis of Flows after actual Operation of Spillway at Rasul Power Station

Spillway at Rasul Power Station was put into operation during 2003, however, its operation was remained questionable. Spillway was designed as siphon. After some modification and operation it was concluded that it should be converted into standard gated spillway. M/S DESCON, Pakistan was the contractor for conversion into gated spillway. Now hydraulically operated radial gates being controlled from

power station have been installed. The TOC (Taking over Certificate) was issued to contractor on August 22, 2014 from then spillway is working properly. Further, the design discharge of Rasul Power Station is 102.63 m^3/s (3624 ft^3/s) and installed capacity is 22 MW. But due to aging of turbines and generators, Rasul Power Station Turbo-generator set can produce only 18 MW on design discharge.

It is learned from Resident Engineer Rasul Power Station WAPDA, that they are planning to refurbish the plant. However, he told that the maximum flows would be up to design discharge of the Rasul Power Station. The flow duration curve on the data of 2015 is shown in the **Figure: 5.41** which is already assessed the dry flows years for LJC Feeder.

Figure: 5.41 Flow Duration Analysis for the year 2015



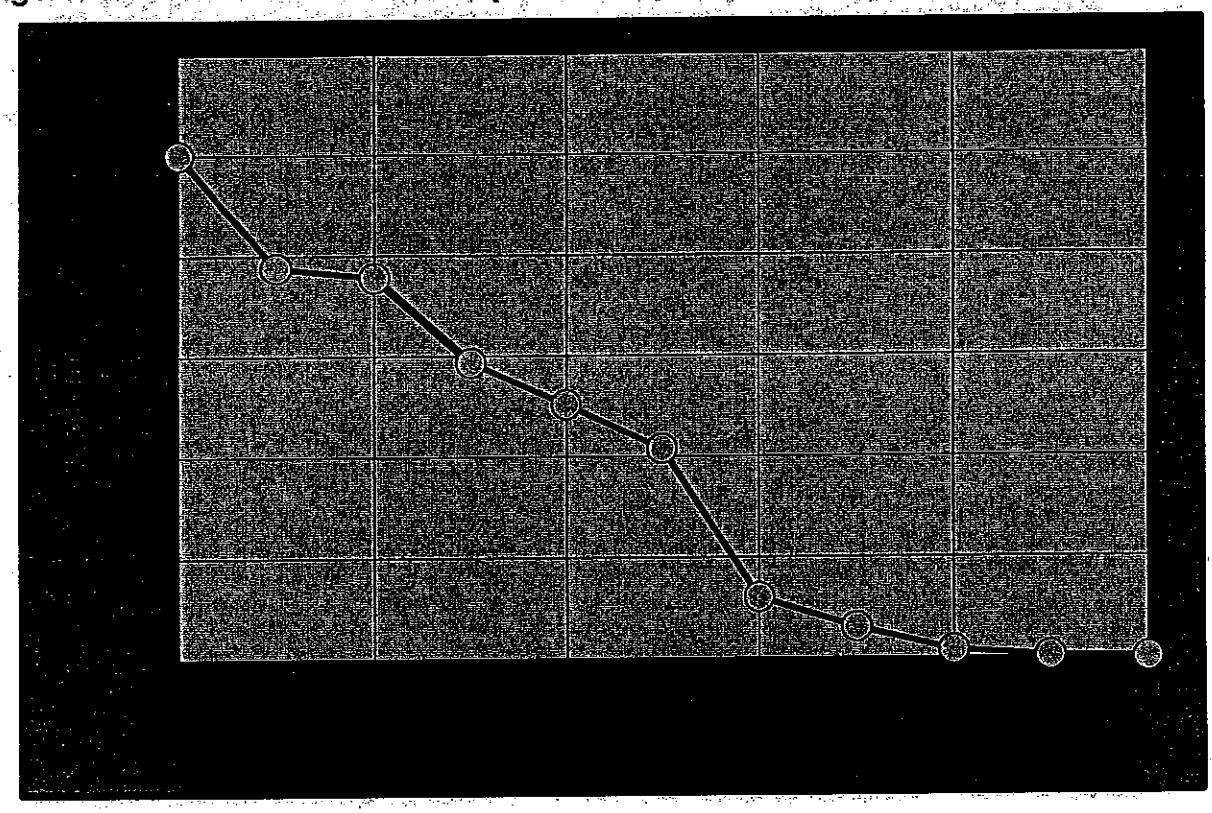
5.4.5. Analysis of Flows in Rasul Power Channel

The indented demands of Lower Jhelum Canal are met with flows of Rasul Power Channel in conjunction with the flows of LJC Feeder. Flow Duration Curve of Rasul Power Channel for the period 1991-2015 is shown in **Figure: 5.42.**

Figure: 5.42 reveals that there were minimum flows in RPC during the year 2007 and 2013 as the Rasul Power House was not operated for more than half of the year. These minimum flows in RPC resulted in maximum flows through the LJC Feeder hence, year 2013 was found to be its wet year. The maximum flow through RPC is during 2015 which is dry year in case of Lower Jhelum Canal Feeder.

Scrutiny of **Figure: 5.42** reveals that the Rasul Power House has never been operated more than 60 m^3/s except for the year 2010, 2011 and 2015 wherein it run close to its designed capacity of 102.6 m^3/s. Daily flow data of RPC for some years is given in **Annexure: 5.10.**

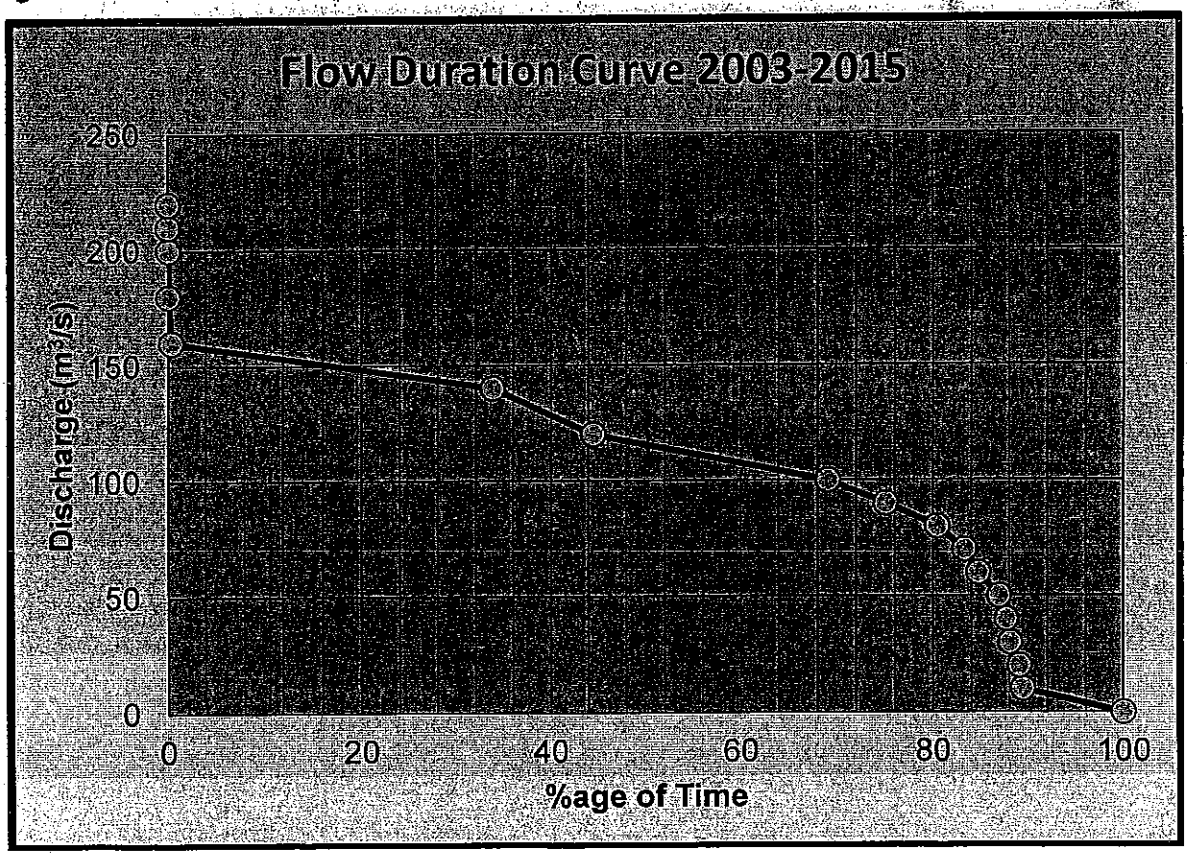
Figure: 5.42 Flow Duration Curve (1991-2015) on Daily Basis for Rasul Power Canal



5.4.6. Analysis of Flows in Lower Jhelum Canal

A close observation of available data given in **Annexure: 5.12** shows that the LJC has never been operated at its designed capacity.

Figure: 5.43 Flow Duration Curve (2003-2015) on Daily Basis for LJC Main Canal



The maximum flow through the LJC is less than its designed capacity of 186.9 m^3/s (6,600 ft^3/s) except in the year of 2007. The flow duration curves (**Figure: 5.43**) reveal that the flows in canal are quite similar with some variation in flows depending on water availability in the system and the indented demands of irrigation supplies.

The flows in Lower Jhelum Canal are shown in **Figure: 5.43.**

5.4.7. Selected Flows Availability for Power Generation

The flow duration curve developed for the Lower Jhelum Canal Feeder, based on daily flow data for the period years 2015 (presented graphically in **Figure: 5.41**) has been used to estimate the actual power and energy potential of the proposed scheme. To evaluate the energy generation as a whole the flow data for the year 2003 through 2015 has been used also.

5.5. Flooding Possibility

The proposed hydro Electric Power Project is located at RD 2+000 of Lower Jhelum Canal Feeder. The center line of proposed Power House building is about 596 m downstream of its headregulator. For optimum energy generation, the upstream water level at proposed powerhouse would be the pond level at Rasul Barrage. Chance of flooding due to flood in the Jhelum River is quite remote because over topping of Rasul Barrage is not allowed. The fuse plug which is placed in right closure bund would be operated in case of extra ordinary flood occurred at Rasul Barrage.

Breaching of headrace canal and over topping of powerhouse due to tripping of turbine units are also remote, because the headrace canal banks have been designed for maximum pond level in the Rasul Barrage Pond and powerhouse upstream deck would also be placed above maximum pond level in the Rasul Barrage.

Flooding due to up-doab is also remote because R-Q link is running parallel to the LJC Feeder on left side and it will act as a flood protection bund for the proposed Hydro Electric Power facility. Further flooding due to lower doab due to rains are also remote due to Jhelum River is running very close and already acting as drainage.

5.6. Sediment Data

Sediment data downstream of Headregulator Lower Jhelum Canal Feeder was collected from office of Executive Engineer Rasul Barrage for the year 2011, 2012, 2013, 2014 and 2015. The data analyzed and recorded as coarse, medium, and fine. Sediment collected are mostly silt particles.

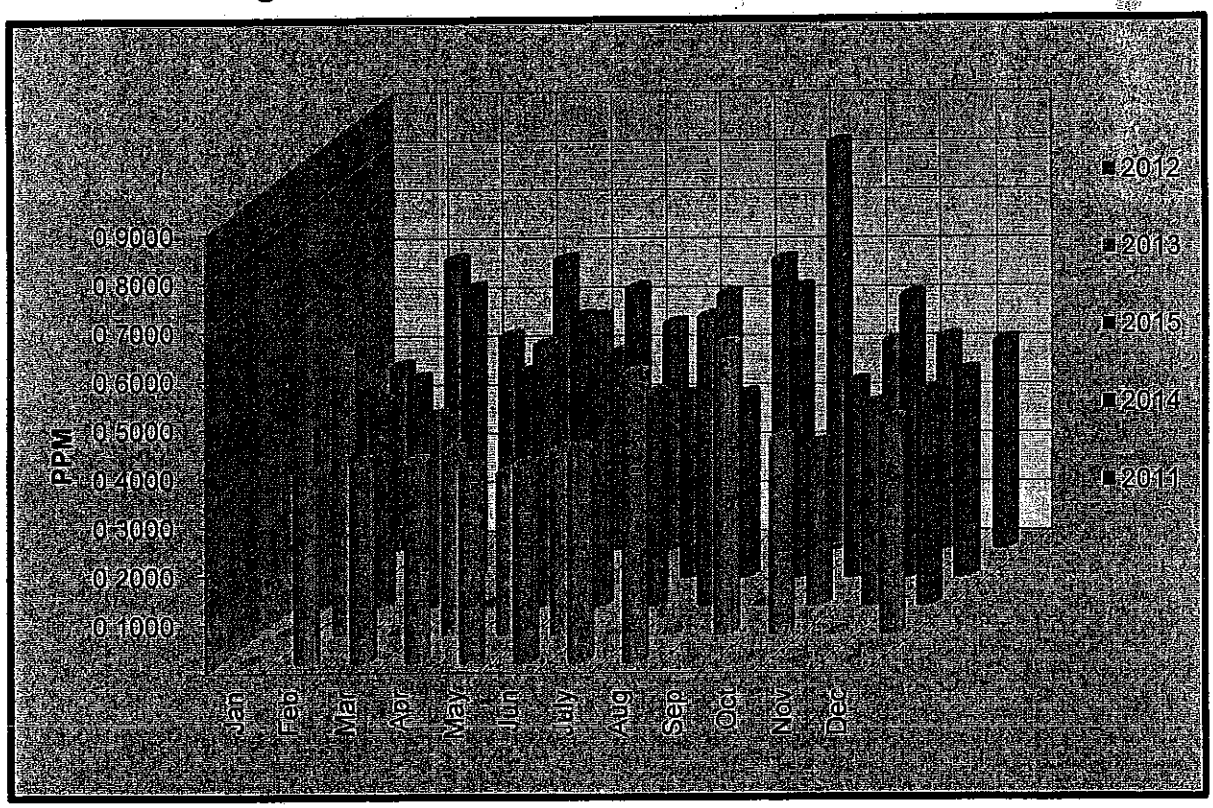
The collected data is presented in **Annexure: 5.13.** The analysis of yearly data was made on minimum, maximum and average concentration is performed and presented in **Table: 5.18** and also presented in **Figure: 5.44.**

Figure: 5.44 shows that more sediment passed during the month of September and less in the month of January. It is noted that coarse and medium sand contribution very less as compared to fine (**Figure: 5.45**).

Table: 5.18 Sediment Data for the Years 2011 to 2015 D/S Headregulator

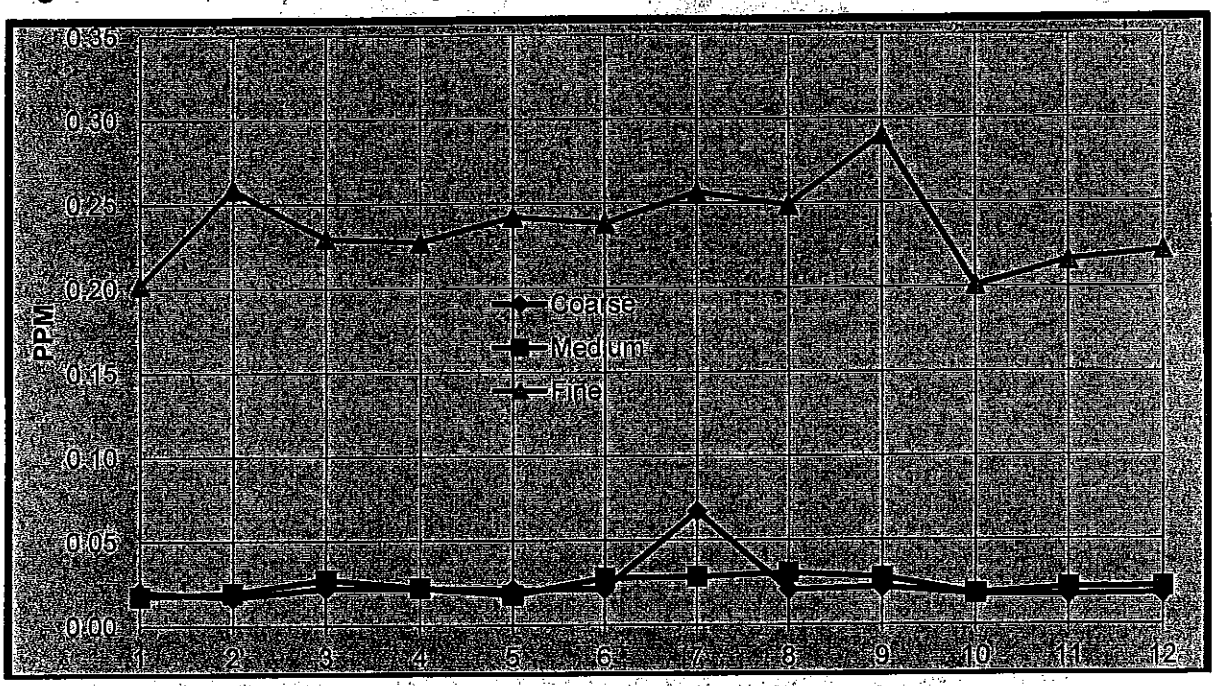
Month	2011	2012	2013	2014	2015
Jan	0.3721	-	-	0.3721	0.3721
Feb	0.5897	0.3876	0.5897	0.4047	0.4172
Mar	0.4332	0.4093	-	0.5897	0.3875
Apr	0.5897	0.4110	0.3750	0.4172	-
May	0.4000	0.3960	0.3280	0.5320	0.5320
Jun	0.4590	0.4047	0.3750	0.5897	0.5897
July	0.5187	0.4332	-	0.3718	0.4332
Aug	0.5897	0.5897	-	0.3721	0.5897
Sep	0.8293	-	0.5897	0.5897	-
Oct	0.4200	-	0.3960	0.3960	0.3280
Nov	0.4293	-	-	0.5740	0.4093
Dec	0.4220	-	0.4352	0.4172	0.4352

Figure: 5.44 Maximum Concentration in a Month



It is important to note that sediment entering in the canal are being observed and controlled by operating the under-sluices placed in the Rasul Barrage just in front of Lower Jhelum Canal Head-regulator. Further, Lower Jhelum Canal is off-taking downstream side of the Rasul-Qadirabad link canal, therefore it may get less share of sediment than R-Q Link.

Figure: 5.45 Concentration (PPM) Coarse, Medium and Fine in a Month (2011)



Considering the existence of Mangla reservoir and Rasul Pond as well as the off-taking position of Lower Jhelum Canal Feeder, the sediment entering canal may be more fine silt. Therefore it is concluded that sediment would not be an issue due to its smaller size for electro-mechanical equipment and hence for civil structures also.

It is also important that the sediment has more impact on fast moving machines, but low head turbines are slow moving, therefore sediment impact would not be significant. However, during detailed design more data would be collected and passed on to the turbine manufacturer for selection of suitable material and ultimately its fabrication design.

CHAPTER – 6

PROJECT PRELIMINARY LOCATIONS AND ALTERNATIVES LAYOUT STUDY

CHAPTER - 6

PROJECT PRELIMINARY LOCATION AND ALTERNATIVES LAYOUT STUDY

6.1. Introduction

A study of preliminary location alternatives and layout alternatives is must under which all possible option for locating the project should be studied into details and preferred location be selected thereafter. Further to be more practical, a preliminary level layout study should also be completed under which one or two best alternatives should be scrutinized and selected to start with the topographic survey and hence geo-technical investigation in the form of bore hole drilling and pitting. Otherwise, geo-technical investigation would be conduct at such location where no structure of the proposed project be placed.

It would have been more economical and preferred option that if Hydro Electric Power Project facility would have been constructed simultaneously when the head-regulator of Lower Jhelum Canal Feeder and bridge-cum-fall structure at RD 8+626 have been constructed.

The project is being pursued by a Consortium of M/s China Sinogy Electric Investment Co. Ltd (CSEIC) Main Sponsor along with M/S China Sinogy Electric Engineering Co. Ltd. (CSEEC), M/s Habib Rafiq (Pvt.) Limited (HRL) and NETCO Rental Services (NETCO) under the terms of an LOI issued on April 18, 2016 by Punjab Power Development Board (PPDB), for site at RD 8+626 of the Lower Jhelum Canal Feeder to conduct the Feasibility Study Report. The head available at RD 8+626 is about 3.68 m when total flows are coming from head-regulator of the Lower Jhelum Canal Feeder. However, it is well known fact that Lower Jhelum Canal Feeder is operating to meet the indent of Lower Jhelum Canal in addition to flows available from Rasul Power Canal. Therefore the head available at RD 8+626 has been reduced due to back water affect caused by flows coming from Rasul Power Canal and by dropping upstream full supply Level due to less flows are passing through the head-regulator of Lower Jhelum Canal Feeder.

As discussed already in Section: 5 Meteorology, Hydrology and Sediment, the head available at RD 8+626 is 2.8 m less than 3.66 m as per designed full supply level, as the Lower Jhelum Canal Feeder is operating most of time less than 3000 m^3/s. But on the other hand the flows downstream of RD 8+626 are equal to full discharge capacity of the canal, therefore the water level on downstream side of RD 8+626 would be equal to Full Supply Level. As the maximum head available at RD 8+626 is 2.8 m which would decrease further as the flows in Lower Jhelum Canal Feeder dropped down.

The head available is considered not economical for development of a Hydro Electric Power Project during these days. A head of 3 m and above is considered economical for hydropower development under present tariff being offered by National Electric Power Regulatory Authority (NEPRA), in Pakistan. Therefore, in order to meet the minimum requirement of available head fall available at LJC Feeder head-regulator is considered for combining with fall at RD 8+626.

6.2. Project Location Alternatives

6.2.1. Introduction

As already discussed above that construction of two hydropower projects (one near headregulator and second near RD 8+626) has merits and demerits. However, these would not be economical in present energy tariff and technology scenario due to head which is less than 3.0 m. Therefore, construction of two powerhouses or single powerhouse at RD 8+626 is not considered further.

In further studies, options were considered in order to make the Proposed Hydro Electric Power Project technically and economically viable under present tariff regime. Therefore, combination of fall available at both structures by excavation of bed of canal or raising of canal banks so that limit of 3 m be met.

Considering combination of falls, the following two options would be explored;

- Project Location – Alternative - 1: Placing the Project Near RD 0+000
- Project Location – Alternative - 2: Placing the Project Near RD 8+626

The above options of hydropower project location have merits and de-merits. However, the option has more merits and less de-merits than other option would be preferred for further studies.

6.2.2. Project Location - Alternative - 1: Placing the Project Near RD 0+000

Alternative-1: Placing the project near RD 0+000requires dismantling of the existing Fall Structure (excluding bridge & piles) at RD 8+626 and lowering of bed of Lower Jhelum Canal Feeder between RD 8+626 and proposed powerhouse location by excavating at the existing bed slope of Lower Jhelum Canal Feeder (**Drawing No. 6.1**). By doing this head available at two fall structures would be combined at or near RD 2+500. This Alternative has the following merits and de-merit over Alternative - 2:

Merits

- The canal bed level lowering means that full supply level in the downstream of proposed powerhouse would also be lowered.
- Lowering of canal bed result lowering of full supply level, means chance of canal breach reduced in all conditions.
- No water logging in the surrounding area especially land lying on canal right bank, because the full supply level in the canal lowered from natural surface level.
- Water losses will be reduced which are happening in the form of water seepage.
- No water losses if compared to Alternative-2 where canal full supply level increased from present full supply level between headregulator and proposed powerhouse near or at RD 8+626.

- After lowering of full supply level, canal will act as drain in this area.
- Tripping/shutdown of power plant normal functioning of spillway gates, canal can be closed from head-regulator and canal would remain save from any breach.
- Raising of canal banks is not required between proposed powerhouse and fall at RD 8+626 as required in case of Alternative-2.
- Being short length between pond and proposed powerhouse, water logging and losses of water will not be a big issue.

Demerits

- Excavation of wet material under canal bed lowering which can only be done during canal closure by normal machinery. Therefore, it is considered as construction constraint.
- Excavated material dumping on the canal right bank, as there is no or little space available on left bank, mean requirement of extra land.
- Strengthen of existing bridge foundations at RD 8+626 by placing stone gabions all around the piers foundation.
- Raising of canal bank is required between powerhouse and head-regulator, to meet the requirement of Rasul Barrage Pond Level fluctuation.

6.2.3. Project Location – Alternative - 2: Placing the Project Near RD 8+626

Project location - Alternative – 2: Placing the Project near RD 8+626 means that the Embankments and bed of existing canal between Fall Structure at RD 8+626 and Headregulator at RD 0+000 should be raised that the head available at RD 0+000 would be combined at RD 8+626 (**Drawing No. 7.2**). Alternative - 2 has merits and de-merit over Alternative - 1 which are:

Merits

- Extra land for dumping of excavated material on canal right bank is not required.

Demerits

- Raising of canal banks are required due to raising of water level between proposed powerhouse near RD 8+626.
- To achieve proper hydraulic gradient, raising of bed level is required. It would be done by constructing controlled section by bricks and filling of bed by earth between these controlled sections.
- Water losses due to seepage will increase as a result of raised upstream water level.
- Water logging of surrounding area especially the land along canal right bank, because the water level will be higher than natural ground surface level.

- Chance of canal breach increased due to raised upstream water level, being higher than surrounding round level.
- In case of tripping of power plant or malfunctioning of spillway gates canal can be closed from head-regulator, but water between head-regulator and proposed powerhouse may breach the canal banks.
- Canal bank raising required material mean more land to be needed on permanent or temporary basis for borrow material.

6.2.4. Optimum Project Location

Considering the merits and demerits elaborated above, Alternative - 1 offered more merits and less demerits than Alternative - 2. Therefore Alternative - 1 is considered the best alternative for locating the proposed project.

Therefore, it is best option that proposed project should be located as near as possible to the head-regulator of LJC Feeder, in order to minimize the raising of canal banks and bed. However, keeping in view construction of powerhouse and spillway/bottom outlets in bypass arrangement or in the canal, diversion of canal is must in both cases. Therefore, proposed project would be located near or around RD 2+500, considering no dismantling of any structure existing along right bank of Feeder near RD 1+200.

6.3. Important Considerations for Layout Alternatives Planning

6.3.1. Introduction

The following important factors that could affect the placing and layout of the power project be studied in details and documented, before starting of any Alternative Layout Planning. These consideration are:

- Site Topography;
- Site Condition around Optimum Project location;
- Subsurface Conditions from Available Report and Documents;
- Climatic Conditions;
- Hydrological Conditions;
- Site Topography;
- Type, Size and Number of Turbines; and
- Operational Criteria for proposed Hydro Electric Power Project.

6.3.2. Topography

The ground surface level around the preferred location of the Mandibahauddin Hydro Electric Power Project is 216.50 m.a.s.l. while canal bank level is 218.70 m.a.s.l. **(Drawing No: 7.3).** The site is relatively level with approximately 1:100 slopes towards south means toward River Chenab downstream of the Rasul Barrage. Present Full Supply Level in the canal is generally below the natural ground level at the preferred location for placing the proposed project. The observed cross-sections of Lower Jhelum Canal from RD 0+000 to RD 10+000 are presented in **Drawing: 6.4, Drawing: 6.5, Drawing: 6.6,Drawing: 6.7** and **Drawing: 6.4.**

6.3.3. Site Conditions Around Optimum Project Location

The proposed project would be placed around RD 2+500 as concluded in **Section: 6.2**.4 above. Fall structures cum village Road Bridge at RD 8+626 of Lower Jhelum Canal Feeder are provided due to change in ground level. It is also provided to protect and strengthen the head-regulator from downstream erosion. Rasul-Qadirabad Link runs in almost straight alignment from headregulator with small curve toward right hand till its RD 10+000, while Lower Jhelum Canal Feeder runs with small curve toward right bank till its RD 1+500 from here onward both canal become almost parallel till LJC Feeder near RD 11+000. LJC Feeder joins the Rasul Power Channel near its RD 11+000 and become Lower Jhelum Canal (LJC).

Lower Jhelum Canal Feeder runs in cut and full supply level in the canal is lower than the natural surface level of the ground in adjoining area from headregulator to RD 8+626. The space between two canals varies from 20 m to 60 m. However, the space between canals is about 50 m between RD 1+000 and RD 4+000,.

Data of both Canals downstream of their headregulator is given in **Table: 7.1**. It is concluded from this data that Full Supply Level is higher in Rasul-Qadirabad Link than in Lower Jhelum Canal Feeder, but the bed level of Lower Jhelum Canal is higher that Rasul-Qadirabad link canal at downstream of their headregulators. It is also noted that bed level and full supply of Lower Jhelum Canal Feeder downstream of RD 8+626 are lower than the bed level and full supply level in Rasul Qadirabad Link.

Table: 7.1 Lower Jhelum Canal Feeder and Rasul-Qadirabad Link Canal Data

#	Description	Lower Jhelum Canal Feeder	Rasul-Qadirabad Link
1	Discharge (m3/s)	186.92	538.09
2	Upstream Full Supply Level (m.a.s.l)	219.15	219.15
3	Downstream Full Supply Level (m.a.s.l)	217.90	218.54
4	Full Supply Depth (m)	3.01	4.27
5	Downstream Bed Level (m.a.s.l)	214.89	214.30
6	Canal Bed width (m)	46.63	100.58
7	Bed Slope	0.12	0.10
8	Free Board (m)	0.91	1.22
9	Laycey's factor	0.96	

The canal bank road is running along its right bank from Headregulator to RD 8+626 and on left bank of LJC Feeder there exists no road even no feet track.

The placing of the powerhouse on left side of Lower Jhelum canal Feeder has restriction due to space limitation because R-Q Link is running parallel and width of the bank between two canals is about 50 m. Any excavation in the left bank will increase in piping flow because of full supply level difference in two Canals.

There is no restriction of space on right side of Lower Jhelum Canal Feeder. Land is barren under shrub and thin forest starting from RD 1+000 to RD 5+5000. This land is belong to Punjab Irrigation Department and will be leased to hydro-electric power project developer as per Power Generation Policy 2006 (revised 2009). There exists a small village near RD 6+000. A village of medium size exists near RD 8+000 also.

6.3.4. Sub-Surface Conditions

The subsoil materials existing along the left bank of the Rasul Barrage are typical of the alluvial soils in the region. This type of soil consisting of predominately of fine grained soils ranging from silty clay to sandy clay, sandy silt, fine sand and medium sand. The clayey content generally found in upper layers and the bed of the Feeder is silty sands with cankers (formed by action of water on calcareous material). The material below the bed of the Feeder is predominantly sand.

It is concluded that foundation subsurface material are suitable for placing raft foundation which is the foundation for proposed powerhouse and also spillway (if proposed). Placing of raft foundation, the Standard Penetration Test (SPT) values should be more than 20 blows at foundation level.

6.3.5. Climate Conditions

Four seasons are being experienced in the project area i.e. winter, spring, summer and autumn. The climate of the project area is semi-arid. Summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months.

Humidity is measured at 0800 in the morning and 1700 in the evening. April, May and June are the months of low humidity while the highest humidity will occur in the months of August, December and January. Average relative humidity varies from 43% to 69 %.

Wind direction is north to northwest from October to May, while during the monsoon period (June to September), it is from east to southeast. Average maximum wind speed recorded at Mandibahauddin city has been 30 km/hr in June. Data shows that May, June, July and August are the month of maximum wind speed.

Average annual rainfall at Mandibahauddin City is about 759.7 mm and mean monthly rainfall is less than 3.0 mm means semi-arid area. Maximum rainfall occurs during the monsoon season (summer months of July, August and September), while the minimum is November (autumn).

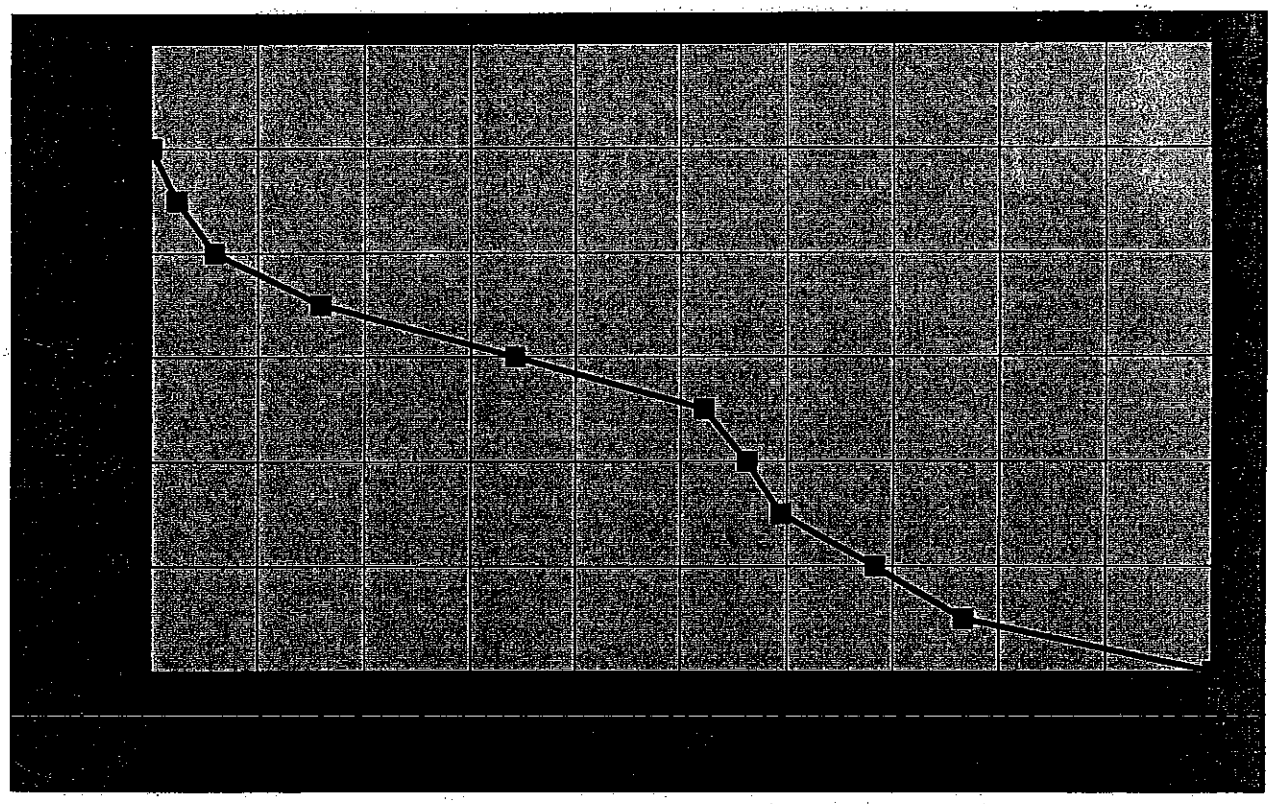
Temperature data shows that the hottest months are May, June, July and August while December, January and February are the coldest. The lowest and the highest values of mean monthly maximum temperature are 20.5 C and 47.5 C for the month of January and May, respectively.

6.3.6. Hydrological Conditions

The Lower Jhelum Canal Feeder was designed for a capacity of 187 m^3/s (6,600 ft^3/s) at headregulator. Measurements of water level and discharge are being made at head regulator only. No measurements at RD 8+626 of LJC Feeder are being recorded.

The canal is named as feeder due the fact that it is being operated to meet the irrigation requirement of Lower Jhelum Canal in addition to water supply coming from Rasul Powerhouse Tailrace. Rasul Power Canal is off-taking from Upper Jhelum Canal. The Rasul Power Station was constructed during 1952 without spillway to pass the discharge downstream of powerhouse during tripping of turbine units. Therefore, in order to safe operation of Upper Jhelum Canal downstream of Rasul Power Canal off-taking point, the Upper Jhelum Canal was running at less discharge capacity. Thus the Lower Jhelum Canal Feeder was being operated at higher discharge to meet the indent requirement of Lower Jhelum Canal during the period when no spillway was constructed at Rasul Power station.

Figure: 7.1 Flow Duration Analysis (2003 to 2015)



It means that canal has two different flow pattern, one is before construction of spillway at Rasul Power Station and second after the construction and operation of spillway at Rasul power station. It is noted that discharges were on the higher side before construction of spillway than after operation of spillway. It is noted that spillway at Rasul Power Plant started its full operation from August 22, 2014.

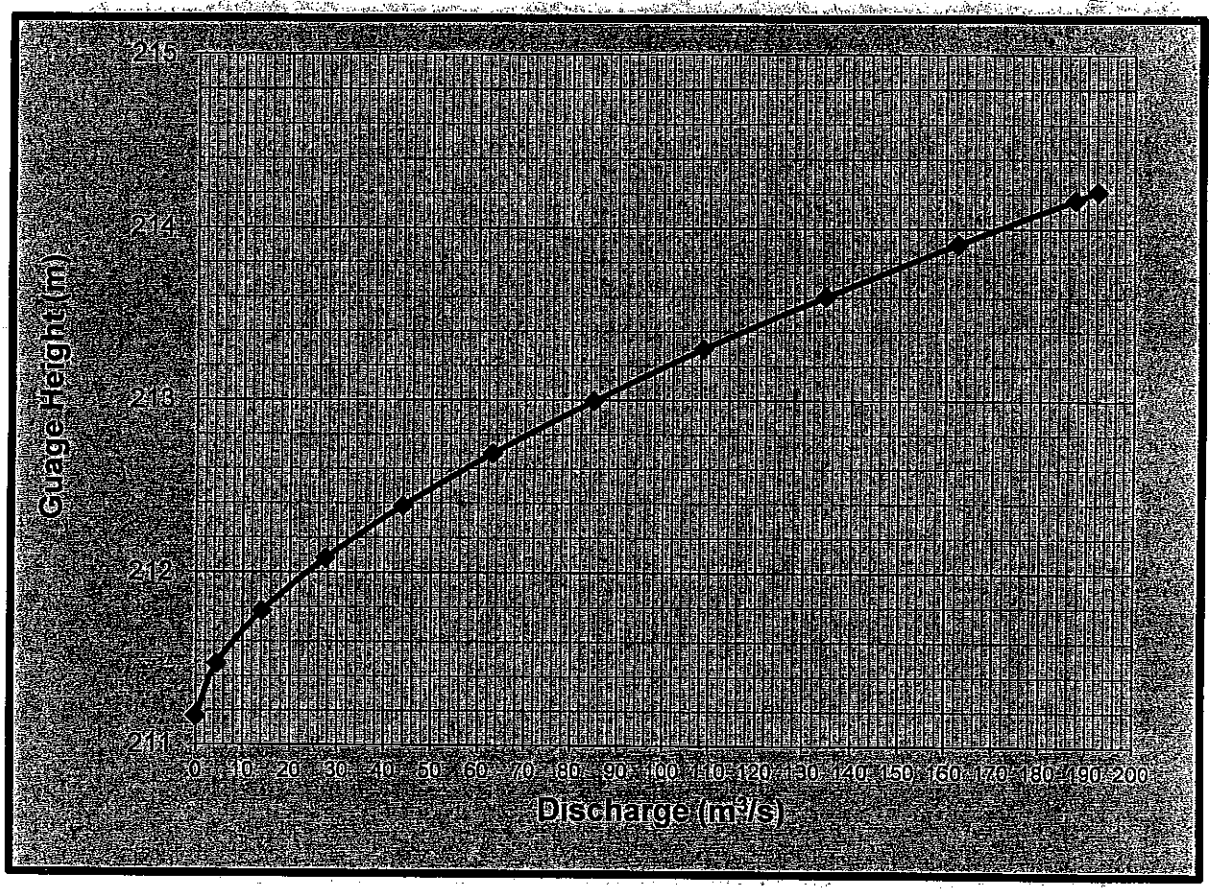
Therefore, data for the year 2015 (**Figure: 7.1)** is representative for designing of proposed power project. However, it is mentioned that spillway or bottom outlets shall be design for full capacity of Lower Jhelum Canal (187 m^3/s).

6.3.7. Project Operation Criteria and Rules

Proposed project operation criteria or rule will not change the operation of LJC Feeder. However, to optimize the power output and energy generation, the following is assumed;

- The normal operation level of Rasul Barrage is 219.15 m.a.s.l. It is assumed that upstream water level will be kept constant at 219.15 m.a.s.l. or on higher (historic) Level.
- Before starting operation of proposed plant, the headrace of proposed powerhouse would be filled up to Reservoir level and thereafter downstream release will be made as per canal operation rules.
- The maximum discharge through the turbine has to be restricted during detailed calculation. However, at this stage it is assumed to pass all flows through the turbines. No discharge is passed through the turbine if the available discharge is less than 30 % of turbine design discharge.
- Downstream rating curve (**Figure: 7.2**) would be used for determining downstream water level.

Figure: 7.2 Downstream Discharge Rating Curve



- Canal should remain in operation as far as possible. Canal closure is to be restricted up to the maintenance requirements only. Other closures as foreseen in the historic data should be avoided.

6.3.8. Turbine Type Alternatives

6.3.8.1. Introduction

The design discharge of Lower Jhelum Canal Feeder near RD 2+000 is 187 m^3/sec with 5.2 m head with respect to water level difference between upstream and downstream full supply level. Therefore, the hydro turbines should be selected for optimal operation at net head of 6.75 m. The data of head and discharge falls in the range of very low head hydropower development and high discharge.

The low head site development as small hydro is difficult at this times to make it financial viable. Low head means low power output per unit of flow, and hence a relatively higher cost than for sites with relative higher heads. Also small power plants suffer from the inverse scale effect, with higher costs relative to larger sites. Therefore, all possible efforts are needed to apply to arrive at an economical and financial viable development.

The major types of turbines (Kaplan types) that are being installed with varying number of turbine units for projects having data like this proposed project are as follow.

- Bevel Gear Turbine
- "S" Type Turbine
- Pit Type Kaplan turbine direct driven or through gear
- Straflo /Rim Generator Type Kaplan turbine
- Bulb Type Turbine
- Kaplan Turbine (Vertical Axis)

Above type of turbine has its own merits and demerits in respect of their operational head and discharge range, peak efficiency, maintenance approach, accessibility, civil work, power house foundation level, powerhouse crane capacity, etc.

For the Mandibahauddin Hydro Electric Power Project, considering discharge and head variation, only two options are recommended for detailed analyses.

- Pit Type Gear Driven
- Pit Type Direct Driven

6.3.8.2. Number and Type of Turbine Units

The Mandibahauddin Hydro Electric Power Project site can be studied for the installation of 1, 2, 3, 4, and 5 units. The installation of 5 units was not found suitable due to site limitation when powerhouse is to be located in the running canal.

The installation of one unit is also not suitable due to operation reliability, dependability, energy loss and flexibility.

The decision regarding number of units and type of unit is also depend upon maintenance requirement. However, this is not important for proposed project site because LJC Feeder remained closed every year for one month period for annual maintenance.

Considering merits of Gear Driven Pit type over Direct Driven Pit type with respect to saving in cost of civil works, easy maintenance, less weight and hence simple and less capacity cranes in powerhouse, etc. Gear Driven Pit Type is selected for details analysis of selection of alternative layout for this plant.

6.4. Bypassing Structure Alternatives

6.4.1. Introduction

Every Hydro Electric Power Project must have powerhouse for installation of hydro turbines, generators and other auxiliaries equipment required for its robust operation. Along with powerhouse structure, a bypassing structure is also an essential part of any hydro power project, in case power turbine are closed due to any problem upon turbine or upon transmission line, the coming discharge has to pass downstream without any loss of time. These bypassing structures would be gated spillway, fixed crest spillway, bottom outlet, spill channel, etc. The following bypassing structures would only be used for this project site.

- Option-1: Gated Spillway
- Option-2: Bottom Outlet

The merits and demerits of both the above structures is defined below.

6.4.2. Option-1: Gated Spillway

In this option, the turbines and generators are housed in simple powerhouse building and standard spillway would be placed very near to powerhouse building (**Drawing No: 6.9**, **Drawing No: 6.10** and **Drawing No: 6.11**). Spillway would be aligned with the powerhouse axis and would be equipped with radial type of gates. The hoisting mechanism would be placed in elevated position on steel platform or hydraulic system. Powerhouse and spillway would be discharging in the same tailrace canal.

This option has merits and demerits.

Merits

- Pakistan has a lot of experience of operation and maintenance of this type of structures;
- In case gates are not operated, the flows can overtop easily and chances of canal breach is rear.

Demerits

- Cannot be accommodated within the canal bed as the canal bed is not enough and need more space. Enlargement of canal is very much

necessary. Hence more land has to be acquired compared with Bottom Outlet Option.

- Powerhouse and spillway will be constructed in single pit, chance of differential settlement due to difference in foundation level, if not properly designed and constructed.
- Flows conditions towards powerhouse would be asymmetric.
- Partial operation of turbines and spillways would create swirl on upstream side which are endangered for turbine operation.
- Additional Space for loading and unloading is required inside the powerhouse building.
- Sediment may deposit in front of spillway

6.4.3. Option-2: Bottom Outlet

Under this option, the turbines, generators and bottom outlets are housed in simple powerhouse building (**Drawing No: 6.12**, **Drawing No: 6.13** and **Drawing No: 6.14**). The gates for Bottom Outlets will be placed on downstream side of the powerhouse building. Bottom Outlets gates are vertical hydraulically operated. Powerhouse and Bottom Outlets would be discharging in the same tailrace canal.

This option has merits and demerits.

Merits

- Flows conditions toward turbines and bottom outlets would be very good.
- Under partial operation formation of swirl in negligible.
- Top space of bottom outlet could be used as loading and unloading bay therefore, additional space for loading and unloading is not required.
- Deposition of sediment upstream of powerhouse will not be happening due to intake of horizontal turbine and bottom outlets at the same level.
- Space required for bottom outlets is much less than standard spillway, therefore less land would be acquired.
- Powerhouse and spillway will be constructed in single pit, chance of differential settlement is not there because foundation level of both is the same.

Demerits

- No experience in Pakistan for operation and maintenance of this type of structures in irrigation system. However, these have been provided in hydropower plant, under WAPDA Control.
- In case gates are not operating or jammed, the flows cannot overtop easily and chances of canal breach is there. However, in case of this project, headregulator of the LJC Feeder is about less than 1 km upstream from the proposed powerhouse, therefore, breach of canal be avoided by raising of LJC Bank above normal pond level of Rasul Barrage and canal can be closed with the operation of canal headregulator gates.

6.4.4. Conclusions

Considering above merits and demerits for both options it is concluded that bottom outlets options have more merits and less demerit as compared to standard spillway. However, it was decided to design both structures. The quantities on the basis of design drawing would be made and then a cost estimate would be prepared. The option having less cost would be selected for further layout planning. The **Drawings No. 6.9, Drawing No. 6.10** and **Drawings No. 6.11** are for spillway option while bottom outlets is presented in **Drawings No. 6.12, Drawings No. 6.13** and **Drawings No. 6.14**. The detailed quantities and cost estimation is presented in **Annexure: 6.1** and **Annexure: 6.2** of both option and summary is presented in **Table: 6.2.**

Table: 6.2 Construction Cost for Spillway and Bottom Outlets

	Base Cost (Rs Million)
Option-1: Spillway	293.396
Option-2: Bottom Outlet	240.357

It is concluded that option for Bottom Outlets have less construction cost therefore, selected for further planning.

6.5. Project Layout Alternative Studies

6.5.1. Introduction

Considering topography of the area, site conditions surround the proposed project location, climatic conditions of the area and hydrology of the LJC Feeder, the following project layout alternatives were marked and drawings were prepared during the office studies. These alternatives were checked during field visits and finally drawing were prepared on topographic survey conducted during the feasibility study:

- **Layout Alternative: 1 Powerhouse with Bottom Outlets in the Existing Canal.**
- **Layout Alternative: 2 Powerhouse with Bottom Outlets in the bypass Canal.**

The placing of the diversion canal and project in bypass canal on left side was not considered due to space limitation and close proximity of Rasul-Qadirabad link canal. Therefore, the proposed project can be placed only on right side of existing canal or inside of the existing canal.

6.5.2. Layout Alternative: 1 Powerhouse with Bottom Outlets in the Existing Canal.

Layout Alternative: 1 means a powerhouse and Bottom Outlets would be placed in the existing canal (**Drawing No: 6.15, Drawing No: 6.16, Drawing No: 6.17, Drawing**

No: 6.18, Drawing No: 6.19, Drawing No: 6.20, Drawing No: 6.21, Drawing No: 6.22, Drawing No: 6.23, Drawings No: 6.24 and **Drawing No: 6.25**). It means that powerhouse would house turbines, generators, all auxiliaries' equipment and bottom outlets also. The bottom outlets and turbine units would be placed alternatively so that better hydraulic conditions could be achieved.

Powerhouse and bottom outlets would be constructed in the running canal shall require diversion of canal flows during construction. This diversion canal would be excavated at the right side of the Lower Jhelum Canal Feeder. Therefore it is well known fact that construction work at proposed powerhouse site cannot be started immediately and linked with canal diversion which may need two to three months. Diversion of canal (**Drawing No: 6.35**) during canal closure is less costly and simple, however, diversion of canal can be completed at any time and has no link with low flow as the case of main rivers.

This alternative requires dismantling of fall structure at RD 8+626, canal bed lowering between proposed powerhouse and existing fall structure at RD 8+626 and raising of canal banks and bed between proposed powerhouse location and LJC Feeder headregulator.

The land acquired for canal diversion would be on temporary basis and would be returned after levelling to the original owners. The only compensation in this case would be lease charges and trees planting. Before start of excavation all environmental requirement would be fulfilled.

6.5.3. Layout Alternative: 2 Powerhouse with Bottom Outlets in the bypass Canal

Layout Alternative-2 mean placing of powerhouse with bottom outlets in the By-pass canal (**Drawing No: 6.26, Drawing No: 6.27, Drawing No: 6.28, Drawing No: 6.29, Drawing No: 6.30, Drawing No: 6.31, Drawing No: 6.32, Drawing No: 6.33**, and **Drawing No: 6.34**). The powerhouse and bottom outlets would be constructed in dry area on right side of the canal at a safe distance from the existing canal, so that dewatering during construction would be minimum. After construction completion of powerhouse & bottom outlets, tailrace and headrace, the existing canal will be plugged and flows diverted would be in the bypass canal toward powerhouse and bottom outlets. The headrace will off-take with s-type curve and tailrace will join the existing canal with s-type curve, having proper hydraulic design and would not create any head losses.

This alternative may offer less construction period, because construction of diversion canal is not need. Less construction period mean benefits from sales of energy starts earlier as compared to other alternatives. There may be less cost for dewatering as compared to alternative in the canal which is surrounded by Rasul-Qadirabad Link and diversion canal.

Much more land would be acquired on permanent basis which is difficult task because land is under forest and very good for forest & agriculture. Land requirement for diversion canal is less than bypass canal arrangement, because in diversion canal smooth flows requirement is not important because there exist fall structure at RD 8+626. However, in case of bypass arrangement smooth flows requirement is prime because surface of flow would be controlled in tailrace.

6.6. Preferred Project Layout Alternative

As stated above design and drawings for both Alternative-1 and Alternative-2 prepared in office and also verified in field with topography and site conditions. The drawings of each Alternative is presented in **Drawing No. 6.15** through **Drawings No. 6.34**. By using these drawings, a quantities estimate for both were prepared in details. On the basis of these quantities, a cost estimate has been prepared for civil works. Cost for environment and social was also included in cost estimate. The cost of E&M works and hydraulic vertical operated gates for bottom outlets were not added being the same for both alternatives.

Direct cost such as Costs of contingencies, engineering & supervision, transportation, insurance, erection, testing and commissioning of E&M would be included. The quantities and cost for each alternative is present in **Annexure: 6.3** through **Annexure: 6.4**. On the basis of economic and financial analysis, the best alternative would be selected and designed for feasibility level for each structure and component would be performed and presented in Section: 11.

Table: 6.3 Construction Cost for Layout Alternative-1 and 2

	Base Cost (Rs Million)
Alternative-1	1439.044
Alternative-2	1507.792

The Alternative: 1 gives less cost than Alternative-2 and hence selected as **Project Preferred Alternative** for further studies under **Section 11** of this Feasibility Study Report.

CHAPTER – 7

SURVEYING AND MAPPING

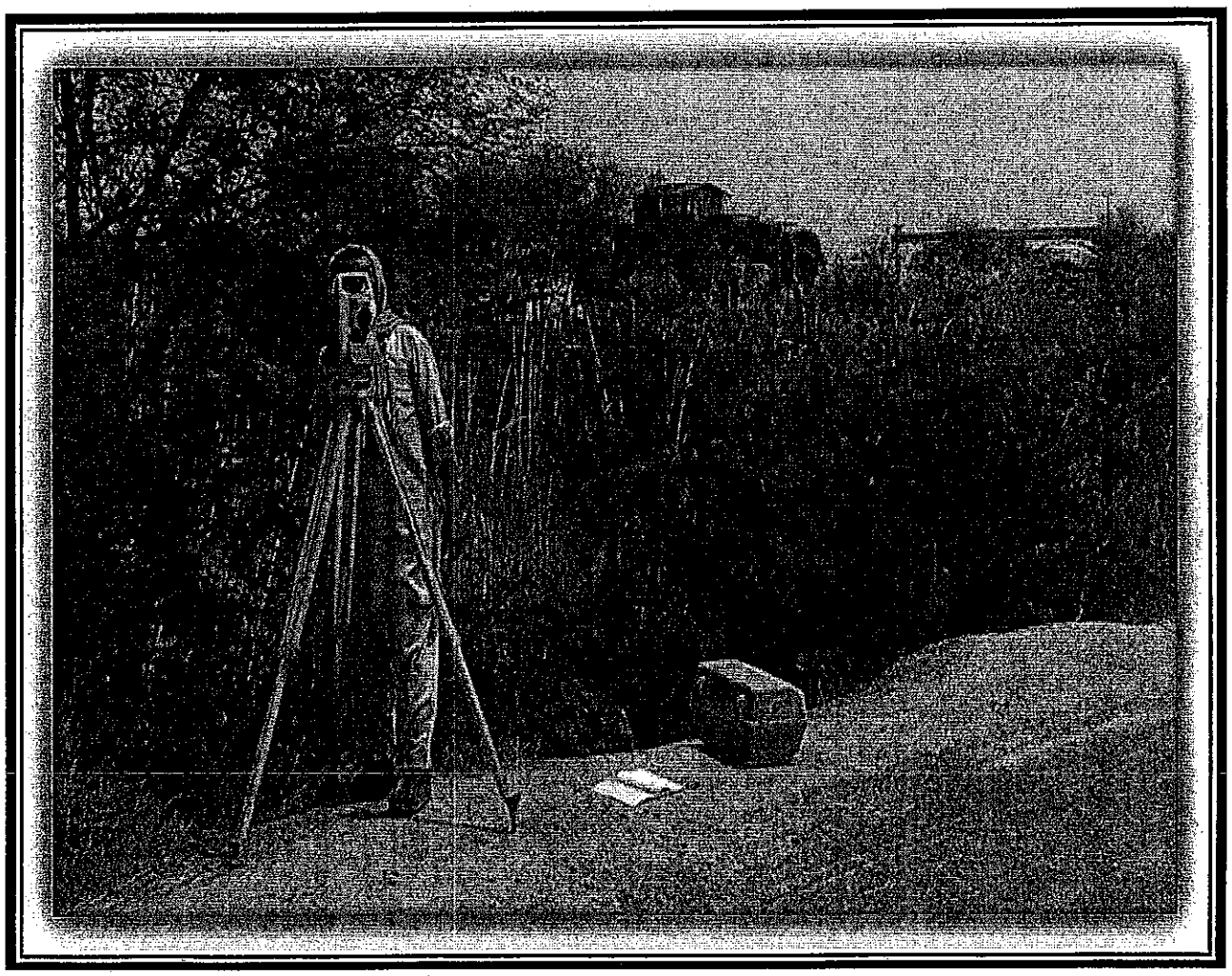
CHAPTER - 7

SURVEYING AND MAPPINGS

7.1. Introduction

Topographic mapping and hydrographic survey has been conducted in surrounding of Lower Jhelum Canal Feeder (LJCF) considering 200 m strip on its right bank & complete left bank till to water surface in Qadirabad-Balloki Link Canal. The mapping and survey starting from RD 0+0000 to RD 10+000 including canal cross sections at each RD. This was planned after completing hydrological and Project Preliminary Locations and Alternatives Layout Study. M/s IM Associates, Lahore hired to carry out the surveying and preparation of the topographic maps. M/S IM Associates mobilized at site dated July, 2016 and completed the whole survey work in field by dated August 18, 2016 (**Figure: 7.1).** Contour maps has been generated in the office through computer by using field data observed and recorded with total station and Global Positioning System (GPS).

Figure: 7.1 Surveyor with Sokia Total Station in Project Area



Discrepancies were noted in survey and mapping. The Survey Team was send again to the field for further data collection. Team spend two days in the field and

recorded data was upload in the already collected survey data. Topographic maps were generated at 0.25 m contour intervals. These maps will be used for preparation of the project alternative layouts, design, quantities and cost estimation.

Total eight bench marks established along LJC Feeder. Details of bench mark points are presented in **Annexure: 7.1**.

7.2. Scope of Work

Topographic mapping and hydrographical surveying was carried out. Surveying and mapping included:

- Checking and Shifting of the XY from GPS and Z from Crest Level of Canal Headregulator.
- Production and installation of eight Pillars/survey markers in the project area.
- Traverse connection and Horizontal & vertical control of all control points.
- Topographic survey in sufficient detail at the proposed area to support preparation of 1:1000 scale with 0.25 m contour interval maps.
- Cross-section of the existing Canal at the time of normal water condition.

7.6.1. Description of Work

M/S IM Associate Lahore conducted the topographic surveying with Total Station of Sokkia Model 630, Total Station of Sokkia Model 3100 was also used. Topographic maps were prepared. The maps contain planimetric features encountered during field surveys, including: houses; roads (paved and unpaved); cultivated & un-cultivated lands; vegetation, electric lines, trees, canal, canal banks and other built-up properties. Topographic features such as road, tracks and spot elevations of water surfaces in the Canals and the high and low points at depressions, are shown on the maps to depict the relief of the area.

All vertical positions are reported relative to UTM datum, and horizontal positioning is based on GPS easting and northing coordinates.

7.3. Establishing of Benchmarks And Control Points

7.3.1. Primary Survey Control

Eight (8) primary control Points (Bench Mark) have been established along the canal at the distance of each RD at the start of the commencement of the topographic and levelling survey. A primary control survey was carried out to determine x and y co-ordinates of the primary control Points by traversing. The elevations of the primary control Points were also determined with reference to UTM datum and also close to UTM datum.

These survey markers have been established on stable position along the canal and are shown in **Drawing No.7.1** through **Drawings: 7.5**. The survey markers having size of 152 mm diameter were constructed with concrete and embedded two feet

into the ground and six inches above the ground with steel rods in the centre of each survey mark, exposed 5 mm above the surface so that they will not be disturbed during the movement of vehicles and animals and can be used during construction works and maintained throughout the construction period. However, maintaining these for such long period in questionable and may not be possible. The data of control point or bench marks is given in **Table: 7.1**.

TABLE: 7.1 Data of Control Points/Bench Marks

Point No.	Easting	Northing	Elevation	Code
1	361577.113	3616354.691	221.265	P 1
2	361772.832	3616121.482	221.182	P 2
3	361963.625	3615882.672	221.274	P 3
4	362138.251	3615632.878	221.631	P 4
5	362297.756	3615373.751	221.386	P 5
6	362436.337	3615099.980	220.736	P 6
7	362577.799	3614833.074	221.191	P 7
8	362780.565	3614258.471	220.566	P 8

These survey marks manifest with its reference number and location were saved through photographs. Each survey mark is shown on description sheet prepared and thus attached in **Annexure: 7.1**.

7.3.2. Secondary Survey Control

About thirty six (36) Secondary control points were established to provide a suitable basis for the topographical mapping and survey along canal bank with 200 m strip toward right bank of LJC Feeder. The survey was carried out to determine X, Y and Z co-ordinates of secondary control points by traversing from RD 0+000 to RD 10+000. Data of benchmarks via primary control Points are given in **Table: 7.2.**

Table: 7.2 Data of Secondary Control Points

SL No.	EASTING	NORTGING	Elevation	CODE	SL No.	EASTING	NORTGING	Elevation	CODE
1	361516.914	3616663.951	215.951	TS 17	19	362721.468	3614068.490	220.468	TS 17
2	361546.025	3616611.128	219.806	TS 16	20	362766.797	3614143.388	220.632	TS 16
3	361476.788	3616562.663	221.153	TS 15	21	362780.567	3614258.486	220.552	TS 15
4	361448.697	3616617.862	222.334	TS 14	22	362755.713	3614364.179	219.625	TS 14
5	361536.476	3616397.430	220.971	TS 13	23	362650.150	3614639.070	220.799	TS 13
6	361674.133	3616227.778	221.316	TS 12	24	362541.306	3614925.174	221.484	TS 12
7	361793.457	3616094.661	220.811	TS 11	25	362517.891	3614957.868	220.805	TS 11
8	362028.647	3615790.070	221.195	TS 10	26	362435.726	3615112.300	220.489	TS 10
9	362183.606	3615543.776	220.905	TS 9	27	362240.684	3615463.958	220.959	TS 9
10	362240.687	3615463.952	220.977	TS 8	28	362183.602	3615543.784	220.893	TS 8

11	362435.727	3615112.296	220.500	TS-10	29	362028.687	3615790.077	221.184	TS-7
12	362517.891	3614957.867	220.808	TS-11	30	361793.452	3616094.667	220.798	TS-6
13	362541.309	3614925.171	221.491	TS-12	31	361674.186	3616227.774	221.318	TS-5
14	362650.153	3614639.067	220.785	TS-13	32	361538.476	3616897.431	220.948	TS-4
15	362755.713	3614364.181	219.604	TS-14	33	361448.697	3616617.862	222.334	TS-3
16	362780.565	3614258.471	220.566	TS-15	34	361476.491	3616552.658	221.143	TS-2
17	362766.797	3614143.388	220.621	TS-16	35	361546.019	3616611.124	219.791	TS-1
18	362721.468	3614068.490	220.468	TS-17	36	361455.936	3616646.316	222.211	HG_HT
Adjusted at Closing Error E= 0.006 N= 0.004 H= 0.015									

The secondary control points were positioned in a way so that minimum of two adjacent points are inter-visible. The points have been located to fully enclose the required area for topographic mapping and survey at sufficient distance from the proposed sites.

7.4. Control Works

Horizontal and Vertical control started from RD 000+000 Headregulator/Bridge of Rasul Barrage with Precise GPS at Fall RD-000+000, both side Point No. TS-1 & TS-2 given at **Table: 7.2.** All survey markers connected with main traversing. An electronic distance meter/total station has been used for distance measuring with accuracy was at least 10 mm + 5ppm X D;

Note: 5ppm: 5cm per 10 km, D: Measured Distance 5

Linear miss-closure of the primary traverse was best then 1/10,000

7.5. Topographic Mapping

Topographic mapping incorporating land profile and man-made features such as roads, buildings, tracks, canals, trees, water levels, bridge cum fall structure at RD 8+626 etc. was carried out to prepare map on scale 1:1000 by using the grid co-ordinates and heights of the established control points. Features for contouring, elevations were picked up at every change of slope and these are presented in **Drawing: 7.1** through **Drawing: 7.5.**

7.6. Hydrographic Survey

LJC Feeder cross-sections were observed at each RD starting from 0+000 to 10+000. The cross-sections cover canal bed levels and levels of both banks of the LJC Feeder. These cross-sections were observed to study the canal behaviour. These cross-sections would also be used for estimation of excavation quantities when fall at RD 8+626 would be combined at RD 2+500. These cross-sections are presented in **Drawing: 7.6** through **Drawing: 7.9.** The readings in the bed of LJC Feeder were taken from 10 to 15 m apart to plot the cross sections and several readings were observed at both banks of LJC Feeder.

7.7. Data Submission

- Survey plan submitted as follows: survey drawing with Contouring (Interval 0.25m & 0.5m) prepared on AutoCAD format (**Drawing:7.1 to Drawing: 7.5**)
- Photographs of Survey Marker, site and surveyor working at site (**Annexure: 7.1**)
- The Co-Ordinates of all Survey Marker & secondary control points/Traverse Points.
- Cross-section of the existing Canal 15 No's (**Drawing: 7.6** through **Drawing: 7.9**).